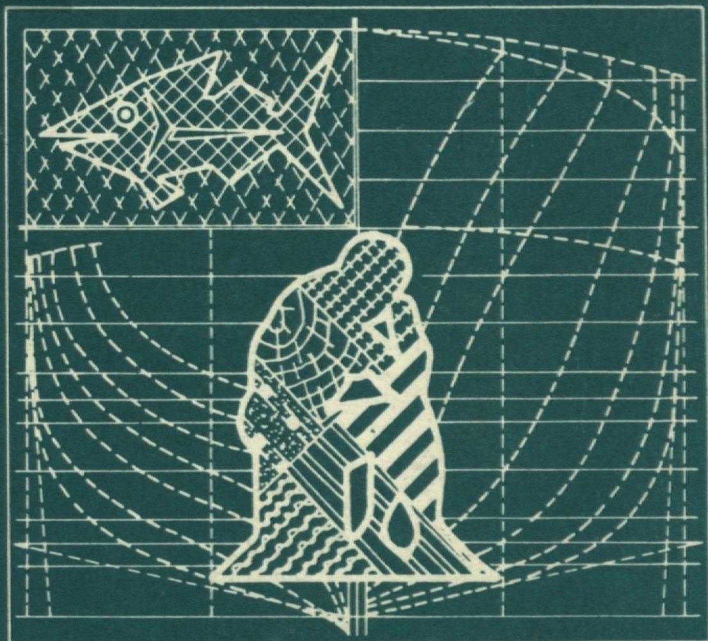
CANADIAN FISHERIES REPORTS NO. 12, JUNE 1969

# Proceedings
# conference on fishing vessel construction materials





montreal,
canada,
october 1-3,
1968

SPONSORED BY THE FEDERAL-PROVINCIAL ATLANTIC FISHERIES COMMITTEE

Secretariat: Industrial Development Branch
Fisheries Service,
Department of Fisheries and Forestry,
Ottawa

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*Canadian Fisheries Reports* is published under the authority of the Minister by the Department of Fisheries and Forestry of Canada, as a means of providing for circulation of specialized information of interest to the fishing industry, from the primary enterprise to the end product. Articles may deal with conservation, inspection, development, economics and related subjects. Responsibility for statements made or conclusions reached in published articles remains with the authors. Correspondence should be addressed to the DIRECTOR, INFORMATION AND CONSUMER BRANCH, FISHERIES SERVICE, DEPARTMENT OF FISHERIES AND FORESTRY, OTTAWA, CANADA. This issue is devoted exclusively to the proceedings of the Conference on Fishing Vessel Construction Materials, held in Montreal, October 1-3, 1968.

Published under Authority
of
HON. JACK DAVIS, M.P.
Minister of Fisheries and Forestry

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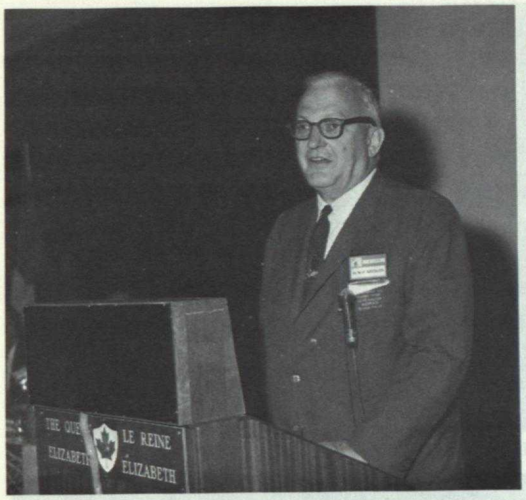
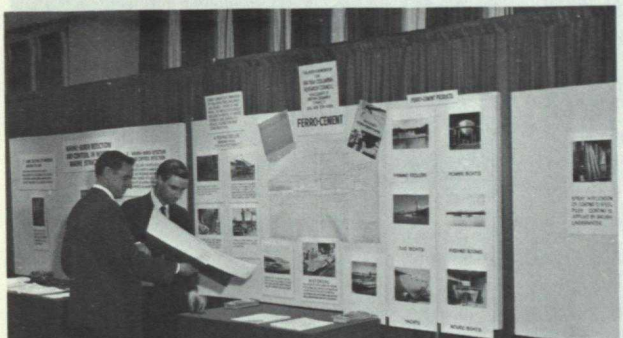
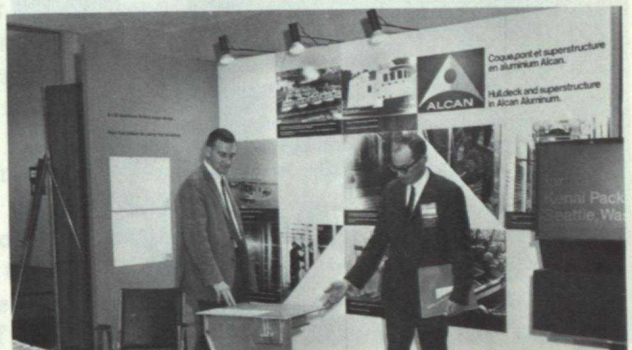
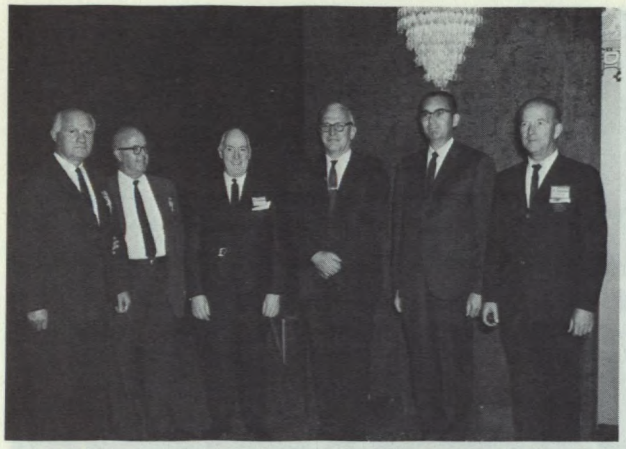



Upper left, Dr. A. W. H. Needler, Deputy Minister of Fisheries and Forestry, General Chairman of Conference; upper right, part of the conference room; left centre, examining a model of a 97-foot GRP combination fishing vessel are, l. to r., L.S. Bradbury, Chairman of the Conference Co-ordinating Committee, Dr. C. R. Barrett, President of the College of Fisheries, Navigation, Marine Engineering and Electronics, St. John's, Nfld., Walter Scott, Department of Fisheries and Forestry, and Jan-Olof Traung, FAO, Rome; right centre, fiberglas exhibit; lower left, ferro-cement exhibit; lower right, Alcan exhibit.




Upper left, members of the Federal-Provincial Atlantic Fisheries Committee. l. to r., Eric M. Gosse, St. John's, Nfld., Eugene Gorman, Charlottetown, P.E.I., Maurice Lessard, Quebec, P.Q., Dr. A.W.H. Needler, Ottawa, Dr. Leonce Chenard, Fredericton, N.B., Brian Meagher, Halifax, N.S.; upper right, Dr. A.W.H. Needler, left, sounding the bell for the banquet highlighting the social side of the Conference. Others are, l. to r., Captain James Thompson, Lossiemouth, Scotland, L.S. Bradbury, Ottawa, Hon. J.W. Pickersgill, President, Canadian Transport Commission, who was the banquet speaker, Captain Merrill Rodgerson, Shelburne Co., N.S., and Hon. J.M. Harding, Nova Scotia Minister of Fisheries; left centre, l. to r., W.J. Milne, W.G. Scott, W.E. Bonn and D.J. Fraser; right centre, l. to r., L.S. Bradbury, Chairman of Conference Co-ordinating committee, and Robert Hart, General Secretary of Conference; lower left, some members of the Secretariat, l. to r., J. Clark, Mrs. G. Ardouin, Mrs. M. Fitzpatrick, Miss Theresa Faille, Mrs. C. Martin, and Miss Rita Benoit; lower right, Mrs. M. Somerville of the Secretariat and part of the mountain of conference documents.

# Chairman's Opening Remarks

*Dr. A.W.H. Needler,* Deputy Minister of Fisheries and Forestry: Mr. Pro-Mayor, distinguished guests, ladies and gentlemen. It is my privilege on behalf of the Federal-Provincial Atlantic Fisheries Committee to welcome you to this Conference on Fishing Vessel Construction Materials. Many of us have happy recollections of our visit to Montreal when we held the Fishing Vessel Conference just over two years ago. I know I speak for all who are present when I say that this city abundantly reflects the very well known Quebec phrase "Hospitalité par excellence" or, as it is sometimes translated into English, "Hospitality spoken here". We have with us today Mr. Leonard Leblanc, the representative of the Mayor, who is unable to attend, and I should like to call on him now to say a few words.

*Mr. Leblanc:* Thank you, Mr. Chairman. Mr. Lessard, representatives of the provincial governments, ladies and gentlemen. I am pleased on behalf of His Worship to welcome here today the participants in the Conference on Fishing Vessel Construction Materials. The fishing industry is, in many countries of the world, one of the most important to their economy. It gives employment to many millions of people and provides us with essential food, a requirement of every nation. The modern fishing industry today requires fishing vessels of all kinds, where construction materials are of utmost importance. Here in Canada we have the natural resources and industrial facilities to produce most of these materials, and this Conference will give us a more comprehensive view of this particular aspect of the fishing industry. Thank you.

*Dr. Needler:* Ladies and gentlemen; this is the fourth conference of this magnitude or nearly this magnitude which has been brought together by the Federal-Provincial Atlantic Fisheries Committee. I think that a word of explanation is needed. At the last conference we had there was some question as to the nature of this body and of the background for the conference itself. Our Atlantic Coast has many thousands of fishermen and, more than any other part of Canada, has fishermen who have been living in fishing communities for many decades, or indeed centuries, and who consequently have perhaps been a bit conservative. Many of these fishing communities are not very prosperous, and indeed it is one of the concerns of everybody in Canada that they should be given means of a good livelihood. It is for this reason that not only the Federal but also the Provincial Governments of the five Atlantic Coast Provinces have been much interested in fisheries development. They have attempted to introduce methods which are more efficient in the catching of fish and processing methods, and to explore for additional stocks of fish which may be put to use. One of the means toward this end has been a series of conferences, of which this is the fourth. These conferences have not been advertised outside of Canada except that we have invited a number of speakers from other countries to help us in our problems, and we hope also to obtain some mutual advantages. The first conference that we held here was on fishing vessel design; the second, which was held in Fredericton, was on the herring industry; the third, held in Ottawa a year ago, was on fish protein concentrate, and now we are holding a conference on materials in fishing vessel construction. In all of the earlier conferences, and indeed in this one, we are very grateful to those who have come to speak to us, and we hope they have been able to get some benefits which will pay them for their trouble. I believe that the subject of this Conference is not only an important one, but also timely. Boats of course are old; there have been vessels for thousands of years. Only a little more than a century ago all of the vessels in our society were made of wood, and wooden shipbuilding rose to great heights.

About a century ago the world turned toward steel as being a better material, especially for large vessels, and I think that steel came into use in fishing vessels on a large scale a little bit before the turn of the century. More recently the shipbuilding industry has been looking at other materials, and it seemed to us that at the present time the use of materials in fishing vessels large and small, the effects of various materials on design and on the capability of the vessels produced, was an important subject to discuss, and so we are now embarked on a conference on this subject. I hope that it is interesting to all of us. Thank you.

SESSION 1, OCTOBER 1, 1968 10.15 A.M.

# WORLD DEVELOPMENTS

Moderator: Maurice Lessard,
Associate Deputy Minister,
Department of Industry and Commerce,
Quebec.


Session 1, left to right, T. Isogai, J. Saethre, S.T. Mathews, Jan-Olof Traung.

# Moderator's Introduction

Mr. Lessard: *We are, I believe, approaching a very critical point in the design and construction of fishing boats. It is a point at which we are compelled by the economics of the fishing industry and of the shipbuilding industry to take a very serious look not only at building and maintenance, but also of materials and construction techniques that can be used. Fishing boats for the Canadian fishery of the future must have attractive financial implications throughout their entire life. They must be safer, more efficient, easier to maintain and to operate and, equally important, they should be constructed in such a way as to avoid early obsolescence, and if need be, easy to modify. I think it is appropriate that we look at the world situation through the eyes of this session's speakers, and so obtain a background to the other papers which will be delivered at this conference. It is now my pleasure to introduce to you our first speaker, Mr. Jan-Olof Traung of the Department of Fisheries, FAO, Rome.*

# New Thinking on the Use of Materials in the Construction of Fishing Vessels

Mr. Traung

Mr. Gulbrandsen

by

Jan-Olof Traung
Assistant to the Director,
Fishery Resources and Exploitation Division,
Department of Fisheries,
Food and Agricultural Organization of the United Nations, Rome

and

Øyvind Gulbrandsen
Naval Architect, Fishing Vessel Section,
Fishing Vessels and Engineering Branch,
Fishery Resources and Exploitation Division,
Food and Agriculture Organization of the United Nations, Rome.

*Mr. Traung was born in 1919 in Goteborg, Sweden, and started his career as a naval architect in 1940 in a boatyard at Sverre. During his time at Sverre, until he joined FAO, he designed and supervised the construction of some 60 fishing vessels for Sweden, Iceland, France and Colombia, as well as hundreds of yachts and small working boats.*

*In 1947 he organized and acted as Secretary for the Nordic Countries Fishing Boat Congress in Goteborg, Sweden, and in 1948 received a fellowship to study fishing vessels and fishing methods in the U.S.A. From 1948 to 1950 Mr. Traung acted as Consultant Naval Architect to the Royal Swedish Board of Fisheries in connection with research vessels. He joined the Food and Agriculture Organization of the United Nations in Rome in 1950.*

*During his time with FAO, he has supervised technical assistance projects in the boat, harbour and fisheries engineering fields in Chile, Dahomey, India, Iraq, Pakistan, Senegal, Thailand, Togo, Tunisia, Turkey, UAR and the West Indies. He is the author of many papers on fishing vessels and fishing methods.*

*He organized and was Secretary of the 1953 FAO International Fishing Boat Congress in Paris and Miami, the FAO Second World Fishing Boat Congress in 1959 in Rome and the Third FAO Technical Meeting on Fishing Boats in Goteborg in 1965, and edited the proceedings "Fishing Boats of the World" (1955), "Fishing Boats of the World: 2" (1960) and "Fishing Boats of the World: 3" (1967).*

*Mr. Gulbrandsen graduated from the Technical University of Norway, Trondheim, as a Naval Architect and Marine Engineer in 1961. He spent two months working as a fisherman on board a purse seiner off the coast of Norway during the herring season in February-March 1962. From April of that year he worked under the Norwegian Naval Architect, Jan Herman Linge, on designs of small power boats, sail boats, and fast marine craft in wood and fibreglass.*

*In October 1962 the Norwegian Agency for International Development initiated an associate expert scheme similar to the ones operated by several other European countries. Mr. Gulbrandsen applied and was accepted as one of the first five Norwegian associate experts to be sent out. He started working for FAO on September 15, 1963.*

*Mr. Gulbrandsen worked for four years and two months as an associate expert under the trust fund arrangement set up between NORAD and FAO until his contract expired on November 15, 1967. From that date he has been employed by FAO and is at present working at its headquarters in Rome.*

## ABSTRACT

The cost of material plays a rather minor rôle in the total cost of fishing enterprises, and very large differences in hull costs are necessary to show up as profit. The wise selection of construction methods might make possible the choice between more space, more carrying capacity, lower construction cost, higher speed or less fuel consumption. Some materials have specific qualities, e.g., wood and steel permit a greater amount of versatility. As yet little is known about strength requirements for fishing vessels and about the optimum distribution of materials.

The general conclusion is that the choice of material is not so important in the economy as a reduction in the number of crew or the selection of a material which increases the efficiency of acoustic fish-detection instruments. Perhaps the ideal fishing vessel will not be constructed of a single material, but a combination of materials suitable for various places in the hull. Much should also be expected in the future from new materials, such as rubber.


## INTRODUCTION

The success of fishing operations is becoming increasingly dependent upon the quick detection, catching and keeping of fish. Indeed, one important trend in the design of modern fishing vessels is to improve facilities for the location and detection of fish. At the same time larger and heavier nets are being developed for more effective catching. These nets in turn require more sophisticated winches and other handling arrangements to save labour and to make work easier. In fact, so much has been happening in the fields of fishing methods and gear lately that any astute investor in new fishing craft will be most careful to have the craft designed so that it can easily be adapted for new developments in methods of catching. Further, since the costs of labour are rising more quickly than fish prices, difficulties are encountered in attracting clever and intelligent men of the type so necessary for the efficient conduct of fishing operations. More attention to crew comfort is therefore necessary – in particular, appointments of crew quarters, seakindly motions of the ship, protection against weather, and the hazards of deck machinery. With the increasing complications of modern fishing vessles, the whole unit has to be made more reliable since the breakdown of only one small component due to a fault in design or materials could lead to a loss rather than a profit over the whole operation.

The traditional way to look upon materials for fishing vessels is first expenditure for material, labour cost, depreciation time and maintenance costs, thus arriving at a quasi-economic efficiency of hull cost per value fish landed. Most people recognize, in addition, that the various materials have specific advantages for certain sizes of vessel. Often it is suggested that a diagram be developed, like Fig. 1, from which one could easily select the most advantageous material for a given size – and, for example, for a given locality. The diagram given is only a hypothetical one – and both the slope of the curves and their magnitude are selected at random. It is difficult in itself to develop a true diagram since it would require many studies for various sizes of fishing vessels like the one for 100-ft vessels which it is anticipated that Fraser will present to this Conference. However, the point is that this traditional way to look upon materials would not necessarily produce the most efficient vessel for harvesting fish from the waters.

The new thinking necessary is to consider the fishing craft much more as a complicated machine comprising many integrated components of very specialized functions, requiring careful tuning in order to work with maximum efficiency and effectiveness.

Quite apart from the instrumentation aspect, consideration must be given to the construction of the vessel itself. A hull material transmitting so much noise that it is scaring fish away or is limiting the range of acoustic fish-detection instruments is certainly not economical, however low its initial cost – or upkeep – happens to be.

## CONSTRUCTION OF FISHING VESSELS

### *Size distribution*

In 1965 Canada caught some 1.2 million tons of fish. This quantity of fish was landed by about 40,000 boats ranging in length from 25 to 160-ft. and representing a total value of around $100 million. Most of these vessels were small (Fig. 2, prepared from Proskie's [1965] data). The "value distribution" (i.e., the number of boats multiplied by the mean value of each boat) has its peak somewhat towards the bigger boats, but perhaps not as much as could be expected. The most important size range, as regards investments in fishing vessels, is still from 20 to 60-ft. The same pattern of fishing boat size and value distribution would probably be found if investigated on a world-wide scale. Although there has been a tremendous development during the last ten years towards bigger and more sophisticated fishing vessles, those below 60-ft. are still the most important producers of fish.

*Building costs*

The approximate cost of longliners and small trawlers built of wood in Canada is shown in Fig. 3 (Proskie, 1965). When comparing building costs in other countries (Hamlin, 1967), as in Fig. 4, it seems that Canadian-built wooden vessels compete favourably with steel vessels built elsewhere. This is in contrast to the relatively high costs for larger steel vessels built in Canada. Fig. 5 (prepared from Proskie's [1966] data) shows percentage distribution of average capital investment in fishing boats from the Nova Scotia area, and a similar distribution is found in other provinces. As the size of vessel increases, so does the importance of hull cost, which varies between 45 per cent for the smallest to 77 per cent for the largest. As an average it can be said that 60 per cent of the total vessel cost can be attributed to the hull. Well worth noting, however, is that the hull cost is low when there is a choice of building materials, but high when steel is the only possible material.

If by various means one could reduce the cost of hull construction by 50 per cent – a rather drastic amount and hardly possible – it would represent a saving of 30 per cent in the total cost of the fully equipped vessel. What is the importance of such a saving? How would it influence the early expenditure of the fishing vessel? Proskie (1967) has given the average distribution of total expenditure of no less than 102 vessels and this is shown in a graphical form in Fig. 6. The parts influenced by cost of construction are the fixed charges (assuming that the hull maintenance will be unchanged). A 30 per cent reduction in cost of construction will correspond to about the same reduction in fixed charges. Since the fixed charges are approximately 18 per cent of the total yearly expenditure, cutting the cost of hull construction in half would, therefore, result in a 6 per cent reduction in total yearly expenditure. While a reduction of this amount in a profitable fishing operation means comparatively little, it makes a lot of difference in a marginal case. If the profit is 3 per cent, a 6 per cent reduction in expenditure means a three fold increase in profit. A 6 per cent reduction in yearly expenditure cannot therefore be neglected but it requires that there must be a rather drastic reduction in the hull cost before it appreciably influences the total yearly expenditure. Although an effort to decrease building costs is still worthwhile, it is evident that a variation of the order of 10 per cent in the cost of hull material will have only a very low effect on the yearly running costs.

*Volume or weight?*

Fig. 7 shows panels of a 55-ft. fishing vessel built of various materials, and the corresponding weight per square foot. The reduction in wood volume between the sawn frame and the laminated frame is considerable and the low material volume of the bent frame version is also remarkable.

All fishing vessels have some kind of inner lining in the fishholds, which is placed inside the frames to make a surface which can be cleaned easily. In metal craft some kind of insulation must also be provided, otherwise the heat transfer from the sea would be too great. Larger wooden vessels have a ceiling running along the entire length. Therefore, in comparing the space required by various types of construction, one has to add to the thickness of the planking or plating and the height of the frames, the thickness of the lining or ceiling and the possible insulation. On the matter of insulation, materials like wood have advantages over metal. The total wall thickness of various constructions do, in fact, influence to an appreciable extent the hold capacity, and often a construction with bent frames turns out to be far more space-saving than one with laminated frames, even if bilge stringers are required, because they can be built into the lining (ceiling).

While the height of frames influences the space available in holds for fish and the determination of how far aft or forward machinery can be placed, the cost of frames is certainly only a very small part of the cost of the fishing unit. Therefore, the frequent proposals to mass-produce frames for fishing vessels in a central place and ship them to local builders have very little chance of leading to greater economy. In cases where the volume of the fishhold is a limiting factor, space-saving should be considered. A volume-saving construction means a smaller boat and, therefore, less investment for the same capacity. The gain can be measured in lower fixed charges but, once again, the economic outcome does not show any remarkable variations without drastic changes in the volume.

The same argument applies to weight in cases where weight is the limiting factor, but economy can be obtained in other ways. A glance at the weight figures in Fig. 7 shows that fibreglass gives very low hull weight. (Aluminium would give an even lower figure but since very few fishing boats of this size are built of aluminium, it has been left out of this comparison). A fibreglass hull can be about half the weight of a steel or ferro-concrete hull. Since the weight of machinery and equipment remains the same, the total weight saving is in the range of 30 per cent. Such a saving in the case of a 55-ft steel fishing boat of 47 tons displacement would, with the same engine, result in an increase in speed of about 4 per cent (Fig. 8). If speed were kept constant, the corresponding savings in fuel consumption would be about 30 per cent, as shown in Fig. 9.

If the catching capacity is assumed to be directly proportionate to the fishing time, i.e., total length of the trip less the steaming time, the increase in catch due to higher speed as a function of the ratio between steaming and trip length varies according to the curves in Fig. 10. A similar curve can also be drawn in the case where the speed is kept constant and a smaller engine is installed, thus showing the savings in fuel costs. It is believed, although without verifying data, that it is more favourable to have increased speed than a low fuel consumption in cases when the steaming time is long compared with fishing time, since the ratio fuel cost to total cost is relatively stable. The main point thus is that reduction in weight can either be utilized for higher speed or for lower engine power, but the choice depends on the type of fishery.

## USE OF MATERIALS

### *Which material?*

The basic constructional materials are limited to fishing vessels of certain lengths (Fig. 11). No single material can be said to offer distinct advantages over the others. Each material has its advantages and disadvantages and it would be a waste of time to become involved in heated discussions about what is the *only* or *most* economic boatbuilding material. More important is a summary of the recent development that has taken place in each of the five main boatbuilding materials and an investigation of the possibilities for an even more rapid development in the future. It is necessary to know all the fundamental characteristics of these materials and how they most economically can be shaped into a boat hull. Since most fisheries are changing constantly, fishing vessels are continually being modified and rebuilt. Winches are replaced by more modern types, net drums and cleats are added, bollards and blocks are shifted about on the deck to make fishing operations as practical and less back-breaking as possible. Certain materials are more suitable than others for changes which generally take place on deck. Wood has the advantage of being easily screwed and nailed into and, with the ease of welding, steel also is an easy material to deal with for modifications and changes. Similar changes are far more difficult to achieve with materials such as fibreglass reinforced plastic and ferro-concrete.

In Europe few fishing boats above 80-ft. are built of wood, and the fact that in Canada wooden boats up to 120-ft. compete very favourably with steel shows that it is necessary to be very careful when generalizing on a world-wide scale on the preference of one material to another. The cost of material and labour differs so much from one country to another that no grounds for a general conclusion exist.

In wooden boat construction the manufacturing techniques of lamination should be studied in order to cut down present high labour costs. Possibly labour savings could be made by using newly developed types of marine glue which give good quality laminations without too strict requirements as to pressure and temperature. Parallel with this analysis of strength requirements, there must be an analysis of the labour required to put a wooden boat together. Complicated and technically sophisticated structures often require too much skilled labour. The additional investment in yard machinery might be offset by reduction in labour costs.

The introduction of new fibreglass reinforced plastic (FRP) has been the greatest breakthrough in small pleasure-boat construction since the war. Its popularity can be noticed at the annual boat shows in such centres as London, Paris and New York, where FRP boats increasingly outnumber boats made of wood and aluminium. FRP will certainly be used more and more for fishing boats below 40-ft. which can be standardized and produced in very great numbers, but it is still not clear to what extent it will be used for bigger boats.

In the 40 to 70-ft. range FRP will probably meet hard competition from ferro-concrete, another newcomer in the boatbuilding field. Use of ferro-concrete can result in a major reduction in building costs and the material has already proved itself in strength and longevity, so the road seems open for a basic change in fishing boat construction. Here again there is a great lack of research on the best use of this material. Fyson (1968) and many others have given descriptions of basic manufacturing methods.

*What strength?*

Although the task is difficult, it is necessary to establish how much strength is really required in a fishing boat. Boats obviously have to be strong enough but the question is – how strong? The surveys made by Gnanadoss (1960) and Pedersen (1967) show that there are discrepancies between the regulations of different Classification Societies as to how strong wooden boats have to be. These regulations are the result of age-old practices and do not rest on a scientific basis. The same can be said for many of the regulations for steel fishing vessels.

There are some encouraging signs that successful research is being undertaken towards a rational assessment of the strength of wooden boats. The Technical University of Norway, in co-operation with Det norske Veritas, has, by means of a computer, calculated the stresses in a 55-ft. wooden boat and also made practical full-scale tests of construction details (Fredriksen, Moe, 1967; Fredriksen, Pedersen, Moe, 1967). Considerable saving in materials has been achieved while maintaining the same strength.

For a fishing vessel of length under 100-ft., travelling on a sea influenced by wave action, the longitudinal bending moments are negligible. What has to be determined under these conditions is the pressure on the shell in various places along the hull and the stresses set up. Very few actual stress measurements on fishing boats have been made, and here is a field which should attract much attention in the future. With knowledge of the stresses, material can be distributed in the most efficient way. More tests will be required to obtain data regarding various types of fastenings and how the shear stresses between the planks can best be managed. In this respect the traditional caulking method for wooden boats is far from satisfactory, and new methods have to be evolved in order to give maximum contact between the planks while retaining the ease to change planks needing repair. What is known of the influence of vibration from those large oversized engines used in fishing vessels on ferro-concrete and FRP structures?

## NEW THINKING

*Rational factors*

In previous sections it was noted that the various measures for improving the construction or design by choice of building material have only a small effect on the economy of the fishing operation. Fig. 6 gives the relative importance of the different cost items. It appears that a much more marked change in the magnitude of expenditure can be achieved by the reduction in the number of the crew rather than by a change in the cost of the material. Considerable work is being done by makers of fishing winches and designers of fishing vessels to reduce the number of crew by increasing automation. The powered blocks and synthetic twines, combined with acoustic fish-detection instruments, have certainly revived purse seining which, not many years ago, was dying out as a fishing method due to its high crew costs. The introduction of pre-cooked food, as on aircraft, caused laughter during the 1966 Montreal Fishing Vessel Conference but could easily make more difference to the total expenditure than any possible changes in materials. Also such a thing as improving the hull form towards less resistance, giving higher speed or lower fuel costs, might be more profitable than a practically possible reduction of construction cost. This, of course, does not mean that one should neglect the possible reductions in fixed charges but merely emphasizes that these are only a part of the total cost. One should also remember that the aim is to produce economical boats and that different materials and construction methods are the means to achieve this. A true picture of the influence of materials and methods can be obtained only if it is studied in a complete cost model.

The qualities of different materials and ways of utilization can be expressed in costs, volumes and weights. Together with known factors such as relations between speed and power, distance to fishing grounds and assumed catch rates, a complete cost analysis will give the most favourable combination. The results will vary with country, area and type of fishery and in one case one might get a light and expensive vessel and, in another, a cheap and heavy one, and the speed could be either low or high.

Studies of this kind, of which so far there have been too few, will put the fisherman in a better position to select the right material for his boat. It would also clean the market of quasi-economic and misleading cost calculations now provided by manufacturers of materials and boats, who always claim that their own product is universally superior to all others.

*Irrational factors*

Unfortunately, the choice of material can seldom be made on the bases of entirely rational or fairly well-known factors. There are many aspects that require good predictions and guesses to get good economic operations. Such a factor is the versatility mentioned above, while another problem, steadily increasing in importance, is that of the production of noise. It has lately been established that noise does scare away certain fish by causing them to dive and escape the fishing gear. It has also been established that noise reduces the range of acoustic fish-detection instruments, such as asdic. It has been stated that comparatively small reductions in noise level might double the range of such instruments.

What creates noise? Certain propellers (particularly controllable pitch ones when not working at designed pitch) are great generators of noise but it should be possible to choose blade profiles of propellers which create less noise than others. The uneven wake field behind a ship creates unsteady propeller forces which are also sources of noise, especially if propeller and rudder shaft bearings do not have the correct tolerances. A small propeller, perhaps driven by the trawl winch motor, placed on top of the main propeller shaft and in front of the main propeller, helps to equalize the wake field – and will decrease noise and vibrations at the same time as it increases propulsion efficiency (Munk, Prohaska, 1968). A further important source of noise is reciprocating machinery, especially if unbalanced and directly bolted to the hull. The way to minimize machinery noise is to isolate the engine from the hull shell by installing it on flexible mountings. While much airborne noise can be absorbed and damped by felt-type materials or perforated plates, the transmission of noise to water can really only be stopped by such dense materials as lead plates or stone. Recently a Canadian journal reported that the machinery of a small fishing boat was isolated by lead plates and the machinery noise then became very "comfortable" for the crew. In future the same type of isolation of engine noise might have to be used in order to protect the fish and the fish-detection instruments rather than the fishermen from the noise. Here also heavy materials, such as ferro-concrete, might play an important rôle.

Further causes of noise might be hull generated and while it is likely that a hull with comparatively little wave resistance may have less noise than one having much, this has by no means been established. Strictly, hull generated noise has little to do with the choice of materials – but designs involving materials like wood and steel often result in unfaired stems and keels which create turbulence. Similarly scoops for water inlets and transducers for echo sounders increase the noise level.

Unfortunately, in spite of the research which has been done by the navies in various countries, the results are considered so secret that very little has been published about underwater noise. This is somewhat surprising because there does exist quite considerable interchange of technical information in the hydrodynamics field between navies of the world and between navies and the merchant marine. However, this is not so when it comes to the problem of noise and the possibilities of increasing fish production might be enhanced if such available information could be released.

*Future*

Any country striving to increase its fish production needs inexpensive and longlasting fishing craft which can be built locally by unskilled people and modified easily for future needs. In many countries the fish industry is experiencing heavy depression, due partly to unduly high labour costs and partly to high investment in their craft. Millions of dollars are spent on developing new materials such as petrochemicals (plastics), while the research on traditional materials, such as wood, for fishing craft is comparatively non-existent. However, research resulting in new paint-systems might do much to revive the importance of wood for fishing craft.

Ferro-concrete seems to offer great advantages in cutti down costs, and it seems a matter of the utmost urgency to clarify all its technical problems so that it can be introduced on a large scale. It should not be necessary to wait another 20 years for a complete answer concerning the longevity because Nervi's first boat is still intact after 24 years. A research program involving accelerated testing of new materials for fishing craft construction, similar to the testing made with new aircraft, when the whole lifespan of the aircraft can be compressed into a short period of time, is still called for.

Some years ago a firm on the U.S. West Coast was building boats with the midship section of steel, and wooden ends. While perhaps not so successful in its first attempt, it revealed a considerable amount of logical thinking in order to use material to its best advantage in various places in the hull. In the future one must decide whether it is really necessary to make a fishing vessel hull of one material only. Certainly many materials which nobody has thought of to-day will be used for fishing craft in the future. Couldn't small fishing boats be built like Greenland kayaks of some kind of wooden framing with nylon cloth sheeting (instead of skin), and why should not rubber be used more? The success during the last ten years of Zodiak-type rubber rafts certainly proves that with rubber one can create a sturdy, reliable, seakindly and fast craft. For mother ships, one could probably well consider the use of inflatable catcher craft.

In order to stimulate discussion, why not consider a fishing vessel with a wooden bow for ease of construction, lead plating under the machinery and lead engine bulkheads to suppress engine noise, steel plating in the midship section for ease of construction and in the stern for best water flow to the propeller, aluminium top sides for stability, steel deck for ease of welding, and aluminium for the superstructure again to ensure stability? The new thinking could extend to equipment also. Various types of rubber containers could be used for holding water, fuel and catches. Perhaps even inflatable fishholds could be constructed; they could be shipped or towed home as soon as full – and new ones created by inflation!

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This paper reflects the authors' views and not necessarily those of FAO.

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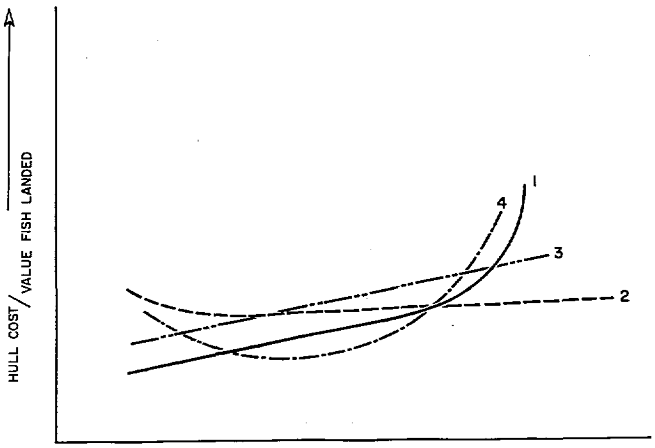


Figure 1 – If one makes 5 or 6 designs of fishing vessels of various sizes and calculates the cost of hulls built out of various materials, such as wood, steel, fibreglass reinforced plastic and ferro-concrete, and calculates the factor of the hull cost (depreciation cost + maintenance + interest) per value of fish landed, one might get a number of curves with quite different characteristics, some of them showing specific minimum costs. It would seem simple from such a diagram to select the most economical material for a given size but unfortunately this type of calculation would not take into account the fishing effectiveness, versatility, reliability and crew comfort of the individual materials.

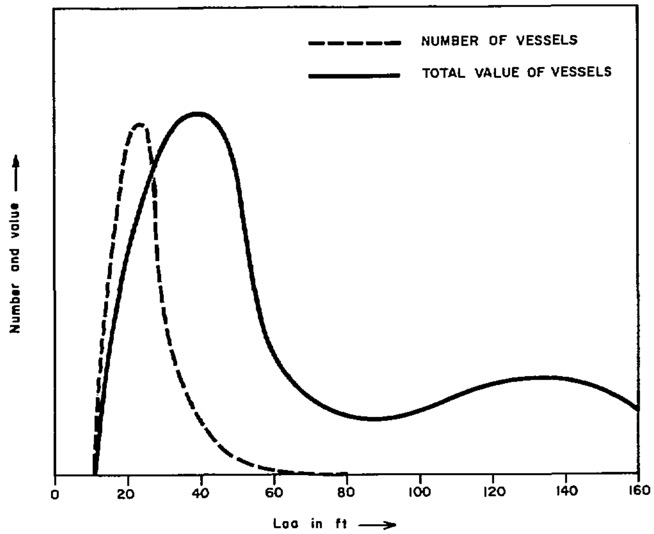


Figure 2. – Approximate distribution of number and value of fishing vessels in Canada (Proskie, 1965).

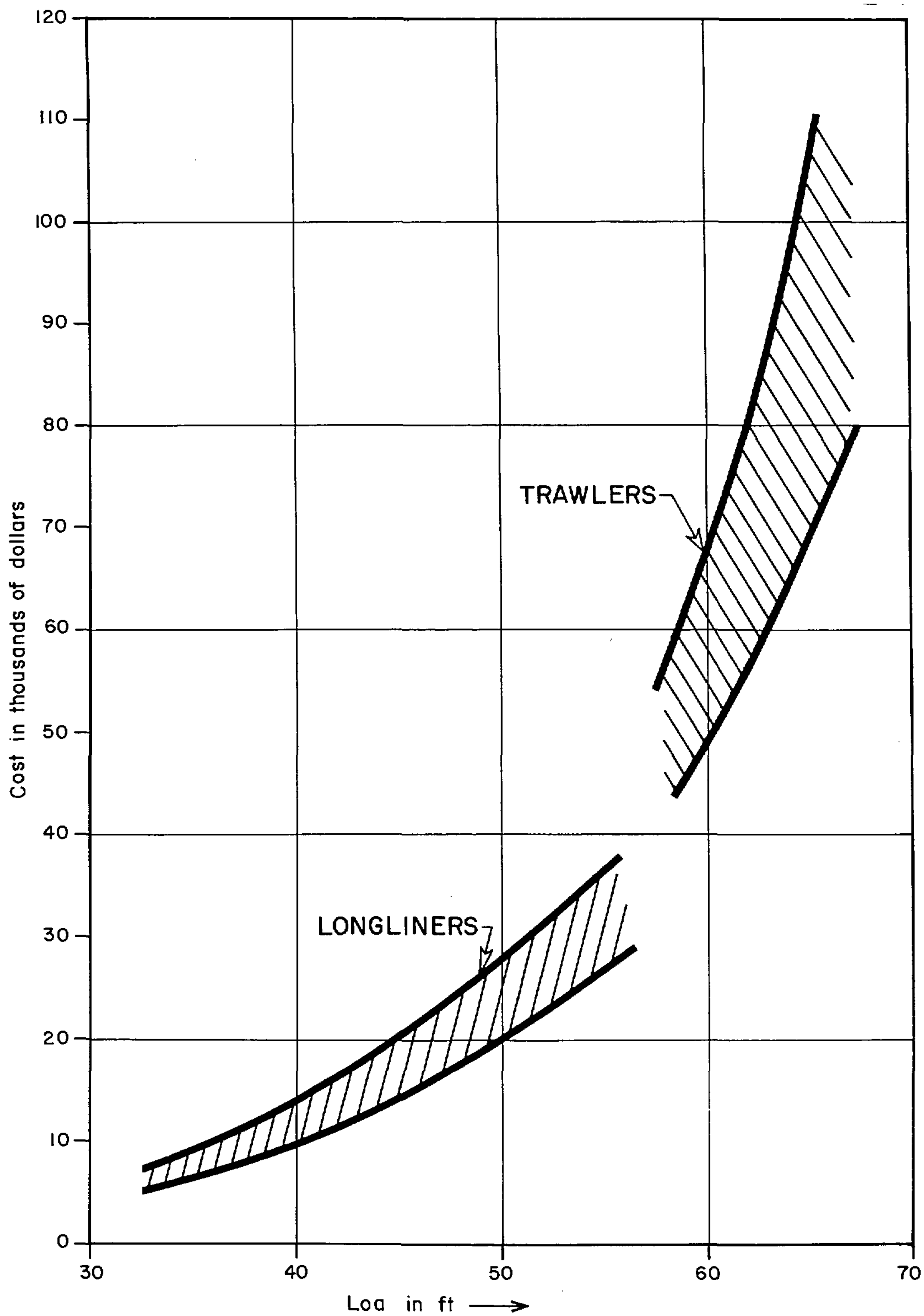


Figure 3. Building costs in Canada (Proskie, 1965).

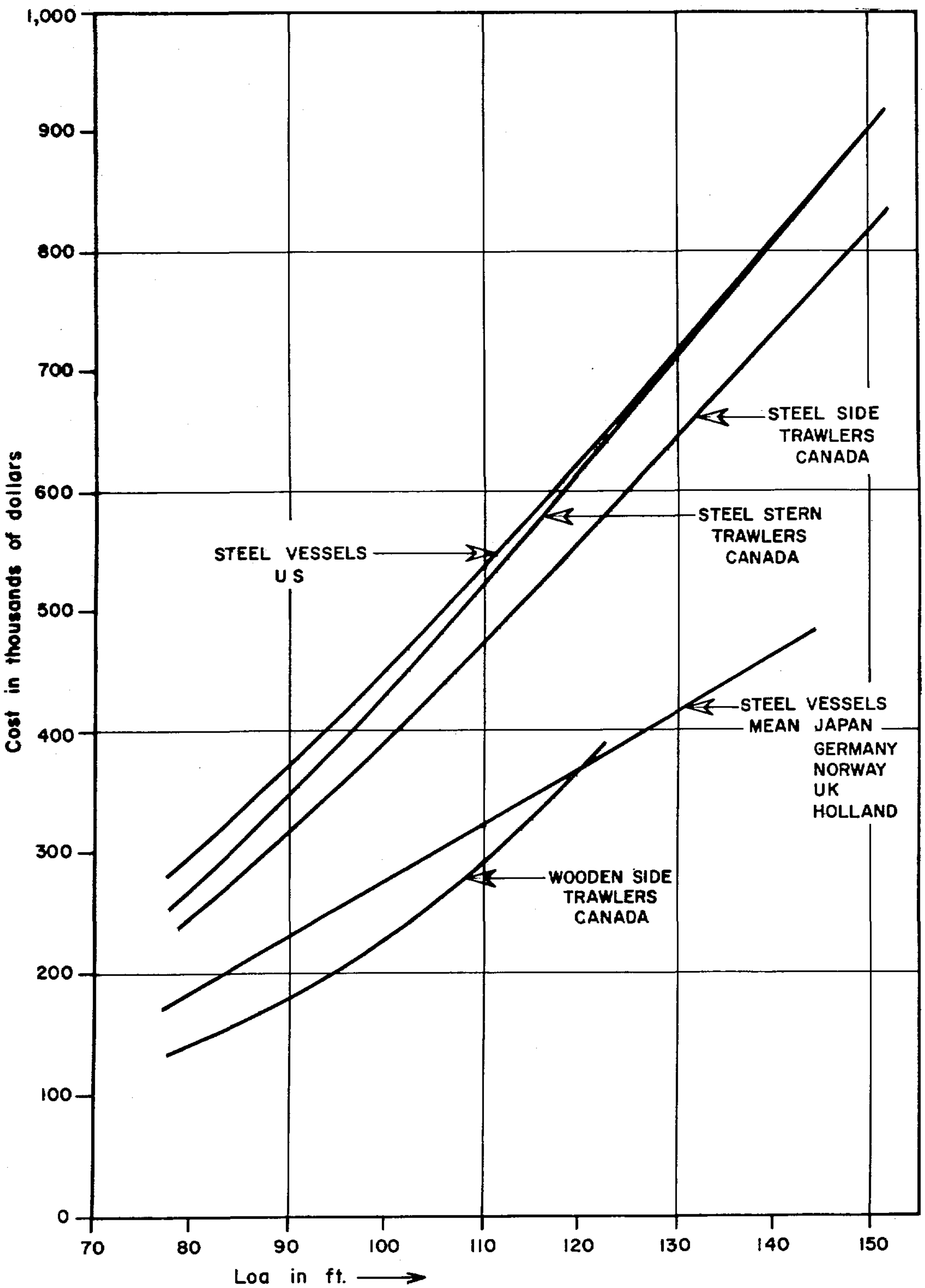


Figure 4. Building costs in Canada according to Proskie (1965) compared with building costs in U.S.A. and elsewhere (Hamlin. 1967).

| VESSEL | DANISH SEINERS | STERN DRAGGERS | SCALLOP DRAGGERS | WOODEN TRAWLERS | STEEL TRAWLERS |
|---|---|---|---|---|---|
| AVERAGE LOA | 60 | 57 | 96 | 115 | 120 |
| AVERAGE COST $ | 31.348 | 57.604 | 166.179 | 300.868 | 547.209 |

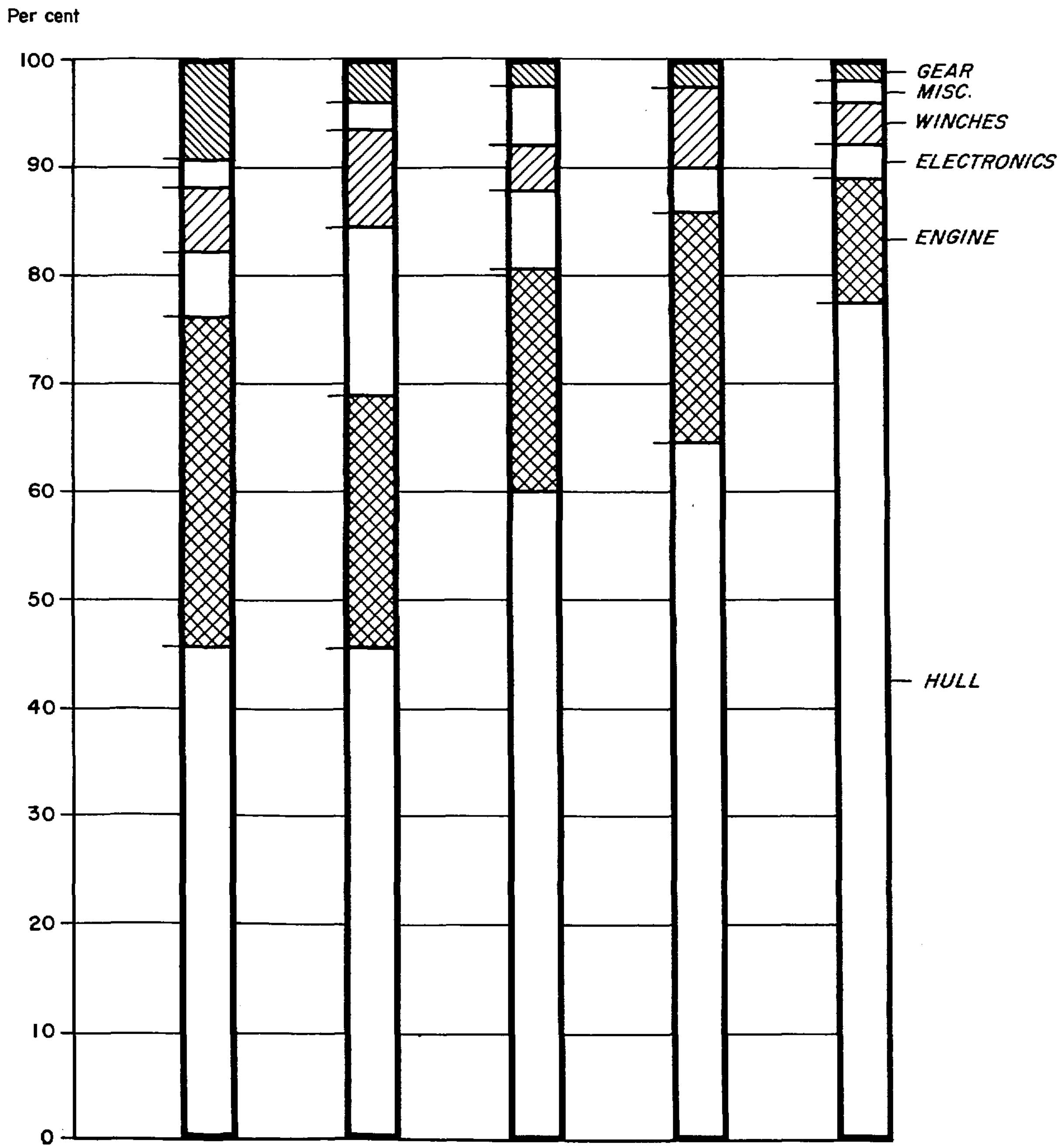


Figure 5. Distribution of average capital investment in fishing vessels of Nova Scotia (Proskie, 1966). The figure indicates that the proportion of the hull cost is larger for larger vessels and thus, for larger vessels when steel is the only possible material, there are slight possibilities of getting large changes in total expenditure due to material selection.

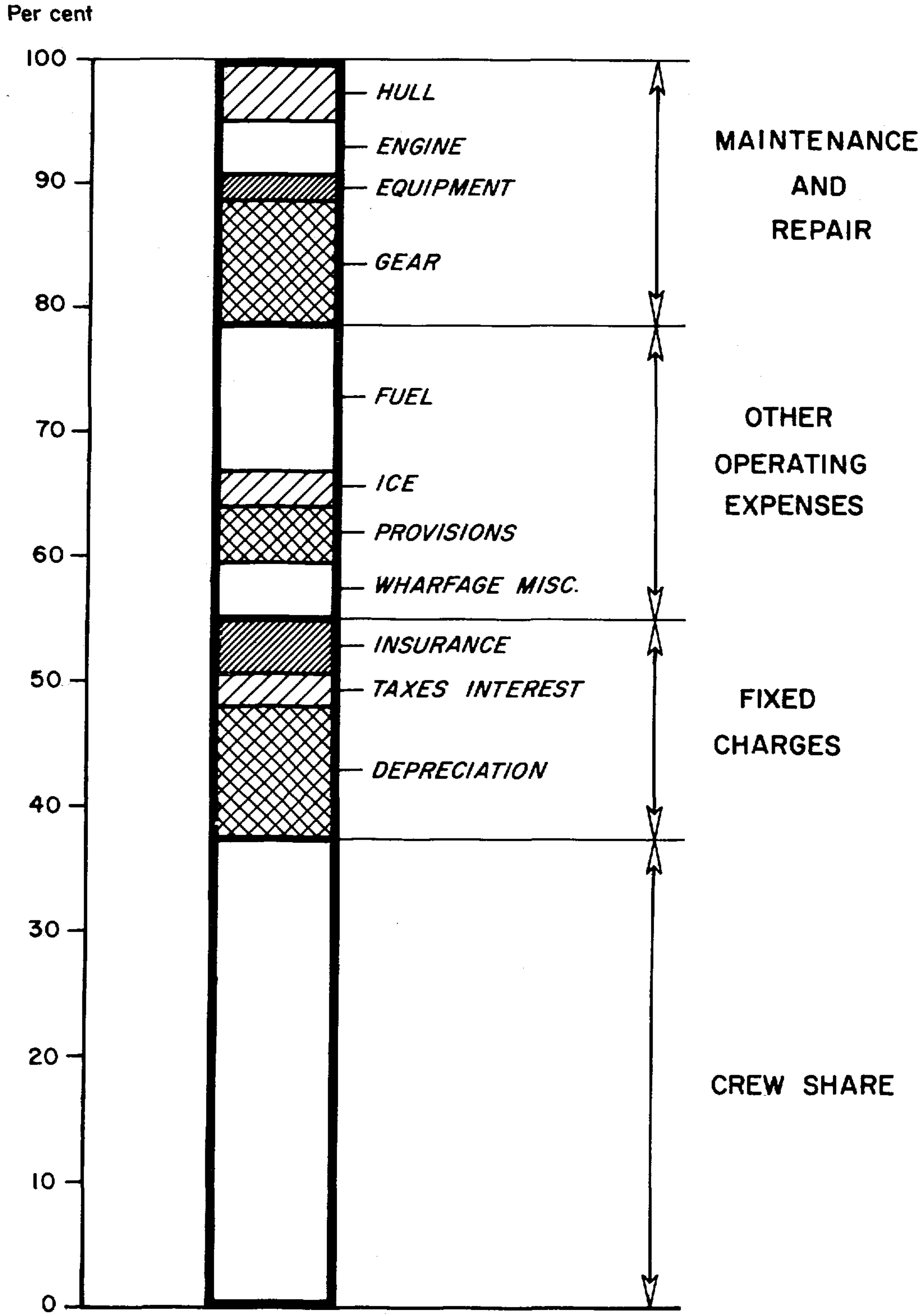


Figure 6. Average distribution of total expenditure of 102 vessels, Atlantic Coast, Canada (Proskie, 1967). The figure indicates that compared with the cost for the hull and fixed charges relating to the hull cost, the crew share is considerable and that a reduction of one man of the crew might mean considerably more than a large difference in hull cost.

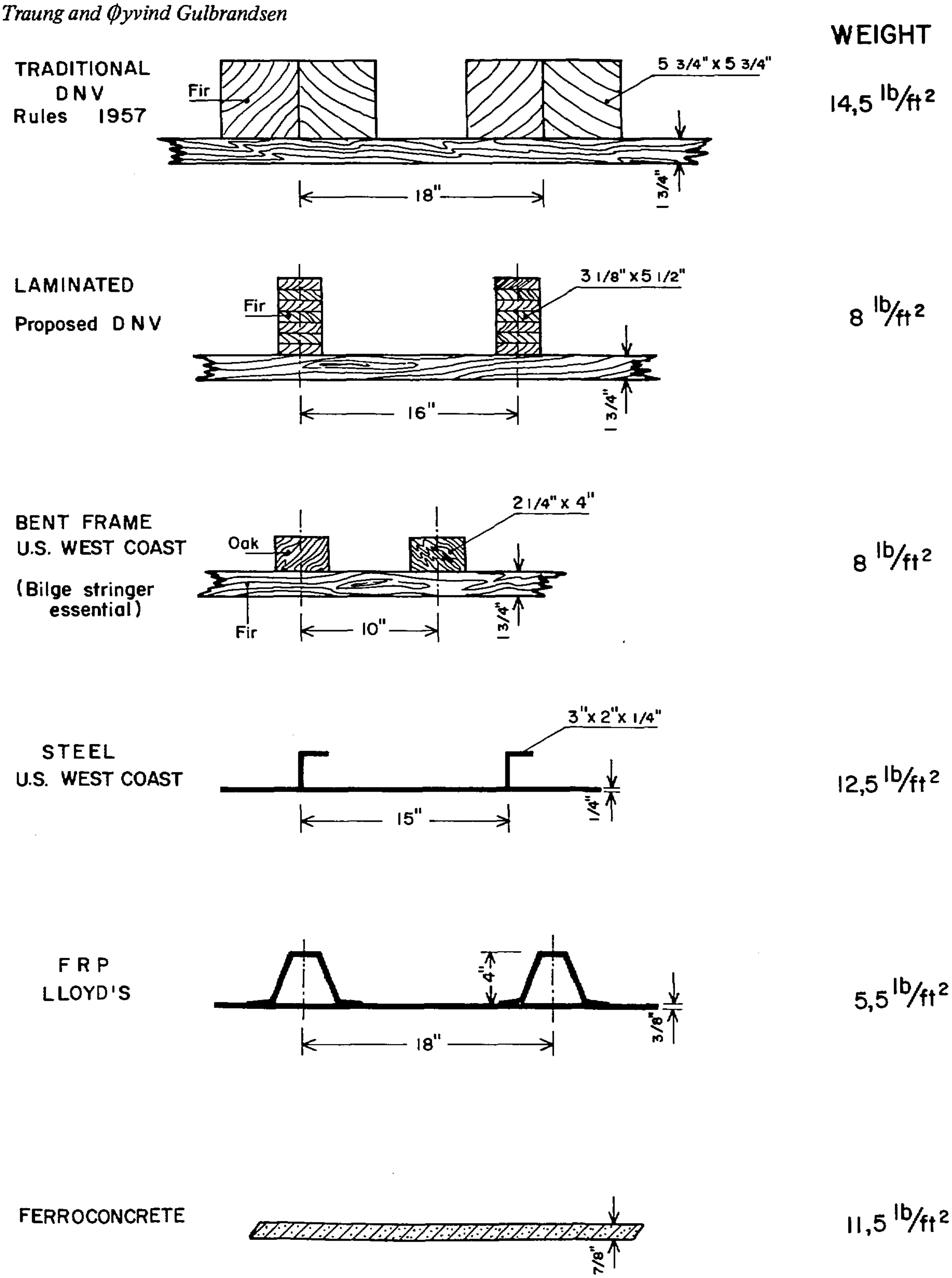


Figure 7. Shell panel proposals for a 55-ft fishing vessel built of various materials. When studying these sketches one should remember that a lining is necessary in the fishhold for all vessels, that larger wooden vessels have to have a ceiling and that steel vessels have to be insulated in the fishhold. Thus the insulating properties of wood have a certain advantage over metal construction.

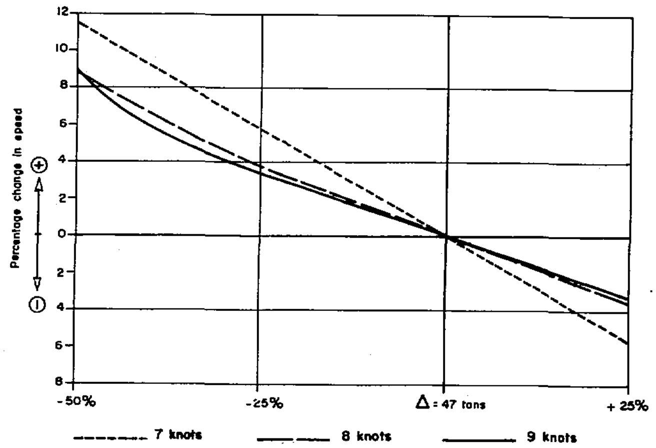


Figure 8. – The necessary power to drive a 55-ft. vessel with various displacements was calculated and this diagram was plotted, using the displacement of 47 tons as a basis. If the displacement is reduced by, say, 30 percent, the speed will increase by about 4 per cent in the 8 to 9 knots range, and if the displacement is increased by 25 per cent, the speed loss will be about 3.5 per cent. This diagram then shows that large differences in displacement mean comparatively small differences in speed. The diagram was calculated from Ridgely-Nevitt (1967).

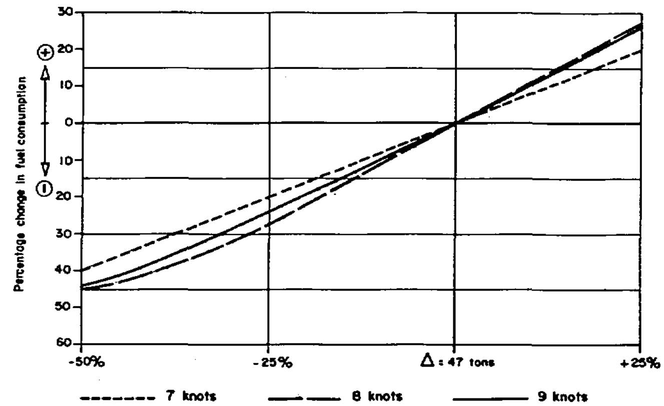


Figure 9. – If the displacement of the 55-ft vessel in Fig. 8 were modified and the speed kept constant one would obtain larger or smaller fuel consumption. Thus, if the displacement were decreased by 30 per cent, the change in fuel consumption would amount to about the same value. Similarly, it would increase by 25 per cent if the displacement were increased by this amount.

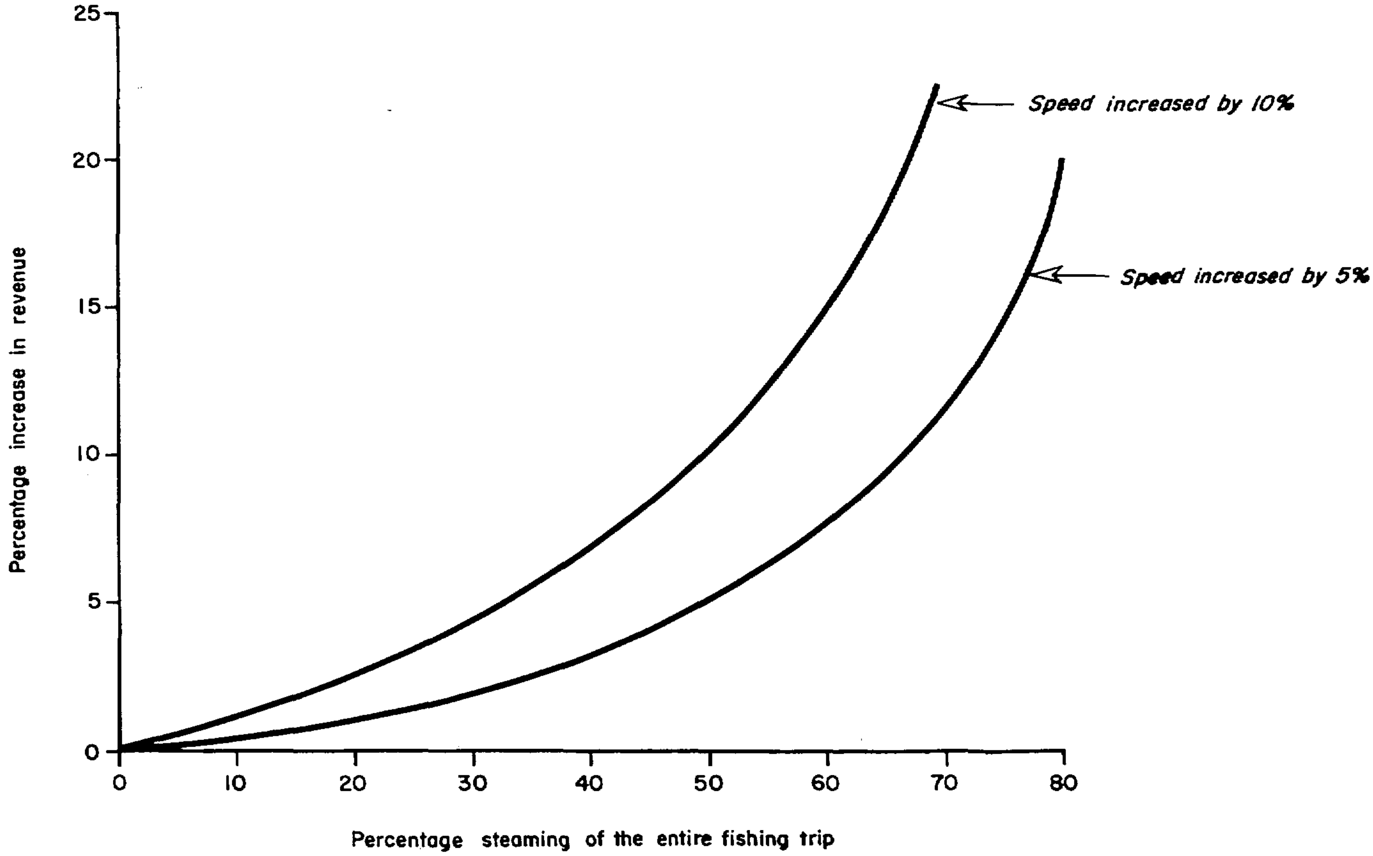


Figure 10. – The preceding Figs. 8 and 9 show that one could choose between a comparatively small increase in speed or a large decrease in fuel consumption, if one is changing the displacement. For cases where the steaming time is comparatively long, a reduction in steaming time might mean that the fishing vessel can spend more time on the fishing grounds and thus a small speed increase might mean comparatively large increase in revenue.

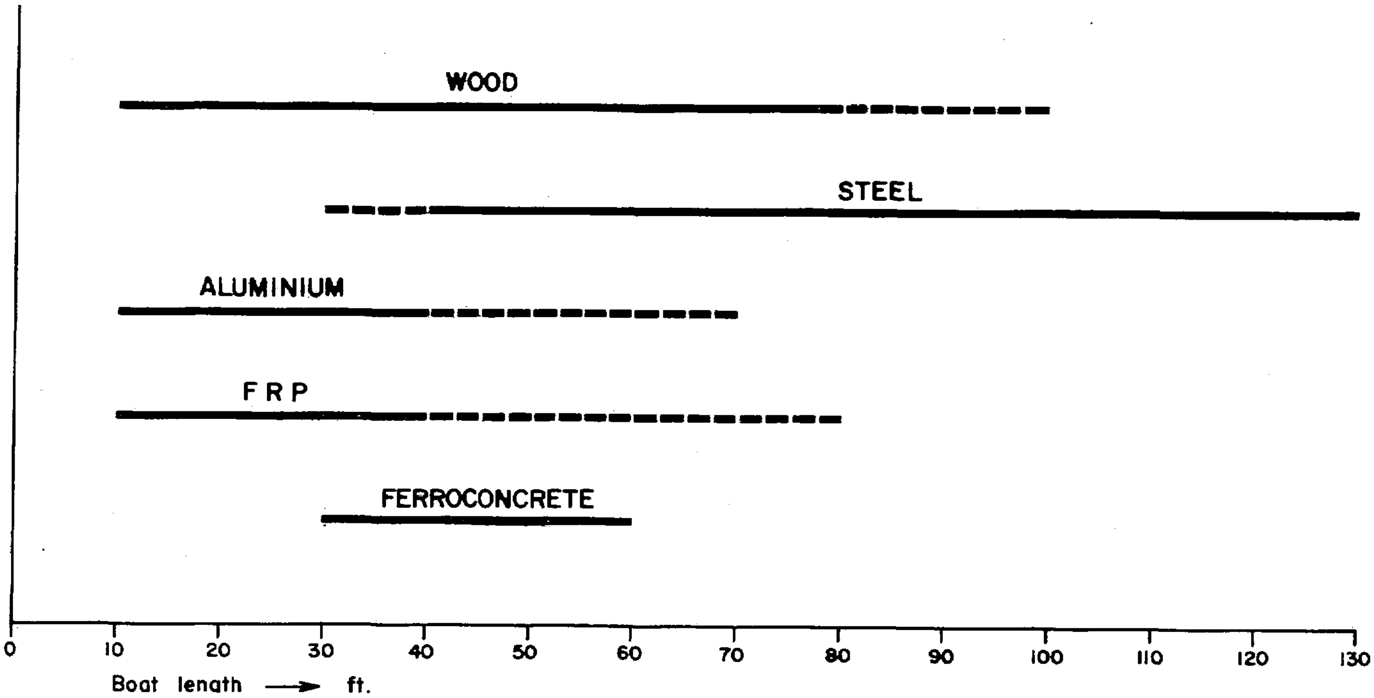


Figure 11. – Approximate sizes when some typical boatbuilding materials are used to advantage.

# The Work of the Society of Naval Architects and Marine Engineers on Materials Research and Applications

Mr. Mathews

by

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(Prepared on behalf of S.N.A.M.E.)

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## ABSTRACT

For those not familiar with the work of the Society some introductory remarks are given on its general operations.

In particular the work of the Aluminum, Steel, and Fibreglass Reinforced Plastics Task Group of the Materials Panel is discussed. Reference is made to the "Report of The Aluminum Weld Test Program" and its conclusions, and the "Guide for the Selection of Wrought Aluminum Plate and Shapes for Ship Structures". A description is given of a major project being carried out in connection with aluminum structural fire protection and some of the initial results.

There are some general remarks on high strength and alloy steels and their development. Reference is made to the "Guide" already published, and the current work of the Steel Task Group including the six-year corrosion program.

For fibreglass reinforced plastics again general comments are given and the Task Group's current program described. The present "Guide" on this subject is abstracted and, perhaps the most important part of the "Guide", a table of physical properties of marine laminates is reproduced.

In the concluding remarks further comments on the Society's wider activities are given.

## THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

It has been indicated that a few words regarding the Society and its operations might be of interest to the delegates, although it is realized that many of those present are members.

The Society has an international membership of approximately nine thousand, with headquarters at 74 Trinity Place, New York. There are fifteen active regional sections throughout the United States and Canada.

The Society is dedicated to advance the state of the science and art practiced by its members. There are fifty-two technical committees, panels and task groups with five hundred and twenty five volunteer members working on the Technical and Research Program. The publications of the Society are also available for purchase by non-members.

The Society spends approximately one hundred and twenty five thousand dollars per annum to provide continuity and initiate projects in its T. and R. program. About twenty times this amount is subscribed to the program by various interested organizations. In so far as the T. and R. program is concerned the Society's activities are similar in many ways to various European Research Associations.

## WORK OF THE SOCIETY ON MATERIALS AND APPLICATIONS

Work on materials and their applications is specifically carried out by the Materials Panel (HS-6) of the Hull Structures Committee, and its Task Groups:

| | |
|---|---|
| Aluminum | HS-6-1 |
| High Strength and Alloy Steels | HS-6-2 |
| Structural Plastics | HS-6-3 |

While no specific program is underway at present for ferro-cement construction technology, the Panel is consulting with various groups involved in these developments.

Although hitherto the T. and R. program has been concerned mainly with large ships, emphasis is now also being placed on smaller ships and working vessels.

It is considered best here to briefly describe the current work according to the above Task Groups.

*Aluminum*

The paper by C.W. Leveau, "Aluminum and its Use in Fishing Boats"*, published in *FISHING BOATS OF THE WORLD: 3,* is an authoritative work dealing with applications, construction practice, mechanical properties, corrosion painting and costs, all of direct interest to this conference. It is one of the works which has inspired the Society to concentrate more of its effort towards small craft applications.

The Society's work on aluminum for marine use can largely be summarized in T. and R. Bulletins which have been recently published or are now being prepared. A "Guide for the Use of Aluminum in Marine Craft" is now being prepared. Its aim is to establish design and use guidance for aluminum small craft builders and operators. The subjects to be covered will include alloys, welding, structural shapes, fabrication techniques and corrosion protection. Only a few chapters have now to be completed.

Two publications dealing with aluminum fabrication are:

T. and R. Bulletins 2-13 and 2-15.

The former, entitled "Report of Aluminum Weld Test Program", gives the results of an investigation which included some six hundred tests of welded specimens prepared in four shipyards. Design criteria based upon the minimum welded joint strength anticipated under field conditions are given. Variables such as alloy and temper, plate thickness and joint design, automatic versus manual welding and vertical versus downhand welding were investigated. Brief conclusions from this work are as follows:

1. Welding process (manual or automatic) has little effect on weld strength. In this series of tests, the manual process produced weld strengths slightly higher than those produced by the automatic process.

2. A weld as deposited has from 1,000 to 2,000 PSI more strength than the same weld with the bead removed.

3. Weld position would appear to have little effect on weld strength. Comparison of strengths of downhand versus vertical welds does not reveal conclusive strength superiority for either position.

4. Fillet or attachment welds do not reduce parent plate strength by the same amount as backbutt welds. In 1/4" material the strength of strap joints exceeds the strength of backbutt joints by about 2,000 PSI.

*Reprinted by the Transportation Committee of The Aluminum Association, 420 Lexington Ave., New York.

5. The tensile strength of backed welds is greater that that of plain butt welds. This is not necessarily true for yield strength. Strength can be improved by eliminating the backing strip fillet welds.

6. Plate thickness does not necessarily affect weld tensile strength. Yield strength of the weld is affected by thickness but there is no direct correlation in this respect.

7. Plate tempers in alloy 5086 do not affect minimum tensile strengths of welded joints. The statistical minimum strengths of welded joints are:

| | Ultimate Tensile Strength (PSI) | .2% Offset Yield Strength on 8" Gauge (PSI) |
|---|---|---|
| 5086 H–32 | 30,000 | 21,000 |
| 5086 H–34 | 31,000 | 20,500 |
| 5086 H–112 | 30,500 | 15,500 |
| 5456 H–321 | 34,500 | 23,700 |

8. Based on the data from four shipyards, it would appear that under normal field conditions 10%–15% of the welds will not meet X-ray criteria established for this test program. However, 80% of these will equal or exceed the statistical minimum strength.

9. The extent of the Heat Affected Zone is approximately one inch on both sides of the centerline of the weld regardless of plate thickness.

10. The strength of the parent material influences the strength of the weld but there is no direct relationship. In many cases an increase in parent plate strength is accompanied by a decrease in average weld strength.

T. & R. Bulletin 2-15 is entitled "Guide for the Selection of Wrought Aluminum Plate and Shapes for Ship Structure". This report gives information on various facets of the application of wrought aluminum on ships. Evaluations of available alloys, sizes and shapes of wrought aluminum suitable for shipbuilding and marine applications are given. North American practice only is considered in this Bulletin. Chemical compositions of the alloys are given together with mechanical and geometric properties of: sheet; plate; tee and angle shapes; extruded rod, bar, and tube. Heat treatment is described and areas of suitable application suggested. The Bulletin is concise and factual and should be considered in its complete form. No further summary here would be of value.

A major project is underway in connection with aluminum structural fire protection where the aim is to obtain information to establish standards for the insulation of aluminum decks and bulkheads and to publish information on acceptable standards. This program is being funded by industry and government organizations and is being coordinated by S.N.A.M.E. The Canadian D.O.T. Marine Regulations Branch and the U.S. Coast Guard are both closely connected with this project. The tests are being carried out at the U.S. National Bureau of Standards in Washington using insulated aluminum panels each 50 sq. ft. in area. Some thirty configurations are to be tested. The first test has now been completed and the following is an extract from a brief U.S.C.G. report on this work:

> The test demonstrates that, with suitable construction details, an approved B-15 panel, installed as a free-standing panel with a 2-inch clearance between the panel and the bulkhead stiffeners, affords suitable fire protection to a typical aluminum deckhouse side where there is no risk of exterior fire exposure. For the purpose of complying with Coast Guard structural fire protection regulations, the protected aluminum can be considered "equivalent to steel" at the end of a one-hour fire test. The tested construction would also be acceptable as A-30 bulkhead construction in those interior locations where the bulkhead could be subjected to fire exposure on only the insulated side.

This successful result, together with succeeding published data, will no doubt be of international interest to all those using aluminum alloys in ship construction.

Due to its abundance, low weight and high strength there is no doubt that aluminum will be used increasingly for small vessel construction and for superstructures on large vessels. Its low Young's modulous limits its use for the main hulls of large vessels.

*High Strength and Alloy Steels*

Before specifically dealing with the Society's work it is appropriate to make some introductory remarks. A most valuable and up-to-date summary of the present position is given in the report Oceanborne Shipping * (June 1968), which has been prepared for the United

*Available from Clearing House for Federal Science and Technology, U.S. Dept. of Commerce, Springfield, Virginia 22151, U.S.A.

States Department of Transportation by Litton Systems, Inc. The following paragraphs as well as some other general remarks made in this brief talk have been largely extracted from this report.

Since the days of the first steel hull, the quality of steel has greatly improved. The improvements consist mainly of increased strength and toughness, improved weldability and formability and increased structural reliability. The most important developments for improving steel have been changing its chemical composition by alloying; heat treatment; and improved manufacturing techniques, vacuum melting and degassing. Of course work hardening (cold rolling and extrusion) is also important. Other special processing techniques are expected to play an important role in further improving steels.

During the last one hundred years the maximum useable yield strength has been increased tenfold from 30,000 $lb/in^2$ (30 ksi) to 300 ksi. Today yield strengths above 225 ksi can be obtained in over one hundred steels.

"High strength" steels start around 42 ksi yield strength. High strength low alloy (HSLA) steels range from 42 ksi to 80 ksi. Quenched and tempered "extra high strength" steels have yield strengths from 80 ksi to 160 ksi. Any steel with a yield strength above 160 ksi is considered an "ultra high strength" steel.

It has long been common practice to use special high strength steels for the more highly stressed members of larger or very weight sensitive ships. Recently, the HSLA steels have become the most serious competitors for the conventional plain carbon steels (see ASTM 4-572 and similar grades). A 50 ksi yield strength steel was used in the construction of the nuclear submarine Nautilus. Since then, 80 KSI yield strength steels have been used in the construction of nuclear submarines. It is confidently expected that there will be enormous increases in the use of "extra" and "Ultra" high strength steels up to 500 ksi strengths with associated reductions in relative cost. Recent developments of quenched and tempered steels in the vicinity of 150 ksi strengths and the evaluation of suitable welding techniques have made such materials attractive for structures of submarines and aircraft carriers.

Assuming that the displacement ship, which is only moderately weight sensitive, will continue to play its dominant role, it is predicted that steel will remain the most commonly used (large) ship hull material. It is further predicted that in five years high strength steels will be used to a larger extent than mild steel for ship construction.

The Society has in the past endeavoured to provide ready use information to the shipbuilding industry and the Guide for the Selection of High Strength and Alloy Steels (T. and R. Bulletin No. 2-11) was published in 1964. It has since been used extensively as a valuable reference work and has now been reprinted this year. Task group HS-6-2 are working on a new edition of this guide to bring it up to date and also to add new chapters on the following types of steel: fracture tough, low temperature and cryogenic, abrasion, for use at high temperatures, and corrosion resistant. The guide in its present form gives chemical compositions, mechanical properties, cost factors as well as information on selection. There is an extensive bibliography.

Corrosion is of course still a problem with steel hulls, although in recent years great improvements have been made in paints and various surface coatings. The steel task group is engaged on a six-year corrosion investigation program, where the aim is to evaluate the long term corrosion resistance in a marine environment of a number of structural grade steels, in relation to that of ABS Grade B, to determine if the normal corrosion allowance may be reduced for some or all of the steels tested.

Steel samples 4″ X 6″ X 1/8″ drilled and welded in a standard way with a standard sandblast finish are to be mounted on test racks, each with 20 or 30 samples. Test racks of the various steels will be installed on board various types of ships on drill rigs, etc. Control tests will be made simultaneously at the INCO Kure Beach Test site. Results will be based on evaluation of test racks exposed 1, 3 and 6 years. INCO will carry out the evaluation work according to their normal procedures.

S.N.A.M.E., INCO, ABS and various steel companies are now directly involved in this program. Due to its wide scope it is expected to receive financial support from some fifteen types of agency.

Evaluation of the specimens will be conducted on the following basis:

1. Test environment

2. Corrosion rate in mils/yr determined by weight loss
3. Type of corrosion product i.e., color, thickness and tenacity
4. Frequency and depth of pitting
5. Assessment of foreign material build-up and susceptibility to crevice corrosion
6. Corrosion character of weldment with respect to base plate
7. Unusual observations

*Reporting of Test Data*

Ship owners, operators and other participants in the program will be required to supply certain data each time a test rack is removed for evaluation. The type of information to be reported to SNAME is as follows:

A. By Ship Owners and Other Operators

1. Type of ship
2. Service, (a) U.S. coastwise or (b) international
3. General description of trade routes
4. Number of days annually at sea and in port
5. Number of days in shipyard per year
6. Type of cargo (product)
7. Frequency and method of cleaning shipboard areas where test racks are mounted
8. For tankers; average time in per cent for (a) product service, (b) in ballast and (c) empty
9. Average daily ambient air and water temperature
10. Test rack location

B. By The International Nickel Co., Inc, (INCO)

1. Corrosion rate in mils/yr determined by weight loss
2. Type of corrosion product i.e., color, thickness and tenacity
3. Frequency and depth of pitting
4. Assessment of foreign material build-up and susceptibility to crevice corrosion
5. Corrosion character of weldment with respect to base plate
6. Unusual observations

Data will be reported to the SNAME committee at regular intervals, depending on the scope of the study. At the conclusion of the 6-year exposure program, corrosion behaviour will be established for each material on the test rack. All test results, test specimens and findings of this study will be submitted to the SNAME Task Group HS-6-2 for disposition.

Data will be recorded by a standard method compatible with established computer storage techniques.

*Fibreglass Reinforced Plastics (GRP)*

During the last two decades, the use of glass-reinforced plastics has gained wide popularity. In the marine field, they are in use especially for the construction of small boats, for applications where wood has traditionally been used. The density of GRP's is about one-fifth of that of mild steel, their strength in the range of 50 per cent, their modulus of elasticity less than 10 per cent of the corresponding values for mild steel. Some further characteristics are: ease of forming complicated shapes and varying the thickness at will, resistance to corrosion, ease of maintenance and repair. On the negative side: a relatively small elongation before failure, hence little ability of absorbing energy; the differing elongations before failure of the two GRP constituents; and the relatively high material cost. It will not be possible to change one significant characteristic – the modulus of elasticity – appreciably. Despite their deficiencies, GRP's appear to be very well suited for certain applications. For a substructure on a submarine, the fairwater, a GRP has been used and its suitability has been proved by over ten years of satisfactory service.

In summary it is widely considered that during the next decade fibreglass reinforced plastics, together with aluminum, will dominate for small vessel construction, substructures and superstructures, and that steel will be used very little for these applications.

The Society is currently involved in preparing technical reports on the following:

a) GRP for Large Hulls

b) Quality Assurance in GRP Construction

c) Fire Problems with GRP Construction

d) GRP Components for Ship Applications

e) Plastics other than GRP, for Marine Use

For item a) it is intended to incorporate scantling tables similar to those in Lloyds Rules for fishing boats.

Report b) will include necessary fabrication precautions and simple physical and mechanical tests that builders should perform. This information will be widely distributed to provide information to builders, brokers, underwriters, surveyors, designers and operators.

For item c), the combustion qualities of GRP have not been completely defined and technical data is necessary for safe usage.

GRP components such as fairwaters, antenna towers, deck-houses, ventilation cowlings, etc. are being increasingly used and a published Guide regarding suitable techniques for successful application is considered necessary.

For other plastics, both thermo-plastic and thermosetting varieties, suitable for shipboard items, are to be investigated.

Priority has been given to Quality Assurance and the Task Group has been communicating with a large number of GRP builders on this subject, and work on the report is progressing well.

A "Guide for the Selection of Fiberglass Reinforced Plastics for Marine Structures" (T. & R. Bulletin 2-12) was published in 1965, with reprints issued in 1966 and 1968. The Task Group is also revising this, in the light of new developments. The Guide contains descriptions of the basic materials and physical properties of the various laminates. The following table is reproduced from the

**PHYSICAL PROPERTIES OF TYPICAL MARINE LAMINATES (1)**

Average Values for Guidance Only

| Physical Property(2) | Chopped Strand Mat Laminate Low Glass Content | Composite Laminate(3) Medium Glass Content | Woven Roving Laminate High Glass Content |
|---|---|---|---|
| Percent Glass by Weight | 25 – 30 | 30 – 40 | 40 – 55 |
| Specific Gravity | 1.40 – 1.50 | 1.50 – 1.65 | 1.65 – 1.80 |
| Flexural Strength PSI $\times 10^3$ | 18 – 25 | 25 – 30 | 30 – 35 |
| Flexure modulus, PSI $\times 10^6$ | 0.8 – 1.2 | 1.1 – 1.5 | 1.5 – 2.2 |
| Tensile Strength, PSI $\times 10^3$ | 11 – 15 | 18 – 25 | 28 – 32 |
| Tensile modulus, PSI $\times 10^6$ | 0.9 – 1.2 | 1.0 – 1.4 | 1.5 – 2.0 |
| Compressive Strength PSI $\times 10^3$ | 17 – 21 | 17 – 21 | 17 – 22 |
| Compressive Modulus PSI $\times 10^6$ | 0.9 – 1.3 | 1.0 – 1.6 | 1.7 – 2.4 |
| Shear Strength Perpendicular PSI $\times 10^3$ | 10 – 13 | 11 – 14 | 13 – 15 |
| Shear Strength Parallel PSI $\times 10^3$ | 10 – 12 | 9 – 12 | 8 – 11 |
| Shear Modulus Parallel, PSI $\times 10^6$ | 0.4 | 0.45 | 0.5 |

(1) Properties from short term loading tests – wet condition. Composite and woven roving values for warp direction.

(2) Tested in accordance with ASTM Standard Specification or equivalent Federal Standard LP-406b.

(3) Based on typical alternate plies of 2-oz./sq.ft. mat and 24 oz./sq.yd. woven roving.

Guide and shows physical properties based upon test results. The Guide states the reservations and technique precautions associated with the data. Photographs of GRP vessels and components are given and there is an extensive bibliography. It is considered that GRP laminates having tensile strengths and tensile modulous values below the ranges indicated in the table should be treated as suspect.

## CONCLUDING REMARKS

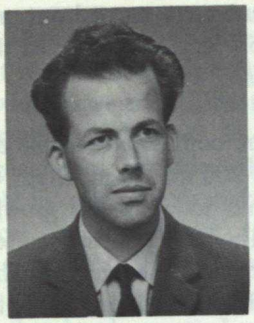
It is hoped that the general remarks made here and the brief account of the Society's work on Materials have been of interest and will perhaps stimulate many who have not been aware of the Society's activities to make use of its work and perhaps participate in the programs. Of course Materials is only one subject considered by one Panel of the Hull Structures Committee. The work of the other Committees: Hydrodynamics, Ships' Machinery and Ship Operations will also be of interest to many in this audience. No mention has been made of exotic materials such as titanium. Referring once more to the "Ocean-borne Shipping Report", it is stated that titanium has a better chance of becoming, within seventy-five years, the base for relatively low-cost, lightweight structural alloys.

While the Society quite properly is devoting its Materials effort to those in common current use, its Committee and Panel Members keep a watchful eye on all potentially useful developments.

## ACKNOWLEDGEMENTS

The writer would like to express his appreciation to the S.N.A.M.E. headquarters staff for their assistance in furnishing the necessary reference material.

# Some Notes on Stress Analysis and Construction of Fishing Vessel Structures



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*Det norske Veritas was founded in 1864, and is today the third largest ship classification society. In October 1967, the Veritas fleet passed 20 million tons gross, after having passed 15 million tons in November 1965. The tonnage on order at the end of 1967 was 5.6 million tons gross.*

*Det norske Veritas has 220 survey stations spread all over the world, and the staff totals about 860 persons, of whom 360 are engaged at the head office. Most of the work of the Institution concerns the large ships. Regarding smaller vessels, however, the Society has recently revised the Rules for the Building of Steel Fishing Vessels, while the Rules for Wooden Vessels are presently being revised. Rules for GRP yachts and fishing crafts are under preparation.*

## ABSTRACT

Today's increasing knowledge about the forces and loads to which a vessel is exposed, and the use of computers to analyze the structure of the vessel, enable the naval architects to determine the necessary material scantlings in a more reliable way than previously. Improved analytical tools are also necessary for the introduction of unconventional hulls and materials. Experimental and analytical research has definitely endeavoured to modify the sole dependence on experience.

The paper presents some results from analysis carried out by Det norske Veritas in connection with the revision of Rules for the Construction of Wooden Vessels. The analysis clearly demonstrates that the main dimensions of a vessel (L, B and D) can hardly be said to represent a satisfactory basis upon which the scantlings of the main structure of a vessel can be determined. Even with B and D constant, the stress resultants of the frame can vary within wide limits, depending on the frame configuration.

In the proposal to new NV-rules for wooden vessels, the frame configuration is considered directly in the calculation. For the smaller and medium sized vessels – say below 25-30 metres in length – the amount of material required for construction of laminated frames will be considerably less than according to the existing Rules. The reduction in weight will be more noticeable, the smaller the vessel is.

## INTRODUCTION

Until fairly recently, shipbuilding has been strongly characterized by empiricism and tradition. The oceans themselves have formed the laboratory for the testing of vessels, and this time consuming process has naturally led to very slow development as regards quantitative determination of loads on vessels and their safety margins. The smaller vessels especially have primarily been built according to experience and tradition only, but certainly in general with favourable results.

The desire for new, improved and economic vessels together with modern developments in the materials field, better analytical methods and engineering tools, have emphasized and required the need for more precise analysis of fishing vessel structures.

In wooden vessels, for instance, the passing over to laminated frames instead of double sawn frames, represents a significant achievement and leads to considerable weight reductions. At the same time the more homogenous structure of the laminated frame makes it possible to carry out more reliable analysis of the frame systems, and the question arises whether further weight reductions are possible, while keeping the standard of safety at a sufficient level. The very low frequency of damages on small vessels has indicated that these vessels are very safely constructed, and that further reduction in scantlings should be possible.

Especially, the development of new construction materials, for instance fibre-reinforced plastics, where tradition plays a very limited part, requires theoretical analysis and untraditional concepts in order to evaluate the expected stresses in the structure.

## LOADS ON VESSELS

A refined strength analysis will, however, be of rather limited use, if we are not able to stipulate the wave loads realistically. The external load consists of a static water load represented by the draught of the vessel and, in addition, a dynamic wave load effect.

When observing a vessel at sea, it seems impossible to evaluate theoretically the wave loads to which the vessel is exposed. In recent years, however, theories which predict the expected wave loads on a vessel in a given sea environment have been developed to a significant extent. This comprises that observed sea characteristics as wave length, wave height, etc., together with theories for ship response to waves, form the basis for statistical analysis of the behaviour of a ship in waves, and for the calculation of expected wave loads. Measurements carried out on ships in service have to a satisfactory degree confirmed the sound basis for these developments.

The computed results are considered reliable especially for ships between 100 and 200 metres in length. On both sides of this range, one has to allow for growing inaccuracies and uncertainties. The most critical wave length for a vessel is approximately equal to the length of the vessel. By now we have not sufficient knowledge about the short waves especially dangerous for the actual fishing vessel size. However, when calculating wave loads by using the theories developed for bigger ships, the results seem reasonable. As an example, consider a vessel 50 metres in length when travelling on the North Atlantic, entirely, the expected largest water pressure likely to occur amidship on the side of the vessel once in her life, corresponds to a water height about 0.7D above deck (1).*

Towards the ends of the vessel the maximum dynamic loads are of course higher, in the order of twice the pressure amidships, but especially for the smaller vessels the prediction of "exact" values is uncertain.

Previously, when the actual wave loads were much less studied, working stresses and structural capability were frequently not too well in accordance with the relevant sea requirements. The loads used consisted usually of the static water pressure, and the additional wave loads had to be taken into account implicitly by corresponding low design stresses. For this reason the actual (higher) loads now expected to appear, cannot be used with the previous conservative design stresses. When applying extreme loads, occurring very seldom during the life of the vessel, also rather high design stresses must be allowed. In steel vessels, for instance, nominal working stresses theoretically approach the yield stress when extreme loads are employed.

## STRENGTH ANALYSIS

In the strength analysis the double curvature of the small hull very much complicates the study of the stresses appearing for a given loading condition. By the use of

* Numbers in brackets designate References at end of paper

computers, however, it is now to some extent feasible to analyze such complex structures, and to consider systematically the effect of all relevant factors.

When developing new rules for the construction of vessels, it may be desirable to include in the rule formulae factors which have a significant influence on the design of various structural elements, in order to obtain rules which are as general as possible. This is of course frequently impossible in order not to make the rules too intricate and unpractical in application. Consequently, one has to exclude some of the less important factors from the rule formulae. Hereby we may introduce a small inaccuracy, but on the other hand, practical use of the vessel involves so many unknown factors (as for instance impacts from fishing gears and from other vessels in harbour) which are out of control of the naval architect, that a factor of safety must be included when calculating the scantlings, which clearly ruins extreme computational precision.

In connection with the revision of the Rules for wooden vessels, Det norske Veritas carried out a thorough analysis by means of an electronic computer for different frame systems, in order to study the influence of various parameters such as B/D-ratio, bilge radius, deadrise, etc. These factors were systematically varied, and bending moments, shear and axial forces were calculated for a number of stations along the frames.

The calculation model used is shown on Fig. 1: a half-frame fixed to the keel and to a deck beam. The applied load is composed of a dynamic wave pressure represented by the amount 0.25 D at the deck, and decreasing linearly to zero at the keel. This load distribution is used for practical convenience, and the dynamic pressure component does not correspond to the largest expected loads given previously (equal to about 0.7 D above deck). The chosen distribution, however, gives an approximately correct relative load distribution along the frame.

Fig. 2 shows a typical bending moment diagram for a frame. The maximum moment is usually found at the lower end where the frame is fixed to the keel. However, at this point the floor will strengthen the frame, and the critical section in most cases will be about halfway between the keel and the bilge, where the maximum positive moment will be located (tension on the inside).

It is not quite correct modelling to keep the frame fixed at the deck-corner. However, as can be seen from Figs. 2-4, the moment at this point is small, and whether this end is fixed or not, is of minor influence for the moments at the lower parts of the frame, i.e., where the largest moments appear.

The analysis very soon indicated that by far the most important factors for the stresses in the frames were the bilge radius and the length of the straight part of the frame between the keel and the bilge. Figs. 2-4 show the variation of the bending moments in relation to these factors. Fig. 4 shows a nearly circular frame with a short straight part at the bottom. The maximum moment of this frame amounts to about 40 per cent of the moment for a frame with a shape as given in Fig. 2, where the straight part is relatively long.

Calculations were also carried out for different values of B/D-ratio, the deadrise and, as mentioned above, the degree of fixation at the upper end of the frame. In every case the straight part near the keel, and the bilge radius, proved to be of dominating influence. To make use of these results in the Rules, a simple formula had to be established which to a satisfactory degree corresponds with the results obtained from the more precise computer analysis. The formula from simple beam theory was used to calculate the bending moment for a beam with one end fixed and the other end simply supported. It was found that when using an equivalent length equal to

$$\ell = \ell_o + 0.3\,R$$

this simple formula gave results of sufficient accuracy. In the above formula $1_o$ means the straight part of the frame, and R is the bilge radius. Actually, the factor 0.3 depends slightly on the deadrise; it might have been reduced to about 0.25 for a rather large deadrise, nevertheless, the reduction in 1 will amount to a very few per cent in the total length. For the normal midship section the factor is very near to 0.3, and we have chosen not to complicate the Rule formulae by introducing the deadrise in the calculations.

## INFLUENCE OF KEEL DEFLECTION

Another important question in connection with stresses in frames is the stiffness of the keel. Besides being a longitudinal strength member, the main purpose of the keel is to support the frames. Usually, the keel will not be stiff enough to prevent vertical deflection completely, and the bending moment will be redistributed when the keel moves upwards, see Fig. 5. Curve 1 on the figure represents the moment diagram when no vertical deflection of the keel is allowed, i.e., the keel stiffness is very large, and curve 2 illustrates the redistribution of the moments when no keel is present (zero keel stiffness). In actual cases the keel stiffness will have a value between the cases illustrated by curves 1 and 2, and the moment diagram will be as indicated by curve 3.

It is seen that both the negative moment in the bilge and the positive moment between the bilge and the keel are increasing when the keel deflection increases, and this has to be considered when determining the frame scantlings. This can be done either by directly considering the stiffness of a given keel in the formulae for the calculation of the frame scantlings, or by incorporating an allowable keel deflection as a constant factor in the formulae, and then determine the keel scantlings so as to keep the deflection within the prescribed limit.

## FACTORS AFFECTING THE REACTION BETWEEN KEEL AND FRAMES

In the analysis carried out, the vertical reaction between keel and frame has been calculated for each frame model, assuming no vertical deflection of the keel. The relative vertical reaction between frames and keel depends primarily on the deadrise of the vessel, but also to some extent on the bilge radius. The relative vertical reaction is defined as the ratio between the vertical load carried by the keel and the total vertical water load on the frame. Fig. 6 gives some illustrative curves showing the variation of the relative vertical reaction as a function of deadrise and the bilge radius. These curves are not implied to be exact, but they cleary illustrate the tendency. However, when the keel deflects, these vertical reaction forces will be reduced, and the curves consequently give the maximum reaction which will appear for a given frame configuration.

Another complicating factor, when analyzing deflection of the keel and stresses in the frames, ought to be mentioned. Towards the ends of the hold both the deadrise and the bilge radius will increase, and consequently the vertical reaction forces will be reduced, as is seen from Fig. 6. For smaller vessels we may even have the case where the reaction forces are changing direction near the bulkheads, and instead of the usual case where the keel supports the frames, the frames will support the keel and try to push the keel downwards.

## SHEARFORCES IN THE SHELL

The total vertical resultant from waterload has to be carried by the keel and the shell. It is already seen from Fig. 6 that the keel usually contributes with a rather small percentage, in many cases less than 10 per cent. The remainder has to be carried by the shell as shear stresses in the hull plating (or planking). When the shell consists of a continuous structure, such as steel plating or FRP-laminates, these shear stresses are not expected to represent any problem. In a wooden vessel, however, consisting of a number of separate hull planks, the shear strength between the planks is mainly represented by the caulking. The shear action will tend to slide the planks along each other, and the efficiency of the shell as a shear carrying structure depends on whether the bonding between the planks and caulking is strong enough to withstand these shear stresses.

The fastening of the planks to the frames may also contribute to the shear strength of the hull, though probably to a rather minor extent. Between the bulkheads the vertically directed forces upwards will deform the hull planking, and the connections between the planks and the frames will be twisted. If this nail- and bolt- fastening is sufficiently strong, it will prevent twisting and thus contribute to some extent to the shearing strength. Fig. 7 illustrates the arrangement for conventional double sawn frames and laminated frames. It seems likely that the fastening to double sawn frames is more capable of resisting the twisting deformation than is the fastening to laminated frames. Anyhow, we believe that this connection adds little to the shear strength represented by the bonding between the planks through the caulking. We need further information on this matter, and therefore we intend to carry out full-scale measurements of deformation and stresses on wooden vessels, in order to obtain more knowledge pertaining to behaviour and shear strength of a hull. The experience up to now, however, indicates that the shear strength of the hull planking is sufficient also for laminated frames. Ultimate strength information is apparently nonexistent.

In this connection much interest has been given to various rubber compounds used instead of conventional caulking. Results published so far indicate very good bonding properties to the planking, and if the durability of these materials proves to be satisfactory, these compounds may improve on the shear strength of conventional hull planking.

## TESTS AND EXPERIMENTS

Previously only wooden plugs were used to fasten the hull planking to the frames in Norwegian wooden vessels. But some time ago the question arose whether the wood plugs might be replaced by steel spikes, because this would be cheaper and easier to use. In 1966 DnV therefore carried out some tests with such connections to check the effectiveness of the different methods of fastening. Samples with alternative use of wood plugs, steel spikes and screw bolts were tested. Both direct pull-out tests and twisting tests where the planks were rotated in the plane of the shell were carried out. The wood plugs and steel spikes showed nearly equivalent strength, while the bolts gave the best results. In a recent proposal to new rules, DnV therefore do not require wood plugs for fastening of the hull planking.

During recent years the Technical University of Norway has done some research on wooden vessels. (2) Full scale tests were carried out on transverse frame sections, one double sawn frame and one laminated frame. Both frames were built according to Det norske Veritas Rules of 1955, implying that the scantlings of the laminated frames are reduced by about 20 per cent compared with the sawn frames. Fig. 8 shows the test arrangement, which very nearly gives the same moment diagram along the frame as the hydrostatic waterpressure does. Despite the reduced scantlings of the laminated frame the collapse load of the laminated frame was nearly double the load carried by the sawn frame. The laminated frame also experienced considerably less deformation than the sawn frame did. This result indicates that the scantlings of the laminated frames may be reduced by more than the above mentioned 20 per cent, and still retain the strength standard of the previous double sawn-framed hull. Accordingly the proposal to new NV-Rules for wooden vessels give further reduction in scantlings, especially for the smaller vessels.

At DnV we are in the process of carrying out some tests on the bolt connection between laminated frames and steel floors. The frames are connected to the vertical floor plate by fore and aft bolts, and the combined loading (moment, shear and axial force) is systematically varied. The results from these tests have not yet been analysed. Some comparative tests with an alternative construction where the floor is placed on the top of the frame and the bolts are going vertically through the face plate of the floor will also be carried out.

## FUTURE NEEDS

As mentioned above, the ability of the hull planking to carry shear stresses is of significant importance in connection with the correct appraisal of the frame system. Proper information on this particular matter can only be obtained by measurements on actual vessels and we intend to do some investigations to this effect in the near future.

In connection with the classification of a FRP fishing vessel some full-scale tests will be carried out on reinforced plastic structures. The details to be tested have not yet been definitely decided, but it will be emphasized to study joints, e.g., between frames and longitudinal girders, and between transverse bulkheads and the hull. We hope these tests will give valuable information about some details used in the construction of FRP craft.

## CONCLUSION

As mentioned previously, most of the results presented were carried out in connection with the revision of the Rules for Building of Wooden Vessels. Most details referred to in this paper therefore deal with wooden constructions. However, the analysis carried out on the frame system is considered to be of rather general validity, notwithstanding the material in question, and may consequently be referred to when dealing with steel or FRP vessels as well.

The results show that when using a characteristic beam length equal to $\ell_0 + 0.3\,R$ in the calculation of frame scantlings, the frame configuration is taken into account to a satisfactory degree. Thus, for an almost circular frame, for instance as shown in Fig. 4, where the bending moments are small, the proposed Rule requirement for the frame scantlings will be considerably reduced compared with the rules of 1955, until now in force. The reduction in section modulus may amount to about 25 per cent for smaller vessels. For larger vessels, say about 100 ft., the Rules of 1955 and the recent proposal will give about equal section modulli for the frames.

In the near future we shall endeavour to extend our research in this field in order to establish a basis upon which a more economic and technically sound construction of the smaller vessels can be carried out.

## REFERENCES


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2. "Strength of Wooden Ships", Part I and II, Report Nos. SKB II/M6 and SKB II/M9. Technical University of Norway, Trondheim (M6 in Norwegian only).


THE CALCULATION MODEL AND THE APPLIED LOAD

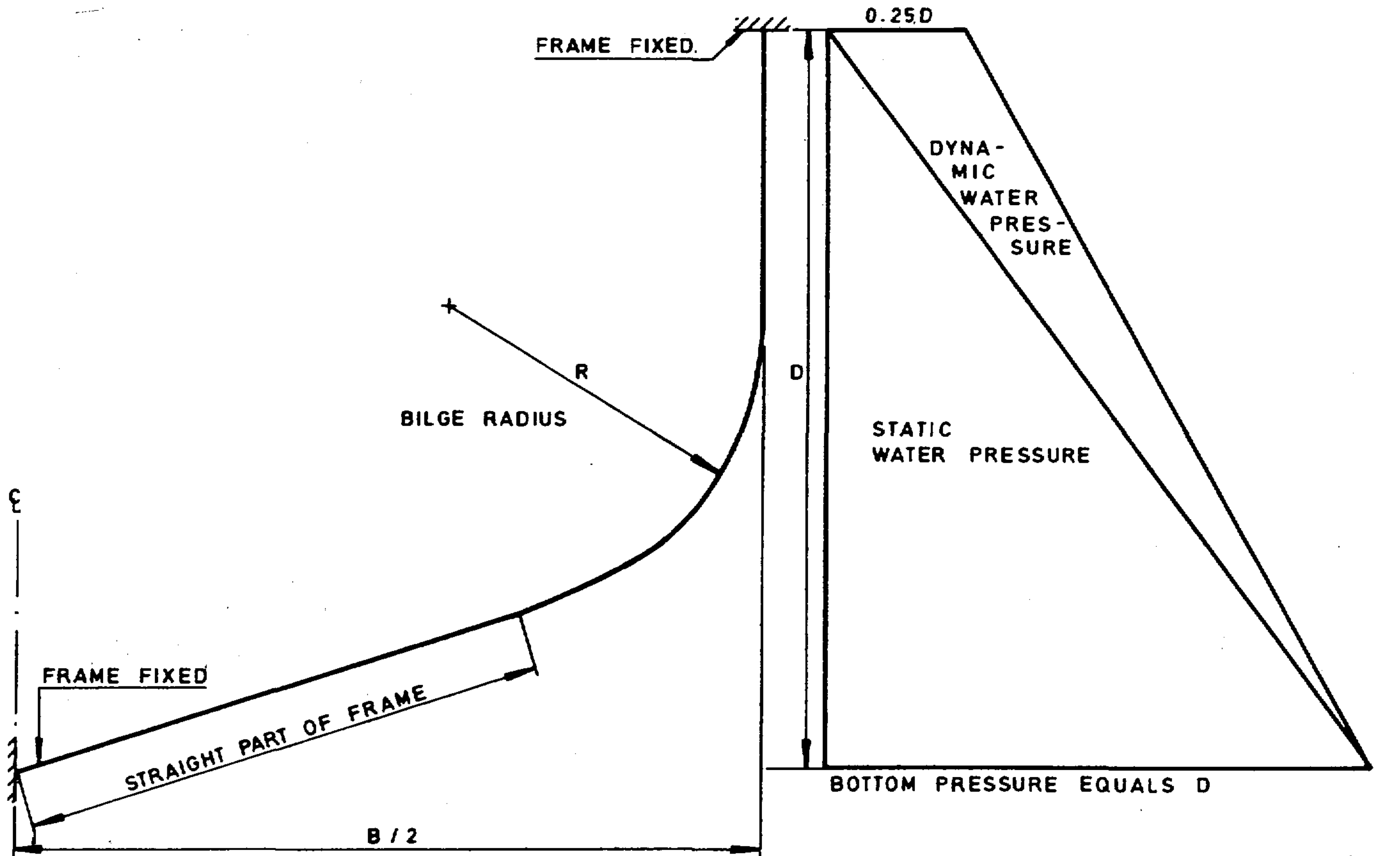


FIG. 1

MOMENT DIAGRAM

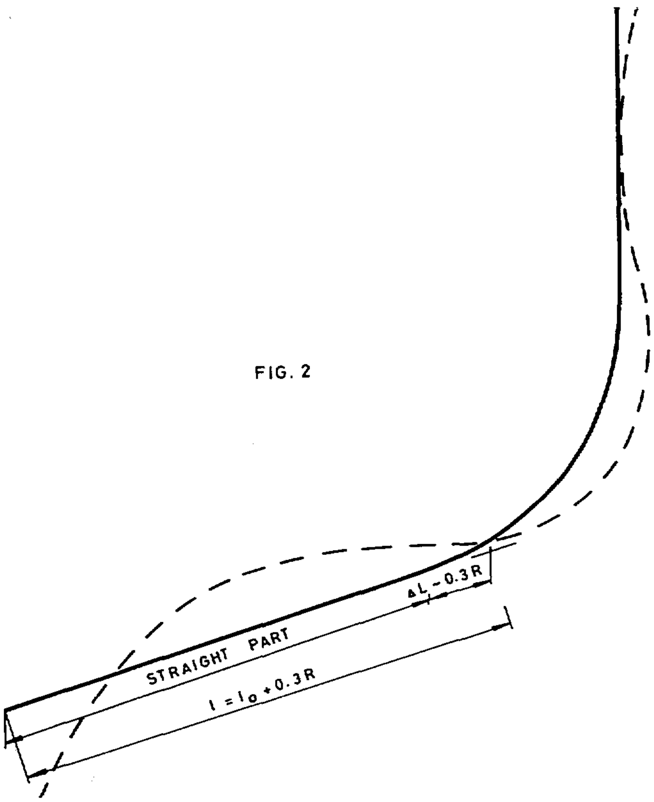


FIG. 2

MOMENT DIAGRAM

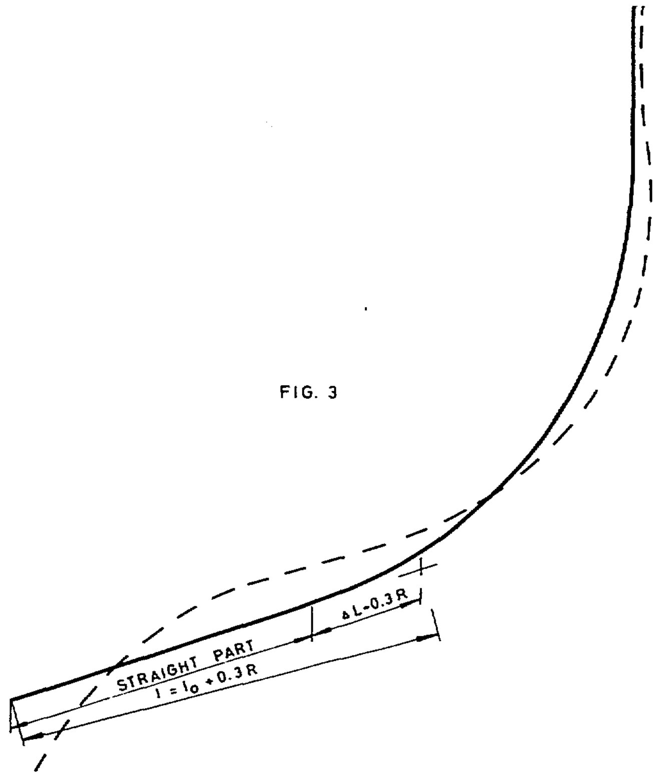


FIG. 3

MOMENT DIAGRAM

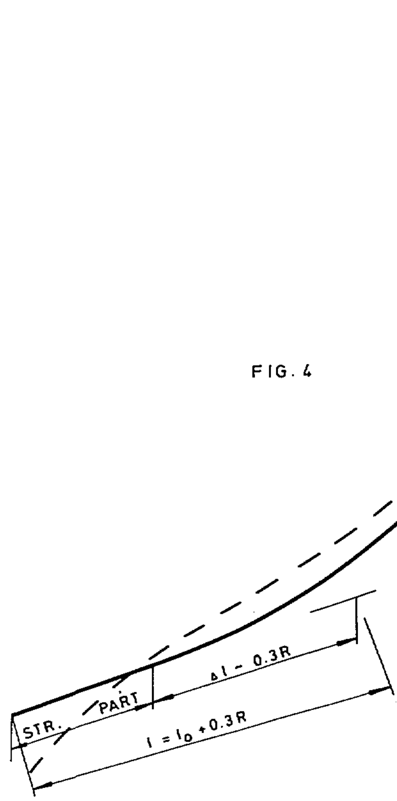


FIG. 4

# MOMENT DISTRIBUTION ON A HALF-FRAME AS A FUNCTION OF KEEL DEFLECTION

(1) MOMENT DIST. WITH ZERO VERTICAL KEEL DEFLECTION

(2) MOMENT DIST WITHOUT ANY KEEL AT ALL

(3) INTERMEDIATE CASE WHERE THE KEEL SUPPOPTS THE FRAMES, BUT IS NOT STIFF ENOUGH TO PREVENT DEFLECTION COMPLETELY

THE FIGURES INDICATES THE SIZE OF MAXIMUM MOMENTS RELATED TO THE MAXIMUM MOMENT ON THE STRAIGHT PART OF THE FRAME IN THE BOTTOM IN CASE (1) (ZERO KEEL DEFLECTION)

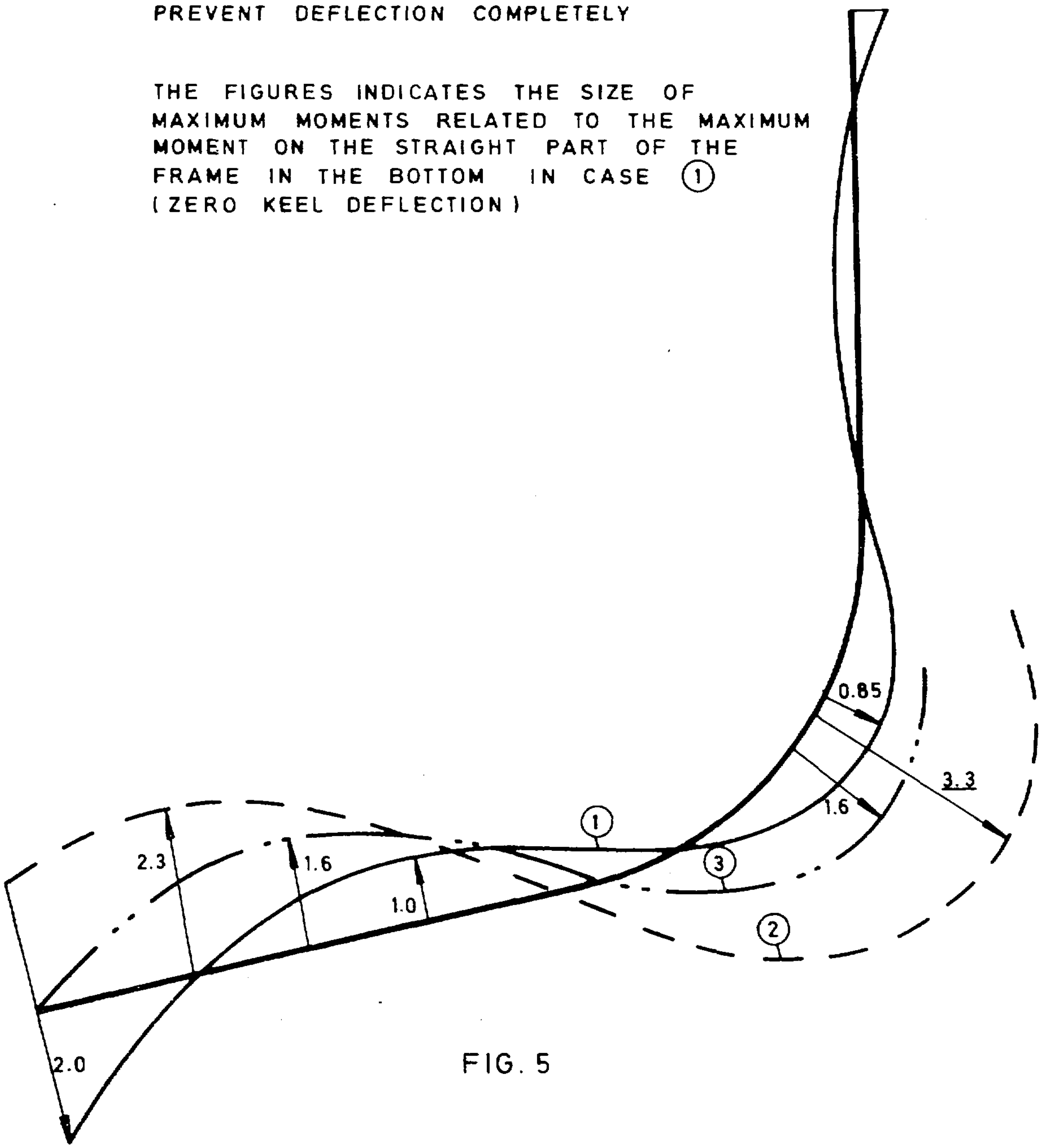


FIG. 5

# VERTICAL REACTION FORCES BETWEEN KEEL AND FRAMES

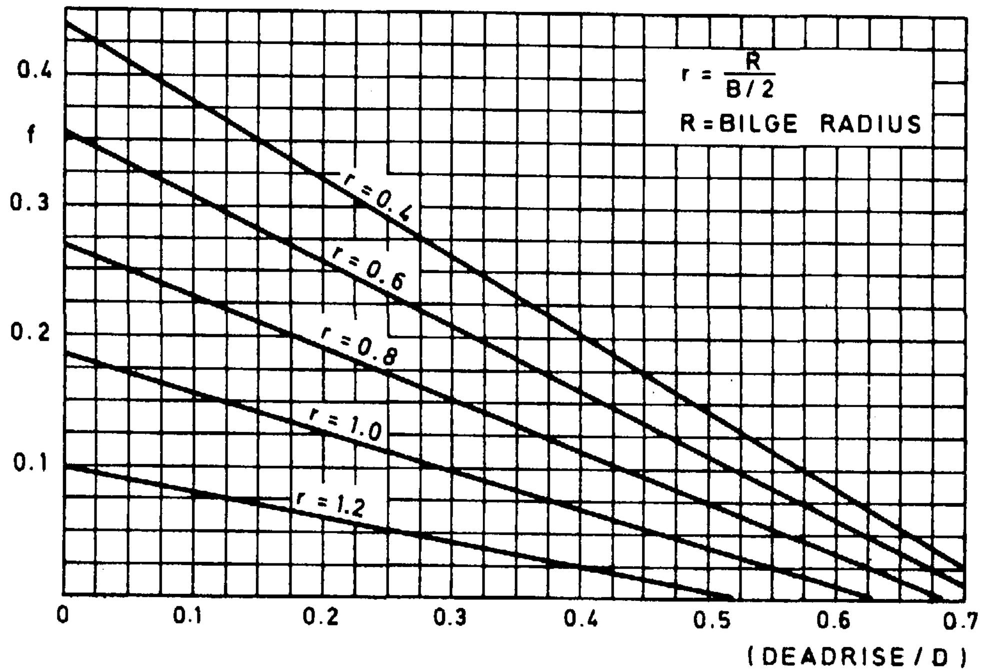


FIG. 6

RELATIVE VERTICAL REACTION:

$$f = \frac{V}{1000\ BDS}$$

V - VERTICAL LOAD (kp) BETWEEN A FRAME AND THE KEEL.

B - BREADTH MOULDED (m)
D - DEPTH MOULDED (m)
S - FRAME SPACING (m)

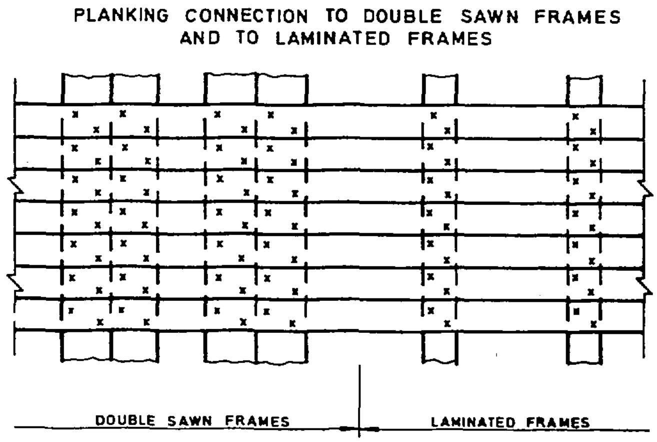
PLANKING CONNECTION TO DOUBLE SAWN FRAMES
AND TO LAMINATED FRAMES
DOUBLE SAWN FRAMES
LAMINATED FRAMES

FIG. 7

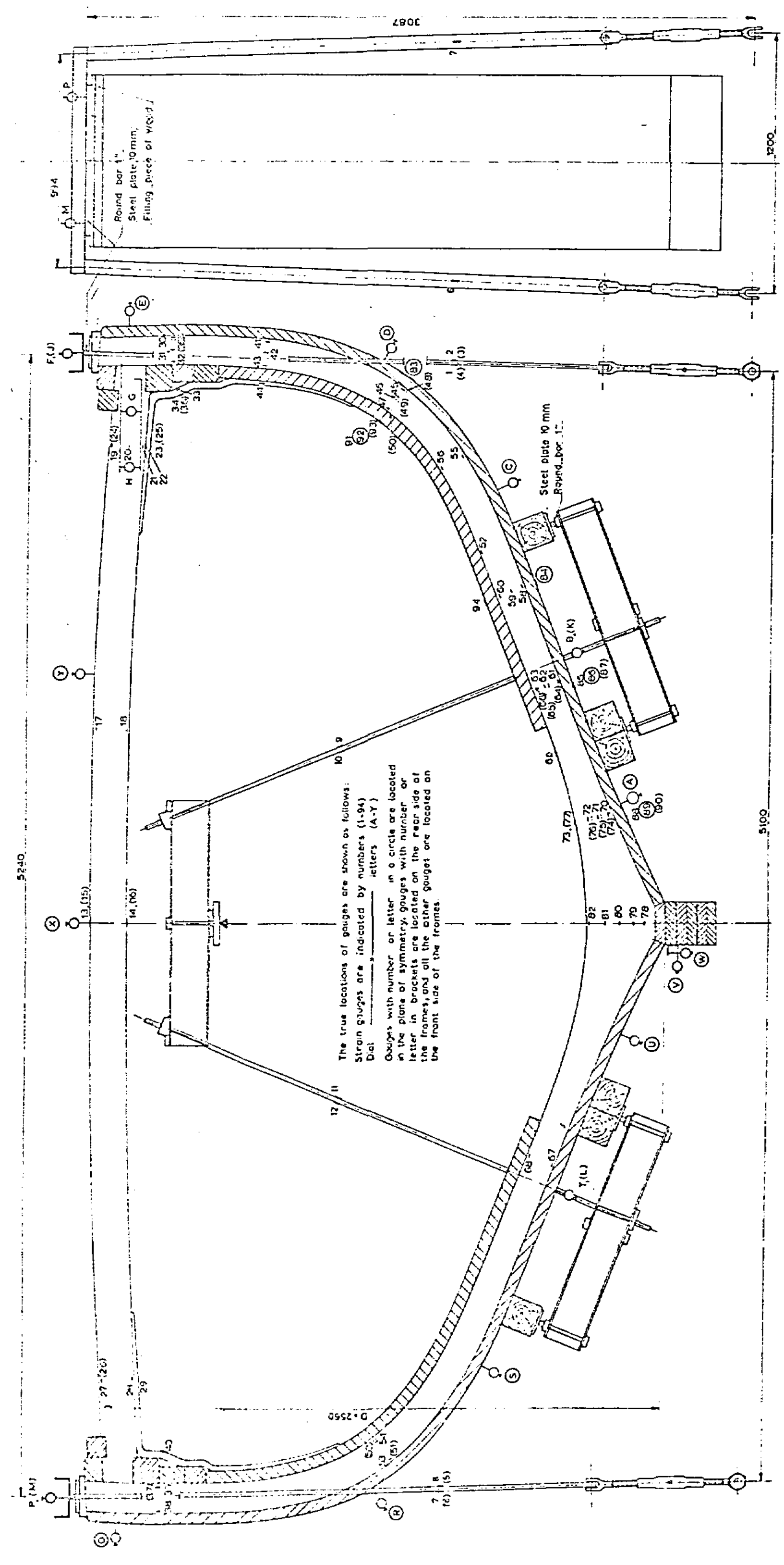

Figure 8. Laminated Frames with Test Arrangement. From [2]

# A General View of Construction Materials of Fishing Vessels in Japan

Mr. Kojima

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by

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*Mr. Kojima has been a member of the I.M.C.O. Meeting of Specialists on Stability of Fishing Vessels since 1963. He attended the First FAO Research Vessel Forum in Tokyo in 1961, the FAO Fishing Vessel Stability Meeting in Gdansk, Poland, in 1963, and the Third FAO World Fishing Boat Congress in Goteborg, Sweden, in 1965.*

## ABSTRACT

The Japanese fishing fleet is composed largely of wooden vessels, but the number of steel vessels being built, especially those of 50 G.T. and over, is increasing. This paper gives the reasons for this trend away from wood and outlines some of the building techniques. Fiberglass Reinforced Plastic was introduced in Japan for smaller craft in 1957 and the progress made in the use of this material is outlined.

## INTRODUCTION

From the viewpoint of construction materials, it is obvious that the Japanese fishing fleet is composed largely of wooden vessels as shown in Table 1, but the current trend is found (1) in the increasing number of steel vessels year by year, (2) in the decreasing number of wooden vessels of 50 G.T. and over, (3) in the appearance of F.R.P. small craft, and (4) in the infrequent adoption of other materials, for example aluminum alloy, because of its high cost in Japan.

## PART 1. DECREASING NUMBER OF WOODEN VESSELS OF 50 G.T. AND OVER

Fishing vessels of this size in Japan are usually engaged in high seas operation. Many of them were formerly built of wood, but the recent five-year experience has shown a decrease in the construction of these vessels, newly built, as shown in Table 2. To explain this situation, the first factor to mention is the lack of timbers suitable for shipbuilding.

Long timbers for shell plank (planks of 10.5 m in length are required for amidship members) are usually of domestic soft wood such as cedar and pine, and are rarely supplied for shipbuilding, being required by the big demand for wooden house building and by the difficulty in transporting such long lengths to the lumber-mills. Other than long size, a large breadth is required (plank of 0.25 - 0.40 m in breadth) for garboard strake and sheer strake of the indigenous type of Japanese fishery vessel. This increases the difficulty of finding suitable timber. Curved timbers are necessary to construct frames and they also are scarce. Sawn frames are usually adopted for Japanese type wooden vessels, and these demand knee-shaped members of fairly curved grain to construct the bilge part of the frame, which forms rather a square shape in the midship part of the hull.

Hardwoods are also scarce. A long piece of hardwood is necessary for constructing keel, keelson, stem, stern post, rudder post or rudder stock. Japanese zelkova (Keyaki) is a well-known good domestic hardwood, but it takes a long time, some 100 years or more, for zelkova to become available as ship construction material. The past three decades of construction of large size wooden vessels has nearly consumed this hardwood in Japan, and nowadays it is difficult to find suitable zelkova for wooden vessel construction.

As shown above most important timbers for wooden vessels in this size are very scarce in domestic supply, and the imported timbers available are rather expensive for the construction of wooden vessels in Japan. The next reason for the decrease in wooden vessels of this size is the scarcity of skilled wooden-vessel shipwrights. Fifteen years ago, the firms where these sizes of wooden vessels were constructed numbered about 120, but nowadays only about seven firms are in operation. Old shipwrights faded out and few recruits succeeded them. Their techniques have been learned by tradition from person to person, and no systematic education has been received except in a few cases. A young apprentice must spend a long time to become skilled in shipwright techniques, and a rather small income often compels him to give up his job halfway. The average age of shipwrights in these firms is about 53 years, and it seems difficult to find younger ones.

## PART 2. STEEL NOW REPLACING WOODEN CONSTRUCTION

The former advantages of wooden vessels over steel ones are mentioned below but are now invalid.

(1) Easy repair of wooden vessels on shore is now replaced by easier methods in steel vessel repairs, performed with welding, cutting and burning.

(2) Good heat insulation of wooden fish holds, maintaining ice unmelted for a week or more, is surpassed by the newly developed insulation materials laid on steel hold walls, such as foamed urethane, etc.

(3) It was said among Japanese fishermen until some years ago that wooden vessels were superior to steel in their behaviour and seaworthiness among waves, and that steel vessels were apt to dart into waves and become flooded with sea water. This could be explained by the unsuitable form of old steel vessels in Japan, and nowadays the improved steel hull form has shown its superiority among waves. Thus during the past six years 323 steel salmon drift netters replaced wooden vessels engaged in the North Pacific Ocean.

(4) Cheap cost of construction was a big advantage for wooden vessels, but today the cost of wooden vessels is almost the same as for steel ones, and sometimes more in the case of large vessels. Many wooden shipbuilders have changed their business into steel shipbuilding because of the scarcity of orders for expensive wooden vessels.

Next, reasons why steel has overcome wood are the unavoidable defects of wood such as (1) the damage by shipworms, especially when operating in tropical zones, (2) the rot caused by bacteria, (3) the shell plank damage caused by being pierced with swordfishes' sharp sword, (4) the sinkings year by year caused by water absorption of wood, and (5) the considerable amount of hull defects due to inefficient joints of members. Against these defects, glue-laminated wood has been recommended, but it has not been adopted to any great extent for fishing vessels in Japan because of its high cost.

## PART 3. INCREASE IN NUMBER OF STEEL FISHING VESSELS

It is not necessary to say that steel is an excellent construction material for large size fishing vessels, and nowadays in Japan newly built fishing vessels of 25 m in length and over are all of steel construction. As to the choice of steel for hull construction, it is of keen interest to guess how far the steel construction will proceed into small fishing craft and replace wood. For this matter, our experiences in the past decade were as follows:

(1) As mentioned before, 323 steel salmon drift netters of 85 G.T. were built during the past six years.

(2) 168 steel pair-trawlers of 75 - 95 G.T., and 289 steel one-boat trawlers of 30 - 100 G.T. were built successfully during 1962-1967, and are expected to have a longer life (12 years in operation) than that of wooden construction (only 4 years of effective life in the trawling operation from past experience).

(3) 199 steel purse seiners of 60 G.T. were built during 1962-1967, and proved their superior strength of hull when engaged in alongside operation.

(4) 251 steel tenders of 30 G.T. for purse-seine fishing were built with success during 1962-1967, the building costs of which were almost the same as for wooden ones.

(5) About 700 steel vessels of 20 G.T. and under engaged in coastal fishing were built with success during 1962-1967.

Judging from these results, we assumed that steel construction could be valid for small fishing craft, and in 1967 we set up standard construction plans for 16 kinds of coastal steel fishing vessels, taking into account the corrosion of steel, which is a serious problem for the thin steel plating of small vessels. To prevent corrosion, sand blast treatment was recommended to be adopted, and today in Japan even in a small local shipyard this treatment is available, and a specially made steel such as "CORTEN STEEL" was recommended for use, which has an excellent quality to keep the coated paint on it, and moreover, paint and zinc anode protection must be renewed at proper intervals of time.

Some new trends are found in design of steel vessel construction. One example is the use of a new type of steel section. An upper deck is constructed with pieces of specially formed section welded to each other, spanning longitudinally between widely spaced strong beams as shown in Fig. 1. Another new design is a double skin steel fish hold constructed like a vacuum bottle. The space between the double steel skins is filled with foamed urethane and some wooden distance pieces which keep the double skins parallel to each other as shown in Fig. 2. This double skin wall is a heat insulation good enough for cold storage, and its inner steel hold wall is convenient for fuel oil storage in wing tanks outboard of the fish hold, the capacity of the tanks being utilized to contain fuel oil on way to the fishing grounds and caught fish in the hold when homeward bound.

## PART 4. F.R.P. CONSTRUCTION

Fiberglass Reinforced Plastic was introduced from the U.S.A. to our country in 1952 and stimulated boat builders in Japan to try to use it as a construction material for pleasure boats and yachts. In 1955, a research association on FRP was established to perform researches on technical matters concerned and some results were achieved by the association as follows:

(1) Rowboats were manufactured by way of trial in 1955.

(2) A research on FRP construction for ultra-cold weather conditions was performed during 1956-1957, being sponsored by the Government.

(3) A test on weather durability and other physical properties of FRP was performed in 1957.

(4) In 1959, a standardization procedure was drafted for the manufacture and inspection of FRP boats.

(5) A fatigue test was performed on a superstructure member of a submarine in FRP.

During the term of 1952-1959 fundamental materials for FRP manufactured in Japan became available. In 1953, polyester resin was made by a firm in Japan and until 1956 three other firms also made it. Japanese-made glass fibre became available in 1957 and roving cloth in 1960. These homemade materials were tested thoroughly and proved to be good enough for vessel construction in 1962. In 1950, vinyl chloride foam "Airex" was introduced from Switzerland and was adopted for trial in a 12 m length boat in 1964 with no mould but a simple jig.

The adoption of FRP to fishing vessels in Japan was commenced in 1957 when an FRP coat on the wooden planking of small coastal fishing vessels was used to resist shipworm harm and to keep the planks dry. It was not a proper adoption of FRP on hull construction, but later, during the 1962-1964 term, about three hundred small coastal fishing vessels were built in FRP and were engaged mostly in the laver-cultivating fishery, and the construction of these vessels was the mono-skin type using a female mould. In 1964, a 9 m coastal fishing vessel was built successfully in sandwich FRP, using no mould but a simple wooden jig. By this non-mould sandwich FRP method some other fishing vessels were built successfully. For instance, in 1965 a tuna fishing vessel of 16.50 m in length overall, in 1966 an angling vessel of 16.00 m in length overall and in 1967 two tuna fishing vessels of 16.80 m in length overall and five purse seiners of 14 m in length overall.

The reason why this non-mould construction was adopted was to avoid bringing the cost up by making a mould, which would be wasteful for building only one vessel. Coming from an expensive female mould in 1967, a coastal trawler of 12.05 m in length overall was built by mono-skin construction with a male mould made up with 4 m/m thick glue-laminated wood, and she had her strength tested in the trawling operation and was proved sufficiently strong for trawling operations. After that, a construction method with a female mould was introduced. In 1968, two tuna fishing boats of 16.50 m in length overall were built in mono-skin construction, using a wooden female mould which is dividable into six pieces. In the same year, a coastal fishing vessel of 8.50 m in length was built using a female mould made of polyester coated wooden plank which was expected to be used for several other vessels. The high expense of FRP hulls is caused not only by the cost of the mould, but also of glass-fibre and resin, necessary to choice FRP construction. The average cost of FRP vessels in Japan is 1.5 - 2 times as expensive as wooden vessels.

In order to reduce the high cost, a mass-production system is now set to start, and 45 vessels of the same type could be expected to be built per day on one conveyor line using female moulds, where both mono-skin and sandwich construction are available. Opposed to the mass-production system, a trend is seen in Japan to build FRP fishing vessels of different types one by one, thinking highly of the variety of boat design inherited in the tradition of fishermen, where a simple male mould or wooden jig is used. One method of this one-by-one construction is expected to be adopted to chined hull vessels, which are the indigenous Japanese type small craft, and are built of thin and wide wooden boards fixed by iron nails. The process of this construction is to make a piece of flat FRP board first and then cut the board into pieces of expanded shell plank figures, and lastly build up these pieces of FRP board into a chined hull form with single curvature. Another method of this one-by-one construction is under test as follows. First a sandwich type hull is formed with a simple jig or male mould, both outside layers of the sandwich being made of FRP and the middle layer a lattice work of soft wood strakes combined by woven glass fibre strap, and the void space filled with air. Then, using a vacuum pump, the air in the void space in the middle layer of the sandwich is drawn out and replaced by resin poured into the void space. The resin becomes hard and a body of the vessel is completed of "fibre reinforced and wood skeleton plastic." It is an important matter for Japanese FRP vessels, to choose between these two construction methods, one the mass production system and the other the one-by-one system.

Judging from the superiority of FRP, proved over the past 15 years, much use of FRP is expected for Japanese fishing vessels as the substitute for wood. We are endeavouring to establish a safety factor of five, and an effective method of inspecting for failures such as voids in FRP layers, in order to reduce the cost of building and to find suitable forms of FRP vessels, rejecting the indigenous forms if necessary.

**Table 1**

No. of Fishing Vessels of Japan (Dec., 1967)

| G.T. \ Built in | Total | Wooden | Steel | Plastics |
|---|---|---|---|---|
| Total | 397,799 | 392,225 | 5,127 | 447 |
| G.T. | | | | |
| – 0.9 | 207,889 | 207,514 | 28 | 347 |
| 1 – 2.9 | 127,642 | 127,492 | 84 | 66 |
| 3 – 4.9 | 34,359 | 34,208 | 130 | 21 |
| 5 – 9.9 | 10,303 | 10,212 | 85 | 6 |
| 10 – 19 | 7,354 | 6,982 | 365 | 7 |
| 20 – 29 | 1,306 | 1,235 | 71 | – |
| 30 – 49 | 3,353 | 2,990 | 363 | – |
| 50 – 99 | 3,353 | 1,494 | 1,859 | – |
| 100 – 199 | 971 | 97 | 874 | – |
| 200 – | 1,269 | 1 | 1,268 | – |

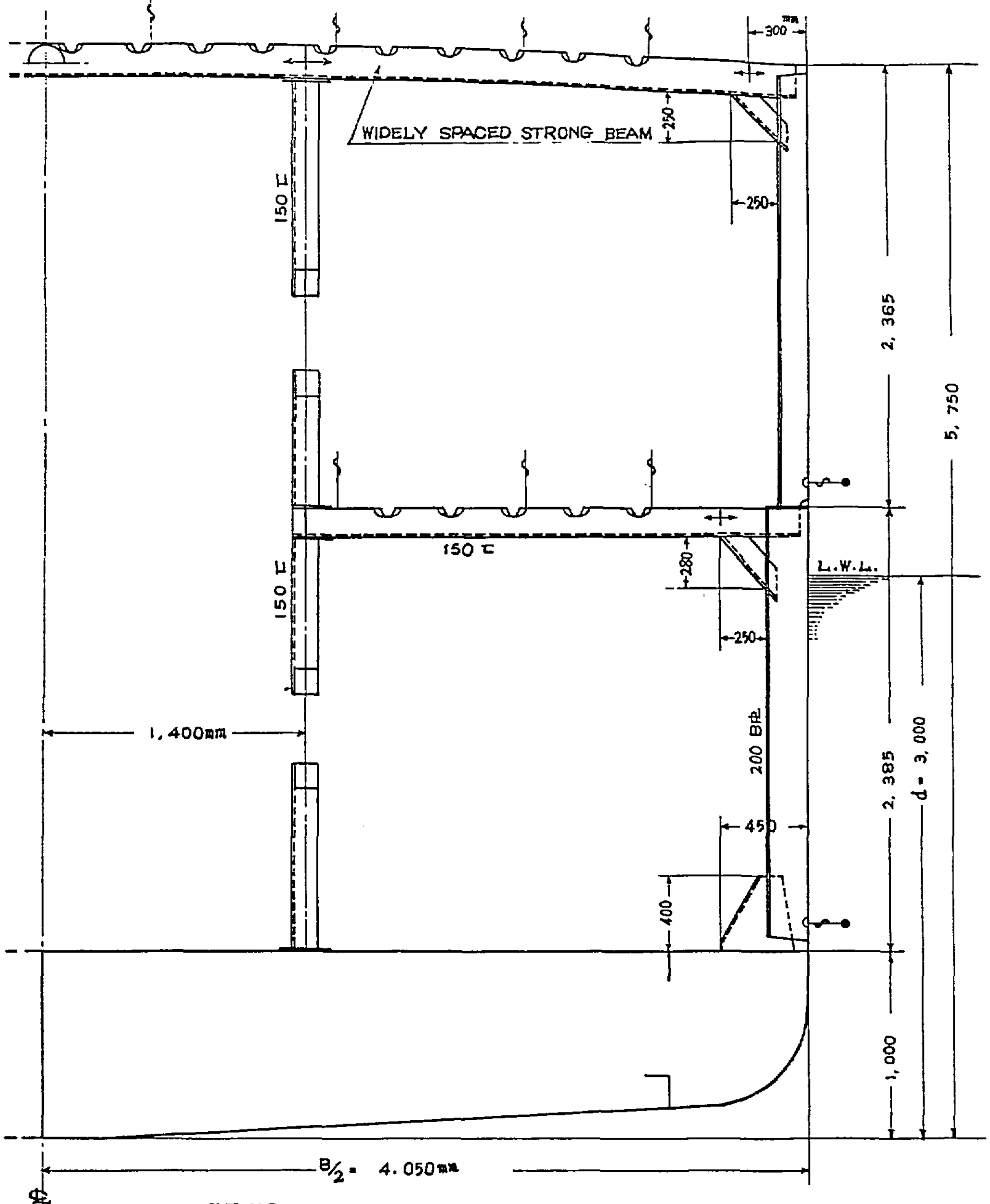
**Table 2**

No. of Fishing Vessels Newly Built Annually

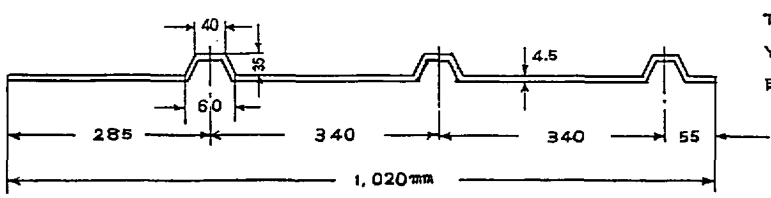
| Year | Total | Wooden | |
|---|---|---|---|
| | | Sub Total | 50 G.T. & over |
| 1967 | 815 | 340 | 77 |
| 1966 | 1,158 | 546 | 22 |
| 1965 | 807 | 366 | 28 |
| 1964 | 774 | 327 | 47 |
| 1963 | 1,521 | 772 | 76 |
| – | – | – | – |
| 1957 | 795 | 715 | 314 |
| 1956 | 825 | 671 | 396 |
| 1955 | 920 | 783 | 449 |
| 1954 | 969 | 868 | 457 |
| 1953 | 781 | 719 | 337 |

DECKS CONSTRUCTED WITH SPECIAL TYPE STEEL SECTION

Fig. 1.



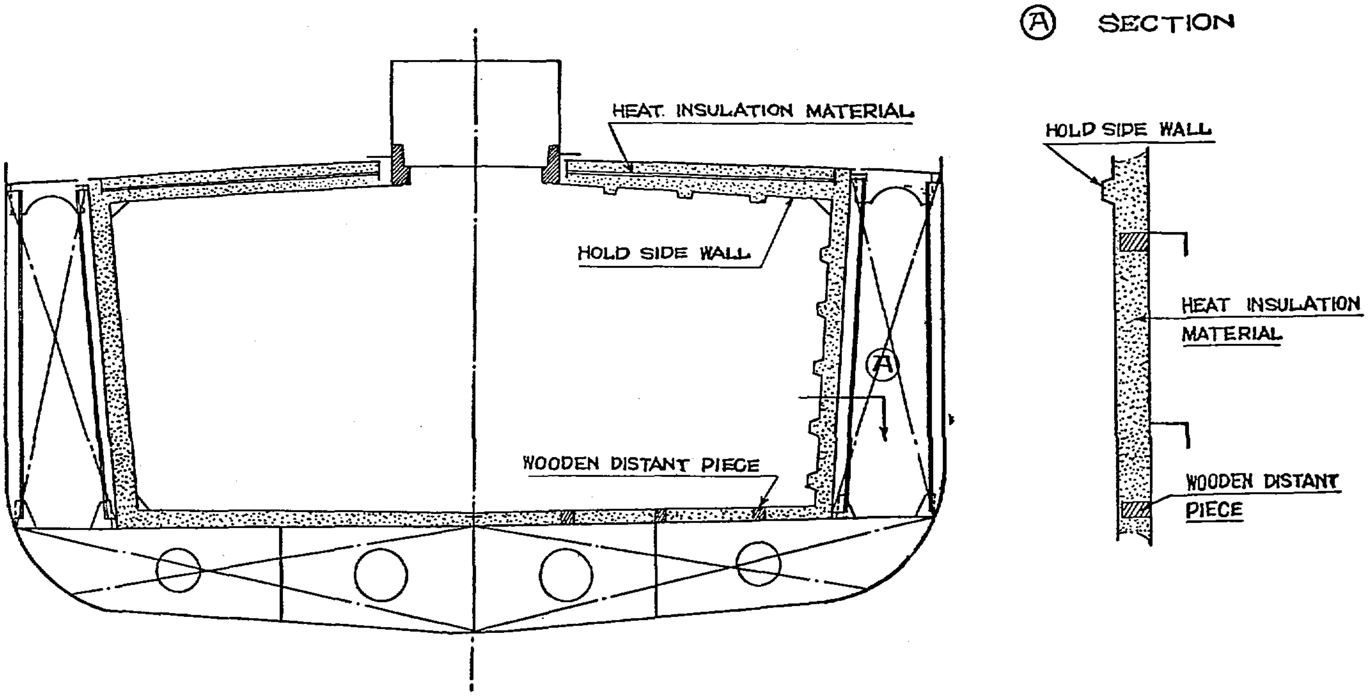

SPECIAL TYPE STEEL SECTION




TENSILE STRENGTH ; 41～55 Kg/mm²
YIELD POINT ; 24 Kg/mm²
ELONGATION ; 21 %

FISH HOLD OF VACUUM BOTTLE CONSTRUCTION

Fig. 2




**Session 1**

## DISCUSSION

*Mr. Traung asked if Det norske Veritas contemplated measuring stresses on small vessels in a seaway, such as is done on large vessels.*

*Mr. Saethre: "About two years ago, we carried out measurements on a wooden fishing vessel about 60 feet long. We tried to measure the longitudinal deflection of the boat and also the stresses in the keel. Unfortunately, we were not able to get any heavy weather on this ship so we didn't get very much in the way of results from it. But measurements obtained seemed to be very small stresses, especially in the keel. The longitudinal deflection was very small. We have not had any tests on FRP vessels as yet."*

*Mr. Traung next asked if Mr. Mathews could say a few words about the program of work of the planned S.N.A.M.E. Task Group on Fishing Vessels.*

*Mr. Mathews: "No, I am afraid I cannot, to be truthful. I just read this morning, as a matter of fact, that a panel was to be set up, and I think it is traditional when they set up a panel of this kind that initially the terms of reference are very wide. I don't know specifically who will head this group or what their main approaches will be. I would suspect that they will look at all aspects of the things connected with the Society of Naval Architects and Marine Engineers in this work."*

*Mr. A.F. Morris, of National Sea Products, Limited, Halifax, N.S., addressed a two-part question to Mr. Traung: "Has any work been done to determine the effect of Kort nozzles in reducing radiated propellor cavitation noise? Has any such noise reduction been shown to affect fish behaviour?"*

*Mr. Traung replied that about two or three weeks before, in Rome, a very large Conference had been organized by the United States Office of Naval Research, to which was submitted a paper by an American scientist on noise radiated by propellers. This paper was classified. He added: "There were also a number of papers on ducted propellers, a subject which is becoming more and more important in cases of all loaded propellers in applications such as we have in super tankers and in fishing vessels towing a net. None of those papers on ducted propellers, if I remember, discussed noise. Noise, as I tried to say in my paper, is taboo in naval circles, and if naval information could 'unsecretize' this problem as soon as it is conquered, it would be very good. To give two examples of this, I know that one of the professors of naval architecture in Goteborg, Sweden, knows a lot about noise. We wrote and said could you please let us know what he knows about it, and they referred us to the Swedish Office of Naval Research.*

*"At the Research Vessel Conference which we held in Seattle in May this year we asked a naval architect working with one of the private oceanographic institutions in the United States to write a paper on noise. He said that he would be very interested to take some of our vessels over a naval ramp and measure the noise produced by our ships and try to find out what was causing it. However, I do not want to be forced to be tight-lipped. I would rather prefer to speak about noise as an amateur. The general feeling among my colleagues, with whom I have discussed this, is that anything which is working efficiently – a propeller working in an even wake flow and I guess a ducted propeller works in a more even wake flow than an unducted propeller – creates less noise. The same applies to hull generated noise. If your ship has a nice acoustic shape, creating not as large waves as other vessels, that will also create less noise."*

*Mr. L. LaChance, Assistant Professor of Civil Engineering at Laval University, Quebec, submitted the following question to Mr. Saethre: "In your analysis, do you take into account both radii of curvature R1 and R2? We have a general two dimensional computer program at Laval University to analyse any shell roofs. This could be used with advantage to analyse any vessel hull. I should be happy to co-operate with you in this field."*

*Mr. Saethre: "In the analysis carried out we have just taken into account the radius of the frame, and not the curvature in the longitudinal direction. I am not quite sure if we have any program to do this.*

*Mr. R.H. Semken, of Reynolds Aluminum Company of Canada, Monreal, asked Mr. Mathews what factors limited aluminum's use in large vessels. He also wanted a definition of large vessel dimensions.*

*Mr. Mathews: "Well, I think, as I mentioned in the paper, the big factor is the large deflection and low Young's modulus. In a seaway, where you get high stresses, you get a large deflection in steel ships, and it would be of a much higher order in an aluminum ship, and this would certainly cause problems. So far as large ships go, this is always a problem – how large is large? I don't know the size of the largest aluminum built vessel, but when we're talking large ships, we're talking bigger than coastal vessels and larger 400-ft carriers, and on up to super-tankers.*

*"Aluminum is used extensively for superstructures. It is considered that cost, of course, is important, as Mr. Bonn has reminded me. I think the abundance of aluminum is likely in the future to make it more attractive from a relative cost point of view. I understand from a very long term that one*

*of the questions in reflecting costs is not so much the abundance of aluminum, but the abundance of the bauxite used in its production. It is generally considered that low Young's modulus, perhaps allied with cost, will maintain its attractiveness. I am sure there are people here who have more personal experience than I have, but these questions will be considered by the materials group, and apart from anything I might say here, official written information from the Society will be available if requested."*

*Mr. Walter Scott, Department of Fisheries and Forestry, Ottawa, referring to Mr. Saethre's paper, said that this excellent contribution identified the methodical and modern approach now being taken by classification societies in stress determination. Wood, however, in the "as-grown" form, has a wide range of properties and in a laminate, while more predictable, the material still represented widespread physical properties per species. He asked: "Do DNV have any recommended code which builders must follow to obtain the properties expected, and what are the essential points in this regard?"*

*Mr. Saethre: "On the first figure in our paper, we showed the applied load which we used when we calculated these bending moment diagrams. And the water pressure used is equal to the vessel immersed up to deck, i.e., the pressure on the bottom. With this load applied we accept a nominal stress in the laminated frame of about 100 k pounds/cm$^2$, which when multiplied by about 14 gives p.s.i.*

*"For double-sawn frames or the previously mentioned conventional method, we multiply the section modulus by 1.5 because it is much more difficult to predict the quality of the frame for a sawn construction. To be sure that we have the predicted quality of the frame, we have given regulations to be followed when laminating.*

*"The moisture content in the wood had to be between 10 and 15% before glueing. I am not quite sure about the actual size of these figures, but they are in that order. The clamping pressure during glueing has to be not less than 8 k pounds/cm$^2$. At the completion of glueing, a number of test pieces have to be transmitted for testing. Both sheer strength of the glue and also delamination tests are carried out. The delamination test is done by immersing the test pieces in water for some hours, and afterwards heating it up, cooling it down, immersing it in water once more, and this cycle is repeated a number of times. After that the percentage of delamination in the glueing is found. If the test then shows a delamination of more than a given percentage, it is rejected, and they have to make another frame."*

*Mr. E.S. Wagner, Department of Fisheries of Canada, Halifax, addressing a question to Mr. Traung, said: "Reference has been made to suggestions concerning the use of rubber in the construction of fuel and water tanks and cargo carrying containers. What are some of the potential advantages in the use of rubber rather than that of other materials now commonly used?"*

*Mr. Traung: "Actually, there are already rubber fuel tanks and rubber water tanks in use on long distance Japanese fishing vessels. Thy have a large rubber container in their fish hold, when they steam out to the fishing grounds, in which they keep their fuel or water. When they have consumed the fuel or water they collapse the rubber and use the same space for, say, refrigerated sea water. In other words, they facilitate the dual use of a fish hold without having to clean the space between the various uses."*

*The following questions and answers were not heard at the Conference because of Mr. Kojima's absence. However, the questions were forwarded to him in Japan and he has returned them with his replies.*

*Mr. Lyle Chase, Ferrocon Industries, Ltd., North Vancouver, B.C.: "Since we (Canadians) must import from Japan wire mesh which is the most expensive material used in ferro-cement construction, it seems logical that such boats could be built at low cost in Japan. Could Mr. Kojima comment?"*

*Mr. Kojima: "Although no ferro-cement fishing boats have yet been built in Japan, a 36-foot pleasure yacht for open sea cruising is presently under construction in ferro-cement. This is being built by a young Japanese interested in yachting, who learned about the advantages of ferro-cement construction, namely its superiority in strength and low cost, through a Japanese yachting magazine, and decided to build a ferro-cement yacht by himself. He has received technical support from Samson Marine Design Enterprise of Canada through the Japan Yachting Association. He reports that compared with wooden boats the cost of construction is much lower, the method of construction simpler, and the strength of the hull greater under the present methods.*

*"I believe that more ferro-cement fishing boats will be built at low cost in Japan in the future, because such fundamental materials as cement, wire mesh, steel bar and steel pipe are available at a low price in our country, and also because the technique for building such boats is rather simple from our standards of technology."*

*Mr. Traung: "In view of the relative lack of information on stress-measurements on small fishing vessels at this Conference, would Mr. Kojima please review the important Japanese work in this field which has been published in Japanese?"*

*Mr. Kojima: "Some reports of stress-measurements on small boats are as follows:*

*a) Shōzō Wada, "Structual Strength Investigations on Aluminum Fishing Boat", Technical Report of Fishing Boat, No. 7, Fishing Boat Laboratory, 1956.*

*In this experiment measurements on*
*i) stress distribution,*
*ii) max. deflection, and*
*iii) shearing stress distribution*
*were performed on an aluminum fishing boat (8.50 m x 2.61 m x 1.00 m) on shore under the sagging condition made by a dummy load amidships and the boat slung at both fore and aft.*

*Conclusion of this experiment was that simple beam theory is effective in the strength calculation of a small boat, provided that i), the section modulus of boat is calculated on all continuous longitudinal members excluding wooden and deck house construction members, and ii), points of measuring are to be as many as possible and the calculation is to be done only with the mean value.*

*b) F.R.P. Boat Technical Committee, "Structural Strength Test on F.R.P. Boats", Technical Guide for F.R.P. Boats, Japan Ship & Boat Manufacturers' Association, 1968.*

*Hull deflections were measured at 24 points, under the condition that the boat was supported at the fore and aft and jacked up or loaded amidships on building berth.*

*c) Technical Staffs of Maritime Safety Agency, "Rough Sea Texts on Small Patrol Boats"*

*"The reports of these tests are not concerned with fishing boats and have not been published, but I understand that they may be published if requested.*

*i) The test was performed on a patrol boat named "Bizan" (24.5 m x 5.6 m x 2.7 m) in 1967. The stresses were measured at 24 points near bottom of the ship in the conditions of head, stern and quarter sea, at every main engine output of 1/2, 3/4 and 4/4.*

*ii) The other test was performed on a patrol boat named "Yamayuki" (21.00 m x 5.1 m x 2.6 m) in 1966. The stresses were measured 19 points in the conditions of head, quarter and beam sea, at every main engine output of 1/2, 3/4 and 4/4."*

*Mr. John Gardner, "National Fisherman", Camden, Maine: "You state that polyester resin and glass fiber are now 'homemade' in Japan. Are these fundamental FRP materials manufactured under licence and if so, would royalties paid account for the high cost of these materials resulting in FRP boats costing 1.5-2 times more than wooden boats?"*

*Mr. Kojima: "Glass fiber is manufactured by three major firms in Japan, and two of them manufacture it under licence from the U.S. companies and the other without any foreign licence. Polyester resin is manufactured by many firms with their original technique.*

*"The high cost of these fundamental materials and labor, as well as royalties paid, accounts for the high cost of FRP boats in Japan. Since these fundamental materials are not yet produced efficiently by means of mass production, and FRP boat building requires extra man hours due to lack of workers' skill, these boats cost 1.5-2 times more than wooden boats."*

*Mr. W.A. MacCallum, Fisheries Research Board of Canada, St. John's, Nfld.: "With reference to the use of tanks to carry fuel oil to the grounds and fish when homeward bound, 1), what procedure is used to clean the tanks before storing the fish, 2), how are the fish refrigerated in these tanks, which appear to be uninsulated, and 3), what species are stored in the tanks and for how long?"*

*Mr. Kojima: "a) Procedure of cleaning:*

*"At first the tanks are cleaned by wirebrushes with sea water soluble cleanser which is composed of sodium salt of alkyl benzene sulphonate and ethylene oxide condensates of alkyl phenols. Then the tanks are filled with sea water for about 24 hours to rinse out the cleanser. After the sea water is discharged, the tanks are ready for storing fish.*

*b) The fish is kept refrigerated. Hair pin cooling coils are arranged inside the steel tank wall. The tank wall is lined on the opposite side of the cooling pipe with 100 m/m thick polyurethane foam insulating materials.*

*c) The tanks have been used so far for storing only tuna, and it is stored for about 4 months in case of 300 G.T. type tuna long line fishing boat."*

*Mr. Thomas O. Otto, Marine Management Consultant, Miami Beach, Fla.: "We have heard that some work is being done on ferro-cement in Japan. Would you please comment on this?"*

*Mr. Kojima: "The answer is the same as that given to Mr. Chase".*

SESSION 2, OCTOBER 1, 1968  2.00 P.M.

# THE CANADIAN SITUATION

Moderator: Brian Meagher,
Deputy Minister of Fisheries,
Nova Scotia


Session 2, left to right, W.E. Bonn, G. Hughes-Adams, W.J. Milne, Inset, upper right, R.I. Nelson.

# Moderator's Introduction

Mr. Meagher: *I am proud to represent the province whose craftsmen produced the world famous fishing vessel* Bluenose. *It seems appropriate that I am moderating a session in which one of the speakers is Mr. Bill Milne, whose paper is on trends in the use of traditional construction materials. We are also to have the pleasure of hearing what Mr. Hughes-Adams, representing the federal Department of Industry, has to say concerning the potential of newer fishing vessel construction materials. Linking these two together, Mr. Warren Bonn will highlight the regulatory aspects of traditional and newer construction materials, and Mr. Richard Nelson will discuss the industry's viewpoint.*

*Six years ago Nova Scotia took its first somewhat cautious steps in the use of plastics for fishing vessel construction by producing a small plastic fishing vessel, in co-operation with the Industrial Development Service of the federal Department of Fisheries. This was a fibreglass Cape Island type boat, a model of which we see here. You will notice that it represents a 38-foot boat. It has been in operation now for between six and seven years; it has gone through some very severe tests, in running ashore, having its nose pushed in by a bulldozer during a launching, and being used as an icebreaker. According to the people who are operating it, the boat is as good today as the day it was built. It is still operating very successfully. We learned a good many useful lessons as a result of constructing and operating this small experimental boat, and as I said before its hull and superstructure are as good now as when it was launched.*

*The three speakers in the first session dealt with the world situation. The speakers in this session will examine the Canadian situation, as well as providing us with more specific background information in the area of our principal interests in Canada.*

# Trends in the Use of Traditional Construction Methods

Mr. Milne

by
W. J. Milne,
German and Milne, Naval Architects and Marine
Surveyors, Montreal

*Mr. Milne was born in Saint John, New Brunswick in 1928. He obtained a degree in Naval Architecture and Marine Engineering from the Massachusetts Institute of Technology. He has had practical training in shipbuilding in Canada and Europe. His experience as a professional naval architect includes the design and supervision of construction of fisheries protection craft and fisheries research vessels as well as commercial fishing vessels.*

### ABSTRACT

This paper is a discussion of the trends in the use of materials now common practice in Canadian shipyards. The growth in volume of work and size of vessels in recent years is outlined. The largest vessels are constructed of steel with some portions in light metal alloy and fibreglass reinforced plastic.

Moderate sized trawlers are preponderantly of wood construction but there is a tendency toward increased use of steel as the hull material. Small fishing boats are virtually all of wood on the East and West Coasts. Inland vessels have steel hulls and aluminum superstructures.

Attention is drawn to the beginning of a trend to standard mass produced hulls of material other than wood. On the West Coast this trend has already begun.

### INTRODUCTION

The Canadian trawler fleet has just ended a period in which there was a phenomenal expansion in size and numbers of steel vessels and at the same time saw revolution in type of hull and gear. The result has been a most beneficial improvement to the capability of the offshore fleet.

During the same period there was a resurgence of building activity in moderate sized vessels of wooden construction which revitalized that section of the shipbuilding industry.

Parallel with this event the construction of smaller types of fishing boats continued at a steady rate.

### TRENDS

The general improvement to size and class of vessel followed the world trend of technological advance, but in our own terms we must conclude that we now have more boats, more productive boats and more seaworthy boats.

It is difficult to assess the trend of this expansion in finite terms. In fact if we are to base opinions upon immediate facts and today's conditions we must assume that the trend is to a static condition.

There is a pause in the expansion and a decline in new orders. This has resulted from the tremendous growth of the fleet and a decline in the market, coupled with rising construction costs.

Now is an opportune time to examine changes that have taken place in recent years and from that information assess the trends that are at work.

As stated the trend has been to more and better ships but this is really a recent development.

From 1930-1960 there were virtually no steel otter trawlers constructed in Canada for the Canadian Atlantic fishery.[1] The only exceptions were several distant water trawlers built for the French Government immediately after the War and a Fisheries Research Trawler. During that time trawler owners who wanted large steel vessels either ordered them from overseas or bought second-hand tonnage.

With the advent of the subsidy program in the early '60s the situation changed completely and many steel hulls were laid down in this country in progressively larger numbers and larger sizes.

Table 1, which lists vessels actually fishing, shows the pattern of growth. An examination of the figures comparing number of hulls to tonnage reveals that many vessels were retired. The trend is illustrated by Figure 1.

The subsidy program was also directly responsible for the increase in the number of wooden hulls in the approximately 100 ft. length range. For example, in 1963 there were no hulls 100 GT and up delivered in Nova Scotia but in the succeeding five years the number of vessels built were 19, 24, 17, 17 and 12 respectively.[2]

The small boat building activity was unaffected by the subsidy as it did not apply to them. A continued growth is readily seen by reference to the figures in Appendix 1.

The most effective trend brought about directly by the increase in volume of work has been the possibility to order *multiple hulls* to one design with little or no change in detail or general arrangement. In some cases it was a matter of repeat orders of an original vessel. However in recent years there have been cases of five and even ten ships on

**Table 1**
Trawlers 100 ft. LOA and over

| | 1963-64 | 1964-65 | 1965-66 | 1966-67 | 1967-68 |
|---|---|---|---|---|---|
| NOVA SCOTIA | | | | | |
| number | 53 | 55 | 61 | 69 | 67 |
| gross tonnage | 16,240 | 17,237 | 18,736 | 23,554 | 23,995 |
| NEWFOUNDLAND | | | | | |
| number | 32 | 41 | 49 | 50 | 65 |
| gross tonnage | 8,187 | 12,556 | 15,175 | 17,185 | 27,434 |
| NEW BRUNSWICK | | | | | |
| number | 3 | 4 | 4 | 2 | 5 |
| gross tonnage | 992 | 1,324 | 1,324 | 571 | 1,595 |
| QUEBEC | | | | | |
| number | 1 | 2 | 2 | 5 | 7 |
| gross tonnage | 248 | 560 | 560 | 2,567 | 3,867 |
| PRINCE EDWARD ISLAND | | | | | |
| number | – | – | – | 2 | 4 |
| gross tonnage | – | – | – | 1,004 | 2,048 |
| TOTAL ATLANTIC COAST | | | | | |
| number | 89 | 102 | 116 | 128 | 148 |
| gross tonnage | 25,674 | 31,677 | 39,795 | 44,881 | 58,939 |

NOTE: On the Pacific Coast, 230 new commercial fishing vessels valued at $10.9 million were completed in 1967. Included are two large tuna seiners valued at $5 million which will operate out of east coast ports. Of the remaining vessels, 144 valued at $2.2 million were gillnet or gillnet-troll combination vessels and 73 valued at $1.96 million were troll or troll combination vessels.

SOURCE: Economic Services, Department of Fisheries of Canada.

order at one time in one shipyard to one specification. If the order is known to be for several ships at the outset more sophisticated design and technical complications can be practical. Moreover steady production and repetition reduces costs at all levels. The trend to multiple orders definitely works in favour of metal construction as opposed to wood. It would be equally favourable to moulded materials such as fibreglass reinforced plastic or concrete.

In order to study trends in detail we should separate our observations into three large categories:

Large steel trawlers 120′ LOA and larger;
Medium sized vessels 80′ to 120′ LOA;
Small fishing boats 30′ to 80′ LOA.

The basic hull of the steel trawler has changed in form and scantlings to suit new working, powering and crew accommodation arrangements. In all facets there has been increase.

The final acceptance of stem trawling has been the most profound influence upon the design of large trawlers. It has altered and increased normal standards of hull size, power plant, working areas above and below deck and accommodation arrangements. It also led to a general rise of hull profile and as a consequence the relation of the beam to the length. These larger, more complicated structures are more suitable for metal construction methods. They are built of steel and in consideration of their size will continue to be so for many years to come. They are too big to be of wood, and plastic hulls are not yet proven and accepted on this scale.

Scantlings have been increased to withstand ice to a moderate degree. Intermediate stiffeners are used extensively but stringers located above and below the working waterlines are the most effective and economic. The vessels are not designed for severe ice service such as sealing.

Classification rules for trawlers are generally followed for the standard sized (120′ to 140′ LBP vessels) but for the largest stem trawlers advantage has been taken of the more flexible rules for steel ships.

The innovation of stem ramps has led to the use of complicated plating, which can best be made economic by building several hulls from a single set of lines.

The more noticeable effect of the stem ramp has been a general widening of the deck line, which indirectly has had other beneficial results. Beaminess is required for more pressing reasons such as work area and stability.

Stem trawling has led to larger power plants which imply deeper keels with stronger stem frames and engine bases.

The innovation of heavier loads suspended on high gantries, power blocks and similar devices has made steel weights increase and again, indirectly, required increased beam.

Fish handling has been mechanized and brought under cover. Space is required for fish processing on many vessels. This has resulted in large forecastles extended aft or ample 'tween decks such as previously were not seen on any but the large factory trawlers.

Access to the hold may be by covered alleyway or extended trunk rather than the simple deck hatch of the earlier vessels.

The larger basic hull has permitted more area and more volume to be allocated to crew accommodations. This tends to increase steel weight and also outfit material weights for cabin linings, furniture and piping.

Wheelhouses have become larger not only to house the growing amount of electronic gear and remote controls but also to provide positions for viewing onto deck aft or other working areas. This increases structure weight, windows, linings, etc.

Vessels are being built with capability to journey to Greenland waters. This increases tankage space but may not require larger hull volume or material.

The severe winter conditions in the area of operation of these vessels has led to the imposition of safety standards limiting minimum statistical stability and minimum range of stability. More rational requirements should be drawn up based upon recorded data and permitting more flexible hull arrangements. However, the rules are met by larger beam and more closed and watertight volumes in the superstructure.

All of the trends described so far are interdependent and complementary. All result in larger ships than were considered adequate ten years ago.

The trend in construction methods has of course followed general improvements in shipbuilding technique. Trawlers have complicated hulls which are not always suitable for scale lofting and automatic plate cutting. The solution here has been multiple ship orders referred to above, which permits more drafting and planning manhours than would be economic if only one hull were to be built.

Prefabrication of hull sections prior to assembly and launching continues to be applied to trawler building. Not only may the main hull be built in sections and partially piped before joining but entire units, such as wheelhouses, fully equipped with wiring, lining, navigation aids and even coat hangers are pre-assembled and hoisted into position.

Standard methods of construction using modern materials have been perfected and made generally acceptable. The best example of this is to be seen in fish hold insulation foamed-in-place and fibreglass covered.

Standard accommodation arrangements based on prefabricated furniture and bulkhead modules are now used.

The basic *material of construction* is mild steel. Newer materials are used in ever increasing quantities.

Wheelhouses are frequently but not sufficiently extensively fabricated in aluminum.

Fish hold linings are now either aluminum or plastic.

Stainless steel is being tried in certain locations but not yet fully accepted as a substitute for more common materials.

Deck compositions are replacing wooden decks and are fully successful.

Fire retardant core materials with plastic laminate finish are in normal use as accommodation linings.

Reinforced fibreglass cowls and small superstructures are available from manufacturers and are used.

It is correct to state that new materials and methods have constantly been studied and suggested by shipbuilders or selected by progressive owners wherever there appeared to be a reasonable alternative to the then traditional material for the service in question. This statement pertains to the large side trawlers and stern trawlers as well as other special purpose vessels in that size range.

The medium sized vessels definitely must be divided into two large groups. Those built of wood and those built of steel.

The pattern or trend in numbers of ships may be seen in Table 2. There was a surge in wooden hulls initiated by the shipbuilding subsidy program which tapered off presumably as the demand was satisfied. The steel vessel construction came to a peak later, probably due to early lack of confidence in the efficiency of small stern trawlers.

**Table 2**

Fishing Vessels 80′ to 120′ LOA
Numbers of Vessels Delivered Per Year

| YEAR | 1961/62 | 62/63 | 63/64 | 64/65 | 65/66 | 66/67 | 67/68 |
|---|---|---|---|---|---|---|---|
| Wood Hull | 7 | 18 | 21 | 27 | 21 | 19 | 12 |
| Steel Hull | 2 | 9 | 5 | 2 | 9 | 13 | 1 |

SOURCE: J. Proskie – Figures for Canadian Atlantic Fishery

The remarks regarding larger steel vessels apply equally to the medium sized steel ones. There is a tendency to beaminess in both stern and side dragger forms. New materials and methods have been used to a limited extent. However, if there is a trend to larger hulls it is neither discernible nor sensible. In this class it would be comparable to the "super-compact" automobile. The actual trend is to more gear, more capability, in a smaller hull.

The characteristic of the hull construction of the steel vessels is simplicity. In many cases they were built by small steel shipyards with limited forming equipment. Hulls tended to be chine type and the form was developable – that is without compound curves. In some cases the stiffening or framing was longitudinal to permit easy pre-assembly flat and then the plate with its framing was bent to the desired curve.

The wooden vessels must be considered to be traditional in material and construction. This fact is dictated by the material itself. That they out-numbered steel hulls by a considerable margin proves their popularity, the basis of which is first cost.

Vessels in this size range, usually owner operated, must be inexpensive. This put certain limitations on construction methods and materials for both wooden and steel hulls despite the generous building subsidy then in effect.

At the end of the war there were fabricators in this country who produced laminated wood members such as stems, stern posts and keels for wooden motor torpedo boats. These elements could have been used to advantage by the fishing fleet. From lack of custom the fabricators ceased operation. This was a negative trend that could be reversed provided sufficient standardization were practiced.

Metal superstructures on wooden hulls have been used to a limited extent. Perhaps fibreglass would be more suitable for this application.

These are trends that may be expected. From known data, we must conclude that a demand for wooden hulls in the medium size range exists and will persist for some time.

We must also assume that there will be a gradual decline in the quantity of good material. Although it can be brought from abroad, manufactured material and synthetics must gradually replace natural ones. This is a trend that has gone on for a hundred years, when we think of it in terms of steel. The trend will now accelerate with the availability of plastics and concrete for smaller boats.

Another factor that may soon be more apparent is a decline in the supply of good skilled labour.

When we consider the small fishing boats, particularly those in the 30′ to 50′ LOA range, the pattern takes an entirely different form.

Boats in this category on the East Coast are virtually all built of wood. In many cases they are built by small boatyards in the locality where they are used or by the fisherman himself.

This is a form of "cottage industry" which does not always reflect the benefits of multiple hull construction and standardization.

Many others are built by boat builders who specialize in small vessels.

It is true that despite some small variations the vessels may be divided into several groups according to type, service and size which would be adaptable to standard or multiple hull construction. The hull form of a trap boat or cape boat is quite rigidly set with some minor differences.

The trend in boat size has been the continued use and preservation of various established dimensions.

The construction materials and techniques have tended to remain static except for the introduction of improved caulking compounds, joining materials, etc.

On the inland lakes, steel was adopted as the hull material many years ago. Basic hull forms and methods evolved and construction has continued on a known pattern. Aluminum is used very extensively for superstructures.

On the West Coast wood is plentiful and is the material most widely used for these small vessels. Aluminum fabricators have established a market for their vessels and there is a strong trend to the use of this metal. There is also an acceptance of fibreglass on the West Coast that is greater than on the East Coast.

That there will eventually be a trend away from wood is certain. The pleasure boat industry – considering small boats – shows rapid growth and an increase in the relative numbers of plastic and aluminum boats at the expense of the traditional wood. Lifeboats are always aluminum alloy or fibreglass construction. Government survey launches and tenders now are usually of fibreglass construction. The inshore fishery must soon follow this lead.

A sound case can be made for the change. The life of the wooden boat is limited. Most boats given constant careful maintenance last many years. If the boat was built with due precautions against rot in the original material preparation and structural detail the problem can be kept within bounds, but there is a steady deterioration inherent in the material.

The loss from fire in wooden hulls is usually total.

Both of these aspects can be ameliorated by the use of metal or plastic hull materials.

A third factor to consider is that losses from structural weakness – foundering, stranding, etc. – are comparable to those from fire as is shown in the following table which is abstracted from recent records.

The extent of damage would have been less if metal or moulded hulls had been more common.

**Table 3**

Comparison – Major Losses

| Area | Size | Period | Fire | Structural |
|---|---|---|---|---|
| Newfoundland | 36'–64' | 1961-65 | 18 | 22 |
| Nova Scotia | 30'–60' | 1961-66 | 41 | 26 |
| Quebec | 35'–45' | 1961-66 | 4 | 4 |
| TOTAL | | | 63 | 52 |

It is cost that prevents the new materials from being used more extensively. This may be reduced by mass production of standard hulls – shell or bare hull only – for delivery to small boatbuilders or individual fishermen for completion.

This is a very definite potential trend in the small boat range. That it is a real trend is inferred from the fact that prototypes have been built successfully. Programs are being studied to organize the industry for the change.

It is at this point and for reason of cost that concrete may be adopted for the small boat field. However it cannot yet be claimed that a trend to that material is evident at this time in this country.

Just as the shipbuilding subsidy permitted large shipbuilders to re-enter the trawler market, judicious application of loan funds or similar redirection of capital will effect this proposed innovation of material and construction.

## SUMMARY

The broad trends in the use of materials in the Canadian situation may be summarized thus:

General: Continuous increase in number of vessels until this year.

Groups: *Large trawlers* steel built, newer materials used internally and in superstructures.

*Medium draggers* mostly wood but tending to steel construction with development of new fishing methods.

*Small boats* mostly wood but on verge of commencement of plastic and/or metal hull production.

A general observation is that in the two larger vessel categories there has been a trend away from the traditional and to the unusual in material as well as design.

## ACKNOWLEDGEMENTS

1. John Proskie, Economic Services, Department of Fisheries of Canada.

2. W.S. Hines, Director of Marine & Engineering Services, Nova Scotia Department of Fisheries.

## APPENDIX 1

Number of Fishing Vessels Built with Federal Department of Fisheries Grants by Type Atlantic Provinces, Fiscal Years 1947-67

| Fiscal Year | Type of Vessel[1] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Draggers | | | Longliners | | | Seiners | | | Multipurpose | | | All Types |
| | 30-50 ft | 50-70 ft | Total | 30-50 ft | 50-70 ft | Total | 30-50 ft | 50-70 ft | Total | 30-50 ft | 50-70 ft | Total | Total |
| | | | | | | | NO. | | | | | | |
| 1947-48 | – | 7 | 7 | – | – | – | – | – | – | – | – | – | 7 |
| 1948-49 | – | 8 | 8 | – | – | – | – | – | – | – | – | – | 8 |
| 1949-50 | – | 7 | 7 | – | – | – | – | – | – | – | – | – | 7 |
| 1950-51 | – | 4 | 4 | – | 2 | 2 | – | – | – | – | – | – | 6 |
| 1951-52 | 1 | 6 | 7 | – | 10 | 10 | – | – | – | – | – | – | 17 |
| 1952-53 | 9 | 4 | 13 | – | 11 | 11 | – | – | – | – | – | – | 24 |
| 1953-54 | 7 | 8 | 15 | 1 | 4 | 5 | – | – | – | – | – | – | 20 |
| 1954-55 | 1 | 15 | 16 | 4 | 17 | 21 | – | – | – | – | – | – | 37 |
| 1955-56 | – | 14 | 14 | 3 | 14 | 17 | – | – | – | – | 1 | 1 | 32 |
| 1956-57 | – | 30 | 30 | 2 | 15 | 17 | – | – | – | 4 | – | 4 | 51 |
| 1957-58 | – | 8 | 8 | 2 | 29 | 31 | – | – | – | – | – | – | 39 |
| 1958-59 | – | 16 | 16 | 17 | 14 | 31 | – | – | – | – | – | – | 47 |
| 1959-60 | 1 | 22 | 23 | 33 | 17 | 50 | – | – | – | – | – | – | 73 |
| 1960-61 | 5 | 21 | 26 | 15 | 8 | 23 | – | – | – | – | – | – | 49 |
| 1961-62 | 5 | 5 | 10 | 27 | 9 | 36 | – | – | – | – | – | – | 46 |
| 1962-63 | 1 | 19 | 20 | 8 | 5 | 13 | 1 | 5 | 6 | 8 | – | 8 | 47 |
| 1963-64 | 3 | 21 | 24 | 9 | 1 | 10 | – | 4 | 4 | – | – | – | 38 |
| 1964-65 | 7 | 26 | 33 | 42 | 15 | 57 | – | 4 | 4 | 2 | – | 2 | 96 |
| 1965-66 | 3 | 16 | 19 | 27 | 8 | 35 | – | 5 | 5 | 46 | – | 46 | 105 |
| 1966-67 | 7 | 10 | 17 | 32 | 17 | 49 | 3 | 2 | 5 | 100 | 1 | 101 | 172 |
| Total | 50 | 267 | 317 | 222 | 196 | 418 | 4 | 20 | 24 | 160 | 2 | 162 | 921 |

NOTE: [1] All vessels equipped with wooden hulls.

Economic Services,
Department of Fisheries of Canada.

## APPENDIX 2

Number of Fishing Vessels Built in Canada With Government Assistance or on Order for Operations from Canadian Atlantic Ports

(Vessels 100 gross tons and over)

| Size Classes LOA | Wooden Hull | | | | | | | Steel Hull | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1961/62 | 62/63 | fiscal years | | | 66/67 | 67/68 | 1962/63 | 63/64 | fiscal years | | | 67/68 | 68/69 | 69/70 |
| | | | 63/64 | 64/65 | 65/66 | | | | | 64/65 | 65/66 | 66/67 | | | |
| ft. | | | | NO. | | | | | | | NO. | | | | |
| 70– 79.9 | – | – | – | – | – | – | – | – | 9 | 2 | – | – | 1 | – | – |
| 80– 89.9 | – | 3 | 6 | 7 | 3 | 7 | – | 2 | – | 2 | – | 5 | 4 | – | – |
| 90– 99.9 | 5 | 14 | 9 | 8 | 5 | 6 | 2 | – | 3 | 3 | 2 | 4 | 2 | – | – |
| 100–109.9 | 2 | 1 | 6 | 10 | 11 | 4 | 8 | – | – | – | – | – | 3 | 1 | – |
| 110–119.9 | – | – | – | 2 | 2 | 2 | 2 | – | 6 | – | – | – | 4 | – | – |
| 120–129.9 | – | – | – | 1 | – | – | – | – | 9 | 3 | 6 | 2 | 6 | 2 | 4 |
| 130–139.9 | – | – | – | – | – | – | – | – | – | 1 | 3 | 1 | 1 | – | – |
| 140–149.9 | – | – | – | – | – | – | – | – | – | 3 | – | 3 | 3 | – | – |
| 150–159.9 | – | – | – | – | – | – | – | – | – | 1 | – | 10 | 14 | 6 | – |
| 160–169.9 | – | – | – | – | – | – | – | – | – | 1 | – | 2 | 10 | 8 | – |
| 200–209.9 | – | – | – | – | – | – | – | – | – | – | – | – | 5 | – | – |
| Totals | 7 | 18 | 21 | 28 | 21 | 19 | 12 | 2 | 27 | 16 | 11 | 27 | 53 | 17 | 4 |

NOTES: [1] Fiscal year built is based on "first year of fishing."
[2] For fiscal years 1968/69 and 1969/70 indicates the number of applications received for subsidy, but for future delivery as indicated by fiscal years.

Economic Services,
Department of Fisheries of Canada.

## APPENDIX 3

Number of Fishing Vessels Built with Government Assistance for Operations on the Atlantic Coast
Vessels Under 70 Feet in the Period 1947-1967 and Vessels Over 70 Feet 1962-1967

| Size Classes LOA | All Vessels | Wooden Hull | | | | | Steel Hull | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Draggers | Long-liners | Seiners | Multi-Purpose | Total | Otter Trawlers | | Tuna Seiners | Total |
| | | | | | | | Side | Stern | | |
| ft. | no. | no. | no. | no. | no. | no. | no. | no. | no. | no. |
| 30– 49.9 | 436 | 50 | 222 | 4 | 160 | 436 | – | – | – | – |
| 50– 69.9 | 485 | 267 | 196 | 20 | 2 | 485 | – | – | – | – |
| Sub-total | 921 | 317 | 418 | 24 | 162 | 921 | – | – | – | – |
| 70– 79.9 | 12 | – | – | – | – | – | 12 | – | – | 12 |
| 80– 89.9 | 39 | 21 | 5 | – | – | 26 | 11 | 2 | – | 13 |
| 90– 99.9 | 63 | 38 | 10 | 1 | – | 49 | 9 | 5 | – | 14 |
| 100–109.9 | 47 | 35 | 4 | 4 | – | 43 | – | 4 | – | 4 |
| 110–119.9 | 17 | 6 | – | 1 | – | 7 | – | 10 | – | 10 |
| 120–129.9 | 33 | 1 | – | – | – | 1 | 19 | 13 | – | 32 |
| 130–139.9 | 6 | – | – | – | – | – | 2 | 4 | – | 6 |
| 140–149.9 | 9 | – | – | – | – | – | 5 | 4 | – | 9 |
| 150–159.9 | 31 | – | – | – | – | – | – | 31 | – | 31 |
| 160–169.9 | 21 | – | – | – | – | – | – | 20 | 1 | 21 |
| 200–209.9 | 5 | – | – | – | – | – | – | – | 5 | 5 |
| Sub-total | 283 | 101* | 19 | 6 | – | 126 | 58 | 93 | 6 | 157 |
| Grand Total | 1,204 | 418 | 437 | 30 | 162 | 1,047 | 58 | 93 | 6 | 157 |

NOTES: [1] Out of 921 fishing vessels built with federal Department of Fisheries grants in the period 1947-1967 (inclusive) one was steel and one fiber glass hull. However it is not possible to identify as to size.

[2] With the large vessel subsidy i.e. on vessels 100 gross tons and over a total of 283 vessels were ordered including 21 for delivery in 1968/69 & 1969/70. This subsidy went into effect in May, 1961.

[3] Draggers and Otter trawlers use the same type of gear but in varying sizes. For administrative purposes the Department defines a dragger as a vessel under 100 feet LOA and an Otter trawler as a vessel 100 feet or more in length overall.

[4] *This total includes 10 projected for delivery in 1967/68.

Economic Services,
Department of Fisheries of Canada

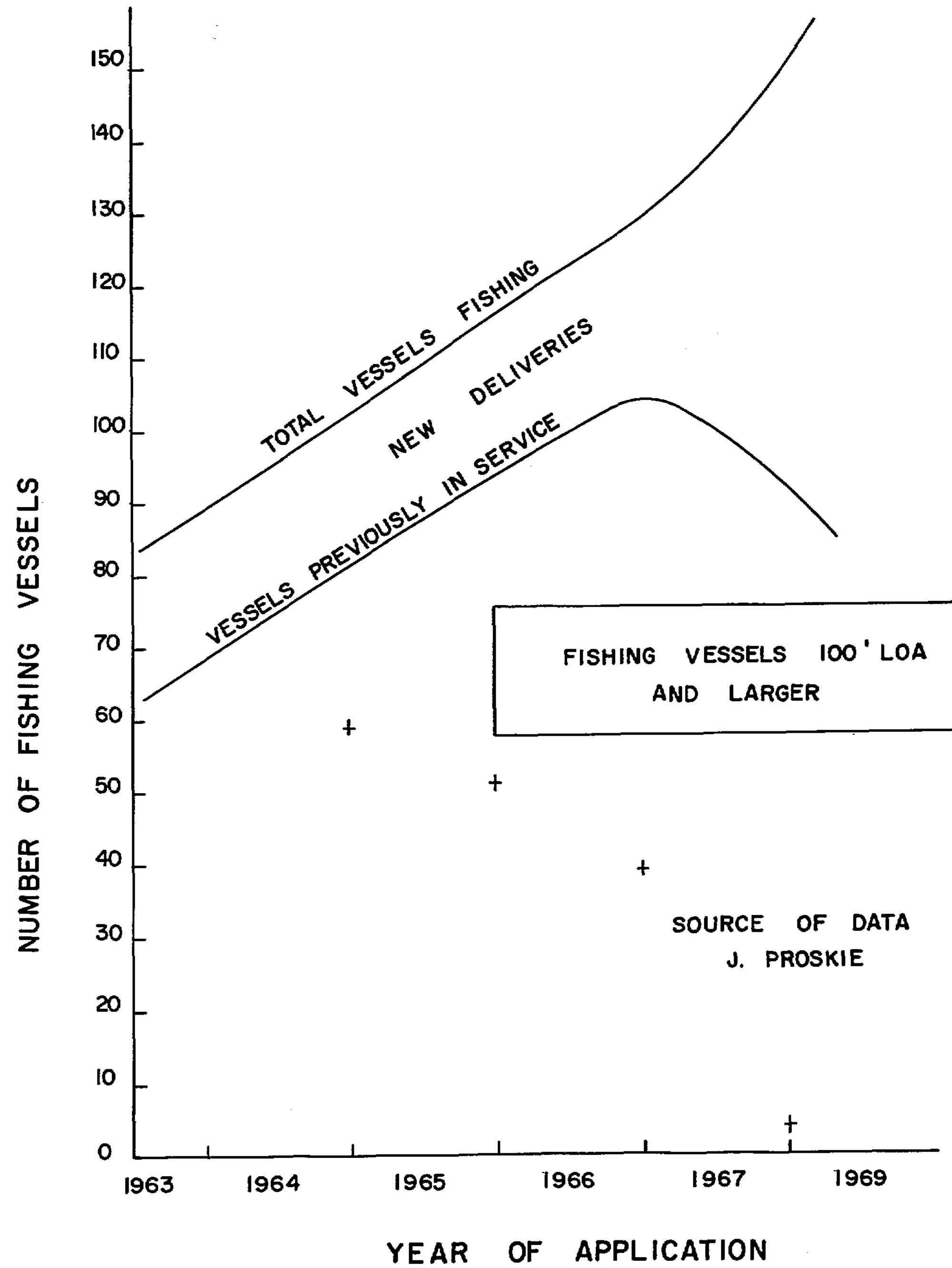
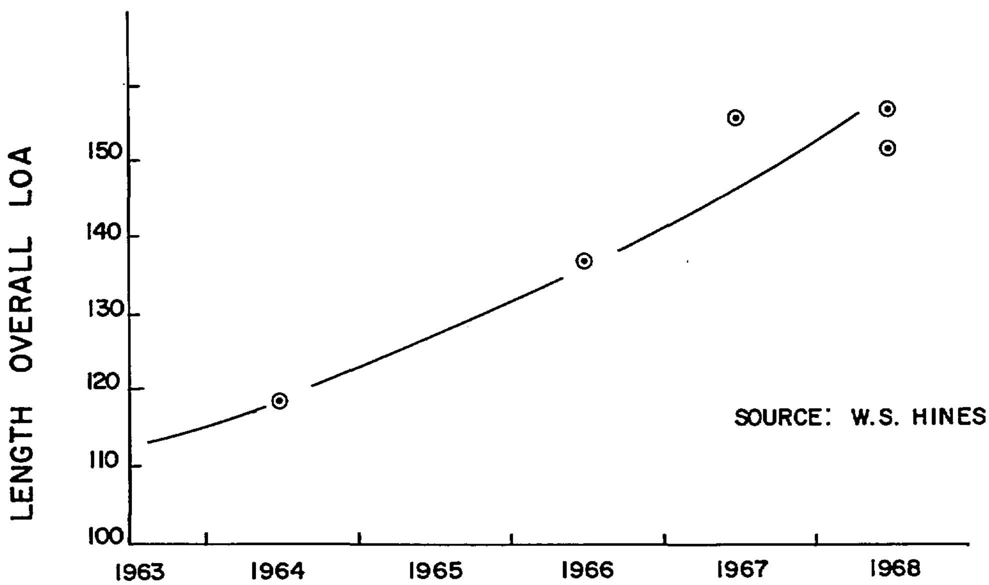

NUMBER OF FISHING VESSELS
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
TOTAL VESSELS FISHING
NEW DELIVERIES
VESSELS PREVIOUSLY IN SERVICE
FISHING VESSELS 100' LOA AND LARGER
SOURCE OF DATA J. PROSKIE
1963
1964
1965
1966
1967
1969
YEAR OF APPLICATION

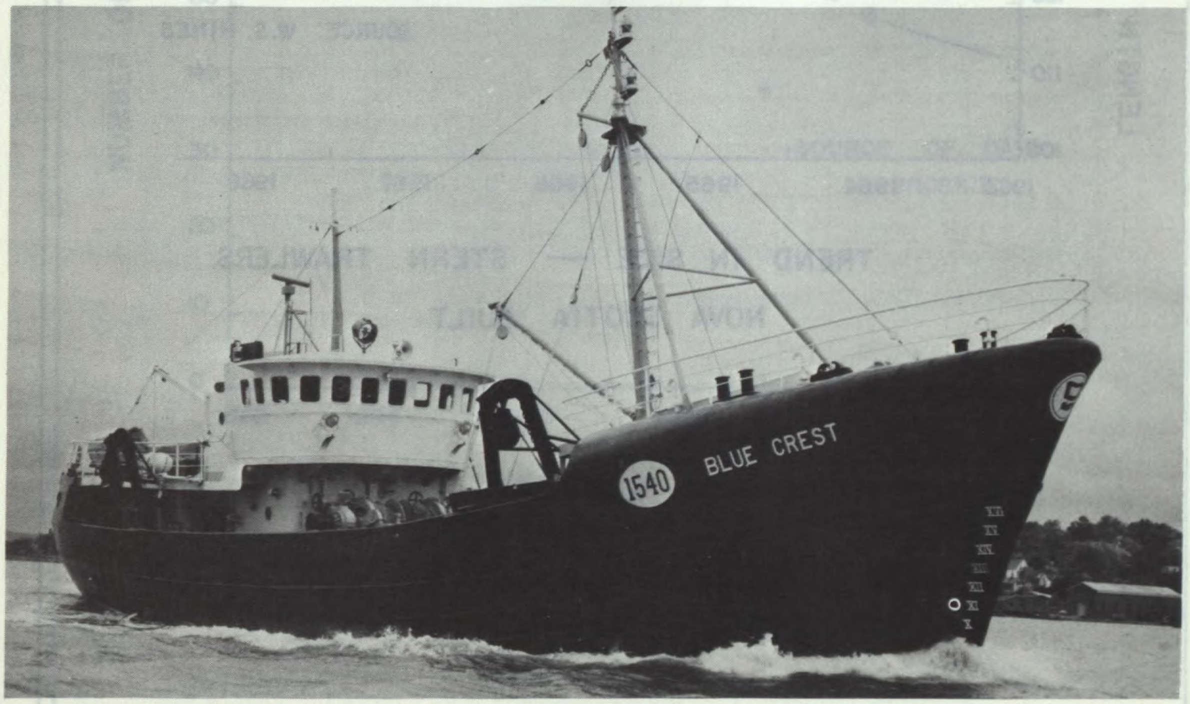
FIGURE 1




TREND IN SIZE — STERN TRAWLERS
NOVA SCOTIA BUILT

FIGURE 2

112-foot Wooden Dragger-Seiner




130-foot Steel Side Trawler


89-foot Steel Seiner Trawler


166-foot Steel Stern Trawler

# The Potential of Newer Construction Materials

Mr. Hughes-Adams

by

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*Mr. Hughes-Adams worked for a number of firms in production, engineering and marketing capacities and just prior to joining the Government in 1961 was Sales Manager of Tipani Electric. His first position with the Government of Canada was in the Shipbuilding Branch of the Department of Defence Production. He was transferred to the Department of Industry, when it was formed, and is currently Chief of the Ship Division in the Marine and Rail Branch of the Department.*

## ABSTRACT

The use of newer materials in fishing vessels can assist the fishing industry in meeting the objectives of increased demand, increased productivity of labour and reduced costs.

The benefits will not come from reduction in capital cost of the vessel since material costs are an insignificant fraction of the cost to the consumer of fish. Also, the total market demand for fish is inelastic with respect to price.

If newer materials are to improve the prosperity of the fishing industry, the improvement will come from their use in different vessel designs which result in a better quality product – vessels which are more efficient, safer and more comfortable and which have lower maintenance costs.

A systems analysis of the industry from harvesting through processing and distribution is suggested, keeping in mind the contribution that newer materials can make.

## INTRODUCTION

We who are involved with shipbuilding are delighted in the interest being shown in ships and new materials and the informed discussions going on on the relative merits of these materials.

The conference has attracted a number of highly qualified experts. Papers are being presented which cover in detail technical and cost implications. Each of these papers is in itself an expression of the potential of the material.

### OBJECTIVE OF THIS PAPER

The purpose of this paper is to augment the specific approaches of these experts. An attempt will be made to provide a general framework which can be used to examine the potential of new material. Some conclusion will be made as to what benefits can and cannot be anticipated and what form these benefits might take. There will be no examination of the potential of any specific material or any effort to compare them against each other.

## GENERAL CONSIDERATIONS

Before considering how material changes can improve the fishing industry, it is necessary to:

- define the objectives of the industry,
- explore ways and means of reaching the objectives,
- examine the capital cost implications of material,
- explore the nature of the fish market.

## OBJECTIVES OF THE FISHING INDUSTRY

It is assumed that various participants in the fishing industry will have different objectives but that these can be reconciled. To illustrate:

- An individual fisherman or deckhand would likely express his objective as "An improved standard of living for myself and my family".
- An official of a fishing and processing company might say "Increased profitability". Today some might say "Just break even".
- Governments would express a desire for "accelerated economic development of a region and improved employment opportunities".

## METHOD OF REACHING THE INDUSTRY OBJECTIVES

Pursuit of these objectives can take a number of different forms. The most significant are given below and the optimum benefits will be achieved by a combination of:

1. Increasing the demand for fish.
   - The increased volume obtained from supplying this increased demand will produce increased employment. It should also produce increased profits from economies of scale. This in turn will produce regional economic improvement.

2. Increasing labour productivity in fishing and processing operation.
   - This will improve profitability and the living standard of the labour force.

3. Reducing costs of specific operations.
   - This again gives increased profitability and permits higher wages.

## THE FISH MARKET

It is also necessary to examine some general characteristics of the fish market. First, the retail market for fish is relatively inelastic with respect to price. Therefore, total demand is not a function of price. Demand can be expected to grow with a continuing increase in population. Hence, a steady slow growth in total demand can be anticipated. If there is elasticity of total demand, it will be as a result of marketing techniques. Any consistent gains will have to be supported by a consistency of quality. Finally, although there is little elasticity of total demand with respect to retail price, on a short-term basis any particular producing country's share of this total demand will have some elasticity with respect to wholesale price.

## POTENTIAL OF NEWER MATERIAL

It should not be assumed that incorporation of newer materials in fishing vessels is a clear and simple road to unlimited prosperity. The use of such materials will not automatically increase demand, increase labour productivity and reduce costs.

For example, the following table relates the impact of capital cost of material to the cost of fish. The figures refer to offshore trawlers and groundfish. They are not precise but are "an order of magnitude". They are shown in terms of an "edible pound" which is defined as a pound of oven ready fish on the grocer's shelves.

VALUE PER EDIBLE POUND

| | |
|---|---|
| Selling price of fish (retail) | $ .60/edible pound |
| Processed value of fish (at the processor) | .25/edible pound |
| Landed value of fish (at the dock) | .10/edible pound |
| Capital cost of the vessel | .02/edible pound |
| Capital cost of construction material | .005/edible pound |

In looking at these figures it can be seen that of the 60 cents per pound charged for fish in the grocery store not more than ½ cent is attributable to the capital cost of the building material. Further, when one considers that demand is inelastic with respect to price, the question can be asked, "Why devote so much effort to the developing of these new materials?"

The answer is to be found in the more indirect long-term and often non-cost benefits. If total demand cannot be increased by price changes—it might respond to quality.

With newer materials it may be possible to design better vessels with improved safety, vessels that are more comfortable, more efficient and capable of delivering the catch in better condition.

How does one examine the potential uses of new materials? It is suggested that a proper examination requires that the industry be treated as a system designed to remove fish from the ocean and place them on the consumer's table. Such a system consists of harvesting, processing and distribution.

There must be an analysis that examines all factors which impinge on the cost and quality of the fish on the consumer's table. The analysis should try and determine what are the effects of changes in any part of the system. The harvesting of the catch is an important part of the system, therefore, implicit in the analysis is the effect of fishing vessel material in such areas as:

1. Quality – Possibility for improved quality control and the reduction of waste and spoilage.
2. Productivity – The place materials can play in reducing labor costs by increasing efficiency.
3. Labour quality – Possibilities of improving safety, working conditions and habitability with a view to the continued attraction of a high quality labour force.
4. Down time – The use of new materials to improve maintainability and reduce time for repairs.
5. Cost – Possibilities in the reduction of the original capital cost and/or maintenance cost.

It is recognized that a systems analysis of the type suggested above is a major undertaking. On the other hand, the alternatives are continuing as is or building the same vessel with different materials. Building the same vessel, but with different materials might produce some benefit. Certainly the benefits obtained would not represent the full potential of newer materials. This full potential will only be realized when unique advantages offered by different materials are exploited through their combination in a vessel designed to meet the overall system requirement.

# Regulatory Aspects of Traditional and New Construction Materials

Mr. Bonn

by

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*In 1964 he moved to Headquarters in Ottawa to assume the duties of Supervisor, Hulls and Equipment and was later appointed Projects Officer. He was then promoted to a position heading the Hulls and Equipment Section entitled Superintendent, Hulls and Equipment.*

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**ABSTRACT**

This paper describes the broad outline of the Steamship Inspection Service's approach to plan approval, inspection and certification of fishing vessels, with the emphasis on safety of life at sea.

All the necessary steps to be observed by owners, naval architects, builders and operating personnel are clearly pointed out to satisfy whatever aspects of the inspection process are involved.

Scantlings for structural parts and advice on good building practice are also highlighted in this presentation. In addition, the Steamship Inspection Service offers recommendations in respect of non-traditional construction materials, which are still essentially in a developmental stage.

## INTRODUCTION

In today's world we see new materials being introduced in all aspects of life, especially in the construction and engineering fields.

Most of us at this Conference are of the marine fraternity and I think we all feel that as far as the building of commercial ships and boats is concerned our approach is very traditional and conservative. Indeed our only accepted major "breakthroughs" in the past three decades have been the change over from riveting to welding in the construction of steel vessels and the introduction, mainly on large vessels, of aluminum deckhouses.

This often leads one to sit back and wonder "how can I assist in developing modern and new approaches to the ship and boat building industry?"

As expressed by a number of our associates we find new construction materials have already been tested on smaller type boats with great success. These materials will, I am sure, inevitably find their place in the construction of large and small fishing vessels and eventually on large vessels of all types.

With the above in mind I feel that regulatory bodies must play their part and keep an open mind on new developments within our industry. As a member of the Department of Transport, I can say that the Government is most anxious to provide as much encouragement as possible to the progress and development of new materials and building techniques in the shipbuilding and marine engineering field. As the Government's regulatory body, the Board of Steamship Inspection will give full consideration to all proposals submitted to them.

The object of this paper is not to explain how to build vessels of new or traditional materials; this area of the Conference is admirably covered by a number of experts. It is merely an attempt to give a broad outline of the Steamship Inspection Service approach to the approval, inspection and certification of fishing vessels from the point of view of safety of life at sea.

## REGULATORY ASPECTS

In the preparation of this section on "Regulatory Aspects" the paper is divided into six parts which are as follows:

1. GENERAL REQUIREMENTS APPLICABLE TO ALL FISHING VESSELS.
2. REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF WOOD.
3. REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF STEEL.
4. REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF ALUMINUM.
5. REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF GLASS RE-INFORCED PLASTIC.
6. REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF FERRO-CEMENT.

## PART 1 – GENERAL REQUIREMENTS APPLICABLE TO ALL FISHING VESSELS

### *Notification of Proposed Construction*

The owner or the builder of the vessel should advise the Steamship Inspection Service of the proposed construction, size of vessel, nature of service, type of material of which it is to be built and the extent of the voyages for which it is required.

### *Submission of Plans*

Prior to commencement of construction the plans and information listed in Appendix I of this paper should be submitted to the nearest Steamship Inspection Service Office for approval and should the owner or builder require any particular information relative to requirements for the type of construction he is proposing the Board will be pleased to provide all possible advice and assistance within their jurisdiction.

### *Inspection During Construction*

During construction a Steamship Inspector will carry out regular inspections to check that the vessel is being built in accordance with the approved plans and that the materials and workmanship are to the required standards. In addition to the hull construction he will witness all necessary hose testing and tank testing and will examine and test the machinery installation, piping installations and steering arrangements. He will also check the life-saving, firefighting and navigating appliances and other statutory requirements.

### *Sea Trials*

On completion of construction the Steamship Inspector shall be present during the sea trials to ensure that the machinery and all essential services are functioning properly and that the vessel is operating in a safe and satisfactory manner.

*Certification*

On completion of the "First Inspection" the Steamship Inspector will issue an appropriate Inspection Certificate for the voyages on which the vessel will be engaged. The period of validity of the certificate will normally be

(i) one year for vessels of more than 150 gross tons,
(ii) one year for vessels that are steam driven, regardless of their tonnage, or
(iii) four years for vessels that are not steam driven and not more than 150 gross tons.

*Periodical Inspection and Certification*

Periodical inspections will be carried out by a Steamship Inspector when renewal of an Inspection Certificate is required and in accordance with the requirements of the Large and Small Fishing Vessel Inspection Regulations, the appropriate sections of which are added as Appendix II to this Paper.

It should always be remembered that it is the responsibility of the owner, operator or master to have his vessel inspected and certificated in accordance with the requirements of the Canada Shipping Act. That is to say he should advise the local Steamship Inspection Office when the vessel is due and ready for inspection and in the case of new construction, the builder should advise when he wants any particular inspection or test etc. carried out.

## PART 2 – REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF WOOD

*Shipbuilder*

The builders, past standards of construction and the physical conditions under which the vessels are built are considered by the Steamship Inspector and the Board when approval of a vessel is given. Acceptable shipbuilding practice must be followed in all aspects of construction and selection of materials to be used.

*Strength*

Although strength standards for wooden vessels are not laid down "hard and fast" each vessel shall have strength characteristics acceptable to the Board.

These are based on the type of construction with particular attention being given to good detail design and the use of local area building materials.

The following scantling tables have been compiled over the years and have proved satisfactory in service. They are provided as a guide to designers and builders and they are acceptable to the Board.

*Periodic Inspection*

Periodic inspection of the hull structure will be carried out at intervals specified in the Large and Small Fishing Vessel Inspection Regulations, the appropriate sections of which are added as Appendix II to this paper.

At the underwater inspection visual examination will normally give the Inspector a good idea of the areas where deficiencies can be expected. Distorted planking, pulled butts, cracking, wetness or weeping are likely indications of deterioration.

Where rotting is suspected internal ceiling may have to be removed, core drilling carried out to check the condition of the wood and fastenings, joints, fittings and caulking will be all carefully examined.

## PART 3 – REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF STEEL

*Shipbuilder*

Close attention is given to the building plant and conditions under which steel vessels, especially the larger type vessels, are constructed.

Construction should be carried out in accordance with acceptable shipbuilding practice and care must be taken with all facets of the operation such as preparation of material, burning, fitting, fairing, welding, riveting, etc.

*Strength*

The strength requirements for a steel vessel are that the modulus of the midship section and the stresses in the structural members shall be acceptable to the Board.

Calculations for the scantlings may be carried out from first principles or the Board will normally accept scantlings derived from acceptable Classification Society Rules.

## GUIDE TO SCANTLINGS FOR EAST COAST FISHING VESSELS

| TONNAGE | 10 | | OVER 10 UP TO 15 | | OVER 15 UP TO 20 | | OVER 20 UP TO 25 | | OVER 25 UP TO 30 | | OVER 30 UP TO 35 | | OVER 35 UP TO 40 | | OVER 40 UP TO 45 | | OVER 45 UP TO 50 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD |
| STEM | 4½" | 7" | 5" | 7½" | 5½" | 8" | 5¾" | 8" | 6" | 8" | 6¼" | 8¼" | 6½" | 8½" | 7" | 8" | 7" | 8" |
| KEEL | 4½" | 7" | 5" | 7½" | 5½" | 8" | 5¾" | 8" | 6" | 8" | 6¼" | 8¼" | 6½" | 8½" | 7" | 8" | 7" | 8" |
| STERNPOST | 4½" | 7" | 5" | 7½" | 5½" | 8" | 5¾" | 8" | 6" | 8" | 6¼" | 8¼" | 6½" | 8½" | 7" | 8" | 7" | 8" |
| KEELSON | 4½" | 4½" | 5" | 5" | 5½" | 5½" | 5¾" | 5¾" | 6" | 6" | 6¼" | 6½" | 6½" | 7" | 6¾" | 7¼" | 6¾" | 7½" |
| SISTER KEELSON | | | | | | | | | | | | | | | | | | |
| FRAMES (SAWN) | 2" | 3" | 2½" | 3½" | 3" | 4" | 3¼" | 4¼" | 3½" | 4½" | 4" | 5" | 4" | 5" | 4½" | 5½ | 4¾" | 5¾" |
| PLANKING | 1" | | 1⅛" | | 1¼" | | 1½" | | 1⅝" | | 1⅞" | | 2" | | 2⅛" | | 2⅛" | |
| CEILING | ⅞" | | 1" | | 1⅛" | | 1¼" | | 1¼" | | 1½" | | 1⅝" | | 1¾" | | 1⅞" | |
| BILGE CEILING | 1¼" | 14" | 1½" | 16" | 1⅜" | 18" | 1¾" | 20" | 1⅞" | 20" | 2" | 22" | 2" | 22" | 2¼" | 24" | 2¼" | 24" |
| Nº OF STRAKES | 2 | – | 2 OR | 3 | 3 | – | 3 | – | 3 | – | 3 | – | 3 | – | 4 | – | 4 | – |
| CLAMPS | 1½" | 5¼" | 1¾" | 6" | 2" | 7½" | 2¼" | 8" | 2¼" | 10" | 2½" | 12" | 2½" | 14" | 2¾" | 16" | 2¾" | 16" |
| Nº OF STRAKES | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 OR | 2 | 1 OR | 2 | 1 OR | 2 | 2 | – |
| SHELF | 2¼" | 4" | 2½" | 4½" | 3" | 4½" | 3¼" | 4½" | 3¼" | 4¾" | 3½" | 5" | 3¾" | 5⅛" | 4" | 4½" | 4½" | 4¾" |
| Nº OF STRAKES | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – |
| BEAMS | 2" | 2½" | 2½" | 2¾" | 2¾" | 3¼" | 3" | 4" | 3¼" | 4¼" | 3½" | 4½" | 4" | 4¾" | 4½" | 5" | 4½" | 5¼" |
| SPACING CR. TO CR. | 30" | | 30" | | 30" | | 30" | | 30" | | 30" | | 30" | | 30" | | 30" | |
| DECKING, THKS. | 1¼" | | 1½" | | 1¾" | | 1⅞" | | 2" | | 2" | | 2¼" | | 2¼" | | 2¼" | |
| FRAME SPACING | 11" | | 12" | | 14" | | 14½" | | 15" | | 16" | | 17" | | 17½" | | 18" | |

| TONNAGE | OVER 50 UP TO 55 | | OVER 55 UP TO 60 | | OVER 60 UP TO 65 | | OVER 65 UP TO 70 | | OVER 70 UP TO 75 | | OVER 75 UP TO 80 | | OVER 80 UP TO 85 | | OVER 85 UP TO 90 | | OVER 90 UP TO 95 | | OVER 95 UP TO 100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD |
| STEM | 7½" | 9" | 7½" | 9½" | 7½" | 9½" | 7¾" | 9¾" | 8" | 10" | 8" | 10" | 8¼" | 11" | 8½" | 11½" | 8¾" | 11¾" | 9" | 12" |
| KEEL | 7½" | 9" | 7½" | 9½" | 7½" | 9½" | 7¾" | 9¾" | 8" | 10" | 8" | 10" | 8¼" | 11" | 8½" | 11½" | 8¾" | 11¾ | 9" | 12" |
| STERNPOST | 7½" | 9" | 7½" | 9½" | 7½" | 9½" | 7¾" | 9¾" | 8" | 10" | 8" | 10" | 8¼" | 11" | 8½" | 11½" | 8¾" | 11¾" | 9" | 12" |
| KEELSON | 7" | 7¾" | 7½" | 8" | 7½" | 8½" | 7½" | 8½" | 8" | 9" | 8" | 9" | 8½" | 9½" | 8½" | 9½" | 9" | 10" | 9" | 10" |
| SISTER KEELSON | | | 4½" | 7½" | 5½" | 8½" | 5½" | 8½" | 6" | 9" | 6" | 9" | 6½" | 9" | 6½" | 9½" | 6¾" | 9¾" | 7" | 10" |
| FRAMES (SAWN) | 5" | 6" | 5" | 6" | 5¼" | 6½" | 5½" | 6½" | 5½" | 6½" | 5½" | 6½" | 6" | 6½" | 6" | 6¾" | 6¼" | 7" | 6½" | 7" |
| PLANKING | 2¼" | | 2¼" | | 2¼" | | 2⅜" | | 2½" | | 2½" | | 2½" | | 2⅝" | | 2⅝" | | 2¾" | |
| CEILING | 2" | | 2" | | 2" | | 2" | | 2⅛" | | 2⅛" | | 2⅛" | | 2⅛" | | 2¼" | | 2¼" | |
| BILGE CEILING | 2½" | 24" | 2½" | 24" | 2½" | 24" | 2¾" | 26" | 3" | 26" | 3⅛" | 26" | 3⅛" | 28" | 3⅛" | 28" | 3⅛" | 28" | 3⅛" | 28" |
| Nº OF STRAKES | 4 | – | 4 | – | 4 | – | 4 | – | 4 | – | 4 | – | 4 | – | 4 | – | 4 | – | 4 | – |
| CLAMPS | 3" | 18" | 3" | 18" | 3¼" | 20" | 3½" | 22" | 3¾" | 22" | 3¾" | 24" | 3¾" | 24" | 3¾" | 24" | 4" | 24" | 4" | 24" |
| Nº OF STRAKES | 2 | – | 2 | – | 2 | – | 3 | – | 3 | – | 3 | – | 3 | – | 3 | – | 3 | – | 3 | – |
| SHELF | 4¾" | 5¼" | 5" | 5½" | 5" | 6" | 5" | 6" | 5¼" | 6½" | 5¼" | 6¾" | 5½" | 6¾" | 5½" | 6¾" | 5¾" | 6¾" | 5¾" | 6¾" |
| Nº OF STRAKES | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – |
| BEAMS | 4¾" | 5½" | 4¾" | 5½" | 5" | 5½" | 5" | 6" | 5½" | 6½" | 5½" | 6½" | 5¾" | 6¾" | 5¾" | 6¾" | 5¾" | 7" | 5¾" | 7" |
| SPACING CR. TO CR. | 30" | | 30" | | 35" | | 35" | | 40" | | 40" | | 45" | | 45" | | 45" | | 45" | |
| DECKING, THKS. | 2½" | | 2½" | | | | | | | | | | | | | | | | | |
| FRAME SPACING | 18½" | | 19" | | 19½" | | 20" | | 20½" | | 21" | | 21½" | | 22" | | 22½" | | 23" | |

NOTE: SCANTLINGS ARE BASED ON VESSEL'S UNDER DECK TONNAGE COMPUTED FROM THE FORMULA $\frac{L \times B \times D \times \cdot 75}{100}$

L = LENGTH IN FEET OF VESSEL ON LOAD WATERLINE.

B = BREADTH AMIDSHIPS IN FEET INSIDE CEILING.

D = DEPTH AMIDSHIPS IN FEET FROM TOP OF BEAM AT CENTRE LINE TO TOP OF CEILING ON FLAT BOTTOM.

| GUIDE TO SCANTLINGS FOR WEST COAST FISHING VESSELS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LENGTH O.A. | 42' | | 48' | | 54' | | 60' | | 65' | | 69' | |
| | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD | SDG | MLD |
| STEM | 6" | 10" | 6 1/2" | 11 1/2" | 7" | 11 1/2" | 7 1/2" | 12" | 8" | 12" | 9 1/2" | 13" |
| KEEL | 7" | 8" | 7 1/2" | 9 1/2" | 8 1/2" | 10" | 9" | 11" | 9 1/2" | 11 1/2" | 11" | 13" |
| STERNPOST | 7" | 9" | 7" | 9" | 7 1/2" | 9 1/2" | 8" | 9 1/2" | 9" | 10" | 9 1/2" | 11 1/2" |
| KEELSON | 5" | 7" | 6" | 9" | 7" | 10" | 7 1/2" | 11" | 8" | 11 1/2" | 9" | 13 1/2" |
| SISTER KEELSON | | | | | | | | | 7 1/2" | 11 1/2" | 8 1/2" | 13" |
| FRAMES (BENT) | 1 3/8" | 2 1/2" | 1 7/8" | 2 3/4" | 2" | 3 1/4" | 2" | 3 1/2" | 2 3/8" | 3 3/4" | 2 3/4" | 3 7/8" |
| PLANKING (ABOVE BILGE / BELOW BILGE) | 1 1/2" / 1 1/2" | 5" / 6"-10" | 1 5/8" / 1 5/8" | 5 1/2" / 6"-10" | 1 3/4" / 1 3/4" | 5 1/2" / 6"-10" | 1 3/4" / 1 3/4" | 5 1/2" / 6"-10" | 1 7/8" / 1 7/8" | 6" / 6"-10" | 2" / 2" | 6" / 6"-10" |
| CEILING | 1" | 6" | 1 1/8" | 6" | 1 1/4" | 6" | 1 3/8" | 6" | 1 1/2" | 6" | 1 5/8" | 6" |
| BILGE CEILING | 1 3/4" | 5" | 2 1/4" | 5 1/2" | 2 1/2" | 5 1/2" | 2 1/2" | 5 1/2" | 2 3/4" | 5 1/2" | 3" | 5 1/2" |
| Nº OF STRAKES | 3 | | 4 | | 4 | | 6 | | 6 | | 6 | |
| CLAMPS, 1ST STRAKE | 1 3/4" | 7" | 2" | 7" | 2 1/4" | 8" | 2 1/2" | 8" | 3" | 8" | 3 1/2" | 9" |
| CLAMPS, 2ND STRAKE | – | – | 1 3/4" | 7" | 2" | 7" | 2 1/4" | 7" | 2 1/2" | 8" | 3" | 8" |
| SHELF | 1 3/4" | 5" | 2 1/4" | 6" | 2 1/2" | 7" | 2 3/4" | 7" | 3" | 7" | 3 1/2" | 8" |
| HATCH BEAMS | 4 1/2" | 4" | 5 1/2" | 4 3/4" | 6 1/2" | 4 3/4" | 7 1/2" | 5 1/4" | 8" | 5 3/4" | 8 1/2" | 6" |
| BEAMS | 3" | 4" | 3 3/4" | 4 3/4" | 4 1/4" | 4 3/4" | 4 1/2" | 5 1/4" | 5 1/2" | 5 3/4" | 6" | 6" |
| SPACING CR. TO CR. | 20" | | 21" | | 22" | | 22" | | 23" | | 24" | |
| DECKING, THKS. | 1 3/8" | | 1 1/2" | | 1 5/8" | | 1 5/8" | | 1 3/4" | | 2" | |
| FRAME SPACING | 10" | | 10" | | 10" | | 11" | | 12" | | 12" | |

*Materials*

The Board requires that steel used in the construction shall be of an approved shipbuilding grade for which mill certificates should be available.

Although to date the new high strength steels have not been used for fishing vessel construction in Canada these steels are acceptable to the Board who will consider a corresponding reduction in the vessel's scantlings.

*Connections*

Connections of welding and riveting are acceptable to the Board and details of all main hull connections should be submitted for approval before construction is started.

Where a vessel is to be of welded construction a "Welding Schedule" should be prepared to ensure that locked-in stresses are minimized. Modern welding techniques are encouraged and only qualified welders should be employed. During inclement weather adequate protection as far as reasonable and practicable should be provided for the welding operation – i.e. the work should be protected against rain, snow and also chilling winds during freezing temperatures. The welding rods used must be suitable for the materials being connected and proper protected storage facilities shall be provided for these rods.

*First Inspection Procedures*

In addition to the general requirements of Part I the Steamship Inspector, during his regular inspections, will give particular attention to main hull connections and local high stress areas.

Where a vessel is of welded construction he will check that the approved "Welding Schedule" is being followed. Visual examination of the welding will be carried out but the inspector may request that non-destructive testing methods, such as X-rays, be employed in way of main hull connections.

In certain cases weld samples may be requested for mechanical testing and in way of local high stress areas such as around the bossings and stern of a vessel pre-heating may also be required. The Inspector will also ensure that welded lugs used for prefabrication, fairing and staging, etc., are removed in a manner that will not produce stress raisers or cause damage to the structure.

*Periodic Inspection*

Periodic inspections of the hull structure will be carried out at intervals specified in the Large and Small Fishing Vessel Inspection Regulations, the appropriate sections of which are added as Appendix II to this paper.

At underwater inspections the external and internal condition of the hull will be examined by the Inspector and where he notes heavy corrosion he may require that drill testing be carried out. He may also call for internal examination and hydrostatic testing of tanks where he feels this is required.

Where repairs are necessary these must be completed to the satisfaction of the Inspector.

## PART 4 – REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF ALUMINUM

*Shipbuilder*

Construction of aluminum vessels shall be carried out at a plant where the personnel are properly trained and familiar with the type of work which they are to perform and close attention will be given to the conditions under which the vessels are being constructed.

*Strength*

An aluminum vessel is required to have an equivalent factor of safety to that of a steel vessel of similar size and design and the modulus of the midship section and the stresses in the structural members shall be acceptable to the Board.

Calculations for the required scantlings may be carried out from first principles or the Board will normally accept scantlings derived from acceptable Classification Society Rules for steel vessels that are converted to equivalent strength aluminum alloy sections.

When carrying out structural design calculations the following general conversion formulae are usually adequate:

PLATING: $t_{al} = \frac{F_{st} \times t_{st}}{F_{al}}$

STIFFENERS, BEAMS, GIRDERS: $\left(\frac{I}{Y}\right)_{al} = \left(\frac{I}{Y}\right)_{st} \times \frac{F_{st}}{F_{al}}$

PILLARS AND MEMBERS SUBJECT TO BUCKLING: $I_{al} = 3 \times I_{st}$

where
$t_{al}$ = thickness aluminum
$t_{st}$ = thickness steel
$F_{al}$ = yield stress aluminum
$F_{st}$ = yield stress steel
$\left(\frac{I}{Y}\right)_{al}$ = section mod. alum.
$\left(\frac{I}{Y}\right)_{st}$ = section mod. steel
$I_{al}$ = Inertia aluminum
$I_{st}$ = Inertia steel

*Material*

All materials used in the main structure of the vessel must be of an approved grade aluminum alloy for which mill certificates should be available. Pure aluminum is not strong enough to be used to structural advantage, therefore careful attention must be given to the selection of a suitable aluminum alloy.

The alloying elements affect the physical and mechanical properties of the aluminum and cause the alloys to fall into two distinct groups.

The first group, which is commonly referred to as *heat treatable alloys,* contains alloys that obtain their strength from heat treatment and therefore are generally not recommended for welded structures; however, these may be incorporated into welded structures, in which case the Board will consider each specific application.

The second group, known as *non-heat-treatable alloys,* contains alloys that obtain their strength from the alloying elements and strain hardening and are suitable for welding and other types of fastenings.

The aluminum companies have developed a wide range of alloys that are suitable for a variety of applications; however, construction alloys containing magnesium have been found most useful for marine structures due to their adequate strength qualities and their resistance to corrosion.

The following tables contain details of some marine alloys manufactured in Canada and the United States, all of which are acceptable to the Board. Other grades of aluminum alloys will be considered by the Board on receipt

## Table of Mechanical Properties of Aluminum Alloys

| Alcan Alloy | Description | Temper | Tensile Strength ULT.(K) | Tensile Strength Yield (K) | Tensile Strength % Elong. | Shear Strength ULT.(K) | Shear Strength Yield (K) | U.S.A. Equivt. |
|---|---|---|---|---|---|---|---|---|
| 50s | Heat-Treatable Alum-Magnesium--Silicon Alloy. | T5 | 22 | 17 | 8 | 13 | 10 | 6063 |
| | | T6, T6c | 26 | 21 | 8 | 16 | 13 | |
| | | Welded | 17 | 10 | – | 10 | 6 | |
| B53s | Non-Heat-Treat. Alum.-Magnesium Alloy with Manganese Added | H11A | 32 | 18 | 8 | 19 | 7 | 5454 |
| | | H32 | 36 | 26 | 8 | 22 | 16 | |
| | | H34 | 39 | 29 | 6 | 23 | 17 | |
| | | Welded | 30 | 15 | – | 18 | 9 | |
| D54s | Non-Heat-Treat. Alum-Magnesium Alloy with Manganese Added | H11A | 40 | 24 | 12 | 24 | 13 | 5083 |
| | | H11B, H31A | 44 | 31 | 10 | 26 | 19 | |
| | | H32 | 45 | 34 | 8 | 27 | 20 | |
| | | H34 | 50 | 39 | 6 | 30 | 23 | |
| | | Welded | 38 | 18 | – | 23 | 11 | |
| 57s | Non-Heat-Treat. Alum-Magnesium Alloy. | H32 | 31 | 23 | 7 | 19 | 14 | 5052 |
| | | H24, H34 | 34 | 26 | 6 | 20 | 15 | |
| | | Welded | 25 | 10 | – | 15 | 6 | |
| 65s | Heat Treatable Alum-Magnesium-Silicon Alloy. | T4 | 26 | 16 | 16 | 16 | 10 | 6061 |
| | | T6 | 38 | 35 | 10 | 23 | 21 | |
| | | Welded | 24 | 16 | – | 15 | 10 | |
| 74s | Heat-Treatable Alum-Zinc-Magnesium Alloy | T4A | 42 | 26 | 10 | 25 | 16 | X7004 |
| | | T6A | 47 | 40 | 8 | 28 | 24 | |
| | | T6 | 47 | 40 | 8 | 28 | 24 | |
| | | Welded | 40 | 24 | – | 25 | 16 | |

## Table of Temperature Effects on Aluminum Alloys

Approx. Effect of Temperature on the Mechanical Properties of Aluminum Alloy – Given as a Percentage of the Room Temperature Values

| Alcan Alloy | Approx. Melting Range °F | | – 300°F | – 100°F | + 200°F | + 300°F | + 400°F | + 600°F |
|---|---|---|---|---|---|---|---|---|
| 50s | 1110 – 1200 | Ultimate Strength | 130 | 110 | 95 | 65 | 20 | 10 |
| | | Yield Strength | 115 | 105 | 95 | 65 | 20 | 10 |
| B53s | 1110 – 1190 | Ultimate Strength | 150 | 110 | 100 | 80 | 65 | 25 |
| | | Yield Strength | 115 | 105 | 95 | 85 | 70 | 20 |
| D54s | 1075 – 1180 | Ultimate Strength | 140 | 115 | 95 | 70 | 50 | 20 |
| | | Yield Strength | 120 | 115 | 95 | 70 | 55 | 10 |
| 57s | 1100 – 1200 | Ultimate Strength | 140 | 105 | 95 | 80 | 60 | 20 |
| | | Yield Strength | 115 | 100 | 95 | 80 | 40 | 15 |
| 65s | 1075 – 1200 | Ultimate Strength | 130 | 110 | 95 | 70 | 40 | 10 |
| | | Yield Strength | 135 | 105 | 95 | 75 | 40 | 5 |
| All Above Alloys | | Elastic Modulus | 110 | 105 | 100 | 95 | 90 | 70 |

of full particulars of proposed use, strength and chemical properties, etc.

*Connections*

The strength of any structure is directly related to the efficiency of the connection provided, therefore it is essential that all connections be carefully considered when choosing the type of alloy to be used.

Welding, riveting and bolting are acceptable but details of all main connections must be submitted for approval before construction is started.

In way of bi-metallic connections riveting and bolting are acceptable and care must be taken with the design of the connection to prevent galvanic corrosion being set up. This is usually accomplished with adequate gasketing arrangements and stainless steel bolts. Aluminum bolts or rivets are not recommended as, should they be fitted, frequent replacement will most likely be necessary.

A recent development for connecting aluminum deckhouses to steel decks, is the use of a vertical glass re-inforced plastic strip separating the steel foundation bar and aluminum deckhouse plating.

Concerning welding of aluminum, this in itself is a subject on which a lengthy paper can be written and I do not propose to deal with it in this presentation. The aluminum companies have published many excellent manuals that are readily available and the methods described are acceptable to the Board. Included in these manuals are the MIG & TIG welding procedures that should be adopted for the various grades of aluminum and the type of preparation required.

*Fire Protection*

One of the disadvantages of using aluminum for main hull structures is its low melting point and the adverse effect of heat on its strength characteristics.

With this in mind the Board has decided that for fishing vessels constructed of aluminum and operating on exposed voyages the following A-30 standard structural fire insulation should be provided:

(i) in machinery spaces:
  - all shell plating from the deckhead to the light waterline,
  - all deckheads and supporting structure,
  - boundary bulkheads on the machinery space side for the full height,
  - oil tank bulkheads.

(ii) outside machinery spaces:
  - oil tank bulkheads adjacent to spaces, such as a galley or paint locker, where a fire hazard exists.

When using insulation on aluminum structures care should be taken by the builder to ensure that a suitable type of insulation is chosen that is compatible with aluminum. In way of bilges suitable protection against oil and water seepage shall be provided for the insulation.

*First Inspection*

The inspector will carry out regular inspections throughout the building of the vessel with careful attention being given to connections, especially to the details and gasketing arrangements in way of bi-metallic connections.

In way of welded construction the inspector will ensure that the approved "Welding Schedule" is being followed. Visual examination of the welding will be carried out but the inspector may request that non-destructive testing methods, such as X-rays, be employed in way of main hull connections.

In certain cases, especially when prototype vessels are being constructed weld samples may be required for mechanical testing.

*Periodical Inspection*

Following completion of the sea trials and the "First Inspection" special attention will be given to the vessel at each subsequent inspection. The underwater inspection periods will normally be the same as the requirements laid down in the Large and Small Fishing Vessel Regulations, the appropriate sections of which are added in Appendix II to this paper. However, should accelerated corrosion be noted, then more frequent inspections may be required.

## PART 5 – REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF GLASS RE-INFORCED PLASTIC

*Shipbuilder*

Glass reinforced plastic moulding is a specialized chemical process and must be carried out at an approved establishment.

Approval of the establishment necessitates that the personnel engaged in the construction must be properly trained for the type of work which they are to perform.

Workshops used for the moulding should be

(a) protected from the weather, adequately lighted and ventilated but free from draughts and direct sunlight,

(b) maintained in the temperature range 60°F – 70°F at a low humidity level, both readings being recorded regularly,

(c) clean and dust free, and

(d) provided with adequate dry and draught free storage spaces for the raw materials.

*Strength*

The modulus of the midship section and the stresses in the structural members shall be acceptable to the Board.

Calculations for the required scantlings may be carried out from first principles or the Board will generally approve scantlings derived from acceptable Classification Society Rules.

*Materials*

The resins and glass fibre reinforcements used in the moulding processes should be of types recommended by the manufacturers for marine use and are to be approved by the Board.

The resins should be suitable for laminates that may be stressed when in a temperature range of –22°F to +150°F and formulated to have a gel time of generally less than 1 hour.

Surfaces of the moulding that will be exposed to the atmosphere or to liquids must be provided with a gel coat and surfaces that may be walked upon shall have a good non-slip finish.

Laminate must be free of voids, air bubbles or other similar faults that may effect their strength and details of wood or metal inserts should be submitted to the Board for approval.

*Connections*

Care should be taken in the design of all connections throughout the construction and special attention should be given to the main hull connections such as the decks to the shell, bulkhead boundaries, deckhouses to the main hull etc.

The following methods of connection are acceptable to the Board:

(a) *Bonding:* the surfaces must be roughened and thoroughly cleaned, the gel coat shall be removed in way of the surface and the total thickness of fillet bonding strips should be approximately equal to the thickness of the thinner parts being joined.

(b) *Riveting:* Rivets should be cold driven and dipped in resin or other suitable sealant to seal the fibres within the hole. Washers or metal strips should be fitted in way of the heads and points to prevent damage to the laminate. The minimum distance between the centre of the rivet hole and the edge of the laminate should be three times the diameter of the rivet; the holes are to be drilled neat. Where a joint is required to be watertight a suitable sealant should be used.

(c) *Bolting:* Bolts should be of non-corrodible metal, other than copper or its alloys, and should be dipped in resin or other suitable sealant to seal the fibres within the holes. To prevent damage to the laminate, washers or metal strips should be fitted in way of the heads and points. Bolt holes are to be drilled neat and the minimum distance between the centre of the bolt hole and the edge of the laminate should be three times the diameter of the bolt.

(d) *Screwing:* Screwing is acceptable only for the connections of items of relatively minor importance and only where a better type of connection cannot be readily used.

*Construction of Tanks*

Tanks for oil or water may be constructed as independent units or moulded as an integral part of the vessel's structure.

Adequate supporting structure is to be provided in way of all tanks and through bolting and riveting should be avoided wherever possible. Longitudinal divisions shall be fitted in wide tanks to reduce the effect of free surface liquids.

*Machinery Seatings*

Due to induced stresses from the vibrations and weight of the machinery special attention should be given to the design and construction of machinery seatings and the adjacent structure.

*Fire Protection*

Ordinary polyester resins will burn even when the source of ignition is removed leaving the glass reinforcement limp and unsupported. With this in mind, and with a view to the probable growth of the G.R.P. boatbuilding industry, the Board is investigating the effect of elevated temperatures on plastic laminates.

Pending the completion of these investigations the Board requires that within the machinery space and galley, and other similar spaces where there exists a fire hazard, the shell, decks, bulkheads, and load bearing structures should be constructed of approved fire retardant resins and insulated to A-30 standards.

*Fire Inspection*

Although, in Canada, a large number of small G.R.P. pleasure craft are manufactured each year only a few commercial vessels have been constructed in fibreglass. For this reason G.R.P. is still considered to be a new method of construction in this country. This being the case the inspector will carry out more than the usual number of inspections during all phases of the construction and random checks will be made of the resins, the lamination reinforcement materials and also the readings for the temperature and humidity in the building sheds.

The inspector will check the gel coat prior to the lay-up of the laminations and he will be present during at least part of the lay-up of the main hull. He will also check attachments of all main stiffening members and will be present when the mould is removed. Special attention will be given to the joining of main sections of the hull such as the deck to the shell, bulkheads boundaries, deckhouses to the main hull etc.

During the course of construction test specimens should be prepared for main hull materials. These are to be prepared concurrent with the building of the hull and at a time when the inspector is present.

The number of test specimens and the tests that are to be conducted will be decided upon by the Board for each individual vessel depending upon its size, design characteristics and other relevant features. Tests will generally be made for tensile and compressive qualities, flexural stress, water absorption etc. These tests may be carried out at a testing laboratory recognized by the Board and they should be witnessed by an inspector.

*Provisional Requirements for Inspection and Certification*

The Board has decided that for vessels constructed of G.R.P. the following provisional requirements shall apply for periodical inspection and certification:

(a) the vessel will be inspected externally and internally after the first year of operation, and
(b) following the first underwater and internal inspection, and provided the vessel is found in satisfactory condition, then normal inspections will be carried out in accordance with the requirements of either the Large or Small Fishing Vessel Inspection Regulations as applicable.

## PART 6 – REQUIREMENTS APPLICABLE TO VESSELS CONSTRUCTED OF FERRO-CEMENT

*Shipbuilder*

Construction should be carried out at an approved builders, where the personnel are properly trained and familiar with the type of work which they are to perform.

*Strength*

The modulus of the midship section and the stresses in the structural members should be acceptable to the Board. Calculations for the reinforcements should be made from first principles.

Care should be taken to ensure that the reinforcements form continuous strength members and discontinuities and that local high stress areas are avoided.

*Materials*

The strength of the ferro-cement hull is obtained from the homogeneous qualities of the cement and the grid re-inforcements which bind together to form a solid structure. The requirements for the materials are as follows:

(a) *Cement* – The cement although contributing to the strength of the vessel's hull has the primary function of giving rigidity to the re-inforcements. For the cement the Board stipulates the following requirements:
  (i) it should be of the Portland or equivalent-type, should be recommended by the manufacturer for marine use and should be approved by the Board.
  (ii) the water used for mixing should be clean fresh water and free of impurities and chemicals that may effect the concrete mix,
  (iii) the aggregate of the mix should be of a suitable type and as recommended by the manufacturer and approved by the Board. The water/cement ratio should be controlled as low as possible to give a good quality and workable material.

(b) *Reinforcements* – The reinforcing pipes, rods, bars and wire mesh used are to be of an approved grade of steel for which certificates should be available. The steel should be clean and free of scale, oil, grease or other similar contamination.

*Connections*

Welding, lacing and clipping of all main hull re-inforcements should be carried out with care and completed to the satisfaction of the Steamship Inspector.

*Construction of Tanks*

Tanks for oil or water may be constructed of steel or ferro-cement that has been treated with a suitable sealer.

Adequate supporting structure should be provided in way of all tanks and through bolting should be avoided wherever possible. Longitudinal divisions shall be fitted in wide tanks to reduce the effect of free surface liquids.

*Machinery Seatings*

Due to induced stresses from the vibrations and weight of the machinery special attention should be given to the design and construction of machinery seatings. Care should be taken that hard notches and corners are eliminated and the continuity of strength maintained.

*Inspection Procedures*

During the construction regular inspections will be carried out by a Steamship Inspector with particular attention being given to the following stages:

(a) when the steelwork re-inforcement is half complete,
(b) when the steelwork re-inforcement is complete,
(c) during the application of the cement mixture,
(d) at the removal of forms or moulds,
(e) at completion of the hull prior to curing,
(f) at completion of the hull after curing, and
(g) on completion of the vessel and during the running of the sea trials.

*Testing Procedures*

At the present time the Board of Steamship Inspection is participating in a research program, instituted by the Industrial Development Service of the federal Department of Fisheries and being undertaken by the British Columbia Research Council, to determine the qualities and suitability of ferro-cement as a shipbuilding material. We hope that results will be forthcoming from this program in the near future that will provide clear guidelines into the construction, testing and inspection procedures which we should follow.

However, pending the completion of the above mentioned research program the Board has decided that the following testing procedures should be adopted:

(a) During the course of construction the Steamship Inspector will carry out standard slump tests on the concrete mix to ensure that the mixture is a good quality and workable material.
(b) There should be prepared, concurrent with the hull plastering, test specimens of the main hull structures, the preparation of which should be witnessed by the Steamship Inspector.
(c) Tests will be required for tensile, compressive, flexural and impact strengths. These tests should be carried out at a recognized laboratory and witnessed by the Steamship Inspector. For vessels built in Canada to date these tests have been carried out at the Department of Public Works testing laboratories in Ottawa.
(d) The number of test specimens will be decided upon by the Board for individual vessels generally depending upon their size, type of construction and whether the vessel is of a prototype design.

*Provisional Requirements for Periodical Inspections and Certification*

Special attention will be given to a vessel of ferro-cement construction for the first four years of operation and provisional inspection and certification will be as follows:

(a) the vessel will be limited to Home Trade Class III Voyages — i.e. not more than 20 miles off shore and not more than 100 miles between ports of refuge,
(b) inspection will be made of the vessel afloat every six months, and
(c) underwater inspection will be carried out annually.

Following the first four-year period and provided the vessel is found in satisfactory condition, the normal inspections will be carried out in accordance with the Large or Small Fishing Vessel Inspection Regulations as applicable.

## ACKNOWLEDGEMENTS

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## APPENDIX I

*Submission and Approval of Plans and Data*

The information contained in this Appendix is extracted directly from:

(a) *The Small Fishing Vessel Inspection Regulations* that are applicable to fishing vessels not exceeding 80 feet registered length that do not exceed 150 tons, gross tonnage; and

(b) *The Large Fishing Vessel Inspection Regulations* that are applicable to fishing vessels exceeding 80 feet registered length or 150 tons, gross tonnage.

The section numbers referred to are those of the Small or Large Fishing Vessel Inspection Regulations.

### CANADA SHIPPING ACT.

### Small Fishing Vessel Inspection Regulations.

FISHING VESSELS EXCEEDING FIFTEEN TONS, GROSS TONNAGE

*Submission and Approval of Plans, etc.*

5. (1) Subject to section 6, before construction of any fishing vessel is begun, the owner thereof shall submit in triplicate to the steamship inspection office for the area where it is proposed to construct the fishing vessel the scantlings, information and data set forth in Schedule A concerning propelling machinery, pumps, piping, fuel tanks, steering arrangements and the hull of the vessel.

(2) Before construction of a subsidized vessel is begun, the owner thereof shall submit in triplicate a lines plan of the hull to the steamship inspection office for the area where it is proposed to construct the fishing vessel.

(3) Before construction of any fishing vessel is begun, the owner thereof shall submit to the steamship inspection office for the area where it is proposed to construct the fishing vessel detailed plans and data of any of the following equipment with which it is equipped, namely: its main, auxiliary and heating boilers (other than heating boilers having a working pressure not exceeding fifteen pounds per square inch), steam pipes, boiler mountings and air receivers.

6. (1) Where, under subsection (1) or (2) of section 5, any scantlings, information, data or plans are submitted to a steamship inspection office, an Inspector may approve them if, in his opinion,

(*a*) the scantlings, information, data or plans conform with the requirements of sections 8 to 26 where those sections are applicable; and

(*b*) the vessel, if constructed in accordance with those scantlings, information, data or plans, will be safe and suitable for the voyages for which it is intended.

(2) Where, under subsection (3) of section 5, plans and data are submitted to a steamship inspection office respecting any equipment mentioned in that subsection, that office shall send them to the Chairman who may approve or reject them.

7. No inspection certificate shall be issued in respect of a fishing vessel unless

(*a*) the scantlings, information, data and plans required to be submitted under section 5 have been submitted under that section and have been approved under section 6;

(*b*) the vessel is constructed in accordance with

(i) such scantlings, information, data and plans, and

(ii) the requirements of these Regulations; and

(*c*) the vessel is in the opinion of an Inspector safe and suitable for the voyages for which it is intended.

**Small Fishing Vessel Inspection Regulations**

*Schedule A.*

The scantlings, information and data respecting machinery and hull required to be submitted in accordance with section 5 are as follows:

(a) *Propelling Machinery.*

Number of engines
Manufacturer's name
Diesel, gasoline or steam
Cycle
Number of cylinders, diameter and stroke (if diesel or steam)
Brake or indicated horsepower at continuous rating
Engine revolutions per minute at continuous rating
Maximum indicated pressure (if diesel)
Mean indicated pressure (if diesel)
Weight of flywheel (if diesel or steam)
Diameter of flywheel (if diesel or steam)
Reduction gear manufacturer
Reduction gear ratio
Diameter and material of intermediate shaft
Diameter and material of tailshaft
Particulars of tailshaft liner
Propeller diameter
Propeller pitch
Type of stern bearing

(b) *Air Receivers.*

Manufacturer's name
Number on board
Internal diameter
Type of construction
Shell thickness
Head thickness
Radius of heads of circular section
Depth of heads of semi-elliptical section
Are heads dished in or out?
Is a safety valve or fusible plug fitted on each receiver?
Working pressure

(c) *Bilge Pumps and Piping.*

Number and capacities of bilge pumps driven by
(i) main engine,
(ii) auxiliary engine, and
(iii) hand

Number of suctions in
(i) machinery space,
(ii) hold spaces, and
(iii) crew and other spaces
Internal diameter of bilge piping

(d) *Fire Pumps and Piping.*

Number and capacities of fire pumps
Internal diameter of hydrant piping
Number of outlets

(e) *Fuel Tanks.*

Number of tanks
Description
Capacity of each in gallons
Thickness of plate

(f) *Steering Gear.*

Steam, hydraulic, electric or hand
Diameter of chain, wire or rod
Diameter of rudder stock
Area of rudder
Average distance between trailing edge of rudder and centre line of rudder stock

(g) *Hull.*

Name of ship and official number
Year built
Name and address of builder
Name and address of owner
Type of vessel (open or closed construction)
Type of fishing for which vessel is designed
Material (wood or steel)
Registered length (that is to say, the length from the foremost part of the stem of a fishing vessel to the after side of the head of its stern post, or if it has no stern post, to the forward side of the rudder stock at the deck)
Breadth (extreme over planking)
Depth (top of beam at side amidships to rabbet line on keel)
Number and location of watertight bulkheads
Length and height of deck-houses
Location of engine room
Number and sizes of engine room entrance and emergency exits
Location of crew accommodation and total number of crew
Height of bulwarks
Height of sills of doors giving access to main hull
Hatches, number and size
Hatch coamings, height and thickness
Hatch fore and afters, vertical and horizontal dimensions
Hatch covers, type and thickness

(h) **Details of Materials**

| Item | Finished dimensions | Material | Spacing (centres) | Details of fastenings |
|---|---|---|---|---|
| Keel | | | | |
| Stem | | | | |
| Sternpost | | | | |
| Keelson | | | | |
| Frames | | | | |
| Deck beams | | | | |
| Hanging knees | | | | |
| Lodging knees | | | | |
| Hatch carlings | | | | |
| Clamps | | | | |
| Shelfs | | | | |
| Bilge ceiling | | | | |
| Floors | | | | |
| Plank or plate | | | | |
| Deck | | | | |
| Engine Foundations | | | | |

NOTE: the above information and scantlings may be submitted as a list, or in the form of plans, or as a combination of both methods.

## CANADA SHIPPING ACT

### Large Fishing Vessel Inspection Regulations

*Submission and Approval of Plans, etc.*

"6. (1) Subject to subsections (2) and (3), before construction of any fishing vessel is begun, the owner shall submit for approval, in triplicate, the plans and data set forth in Schedule A concerning boilers, superheaters, economizers, air receivers, propelling machinery, pumps, piping, fuel tanks, steering gear, rudder and hull."

(2) Plans of the following are not required to be submitted:

(*a*) heating boilers having a pressure not over 15 pounds per square inch,

(*b*) diesel engines not exceeding 75 brake horse power, continuous rating, unless of unusual design,

(*c*) gearing for main engines and electric propulsion motors not over 300 brake horse power, continuous rating,

(*d*) gasoline engines unless of unusual design, or

(*e*) parts that are found by an Inspector to agree with plans already approved by the Chairman.

(3) Notwithstanding subsection (2) the Board may require that plans and data of parts not listed in Schedule A shall be submitted.

"(4) Where under this section plans and data are submitted to a Divisional Supervisor, one copy of each submission approved by the Divisional Supervisor for the Chairman shall be forwarded to the Chairman by the Divisional Supervisor."

(5) No inspection certificate shall be issued in respect of a fishing vessel unless

(*a*) The plans and data submitted under this section have been approved by the Chairman,

(*b*) the vessel is constructed in accordance
(i) with such plans and data, and
(ii) with the requirements of these regulations, and

(*c*) the vessel is in the opinion of an Inspector safe for the voyages for which it is intended.

Large Fishing Vessel Inspection Regulations

"Schedule A

1. The plans and data respecting machinery and hull required to be submitted for approval in accordance with section 6 are as set out in this Schedule.

"2. (1) Where a fishing vessel does not exceed 100 feet in length

(*a*) The plans for the following equipment and parts of the vessel shall be submitted to the Board:
(i) new air receivers,
(ii) boilers having a working pressure of 15 pounds or over per square inch,
(iii) diesel engines over 500 B.H.P.,
(iv) gearing for all engines over 500 B.H.P.,
(v) lifeboats, life rafts and buoyant apparatus, and
(vi) aluminum superstructures; and

(*b*) the plans for the following equipment and parts of the vessel shall be submitted to the Divisional Supervisor who may approve those plans for the Board or forward them to the Board for approval:

(i) new boiler mountings,
(ii) steam turbines over 500 B.H.P.,
(iii) reciprocating steam engines over 500 B.H.P.,
(iv) general arrangement of ship,
(v) midship section,
(vi) longitudinal section and deck plans,
(vii) rudder,
(viii) electric circuits and protective devices, and
(ix) such other equipment and parts of the vessel as the Divisional Supervisor may consider necessary.

(2) Where a fishing vessel exceeds 100 feet in length

(*a*) the plans for the following equipment and parts of the vessel shall be submitted to the Board:

(i) new air receivers,
(ii) sprinkler and foam pressure tanks,
(iii) boilers, main, auxiliary and heating, superheaters and economizers,
(iv) boiler mountings,
(v) electric circuits and protective devices,
(vi) steam turbines over 500 B.H.P.,
(vii) diesel engines over 500 B.H.P.,
(viii) reciprocating steam engines over 500 B.H.P.,
(ix) gearing for all engines over 500 B.H.P.,
(x) general arrangement of ship,
(xi) midship section,
(xii) longitudinal section and deck plans,
(xiii) subdivision details and data if required by owner,
(xiv) unusual cargo gear,
(xv) sprinkler system if required by owner,
(xvi) fire-resistant bulkheads if required by owner,
(xvii) lifeboats, life rafts and buoyant apparatus, and
(xviii) aluminum superstructures; and

(*b*) the plans for the following equipment and parts of the vessel shall be submitted to the Divisional Supervisor, who may approve those plans for the Board or forward them to the Board for approval:

(i) general arrangement of machinery,
(ii) stern tube, stern bush or bearing,
(iii) shafting, including thrust, propeller, intermediate shafting and couplings,
(iv) diagram arrangement of feed water, oil fuel and cooling systems,
(v) compressed air systems,
(vi) existing boiler mountings,
(vii) existing air receivers,
(viii) arrangement of steam pipes,
(ix) propane gas installations,
(x) bilge and ballast pumping and piping,
(xi) fuel oil tanks separate from hull,
(xii) main and auxiliary steering arrangements with details of quadrant and tiller,

(xiii) fixed fire extinguishing equipment as outlined in section 6 of the *Fire Detection and Extinguishing Equipment Regulations,*
(xiv) rudder
(xv) stem, sternpost or sternframe,
(xvi) pillars and girders,
(xvii) shell expansion,
(xviii) W.T. and O.T. bulkheads,
(xix) engine and boiler seatings,
(xx) shaft brackets and bossing,
(xxi) schemes of riveting and welding,
(xxii) list of fastenings in the case of wooden ships,
(xxiii) sea chests,
(xxiv) boat arrangement,
(xxv) natural and mechanical ventilation,
(xxvi) usual cargo gear,
(xxvii) fresh and salt water systems, and
(xxviii) scuppers and dischargers."

3. In the case of reciprocating steam engines, the following data shall be supplied with the plans:

(1) Designed indicated horsepower
(2) Revolutions per minute
(3) Number of cylinders, diameter and stroke of pistons
(4) Diameter and weight of flywheel (if fitted)
(5) Diameter of propeller
(6) Physical properties of principal forgings and castings.

4. In the case of diesel engines, the following data shall be supplied with the plans:

(1) Designed brake horsepower
(2) Revolutions per minute
(3) Two or four cycle
(4) Maximum and mean indicated pressure
(5) Balance weights (weight and number) and radius of gyration
(6) Number of cylinders, diameter and stroke of pistons
(7) Diameter and weight of flywheel
(8) Diameter of propeller
(9) Physical properties of principal forgings and castings.

5. In the case of gears in excess of 300 brake horsepower, the following data shall be supplied with the plans:

(1) Designed shaft horsepower
(2) Revolutions of each pinion and gear
(3) Number of teeth, pitch and pitch circle diameter in each gear and pinion
(4) Length and thickness of teeth
(5) Helix and pressure angles
(6) Physical properties of principal forgings and castings.

## APPENDIX II

*First and Periodic Inspections*

The information contained in this Appendix is extracted directly from:

(a) *The Small Fishing Vessel Inspection Regulations* that are applicable to fishing vessels not exceeding 80 feet registered length that do not exceed 150 tons, gross tonnage; and

(b) *The large Fishing Vessel Inspection Regulations* that are applicable to fishing vessels exceeding 80 feet registered length or 150 tons, gross tonnage.

The section numbers referred to are those of the Small or Large Fishing Vessel Inspection Regulations.

### CANADA SHIPPING ACT.

### Small Fishing Vessel Inspection Regulations.

FISHING VESSELS EXCEEDING FIFTEEN TONS, GROSS TONNAGE

*First Inspection of New Construction.*

41. (1) Every fishing vessel shall be inspected during construction at such times as the Inspector deems advisable.

(2) The owner of a fishing vessel shall notify the Inspector at least one week in advance of
(*a*) the commencement of framing;
(*b*) the commencement of planking or plating;
(*c*) the launching; and
(*d*) the dock and sea trials.

(3) An Inspector may accept machinery in respect of which plans are not required to be submitted under these Regulations even though it has not been inspected during construction without its being opened for inspection if he is satisfied that it is safe and suitable for the purpose for which it is intended.

(4) Inspection and construction of boilers, steam pipes, boiler mountings and air receivers of fishing vessels for which plans are required to be submitted under these Regulations shall be in accordance with the *Steamship Machinery Inspection Regulations* and the *Steamship Machinery Construction Regulations.*

(5) Dock trials and sea trials of a fishing vessel shall be held in the presence of an Inspector, at which time the bilge and fire pumps shall be tested, the speed in knots estimated, the steering and stopping powers of the vessel tested and the launching arrangements for the lifeboats, boats, dories or skiffs tried out, and such further tests shall be made as the Inspector considers necessary to satisfy himself that the vessel is safe and suitable for the purpose for which it is intended.

*Periodic Inspection.*

42. Every fishing vessel propelled by steam shall have the following parts inspected annually by an Inspector:

(*a*) boilers, boiler mountings and steam pipes;
(*b*) life saving equipment; and
(*c*) fire extinguishing equipment.

43. (1) Subject to subsection (2), every fishing vessel shall be inspected once every four years as follows:

(*a*) Air receivers shall be tested by hydraulic pressure to one and one-half times the working pressure but the Inspector may waive this test if the air receiver has a manhole or other opening that permits a thorough examination of the interior and he is satisfied that it is in a safe and sound condition;
(*b*) an engine trial shall be held and if the engine is found in good operating condition the Inspector may accept it without opening it up for inspection; but where the running trial is not to the satisfaction of the Inspector he may require that the engine, or any part thereof, be opened up for inspection; the owner shall notify the Inspector whenever the engine is opened up for overhaul so that the Inspector may have an opportunity of examining the engine;
(*c*) the hull shall be examined inside and out by the Inspector while the vessel is in dry dock or while beached;
(*d*) fire and bilge pumps shall be tested by trial and overhauled if necessary;
(*e*) the rudder shall be examined in place, the weardown of the tailshaft measured and all sea connections opened up for inspection;
(*f*) all life saving, fire extinguishing and navigating equipment shall be inspected;
(*g*) tailshafts shall be inspected in accordance with section 44; and
(*h*) air compressor relief valves and air receiver relief valves shall be set to blow off at the assigned working pressure.

(2) The periodic inspection required by paragraph (*a*) of subsection (1) in respect of a new air receiver shall commence eight years after the date of the first inspection of the air receiver.

44. Tailshafts of a fishing vessel shall be inspected as follows:

(*a*) carbon steel tailshafts, where used in salt water, shall be completely withdrawn for inspection and the propellor removed at least once every four years; in order to facilitate such inspection the owner shall notify the Inspector whenever the tailshaft is withdrawn and the propellor removed; and
(*b*) bronze, monel, stainless steel or other non-corrosive tailshafts used in salt or fresh water and carbon steel tailshafts used in fresh water shall, if considered necessary by the Inspector, be partially or completely withdrawn for inspection once every four years and the propellor shall, if considered necessary by the Inspector, be removed once every four years; in order to facilitate such inspection the owner shall notify the Inspector whenever the tailshaft is withdrawn.

45. An Inspector may, in addition to any inspection or test required by these Regulations, conduct any inspection or require any test to be made to satisfy himself that anything on a fishing vessel that may affect its seaworthiness is safe and suitable for the purpose for which it is intended.

46. (1) Notwithstanding the requirements for periodic inspection prescribed in this Part, an Inspector may issue or extend an inspection certificate for a period not exceeding

(*a*) two months beyond the due date of periodic inspection; or
(*b*) five months beyond the due date of periodic inspection if authorized to do so by the Divisional Supervisor.

(2) Prior to issuing or extending an inspection certificate under this section the Inspector shall satisfy himself from such inspection of the hull, machinery and equipment, as is possible afloat, and without opening up any machinery except boilers and boiler mountings, that the fishing vessel is in a seaworthy condition.

(3) An inspection certificate issued or extended to the maximum period allowed under this section shall not be renewed or further extended without the permission of the Board.

47. Any alterations affecting the seaworthiness of a fishing vessel shall be equivalent to the standards of these Regulations and to the satisfaction of an Inspector.

## CANADA SHIPPING ACT

### Large Fishing Vessel Inspection Regulations,

*First Inspection of New Construction*

23. (1) Every fishing vessel shall be inspected during construction at such times as the Inspector deems advisable.

(2) The owner of a fishing vessel shall notify the Inspector at least one week in advance of

(*a*) the commencement of framing,
(*b*) the commencement of planking or plating,
(*c*) the launching, and
(*d*) the dock and sea trials.

(3) Dock trials and sea trials of a fishing vessel shall be held in the presence of an Inspector, at which time the bilge and fire pumps shall be tested, the speed in knots estimated, the steering and stopping powers of the vessel tested and the launching arrangements for the lifeboats, boats, dories or skiffs tried out, and such further tests shall be made as the Inspector considers necessary to satisfy himself that the vessel is safe and suitable for the voyages intended.

*Periodic Inspection of Hulls of Wooden Fishing Vessels*

31. (1) Every wooden fishing vessel over 150 tons, gross tonnage, if operating in salt water, shall be dry docked and inspected every two years.

(2) Every wooden fishing vessel over 150 tons, gross tonnage, if operating in fresh water, shall be dry docked and inspected quadrennially.

(3) Every wooden fishing vessel not over 150 tons, gross tonnage, shall be dry docked and inspected quadrennially.

(4) The hull inspection shall be carried out as follows:

(*a*) the Inspector shall examine the hull externally and internally in order to satisfy himself as to the condition; such parts of the ceiling shall be removed as the Inspector may require in order that the condition of the hull, timbers, floors, etc. may be ascertained; fastenings and sheathing shall be removed where considered necessary by the Inspectator; boring shall be carried out where and as considered necessary by the Inspector;
(*b*) hatchways, ventilators, doorways and other deck openings with their closing and opening appliances, superstructure bulkheads with their closing appliances, hatch coamings and door sills shall be inspected;
(*c*) such further opening up shall be done as the Inspector may require in order to satisfy himself that the hull is in good condition;

(*d*) all repairs and renewals shall be carried out to the satisfaction of the Inspector; and

(*e*) any alterations made to the vessel since the previous inspection shall be reported in detail by the Inspector to the Chairman.

*Periodic Inspection of Hulls of Steel Fishing Vessels*

32. (1) Every steel fishing vessel over 150 tons, gross tonnage, if operating in salt water, shall be dry docked and inspected every two years.

(2) Every steel fishing vessel over 150 tons, gross tonnage, if operating in fresh water, shall be dry docked and inspected quadrennially.

(3) Every steel fishing vessel not over 150 tons, gross tonnage, shall be dry docked and inspected quadrennially.

(4) The hulls of steel fishing vessels not over 145 feet in length shall be inspected as follows:

(*a*) the Inspector shall examine the hull externally and internally in order to satisfy himself as to the condition; such parts of the ceiling shall be removed as the Inspector may require in order that the condition of plating, frames, floors, tank tops etc., may be ascertained; drill testing of the plates shall be carried out where and as considered necessary by the Inspector;

(*b*) hatchways, ventilators, doorways and other deck openings with their closing and opening appliances, superstructure bulkheads with their closing appliances, hatch coamings and door sills shall be inspected;

(*c*) where considered necessary by the Inspector fore and after peaks, bunkers, double bottom tanks and bilges shall be cleaned and examined;

(*d*) steel work shall be cleaned and exposed for examination where considered necessary by the Inspector;

(*e*) where considered necessary by the Inspector double bottom tanks shall be tested by a head of water at least to the light waterline but not less than 8 feet above the inner bottom, and peak tanks used for water ballast shall be tested to a head of water not less than 8 feet above the crown of the tank;

(*f*) such further opening up shall be done as the Inspector may require in order to satisfy himself that the hull is in good condition;

(*g*) all repairs and renewals shall be carried out to the satisfaction of the Inspector; and

(*h*) any alterations made to the vessel since the previous inspection shall be reported in detail by the Inspector to the Chairman.

(5) The hulls of steel fishing vessels over 145 feet in length shall be inspected as required by the *Hull Inspection Regulations.*

*Periodic Inspection of Sea Connections, Windlass, Rudder, Steering Gear, Anchors and Anchor Cables*

33. (1) All sea suction and discharge valves and cocks situated below the load water line or which exceed 2 inches in internal diameter shall be opened up for inspection at least every four years.

(2) On every occasion that a fishing vessel is drydocked in compliance with these regulations the sea connection fastenings, windlass, rudder, steering gear and anchors shall be given a general examination by the Inspector, who may request any opening up that he deems to be necessary.

(3) Anchor cables shall be ranged eight years after construction of the vessel and every four years thereafter; where the chain is so worn that the mean diameter at any part is reduced to the minimum size shown in Schedule E as requiring renewal, that part shall be renewed.

(4) Steering chains so worn that the mean diameter at any part is reduced to the minimum size shown in Schedule E as requiring renewal shall be renewed at that part.

*Periodic Inspection of Screw Shafts and Tube Shafts*

34. (1) Fishing vessels over 150 tons, gross tonnage, making voyages in salt water, shall have the screw shafts and the tube shafts withdrawn for inspection at least once every two years, except that shafts of the following types need be withdrawn for inspection only once every three years in the case of single screw fishing vessels, and one every four years in the case of fishing vessels having two or more screws:

(*a*) shafts fitted with a continuous liner in way of the stern tube, and in way of outside bearings where fitted;

(*b*) shafts fitted with approved glands or other approved appliances at the after end to permit of their being efficiently lubricated;

(*c*) shafts of bronze, monel metal, or other approved non-corrosive material;

(*d*) shafts that are fitted with non-continuous liners and that are completely covered between the liners with rubber or neoprene that has been applied and bonded by an approved method.

"(1a) Notwithstanding subsection (1), where a single screw fishing vessel has a shaft of a type described in any of paragraphs (*a*) to (*d*) of subsection (1), the shaft need only be drawn for inspection once every four years if

(*a*) the key way, if fitted, has well rounded ends or is of the sled type, has an adequate root radius and has rounded edges at the shaft surface; and

(*b*) at each inspection, the shaft between the after end of the liner, or the after end of the stern tube if no liner is fitted, and a position one third of the length of the taper from the large end, is examined by an efficient crack detection method and found free from defects."

(2) Fishing vessels not over 150 tons, gross tonnage, making voyages in salt water, shall have the screw shafts and the tube shafts withdrawn for inspection at least once every four years.

(3) Fishing vessels making voyages in fresh water shall have the screw shafts and the tube shafts withdrawn for inspection at least once every four years.

(4) When a screw shaft or tube shaft is withdrawn for the inspection required by this section it shall be completely removed from the stern tube and bearings and the propeller shall be taken off the shaft.

(5) When a fishing vessel is inspected in drydock and the shafts are not withdrawn for periodic inspection, the propellers and stern bearings shall be examined in place and the wear-down of the stern bearings shall be noted and reported.

*Postponement of Inspection*

35. (1) The Board may authorize the requirements of the quadrennial inspection of the machinery and hulls of fishing vessels over 150 tons, gross tonnage, to be postponed from the due date, either wholly or in part, for a period not exceeding twelve months from the due date if the annual inspection requirements have been carried out.

(2) The Board may authorize the requirements of the annual or quadrennial inspection of the hulls of all fishing vessels to be postponed from the due date, either wholly or in part, for a period not exceeding six months from the due date.

"(3) Notwithstanding the requirements for the periodic inspection of hull and machinery prescribed in these Regulations, an Inspector may issue or extend an inspection certificate for a period not exceeding

(*a*) two months beyond the due date of periodic inspection; or

(*b*) five months beyond the due date of periodic inspection if authorized to do so by the Divisional Supervisor.

(4) Prior to issuing or extending an inspection certificate under this section the Inspector shall satisfy himself from such inspection of the hull, machinery and equipment, as is possible afloat, and without opening up any machinery except boilers and boiler mountings, that the fishing vessel is in a seaworthy conditon.

(5) An inspection certificate issued or extended up to the maximum period allowed under subsection (3) shall not be renewed or further extended without the permission of the Board."

*Continuous Inspection*

36. The quadrennial inspections may be carried out on a continuous basis if all parts subject to inspection are inspected at least once every four years; where this method of inspection is adopted the owner shall furnish a chart for recording the inspections carried out; this method of inspection, however, shall not exempt any fishing vessel from the annual inspection required by these regulations.

# The Fishing Industry's Viewpoint on Vessel Construction Materials

Mr. Nelson

by

Richard I. Nelson
Vancouver, B.C.
President, Fisheries Council of Canada

*Mr. Nelson is President of Nelson Brothers Fisheries Limited, Vancouver. He has been a Director of the Fisheries Council of Canada for a number of years and is President for the 1968-69 period.*

*A native of New Westminster, B.C., he is a graduate of the University of British Columbia in Mechanical Engineering and the Harvard Graduate School of Business Administration.*

I am pleased to have been offered the opportunity of presenting to you some views, as a member of the industry, on vessel construction materials. It is essential in the development of any product, including fishing vessels, that the needs of the consumer, in this case the fishermen or operator, be kept very much in mind.

The fishing industry is of vital importance to a considerable number of people in Canada. It has an old and proud tradition, and although it is presently passing through a difficult and painful period of adjustment, the future holds much promise.

In recent years the selling prices of fishery products have generally declined in the face of steadily rising costs. Not the least of these costs has been the one of building and operating fishing vessels. If this Conference is able to provide ideas for controlling these costs, it will have made a significant contribution to the future of the industry.

It is a view held by many that the fishing industry is slow in adopting new ideas. I feel the reverse is true. Fishermen are generally venturesome entrepreneurs who gladly adopt promising new techniques. But, as pointed out by Dr. A. D. Scott of the University of British Columbia, they are confronted with many obstacles to innovation.[1]

First, a fishing vessel is small relative to the biological scope of the fishery. At most the fisherman is permitted to improve his method of hunting and catching. He is like a hunter who is allowed only to adopt new weapons for killing game birds on the wing. He is not justified in investing a great deal, for he has no control over the resource. His expensive capital investment may yield him no benefit if other equally well-equipped vessels forestall him in the catch.

The consequence is that the fisherman is precluded from adopting innovations except those that will enable him to forestall his rivals on the grounds, in finding fish, or in getting back to port. Given the shortage of capital, the risks that even good inventions will not work, and the fact that none in the industry (except designers and equipment manufacturers) has an incentive to find new methods, there has been a relatively rapid adoption of new techniques. Within these narrow limits, even the most

1. "Food and the World Fisheries Situation". A. D. Scott, The Johns Hopkins Press. Baltimore, 1964.

uneducated fishermen in the most isolated ports are willing to listen to new ideas.

My point is that if a particular innovation has a demonstrated value, it will be adopted, if at all possible. The rapid introduction of power blocks and sonar might be cited as examples. Because a fisherman is competing for his share of the resource, his emphasis will be on methods of catching more fish as a direct means of increasing his income. Unfortunately, vessel construction materials largely make no easily demonstrated contribution to earnings. Their effect is in cost reduction, which may have an important bearing on earnings, but is a more remote concept with long-term implications. One of the most important contributions that can be made by experts such as those attending this meeting is to demonstrate these advantages in a manner that can be understood by fishermen and operators.

I am pleased to see that the Conference is devoting attention to the economic evaluation of vessel design, since after all it is a basic objective of a fishing vessel to be profitable. There have been far too many vessels designed and built in Canada that can "never make it pay". Easy credit has made it possible for fishermen to build vessels beyond their knowledge and experience, often with unhappy results. Subsidies, necessary as they are in many instances, have distorted economic evaluations. Fishermen forget that although subsidies may reduce the original investment, operating costs such as repairs and maintenance and insurance are functions of the actual cost. In my opinion, what is required is greater use of feasibility studies before construction is commenced or before loans or subsidies are granted. This will require the co-ordinated efforts of designers, builders, fishermen and operators to achieve realistic results.

I am also pleased to see that the Conference is discussing the system approach to design. This is highly desirable, but I hope the total system of taking fish from the water to the consumer is considered, not just the traditional part the vessel has played. The entire system must be continuously watched for opportunities for combining or separating functions in ways they have not been done before. For instance, perhaps dressing fish on Atlantic trawlers could be eliminated if refrigerated seawater or a suitable substitute could be used to keep the fish in fresh condition until they are processed more effectively and economically ashore.

Almost every conceivable type of fishing vessel is operating in the diverse Canadian fishing industry: from outboard skiffs to large stern trawlers. Certainly there is no "best" material for all these vessels. What is "best" for any one vessel will depend on the requirements of the fishery, the fisherman and the availability of capital. However, an ideal material should provide:

1. Low initial cost of vessel.
2. Easy and inexpensive maintenance.
3. Safety and comfort for the crew.
4. A reasonable life span.

By discussing the possibilities of various construction materials, including the traditional, this Conference should provide a firm basis on which to make alternative choices.

Canada will require a large number of fishing vessels in the coming years. I hope that through the co-ordinated and co-perative efforts of designers, builders, fishermen, operators and government, the most effective possible vessels will be supplied. The industry will welcome them.

I wish you a very successful conference, and I hope the results will assist in the further rational development of our valuable Canadian fishing industry.

**Session 2**

## DISCUSSION

*Mr. Lyle Chase, Ferrocon Industries, Limited, asked Mr. Bonn if a certificate for a ferro-concrete vessel over 15 gross tons would be issued, and if so, under what conditions.*

*Mr. Bonn: "In answer to that question, a certificate certainly will be issued. Special attention, of course, will be given to the structure for the first four years of operation, and provisional inspection and certification will be on the following basis: that the vessel would be limited to home trade Class Three voyages–that is, 20 miles offshore and 100 miles between ports of refuge; inspection will be made of the* *vessel afloat every six months at least for the first two years and underwater inspection will be carried out annually; following the first four-year period, provided the vessel is found in satisfactory condition, normal inspections will be carried out in accordance with the Large or Small Fishing Vessel Regulations."*

*John Gardner, editor of "The National Fisherman", asked Mr. Bonn what was the source of standards now enforced for inspection of fiberglass fishing vessels.*

*Mr. Bonn: "We have not had the requirement, really, to inspect or approve a large fishing vessel. In fact, I think most of them today are under 15 tons and don't really fall within our inspectional jurisdiction. We have quite a bit of information and knowledge of the pleasure boating field, and there are classification rules that have been published. We are O.K. with these. We are at present doing research into the effects of elevated temperatures, something we are very interested in, but it certainly is structure that lends itself to the calculation of stresses, and I think there is no problem really in approving the structure. I believe that the Industrial Development Branch of the Department of Fisheries and Forestry's Fisheries Service is at present engaged in looking into the building of a GRP vessel, and we certainly will be involved in that. In, fact, I know we are now."*

*Walter Scott, Department of Fisheries and Forestry, said that with reference to ferro-cement, there was a stated phrase, "construction at an approved builder's." He asked what requirements must be satisfied to receive an approved rating.*

*Mr. Bonn: "Well, primarily, demonstration by the builder that he can handle the media in which he is working. We would want, before we would even approve the plans, the submission of panels with the grid work that he proposes to use, and the materials of construction–in other words, his mix, and we would do slump tests and various other tests necessary before panels are laid up. We would then take these panels and do exhaustive mechanical tests somewhat similar to normal material tests. We would be interested in trying to establish (and again, we are into the research end of this) tensile and bend stresses, flexural stresses, impact, and the effects of freezing and thawing. This is the nature of the tests that we are looking into at present. If he can produce this type of panel and we can establish what the strength of that panel is, well, then , we are in a position to approve his plan."*

*R. Richardson, of the Department of National Defence of Canada, put the following question to Mr. Bonn: "Can you amplify the work being done in investigating temperature elevation effects on laminates? Is it your view that fire insulation of the conventional style could be eliminated by using dense glass rovings on the surface of laminates in association with fire retardant resins?"*

*Mr. Bonn: "Certainly this is the area in which research hasn't even been started. We have laid down some basic guidelines for the type of research we wish to have the specialists and research scientists look into in this field. Certainly this is a possibility. In fact, during the lunch hour I was speaking to a friend from Great Britain who tells me that roving does in fact act as a fire shield, and this I find very encouraring, because from my point of view roving is very necessary for impact strength in the laminates. So it serves two very useful purposes. Also, of course, traditional types of insulating materials to reduce the heat transfer and produce a core temperature sufficient to maintain the structural strength can be used in both of these. We hope to produce some numbers on them in the near future."*

*Mr. W.A. McCallum, of the Fisheries Research Board of Canada, St. John's, Nfld., said he was asking the following question on behalf of members of the fishing industry: "With steel trawler construction deck houses built only partially of aluminum alloys, e.g., houses erected on steel decks, it is not felt that the compass can be kept at least 10 feet from the nearest magnetic material, as specified in the proposed regulations. How, in your opinion, can this matter be resolved?"*

*Mr. Bonn: "Of course, aluminum is non-magnetic. Corrections can of course be made. I realize these new navigation regulations and navigating equipment regulations are just coming to the fore. I think you do the best you can and then you have to resort to corrective magnets. I really don't speak with authority on this subject because I would have to call on one of our master mariners who is responsible for this regulation."*

*Mr. G. Sylvester, of the Department of Fisheries and Forestry, also addressed a question to Mr. Bonn: "You state that the construction of aluminum vessels shall be carried out at a plant where the personnel are properly trained. What is your yardstick for this training?"*

*Mr. Bonn: "This would be knowledge in the use of the material. We carry out welding tests, test samples, and do bend tests. If the inspector is not completely satisfied, or if we have any doubts, we can send the samples to a lab for analysis to see if they are employing proper techniques and that they are getting good and efficient welds. There are some limitations in welding if it is not properly applied, and this is one of the main points we look for, in other words, we expect good shipbuilding techniques and the production of good welds. We employ various types of non-destructive testing during the course of inspection of a vessel, and hope to ensure that we always have a good hull."*

*Mr. L. LaChance, of Laval University, Quebec, quoted from a section of Mr. Bonn's paper which stated that strength calculations for the reinforcements should be made from first principles. He asked if any handbooks were available for calculating ferro-concrete hulls.*

*Mr. Bonn: "I am afraid you have caught me in a very vulnerable position here. We had a set of plans to look at when we were attempting to try to evaluate what the strength might be. We took out the strength of the grid that was supplied, and this was a grid that was welded together. Then, associated with this, we are doing some panel tests at present, and we are trying to get this correlation of the grid with the cement impregnated into it. We have seen lots of figures on this, and we have very little to substantiate them with, which makes it very difficult to design the vessel at present. However, we hope to resolve this in co-operation with the research program being carried out for the Industrial Development Branch by the British Columbia Research Council and our own test program. I am afraid it is not a very satisfactory answer; I don't happen to have a handbook to refer to."*

*Mr. Traung asked Mr. Bonn if the Department of Transport of Canada had any opinion of stresses in a fishing catamaran.*

*Mr. Bonn: "I am afraid you have struck me with a very unusual question. We have never had a fishing catamaran submitted, and we haven't done a calculation or even considered this type of vessel to date. However, we would be very interested in doing a study on this type of vessel. I must say we haven't looked at this at all, and I am sorry that I cannot reply more positively to this question."*

*In answer to a further question from Mr. Traung, Mr. Bonn said: "There is a catamaran being designed now by another Service in our Department as a buoy tender but again, I haven't seen the details of it yet."*

*Mr. Robert N. Leslie, of Queen City Distributors, Ltd., Toronto, asked Mr. Nelson if the fishing industry had any views on the material of tomorrow for fishing vessels of offshore, year-round capability.*

*Mr. Nelson: "I don't feel that the industry is in a position to say at this point what the material of the future is for any kind of vessel. It would be our hope that in a conference such as this the background material would be developed that would enable the industry to make a rational choice between the various alternative materials that are available or will be available."*

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*Mr. J.R. Fulcher of Davie Shipbuilding, Sorel, Quebec, asked if Mr. Nelson could express an opinion on the number, size, and type of trawlers to be built or which would be required by the Canadian fishing industry within the next five years.*

*Mr. Nelson replied that he would not like to offer a definite opinion, but he thought that unless things were better there might not be too many.*

*Mr. Meagher, commenting on this question, said it would be difficult for Mr. Nelson to answer for all of Canada, but he thought that it might be of interest for the conference to know that during a meeting held in Halifax on December 9, Hon. Jack Davis, Minister of Fisheries and Forestry, has asked the five Atlantic Coast Provinces' Departments of Fisheries to provide him with information as to the number of boats that would be required for which firm applications to the various loan boards would be on hand for building up to the end of the next fiscal year, and then try to make a projection of what the requirements would be for the next five years. "We are working to provide that information ourselves in Nova Scotia", said Mr. Meagher. "I know the other provinces are doing the same, and I think that perhaps within a month or so the Federal Minister will have an idea of what the requirements are from the viewpoint of industry."*

*Mr. W.M. Sutherland, Ferro-Cement Limited, Auckland, New Zealand, said that there were problems in his country with cray fishing boats made of ferro-cement, which had to go in around rocks. "The problem we have is that we can't get any design criteria by the specifying authorities as to the specific requirements. In other words, we know that the material of the hull itself is a structurally sound monolithic unit, but this is not the governing point. It's the ability to withstand bumping against rocks frequently, unfortunately, and there are certain materials which seem to behave much better than others. There is also the question of high speed hulls and I would be very interested to hear from anybody in these waters who has had experience with fishing boats for high speed work or medium high speed work when they had to carry loads, etc."*

*Mr. Brandlmayr replied: "I have been involved in the design of some relatively high speed fishing vessels in a range of from 15-20 knots; these are small boats, 30 to 50 feet in length. I believe that a good part of the subjects were covered in the paper I gave at Goteburg in 1965 – there isn't as much data perhaps as Mr. Sutherland would like to have, but if he is interested we have done a lot of work on planing hulls and this could be used. As for bumping up against rocks, I don't know of any vessel that will stand up to that."*

*Mr. R.G. Wade, Hovermarine (Canada) Ltd., Ottawa, said he thought that both arguments of Mr. Sutherland could be answered by the use of Hovercraft for fishing. "There is no application at the moment for Hovercraft in this field," he said. "They are extensively used now as a means of transport, but in the years to come the economics of the thing should get much better, and he might be interested in pursuing this with the Hovercraft manufacturers."*

*Mr. Traung said that crayfish, referred to in northern Europe as lobsters, except that perhaps they had no claws, had a rather high value to fishermen. "They are placed in pots and these pots are normally placed in rocks. On the western coast of Australia they have the same problems as you seem to have in New Zealand, and have developed comparatively fast crayfish catching boats of about 40 feet in length, mainly of plywood. The point that Mr. Brandlmayr is talking about is that these boats are actually far too highly powered to justify the investment in machinery. Manoeuverability is mandatory, as they haul the pots very close to the ridges of these rocks and with extremely powerful engines they can get away if there is any danger of being washed on the rocks. But I don't think anybody has ever tried to design a fishing boat strong enough to bounce on the rocks. Not that it couldn't be done, material-wise, but there would be certain problems with propeller shafts and propellers, etc."*

*Mr. Sutherland: "I don't want to throw cold water on the ferro-cement material, because it is something I am interested in. But I have come to the opinion that at the moment I don't feel confident in building a crayfishing boat for working in our waters around the rocks. Only recently I was down in the deep south and discussed the problem with the fishermen, and they said 'Oh yes, we bump the rocks; at least twice a day we drop the boat on the rocks'. They have taken the precaution of filling the bottoms of their (45-foot) boats with about seven or eight tons of concrete, to try to give some resistance. So I do suggest that until the ferro-cement research people, and we are working on this very hard, can guarantee sufficient impact strengths I ask you to design your concrete boats for mid-water or normal operations; they will certainly not stand bumping on the rocks, nor will plywood. Steel seems to be the perfect material for this; nevertheless, they lose a lot."*

*Mr. D.A. Eisenhauer, of the Atlantic Bridge Company, Lunenburg, said that Mr. Sutherland might be interested in the results that were obtained with the Cape Islander boat, a model of which was on display, and which had been built of FRP six or seven years ago. He said: "Admittedly, it was overbuilt on purpose, because we wanted to be on the safe side with it, since it was the first time that a reinforced plastic boat had been built for fishing on the Atlantic coast of Canada. I don't think that, as far as bumping on the rocks is concerned, a standard design would suffice. I would suspect that one would have to be over-designed, and perhaps on a 'by guess and by God' basis, a little more than on a standard design. However, that particular boat was used in her first season for lobster fishing, which I presume was not unlike the cray fishing that the gentleman was talking about. It spent that first season among shale shoals. It was grounded and it hit the reefs frequently. It was taken to a country fair after it had been in use for a while. While it was in transit to the fairgrounds the cradle broke and it fell to* *the pavement. After it was launched again the fishermen who were using it in that locality had the misfortune of running her at about half-speed onto a shoal in the harbour. She was subsequently hauled out for the wintertime. She was launched by having a bulldozer placed against her bow and pushed into the water. She was used in subsequent years in one port, as Mr. Meagher has said, for icebreaking. In order to get weight in the boat they loaded rocks inside her and used her for breaking ice in the harbour. In the number of years that that boat has been in service I am familiar with her repair costs, and there hasn't been $100 spent on her hull in spite of this knocking about. We have the laminate structure of that boat and if the gentleman is interested we could give it to him."*

**SESSION 3, OCTOBER 2, 1968 9.00 A.M.**

# THE MATERIAL

Moderator: Dr. Leonce Chenard,
Deputy Minister of Fisheries,
New Brunswick.


**Session 3, Upper photo, left to right, E.J. Frontini, A. Lippay, K. Brandl, Boughton Cobb, Jr., A.M. Kelly, Insert, lower left, left to right, E.E. Buswell, J. Brandlmayr, H.I. Chappelle, W.A. Hopkins.**

# Moderator's Introduction

*Previously speakers have provided us with a great deal of background information on the world and the Canadian situations in fishing vessel construction. This morning we shall consider some of the factors governing alternative materials which are available for use in the construction of fishing vessels. Eleven speakers are about to address us on the prime consideration in our deliberations, the material itself. They will discuss steel, wood, plywood, laminated wood, aluminum, concrete, cellular plastics, foam sandwich construction, balsa cored reinforced plastics and polyester resins.*

# Steel Trends Related to Fishing Vessels

Mr. Hopkins

by

W. A. Hopkins
Supervisor, Field Sales Engineering,
The Steel Company of Canada, Limited,
Hamilton, Ont.

**ABSTRACT**

*This paper explores the present and possible use of steel in fishing vessels under three headings–Lloyd's Specifications, Choosing Steel Grades, and Design. Under the first, Lloyd's Register of Shipbuilding specifications are reviewed from a steel producer's point of view. Steel grades are discussed, and interpretation of the specifications is amplified. Under the second, the author points out that recently the steel industry has been telling many end users: "You specify the function; we'll meet your requirements".*

*The paper explains that the steel and shipbuilding industries could be similarly allied when it comes to specifying grades of steel. The newer high strength grades and their uses are also presented. Under the third heading, the conventional design approach of the civil engineer is applied to design problems, particularly those which fall outside Lloyd's requirements, such as deck houses and masts. Cost saving and weight saving aspects are emphasized.*

The subject of my talk is "Steel Trends Related to Fishing Vessels". I would have liked to confine myself exclusively to the design areas in fishing vessels, which is of course your major interest, but I regret that I have to admit to a limited contact with this field of endeavour.

I will, however, review the specifications pertaining to the shipping industry, along with the steelmaker's approach to achieve the proper product for this end use. I will also develop some areas of interest in the use of these steels and others which could be used in fishing vessels. Being a civil engineer rather than a naval architect, I would like to discuss some of the structural aspects from a conventional civil engineering point of view.

Before I review the Lloyd's specifications, I would first like to review some of the tests which are required to be performed by the producing mill:

- tensile
- impacts
- bend tests
- chemistry

I would now like to review the main areas of the Lloyd's specifications and the characteristics of each. I have chosen Lloyd's rather than the American Bureau of Shipping because I feel you are more familiar with the former and if you understand one, it is relatively easy to understand the other.

The minimum specification in this group and the material used when high stress and brittle fracture are not significant factors is Lloyd's Grade A. The Grade A material has few steelmaking restrictions. These are:

Phosphorus .05% max.

Sulphur .05% max.

This requirement is continued throughout all Lloyd's grades.

The only other chemistry restriction in Grade A material is for over ½" in thickness, in which case the manganese content must be a minimum 2.5 times carbon.

The tensile requirements for all grades other than those noted under high tensile are the same; they are:

58-72,000 p.s.i.

or in long tons/sq. in.: 26 to 32

Elongation—22% minimum.

For comparative purposes, I will give you an approximation of the Lloyd's grades throughout the discussion. Prices vary with size, etc; therefore, I will give them to you on a relative basis using Lloyd's Grade A as a base of 100. Therefore, price index of Lloyd's Grade A is 100.

Lloyd's Grade B is very similar to the Grade A material. The chemistry restrictions have been increased mainly to ensure proper weldability. The new restrictions are:

Carbon .21% max.
Manganese .80% min.
—unless made

fully killed. Under this condition, the manganese may be reduced to .60% min.

Price index: 101

The grades now become more sophisticated. Suppliers for Grades C, D and E must all be specially approved by Lloyd's.

Grade C must be fully killed, thus enhancing its average impact properties, and must be normalized when the thickness is over 1-1/4". It also maintains the maximum $C + \frac{Mn}{6}$ of less than .40% to ensure good weldability.

Price index under 1-1/4": 113

Lloyd's Grade D increases the impact requirement by requiring a minimum guarantee. The requirement is:

35 ft. lbs. at 32°F

Frequency of testing is based on the thickest plate per heat per 44-ton lot. The material, however, can be made killed or semikilled. We make our Grade D killed as standard practice. The chemistry continues to be somewhat restrictive in order to maintain good weldability.

Price index: 117

The Grade E is the most restrictive of all the medium-strength grades. The chemistry becomes tighter and must be killed material. All plates must also be normalized. The impacts must be run on every plate and must meet 45 ft. lbs. at +14°F. Tensile and bend tests are required per heat/44-ton lot. A variation in thickness of over .20" requires additional tensile tests. All of these requirements are of course related to the material's functional requirements in the ship and are reflected in the price.

Price index: 162

The high tensile materials are becoming more popular and are suffixed by the letter "H". Presently, there are three grades within this group: AH, DH and EH.

Suppliers for these grades also require prequalification with Lloyd's.

For Lloyd's Grade AH, we at Stelco supply killed fine grain material for this product and control roll in order to meet the mechanical requirements. The material has a minimum yield of 50,000 p.s.i. and an ultimate between 70- and 85,000 p.s.i. The Charpy V-notch test must meet 20 ft. lbs. at +32°F. Frequency of testing requires one set of tests per 44-ton lot unless the thickness variation exceeds .20; if so, additional tests are required.

Price index: 145

The EH Grade requires normalizing. Our product has a yield point of 46,000 p.s.i. minimum and a tensile of 67-82,000 p.s.i. The impacts required are 49 ft. lbs. at +14°F. Both impacts and tensile tests must be performed on a per plate basis.

Price index: 173

The carbon equivalent of the high strength grades becomes important and is related to the welding materials and procedure.

The above has given a general description of the steel-making requirements of the Lloyd's grades.

It is interesting to note that the use of high strength steel is not new. The railways have been extensive users, and now design and fabricate cars from these steels without apprehension. I should point out, however, that the majority of the work is in thicknesses of 1/2" and under.

Bridges are constructed of steels with strength levels of 40- to 100,000 p.s.i. yield. The Concordia Bridge in Montreal has very similar material requirements and shop procedures to those used in shipbuilding. High strength steels have been used in critical marine applications which fall outside Lloyd's requirements. Some examples of this are hatch covers using a structural grade material with a minimum yield strength of 50,000 p.s.i., or the "Hercules" crane, which is active on the St. Lawrence Seaway.

To further investigate the use of high strength steel in the ship industry, the Steel Company of Canada commissioned a study to appraise the use of this material in a seaway laker. The study included the investigation of three areas:

1. The use of 50,000 p.s.i. yield steel in areas remote from the neutral axis including the deck plate, shear stake, bilge plate, bottom shell, tank top, and associated longitudinals.

In this study, full allowable thickness reduction was obtained together with the required section modulus. The estimated total weight saving was 6.0% for the complete hull, or 360 tons for a hull weight of 6,000 tons.

2. An extension of No. 1 to include the use of 50,000 p.s.i. yield steel in the side shell and secondary or transverse members, some of which contribute to the section modulus.

It was found that the full allowable thickness reduction could not be achieved in all elements and some elements had to be increased to maintain the required section modulus. However, all other elements were reduced in thickness by approximately 10%. The estimated total weight saving was 9% or 540 tons for the complete hull.

The first two studies involved the use of a steel grade already approved by Lloyd's. The studies had also indicated that there was little potential advantage in excess of the 50,000 p.s.i. yield material at the extreme fibres of the hull because of the fixed section modulus requirements.

It was therefore decided that consideration be given to the use of an extra high strength steel in the areas where a reduction in thickness would have the least effect on the section modules. We arbitrarily chose to use a 70,000 p.s.i. yield material.

In order to satisfy the section modulus requirements, the spar deck plate was again increased in thickness, but no changes were made from Study No. 1 in the keel and bottom plating.

This approach yielded an estimated 16% saving or 960 tons for the complete hull.

All three designs were submitted to Lloyd's and have received their approval.

Study No. 1 yielded the least weight saving at the lowest cost per pound of weight saved. The influence of the formula governing section modulus was reflected in studies No. 2 and No. 3 and the increased saving in the hull weight was only achieved at a higher cost per pound of weight saved.

Economic justification for the additional expenditure will depend on the type of service and number of trips anticipated during the life of the hull.

To provide a rough economic comparison for the three studies, I have assumed that the ship will accomplish 20 movements per season in ore service and 10 movements in wheat service. Over a 20-year period, this would yield increased revenue of $76/ton/season.

The report which was prepared by Gilmore, German & Milne covers the study in considerably more detail and is available upon request.

I would like to touch on three last items which I feel worthy of study to the ship designer. They stress the civil engineering approach to design and appear to indicate savings in a fishing vessel.

The first is the use of abrasion resistant plate on the decks and more significantly on the rear deck of the stern trawler. From what I have learned from owners, abrasion on the rear deck reduces the life of these deck plates. Many of the steel companies produce such plate, some in the quenched and tempered condition and some in the as-rolled condition similar to the Steel Company of Canada's Wearwell.

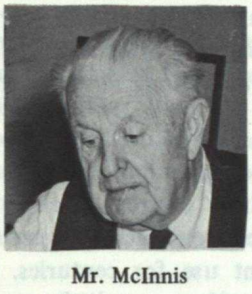
The second is the structural work on the stern of this trawler. From a conventional design approach, it appears that weight reductions could be achieved by the use of a 50,000 p.s.i. yield material rather than the Lloyd's Grade A presently in use.

I have an example of an unstayed foremast which was originally designed in Lloyd's Grade A and weighed 50,000 lbs. at an estimated cost of $17,500 fabricated. This mast was then redesigned using 50,000 p.s.i. material to weigh 24,295 lbs. and cost $9,200 – an obvious saving.

I would like to conclude by saying that we have reviewed a recently built stern trawler. This vessel is 155 ft. in length and has a maximum width of 32′10″. Its total displacement is 850 tons, with a capacity of 235 tons of fish and ice. The hull plates are Lloyd's Grade A and vary from 5/8 to 3/8″ in thickness. The deck house appears to be excessively rugged, using 1/4″ plate panels of 3 X 3′ with two 2 X 3″ angles as stiffeners. This appears to be one of the areas which is overdesigned based on a conventional approach. All in all, the craft uses steel advantageously, and as a representative of the steel industry, I do not see how great improvements can be made.

I would like to thank you for the opportunity of giving this paper and expressing some general thoughts on the basic steel product used in ships and describing some areas I feel warrant further investigation by the design people.

# Wood as a Fishing Vessel Construction Material



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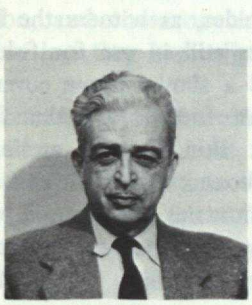

Mr. Chappelle

*Mr. McInnis is a graduate of Boston Technical High School and the Lowell Institute. He had two years' study of law and two years at art school, and took additional courses in internal combustion engines, airconditioning, and refrigeration. He spent 14 years at the George Lawley and Son Shipyard as a draftsman, Chief Engineer and Manager. The Yard was completely self-contained, employed up to 1,000 men, and built vessels in wood and steel, boilers, all types of engines and all needed fittings.*

*To date, Mr. McInnis has had 42 additional years as a practising professional naval architect and marine engineer.*

*He has been a member of the American Association of Naval Architects since 1927, is a Past National President of the Yacht Architects and Brokers Association, Inc., and a Past President of the New England Marine Trade Association. He is also a member of the Massachusetts Governor's Safe Boating Committee, and served for eight years as its Executive Chairman.*

*Mr. Chappelle began practising naval architecture as a draftsman in 1919 in the design office of William H. Hann and Charles D. Moller. After being associated with the firms of John Alden and Eldredge McInnis in Boston, he went into business by himself in 1935. Most of his design work was in small fishing craft and he designed his first dragger in 1936.*

*At the outbreak of World War II he was president of the Eastern Shore Industries operating two shipyards. In 1943 he was inducted into the Army as Captain and became Chief Production Officer of the First Army, having charge of the shipbuilding army contracts in New England. In this capacity Mr. Chappelle was in charge of inspection, management and to a certain extent engineering, and was Property Officer responsible for the vessels, etc.*

*In 1944, he reported to Washington and became Chief, Division of Marine Research and Development. In this capacity, he was responsible for setting up research contracts and for the guidance of the contracts and for the selection of projects to be developed for marine transportation in military use.*