UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

Report of Meeting

on

NEEDS FOR AN ALASKAN ARCTIC RESEARCH VESSEL

August 14-15 1974
Seattle, Washington

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UNOLS OFFICE
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

1 February 1975

ABSTRACT

In order to examine the needs for Arctic research vessels a meeting was convened August 14-15 at the University of Washington, Seattle, under the auspices of the University-National Oceanographic Laboratory System (UNOLS). Participants included 22 representatives from academic institutions and Federal agencies.

The meeting reviewed and discussed the ongoing and projected research in the Alaskan Arctic region and the ships needed to accomplish this research. The principal concern was with academic research both inside and outside the seasonal ice limits but excluded research within the permanent ice pack.

The conference concluded that an iceworthy research vessel was needed to meet the research requirements of the Alaskan Arctic Region. Such a vessel would best be operated as a National Oceanographic Facility and the possibility of joint use in the Antarctic should not be excluded.

No suitable research vessel presently exists which can conduct the multi-discipline research requirements both in and outside the seasonal ice cover. A means to acquire such a facility should be instituted promptly including design studies, planning for new construction and seeking interim alternatives.

The principal recommendation of the meeting was that the University of Alaska jointly with an advisory group of experts from interested laboratories, and on behalf of UNOLS, proceed with a conceptual design study for an Alaskan Arctic research vessel including a comprehensive survey of requirements and interim alternative measures.

PART I - BACKGROUND AND PURPOSE OF MEETING

The needs for a capable Arctic Research Vessel is a matter of long standing. For the past half-century and even earlier the National Academy of Sciences and the National Research Council has posed the problems of polar research and the particular difficulties of adequate facilities to cope with these problems. More recently, the aspects of developing Arctic resources - both biological and mineral - has lent increased emphasis to the requirement for suitable ships to work in Arctic as well as sub-Arctic waters. Most recently the recommendations of a workshop in Bering Sea Research held under the auspices of the National Science Foundation cited the need for an iceworthy research vessel capable of working in high-latitude seas.[1/]

The 1973 Annual Report of the UNOLS Advisory Council singled out this need for early attention and in response the University of Alaska proposed that the National Science Foundation fund a planning grant for an Alaskan research ship. In the development for this proposal, it was recommended that it proceed as a joint effort bringing together the planning resources and guidance of several institutions. As a first step it was proposed that UNOLS convene a forum for discussing this and recommend a course of action.

Accordingly, and in cooperation with the University of Alaska and University of Washington a meeting was convened at the Department of Oceanography, University of Washington, Seattle on August 14-15, 1974. Invitations were extended to twenty-five individuals

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1/ *PROBES: A Prospectus on Processes and Resources of the Bering Sea Shelf, 1975-1985*. Deliberations of a workshop in the promotion of the U.S. Program for Bering Sea Oceanography, 24-30 November 1973; Office of Polar Programs-National Science Foundation (Alaska Sea Grant Report 73-10)

Participants at Arctic Research Vessel Conference
Seattle, Wash. 14-15 August 1974

P. S. Branson
Marine Superintendent
Marine Facilities Division
Scripps Institution of Oceanography
P. O. Box 1529
La Jolla, California 92037

Colin Brown
AIDJEX Project Office
Division of Marine Resources
4059 Roosevelt Way
Seattle, Washington 98105

Andrew Carey
Associate Professor
Oregon State University
Corvallis, Oregon 97331

Joe S. Creager
Associate Dean
College of Arts & Sciences
University of Washington
Seattle, Washington 98105

John Dermody
University of Washington
Division of Marine Resources
3716 Brooklyn Avenue, N.E.
Seattle, Washington 98195

R. P. Dinsmore
Executive Secretary, UNOLS
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Robert Elsner
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

T. Saunders English
Associate Professor
University of Washington
Seattle, Washington 98105

Theodore D. Foster
Scripps Institution of Oceanography
P. O. Box 1529
La Jolla, California 92037

Arnold Hanson
Office of Naval Research
800 North Quincy Street
Arlington, Virginia

Donald W. Hood, Director
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Bruce McAlister
National Marine Fisheries Service
Northwest Fisheries Center
2725 Montlake Boulevard, East
Seattle, Washington 98122

J. J. McClelland, Jr.
Office of Operations
U. S. Coast Guard Headquarters
400 7th Street, S.W.
Washington, D.C. 20590

Kendall N. Moulton
Acting Deputy Head
Office of Polar Programs
Washington, D.C. 20550

David G. Mountain
University of Washington
Department of Oceanography
Seattle, Washington 98105

R. A. Muench
Physical Oceanographer
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Francis A. Richards
Department of Oceanography
University of Washington
Seattle, Washington 98105

John E. Sater
Research Co-Ordinator
The Arctic Institute of North America
1619 New Hampshrie Avenue, N.W.
Washington, D.C. 20009

Mrs. Sandra Toye
Office for Oceanographic Facilities & Support
National Science Foundation
1800 "G" Street, North West
Washington, D.C. 20550

R. P. Voelker
ARCTEC, Inc.
9104 Red Branch Road
Columbia, Maryland 21043

Boyce Watkins
Marine Superintendent
Department of Oceanography
University of Washington
Seattle, Washington 98105

R. E. Williams
Division of Marine Resources
University of Washington
3716 Brooklyn Avenue, N.W.
Seattle, Washington 98105

representing eight academic and five Federal Agencies.

The objectives of the meeting were set forth in the convening letter to all participants. They were:

- *To examine the ongoing and projected research in the Arctic and discuss the ship needs associated with the research programs.*

- *To recommend a course of action which will best provide ship services to meet the research requirements by scientific investigators.*

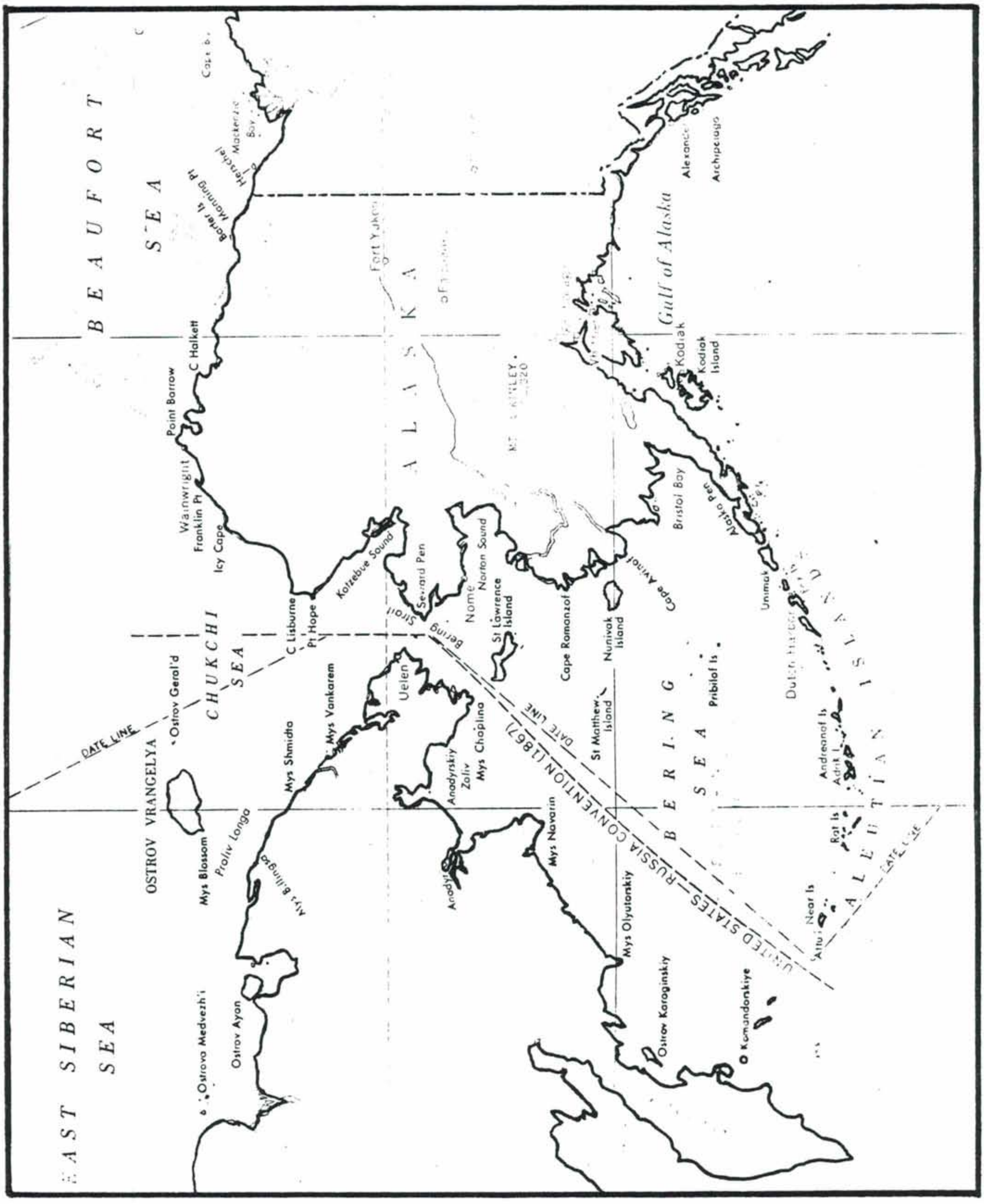


Fig. 1 - THE ALASKAN - ARCTIC REGION

PART II - SUMMARY OF MEETING

The Arctic Reserach Ship Conference was attended by twenty-two participants representing eight academic institutions and five Federal agencies. The list of participants is attached as Appendix B.

The preliminary agenda dated July 15th was adopted and was followed throughout. A copy of the agenda is attached as Appendix A. R. P. Dinsmore, Executive Secretary of UNOLS was asked to act as chairman of the meeting.

In an introductory statement Dr. Donald Hood cited the emergent nature of Arctic information needs and the tools to accomplish it. He advised that the U.S. is preparing to lease 10 million acres of outer continental lease sales and the successful development of this effort requires impact statements for which much knowledge does not yet exist. Furthermore, the development of fisheries resources, in conflict both with petroleum exploitation and foreign competition needs a greater measure of oceanographic investigations than has been accomplished in the Arctic. The deficiency is largely brought about, according to Dr. Hood, by the absence of suitable research ships available to the area. The R/V ACONA is the only permanently assigned U.S. ship to the Alaskan and adjacent Arctic region. ACONA is only 85-ft in size and is not ice strengthened or capable of operations in severe winter weather.

Current and Projected Research Efforts

It was not the purpose to establish any coherent program of research in Arctic waters, but rather to review on-going efforts and other projected research in order to assess the ship needs to accomplish the research. Each participant spoke to the on-going and planned efforts by his institution and agency, and further addressed some of the gaps in the specific disclipline of his own specialty. These are summarized in the following section "ARCTIC RESEARCH":

It was generally agreed that priorities in research of the American Arctic regime appears to be associated with developing the food and energy resources of this area. It was further agreed however that the first order exploration generally associated with these priorities cannot be completed or explained without the elemental research of basic scientific disciplines and their interrelating dynamics.

Much discussion centered upon the Alaskan Arctic as a unique environment brought about by the seasonal ice cover, broad shelf, and nutrient rich waters. Of special importance is the seasonal ice cover in that it not only plays a vital role in ecosystem dynamics but itself is an environmental factor important to climate, transportation and operations in general. The area of greatest deficiency in research information is winter and spring observations in ice encumbered waters where almost nothing is known.

The meeting defined for the term Alaskan-Arctic Region those areas generally including the Gulf of Alaska, Bering Sea, Chukchi Sea and Beaufort Sea. (See Map). This area includes 74% of the U.S. Continental Shelf, 5% of the world fishery catch and an estimated 16% of U.S. petroleum reserves. Commonalities of this region with other polar and subpolar regions were discussed noting that many scientists share interests both here and elsewhere, especially the Antarctic. It was therefore agreed that research facilities developed for the Alaskan Arctic should not be exclusive but could and should be shared with other regions where commonality of research interests and problems are similar.

Ship Needs

The requirements for suitable research vessels occupied a major part of the conference deliberations. Factors which emerged in determining the specific requirements were:

- Ice Cover ranging from ice free in the Gulf of Alaska to the true polar pack in the Chukchi and Beaufort Seas. Of particular importance here is the need for operations in the winter ice and pack edge of the Bering Sea and extending to the Beaufort Sea in summer.

- Research Needs in response to ongoing and projected programs show requirements for multi-purpose ships about equally distributed between geology, biology and physical oceanography (including ice dynamics). Chemical oceanography would be supportive to each of these.

- Sea Conditions becomes an important factor if effective use is to be made of any ship. Because a large scope of the area is ice free either seasonally or permanently, and sea states therein can be encuringly severe, seakindliness is a mandatory need.

- Remoteness of the region dictates a ship need which has endurance in fuel, stores, equipage and people.

In terms of numbers and kinds of ships, it was obvious that no single ship would fulfill the needs discussed. Furthermore, more than one ship is required when Federal Agency requirements are totalled along with those of academic research. The following different kinds of ships were considered.

1. Icebreakers - an essential type when operating in extremely heavy ice and the polar pack. However, icebreakers are large, expensive, high performance ships whose availability to research is limited and whose operations should be confined to heavy ice.
2. Fisheries Research - important to exploratory fishing, gear research and stock assessments. Should be a large specially equipped and Federally operated. Generally not suited for any significant ice penetration.
3. Geophysical Exploration - usually single purpose ship continuously underway for seismic profiling and using multi-channel arrays. Operations in ice neither feasible nor necessary.
4. Deep Sea Research - by existing type large multipurpose oceanographic research ships needed because of

their capability to mount large scale experiments and operate in high sea states. Because of high operating costs and worldwide use such ships will have only occasional use in the Alaskan Arctic.

5. Multipurpose Arctic Research - a vessel envisioned to span a gap between the icebreaker and deep sea research, capable of operating effectively in ice or open water. Because of localized use (in the arctic or antarctic) size and operating costs must be made as economical as possible.

In reviewing the foregoing categories and based on inputs by representatives of Federal Agencies participating, it was agreed that items (1-4)above are essential to an overall research effort in the Alaskan Arctic but that they already exist or are planned for in ongoing efforts to some extent. Category 5 above, is one for which no capability exists or is planned for; and therefore is the area on which the conference should focus.

Concepts of an Arctic Research Vessel

The meeting turned its attention to the specific needs for a research ship as noted in (5) above. A point of concern was that an iceworthy ship is generally acknowledged not to be a suitable ship for open water operations and discussion centered around whether these two requirements were compatible. It was decided to make every attempt to retain both requirements but assign priority to ice operations.

Dr. Elsner reported that such a vessel was the kind envisioned by the University of Alaska in its proposal to the National Science Foundation described in the Background and Purpose of Meeting. A copy of that proposal is attached as Appendix E.

Criteria for operation discussed included geographic, environmental, scientific. These are summarized as follows and addressed in greater detail in Part IV.

1. Geographic -
   - Gulf of Alaska
   - Aleutian Chain
   - Bering Sea & Strait
   - Chukchi Sea
   - Beaufort Sea (shelf)
2. Environmental -

   Ice:
   - Winter Ice 0-3 ft; 0-6 oktas
   - Fast & consolidated ice 0-1.5 ft.
   - Pressure - withstand besetment

   Weather
   - Air Temp: -40°C @ 50 knots
   - Sea Temp: -02°C
   - Sea State: operate in State 5
   - withstand severe icing
3. Scientific
   - multi-discipline on board research
   - geophysical and fisheries - limited to reconnaissance surveys.
   - Cruise duration - 60 days
   - Scientists - 10-20

To the question of whether the ship concept should be limited exclusively to the Alaskan Arctic it was agreed not to so limit it but consider the ship available to Antarctic research on a mutually compatible basis.

Characteristics of such a vessel were discussed at some length and are set out in Part IV. These envision a ship of about 160-170 ft. in length having a crew of 15 and to accommodate 15 scientists. Mr. Voelker of ARCTEC, Inc., advised that with a 50-ft beam and 3,000 shp it is feasible for a ship to have good open sea characteristics and for working in consolidated ice up to 2 ft thick with severe pressure.

It was suggested by Captain Williams that any new design specifications should conform with ABS Classification Rules. Otherwise, the possibility of runaway specifications would result in exorbitant construction costs. It was noted that the 1973 ABS rules expanded the classes for ice navigation. There was general agreement to this proposal provided that the envisioned iceworthiness would be met and that it be considered by any conceptual design study. A copy of the current ABS Building and Classing Rules for ice strengthening is attached as Appendix F.

Management

The manner in which an arctic research vessel should be operated was considered with the conclusion that it would best be managed as a National Oceanographic facility as defined by the UNOLS Charter. (Appendix G). Some concern was expressed that if the ship replaces R/V ACONA as proposed by the University of Alaska, it would remove the University from direct use for its own projects. It was pointed out however that the concept of a UNOLS National Facility provides for some fraction of the ship time being controlled by a review committee, and the remainder assigned directly to the operating laboratory. This appeared to be a feasible arrangement but specific assignment of the portions and actual operator institution should be deferred for future action.

Alternatives

Recognizing that the ship envisioned by the foregoing does not now exist and probably could not be funded and built within four years, various alternatives to meet ship needs now were discussed. These included:

1. Reassign an existing research vessel (R/V ALPHA HELIX or R/V HERO)
2. Charter a suitable vessel (probably a foreign fishing hull)
3. Utilize existing icebreakers for research in ice and existing deep sea research vessels for open water research.

These alternatives are further discussed in Part V.

Of the above the most likely would be the reassignment of R/V HERO and the combination of using existing icebreakers and deep sea research vessels. Each has severe limitations and could only be looked upon as a short term interim measure.

Further Action

Concluding its meeting, the participants discussed further action for achieving facility requirements for arctic research. These included further definition of research requirements, conceptual design of a suitable vessel, examination and implementation of alternative facilities, and identifying agencies and other activities for sources of support.

1. Definition of requirements - is required because no comprehensive listing of ongoing research and facility needs for the entire region appears to exist. This should be done by a planning group brought together as a part of a conceptual design study.

2. Design of iceworthy arctic research vessel - should proceed to include definitions of requirements and a conceptual design by a competent engineering group.

3. Alternative Facilities - should be implemented as an interim measure both to get an immediate start and to test the feasibility of alternatives for enduring measures. Exploration of alternatives should proceed through UNOLS.

4. Sources of Support - for further planning, design, acquisition and operations should be a parallel fun-

ction to definition of requirements. In this regard the increasing role of industry in arctic interests should not be overlooked.

Final recommendations suggested that the University of Alaska withdraw its ship planning proposal to the National Science Foundation and in its place place a new proposal by the University of Alaska on behalf of UNOLS be prepared and submitted to NSF in order to accomplish items 1, 2 and 4 above. Important to such a proposal would be including an Advisory Committee comprising several experts from various institutions having arctic research interests. Item 3 above should be undertaken jointly without delay by the University of Alaska and the UNOLS Office.

PART III - REVIEW OF ARCTIC RESEARCH

It was not the purpose of the meeting to establish any coherent program of research in Arctic waters, but rather to review on-going efforts and other projected research in order to assess the ship needs to accomplish the research. For the purposes here this can be divided into ongoing efforts and nature of the intended research.

Ongoing efforts:

A comprehensive 5-year oceanographic study of the Gulf of Alaska shelf region extending later to Bering, Chukchi and Beaufort Seas, which commenced on July 1, 1974 under funding of the Federal Bureau of Land Management (BLM). The continental shelf of the North Pacific ocean is one of the highest in priority for offshore leasing for petroleum extraction. Baseline information necessary for preparation of the impact statement required for offshore lease sales will be collected during fiscal 1975 and 1976. This study will be undertaken by NOAA Environmental Research Laboratories, Fish and Wildlife Service, National Marine Fisheries, and the University of Alaska.

- Studies of ice dynamics, oceanography and environmental assessment in the Chukchi and Beaufort seas, in particular, the AIDJEX (Arctic ice dynamics joint experiment) project funded largely by the National Science Foundation and Office of Naval Research.

- The Processes and Resources of the Bering Sea Shelf (PROBES) has recently been designated as the first priority problem area for Bering Sea oceanographic studies by a recent workshop held to designate a U.S. Research program for the Bering Sea. The project proposes work from 1975-1980 and will operate in all seasons of the year. The scientific program will consist of an interdisciplinary oceanographic study with particular emphasis on the processes responsible for the unusual high abundance of marine life of the Bering Sea Shelf.

- A Japanese study of the Bering Sea, funded by the Japanese Science Council and scheduled to commence in early 1975 in cooperation with IDOE and involving use of a Korean vessel.

- The NORPAX (North Pacific Experiment) program, directed at air-sea exchange over the North Pacific Ocean, including the Bering Sea region. Supported by ONR & NSF.

- The POLEX (Polar Experiment) project which focuses on air-sea exchange in the polar regions.

- Several projects now underway aimed at better understanding of the Alaskan Arctic marine processes include:

  Environmental Studies of Prudhoe Bay, a joint effort of Univ. of Alaska, Sea Grant and ARCO Petroleum Company; Sediment regime of Beaufort Sea Continental Shelf, a joint effort between the Univ. of Alaska and U.S. Geological Survey; Ice dynamics on Alaska arctic continental shelf, a joint effort between the Univ. of Alaska and Sea Grant over the next three years.

. An extensive series of environment-related studies now in the planning stages, to be carried out in the Arctic offshore regions by the National Science Foundation, Office of Polar Programs. These studies are a reflection of the current national awareness of the economic and scientific significance of the Arctic.

Research-Prospects:

. Priorities in research of the American Arctic regime appear to be associated with the developing the food and energy resources of this vast area. The continental shelf region of the Gulf of Alaska, Bering Sea and Alaska Arctic total 830,000 square miles or 74 percent of the total (1,120,000 square miles) of continental shelf adjacent to the United States. Because this area of abundant renewable resources supports one of the world's largest fisheries, extensive bird and marine mammal populations; is a transportation corridor to the arctic; and a most promising area for petroleum and metal extraction, it is extremely important that it be carefully studied now to provide information for rational management decisions in the immediate years ahead.

The oceanographic processes on these shelves and the adjacent oceanic waters are poorly understood and in fact in some areas important for understanding of the environment are totally without information on certain important environmental aspects. Particular attention is aimed at the longshore processes including sediment transfer, circulation and ecosystem analysis. Transportation systems, especially as related to movement of energy resources, will have a severe impact on this environment. At present the scientific data base is much too limited to allow intelligent discussion of development with regard to environmental quality.

The current annual fisheries catch from the Bering Sea is 2.5 million tons annually, which is about 4% of the total world marine catch. The history of intensive fishery efforts in this region is relatively short. Most demersal species are already fished intensively, but observations of stomach contents suggest that such forms as capelin and sandlance exist in relatively large numbers. Squids, bathypelagic fishes, and some of the larger zooplankton may also be considered resources for future exploitation.

Most of the carbon produced in a marine ecosystem is channeled through invertebrate species,many of which interact in food webs that terminate in commercially valuable food species. The harvesting of great numbers of certain commercially valuable species such as shrimps, crabs and demersal fishes in the Bering Sea could eventually result in their replacement by and a subsequent drastic increase in the standing stock of commercially less desirable forms. Heavily exploited areas should be studied to provide insight into possible significant perturbations of the natural food web.

Biological studies have a long range goal of gaining a predictive understanding of the trophic structure and dynamics. Research accomplished over the past years has addressed both general and specific questions of organic matter synthesis by primary producers as a point of departure for further trophic studies. Temporal and spatial variations in rates of photosynthesis, nutrient cycling, and effects of trace metals need to be examined in the open water, in the water column beneath the seasonal ice pack, and in the ice in association with the sea ice community. Current investigations are underway to identify the ecologically important components responsible for, and to describe the process involved in, the transfer of organic matter from primary producers to pelagic grazers in the near-ice zone. The Marine Mammal Act of 1972 indicates an intense concern that marine mammals and their environment be carefully conserved in a healthy state. Much of the knowledge required to do that is not yet available and must be obtained if the Marine Mammal Protection Act is to be effectively implemented.

Sea Ice Communities:

Although the Arctic ecosystem might be expected to operate on the same broad scale as that found in marine systems elsewhere, the seasonal ice cover over much of the shelf suggests unique variations in energy flux and nutrient cycling. The ice itself acts as a matrix for vigorous phytoplankton growth and thus contributes significantly to primary productivity.

Shallow Arctic shelf waters at times support an extensive growth of phytoplankton because light and abundant inorganic and organic nutrients are readily available. In shelf areas, nutrient supply is often attributed to proximity of freshwater runoff or to coastal upwelling. The importance of nutrient regeneration in bottom sediments, however, has not been investigated. Studies of detrital organic matter decomposition in sediments as well as in the water column should be undertaken before the mechanisms and the importance of the in-place regeneration of nutrients in sustaining primary production in shelf water can be assessed.

More information is needed about the physical aspects of the pack ice itself, especially its gross morphology - the size of floes, their thickness and surface texture, and the amount of open water between them - and the kinetics, direction and rate of ice movement. It is already apparent that these conditions can exert important influences on the distribution and welfare (therefore, the productivity) of the marine birds and mammals that normally reside within the boundaries of the pack or are excluded from that area when ice is present. Specific needs are: (1) How the distribution of open water and types of ice are related to the distribution of each species; is this a biologic preference of the species for certain ice conditions, or more a function of other factors such as climate and availability of food? (2) How the movements of the pack ice affect the distribution and energy expenditure of each species; that is, do the animals drift with the pack and therefore distribute their impact on the food supply over a very wide area, or do they actively maintain their position and thereby utilize more energy and concentrate their effects in a smaller more restricted area?

Petroleum and Minerals, Geological Studies:

Probably 75% of the Arctic shelf holds some likelihood of hydrocarbon accumulation. The most promising non-renewable resources of the Bering Sea shelf are petroleum, natural gas, and certain heavy metals. Although the heavy metal resources may be areally restricted to near shore, the petroleum and natural gas resources may be expected in the same areas of the shelf as the greatest concentration of renewable resources, again in part for the reason of long-term high productivity. Conflicts between utilization of the renewable resources may be expected. Geologic studies are requisite to developing the non-renewable resources and can provide information to help resolve the expected conflicts in resource utilization.

Geological studies necessary for an understanding of the renewal resources of the Bering Sea continental shelf are: 1) the nature of the nutrients in the bottom sediments. 2) the stability of the substrate for benthic organisms. 3) the long-term historical baselines for comparison with typical short-term measurements of the oceanographic regime, and 4) the nature of non-renewable resources and the likelihood of conflicts in resource utilization. The first two contributions can be made by studying the processes which are eroding, transporting, and depositing the sedimentary particles on the shelf. The study of the sediment budget on the continental slope is separate but closely related. In order to provide a historical baseline of sufficient duration to evaluate the temporal significance of some measurements of the oceanographic regime, a stratigraphic study should be made of the sediments deposited since the beginning of the last rise in sea level.

Physical Oceanography:

Complimentary to geological and biological studies, a thorough understanding of the physical oceanographic conditions is essential to a rational approach to resource development. Focal subjects must include studies of the circulation and its time-variability which governs the supply and distribution of nutrient elements, the formation and circulation of specific water masses that play a key biological role in constraining the distribution of bottom flora and fauna, the location and strength of the strong tidal currents (particularly over the shelf) which strongly influence sediment distribution, and the nature and movement of sea ice and its relationship to surface circulation and winds, which may prove to be a limiting factor in commercial exploitation. The influence of the extent of the ice ocver on atmospheric circulation, particularly the location of the Aleutian low, needs investigation. The seasonal and year-to-year variability of the ice cover are potentially very important influences on the atmospheric circulation. The ice also has a large influence on the radiation balance since its albedo is typically much higher than that of the sea surface. The ice cover then tends to maintain itself by limiting the amount of incoming radiation absorbed.

The Bering Sea lends itself exceptionally well to investigations of physical, chemical and biological budget studies because of its relatively restricted proximity to the adjacent Arctic and Pacific ocean waters and present lack of reliable year-round oceanographic data. A dominating physical feature is its winter ice-cover over most of the shelf region. Many of the chemical source materials to this region are identified; the importance, however, of each substance on an annual basis is poorly understood. It should be possible to define these chemical sources and processes vital to high productivity in the deepwater, shelf and slope regions, once a better understanding is reached of the heat and salt budgets and the amounts and forms of carbon nutrients and trace elements.

In summary, Oceanographic information requirements are now reaching serious proportions in Alaska and adjacent Arctic waters and must be met without delay in order to fulfill the role of science in the national needs for fuel production, sustainable yield of food materials and protection of large stock of mammals, birds and marine wildlife.

PART IV - CONCEPTUAL DESIGN OF AN ARCTIC RESEARCH VESSEL

Design criteria for an Alaskan Arctic Research Vessel should be based on three general factors: (1) geographic, (2) environmental and (3) scientific.

Geographic Factors

The Alaskan Arctic Region is defined to include the Gulf of Alaska, Aleutian Chain, Bering Sea and Strait, the Chukchi Sea and the shelf area of the Beaufort Sea. This area has a breadth of about 1200 miles in both latitude and longitude (see Fig. 1). It encompasses almost one million sq. miles including 830,000 sq. miles of shelf area and 47,300 miles of U.S. coastline. The Aleutian Basin and Gulf of Alaska exceed 3800 meters in depth and the Aleutian Trench reaches 7600 m. depth.

Environmental - Ice

During the maximum seasonal ice cover from January to March, heavy, close pack ice occurs almost everywhere north of Lat. 60°N and covers about half the Bering Sea. Loose pack ice requiring ice strengthened vessels occurs as far south as the Pribilof Islands and all of Bristol Bay. This results in an ice cover of moderate to severe conditions over the entire Alaskan shelf north of the Aleutian Chain. See Fig. 2.

Minimum ice cover occurs in late summer when the Bering Sea, Bering Strait and the Southeastern Chukchi Sea are essentially ice free. (See Fig. 3). However, the North Shelf from Cape Lisburne to Point Barrow and eastward is always subject to sea ice and may require ice strengthened hulls or icebreaker escort.

Desireable criteria for a research ship to achieve 66% mobility is to be able to operate in winter pack ice up to 3-ft thick and

Fig. 2 - Average Ice Conditions; Feb-March

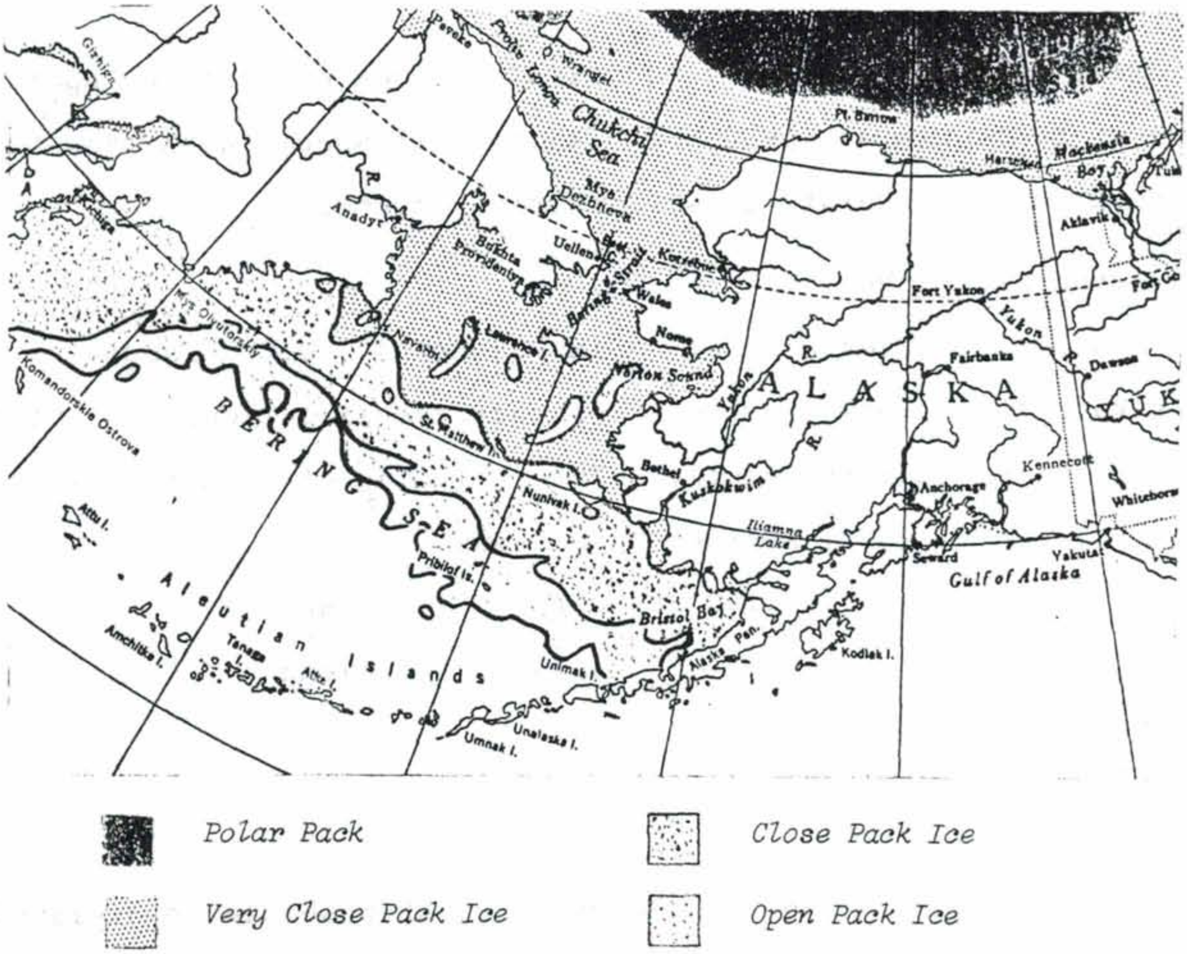
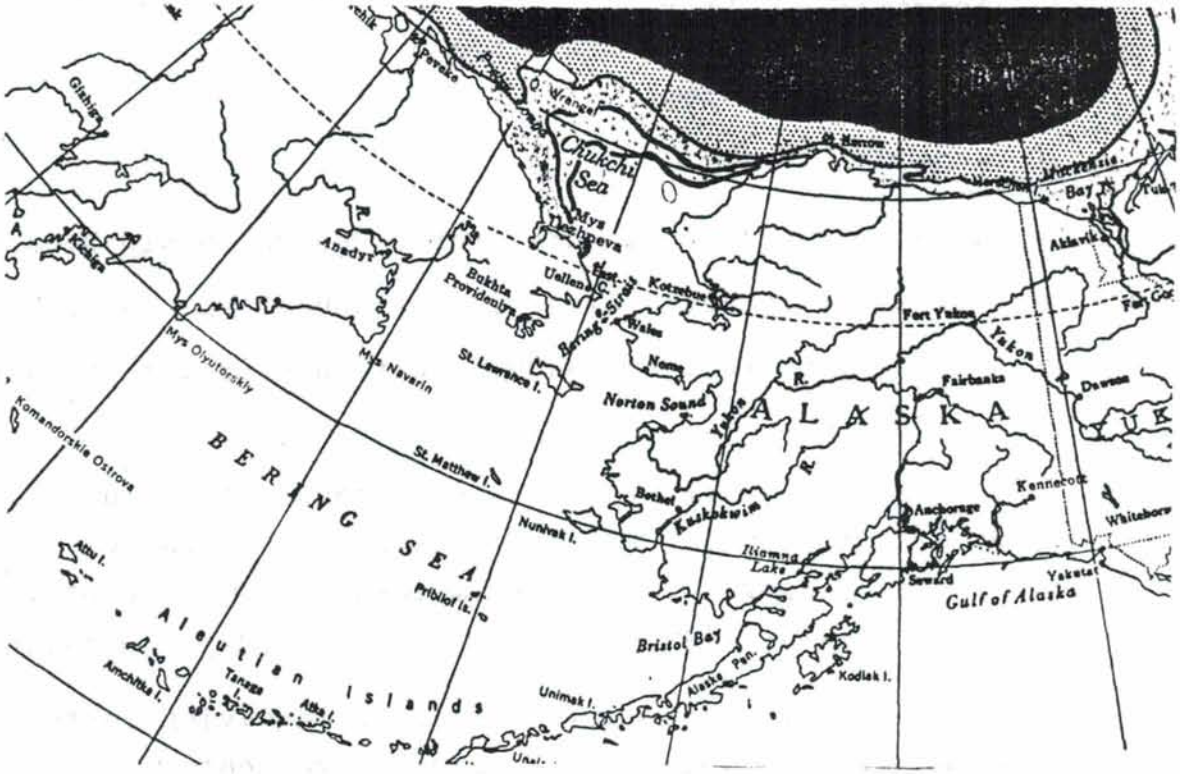


Fig. 3 - Average Ice Conditions Aug-Sept



6 oktas concentration, and consolidated pack or fast ice up to 1.5 ft thickness at speeds of 3 knots. It should withstand besetment under moderate to severe pressure ice.

Environmental - Weather

A research vessel in the Alaskan Arctic region should be designed to the most severe of weather specifications. Sea states 5 and above occur frequently. The following gives a table of the most severe (winter) average conditions:

	wind velocity % time over 22 knots	Mean Air Temp
North Shelf	25%	-19°F
Bering Sea	40%	23°F
Gulf of Alaska	30%	24°F

Criteria to which a year round research ship should be disigned are:

Air Temperature -40°C at 50 knots
Sea Temperature -02°C
Continuous operation in Sea State 5
Withstand severe icing

Scientific Factors

A research ship in the Alaskan Arctic Region should be able to accommodate about fifteen scientific personnel on cruises up to 60 days. It should be able to conduct multi-discipline oceanographic research including:

- Biological - wide variety of observations, collections and laboratory sorting and analyses of both pelagic and benthic biogorms ranging from inshore (> 15m depth) to oceanic basins (4000m). Experimental biology on living specimens.
- Fisheries - limited fisheries research involving bottom and midwater trawls and associated environmental obser-

vations and laboratory analysis of samples. Full scale exploratory and commercial fishing techniques not required.

- Marine Mammals & Birds: Collection, processing & stor-storage of marine mammals & birds. Wet & dry laboratory studies.
- Geological - precise bathymetry; rock dredging, sediment sampling and coring in depths to 6000m; laboratory sorting and analysis; sample and core storage.
- Geophysical - Underway sub-bottom profiling using air gun or reconnaissance surveys not to include multi-channel arrays; magnetics, thermal probes and gravity observations.
- Physical Oceanography - hydrographic and STD casts to 6000m; deep towed instrument arrays, emplant and recover moored current meter and other arrays.
- Water Quality and Chemistry - wide variety of water, sediment and air sampling and laboratory analyses including nutrients, trace metals, hydrocarbons and radio isotopes.
- Ice - observations of cover, thickness and form analysis; laboratory processing and storage; ice physics, strain and deformation.

Design Characteristics

A final design, even conceptual design, for a research vessel should be the result of a more substantial study of the various requirements and operational and scientific factors that the two day conference was able to provide. However, based on a cursory review of information at hand and the experience of the participants, the following specifications were generally agreed upon: (Refer to notes where indicated)

Length - 160-170 ft. LOA
Beam - 40-50 ft.
Draft - 16-18 ft.
SHP - 3000 hp [Note 1]
Speed - cruising - 12
min - 1.5
Propulsion - Twin screw, CPR
Endurance 10,000 mi
90 days
Personnel: Crew - 15
Scientists - 15
Ice Strengthening - ABS - Class 1AA (min) [Note 2]
Outfitting:
Hydrowinch (2)
Trawling & Coring
Fisheries [Note 3]
Cranes (2)
Launch(s)
Center Well [Note 4]
Bow Thruster

Note 1 - SHP estimated desired icebreaking characteristics. Based on ABS1AA rules and a displacement of 1500 tons, the SHP would be 2100 tons but rules state a minimum SHP of 3500 less 10% for CRP and reversing machinery. (See Appendix D)

Note 2 - ABS1AA ice strengthening should be specified wherever possible provided desired ice worthiness is retained especially for withstanding heavy pressure ice. (See Appendix D)

Note 3 - Fisheries limited to exploratory and assessment research. Full scale commercial net and trawl handling and tank storage is not here specified.

Note 4 - A usable center well would appear to be a highly desireable feature and should be thoroughly examined.

> Most existing center wells on R/V's have not proven feasible except where it was part of the "hull mission" (ALCOA SEAPROBE & MIZAR) where they have proven eminently successful but at the expense of much interior space.

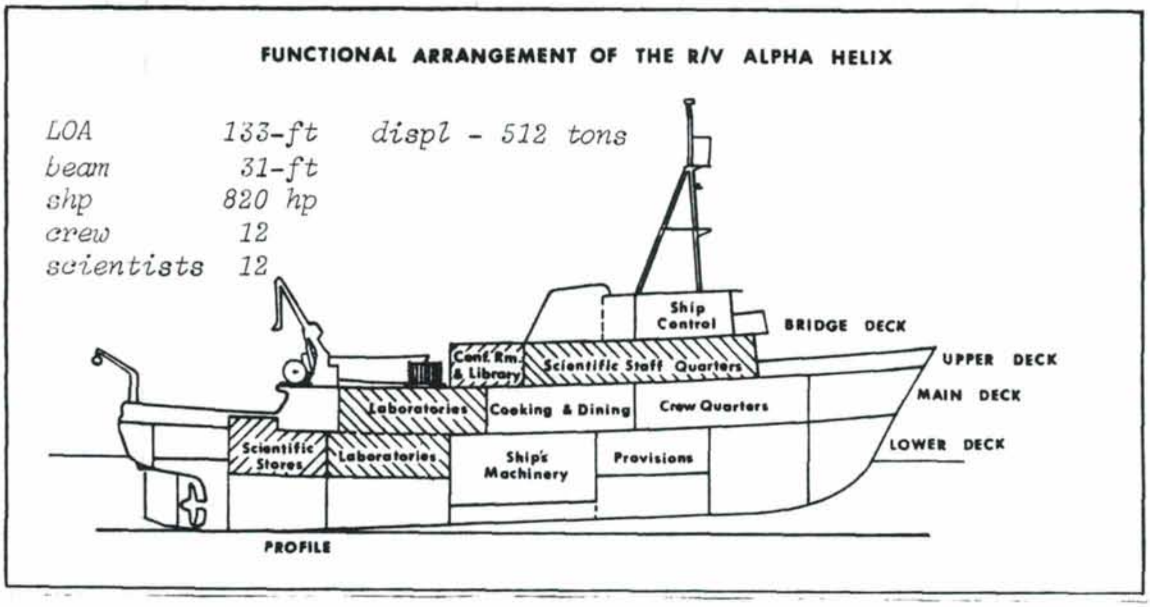
Laboratories

A special consideration which ought to be included in the concept of design is the quality and adequacy of laboratory and research space along with associated shops and storage. Some laboratories lend to multidisciplinary use, others do not. Both should be incorporated. Most scientists agree that the greatest deficiency in U.S. research ships is the suitability of laboratory and working space. Because of its large hull form for iceworthiness an opportunity exists here to fully meet this requirement.

PART V - ALTERNATIVE ARRANGEMENTS

It is unlikely that any Arctic Research Vessel could be designed, funded & built within four years. Research needs indicate that a more timely assignment of facilities is necessary. Therefore alternative arrangements should be implemented. These include reassignment of existing academic ships, use of USCG and NOAA ships on an opportunity basis, part time assignment of deep sea university ships and continuation of existing ships. Each of these is discussed in the following:

1. Reassign an existing research vessel. The two most likely candidates would be the R/V ALPHA HELIX and the R/V HERO.

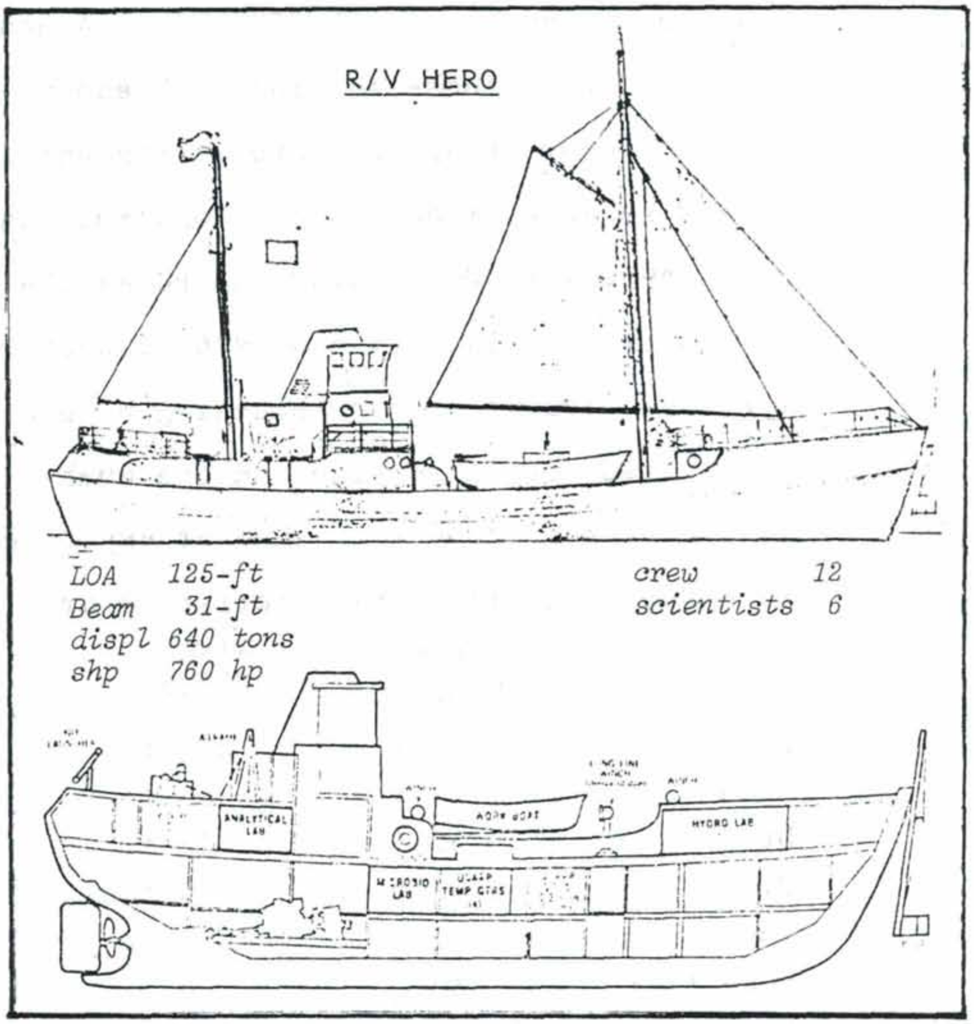


FUNCTIONAL ARRANGEMENT OF THE R/V ALPHA HELIX

LOA *133-ft* *displ - 512 tons*
beam *31-ft*
shp *820 hp*
crew *12*
scientists *12*

ALPHA HELIX is ice strengthened and has operated in the Alaskan Arctic. However the hull previously has suffered ice damage under moderate pressure and an inspection group has recommended that it not operate in any significant concentrations. Its single screw and 820 hp makes it extremely vulnerable to ice. This alternative probably should not be further considered.

R/V HERO was built for research work in ice and to some extent would be eminently suited. Its small size (125-ft) makes it limited in capability for research and low horsepower limits its mobility in ice. Ability to withstand pressure is unquestioned and experience in Antarctic waters has proven its seaworthiness. Officially assigned to the U.S. Antarctic Research Program there is some question whether it could be reassigned. HERO would be a feasible interim alternative if suitably outfitted although it probably would not replace the existing R/V ACONA. HERO is severely limited in laboratory and storage space. Some modification would be required to provide adequate hydrographic sampling capability.



R/V HERO

LOA	*125-ft*
Beam	*31-ft*
displ	*640 tons*
shp	*760 hp*
crew	*12*
scientists	*6*

2. Use of USCG Icebreakers. The only truly capable ice-worthy ships in the U.S. inventory are Coast Guard ships designed for this purpose. Foremost among these are the true polar icebreakers. Originally eight there are now five "Wind" Class and the somewhat larger and newer GLACIER. (See Appendix D). In addition to these the 180-ft "Tender" Class have limited icebreaking characteristics and the 230-ft STORIS somewhat mroe. Under construciton are two new icebreakers POLAR STAR and POLAR SEA scheduled for completion in 1975 and 1976 respectively. Over the next five years the remaining WIND Class will be retired out of service and the number of U.S. icebreakers will be less than at any time since before World War II. Characteristics are:

	POLAR CLASS	WIND CLASS	TENDER CLASS
LOA	400-ft	269-ft	180-ft
Beam	84-ft	63-ft	37-ft
Draft	30-ft	29-ft	13-ft
Displ.	12,000 tons	6,500 tons	1,025 tons
SHP	60,000 hp	10,000 hp	1,200 hp
Scientists	10	6	(2)
Built	1975-1976	1943-1946	1943-1944

USCG icebreakers have always been available for research projects and will continue to be the only U.S. surface vessels able to penetrate multi-year pack ice. The new ships will have greatly increased laboratory capabilities but the demands on their time will be highly competitive. Antarctic logistics and Navy projects will continue to receive first priority and probably will absorb the total availability. Decreasing number of WIND Class will be available through 1979 but these probably will be assigned to the Atlantic Arctic. Tender class ships have almost no research capability and little time available.

3. <u>NOAA Research Ships</u>: These include NOAA ships of which three, OCEANOGRAPHER, SURVEYOR AND MILLER FREEMAN are intended for extensive resources acesement in Alaskan waters. The first two have limited ice strengthening as do all NOAA Class I and II Survey Vessels but no NOAA fisheries research ships are reinforced for ice operations.

	OCEANOGRAPHER	SURVEYOR	MILLER FREEMAN
LOA	303-ft	292-ft	214-ft
Beam	52-ft	46-ft	42-ft
Draft	18-ft	18-ft	19-ft
Displ.	3,959 tons	3,150 tons	1,782 tons
SHP	5,000 hp	3,200 hp	2,150 hp
Scientists	18	9	12
Built	1966	1960	1967

The use of NOAA ships should be undertaken on a regular basis and the availability of these ships to provide specific time allotments and under what conditions should be ascertained.

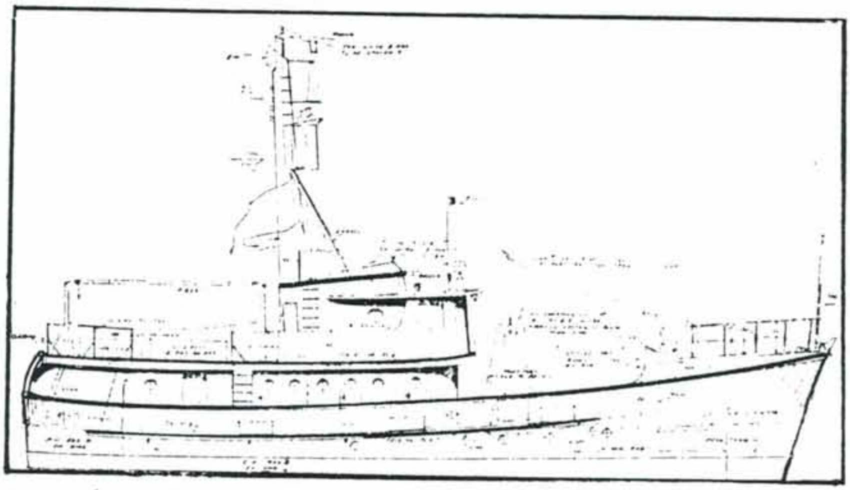
4. <u>Oceangoing University Ships</u>: The two ships usually operating nearest to Alaskan waters are the R/V THOMPSON (Univ. Washington) and the R/V YAQUINA - being replaced by R/V WECOMA (Oregon State University).

The THOMPSON is ice strengthened but the WECOMA is not. Both ships are capable open sea multi-discipline research vessels and probably have some availability to the open sea parts of the region.

	THOMPSON	WECOMA
LOA	209-ft	177-ft
Beam	39-ft	33-ft
Draft	15-ft	17-ft
Displ.	1,362 tons	962 tons
SHP	1,000 hp	2,800 hp
Scientists	20	13
Built	1965	1975

5. Existing Ship - As a comparison for the final alternative the R/V ACONA has proved to be a very able and successful ship. However, the ACONA is capable of conducting only a fraction of the needed research. It is not ice strengthened and has limited laboratory space. A recent inspection revealed further potential limitations because of its advancing age in the hostile arctic environment. There appears to be full agreement that the ACONA should be replaced in its present assignment as soon as possible and reassigned to a longer life elsewhere.

	ACONA
LOA	85'
Beam	22'
Draft	12'
Displ.	208
SHP	300
Scientists	9
Built	1961



Sic Transit Scientia Borealis

PART VI - CONCLUSIONS & RECOMMENDATIONS

With an increasing emphasis on national needs for resource development priorities in research in the Arctic will be associated with food and energy assessment, development and related environmental impacts. Although icebreakers, fisheries and occasional ocean going research ships are available to the Alaskan Arctic, the only permanently assigned university research ship - the 85 - R/V ACONA - is totally inadequate to meet the needs.

1. *It is recommended that, as a matter of urgency, increased means of access by university scientists to Arctic waters be provided.*

Although new and capable icebreakers are under construction and Federally operated non-icebreaking ships are being assigned for specialized purposes, there is no iceworthy multipurpose research ship now available to this area.

2. *It is recommended that along with Federal icebreakers, fisheries and geophysical research ships, there be a multidisclipinary university research vessel assigned to the Alaskan Arctic Region capable of operations in ice as well as open seas beyond ice limits.*

Such a vessel would bridge a needed gap between larger icebreakers and deep ocean research ships. It would conduct the geological, biological, chemical and physical oceanographic research needed in partnership to resources exploitation. It should be economical yet capable of withstanding pressure ice and able to operate in seasonal pack ice. It's laboratories should provide for quality and kinds of research not presently available.

3. *It is recommended that a combined scientific and engineering study be undertaken for a conceptual design of a suitable vessel. Pending results of such a study suggested specifications are for a 160-170 ft hull accommodating 15 scientists for 60 day cruises and possessing unexcelled research spaces. To achieve economy American Bureau of Shipping ice strengthening rules should be conformed with wherever possible.*

An Arctic research ship should serve as wide a range of investigators as possible. Furthermore, it should not be reserved exclusively to the Alaskan area but should be operated according to priorities and wherever research interests and capabilities are mutually compatible.

4. *It is recommended that an Arctic Research Vessel be operated as a UNOLS National Oceanographic Facility and that it be available to other regions, including the Antarctic, as required.*

Planning should proceed forthwith for a conceptual design study to be administered by a university research institution and advised by a group of individual experts drawn from research laboratories, Federal agencies and the naval engineering profession.

5. *It is recommended that a Conceptual Design Study for an Alaskan Arctic Research Vessel be conducted by the University of Alaska Institute of Marine Sciences on behalf of UNOLS and jointly with body of participating experts. The Study should include a comprehensive review of scientific requirements by practicing scientists and the engineering phase should be done by a competent engineering firm. The study should be supported by a*

grant by the National Science Foundation.

Recognizing that any ship envisioned in this context does not now exist and that any new design cannot be funded and built within at least four years, alternative means of accomplishing the projected research should be explored. These include reassigning existing ships and assignments of partial use of icebreakers and other ships.

6. *It is recommended that alternative, interim facility use be implemented. In particular the feasibility for reassignment of R/V HERO should be examined. Elsewhere succinct time assignments by USCG icebreakers (for the ice phase) and by NOAA and the research ships of the Universities of Washington and Oregon State University and Scripps Institution*

UNOLS Office
July 15, 1974

AGENDA FOR ARCTIC RESEARCH VESSEL MEETING

14 - 15 August 1974
University of Washington, Seattle, Wash.

Convene 0900 a.m.
Room 123 Marine Science Building, University of Washington

1. Background of Meeting - R. P. Dinsmore, UNOLS
2. Elect meeting chairman.
    - It is proposed that the Executive Secy UNOLS serve as secretary for the meeting.
3. Discussion of current and projected Arctic research efforts.
    - All participants should attempt to summarize programs within their cognizance.
4. Discussion of ship needs for projected work.
    - Those portions of #3 which require ships should be identified.
5. Discussion of available and projected ships and their capabilities.
    - The meeting should identify what is the current U.S. ship capability for arctic research.
6. Deficiencies between required and available ships.
7. Define the scientific requirements and capabilities of new ship(s) needed.
8. Define the operating requirements and capabilities of new ship(s) needed.
9. Conceptual specifications for an Arctic research ship.
10. Concepts of operation for an Arctic research ship.
11. Further action
    - Report a meeting
    - Formation of Working Group
    - Development of a planning proposal
        - from whom to whom
        - scope (specs, design, etc.)
        - operating and utilization factors

    - Time schedule
12. Adjourn (about noon 15 August).

APPENDIX B

ARCTIC RESEARCH SHIPS

A NATIONAL REQUIREMENT

R. Elsner
Institute of Marine Science
University of Alaska

Polar Marine Studies

As the sophistication of American research activities in polar seas steadily increases, the need to resolve the problems of obtaining truly adequate ice-going ships to serve as laboratory platforms for that work is ever more urgent. In recent years investigators have shown increasing interest in continuing and expanding studies of biological, chemical, geological and physical oceanography, marine mammal ecology and physiology, fish biology, ornithology, ice physics and special matters which are vital to the non-destructive exploitation of arctic resources. These studies are attracting ever greater numbers of workers from universities and other institutions around the nation. The need for logistic support of marine investigations in the north, specifically in the region of Alaska, merits special attention, because of concern related to current and projected rapid developments in that region. No ice-worthy American research ships are operating there on a regular basis.

The results of researches in our arctic marine frontiers can be of highly significant practical and economic importance as well as of theoretical and long range value in the understanding of our environment. Indeed, wise and sensible development and use of resources in that environment will depend upon new knowledge obtainable only from the kind of investigations proposed. We know of the dedicated concern of many of our best scientists in Alaska and throughout the nation for this research effort and the need to continue efforts to fill this serious gap in our national scientific capability.

Arctic marine scientists can generally compete successfully with others in the national scientific community for research funds. What they lack and desperately need is suitable ships to serve as laboratory platforms from which to perform their work. In recent years they have been able to make use of occasional Coast Guard icebreaker cruises and the partially ice-strengthened Scripps research ship *Alpha Helix* and shore stations at Point Barrow and Cold Bay in Alaska. These partial solutions fall short of truly effective means for productive implementation of the scientific programs.

International Implications

There are important international implications for the northern marine scientific program. Much of the biological and oceanographic work done in the Bering Sea, for instance, has been accomplished by the Soviet Union. They are today the navigational masters of the region, with fleets of sturdy ice-going trawlers, factory ships and freighters. The Russians, Japanese and Koreans are reaping a bountiful fishery harvest in those waters. We must be prepared for the occasions when we meet with those nations at the conference table for decisions regarding conservation of our neighboring marine resources. To arrive at that confrontation in ignorance can only work to our disadvantage. We can instead join with scientific colleagues of those nations in an attack on problems of common concern.

Two Soviet scientists participated in the 1973 Bering - Chukchi Sea cruise of the *Alpha Helix* as part of the exchange fostered by the US - USSR Environmental Program Agreement. We anticipate that that productive exchange will lead to regular and expanding joint scientific programs aboard *Alpha*

Helix or other American platforms and at corresponding Soviet installations and aboard Soviet research ships.

Icebreakers

Our icebreaker fleet is old, some of the ships are obsolete and are being retired, and one new icebreaker having expanded scientific capabilities is under construction. The primary mission of these ships is icebreaking, and science has often been a secondary activity. Laboratory space and facilities are inadequate, and their operation is uneconomical compared with research ships. Even with these deficiencies they cannot meet the demand for scientific cruises. Where penetration deep within the pack ice is required, we will have to continue to rely on them. By 1976 our oceanic icebreaker fleet will most likely consist of two new icebreakers, two refurbished wind-class ships, and *Glacier*. Their availability for scientific cruises will depend upon other demands and is likely to be reduced compared to current utilization due to increased demand for their support of commercial maritime traffic.

The National Requirement

Much of the scientific interest is not in regions of the heaviest ice pack, and an icebreaker is not required for very considerable scientific exploitation of ice-covered seas. Urgently needed are modern, powerful, ice-strengthened laboratory ships capable of maneuvering in the loosely-packed ice which makes up a large part of the seasonal Bering Sea ice and for summer activates in the Chukchi Sea and Arctic Basin.

There are presently only two ships of American registry which marginally meet the requirements. *Hero*, is a 300 ton, 125 foot, wooden hulled ship built as a research vessel for the National Science Foundation antarctic program. That ship is presently committed to summer support activities at Palmer Station, Antarctica. *Eltanin*, productively operated for nearly ten years in antarctic waters by the National Science Foundation, was recently taken out of service for lack of funding, but has now been returned to the antarctic program under operation by Argentina. That vessel, 266 feet in length, was launched in 1957 as an ice-strengthened supply ship and was converted to scientific operations in 1962. *Alpha Helix* is a 133 foot, 289 ton biological laboratory ship built in 1966. That ship operates throughout the world as a floating laboratory making possible sophisticated *in situ* scientific activities. Although the hull is moderately ice-strengthened, *Alpha Helix* can not be used in sea ice, except in mild summer conditions, until modifications for protection from freezing in fresh water tanks and engine room cooling systems have been made. *Alpha Helix* is committed to many programs throughout the world and is only occasionally available for arctic work.

A lasting solution for accommodation of present and anticipated new research programs will require new construction of ice-worthy laboratory ships suitable for multi-disciplinary research activities. Recent new interest in American construction of ice-strengthened ships for arctic marine transportation and oil exploitation has resulted in a considerable increase in the interest and capability of American marine designers for such production. There is no reason to think that the ships required could not be designed and built in the United States.

The accompanying compilation of ice-worthy research ships of the world demonstrates the weak position of the United States, particularly when compared with the Soviet Union. Our programs, current and proposed, are promising, scientifically meritorious and realistic, but our ability to implement them is severly limited because we lack polar research ships. We regard the requirement for adequate polar research ships to be the most fundamental priority if we are to carry out a national commitment to scientific investigations of our northern marine frontiers.

APPENDIX D

Ice-worthy Research Ships of the World

	Year built	Name	Length (feet)	Remarks
Canada	1956	Baffin	285	
	1958	A. T. Cameron	177	
	1963	G. B. Reed	177	
	1968	Ehkoli	130	
Denmark	1958	Erika Dan	299	(1)
	1961	Nella Dan	247	
Finland	1953	Aranda	173	
France	1965	Jean Charcot	246	
Federal Republic of Germany	1941	Gauss	186	Converted, 1949
	1955	Anton Dohrn	205	
Norway	1948	Reder Rønnestad	86	Converted, 1959
	1950	G. O. Sars	170	
	1957	Helland-Hansen	114	
	1958	Johan Hjort	172	
	1960	H. U. Sverdrup	127	
Union of South Africa	1961	RSA	223	
USSR	1951	Sevastopol'	244	
	1953	Ob'	426	
	1956	Polyarnik	126	
	1956	Pervenets	128	
	1957	Mikhail Lomonosov	335	
	1958	Okeanograf	126	
	1964	Akademic Knipovich	280	
	1967	Professor Viese	408	
	1967	Professor Zubov	408	

Ice-worthy Research Ships of the World (cont.)

	Year built	Name	Length (feet)	Remarks
United Kingdom	1948	Ernest Holt	176	
	1955	Explorer	202	
	1962	Discovery	260	
USA	1957	Eltanin	266	NSF, Antarctic, Note 2
	1968	Hero	125	NSF, Antarctic, Wooden Hull

NOTE: (1) Two vessels of the "Dan" fleet which have been used for research activities.

NOTE: (2) USNS ELTANIN is on five year loan (1974) to Argentina for joint Southern Ocean studies. Has been renamed ISLAS ORCADAS.

Icebreakers and other vessels with limited research capability and/or limited availability to the scientific community.

	Year built	Name	Length (feet)	Remarks	
Argentina	1952	General San Martin	280	I. B., Navy	
Canada	1954	Labrador	269	I. B., Canada Coastguard	
	1963	Hudson	296	Arctic research ship (Bedford Inst.)	
		St. Laurent	294	I. B., Canada Coastguard	
Japan	1965	Fuji	328	I. B.	
USSR		(See Note 1)			
UK	1970	Bransfield	325	Antarctic Survey Ship	
USA	1943	Staten Island	269	I. B., USCG	Note 2
	1943	Westwind	269	I. B., USCG	
	1945	Northwind	269	I. B., USCG	
	1946	Burton Island	269	I. B., USCG	
	1946	Edisto	269	I. B., USCG	
	1954	Glacier	309	I. B., USCG	
	(1975)	Polar Star	400	I. B., USCG (under construction)	
	(1976)	Polar Sea	400	I. B., USCG (under construction)	
New Zealand	----	Endeavour	-		

Abbreviations:

I. B., Icebreaker

USCG, United States Coast Guard

NOTES:

(1) Many icebreakers and strengthened cargo and fishing vessels in national fleet. For instance, 12 to 15 icebreakers are routinely used on the Northern Sea Route while others may be simultaneously employed in oceanographic work.

Icebreakers and other vessels with limited research capability and/or limited availability to the scientific community. (continued)

NOTES: (continued)

(2) "Wind" Class icebreakers are being retired from service as follows:

Eastwind - 1969 (Purchased by Sun Oil Co. for Arctic oil exploration)

Southwind -1974 (Awaiting disposition)

Edisto - May 1975
Staten Island - May 1975
Burton Island - June 1976

Westwind - June 1979
Northwind - May 1980

Sources:

Oceanographic Vessels of the World, IGY World Data Center A for Oceanography, National Oceanographic Data Center.

Polar Record:

Arctic and Antarctic Research Institute, Leningrad

National Science Foundation

Scripps Institution of Oceanography

University-National Oceanographic Laboratory System

Compiled by R. Elsner, November, 1972; revised March, 1973; revised September 1974

APPENDIX D

AMERICAN BUREAU OF SHIPPING
RULES FOR BUILDING & CLASSING STEEL VESSELS
1974

SECTION 29

trengthening or Navigation in Ice

.1 Intent

This section is intended to detail the requirements for ice strengthening. At the owner's request, a vessel intended for class will be reviewed for "Ice Strengthening" Class A, B or C as detailed in Part I, Paragraphs 29.3 to 29.19 or, "Ice Strengthening" Class IAA, IA, IB or IC as detailed in Part II, Paragraphs 29.21 to 29.51.

It is the responsibility of the Owner to determine which ice class is most suitable for his intended service.

art I: Class A, B, C

9.3 General

Vessels constructed with special strengthening to one of the ice classes described in this part will be distinguished in the Record by the words "Ice Strengthening," followed by Class A, B or C to indicate the type of strengthening adopted. All vessels so designated are to be self-propelled, be equipped with an approved radiotelegraph or radiotelephone and are to comply with the other applicable Sections of these Rules. The requirements of this part apply to vessels constructed with transverse framing. Reinforcing of vessels with longitudinal framing will be specially considered to provide equivalent protection.

9.5 Special Requirements for Class A Strengthening

29.5.1 *Shell Plating*

The thickness of the shell from 508 mm (20 in.) above the winter load line to 508 mm (20 in.) below the lightest service waterline and for a length abaft the stem at least 10% greater than the distance from the stem to the point where the winter load line reaches its greatest breadth is to be 50% greater than the midship Rule thickness. Abaft this location and for the remainder of the length the thickness is to be at least 25% greater than the midship Rule thickness. Any of the bottom shell plating which may be within the lower vertical limit of the ice belt is to be of the same thickness as the belt plating in that location. The specified thicknesses need not

exceed 25 mm (1 inch), but are not to be less than 12 mm (0.48 in.) Where ships are of riveted construction, the seams and butts in the strengthened area are to be at least double riveted.

29.5.2 *Peak Frames*

Frames in the fore and after peaks are to have the same strength as the Rule midship frames and in the fore peak a shell stringer is to be located approximately 254 mm (10 in.) below the winter load line.

29.5.3 *Intermediate Frames*

Intermediate frames having the same strength as the Rule midship frames are to be fitted between the main frames throughout the length of the ship. These are to extend downward from a point not less than 626 mm (25 in.) above the winter load line to about 76 mm (3 in.) above the margin plate, to a point below the top of the floors where there is no double bottom or for the extent of the ice-belt shell plating if that be lower. The upper ends are to be attached to intercostal stiffeners between the main frames; however, if extended upward to the next deck, the end attachment may be sniped. In way of the area where the shell thickness has been increased 50%, all framing is to be attached to the shell with double continuous welding.

29.5.4 *Plate Stems*

Where a plate stem is fitted, the thickness to at least 626 mm (25 in.) above the winter load line is to be 65% greater than the midship Rule shell thickness, but need not exceed 25 mm (1 in.). Above this position the thickness may be gradually reduced to that of a normal plate stem at the upper deck. Plate stems are to be reinforced on the inside by a vertical centerline flat bar welded to the stem plate.

29.5.5 *Stern Frame*

The strength of the stern post, rudder post and the shoe or sole piece is to be increased 15% over that required by Section 4.

29.5.6 *Rudders and Steering Gears*

The strength of rudders and steering gears is to be increased over that required by Section 5. The thickness of rudder plates, horizontal and vertical diaphragms is to be increased 50%. The strength of pintles and gudgeons and any associated bolting arrangements to the stern frame, as well as the strength of the rudder stock, is to be increased 85%. Couplings and other parts of the steering gear are to be proportioned on the increased diameter of the upper stock.

29.7 Special Requirements for Class B Strengthening

29.7.1 *Shell Plating*

The thickness of the shell plating from 508 mm (20 in.) above the winter load line to 508 mm (20 in.) below the lightest service waterline and from the stem to the point where the winter load line reaches its greatest breadth is to be 50% greater than the midship Rule thickness. Abaft this location and for the same vertical extent the thickness may be gradually reduced to not less than a 15% increase at the stern. Any of the bottom shell which may be within the lower vertical limit of the ice belt is to be of the same thickness as the belt plating in that location. The specified thicknesses need not exceed 25 mm (1 in.) but are not to be less than 10 mm (0.40 in.). Where ships are of riveted construction, the seams and butts in the strengthened area are to be at least double riveted.

29.7.2 *Peak Frames*

Frames in the fore and after peaks are to have the same strength against bending as the Rule midship frames and in the fore peak a shell stringer is to be located approximately 254 mm (10 in.) below the winter load line.

29.7.3 *Intermediate Frames*

Intermediate frames having the same strength as the Rule midship frames are to be fitted between the main frames from the stem to at least 4 frame spaces abaft the point where the winter load line reaches its greatest breadth. These are to extend downward from a point not less than 626 mm (25 in.) above the winter load line to about 76 mm (3 in.) above the margin plate, to a point below the top of the floors where there is no double bottom, or for the extent of the ice-belt shell plating if that be lower. End attachments and welding are to be the same as required by 29.5.3.

29.7.4 *Plate Stems*

Where a plate stem is fitted, the thickness to at least 626 mm (25 in.) above the winter load line is to be 65% greater than the midship Rule shell thickness, but need not exceed 25 mm (1 in.). Above this position the thickness may be gradually reduced to that of a normal plate stem at the upper deck. Plate stems are to be reinforced on the inside by a vertical centerline flat bar welded to the stem plate.

29.7.5 *Stern Frame*

The strength of the stern post, rudder post and the shoe or sole piece is to be increased 10% over that required by Section 4.

29.7.6 *Rudders and Steering Gears*

The strength of rudders and steering gears is to be increased over that required by Section 5. The thickness of rudder plates, horizontal and vertical diaphragms is to be increased 25%. The strength of pintles and gudgeons and any associated bolting arrangements to the stern frame, as well as the rudder stock, is to be increased 40%. Couplings and other parts of the steering gear are to be proportioned on the increased diameter of the upper stock.

29.9 Special Requirements for Class C Strengthening

29.9.1 *Shell Plating*

The thickness of the shell plating from 508 mm (20 in.) above the winter load line to 508 mm (20 in.) below the lightest service load line and from the stem to the point where the winter load line reaches its greatest breadth is to be 25% greater than the Rule midship thickness. This increase is not to be less than 2 mm (0.08 inch) to the point where the winter load line reaches its greatest breadth, but the thickness need not exceed 25 mm (1 in.). Any of the bottom shell which may be within the lower vertical limit of the ice belt is to be of the same thickness as the belt plating in that location. Where ships are of riveted construction, the seams and butts in the strengthened area are to be at least double riveted.

29.9.2 *Peak Frames*

Frames in the fore and after peaks are to be of the same strength against bending as the Rule midship frames and in the fore peak a shell stringer is to be located approximately 254 mm (10 in.) below the winter load line.

29.9.3 *Intermediate Frames*

Intermediate frames having a strength equal to 75% of the Rule midship frames are to be fitted between the main frames from the stem aft to the point where the winter load line reaches its greatest breadth. These are to extend downward from a point 626 mm (25 in.) above the winter load line to about 76 mm (3 in.) above the margin plate, to a point below the top of the floors where there is no double bottom or, for the extent of the ice-belt shell plating, if that be lower. End attachments and welding are to be the same as required by 29.5.3.

29.9.4 *Shell Stringer*

In a single deck vessel a shell stringer is to be fitted abaft the fore peak bulkhead. This stringer is to be in line with the peak stringer (see 29.9.2) and is to extend aft to a point at least 4 frame spaces beyond the extent of the intermediate framing Alternatively, this stringer may be omitted if the intermediate frames are of the same strength as the main frames.

29.9.5 *Rudder Stock*

The strength of the rudder stock is to be increased 25% over that required by Section 5.

29.11 Sea Connections

Sea connections are to be so arranged as to minimize the risk that attends their attachment to plating which is subject to ice damage. Main injections are to be provided with steam connections for clearing the strainers.

29.13 Power for Propulsion Machinery

The power (SHP) delivered to the propeller shafting is to be at least equal to BCL.

Where L = length of ship, between perpendiculars, in meters or feet
B = breadth of ship, molded, in meters or feet
For use with metric units,
$C = 1.75$ Class A
$= 1.30$ Class B
$= 1.00$ Class C
For use with inch/pound units,
$C = 0.162$ Class A
$= 0.121$ Class B
$= 0.093$ Class C

29.15 Propulsion Shafting

The propulsion shafting and couplings are to be of steel and the diameters as required by the Rules for ocean service are to be increased by the percentages given in the following table:

Ice Class	A	B	C
Thrust and Intermediate Shafts	8%	4%	—
Tailshaft	15%	8%	5%

Special consideration will be given to minor departures from the above dimensions in special cases where the calculations of the torsional vibrations justify such a change.

29.17 Reduction Gears

Pinions, gears and gear shafts are to be designed to withstand a twisting moment of 125% of that normally required for ice-free service for Class A ice strengthening, and 115% for Class B.

29.19 Ice-strengthened Propellers

29.19.1 *Materials*

Propellers are to be of cast carbon or alloy steel or bronze having a tensile strength of not less than 46 kg/mm² or 65,000 psi.

29.19.2 *Propeller-blade Thickness*

Where propeller blades are of a standard design, the thickness of the blades at the one-quarter radius as determined by 37.5 is to be increased by the coefficient given in the following table:

Ice-strengthening Coefficients

Installed SHP	ICE CLASS A	B	C
3,000	1.30	1.20	1.13
4,000	1.27	1.18	1.12
5,000	1.25	1.17	1.12
7,000	1.21	1.13	1.08
9,000	1.18	1.09	1.06
11,000	1.16	1.06	1.03
13,000	1.14	1.05	1.00
15,000	1.12	1.03	1.00
17,000	1.10	1.00	1.00
19,000	1.09	1.00	1.00
21,000	1.08	1.00	1.00
27,000	1.05	1.00	1.00
32,000	1.03	1.00	1.00
over 32,000	1.00	1.00	1.00

Coefficients for intermediate horsepowers may be obtained by interpolation.

29.19.3 *Blade-tip Thickness*

The thickness t_a at the tip of the blade is to be not less than given by the following equations:

a If D is greater than 3.3 meters, then t_a (in mm) $= 6\ D$ in metric units. If D is greater than 10.84 feet, then t_a (in inches) $= 0.072\ D$ in inch/pound units.

b If D is not greater than 3.3 meters, then t_a (in mm) $= 3\ D + 10$ in metric units. If D is not greater than 10.84 feet, then t_a (in inches) $= 0.036\ D + 0.39$ in inch/pound units.

The blade thickness at any radius is not to be less than that given by a straight-line relationship between the thickness found from 29.19.2 and the tip thickness t_a. When the propeller material is an alloy steel or bronze whose tensile properties exceed 46 kg/mm² (65,000 psi), the propeller-blade tip dimension may be corrected proportionally by multiplying the above value of t_a by the square root of the ratio of 46 kg/mm² (65,000 psi) to the tensile strength of the propeller material. The propeller-blade tip may be tapered for a distance which is not to exceed 1.5 t_a measured from the tip of the blade.

29.19.4 *Other Design Criteria*

Special consideration will be given to propellers designed in accordance with other ice-strengthening criteria which are not less effective than these requirements.

Part II: Class IAA, IA, IB, IC

29.21 General

This part details ice strengthening requirements which are in agreement with the "Finnish-Swedish Ice Class Rules 1971," developed for ships trading in the northern Baltic in winter. Vessels constructed with special strengthening to one of the ice classes described in this part will be distinguished in the Record by the words "Ice Strengthening," followed by Class I AA, I A, I B, I C to indicate the type of strengthening adopted. All vessels so designated are to be self-propelled, be equipped with radio telephone (VHF) and are to comply with the other applicable sections of these Rules.

29.22 Ice Classes

Due to the variety of ice conditions to be met, the requirements for four different ice classes are detailed:

Class I AA is for navigation in extreme ice conditions.
Class I A is for navigation in severe ice conditions.
Class I B is for navigation in medium ice conditions.
Class I C is for navigation in light ice conditions.

It should be noted that not even vessels built to Class I AA can withstand heavy ice jamming, and that small vessels will be unable to navigate in as severe ice conditions as larger vessels having the same ice class due to their relative hull strength and lesser power.

29.23 Definitions

29.23.1 *Ice Belt*

The ice belt is that part of the shell plating which is to be reinforced (see 29.31 and 29.37.3).

29.23.2 *Load Waterline*

LWL is the winter load line. The *LWL* is to be clearly indicated on the shell expansion drawing.

29.23.3 *Ballast Waterline*

BWL is the ballast waterline. It is to be located so that the propeller, if possible, is wholly submerged and the draft forward takes into account a normal amount of fuel and a suitable amount of water ballast. The ballast waterline is to be indicated on the shell expansion drawing.

29.23.4 *Displacement*

The displacement Δ is the molded displacement in metric or long tons at the assigned summer load line. For the purposes of this section the displacement may be calculated using a specific gravity of 1.00.

29.23.5 *Shaft Horsepower*

The shaft horsepower *SHP* is the maximum continuous shaft horsepower.

29.25 Power of Propulsion Machinery

29.25.1 *General*

The shaft horsepower *SHP* is not to be less than determined by the equations in 29.25.2 below, and is not to be less than 3500 *SHP* for Class I AA and 1000 *SHP* for other ice classes. The minimum required *SHP* and the lower limits may be reduced by 10% if the vessel is fitted with a controllable-pitch propeller and reversible main machinery. For vessels fitted with steam turbine propulsion the astern power is to be at least 70% of the ahead *SHP*.

29.25.2 *Minimum Shaft Horsepower*

a *Class I AA*

$SHP = 0.400\,\Delta + 1500$, but need not exceed 25500 **Metric Units**
$SHP = 0.406\,\Delta + 1500$, but need not exceed 25500 **Inch/Pound Units**

b *Class I A*

$SHP = 0.350\,\Delta + 1000$, but need not exceed 22000 **Metric Units**
$SHP = 0.356\,\Delta + 1000$, but need not exceed 22000 **Inch/Pound Units**

c *Class I B*

$SHP = 0.300\,\Delta + 500$, but need not exceed 18500 **Metric Units**
$SHP = 0.305\,\Delta + 500$, but need not exceed 18500 **Inch/Pound Units**

d *Class I C*

$SHP = 0.250\,\Delta$, but need not exceed 15000 **Metric Units**
$SHP = 0.254\,\Delta$, but need not exceed 15000 **Inch/Pound Units**

where

Δ = displacement as defined in 29.23.4

29.27 Hull Strengthening Criteria

29.27.1 *General*

The scantlings of the frames, plating, decks and ice stringers in the ice belt are to be determined by the requirements and equations of 29.29 through 29.43 based on the pressure between the vessel's hull and the ice. The ice belt of the vessel is divided into the following regions, where *L* is the vessel's length in meters or feet as defined in Section 2. These regions are to be indicated on the shell expansion drawings.

a *Forward* From the stem to a line through the ice belt parallel to and $0.04L$ aft of the forward line of tangency of the parallel midbody (i.e., the forward end of the buttock line located at the maximum beam).

b *Midship* From the above defined line to a line parallel to and $0.04L$ aft of the after line of tangency of the parallel midbody.

29.29 Transverse Framing

The transverse main and intermediate frames in association with the plating to which they are attached are to have section moduli SM as determined by the following equation.

$$SM = 1250\, ps\, (l-0.4)/Y \text{ cm}^3$$

$$SM = 709\, ps\, (l-1.31)/Y \text{ in.}^3$$

where

p = pressure in the appropriate region, as per 29.27.2, in kg/cm^2 or psi

s = frame spacing in meters or feet

l = span in meters or feet, measured along the frame

Y = minimum yield stress of the material in kg/mm^2 or psi

Where the span l of a frame traverses two regions, the higher pressure, as determined from the equations given in 29.27.2, is to be used. Where end connections of intermediate frames differ from those of the main frames, giving different spans, the mean span is to be used when determining main and intermediate frames. See 29.39.2 and Figs. 29.1, 29.2 and 29.3.

29.31 Vertical Extension of Transverse Framing

29.31.1 *General*

The minimum vertical extension in meters (feet) of transverse ice framing is to be in accordance with the following:

	above LWL, meters (feet)	below BWL, meters (feet)
Class I AA		
From stem to 0.3L	1.2 (4.0)	to double bottom or below top of floors
0.3L through Midship Region	1.2 (4.0)	1.6 (5.25)
Aft Region	1.2 (4.0)	1.2 (4.0)
Classes I A, I B and I C		
From stem to 0.3L	1.0 (3.25)	1.6 (5.25)
0.3L through Midship Region	1.0 (3.25)	1.3 (4.0)
Aft Region	1.0 (3.25)	1.0 (3.25)

29.31.2 *Upper End of Framing*

a *Not Terminating At or Above a 'Tween Deck* Where not terminating at or above a 'tween deck, as indicated below in **b** and **c**, the upper end of intermediate frames is to be extended to the deck above or is to be attached to an ice stringer as per 29.39.2. See Fig. 29.1.

c *Aft* From the after boundary of the midship region defined above to the stern.

29.27.2 *Ice Belt Pressure*

For the four ice classes the pressure p in the appropriate region of the ice belt is to be obtained from the following equations.

a ***Forward***

Class I AA	$p = 6.4 + 0.73k$	max p = 16.5 kg/cm^2
	$p = 91 + 10.38k$	max p = 234.5 psi
Class I A	$p = 5.8 + 0.64k$	max p = 15.0 kg/cm^2
	$p = 82.5 + 9.1k$	max p = 213.5 psi
Class I B	$p = 5.2 + 0.55k$	max p = 13.5 kg/cm^2
	$p = 74 + 7.8k$	max p = 192 psi
Class I C	$p = 4.6 + 0.46k$	max p = 12.0 kg/cm^2
	$p = 65.4 + 6.54k$	max p = 171 psi

b ***Midship***

Class I AA	$p = 5.7 + 0.21k$	max p = 8.6 kg/cm^2
	$p = 81 + 3.0k$	max p = 122.5 psi
Class I A	$p = 4.6 + 0.14k$	max p = 6.9 kg/cm^2
	$p = 65.4 + 2.0k$	max p = 98.0 psi
Class I B	$p = 3.5 + 0.07k$	max p = 4.6 kg/cm^2
	$p = 49.8 + k$	max p = 65.5 psi
Class I C	p = 2.4 kg/cm^2	
	p = 34.1 psi	

c ***Aft***

Class I AA	$p = 4.6 + 0.13k$	max p = 6.3 kg/cm^2
	$p = 65.4 + 1.85k$	max p = 89.5 psi
Class I A	$p = 3.5 + 0.09k$	max p = 4.6 kg/cm^2
	$p = 49.8 + 1.28k$	max p = 65.5 psi
Class I B	$p = 2.4 + 0.05k$	max p = 2.9 kg/cm^2
	$p = 34.1 + 0.71k$	max p = 41.0 psi
Class I C	p = 1.2 kg/cm^2	
	p = 17.1 psi	

where

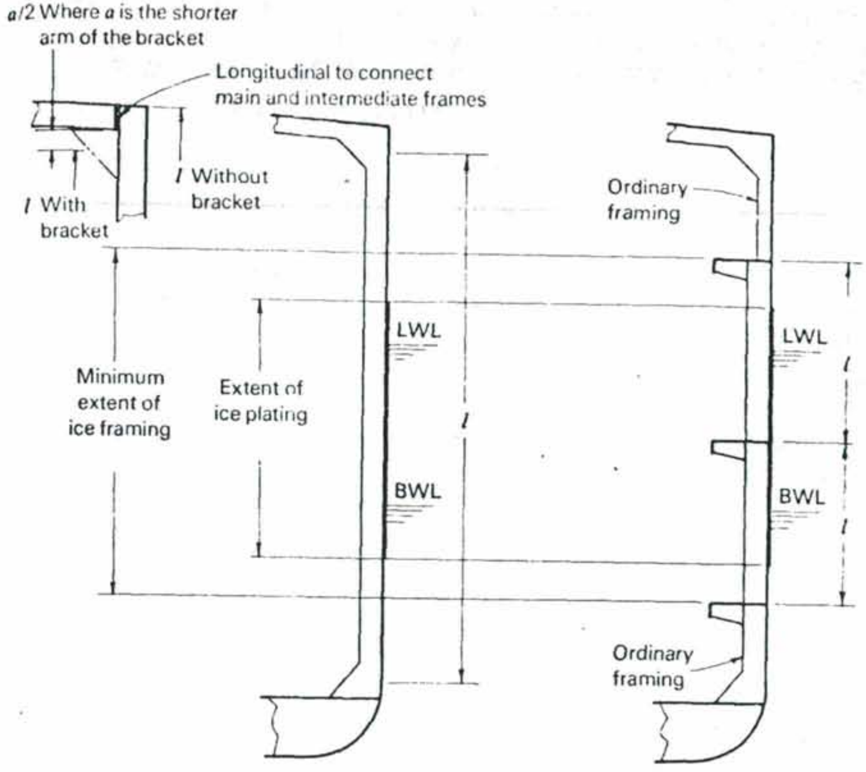
$k = \sqrt{(\Delta SHP)}/1000$ **Metric Units**

$k = \sqrt{1.016(\Delta SHP)}/1000$ **Inch/Pound Units**

Δ, SHP = as defined in 29.23

Note 1 Where a calculated p value exceeds the maximum, the latter may be used.

Note 2 The k and p values used are to be stated on the shell expansion and framing plans.



Without ice stringers

With ice stringers

Fig. 29.1

b ***Terminating 1.0 m (3.25 ft) or Less Above a 'Tween Deck*** Where the ice framing terminates 1.0 m (3.25 ft) or less above a 'tween deck, the above-deck part of the frames may have the scantlings of 'tween deck frames as required by Section 8. The upper ends of intermediate frames are to be connected to the adjacent main frames by longitudinals having the same scantlings as the main frames. See Fig. 29.2. Where the ice framing terminates less than 250 mm (9.84 in.) above a 'tween deck, the intermediate frames may be omitted above the 'tween deck.

c ***Terminating more than 1.0 m (3.25 ft) Above a 'Tween Deck*** Where the ice framing terminates more than 1.0 m (3.25 ft) above a 'tween deck, the ends of main and intermediate 'tween deck frames are to be attached to an ice stringer or are to be extended to the deck above, in which case the section modulus SM is to be not less than that determined from the following equation.

$$SM = 5000\, dsp\, (l-0.4)\, (l-d)/Yl^2 \qquad \text{cm}^3$$
$$SM = 2835\, dsp\, (l-1.31)\, (l-d)/Yl^2 \qquad \text{in.}^3$$

where

d is in meters or feet as indicated in Fig. 29.3 and s,p,l,Y are as defined in 29.29. For Class I AA, $d+0.25$ m ($d+0.84$ ft) is to be used. If d or $d+0.25$ ($d+0.84$) exceed $l/2$, the equation in 29.29 is to be used. Where d is $\leq l/3$, the ends of intermediate frames may terminate not more than 25 mm (1.0 in.) from the deck and need not be connected by a longitudinal. See Fig. 29.3.

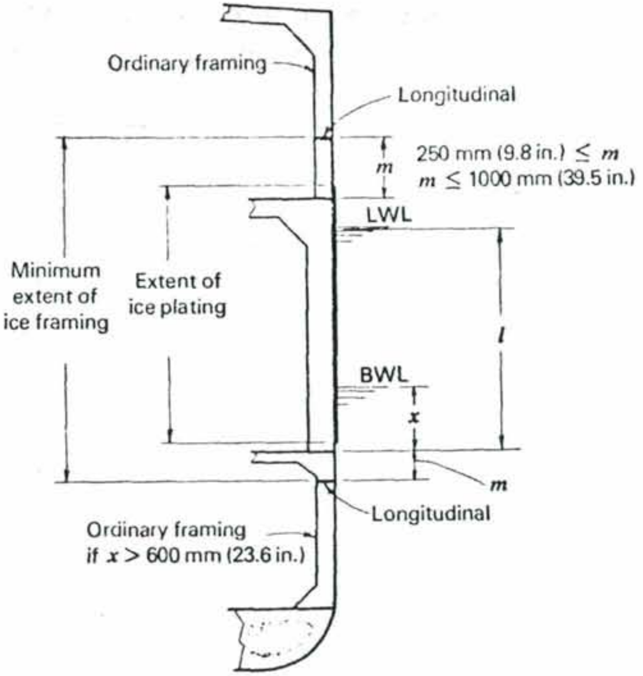


Fig. 29.2

29.31.3 *Lower End of Framing*

a ***General*** The lower ends of intermediate framing are, except in **b** below, to be extended to approximately 25 mm (1.0 in.) above the margin plate, to a corresponding distance below the top of floors, or are to be attached to a tank top, deck or ice stringer. The ends are to be connected to adjacent brackets, floors or main frames by longitudinals having the same scantlings as the main frames. See Fig. 29.3.

b ***Terminating Less than 1.0 m (3.25 ft) Below a Deep-tank Top*** Where the ice framing terminates less than 1.0 m (3.25 ft) below a deep-tank top, a deck or an ice stringer, the intermediate frame ends may be attached to adjacent main frames by longitudinals as in **a** above. Where the distance is less than 0.25 m (0.84 ft), intermediate frames may terminate at a deep tank top or a deck. See Fig. 29.2.

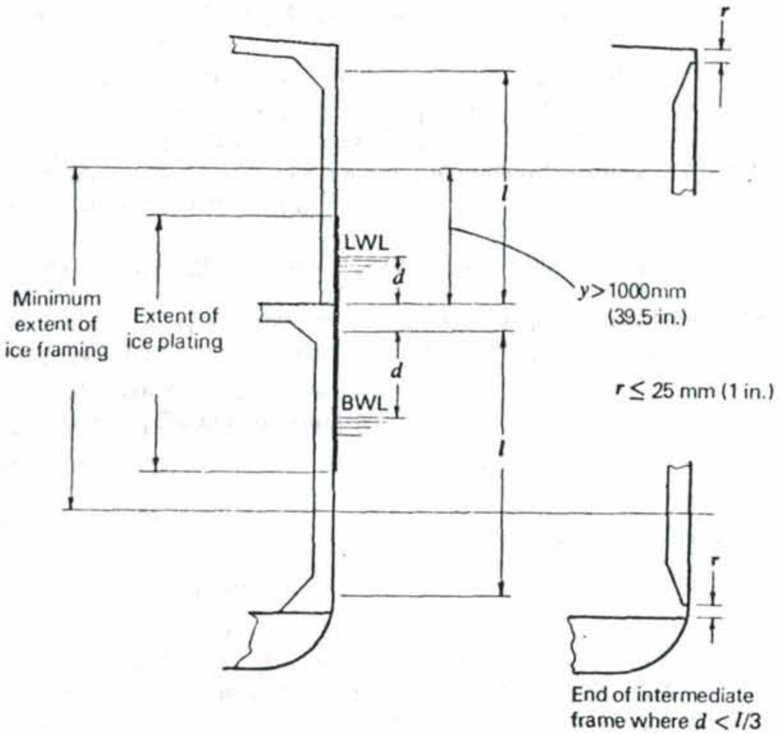


Fig. 29.3

c *Alternate Section Modulus* Where appropriate, the equation in 29.31.2c may be used in determining the required *SM*. See also Fig. 29.3.

d *Additional Lower-end Requirements* In general, ice strengthened main frames are to extend to the bottom construction, but main frames below a deck, deep-tank top or ice stringer situated at least 600 mm (23.6 in.) below the *BWL* need only be of the scantlings as required elsewhere in these Rules. In twin-screw vessels, three intermediate frames forward of and three aft of the propeller plane of rotation are to extend to the double bottom. The different parts of a frame are to be effectively welded. Frames are to be attached effectively to the decks and ice stringers through which they pass.

29.33 Longitudinal Framing

The section moduli *SM* of longitudinal main or intermediate frames, in association with the plating to which they are attached, are to be

---

obtained from the following equation.

$SM = 769\, p_2 l^2 s/Y$ cm³ $\qquad SM = 133\, p_2 l^2 s/Y$ in.³

where

$p_2 = 0.64p$ in the forward region
$\quad = 0.70p$ in the midship and aft regions
p, l, s, Y = as defined in 29.29

The end connections of intermediate frames are to be the same as for main frames. Intermediate frames are to be fitted above the upper edge and below the lower edge of the ice belt, strengthening the area to the same vertical extent as with transverse framing. (See 29.31).

29.35 Additional Framing Requirements

29.35.1 *Tripping Arrangements*

Main and intermediate frames calculated for a pressure *p* exceeding 4.6 kg/cm² (65.5 psi) are to be supported by stringers, intercostal brackets or similar arrangements in order to prevent tripping. The distance between the tripping arrangements is not to exceed 1.30 m (4.25 ft).

29.35.2 *Scalloped Framing*

Main and intermediate frames, calculated for a pressure *p* equal to or exceeding 4.6 kg/cm² (65.5 psi), are not to be scalloped except at shell plating seams or butts, and are to be attached to the shell plating by double continuous welds. The thickness of the frames is to be at least one-half that of the attached shell plating with a minimum of 10 mm (0.40 in.).

29.35.3 *Bulkhead or Platform Deck*

Where, in lieu of an ice-strengthened main or intermediate frame, a bulkhead or a platform deck is fitted, the thickness of which is less than that of the omitted frame, the bulkhead or platform border plate is to be made of steel plate at least as thick as the frame and wide enough so that the border-plate section is equal to that of the frame.

29.37 Shell Plating

29.37.1 *Thickness with Transverse Framing*

The thickness of shell plating in association with transverse framing is to be obtained from the following equation.

$t = (s/15)(\sqrt{p_3/Y}) + 2$ mm $\qquad t = (2s/3)(\sqrt{p_3/Y}) + 0.08$ in.

where

t = the thickness of the shell plating in millimeters or inches
$p_3 = 1.2\,p\,(1.1 - s/3000)$, but need not exceed 16.5 kg/cm²
$\quad = 1.2\,p\,(1.1 - 0.0085s)$, but need not exceed 234.5 psi
p, Y = as defined in 29.29
s = spacing of the frames in millimeters or inches

29.37.2 *Thickness with Longitudinal Framing*

The thickness of shell plating in association with longitudinal framing is to be obtained from the following equation.

$$t = (s/15)(\sqrt{p_1/Y}) + 2 \text{ mm} \qquad t = (2s/3)(\sqrt{p_1/Y}) + 0.08 \text{ in.}$$

where

p_1 = $1.4p$ in the forward region

= $1.2p$ in the midship and aft regions, but need not exceed 16.5 kg/cm² (234.5 psi)

s = spacing of the frames in millimeters or inches

p, t, Y = as defined in 29.29

29.37.3 *Vertical Extension of Plating*

The vertical extension of the ice belt is to be as follows:

Ice Class	Above LWL	Below BWL
I AA	750 mm (29.5 in.)	600 mm (23.6 in.)
I A	600 mm (23.6 in.)	500 mm (19.5 in.)
I B, I C	500 mm (19.5 in.)	500 mm (19.5 in.)

29.37.4 *Bottom Plating and Floors*

The bottom plating and floors in the forward region are to be adequately strengthened where the distance from the lower edge of the ice belt to the keel plate is less than 1.5 m (4.92 ft) or where the draft is less than 1.5 m (4.92 ft).

29.37.5 *Changes in Plating Thickness*

Changes in plating thicknesses in the longitudinal direction are to be gradually tapered.

29.39 Decks and Ice Stringers

29.39.1 *Decks Adjacent to Hatchways and Supporting Ice Framing*

a ***Deck Strength*** The required SM of decks that are adjacent to hatchways and support ice framing is to be obtained from the following equation.

$$SM = 455\, pKl^2/Y \text{ cm}^3 \qquad SM = 258\, pKl^2/Y \text{ in.}^3$$

where

p and Y are as defined in 29.9

l = unsupported length of the longitudinal member in meters or feet

$$\left.\begin{aligned} K &= 1.1 - l/10 \text{ where } l \text{ is in meters} \\ &= 1.1 - l/32.8 \text{ where } l \text{ is in feet} \end{aligned}\right\} \begin{aligned} &(K \text{ max.} = 1.0) \\ &(K \text{ min.} = 0.7) \end{aligned}$$

The product pK is not to be taken as less than 7 kg/cm² (100 psi) in the above equation.

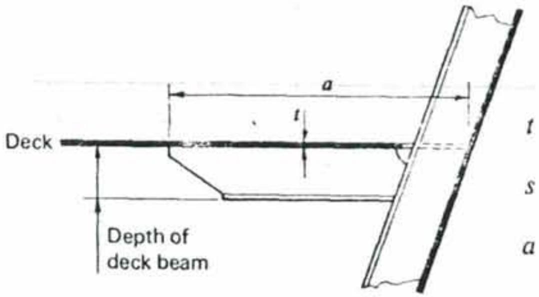
b ***Shear Area of Supporting Member*** The shear area of the supporting member is to be not less than obtained from the following equation.

$$A = 42\, pKl/Y \text{ cm}^2 \qquad A = 199\, pKl/Y \text{ in.}^2$$

where

p, l, K, Y and pK are as defined in **a** above

If $pK \geq (4800t^3/s^2)$ kg/cm² [$pK \geq (1733700t^3/s^2)$psi], the intermediate frames are to be supported also at the deck in accordance with Fig. 29.4.



t = thickness of deck plating, mm or in.

s = deck beam spacing, mm or in.

$a \geq 150 + 60\, pK$ mm

$\geq 5.9 + 0.166\, pK$ in.

Fig. 29.4

29.39.2 *Ice Stringers*

a ***General*** The section moduli SM of ice stringers where provided in association with web frames are to be not less than obtained from the equation in 29.39.1 above with l being equal to the distance in meters (feet) between web frames, and with the product pK being not less than 5 kg/cm² (71 psi). The ice framing is to be attached by brackets or similar arrangements to the stringers. Tripping brackets are to be fitted, and are to be spaced to satisfy the following equation. See Fig. 29.5.

$$pK \leq 4800t^3/b^2 \text{ kg/cm}^2 \qquad pK \leq 1733700t^3/b^2 \text{ psi}$$

where

t = thickness of stringer, mm or in.

b = distance between brackets, mm or in.

pK = not less than 5 kg/cm²(71 psi)

p, K = as defined in 29.19.1a

Fig. 29.5

b ***Web Frames Supporting Stringers*** The section modulus SM of web frames supporting ice stringers or longitudinal frames is to be not less than obtained from the following equation.

$$SM = 800\, pKsZ/Y \text{ cm}^3 \qquad SM = 453\, pKsZ/Y \text{ in.}^3$$

where

s = the sum of half lengths in meters or feet (on each side of the web frame) of the members supported

Z = span of web frame in meters or feet

$K = 1.1 - s/10$ where s is in meters $\big\}$ K max. = 1.0

$K = 1.1 - s/32.8$ where s is in feet $\big\}$ K min. = 0.7

pK = not less than 5 kg/cm^2 (71 psi)

p, Y = as defined in 29.39.1a

The required shear area of a web frame supporting one stringer is the same as required for the stringer. For a web frame supporting several ice stringers or longitudinal frames, the largest shear area required for one stringer is to be increased 50%.

c *Frame Span* Where ice stringers are fitted, the span l in the equation in 29.29 for determining main and intermediate frames may be taken as the distance between ice stringers or between stringer and deck.

29.41 Stem and Stern Frame

29.41.1 *Stem*

a *Material and Shape* The stem is to be made of rolled, cast or forged steel, or of shaped steel plates. A stem such as that shown in Fig. 29.6 improves the ability to cut into ice, in particular when the length of the vessel is less than 150 m (492 ft).

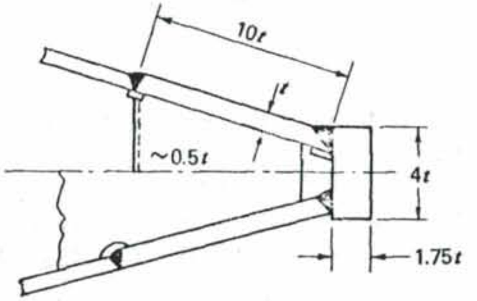


Fig. 29.6

b *Section Modulus* The section modulus SM of the stem in the fore-and-aft direction is not to be less than obtained from the following equation.

$$SM = 22\sqrt{p^3} \text{ cm}^3 \qquad SM = 0.025\sqrt{p^3} \text{ in.}^3$$

where

p = ice pressure as defined in 29.27.2 for the forward region

1 The dimensions of a welded stem as per Fig. 29.6 may be obtained from the following equation.

$$t = 7.6\sqrt{p} \text{ mm} \qquad t = 0.0793\sqrt{p} \text{ in.}$$

where

t = thickness of the side plates in millimeters or inches

p = ice pressure from 29.27.2 for forward region

The reinforced stem is to be extended from the keel plate up to 750 mm (29.5 in.) above the *LWL* and is to be internally strengthened by floors, brackets or webs having a thickness of at least $t/2$ mm or inches, spaced no more than 600 mm (23.6 in.) apart.

2 The plate thickness of a shaped plate stem or a bulbous bow is to be obtained from the following equation.

$$t = 0.08s\,(\sqrt{p_1/Y}) + 2 \text{ mm} \qquad t = (4s/5)\,(\sqrt{p_1/Y}) + 0.08 \text{ in.}$$

where

$p_1 = 1.4p$ for the forward region

s = the distance in mm or inches between horizontal webs or diaphragm plates having a thickness of at least $t/2$ mm (in.)

Y = as defined in 29.29

Where the radius of the stem or bulbous bow in the ice belt is large, one or more vertical stiffeners are to be fitted to meet the section modulus requirements.

c *Arrangement* The dimensions of the stem may be tapered to the requirements of Section 4 at the upper deck. The connections of the shell plating to the stem are to be flush.

d *Bow Chock* A closed towing chock with an opening of not less than 250 by 300 mm (10 x 12 in.) and a rounding radius not less than 100 mm (4 in.) of inner surfaces at least 150 mm (6 in.) wide is to be fitted in the centerline of the bow bulwark for towing purposes. A bitt or other suitable means of securing the line is to be fitted.

29.41.2 *Stern Frame*

a *Increased Strength* Where the tail-shaft diameter is increased over the Rule required diameter as detailed in 29.49.2, the inner post is to be correspondingly strengthened.

b *Bossings and Shaft Struts* Shafting and stern tubes of vessels with two or more propellers are to be enclosed within plated bossings. Detached supporting struts should be avoided; however, when necessary, their design, strengthening and attachment to the hull are to be specially considered.

29.43 Rudder and Steering Arrangements

29.43.1 *Minimum Speed for Increased Strength*

The rudder post, rudder head, pintles, steering gear, etc. are to be in accordance with Section 5; however, the speed used in determining the scantlings is not to be less than indicated below. If the actual maximum service speed of the vessel is higher than the following values, the maximum speed is to be used in the appropriate equations.

Class	Minimum Speed
I AA	20 knots
I A	18 knots
I B	16 knots
I C	14 knots

29.43.2 *Double Plated Rudders*

For double-plated rudders the minimum thickness of plates and horizontal and vertical webs in the ice-belt region is to be determined as for shell plating in the aft region in accordance with 29.37.

29.43.3 *Rudder and Steering Gear Protection*

The rudder head and the upper edge of the rudder are to be protected against ice pressure by an ice knife or equivalent means for Classes I AA and I A. Efficient rudder stoppers, a slip coupling or equivalent arrangements are to be fitted to protect the steering gear against excessive external loading.

29.45 Determination of Ice Torque for Propulsion Systems

The dimensions of gears, shafting and propellers as determined from the following subsections take into account the impact that occurs when a propeller blade hits ice. The increased loading that results is designated the ice torque M, and is determined from the following equation.

$$M = mD^2 \text{ ton meters or ton feet}$$

where

D = propeller diameter, meters or feet
m = value from the following table

Class	Metric Units	Inch/Pound Units
I AA	2.15	0.645
I A	1.60	0.480
I B	1.33	0.399
I C	1.22	0.366

29.47 Propellers

29.47.1 *Propeller Section*

a ***Width and Thickness*** The thickness T and width W of propeller blade sections are to be determined from the following equations.

1 *At the 0.25 radius for solid propellers*

$$WT^2 = [270/U(0.65 + 0.7\,P_{0.25})]\,[(200H/NR) + 220\,M] \quad \text{cm}^3$$
$$WT^2 = [27000/U\,(0.65 + 0.7\,P_{0.25})]\,[(176H/NR) + 59.134M] \quad \text{in.}^3$$

2 *At the 0.35 radius for controllable-pitch propellers*

$$WT^2 = [215/U\,(0.65 + 0.7\,P_{\text{nominal}})]\,[(200H/NR) + 230M] \quad \text{cm}^3$$
$$WT^2 = [21500/U\,(0.65 + 0.7\,P_{\text{nominal}})]\,[(176H/NR) + 61.822M] \quad \text{in.}^3$$

3 *At the 0.6 radius for all propellers*

$$WT^2 = [95/U\,(0.65 + 0.7\,P_{0.6})]\,[(200H/NR) + 280M] \quad \text{cm}^3$$
$$WT^2 = [9500/U\,(0.65 + 0.7\,P_{0.6})]\,[(176H/NR) + 75.261M] \quad \text{in.}^3$$

where

T = maximum thickness at the appropriate radius from propell drawing, cm or in.
W = expanded width of a cylindrical section at the appropria radius, cm or in.
H = maximum continuous shaft horsepower (See 29.25)
N = number of blades
R = rpm at the maximum continuous rating
P = pitch at the appropriate radius divided by the propeller diamete (For controllable-pitch propellers, the nominal value of pitc is to be used)
U = tensile strength of propeller material, kg/mm² or psi
M = ice torque as defined in 29.45

b ***Blade Tip Thickness*** The minimum blade thickness t_a in mill meters or inches at the tip of the blade is to be determined from th following equations.

1 *For Class I AA*

$$t_a = (20 + 2D)\,\sqrt{46/U} \quad \text{mm}$$
$$t_a = (0.787 + 0.024D)\,\sqrt{65000/U} \quad \text{in.}$$

2 *For Classes I A, I B and I C*

$$t_a = (15 + 2D)\,\sqrt{46/U} \quad \text{mm}$$
$$t_a = (0.591 + 0.024D)\,\sqrt{65000/U} \quad \text{in.}$$

where

D = propeller diameter, meters or feet
U = tensile strength of the propeller material, kg/mm² or psi

29.47.2 *Additional Requirements*

a ***Other Sections*** The thicknesses of propeller sections at radii inter mediate to those required by 29.47.1 are to be determined from fair curve connecting the required section thicknesses.

b ***Rule Required Thickness*** Where the blade thickness derive from the equations in 29.47.1 is less than the required thickness detaile in Section 37, the latter is to be used.

c ***Blade Edges*** The thickness of blade edges is not to be less than 50% of the required tip thickness t_a measured at a point 1.25 t_a from the leading edge for controllable-pitch propellers, and from each edge for solid propellers.

d ***Controllable-pitch Propeller Bosses*** The strength of the internal mechanisms of controllable-pitch propellers is to be at least 1.5 times that of the blade when a load is applied at the 0.9 radius in the weakest direction of the blade.

29.49 Shafting and Reduction Gears

29.49.1 *Line and Thrust Shafts*

The diameter of line shafts and thrust shafts in external bearings as determined by the appropriate equation in Section 33 or 34 is to be increased by at least 10% for Class I AA. No strengthening is required for Classes I A, I B and I C.

29.49.2 *Tail Shaft*

The diameter T_s of the tail shaft at the aft bearing is not to be less than obtained from the following equation.

$$T_s = 1.08\sqrt[3]{UWT^2/Y}$$

where

T_s = required tail-shaft diameter, cm or in.
WT^2 = value derived for the propeller blade section at the 0.25 radius, see 29.47.1a1
U = tensile strength of the propeller material, kg/mm^2 or psi
Y = yield strength of the shaft material, kg/mm^2 or psi

If the diameter of the propeller boss is greater than $0.25D$, the tail-shaft diameter T_s is to be determined from the following equation.

$$T_s = 1.15\sqrt[3]{UWT^2/Y}$$

where

WT^2 = propeller section value derived from 29.47.1a2
T_s, U, Y = as defined above

29.49.3 *Reduction Gears*

Pinions, gears and gear shafts are to be designed to withstand an increase in torque over that normally required for ice-free service as follows:

Class	% Increase in Torque
I AA	50
I A	25
I B	15
I C	0

29.51 Additional Ice-strengthening Requirements

29.51.1 *Starting Air Systems*

The capacity of air receivers, compressor and other starting equipment is to be sufficient for frequent starts within periods lasting several hours.

29.51.2 *Sea Inlet Chests*

At least one large cooling-water inlet chest is to be connected to the cooling-water discharge pipe line by a branch pipe line having the main pipe-line diameter, in order to stay free from ice and slush ice. An inlet chest situated well aft in the garboard strake is recommended.

UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

ANNEX II

to the Charter

National Oceanographic Facilities

1. In addition to regular institutional UNOLS facilities there may be identified National Oceanographic Facilities, defined as those facilities, specialized and otherwise, that are made available for the use of qualified scientists from any institution and the use of which shall be determined by a UNOLS Review Committee.

2. A research vessel or other research facility may be designated as a National Oceanographic Facility upon the approval of the UNOLS Membership after review by the UNOLS Advisory Council, with the concurrence of the owner and operator of the facility and with reasonable assurance of support. National Oceanographic Facilities may be multi- or special purpose facilities and may be designated for the entire annual operating period or any significant period thereof.

3. The purpose of National Oceanographic Facilities is:

    - To provide oceanographic vessel and other facility support to scientists who do not operate or have available the required facilities.

    - To provide for the support and use in academic research of specialized and unique facilities.

4. A Review Committee for each facility shall be established for the purpose of considering proposals for facility use and for recommending programs to be scheduled. Members of the Committee shall be nominated by the UNOLS Advisory Council and shall be appointed by UNOLS. Members shall serve for terms of three years on a rotating basis. Each institution operating a National Oceanographic Facility may designate an ex-officio member in addition to those members appointed by UNOLS. The Review Committee shall elect its own Chairman from among the members appointed by UNOLS.

5. In recommending the allocation of facility time the Review Committee shall act primarily on the scientific merit of the proposed research and its compatibility with the individual facility.

6. Operational scheduling of the facility will be the function of the operating institution The time frame for scheduling generally shall be in accordance with Annex I of the UNOLS Charter.

7. Information and announcements advertising the availability of a National Oceanographic Facility will be a joint function of the operating institution and the UNOLS Office.

8. Receipt, acknowledgement, collating and structuring of requests for facility use will be the function of the operating institution in consultation with the UNOLS Office.

9. An annual report to UNOLS on the use of each National Oceanographic Facility will be prepared by the appropriate operating institution in cooperation with the Review Committee and UNOLS Office.

10. Requests for funding the operation of the facility will be the responsibility of the operating institution.

Approved and adopted: May 5, 1972, College Station, Texas