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WINTER NAVIGATION IN THE BOTHNIAN BAY AND THE ICEWORTHINESS OF MERCHANT VESSELS

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W I N T E R N A V I G A T I O N I N T H E B O T H N I A N B A Y A N D T H E I C E W O R T H I N E S S O F M E R C H A N T V E S S E L S

Introduction

Winter navigation in the Bothnian Bay is a subject that continues to be discussed both among professionals, and in the news media. This is particularly true in late fall and early spring. All the parties involved have participated in this discussion: the industry, the Government and municipal administrators, and the shipowners. Naturally, each party tries to promote his own interests in what seems to him the most effective way. Consequently, at times the crux of the matter seems to have been forgotten. Winter navigation in the Bothnian Bay should first and foremost provide an economical mode of transporting goods so that three important qualities of transportation are ensured: dependability, speed, and low cost. The chronic discontent concerning winter navigation in the Bothnian Bay implies that these qualities have not been fully attained. Actual navigation appears at times to have been neglected in the discussion concerning the Bothnian Bay. After all, it is the ships that perform the transportation. Therefore it seems impossible to solve the problem without clarifying the role of navigation itself. The Foundation for Navigation has given the present writer the task to compile this memorandum, the purpose of which is to try to bring out navigational considerations.

As we begin to study the problems involved, we will soon realize that it is an extremely complex matter involving many groups. An individual person within this limited program can only superficially deal with the various aspects of the matter. It has been my aim to collect a rather limited amount of selected data, and avoid the historical background, which may not be of interest in this connection.

I want to express my sincere gratitude to the following experts who have without exception displayed great interest and understanding concerning this cause.

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In Matinkylä, September 9, 1969

Pentti Mäkinen

I. GENERAL CONDITIONS

1. Winter in the Bothnian Bay

Winter in the Bothnian Bay is longer and more severe than the winter in the Sea of Bothnia or in the Gulf of Finland. As a result, the Bothnian Bay freezes in its entirety even in mild winters. The junction between the Bothnian Bay and the Sea of Bothnia, called Merenkurkku, freezes on the average at the beginning of January and thaws on the first of May. The northern shore waters freeze about the 20th of December and thaw around the 20th of May. The number of so-called ice days in Merenkurkku is about 100 and it increases up to 190 as you go north. These figures are two times greater than in the Gulf of Finland. The ice is thickest during March and April. It is 75 cm thick in Ajos and 50 cm in Vaasa. The ice increases in thickness slowly but melts 3 or 4 times faster. For ice to reach its full thickness takes about 4 months but the final thawing takes place much faster. During the last three weeks, about 90% of the ice will melt.

Freshwater ice is stronger than saltwater ice. This is because salt collects in salt water pockets in the ice. Also the lower temperature of the ice increases its strength. The concentration of salt in the Bothnian Bay is comparatively low; about 3 or 4 parts per thousand. Freshwater ice at -20C can be two times stronger than 0.4/1,000 ice at -3C. Unfortunately, information about the effective pressure of ice masses against the sides of the ship has not been available. This is simply because no one has studied it.

2. Sea Transportation in the Bothnian Bay

In 1968 the volume of sea transportation in the Bothnian Bay was 4.30 million tons, which was 16% of the total sea transportation of the whole country. Export was 2.79 million tons, or 26% of the total for the country. Import was 1.51 million tons or 9.5% of the total. This was divided between 12 different ports. Yet we have to realize that 90% of the whole traffic goes through 5 ports: Kemi, Oulu, Kokkola, Pietarsaari, and Rautaruukki. About half goes through only two of them: Kemi and Oulu.

The transported goods fall into three main groups: wood products, mining and mineral products, and oil. All these share the problems caused by the winter season and yet their problems are not similar. The goal of the wood product industry is economical continuity of exports. In 1968 the wood products industry of the Bothnian Bay produced about 950,000 tons of cellulose and 230,600 tons of paper and cardboard. Because the degree of processing will rise in future, the figures will change accordingly. An essential part of this need for transportation falls in the winter, which emphasizes the importance of winter traffic for the wood refining industry of the North of Finland. The common notion that transportation is necessary only in the summer is unfortunately not true as far as the vitally important wood processing industry is concerned.

The main problem concerning oil and other imported fuel is the transportation and storage costs. In 1968 Bothnian Bay ports received about 1,100,000 tons of oil, or about 30% of all oil imported by sea. Sea transportation added with winter allowances and above all storage costs during the 5 winter months is clearly a more economical way to take care of the oil needs of northern Finland than to transport it by railroads at 25 Finnmarks/ton (1). On the other hand, in considering storage problems one has to take general production and safety considerations into account.

Finland's mining and mineral industry involve both import and export. Raw materials and finished products are completely different. It is possible to store raw materials and even the semi-finished products of the metal industry. Each year about a quarter of a million tons of ore, coke, etc. sail in and out of the hargors of the Bothnian Bay. The finished products, above all steel, are not storable. In 1968, 388,872 tons of iron bars and 64,326 tons of sheets were transported by ship. Steel sheets in particular are difficult to store because they are sold in small amounts.

In spite of that they are heavy packages (from 5 to 40 tons). The improvised winter harbors have to be especially equipped for this. Similarly, the small ships suitable for carrying steel products will be the first to suffer from the restrictions imposed each fall by the Board of Navigation.

Oulu and Kemi will serve as examples of winter navigation in the Bothnian Bay. From the year 1963 up to 1967, the winter season has lasted an average of 5 months and 3 weeks. Fall assistance has lasted for two months and the harbors have been entirely closed for three months on the average.

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(1) The Finnmark (Fmk): $1.00 = 4.25 Finnmarks (1965).

3. Organization of Winter Navigation

The year is divided into 4 seasons: season of fall assistance, the closed season, season of spring assistance, and the summer season. The Bureau of Navigation determines the seasons according to developments from the first appearance of ice. The Bureau uses traffic restrictions to control winter navigation. These restrictions are comparable to those on thawing highways. In fall the restrictions naturally increase toward a complete standstill. In spring the order is reversed. From 1965 on two parameters have been used (2): the size of ships and the ice class. There are three size groups: 700 dwt, 900 dwt and 2000 dwt. These classes have naturally their own practical counterparts. In theory there are five ice classes: Class II or the unreinforced, and classes IC, IB, IA, and IA Super. In practice, IB is combined with either class IC or class IA. IA-Super has not been used.

New restrictions become effective within 3 days after their publication. This time is considered sufficient for emptying the area of the ships under the restriction. Exceptions are allowed only by special permission of the Director of Traffic. In practice, this concerns only tankers. Neither cancellation of restrictions nor opening of harbors are announced ahead of time. This no doubt inconveniences both shipowners and industry because it disturbs rational planning of both transportation and production. For instance, the opening of the St. Lawrence Seaway is made public long before (3).

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(2) Institute of Marine Research: Ice Forecasts

(3) The same seems to be true of the Saimaa Canal.

In the freight agreements signed by shipowners and the suppliers of freight there is no actual legal ruling concerning the traffic restrictions of harbors. It is evident that a sudden opening of a harbor imposes a strain. At times problems concerning labor relations in harbors have not been solved before the arrival of the first ship. Consequently, the first ship has not been received with cheers. Instead, the harbor has been on strike.

Because the closing and opening of harbors is absolute, and because it depends on the decision of the Bureau of Navigation, the position of the Bureau of Navigation is important in winter navigation, and has great commercial significance. During the closing period, the icebreakers wage a delaying battle, withdrawing southwards, later to counterattack in spring. It is obvious that this tactic programed by the ice is not quite the optimal program needed for the transportation system of the whole country. The navigational restrictions and final closing of harbors naturally cause a thorough change in the transport system of the Bothnian Bay. Part of the traffic ends. Part of it is directed to the southern most harbors, with railroad transport holding they keep position. Significant in this situation are the choice of winter harbors and the freight policy of the railroads with their winter reductions. The closed harbors are left without jobs and the municipalities have to register harbor expenses instead of harbor income because of the aid to the unemployed. The costs of industry increase because of higher transport and storage costs. The costs to the shipowners also increase because of the slowness, and actual damages caused by navigation in ice during the period of assistance. The expenses to the state increase because it maintains an expensive icebreaker fleet.

In Sweden, the assistance has been organized somewhat differently (4). The icebreakers belong to the Navy and their winter operations are led by the Director of Icebreaking Operations in the Royal Board of Navigation. He is assisted in each harbor by an agent. The restriction system is similar in principle, but more flexible. They use expressions (5) like Finnish Ice Class IA or a corresponding one, or Ice Reinforced Ship of 900 dwt. Officially they do not recognize ice classes but they have started to use these as a technical tool. Closing of harbors is also more flexible than with us. The icebreaker costs are about 18 million marks(6). The Government Icebreaker Bureau rents individual tug ships for icebreaking purposes. This makes about 20% of all operational costs. The government does not collect an ice fee.

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(4) Redogörelse för Sveriges statliga is Grytar verksamhef

(5) Sveriges meteorologiska odr hydrologiska institut: is Gerättelse 10.2. 1969.

(6) De statliga Sjöfarts avgifterna. Betänhande av givet år 1968 av sjofarts utredningen.

II. STRUCTURAL STRENGTHENING OF SHIPS AGAINST ICE

A normal ship, built according to the requirements of the classification society, belongs to ice fee class II. According to ice strengthening rules that go back to 1930, the basic measurements are given in percentile increments. This is how the ice classes IC, IB, and IA and last of all IA-Super (1965) were formed. This system is important in the winter navigation of our country. It has proved useful to navigation controllers, insurance companies and shipowners. However, the basis for the regulations is not the pressure of ice or the load caused by ice against the hull of the ship. The basis is the norm of the classification society, which is based on open water conditions.

In addition, surprisingly great differences in strength are known to exist between different ships even though they have identical ice reinforcement certificates. This is due to the development of basic measurements and differences that stand out when magnified by the percentile method. The old regulations are subject to criticism from other points of view as well.

In June 1968 the Cabinet formed a committee to set up new ice reinforcement rules and to study their costs. The Cabinet intends to publish the suggested regulations in February 1970 and to enact them on December 1, 1970. The basis for the regulations will be the pressure against the hull of the ship. This can be regarded as the right principle and the new regulations will no doubt be an improvement. Nevertheless, the ice reinforcement of ships always means changing the optimal structures, which are made for open water. Ice reinforcement weakens a ship's technical and commercial characteristics. Neither can ice reinforcements alone solve the technical and commercial problem of winter navigation because the merchant ship is a vehicle of transportation functioning in the field of international competition. Obviously, no ice reinforcement can give a merchant ship enough strength against ice pressure in all conditions. Only an icebreaker can meet this requirement.

The new regulations also aim at taking the size of the ship into consideration. In the final analysis, it is the strength of the ship that matters. A bigger ship is naturally stronger than a smaller ship. The restriction system adopted by the Board of Navigation is also based on this fact. Now there are 5 ice classes and 3 size classes. Theoretically, these can produce 15 different ship models. To control these may not be easy. The selection seems unnecessarily large. So far no one has been able to state what kind of reinforcement is necessary in a given navigational situation. First of all, ships should be optimized so as to clear the traffic restrictions imposed by the Board of Navigation. These again fluctuate according to weather conditions, etc. The new ice reinforcement regulations are based on the analysis of the damage statistics of a classification society. Thus, it has been possible to define some kind of nominal ice pressure for which the scantlings of a ship are specified. Thus, structural design can be more rational, unnecessary reinforcement can be eliminated, and more can be added where needed. So far, however, we do not know what ice proof merchant ships would be like or what would be the best ship for a certain purpose. There is practical evidence that heavy reinforcements become more expensive because the damages also will be heavy and the cost of repairs considerable. There are also cases of over-reinforced ships. It is clear that the ship designer is duty-bound to aim at optimal structures. This is also true of ice reinforcements.

Ice reinforcement is the cause of additional costs both in shipbuilding and in repair work. It diminishes both the deadweight of a ship and the capacity of its hold, while downgrading the quality of the hold, which today is of prime importance to the customers of shipowners. Also the ice reinforcements diminish the resale value of the ship because in Greece or India prospective buyers would consider the reinforcement an outright burden.

In order to improve the winter characteristics of ships, more is needed than just strengthening the hull of the propeller against ice. The right ballast and heeling, propeller and rudder structures, supply of water for the condenser, preparedness for the so-called standard backing power, modern communications, etc. are important both for the ship itself and for a successful management of navigation generally. Also, it might be wise to consider possibilities for repair and docking in case of emergency. It may turn out to be necessary to dock the ship because of a damage to the propeller before she can continue from Finland to the South of the Baltic Sea. It would be good to obtain recommendations for this type of problem because most shipbuilders do not know anything about them.

In the last 10 years, a brand new ice breaker fleet has been built. The ice breaker and the merchant ship can be considered as one machine whose parts should dovetail into a common whole. In practice we have seen, however, that the merchant ship is the weak link of this machine. Unfortunately, as the effectiveness of ice breakers has grown, so have ice damages, because it has been possible to assist a ship into more difficult ice conditions than before.

There has been no actual technical research so far in this field. For instance, we have no information about the amount of pressure of the ice mass against the sides of the ships.

III THE COSTS OF WINTER NAVIGATION

1. Ice Damages

Ice damages are common in ships that navigate in winter. Damages can occur in the hull, the rudder, the propeller, and more rarely, in the engine. The most serious are the shell indents in the middle of the ship.

In the severe winter of 1965-66, the insurance refunds in this area were about 4 1/2 million Fmk (7). The Finnish Association of Ship Owners has studied ice damages in the districts of Oulu and Kemi in the winters of 1965-66 and 1966-67 (8). It has gathered information on ice damages that took place during two weeks at the end of Fall and the beginning of Spring. In 1965-66 the damages were 252,000 Fmk or 6 marks per transported ton. And in 1966-67, 1,156,786 Fmk, or 15 marks per transported ton, were spent on ice damage repair.

Unfortunately, there are no statistics available that would classify ice damages according to time and locality. Foreign ship statistics are totally unavailable. There is no reason to assume that their damages are smaller than those of the Finnish ships. In this connection it has not been feasible to attempt to collect such data. The memorandum of the Ship Owners Association has received rather aggressive criticism from some, even though the critics have not made any attempt to show that the information given in the memorandum is erronious. The frequent remarks that the Association has collected the data itself and that the foreigners are not included are certainly not any fault of the Association.

The following is a list of ice claims illustrating the nature of such damages.

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(7) Lars Beckman: "On Ship Insurance," Navigator, March 1969.
(8) Finnish Association of Ship Owners, Memorandum of Winter Navigation in the Gulf of Bothnia. November 1967.

The most difficult damage known to the present writer occurred to M/S Kaipola on the 21st and 22nd of February 1963 on the Sea of Bothnia. The dock repair bill was 420,519 Fmk and the ship was out of traffic for 6 weeks. The gross freight was about 150,000 Fmk. In addition to the technical repair bill, there are considerable general costs due to docking. In addition to this there are the costs due to the actual interruption in navigation. In order to estimate the length of repair periods, we might use as a rule of thumb the cost of a repair day in dock which is about 10,000 Fmk.

Vessel	Voyage	Repair Bill	Gross Freight
M/S Tellus	Apr 7-14/64 from Pietarsaari	Fmk 195500.00	Fmk 64135.00
M/S Inha	Jan 17-20/67 to Kemi	Fmk 200000.00	Fmk 40880.00
M/S Finnkraft	Mar 28-30/67 to Leppäluoto	Fmk 143924.00	Fmk 141438.00
M/S Finnseal	Apr 24-26/67 from Kemi	Fmk 159386.00	Fmk 119495.00
M/S Iniö	Apr 26-29/67 to Oulu	Fmk 196000.00	Fmk 81376.00
M/S Taurus	Jan 16/67 to Oulu and Kemi	Fmk 182000.00	Fmk 77445.00
M/S Asta	May 8-10/67 to Kemi	Fmk 27000.00	Fmk 78334.00
M/S Alca	Feb 26/68 to Ykspihlaja	Fmk 51000.00	Fmk 164948.00
M/S Argo	May 6-11/68 to Oulu and Kemi	Fmk 90000.00	Fmk 160388.00
M/S Nina	Feb 15/64 to Ykspihlaja	Fmk 161785.00	Fmk 54511.00
M/S Nina	Feb 26/68 to Ykspihlaja	Fmk 70036.00	Fmk 209780.00
M/S Annika	Apr 26/68 to Oulu	Fmk 20000.00	Fmk 145572.00

The median value of the above damages (which are extreme cases) is about 65 marks per ton, with M/S Kaipola included. The most expensive damages cost 250 Fmk per freight ton.

We may conclude that ice damages are rather expensive. Even in moderate cases, the total costs of the damages make a considerable part of the gross freight and in the most severe cases the cost can be many times greater than the gross freight. The question arises whether there is any sense in making trips like this.

Suspicions about other damages being listed as ice damages are totally unfounded. In principle, damages to a ship can be of three kinds: storm, contact, or ice damage. The shipowner has no interest in trying to make ice damages appear bigger than other damages. On the contrary, till very recently, 25% of ice damages have been the shipowners' own responsibility.

Obviously, identification and classification of damages is an important stage at the beginning of docking. In the inspection there are always 3 main participants: the representatives of the insurance company, the classification society, and the shipowner. This procedure is generally accepted and guarantees fairness to all concerned.

The damages discovered in the inspection are of various kinds. The inspector of the classification association can recommend that they be repaired immediately in the annual docking, in connection with classification, or the matter can be postponed till the next docking, or it can be left for the shipowner to decide. The accomplishment of a ship's repair work is of course incumbent on the functional considerations of the shipowner. There is no sense in keeping the ship unnecessarily out of commission because of an unessential repair job if this can be done better, quicker, and cheaper at a later date. Because of this kind of inspection and repair system, the damages cannot be repaired immediately, one after the other. A damage can be up to 12 years old before it is repaired.

Also the immediate discovery of the damages is often impossible. Damages can occur in the dark, under the water or under the cargo, or in some other concealed way. For these reasons it is not always possible to inspect ships even though damages are suspected.

Observations hardly support the view that a stronger ship has fewer ice damages. In the fleet of Oy Finnlines Ltd, which has 10 ships in each ice class, the IA class ships have suffered more ice damages than the other two classes combined. The only rational explanation for this is that the IA ships are called upon to sail more frequently in severe ice conditions.

It is unfortunate that statistics of ice damages are not available. According to the Shipowners' Association study mentioned above, the ice damages on an average were 11.66 Fmk per transported metric ton over the winter season. Note also that the damages were 2 1/2 times bigger per transported ton in a mild winter than in a severe winter.

In addition, sailing in ice causes other extra costs like expenditures of time, labor, and fuel. According to the Shipowners' Association these costs have also been considerable, i.e., 5.83 marks per ton on an average.

2. Ice Insurance

The ice damage risk of IA ships used to be included in the inclusive insurance with 25% deductible. Accordingly, the insurance company paid 75% of the damages. This has undoubtedly influenced the structure of the ice-reinforced tonnage of Finland. The insurance companies did grant inclusive ice insurance also to the IB and IC ships but the rate of insurance was high. Especially Class IB has been neglected because of this. Because the above system had its defects, it has been improved in recent years.

Since 1968, all ice reinforced ships can be insured in Finland, and the 25% liability has been abolished. The smallest damage to be reimbursed may be 50 pennies per gross ton plus 250 marks but it may not exceed 3,000 marks. In practice this lower limit has not had significance because the ice damage is always bigger. In the new system, IA ships pay a certain insurance fee and the fees for other classes are escalated from this basis. This seems illogical and does not quite correspond to the division of damages to the various classes.

Because insurance fees are determined according to damage statistics, the ice damages will eventually have to be paid by shipowners, and ultimately by the industry.

The improved ice breakers have increased the number of damages progressively. Both ice insurance and sailing in ice are often foolish because the ice conditions are not known. Neither do the navigation restrictions of the Board of Navigation or the ice reinforcement classifications give any guarantee against damages. The icebreakers have practically no chance to protect the merchant ships.

For instance, in the case of M/S Finnseal mentioned above, the ship reached Kemi all right, but during the return trip in the South of the Bothnian Bay it was severely damaged.

Opening a channel to a harbor may only mean that the icebreaker has reached the harbor in question, because under certain conditions the channel closes in after the ice breaker.

With us in Finland insurance is usually taken as an annual insurance. There are also insurances for an individual voyage which are, however, comparatively more expensive.

In Sweden, the procedure is different. The Swedish Steamship Insurance Association publishes perhaps once or twice a week an insurance index that covers the whole of the Baltic by districts. These districts have been classified from forbidden areas to clear water, with 10 different insurance levels. Technically, the ships have been divided into 2 classes, I and II only, according to length over and under 75 meters. The insurance fee is a certain part of the insurance value of the ships added with increment by size, (in Class I per gross ton and in Class II per deadweight ton). This system is cumbersome although it does try to be realistic. Evaluating the risk, and following it up are obviously difficult tasks. It is to be noted that the ice reinforcement classes are not used here.

In cases of damage the question of liability comes up as well. The Board of Navigation has published instructions to ships that require assistance (9). Points 1, 7 and 8 are as following:

1. The orders of the icebreaker have to be obeyed.
7. A ship that does not follow these instructions or the orders given by an icebreaker or its commander cannot expect to get assistance of icebreaker.
8. The Government and the icebreaker are not responsible for the ship being late, damaged, or suffering other losses because of ice conditions, nor in the event these losses are suffered by her crew, passengers, or cargo.

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(9) Government Icebreakers, Appendix to TM leaflet, No. 33/1968.

The captain is always responsible for the ship, passengers, and cargo whether it is a matter of navigation or any other kind of safety including ice conditions. Yet, it is understandable that the commander of an icebreaker needs a certain authority in order to lead an entire convoy. On the other hand, these instructions are clearly conflicting with the responsibility of the captain of the ship. The captain will be in a difficult situation if he is denied authority over his own ship, while his responsibilities are undiminished. It is evident that the captain cannot refuse to do his duty even in this case.

The Board of Navigation as the supreme overseer of the merchant marine also acts indirectly as prosecutor. It seems nevertheless strange that the Board of Navigation has to do this even when the damage in ice traffic was possibly caused by an icebreaker. At the same time, the Board of Navigation directs the operations of the icebreakers and is responsible for them. This matter also seems to call for further study.

3. Winter Navigation Fees

Winter navigation causes both the Government and the harbors additional costs. This is the reason why the ships are charged a so-called ice fee. The ships are divided into ice fee classes which is the real name of the ice reinforcement classes. The Government charges the fee according to the ice class of the ship with the so-called lighthouse fee between Dec. 1 and April 30. The ice fees for each visit to Finland are:

IA Super	--	marks per net ton
IA	--	marks per net ton
IB	0.225	marks per net ton
IC	0.345	marks per net ton

Because IA Class ice fee is zero, a 50% reduction of the lighthouse fee has been granted to the IA Super Class. This amounts to 0.30 mks/NRT.

The harbors charge a winter fee which is 0.126 mks/NRT. In the harbors of the Gulf of Bothnia the fee is charged during the following periods.

Kokkola	Nov 1-Apr 30
Oulu	Oct 15-May 15
Kemi and Tornio	Oct 15-May 31

In order to evaluate the significance and comparative value of these fees, we can easily compute them in a few cases as examples.

1. A North Sea Ship
   2500/3700 dwt
   1700/2700 GRT, 750/1400 NRT, OSD/CSD
   Ice Class IA
2. A Mediterranean Ship
   4600/6100 dwt
   3000/4800 GRT, 1400/2500 NRT, OSD/CSD
3. An American Ship
   7700/9500 dwt
   5500/7700 GRT, 2800/4300 NRT, OSC/CSD

Note: GRT: gross registered tons; NRT: net registered tons
OSD: open shelter decker; CSD: closed shelter decker

Class IA Super could be possible for a Sea of Bothnia ship although there is no Finnish ship of this designation in spite of the five year existence of this class. By computing the reduction of the lighthouse fee, we realize that it equals less than 2 days' daily costs and is 0.04% of a ship's annual total expenditure. By computing the annual costs of capital recovery, we realize that the capital can be amortized in 15 years if the rate of interest is 1%. This does not even begin to be sufficient for the amortization of the expenses caused by reinforcement and operational costs during the lifetime of a ship.

The following table shows what part of the annual expenditure of ships is made up of ice fees.

	North Sea	Mediterranean	Atlantic
State Ice Fee	--	0.057%	0.040%
Harbor Ice Fee	0.145%	0.070%	0.022%
Total	0.145%	0.127%	0.062%

As shown, the ice fees are a trifling part in the total budget of a ship and have no significance in defining the ice class of a ship. We may ask why these fees are charges at all. The zero fee should really begin at Class IC if its purpose is to promote the building of reinforced ships. The ice fees contribute a comparatively small amount to the operating costs of icebreakers. It is 1% for the Bothnian Bay and 7% for the whole country.

The same is true also of the winter fees of harbors. If the harbors want to encourage winter navigation, changing winter fees is illogical. The immediate loss caused by a ship that fails to come to the harbor is about 3,000 mks.

The additional winter fee is from 100-350 mks in the cases that served as examples above.

In Sweden where winter navigation has been arranged more flexibly than here, the winter fees of the harbors have been abolished in some cases in order to promote navigation.

4. Winter Freightage

Because the voyage to the Bothnian Bay is longer than to the South of Finland, the freight agreements grant so-called zone allowances. For the winter season they also pay a winter allowance.

These allowances are, in case of important articles of export, about 5% plus 5%, that is, 5 Fmks per ton. Both allowances have been intended to cover the longer trip and the slower sailing in ice.

The harbors have also been divided into different zones, which are not the same for all articles of export. It would take too long to give their detailed description here.

Winter allowances are paid from the first of October to the 14th of May (about 2.50 Fmk/ton). This timing seems strange because Kemi and Oulu have not been closed once in this decade before the New Year, while they have often been opened before the middle of May.

5. Ice Breakers

At the moment, we have the following ice breakers:

Name	Year of Construction	Engine Power
Sisu	1939	4,500 hp
Voima	1954	10,500 hp
Karhu	1958	7,500 hp
Murtaja	1959	7,500 hp
Sampo	1960	7,500 hp
Tarmo	1963	12,000 hp
Hanse(10)	1967	7,500 hp
Varma	1968	12,000 hp
Apu(11)	1970	12,000 hp

Ice breakers are specially built with the greatest possible technical perfection. In this respect we have no doubt made a great deal of progress.

The expenses of icebreakers have earlier been studied by Erkki Palosuo(12), and at a later date by the Council of Conveyance. The statistical supplement written by Pertti Kukkonen and Islo Tikkanen(13) has been kindly made available to me, although the text part is not yet quite finished. I have attempted to pick from the extensive statistical material only such information as pertains to merchant ships in general and winter navigation in the Bothnian Bay in particular.

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(10) Owned by the Federal Republic of Germany, but in Finnish use according to agreement.
(11) Being finished in dock.
(12) Erkki Palosuo, The Operational Costs of Ice Breakers in Winter Navigation, Vammala, 1967.
(13) Pertti Kukkonen-Esko Tikkanen, The Costs and Acquisition of Icebreakers, Statistical Supplements, Helsinki, 1969.

We can see that icebreakers are both by price and by operating expenses more expensive than merchant ships of corresponding power. The following information will illustrate the comparison. Because the consumption of fuel in diesel engines of different types does not vary much, there is not much difference between icebreakers and merchant ships in this respect. Different types of engines again demand different kinds of fuel. This difference is seen in the cost of fuel. Ice breakers use as fuel so-called POK - 10. This costs about 110 mk/ton(14). This fuel corresponds qualitatively to the diesel oil used in merchant ships which is known by the name "marine diesel," with viscosity of about 40 Redwood degrees. Merchant ships gave up using such expensive fuel quite some time ago, and the new ships burn what is called heavy oil with viscosity of about 1,500 up to 3,500 Redwood degrees at half the price of the fuel used previously. In smaller engines intermediate oil is used. Its viscosity is about 400 Redwood degrees and its price about 70% of diesel oil. The fuel expenses of icebreakers are about 1.25-1.45 pennies* per HP-hr.

The merchant ship of corresponding power has fueling of 0.65 pennies/HP-hr. The ship using intermediate oil has an expense of 1.10 pennies/HP-hr and a ship using diesel oil 1.25 pennies/HP-hr.

As the engines of icebreakers develop 100,000,000 horsepower annually, the difference in cost is 650,000 Fmk/year, compared to a merchant ship. Without reference to the choice of fuel, we can see that the difference in cost is considerable.

In other respects, too, the conditions of icebreakers differ from merchant ships. Their sailing hours are 1,500-2,000 a year, depending on what the winter is like. Of this time, they use 60% for actual assistance. The merchant ships

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(14) All prices mentioned in the above study have been deflated to the standard of 1960 by index per article.

* A penny = Finnmark/100.

at sea 4,500-7,000 hours a year. They are out of commission for repairs from 1 to 2 weeks a year. Icebreakers are usually idle for 5 months of every year.

In the study mentioned above (Kukkonen-Tikkanen) we can see that the icebreaker Tarmo's operating expenses were 890 Fmk per hour in 1967. Together with capital expenses they are 2,090 Fmk per assistance hour.

Because it is the task of an icebreaker to assist, the costs per assisted freight ton should be of interest. On an average, these costs are probably 3.30 Fmk per ton. For the harbors of Kemi, Oulu, and Raahe it probably is about 5.90 Fmk per ton. The operational costs for the same group of harbors are 2.50 Fmk per ton.

The operational costs per ton very greatly in different months. If individual assistance trips could be analyzed, there would be even more variation. This is because cargoes tend to be small at the beginning and at the closing of the sailing season. The more severe conditions must also have their role in this. In the mild winter of 1960-61, the average operating costs were 0.24 Fmk per ton in the whole country and 1.56 Fmk per ton in the Bothnian Bay. In December 1960 they were 1.12 Fmk per ton, January 1961: 6.40 Fmk per ton, in March: 20.63 Fmk per ton and in April 13.40 Fmk per ton (15). The operational costs, then, can amount to ten times the average costs. In the same winter, Kemi was closed January 30 and opened March 25. We can estimate that the total costs before closing are about 10 Fmk per ton and after the opening 20 Fmk per ton.

One more difficulty facing winter navigation is the lack of harbor icebreakers. It is clear that the Government icebreaker is impractical and too expensive to be a harbor icebreaker or a tow boat. This lack causes actual damages to ships in addition to waste of time.

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(15) 1961 monetary system.

6. Railroads

When the harbors of the Bothnian Bay are frozen, exports are transported by train to the more southern harbors. Only export is studied here because it is by far the more important. The export traffic of the Bothnian Bay amounts to 315,000-355,000 tons per month in the summer. In winter, exports of the industry on the Bothnian Bay amount to only half of this.

Kaskinen is the best known of the winter harbors. Yet only 1/3 to 1/4 of the Bothnian Bay winter export is shipped through this harbor. The rest is divided between other harbors of the south. The role of Kaskinen is important but apparently not decisive. Its possibilities are limited and improvised. The most obvious shortcomings are its limited dock space, loading facilities and capacity for railway transportation. The traffic of Kaskinen is 6% of the annual traffic of the Bothnian Bay harbors. Considering modern requirements, Kaskinen with its terminal traffic can scarcely accommodate the trade of the developing Bothnian Bay industry.

To support industry, the State Railways have a freight balance system according to which the State pays to the State Railways reparations for freight reductions(16). According to the report of the committee reparations are paid for railroad freight, caused by the retreat in winter to the southernmost harbors. The total sum of the reparations is about 950,000 Fmk per year. According to the Nedeco study (17), the railroad freight is about 25 Fmk per ton. This probably means gross freight, because the reduction referred to above is 20-30%.

The freight reduction has been tied down to fixed dates, beginning partly on December 15 and partly on January 1, and ending correspondingly on May 15 or April 30. A system of

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(16) The Committee Report 1968, B98:The report of Railroad Tariff Reduction Reparation Committee.

(17) A Study of Transportation in Finland, Appendix VI: The harbors and their traffic. December, 1965, Den Haag.

fixed dates is apparently desired by the State Railways.

Sometimes the opinion is voiced that enlarging the winter traffic of railroads would mean increasing the equipment of the State Railroads and raising the expenses. Lengthening the transportation season of the railroads would probably not require additional equipment and primary expenses. Increasing actual transportation efficiency can add to the expenses but there are no studies on this subject, at least not in comparison with sea transportations. In any event the goods are often loaded first into a railway car at the factory.

In principle, the freight balance system mentioned above amounts to dividing the Government aid between the different harbors. The distance, by railway, from Kemi to Vaskiluoto is 518 km, and from Kemi to Kaskinen 552 km.

7. Sweden

The conditions in Sweden have already been referred to. It is interesting because their side of the Bothnian Bay is in many ways the mirror copy of the Finnish side. The ice conditions change with the wind. In the East they are easier when the east wind blows, and in the West when the west wind blows. The structure of industry is similar: ore, steel, and wood products.

Between May 15 and December 15 Luleå exports about 4.5 million tons of ore. This is 95% of the annual output of the mine at Malmberget. The rest, 5%, is taken by train to Narvik. All of Kiruna's ore is taken to Narvik.

Norrlands Järnverk exports 110,000 tons of steel from its own dock at Luleå. About 20,000 tons leave from Umeå and an equal amount from Uddevalla. Uddevalla can compete with Luleå even in summer because it can offer the advantages of small ships. The finished products are more suitable as cargoes for the small ships.

The traffic of Sweden is about 2/3 of the Finnish traffic if the ore of Luleå is not taken into account.

The winter harbors are Umeå, Sundsvall and Gävle and Gothenburg - Uddevalla. Narvik does not qualify as a winter harbor for the industry on the Swedish Gulf of Bothnia.

It is interesting to note that SCA (Svenska Cellulosa Ab) has stopped sea transportations from Piitime and brings its export goods to Umeå both summer and winter. 200,000 tons of cardboard and lumber are brought by train to the modern terminal of Holmsund in big units. The distance by rail is 340 km.

In addition, an interesting committee report has been (18) published in Sweden which assumes that 75% of icebreaker costs occur in the Bothnian Bay. With us the corresponding figure is probably 35%. The committee suggests acceptance of the

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(18) The Government Navigation Fees, Memorandum published by the Board of Navigation in 1968. Stenc. K 1968:9.

Finnish ice class system as a technical solution for merchant ships. As an economical solution, Sjöfartsverket (that is, the Swedish Bureau of Navigation) should be made to bring profit, i.e., each operation (including winter navigation) should be economically self-supporting. The winter fee should be divided between the ship and the cargo. The ships fee should be escalated according to the advance of the winter and the accessibility of the harbors, thus corresponding to actual expenses. The time limits and the fees have been made according to a normal winter. In the lowest ice class the charge would be from 3-6 Swedish crowns/ net register ton. The suggestion has naturally met with fierce opposition in Norrland because there it would mean considerable increase in transportation expenses. The Swedish shipowners have only slight interest in winter navigation, and the proportion of foreign ships is greater here than in other Swedish trades. They also carry on a public discussion about the chances of survival for navigation in Norrland (19).

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(19) Per Bering: Is Navigation Necessary for Norrland or are There Better Transportational Alternatives?

IV. SUMMARY

The participants in winter transportation in the Bothnian Bay are the icebreakers, the railroads, and the merchant ships. The first two are state owned, while the third functions under strict state supervision in winter navigation. Accordingly, the role of the state is of primary significance in this area, although the costs of running the merchant ships are the responsibility of the shipowners themselves.

After icebreakers reached their present standard, the fact that this was not the final solution to the problem of winter transportation has been a surprise to many. On the contrary, the number of problems has not diminished in the least, and the demand for good winter transportation still awaits realization.

According to the study by the Finnish Shipowners' Association, in the winters 1965-1966 and 1966-1967, the average extra costs for the Bothnian Bay winter navigation were 35:85 Finnmarks per ton, with a variation of +10% and -20%. The data collected by the present writer present considerably higher records. The sum total of the damages of the examples given above is practically identical with the above-mentioned freight balance of the railroads, and the damages per ton appear to be about three times the amount of the railroad freight to the ports in the South. The cost of the icebreaker allowance is, at its highest, practically the same as the abovementioned unreduced railroad freight. It is to be noted that the operating costs of icebreakers are about 40% of their total cost. The additional cost to the ships, caused by winter navigation, is about one third of the railroad freight and the freight allowance for Northern Finland is about one fifth of the railroad freight.

It is interesting to note that the difficulties of the ships are greatest during mild winters, and those of the industry in cold winters. One of the parties always suffers.

Icebreakers are naturally necessary in Finland, and their importance grows with winter navigation. It is a matter of opinion whether the greater part of the costs of icebreakers should be society's investments as are the highways and the water ways. The practical situation has clearly indicated that we drift to expensive solutions if we forget the capital costs of icebreakers. As we have seen, there are many reasons to study winter navigation in the Bothnian Bay. It seems necessary to attempt to clarify the optimal costs of the whole transportation system, and not only some parts of it. If we consider the matter even superficially we realize that sea transportation just before the closing of the ports, and especially in the first weeks after reopening them, is extremely expensive. It may be that in the future the attitudes toward winter navigation will be different, and the old preconceived notions will have to be changed. The winter transportation system of the Bothnian Bay can certainly be managed better than it is at the present, but it can scarcely be advanced by lengthening the navigation season.