TRANSPORTING LIQUIFIED NATURAL GAS BY SURFACE SHIPS FROM THE NORTH SLOPE OF ALASKA TO WORLD MARKETS

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Theses

DECLARATION

In accordance with regulations of the University of Cambridge, I do hereby declare that this thesis represents my own original work, and conforms to accepted standards of citation in those instances in which I have used the works of others. This thesis is not now being submitted nor has ever been submitted in the past for any other degree, diploma, or any other qualification at any university or similar institution. This thesis does not exceed the maximum allowable length of 20,000 words excluding: footnotes, tables, appendices and references.

Cambridge, June 1996

Joseph H. Wubbold III

Cover photograph-M. Levy, Cleveland Plain Dealer, 1996
"Great Lakes Battleground"

TABLE OF CONTENTS

DECLARATION		II
TABLE OF CONTENTS		III
ACKNOWLEDGMENTS		IV
ABSTRACT		1
CHAPTER ONE	INTRODUCTION	2
CHAPTER TWO	HISTORY OF WATER-BORNE TRANSPORT OF PETROLEUM PRODUCTS IN ALASKA	4
CHAPTER THREE	WAYS THAT HAVE WORKED: THE BALTIC, THE RUSSIAN NORTHERN SEA ROUTE, AND WINTER NAVIGATION ON THE GREAT LAKES OF AMERICA	11
CHAPTER FOUR	ICE RECONNAISSANCE, INCLUDING REMOTE SENSING	14
CHAPTER FIVE	ICE COVER AND DYNAMICS	19
CHAPTER SIX	VESSEL TYPES AND CONSTRUCTION	26
CHAPTER SEVEN	OPERATIONAL CONSIDERATIONS	31
CHAPTER EIGHT	COMMAND AND CONTROL	36
CHAPTER NINE	TRAINING AND CERTIFICATION OF CREWS	41
CHAPTER TEN	ENVIRONMENTAL ISSUES AND REGULATORY CONCERNS	45
CHAPTER ELEVEN	RECOMMENDATIONS AND CONCLUSIONS	50
REFERENCES		53
APPENDIX I	CHART	56
APPENDIX II	GLOSSARY	57
APPENDIX III	SEA ICE ANALYSIS	58
APPENDIX IV	AUTOPOLLING INSTRUCTIONS	59

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Having said that I would name no one from SPRI, I now break that by thanking my supervisor, Bob Headland. A gentleman, archivist, curator and friend, he handled the challenge of having me as a student, well in the second half of my life, beautifully.

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TRANSPORTING LIQUIFIED NATURAL GAS BY SURFACE SHIPS FROM THE NORTH SLOPE OF ALASKA TO WORLD MARKETS.

ABSTRACT

This thesis reports the work that has been done in Alaskan waters on ship transits; gives examples of a system that has worked in the past-the Winter Navigation Program on the American Great Lakes-and two that are operating now, the Baltic , and the Russian Northern Sea Route in greater detail; discusses problems with ice: how to find it, and determine its characteristics; and how to decide on routing using various ice reconnaissance techniques. Vessel types and their special construction are discussed. In the chapter on operational considerations, the concept of ice-strengthened carriers under icebreaker escort is elaborated. The thesis continues with discussions of command and control arrangements, training and certification of crews, and environmental and regulatory issues. It closes with recommendations for further study, and summarized conclusions. Much of the material, especially on ship management, command and control, and relationships with regulatory bodies and environmentalists is based on the author's own experience. That experience includes command of several U.S. Coast Guard ships including a polar icebreaker, experience in the Winter Navigation Program on the American Great Lakes as an icebreaker captain, convoy commander on a number of convoys, and as a field commander of one of the operational sectors. Duties have also involved both writing Federal regulations when in a staff position, and enforcing Federal statutes and regulations in command positions afloat and ashore. That experience has led to certain biases, which are indicated as appropriate.

CHAPTER ONE

INTRODUCTION

It may seem unrealistic that there be a study of moving liquified natural gas (LNG) from the oil fields of Prudhoe Bay to world markets, using surface ships. These markets have not yet begun to demand LNG from Prudhoe Bay, and the gas is being pumped back into the ground after the oil is separated. Further, there is no way of moving that gas to market. There is no gas pipeline, there are no ice-capable LNG carriers under the United States flag, and no operating scheme yet developed to sail those ships. There has indeed been a considerable amount of work by the Yukon Pacific Corporation to design a gas pipeline from Prudhoe Bay to Valdez, Alaska, running parallel to the existing oil pipeline, called the Trans-Alaska Gas System (TAGS) (Macy 1994). Further, there is a proposal being examined by the companies that own the Prudhoe gas to build a pipeline from Prudhoe Bay to either Wainwright or Kivalina. The gas would then be liquified, loaded into ice-strengthened LNG carriers and sailed to world markets, especially in Asia (Macy 1995). Regardless of how it is done, the environment is harsh, the distances long (approximately 900 nautical miles from Prudhoe Bay to south of St. Lawrwnce Island), and the hazards great. In view of the work reported in the TAGS papers,it would seem on the face of it that this paper is a theoretical exercise-wishful thinking by a professional seaman firm in the belief that all cargoes are best carried by sea. In fact, THIS professional mariner has no such belief. Many cargoes are best moved by some other means of transport. However LNG can be moved in only two ways. One is by pipeline as a gas and then liquified, and the other is by especially configured ships. The study of the pipeline options is taken up in other work. As mentioned, the author is aware that a pipeline from Prudhoe Bay to either Kivalina or Wainwright, Alaska is under consideration. However, it is possible that this pipeline, called the Western Route, will not be built. Even if it is, the outline of work would be just as valid for the shorter distances and less severe ice conditions. Further, there is a deliberate intent to focus the attention of the reader on the possibilities of LNG transmission by ship, through the ice-laden waters of Alaska, for some length of time each year. The paper will discuss the difficulties, the dangers, and the complications of operating ships in ice-infested waters in the high north, and in particular in the area from Prudhoe Bay, Alaska to St. Lawrence Island, south of the Bering Strait. However, by the time the reader arrives at "Recommendations and Conclusions", he should be ready to accept that it is POSSIBLE to do this. Any further study could then go along at the same time as the planning work on the Trans-Alaska Gas System (TAGS) and the Western Route to supplement that work. Should it be determined that TAGS or the Western Route could not be built, or would not be built for economic reasons, even if all of the environmental and engineering problems could be solved, an alternative plan would be ready. One of the most firmly held opinions of the author, discussed in Chapter 10, is that whatever system is built must be environmentally sound. That means that early and active cooperation between the regulators and the regulated must take place. Finally, "Recommendations and Conclusions" will indicate subjects for more detailed study. It is intended to provide a survey of past occurrences, the present situation with regard to shipping in the Alaskan Arctic and other systems worth studying for these purposes, and to give some areas for further investigation.

The author makes no attempt to develop costs for the following reasons: a) cost information is often proprietary to the companies involved, and would not be available either at all, or within a practicable time; b) the companies which would be considering such a system have economists, accountants and estimators who would do costing at any level desired, should an operating company decide to go to the next step; and finally and most importantly, c) costing must be done at the same time that more detailed studies of other aspects of the system are considered, using the best estimates and projections available at the time of the analysis, especially using those cost figures most closely held by management.

The word "system" has already been used in this introduction, and it will reappear several times. In this context, "system" is defined as the entire operating continuum-the ships and people that man them, personnel selection and training, the communications arrangements, the command and control arrangements, and the operating instructions, all surrounded by the physical constraints decided by the operating company management. For the purposes of this paper, the area Prudhoe Bay-Point Barrow-Saint Lawrence Island has been selected, and is shown on the chart attached as Appendix I.

ASSUMPTIONS-The following assumptions have been made:

a) That the owners/operators of the system will want to operate as close to all year around as practicable;

b) That the pipeline alternative will be examined by other researchers;

c) That costing will be done by accountants and economists with access to internal company details;

d) All federal and state statutes and regulations for the overseas sale of LNG would be enacted;

e) That the ships envisioned by this paper would sail under the American flag, manned by American seaman, and in full compliance with the ship construction and environmental standards in effect at the time of the opening of the system.

This thesis provides only a foundation from which other more detailed studies could be developed. For example, the required environmental impact work, the costs, manning studies, and the plan for early cooperation among commercial interests, environmentalists, and the many government regulators who would have an interest in such a project are all follow-on activities.

CHAPTER TWO

HISTORY OF WATER-BORNE TRANSPORT OF PETROLEUM PRODUCTS IN ALASKA

INTRODUCTION-In the most literal terms, there is virtually no "history of water-borne transport of petroleum products in Alaska", not counting the annual convoy of tug and barge trains from Seattle to Prudhoe Bay with construction equipment and materials, including, certainly, some fuels and lubricants. A great deal of theoretical analysis was done, and at least one significant symposium was held, up to 1969. In 1969, the especially ice-strengthened tanker SS MANHATTAN made the first transit of the Northwest Passage by a commercial vessel, sailing as far west as Point Barrow, Alaska. Her story, and subsequent work in the Alaskan Arctic during the mid-1980's using full-powered icebreakers, provides the background for the use of ice-strengthened ships in Alaskan waters. Advances in icebreaker technology since the MANHATTAN voyage now make the idea of ice-strengthened ships under icebreaker escort worth reexamining.

DISCUSSIONS AND PLANS PRIOR TO 1969-Little was done about water-borne transport prior to 1969, because there was no requirement. The big event that caused planners, engineers, politicians and businessmen to investigate transport in Alaska in general, and water transport in particular, was the discovery of oil at Prudhoe Bay, Alaska. This discovery generated great interest and concern as to how the oil from Prudhoe Bay would be transported. At one conference, the enthusiasm for developing the transport required came through even the conference summary (Bader, Tyree and van Steenburgh 1969). Predictions were made of great profits, and warnings made against environmental damage to the land and water (Sater 1969). Calls were made for a comprehensive transport system in Alaska that would not only stimulate resource development and support commerce, but would enhance the general welfare of the citizens of Alaska (Trimble 1969). Later discussions dealt particularly with sea transport. The hope then was that there would be a fleet of U.S. Coast Guard icebreakers available to facilitate commerce in the Alaskan Arctic, and that the ships that would be used to carry the Prudhoe crude oil would break their own ice. The system envisioned in one proposal included a dozen 250,000 ton tankers, sailing through the Northwest Passage to the American Atlantic coast. Icebreakers would be "standing by" for the occasions when the tankers became beset (Cass 1969). One response to this proposal commented on the desirability of further study. In addition, two points were made that will be of concern further on: the need for developing true ice pilots-another term for training conning officers to "read" the ice, and handle their ships as their training and experience dictate; and that the friction of the ice against the hull is a more powerful force than ice thickness in stopping ships (Robertson 1969).

THE MANHATTAN-Although there had been considerable discussion about means of transport of Prudhoe Bay crude oil, as late as 1969 no decision had been made as to how to bring it out. At that time, the means under active consideration were to bring the oil through Alaska by pipeline, (the method ultimately selected and still in use), or to ship it out by icebreaking tanker through the Northwest Passage. To test the tanker idea, the MANHATTAN voyage was executed. This journey is given some attention here because of both the similarities and differences to the ideas in this thesis. It is these differences that make the idea of water transport of LNG from Prudhoe Bay worth examining in some detail.

The steamship MANHATTAN was chartered by the Humble Oil and Refining Company, with collaboration by Atlantic Richfield and British Petroleum, and was substantially modified to operate in the ice. An icebreaking bow and an ice belt were added, as well as ice horns to protect the rudders, and some internal strengthening. Other changes were made which are of no concern here. What were not changed were the power plant, and the long run of the hull. Because the power plant was not changed, no change in MANHATTAN's backing capability was practicable. This shortcoming will be discussed below.

Because of the scope of the job, several shipyards worked on the hull. She was finally reassembled at Chester, Pennsylvania. MANHATTAN then got underway on 24 August 1969, headed for Baffin Bay and the Northwest Passage (Payzant and Shannon 1970). The story of the actual transit of the Northwest Passage has been related in several works, and in all of them the description of ice management is the same, and will be described below. To get to that point, however, it is worth relating that MANHATTAN, as the first commercial vessel to transit the Northwest Passage, also went as far as Point Barrow, reaching that desolate place on 21 September 1969. She then turned around, and headed back through the Northwest Passage, arriving in New York on 12 November 1969 (Smith 1970). In the Spring of 1970, MANHATTAN once again went to the Canadian Arctic. The mission on this voyage was not to make another transit, but to test icebreaking capability in multiyear and ridged ice, and to derive engineering data from which power and size requirements could be extrapolated for future icebreaking tanker construction (Swithinbank 1970).

It was always the intention of the oil companies making this extraordinary voyage with their chartered servant MANHATTAN that she would be her own icebreaker. The true icebreakers that were part of the experiment, provided by the Canadian and United States Governments, were intended only to assist should MANHATTAN get into trouble. It was always intended that she should break her own track, backing and ramming if necessary. She was to perform a task for which she was not designed, and for which she was unsuited. The evidence is that it was always intended that if the oil from Prudhoe Bay was to be brought out by tanker, it would be by scaled-up MANHATTANs, operating independently of icebreaker support unless beset. It was also intended that these ships would operate through the Northwest Passage, rather than to the west (British Petroleum 1977).

Two major characteristics of MANHATTAN were not changed for this journey: her power plant and her hull form aft of the new icebreaker bow. It would have been extremely expensive to modify either, and in any case, she represented the best in her power plant and tanker hull form for the time. She had steam turbine engines, driving propellers through reduction gears. One of the characteristics of most steam turbine engines is that backing power is less than ahead power, because there are fewer turbine blades on the astern section of the turbine shaft. Why this is so is beyond the scope of this paper. The author was educated as an engineer and trained as a sailor, has commanded a steam turbine-powered ship, and can verify that a ship with this type of plant does not back down as nimbly as she goes ahead. Further, because of the arrangement of the cooling system, a ship so powered can back down for only a few minutes before her engines overheat. This is not significant in ships that operate in open water, but ships that must back off and ram into ice must be able to back down for long stretches. MANHATTAN was not able to do this.

The second unchanged characteristic was the underwater body aft of the new icebreaking bow. That meant that the midship section had the typical tanker long parallel run, presenting long flat surfaces for the ice to bear against, thus potentially locking MANHATTAN into the ice (Polar Record 1970).

The lesson learned from this so far as the power plant is concerned is not to use a steam turbine reduction geared plant in ships going into the ice. In fact, few ships are now being built with such a plant, most large ships now being constructed with slow-speed diesel engines, driving propellers directly and reversing directly, thus providing as much backing power as ahead power.

POST-MANHATTAN STUDIES-By 1971, the POLAR class of icebreakers had been designed, resulting in POLAR SEA and POLAR STAR. At the same time, preliminary design work was being done on a speculative basis for a much larger icebreaker, which would be able to operate in the Arctic all year round. The estimates of ice to be encountered in one study was of a maximum thickness of 3.5 m level ice, not taking into account ridging or ice under pressure. Although this ship was never built, the engineering and architectural work was in place to proceed with construction (Voelker 1971). This is also the first mention of air bubbler systems in the literature researched for this paper. These systems, to reduce hull friction, will be mentioned later.

Until 1979, little practical work was done to further the cause of Arctic marine transport. Symposia and workshops were held, and optimistic words were written. One such workshop report forecast that large icebreaking tankers, ore carriers and gas carriers would be developed from 1970 until 2000. It further stated "there are no basic gaps in the state of the art as far as research is concerned to permit the design of large icebreaking tankers now" (Arctic Marine Commerce Workshop 1973). However, in 1979 it was decided to translate some of the talking and writing into concrete action.

TRAFFICABILITY TESTS IN ALASKA, 1979-1985.

From 1979 until 1985, The United States Maritime Administration, a component of the Department of Transportation, conducted a programme called the Arctic Marine Transportation Program, also known as the Trafficability Program. Although the Maritime Administration was the programme administrator, there were a number of public and private participants. The part of the U.S. Coast Guard in this was to provide a POLAR class icebreaker, which would penetrate the ice in the Bering, Chukchi and Beaufort Seas. Voyages were made at all seasons of the year, with the unfortunate exception of winter voyages in the Beaufort Sea between Point Barrow and the Canadian border (Brigham and Voelker 1985).

The primary areas of data collection during the Trafficability Program are shown at Figure 1. Figure 2 shows the approximate tracks of successful icebreaking voyages during this program. Figures 3,4 and 5 show zones of environmental severity as determined by the researchers. The numbers within the zones indicate relative degree of difficulty for winter marine transport, as determined after reducing the data collected on the various voyages. The zones were based on average winter conditions, and winters and ice conditions are widely variable (Brigham 1986).

The research program was carried out aboard the U.S. Coast Guard icebreakers POLAR STAR and POLAR SEA. These ships have both a gas turbine and a diesel electric plant. The former can generate 20,000 shaft horsepower (SHP) into each of 3 shafts turning controllable pitch propellers, for a total of 60,000 SHP. The diesel electric plant is capable of providing 6,000 SHP per shaft for a total of 18,000 SHP. The plants cannot be cascaded, i.e. one plant added to the other, although it is possible to run the centre shaft on gas turbine propulsion, and the two wing shafts on the diesels. At maximum power, and maximum (and enormous) fuel consumption, these ships have shown the ability to break 2 m thick first year ice at a sustained speed of 3 knots. Other specifications that apply to these ships are a length (LOA) of 121.6 m, beam of 25.5 m, a full load draft of 9.8 m, and a displacement of just over 13,000 tons. In other words, these are big ships, very powerful ships, and are beyond the size and cost needed for the work envisioned for the Alaska transport system.

There is no similarity between any merchant vessel that would be used to carry LNG, and the ships used in these studies. What these studies did provide was a baseline for deciding on further studies, including most importantly, actual experience in the ice along the possible trade routes. One of the most intriguing questions to be investigated, and it could be done in one season if that season's work were carefully planned and fully funded, are the actual ice conditions from a ship's bridge along potential tracks for the LNG carriers from Prudhoe Bay around Point Barrow, in zones 10, 11, 12, and 13, in the deep winter. A discussion of this work is included in Chapter Eleven," Recommendations and Conclusions."

The conclusions of the Trafficability Study were that:

a) year -round operations in the North Bering Sea and the South Chukchi Sea are possible;

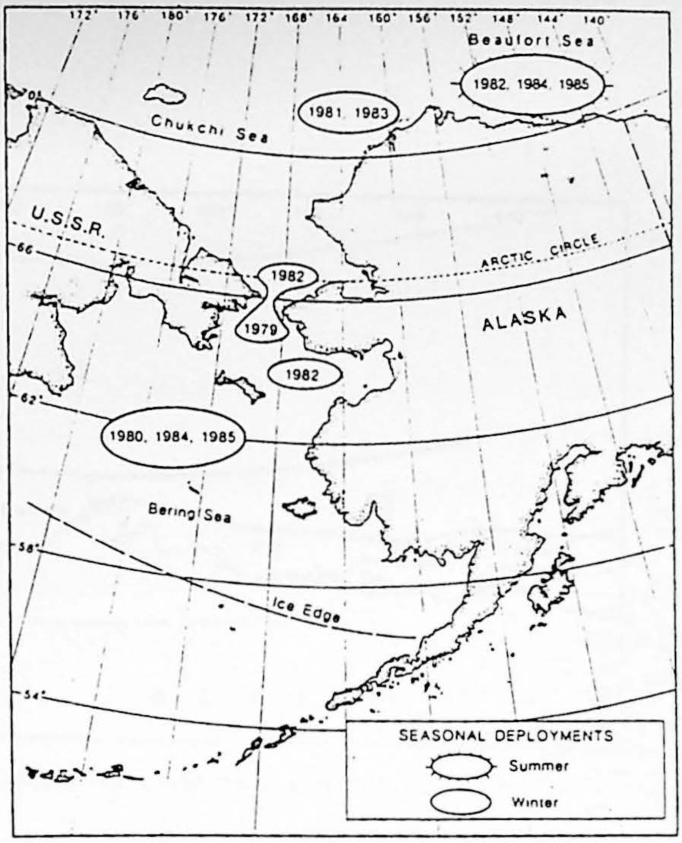
b) ships with high power would be required to operate in those areas year-round;

c) the voyages made into the northern Chukchi Sea showed that ships with high power would be able to operate, but that some backing and ramming would be necessary to get through;

and

d) that ice piloting skills, adequate ice reconnaissance, and a high level of training of conning officers will be essential to the effective and safe operation of the system. These conclusions seem to be self-evident, and to the experienced ice pilot, they are. The significance of these voyages is that they represent the only data collected for the specific purpose of determining the possible use of the routes of interest in this study, for commercial purposes (Personal communication F. Seibold 1996).

The two programmes described above point out the major information deficiency yet to be filled. The operation of real ships, in real ice, in real winter, is the only way to adequately test both the feasibility in actual conditions, and the acceptability from economic and operational viewpoints. The entire route, all the way to open water south of the ice edge in the Bering Sea, would have to be sailed-but it is essential that the part not yet tested, from Prudhoe Bay to Point Barrow, be explored in deep winter, using vessels similar to those that would be used in an actual system. Notwithstanding the confidence placed in tank testing and computer simulation by naval architects and marine engineers, there is no substitute for using the actual ship in actual conditions. "Model tests and analytical models alone are of limited use in designing and building Arctic ships. The skill in interpreting the data must be correlated with full scale experience" (Duff and Keinonen, 1983, p. 621).



PRIMARY AREAS OF DATA COLLECTION DURING
THE TRAFFICABILITY PROGRAM (1979-85)

Figure 1

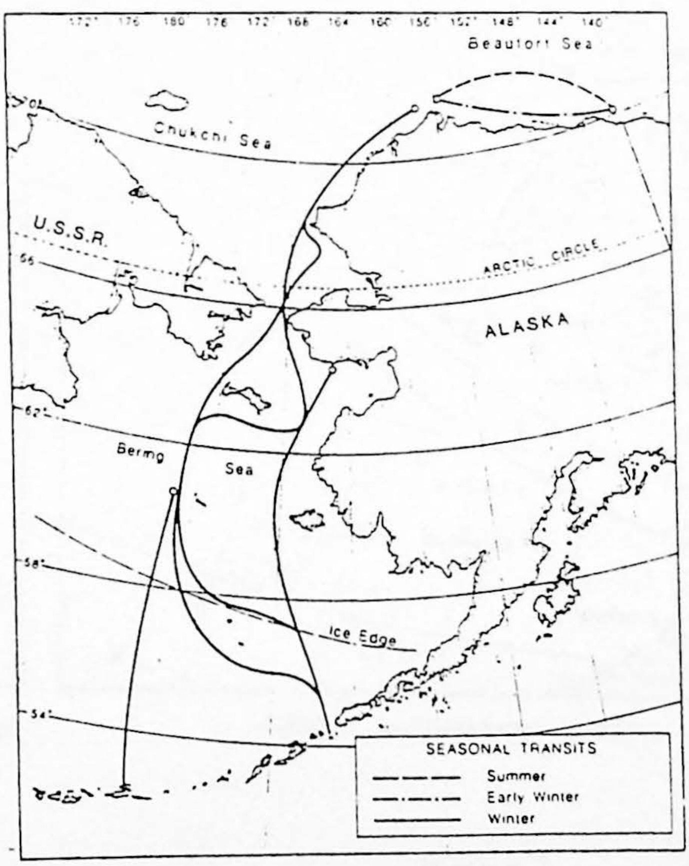
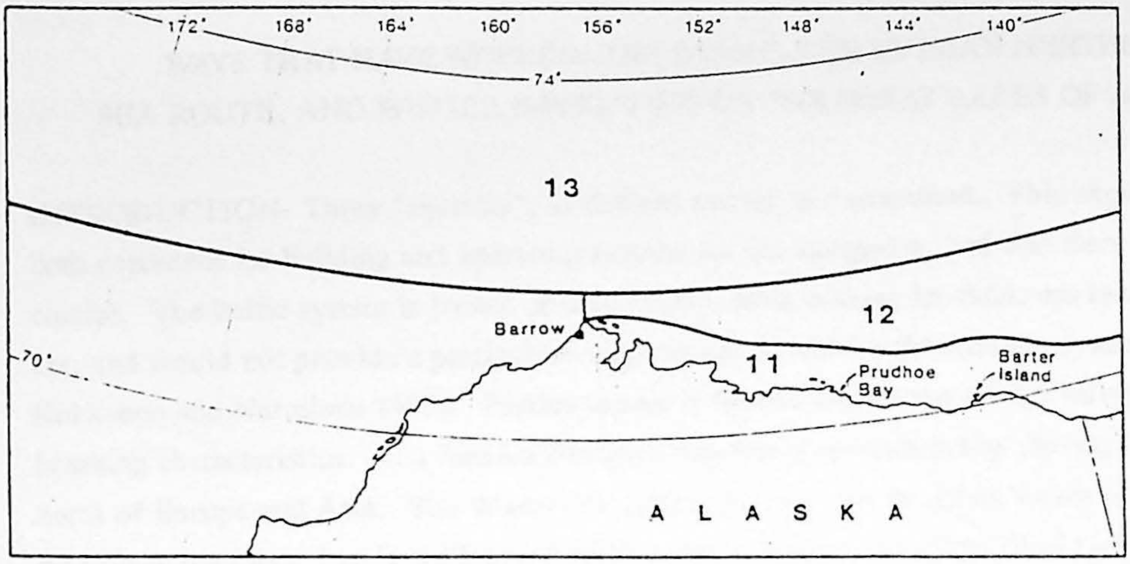


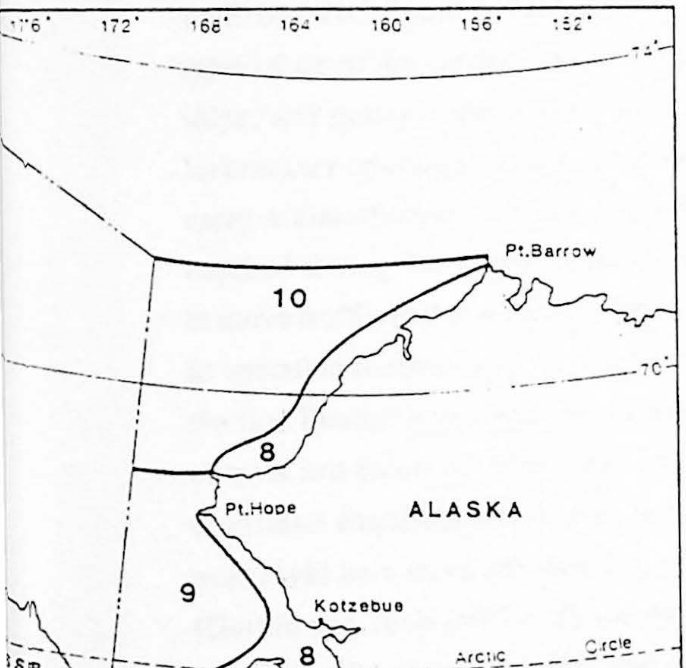
Figure 2

After Brigham and Voelker 1985



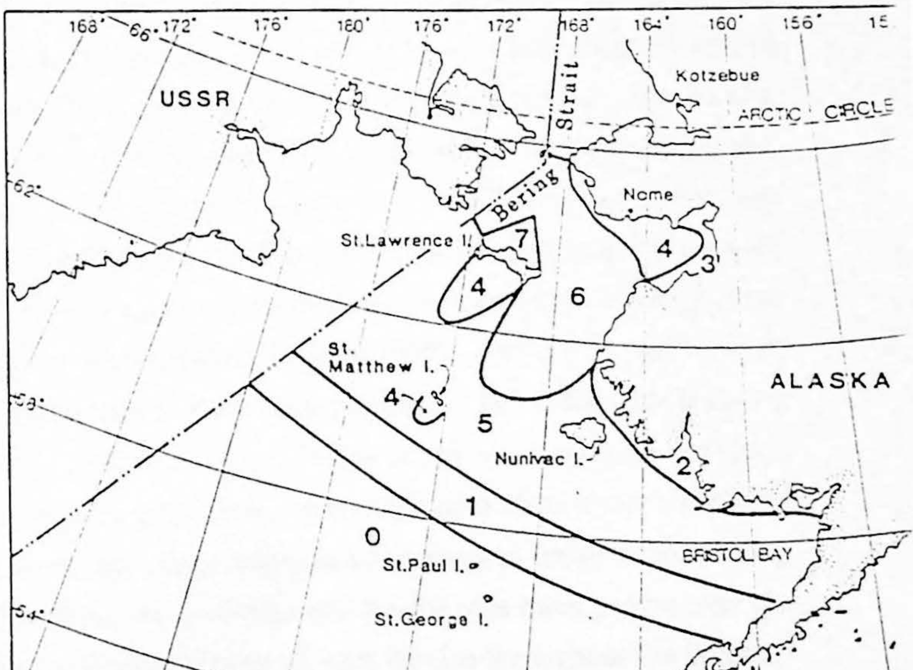
ZONES OF ENVIRONMENTAL SEVERITY - BEAUFORT SEA

Figure 3



ZONES OF ENVIRONMENTAL SEVERITY - CHUKCHI SEA

Figure 4



ZONES OF ENVIRONMENTAL SEVERITY - BERING SEA

Figure 5

After Brigham and Voelker 1985

CHAPTER THREE

WAYS THAT HAVE WORKED: THE BALTIC, THE RUSSIAN NORTHERN SEA ROUTE, AND WINTER NAVIGATION ON THE GREAT LAKES OF AMERICA

INTRODUCTION- Three "systems", as defined earlier, are examined. This shows that there is both precedent for building and operating systems for ice navigation, and that these have been successful. The Baltic system is looked at only briefly, since average ice thickness seldom exceeds 70 cm, and would not provide a particularly appropriate model for the Alaskan system (Ehrensvard, Kokkonen and Nurminen 1995). Further the ice is formed from water of low salinity, with distinct breaking characteristics. The Russian Northern Sea Route operates today, moving cargo across the north of Europe and Asia. The Winter Navigation Program on the Great Lakes of North America no longer operates, but is well-documented, within the personal experience of the author, and provides a good model for operational arrangements described below. The ice in the Great Lakes is, of course, formed from fresh water.

THE BALTIC-Commercial traffic has been moved in the Baltic all year round for decades. All types of cargo are carried, including petroleum products. The traffic is partly independently routed ships, and partly under icebreaker escort, depending on ice severity and location in the Baltic. Icebreakers operate in ice covered areas for about 6 months from December to May. Ships that carry a classification of iceworthiness, as awarded by the national classification societies, are required during the winter months. In 1993, there were 8 Finnish and 4 Swedish icebreakers used to move traffic in the winter months. The Baltic system is instructive for two reasons: a) it has been in operation continuously for longer than the other systems (Jansson 1977), and b) from 1890, when the first Finnish icebreaker was launched, icebreakers have been used in the Baltic for both breaking of track and escort of ships (Jaasalo 1977). Further, testing of ships astern of icebreakers was done to validate empirical beliefs that, at least in some conditions, ice-strengthened ships under icebreaker escort will be a more efficient way of moving the cargo ships, in preference to independent routing (Gordin and Topp 1977). The icebreaker fleets of the Finns and the Swedes have grown over the years in both numbers of ships and power, and now provide all year service throughout the Baltic.

THE RUSSIAN NORTHERN SEA ROUTE-The Northern Sea Route (NSR) is a series of shipping routes stretching from Novaya Zemlya in the west to the Bering Strait in the east. Depending on the routing, the total distance can be as long as 2900 nautical miles of ice-infested and shallow waters. There is no single set channel to be followed, and the one chosen is dependent on the prevailing ice conditions. The NSR has been used by Russian military and mercantile shipping for over 60 years, and in 1991 was opened to international shipping by the Russian authorities. Because of the work that has already been done by the Russians, and the work now underway by the International Northern Sea Route Program (INSROP), of which more below, the NSR is worth examining in some detail, and from this can come areas of further investigation for the Alaskan system.

The early history of the NSR reveals that the economic results of the first years of operation were small and out of proportion to the money and effort expended. The NSR, according to Stalin, was brought into existence to incorporate the wealth of the north into the socialist economy (Armstrong 1952). Armstrong then related opinions on the early strategic thinking of the Russian authorities about the NSR. One of the early considerations was that Russian ships could pass from one end of the Russian Arctic to the other without crossing through foreign and potentially hostile waters. He concludes with the finding that the primary motive of the Russian government in establishing the route in the first place was economic. That conclusion is just as valid today. The major difference between early times and today is the opening of the route to international research and scrutiny, financing of that research, and finally the opening of the route to international shipping.

The evolution of the NSR through the times of the USSR, and subsequently the Russian Federation are of interest to specialists in the Russian economy and transport, rather than operators. The lessons learned by the NSR administrators over the years have been published in various journals, and are summarised in "The Soviet Maritime Arctic" (Brigham 1991). What is of interest to us here are the operational aspects of the NSR, such as convoying (Watson 1991). These aspects will be further discussed in the appropriate chapters.

A most significant development for the NSR occurred in 1989, when M. Gorbachev, in a speech at Murmansk, issued a historic declaration of the internationalisation of the route (Sasakawa 1995). Out of that flowed the formation of the International North Sea Route Programme (INSROP). In its present form, INSROP is composed of fully participating partners from Japan, Norway and Russia, with other countries such as the United Kingdom also involved. The purpose of INSROP is to build up a foundation of knowledge "encompassing all relevant aspects of this problem complex to enable public authorities and private interests to make rational decisions based upon scientific insight rather than upon mythology and insufficient knowledge" (Ostreng 1995, p. 3). This cooperative effort has already produced much information, and there is evidence that this information base is enlarging rapidly (Gold 1995). The importance of this is that there is a great deal of information in the INSROP data base that would be useful in the detailed planning for an Alaska system, eliminating duplication, and thus freeing funding and personal energy for the Alaska route-particular work.

WINTER NAVIGATION ON THE GREAT LAKES OF NORTH AMERICA-In 1970 the American Congress authorised a demonstration program to determine the feasibility of extending the navigation season on the Great Lakes. The political and economic reasons for conducting this program do not concern us here. However, by performing the studies and conducting the operations that were allowed by the program, a body of experience was built up for developing and operating a system that has some of the features that are to be recommended for the Alaska system (Wuebben 1995).

Some of the features of the Winter Navigation Program were:

a) Almost all of the cargo shipped was taconite, a treated form of iron ore. A coating is put on iron ore pellets, which helps prevent the ore from freezing into one huge lump, making it possible to handle the ore in the winter;

b) Almost all of the cargo was one-way, from the head of the Lakes to the steel plants on the south shore of Lake Erie, with the carriers returning in ballast, and at much lighter draft;

c) The route had several interesting navigational challenges: open lakes, a set of locks, two river systems, both deep water and very shallow water, and aids to navigation that were in constant need of attention in order to stay on station and watching properly;

d) Ships formed into convoys, these ships being of widely varying power, size, and manoeuvrability;

e) Icebreakers of the U.S. Coast Guard and the Canadian Coast Guard, which both broke track and rescued beset vessels; and

f) A rudimentary written command and control arrangement by which all vessels in a convoy were intended to operate. However, because ships of a number of owners were in each convoy, adherence to this document was at best one of toleration and at worst a scrum.

In 1979, the final Survey Report was written, the actual operations having ceased. The political and economic reasons for ending the program do not concern us. However the program was not stopped because it was an operational failure, for it was not. The author both commanded a polar icebreaker-sadly mismatched with her operating environment-during this program and thus served as convoy commander on many voyages, and then as the commander of one of the sectors, which included the locks. It was proved that the movement of cargo from one end of the Great Lakes to Lake Erie ports was possible year round, that the convoy system using icebreakers to break track as well as rescue beset vessels was the best way, and that the hazards of operating in convoy can be mitigated by extensive training of the new hands by the experienced ones. An accompanying point to this is that owners, whether it be government or civilian, must provide the opportunity for this training, and the ship captains must realise that the best way to train junior officers is to let them handle the ships in actual conditions. More on this in Chapter Nine.

It can be seen that there is no direct analogue between any of the systems described above, and the Alaska system. In particular, ice conditions in Alaska are much different from either the Baltic or the Great Lakes. However, there is something to be learned from each of the systems, which can be applied to Alaska. It is that application, so that old ice need not be rebroken, that will occupy much of the material to follow.

CHAPTER FOUR

ICE RECONNAISSANCE, INCLUDING REMOTE SENSING

INTRODUCTION-To know in both a tactical and a strategic sense the character of the ice to be encountered, as to age, thickness, location of ice edge and leads, and of movement, it is necessary to understand the various ways of obtaining this information. This chapter describes both direct and remote means of determining the various parameters of ice important to the mariner and to his shore-based advisors. In the tactical, or close-aboard sense, this chapter looks at the means immediately available to the captain on the bridge and to the convoy commander. The strategic or longer-range look to be derived from remote sensing techniques will then be discussed. This information will help the managers ashore make decisions about, among other things, days on which to sail convoys, weather which can be expected, and ice conditions in the longer term sense. In addition, through direct readout in the chartrooms of the ships in a convoy, ice conditions ahead of the convoy can be displayed to the convoy commander, and the ship captains, to assist in making decisions on courses to be steered, speeds to be made good in order to enter developing leads, and dangers to be avoided.

DIRECT SENSING-For the purposes of this chapter, "direct sensing" means those techniques of observing objects, such as ice or other ships, relatively close aboard. The term then would include lookouts, with and without binoculars; ice observation by the conning officer from the various conning stations, especially a conning station high on the mast; and observation of ice from aircraft, especially helicopters, without the use of any equipment other than the observer's eyes. It does not include surface search radar, which will be mentioned in the section on remote sensing.

Notwithstanding the emphasis now being placed on the use of satellite imagery, and to a lesser extent, aircraft-mounted side looking radar, the use of the human senses must not be overlooked. To that end, consideration must be given in ship design to the optimum placement of lookouts, and the provision of the best binoculars available. Lookouts have been used by the prudent mariner since man started going to sea. They have been prescribed in the written rules for the prevention of collisions at sea since those rules have ever been codified into writing. Courts have consistently found fault with captains who did not set and maintain a human lookout. Some of the most important cases in admiralty law were about the use of lookouts in the early days of radar. It is just as important to use lookouts as advisors to the captain on the presence of ice, leads, and of course, other ships. It is especially important that lookouts be provided with shelter from the weather, yet have an all around view from the lookout position. There must be a lookout position close to the eyes of the ship, and there must be adequate communications with the bridge. The best night vision devices must be provided, as well as the best binoculars. In addition, both powerful searchlights and headlights mounted in the eyes should be provided. The lights used on the Russian Northern Sea Route provide a good example.

All ships which are to be employed in the ice should have an ice conning station, placed as high in the ship as possible, preferably on a mast, and provided with a means of communicating helm and engine orders either directly, or to the crewmembers below. The ideal arrangement is one in which a helm is provided, and direct control of the direction of propeller rotation and speed is available. Some conning officers, of which the author is one, prefer to have a helmsman perform the steering function, and to handle the engine controls themselves. Regardless, the aloft conning station should be set up to provide as high a position as possible, and maximum flexibility in the manipulation of rudder and engines.

A feeling is developing among users of remote imagery products that aircraft no longer have much place in ice operations (Personal communication-R. Parsons 1996). It will be shown that some remotely sensed products, e.g. side-looking aircraft radar (SLAR) pictures, are still provided by aircraft. However, the use of aircraft envisioned here is in the traditional role of ice reconnaissance, logistics, and rescue. Recognising that much steaming will be in darkness, helicopters can still provide useful services, those services limited only by the imagination and operational aggressiveness of the owners. Helicopters should be provided along the route, and each ship that operates in the ice should have both a helicopter deck, a refuelling capability, and hands trained in handling the machines, both in light and darkness. The missions of the helicopters are to provide ice reconnaissance in real time, with a trained ice observer who is not the pilot, who radios back lead location, lead length, and distance to go before a lead runs out; provide logistics support as required; and to provide rescue services for the convoys, especially medical evacuation. A logical place to base one machine each would be near the operations centres mentioned below.

REMOTE SENSING-The field of remote sensing grew out of aerial photographic interpretation and has been rapidly evolving since the term was first coined by Evelyn Pruitt in 1960 (Estes and Sanger 1974). Remote sensing means the observation of, and gathering information about, a particular target or area by a device or devices separated from it by some distance. This definition thus includes the surface search radar carried aboard each ship. Although satellites are often regarded as the major source of remotely sensed products, there are several other techniques that continue to be used. In fact, it should be understood that remote sensing activity far precedes the development and use of artificial satellites (Cracknell and Hayes 1991).

Simpler instruments, especially cameras, which are used in remote sensing, date back long before satellites. Some of the earliest work in ice observation was with aerial photography, cameras being carried aloft in fixed wing aircraft and the film being returned to base for developing and the photos then analysed. Although not real time intelligence, these photographs provided the first permanent records of what ice in all of its variations looks like from a horizon farther away than what can be seen from a ship's aloft conning station. Especially important was the ability to see the variations caused by ice of different thickness, age, and pressure (Thomas 1951).

The use of surface search radar, carried by ships and aircraft for the examining of the surface of the earth around a vehicle, and air search radar, carried by ships and aircraft for searching the surrounding atmosphere, also come within the definition of remote sensing. The description of the parameters used in the selection of appropriate radars is beyond the interest of this chapter. It is sufficient to say that the most effective radars for the detection of hard targets around the carrying vehicle are not the most effective for the detection of ice, and determining its characteristics. However, it is possible and desirable to select radar sets that will provide some ice intelligence. A great deal of work has been done in this area, and the results of that work are readily available (Currie, Haykin, and Lewis 1987). There still is no substitute for the alert lookout for the detection of icebergs.

The use of aircraft to carry sensors other than cameras has provided considerable imagery of ice. Because aircraft fly at much lower altitudes than satellites-aircraft in the range measured in feet or meters, and satellites in hundreds of miles or kilometres-far more detail can be seen from aircraft sensors. Conversely, satellite sensors can cover far greater areas. The ideal presentation for strategic purposes would be one in which all sensor products are integrated into one display, map or chart. An example of a practical use of aircraft using synthetic aperture radar (SAR) is described here. In November 1984, USCGC POLAR SEA became beset in a shear ridge about 60 miles north of Prudhoe Bay, Alaska. A shear ridge is a ridge formed by the relative motion of two ice features, moving in a direction primarily parallel to their common boundary. Sufficient pressure must be present to keep the two features in contact. Because of the size of the ice features involved, enormous forces were at work, and POLAR SEA was well and truly stuck. During the five and one half days that she was beset, before she could extract herself, overflights were made with aircraft equipped with SAR. One of the photographs taken of the SAR display is shown at Figure 6. The location of POLAR SEA and the ridge itself can be clearly seen (Seibold and Voelker 1990). This incident occurred north of Prudhoe Bay, one of the terminal points being considered in this study. It points out the necessity of timely and accurate knowledge of the ice ahead of convoys, and the routing around areas of difficulty, especially moving ice fields.

The final paragraphs look at the use of satellites for studying the Arctic. Notwithstanding the opinion of one author, who stated that marine shipping suffers little from route restrictions, but is exposed to many dangers, such as weather and ice (Drury 1990), the shipping system being considered will indeed suffer from route restriction. In order to avoid dangerous ice conditions, such as ridges in the POLAR SEA example, all available sources of ice intelligence must be used. Satellites provide the opportunity to look at large areas with a high rate of data acquisition. Some satellite systems function at night or through clouds or precipitation (Massom 1991).

The methods of extracting satellite information by a user will be discussed in the next chapter. However, it is necessary to complete the discussion of satellite imagery by listing some of the satellites used for providing ice information, and describing their characteristics.

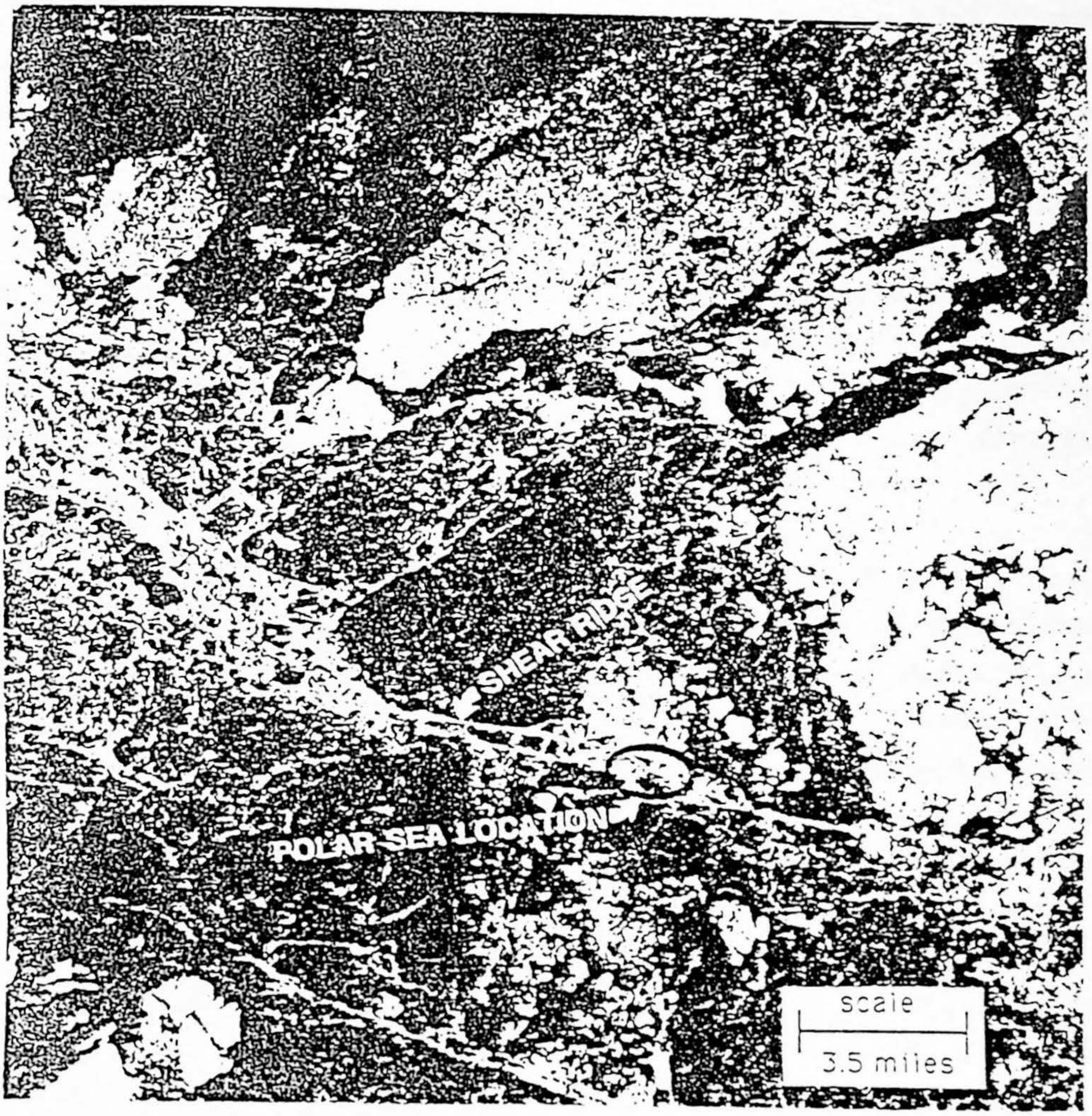
The National Ice Center, a component of the United States Naval Oceanography Command, is physically located in Suitland, Maryland, a suburb of Washington, D.C. Among other products, an annual atlas of ice conditions called the Eastern-Western Arctic Sea Ice Analysis (Yr) is produced. Another product is a daily ice chart of the Arctic, broken down into several areas. In the production of these charts and the atlas, the following satellites are used as sensor platforms. Data are given for the latest atlas available, 1994. Subsequent editions will list the satellites used for that particular issue (Naval Polar Oceanography Center 1994).

a) NOAA 11, 12.
Sensor type-Advanced Very High Resolution Radiometer (AVHRR)
Resolution-1.1 km
Coverage-Arctic region
Products derived-sea surface temperatures, high resolution data to define sea/ice conditions, and ice leads in support of shipping activities.

b) ERS-1
Sensor type-Synthetic aperture radar
Resolution-100-240 m
Coverage-local within the Arctic region
Products derived-imagery of sea ice, snow cover, leads

c) DMSP f-10, 11 and 12
Sensor type-Special Sensor Microwave Imager-SSM/I
Resolution- 25 km
Coverage-global

Sea ice is a complex material, with wide variations in all parameters. In particular, interpretation of sea ice pictures from synthetic aperture radar, such as carried by ERS-1, must be correlated with those parameters in the field (Askene and others 1994). Even this late work repeats the idea that has been expressed in other areas of investigation - modelling and remote sensing are fine, but the only way to get at the "ground truth" is to actually go to the area under investigation. Models and remotely sensed data must be compared and validated against actual conditions.



Synthetic Aperture Radar (SAR) imagery showing shear ridges and POLAR SEA

Figure 6 From Seibold and Voelker 1990

CHAPTER FIVE

ICE COVER AND DYNAMICS

INTRODUCTION-Once the means of determining the characteristics of ice in a particular area has been established, it is then necessary to collect and display ice information. This chapter will show some samples of ice cover and other parameters from the Canadian border to south of Saint Lawrence Island, using both remote sensing techniques, and ice atlases. These atlases contain information collected over many years, and are a record of past conditions rather than the "snapshots" possible with the real time or close to real time display of remote imaging. The possibilities of earth observation from space were appreciated at the earliest launches of satellites orbiting the globe. As early as 1983, the applications of ERS-1, the European Space Agency's first remote sensing satellite, were being anticipated (Charnock, Cook, and Goughton 1983). The result of this work, and a great deal more, is now being used to give many types of data. The information pertinent to a particular area of interest to this study, the Alaskan Arctic, can be obtained from several sources. Three of them, the U.S. National Ice Center, Ice Centre Environment Canada, and a non-governmental source, TeraScan by SeaSpace Corporation, are described here.

U.S. NATIONAL ICE CENTER-The National Ice Center, formerly known as the Navy/NOAA Joint Ice Center, is located in Washington, D.C. It was established in 1976 to provide global ocean sea ice and Great Lakes ice data to military, government, and commercial users. The Great Lakes Season Extension Program was an early beneficiary of what was then the JIC. A much-refined version of the Great Lakes product is still available. Satellite derived data are the primary sources for NIC ice analysis and forecast products (Bertoia and Carrieres 1994). One of the most important analysis products for the purposes of this study is the Eastern-Western Arctic Sea Ice Analysis (YR). It contains weekly charts showing sea ice coverage and ice edge location in the Northern Hemisphere. The Foreword to the 1994 Edition, the most recent available, states that "the use of high resolution digital satellite imagery combined with aerial ice reconnaissance data and various ground-truth data sources (shore stations, ships and buoys) have greatly improved the accuracy and detail of ice analyses in comparison to past years" (Anon. Foreword, 1994 Arctic Sea Ice Analysis). It can be expected that this improvement will continue. A sample page is shown at Appendix III.

For access to current information from the NIC, a different system is used. The NIC Autopolling Facsimile System is a completely automated method of getting current information 24 hours a day. The details of how this works are included in information sent to prospective users before checking into the system for the first time. The important feature of this system is that the management of the transport system discussed herein would be eligible to use the system at no cost, and without making any contract or other agreement. Certainly all ice reports submitted by convoy commanders would be happily received, and would form some of that all-important ground truth.

Some of the products available from the autopolling product list are: Arctic ice analyses/forecasts(weekly), Arctic 30 day forecasts, Arctic seasonal outlooks (issued annually), and Alaskan regional analysis charts, issued twice a week. A sample of a regional analysis chart is shown at Figure 7 and Figure 8. (National Ice Center 1996). It can be seen that the map quality is such that some practise is needed in order to understand the diagrams. Further, it is necessary to match the top edge of one chart with the bottom of the other to get full Alaska coverage. The decode of the lozenge is included on the chart shown at Appendix III. The instructions for entering the autopolling system and the autopolling product list are at Appendix IV.

ICE CENTRE ENVIRONMENT CANADA-This organisation is located in Ottawa, Canada, and is referred to as ICEC. Its mission is to provide a service contributing to safe and efficient marine operations in sea ice in Canadian waters. The geographic area of responsibility includes all Canadian ice-covered waterways, and their access routes. The importance of ICEC to the NIC is the North American Ice Link (Bertoia and Carrieres 1994). ERS-1 is a contributor to both centres,but the Canadians have chosen to continue to use synthetic aperture radar and side-looking radar equipped aircraft as a real-time capability. The significance of this to this study is that American users of NIC products can be sure that applicable data from both the Canadian and the American sides are consolidated and presented from one source, the NIC.

TERASCAN-TeraScan (sic) is a system owned by SeaSpace (sic) Corporation, of San Diego, California. It is a combination of proprietary software and hardware which allows buyers to acquire, process and analyse weather satellite data. The author does not endorse this or any other commercial system. It is included here as illustrative of the kind of information that is available on the commercial market. The claims made by the literature must be taken with some judgment applied. However, it would be recommended that the prudent managers would not only use the official sources such as that described above, but would seek out and purchase the best commercial system as a complement.

Of interest now is satellite-derived information concerning ice cover, which will improve ice navigation, and will assist the organisation's convoys find the best route through the pack ice. To do this, TeraScan can be configured to several levels of complexity, sophistication and cost. In addition, it appears that shipboard equipment can be adapted for shoreside use in the operations center(s) with little or no difficulty. The shipboard TeraScan includes a stabilised antenna, a Global Positioning System antenna/receiver, a workstation which includes the system receiver, monitor and other components, and a stabilised power supply. The package is completed by the software which provides for telemetry acquisition, processing and analysis. Among the claims made for TeraScan by SeaScape are the acquisition, processing, analysis and display of real-time high resolution telemetry from the entire spectrum of polar orbiting weather satellites. Satellites listed in the literature are the NOAA satellites, SeaStar, and China's FY-1. Further, an optional and further-cost upgrade will allow acquisition of high-resolution telemetry from the American DMSP polar orbiters (SeaScape literature 1995). A sample of TeraScan imagery is at Figure 9.

The use of TeraScan or any other commercial system will bring with it some costs. Buried within those costs are those related to the training of operators and analysts in the operations center(s) and aboard ship. In addition, maintenance personnel must be trained to service and repair the equipment, especially the components that must operate in adverse weather. However, it should be possible to lease systems for evaluation, with an option to buy. Part of the planning and evaluation of various aspects of the transport system should include evaluation of all sources of ice information, and the selection of those which will give the most accurate results.

WORLD WIDE WEB-The Web Site at <http://www.asf.alaska.edu> contains a great deal of information on the Alaska Synthetic Aperture Radar (SAR) facility. Access to this is through an Internet server. A sample of ice information at Point Barrow is shown at Figure 10. The image was originally in color, and the scale on the left side of the image correlates with the colors on the main map. However, even in monochrome there is a great deal of information to be read, such as leads.

Almost 40 years ago, an expert in ice matters wrote a paper about an ice atlas for the North American Arctic. He was particularly concerned about sources of ice information for the use of shipping in ice-laden waters. Three main sources of information were listed at that time: the ice atlas, synoptic ice observations, and ice forecasts (Swithinbank 1958). These sources remain valid today. The big advance is that synoptic data is now collected using remote sensing techniques, such that forecasts can be more timely, and atlases more accurate. Further, real-time data can be sent down from the satellites for display aboard ship and at control centres. All of this information, coordinated with the directly sensed information that each captain derives for himself from his own observations, will provide the best available information for ice navigation.

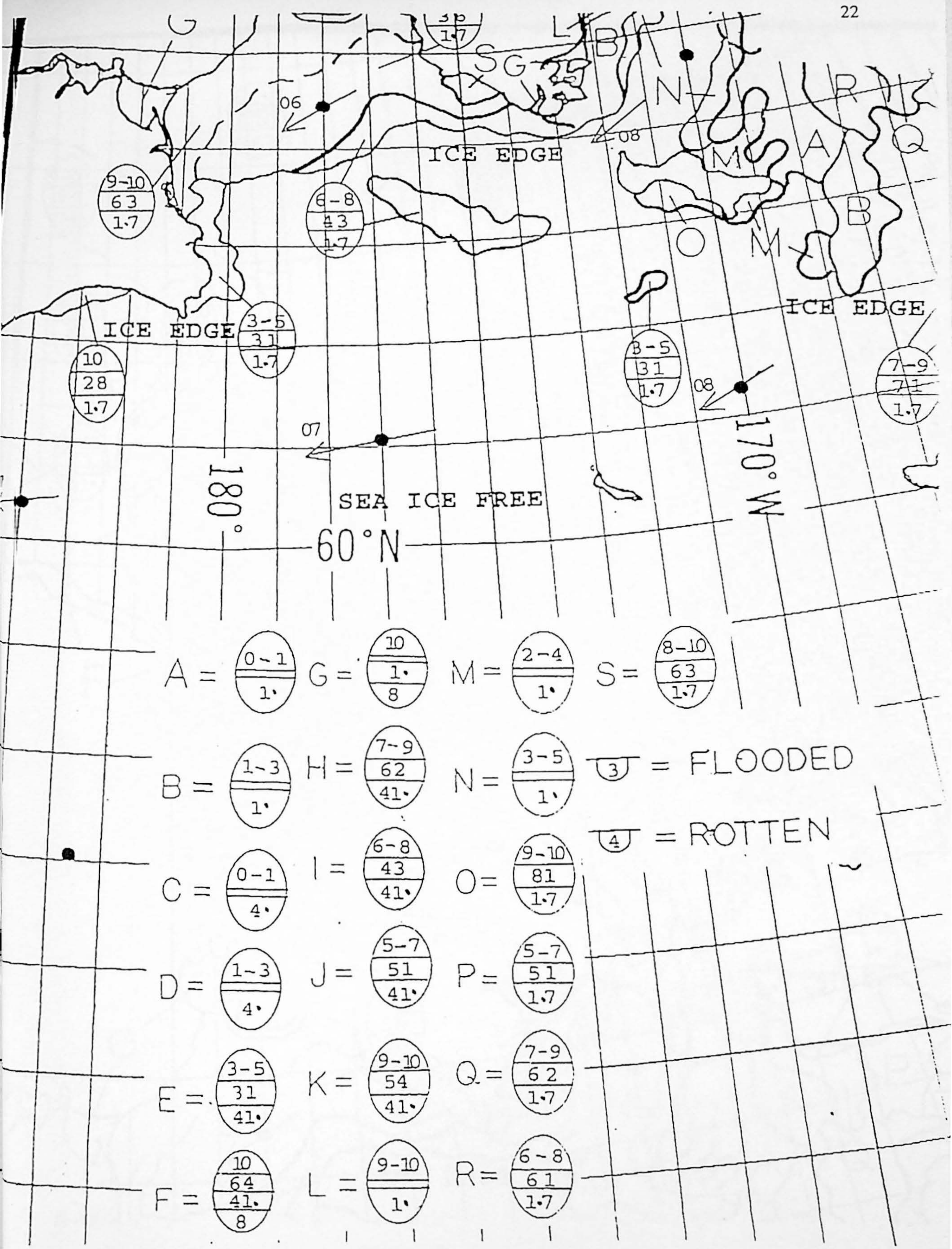


Figure 7
National Ice Center 1996

Figure 8
National Ice Center 1996

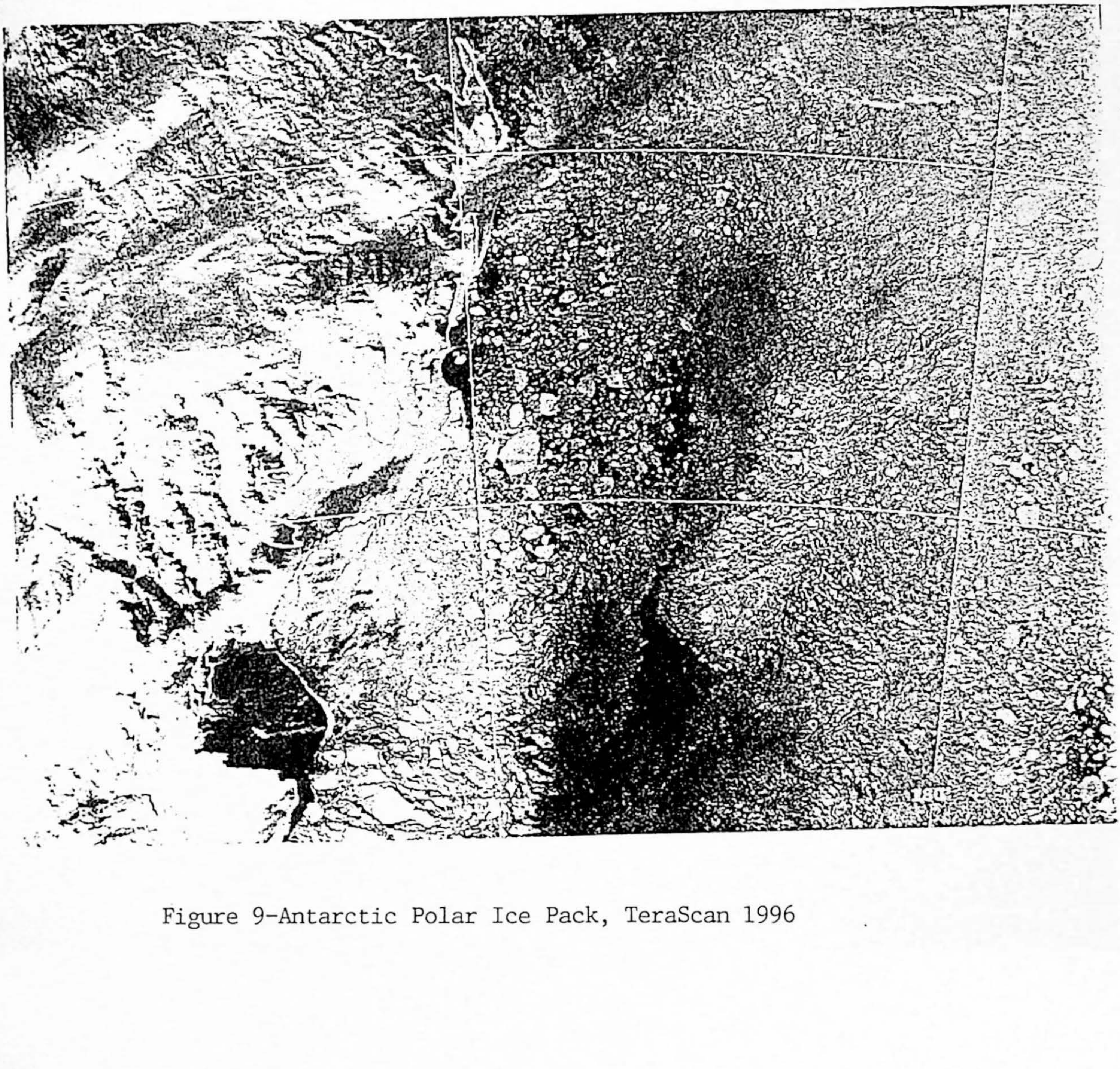


Figure 9-Antarctic Polar Ice Pack, TeraScan 1996

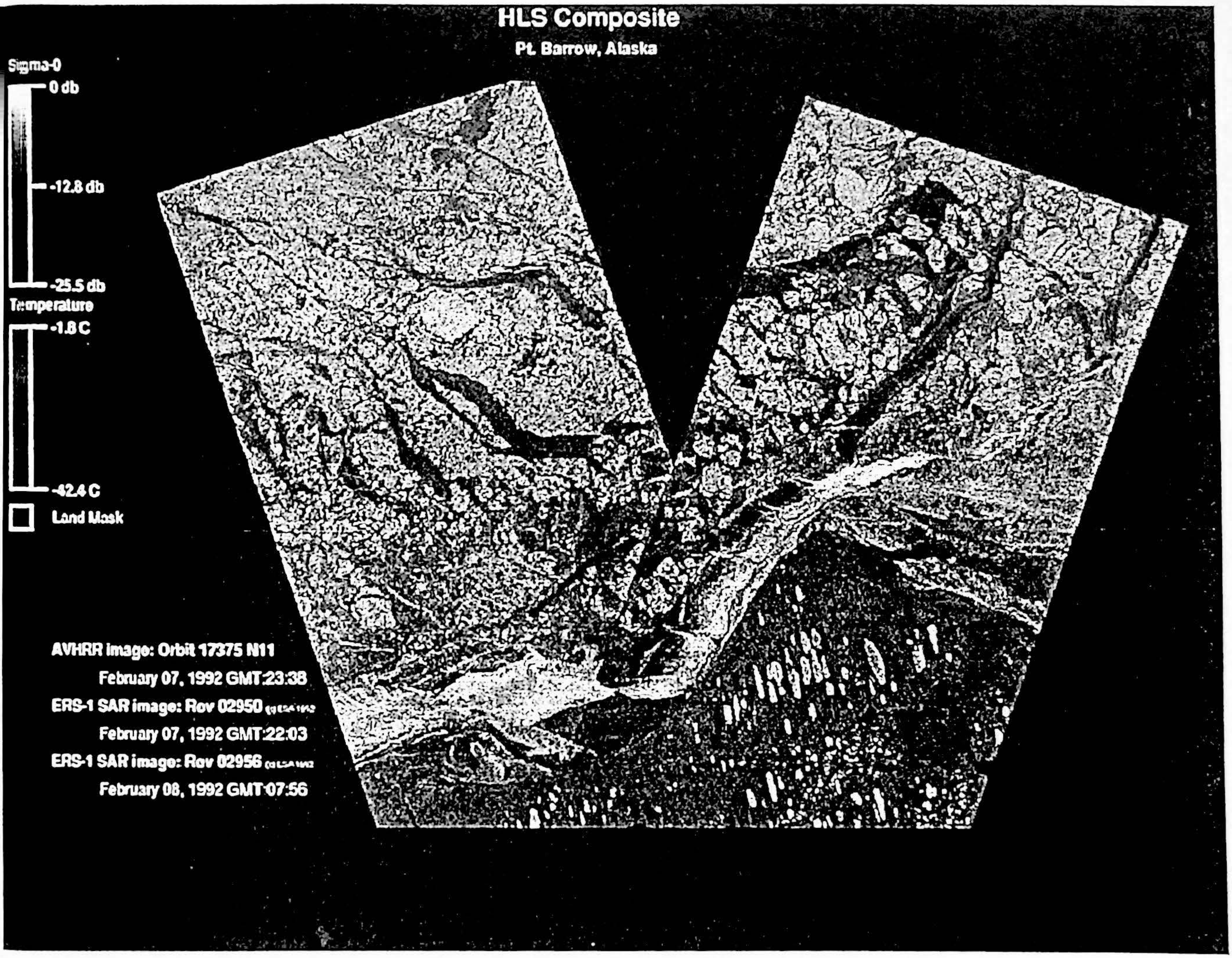


Figure 10
Alaska SAR Facility

CHAPTER SIX

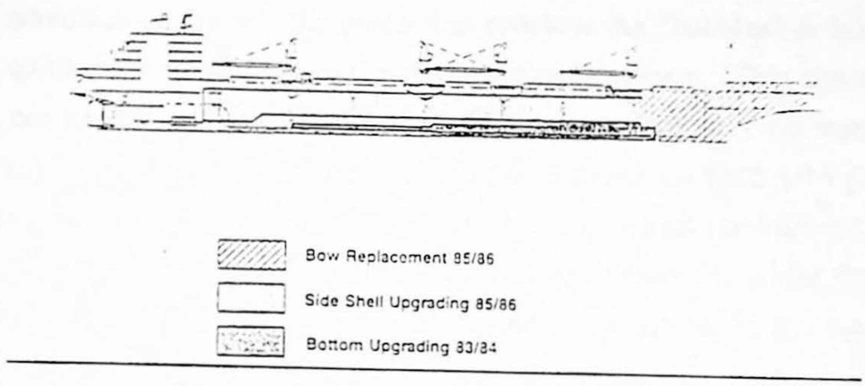
VESSEL TYPES AND CONSTRUCTION

INTRODUCTION-This chapter considers both the ships which would carry the cargo, and the ships that would escort them, the icebreakers. It is stated at the outset that all of these ships would be built to U.S. standards, to sail under the American flag, and to be manned by American crews. This is to be in conformity with U.S. laws. Further, the icebreakers would be part of the "system", owned and operated by the same organisation that produces the LNG, or under contract, and no U.S. Government icebreaking assistance would be expected.

THE LNG CARRIER-A number of attempts have been made to design and build a ship which would be the answer to all of the problems of operating in the ice, carry a profitable cargo, and be able to make open water transits at good speed and reasonable comfort. One approach that has been discussed ever since the invention of the submarine is to go under the ice, thus avoiding the icebreaking problem altogether (McLaren 1982). There are serious problems of navigation, hull strength, cost, and training of personnel. As late as 1995, engineers at the St. Petersburg Marine Engineering Bureau in Russia were working on an underwater transport system for the Arctic (Chernousov, Dronov, and Kuteinikov 1995). The conclusion drawn in this study is that the problems are great and "sufficiently complicated, but they all can be advantageously solved, provided a general progress of Russia's economy at a support and participation of foreign firms and organisations" (sic) (IST '95, p. 503). Although the cost figures show an advantage to the underwater tanker, the methodology is not shown, and since conventional ships are now used on the Russian North Sea Route, and underwater tankers have not passed the theoretical stage, it would appear that any further investigation of them should be especially rigorous.

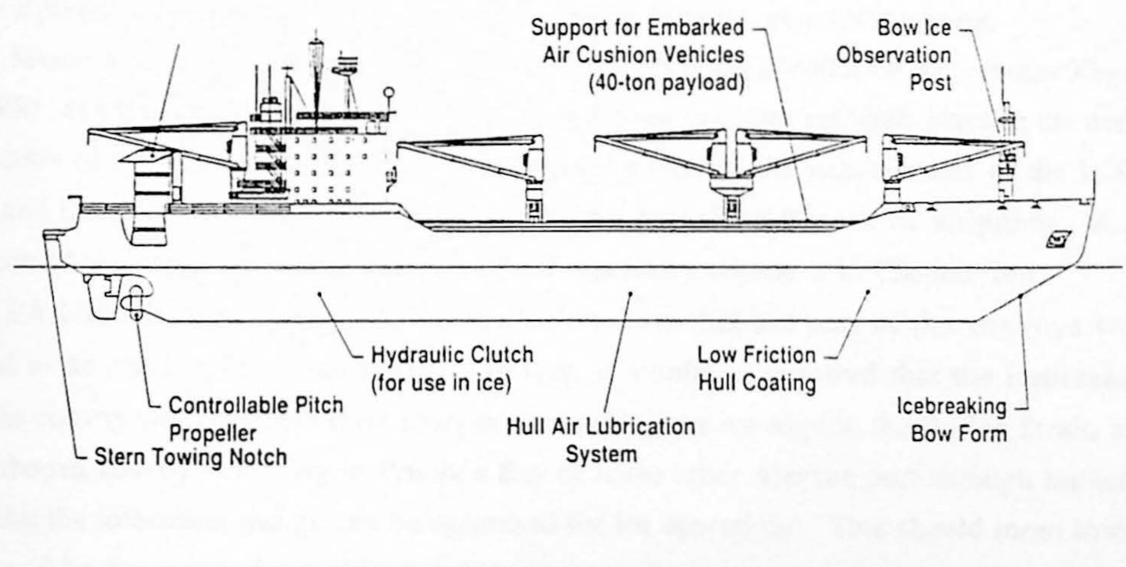
An historical treatment of ships already built for the LNG trade, along with a discussion of the role of classification societies, further discussed later, dealt with several ships that have already seen service (Ffooks 1993). There are, however vessels, that although not built specifically for the carriage of LNG, could form two baseline designs for the vessel which could be used as the LNG carrier in the Alaska system.

M.V. ARCTIC-This ship was purpose built by Canarctic Shipping Company Ltd, Canada, for the development of extended season shipping in Canada's north. It was always intended that she sail independently, without icebreaker escort. Beginning in 1981, M.V. ARCTIC sailed in early and late season voyages to a mine site on northern Baffin Island. Originally built to Class 2 of the Canadian Arctic Shipping Pollution Prevention Regulations (CASPPR), she was subsequently upgraded to Class 4. Her midbody was improved with a higher strength steel, and a new icebreaking bow was fitted. This resulted in a significant improvement in her icebreaking capabilities. Although she normally operates without icebreaker escort, she does not operate year round. After her refit, completed in early 1986, she subsequently was able to break 1 m thick ice at about 8 knots, and on the first voyage made after that refit, she consistently broke 2 m thick ice, although with some ramming (Luce and Sneyd 1992). Figure 11 shows the upgrade work that was done through early 1986.



M.V. Arctic Ice Class Upgrading 1983 - 1986

Figure 11 From Luce and Sneyd 1992



Noril'sk class (SA-15) icebreaking cargo carrier showing relevant ship systems.

Figure 12 From Brigham 1991

NORIL'SK (SA-15)-As of 1991, there are 19 ships of this class in the Russian fleet. They are 174 m long, 21,000 hp (16,660 kw) and are geared diesel drive, i.e. the controllable pitch propeller is driven directly by the main engine through reduction gears. They are designed to operate in convoy in ice at least 2 m thick. Figure 12 shows an outboard profile of an SA-15, and shows some of the design features to make her an effective ice vessel (Brigham 1991). The hull air lubrication system and low friction coating on the underwater body are examples. Brought to its present state of refinement by the Finns, the hull air lubrication system, known in America as a "bubbler", has been installed in a number of ice-worthy ships to provide lubrication of the hull with an air-water mixture at the waterline. One installation familiar to the author is in the "Bay" class of 42.7 m LOA icebreakers operated by the U.S. Coast Guard. Because these ships are used for other less specialised duties when not in the ice, the pump that provides the "bubbles" is installed in a deck-loaded van, with quick-connect fittings to the internal piping system. This van is offloaded by a dock crane when not needed. It would be expected, however, that only permanent installations would be used in any large ships. The other special feature shown on the SA-15 profile is the low-friction hull coating. Ordinary antifouling paint will be stripped off the hull the first time a ship enters the ice. In recent years, however, special coatings have been developed that are expensive, must be applied under carefully-controlled conditions, and are worth all of the extra cost and care. The friction between the hull and the ice is materially reduced and the bonding action between the coating and the steel is such that the coating will remain in place. Another feature that has already been discussed is the ice observation post in the bows. Note that it is placed both high and well forward, and also provides shelter for the personnel manning the station.

Both of the ships described above are now in service and are being constantly evaluated for improvements. Further, the International Northern Sea Route Programme (INSROP) is studying the next generation of even more capable, strong and iceworthy cargo ships. It should not be difficult to become a participant in these studies, especially if some funding were forthcoming.

Mention has been made of the Canadian Arctic Shipping Pollution Prevention Regulations (CASPPR), and this introduces the subject of classification societies and their place in the design and construction of merchant vessels. The vessels must be built to the requirements of the U.S. Coast Guard and the American classification society, the American Bureau of Shipping. A further discussion of classification societies as part of the regulatory regime is in Chapter Ten.

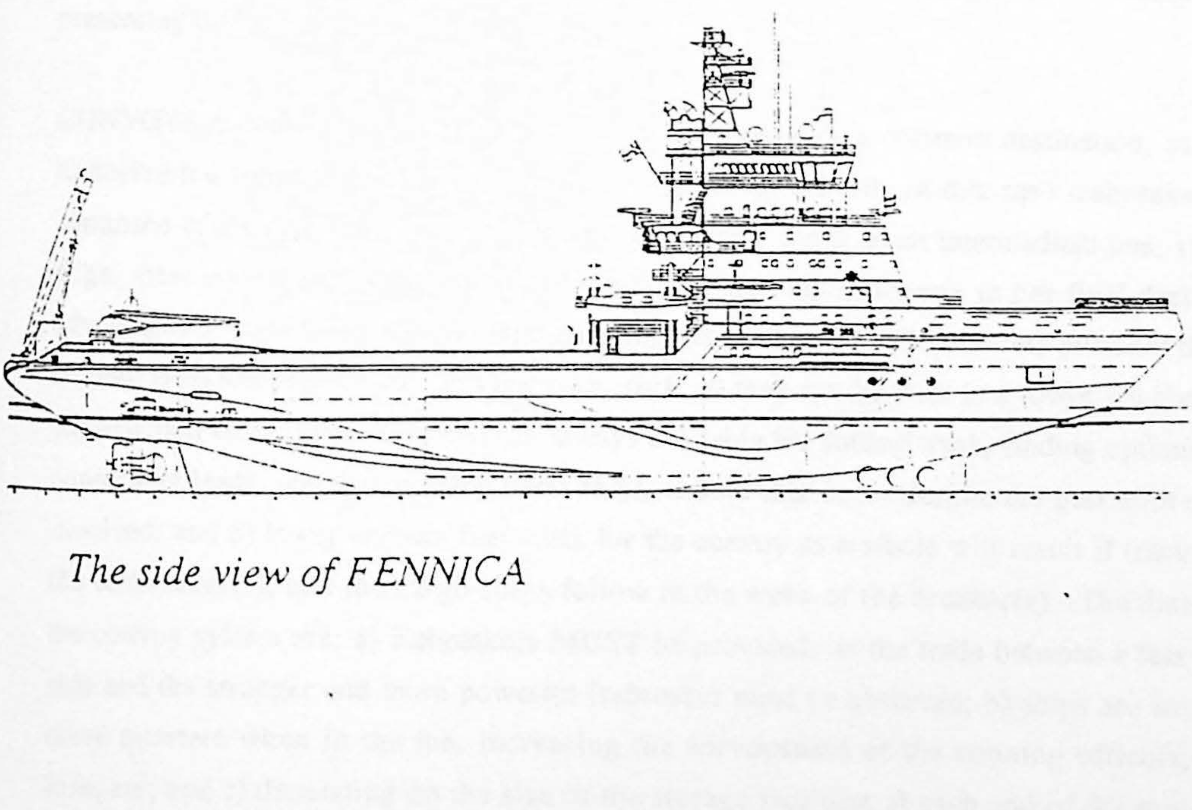
ICEBREAKERS-It is not intended that the icebreakers that are part of the convoys would be required to do much open-ocean sailing. In fact, it would be required that the icebreakers in a particular convoy would release their charges on reaching the ice edge in the Bering Strait, and pick up an inbound convoy, returning to Prudhoe Bay or some other Alaskan port through the ice. This means that the icebreaker design can be optimised for ice operations. This should mean lower costs than would be necessary for a ship that also must make long open water transits. This would eliminate such costly designs as the American POLAR class ships, and the Russian nuclear icebreakers. The objective would be to build a very powerful ship, capable of being operated by a relatively small crew, with enough fuel capacity for only the round trip from whatever port is being used to the ice edge, and home. Even then, both icebreakers and LNG carriers would have the capability of fuelling each other, but only when absolutely necessary. An example of an icebreaker that might form a basis for further investigation is M.V. FENNICA.

Admittedly, FENNICA was designed for the low-salinity Baltic. However, she was tested extensively in level ice, old channels and ridges in the Baltic, and performed beyond estimates. Of interest to the ice pilot, she has no "bubbler' although she does have a heeling system, by which the ship can be made to roll by shifting water from one side of the ship to the other, large pumps making the transfer very quickly. She was intended to operate in 1.8 m thick ice, at continuous speed. Figure 13 shows both the principal particulars of the ship, and an outboard profile (Lohi and others 1993). Of interest to the naval architect is the "reamer" bow, and the high superstructure. Because FENNICA was intended to operate in the summer in the North Sea under charter to help pay her way, she was built with bow thrusters and features to increase her seakindliness. Any investigation of her design for the Alaska application should also include a thorough look at what would NOT have to be included.

Whatever new design work is undertaken for the Alaska application, there is already an enormous amount of work that has been done both in computer modelling and in test tank simulations. The author's experience is that the engineers want to build something that hangs out on the edge of technology. But what is needed for this system is a series of ships, both in the LNG carrier and the icebreakers, that are strong, simple, powerful but no more powerful than the needs of the ice to be encountered plus a healthy margin, and easily maintained. The methodology for determining size and power requirements is known (Backlund, Juurmaa, Mattsson 1993). The challenge will be to translate those values into ships that will operate efficiently at the lowest practicable cost.

particulars of the vessel are listed below.

Length, oa	116.0 m
Breadth, max.	26.0 m
Depth	12.5 m
Draught/deadweight	
Baltic icebreaker	7.0 m / 1650 dwt
Arctic icebreaker	8.0 m / 3900 dwt
Offshore operations	8.4 m / 4800 dwt
Propulsion power	2x7500 kW
Speed, open water	16 kn
Bollard pull	2.30 MN
Bunker capacity	2500 m^3
Classification	Det Norske Veritas +1A1, Icebreaker Polar 10



The side view of FENNICA

Figuer 13, after Lohi and others 1993.

CHAPTER SEVEN

OPERATIONAL CONSIDERATIONS

INTRODUCTION-The discussion of the SS MANHATTAN adventure showed that she was intended to be her own icebreaker, although there were icebreakers in company. The same operational philosophy was used in her second voyage into the ice, in 1970 (Swithinbank 1970). Conversely, the examples in Chapter Three showed that full-powered icebreakers were or are used to break track and to keep the ships moving. This chapter discusses the convoy system, the use of icebreakers in convoys, and ship management in convoys where the ships are moved in a unit. Work done as recently as 1992 attempted to quantify the size of cargo ship which would be better sailed independently, taking advantage of the mass of the ship to help in the icebreaking process. The analysis disclosed that a ship of at least 200,000 tons would be necessary to sail independently. Admittedly some of the reference information in the study was dated, and some of the methodology would have to be reviewed before accepting the study. However, the conclusion that the icebreaking gas carriers used in the modelling in the study would not be able to operate independent of icebreakers appears valid (Tsoy 1992). One further consideration, not mentioned by Tsoy, is that the longer a ship is, the more difficulty it has in turning in the ice. In fact, MANHATTAN found herself unable to turn at all on several occasions, and icebreaker assistance was needed to cut track for her (Smith 1970). A 200,000 ton ship would not only be very long, but she would also be deep, presenting difficulties with harbour depths.

CONVOYS-A convoy is described as a group of ships with a common destination, sailing together to derive the support and protection of accompanying escorts, in this case icebreakers, under the command of a single officer. The common destination could be an intermediate one, such as the ice edge, after which each ship would be released to sail independently to her final destination. The advantages of convoying are: a) cargo carrying vessels can be built with less power if they are not to be their own icebreaker, and cut their own track; b) they can be built to a lower ice class with lower construction costs; c) an icebreaker is always available for cutting track, finding optimum routing by connecting leads, and for rescuing beset ships, should that occur despite the best efforts of the ships involved; and d) lower enroute fuel costs for the convoy as a whole will result if track is broken by the icebreaker(s), and the cargo ships follow in the wake of the breaker(s). The disadvantages of the convoy system are: a) icebreakers MUST be provided, as the trade between a less strong cargo ship and the stronger and more powerful icebreaker must be observed; b) ships are working in very close quarters when in the ice, increasing the nervousness of the conning officers, owners and insurers; and c) depending on the size of the storage facilities at each end of the route, ships may have to line up to load and unload.

One of the objections to the use of icebreakers has been the initial cost of the full-powered icebreaker in comparison to the cost of the cargo carriers. However, for the route envisioned in this study, it would not be necessary to build either the nuclear-powered icebreakers favoured by the Russians for the NSR, nor huge ships similar to the POLAR class of American icebreakers. Chapter Six describes an icebreaker which would be less expensive, and would do the same job, but for a much shorter distance, and without the need for large crews. For the purposes of this chapter, it is accepted that the convoy system will be employed in all ice operations.

Convoys have been used in the three systems described in Chapter Three, and continue today in the Baltic and the Northern Sea Route. There are a few early texts that contain tips and hints for icebreaker captains, and one of the best is a Russian text, published by a Moscow maritime publisher in 1957 (Gotskiy 1957). It is clear from this source that the preferred method of moving ships in the ice along the Northern Sea Route at that time was by convoy. In fact, the inference can be made that ships would only be moved, except in unusual circumstances, in convoys with icebreaker escort, and at least one icebreaker out on the point. The techniques described for forming up a convoy, the placement of ships according to power and size, speed of advance, and many other elements of convoy seamanship are as valid today as when written. They conform to the actual experience of the author of this paper, in both salt water and fresh water ice. The entire contents of the cited publication would form the beginnings of a syllabus on ice seamanship for icebreaker captains and conning officers. One particular technique described in the text is the close tow. The icebreaker and the ship being assisted make up into a tug-tow combination, and the combined power of the two ships is used to get through the difficult area.

By describing a typical voyage, the principles of operating several ships in a convoy will be illustrated, and other elements of the system will be demonstrated. In order to get to that point a setting of the stage is necessary.

a) Preliminary considerations. Before the first convoy is ever formed, the operations manager, cooperating with the incumbent ship captains, will have drafted an Operations Plan. This will contain all the standing instructions from management, and will especially define the command relationships among the captains. Having been accepted and promulgated by management, the Operations Plan forms the basic document which will guide all personnel in their relationships with each other, and in all operations. It will be directive in nature, rather than permissive. Using this directive as the basis, each voyage will have a particular Operations Order. This will contain all of the information needed to govern a particular voyage and convoy.

b) Convoy conference-One of the elements of the Operations Plan is the prescription that the senior icebreaker captain will be the convoy commander. In this capacity, he will call a meeting of all of the captains, well in advance of sailing time. He will designate the order in which ships in the convoy will sail from their berths or anchorages, the location of the rendezvous point, and the order of lineup in the convoy. Much of the information passed at this meeting will depend on the ice and weather conditions at the time and to be expected during the first days of the voyage. At this meeting the personalities of ships and masters are considered in the decisions reached, and any changes made by the convoy commander to the Operations Order, for he will have the authority to amend it as circumstances change during the voyage. The communications arrangements will be reviewed, and other matters, such as emergency procedures, besetment of the leading icebreaker(s), and helicopter operations are all discussed. This meeting would probably be held ashore in the departure port on the outgoing voyages. On inbound voyages, bringing cargo ships back to Prudhoe Bay either in ballast or with some retrograde cargo in the holds, this meeting could be held aboard the convoy commander's ship just inside the ice edge, with ship captains being transferred by helicopter. An alternative would be, if all the captains were experienced and had worked together before, to do it by radio, following the format of the Operations Order. In all cases, there must be an acknowledgment on the part of all the ship captains that they understood the Operations Order, and that any questions have been resolved before the convoy gets underway.

The preliminaries to any convoy activity having been observed, the convoy commander gets his charges underway, in the order prescribed. As the Operations Plan and the Order written under it will be more fully described later, suffice it to say that normally the icebreaker with the convoy commander will start the procession out on the point. The next part of the narrative describes events occurring while underway in the ice.

a) Enroute. There are many things that can happen during convoy operations, particular to sailing in the ice. The captain of each ship in the convoy is totally responsible for the operation and safety of his own command. That includes damage control of any damage that threatens the safety of his own ship. In the most extreme case, he must determine if the situation in his own ship is so severe, should he have a fire or some other life-threatening casualty, that he should abort the voyage, and return to port. However, in our sample voyage, no such calamities happen. Because the convoy commander has placed the ships in the optimum positions in the convoy, based on size, power, and known capabilities of captains and ships in the ice, all moves along smartly. As the voyage progresses, and especially in the first day in the ice, captains make adjustments of ship spacing, propeller revolutions, and personnel assignments to maximise their sense of security that this adventure can be completed without serious mishap. At the same time, the convoy commander is deploying any junior icebreakers as needed. One technique is to employ the senior ice breaker and the junior icebreaker in echelon, breaking a channel half again as wide as the beam of the widest cargo ship in the convoy. A third icebreaker is astern of the last ship in the convoy, ready to come up alongside and free any ship that is becoming beset. Experience will tell the captain when his ship is about to become stuck in a channel and can call for help before he actually is at a stop. The matter of spacing between ships is not susceptible to any hard rules. The objective of the exercise is for each ship to have her bow in the relatively open water left by the passage of the icebreaker opening up the channel and the screw wash of her predecessor, but not to be so close that she will not have room to turn her bow into the ice if the ship ahead of her becomes stuck. Efforts have been made in the past to develop tables of distances for specific ships, called in the NSR ice passports. Apparently no ice passports have been developed for new construction (Watson 1991). Experience gained in convoy training, to be discussed in the chapter on training, will help captains determine what is the best interval for their particular ship. Prearranged signals must be used to tell ships astern when a particular ship is about to become stuck. These signals should be reproduced in each Operations Order, should be posted prominently at each control station, and should be drilled as part of the training programme.

b) Other enroute considerations. There is a fine line to be drawn between the internal operation by each captain of his own command, and the operation of the convoy by the convoy commander. For example, fuel state information-the amount of fuel remaining in the tanks, and the estimated days fuel available- is normally of concern only to a particular ship captain and his owners. However, if that ship begins consuming fuel at a greater rate than normal, that then becomes a matter of concern to the convoy commander. Therefore, although it is desirable to keep reporting to a minimum-the internal reports required of each ship by ownership being already at a high level-a daily fuel status report from each ship to the convoy commander is essential. The author found that a morning conference call each morning was a good time to collect the fuel and water reports. This had two advantages. The first was that any casualties that would concern the convoy as a whole could be passed, regardless of the natural reluctance of captains to point out deficiencies in their commands. If casualties were brought up, offers of help from other ships in the group-spare parts, loan of a skilled mechanic, materials-would be made, discussed, and if accepted, arrangements for transfer made. Here is where the helicopter performs an invaluable service, acting as a ship's boat for the transfer of men and materials. The second is that routine reports, e.g. the daily fuel and water report, can be collected all at once, and if any captain is developing concern about his own fuel or water state, can give timely warning to his convoy commander. In fact, the author commanded one convoy bringing ten low-powered ore boats into Cleveland, Ohio. One of the ships in that convoy did indeed experience an abnormally high fuel oil consumption rate. Plans were being made to refuel her from one of her fleetmates if she expired before reaching port. Although it was not necessary to refuel her, she was the first alongside the oiling pier, and her tank soundings before fuelling showed that she had only one day's fuel in her bunkers. Besides reporting, a high state of readiness to combat all of the casualties to be met at sea must be maintained. In particular, the readiness to combat collision damage must be kept to the highest standards.

Having gotten the convoy to the ice edge, it is time for the convoy commander to release his charges to sail to destination ports.

Post-ice considerations. The Operations Order will specify the port to which each ship in the convoy is to sail. Once released by the convoy commander, each captain is then responsible for following his instructions in the Operations Order. He can also use this time to write up the post-convoy report, which will be used by management to make improvements in the system. The convoy commander will remain at the ice edge with the other icebreakers, waiting for the ships that he will take back through the ice to Prudhoe Bay. He, too, will be required to submit a post-voyage report.

It can be seen that the convoy system is simple in concept, and need not be complicated in practise. The key words here are "cooperation" and "unity". The captains of all ships, icebreakers and cargo ships, must keep firmly in mind that cooperation among themselves is the key to their success in bringing the cargo through successfully, and in the case of casualties, their survival. The second word, "unity", indicates that the convoy operates as a unit, with each ship in it a part of that unit. The individuality of each ship and captain is to be considered by the convoy commander in making up his convoy, certainly, but at the same time, this individual initiative is to be used for the good of the group.

CHAPTER EIGHT

COMMAND AND CONTROL

INTRODUCTION-Experience gained in the examples in Chapter Three show that there must be a prescribed scheme of command and control, that this scheme must be written down and understood by all in leadership positions, and that training must include use of all elements of this plan. This chapter will describe the outlines of such a scheme. One of the features of this chapter is the recommendation that the "writing down" be in a format similar to a military operations order. The advantages of this will be further described. The only disadvantage apparent to this author is the reluctance of civilians to adopt many military procedures.

Chapter Seven, OPERATIONAL CONSIDERATIONS, indicated that there would be a discussion of the various plans, orders and instructions that are included in the overall category of means of command and control. The two words and their meanings are so closely linked that they are considered together. There is a subtle difference, however. "Command" refers to the imperative actions taken by a person who has the authority to direct the actions of his unit. Therefore, a ship captain has absolute command over his own ship and crew. There are limits to this authority, spelled out in national statutes, international law, e.g. the Rules for Prevention of Collisions at Sea, and even in union contracts. However, within these limits, the responsibility of a ship captain for his command is absolute, and his authority to fulfil this responsibility is equally absolute. Another example of "command" in this context would be the convoy commander. He has the responsibility for shepherding his convoy from the beginning of the voyage until the ice edge, at which point it disbands, each ship proceeding independently. In the opposite direction, the convoy commander would exercise his authority from the ice edge, when he, by signal, formally assumes responsibility for the convoy, until arrival at Prudhoe Bay, or some other designated port.

"Control", on the other hand, is the term used to describe the actions taken by shore supervisors, in the operation centre(s). This term must therefore be defined in the regulations issued by the operating company or companies. These regulations would be issued as an Operations Plan. This Plan, and the Operations Order issued to implement it for a particular voyage, would define "control" as those actions taken by management ashore, providing direction to the convoy commander as to routing, expected estimated time of arrival (ETA) at the various check points and the terminal points of the voyage, vessel additions and deletions to the convoy, and providing coordination and control of aircraft flying out to the convoy and returning to base.

As in the previous chapter, a voyage using the various tools of command and control will be simulated. Before the voyage can get underway, and in fact, long before the first commercial voyage takes place, the basic Operations Plan must be prepared. A team comprised of operations specialists from management, ship captains, prospective convoy commanders who are also icebreaker captains in their own right, and port operations specialists would gather for an intensive drafting and writing exercise. This author would recommend that some variation of the military operations plan format be used. This format is simple, direct, and allows for amendment when needed. A good plan should always allow rapid amendment as operational experience is accumulated. It would have a basic section, amplified by a number of annexes. This basic section would contain a mission statement of the organisation. This most important piece of direction is sometimes not included in civilian drafting, and yet it is the primary statement as to what the whole organisation is all about. It should be particular to the transport function, not overall to the entire production, liquification, transport and marketing. A sample mission statement for our organisation would be "to transport LNG from the loading port to the ice edge in the Bering Strait, using the most efficient route, using the icebreaking fleet in escort of the tankers, to assure a safe and swift passage. Further, to bring ships in ballast from the ice edge to the loading port. All of the above is to be done using all available means of ice reconnaissance to assure the most direct and safest routing." It should be noted that this mission refers only to the activities of moving LNG, has nothing to do with any of the other manifold activities involved with the extraction and sale of the product, and does not spell out any particular duties and responsibilities.

The basic plan would also contain a list of all of the ships, operations centres, communications facilities, and aircraft available to the organisation covered by the mission statement. It is customary to list the names of the commanders of the various units in a military operations plan, but in cases where these might change frequently , it might be more convenient to include those in the Operations ORDER, separate from the plan, and which will be discussed further on.

Once the basic plan, very concise, has been agreed by the team, the next step is to write the annexes. The use of annexes has these advantages: each team member is made responsible for the drafting of one or more annexes, according to his specialty, and is responsible for any subsequent amendments; and the annexes allow the various functions to be broken down into manageable parts, both for writing and for understanding. Our sample Operations Plan has the following annexes:

a) Concept of Operations-the overall philosophy of operation as seen by management. For example, here is the place to insert the words about safety taking precedence over schedule, and to make this paragraph strong enough that it is believable by the ship captains. Other material that would go in here would be a list of the various national statutes and regulations, union agreements, and other documents that would affect the operation. It is assumed that copies of all of these documents would be readily available to the commanders involved, and a citation of them would be sufficient.

b) Ship Operations-how ships are to be operated in the convoys. This annex would deal only with convoy operations, as independent sailing would be outside the mission of the organisation, and would be covered in other instructions, of no interest at this time.

c) Air Operations-Where the helicopters and other air assets are to stage from, the services they are to provide, and who controls them and when.

d) Logistics-Enroute logistics, icebreaker refuelling from cargo ship bunkers if necessary or desirable, replenishment enroute using aircraft.

e) Command relationships-One of the most important, and difficult annexes to write, and the one which will probably need amendment first. The author of this thesis has written annexes on command relationships among ship captains of various seniority and in various levels of command in a task organisation. It is a job that must be fitted to the particular organisation and its mission. The gist of it is that each ship captain retains responsibility for the safety of his own command, and has the right to declare that he can no longer proceed with the convoy because of machinery or other casualties. He must, of course, be prepared to justify his actions to the convoy commander, and to his management. The convoy commander must decide whether to break off one of his icebreakers to escort the cripple back to home port, or whether she is to remain in place until someone can come to the rescue. It can be seen that this annex must be written with care, adapted to the particular operation, that it must be understood by all in command and in the control centres, and that it must be included in the training given to all personnel.

f) Communications-This is an extremely important annex. It will specify the communications system for the organisation. The locations of the communications centres, the frequency plan, emergency communications, the air-ship communications arrangements, and lost aircraft communications procedures are all part of this annex. Nothing is more disconcerting to operations centres than to lose contact with its units. This annex covers as many of the operational contingencies involving communications as can be predicted, and is made as proactive as possible.

g) Search and Rescue-This pertains in particular to the aircraft in the organisation. However, there may be times when it is necessary to provide medical evacuation of personnel from one of the ships, and the procedures for this are included in this annex.

h) Hydrography, Oceanography, and Meteorology- The information to be collected by the ships in the convoy. These operations provide a golden opportunity, not to be missed, to add to the data base along the north coast of Alaska, and through the Bering Strait. Although the mission of the organisation does not include scientific work in itself, it would be appropriate, good business, and good public relations to offer ships as platforms of opportunity for scientists, and management policy on this would be included.

i) Wildlife Conservation-The rules for protection of wildlife.

j) Pollution Control-The rules for pumping bilges in an emergency, dumping rubbish.

k) Training-Management policy and references to the training syllabi described in Chapter Nine.

l) Reports-All reports required by the organisation would be listed in this annex. For example, once the frequency of position reports is determined, a statement that the convoy commander would make that report for all ships in company would be sufficient. The objective of this annex is to collect in one place all the reports required, allowing for oversight such that unnecessary reports can be eliminated.

It can be seen that there might be other annexes that could be added, and possibly some not included. However, the ones listed are, in the opinion of the author, the particular ones that would form the first edition of the Operations Plan. The step after the drafting is to forward to management for signature. The signature should come from the highest level of the organisation, assuming that he has been given the authority from his management to set up and operate this system. If he does not yet have that authority, then the signature must come from the next level up in management, such that when the plan is issued, it is directive in nature (Operation Deep Freeze Operation Plan 1-62).

Once the plan is issued, and has been made a part of the training programme, such that all hands affected by it understand it and their part in it, it is time to send out the first training convoy, both to test the plan, and to gain experience in convoy operations by the ship captains and watchkeepers. The implementing directive that does this is an Operations Order, written under the authority of the Operations Plan. This operations order covers one convoy, and is serially numbered for a particular period, e.g. a calendar year. It follows the format of the operations plan, uses the same lettering or numbering of annexes, and is issued by the same supervisor who issued the operations plan. As it is particular to one round trip, i.e. two convoys, it is much shorter. It contains such things as the order of succession in the command of the convoy, should something happen to the designated commander, desired ETAs at various check points or boundary lines, and in each annex, those particular details that pertain only to this round trip. Finally, it contains the authority for the convoy commander to make such adjustments as he deems necessary to the accomplishment of his mission, i.e. to get his charges through safely, without damage, and in accordance with the schedule in the order. Naturally, he reports back to his controllers in the operations centre when he has made any of these adjustments.

Finally, sailing day has arrived. The convoy commander has held his presailing conference, the Operations Plan and the particular Order have been discussed, all captains understand what will happen. This first convoy is a training one, with possibly one icebreaker, and two cargo ships in the van. Each bridge will be crowded with as many trainee captains as can be accommodated. The purpose of this first trip is not to bring out any LNG, but to test all of the elements of the Plan and the Order, and to provide ice seamanship training. It will be expected that there will be a number of changes to the Order made by the convoy commander. In any case, flexibility must be the order of the day. It would be recommended that management hands remain ashore for this first run, except for the members of the team that drafted the Plan and the first Order. It has been shown that managers who are not themselves mariners often don't appreciate shipboard customs or hierarchy, and that the shipboard people should be allowed to work out their problems among themselves. The time for management trips through the ice will come later (Smith 1970).

After the test voyage has come to a successful conclusion, it is time to make whatever amendments to the Plan are necessary, and to write the Order for the first commercial voyage.

The Operations Plan and the Operations Order are living documents. In order for them to be effective, they must say what is to be done yet allow for maximum flexibility. They must be kept current, and a procedure for doing this is included in the Operations Plan, usually in the basic plan itself. Finally, they must be proactive, as well as providing instructions for the cleaning up of disasters, spills, collisions after the fact. In fact, it will be seen that the emphasis in the sample Plan and Order is on current operations, rather than casualty control. This is not to say that casualty control is not important, but that emphasis must be placed on doing things the proper and seamanlike way the first time.

CHAPTER NINE

TRAINING AND CERTIFICATION OF CREWS

INTRODUCTION-Because there is little experience in operating in the ice in the American merchant marine, and that concentrated in relatively few people, little thought has been given to training of crews in ice seamanship and related activities. Further, the experience base in the United States Coast Guard is highly concentrated in a relatively few officers. This chapter will lay out considerations for the training of ship's officers in ice-related skills, as well as the training of shore-based advisors in such things as ice reconnaissance and route selection. Finally, some suggestions for training sources and qualification of licensed officers and documented seamen are made.

SHIPS' OFFICERS AND CREW-The licensing requirements for ships' officers and the requirements for the various kinds of documents required of unlicensed personnel are contained in Title 46, U.S. Code of Federal Regulations. These requirements, including examinations and procedures for the issue, renewal, suspension and revocation of the various documents are administered by the United States Coast Guard for American merchant seamen (United States Government). These regulations, in turn, conform to the rules set down by the International Maritime Organisation, of which the United States is a founding member (IMO 1995). All of these rules pertain to the documentation of merchant seamen in the open waters of the world. There are no separate certifications or endorsements in the American regulations which confer qualifications for operating in the ice. This is not a strange phenomenon, as heretofore, there has been little need for ice pilots or ice-qualified captains in American trade. In fact, the ones that come to hand-the extended season on the American Great Lakes, the annual tug-barge trains to Prudhoe Bay in the Summer, and the breakin to McMurdo Sound in the Austral Summer- have been operated with ships whose captains acquired their knowledge by on the bridge experience in the ice, and then passed that down to their juniors. In the case of the American icebreakers, the same system has been used, where the captains have been assigned to icebreakers starting as junior watchkeepers, and then in succeeding tours are either assigned to one of the smaller icebreakers as captain or to one of the polar ships in successively higher positions, eventually rising to captain. Unlike the highly organised system for qualifying at various levels of skills in other areas of seamanlike endeavours-qualifying as an unsupervised Officer of the Deck underway requires the completion of a massive checklist, a separate examination on the Rules for the Prevention Of Collisions at Sea, an oral examination before a board, and many watches stood as a JOOD- qualification for working in the ice is still on a ship-by-ship basis. The author used a multi-level path to full qualification as an unsupervised Officer of the Deck in convoy operations at night-and even with the most highly qualified OODs on watch, spent many hours in the chair on the bridge. This was a written programme, with a record kept of the officers who had qualified at the various levels, beginning with Junior Officer of the Deck breaking track with no ships in company, culminating in full qualification as Officer of the Deck in convoying operations at night, working under the lights.

There is so much to be said for a formal training programme leading to various levels of qualification, that this discussion will assume that any objections to this idea by captains who feel they are already overburdened with training and certifications will be overcome, by fiat if necessary. Such a training programme might best be formulated by a consultant, unless the organisation already has on staff experienced master mariners who are also experienced ice navigators. A team, similar to the one that put together the Operations Plan and the Operations Order, would draw up the syllabus. This syllabus should provide for a minimum of classroom work, and a maximum of bridge time. It is at this point that simulators would be examined. There was one ice simulator programme tried out in 1980, and since then there have been bridge simulators built all over the world (Menon, Samwel, and Steele 1988). The problem with simulators and ice is that ice is neither homogeneous, nor predictable. It should be possible to model working in the ice in steady state conditions, but there is no substitute for getting out in the worst ice that can be found, in the worst weather, and breaking through it. As the body of knowledge in the American merchant marine is limited, hiring non-company captains on a consultancy basis would be money well-spent, both in the training phase and for the first few convoys, while the icebreaker and cargo ship captains gain experience. These consultants would stand in the same capacity as pilots in foreign ports-as advisors to the captains in training. All of this training would conform to the syllabus, and would require a certain number of trips before a captain would be qualified to make a voyage without an advisor. The syllabus would be different for each level of deck officer, culminating in the most rigorous, that of captain. The one for icebreaker captain would include such things as rigging tows, convoy procedures, cutting out and getting moving ships beset, and major damage control of holed ships. This is only a sample of the material to be covered and the skills to be demonstrated. All of the syllabi would include training in the Operations Order and Plan, the communications plan in particular, rigging emergency communications, and survival skills. There would also be a syllabus for engineering officers, with emphasis on cold weather engineering, care of deck machinery in extreme cold, and survival skills. It should be emphasised that the material to be covered in these syllabi is not to duplicate skills already required for licenses. Further, the emphasis is on practical demonstration and application, and the best place for this is on the training voyage, or more than one training voyage if necessary to get everything in shape for commercial voyages. Once these voyages have started, every ship should have as many trainee officers as can be accommodated, until the number of trainees is sufficient for replacements. It is envisioned that this training effort would be constant, that there would be some trainee officers in every convoy.

The syllabi for unlicensed personnel need not be so complex. However, at a minimum there should be training in survival skills, and handling, maintaining and repairing machinery in extreme cold weather. Those hands who will be qualified as helmsmen in the ice should receive training in steering under actual conditions, under the supervision of a qualified steersman. Part of the training for all hands should be familiarisation with the Operations Plan and Order. The author's experience is that a thoroughly briefed crew provides the best results, and if the newest and least experienced member of the crew is brought in to the overall plan, he will understand the importance of the work being done, the importance of his part in that work, and will be a much more willing participant in the overall crew effort. This seemingly idealistic theme, in the face of the outward cynicism of the lower deck seamen, can also provide insight to the overall attitudes of the men hired. If by their actions, they demonstrate an enthusiastic acceptance of the overall plan, then there is a much higher chance of a safe and efficient operation. This is no place for a Pollyanna attitude, but the writer has steamed many miles with well briefed and enthusiastic crews, and the effort that goes into a well-constructed training programme, presented at the appropriate level, pays dividends far in excess of the time and money invested.

AIRCREW TRAINING-There are syllabi for the training of aircrews in polar operations. One is the syllabus developed by the Polar Operations Division, U.S. Coast Guard Air Station, in Mobile, Alabama. This organisation trains the aircrews that fly helicopters attached to the polar icebreakers of the U.S. Coast Guard. There is considerably more information on training for polar flying than there is for training on ship operations, and it is readily available in the Western world. The task here would be to collect, evaluate and then assimilate into one syllabus that information particularly applicable to this organisation. One valuable source of particular interest to the merchant officer is a publication, author unlisted, called the "Guide to Helicopter Ship Operations, published by the International Chamber of Shipping (International Chamber of Shipping 1989).

SHORESIDE PERSONNEL TRAINING-There should also be a syllabus for personnel who will be manning the various shore installations. Although this would seem self-evident, many such facilities have a "as we go along" training programme, with no formal requirements. The syllabus for each facility should be specific to it, especially in the operations centres, which will have watchstanders who rotate on a regular basis, such that there are hands on watch 24 hours a day. It is envisioned that the communications sites-transmitters and receivers-would not be manned, but would be colocated with the operations centre(s). Therefore, the personnel manning these centres must be trained in the operation of the communications/radio equipment, and basic casualty recovery. They must be fully conversant with the procedures for switching over equipment, and how to call in repair personnel, who must be available at any time. They must be able to rig emergency equipment, and have basic survival skills. Again, this list is not all inclusive, nor does it go into details about the various levels of watchstanders. The syllabus must also include training in the Operations Plan and Order, the authority delegated to the senior watchstanders under the Plan, and other administrative matters not applicable to the ships. For example, the operation centre(s) might be given the authority under the Operation Plan to "lend" aircraft to a search organisation looking for someone in the interior of Alaska. This would be covered in the Search and Rescue Annex to the Operations Plan, but not in any of the Orders issued under that Plan.

CROSSTRAINING-One of the best ways to build commitment to a particular organisation and to its operations is by crosstraining. To this end, each syllabus developed under the training annex of the Operations Plan would require familiarisation tours by a trainee in all of the other parts of the organisation, to include actual watchstanding. This would mean, for example, that a controller in the operations centre would make a certain number of round voyages, and on those voyages, would rotate through all of the positions in the ship to which he was assigned. It probably would be found that one round voyage would be sufficient, riding an icebreaker on one segment and one of the cargo ships on the other. Conversely, a captain in training would spend time in each of the shore facilities, and would do a tour with the aviation component, including some flying under actual working conditions. By this method, each person in the organisation has some familiarity with the problems and their solutions in all other elements in the organisation. The author hated every minute spent in the engine room and the boiler room of a steam-powered ship during a required course of qualification leading to designation as Engineering Officer of the Watch. However, the information and skills learned were used in every subsequent command, and especially when commanding another steam-powered ship. Not every operations watchstander will enjoy being wet, cold and not being able to lay below until relieved, but he will certainly know what the convoy commander is up against when he reports some difficulty with his flock.

RECORDS-Records should not be an end to themselves, but are necessary if all of the rest of this is to work. To that end, the simplest of records should be kept, and a simple checklist keyed to the syllabus has been found to work well. The important thing here is to keep up with the records as the tasks are completed, so that there is not a big press to get everything caught up just before a newly-qualified captain goes to sea for his first unsupervised convoy. Records are especially important after an accident. Insurers,government investigators, and management will want records that are clear, accurate, and not gundecked. Since the insurers will be especially interested in a programme of training such as described above, a corollary to this programme is that good, simple records be maintained, which accurately reflect the level of qualification of each person in the organisation.

It was not intended to write a training plan for the LNG shipping organisation. A full plan would contain many details not mentioned here. However, if this is to be a professional operation, run as safely and efficiently as possible, then the most proactive measure that can be taken is to train all hands as thoroughly as possible. To that end, the training annex to the Operations Plan should be drawn up by a team made up of professional trainers, professional operators and professional seamen.

CHAPTER TEN

ENVIRONMENTAL ISSUES AND REGULATORY CONCERNS

INTRODUCTION-Environmental issues and regulatory concerns are difficult to move from the abstract to the concrete, principally because of the emotions involved. This short chapter will list some of the environmental issues that have been of political and economic interest. It will then discuss some of the concerns of the various regulatory agencies, including building of ships to ice classification, and ends with a call for early and significant interaction between those regulating and those being regulated.

ENVIRONMENTAL IMPACT AND ASSESSMENT-In the United States, most activities that can alter the environment are subject to environmental impact assessment before any permits are issued. The formal document which contains this assessment is called an Environmental Impact Statement (EIS). Figure 14 shows the cover sheet for an EIS that has just been issued, for oil and gas lease sale number 144. The word "final" implies that this particular EIS has gone through several stages. In fact, the Federal requirements for such statements are that there be at least one draft EIS for public comment. In practise, there may be more than one informal "draft EIS" with informal discussions with interested parties. The "real draft EIS" must be open for public comment, and the practise is often to hold public hearings, at which interested parties may testify, a verbatim record taken which is incorporated in the "final EIS". Written comments are encouraged from people who may not be able to attend one of the hearings. Once the hearings are complete and the written comments received, a "draft final EIS" is usually prepared. This may be an internal document to the particular agency, in this case the Minerals Management Service, but there is a great deal of informal communication among the bureaucrats, consultants and those who submitted comments. This is a good stage for determining who any possible litigants might be. In any case, the Final EIS is ultimately issued, and becomes a part of the permit-issuing procedure. In this case, the FEIS was of such strength that the MMS expects to hold the lease sale in September 1996 (OCS EIS/EA MMS 96-0012 1996). This FEIS differs from one that would be required for the Alaska transport system Because the area considered extends all around Alaska, and it involves transport instead of extraction. It would probably have a different lead agency, probably the U.S. Coast Guard. However, it contains many of the elements that would also be applicable to the Alaska transport system.

The following is a list of some of the concerns that were considered in the FEIS. Even though not all-inclusive, it gives an idea of the range of interests and the various agencies and institutions involved in writing the final document. This list is not necessarily in order of importance, "importance" being in the eye of the beholder.

a) Community participation in planning, especially operations planning.
b) Information on the Arctic Biological Task Force. One of the stipulations in the FEIS is titled "Protection of Biological Resources." In this stipulation, the BTF, made up of the MMS, the Fish and Wildlife Service, the National Marine Fisheries Service and the Environment Protection Agency, will make recommendations, which must be considered.
c) Bird and mammal protection. A number of Federal statutes and international treaties must be followed in the protection of birds and mammals.
d) Whales. Many sections of the report deal with whales, including monitoring whales, subsistence hunting of the bowhead whale, and protection of bowhead whales in leads.
e) Interaction with polar bears.
f) Consideration of areas valuable for their concentration of marine animals, plants or cultural resources, especially in the development of oil spill contingency plans.
g) Oil spill response and cleanup capability.
h) Offshore pipelines.

A final and relatively new requirement is one called "environmental justice". The environmental justice policy contained in Executive Order 12898, a document issued by the President, and over his personal signature, requires agencies to identify and address environmental effects of their programmes on minorities and low income populations and communities. The effect of this Executive Order is to require the involvement of Alaskan communities and tribal organisations in the production of the FEIS through all its stages.

One approach to the problem of involvement of concerned individuals and organisations is that taken by the Yukon Pacific Corporation in the planning for the Trans-Alaska Gas System (TAGS) (Macy 1994). Yukon Pacific holds the FEIS for a natural gas pipeline from Prudhoe Bay to Valdez. Most of the other documentation is also completed. What is not in place is the desire to ship gas from the North Slope, and of course, the funding to build the pipeline. It is beyond the area of interest of this paper to describe this project farther. What is of interest is the TAGS Environmental Review Committee. Yukon Pacific knew that environmental activists had considerable experience in being principal initiators of environmental objections. To demonstrate the commitment of Yukon Pacific to responsible environmental action, and to avoid as much litigation as possible, the company invited the environmental community to be a part of the permit and planning activities. The TAGS Environmental Review Committee is funded by the Company through the Alaska Conservation Foundation. The Committee specifically has not surrendered the right to litigate, and in return the Company is not to use the Committee for public relations purposes (Macy 1994).

This is a sensible approach to a difficult problem. The problem becomes even more complex when it is realised that the Committee deals with the environmental community only, its relationship with the various regulators being that of an interested party with the right to testify at the hearings, and to submit written comments. It would be in the interest of any organisation about to embark on the perilous voyage through the rocks and shoals of acquiring permission to operate to establish early and meaningful dialogue with all regulators. A glance at any FEIS for a large project, such as lease sale 144, will disclose the various Federal, state and local official agencies. Add to that all those who have a legitimate interest, and it can be seen that some way of organising these contacts is highly desirable. One technique that could be investigated is to establish a committee similar to the TAGS Committee to deal with environmental matters, and another to deal with the regulators. In a workshop over 3 years ago that was taking a very preliminary look at the Alaska system as described in this paper, the author, before an audience of oil company executives and engineers, made the point that early and significant interaction among management, the regulators, and the environmentalists was not only good management, but would save money. Further, any effort to diminish the adversarial relationships that have evolved over the years among those groups would be worth the effort put into it. If anything, it is believed even more strongly now than then that not only can this objective be realised, but that it is good environmental policy, good management, good government policy, and good business to strive for this. No group need forfeit long-treasured ideas-but that in an atmosphere of cooperation all ideas of all participants can be taken into account.

CLASSIFICATION SOCIETIES-Classification societies specify such things as hull strength, allowable shaft power, and a number of other characteristics that are not significant here. The classification societies that have developed ice classes are listed here, for ease of reference to Table 1.

a) MRS-Maritime Register of Shipping, Russia

b) CASPPR-Canadian Arctic Rules, Canada

c) GL-Germanisher Lloyd, Germany

d) ABS-American Bureau of Shipping, United States

e) LR-Lloyd's Register, Great Britain

f) DNV-Det Norske Veritas, Norway

It can be seen from Table 1 that ABS class A5, the highest American ice class, only provides for working in ice > 1 m, not further defined (Glebko and Karavanov 1995). It would be worth examining in detail the rules of the other classification societies, especially those later than the 1986 ABS rules. It is the intent of this section to point out the complexity of ship classification and the role that the classification societies play in ship construction. One aspect of classification is the insurability of the vessels. If a vessel is being operated in conditions outside her ice class, not only is she jeopardising her safety, but may also be running afoul of her insurers, to say nothing of the U.S. Coast Guard, who has jurisdiction for pollution control and marine law enforcement in the waters of interest to this study.

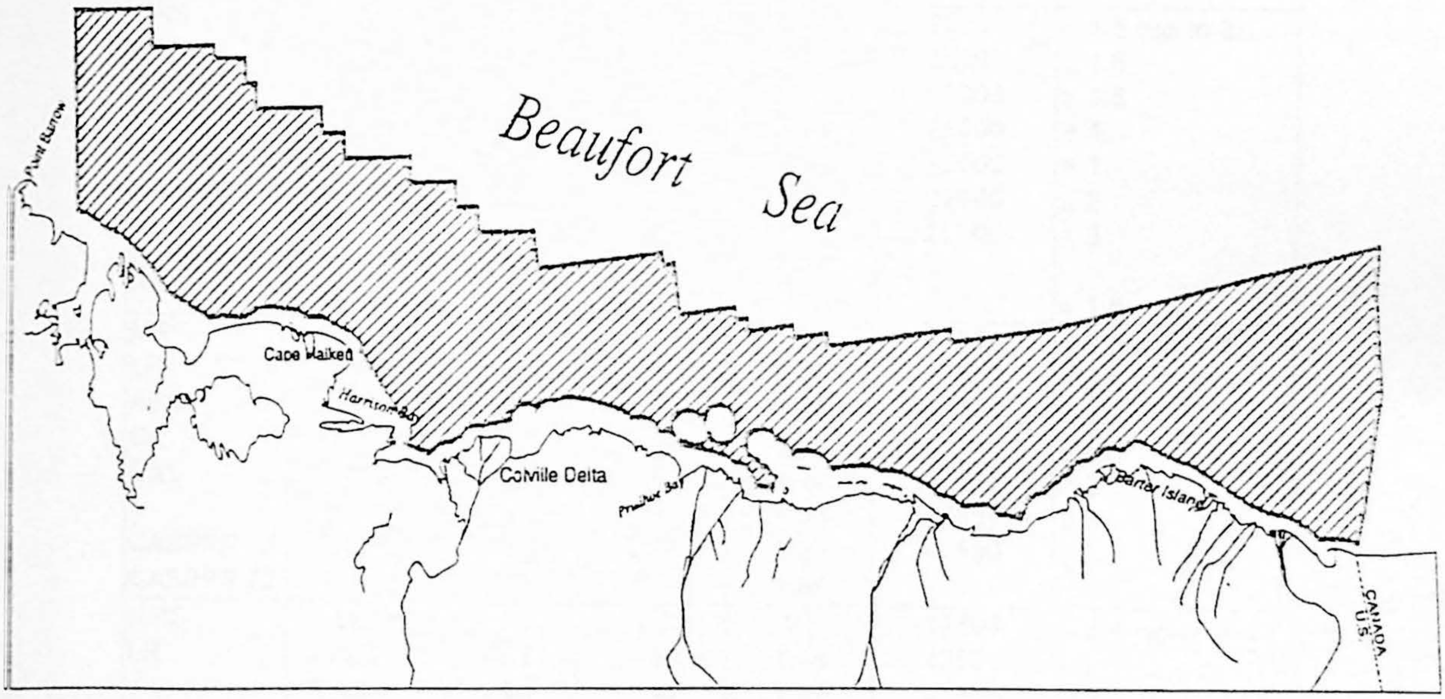
Alaska Outer Continental Shelf

OCS EIS/EA
MMS 96-0012

Beaufort Sea Planning Area Oil and Gas Lease Sale 144

Final Environmental
Impact Statement

Volume I



U.S. Department of the Interior
MMS Minerals Management Service
Alaska OCS Region

Figure 14

Comparison of ice belt thickness in dimensionless form

Society	Ice class	Hull area: Bow	Middle	Stern	Shaft power, kW	Ice thickness (ramming), m
MRS	ULA	1	1	1	12000	≤ 1
CASPPR	CAC4	0.9	1.05	0.88	12000	≈ 1.2 (up to 1.8)
MRS	LL4	1.15	1.26	1.19	12000	≈ 1 (up to 2.5)
CASPPR	CAC3	1.11	1.18	1	12000	≤ 2 (up to 2.4)
	CAC2	1.28	1.28	1.08	12000	≤ 2 (up to 2.4)
CASPPR'72	2	1.09	1.3	1.22	-	-
GL	Arc1	1.05	1.2	1.11	-	≈ 1
ABS	A2	1.05	1.12	0.95	12000	> 1
	A3	1.27	1.38	1.18	12000	> 1
LR	AC1	1.16	1.14	1.05	12000	≥ 1.5
DNV	ICE 05	1.05	1.18	0.99	12000	≥ 0.5
	ICE 10	1.24	1.38	1.17	12000	≥ 1
MRS	LL3	1.39	1.52	1.44	22000	≈ 1.5 (up to 3)
LR	AC1	1.44	1.41	1.29	22000	≥ 1.5
DNV	ICE 15	1.38	1.53	1.3	22000	≥ 1.5
	Polar10	1.38	1.53	1.3	22000	> 1
ABS	A3	1.34	1.45	1.25	22000	> 1
CASPPR	CAC2	1.29	1.29	1.09	22000	≤ 2
	CAC1	1.44	1.44	1.22	22000	≥ 3
CASPPR'72	4	1.41	1.6	1.56	-	-
GL	Arc2	1.27	1.48	1.35	-	≈ 1.5
MRS	LL2	1.6	1.75	1.66	47500	≈ 2 (up to 3.5)
LR	AC2	1.63	1.59	1.48	47500	≈ 2
ABS	A4	1.63	1.79	1.58	47500	> 1
GL	Arc3	1.56	1.78	1.64	-	≈ 2
DNV	Polar20	1.51	1.68	1.42	47500	≥ 2
	Polar30	1.63	1.81	1.53	47500	≥ 3
CASPPR	CAC1	1.46	1.46	1.23	47500	≥ 3
CASPPR'72	6	1.55	1.7	1.66	-	-
MRS	LL1	1.65	1.8	1.7	47500	≈ 2.4 (up to 4-5)
LR	AC2	1.63	1.59	1.48	47500	≈ 2
	AC3	1.94	1.92	1.77	47500	≈ 3
ABS	A5	1.77	1.94	1.77	47500	> 1
GL	Arc4	1.74	1.94	1.87	-	≈ 3
CASPPR'72	6	1.55	1.7	1.66	-	-
DNV	Pola,30	1.63	1.81	1.53	47500	≥ 3

Table 1, after Glebko and Karavanov, 1995

CHAPTER ELEVEN

RECOMMENDATIONS AND CONCLUSIONS

In this thesis it is particularly appropriate to make some recommendations, following the concept that the transport of LNG by surface vessels is worth further evaluation. With that assumption, the following recommendations are proposed, in the same order that the applicable material is discussed in the various chapters.

CHAPTER ONE-Continue further study of the ideas laid out in the following chapters, so as to have more detailed information on the various parameters listed and briefly described. This thesis could only touch on salient points within time and length restrictions.

CHAPTER TWO-Extend the literature search to obtain more detailed voyage information, especially the Maritime Administration Trafficability tests.

CHAPTER THREE-Establish firm relationships with INSROP, Murmansk Shipping, and the Russian Northern Sea Route Administration. Shipride both icebreakers and cargo ships, especially in the high winter. Audit the activities of the control and administration centres. Conduct a similar study with the Finnish Board of Navigation. Do a literature search on the Extended Navigation Season, and interview participants.

CHAPTER FOUR-Identify the most current remote sensing techniques, for direct application to the Arctic transport system.

CHAPTER FIVE-Establish contact with the National Ice Center, set up an account, begin receiving all applicable product. Write an outline ice management plan, which would be the framework on which the full plan would be based for inclusion in the Operations Plan. Determine worst case ice conditions on record, especially in the band from Prudhoe Bay to Point Barrow. Locate possible routes. If the project then is funded to the point of actual ice trial, charter a suitable icebreaker for the first tests, such as FENNICA, and a cargo ship, such as an SA-15 or MV ARCTIC.

CHAPTER SIX-Inventory, visit and sail in icebreakers and cargo ships that might be adapted. Set up relationships with the classification societies and the U.S. Coast Guard. Begin informal discussions with shipyards, for pricing information.

CHAPTER SEVEN-Sail with as many convoy commanders as possible, to get a feel for different styles of leadership and command.

CHAPTER EIGHT-Do a literature search of various Operations Plans and Orders. Do not reject the military format out of hand. Do a draft outline of an Order and a Plan, particularly applicable to the Alaska transport system.

CHAPTER NINE-Collect as many syllabi, training manuals, and commercial literature as possible. Contact all operators of simulators.

CHAPTER TEN-Inventory all regulators, environmentalists, and other organisations that would have any interest if the system were to be built. Draft a plan for solving the regulatory problems and environmental concerns listed in this chapter. List all of the others. Include some sort of organisation similar to the TAGS group.

CONCLUSION-As much as the author would have wanted it so, it is not possible to draw the conclusion that a system can be established to carry LNG all year round from Prudhoe Bay to open water in the Bering Strait. At least it is not possible at this point to draw that conclusion in a way that makes operational, much less economic, sense. However, the following conclusions, based on the work in this thesis, are submitted:

a) A system to carry LNG or any other petroleum product by surface ship has not been built for Alaskan waters. The pipeline from Prudhoe Bay to Valdez, Alaska, was chosen instead.

b) There is no system to bring natural gas from the North Slope of Alaska to the south now, and none is under construction. The Yukon Pacific Corporation has most of the permits to build TAGS, a pipeline running parallel to the oil pipeline, but has no plan to begin construction.

c) Since it is possible that no gas pipeline will be built, for engineering, economical, or environmental reasons, prudent management would have a preliminary plan in case for the "ifs"-if the pipeline is not built; if the market expands and it is time to sell North Slope gas; if a pipeline costs too much; or if it will take too long to build the pipeline, and it is desired to get gas to world markets, especially in the Pacific Rim.

d) Ample ice information is available, both in the archival sense in atlases and other presentations, and in real time displays for any time and day of the year.

e) There are a number of icebreaker and cargo ship designs that exist today, and a considerable amount of work has been done on even more capable icebreakers and cargo carriers. It would not be necessary to start with a clean screen.

f) The concept of using icebreakers in convoy formations with ice strengthened ships, not expected to do their own icebreaking, has been tested, and is in operation in two systems in the world today. These systems would provide invaluable information in the building of the Alaska transport system.

g) The training, certification and management of the crews presents challenges to management, but can be overcome with hard work and an open attitude towards innovation.

h) Environmental and regulatory matters present equally challenging situations. These can also be mastered by early and aggressive approaches to the organisations and individual concerned. An aggressive approach does not mean a confrontational approach in which there must be a winner, and therefore a loser. The experience of the author is that individuals of good will, with an honest outlook on the interests of their organisations, can be brought to some agreement without the need of an arbitrator. Professional conduct by professional people will carry the day.

The final conclusion is that this has not just been an intellectual exercise with no outcome other than a completed thesis. There has been information collected and displayed herein that can be adapted to an Alaskan transport system using ships from Alaskan ports "around the corner" from Point Barrow, alluded to earlier. The modifications to the overall plan laid out in this thesis would be simple to make. Regardless of whether ANY surface ship system is ever built, this thesis presents in outline form the problems that would arise, and how to go about solving those problems.

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180 NM
300 NM
180 NM
150 N.M.
CHUKOTSK PENINSULA
BERING SEA
ALEUTIAN ISLANDS
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALASKA
National Interest Lands boundaries compiled in 1980 by the Department of the Interior Alaska Planning Group. Boundaries shown represent new conservation system units and additions to existing conservation system units. For detailed boundary delineation refer to larger-scale boundary maps on file at the Department of the Interior.
Base map compiled in 1973 by the U.S. Geological Survey
SCALE 1:5 000 000
1 INCH EQUALS APPROXIMATELY 80 MILES
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ALEUTIAN ISLANDS
SUBUNIT

APPENDIX II: GLOSSARY

CFR-United States Code of Federal Regulations, issued by an Executive Department to implement statutes.

Eyes of the Ship-farthest forward part of a ship.

Horsepower (HP)-equals 0.746 kw

Ice Horns-projection(s) over the rudder(s), to protect from ice damage

IMO-International Maritime Organization, an arm of the United Nations, formerly the International Maritime Organization (IMCO).

Knot-one nautical mile per hour

LNG-Liquified natural gas

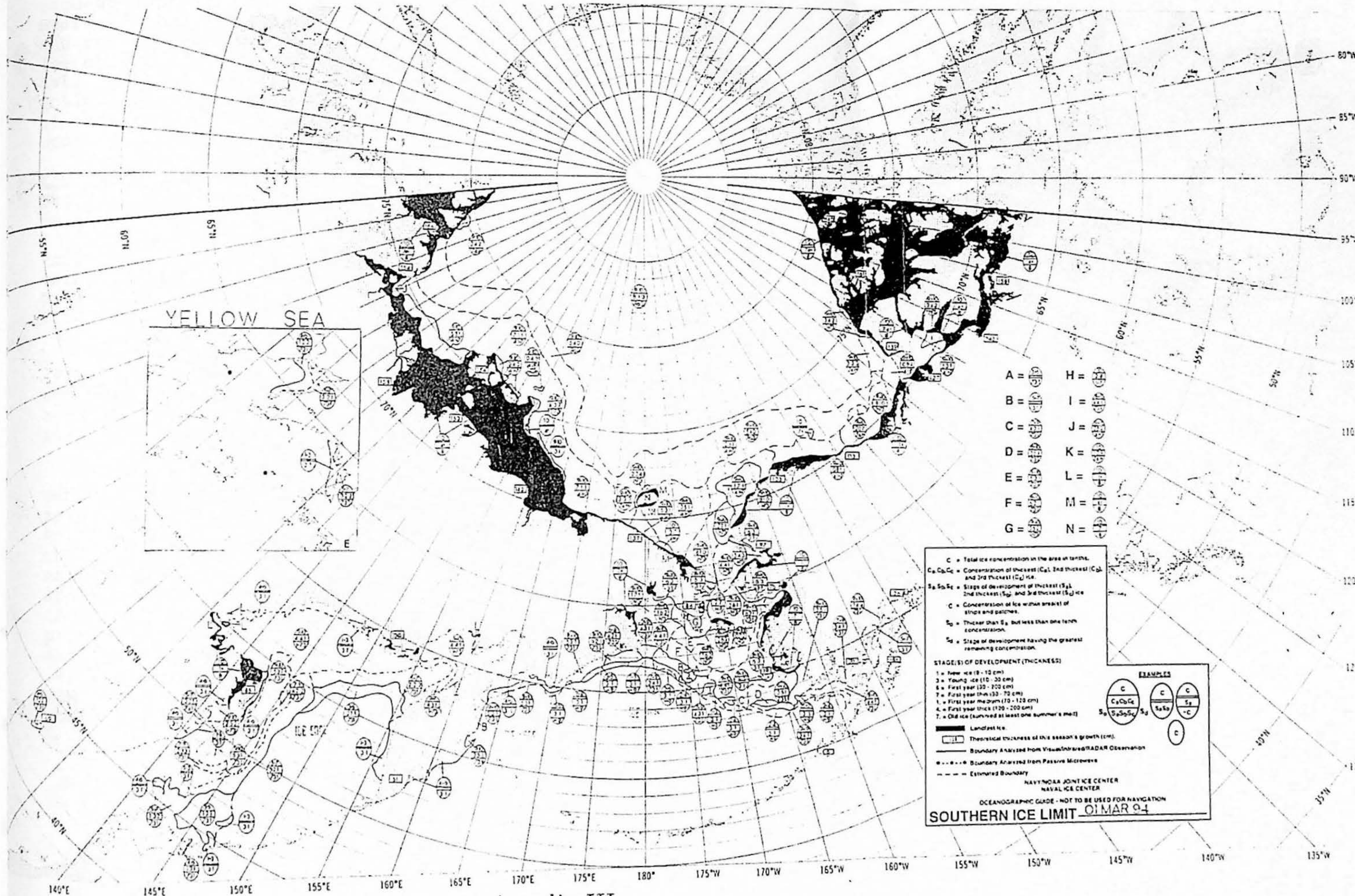
NM-Nautical mile, one minute of latitude, approximately 2000 yards (1.821 km)

NSR-Russian Northern Sea Route

Plant, power plant-all propulsion machinery in a ship, up to the inboard propeller shaft coupling
Run of the hull-the parallel-sided midbody of a ship

SAR- a) Synthetic Aperture Radar, b)Search and Rescue

TAGS-Trans-Alaska Gas System



Appendix III
From Eastern-Western Arctic Sea Ice Analysis

APPENDIX IV: AUTOPOLLING INSTRUCTIONS

NATIONAL ICE CENTER AUTOPOLLING

The NIC Autopolling Facsimile System is a fully automated system available twenty-four hours a day. It allows dial-in users to request and receive facsimile copies of current NIC products. Routine sea ice analyses and forecasts, as well as special request support products, are available on this system. Dial-in users are prompted by a voice menu that allows product selection and reception using a touch-tone keypad and a facsimile machine. The only cost incurred by the customer is the cost of the phone call. Detailed instructions for accessing this system are in the following paragraph. A sample Product List is included. As many of these products change seasonally, be sure to consult the updated Product List available on Autopolling.

Equipment: The NIC Autopolling system is compatible with CCITT Group 3, CCITT Group 2, and North American Group 1 type facsimile machines.

Procedure: The NIC Autopolling system can be accessed by dialing either (301) 763-3190 or (301) 763-3191 [763-3190/3191 on FTS]. Follow the voice prompt instructions for product selection using a Touch-tone keypad.

All customers must enter a personal identification number (PIN) to access the NIC Autopolling system. There is no cost or agreement required for PIN access. It allows the NIC to identify and track users and requests to maximize services and product availability.

After entering the PIN, the user is transferred to the main menu. The user is offered a list of geographical areas for selection. Once the user has entered the selection, the next voice prompt offers the product list for that area. After making the initial product selection, the system returns the user to the main menu. At this point, the user can either select an additional product, or press keypad # 7 to begin transmission of the product(s). Once the facsimile tone is heard, the user is prompted to press the **start** or **receive** button on their facsimile machine to download the requested product(s). The facsimile link is terminated following transmission of the product(s). To get a PIN or to receive assistance with using the autopolling system, contact the NIC at:

Voice: (301) 457-5315 or (301)763-2000 ext 317
TELEX: 7402918 ANS:NOAA
Fax: (301) 457-5305

AUTOPOLLING PRODUCT LIST: The following is a list of standard ice products and their update days available through the NIC autopolling system. All products are updated by 2300 UTC.

MAIN MENU

KEYPAD#	PRODUCT
*	INSTRUCTIONS/PRODUCT LIST
1	ARCTIC ICE ANALYSES/FORECASTS

SUB-MENU

KEYPAD #	PRODUCT
2	EAST ARCTIC ANALYSIS/FORECAST (THURSDAY)
3	WEST ARCTIC ANALYSIS/FORECAST (WEDNESDAY)
4	ARCTIC 30-DAY FORECAST (Issued by 7th and 21st of each month)
5	EAST ARCTIC SEASONAL OUTLOOK (Issued 15 May)*
6	WEST ARCTIC SEASONAL OUTLOOK (Issued week of 15 May)*
7	MONTHLY SUMMARY OF ARCTIC BUOYS (Issued 7th of each month)*
8	NORTHERN HEMISPHERE ICEBERG LIMIT (MONDAY, THURSDAY, DURING THE IIP SEASON FEBRUARY THROUGH AUGUST)
9	RETURN TO THE MAIN MENU

2 ARCTIC REGIONAL CHARTS

SUB-MENU

KEYPAD #	PRODUCT
0	EAST SIBERIAN/LAPTEV REGIONAL ANALYSIS (WEDNESDAY)
1	ALASKAN REGIONAL ANALYSIS (TUESDAY, FRIDAY)
2	SEA OF OKHOTSK, JAPAN, AND YELLOW SEA REGIONAL ANALYSIS (WEDNESDAY)
3	CANADIAN ARCHIPELAGO REGIONAL ANALYSIS (WEDNESDAY)
4	BAFFIN BAY AND DAVIS STRAIT REGIONAL ANALYSIS (THURS)
5	EAST GREENLAND REGIONAL ANALYSIS (THURS)
6	BARENTS AND KARA SEA REGIONAL ANALYSES (THURS)
7	HUDSON BAY AND LABRADOR SEA REGIONAL ANALYSIS (THURS
8	WHITE AND BALTIC SEAS REGIONAL ANALYSIS (THURS)
9	RETURN TO THE MAIN MENU

3 ANTARCTIC ICE ANALYSES/FORECASTS

SUB-MENU

KEYPAD #	PRODUCT
1	FULL ANALYSIS (FRIDAY)
2	EDGE UPDATE AND 72 HOUR FORECAST (MONDAY, NOVEMBER TO MID-MARCH)
3	SOUTHERN HEMISPHERE ICEBERG POSITIONS (THURSDAY)
4	ROSS SEA SEASONAL OUTLOOK (Issued 15 Oct)
9	RETURN TO THE MAIN MENU