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CANADIAN FISHERIES REPORTS NO. 8, DECEMBER 1966

proceedings

canadian atlantic herring fishery conference

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fredericton, new brunswick, may 5-7, 1966

SPONSORED BY THE FEDERAL-PROVINCIAL
ATLANTIC FISHERIES COMMITTEE

Secretariat: Industrial Development Service

Opening session of Conference.

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THE FEDERAL-PROVINCIAL ATLANTIC FISHERIES COMMITTEE

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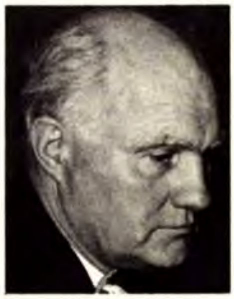

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Canadian Fisheries Reports is published under the authority of the Minister by the Department of Fisheries of Canada, as a means of providing for circulation of specialized information of interest to the fishing industry, from the primary enterprise 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. Those who wish to discuss articles herein are encouraged to do so, and space will be made available in future issues. Correspondence should be addressed to the DIRECTOR, INFORMATION AND CONSUMER SERVICE, DEPARTMENT OF FISHERIES, OTTAWA, CANADA. This issue is devoted exclusively to the proceedings of the Canadian Atlantic Herring Fishery Conference, held in Fredericton, N.B., May 5–7, 1966.

Published under Authority
of
HON. H. J. ROBICHAUD, M. P.
Minister of Fisheries

Welcome to New Brunswick

Hon. R. Ernest Richard, Minister of Fisheries of New Brunswick: "Mr. Chairman, Gentlemen: On behalf of the Department of Fisheries of New Brunswick and the Government of this province, I wish to extend to the chairman and members of the Federal-Provincial Atlantic Fisheries Committee, the sponsors of this conference, and their numerous guests, a most cordial welcome to the Picture Province of Canada, New Brunswick.

"For many among you who are making their first visit to New Brunswick and to its capital city of Fredericton and also those who have been here before, I hope that you will enjoy your short visit and that you will return soon. For your convenience we have distributed to all the delegates a booklet on the Province published by the New Brunswick Travel Bureau. If any among you did not receive his copy, please give your name to the secretariat and a copy will be delivered to you before your departure.

"We wish to apologize for having to scatter so many of you around the city and even outside the city limits. These were unforeseen circumstances caused mainly by a change in the original dates of the conference, and a much larger number of participants than everyone had expected in the first place. We had no idea that the lowly herring, which has been neglected for so long in eastern Canada, would create such an interest among scientists, technicians, fishermen, processors and government officials of both the Pacific and the Atlantic coasts of Canada and the U.S.A.

"Monsieur le président, messieurs: Au nom du ministère des Pêcheries du Nouveau-Brunswick, il me fait grandement plaisir de souhaiter à tous la plus cordiale bienvenue au Nouveau-Brunswick et en particulier dans notre capitale provinciale.

"Malgré les inconvénients créés par les nombreuses conventions qui se tiennent à Fredericton cette semaine, j'espère que vous jouirez de votre passage parmi nous et que vous nous reviendrez lorsque nous serons moins entassés.

"Il nous fait particulièrement plaisir d'être les hôtes à cette conférence puisque le Nouveau-Brunswick a joué le rôle de pionnier dans le domaine de la pêche au hareng et de la sardine au cours des années. Même aujourd'hui, notre province produit la moitié de tout le hareng capturé par les cinq provinces de l'Atlantique. Nos prises de 1965 ont accusé une augmentation de 32 millions de livres sur celles de l'année précédente et nous envisageons la possibilité de tripler les prises moyennes d'ici dix ans pour satisfaire à la demande croissante des nouvelles usines de farine et d'huile à hareng.

"Mr. Chairman: We are very proud of the fact that you and the other members of your committee have chosen Fredericton to hold this very important conference, the first of its kind in eastern Canada. We feel that by bringing together here many experts in the fields of herring catching,

processing and marketing from various parts of Canada, the U.S.A. and other countries of the world, you are paying a fitting tribute to the fishermen, processors and government of this province, who have worked closely together throughout the years to establish a flourishing herring and sardine industry.

"This industry has been the backbone of the commercial fisheries of New Brunswick, particularly in the Bay of Fundy where small herring or sardines have been caught successfully for years with weirs. Some 30 years ago, the purse seine method was introduced in this area and we are now boasting a highly efficient fleet of some 27 purse seiners contributing over half of the total landings.

"We produce 50 per cent of all the herring landed annually in the five Atlantic provinces and with the addition of larger vessels of the trawler-seiner type at the rate of five units per year, we expect to triple our present catches of herring during the next ten years to reach the amount of 325 thousand tons per year.

"In view of the enormous quantities of herring which are known to exist in the Bay of Fundy and in the Gulf of St. Lawrence, we do not foresee any serious problem in meeting this objective. We are pleased to learn that other provinces are likewise planning long-term development programs aimed at a fuller and a better utilization of this great resource.

"We are putting great faith in the role to be played by the Federal-Provincial Atlantic Fisheries Committee in co-ordinating the efforts of both governments and industry and in meeting the objectives of this conference, which are to assess the potential of the Canadian Atlantic herring fishery and to encourage the orderly development of this sector of the east coast fishing industry.

"I wish you all a pleasant stay in our fair city and a very successful conference."

Speakers at first session of Conference.

Chairman's Remarks

Dr. A.W.H. Needler: "It is less than three months ago that many of you attended another conference called by the Federal-Provincial Atlantic Fisheries Committee–the committee which brings together the fisheries deputy ministers of the five Atlantic Coast Provinces and of the Federal Government. The conference on Atlantic Offshore Fishing Vessels, held in Montreal in February, brought together fishermen, fishing companies, marine architects, scientists and administrators. It was a successful conference characterized by large attendance, intense interest, good papers, frank discussion and, I am sure, the production and dissemination of many ideas which will benefit our fishing industry.

"Why did the Federal-Provincial Committee decide to hold another conference so soon and why on herring? The reasons are the ferment which is evident in the herring fishery of the Atlantic coast, the growing interest on the part of the fishing industry in making fuller use of the great herring stocks at our doors, the expansion already initiated and the obvious need for better knowledge of the resource and of how to exploit it to the best advantage of our people.

"Fishing is not only one of man's oldest sources of livelihood, it is a long established industry and the herring fishery of Europe is one of the oldest and most important. More than two centuries ago the dominance of the North Sea and neighboring waters by a large aggressive Dutch fleet of herring drift-netters led the British Government of the day to subsidize its own herring fishery to enable it to compete. From those and, indeed, much earlier days herring have been important in the European diet, both because they are good nutritious food and because they can be prepared in so many delicious forms. With the advent a few decades ago of trawling and purse seining and of the reduction industry, the European herring fishery has grown in scope and intensity. We would like to have such a herring industry here.

"I do not wish to imply that Canada does not have important fisheries based on herring. The Pacific coast purse-seine fishery of herring for reduction is intensive, efficient and catches up to a quarter of a million tons in a year; the sardine canning industry of this province has been based for decades on a large catch of young herring and its importance is well known. There are other facets of the industry which are not inconsiderable. But it is clear that there is room for expansion and diversification in our herring fisheries. Most Canadian Atlantic herring stocks show by their age composition that they could support much more intense exploitation.

"The stocks are there, demands for herring products are increasing, and industry is already extending its efforts. The purpose of this conference is to help lay the basis for sound development by bringing together knowledge and expert opinion on the resource itself, on fishing methods and on utilization. Later this morning our first session will look at our knowledge of the herring stocks; this afternoon our second session will consider fishing methods; tomorrow morning herring fishing vessels will be considered; tomorrow afternoon utilization of herring for various purposes. Finally on Saturday morning, we shall hear the fishing industry's views on the development of the Canadian Atlantic herring fishery.

"The Federal-Provincial Atlantic Fisheries Committee is most pleased at the interest shown in this Conference—which again is even greater than we had hoped. We are pleased, too, to have been able to bring together eminent authorities from Europe, the United States and from Canada, including our Pacific Coast. We look forward to interesting papers and good discussion and to an exchange of ideas which will help us develop a much larger herring industry on a sound and profitable basis to the benefit of all concerned."

Canadian and foreign participants. Left to right: Alan Glanville, Ireland; Peter Boot, the Netherlands; Hon. H.J. Robichaud, Canada; Dr. J. Schärfe, Germany; Dr. Hans Baasch, Germany and Dr. A.W.H. Needler, Canada.

Session 1 May 5, 1966 – 9.15 a.m.

The Herring Resources of the Northwest Atlantic

Moderator

Brian Meagher,
Deputy Minister of Fisheries,
Nova Scotia.

The Canadian Atlantic Herring Fishery

by

S. N. Tibbo

Scientist in Charge, Pelagic Fish Investigations,

Fisheries Research Board of Canada, St. Andrews, N. B.

INTRODUCTION

The catch of herring *(Clupea harengus)* by Canadians on the Atlantic coast ranks second to cod in landed weight and fifth (after lobsters, cod, scallops and haddock) in landed value. In 1965 the herring catch amounted to 183,000 metric tons (404 million pounds) valued at 4.3 million dollars. In spite of the current relatively high landings, however, there seems to be little doubt that herring fisheries in the north-west Atlantic can be increased substantially.

Herring are fished on both sides of the North Atlantic. In Europe they occur from Gibraltar to Norway, Spitzbergen and the White Sea as well as in the waters of Iceland and Greenland. In America, they occur from northern Labrador to Block Island – occasionally to Cape Hatteras in winter. Their economic importance stems from their great abundance. It is characteristic of the herring tribe to occur in vast numbers as is indicated by the fact that nearly half (46%) of world landings of marine fish in 1964 consisted of herring and allied species (18.6 x 10^6 metric tons).

HISTORICAL BACKGROUND

The early history of Canadian herring fisheries is not well documented, but some of it can be inferred from the history of other fisheries that used herring for bait. The early colonists undoubtedly used some herring for food, but probably used far greater quantities in the catching of cod for the salt cod export trade. United States vessels fished for herring in Canadian waters towards the end of the eighteenth century and in the early part of the nineteenth century bought herring in the Gulf of St. Lawrence and transported them to Maine and Massachusetts for bait and food. Late in the century, however, both the bait and food markets in the United States declined drastically.

Fishing for herring in the Bay of Fundy goes back beyond the earliest visits of European fishermen about 450 years ago. The Indians had simple forms of weirs and also caught herring by "torching." The weir fishery as we know it to-day started about 1820 but prior to and during the devolopment of the weir fishery large quantities of herring were taken by gill nets. Spawning grounds at the southern end of Grand Manan were well known and were fished heavily. Perley (1852) refers to 120 vessels being congregated at Southern Head, Grand Manan, and engaged in gill-netting of spawning herring which were either salted or smoked.

After their introduction the number of weirs in the Bay of Fundy increased steadily. In 1849 there were 55 weirs at Grand Manan, Campobello and Deer Island. By 1880 there were 142 and in 1933 there were 293 weirs. In recent years from 300 to 400 weirs (occasionally more) have been operated annually although the total number of weir sites exceeds 1000.

Various authors including Perley (1852), Bensley (1901), Leim (1919), Battle (1931), McKenzie (1932), Tibbo (1951), Huntsman (1953), Leim and Tibbo (1954) Leim (1956), Scattergood and Tibbo (1959) and McKenzie and Tibbo (1960) have all given historical accounts of herring fisheries in Canada and reference to their writings will provide much interesting detail that cannot be included here. It is worth noting, however, that towards the end of the nineteenth century there was great alarm about the future of the herring fishery in the Bay of Fundy. The catch of large herring was declining rapidly; it was believed that this resulted from the large take of small herring in weirs. It was generally believed that the fishery for immature individuals would soon wipe out the stock completely. That this has not happened is evidenced by the fact that in the intervening 70 years the total take has increased about 7 times from less than 16,000 metric tons in the late 1890s to more than 115,000 tons in the mid 1960s.

From 1960 to 1964, annual landings of herring from the northwest Atlantic varied from 182,000 to 344,000 metric tons. On the average, 20% came from the Gulf of Maine (U.S.A.); 35% from Georges Bank (U.S.S.R.); 30% from the Bay of Fundy and outer coast of Nova Scotia and 15% from the Gulf of St. Lawrence and Newfoundland.

Canadian landings during recent years are shown in the accompanying tables and charts. The total catch has been remarkably consistent, although within areas there has been considerable variation. As an example, the catches in Newfoundland and Labrador have ranged from a low of 5,627 metric tons (1961) to a high of 74,300 metric tons (1945). The smallest total catch since 1940 was 87,712 metric tons (1961) and the largest 187,677 metric tons (1946).

Although there have been yearly fluctuations in the availability of herring in various areas, there has never been much concern about abundance. In general the problem has been one of disposal rather than catch and this is probably the main reason for the failure of herring fisheries on the Atlantic coast to reach their full potential. In addition, the competition from other species has been overpowering and it is easy to appreciate the reluctance of fishermen to land herring for less than one cent per pound when he can land a wide variety of groundfish species for from three to five times as much. Not only does the fisherman have to land three to five times the weight of herring, but he has to do three to five times more work for the same amount of money. If a comparison is made with the returns from the lobster fishery, the situation is much worse. Since in many areas the lobster and herring seasons coincide and since many fishermen fish for both species, the lack of substantial increase in herring catches is understandable.

UTILIZATION OF CATCHES

The Canadian herring catch has always been and is still used chiefly for food, although industrial uses are becoming increasingly important. In 1946, 49% of the catch was marked as fresh and frozen; 39% was pickled and smoked, 11% was canned and 1% used for meal and oil. By 1954, the food uses had declined somewhat and 14% of the catch was used for meal and oil. There was virtually no change in the utilization of herring until 1965 when new reduction plants were built, and in that year 27% of the total catch was used for industrial purposes.

In southern New Brunswick where the fishery is chiefly for immature herring, most of the catch is canned as sardines with the remainder used for lobster bait or exported fresh. In southwest Nova Scotia and along the Atlantic coast, most of the catch has, until recently, been used for a variety of smoked and pickled products. In the southern Gulf of St. Lawrence smoked bloaters, canned round herring and kippered snacks are the important food products. There has been a change in utilization at Magdalen Islands where a reduction plant was established in 1953 and most of the catch there is now sold for reduction to meal and oil. In Chaleur Bay about 35% of the catch is used for food and the remainder as bait and fertilizer. In Newfoundland the herring industry reached a peak in 1946 when 57% of all exported fish and fishery products consisted of herring. The catch has declined drastically since that time, but most of the catch still goes to food processors. The remainder is used for bait in the lobster and cod fisheries and for reduction purposes.

THE NATURAL HISTORY OF HERRING

It is essential for considerations in the management of a fishery (whether this be conservation or development) to have as background a general knowledge of the live history of the species involved. It should be stressed, however, that each of the many populations of herring along the Canadian Atlantic coast has a life history that is peculiar to that population alone and while the following descriptions apply generally, each population must eventually be considered separately.

SPAWNING

The herring is the only member of the family *Clupeidae* that deliberately lays its eggs on the sea-bed, and for this purpose selects areas where the bottom is firm. The eggs sink to the bottom and stick in layers or clumps to sand or clay, seaweeds, stones or other objects on which they chance to settle. The eggs are 1.0 to 1.4 millimetres in diameter and each female deposits from 20,000 to more than 100,000 eggs. Fertilization probably takes place before the eggs reach the sea-bed, although this process is not fully understood.

On the Atlantic coast herring spawnings occur in spring, summer or autumn, depending on the locality and the herring stock that occupies it. Spring spawnings tend to be in shallow (203fm) water close to the shore, whereas summer and autumn spawnings are in deeper water to 30 fm and occasionally to 100 fm. Incubation is governed by temperature and hatching takes place after 40 days at 38°F or 11 days at 50°F. The average incubation period for the Bay of Fundy-Gulf of Maine area is 10-15 days.

Egg mortality is undoubtedly not as heavy for Atlantic herring as it is for its Pacific relative whose eggs are deposited in the intertidal zone and exposed to wave action and to air and to predation by gulls and ducks. Heavy storms sometimes destroy vast spawnings by washing the eggs ashore and there is some mortality caused by trawlers and other fishermen. Apart from this the major source of egg mortality is predation by fishes that are attracted to the spawning beds. There is very little factual information on egg predation—cod, pollock and haddock all eat large numbers of herring eggs, but the proportion of the total number destroyed in this way is unknown. In one study area where winter flounders were the major predator, the resultant egg mortality was calculated to be 7%.

LARVAL LIFE AND METAMORPHOSIS

At hatching the young herring are about five or six mm long. They are very feeble swimmers and consequently are at the mercy of predators and the environment. It is undoubtedly at this stage that most of the natural mortality takes place. Predation by many fishes including herring is heavy and mortalities are caused by starvation and by unsuitable temperatures and salinities. For fall-spawned herring the larval period usually extends well into the following year and with such a lenghty larval life the chances for survival are small. Metamorphosis occurs at from 40 to 50 mm (2½ in).

GROWTH

Herring hatched in the autumn are 17-20 mm long by December. There is little growth during the winter, but by the end of their first full year of life they are about 10 cm (four inches) long. They are about seven inches at the end of their second year and 10 inches at the end of their third. They spawn first at 10-10½ inches, but mostly at 12 or 13 inches. In other words, a few spawn at three but most at four years or more. They may live for 20 years or more and reach a length of 17 inches.

FACTORS CONTROLLING ABUNDANCE

Food is, of course, essential for survival and for the larval herring this must not only be in adequate supply, but must be small enough to be caught and eaten. Adult herring are plankton feeders, occasionally eating larval fishes including herring.

The enemies of herring include cod, pollock, haddock, silver hake, mackerel, tuna, salmon, sharks, squid, whales and seals. Man himself is one of the chief predators. Disease organisms also take their toll. In the Gulf of St. Lawrence, a fungus disease in the 1950s probably destroyed 50% or more of the herring in the area.

HABITS

In general the young herring are found inshore and the immature fat herring offshore. They are usually near the surface at night but descend to considerable depths during daylight. They form large schools particularly as young herring and as spawning adults. They are sensitive to temperature and salinity as well as light. They probably move into deep water in winter and sometimes migrate long distances (500 miles or more). After spawning adult herring leave the inshore waters and move offshore in scattered schools to feed. In the autumn the spring-spawning stocks concentrate in larger schools and move inshore remaining there until after spawning in May and June. The autumn spawning stocks probably winter in offshore areas and start moving inshore aboud mid-summer, remaining there until after spawning from late August to the end of October. The timing of the pre-spawning migration varies with populations and from year to year and it is on these migrations that the fisheries for adults depend.

TABLE I. Canadian Herring Landings 1940-1965 (Metric Tons)

Year	Bay of Fundy and Yarmouth	Atlantic Coast	Southern Gulf	Northern Gulf	Nfld. and Lab.	Total
1940	33,075	8,137	22,254	13,834	18,414	95,714
1941	50,073	8,342	19,441	9,608	14,956	102,420
1942	43,753	10,123	20,200	12,391	23,623	110,090
1943	49,913	11,340	25,408	11,494	32,154	130,309
1944	49,378	16,048	22,011	9,812	38,591	135,840
1945	42,864	16,744	19,480	9,812	60,205	149,105
1946	60,347	17,389	26,656	8,985	74,300	187,677
1947	56,750	16,037	29,497	6,310	46,106	154,700
1948	50,919	11,223	34,073	6,320	51,692	154,227
1949	36,361	14,781	26,595	6,510	27,553	111,800
1950	49,821	13,160	34,880	6,783	25,827	130,471
1951	43,324	7,992	37,615	5,485	27,056	121,472
1952	50,964	11,435	40,164	5,907	24,391	132,861
1953	32,996	11,965	32,541	7,473	17,091	102,066
1954	37,890	8,826	31,611	5,985	23,095	107,407
1955	19,325	13,988	39,722	5,096	13,082	91,213
1956	33,497	10,748	28,318	3,203	13,229	88,995
1957	47,602	13,563	26,580	3,197	9,960	100,902
1958	54,195	11,103	25,121	2,254	13,035	105,708
1959	70,417	6,116	21,956	2,895	6,987	108,371
1960	72,952	8,827	20,568	2,556	6,831	111,734
1961	51,380	10,515	15,264	4,926	5,627	87,712
1962	62,098	8,461	30,963	3,266	7,024	111,812
1963	58,147	9,634	35,384	3,415	8,046	114,626
1964	83,905	10,094	37,026	2,383	8,538	141,946
1965	115,831	11,829	39,944	3,112	12,525	183,241

RECRUITMENT TO THE FISHERY

Recruitment to the commercial fishery varies with areas. The sardine fishery takes large numbers of herring that have just completed their first year of life. In other areas recruitment is synonymous with recruitment to adult (spawning) stocks since fisheries in areas other than the Bay of Fundy are dependent on spawning concentrations.

RECOGNITION OF HERRING POPULATIONS

There are at least 11 major populations of herring on the Canadian Atlantic coast and their characteristics are shown in the accompanying chart. These stocks are believed to be relatively discrete although there may be some mixing of adjacent ones. In one area (Chaleur Bay) there is a substantial amount of mixing between the spring and autumn spawning stocks.

PROSPECTS FOR DEVELOPMENT

In general the Canadian herring catch is controlled by both economic and biological factors. On the economic side, landings reflect the size of the demand. They are dependent on prices paid to fishermen and prices fluctuate with the domestic and imported supplies that are available to distributors. Canadians tend to fish for dollars rather than food and hence efforts are directed to species that are likely to afford maximum profit. Biologically, the catch is affected by variations in the abundance and availability of herring. Poor survival of young is reflected in a small year-class of sardines. Disease can and does decrease abundance and lower quality. Hydrographic conditions have enormous influence on availability and especially is this so for stationary types of catching equipment.

Our knowledge of the present herring fisheries on the Canadian Atlantic coast indicates that most of the catch is made in inshore waters where they are seasonally abundant. While the herring are living in the open sea, they are relatively free from exploitation. The possibility of an offshore herring fishery has been considered for a long time, but except for recent efforts by European nations on Georges Bank, very little has been done about it. There seems to be no doubt whatsoever that Canadian catches can be increased substantially. Even with major increases in the last two years, present landings are still below the landings in the mid-1940s. What the ultimate annual harvest might be is unpredictable, but the best management practice at present would appear to be encouragement of industry to further develop the harvesting of this resource.

TABLE II. Herring Landings – Bay of Fundy 1956-1965 (Metric Tons)

	Dist.	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Yarmouth	–33	1,628	1,638	7,496	1,346	891	871	419	1,521	1,387	12,667
	–34	3,619	3,030	1,390	2,019	2,632	2,810	3,169	3,851	2,582	3,353
Digby	–36	2,270	747	948	2,126	2,200	6,002	14,807	4,041	3,015	5,948
	–37	3,203	7,595	22,264	14,332	16,257	21,482	9,027	7,092	26,458	28,757
	–38	1,085	706	3,099	2,653	1,075	1,296	156	55	286	1,666
Annap	–39	102	72	55	123	269	212	68	56	226	310
Kings	–40	55	81	88	50	58	88	42	74	110	78
Saint John	–48										
	–49	888	2,306	2,695	3,536	2,406	5,774	1,717	31	1,882	1,308
Gd. Manan	–50	5,763	9,287	6,032	26,375	25,307	3,565	11,417	14,053	12,210	14,056
W. Isles	–51	4,877	5,225	1,076	4,663	7,446	2,078	12,427	5,070	8,372	9,621
W. Charlotte ..	–52	2,611	11,974	4,551	2,124	2,933	542	2,043	846	541	3,877
E. Charlotte ..	–53	7,394	4,940	4,500	11,064	11,471	6,655	6,798	21,451	26,827	34,184
Totals		33,495	47,601	54,194	70,411	72,945	51,375	62,090	58,141	83,896	115,825

See Accompanying Figures on following Pages.

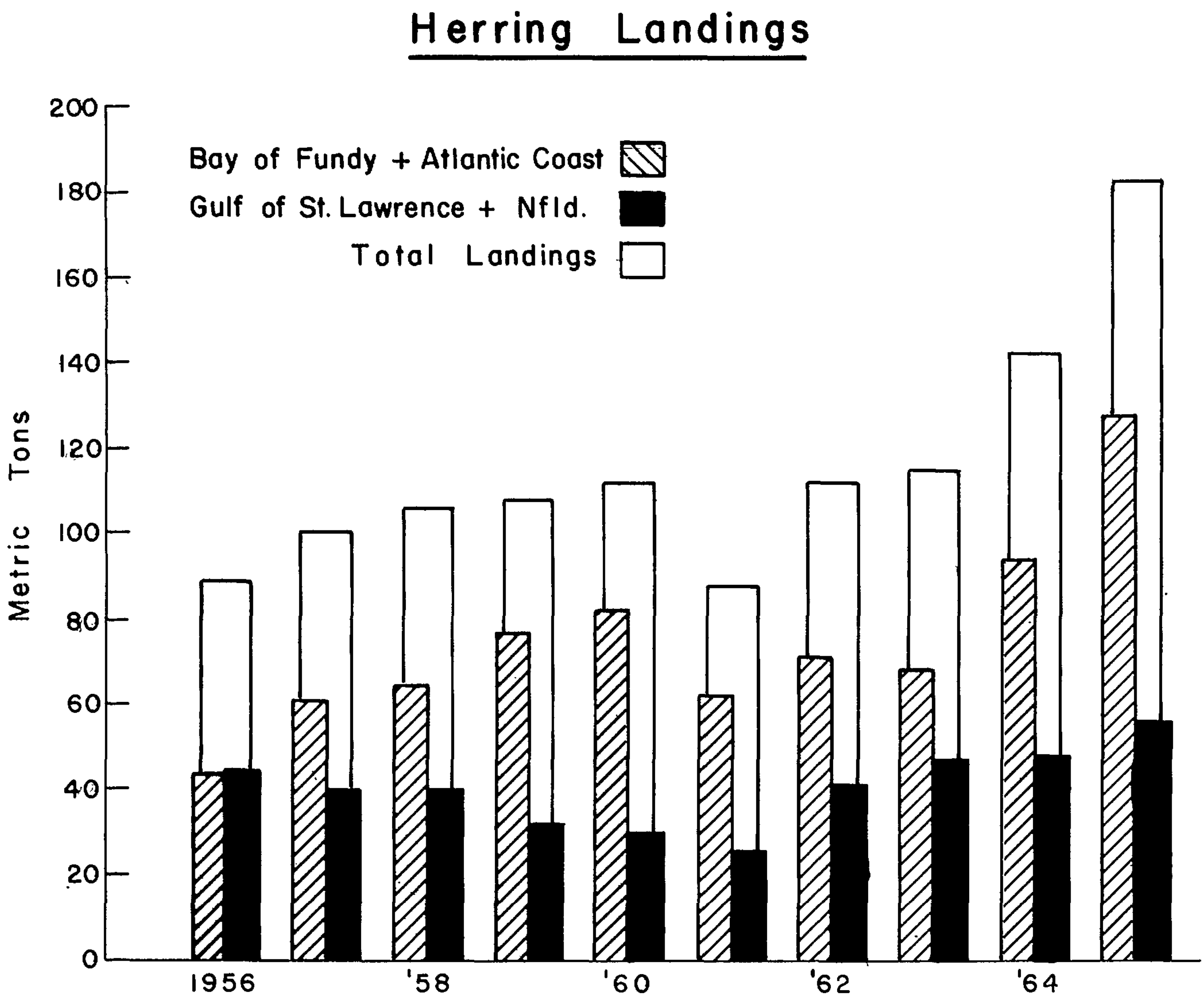


Fig. 1. Canadian herring landings all areas 1956–1965.

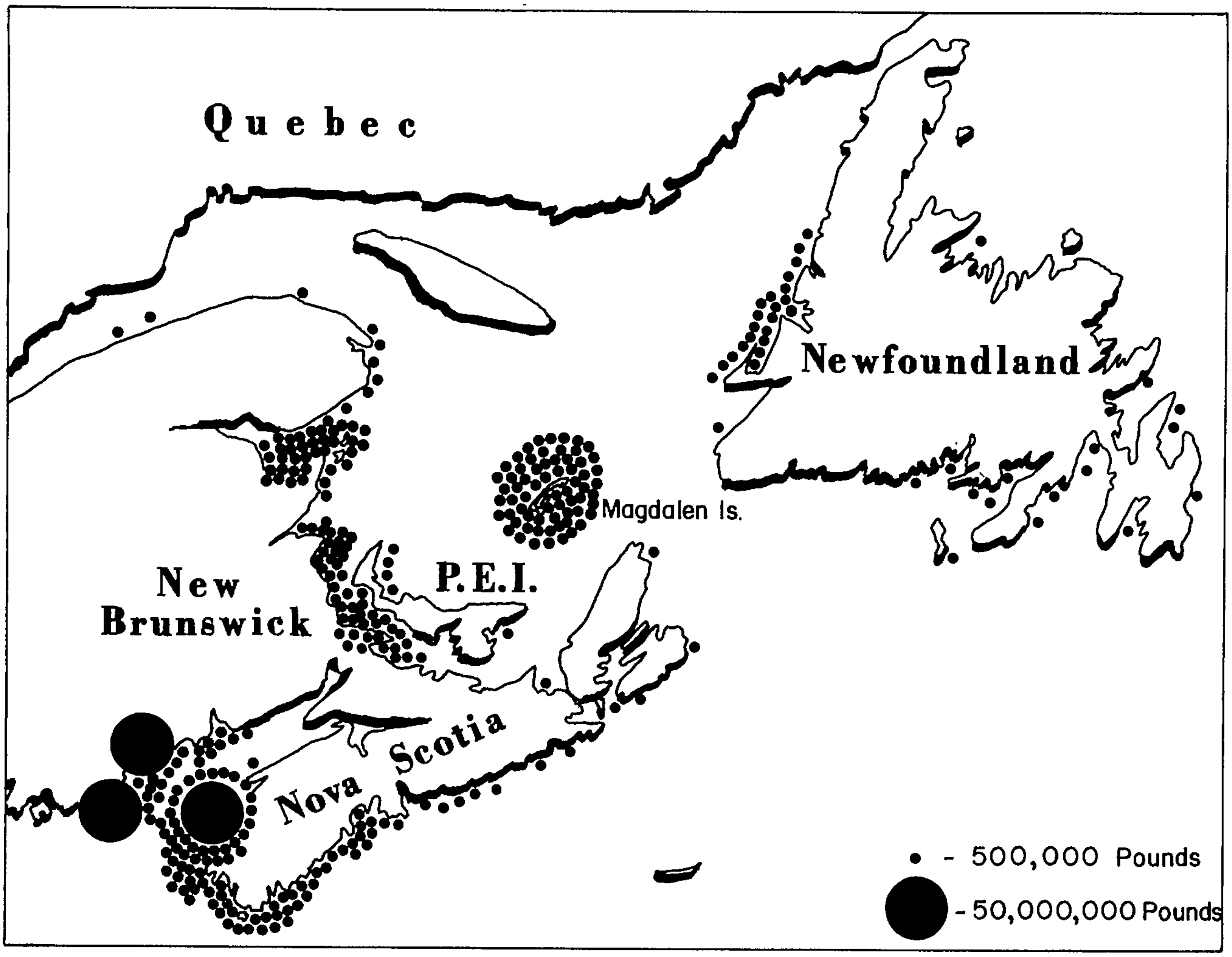


Fig. 2. Distribution of Canadian herring catches 1964.

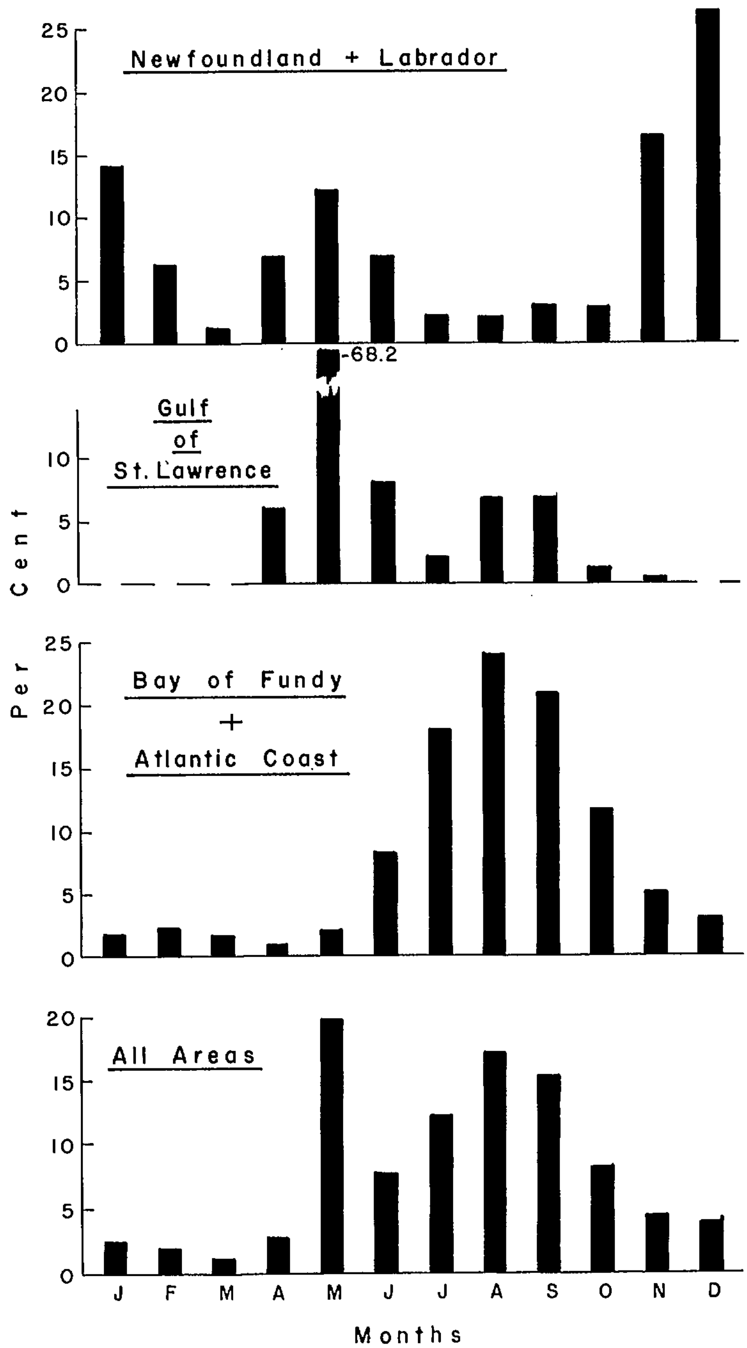


Fig. 3. Percentage monthly herring landings averages for 1956–1965.

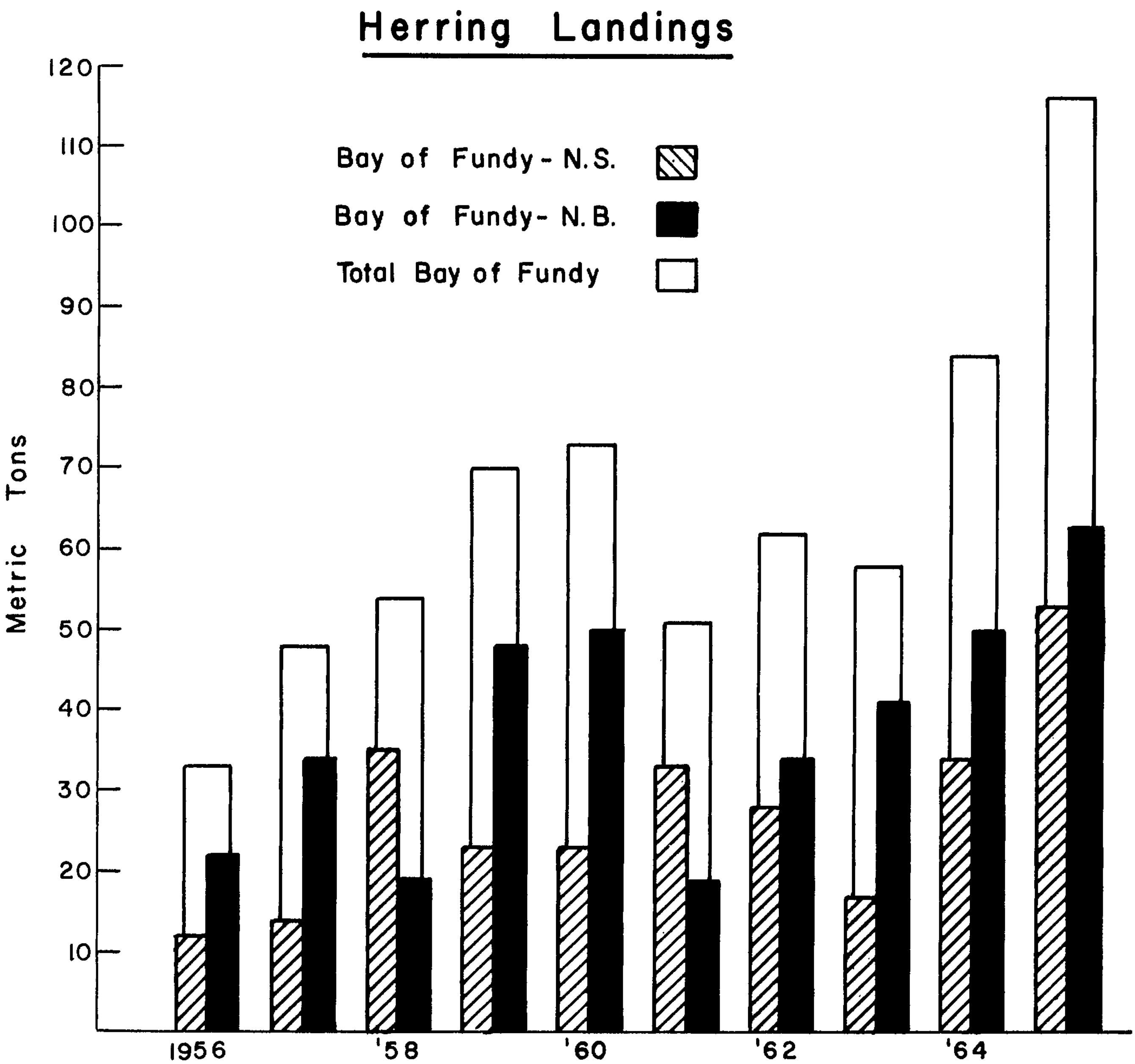


Fig. 4. Canadian herring landings in the Bay of Fundy 1956–1965

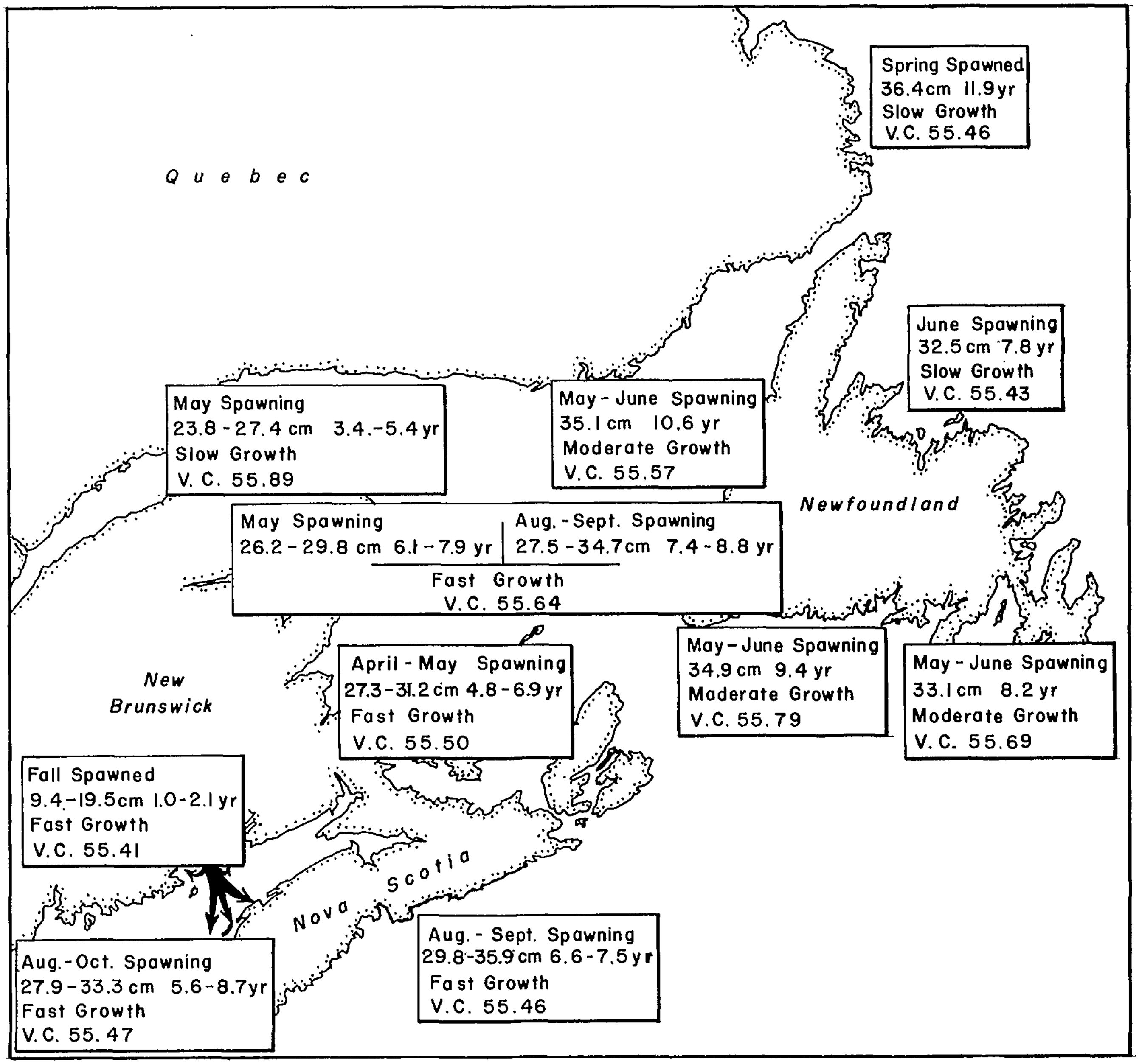


Fig. 5. Biological characteristics of herring populations.

U.S. Herring Fishery and Research

by
Bernard E. Skud, Laboratory Director
U.S. Bureau of Commercial Fisheries
Biological Laboratory
Boothbay Harbor, Maine

I was very pleased to receive an invitation to attend this meeting, and welcome the opportunity to talk about U.S. herring fisheries. It also provides the opportunity of acknowledging the co-operation we have received from the Canadian scientists and industry members. My first contact with your herring biologists was at Nanaimo while I was working on Alaskan herring, and 10 years ago I began an association with Canadian biologists on the Atlantic coast through the International Passamaquoddy Project, when our staff at Boothbay Harbor worked with the scientists from St. Andrews. Our collaborations have been productive and rewarding and will continue to be so.

The major use of Atlantic herring in the United States is for sardine canning and the annual catch for this purpose has averaged 100 million pounds in the past five years. The 1950 catch, the highest ever, totalled 200 million pounds. Prior to 1960 some two million cases of sardines were packed each year. Since 1960 production has generally been geared for 1.5 million cases. The catch of herring for other uses—such as meal—has fluctuated widely and seldom exceeds 20 million pounds.

For purposes of comparison, I will mention at this time the catch of the Russian fishing fleet on Georges Bank. This fishery started in 1961 at the level of 150 million pounds. The catch doubled in 1962, reaching 300 million pounds, but in 1963 dropped to 200 million pounds. In 1964, the catch was up to 250 million pounds; the 1965 figures will be available later this month when we meet with the Russian scientists at the annual meeting of the International Commission for the Northwest Atlantic Fisheries (ICNAF). From our observations on the fishing grounds, we expect their herring catch to drop to a level of about 150 million pounds. The Russian fleet has decreased its effort on herring and increased its effort on whiting and other species. This change in effort was anticipated by the Russians a year ago and is apparently related to a lower demand for herring in the U.S.S.R. I'll have more to say about the Georges Bank herring populations in my discussion of our research in the United States.

Herring have been part of the research program at Boothbay Harbor for almost 20 years, but the intensive study now in progress was not initiated until 1962. In the early years, there were only two biologists and their research was concentrated on diseases of herring and the collection of catch statistics. In our present program, there are 10 biologists and 10 technicians. Our research include all stages of the life history of herring and is divided into three components—(1) the pre-recruit program, which includes all phases from hatching through larval development and up to the time the fish complete their first year of life; (2) the sardine program, which concentrates on the inshore fish from 1 to 3 years old used for canning sardines; (3) the adult herring program, which studies the coastal spawners as well as the offshore populations on Georges Bank. These spawning herring are generally 4 years and older.

The major goal of our studies on immature herring is to predict the supply. Our emphasis on the offshore adults is to study the effects of the Russian fishery on the Georges Bank stocks and to determine the relationship, if any, between the inshore and offshore populations. To attain these and other goals, we stress the study of basic biological parameters. Only through knowledge of the basic biology of the herring can we answer many of the problems of the fishermen and canning operators.

Perhaps the bes. .esumé of our research can be provided by listing our various research projects and then, as time permits, I will describe some of the objectives and results that have been attained so far. These major projects study: larval abundance and distribution, plankton, age and growth, catch statistics and fishing effort, herring behavior, spawning populations, and stock identity.

The studies of larval herring are of particular importance as relatively little is known about this life history stage which is so critical in the determination of future supplies. Four years ago, we could only follow these 1/2-inch herring for two or three months after they were spawned in the fall. Now, along the Maine coast, we can locate larvae at any time during their 9-month development and with special sampling gear, we are making estimates of their abundance in the rivers and estuaries. These larvae have been found in low salinity waters—as far inland as 15 miles from the open coastal waters—and to trace these movements, we are studying the oceanographic conditions along the entire coast from Cape Ann, Mass., to Grand Manan.

The plankton project is also concerned with the movements of larvae. These small food organisms can serve as indicators of hydrographic conditions, particularly water movements. But our prime interest in plankton is as food for herring. We make eight coastal cruises a year to determine the abundance and distribution of these food organisms and their relation to the distribution of herring. We have found that herring are selective feeders at various stages of their life and do not feed on just any type of plankter. This aspect has a direct concern in our sardine fishery, for when the fish are feedy and cannot be held for clearing, they are not suitable for canning. This situation is particularly important in early spring when the barnacle larvae occur in great abundance, so we monitor the occurrence of these barnacles for the industry.

Our projects on sardine age and growth and on the catch data are directed at understanding and predicting the fluctuations of year class strength. Between 70-90% of the herring taken in the sardine fishery each year are 2-year-olds. Because both larval and 1-year-old (brit) herring are present along the coast, we are designing sampling schemes to estimate their abundance, as a means of predicting the sardine catch. Growth of immature herring appears to be density dependent and data from past years suggest that this too may be useful in prediction. For example, the 1960 year class was an abundant one and the fish were small, while the 1959 year class was not abundant and the fish were large. We also follow stock-recruitment curves (parent-progeny lines) and catch/effort data to gain knowledge of year class strength.

An understanding of herring movements along the coast and an ability to predict these movements is an important need of the sardine industry. With this in mind, investigations of herring behavior have been oriented towards discovering the responses of juveniles to environmental variables. Temperature and salinity preferences have been determined and the effect of previous adaptation evaluated, so that it is now possible to state, in theory, whether the herring would move away from or towards water of certain characteristics. Fish adapted to relatively cold waters show preferences for warmer water, whereas fish adapted to relatively warm water prefer colder water. Recent experiments have also shown that herring tend to avoid water supersaturated with air. This condition has been observed in the Gulf of Maine during the early summer months, and its avoidance by herring may influence their coastal movements and affect their catchability.

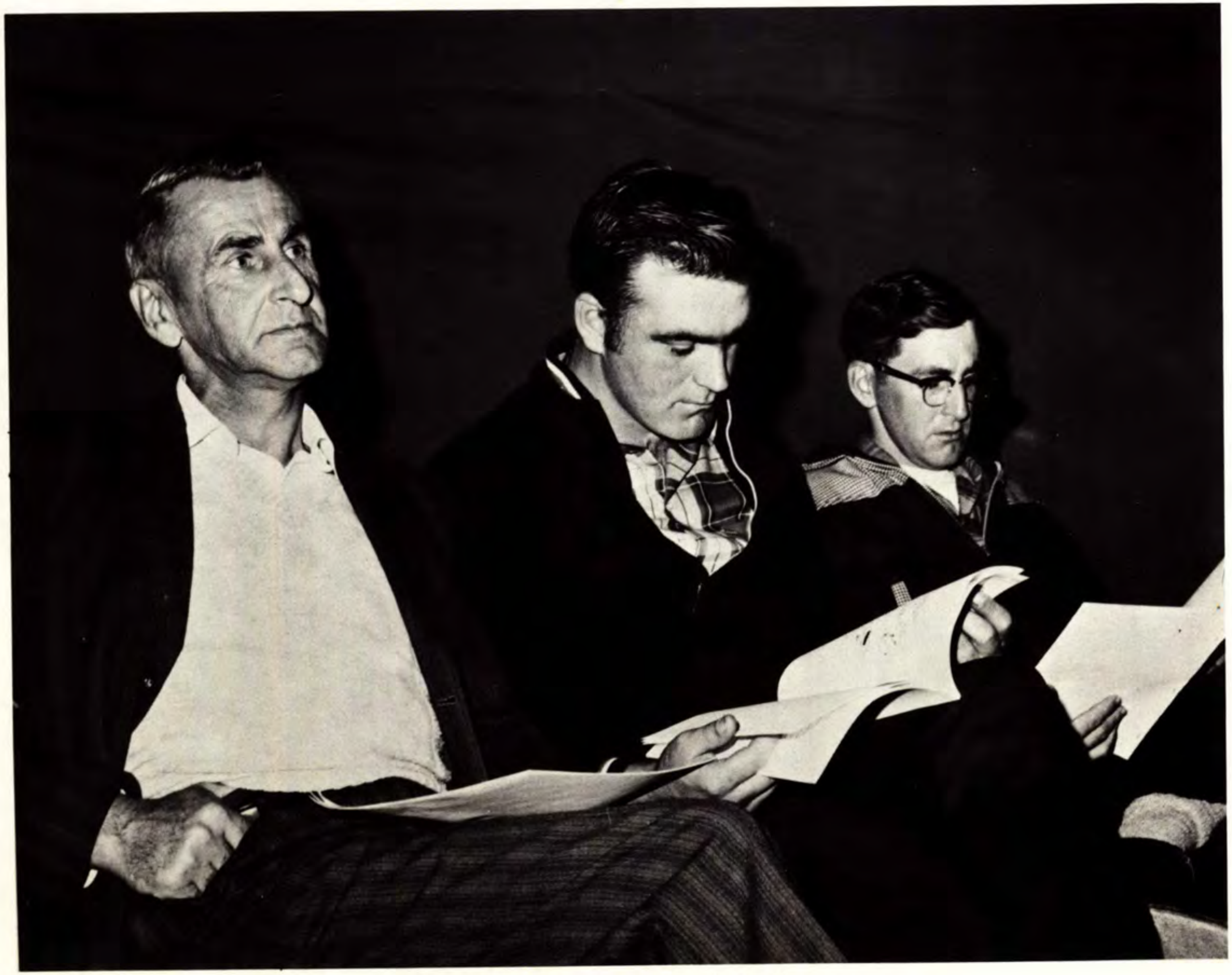
The adult herring program has documented the age structure, spawning time and growth rates of adult herring from Georges Bank and the Gulf of Maine. Results of research cruises enable us to locate concentrations of herring on the Banks at all seasons of the year. Analysis of these data allows us to follow the progression of year classes in the fishery and to estimate the contribution of each year class in subsequent years. Significant differences have been found in spawning time, year class, and length frequency distribution between Georges Bank and inshore stocks, suggesting that the offshore populations are discrete.

Other studies are also designed to determine the identity of the North Atlantic herring stocks. Characteristics of the blood are studied by biochemical and serological techniques. To date, these studies indicate that Georges Bank fish do not significantly contribute to the inshore fishery. Anatomical differences (meristic counts) have also been measured and the data have been transferred to IBM cards for computer analysis. Certain parasites also are indicative of population discreteness, and these organisms are checked regularly in our sampling scheme.

Sampling constitutes a major segment of our research, and the co-operation of the Maine Sardine Industry has been particularly helpful. Other sampling is accomplished through research cruises. One area is sampled on a bi-weekly basis; the Maine coast is sampled on a seasonal basis with two cruises per season; and the Georges Bank area is sampled with five cruises annually.

We are encouraged by the results of our research, and we are gaining knowledge of use to industry. We are also encouraged by the interest and support of our industry—the same interest and support displayed by the Canadian industry at this meeting. Continued co-operation and committee meetings of this type will, I'm certain, pay dividends to all concerned.

Left to right: Dr. Leonce Chenard, Deputy Minister of Fisheries of New Brunswick; Dr. A.W.H. Needler, Deputy Minister of Fisheries of Canada; Hon. R. Ernest Richard, New Brunswick Minister of Fisheries, and L.S. Bradbury, Director, Industrial Development Service, Department of Fisheries of Canada, General Secretary of the Conference.



Three fishermen participants in the Conference.

Canadian Research on the Biology of the Bay of Fundy - Gulf of Maine Herring Populations

by

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St. Andrews, N.B.

INTRODUCTION

The ultimate objectives of the present herring investigation are to acquire a sound basis for forecasting prospects of the Canadian Atlantic herring fisheries and to formulate a management policy. In order to satisfy these objectives, we have concentrated our efforts on the investigation of the main features of the biological and ecological characteristics of the exploited populations. This paper attempts to summarize the results of some of this research with special reference to the major exploited herring populations of the Bay of Fundy-Gulf of Maine area.

SPAWNING AND LARVAL SURVEYS

Location of spawning grounds

Canada and the U.S. have a common interest in a fishery for young herring found in vast numbers in the inshore waters of Charlotte County, N.B., and along the Maine coast. In recent years there has been no evidence of major spawnings within the principal coastal "sardine" areas. Where then are the breeding grounds for the fish that populate the region? What are the survival and growth rates of the early developmental stages and how are the larvae dispersed?

In determining the spawning grounds in the Gulf of Maine and the Bay of Fundy, larvae from four to nine mm in total length were considered newly hatched and not far removed from the spawning area (Tibbo, *et al.*, 1958, 1959; Tibbo and Legaré, 1960). Fig. 1 illustrates the distribution of larvae during September to December of one year. In a few instances, chiefly in southwest Nova Scotia, direct evidence of spawning is available from collections of eggs.

The largest spawning area in the Gulf of Maine is on the northern edge of Georges Bank (Fig. 2). This is a shoal area varying in depth from 3½ to 50 fm and characterized by strong tidal currents and heavy mixing. The substrate varies from a granular boulder type to a fine sandy type.

In the Bay of Fundy, herring spawn from the Seal Island group northward along the Nova Scotia coast to Digby (Fig. 2). Another spawning area lies just north of Digby and could be an extension of the first area. Depths vary from three to 50 fm and temperatures are fairly uniform from top to bottom due to strong tidal mixing.

Other spawning areas are not very extensive, but may contribute to the stocks of herring in the region. There is evidence of small spawnings around Penobscot Bay, Stellwagen Bank, and Nantucket shoals (Fig. 2). Spawning occurs regularly in the waters south of Grand Manan, but not to the same extent as in southwestern Nova Scotia and on Georges Bank.

Spring spawning in the Gulf of Maine and the Bay of Fundy region is very light and very much less in importance than the heavy autumn spawning. The heavy period of autumn spawning occurs on Georges Bank and along southwestern Nova Scotia from August to October.

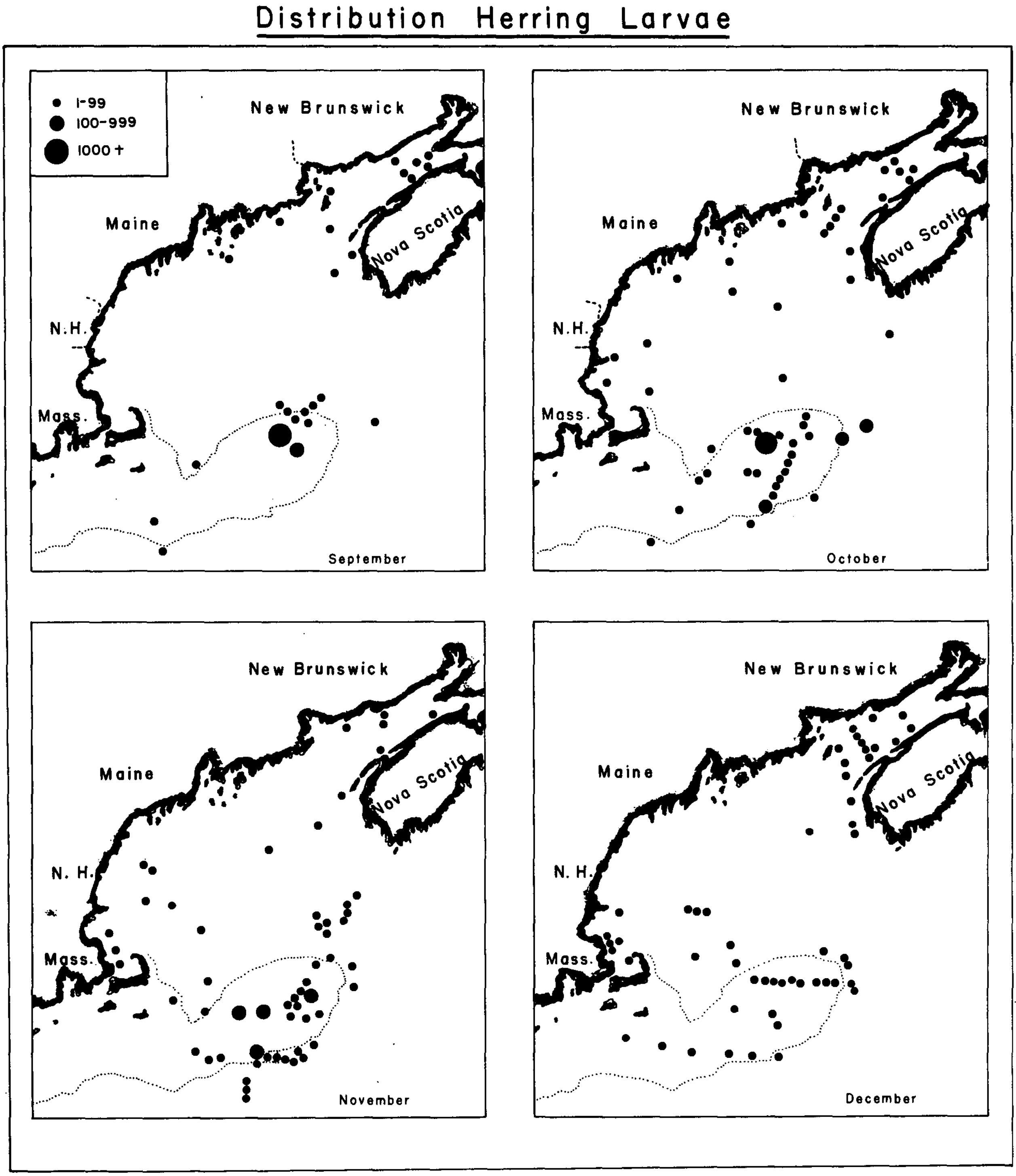

Fig. 1. Distribution of herring larvae in the Bay of Fundy-Gulf of Maine area from September to November 1956 and December 1957 (from Tibbo, *et al.*, 1958).

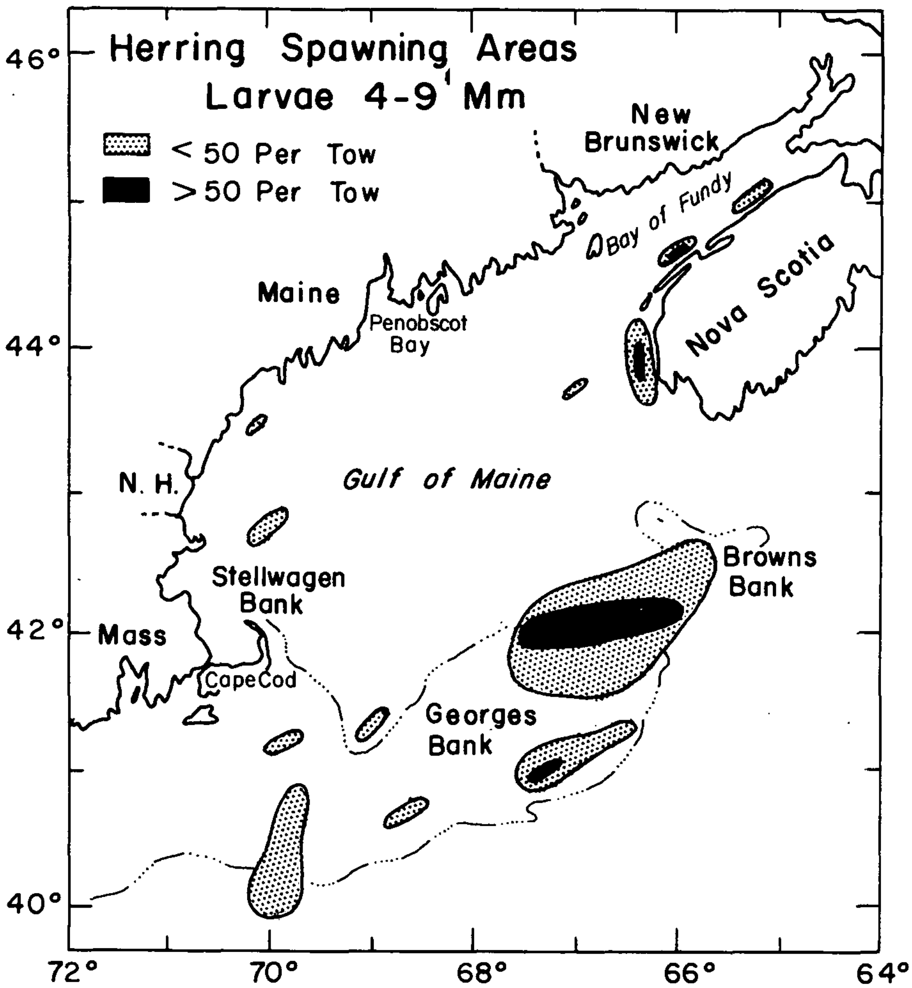

Fig. 2. Herring spawning grounds in the Bay of Fundy-Gulf of Maine area (from Tibbo, et al., 1958).

Estimation of egg production

For the herring of the northwest Atlantic, the results of two attempts to estimate directly the seasonal egg production of a spawning stock have been published. On September 5-6, 1961, McKenzie (1964) located a small spawning ground 1.4 miles west by south of Black Point near Cape St. Mary, southwest Nova Scotia, in 6-7 fm of water by dredging with Ekman, Petersen and van Veen dredges. Through sampling in various directions, the extent and outline of the bed was determined and its total area of 725,000 square feet (67,353 sq m) was calculated. These samples showed the eggs to be in a sheet of maximum thickness 1½ in (3.8 cm) on a flat sand bottom. A few tiny, flat, black stones occurred on this sandy bottom, but no vegetation. Calculations based on counts of eggs in subsamples indicated that there were between 206 and 215 billion eggs on this ground. The average length of the spawners was found to be 30.7 cm. Using the formulae for the fecundity of north European herring (since no Canadian Atlantic data were available), McKenzie calculated that the female spawners in this area in August and September 1961, should have had from 40 to 104 thousand eggs each. In the first case, the spawning school should have consisted of about 10.5 million fish or 3,075 tons and in the second case, about 4.0 million fish or 1,175 tons.

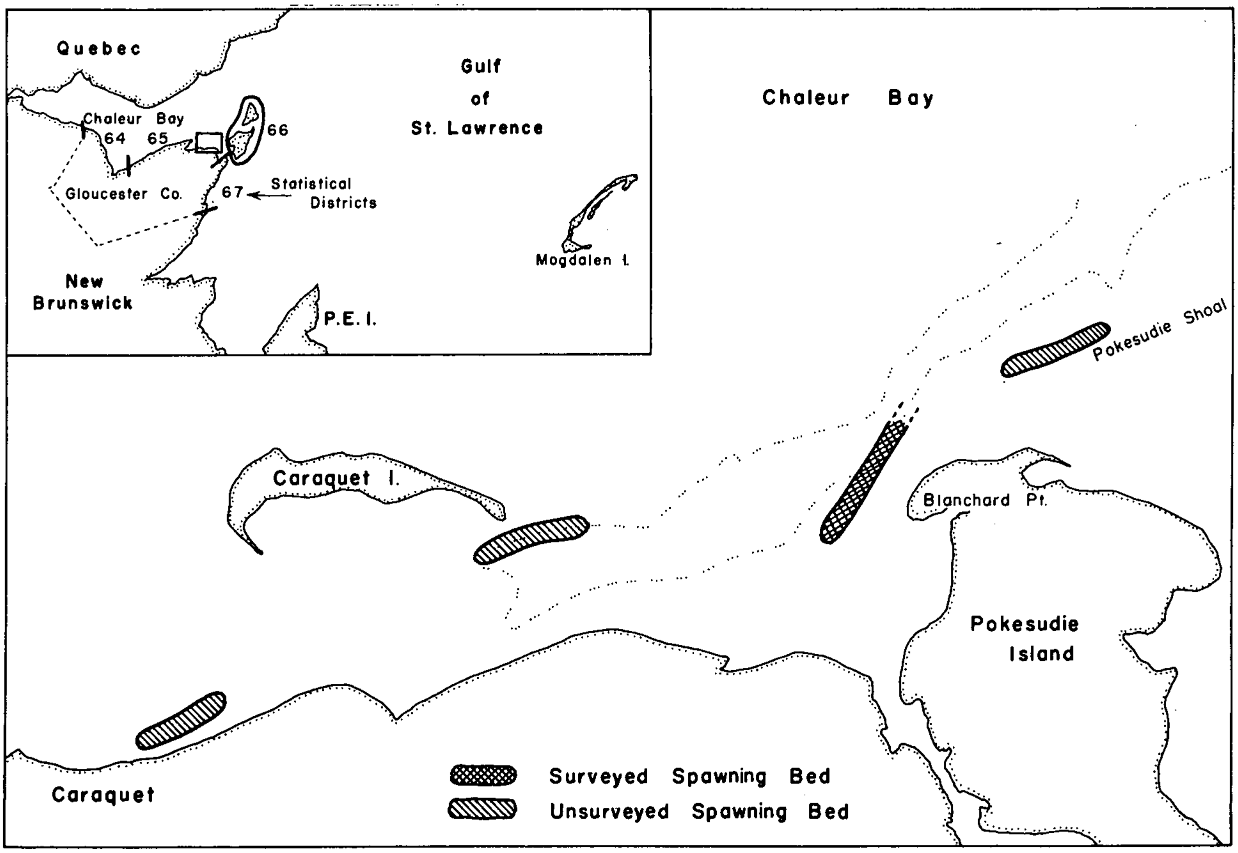

Fig. 3. Chart of the southeast portion of Chaleur Bay showing spawning areas (from Tibbo, *et al.*, 1963).

The other direct attempt to estimate the seasonal egg production of a spawning stock was carried out under the direction of Mr. S.N. Tibbo, using free-diving (scuba) techniques (Tibbo, *et al.*, 1963). This work was done on a spawning ground off Blanchard Point, Chaleur Bay, N.B., in May 1962. The egg patch was a long, narrow bed running parallel with the shore in 1.3 to 6.0 m of water and occupying an area of about 375,200 sq m (Fig. 3). The sea bed was composed of small stones and gravel with large masses of red sandstone. The eggs were found only on vegetation, none on the bare ground (Fig. 4). The estimated total number of eggs was 35.46 x 10^{11} and from this it was calculated that the spawning school involved consisted of 185 million fish or 24,812 metric tons. About one thousand metric tons of herring were caught in the vicinity of the survey area, representing a fishing mortality of 4.0%.

Dispersal of herring larvae

On the basis of what was known of non-tidal surface currents, Tibbo, *et al.* (1958, 1959) described a general pattern of movements of herring larvae from spawning grounds. They concluded that larvae spawned on the northern edge of Georges Bank would be swept across Browns Bank towards the southern coast of Nova Scotia. Larvae found elsewhere on Georges Bank would be swept southward (Fig. 5).

Nantucket shoals larvae would appear along Rhode Island and New Jersey. Stellwagen larvae would be swept southward along Cape Cod.

In the Bay of Fundy, movement is somewhat more complex, but would be northward along the southwest coast of Nova Scotia and southward along the coast of New Brunswick and Maine. Eddies complicate this movement, but in general, it will be counterclockwise.

However, subsequent compilation and analysis of drift bottle data (Bumpus, 1960) has indicated that the conclusion regarding the Georges Bank spawning is probably incorrect.

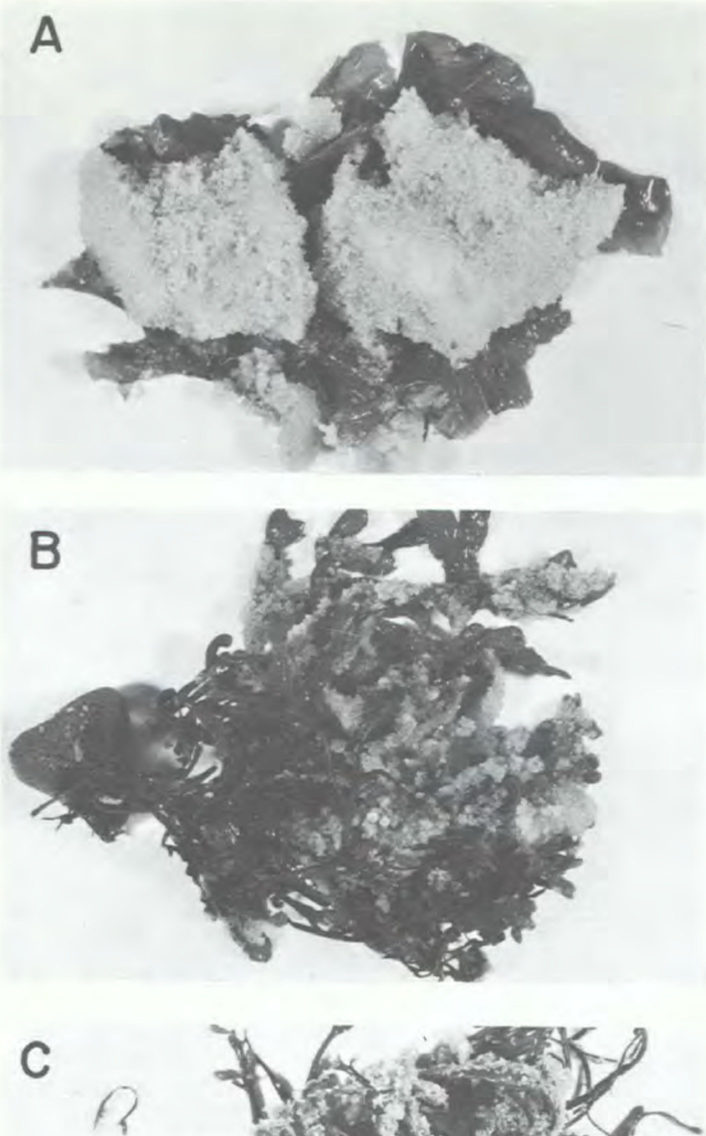

Fig. 4. Photographs showing herring eggs on various types of vegetation (from Tibbo, *et al.*, 1963).

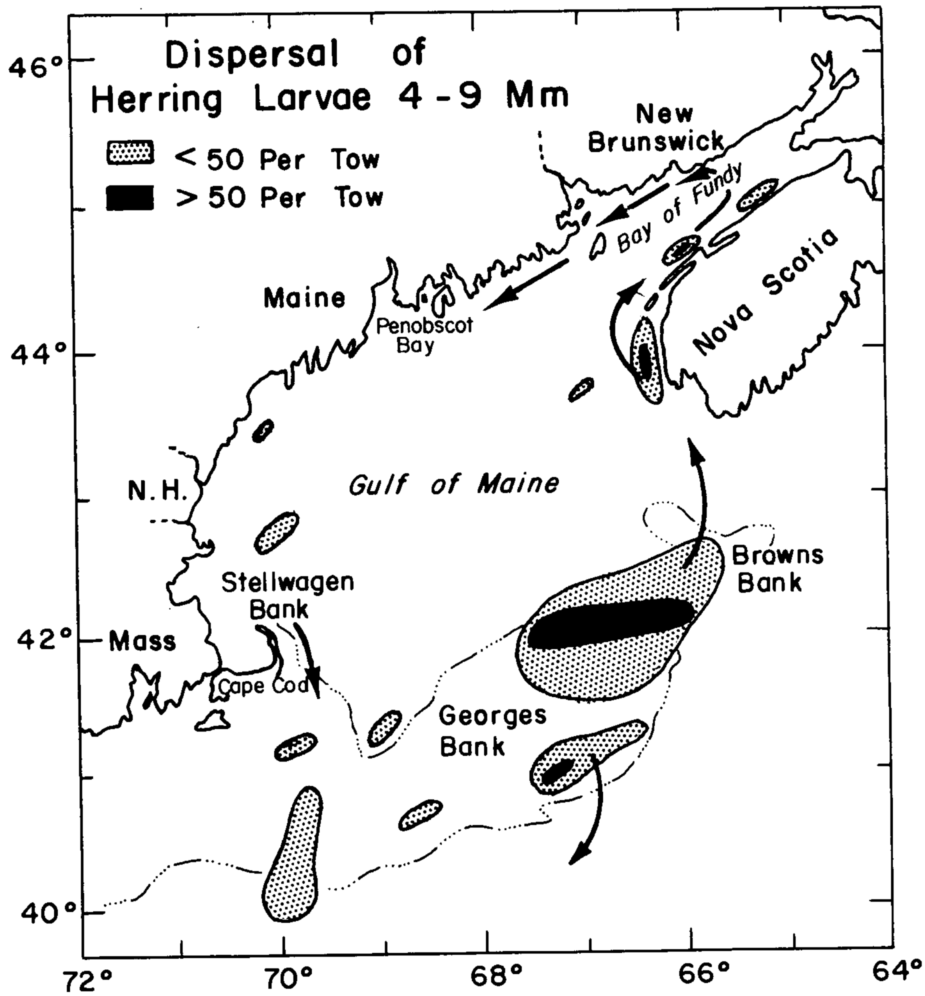

Fig. 5 Theoretical patterns of larval movement.

Bumpus (op. cit.) has drawn two contours for each month (Fig. 6). The contour enclosing lightly shaded areas limits the "possible" sources of water which may reach the bay through surface circulation. The heavily shaded portions delineate the areas from which 5% or more of the drift bottles have consistently reached the Bay of Fundy. These charts indicate a restricted source of surface drift into the Bay of Fundy during the herring spawning season. Water from Georges Bank is not circulated into the Bay of Fundy during September, October, November, December or January.

Note, however, that the eastern boundary of the source area is annotated in some instances with question marks, indicating no data. Hence, the Nova Scotian herring spawning ground may be within the limits of the Fundian circulation during the early autumn.

Survival and growth rates during the early developmental stages

Tibbo, *et al.* (1963) noted that mortality of eggs on the Blanchard Point spawning ground in Chaleur Bay was apparently due almost entirely to fish predators. The number of dead or unfertilized eggs in the samples appeared negligible. However, winter flounders *(Pseudopleuronectes americanus)* could be seen everywhere and were extremely abundant in areas of medium and heavy egg deposition (Fig. 7). It was estimated, assuming that 50 days would elapse from the beginning of spawning to the end of hatching, that the egg mortality due to flounders was probably not less than 7% and may have been much higher.

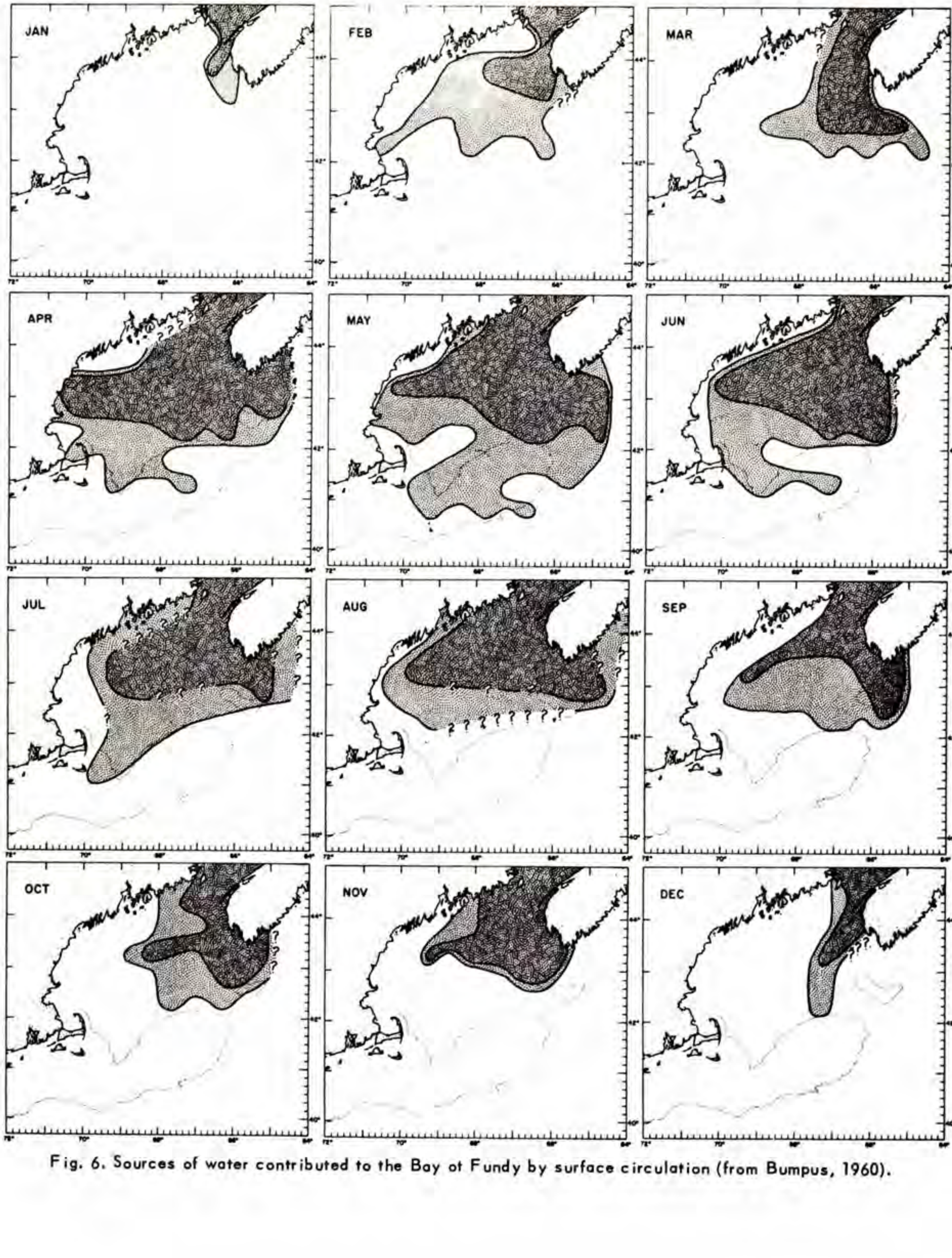

Fig. 6. Sources of water contributed to the Bay of Fundy by surface circulation (from Bumpus, 1960).

Fig. 7. Underwater photograph of "heavy" egg deposition and predators (winter flounders). (from Tibbo, *et al.*, 1963).

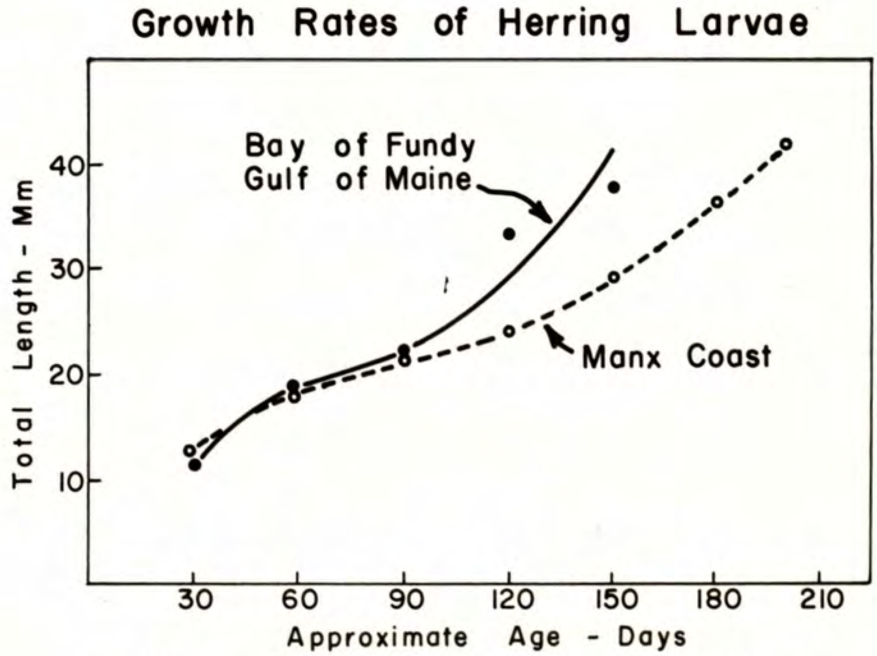

Fig. 8. Growth rates of herring larvae (from Tibbo, *et al.*, 1958).

A thorough study of herring survival rate at every stage of early development from egg to postlarva has never been attempted in Canadian Atlantic waters. A study of this nature would be a valuable contribution to the knowledge of our herring resources.

Reliable data on the growth rate of herring larvae are still sadly lacking. Huntsman (1917a) reported herring larvae 6-8 mm long on September 19; 11-13 mm long on October 2; and 17.5 mm long on November 2.

Tibbo, *et al.* (1958) obtained an approximate measure of growth by plotting mean lengths of larvae taken during each month of a co-operative investigation carried out during 1956-58 by the Fisheries Research Board of Canada and the U.S. Fish and Wildlife Service. A striking similarity was found between growth curves for the Bay of Fundy-Gulf of Maine larvae and the autumn-spawned larvae on the Manx coast off northwestern England for the first three months (Fig. 8). Subsequently, growth rate was more rapid in the Bay of Fundy-Gulf of Maine area than on the Manx coast. This may be accounted for by higher surface water temperatures on Georges Bank. Supporting evidence for substantial growth in January and February (estimated 120 and 150 days after hatching) is available from studies of the scales of 1- and 2-year-old herring from the Bay of Fundy and the Gulf of Maine areas. Examinations of scales show that new annual growth zones on the scales of "sardine" herring are apparent in January.

ENVIRONMENTAL FACTORS INFLUENCING HERRING DISTRIBUTION AND MOVEMENTS

Huntsman (1934, 1952, 1953) has put forward the theory that herring behave like plankton and are passively carried by water currents. On this basis, he is able to explain certain movements of herring into estuaries and even into some weirs, the concentration of sardines near the entrances to Passamaquoddy Bay and the movements of large herring in the Bay of Fundy prior to their disappearance in the 1880's.

Huntsman postulates that freshwater run-off mixing with salt water moves away from the mixing point and deep return currents bring a replacement of the sea water which is used up in the mixing. Since run-off is variable, the strength of these currents varies and light, temperature and probably other factors influence the depth at which the herring are and, therefore, their passive movement horizontally. Huntsman considers that it is not just coincidence that the sardine area is bounded in one direction by the up-current end of the Saint John River influence and in the other direction by the seaward end of this outflow.

Graham (1936) also points out that the concentrations of herring are west of large rivers, the Saint John and the Penobscot; this places them in the areas where the outflows of these rivers spread. He considers that turbidity of water is a characteristic of the sardine area.

Because of their habit of keeping to the surface in summer the herring, according to Huntsman (1952), are drawn into the Bay of Fundy from the Gulf of Maine by the Saint John River mixing. They are then believed to be carried from the stratified water of the outer Bay of Fundy to the mixing places just outside and in the entrances to Passamaquoddy Bay. The Coriolis force ensures slow circulation of the water into Passamaquoddy Bay through L'Etete Passage which is on the right going inward. Inside the Bay, extensive mixing of the stratified water near the shore from the middle of the west or inner side to the head, takes such surface forms thitherwards and, thus, holds and concentrates them in Passamaquoddy Bay.

As the herring grow larger they go deeper and tend to be carried from the mixing places to the centre of the Bay and thence, in the outward movement, which from the action of the Coriolis force is through Head Harbour Passage on the right going out. The larger the herring grow, the farther out they are distributed on the whole, until as adults they are almost entirely outside Grand Manan during the summer.

Summarizing his information on herring and water movements, Huntsman (1934) indicated that weir catches of herring were determined by temperature, feeding, light, enemies, and tidal currents, but these were not believed to move herring any considerable distance. He concluded that herring were shifted from place to place by superficial water movements set up by the wind. Spring freshets or heavy rains result in water of low density in the middle of Passamaquoddy Bay moving to localities of deep mixing carrying the herring to the so-called "spring weirs" irrespective of time of year. With reduction in freshwater outflow in the autumn or about two weeks after a heavy rain, the process reverses and the herring are moved to the estuaries and big catches are usually made in the "fall weirs."

During 1957 and 1958, 137,469 sardine herring ranging in mean total length from 9.9 to 20.0 cm and in age from one to three years were tagged in the southern Bay of Fundy and northwestern Gulf of Maine (McKenzie and Tibbo, 1958; McKenzie and Skud, 1958; McKenzie and Tibbo, 1959b, 1961).

Recovery of 3,582 (2.6%) of the tagging showed herring to move in and out of Passamaquoddy Bay irregularly throughout the summer and autumn with some tendency to concentrate at the head of the Bay (Fig. 9). Outward movement reached a peak in July, considerable movement being eastward toward Point Lepreau. Herring moved into Passamaquoddy Bay from as far south as Grand Manan and as far east as Point Lepreau. Little interchange with Nova Scotia or Maine occurred. Drift bottles released with the tagged herring showed no apparent relationship between herring movements and surface drift.

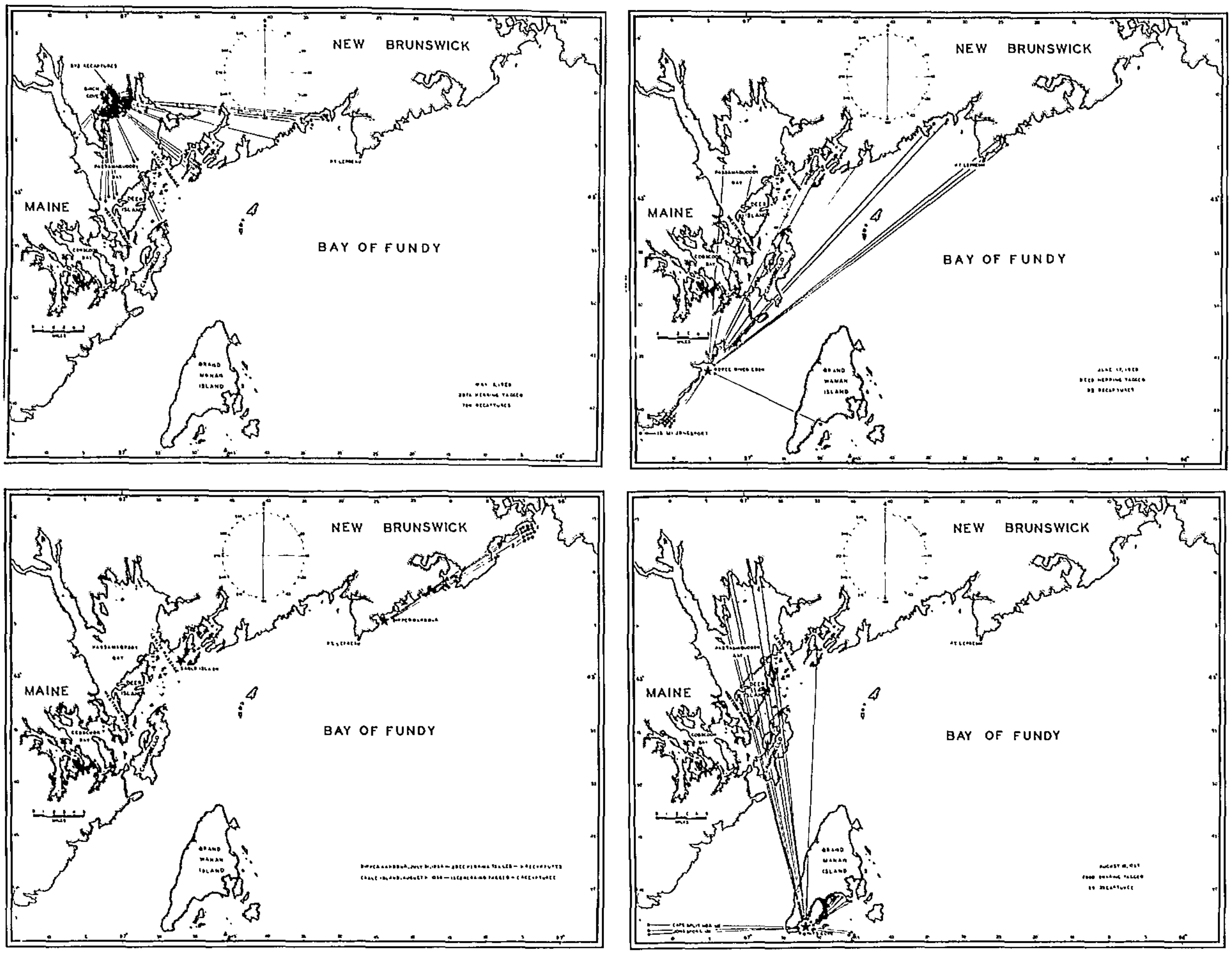

Fig. 9. Recaptures of herring tagged at (a) Birch Cove, N.B., on May 16, 1958; (b) Moose River Cove, Maine, on June 17, 1958; (c) Dipper Harbour, N.B., on July 31, 1958; Eagle Island, N.B., on August 6, 1958; and (d) Pats Cove, N.B., on August 16, 1957 (from McKenzie and Tibbo, 1961).

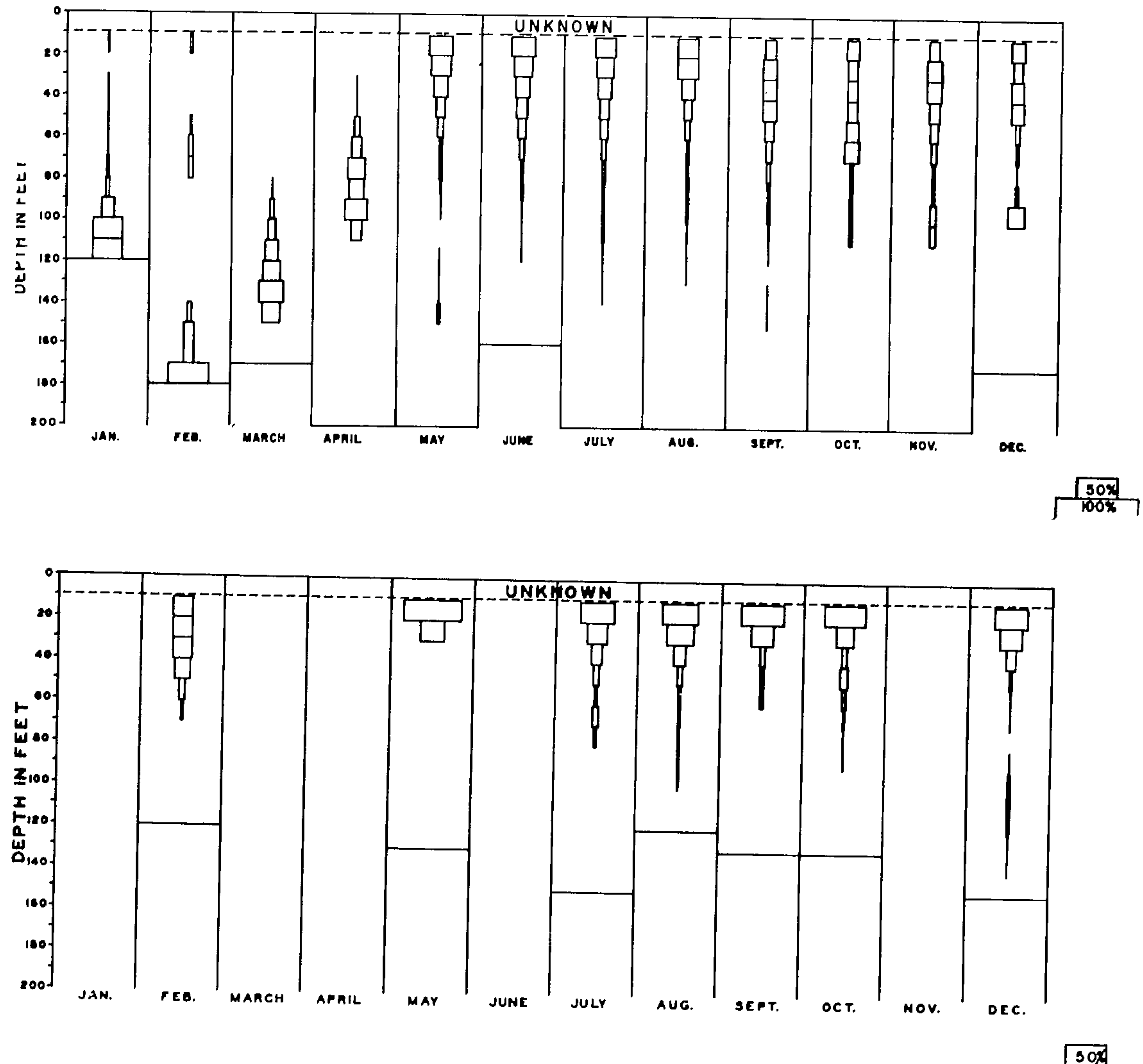

Fig. 10. Vertical distribution of herring in Passamaquoddy Bay, (a) by day, and (b) by night (from Brawn, 1960b).

Brawn (1959, 1960a) observed that herring respond to currents greater than 3-9 cm/sec by swimming upstream at a rate in excess of the current speed until their maximum swimming speed had nearly been reached. Maximum swimming speed varied from 91 cm/sec for groups of mean length 15.2 cm to 143 cm/sec for fish 26.7 cm mean length.

Herring also respond to changes in light intensity. Brawn (1959, 1960b) studied the diurnal vertical movements of herring through examining echo-sounder records made from 1947 to 1958 on schools of immature herring in Passamaquoddy Bay. Herring schools were closer to the surface by night than day during every month of the year (Fig. 10). From May to December the median depth varied from 9.1 m (30 ft) to 13.4 m (44 ft) by day and from 6.4 m (21 ft) to 7.9 m (26 ft) by night. From January to April the schools were deeper in the water by day with a median depth of 25.3 m (83 ft) to 38.4 m (126 ft) though still rising toward the surface at night to a median depth of 11 m (36 ft) in February.

Preliminary studies in tanks suggest that herring on the Atlantic coast of Canada occupy almost the complete range of temperatures allowable within their range of resistance to both low and high temperature extremes (Brawn 1959, 1960c). At the appropriate season, herring have an upper lethal temperature of 19.5°C to 21.2°C according to size and can survive exposure to temperatures below –1°C, at least for a short period. Along the Canadian Atlantic coast, herring have been taken in water ranging from 0°C to 18°C or practically the whole range of temperatures within which they can survive.

Brawn (1959, 1960d) also found that 10- to 24-cm herring, when tested at temperatures mainly between 4°C and 8°C, could stand salinities down to 5% for four weeks with but low mortalities.

FOOD AND FEEDING HABITS

Herring feed by a definite act of capture rather than a non-selective filtering off of all organisms of a size capable of being retained by the gill rakers. Battle *et al.* (1936) observed selective feeding in aquaria and demonstrated the importance of vision in feeding by observing that herring stop feeding in darkness.

Johnson (1940b) found that in temperatures of 8°C to 13°C, herring held in aquaria fed well, but at 3.8°C and 4.5°C they ate little. He also observed that they took feed from below, feeding where the light was best and ignoring the feed which settled to the bottom. In outdoor tanks, they ate throughout the day whether clear or cloudy and on moonlight nights, but not otherwise at night.

Somerville (1956) reported that small herring eat small copepods, crab larvae and eggs. For herring in general, Battle *et al.* (1936) list the following food organisms: *Meganyctiphanes norvegica, Calanus finmarchicus, Pseudocalanus elongatus, Acartia clausi, Eurytemora herdmani,* and *Tortanus discaudatus.*

Numerous investigators have reported a reduction of plankton inside, compared to outside, Passamaquoddy Bay. Studies by Legaré and Maclellan (1959, 1960) confirmed these reports. They also presented evidence that herring were feeding in the upper water layers with low feeding activity from March to August and active feeding from September to November. The fat content of the herring was found to be directly related to active feeding, but there seemed to be no relationship between degree of feeding activity and the amount of zooplankton nor any relationship between zooplankton volumes and herring catch during a 10-year period.

DIGESTION AND FATNESS

Battle (1934) established the relation between clearing time and temperature showing feedy fish become clear in 8 hours at 20°C, while it required 32 hours at 6°C.

In carrying out investigations on fatness, digestion and food of Passamaquoddy sardines, Battle *et al.* (1936) found the fish to be fat in every part of this region. The fattest herring were found to contain the most food and this of the larger kinds. Herring were mainly in the upper water layers in summer and near the surface when the light intensity was low and good correlation was found between fatness and the quantity of food present near the surface in a particular locality. Deepwater forms from the Gulf of Maine were found at the surface in the passages at the mouth of Passamaquoddy Bay at all times of day and this was correlated with the presence of the fattest herring.

Leim (1943) found fat values of sardines ranging from 6.1 to 20.3% of the wet weight. In general, large fish were fatter than the smaller ones within the same sample. While there was great variation from year to year, fall and winter fish were fatter than spring and early summer ones. In a later report, Leim (1958) found a range of between 1.2% and 27.5% of the wet weight of Passamaquoddy region sardines, lowest in April to June and highest from August to November. Significant variations occurred from year to year—the herring being extremely fat in the winter of 1942-43 and quite poor the following winter. Fatness increased with size until the sardines reached sexual maturity.

GROWTH

The only published information on the rate of growth of Bay of Fundy herring in nature is that of Huntsman (1919). He reached tentative conclusions that spring-spawned fish reach a length of about 9 cm (3½ in) by the first winter and about 15 cm (6 in) by the second winter. Fall-spawned schools reach a length of about 12½ cm (5 in) by the second winter. Growth of about 5 cm (2 in) occurs in the third season and another 4 cm (1½ in) is added in the fourth season. The period of most rapid growth is from May to September. Huntsman's conclusions were based on length-frequency observations as scales were found to be difficult to read. Recently, however, age determinations based on otolith readings appear to confirm his findings regarding growth.

ENEMIES OF THE HERRING

Moore (1898) lists as enemies of the herring the cod, haddock, pollock, hake, sculpin, sea raven, flounder, dogfish, silver hake, albacore, squid, porpoise, seal, whale, gull and sea fowl. He considered that the enemies are important in determining the distribution of the herring.

Huntsman (1933) suggests that the cold surface waters usually keep mackerel away from the Passamaquoddy region, but during some summers mackerel schools invade the area and reduce the supply of herring by eating the small ones and scattering the larger ones. However, he does not present any data for this phenomenon.

Graham (1936) states that fishermen believe dogfish and silver hake keep the herring penned up in some areas.

DISEASE

In 1930-31 a serious outbreak of a disease occurred amongst herring in the Bay of Fundy. It was studied first by Fish (1934) who identified the causative organism as *Ichthyosporidium hoferi*, one of the lower fungi. This fungus, which is also known from winter flounders and alewives, attacks visceral organs such as the heart, liver and spleen and also the lateral line musculature (Fig. 11A). In advanced cases, the cysts break through the epidermis and the characteristic "pepper-spot" appearance is produced (Fig. 11B). In 1930-31 so many fish had open sores on the sides that their use for canning was seriously curtailed.

Fish believed that the organism is a normal parasite of the herring and that it reaches epidemic proportions only when certain unknown factors are operative. The organism is not believed to be capable of infecting warm-blooded animals.

The fungus disease and its effect on herring are reviewed by Sindermann and Scattergood (1954).

Sindermann and Rosenfield (1954a,b) report two additional diseases among sardine herring: (1) an ulcer disease, caused by a myxosporidian, *Kudoa clupeidae*. It produces large surface ulcers which ooze a white or yellowish material (Fig. 11C) and (2) a pigment spot disease, caused by a trematode, *Cryptocotyle lingua*. The cercariae encyst in the skin and occasionally in the underlying muscle of the herring (Fig. 11D).

CONCLUDING REMARKS

Adolescent herring in the Bay of Fundy area enter the coastal weir fishery on the New Brunswick side of the bay in late fall (October to November) by which time they have attained a length of about 11 cm (4½ in). These are mostly autumn-spawned fish which are in their second year of life (Age Group I). During their first full year of exploitation by the fishery, these fish (now II-group herring) make up about 80% of the sardine landings by number (Fig. 12).

The Passamaquoddy investigations included an exploratory fishing project designed to supplement the shore-sampling program and to locate schools or populations of herring that were not being subjected to commercial exploitation (Tibbo and Brawn, 1960).

The program included fishing experiments with bottom and pelagic trawls, and with gill nets. Echo-sounder surveys were made weekly in Passamaquoddy Bay during the summer and early autumn of 1958 and frequently, but irregularly in other areas and seasons.

The amounts of herring taken with experimental gear in the Passamaquoddy area were small. There was echo-sounder evidence, however, of extensive distribution, with most of the large schools appearing in open areas away from the small coves and inlets where most herring weirs are located. This was confirmed on one occasion by commercial purse-seine operations in the open waters of Passamaquoddy Bay where during the first two weeks of September 1958, five seiners caught more than 2¼ million lbs (1,020 metric tons) of herring.

However, the "sardine" industry depends heavily on fish of Age Group II, so that failure or lowered abundance of one year class could have a drastic effect on a season's catch.

The end of the juvenile or adolescent stage can be considered as the onset of sexual maturity. This takes place normally when the fish are in their fifth year of life (Age Group IV). Only small numbers of fish four years old are present in the "sardine" area at any time of the year.

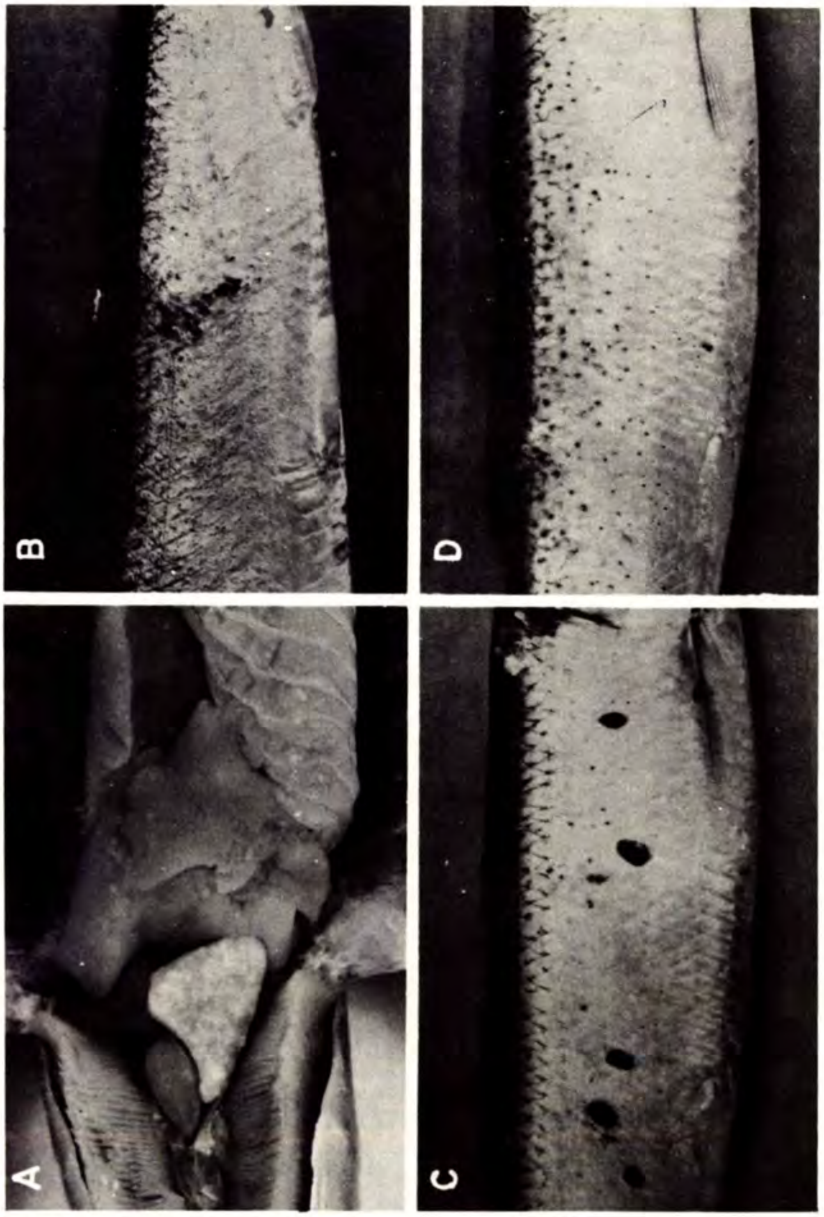

Fig. 11A. Visceral symptoms of advanced Fungus *(Ichthyosporidium)* Disease.

Fig. 11B. External symptoms of Fungus *(Ichthyosporidium)* Disease (from Sindermann and Rosenfield, 1954a).

11C. External symptoms of Ulcer *(Myxosporidiam)* Disease (from Sindermann and Rosenfield, 1954a).

11D. Herring with moderate Pigment Spot Disease (from Sindermann and Rosenfield, 1954a).

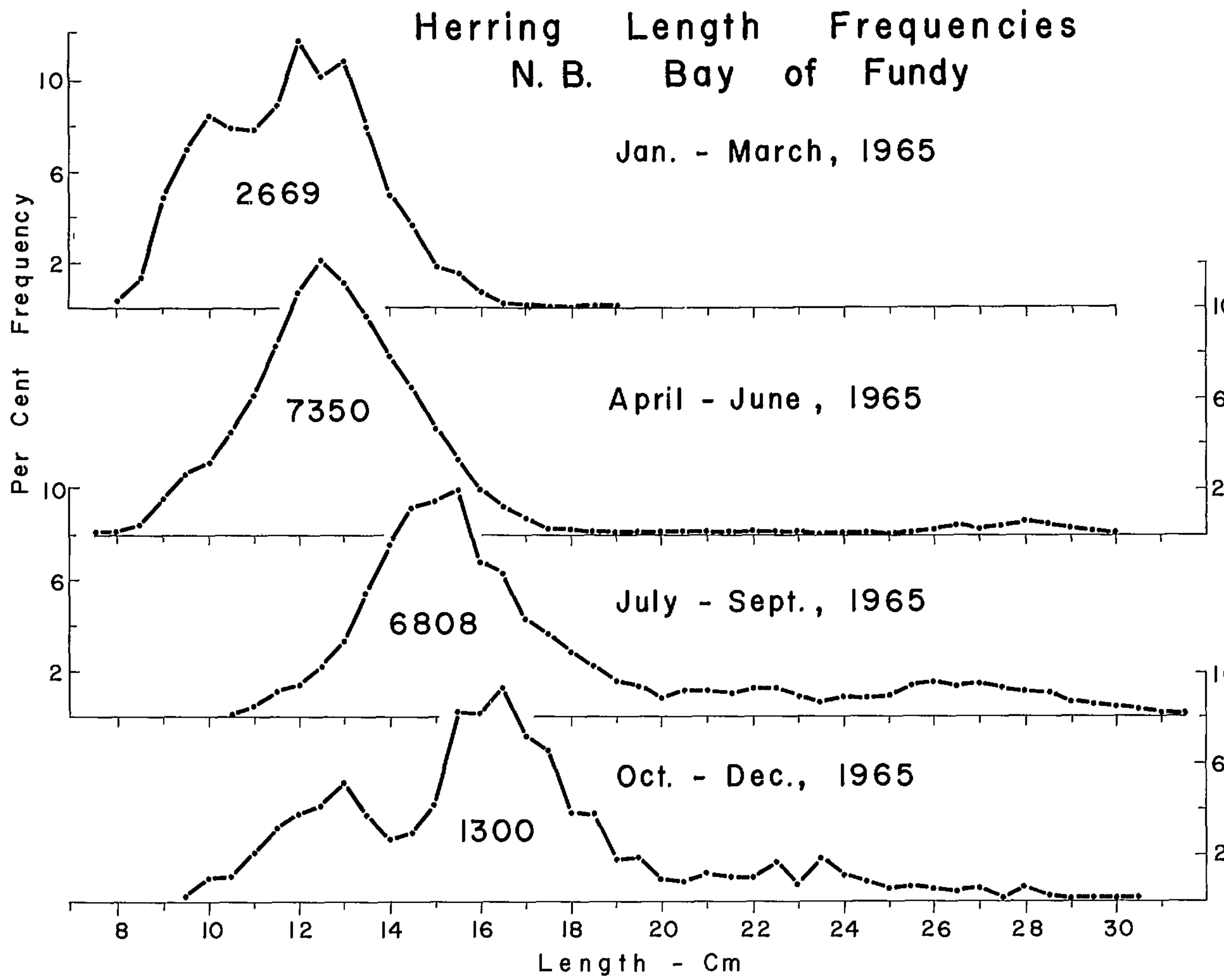

Fig. 12. Size composition of New Brunswick "sardine" herring, 1965

Immediately prior to, and during the spawning season, large concentrations of mature herring Age IV and older are found on the two major spawning areas (i.e., southwest Nova Scotia and the northern edge of Georges Bank). Fish up to Age Group X have been found in the samples of spawning stocks of both areas.

After spawning in October, herring move away from the spawning areas and fishing operations are terminated. Where the fish spend the winter months and what factors influence their migrations are not known. A full-scale investigation is needed in order to describe the distribution of herring stocks during the non-spawning season and to relate this distribution to physical, chemical and biological properties of the environment and their changes in space and time. A study of this nature would aid greatly in the development of the commercial fisheries and be of invaluable assistance to the reliable forecasting of future events.

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Herring products from several countries are sampled during a break in the Conference session.

Recent Herring Investigations in Newfoundland Waters

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INTRODUCTION

Herring investigations in Newfoundland waters have in the past been carried out rather sporadically. While there exist many accounts of the prevalence of herring in the past century and the need for extensive research had been stressed on many occasions, the first real investigation was in 1914-15 by a Norwegian scientist, Johan Hjort (1915), who was invited by the Biological Board of Canada to study the Atlantic herring fisheries. These investigations were carried out off the coast of Nova Scotia and in the Gulf of St. Lawrence, including the west coast of Newfoundland. During the next 30 years very little in the form of biological research was carried out until Tibbo (1956, 1957), initially at the Newfoundland Fisheries Research Station and later as a member of the Atlantic Herring Investigations Committee, conducted studies of the herring populations in Newfoundland waters in 1942-44 and again in 1946-48, with emphasis on the south and west coasts, where extensive herring fisheries existed at the time. During the next 9 years, except for minor exploratory experiments in certain areas, no general survey of Newfoundland herring resources was undertaken. Then in 1957-58 herring research and exploratory fishing was again initiated by the Fisheries Research Board of Canada at its St. John's Biological Station with assistance from the Industrial Development Service of the Department of Fisheries. The survey was conducted by S. Olsen (1959, 1961) again largely on the south and west coasts.

After a lapse of several years investigations on pelagic fishes with initial emphasis on herring and capelin were reactivated in April 1965. The 82-foot research vessel *Investigator II* was assigned to the herring project at the end of August. Pending the acquisition and installation of mid-water trawling equipment, which will be available by July 1966, the vessel was equipped for gillnetting with synthetic gillnets ranging in mesh size from two to three inches by ¼-inch intervals. A fleet consists of a continuous string of 5 nets, each of a different mesh size. When working inshore individual fleets are anchored on both ends usually near the shore. When drifting a string of several fleets may be set.

The first cruise was to the west coast (Bay of Islands and Bonne Bay) in November, 1965. Subsequent cruises in December to March 1966 were carried out on the south coast between Rose Blanche and Placentia Bay. Surveys involved rather extensive echo-sounder surveys of many bays and inlets along the coast and the collection of much biological data from herring samples obtained largely from the catches of anchored fleets of gillnets. It has not been possible in the short time available to examine and analyze all of the data collected, e.g. age determinations have not yet been completed, so that this paper deals with only selected aspects of the investigation. Fig. 1 gives the location of place names referred to throughout this report.

BRIEF REVIEW OF THE HERRING FISHERY

The history of the herring fishery in Newfoundland waters is very poorly documented and statistics of landings are available for only a relatively short period. From reports of protection officers assigned to patrol the coastal waters in the 19th century (in Journals of the House of Assembly, Newfoundland) herring were prevalent in the winter and spring along

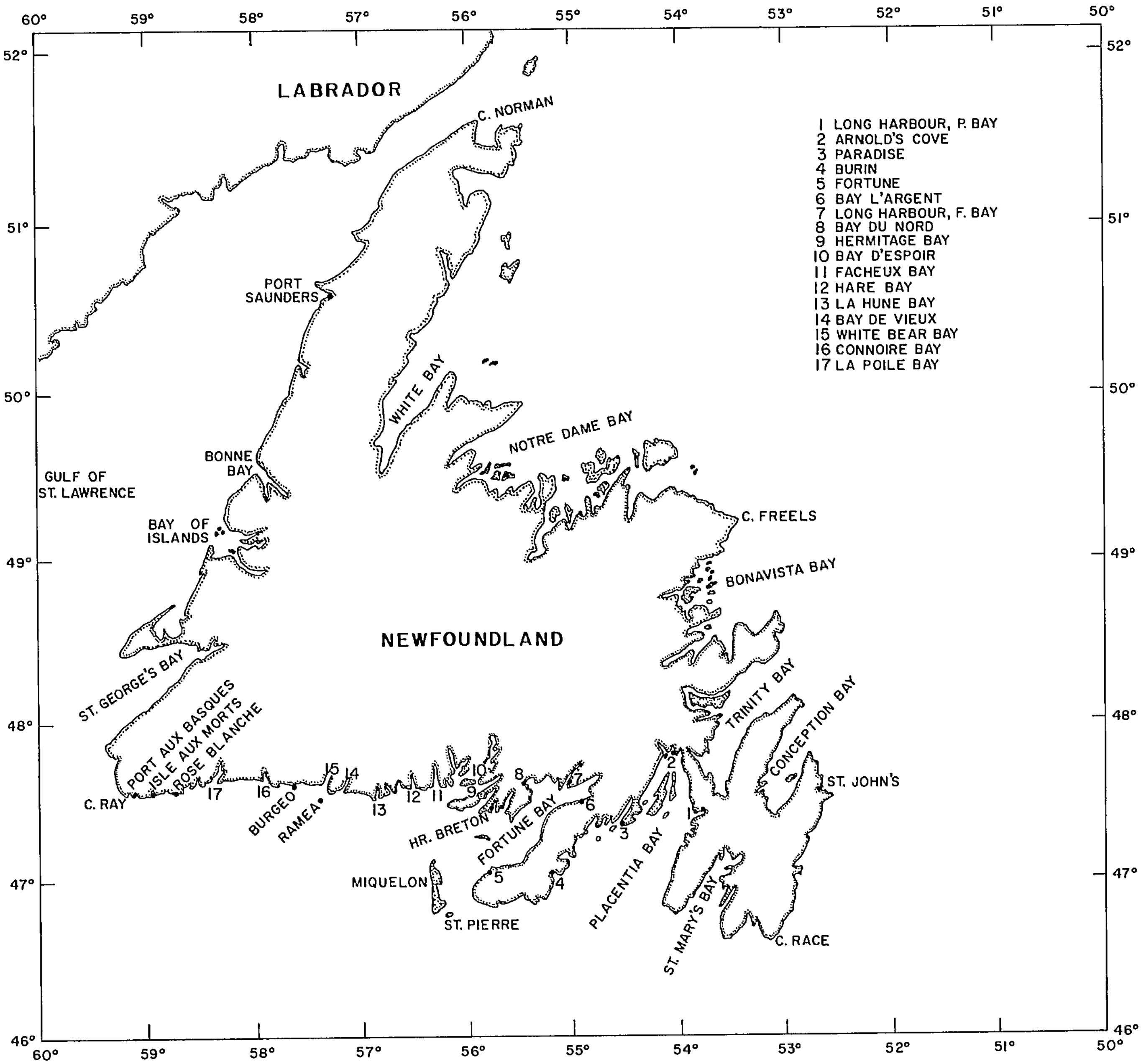

Fig. 1. Map of Newfoundland showing the place names referred to in the text.

the south coast, particularly in Placentia, Fortune and Hermitage Bays. In fact it has been stated (Report of the South Coast Commission, 1957) that, while some centres on the south coast developed as a result of the bank fishery for cod, it was mainly the association of local inhabitants with the French and United States cod fisheries that brought about the rapid settlement of the south coast during the 19th century. Before the end of the 18th century United States cod-fishing vessels had expanded their operations to the Newfoundland Banks and it was customary for them to purchase herring in Fortune and Hermitage Bays. In addition, of course, large quantities of pickled herring were exported to the United States from both the south and west coasts throughout this early period.

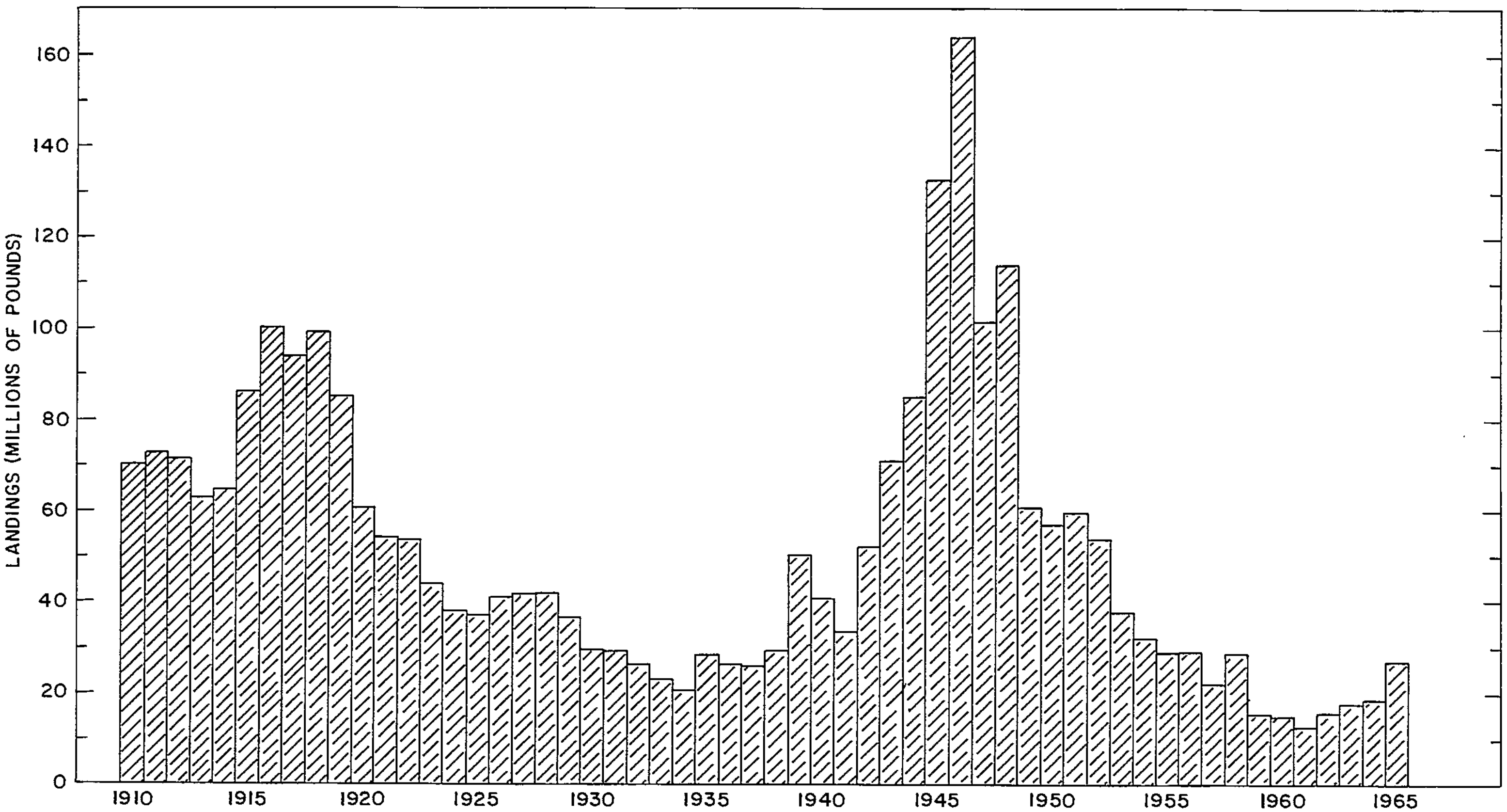

Fig. 2. Newfoundland herring landings (millions of pounds round weight), 1910–65. Drawn from statistics used by Templeman (1966).

The rapid development of St. Pierre and Miquelon after 1815 also played an important part in the economy of the south coast. A very lucrative trade developed whereby south coast fishermen supplied great quantities of herring for the French codfishing fleets which were based at St. Pierre and, when the opportunities arose, foreign fishing vessels were supplied with bait directly by the fishermen in many of the isolated harbours of the south coast. Inevitably, the bait trade developed on a large scale and this continued into the early part of the 20th century.

While information on the exports of pickled herring is available for most of the 19th century, the illegal bait trade had reached such high proportions that estimates of herring landings from Newfoundland waters during this period are not possible. However, with the introduction of trawlers in the early part of the present century and the subsequent rapid decline in traditional banking fleets, the bait trade dwindled and the estimates of herring yields based largely on exports of pickled herring become somewhat more realistic.

Between 1910 and the start of the First World War about 70 million pounds of herring were taken annually (Fig. 2). Landings increased to 90-100 million pounds during that war but rapidly declined to a low level of 20-30 million pounds during the depression period of the 1930's. The Newfoundland Fisheries Board was established in 1936 and immediately explored the possibility of expanding the herring fishery by investigating the establishment of new markets. Financial support was given to the establishment of experimental herring meal and oil factories and two were built in 1941, one in Labrador and the other in Bay of Islands. The Labrador plant discontinued operations after a few years due to the irregular appearance of herring, but the Bay of Islands plant continued operations until 1959, when the supply of herring in the area dropped to a very low level. However, between 1940 and 1946 with greatly increased fishing effort the catch increased more than five times to 163 million pounds. Most of this expanded fishery was due to the great demand for food during and immediately following the Second World War, particularly with large orders for pickled herring from UNRRA (United Nations Relief and Rehabilitation Administration).

While economic factors undoubtedly played an important role in the peak landings of 1915-19 and 1943-48 and the low catches during the inter-war years (Fig. 2), the tremendous decrease in the landings subsequently has in large part been due to the disappearance of the herring stocks from the traditional fishing areas (Table I). The difference between the two periods is probably greater than indicated since, unlike the more recent figures, no estimate was made for quantities caught and used as bait by individual fishermen and also, during the earlier period of large landings, great quantities were undoubtedly killed by the bar-seines and not accounted for in the landings.

TABLE 1. AVERAGE ANNUAL HERRING LANDINGS (IN THOUSANDS OF POUNDS ROUND WEIGHT) FOR 1945-50 AND 1960-64.

Area	1945-50	1960-64	% of 1945-50 average
NE. coast (Cape Norman to Cape Freels)	2,900	1,115	38
E. coast (Cape Freels to Cape Race)	13,000	2,605	20
S. Coast (Cape Race to Cape Ray)	73,900	6,630	9
W. Coast (Cape Ray to Cape Norman)	33,000	5,465	17
Newfoundland total	122,800	15,815	13

Traditionally up to the early 1950's Fortune Bay on the south coast and Bay of Islands on the west coast were the main centres of the herring fishery. Undoubtedly the almost complete disappearance of herring from those areas was largely responsible for the tremendous decrease in the landings. In the last few years most of the herring landed from the west coast has been taken in Bonne Bay and from the south coast in Placentia Bay and along that part of the coast west of Hermitage Bay.

FALL AND WINTER SURVEYS, 1965-66

In November 1965 the *Investigator II* carried out an echo-sounder survey of Bay of Islands including the North, Middle and Humber Arms. No concentrations of herring were located and only four herring were taken in a drift-set of 10 nets in the outer part of the bay and none in an anchored set of five nets in North Arm. Upon moving to Boone Bay, however,

TABLE II. Summary of gillnet operations, November 1965 to March 1966.

Date	Locality	Gear	No. of nets	Catch No.	Catch Wt (lb)
1965 Nov. 9	Bay of Islands (North Arm)	Set Nets	5	0	0
" 12	Bay of Islands	Drift Nets	10	4	2
" 16	Bonne Bay (Woody Pt.)	Set Nets	10	152	113
Dec. 9	Bay de Vieux	" "	5	2,234	1,213
" 10	Off Bay de Vieux	Drift Nets	5	11	5
" 13	Fortune Bay	" "	10	0	0
1966 Jan. 15	Burgeo	Set Nets	5	3,974	2,102
" 19	La Poile Bay	" "	5	1,195	744
" 21	Connoire Bay	" "	5	870	524
" 23	Rose Blanche	" "	5	828	448
Feb. 22	Placentia Bay (Long Hr.)	" "	10	1,782	1,187
" 23	Placentia Bay (Arnolds Cove Come by Chance)	" "	10	898	647
" 28	Placentia Bay (Paradise Sound)	" "	10	0	0
Mar. 1	Placentia Bay (Long Is. Maricot Is.)	" "	10	1	1
" 3	Placentia Bay (Burin)	" "	5	0	0
" 17	Fortune Bay (Bay L'Argent)	" "	5	267	167
" 18	Fortune Bay (Long Hr.)	" "	10	228	163
" 19	Fortune Bay (Bay du Nord)	" "	10	34	24
" 22	Hermitage Bay	" "	10	104	56
" 24	Hare Bay	" "	5	2,471	1,271
" 25	La Hune Bay	" "	5	1,321	731
" 26	Bay de Vieux	" "	5	244	127

large concentrations of herring were located at the mouth of the bay and purse-seiners from Harbour Breton, Curling and the Magdalen Islands were fishing there when the weather permitted. Within Bonne Bay a sounder survey revealed no concentrations of any consequence and only 152 herring were taken in two anchored fleets of five nets each set near Woody Point on the southern side of the Bay (Table II).

In early December the area of the south coast between La Hune Bay and Ramea was surveyed by echo-sounder. Over most of this area extending from near the coast up to 7-8 miles off-shore was a dense scattering layer at a depth of approximately 20-30 fathoms during daylight. Several vertical and oblique plankton hauls were made through the scattering layer with a 1-metre plankton net yielding no visible indications of plankton. Assuming that the scattering layer consisted largely of herring, a drift-set was made off Bay de Vieux with nets set at 6-9 fathoms from the surface. During the course of the drift sounder recordings revealed that the scattering layer did not come closer to the surface than about 10 fathoms and the set yielded only 11 herring, all meshed near the footrope of the nets. Some concentrations had already moved into the outer parts of some of the inlets, as an anchored set of five nets in the outer part of Bay de Vieux yielded 2200 herring from an overnight set. Later in December the herring forming the scattering layer offshore presumably moved into the bays and inlets in the vicinity, as none worthwhile were recorded in a similar survey over the offshore area in early January 1966, while large concentrations were reported inshore, particularly in Bay de Vieux and Bay de Loup.

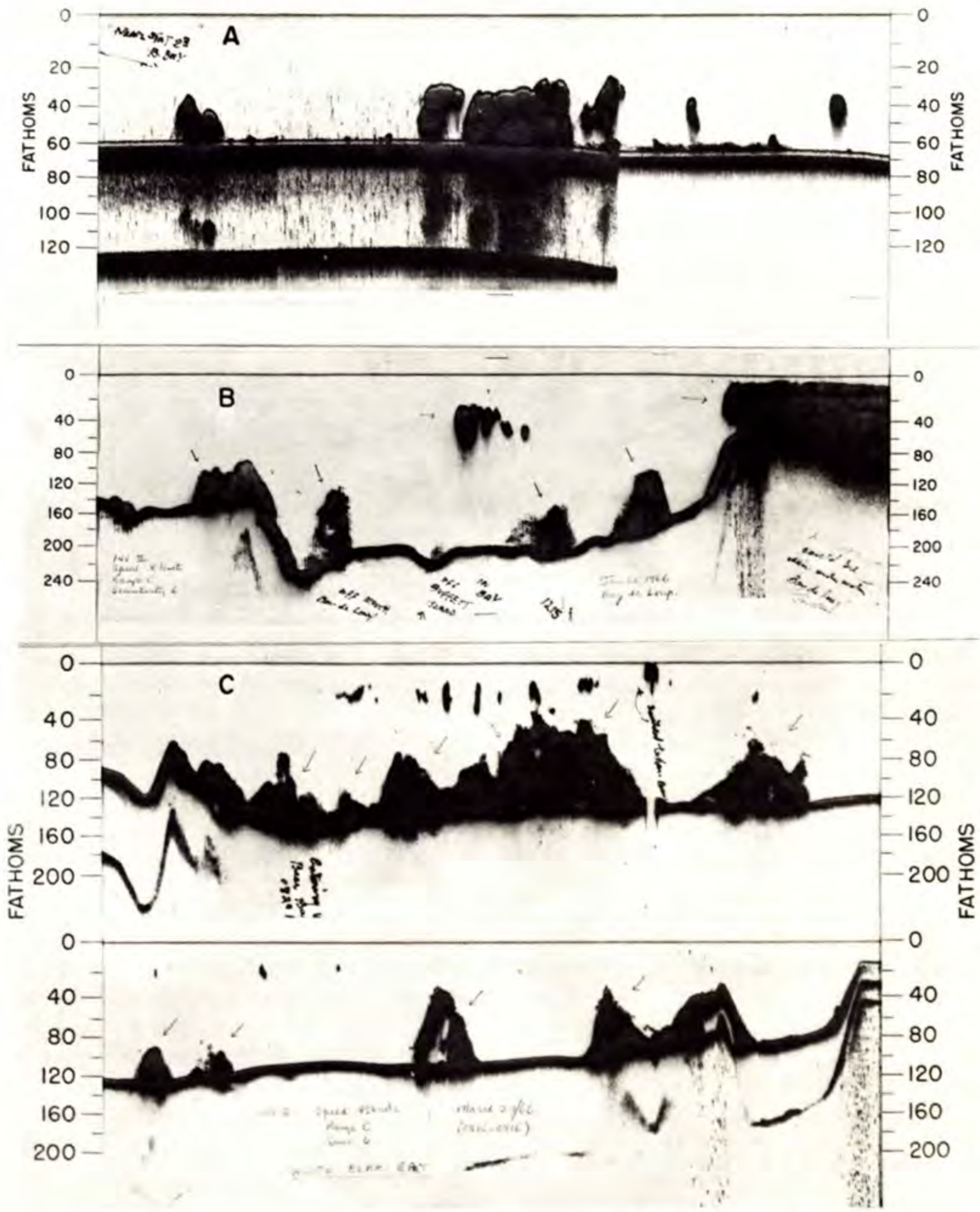

Fig. 3. Echo-sounder recordings of herring concentrations: A, at the mouth of Bonne Bay, Nov. 13, 1965; B, Bay de Loup near Burgeo, Jan. 25, 1966; and C, White Bear Bay, Mar. 27, 1966.

In January 1966 the coastal area between Ramea and Rose Blanche was surveyed, including several of the inlets, and anchored sets of gillnets were made to obtain the necessary biological data. Herring were extremely abundant in Bay de Loup near Burgeo and could be seen just below the surface as the vessel passed over the large concentrations. A fleet of five nets set out in this bay in the early afternoon were hauled in less than two hours after setting with nearly 4000 herring. Similar surveys and gillnet sets were made in Connoire Bay, La Poile Bay and near Rose Blanche. While herring were not found to be as abundant in these latter localities as they were farther eastward in Bay de Loup, anchored gillnets left overnight yielded 800-1200 herring per fleet.

In February surveys were conducted in Placentia Bay between Long Harbour on the east side to Arnold's Cove and Come by Chance in the bottom of the bay and thence to Paradise and Burin on the west side. Some small concentrations were recorded at the first three of the above-mentioned localities and some were caught in each of four fleets of gillnets set near the shore. On the western side of the bay no indications were recorded by sounder and only one herring was caught in five anchored fleets of nets set in various localities.

In March the *Investigator II* visited Fortune Bay and many of the inlets between Hermitage Bay and Ramea. On a track along the eastern side of the bay from Fortune to Terrenceville, the only indications of herring were recorded near Bay L'Argent, where a fleet of five nets yielded less than 300 herring. Along the northern part of the bay between Terrenceville and Bay du Nord and thence to Harbour Breton no echo-sounder traces of herring were recorded, except for a few small isolated concentrations in Long Harbour and very few were caught. West of Fortune Bay surveys were carried out in Hermitage Bay, the outer part of Bay d'Espoir, Facheux, Hare, Rencontre, Chaleur, La Hune and White Bear Bays as well as Bay de Vieux. Concentrations of herring were prevalent in all these inlets (except Hermitage Bay), particularly in the outer parts, and good indications were recorded outside the bays along the coast between Hare Bay and Cape La Hune. The usual gillnet sets were made in four of those localities (Table II).

Figures 3 and 4 give examples of herring concentrations from echo-sounder surveys. The section at the mouth of Bonne Bay (Fig 3A) represents a distance of about two nautical miles, the section in Bay de Loup (Fig 3B) a distance of nearly four miles, and the section in White Bear Bay a distance of about 8.5 miles. The recordings of Fig. 4 were made in early December when the herring were approaching the southwest coast from offshore waters. Prior to this time Harbour Breton purse-seiners in going to and from the Bonne Bay area recorded no significant concentrations of herring along the southwest coast.

From the extensive sounder surveys and gillnet sets carried out on the research vessel *Investigator II* between November 1965 and March 1966 the following observations may be made:

West coast: Herring were very abundant at the mouth of Bonne Bay in November and early December and several purse-seiners fished the concentrations until mid-December or after.

Southwest coast: Herring moved into the inlets and bays along the coast, especially between Francois and Ramea in early December. From January to March herring were prevalent in most inlets between Bay d'Espoir and Rose Blanche. Particularly in Facheux Bay, Hare Bay, La Hune Bay, Bay de Vieux and Bay de Loup.

Hermitage Bay: No herring recorded in March.

Fortune Bay: Survey in March revealed no concentrations of any consequence and gillnet catches were very small.

Placentia Bay: Small concentrations were recorded around the bottom and eastern side of the bay in February, but none were found along the western side of the bay.

LENGTH COMPOSITION, SEX AND MATURITY

During the course of the surveys of the west and south coasts herring concentrations were located mostly in the bays and inlets and samples for biological data were obtained by anchored fleets of synthetic gillnets. Usually all herring caught were measured (total length to the nearest centimetre from the tip of the lower jaw with the mouth closed to the end of the longest lobe of the caudal fin extended straight back in line with the body). From each catch samples of 100 or more herring were selected at random for more detailed examination.

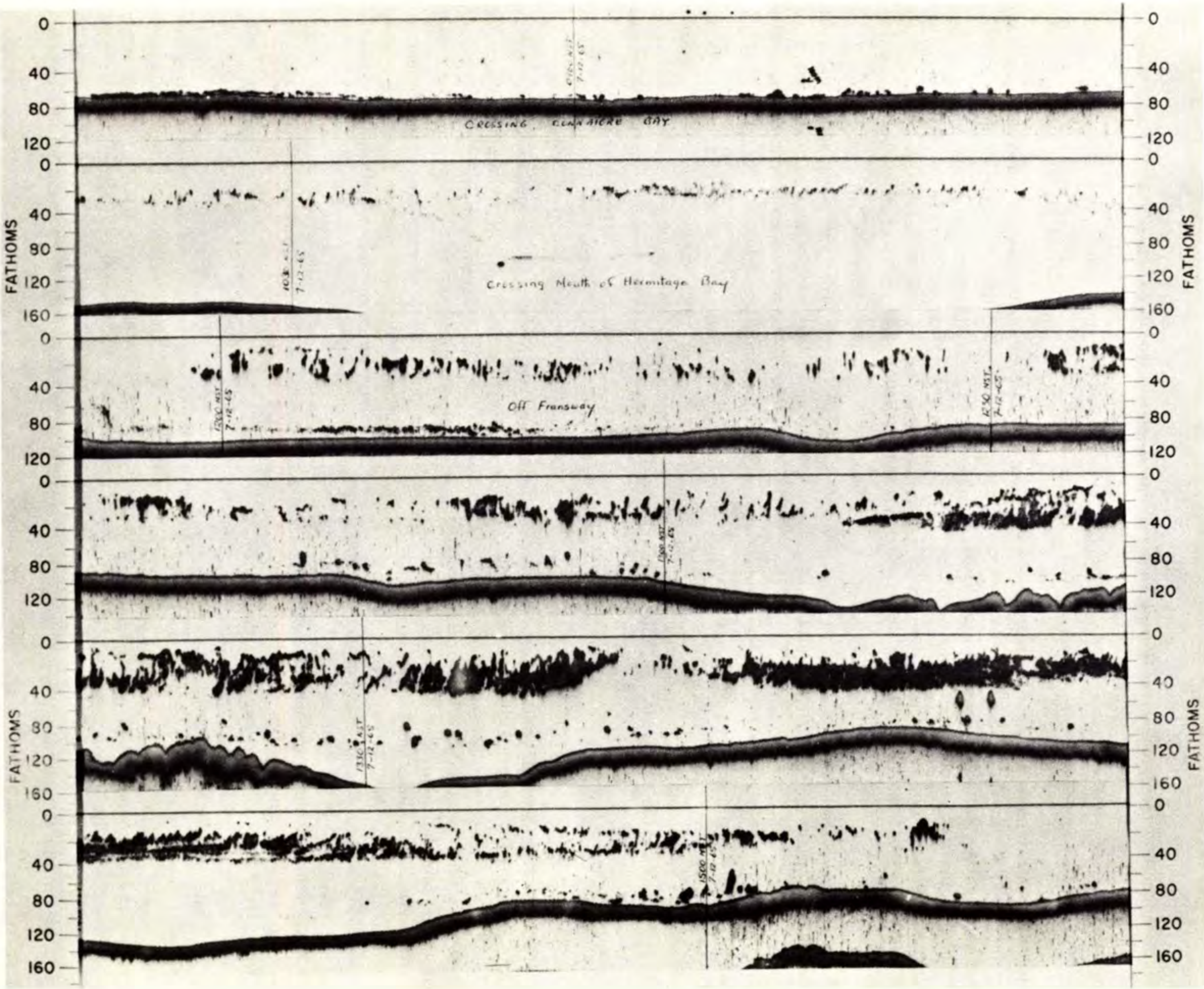

Fig. 4. Echo-sounder recordings of scattering layer on a track from Harbour Breton to Ramea, Dec. 7, 1965.

Table III gives the mean lengths and sex and maturity observations for all gillnet samples taken between November 1965 and March 1966 as well as for several purse-seine samples obtained on periodic visits to Harbour Breton. The sample from off Port Saunders was taken by otter trawl in 40–60 fathoms. The length composition and maturity of herring samples from research vessel surveys and purse seine catches along the south coast are illustrated in Figs. 5 and 6. Because there were no partly spent or spent herring in any of the samples, the spent category which normally falls between maturing and recovering in table III and Figs. 5 and 6 has been omitted.

The otter-trawl sample from off Port Saunders and the gillnet sample from Bonne Bay, near Woody Point, both consisted of larger herring than those taken by purse seine at the mouth of Bonne Bay. Also most of the herring in the otter-trawl and gillnet samples were in the spent condition with little if any gonad development for spring spawning, while 42% of those sampled from the purse-seine catches in early December had well-developed gonads (testes large and white, ovaries orange in colour with eggs clearly visible). About 50% of the herring in the purse-seine sample showed little if any gonad development following a recent spawning.

Along the south coast between Isle aux Morts and Hermitage Bay the average length of herring varied between 31.7 and 33.6 cm (mean 32.8) for the gillnet samples and between 31.0 and 32.9 cm (mean 32.1) for the purse-seine samples. Herring in samples taken in Fortune and Placentia Bays were on an average a little larger than those to the west.

From Rose Blanche to Cape La Hune the gillnet samples indicated a gradual decrease in the number of spring spawners from 77% in the west to 4-9% in La Hune Bay and eastward to Hermitage Bay. In Fortune and Placentia Bays about 60% of the herring in the samples were maturing for spring spawning. Those given as recovering, while some slight gonad development had taken place between December 1965 and March 1966, presumably spawned in the late summer or autumn of 1965.

TABLE III. Average length, sex ratio and maturity of herring from various areas surveyed by research vessels (above) and from the catches of purse seiners (below) from November 1965 to March 1966.

Locality	Date	No. meas-ured	Average length	No. sampled	% males	Maturity*		
						Imm.	Mat.	Rec.
Port Saunders	Nov. '65	100	35.0	100	43	6	6	88
Bonne Bay	" "	152	37.3	100	...		mostly spent	
Rose Blanche	Jan. '66	828	31.7	100	44	4	77	19
LaPoile Bay	" "	1,195	33.6	116	50	1	65	34
Connoire Bay	" "	870	33.4	100	45	6	52	42
Burgeo	" "	3,974	32.3	100	45	2	37	61
Bay de Vieux	Dec. '65	2,234	32.8	125	40	2	16	82
" " "	Mar. '66	244	32.7	106	45	4	5	91
La Hune Bay	" "	1,321	33.3	133	48	3	5	92
Hare Bay	" "	2,471	33.0	119	47	2	9	89
Hermitage Bay	" "	104	32.8	102	46	2	4	94
Fortune Bay	" "	529	34.6	216	46	5	59	36
Placentia Bay	Feb. "	2,680	33.7	228	52	14	60	26
Bonne Bay	Dec. '65	4,500	33.2	435	50	8	42	50
Isle aux Morts	Mar. '66	1,000	31.9	100	55	16	25	59
Bay de Vieux	Dec. '65	2,000	31.9	200	49	4	32	64
" " "	Jan. '66	1,000	31.0	100	57	16	36	48
Cape La Hune	Mar. '66	1,200	32.9	300	48	5	6	89
La Hune Bay	Feb. '66	1,500	32.5	150	49	7	11	82

*Imm. = Immature; Mat. = Maturing;
Rec. = Recovering from a previous spawning.

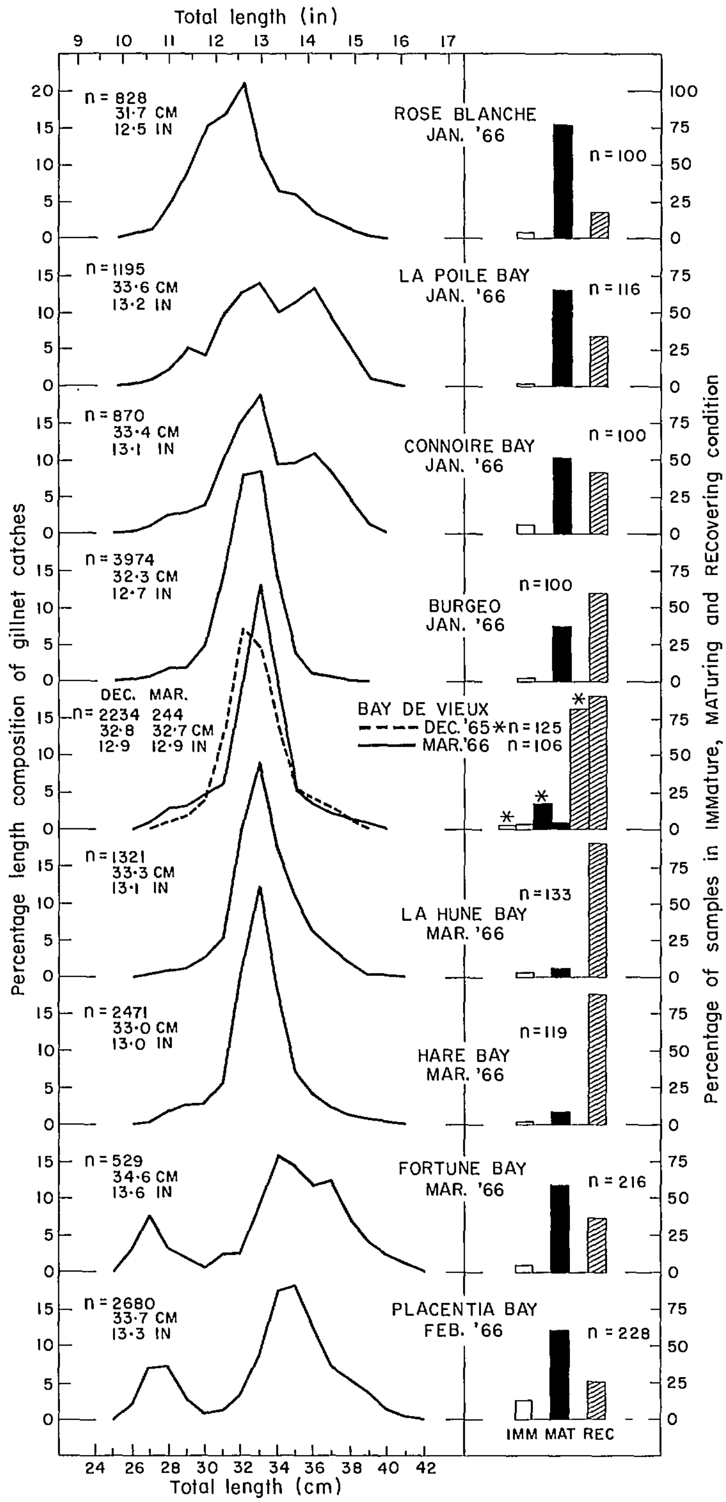

Fig. 5. Length composition and maturity of herring in gillnet samples taken along the south coast.

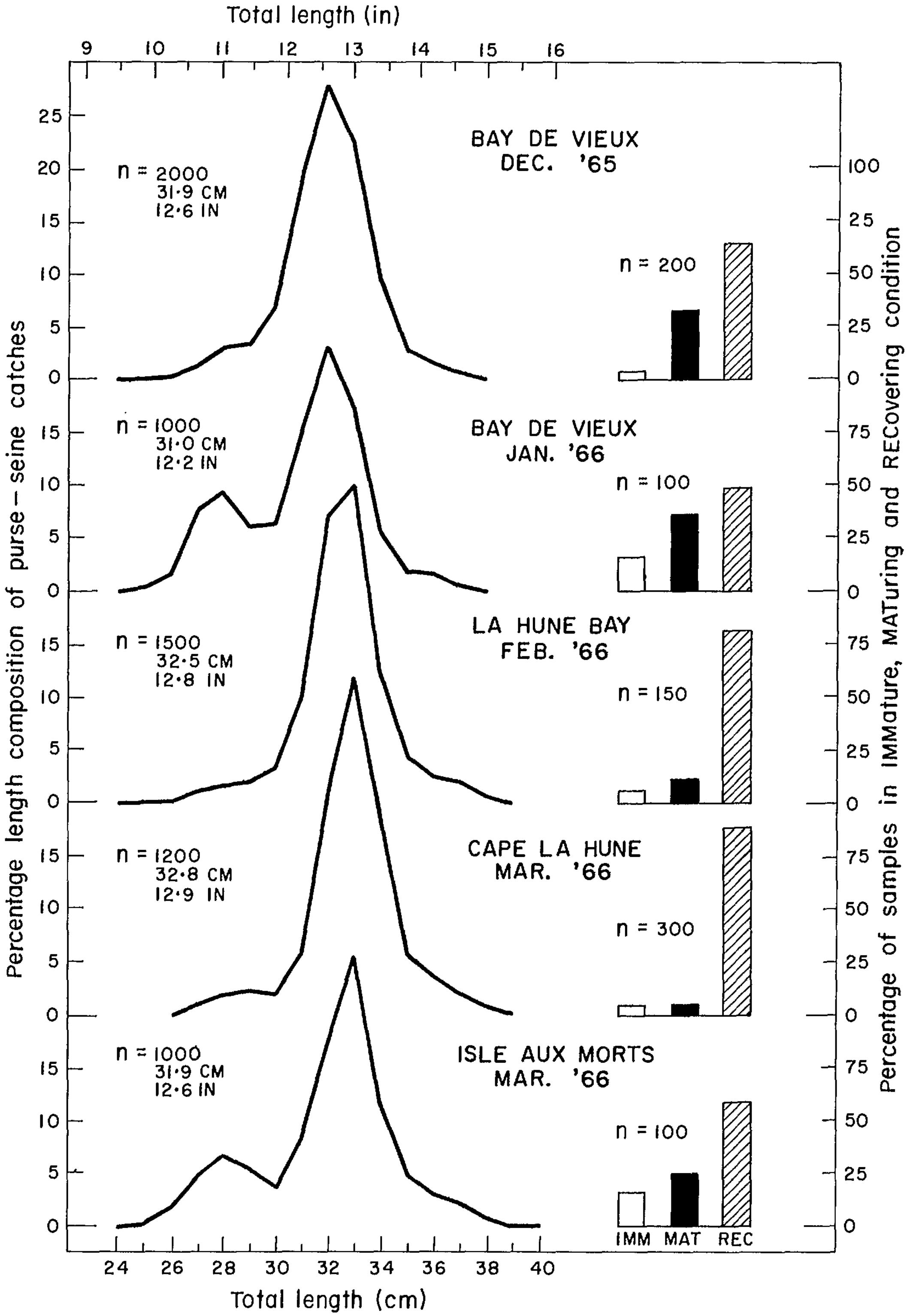

Fig. 6. Length composition and maturity of herring in purse-seine catches along the south coast.

While the percentage of spring spawners in the samples (gillnet and purse-seine) from La Hune eastward to Hermitage Bay is low (4-11%) for February and March, in the Bay de Vieux area there is considerable variability – 16% and 32% respectively in the gillnet and purse-seine catches taken about the same time in December, 36% in January by purse-seine and 5% in March by gillnets. In the Rose Blanche area in January 77% of the gillnet catch gave indication of spring spawning, but a sample from a purse seine catch in March off Isle aux Morts, about 15 miles farther west, gave only 25% of the herring as maturing.

An interesting feature of the purse-seine samples from Bonne Bay in early December and the southwest coast samples from Rose Blanche to Bay de Vieux in January was the distinct difference in size composition between herring in the maturing and recovering condition (Fig. 7). While there is considerable overlap in the size composition of the two maturity stages in both areas, those in the maturing condition averaged over two cm in length shorter than those in the recovering condition. Similar differences were not so evident in the samples from Fortune and Placentia Bays. Thus the average length of the spent herring in the purse seine sample at the mouth of Bonne Bay (35.1 cm) is similar to the gillnet sample from Woody Point which consisted mostly of spent herring.

It is clear from the above results that herring on the west and south coast of Newfoundland are not restricted to either spring or fall spawning. Since the greatest concentrations on the south coast appear to be located between Burgeo and Bay d'Espoir and since the greatest proportion of herring in the samples from this area was found to be in a recovering condition, it seems certain that there are on the south coast more late summer and autumn spawners than spring spawners.

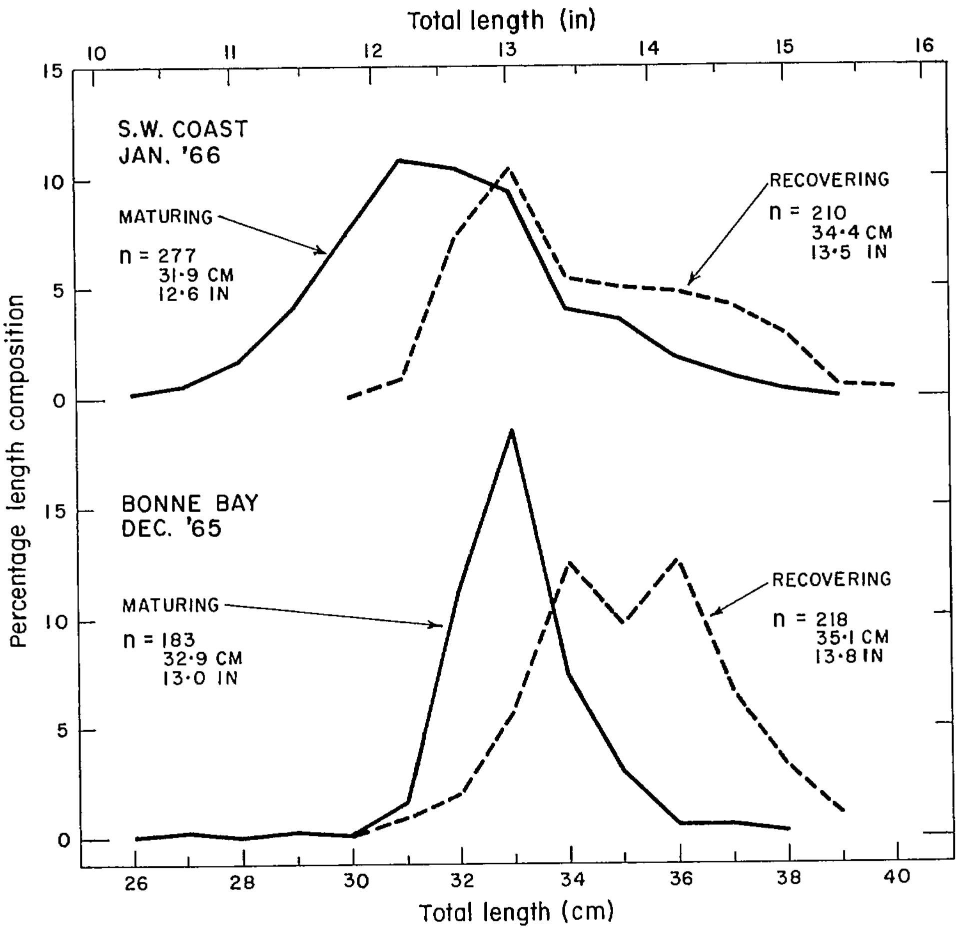

Fig. 7. Length composition of herring in samples from Bonne Bay and the Southwest Coast by maturity condition.

VERTEBRAL COUNTS

An important aspect of any investigation involving animal populations is to determine whether the concentrations found in an area belong to a single homogeneous population or whether there are a number of separate and distinct localized groups that mix only to a limited extent if at all. There are many reports in the literature where such meristic characteristics of fish, as fin ray and vertebral counts, have been correlated with environmental conditions, particularly water temperature; this factor has been shown experimentally in many cases to have a determining effect on the number of vertebrae during the egg stage before hatching of the larvae. Water temperature conditions vary from place to place and seasonally so that it is conceivable that this factor may be reflected in the vertebral pattern throughout a large area, particularly if the stocks remained separate throughout their existence.

Vertebral counts were made on many of the samples collected between November 1965 and March 1966. The herring, with viscera removed, were carefully laid out on lead trays and X-rayed with their individual tag numbers for identification. The negative plate, 14 x 17 inches, usually accomodated from six to 10 herring each, the skeletons of which were examined by means of an X-ray film illuminator.

Table IV gives the mean vertebral counts of herring samples from various localities surveyed during the past winter and autumn. No significant differences exist between any of the samples except for Fortune Bay with its high count of 55.82 and high variance of 0.62. Even the sample from Placentia Bay (55.71) did not differ significantly from the west and southwest coast samples with mean vertebral counts of 55.58 to 55.76. However, the variance for two of the west coast samples was rather high, 0.621 and 0.676 respectively for the otter-trawl and gillnet samples, both samples of which consisted almost entirely of spent herring.

In the bottom section of Table IV are the percentage vertebral frequencies and mean counts for the combined samples of four areas. The vertebral pattern in all areas is essentially the same except for Fortune Bay where the samples contained a higher proportion of fish with 57 vertebrae.

Table IV. Mean vertebral counts of samples of herring from various localities, Nov. 1965 to March 1966 (above), with the percentage vertebral frequencies by areas (below).

Locality	Date	Method of capture	No. in samples	Av. no. vertebrae	Variance
Off Port Saunders	Nov. 65	Otter trawl	98	55.65	.621
Bonne Bay	" "	Gillnets	98	55.67	.676
" "	Dec. '65	Purse seine	433	55.68	.483
Isle aux Morts	Mar. '66	" "	100	55.62	.480
Burgeo	Jan. '66	Gillnets	90	55.76	.411
Bay de Vieux	Dec. '65	"	112	55.70	.502
" " "	Jan. '66	Purse seine	99	55.63	.400
La Hune Bay	Feb. '66	" "	100	55.68	.442
Cape La Hune	Mar. '66	" "	100	55.58	.408
Hermitage Bay	" "	Gillnets	52	55.62	.477
Fortune Bay	" "	"	216	55.82	.620
Placentia Bay	Feb. '66	"	228	55.71	.416

Locality	% vertebral frequency 54	55	56	57	58	59	No. in samples	Av. no. vertebrae	Variance
West coast	4.1	34.8	51.8	8.1	1.1	–	629	55.67	0.533
Southwest coast	1.7	40.0	49.8	8.3	0.3	–	653	55.65	0.444
Fortune Bay	0.9	35.2	47.2	14.3	1.9	0.5	216	55.82	0.620
Placentia Bay	0.4	37.3	53.1	8.8	0.4	–	228	55.72	0.416

Not having completed enough age determinations to analyze the vertebral data by year-classes, the samples were combined by areas and examined for differences in vertebral counts by size groups (Table V). There was no difference in mean vertebral count between small (total length of 30 cm and less) and large herring (>30 cm) for the west coast samples. In all three areas of the south coast the mean vertebral counts for small herring were less than for larger herring, with the most pronounced differences occurring in the samples from Placentia Bay and from the southwest coast between Isle aux Morts and Hermitage Bay. However, because of the relatively small numbers of small herring in the samples, the mean counts for the larger herring are not very different from those for the samples as a whole.

From earlier, but rather sporadic, herring investigations in Newfoundland waters vertebral studies were reported by Hjort (1915) for a sample from the west coast in the fall of 1914 and by Tibbo (1956, 1957) for many samples from various areas in 1942-44 and from the west and south coasts in 1946-48. A summary of past and present mean vertebral counts is given in Table VI. While no comparison can be made for Labrador, the northeast coast and the south coast west of Fortune Bay, the available data for Placentia and Fortune Bays show little change between 1942 and 1966. On the west coast, however, the mean vertebral count decreased substantially between 1914 and the 1940's with a slight increase indicated for 1965-66.

Table V. Mean vertebral counts by size groups for herring in samples taken on the west and south coasts of Newfoundland, November 1965 to March 1966.

	No. in samples			Mean vertebral counts		
	Less than 31 cm	More than 30 cm	Total	Less than 31 cm	More than 30 cm	Total
West coast	45	584	629	55.64	55.67	55.67
Southwest coast	80	573	653	55.45	55.68	55.65
Fortune Bay	33	183	216	55.70	55.85	55.82
Placentia Bay	49	179	228	55.49	55.77	55.71

Table VI. Summary of mean vertebral counts, past and present, for various Newfoundland areas.

Area	Mean vertebral count with number of herring examined in parenthesis			
	Hjort (1914)	Tibbo (1942-44)	Tibbo (1946-48)	Hodder (1965-66)
Labrador	–	55.46(290)	–	–
Notre Dame Bay	–	55.43(352)	–	–
West coast	55.83(75)	55.57(5617)	55.52(639)	55.67(629)
South coast, west of Fortune Bay	–	–	–	55.65(653)
Fortune Bay	–	55.79(2750)	55.77(1147)	55.82(216)
Placentia Bay	–	55.69(108)	–	55.72(228)

DISCUSSION

The material forming the basis of this report is so recent that complete analysis of the data has not been possible in the short time available. However, certain features of the distribution and biology of these herring warrant further consideration, particularly the relatively recent variation in spawning times and the narrow size range in most of the samples.

From the investigations of 1942-48, Tibbo (1956, 1957) found that herring in Newfoundland waters spawned in May and June, and prior to his studies all reports indicate that there was no major departure from spring spawning. However, Squires (1957) presented the first evidence of a change in spawning habits. In late September 1955 he found recently hatched herring larvae in plankton samples from the northern part of the Gulf of St. Lawrence near the Newfoundland coast. Further evidence of the departure in recent years from spring spawning was reported by Tibbo (1959) who, from exploratory fishing with drift nets along the south coast during the summers of 1956 and 1957, concluded that spawning extended over most of the summer. Olsen (1961) from his studies conducted in 1957 and 1958 reported that Newfoundland herring showed evidence of spawning not only in the spring, summer and autumn but during the winter as well. His samples during the winter months were taken in Placentia and Fortune Bays.

Before Olsen's (1961) observations can be confirmed for the present herring stocks, data are required from a much longer period than are now available. However, one feature of the present stocks on the south and west coasts seems certain: that the populations in the areas recently surveyed consist of both spring and late summer or autumn spawners, with the latter type being more prevalent in the areas of greatest concentrations along the western half of the south coast.

What effect such a major change in biology has had on the distribution and supply of herring stocks must remain in the realm of theory. The change must have occurred, perhaps gradually, in the early 1950's, a period which coincided with the rapid decline in the herring fishery. Olsen (1961) mentions several effects that a change in spawning habit might have on the fishery. Because of seasonal variation in surface water temperature a change from spring spawning to spawning later in the season would tend to move the herring into deeper water farther offshore where the pre-spawning and spawning concentrations would not be available to the rather primitive shallow water gillnets and beach seines. Another aspect which may be even more important is that a wide spread in spawning time might lead to a general dispersion of herring, with no really large concentrations at any particular time of the year. Finally Olsen speculates on the effect that an unusually wide spread in spawning time would have on recruitment and thereby on the ultimate size of the adult population. Since most of the known herring populations of greatest abundance are usually characterized by a short and well-defined spawning period, one can only conclude that this situation is one which provides the best recruitment. Newfoundland herring, particularly on the south and west coasts, have evidently deviated from this ideal situation with the possible result of unusually low recruitment and thereby reduced abundance of adult herring.

Widespread mortality of herring in the Gulf of St. Lawrence, including the west coast of Newfoundland, occurred in the mid-1950's (Leim, 1955; Sindermann, 1958) during an epidemic of fungus disease *(Ichthyosporidium hoferi)*, and it has been estimated that at least half of the mature herring in the area were destroyed during 1954-56. To what extent the herring stocks of the south coast (and indeed those for other Newfoundland areas) were affected by this disease is unknown, since no biological investigations were in progress at the time. However, Tibbo and Graham (1963), mainly from studies in the southern Gulf of St. Lawrence, attribute the reduced abundance of herring to the fungus disease. They also report changes in herring biology, similar to those observed for Newfoundland herring (e.g. decrease in mean age, fewer year-classes, and an increase in the relative abundance of autumn spawners), and they maintain that the changes observed by them as well as those by Olsen (1961) were caused by the fungus epizootic.

The present data, though far from adequate, give the impression that perhaps spawning habits of herring along the southwest coast are becoming more stabilized with a tendency toward spawning mostly in late summer or early autumn. Since most of the southwest coast herring were generally in a spent condition, when they moved inshore in December, they probably spawn in relatively deep water off the coast or perhaps as far away as the banks off northern Nova Scotia.

Another interesting feature of the present data is the similarity of the maturity condition in the purse-seine samples from Bonne Bay in early December and in the gillnet samples taken along the extreme western part of the south coast in January. It is a well-known fact that cod, which spend the summer and autumn along the west coast of Newfoundland, move out of the Gulf of St. Lawrence in winter, thus providing an extensive winter and spring fishery along the southwest coast. It is not inconceivable then that a similar migratory pattern might also apply to herring.

While the over-all vertebral pattern of herring in the samples from the west and southwest coasts gives no evidence of separate populations, the fact that small herring along the south coast have a lower vertebral average than the larger and older fish, implies that recent changes in hydrographic conditions have perhaps occurred in this area.

Finally, the question can be raised of how the future distribution and supply of herring will be affected by the relatively narrow size range so evident in many of the samples. The earlier reports of Tibbo (1956, 1957), whose investigations were conducted over a period (1942-48) when the fishery was at a high level, show that the populations consisted largely of large and old herring with many ages represented in the samples, the average length for both the west and south coast being in the vicinity of 35-36 cm with mean ages of 10-12 years. In the present data the average size for most samples is about 32 cm with very few herring larger than 36 cm in length. The relatively narrow size range implies that a narrow range of year-classes is represented. From age determinations of about 100 herring from Bay de Vieux in January, the mean age was just over 8 years with a range of 6-11 years for the sample. Since the supply of herring consisting of these age-groups is not inexhaustible, the future of the industry must depend on the continuous recruitment of new year-classes to the adult spawning and feeding concentrations, an aspect requiring much consideration in future herring investigations.

ACKNOWLEDGEMENTS

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Quebec Herring Fishery and Research

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In this paper I wish to present some of the principal facts acquired by several years of research on the inshore herring fisheries of Quebec.

I will speak more precisely on the biology of the herring, of the resource itself, and finally of the herring fishery in the coastal waters of Quebec; which takes in the St. Lawrence River Estuary, the Gaspe, and the Magdalen Islands.

The information given here is taken, for the most part, from work previously published by the following institutions:

Fisheries Research Board of Canada
Atlantic Herring Investigations Committee
Station Biologique du St-Laurent, de l'Université Laval
Station de Biologie marine de Grande-Rivière

THE BIOLOGY OF THE HERRING

Reproduction

We know that in the Bay of Chaleur there are two spawning seasons while in other regions there is only one. It has not yet been determined what factors create this particular situation. At Grand River, we note that the spawning period lasts for about two months. It generally starts about the end of April or at the beginning of May and terminates in July with a maximum concentration of spawners near the middle of May. About 80% of the herring runs take place during the first month of the spawning period. The spawning is not all regular at this time but varies in intensity from day to day. The days of large herring concentrations coincide with the rising of the water temperature.

In the fall at Grand River we observed a much shorter spawning period, extending from August 15 to the end of September, with maximum concentrations towards the beginning of September.

The temperature of the sea water is an important factor during the spawning period.

A review of the literature covering this fact shows that the spring runs of the Atlantic herring spawn in water temperatures ranging between 0°C and 12°C, and in the fall runs between 8°C to 15°C.

At Grand River during three years of consecutive observations, we were able to determine that the temperature at the time of spawning could vary between 0.5°C to 12.9°C, with an average of 7°C for spring. In the fall we observed that the temperatures ranged from 10°C to 16.6°C with an average of 13.6°C.

In the spring runs spawning is accompanied by a rising of the water temperature, while in the fall runs it is just the opposite. The average temperature of the sea water at the time of spawning is approximately 5°C much lower in spring than in fall.

The temperature of the sea water appears to have a great influence on the start of the spawning season. As an example, at the Magdalen Islands it was established that the mean water temperature between 1933 and 1950 was 0.3°C in April and 4.5°C in May; as a result the herring catches were found to be more abundant in May than in April. On the other hand, in 1951, the average temperature of the water was 3.8°C in April and 6°C in May which produced considerably more catches in April than in May.

After fertilization the incubation of herring eggs in the region of Grand River could vary in the spring between 30 to 35 days, whereas in the fall it might be anywhere between 11 and 21 days. The incubation period is more or less controlled by the temperature of the water. As an example, the incubation of eggs lasts 35 days when the mean temperature of sea water is at 3.7°C, but with a mean temperature of 4.4°C the hatching of herring eggs may occur in 31 days.

The total production of herring larvae is considerably more in spring than in the fall.

The herring runs in the Bay of Chaleur do not always occur in the same coastal zones. In certain years we noticed a massive concentration of spawners in the eastern sections of the Bay, while in other years this incidence would take place in the western areas, that is to say, towards the interior regions of the Bay of Chaleur.

In those areas where two yields take place there is an interval of six weeks separating the spring runs from those of the fall.

Larval Stage

After hatching, young herring are subjected to the movements of currents and tides and other environmental factors such as temperature, food, predators, etc. It is important to note that after hatching herring larvae have been easy to trace in the sea, mainly because of their relative abundance.

From observations at Grand River it was possible to establish a relationship between the intensity of spawning and the abundance of herring larvae throughout the different sectors of the Bay of Chaleur. In this way we were able to see that whenever there was an intense concentration of spawning there appeared an abundance of herring larvae in the plankton.

Another fact noticed was that we encountered herring larvae at almost every depth. Plankton catches made from the surface to depths of 110 meters permitted us to establish that herring larvae occur at all depths as well as on the bottom, but they were especially abundant in the first 30 meter layers of water.

Further, one can discover the occurrence of numerous herring larvae in the plankton hauls during an entire season's fishing, or from May to November; which gives an estimation of the relative growth of herring larvae.

Herring larvae appear to make vertical migrations. Towards nightfall they will approach the surface. Plankton samples taken at night show some evidence of this fact.

Being able to trace the herring larvae so easily allows us to evaluate the production of the larvae, and this is very interesting because we should be able to establish a direct relation between the number of larvae produced and the success of the reproduction for a given year; but it remains to be seen whether this evaluation is a satisfactory indication of the importance of future year classes.

Adults

Before proceeding to talk about the adult herring as an element of exploitable fish, I should like to point out some other biological observations accomplished in the coastal waters of Quebec. It has been established that the herring feed on plankton, and in particular the copepod *Calanus*, *Cladocera*, and their own eggs as well. The herring do not frequent water where there is phytoplankton.

Unfortunately, we have little knowledge on the migration of this species. We know that during 4 to 6 weeks this fish is very abundant along our coasts but seems to disappear for the rest of the year. It is a fact that the spring herring stay near the coasts some time after spawning but the fall herring react in the opposite manner and prefer much deeper water soon after thev have spawned.

From studies on the behaviour of cod we have confirmed the fact that this fish is one of the principal predators of herring. This is particularly true for cod of 40 cm and over.

The behaviour of herring under solar or artificial light is still not fully understood. We generally admit the existence of a vertical migration of herring from the surface layers during the day to the lower layers at night, but this does not appear to be a general rule. Herring have also been located on the bottom on very clear days. On the other hand, fishermen always argue that catches of herring in the gill nets are better on a dark night when there is no moon. From preceding statements on the reproduction, larval and adult life of the herring, it is evident that we lack much knowledge on the finer points of this species.

THE RESOURCE

Comparisons given on the age, size, growth, maturity, and vertebral counts, permit us to differentiate between the various populations of herring existing in the Gulf of St. Lawrence.

In the territory that concerns us they appear as three populations corresponding to three following regions;

1. St. Lawrence Estuary
2. Bay of Chaleur
3. Southern Section of the Gulf of St. Lawrence

St. Lawrence Estuary

Here briefly are some facts on the populations of the St. Lawrence Estuary herring. The herring make their appearance in the estuary in appreciable quantities at the beginning of May. By May 15 large numbers of heavy catches are taken in the herring weirs. However spawning itself may not start until May 20.

The fishery there remains good for about three weeks.

In the month of August the herring return again to this area for a period of 15 days or 3 weeks. At that time the herring are large and fat – the local fishermen call them, "Labrador herring".

With these catches of herring in August there is also a mixture of numerous year old herring that the local people improperly term "sardines".

Between the spring herring and the larger herring in the fall there is an actual difference.

The mean year class of herring samples in the St. Lawrence Estuary is between 4.1 and 6.0 years. According to investigations on the average age of the herring of this region it varies a great deal from year to year, from season to season, and from place to place. As an example of this large variation occurring in the mean year classes of estuary herring we quote the average age of herring from registered samples taken at the following places:

Ile Verte	6.43 to 8.11 years
Matane	3.40 to 8.63 years
Fox River	4.41 to 5.63 years

The large variations that we observed in the year classes of estuary herring applies equally to the phenomena of their growth.

Nevertheless, the population of herring from this sector which spawn in spring have a much lower growth rate and a higher vertebral count than any other herring anywhere along the east coast of Canada.

We have an idea of the average length of the estuary herring from samples measured at the following places:

Ile Verte	27.64 to 31.36 cm
Matane	23.78 to 31.19 cm
Fox River	26.15 to 29.23 cm

The large differences in the average size indicates what I have mentioned above on the subject of the age and growth of the herring from these areas.

The fact that the estuary herring is not being used to its fullest potential is very evident by the accumulation of older classes of herring which make their appearance in the catches whenever the fishery is under-exploited. This means that in this region there could be a much better fishing potential than what is presently being utilized.

Like other populations of herring in the Gulf, the estuary herring disappear after spawning and we have no knowledge of their movements. Summing up, the characteristics of the St. Lawrence Estuary populations show that there are actually two populations, the spring herring and the fall herring. Grouping of these populations by mean age, length and growth, we find that they are subject to some variations as well as local, seasonal and annual. The exploitation of these stocks certainly does not correspond to the actual potential of this fishery.

The herring populations of the two other following regions, either the Bay of Chaleur or the coastal waters of the Magdalen Islands, have been subjected to a more extensive commercial fishery and probably for this reason have been the object of more elaborate research, therefore we are able to better understand some of their characteristics.

Bay of Chaleur

The principal characteristics of the Bay of Chaleur herring are as follows:

The first population of herring corresponds to the spring runs and generally consists of young herring of an average size. By contrast the fall herring are rather large and of mean age.

The youngest herring encountered at Grand River in the course of our observations were two years old, and the eldest were aged at 11 years. At Caraquet we caught herring that were aged between three and 19 years.

The year classes did not show any difference in growth from the various places in the Bay of Chaleur. It did show, however, that in the fall herring there is a somewhat more rapid growth compared to the spring herring.

For your information here are some figures of the lengths of herring corresponding to their ages:

3 years	24.2 cm
4 years	27.0 to 28.5 cm
5 years	28.7 to 32.5 cm
6 years	30.5 to 31.4 cm
7 years	30.0 to 33.3 cm
8 years	32.0 to 32.8 cm
9 years	32.0 to 34.7 cm

At Grand River the minimum length observed was 16 cm while the maximum length was 39.9 cm.

A certain number of herring from this region may reach maturity at 3 years, but for the majority it is often 4 years, while the mean size varies between 23 and 27 cm.

The largest herring approach the coast first for spawning and these are gradually replaced by other schools of smaller sized herring which diminish in size until mid-August, at which time the fall herring arrive.

The spring and autumn populations in the Bay of Chaleur do not necessarily spawn in the same season as when they were laid. Results of the populations of spring and fall herring of this region represent mixtures of both spring and fall spawners. This phenomenon allows one to believe that there is a mingling of the populations during the course of the season following spawning.

After some studies were made on the herring of the Bay of Chaleur we ascertained that the fall herring populations were composed of larger and older specimens, which had spawned several times or were ripe and in various stages of spawning.

The mean age of spring herring observed at Caraquet was 6.1 years in 1947 and 7.9 years in 1948. In the same region the fall herring showed 7.8 to 8.8 years. By contrast, the mean age samples of herring at Grand River were between 3.72 to 5.95 years.

In some areas of the Bay of Chaleur the average ages recorded in the populations of herring is higher, which would indicate that these stocks have been under-exploited. There would be a particular advantage in trying to recover herring after spawning because they are of a much higher quality than when they first come to spawn and therefore more valuable to the consumer.

It is important to remember that the different year classes fluctuate considerably in their abundance. We established that in certain years a major portion of the available stock (from 60% to 90%) was only from single year classes.

Summing up, the characteristics of the Bay of Chaleur herring prove they are somewhat larger and much older, that the rate of growth is somewhat higher and the mean vertebral count much lower than herring from the St. Lawrence Estuary. Finally, it is certain that there is a possibility of receiving a better potential by increasing our methods of fishing these stocks.

Magdalen Islands

For the herring from the Magdalen Islands I refer mainly to work that was carried out by the Fisheries Research Board of Canada and the Atlantic Herring Investigation Committee.

The populations of herring that come to the shores of the Magdalen Islands present the following principal characteristics:

There is only one spring run: the length is average; the mean age of the herring is about average; and finally the growth is faster.

The herring generally arrive at the shores of the Magdalens when the temperature is in the vicinity of 2°C. On the other hand, the first herring have often been caught 10 days after the complete disappearance of the ice.

In this sector the herring reach maturity between 3 and 5 years. The growth of the Magdalen Islands herring is fairly rapid particularly during the first 3 or 4 years of life; following that it is somewhat slower.

Information on the length of the Magdalen Islands herring for the different ages is established as follows:

3 years	25.7 to 25.9 cm
4 years	27.8 to 28.1 cm
5 years	28.6 to 30.4 cm
6 years	30.2 to 31.2 cm
7 years	30.4 to 31.8 cm
8 years	32.1 to 32.7 cm

Samples from the Magdalen Islands show that the average age of herring is between 5.4 and 6.9 years. The ages of Island herring reveal that there are just a few year classes compared with the other regions of the Gulf.

The herring stocks of the Islands have been the object of intensive fishing for several years. However, it does not appear that these stocks are seriously affected by this.

The herring remain in the vicinity of the Magdalen Islands for about 6 or 8 weeks, after which, like the other regions in the Gulf, they disappear.

THE HERRING FISHERY

In 1965, Quebec landings totalled 46 million pounds of herring. This was an increase of more than 5 to 6 million pounds over the preceding year. It has been verified that total landings of herring in the coastal waters of Quebec vary considerably from year to year. As an example, in 1951 registered catches totalled 29 million pounds; in 1953, 46 million pounds; in 1955, 59 million pounds; in 1959, 22 million pounds; in 1960, 19 million pounds. Since 1960 statistics show a gradual increase in landings which rose to 46 million pounds in 1965.

These fluctuations are important and may take into account the exploitation of this species. One of the first causes of the variations would also be the success or failure of the reproduction. It is a fact that certain year classes contribute a great deal to maintaining the stocks while other year classes add little to their populations.

I have mentioned previously that the herring do not always come to the same area for spawning. This may also explain some of the variations encountered in the yearly landings.

How does one assess the landings in the regions of Quebec?

From 46 million pounds landed in Quebec in 1965, the major portion of this total (representing 80%) comes from the Magdalen Islands. Gaspe contributes 6,200,000 pounds; the St. Lawrence North Shore 1,290,000 pounds, and the balance of 300,000 pounds comes from the St. Lawrence Estuary.

For the herring fishery 3 types of gear are utilized in Quebec. In the upper Estuary they employ herring weirs; in Gaspe and the North Shore of the St. Lawrence they use gill nets; while on the Magdalen Islands the only gear now used is the herring trap; although I believe in the last 2 years they have also tried the purse seine. The catches from this latter gear did not necessarily come from the southern part of the Gulf.

Needless to say, even with catches from different types of gear it would be difficult to make an evaluation and say what would be the normal potential for this fishery. We do believe that at the Magdalen Islands we are taking a good advantage of the stocks coming to the shore. The gill net fishing in Gaspe and the St. Lawrence North Shore is used mainly for the purpose of obtaining bait for hand lines and lobster fishing, and is not continued for more than a week or two, or until sufficient quantities have accumulated in the refrigeration plants for bait. The same may be said regarding the herring weirs in the Estuary. The proprietors of these weirs only take what they can sell locally, or use as fertilizer, and the balance is thrown back in the sea. Therefore, it can be said that the herring stocks frequenting the Bay of Chaleur and St. Lawrence Estuary are not used to their fullest and would present a very important fishing potential with the existence of a better market.

The landings of herring in Quebec are utilized in the following manner: 25 million pounds are transformed into fish meal; 5 to 6 million pounds are sold fresh; 7 to 8 million pounds are made into bloaters; and the balance is used as bait or fertilizer.

We have seen from what has already been stated that large variations exist in the over-all catches. We would like to mention a few of the factors that might possibly cause some of these differences. First, the temperature of the water greatly influences the success of reproduction as well as the arrival of the herring along the coasts. The winds and tides are important factors when speaking of the herring fishery in the Estuary. We see also that there are many important variations in the year classes and that in certain regions there are only one or two year classes which constitute the major portion of the available stocks.

Actually, in most instances, the herring fishery in Quebec is limited to a few weeks in the spring.

I would like to mention also that the diseases of herring can cause certain perturbations in the populations of this species. Another important factor to consider is the price paid for landings of herring.

It should be possible to eliminate some of the causes which make our herring fishery so unstable. A better use of the fishing potential that is offered in the herring stocks of the Gulf, can help to balance some of the inconveniences.

CONCLUSION

In the course of this paper I have mentioned that the herring fishery of Quebec is limited to the spring runs almost exclusively, and that the herring caught during this period is not of the best quality for the consumer market.

From this it is evident that much could be done to lengthen the fishery by trying to recover some of the stocks after they have spawned. Already studies have been made in the different regions for this purpose. These investigations, notably by echo-sounder, have shown favourable results.

We are under the impression that the biology of the Atlantic herring needs much further investigation. If we are to make the herring fishery a profitable one and extend it over a longer season, it is essential that we intensify our research in the following ways: Experimental fishing, exploratory fishing, studies of herring behaviour and in particular the migrations of this species.

HERRING CATCHES AND LANDED VALUE, QUEBEC, 1950-65

1950	31,664,000	$209,000.
1951	28,810,000	170,000.
1952	42,821,000	225,000.
1953	46,100,000	261,000.
1954	34,491,000	251,000.
1955	59,175,000	206,000.
1956	38,642,000	192,000.
1957	36,569,000	212,000.
1958	23,422,000	139,000.
1959	21,872,000	261,000.
1960	18,919,000	186,000.
1961	26,414,000	322,000.
1962	41,242,000	332,000.
1963	39,668,000	367,000.
1964	41,053,000	298,000.
1965	45,741,000	271,000.

From Monthly Review of Canadian Fisheries Statistics 1950-1965.

HERRING – Quantity and value of products marketed in 1964.

Products	Quantity	Value
HERRING		
Fresh...............	5,552,000 lbs	$109,877.
Frozen..............	94,100 lbs	5,428.
Smoked	146,097 boxes	242,208.
Pickled	1,260 barrels	14,945.
Bait	5,705,700 lbs	78,654.
Fertilizer	30,000 lbs	300.
TOTAL VALUE:.....		$452,412.

MONTHLY HERRING CATCHES AND LANDED VALUE QUEBEC – 1960-65

	1965		1964	
	Lbs	$	Lbs	$
April...	4,089,800	29,151.–	1,978,300	30,009.–
May....	37,051,400	175,907.–	36,349,200	174,301.–
June ...	2,963,900	27,761.–	796,200	19,469.–
July ...	484,700	9,856.–	363,200	13,321.–
August .	545,400	11,131.–	573,500	17,155.–
Sept....	395,200	7,911.–	364,500	13,393.–
Oct. ...	333,200	5,789.–	314,400	11,911.–
Nov. ...	150,500	2,202.–	178,300	9,800.–
Dec. ...	50,800	623.–	39,700	595.–

	1963		1962	
	Lbs	$	Lbs	$
April...	1,130,200	27,193.–	145,800	5,197.–
May....	35,131,200	245,687.–	36,883,000	231,701.–
June...	434,700	11,230.–	1,308,400	17,764.–

	1963		1962	
	Lbs	$	Lbs	$
July ...	558,100	20,272.—	522,700	12,912.—
August .	1,074,200	23,841.—	1,082,000	28,128.—
Sept....	593,000	13,603.—	421,800	10,311.—
Oct. ...	492,000	12,701.—	270,400	5,315.—
Nov. ...	139,300	8,557.—	240,500	4,942.—
Dec....			32,800	895.—

	1961		1960	
	Lbs	$	Lbs	$
April...	12,300	528.—	832,700	9,972.—
May....	20,000,400	211,901.—	12,731,800	96,680.—
June ...	1,447,900	20,498.—	411,000	7,895.—
July ...	313,300	8,931.—	360,500	11,768.—
August .	960,000	22,251.—	952,700	27,300.—
Sept....	484,900	11,610.—	359,500	11,537.—
Oct. ...	114,400	2,455.—	100,200	3,537.—
Nov. ...	115,400	2,708.—	5,900	82.—
Dec. ...	13,400	256.—		

Herring Resource Research Needs

by

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BACKGROUND

The herring resources of the Canadian Atlantic Coast have been studied, with varying degrees of intensity, for more than 50 years. In general, the accumulation of knowledge about herring has been restricted by the limited demand for information and the resultant low priority given to herring research. Rarely have we had more than two scientists investigating Canadian Atlantic herring at any one time. Exceptions have been the Canadian Fisheries Expedition in 1914-15, the Passamaquoddy Investigations in 1931-32 and 1956-59, and the Atlantic Herring Investigation Committee program in 1944-49.

A list of literature on herring in the Northwest Atlantic is available to those interested in referring to approximately 300 papers on Canadian Atlantic herring.*

UNSOLVED PROBLEMS

In spite of this impressive accumulation of background information, we are still unable to provide satisfactory answers to some of the important questions concerning our herring resources. Scientists can advise that available herring resources are grossly under-exploited. They can offer general advice on where, when and how herring are concentrated for capture. They can answer many questions concerning stocks and migration, fish sizes and ages, spawning and feeding, and fatness and disease. But they do not have enough information to provide the quantitative advice required to make best use of our herring resources. More research is needed to assess the size of the resources, by their component stocks, and the quantity of herring that can be taken from each on a sustained basis. More research is needed to forecast the availability and stability of concentrations of herring required to sustain profitable fisheries. More research is needed to understand herring physiology and behaviour as they relate to more efficient exploitation of available resources. Finally, more research is needed to predict effects of expanding exploitation on traditional herring fisheries, such as the valuable sardine fishery at the mouth of the Bay of Fundy, and to advise on appropriate management practices which may be desirable to produce the greatest long-term profits from herring resources available to Canadians.

The Fisheries Research Board is currently expanding research efforts on these problems in response to national and international interests in increased exploitation of Northwest Atlantic herring resources.

* International Commission for the Northwest Atlantic Fisheries 1964. Document 4. Serial No. 1289.

A bibliography of herring (Clupea harengus) in the Northwest Atlantic (a compilation of references submitted by Canada, U.S.S.R. and U.S.A.) available from Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. or ICNAF HQ, Bedford Institute of Oceanography, Dartmouth, N.S.

RESEARCH MEDIA

There are three main avenues of investigation which must be pursued to answer the key questions currently posed to research scientists – (1) The commercial fishery must be carefully followed through good statistics and sampling of landings; (2) Extensive investigations must be carried out at sea from research vessels; and (3) Laboratory studies of herring physiology and behaviour are required to provide bases for interpretation of distribution and behaviour of fish at sea, and for improvement of fishing operations at sea.

All these lines of research should be intensified if development of our herring fisheries is to be pursued intelligently:

1. *Commercial fishery* statistics of catches by area, month and method fished, and in relation to fishing effort are essential data for evaluating the herring fishery potential. Samples of landings for fish sizes, ages, sexes, maturities, food, parasites, diseases, oil contents, vertebral counts, and protein electrophoretic patterns enable biologists to define the various stocks of herring, to describe the life history of each, to evaluate seasonal and long-term changes in quantity and quality of catches, and to assess effects of fishing on supply and availability of herring. The expansion of fisheries by vessels capable of fishing at considerable distances from landing ports is creating heavier demands on those responsible for following the commercial fishery. Co-operation among industry, provinces, Department of Fisheries and the Fisheries Research Board is mandatory in this area of investigation.

2. *Research vessels* are needed to sample areas not fished commercially, to mark and tag fish, to survey with sounders the distribution and density of herring in relation to water transport, temperature barriers, light penetration, feeding and spawning areas, to study transport, food, growth and survival of larval and juvenile fish, and to explore ways and means of improving fishing gears and fishing techniques. The Fisheries Research Board is providing for more herring research at sea by assigning the 84-foot *Investigator II* to full-time herring work from the Biological Station at St. John's, Newfoundland, by building a new 130-foot pelagic fish research vessel, the *E.E. Prince* for the Biological Station at St. Andrews, N.B., and by expanding research on oceanography and fish production at the Bedford Institute of Oceanography in Dartmouth, N.S. The Province of Quebec is contributing effective herring research in the Gulf of St. Lawrence.

3. *Water laboratory studies* of herring physiology and behaviour have been carried out on a very small scale to date. Expansion of this research is required to study effects of light, temperature and food on larval, juvenile and adult herring. Research on fish behaviour can aid our understanding of schooling, effects of gear, and techniques for attracting, guiding, shocking and capturing herring. Facilities for such water-laboratory research are to be increased at St. John's, Dartmouth and St. Andrews.

PRIORITIES

Although increases in scientific staff and facilities are providing a more aggressive program of herring research, the problems are too large for rapid solution. To be most helpful, it is necessary to establish priorities for herring research projects.

The most important question asked by industry and governments is: "How large are our herring resources?". Two approaches are being followed to answer this very large question. The traditional approach is to determine fish mortalities from age compositions of herring and observe the effects of increased fishing intensity on these mortalities. The relationship of landings to exploitation rate measures stock sizes. The present herring fishery expansion will aid this research. However, the multiplicity of stocks, the segregation of herring by sizes and in schools, the diurnal vertical movements of herring, and the seasonal migrations for feeding and spawning all contribute to the complexity of the investigation. To date, we are only able to say that fishing mortality in most areas appears to be very low and that stocks appear to be very large. This traditional approach to quantitative assessment of resource sizes is fraught with so many difficulties that a new approach is being attempted by the oceanographic laboratory at Dartmouth. Instrumentation is being developed to measure fish density with echo-sounder equipment. It is hoped that this approach to the study of fish distribution and abundance will provide useful estimates of herring stock sizes. Both approaches are so full of technical and sampling difficulties that much more effort will be needed in both directions if we are to achieve quantitative estimates of resource sizes.

A related and almost equally important question is: "Are concentrations of marketable herring so distributed in time and space that fisheries can be developed to fully exploit the available resources?". Here again, traditional population-dynamics and new echo-sounder techniques must be used to quantitatively predict opportunities for development of Atlantic herring fisheries.

Third priority might be given to the questions: "Will the development of new herring fisheries affect traditional inshore fisheries such as the sardine fishery in the mouth of the Bay of Fundy?", and "What management practices can be recommended to provide the greatest long-term benefit to all concerned with exploitation of Northwest Atlantic herring?". These questions have no easy solution. They involve determination of the spawning sources of herring recruits and the factors affecting abundance and availability of herring. Long-term studies of this problem by St. Andrews and Boothbay Harbour laboratories are throwing light on the subject, but reliable predictions and determination of management requirements still appear to be a long way off.

CONCLUSION

Canadian Atlantic herring resource research is carried out from laboratories at St. John's, Nfld., St. Andrews, N.B., Dartmouth, N.S. and Grande-Rivière, P.Q. Scientific staff and research facilities are being increased in response to the demand for new information on resource size and distribution, on maximum sustained yields to be expected from each major stock, and on improved fishing techniques. Long-term research on herring resources, with shifts in emphasis to deal with the major problems of the day, provides the most efficient method of dealing with the major resource questions posed by industry and governments.

Session 1

DISCUSSION

Dr. Marcotte was asked to elaborate further on the price for herring as a factor in variations of catch. He replied that his reference to this was in connection with Quebec landings for which prices had been fairly low. It did not concern the whole Atlantic coast.

Mr. Humphreys, in answer to a question, said that the objective of the most recent research *referred to in his paper was to define spawning populations and perhaps from this basis to be able to predict the year class strength, several years in advance, measuring the abundance of eggs, larvae, or both, and also to learn something about the rates of mortality between the time that the fish is hatched and the time that it enters the fishery.*

Mr. Donald McLean, Black's Harbour N.B., asked what percentage of increase in the herring landings predicted for New Brunswick could be expected for the Bay of Fundy and what effect the increased landings had on the existing sardine industry.

Mr. Tibbo said that the Biological Station at St. Andrews had not made predictions on which the question was based. "We have made statements that we believe the catches could be increased substantially but we did not quote figures on them. We have always had reservations about how much the fishery in the Bay of Fundy could be increased. As has been said today, the catch is dependent to a large extent on one- and two-year-old herring and in any statements that have *come from the Fisheries Research Board as to what possible increase there might be, we have always reserved comments on the Bay of Fundy. However, we have been brash enough at times, and I was reminded of this yesterday, to give some indication of what we thought the increase might be, and Mr. Meagher reminded me that some time ago I said that it might be doubled and he thought it was pretty ridiculous at the time, but this has already happened. I think the major increase is likely to come from the Gulf of St. Lawrence. This is the area where we have large stocks, many populations of large and old herring and these are the ones that would appear, to us at St. Andrew's anyway, to have the greatest potential. The catches in these areas are not very great at the moment. The total catch (for Magdalen Islands) for the Gulf of St. Lawrence is less than half that of the Bay of Fundy and we believe that as far as New Brunswick is concerned, and this was the question, I believe, the major part of the increase might come from the Gulf of St. Lawrence rather than from the Bay of Fundy, although we might anticipate some modest increase in that area, too."*

Carl Liden, of the United Fishermen and Allied Workers Union, Vancouver, B.C., asked Dr. Martin, with regard to the priorities mentioned in his paper, what management practices could be recommended to provide the greatest long-term benefit to all concerned. He said: "I am concerned with what priority the fishermen themselves would come into and just where their long-term benefits are and how they are being considered."

Dr. Martin: "We are very much concerned with the development of the fishery as a whole, i.e. fishermen, producers and consumers. My remarks referred to the equal weight that we are giving in our research to opportunities for development and expansion, and to the need to see that expansion of new fisheries does not seriously affect some of our traditional fishermen. In other words, we are looking for maximum long term benefits for all concerned."

At this point Mr. Skud, in response to a previous request from Ken F. Fraser, Vancouver, B.C. showed slides to provide an idea of the size of vessels in the operation on Georges Bank being carried out by the Russians. Three of the slides were views of a factory ship with side trawlers unloading their catches at its side. Mr. Skud said:

"Their operation, as I think you know, is with both side trawlers and stern trawlers using what the Russians term an off-bottom trawl. Early in the start of this fishery in 1961 and '62 they did a lot of gill netting as well, mostly in the late winter and early spring and part of the summer, but their catches were so much better with trawling in the fall and in the spawning season that gill netting has ceased entirely by this time.

Mr. Skud also showed a view of a Russian stern trawler. He commented: "In our research cruises out there we used the Dutch herring trawl very successfully. To my knowledge no purse seining has been detected out there, but the water on Georges Bank is shoal enough that it could conceivably be used at certain times of the year depending upon the behaviour of the herring. They spawn out there starting in September and of course are at the bottom at this time and spawning continuously through until November."

He then showed a photograph of one of the Russian side trawlers, drawing attention to the barrels on the bow. "Most of the fish are salted down. Herring in Russia, as in most of Europe, is considered quite a delicacy and some estimates on the cost to the buyer over the retail market in Russia indicate that they pay more than we do per pound for tuna in the U.S., so it is a relatively expensive item over there. This was the first time during our research cruises that we noted the transfer of fishermen. The fishermen are on a rotation basis on Georges Bank."

Mr. James Stewart said that one's initial reaction to the Conference was perhaps that there had been an apparent lack of research carried out over the past 10–20 years on the Atlantic *herring, and wanted to know how such research compared to that carried out on the Pacific herring during the same period, and how one could initiate (on the Atlantic coast) the various methods of protection and conservation which had gone into effect in British Columbia during the past few years.*

Dr. Martin replied: "Research on herring on the Atlantic coast has been as extensive as that on the Pacific coast. In general, we have only had one senior scientist assigned to herring biology at any one time in British Columbia. I think it would be unfair to say that the research has been greater on the Pacific Coast of Canada than on the Atlantic. With regard to the second part of the question, the evidence indicates that the herring resources along the British Columbia coast are pretty fully used. The fishing mortality is high and we don't think that substantial increases in landings could be achieved by increased fisheries. On the Atlantic coast we see quite a different situation; a larger number of stocks ranging over a much larger geographic area. There are great differences among these – some are pretty fully used and some are grossly underexploited. We need more research in order to provide a sound basis for advice on management on these fisheries, including restriction wherever it it necessary. However, our general observation for the whole area is that expansion should be the general course of events for some time."

Gordon Riley asked Mr. Tibbo about catch rates at the boat level, the year class catch structure, and how total mortalities compare to those of the Pacific herring.

Mr. Tibbo said: "I am not sure how much of your question I can answer. The information regarding boats, their catch and the effort that's involved and so on is not available – at least not to us. It is a rather peculiar situation really, in that the mobile fleet that's been involved in herring fishing has operated under difficulty so that its efforts have been restricted because of lack of markets for catches. This situation is very rapidly changing, of course, here in the Bay of Fundy, but certainly this was the situation up to the last year or so. I think you have to have more than just a year or two of observation in things like this to see how catch effort varies, and we don't have this. We've had difficulty trying to get effort figures from the seiner fleet anyway. They are quite secretive about some of their observations, and we have not had as much information on this as we would like to have.

With regard to the other part of the question, regarding year classes, age composition, total mortalities and so on, again we don't have nearly as much information as we would like to have on this – it varies with areas – it's already been mentioned that for the Bay of Fundy area we are dealing mostly with 1- and 2-year-old herring. These are juveniles and the so-called sardines that are canned here. This is true particularly for the inner parts of the Bay. There are some large herring that are caught towards the outer part of the Bay, both on the New Brunswick side and on the Nova Scotia side. I don't recall offhand the recent age-class composition of the southwest Nova Scotia stock, but this can be passed along to Mr. Humphreys who I am sure can give you the answer to this; as for the other areas – the Newfoundland area and the Gulf of St. Lawrence – perhaps Dr. Marcotte and Mr. Hodder can answer these parts of your question."

Mr. Riley then asked for an estimate of the total mortality. "The reason I'm questioning this a little bit is that these are some of the key areas and everyone has spoken about underdevelopment related to the year class structure."

Mr. Tibbo: "We believe that the total mortalities are quite low in this area. We've had a disease situation in the Gulf of St. Lawrence particularly which destroyed a lot of the herring in the area, but ages ran up to 17 or 18 and sometimes to 19 years in some of these stocks. We've had average ages of 10–12 years, particularly in the Newfoundland area. They vary by populations – we have at least a dozen individual populations of herring on this coast that we can recognize *and the age structure for each of them is different. I would think that on the average the total mortality rate is not greater than 10 per cent in this area.*

Mr. Hodder, in reply to a question, stated: "As was mentioned of course, earlier, our program just started late last year and we've concentrated our efforts this past winter on the south coast. We're hoping, in the near futute, to move to the Labrador area where a large population existed at one time and perhaps may still be there. The east coast, of course, the Notre Dame Bay area, I think has potential, and while our surveys will perhaps not be as comprehensive as we would like them to be, we hope in the next year or two to carry out fairly widespread coverage of the whole of the Newfoundland area, including the southern part of the Labrador coast as well."

Mr. Tibbo was asked what exploration had been done in the Sable Island area. He said that some work had been carried out there: "We chartered a vessel to search for herring in the offshore areas of Nova Scotia some years ago – in 1953, if I remember rightly. We were trying to follow up reports of large quantities of herring that had been observed in the Sable Island area. We caught herring fairly consistently, but we didn't catch many in very large quantities.

"I suspect from the reports that we have had from fishermen that they are abundant there at times, but we certainly weren't able to locate any large quantities at the time that we were there, and I think that the situation was the same as far as the Russians were concerned. When they came over here searching for offshore concentrations of herring they covered the whole area, not only the Georges Bank. Herring concentrations on Georges Bank had been reported previously and they eventually ended up by putting most of their effort there, but their surveys show that they covered the Sable Island area perhaps just as thoroughly as they did Georges Bank before they started fishing there. So although I think there are quantities of herring in the Sable Island area at times, I don't believe that they are there to the same extent that they are on Georges Bank. I might add that we're not happy about the state of our knowledge in the Sable Island area and we do have plans this year to have another survey carried out there."

L.S. Bradbury, General Secretary of the Conference, said that two written questions had been submitted. One was directed to Dr. Martin by Mr. Don Petrie of the Atlantic Fish Processing Co. Ltd. "A number of speakers this morning pointed out that cod and haddock, to name two species, feed on herring. My question is, therefore, are we in danger of cutting off our noses to spite our faces? How dependent on herring are these more valuable species? Can the utilization of herring cause a decrease in the stocks of cod and haddock? Have the biologists any fear in this regard?"

Dr. Martin: "We don't have any reason for concern about the effect of increased exploitation of herring resources on existing resources of cod and haddock and catches of these. Haddock are bottom feeders. They live on invertebrates and they do not feed on herring. Cod feed on invertebrates at smaller sizes; large size cod feed quite extensively on herring. In the Gulf of St. Lawrence during the '50s when we had a big mortality of herring due to fungus disease, there was quite an apparent increase in growth rate of cod, showing the relationship between cod and herring as its food. With increased exploitation of cod the average size of cod is decreasing; as a result cod are less and less dependent on herring as time goes on. I think that an indication of lack of concern about this problem can be pointed out by referring to comparative statistics for the species mentioned for the two sides of the Atlantic. In the North east Atlantic the herring fishery has grown to a size where landings are about 10 times those of herring in the Northwest Atlantic, and in spite of this very large herring fishery in the Northeast Atlantic, we still have the largest cod and haddock fisheries in the world in that area."

Dr. Needler: "Might I add a word. When I was a little bit younger – in my 20s, I examined some 10,000 haddock stomachs and fish of all kinds were practically absent – they don't depend *fish at all. They sometimes eat fish eggs, herring eggs included, in large quantities, but this is in our waters a very local and relatively unimportant phenomenon so far as supporting the haddock are concerned. They are bottom grubbers and not fish eaters."*

J.C. Gallant, Souris, P.E.I., to Mr. Tibbo: "Has any survey been made of the potential of the herring in the Pictou Island area and if not, can a survey be made this coming summer? Herring hit this shore from August onward."

Mr. Tibbo: "The answer to Mr. Gallant's first question is yes. There have been some surveys carried out in that area. They were done (some of them) during the days of the Atlantic Herring Investigation Committee in the late '40s, and some attempts at purse-seining with very small vessels were made in that area in August and September, so far as I can recall. The reports of these surveys were given in the report of the Atlantic Herring Investigation Committee which was published in 1957. It is Bulletin III of the Fisheries Research Board. Subsequently, there were some other explorations carried out in the area. These were done in 1953 and 1954, and were not quite so close to Pictou Island as the seining surveys that we made, but they were in that general vicinity, and they were done with bottom trawls and drift nets.

"The answer to your second question is no. I don't think that we have the facilities for carrying out explorations in that area this year. We're committed to other programs that will tax our resources to the limit and while we're quite interested in the area, we had not planned to do anything in that area this year."

Session 2 May 5, 1966 – 2.00 p.m.

Herring Fishing Gear and Techniques

Moderator

E.M. Gosse,
Deputy Minister of Fisheries,
Newfoundland.

Winter Herring Fishing on the South Coast of Newfoundland

by

Adrian Peuvion

Technical Adviser, Department of Fisheries of Canada

The four units described below were not originally intended for purse-seine fishing, and the changes made to adapt them to the new gear resulted in more or less increased yields according to the type of vessel, the layout of superstructures and available deck space.

DESCRIPTION OF FLEET

The fleet supplying the B.C. Packers' fish plant at Harbour Breton is mainly made up of the company's trawlers. The plant thus carries out cod filleting as well as the filleting of various gadidae of the Gulf, in addition to the Atlantic redfish, wolffish and flounders.

The following vessels are used in herring fishing and equipped as seiners:

M. V. Lavallée Registered length, 114.3; width, 22 ft. This vessel was a minesweeper and a former whaler in the Pacific. It is the most efficient unit. Construction is wood. Tonnage, 190 t. Engine, 375-H.P. diesel. Vessel has two generators coupled with a hydraulic pump for the machinery on board. Skipper, – Kirk Anderson. Seine dimensions, – 325 x 45 fathoms.

M. V. Eastern Pride Registered length, 84.3; width, 23.1 feet. 147 tons. Seine, – 325 x 45 fathoms.

M.V. Quadra Isle Registered length, 69.8 ft.; width, 20.4 ft. 101 tons. Seine dimensions, – 325 x 45 fathons. 290 H.P.

The following unit was also part of the B.C. Packers' fleet under contract:

M.V. Stuart & Lynne Registered length, 84.8 ft.; width, 23.3 ft. 167 tons. Seine, – 275 x 45 fathoms. 495 H.P.

A vessel from the Magdalen Islands, under contract with Fortune and Grand Bank plants, was also operated in the same waters:

M.V. Mary Joanne total length, 89 ft.; width, 21.8 ft. 120 tons. Seine, – 275 x 45 fathoms.

It may be of interest to mention the *Sen-Sen*, 450 H.P., a light unit intended for liaison purposes and not for fishing, but equipped with an echo sounder and appropriate for explorations.

EQUIPMENT

Echo sounders

There were, for instance, on the four units, three different types of echo sounders: one from 0 to 40 fathoms, another one from 0 to 80 fathoms, and a third one from 0 to 120 fathoms.

In this case the second one was the most appropriate due to its mean ratio of 0-80 fathoms as a first reading.

The definition of the signals is sharp and does not lead to confusion, as the first one does.

Asdic.

Two of the vessels were equipped with Asdic (scanners). One was Swedish, the other German made, the latter of a very complicated interpretation, but quite accurate and with great possibilities. Asdic is at present very little used for fishing purposes in the south coast bays, which should rather be called "fjords" due to their bluff coasts and narrow width. These send back the Asdic sounds, resulting in utter confusion of sound and diagram. By way of compensation, from half a mile offshore, the apparatus is used successfully, as was the case during the month of March when herring began leaving the fjords.

Loran and Decca

Two of the units, the *Stuart & Lynne* and the *Eastern Pride,* had both instruments on board, but only the first mentioned was sometimes used, navigation being carried out at sight or with radar. The Decca system is rather useful for navigation on the high seas for identifying the exact location of a fixed school. Moreover, skippers apparently are not sufficiently trained to derive all the advantages from it.

Radar

Each unit had one or two radars. The apparatus is essential for this type of fishing, which is mainly carried out by night and quite near the shores or walls of the fjords. Skippers and pilots make liberal use of it, which, together with the echo sounder, permits of fishing within a few fathoms of the bluffs in all security.

FISHING GEAR

Seines

The drop of the seine and mesh size are the same for all units. Length only varied, but not in ratio to tonnage of the vessel, as will be seen by the following:

	Hold capacity	Seine	Mesh size
Lavallée	225 tons	325 x 45 fathoms	1 1/4"
Eastern Pride	160 "	325 x 45 "	1 1/4"
Stuart & Lynne ...	135 "	275 x 45 "	1 1/4"
Quadra Isle	90 "	325 x 45 "	1 1/4"

The meshes are knotted and the skippers do not seem too confident with knotless meshes, which appear too delicate to them for this type of fishing.

Yet, the knotless nets should give better results due to less resistance to the water and would certainly make lifting easier while reducing traction on the bottom warps. Up to date, no one was apparently willing to try the experiment.

Buoys used on these seines are not numerous enough and of inadequate size. In cases of heavy catches of 300 to 500 tons, and even up to 1,000 tons, the upper part of the seine submerges in proportion to the size of the catch, and practically all the herring thus finds a means of escaping rapidly. The buoys emerge very slowly, which seems to show inadequate buoyancy.

In the case of heavy catches it would be desirable that a series of inflatable buoys could rapidly be attached to the line of floaters.

This could be done by the crew of the skiff, who would be equipped with a compressed air bottle. This practice would prevent the seine from sinking and possibly tearing when fishing on shallow grounds, where the lower warp could foul itself on isolated rocks. Such an incident happened twice, and one of the vessels almost completely lost its seine; the repairs involved over two weeks' loss of time.

Skiff

This craft is propelled by a powerful engine; it is used while setting the seine by retaining the end of the seine until closing is complete; then in keeping the vessel against the wind and preventing drifting.

This manoeuvre is especially essential when fishing in the fjords, the limited space being like a corridor for rather stiff winds which seriously affect the position of the vessel. However, use of the skiff requires one of the eight crewmen for the whole duration of the sets, while his presence on board would accelerate the lifting operation.

Moreover, fuel consumption is not negligible and could be reduced by 90 per cent while decreasing the dimension and weight of the craft if the vessels were equipped with side propellers. These would give the vessel autonomy and complete maneuverability, while allowing for an economy of space and fuel used by the skiff.

Engine

The use of slow running engines seems advisable.

It was possible to carry out an observation on a new, 125-ton unit, whose 2–cycle, 16–cylinder engine was excessively noisy both for crew and fishing. In fact, comparative observations between slow – and fast – engine vessels were made and seemed to prove that while searching for herring schools with echo sounder, the latter vessels caused a marked descent of the fish that could be detected on the recording, while the slow–engine vessels could travel over these schools without causing such phenomena during the same operations.

Sound-proofing at the base of the engines and even on the propeller shaft by means of a flexible or pneumatic coupling should therefore be provided. The crew would benefit from this, as sound-proofing of the new units does not seem to have been much improved upon, in spite of the fact that crew comfort was considerably furthered in recent years.

Wind and temperature

Fishing such as is practised in the fjords can be carried out under fairly strong winds. Sets were made with 20-m.p.h. winds in these fjords, a speed that seems the maximum permissible at present. In this case, the height of the waves reached about 3 feet, which prevents the stabilization of the floater line, particularly in this instance where the buoyancy of floaters was too low. However, it was mainly when the seine was wound on the power block that the wind began to be felt and made work more difficult and even dangerous for the lifting gear and the seine. Further rolling of the vessel again increased the alternate tension on the seine and the loading boom. The use of stabilizing tanks is recommended in the new units. Low temperatures do not make lifting any easier either particularly when, between sets, there are too long intervals; the seine, which is laid out on the platform, freezes stiff and its winding may bring about incidents such as tears or immersion in one piece.

The limit observed in low temperatures seems to be about 10°F., depending on the prevailing wind.

Herring tonnage estimation on the south coast

Before giving a list of the estimates made during the first three months of 1966, it is necessary to explain how these estimates were arrived at:

The inclusion of echogram reading results obtained during each set of the seine was made taking into account the following components:

- Speed of vessel during echo registration in relation with the registering band feeding speed.
- Thickness and width of the schools.
- Length of the schools.
- Possible total catches with a 325 x 45–fathom seine.
- Estimated volume of submerged seine.

A seine that has just been submerged theoretically represents a vertical cylinder 45 fathoms high and 325 fathoms in circumference. The bottom of the seine being closed, the lower edges rise and the height of such a cylinder can be estimated as being 10 fathoms, which gives a capacity of 6,337,000 cubic feet.

The seine having been closed on a herring school with a known density and thickness, if *one herring only per cubic foot* is estimated, we have thus caught 6,337,000 herrings in the seine.

If, on the other hand, it is known that three herrings are needed to make a pound of fish, we shall then have in this seine set a quantity of 2,112,000 lb, or more than 1,000 tons.

If, lastly, the echograms together with the daily reports are read, it will be noted that the thickness of herring schools reaches 40 fathoms and that the upper stratum of the school only is caught by the seine, or about 10 fathoms. The seine, therefore, takes only a reduced thickness of the school worked on, which makes our estimation quite conservative, inasmuch as catches of over 1,000 tons were made several times, and that the average catch was in the neighbourhood of 150 tons. Lastly, it must be borne in mind that fishing was carried out in fjords where waters were still and the herring population was rather sedentary, which permits of reckoning on fairly precise components.

Echogram readings were made giving a length of almost three miles, a width of 500 feet and a thickness of 40 fathoms for a single herring school in one bay, while the other fishing units were observing just as important concentrations in different bays. The following figures are, therefore, certainly under-estimations.

From Harbour Breton West, the following bays were fished on different dates, and the observations below take into account the various components such as herring behaviour and fishing season.

Bay d'Espoir

Two sets were made on March 21, near Galet Island, opposite Raymond Point, and yielded 240 tons. Observations made previously by the *Sen-Sen*, a light transport unit of B.C. Packers equipped with research installations, had several times detected more or less considerable concentrations, and from the echograms a floating population of approximately 20,000 tons can be estimated. This figure should be tenfold in June, at the time of spawning, since a number of coves are spawning areas for herring.

Facheux and Dragon Bays

Great concentrations were observed from early March, and successful sets yielded 1,000 tons in the last weeks. It seems these populations were from the west since in January and February the bays were hardly populated while western bays were teeming. A figure of 100,000 tons for March seems normal.

Hare Bay

In January and February many populations covering small areas but quite thick were detected by 8 echograms. The stocks can be estimated at 50,000 tons in January and at 80,000 in February, when 950 tons of fish were caught in 7 sets.

Devil and Rencontre West

On February 10, 3 fishing units were in these bays, where, at Rencontre West, the herring schools were observed at their shallowest, i.e., 2 fathoms. During the whole month and up to March 15, the stocks present can be estimated at 80,000 tons. All told, 1,400 tons of fish were taken in these bays.

Bay de la Hune

In January, heavy concentrations permitted the taking of more than 1,000 tons; thereafter nothing was taken up to February 10, when herring reappeared near the surface. Whether the fish were on the deep grounds or had migrated to other bays cannot be said. In February and March about 800 tons were fished in this bay, which must support about 100,000 tons.

Bay des Vieux

This bay was quite heavily worked and yielded very successful catches, since in January, 3,480 tons, and in February, 935 tons had been taken. In March, 1,500 tons were also taken at the mouth of the bay. The present stocks can be estimated at 200,000 tons, since it was in this bay that a school over 3 miles long was detected.

Port aux Basques

During the last half of March, the *Lavallée* and the *Stuart & Lynne* each made two trips yielding 750 tons of herring. The fish was found about 2 miles off the harbour and many concentrations were detected between Rose Blanche and Port aux Basques. This territory is not regularly fished and populations there apparently come from the Strait of Belle Isle, considering that the individuals taken there had 57 vertebrae, the typical number for these stocks, while the stocks on the southern coast generally have 56 vertebrae.

The area between Port aux Basques and Ramea Island, opposite Bay des Vieux, was not worked; but it is likely that concentrations are to be found in all of the bays along the coast similar to those east of Ramea. Echo soundings were taken on the return trip and numerous signals were registered showing the presence of fairly considerable schools.

Fortune Bay

Following several explorations by the *Sen-Sen* in January and February, many concentrations were detected here and there, and the *Lavallée* made two trips in this bay. The first was without any result, due to overwhelming winds and to the fact that the bay was not well protected from the north-easterly winds. The second trip was made in Mal Bay, where 1 1/2 tons of 4-year-old herring were taken, the youngest stock during the three months: these herring were sexually quite advanced and of great mobility, which may explain their escape through the bottom, although echosounding had been excellent.

Fortune Bay is thus little fished in winter, but in May and June very heavy concentrations are to be found there; the bay being the assembling area of herring on the south coast for spring spawning. This is dealt with in a separate paragraph.

General estimation

The foregoing accounts are enough to make an estimation that can be figured up to *1,000,000 tons* for the present stock during the first three months.

Several observations must be made:

About February 20, progressive runs of the herring schools begin to be observed from the heads of the bays towards their mouths, then off the mouths to one mile from the coast. Concurrently with these runs one observes a progression in the feeding of herring from nothing up to practically complete feeding by the end of March, together with an increase in sexual activity. Such runs are accompanied by a scattering of the schools, which become slightly more difficult to locate, although they remain just as dense vertically.

From March 10, it seems there is a tendency to move slowly in an easterly direction for the populations outside the bays, which would confirm the herrings' migration into Fortune Bay for the spawning time in May-June.

The skillful use of detecting apparatus permitted one to follow the fish in their runs and even to increase catches since these were 30 per cent heavier in March than in January and February.

It is almost certain that the coming months will witness a near-exhaustion of the bays worked during the winter and that fishing operations will be mainly carried out offshore and perhaps in a general easterly direction rather than in the center of the south coast. Observations will permit confirmation of these suppositions.

Various recommendations

The very slight 12,588-ton take made during these first three months on the population of *half of the south coast* thus represents only 1.26 per cent of the general estimation. The mean age of the fish was 9 years, which proves that the populations were scarcely exploited and that they were doomed to die of old age rather than extinction through overfishing. These resources are extraordinary and it is to be hoped they will be worked rationally. *This is under present conditions where only 4 seiners were used.* Now, the success of this winter fishing "first" on the south coast will certainly bring a host of vessels which will want to partake of this immense resource.

Herring takes *four years* to reach maturity.

It takes 6 to 7 years for the fish to attain commercial value.

Conditions of winter fishing

Fishing conditions are very good in the bays due to their almost constant lay, corresponding to the prevailing winds. Moreover, the walls of the fjords being from 600 to 800 feet high, permit fishing under 40-50-M.P.H. outside winds, the bays providing a perfect shelter against waves and winds.

During three winter months, fishing was interrupted only 16 days due to storms and bitter cold.

Output of seiners

The capacity of a 325 x 45-fathom seine is 200 tons, which is an almost current catch under present conditions. Therefore, there will be a considerable loss of fish which cannot be loaded on a 100 – 150 – ton unit, the surplus being returned to sea if another fishing unit is not in the immediate vicinity. Such fish have been severely scaled and are doomed to an early death, the scales forming their natural epidermis.

In short, one can listen to the complaints of the fishing vessel skippers, who are of the opinion that the dimensions of a 325x45-fathom seine are perfectly adapted to the requirements of the south coast. However, such a seine can be really efficient if it serves a unit of at least 200 tons, 250 tons being the ideal tonnage recommended for new constructions.

Light fishing

Studies and research work still have to be carried out on this more or less debated technique, as success depends on a thorough knowledge of herring behaviour under conditions such as:

Height of tide,
Time when fishing is carried out,
Environmental conditions and specific quality of the plankton,
Water temperature and salinity,
Existence of submarine currents,
Disposition of the herring to rise, and
Quality and intensity of light.

There are two positive facts:

a – Day-night effect has a positive influence on the fish, which remains in deeper water by day.

b – Artificial light cannot be considered as an infallible means of attracting herring.

However, following numerous observations and tests made during the three months, certain factors lead to the conclusion that light *quality* and *intensity* are to be studied, for they can produce a solution to the problem.

It can be noted in the daily reports that 80 per cent of the catches are made during the night, when the fish stays nearer the surface, the upper layer of the schools being at approximately 10 fathoms. The skipper has learned through experience that during exploration with an echo sounder all lights on board should be put out and that noises should be reduced to a minimum, especially percussive noises that have an immediate affect on the herring's descent. Up to the time when the seine is submerged and its bottom completely closed everything goes on in total darkness. After this there is no objection to putting all lights on. At this time, however, if panicky bands of herrings are near the surface and can be plainly seen, they make it as fast as they can to the bottom of the net as soon as they see light. Which proves a certain photophobia to brilliant light. On the other hand, we have several times made an experiment consisting in putting on the water a home-made light; this was an old pail with holes around its upper periphery and whose bottom was covered with fuel oil burning with a wick. The properly weighted pail was placed on the water and we awaited nearby for some time. Then a search was begun with the echo sounder to define the size of the school. The set was then made around this dim light which was considered as the center of operations. We were successful every time and interesting catches of more than 100 tons were made. This method seemed to attract herring towards the surface, but fairly slowly; which seems to show a certain sluggishness in rising, but also an attraction towards a *dim Kelvin light*. It would be interesting if photometry equipment could be used for tests and if a thorough study were made of the components of the problem which are set forth at the beginning of this section. The behaviour of herring during these experiments could be followed with an Asdic scanner set for measurements of shallow depths and short distances.

It seems that successful light fishing experiments were carried out on the west coast, but it must be borne in mind that fishing conditions there are not the same as on the south coast of Newfoundland, since we are working on herring populations apparently wintering in these deep bays without feeding or moving for several months.

Technical suggestions

As already described the present vessels were not true seiners but more or less efficient adaptations. Considering that the purse seine is used in the herring fishery, that it is the most efficient gear and that the fishery will spread at an increasing rate, the construction of new units should be carried out following the advice of fishing masters who have experienced the drawbacks of present units. A vessel is designed on the drawing table, but often without any adaptation to particular requirements laid down by actual practice. Corrections are always costly and skippers will be reluctant to cover such expenses due to loss of time and additional capital requirements; they must therefore put up with errors made during construction.

Here are a few suggestions likely to help in increasing yields and profits in the new units that will sooner or later be commissioned.

Use of a skiff on board involves problems of weight, space and cost which can greatly be reduced by the use of side propellers (or transverse thrusters) located fore and aft of the fishing vessel. This system would allow the vessel to move more easily during the set and to make up for wind and current thrusts. Moreover, the use of a crew member during the whole fishing season only to operate the skiff could be avoided, or this member could at least be put to more profitable tasks. The skiff would be replaced by a smaller craft that could be used for life saving or joint echo sounder operations with the vessel.

The use of medium-speed diesels is apparently preferred to high-speed diesels, particularly on account of a lesser response to sound. A study of the different propulsion systems in relation to sound influence should be undertaken. Flexible couplings between engines and propellers would reduce the transmission of sound into the water as well as vibrations to the hull. The installation as a whole would also increase crew comfort. Sound-proofing in fishing vessels is not always adequately considered.

Experimentation with and use of certain means having a traumatic or paralyzing effect, such as the "Ribair Plunger," an apparatus causing submarine explosions by means of compressed air or the use of well-proportioned electrical discharges, would permit paralyzing the fish and facilitating the lifting of the seine where the catch is heavy, while avoiding the lateral thrust of the fish whose gregarious behaviour and massive movements are well known.

Submarine explosions of compressed air under the net before closing it would prevent the escape of herring through the bottom or, after its closing, prevent the herring from resting on the bottom of the seine up to the time when the net is gathered alongside the vessel. Such explosions frighten the herring and cause them to rise quickly towards the surface, by either one of these methods immersion and tearing of the seine would be prevented, as well as loss of the whole catch. Such mishaps are frequent.

The joint use of these methods with that of additional buoys on the line of floaters would go far to improve the efficiency of the seine.

Fish finding apparatus such as the sonar echo sounder could be used on the skiff during the search for herring schools. The skiff would also be equipped with two-way radio so that the operator could communicate the messages received through the fish finding apparatus to the vessel master. This would be an advantage for units without any sonar, for a school's location and extent would be determined faster and more accurately. As a matter of fact, the signal received through the echo sounder does not show whether the vessel is travelling along or over the center of a school, and several manoeuvres are necessary before its circumference can be ascertained and the seine successfully set. Sonar, whose use offshore is a positive success, cannot be used without any drawback in the fjords where the echo is returned from their walls, which causes confusion in the reading of results. The device is used successfully when the herring leave the bays and keep offshore. Unfortunately, the use of sonar is not always understood, and training courses would be a solution for masters who are more or less at a loss in making out the three dimensions given by the visual and sound signals. A direct screen reading sonar would solve many difficulties. The apparatus includes a semi-circular, or 180-degree screen, where the fish schools are shown as soon as detected, while another, rectangular, screen, gives a vertical reading. Reading of both screens will easily locate the goal.

Pumps are quite efficient in loading or unloading adult herring, but only when the fish is used for reduction into meal. The fact is that pumps will cause fractures in the spine, followed by haemorrhages and bruises in a proportion of 30 per cent of the catches. Such herring cannot be filleted for human consumption.

Other loading devices should be studied to remedy these drawbacks.

Marketing

It is really distressing to see such quantities of food being processed into meal for animal feed when requirements and demand for human consumption are so great.

One ton of herring will yield 350 lb of meal, with an average protein content of 74 per cent, or 259 lb per ton.

The 12,588 tons of herring caught during the first three months of 1966 thus represent 3,144,792 lb or protein which chicken will again transform into protein with a loss of at least 50 per cent, without taking into account offal waste and labour!!! It would at least seem beneficial to process the fish into colourless and odorless meal for human consumption according to known methods. Fish blocks or briquettes could at least be made from the meal, or this could be added to bread or used in the preparation of drugs. The relative food value of such meal, for instance, in ratio to a pound of beef, could be produced at a cost of 4 cents per lb.!

Processing into fillets, smoked or pickled herring, and even processing the fish on board refrigerated cargo vessels, would not only result in the hiring of more labour in fishing operations and related industries, but would also increase profits.

Harbour Breton

In this case the experiment of winter fishing for herring on the south coast of Newfoundland must be regarded as having been undertaken and successfully carried out with a great deal of courage. The results were convincing and tangible, were it only for the launching of an industry in such an utterly isolated community as Harbour Breton. Within a year's time, this little harbour has seen the coming of electricity, water, an embryonic road communicating with Bay d'Espoir, and thence to Grand Falls and to the highway system from which it had always been isolated. The average income, which had always been well under $1,000.00 per year, more than doubled. Eighty per cent of the male population, who formerly had to be absent from the community 8 months in the year, now stay at home, and certain fishermen earn up to $2,000 per month.

The population increased by 450 people, and B.C. Packers intend doubling their capacity by undertaking extensive works this year.

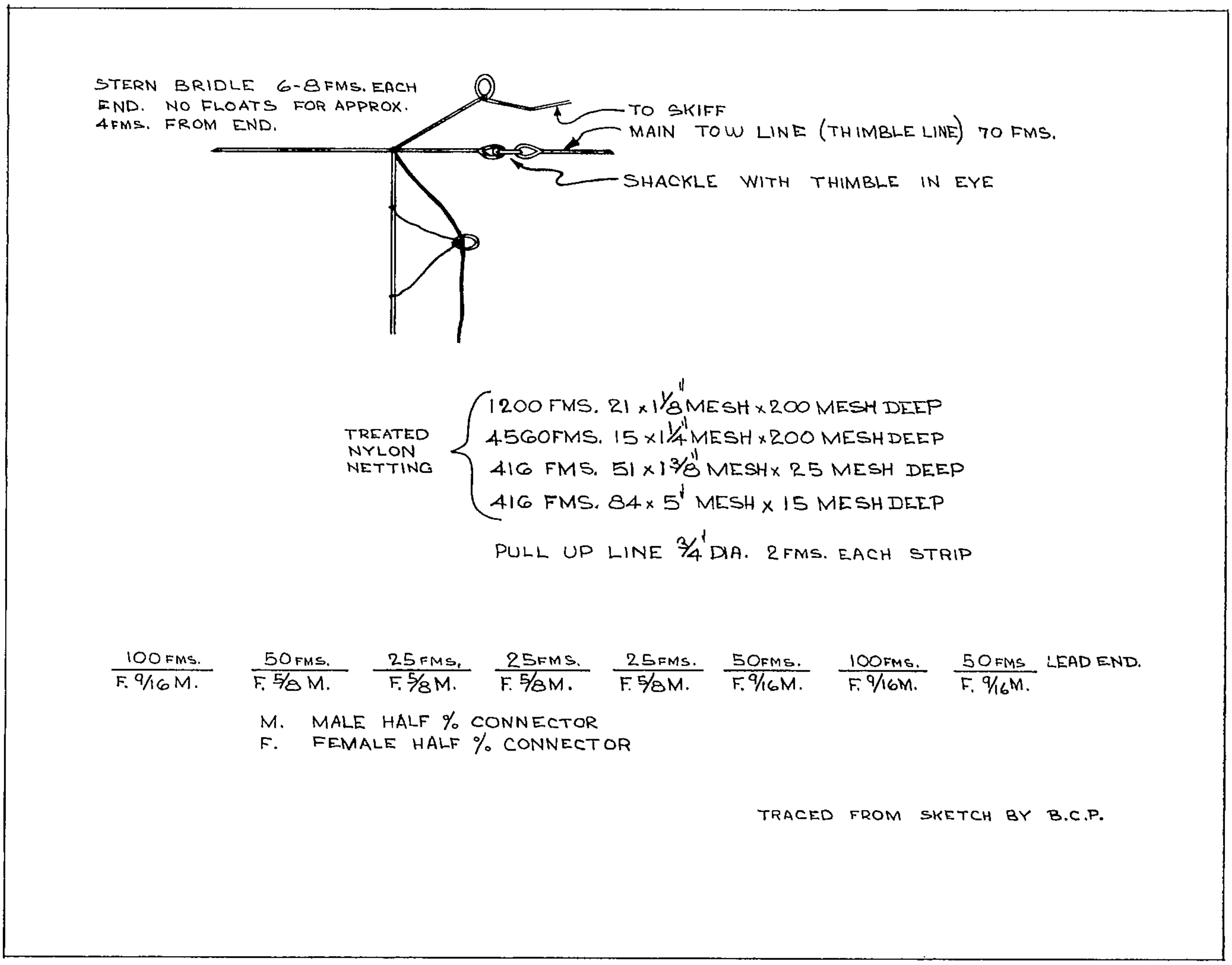
CONCLUSION

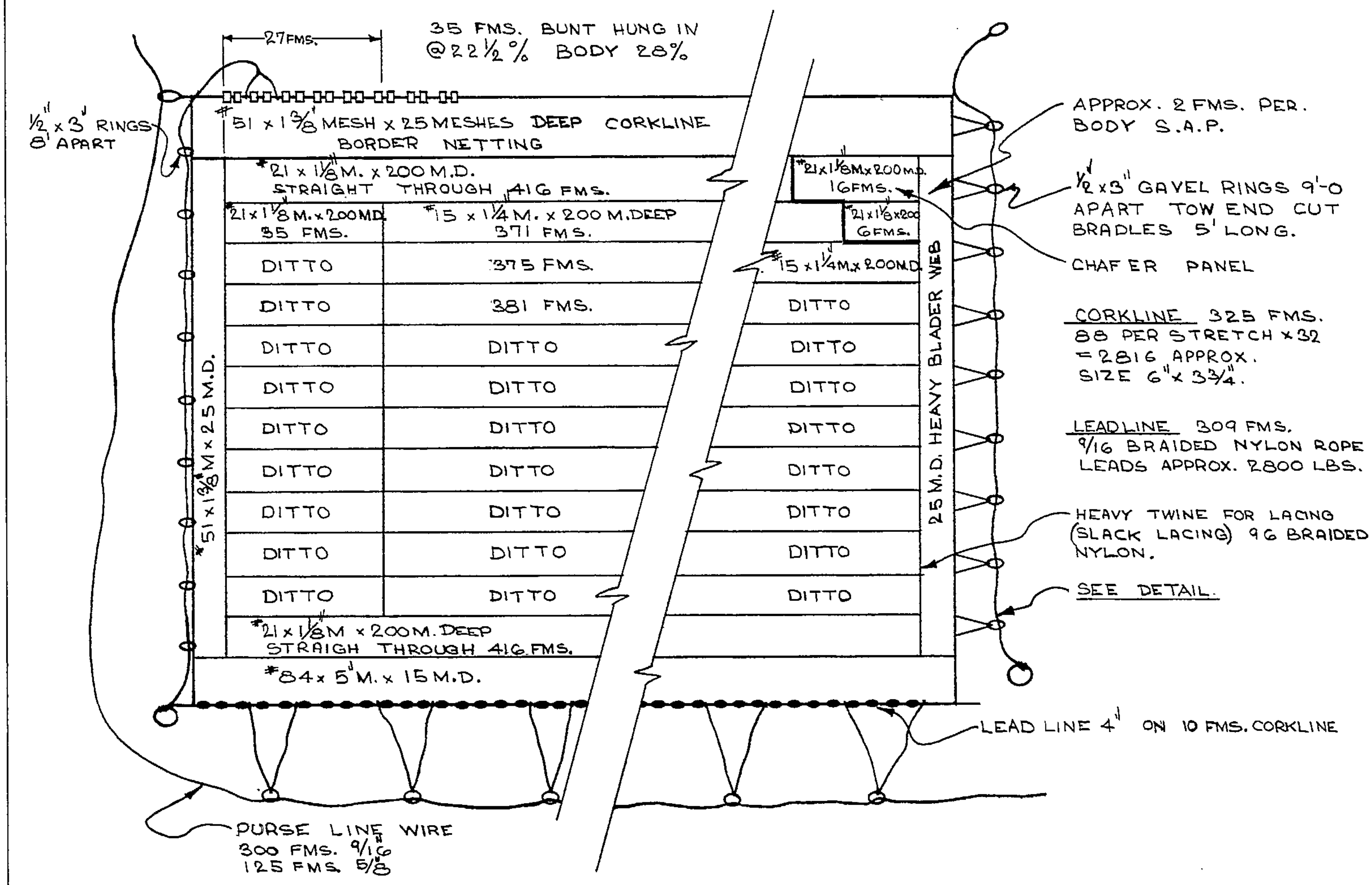
An extensive development of the fishery and related industries can be based on the herring resources off the south coast of Newfoundland. Capital investment required for the conversion of fishing units into seiners or the construction of new units is assured of being rapidly paid off.

This first winter seine fishing season permitted the training of crews who quickly mastered the technique of purse seining. Improvements in the knowledge required to operate certain fish-finding apparatus, such as sonar, and the organization of practical popular courses are recommended. The interpretation of messages received would be considerably better and the results expected from this equipment would be obtained. Partial conversion of herring processing methods through an increased production of smoked herring and salted fillets must also be recommended.

There exists a strong demand for frozen herring and an effort should be made by the industry to fill such demand. This processing method ensures sales with a much greater profit margin and better returns for investments; it would certainly be more profitable than the reduction of herring into meal. A technical and economical study is recommended on the possibilities of using refrigerated cargo vessels for the fast and intensive processing of catches. Herring resources on the south coast of Newfoundland are practically inexhaustible: annual catches of 50,000 tons represent only 5 per cent of the very conservative assessment of existing stocks.

The relative facility of pursuing winter fishing is due to favourable geological and climatic conditions on the south coast, and Canadian fishermen should understand that they have all to gain in exploiting this resource. It must be repeated that this experiment was attempted and successfully carried out with a great deal of courage. The results are tangible and nothing now should stop further developments.

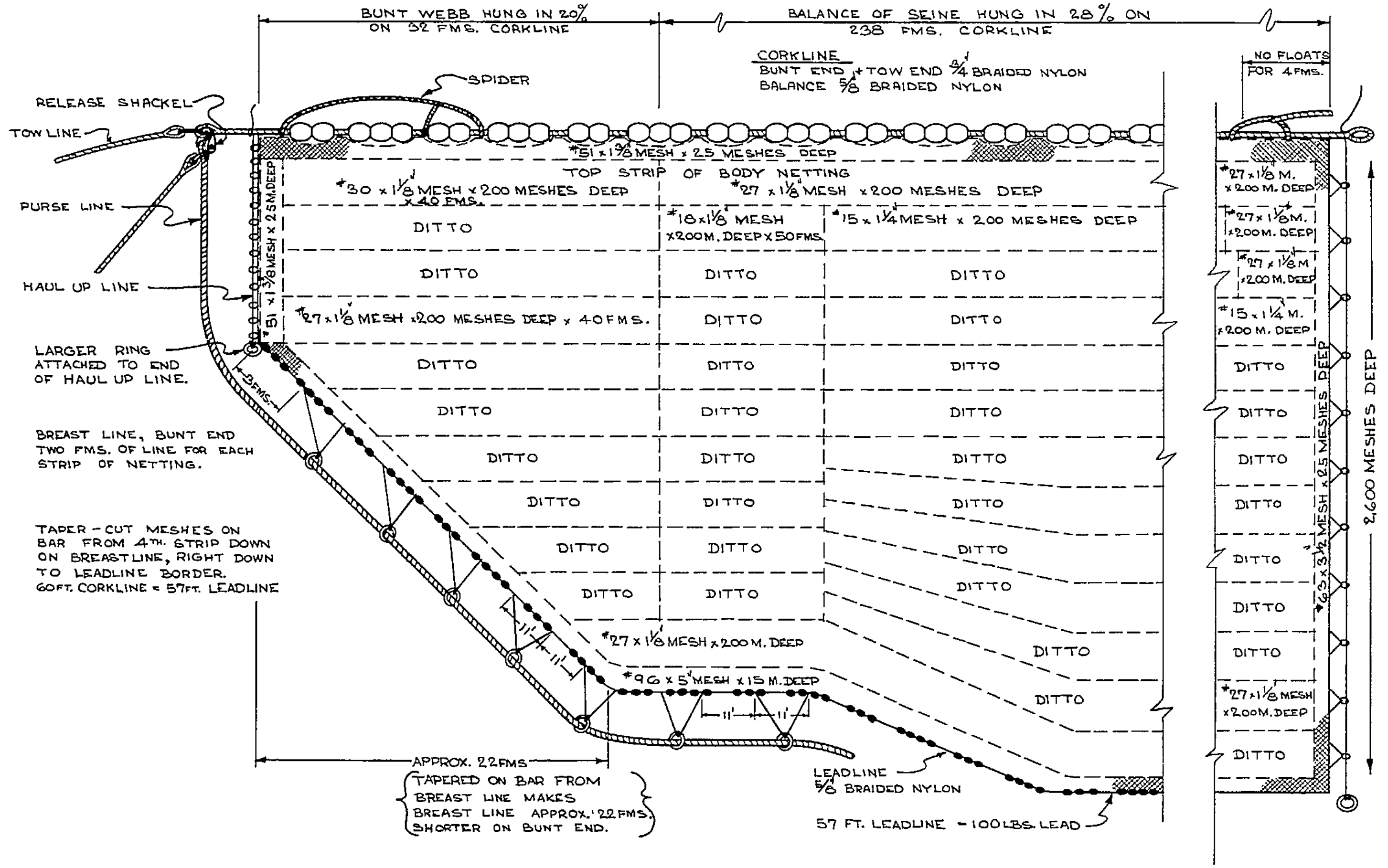




M/V LAVALLEE HERRING SEINE

2800 MESHES DEEP x 325 FMS. LONG

TRACED FROM SKETCH BY B.C.P.



M/V STUART AND LYNNE HERRING SEINE

TRACED FROM SKETCH BY L. DOVING

Herring Fishing in British Columbia

by
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North Surrey, B.C.

Herring are seined throughout the British Columbia Coast, the main season being from October to March. They are found in inlets and specific spots in the inside waters such as Nanoose Bay, Deepwater Bay, Nootka Sound and Jedway Inlet. There is also an open sea fishery in some areas such as the Goose Island grounds and Hecate Strait. In general the fleet progresses from south to north in the winter season.

VESSEL

The vessels used for herring fishing are 70-95 feet, carrying 100-280 tons. Wood or steel construction is used. Wheel house and engine are forward giving good visibility for scouting and a large clear working deck for handling gear. Accommodation for the 8-man crew is comfortable – even luxurious in many boats. They are powered by diesel engines of 300-500 horsepower, usually the high speed type with reverse gears.

DECK EQUIPMENT

The pursing-winch is a two-nigger-head or double-drum type usually mechanically driven from the main engine. Recently some hydraulically powered winches have been used. Other deck equipment is the boom-topping-winch, purse line spool, power-block, and fish-pump. All of these are hydraulically powered.

ELECTRONIC EQUIPMENT

Electronic equipment for the vessel is: two six-channel two-way-radios, radar, and two echo-sounders.

SEINE NET

Seine nets are all 300 fathoms in length, by Department of Fisheries Regulation. Their depth is unrestricted, however most are 40 fathoms. The net is all nylon, one to 1½ inches mesh size. A heavier web is used in the bunt end of the net for holding the weight of fish when they are concentrated there before brailing.

The net is heavily leaded and the cork line is designed to float one and one half times the weight of lead line and web. Purse line rings are the snap type. Net value is $15,000.

AUXILIARY BOATS

Auxiliary boats are: a power skiff, a dead skiff and an inflatable life raft. The power skiff is an open boat 20 feet in length by 10 beam, power skiff engines are mostly gasoline, 70 - 200 HP. This skiff is also equipped with 2 way radio and echo sounder.

The dead skiff is about 18 x 8 feet, has no engine but is equipped with a portable gasoline driven A.C. generator, and pit lamps, usually 2 - 200 watt mercury vapor and 10 - 100 watt floods.

SCOUTING AND SETTING

When the location of fish is not known they are found with the echo sounder, which will indicate the size and depth of the school. When a school is found, its direction of travel is determined. The power skiff is sent out to stay on the school and help in determining the direction of travel. When this is established, the net is set using the dead skiff and a sea anchor. The setting must be done ahead of the school to cut them off. About 15 minutes is the required time for the lead-line to sink. This must be allowed for in leading the fish with the net and encircling them. If the lead-line cuts the school, it often happens that the whole school is lost as herring tend to follow the leader.

When herring are known to be, or hoped to be in a certain area, a different technique is used. A suitable place is found with sufficient depth and smooth bottom, the anchor is dropped and nothing is done further until evening when the mercury vapor lights are turned on. Waiting continues while fish gather under the lights. These can be seen with the echo-sounder and when a school of worthwhile size has gathered or dawn is approaching when the school will break up, preparations are made to set. Then the dead-skiff is anchored alongside the boat. The mercury-vapor-lamps are put aboard it and turned on. The vessel is then slowly and quietly moved away from the dead-skiff leaving the lights on the skiff to continue to attract the fish. The boat then proceeds to set the net around the fish.

PURSING

When the set is complete, both ends of the net are made fast to the davit which holds the lead-blocks for the wire purse-line. The purse-line is hauled in with the winch. The angle of the purse-line coming up must be watched carefully as it indicates how deep the net is fishing. The purse-line is brought in as rapidly as possible but must be kept under the fish. The operation takes 15 to 45 minutes.

TAKING THE NET BACK

The net is hauled in with the power-block. One man handles the lead-line, one the cork-line and two the web, in piling the net on the stern. One man unsnaps the purse-rings from the purse-line at the davit. The operation takes about 20 minutes to reach the point where only 10 - 30 fathoms of net, depending how the fish are acting, are left and the net is ready for drying up.

DRYING-UP

The dead-skiff is put on the cork-line and the web is fleeted up with block and tackle. The cork-line is securely tied at both power-block and davit ends, making a strong bag to hold the fish. With large sets the power-skiff may be brought around to provide additional buoyancy on the cork-line, or even another fishing vessel may be called in to help.

PUMPING

Pumping has replaced brailing on larger vessels and has made their use possible. The speed of pumping is about twice that of brailing. Maximum rate for an 8-inch pump is about 7 tons fish per minute. In pumping the drying-up of the net must continue evenly to keep the fish as concentrated as possible to keep the pumping speed up. Speed is essential as the life of the fish is short when tied up.

NUMBER OF SETS

The average size of set has become smaller with the advent of the pump and the elimination of pool fishing. Sets of 100 tons are still common but as little as 10 tons is set on.

HAZARDS

I find herring the most interesting of all fish to catch. Many things can happen even after the fish are in the net. The skipper and crew must be on their toes until the fish are in the boat. A set of 200 or more tons must be brought about quickly before they die from crowding. They may also be killed by fresh water on the surface from heavy rains, or large rivers running into inlets. The weight of dead fish is more than the net can stand and results in damage to the costly seine and loss of the fish.

The weather and sea must always be considered. Most fishing is done at night, close to reefs and along a rough shore line. There is constant danger of drifting over a reef or into shore. Other boats are also a hazard as much fishing is done in close quarters where they may drift over your net or vice versa.

Radar is in constant use to avoid these dangers. Being a winter fishery, rain, fog, snow, wind and heavy seas compound these dangers as well as all those usually encountered at sea.

Progressive Herring Trawling Methods in Germany

by

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ABSTRACT

For herring bottom trawling in Germany a special gear was designed with false headlines and kites to provide a high opening. Since its introduction in the early twenties until recently this gear has given satisfactory results. In the fifties it was supplemented by midwater trawling, which allowed herring fishing to be extended from summer only to almost the year round.

Commercial midwater trawling in Germany was started with the two-boat technique, which is suitable for vessels up to about 600 hp. The reconstruction of the trawler fleet with a growing number of larger and more expensive vessels, together with improving market conditions, has favoured the development of the combination one-boat midwater and bottom trawl.

The comparative merits of one-boat and pair trawling, the different types of gear and the problems of fish detection and fishing tactics are discussed, using the German herring fishery as an example.

The summer season on spawning herring in the North Sea used to be the backbone of the German sea-fishery. The fishing gear was the special German herring bottom trawl with false headlines and kites. The net had an opening height of ca. 3 to 4 m (10 to 13 ft.) with the first kite in about 7 m (23 ft.) and the second kite in about 12 m (40 ft.) distance above the bottom. This was at the time considered already a high opening trawl, particularly with respect to the false headlines and kites which were supposed to chase the herring down into the net. From the early 'twenties, when this gear was introduced, until almost today the catching efficiency of this herring trawl was adequate, so that the proceeds from the catches, which in Germany are exclusively used for human consumption, often compensated for eventual losses from roundfish trawling during the rest of the year.

In course of the reconstruction of the German fishing fleet during the last 20 years, herring fishing declined in favour of roundfish fishing (mainly cod and redfish) and a growing number of large factory trawlers came into operation. Due to changing market conditions, however, just now herring is again gaining interest for the German fishing enterprises. Consequently there is a growing demand for progressive herring fishing techniques which have to be efficient enough to meet the high operation costs of modern vessels.

Before the introduction of fish finding echosounders, fishing success depended mainly on the experience and luck of the skippers and fishing was restricted to the bottom or near to the surface. With acoustic fish detection also fish in midwater (pelagic) can be found and conventional methods adjusted or new means designed for their exploitation. Consequently existing near-to-the-surface fishing techniques, such as purse seining and drift netting, were extended to greater depths and bottom trawling was supplemented by midwater trawling.

The first commercially successful midwater trawling technique was developed by the Danish net maker Larson from Skagen. Since pelagic fish can escape in all directions, trawls with larger openings are needed than for bottom trawling where the sea floor is the natural hiding place and at the same time an efficient trap for fish trying to escape downwards. Because of their higher towing resistance the large nets could not be towed with sufficient speed by only one of the conventional Danish cutters. The midwater trawl of Larsen was, therefore, a pair-trawl towed by two vessels.

Besides the advantages of combining the power of two comparatively small and cheap vessels, the saving of otterboards, and the more advantageous course of the warps for guiding the fish into the net, *pair-trawling* has navigational and also psychological drawbacks. For shooting and hauling the vessels have to come close together to pass lines, which requires skill and reasonable weather conditions. The fish schools observed by the echosounders of the vessels are not in front of the net, so that it is more difficult to hit them. Sharp turns may lead to damage to the gear, so that navigation in a crowd of vessels is complicated, particularly because the boats have to keep a distance between each other of about 1/3 to 1/2 of the warp length and consequently need considerable space. Finally, due to the mentality of most fishermen, it is usually difficult to find skippers suitable for successful team work over a longer period. The technical problems restrict pair-trawling to vessels of small to moderate size. Furthermore, it is practically impossible, as was underlined by German trials with larger sidetrawlers, to make it pay for larger vessels with their higher investment and operation costs. Midwater pair-trawling is, therefore, not only in Germany, common for trawlers of up to about 300 GRT and 600 hp. Because of the warp arrangement on board and the possibility of splitting large catches, sidetrawlers can be considered more suitable than small sterntrawlers. For better manoeuvrability, active rudder or Kort-nozzle rudder are advantageous but not indispensible. The control of the main engine should be direct from the wheel house.

Because of the above drawbacks of pair-trawling and the desire to extend midwater trawling also to larger vessels, several fishing countries have been and are still engaged in developing *one-boat midwater trawling.*

Two basic types of gear have so far been adopted for commercial herring fishing on a larger scale, namely the so called "semi-pelagic-trawl" for fishing near the bottom, and the German pelagic trawl described below which, with slight modifications, can actually be used as a combination midwater and bottom trawl.

Because of its limitation to near the bottom, the semi-pelagic trawl, which is based on an Icelandic design (Breidfjord Trawl) and for instance used by French trawlers in the southern North Sea, has so far in German commercial herring trawling been used only to a small extent by combination drifter-trawlers. The conventional flat otterboards of this gear, which travel on the ground, are connected only to the groundrope legs, while the headline legs of the four-side-seam net are attached to the warps in front of, and thus also higher than the otterboards. In this way sufficient opening height is provided and at the same time the net is slightly lifted off the bottom, depending on the relative length of the headline and groundrope legs.

The towing resistance of the otterboards, which is one disadvantage of the one-boat trawl, can be decreased to a minimum by choosing an efficient hydrofoil shape. Another basic disadvantage is the course of the warps which diverge towards the otterboards. They can, therefore, not herd the fish, as the warps in pair-trawling are expected to do, but may even chase the fish away from the net opening. On the other hand, the one-boat method does not suffer from the navigational and psychological implications mentioned above. It is, therefore, preferable, provided that the problems regarding towing resistance and catching efficiency can be overcome. Although under favourable fishing conditions, as for instance spawning herring, sprat, and cod, also some smaller and less powerful German vessels have had some success, one-boat midwater trawling is so far mainly done by larger trawlers of 1,000 hp. and more. It can be applied by sidetrawlers as well as by sterntrawlers, but sterntrawlers are more convenient for the same reason as in bottom trawling.

Efficient fish findingis obviously a *conditio sine qua non* for all midwater trawling. When the fish schools are scattered and difficult to find, apart from echosounding, echoranging, eventually in connection with DECCA navigation, can be desirable or even indispensable for successful commercial operation. Furthermore, a reliable depth gauge for the net, preferably with continuous indication, is needed for an efficient control of the net depth in regard to the fish schools. Otherwise no additional means or auxiliaries are required for a bottom trawler to take up midwater trawling.

The problems of fish location and net control are practically the same for both, pair- and one-boat trawling.

LOCATION AND DETECTION OF FISH

The location of herring resources is a matter of background knowledge regarding the size and the composition of certain stocks, their migration habits, and the correlation between distribution and hydrographic conditions (salinity, temperature etc.). In practice it is mainly the experience of the skippers combined with scientific research, and eventually governmental searching activities, which lead the fishing vessels to the fishing areas where and when fishable concentrations are likely to occur. After the area is found the next step is to detect particular fish schools and to adjust the fishing tactic to the respective local conditions. The following examples of German herring fishing deal with at least some of the problems involved.

Spawning herring occurs in the North Sea from about July to October in shallow water of not less than about 7° C, either in dense schools which may have contact with the bottom, or start only several metres off the bottom reaching almost to the surface (Fig. 1), or in dense but thin layers on the bottom. The echo detection of the bottom layers was considerably improved by the introduction of the cathode ray tube (CRT) and for instance the "white-line" display. For such bottom herring which may be spread over wider areas, echoranging is, of course, useless. The higher reaching schools usually occur only in small numbers for a limited time of sometimes only half a day or less, and are then the target of a numerous fleet of sometimes a hundred and more trawlers of different size, type, and nationality. In competition with this crowd of vessels it is, of course, of great advantage to know the position of a school in advance. In spite of the unfavourable sounding conditions horizontal echoranging has become an effective means for detecting such schools, spot plotting them for the first tow and, in connection with DECCA navigation, to relocate them for later tows.

By midwater trawling, the conventional German herring season could be extended from summer over autumn and winter to spring and from spawning herring to spent, recovering, and prespawning herring. The main fishing areas are now the Norwegian Trench, the Irish Sea, the waters off NW Scotland and England and lately the NE Atlantic from Iceland to the Norwegian coast. Depending on the population and the season, the herring may occur in dense schools of varying size or may be distributed in "clouds" of larger size but low concentration.

Dense schools, particularly over deep water and not too close to the surface, are very good targets for horizontal ranging. With the fish finding echorangers presently available, such schools can be picked up in distances of 1,000 m (550 fms.) and more and the course of the vessel adjusted accordingly (Fig. 2). While passing over the school, its depth and size is determined by echosounding. The actual fishing may be started after the location of one or several schools have been spot plotted in this way or, if several suitable schools are known to be in this area, fish detection and fishing may be done simultaneously. The guiding of the net, which, in accordance with the depth of the school and the respective warp length, may reach the school only 5 to 7 minutes after the vessel, can be improved by echoranging backwards. This is particularly important with smaller schools which may move more actively or when, because of drift by wind and/ or current, the net is not astern the vessel. While the vessel passes over the school the comparative size and density can be estimated by echoranging in oblique direction alternatively to both sides. In this way the course can be adjusted so that the net will pass through the most promising part of the school. The fish finding echorangers at present are equipped with turnable and preferably also tiltable transducers. Depending on purpose and size, the units have an output of about 0.5 to 4.0 k.w. The training of the transducers may be done by hand or electrically.

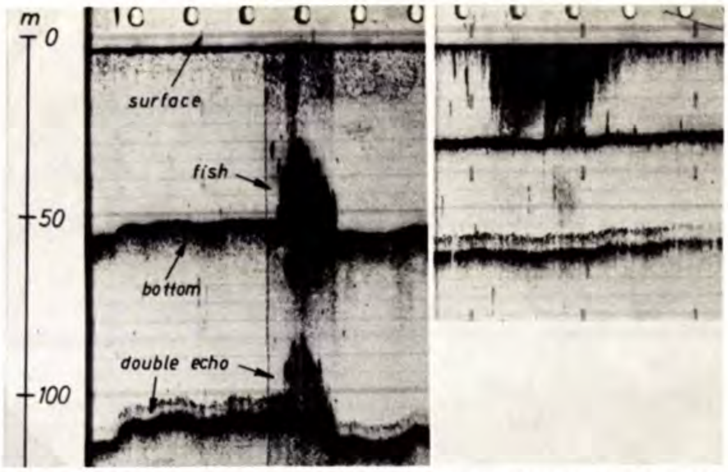

Fig. 1: Echograms of two typical schools of spawning herring in the North Sea.

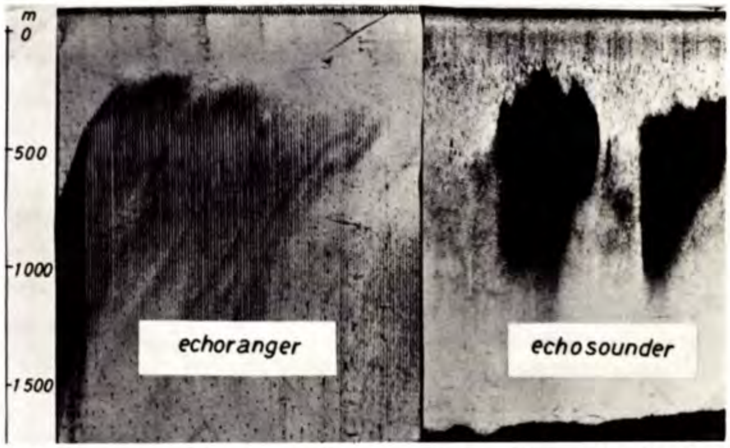

Fig. 2: Echoranging and echosounding recordings of large schools of atlanto-scandic herring off E – Iceland.

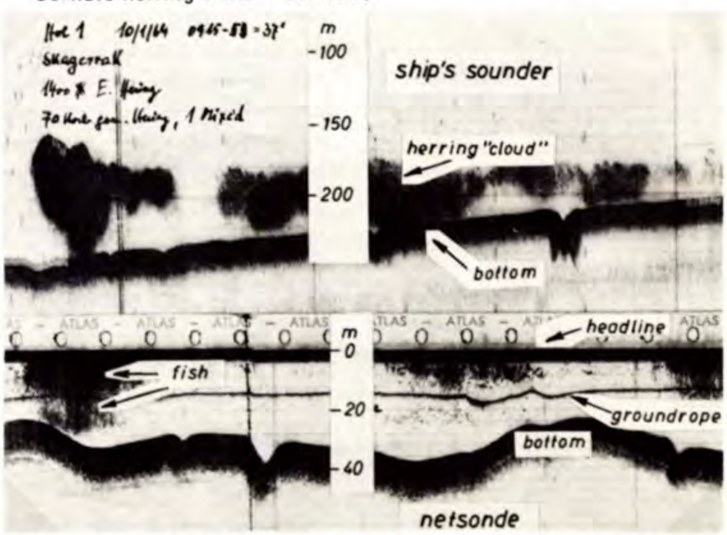

Fig. 3: Recordings of the ship's echosounder and the netsonde during midwater trawling on a large herring "cloud" at the Norwegian Trench.

Herring detection by vertical echosounders is standard practice and the experience of the skippers is adequate for successful operation. Echoranging, however, is only just now being introduced in Germany on a larger scale along with the developing midwater trawling. It is by nature considerably more complicated than echosounding and, therefore, needs more training and experience for optimal utilization. A discussion of the various physical problems involved would lead too far in this short account.

The rather scattered herring "clouds" occur in depths of about 180 m (ca. 100 fms.) and more and can, therefore, be detected by echosounding only at a rather high amplification. With appropriate care they can also be traced by echoranging. In view of their large size (several miles) they are, however, satisfactorily found and also followed with the help of echosounding alone (see Fig. 3).

NET GAUGE

In the beginning of commercial midwater trawling no suitable gauge was available for accurate depth control of the net during towing. The net depth was, therefore, determined experimentally by means of recording depth meters or echosounding from a second vessel over the net. Often also the angle between the warps and the horizontal was used as a measure for the net depth. For obvious reasons these simple methods and the "depth tables" derived therefrom are not very accurate, but they help, at least under favourable conditions, and are still used successfully enough by many smaller vessels which cannot afford better means. For more accurate and continuous measurements during towing, several depth gauges have been proposed, most of which actually measure the hydrostatic pressure. Since additional wire or tube connections for telecommunication are inconvenient, wireless system would be preferable. Due to the high level of disturbing noise mainly from the propeller, the wireless acoustic links proposed so far are not satisfactory yet for powerful trawlers.

As some connection for telecommunication between the net and the ship has to be accepted, in Germany echosounding with the transducer (s) on the net was chosen because of its additional advantages over mere depth gauges. The so called "netsonde", which has meanwhile been adopted also by other countries, measures not only the distance of the net from the bottom and/or the surface. It also shows the groundrope of the net and the fish in and around the net opening, so that the net can be operated with much higher accuracy to the bottom and to the fish, and furthermore some evidence is given for estimating the amount of catch (Fig. 3). At present the netsonde unit consists of a powerful echorecorder on board connected to a transducer on the headline of the net by a special two core cable of about 1.5 t breaking strength. Up to about 300 m (160 fms.) length the cable can be operated by hand or a handdriven winch. Longer lengths of at present 2,000 m (1,100 fms.) require a special electric driven winch. For commercial operation one transducer usually sounds from the headline bosom downwards. For more detailed observation of the fish distribution around and also in front of the net opening and in the belly, several transducers can be employed facing from various points (headline, wingtips, upper net etc.) in different directions, which may operate simultanously or switched alternatively by means of a relay. CRT indication is being considered for better evaluation of the echos in regard to fish quantity.

NET DEPTH CONTROL

With a continuous indication of the position of the net depth during towing, as is provided by the netsonde, any trawl gear can be adjusted to the fish school or the ground with high accuracy and under all weather conditions and current. The means of the depth control for both pair- and one-boat trawling are the variation of warp length and towing speed. For one-boat trawling otterboards with depth steering devices have been proposed. They are, in our opinion, not needed and would probably not be sturdy and reliable enough for the rough treatment on commercial trawlers.

The relation of net depth to warp length is in the order of 1:4-7 depending on the depth. The towing speed should be around 3.5 knots. For spawning herring it can be less. A variation of the warp length by 25 fms. results in a change of the net depth of about 10 m (33 ft.). In pair-trawling the towing speed has less effect on the net depth than in one-boat trawling, where depth regulation by speed only can be supported by suitable rigging of special otterboards.

PAIR-TRAWL AND ITS OPERATION

The midwater pair-trawl nets are of the four-sideseam type with equal panels. The net opening is, therefore, approximately "square". The material is synthetic, mainly polyamid, throughout. For vessels of about 600 hp., like the German combination drifter/trawlers, the standard size of the net is 1,400# circumference, meshsize 200 mm (8 inc.) stretched. Smaller nets (1,200# circumference) or larger nets (1,600# circumference) are exceptions. Because of the considerable size of these nets – opening height about 14 to 20 m (46 to 66 ft.)– and the correspondingly high towing resistance, the net material should be as light as possible. This has the additional advantage of better filtering ability which results in less water stow and correspondingly better catching efficiency. A typical net of this type is shown in Fig. 4. Such flimsy nets have, of course, to be handled with utmost care, which is easier on smaller vessels of the sidetrawler type.

The flotation of the headline usually consists of 50 to 80 spherical plastic or aluminium floats of 20 cm (8 in.) diameter. The groundrope is ballasted with around 100 kg (200 lbs.) of iron chains or rings. A special cone shaped weight of about 18 kg (40 lbs.) is attached to the lower wingtips. At the connection point of the lower bridles, which like the upper bridles, are of combination, or nylon rope of about 20 to 24 mm diameter (2.5 to 3.0 in. circumference) and about 60 to 80 m (33 to 44 fms.) long, with the warps, a heavy iron front weight of about 150 to 350 kg (330 to 1,000 lbs.) each is attached. The warps are steel wire cables of about 12 to 14 mm diameter (1.5 to 1.7 in. circumference). From each vessel one warp leads to the respective headline bridle and the other to the respective groundrope bridle. The groundrope warps and/or bridles are several meters longer than those for the headline, depending on netsize and fishing depth.

To facilitate the hauling of the net, particularly with large catches by means of the trawl winch, on sidetrawlers two auxiliary lines of heavy nylon are provided, leading from the headline to the aft belly and the splitting strop respectively. A schematic view of the gear is given in Fig. 5. Each of the two vessels has several nets ready. Normally one vessel shoots the net while the other is still busy with hauling in the catch of the preceding tow. After the net is in the water, the other vessel passes in close distance and the bridles of her side are handed over by means of a casting line. Since only one of the two vessels has a netsonde sounding unit with cable winch and cable, the aft end of the cable connected to the transducer on the net may have to be handed over as well. The connection of the cable to the winch is made by special watertight and load resistant plugs. The receiving vessel connects the bridles to the warps, the vessels take course and start paying out the desired length of warps. While shooting the warps, the vessels gradually increase the distance between each other in accordance with the warp length. During towing the setting of the engine throttle, navigational manoeuvres etc. are co-ordinated by means of ultra short wave communication.

Under unfavourable conditions or with insufficient experience, the vessels may get too far apart, which can result in a break of the headline and/or the groundrope followed by a complete tear up of the net. This risk can be diminished by means of a strong nylon or steel safety rope between the upper wingtips, which is shorter than the headline so that it takes the excessive loads.

During towing moderate changes in course can be taken without special precautions. It has, however, to be taken into account, that with the large net, long warps, and corresponding distance between the vessels, such manoeuvres are rather slow and considerable space is needed. When going on reverse course, it is, therefore, advisable to haul most of the warps in, then turn around quickly and shoot again. Fortunately the distribution of load on the warps on each side depends very much on the relative length of the warps. It is, therefore, not too difficult for the vessels to keep pace, also with slightly different towing power and when turning. Nevertheless, unequal tow on both sides of the net always creates unequal stress on the webbing and the risk of damage to the net. When towing before the wind, care must be taken to avoid shock loads which may lead to bursting of the net.

After completion of the tow the warps are hauled in either with the main engine slow ahead or, on clean ground, by letting the net drop to the bottom while both vessels go on counter course towards the net and haul in only the slack. The boats then come close together, the bridles are returned from one vessel to the other and hauled in over rail rollers with the warping heads of the trawl winch. The rest of the operation of hauling in the net and securing the catch by splitting is the same as in conventional sidetrawling.

ONE-BOAT TRAWL AND ITS OPERATION

The one-boat trawl nets originally were of the two sideseam type with two equal panels. The construction was similar to the so called "Vinge Trawl", i.e. most of the pull was concentrated on the sideseams. Headline and groundrope had considerable slack so that, under the influence of the water stow, they could spread like a parachute. Extensive fishing trials with this net type gave satisfactory results only on spawning herring. The catches of the more active non-spawning herring, however, reached only about 1/5 of the pair-trawl catches with "square" four-sideseam nets. By model testing an explanation for the inferiority of the two-sideseam type could be found in the considerable distortion of the netting and the shape of the net bag in the wings, along the sideseams, and particularly at the end of the aft belly near to the connection to the tunnel. These shortcomings, together with the higher towing resistance of this net type, indicating a stronger water stow, obviously resulted in a considerable frightening effect of the net opening and facilitated the escape of fish through the meshes, which, at the critical sections of the net, were wide open.

The two-sideseam net type was, therefore, abandoned in favour of the four-sideseam type. Because of the obvious difficulties in obtaining a large opening height with the limited length of bridles of the one-boat gear, the design was made "rectangular". In order to provide some downward sharring effect, the lower wings may be longer than the upper wings. At present the standard one-boat midwater trawl consists of two pairs of equal panels, namely the upper and lower panel on the one hand, and the side panels on the other hand, except that the lower wings may be longer.

Originally the one-boat technique was intended for the smaller and less powerful sidetrawlers, which at the time had increasing difficulties in earning a living on the northern roundfish grounds. Commercial operation in Germany was, however, actually started by medium sized to large sterntrawlers. The higher demands of sterntrawling for strength and sturdiness, particularly with larger vessels and with larger catches overrule the disadvantages regarding catching efficiency, towing resistance and price. The nets for sterntrawlers have to be made of much stronger material. The most common net size for vessels of about 1,000 hp. and more is 1,400# circumference, meshsize 200 mm (8 in.) stretched. The construction drawing of a net of this type is shown in Fig. 6. For spawning herring even stronger nets but of smaller size (1,000# to 1,200# circ.) may be used. The largest nets so far have 1,600# circ.

The flotation of the headline consists of 60 to 80 spherical plastic or aluminium floats of 200 mm (8 in.) diameter. In addition a normal wooden kite of about 1 m² (ca. 11 sq.ft.) may be rigged at the centre of the headline bosom. The groundrope is ballasted either with chain weights of about 150 to 250 kg (330 to 550 lbs.) or, for combination midwater and bottom trawling, with a bobbin groundrope of about 300 to 650 kg (660 to 1,400 lbs.) weight in water. At the connection point of the groundrope legs with the bridles heavy front weights of about 250 to 700 kg (550 to 1,500 lbs.) each are attached. These front weights, together with the elongation of the lower bridles (about 2 to 6 m (6.6 to 20 ft.)) in relation to upper bridles, are the principal means for providing sufficient vertical net opening. The bridles connecting the four wings of the net with the two otterboards are of steel wire cable of around 14 mm diameter (1.7 in. circ.). Depending on the fishing conditions the length may vary from 40 to 150 m (22 to 80 fms.). For unrestricted performance of the boards and for ease of operation, the bridles are usually connected to the otterboards by means of a crowfoot.

For the otterboards in Germany the design of the late Ing. F. Süberkrüb was chosen, because it is simple and lends itself to sturdy and comparatively cheap construction. In the beginning they were built in combined wood-iron construction. Since this was not satisfactory, particularly for larger sizes, they are now made of steel throughout. The Süberkrüb-design, an example of which is given in Fig. 7, is patented. A special feature is the improvement of depth regulation by speed variation, which is obtained by having the point of attachment for the warp slightly above the centre line of the board, so that a speed dependent upwards sheering component is created, the amount of which is controlled by ballast at the lower edge of the board. The Süberkrüb-otterboards reach maximum sheer already at about 15° to 20° angle of attack. They have a slightly better sheer at only about 1/5 of the towing resistance per unit area, as compared with the conventional flat otterboards.

The rig of the gear, a schematic view of which is given in Fig. 8, depends on the fishing conditions. For spawning herring, shallow water, and better manoeuvrability smaller nets, shorter bridles and correspondingly smaller otterboards are preferable. For the active, non-spawning herring, however, larger and lighter nets, longer bridles, and larger otterboards are required. The setup for these two conditions presently used in Germany is as follows:

	non-spawning herring	spawning herring
otterboards	3.5 to 4.5 m^2 (38 to 48 sq.ft.)	6.0 m^2 (65 sq.ft)
bridle length	40 m (22 fms.)	100 to 150 m (55 to 80 fms.)
front weights	250 kg (550 lbs.)	up to 700 kg (1,500 lbs.)
net size (meshes circ.)	1,000 to 1,200	1,200 to 1,600

There is, however, a tendency to use the gear for non-spawning herring also on spawning herring, because the provision of two different gears is considered undesirable in regard to ease of operation and costs. There is, furthermore, a tendency to increase the size of the otterboards in favour of the opening width. 6 m^2 (65 sq.ft.) otterboards are becoming more popular for the larger vessels and promising trials have been made with 8 m^2 (86 sq.ft.) boards.

Smaller vessels of about 600 hp. are using 3.5 to 4.5 m^2 (38 to 48 sq.ft.) otterboards, and the smallest vessel working with this gear, not only on herring but also on sprat and cod, is a cutter of 24 m o.a. (80 ft.) and 240 hp. and uses otterboards of 2.5 m^2 (27 sq.ft.) each.

Apart from the separate cable for the netsonde, the operation of the combination one-boat midwater and bottom trawl is practically the same as in conventional bottom trawling. On sidetrawlers the larger and longer net requires some more time for shooting and hauling and, on shallow and rough grounds, some more care for avoiding net damage. On sidetrawlers the catch is taken on board by splitting so that also large quantities of 50 t and more can be handled in the conventional way. Sterntrawlers with a chute have to hoist the whole catch in one go. Although tunnel and codend are strengthened with a strong, large mesh cover and longitudinal and circular strengthening ropes, catches of more than about 60 t are too much for the hoisting power of the winches, the strength of the tackle and the length of the deck even of large sterntrawlers. In such cases the aft belly either bursts or has to be cut open to release the surplus, which may be 50 t and more, before the rest can be hauled on deck.

Since under favourable fishing conditions, such as the spawning herring season or the recently started exploitation of the atlanto-scandic herring, catches of this size are not rare, means have to be found to avoid this waste. One promising way, which applies also to pair-trawling and to vessels of all sizes, seems to be the pumping of the excessive amount while the net is still in the water. This would probably also help to maintain a good quality of the fish which may suffer when being hoisted up in too large quantities. The main problem of pumping fish out of trawl nets under all weather conditions is the arrangement and the operation of the pump hose which will have to be worked out by practical trials.

FISHING TACTICS

When fishing for dense schools of spawning herring in the North Sea summer season success is mainly a matter of skillful manoeuvring in a crowd of trawlers competing for one or very few distinct schools. Optimal catching efficiency is of lower importance, because spawning herring does not seem to react to trawls at all. Still, a larger net cuts more out of a given school than a smaller net, and the combination midwater and bottom trawls, therefore, yield much larger catches than the conventional bottom trawls. The most efficient procedure so far is to try and detect such a school in advance by echoranging, determine its position, shape and size when passing over it by echoranging and echosounding, and to tow the net through its densest part. Naturally, even spawning herring is scattered after several trawls have passed through a school. The first trawler, therefore, has the best chance, and good manoeuvrability is essential. Consequently the one-boat technique is superior to the two-boat technique.

On dense bottom layers of spawning herring the high opening of the combination midwater and bottom trawl gives no advantage. The trawlers, therefore, often switch over to the conventional herring bottom trawl which may be more efficient under such conditions. For facilitating the exchange of otterboards, some sterntrawlers have additional gallows fitted to have both types ready. Recently some trawlers have started to maintain the combination trawl for bottom fishing on soft grounds. On rough grounds the large four-sideseam nets, which are naturally more susceptible to damage, have to be equipped with a bobbin groundrope, and the headline bridles should be lengthened to get the lower panel off the bottom. Such herring layers usually have larger size and the trawlers are less crowded. Under these conditions the chances of pairtrawling and one-boat trawling are practically equal. Echoranging is useless and echosounding may be problematic.

The large pelagic "clouds" of non-spawning herring at the Norwegian Trench conduct diurnal vertical migrations. During daytime they keep below about 180 m (100 fms.), during night they come close to the surface and may be even more scattered. Usually day fishing is more productive. Sometimes the fish try to escape upwards and the net should be towed through the upper part, or with the groundrope even some distance above the school. At other times the schools may be closer to the bottom and try to escape downwards so that it is more advantageous to tow the net through the lower part, or partly below the school and rather close to or even on the bottom. The correct tactic is determined according to the netsonde recordings. The tows may last for 6 hours and more. One-boat and pairtrawling are equally suitable. The headline bridles of the one-boat gear have to be shorter to place the otterboards above the centre line, or even the headline, of the net so that the warps will not disperse the fish in front of the net opening.

For night fishing the net has to be towed near the surface. Pairtrawling is, therefore, superior, because the vessels do not pass over the fish in front of the net opening and the warps can develop maximum herding effect. Nevertheless, also one-boat trawling has at times given good success, even without special manoeuvres (circling, zig-zagging) to keep the net out of the course of the vessel. In order to get the one-boat net high enough and at the same time keep the otterboards under the surface, the headline bridles should be equal to the groundrope bridles or even slightly shorter. Horizontal ranging is almost useless during the night, and for echosounding proper amplification is essential to avoid misinterpretation of the amount of herring in these "clouds", particularly near the surface. The reasons for the varying behaviour of the fish leading to complete failure or good success of night fishing in this area are not clearly understood yet.

The dense herring schools of "pole" shape which at certain times occur along the Norwegian Trench in midwater, are very good targets for echoranging. Because of their limited horizontal extension which requires rather accurate steering of the net, one-boat trawling is superior to pair-trawling, because the net is more or less behind the trawler with the fish finding equipment. For spot plotting the schools the combination of echoranging, echosounding and Decca-navigation is advantageous. Experience so far indicates that better catches are obtained when the net passes the school in a downwards direction, compared with unchanged depth or upwards direction. The actual catch lasts only for around 5 minutes. One school often yields enough for hauling. The amount of catch is estimated from the netsonde traces.

The large schools of atlanto-scandic herring off E-Iceland and during the migration to the Norwegian coast are excellent targets for both echoranging and echosounding (Fig. 2). Because of their large size in length and depth, the proper adjustment of the netdepth usually is no problem. During daytime this herring does not seem to react strongly to the gear, and surprisingly large catches have been obtained with tows of one half to one hour duration. Sometimes a vertical zig-zag course of the net was found more effective compared with towing in unchanged depth. During the night, when this herring also comes close to the surface and scatters, midwater trawling was so far clearly inferior to gillnetting or purse seining.

Over water depths of more than about 800 m (ca. 450 fms.) it is preferable to attach the netsonde transducer to the groundrope bosom in upward sounding direction and use the surface as reference for the net depth.

There are, of course, many more "tricks to the trade" which cannot possibly be discussed in this short account, and even more are likely to be found along with the spreading of midwater trawling to other areas and fishing conditions. The above report on the present state of the German experiences with combination midwater and bottom trawling for herring should, therefore, be considered as an attempt to illustrate some of the problems involved, as far as they are presently understood, and certainly not as a "guide to midwater trawling" in general.

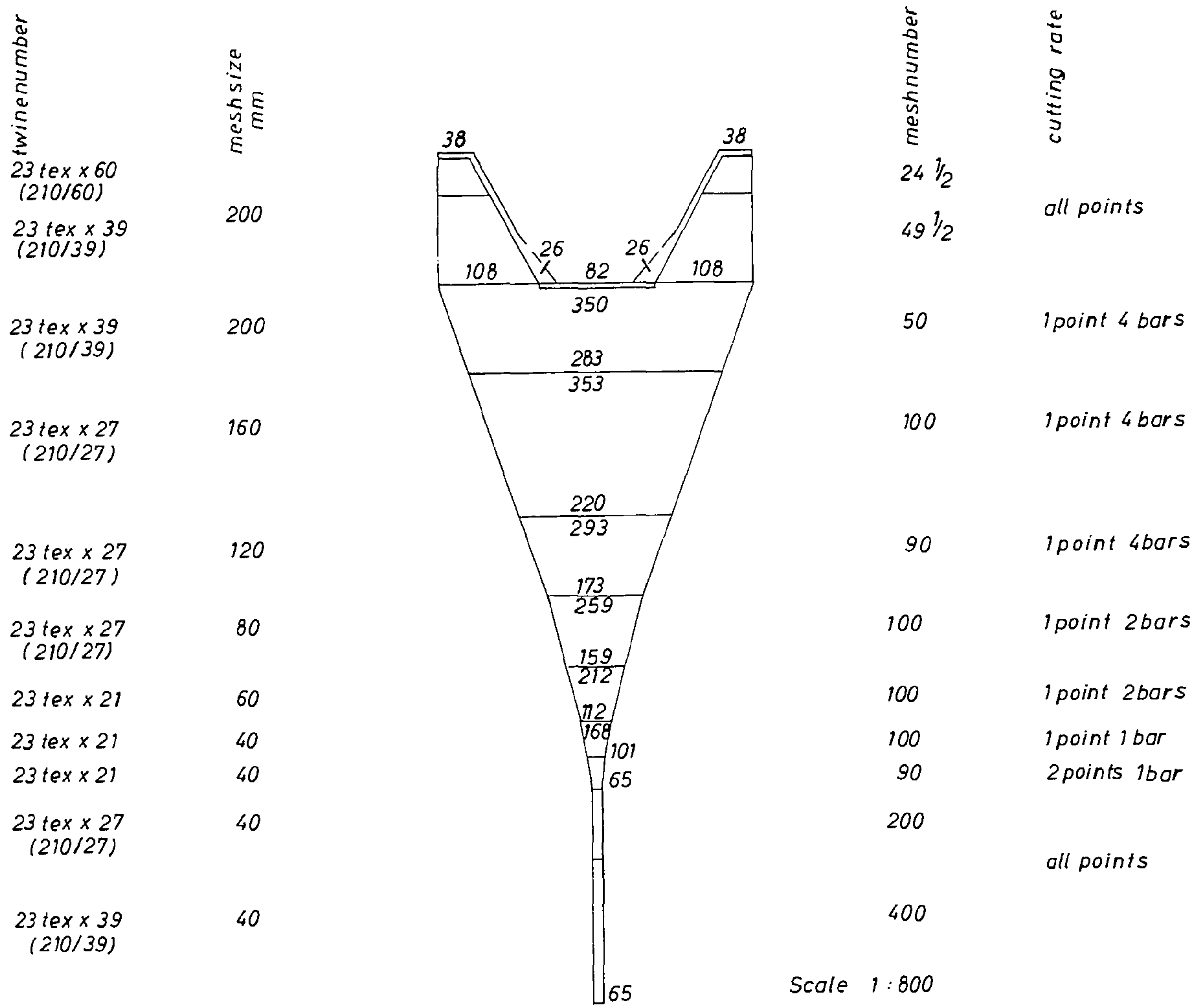

Fig. 4: Example of a midwater pair trawl net, four equal panels, 1400 meshes circumference.

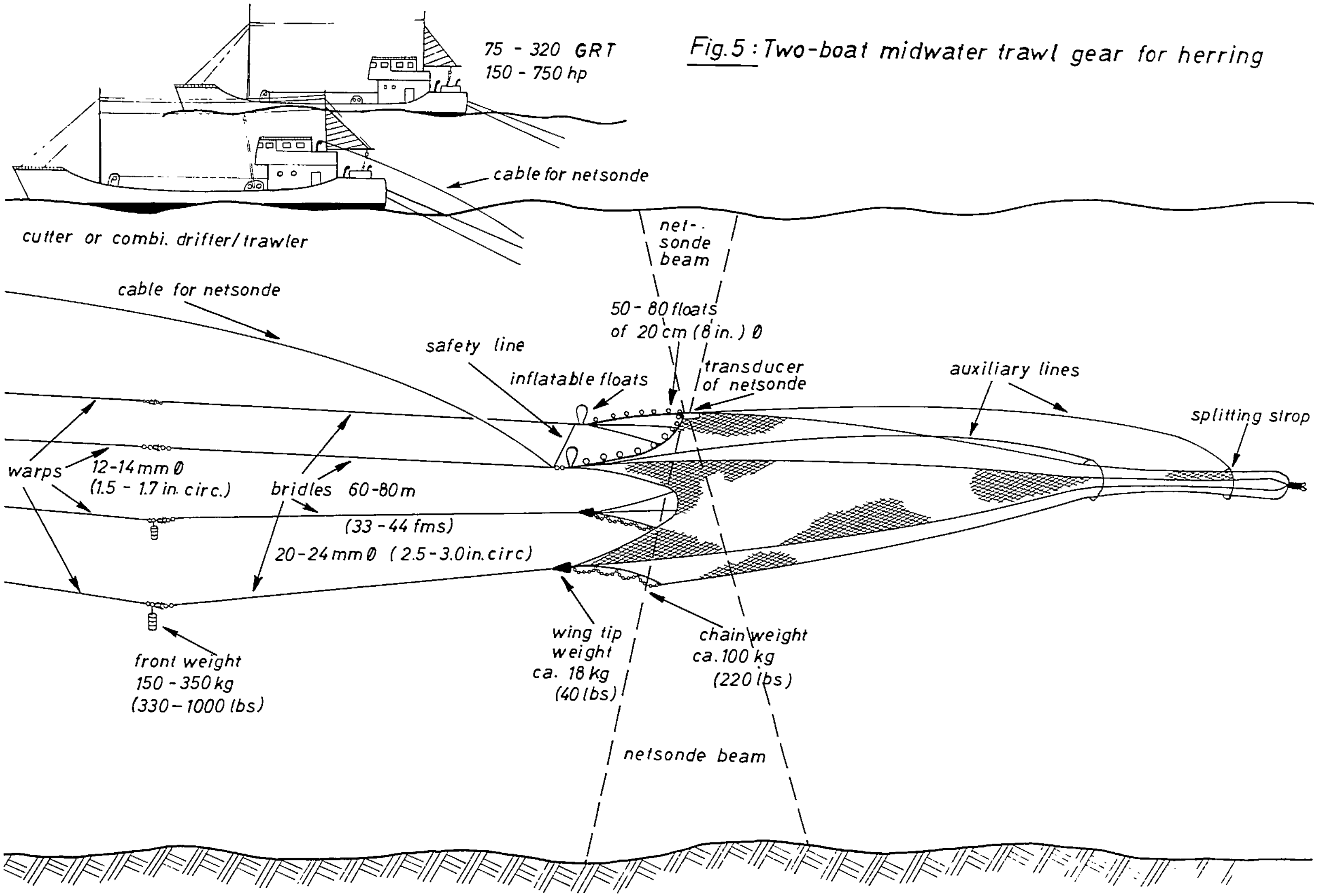

Fig. 5: Two-boat midwater trawl gear for herring

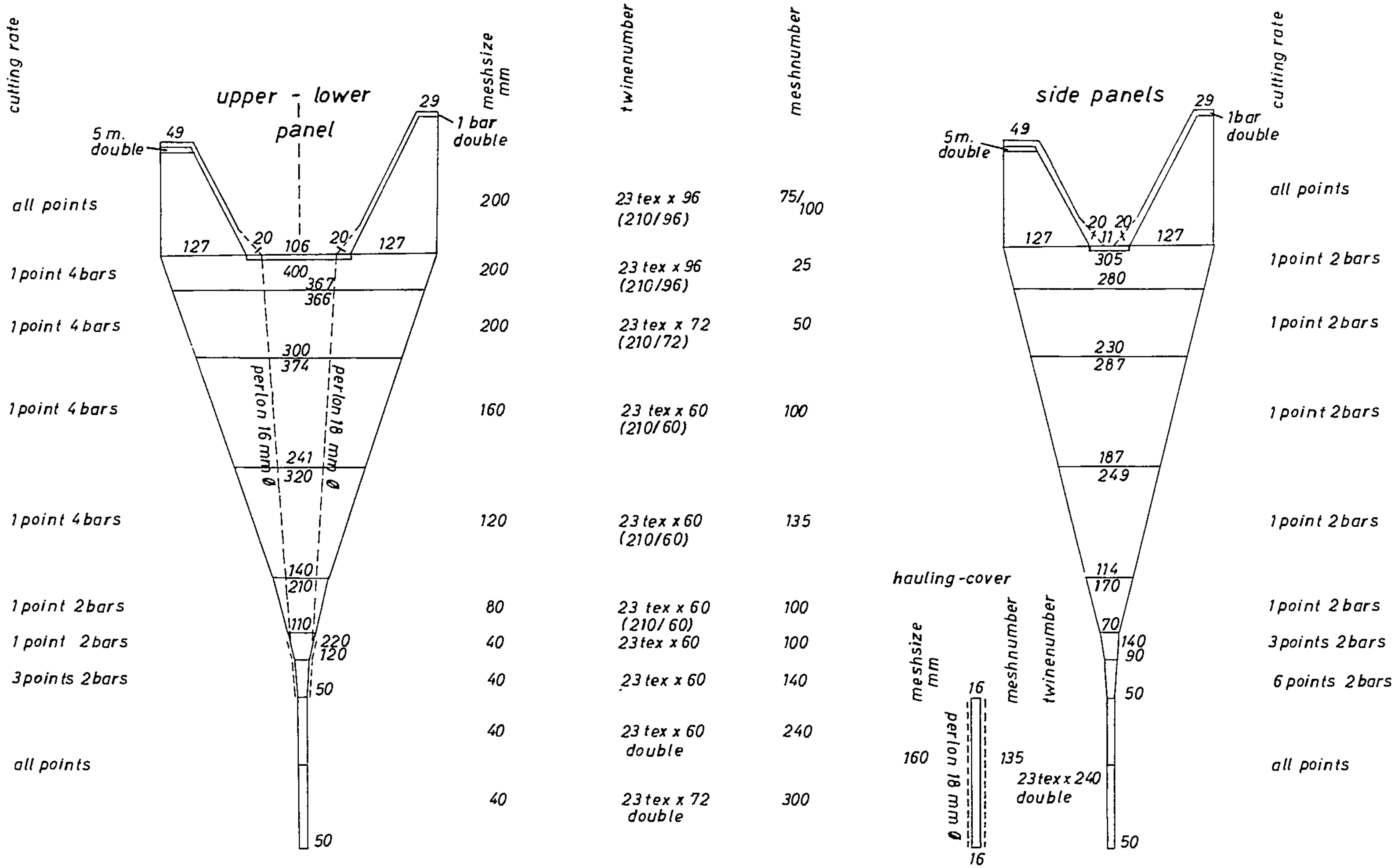

Fig. 6 : Example of a German one-boat midwater- and bottom trawl net, 1400 meshes circumference, for stern trawlers.

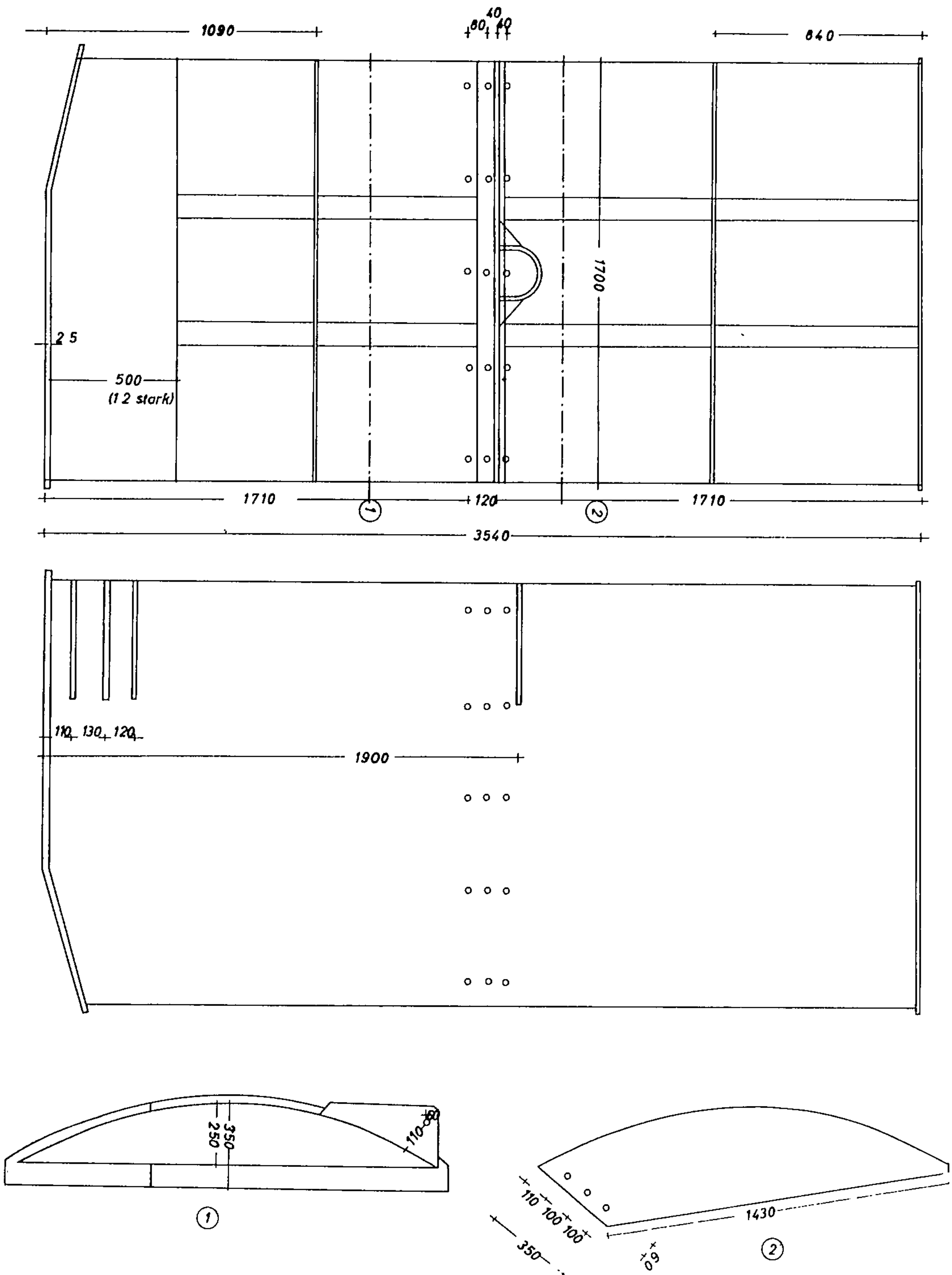

Fig.7: Example of a SÜBERKRÜB otter board (patented) of 6 m² (65 sq.ft.) for trawlers of more than 600 hp.

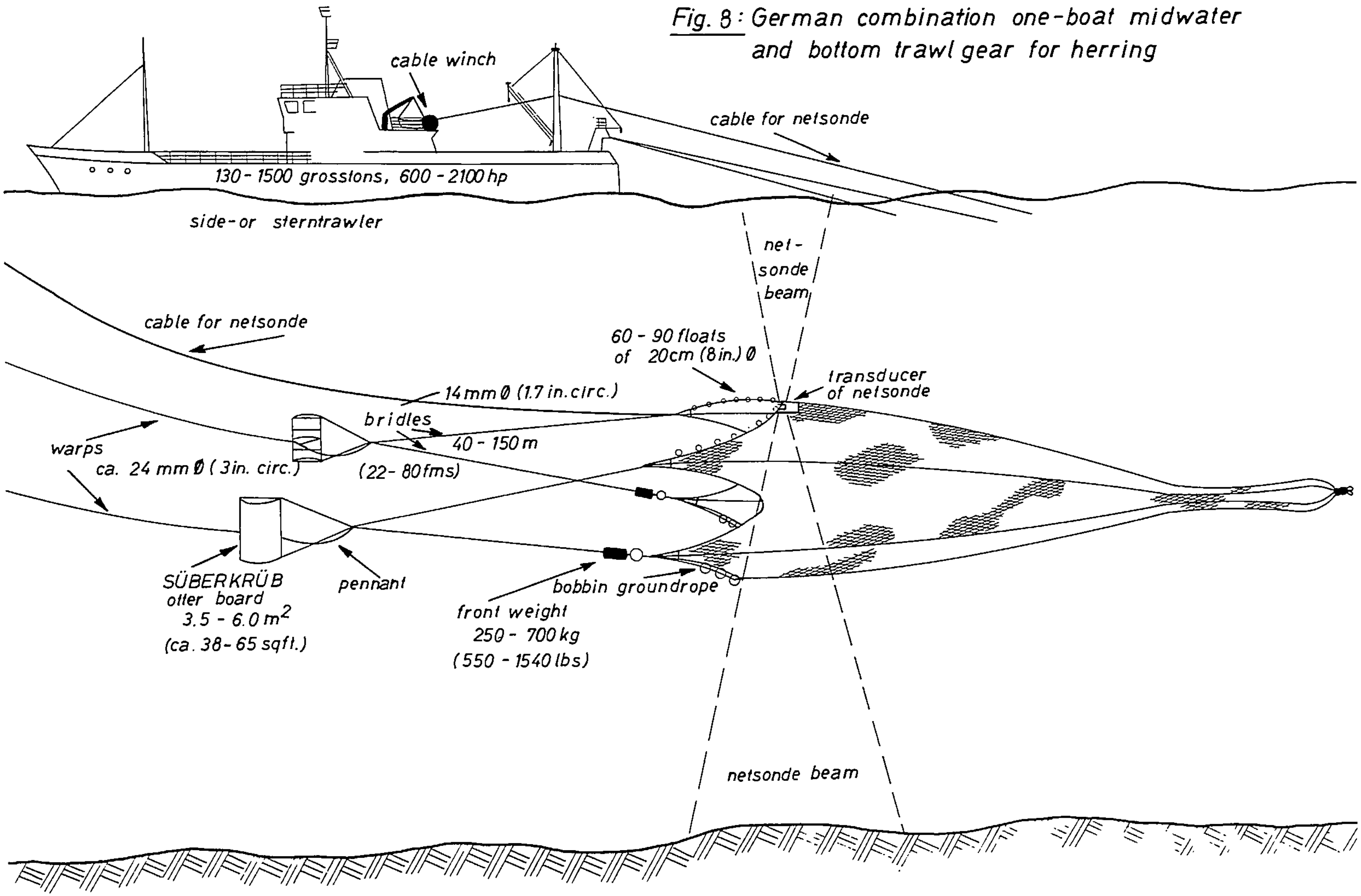

Fig. 8: German combination one-boat midwater and bottom trawl gear for herring

Herring Fishing Gear Generally

by
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Industrial Development Service
Department of Fisheries of Canada
St. John's, Nfld.

NORTH EAST ATLANTIC REGIONS

I would be safe in stating that, in the main, herring are captured in this region by the following types of fishing gear–drift gill nets, set gill nets, ring nets, purse seines, bottom trawls, and midwater trawls. The fish caught are processed in the following ways: utilized for fish meal; fresh; fresh frozen; smoked; salted or cured in one form or another, and canned.

METHODS IN USE IN SPECIFIC COUNTRIES

Norway

The main methods of catching herring are by drift gill netting, set gill netting, purse seining and trawling.

Drift gill nets are used mainly when the season opens in the winter when the herring are in more offshore locations. Set gill nets are employed when the fish are in close proximity to the land, or in the fjords, by smaller inshore fishing vessels. Purse seines are used in the open sea and also when the fish are in close to the land. Catches have been made two hundred miles off the Norwegian coast. These schools of fish are located with the aid of Sonar, also, light attraction systems are used extensively. Trawling is becoming increasingly popular, both in the bottom and midwater presentation.

Norwegian fishermen prosecute the herring fishery off the coast of other countries such as Iceland, Faroe Islands and Jan Mayen. They leave the Norwegian waters in the larger boats around the beginning of July and return to their home ports as late as the end of November.

Sweden

Fishing methods in use to capture herring in Sweden are much the same as those in Norway, although on a much reduced scale.

Germany

The principal fishing methods in Germany are trawling and drift gill netting. The fleet working the English Channel and North Sea was at one time made up almost entirely of drifters and small motor boats. However, the Germans have perfected trawling for herring and now a large part of the catch is landed by bottom and midwater trawlers. The main fishing season is from May to December.

Denmark

The catching methods are much the same as those of Germany.

Faroe Islands

Of late years the main method of capturing herring has been with purse seine. The inshore fleet in the Faroe Islands still uses the bottom and floating gill nets.

Netherlands

The fishing methods in the Netherlands are, again, much the same as those of Germany, with the emphasis placed on trawling. The principal fishing areas for the Dutch fleet are the North Sea, the English Channel, and the Irish Sea.

Great Britain

The principal methods of herring fishing in use today in Great Britain are purse seining, ring netting, trawling and drift gill netting. The main fishing areas are (1) off the Shetland Islands from May to July, (2) off the coast of north east Scotland from June to August, and (3) off east Anglia from October to December.

Iceland

The main fishing methods in use in Iceland are purse seining and drift gill netting. The major fishing grounds are off Iceland and the Faroe Islands.

U.S.S.R.

The main method of capture is the bottom and drift gill net and purse seine. The major fishing areas are off Murmansk, the White Sea, Barents Sea, the western part of the Baltic Sea, the Norwegian Sea, the North Sea, and the Atlantic Ocean.

Japan

Most of the herring landed in Japan are caught by means of bottom and drift gill nets; a small amount of herring is caught in herring traps. The main fishing areas are along the coastline of Hokkaido and northern Japan.

DRIFT GILL NET FISHING

Before World War II, most of the herring caught in European waters was taken by means of gill nets, in particular drift gill nets. There are two types of arrangement for drift gill nets, one is for setting in shallow water (see FAO sheet 405 entitled Floating Drift Net) and the other for setting in deep water. The shallow water type drift gill nets were hung above the warp and were supported in the water by floats or canvas or plastic buoys which floated on the surface of the water. This method was used for herring when they were near the surface. The deep water types were hung below the warp and were supported by floats to which canvas or plastic buoys were secured. This was used for herring when they were near the sea floor. The average drifter carried about 100 to 150 nets.

To set a fleet of gill nets would take approximately one and a half hours. The floats would be tied to the warp as it was paid out over the side of the vessel. It should be pointed out that the ship had to manoeuver slowly astern and down wind to execute this operation. When retrieving the nets, the warp was hauled in by means of a winch. During this operation the ship had to move slowly in the direction of the fleet of nets. The floats and the nets themselves were disconnected when the nets came in over the side roller. The nets were spread apart and the fish were shaken out prior to being coiled down ready for the next setting.

Herring drift gill nets are usually hung on the thirds and are generally 35 yards long by approximately 7 fathoms deep.

The netting material most commonly used is cotton. Synthetic herring gill nets, while fished, are usually made from nylon or terylene, but many fishermen feel that the nylon has a tendency to cut into the fish and thus spoil it for market, so they prefer the natural fibres for this reason.

Three net plans are presented as illustrations:

1. *FAO No. 405* is a herring drift net used in the Netherlands on luggers ranging from 100 – 200 gross tons, with 80 – 400 H.P. These nets are hung in framing lines of approximately 10 F. long by 4 F. deep, and up to 100 of these nets are fished per boat.

   Hanging ratio and other pertinent construction details can be extracted from the Data Sheets.

2. *FAO No. 410* is a Kessock type net used in the Moray Firth on 40 – 60 foot drift net boats of 20 – 50 gross tons. These vessels are very lightly powered, having from 20 – 100 H.P. The nets are hung on 12 fathom float lines and 17 fathom side lines. Each vessel will use from 20 – 40 of these nets. The sinkers appear to be beach rocks.

   Again, the hanging ratios and other pertinent information can be obtained from the FAO Data Sheet.

3. *FAO No. 411* (Looe Style Net) is a drift net used in Cornwall, England, to catch pilchards. It is hung on 38 x 7 framing lines. Fleets of 30 – 40 of these nets are used on 30 – 45 foot drift net boats. Further information is available on the accompanying data sheet.

Before World War II herring fishing in Great Britain was carried out almost exclusively by drift gill netting; most of the vessels were steam drifters of 70 – 90 feet in length. These were operated from such ports as

Yarmouth, Lowestoft, Milford Haven, Aberdeen, Peterhead and the Moray Firth. The rising cost of coal, coupled with a decline in herring landings, led to the gradual departure from this type of fishing. The few drift gill net vessels left are powered by diesel engines and are dual purpose, converting to trawling for whitefish in the off season.

In conclusion, it might be safe to say that this type of fishing is declining greatly in almost all countries, with the major exception of the U.S.S.R.

RING NETTING

The most common ring net in use is the small two-boat type with a corked line of approximately 100 fathoms long and a depth of about 8 fathoms. The Scottish ring net has wide mesh wings outside a narrower stronger bag or middle part. Actually, it is not a bag but square netting set in, very slack on ropes, to form a bunt as the gear is hauled in. To achieve this bag effect, the net must be pulled in very swiftly. The ends are towed together and the net hauled quickly until the wide mesh wings are inboard (See FAO sheets 302 and 303 for construction details).

History of Ring Netting in Great Britain and Ireland

After World War II, the introduction of purse seining brought a revival of the herring fishery on the west coast of Scotland. The type of purse seine used was the small two-boat type. The corkline is approximately 100 fathoms long with a depth of 8 fathoms. In Britain this gear is known as a ring net.

This type of fishing is carried out by pairs of fishing vessels in the 50 foot class, having 75/125 H.P. diesels. These are dual purpose vessels because in the off season they put on Danish seines.

The ring netting method spread to Eire in the 1950's when there was an increase in the herring fishery on the south and west coasts. There was a fairly large fleet in Irish waters, using Danish seines and trawls to catch herring spawning in large quantities on the sea floor. This method involved the use of short warps of 100 – 250 fathoms a side when the fish were in fairly shallow water.

Later, the Swedish "Vinge" trawl was introduced, with considerable success. However, the trend was more to ring netting because the Danish seines and the Vinge trawl only caught the fish when they were lying close to the bottom.

PURSE SEINING

Construction details of Icelandic herring seines are shown in FAO Data Sheet 308-309B.

The Icelandic purse seines, that is with a bunt in one end, have been in the development stages for over twenty years, first designed to serve the one skiff system and later for hauling with a power block. In Iceland, herring seine construction and design is not standardized. Each net loft and, for that matter, each fishing captain, has his own preference and these are incorporated in the seine.

Icelandic seines are usually hung with less slack web than Canadian types, and the weights have been increased to 1 – 1½ pounds per foot to accelerate the sinking rate. The power block has had a marked effect on Icelandic and Norwegian seining techniques.

Setting and Hauling the Seine

Instead of using a powered skiff to tow off the net when setting operation begins, the Icelanders use a ready buoy and flag pole. The buoy is secured to the headline and the end of the purse line is also shackled to the float. The vessel makes the set and returns to pick up the buoy upon completion of this operation. The purse line is then shackled to a short line running through the pursing gallows to the winch. When the pursing is completed, the ropes and the wing ends of the nets are taken through the power block and the net is hauled continuously until drying up is sufficient for brailing.

Construction details for Norwegian herring seines are shown in FAO sheets 304A and 307. There were the two-boat type of seines; this accounts for the large number in the crew, as noted in the FAO sheets.

The two-boat system of purse seining is all but a thing of the past in Norway, the one boat Icelandic type of operation having become the accepted method of fishing.

A recent press story entitled "Attempts to Revise Herring Fishing", carried in the March 25, 1966 issue of "Fishing News", will best describe the important place seining has gained in northeastern European waters – "For a thousand years, some say since Roman times, herring catchers on the East Coast have relied on the drift net method of taking their fish. Now there is the likelihood of purse seine netting being developed by Boston Deep Sea Fisheries Limited. Small and Company, the largest drift net firm in the herring business, are to try out pair trawling....... The next step will be to try out a purse seine net from the 421 ton Fleetwood middle water trawler the *Princess Ann*. These experiments are seen as very definite steps to try and rescue the fishery from the desperate position it has fallen to on the East Anglian shore".

TRAWLING

Countries such as Germany, Denmark and Holland have had a great deal of success in the catching of herring by means of trawls, either by using the single or two vessel midwater type, or the bottom or wing trawl.

Midwater trawl fishing in European waters can be divided into two categories: (1) two vessel operation, (2) single vessel operation.

The first midwater trawl (see FAO Data Sheet # 128A) was originally developed for fishing off the Danish coast. After successful testing in these waters, other countries became interested and midwater trawling became an accepted method for catching herring.

Operation (Two boat system)

Since the operation of the four seamed trawls is with two vessels, a high degree of skill and co-operation is needed by the crews.

The vessel holding the trawl will begin to pay out the net, as it lays broadside to the wind. This operation is much the same as in normal side trawling operations. The sister vessel "noses" up to the setting vessel, a heaving line is thrown over and one set of bridles is passed to the second ship. The bridles are attached to the main warps and they are now ready to begin setting. Both vessels proceed on predetermined courses as the warps are paid out. Once the gear has been set, both vessels proceed to tow on parallel courses. The distance between the two ships is most important, the usual "gauge" is one-half the warp length, excluding the bridles.

Advantages of the two boat midwater trawl method are said to be that there are no doors or other boards to disturb fish. Also, there is no propeller noise in the direct path of the trawl and, of course, larger trawls can be used, thereby increasing the catching potential.

Disadvantages are said to be higher operational costs (two boats), more skilled manpower required, and serious limitations due to weather.

Operation (Single boat system)

This operation is much the same as that of bottom side trawling. The ship drifts down wind as the four seamed net is set over the windward side. The main difference, as compared to two boat trawling is the use of a smaller net and otter boards, depressors and other devices to ensure the maximum opening of the trawl. The single boat trawl does not have the advantage of the great "spread" as in the two boat method, therefore this is considered by many to be a serious limitation in catching ability. The one boat midwater trawling system has only enjoyed limited success in certain countries.

Net sounding equipment is considered to be an essential part of midwater trawling in general for it allows the captain to place his net in the exact depth the herring are known to be.

Bottom Trawling Method

This method is used to catch herring when they are located very close to the sea floor. Usually the net "rides" just above the sea floor and it fishes much in the same manner as the bottom trawl. Most trawls of this type are fitted with a lead line for a "ground rope" and only "tickle" the bottom.

This method is considered to be a consistently good producer of herring. Also, there are no major changes in fishing techniques; rough bottom is a cause for concern as in conventional bottom trawling.

For further data concerning herring trawls, see FAO Data Sheets 110A, 112A, 113A, 114, 115A, 116A, 117A, 126 and 127.

The two-boat midwater trawl was taken to Scotland in 1963 when experiments began to test its suitability. Since then a few drifter seiners have converted to this method, and a number of new vessels have been built to operate it. These boats are about 70 – 80 feet long with 200 – 300 H.P. engines.

More recently there have been experiments in Scotland with the larger Norwegian type purse seine for herring and at least one Scottish port (Peterhead) has used the gear successfully. This gear requires a vessel of about 100 feet in length with around 500 H.P.

TRAPS

These are not considered today to be large producers of herring in any country. In most areas, the trap is subject to the migrations of the fish and also the pressures of other fishing methods on the stock. Therefore the use of traps for the catching of herring has declined greatly.

For a general design and material list, see FAO Data Sheet No. 505.

In Japan, the herring trap, which at one time caught most of the 10,000 to 50,000 tons annually, now accounts for less than ten per cent of the catch. Gill nets, floating and sunken, have become the main producers of herring.

The Japanese herring trap net measures, in the pocket, approximately 20 fathoms long by 8.5 fathoms wide by 1.5 fathoms to 15 fathoms deep. The depth varies, as in all traps, according to the contour of the sea floor.

The trap is operated by three boats; one approximately 45 feet in length, is used to lift the net, the others, which are in the 50 – 60 feet class, are used as carriers.

The pocket of the net is dried up from one end by the net lifting boat after the entrance to the trap has been closed off. The catches are transferred to floating bag nets which are towed to the shore by the carrier vessels.

Conclusion

Of all the catching methods dealt with in this paper, purse seining is becoming, very quickly, the most popular manner in which herring are caught. This is the case in almost every fishing country in the world. Much of this popularity can be credited to, not only the fact that the seine is a volume producer, but also to the introduction of new construction materials, new net hauling devices such as the power block, and the use of electronic searching devices such as Sonar. The latter equipment has allowed the Norwegian and Icelandic purse seiner to leave the bays and inlets of the coastal shore and range far out to sea. They are able to conduct effective offshore searching programs. Canadian herring purse seiners will have to be so equipped if they wish to take full advantage of all the herring stocks. This more offshore approach to the herring fishery will dictate the size of vessel which should be used.

Although interest in drift gill netting has been declining steadily since World War II in European waters, for various reasons, I feel that the introduction of this particular method in Canadian waters should be seriously considered. In Newfoundland the bottom set gill net is employed with far from encouraging results. This, of course, has had a direct effect on the size of the processing industry. Plants which have had standing orders for years have not been able to fill them because the fishermen could not catch sufficient quantities.

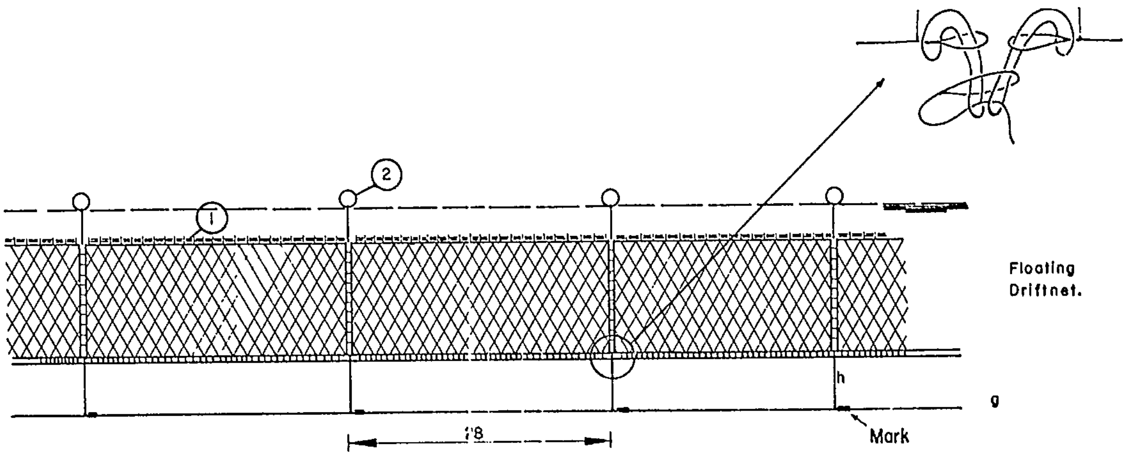
The present expansion in the herring fishery on Canada's East Coast appears to be slanted in only one direction, that of reducing fish for meal and oil. It would appear that countries which process herring for food, as well as for reduction purposes, maintain a "balance" which appears to be so necessary in this particular fishery. Therefore, it is conceivable that the introduction of other efficient methods of capture would tend to provide a better climate for a food processing industry.

Midwater and bottom trawling experiments should be carried out to prove the value of such gear in Canada, as is being done in other countries.

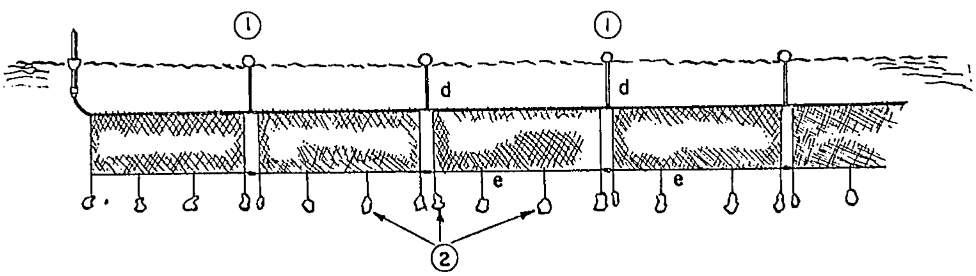
Finally, by diversifying the types of fishing gear used in the herring fishery, from the relatively low cost gill net to the high priced purse seine, fishermen in various economic circumstances can take advantage of this fishery resource.

(Figures on following pages)

Data Sheet **FAO No. 405**



Data Sheet **FAO No. 410**



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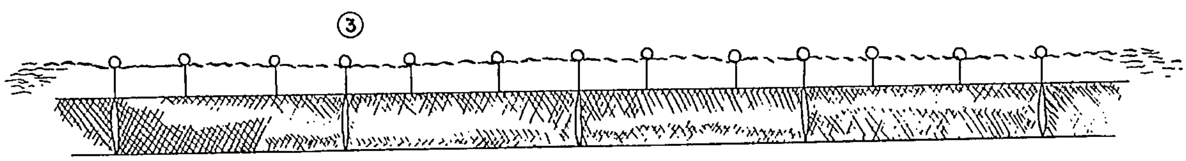

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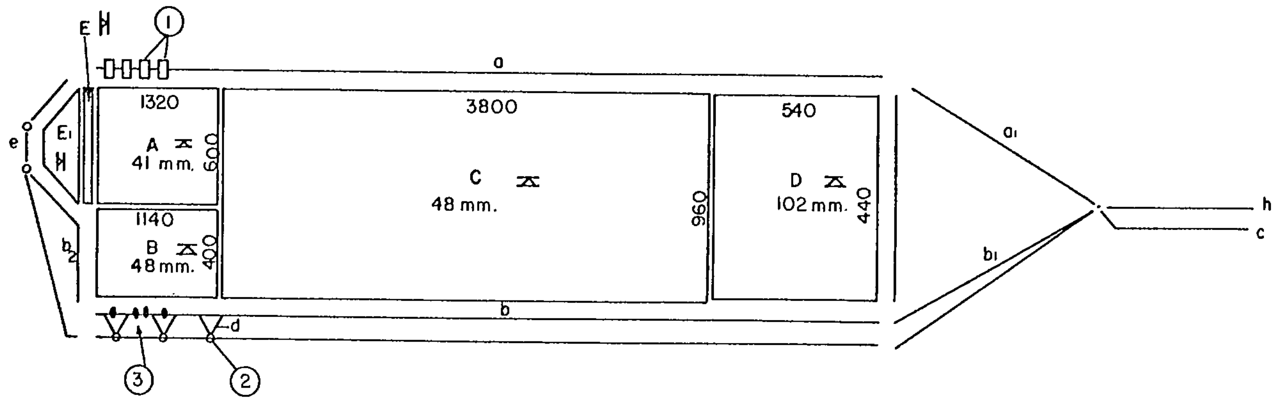
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C
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540
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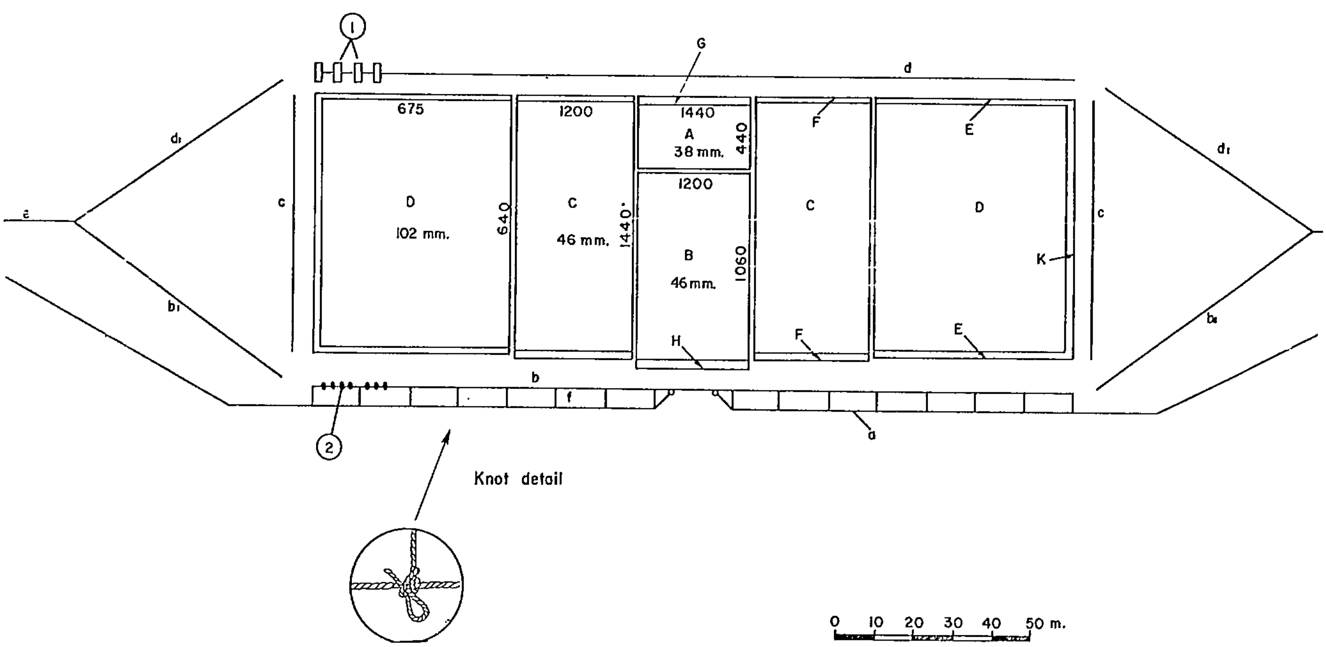
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Knot detail
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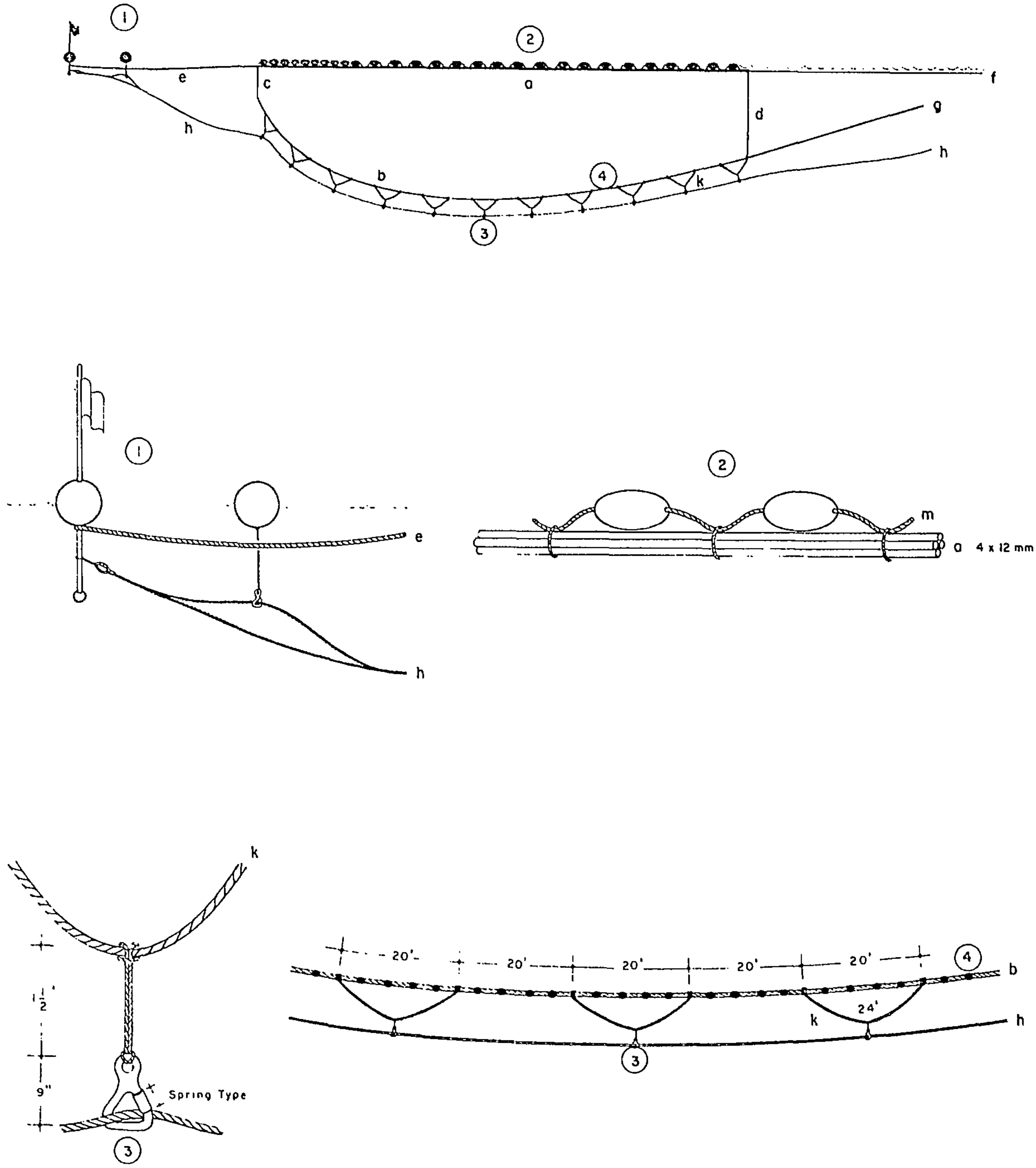

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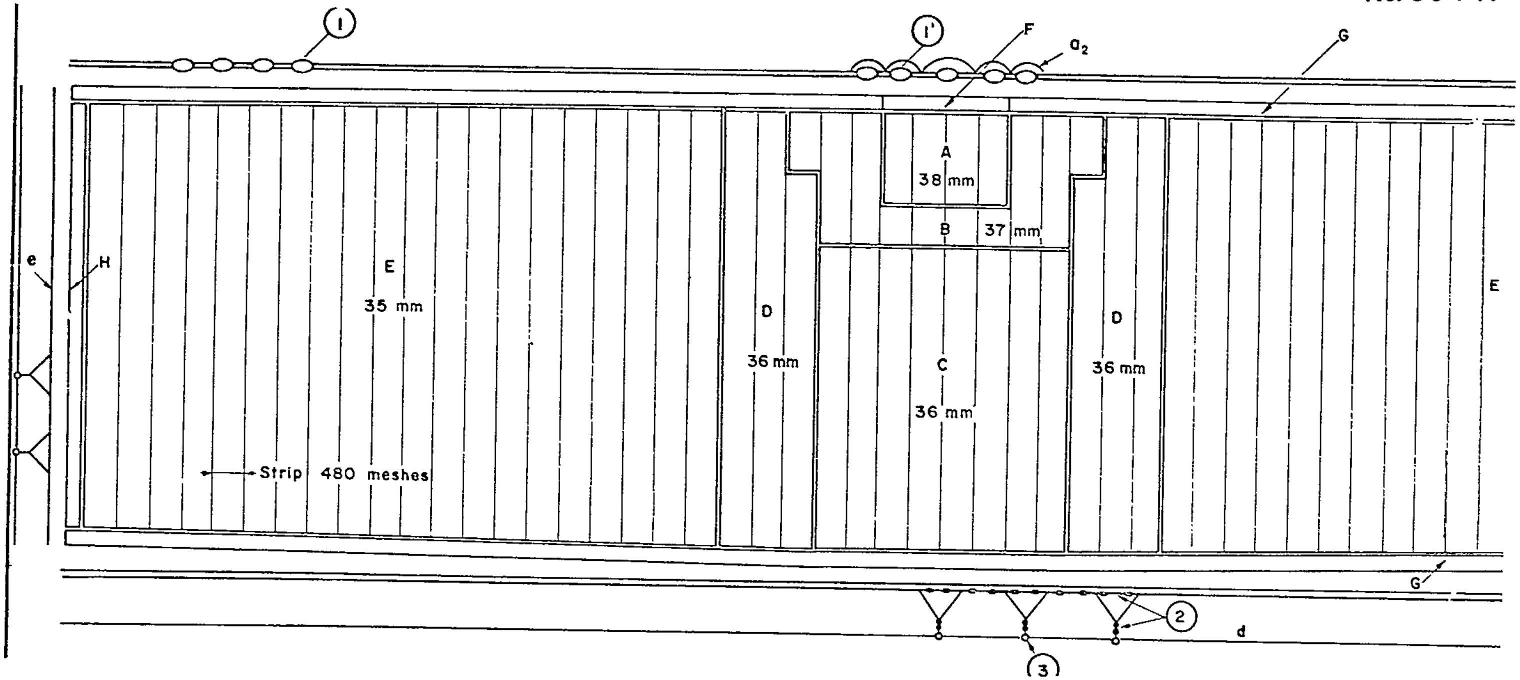

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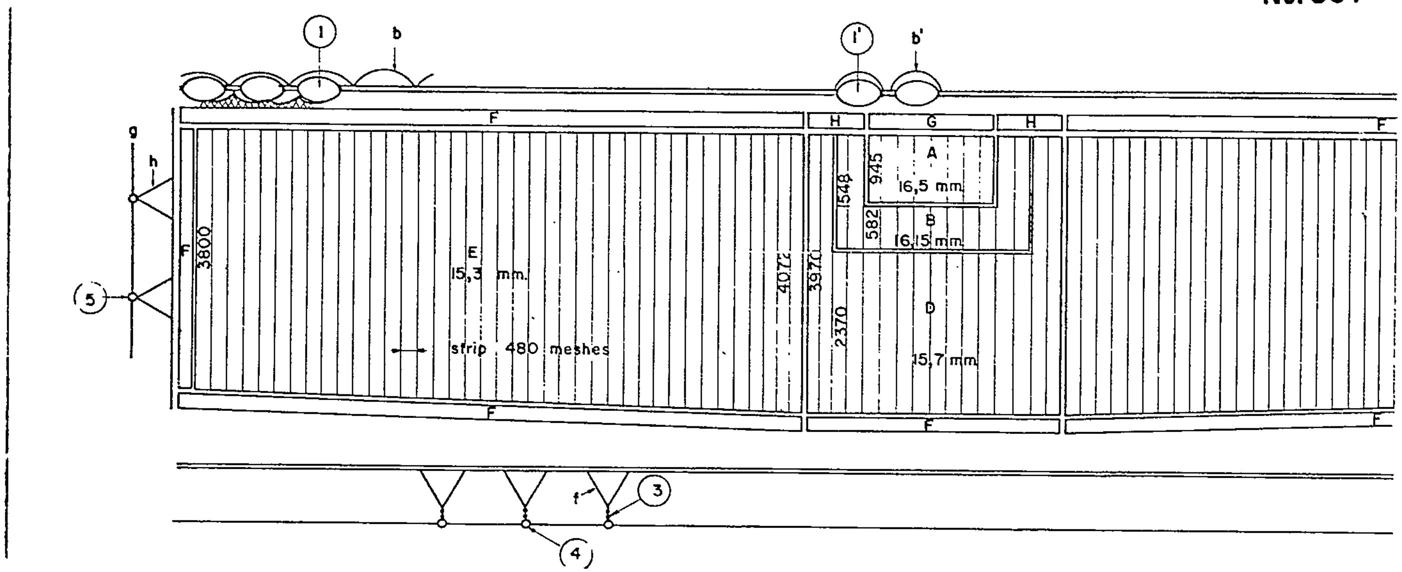

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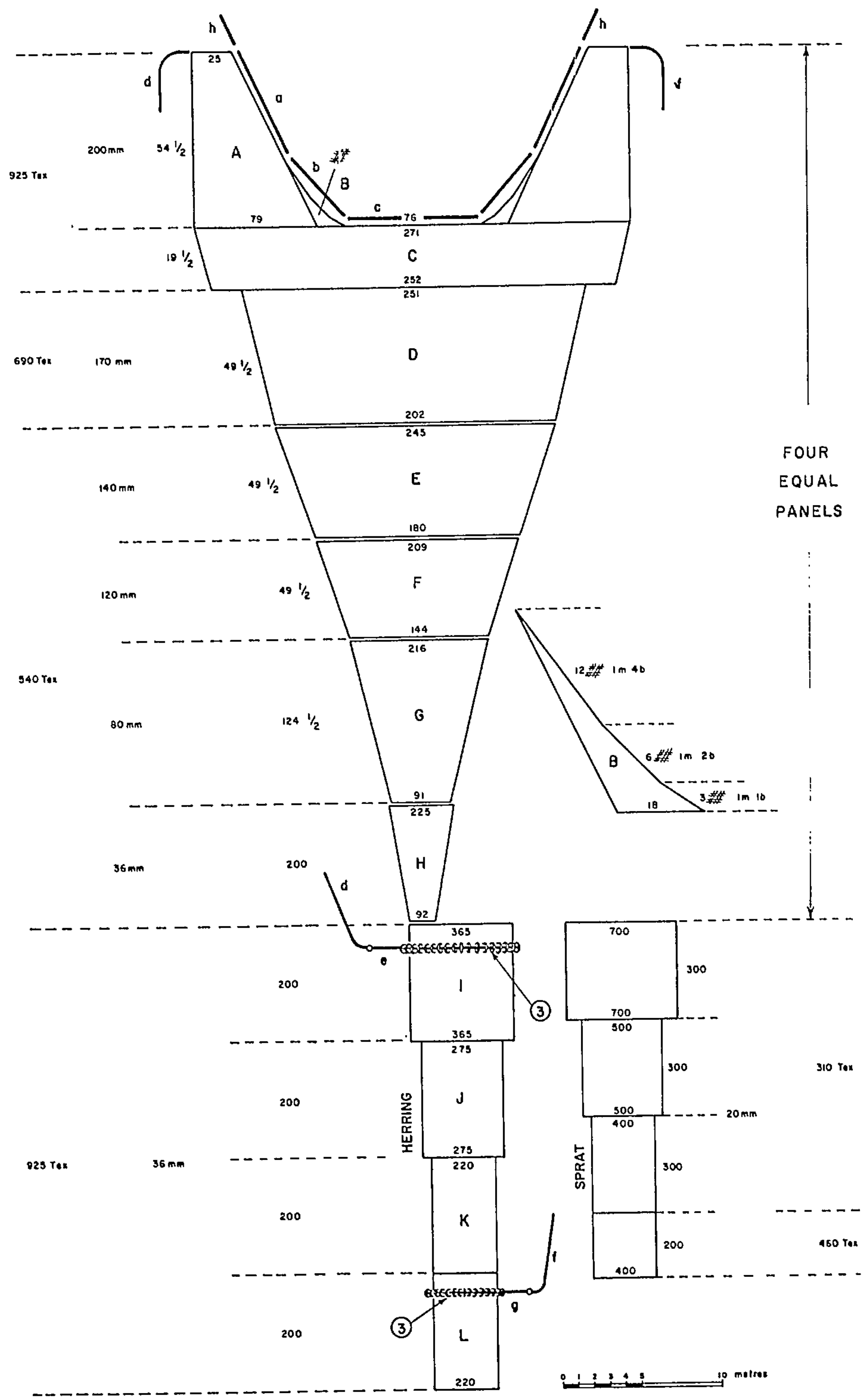
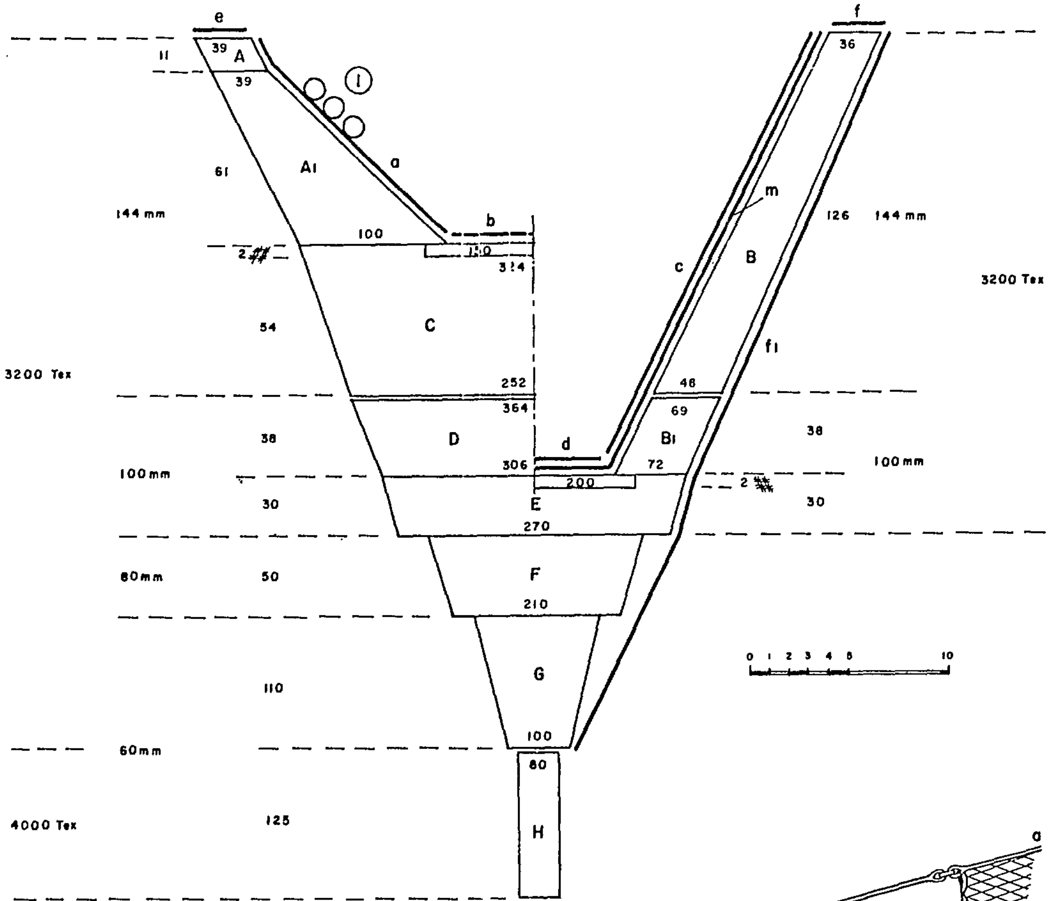
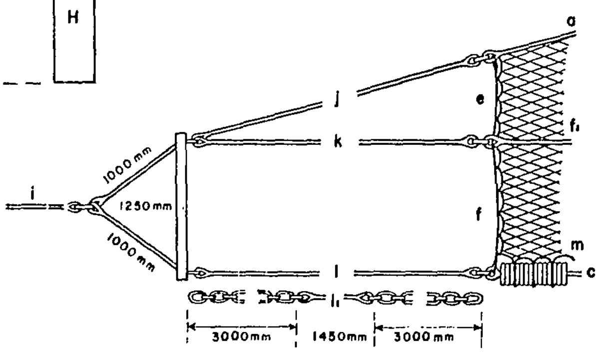
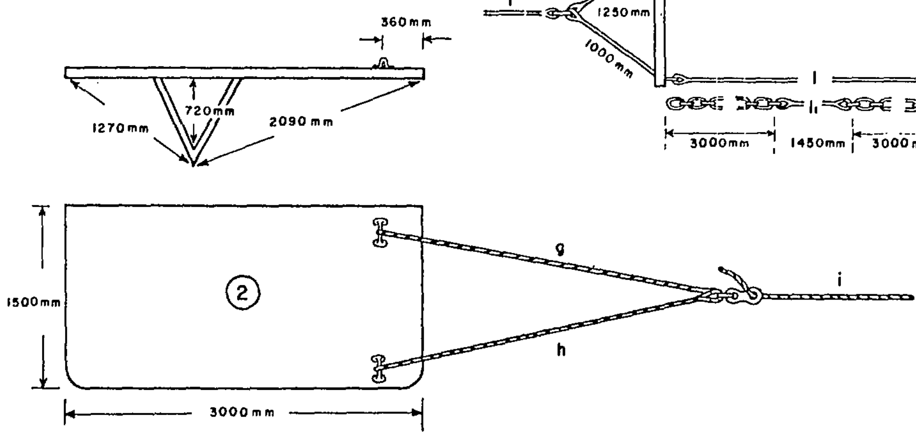


h
h
d
a
25
200mm
54 ½
A
925 Tex
b
B
c
79
76
271
19 ½
C
252
251
690 Tex
170 mm
49 ½
D
202
245
140mm
49 ½
E
180
209
120mm
49 ½
F
144
216
540 Tex
80 mm
124 ½
G
12 Im 4b
6 Im 2b
B
3 Im 1b
18
91
225
36mm
200
H
d
92
365
e
200
I
3
365
275
200
J
HERRING
275
220
925 Tex
36mm
200
K
f
g
3
200
L
220
FOUR
EQUAL
PANELS
700
300
700
500
300
310 Tex
500
400
20mm
SPRAT
300
200
450 Tex
400
10 metres

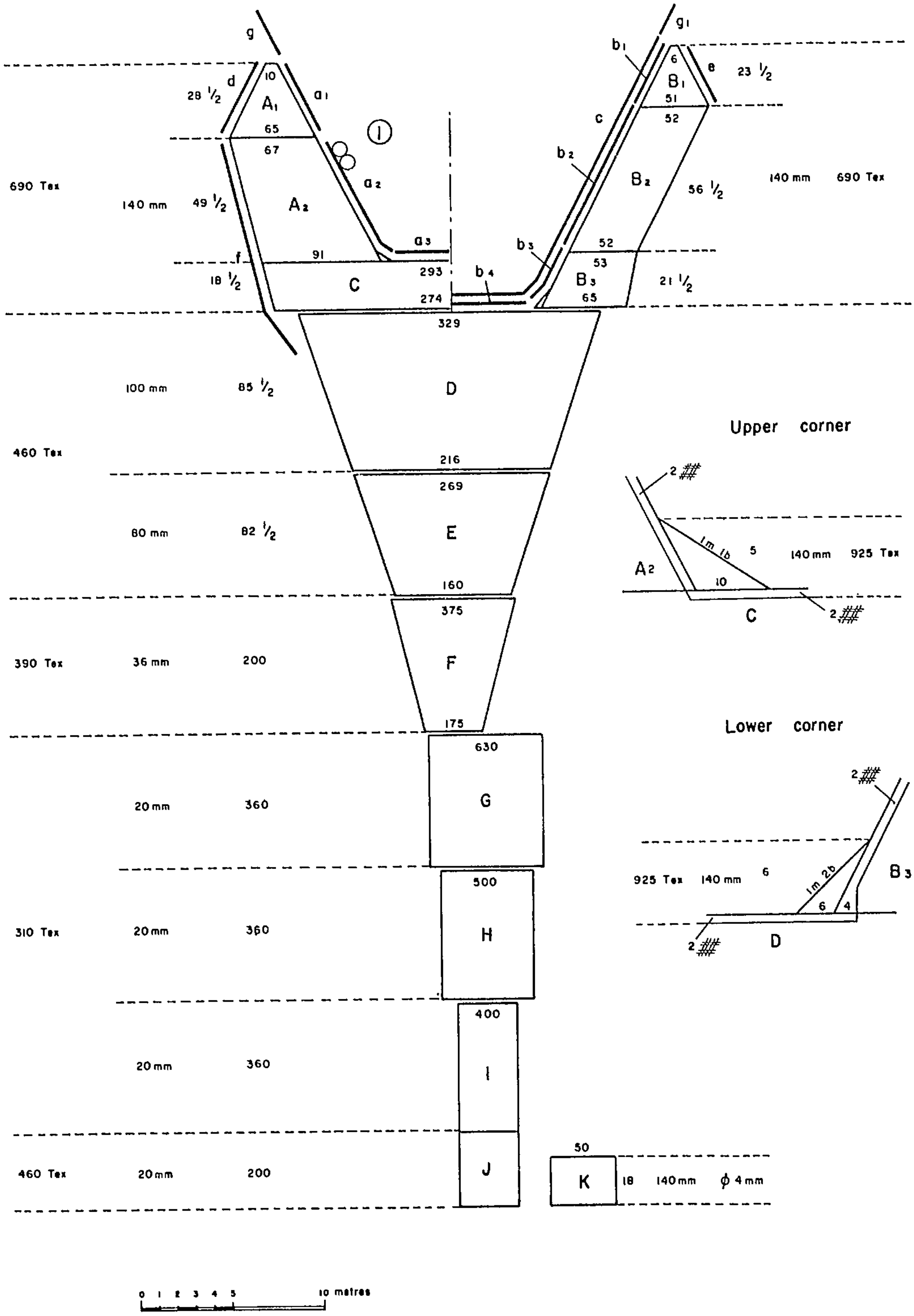
No. 110 A


e
f
39
A
11
39
1
36
A1
a
61
144 mm
m
126
144 mm
b
100
C
B
3200 Tex
54
C
f1
3200 Tex
252
364
46
69
38
D
B1
38
d
306
72
100 mm
100mm
200
E
30
30
270
80mm
50
F
210
0 1 2 3 4 5 10
G
110
100
60mm
80
4000 Tex
125
H


a
j
e
f1
k
1000 mm
i
1250 mm
f
1000 mm
m
l
c
l1
3000mm
1450mm
3000mm

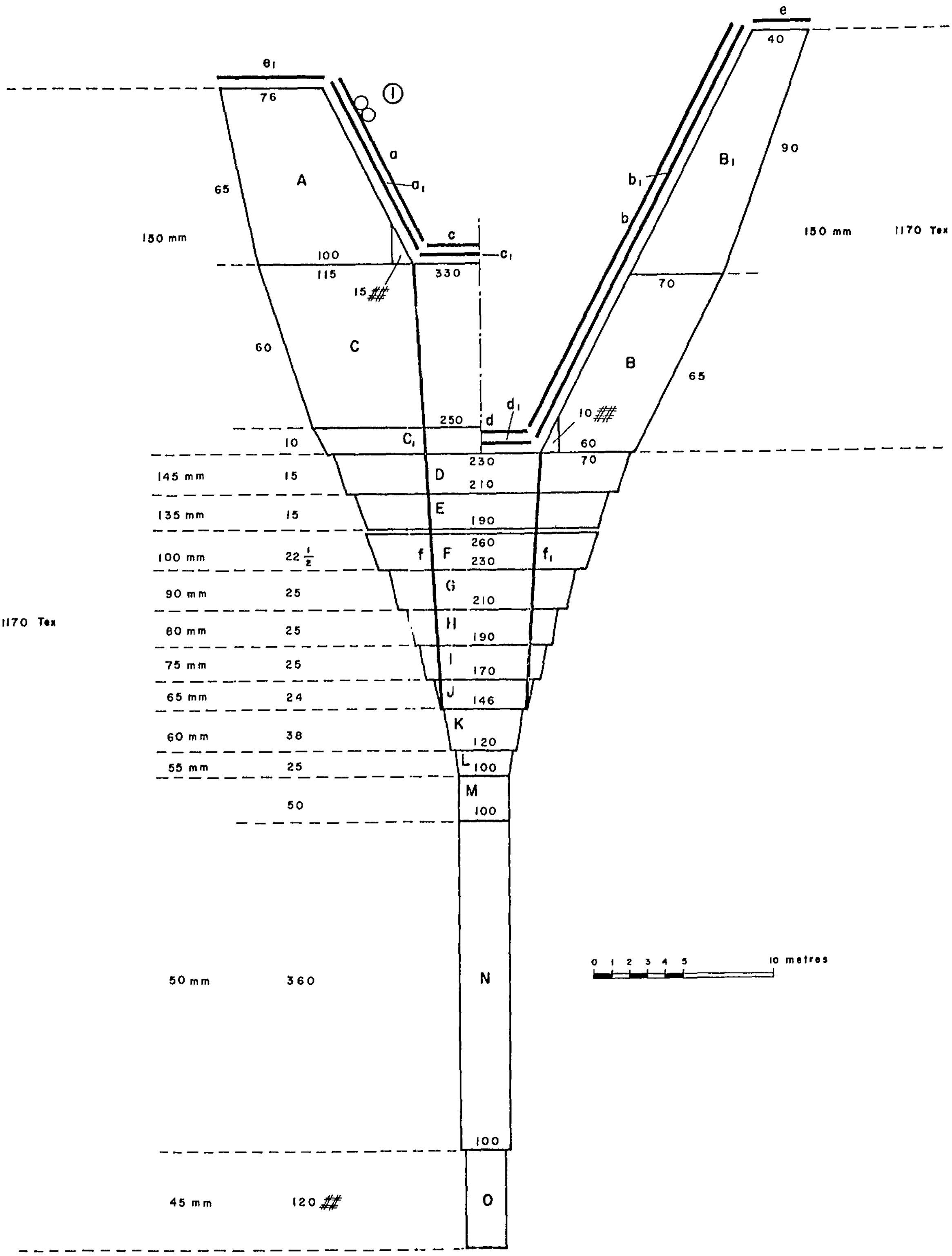

360 mm
720 mm
1270 mm
2090 mm
g
1500 mm
2
i
h
3000 mm

No. 112 A

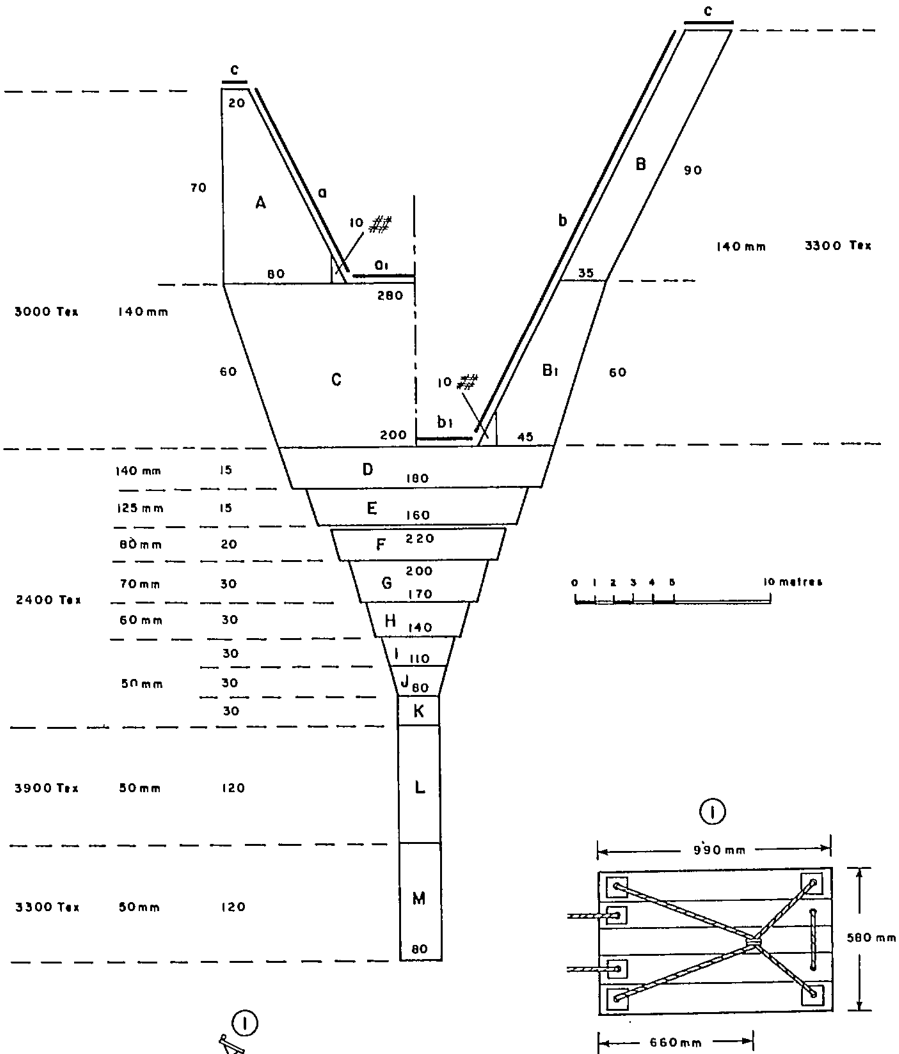


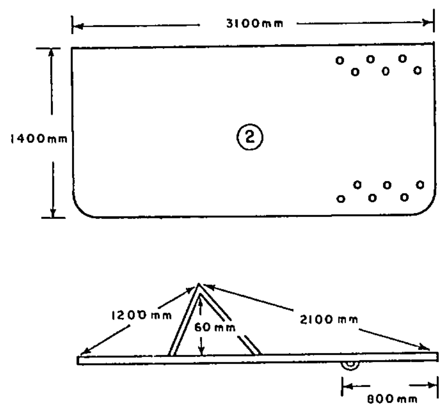
g
g1
A1
A2
a1
a2
a3
b1
b2
b3
b4
B1
B2
B3
c
d
e
f
C
D
E
F
G
H
I
J
K
690 Tex
140 mm
49 1/2
28 1/2
18 1/2
23 1/2
56 1/2
21 1/2
140 mm 690 Tex
100 mm 85 1/2
460 Tex
80 mm 82 1/2
390 Tex 36 mm 200
20 mm 360
310 Tex 20 mm 360
20 mm 360
460 Tex 20 mm 200
329
216
269
160
375
175
630
500
400
50
18 140 mm ϕ 4 mm
Upper corner
1m 1b
140 mm 925 Tex
2 ##
Lower corner
925 Tex 140 mm
1m 2b
10 metres

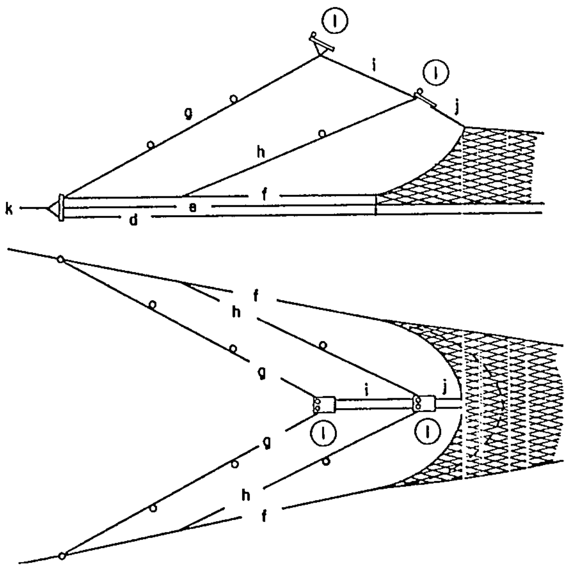
No. 113 A


e
40
e1
76
a
a1
b1
b
B1
90
A
65
150 mm
150 mm 1170 Tex
c
c1
100
115
330
15 ##
70
C
60
B
65
d1
250
d
10 ##
10
C1
60
230
70
145 mm 15
D
210
135 mm 15
E
190
260
100 mm 22 1/2
f
F
230
f1
90 mm 25
G
210
1170 Tex
80 mm 25
H
190
75 mm 25
I
170
65 mm 24
J
146
60 mm 38
K
120
55 mm 25
L
100
50
M
100
50 mm 360
N
0 1 2 3 4 5 10 metres
100
45 mm 120 ##
O

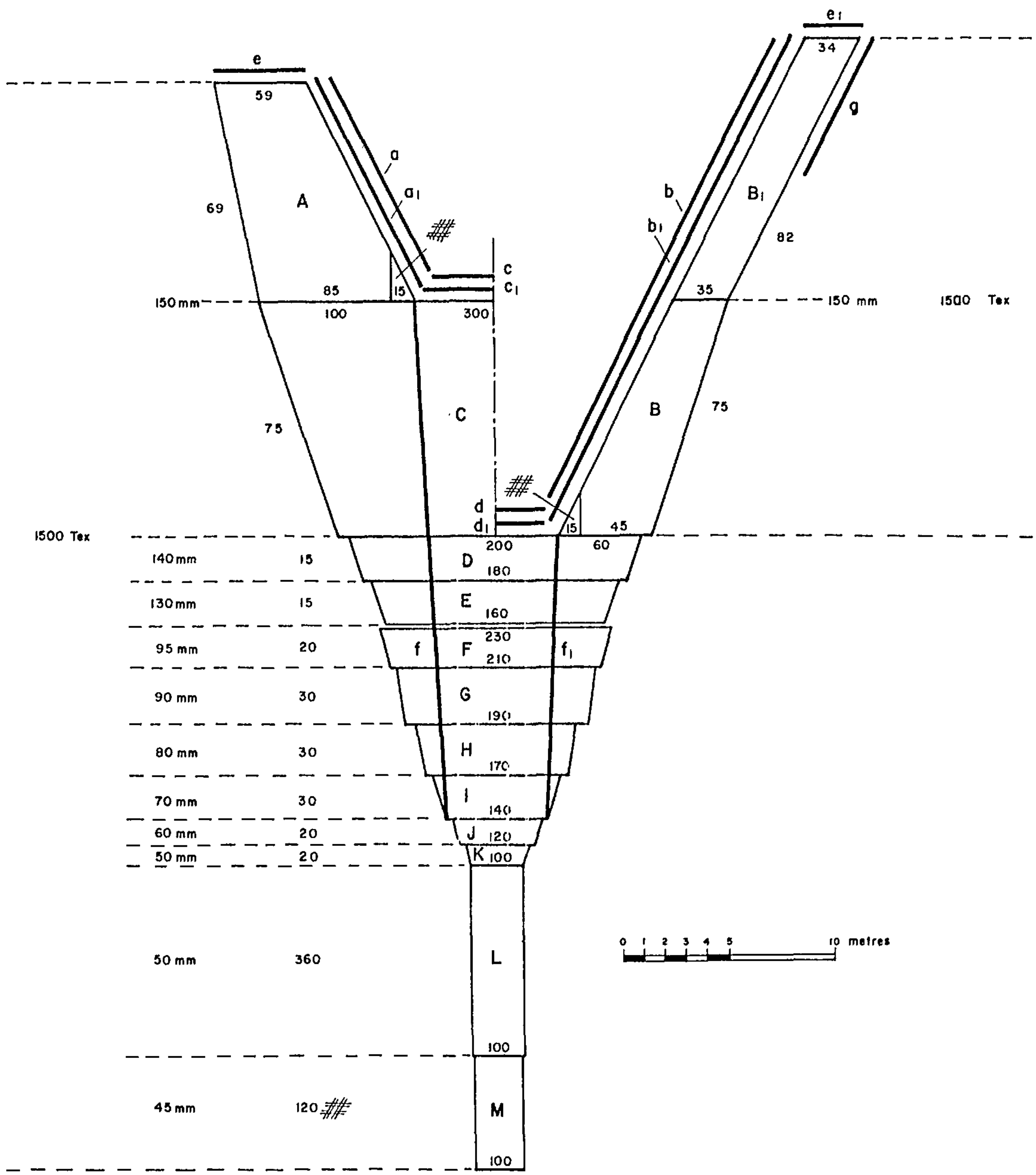
No. 114


c
20
70
A
a
10 ##
a1
80
280
B
90
b
140 mm
3300 Tex
35
3000 Tex
140 mm
60
C
10 ##
B1
60
b1
200
45
140 mm
15
D
180
125 mm
15
E
160
80 mm
20
F
220
200
70 mm
30
G
170
2400 Tex
60 mm
30
H
140
30
I
110
50 mm
30
J
80
30
K
3900 Tex
50 mm
120
L
3300 Tex
50 mm
120
M
80
0 1 2 3 4 5 10 metres
1
990 mm
580 mm
660 mm

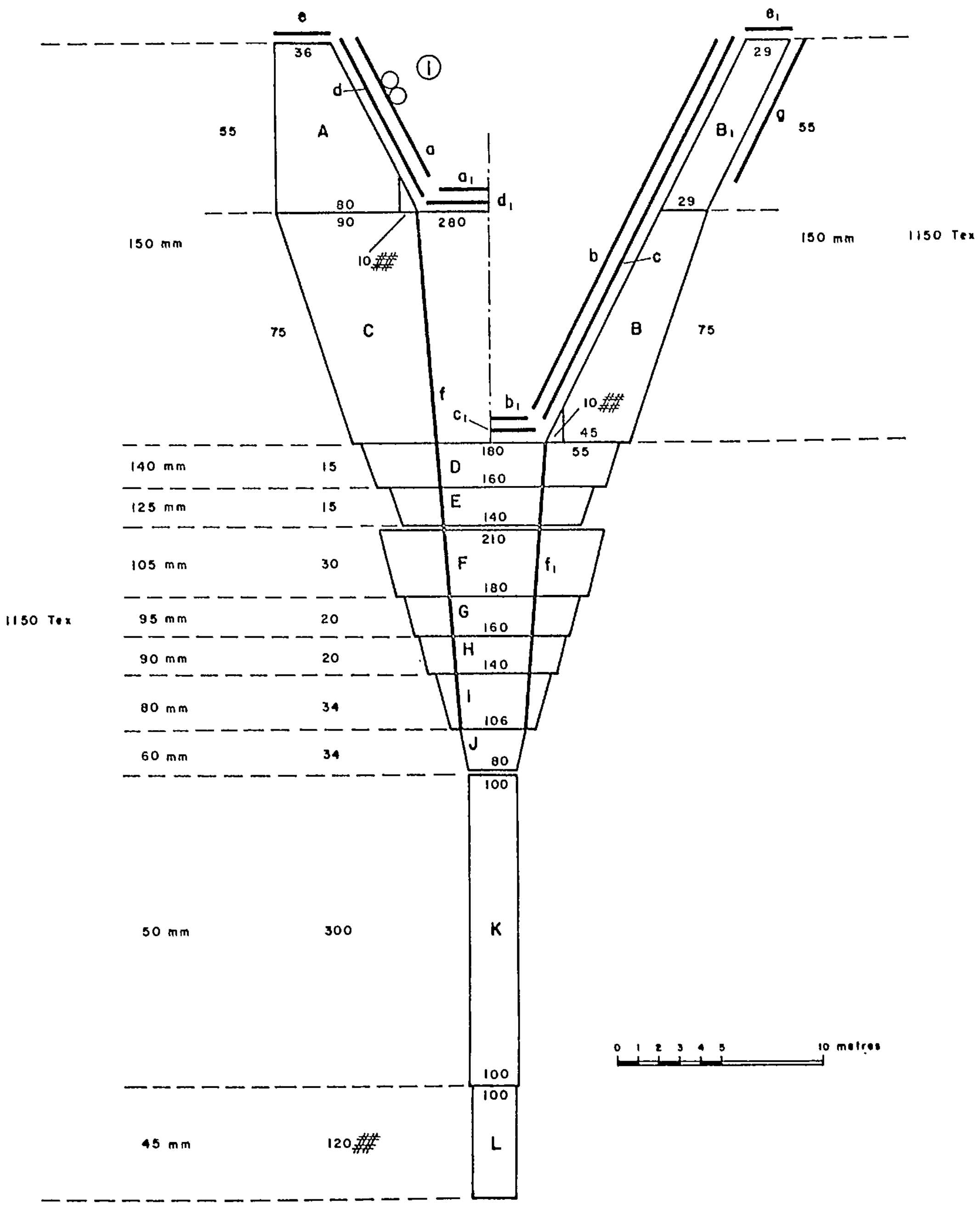

3100mm
1400mm
2
1200 mm
60 mm
2100 mm
800 mm


1
i
1
j
g
h
f
k
e
d
f
h
g
i
j
1
1
g
h
f

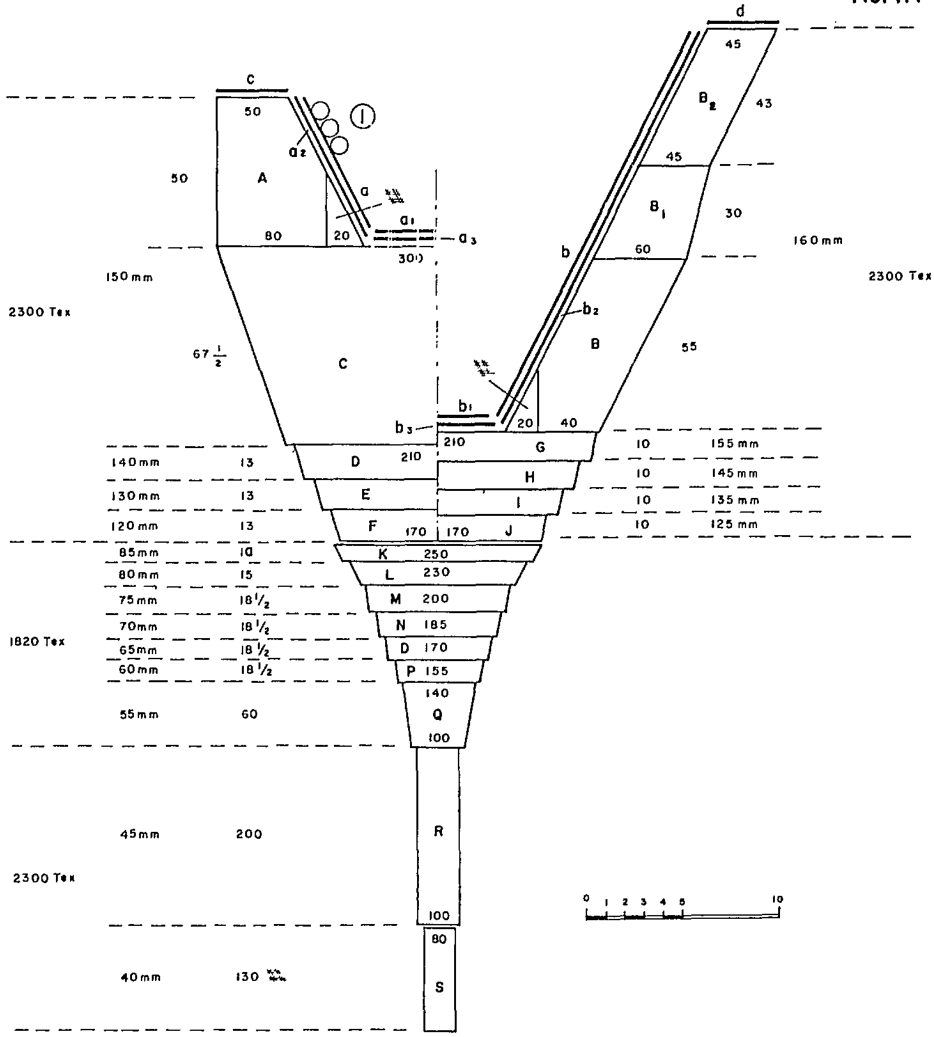
No. 115 A

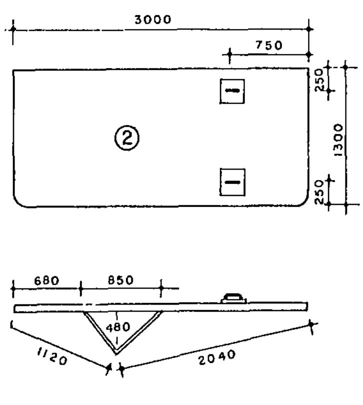

e
59
69
A
a
a1
85
15
c
c1
150 mm
100
300
C
75
e1
34
g
b
b1
B1
82
35
150 mm
1500 Tex
B
75
d
d1
15
45
1500 Tex
200
60
140 mm
15
D
180
130 mm
15
E
160
95 mm
20
f
F
230
210
f1
90 mm
30
G
190
80 mm
30
H
170
70 mm
30
I
140
60 mm
20
J
120
50 mm
20
K
100
50 mm
360
L
100
45 mm
120
M
100
0 1 2 3 4 5 10 metres

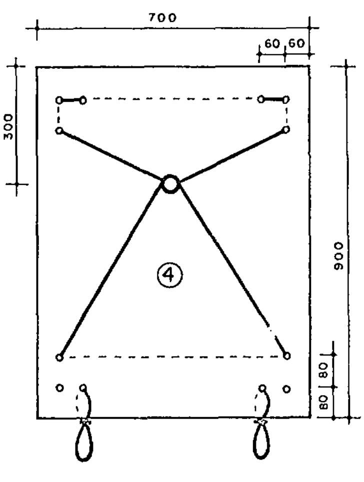
No. 116 A

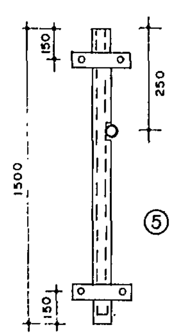

e
36
d
A
a
a1
d1
55
80
90
280
150 mm
10##
C
75
f
c1
b1
180
e1
29
g
B1
55
29
150 mm
1150 Tex
b
c
B
75
10##
45
55
140 mm
15
D
160
125 mm
15
E
140
210
105 mm
30
F
f1
180
1150 Tex
95 mm
20
G
160
90 mm
20
H
140
80 mm
34
I
106
60 mm
34
J
80
100
50 mm
300
K
100
0 1 2 3 4 5 10 metres
100
45 mm
120##
L

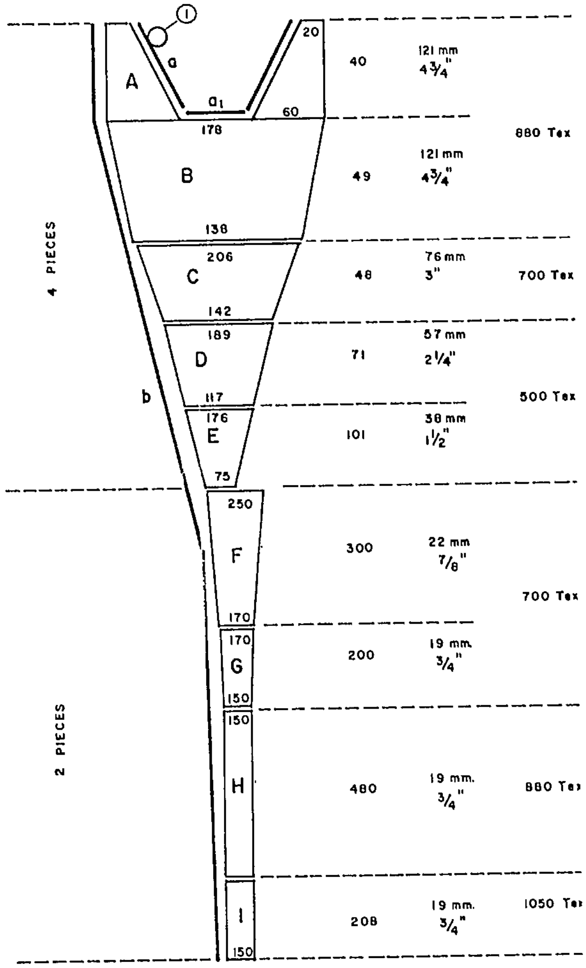
No. 117 A


d
45
B2
43
45
B1
30
160 mm
2300 Tex
60
b
b2
B
55
c
50
1
a2
50
A
a
a1
a3
80
20
300
150 mm
2300 Tex
67 1/2
C
b1
b3
20
40
210
G
10
155 mm
140 mm
13
D
210
H
10
145 mm
130 mm
13
E
I
10
135 mm
120 mm
13
F
170
170
J
10
125 mm
85 mm
10
K
250
80 mm
15
L
230
75 mm
18 1/2
M
200
70 mm
18 1/2
N
185
1820 Tex
65 mm
18 1/2
D
170
60 mm
18 1/2
P
155
140
55 mm
60
Q
100
45 mm
200
R
2300 Tex
100
0
10
80
40 mm
130
S

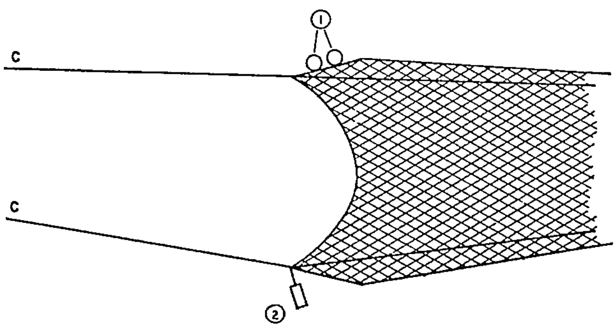

3000
750
250
1300
250
2
680
850
480
1120
2040


700
60
60
300
900
4
80
80


150
250
1500
5
150

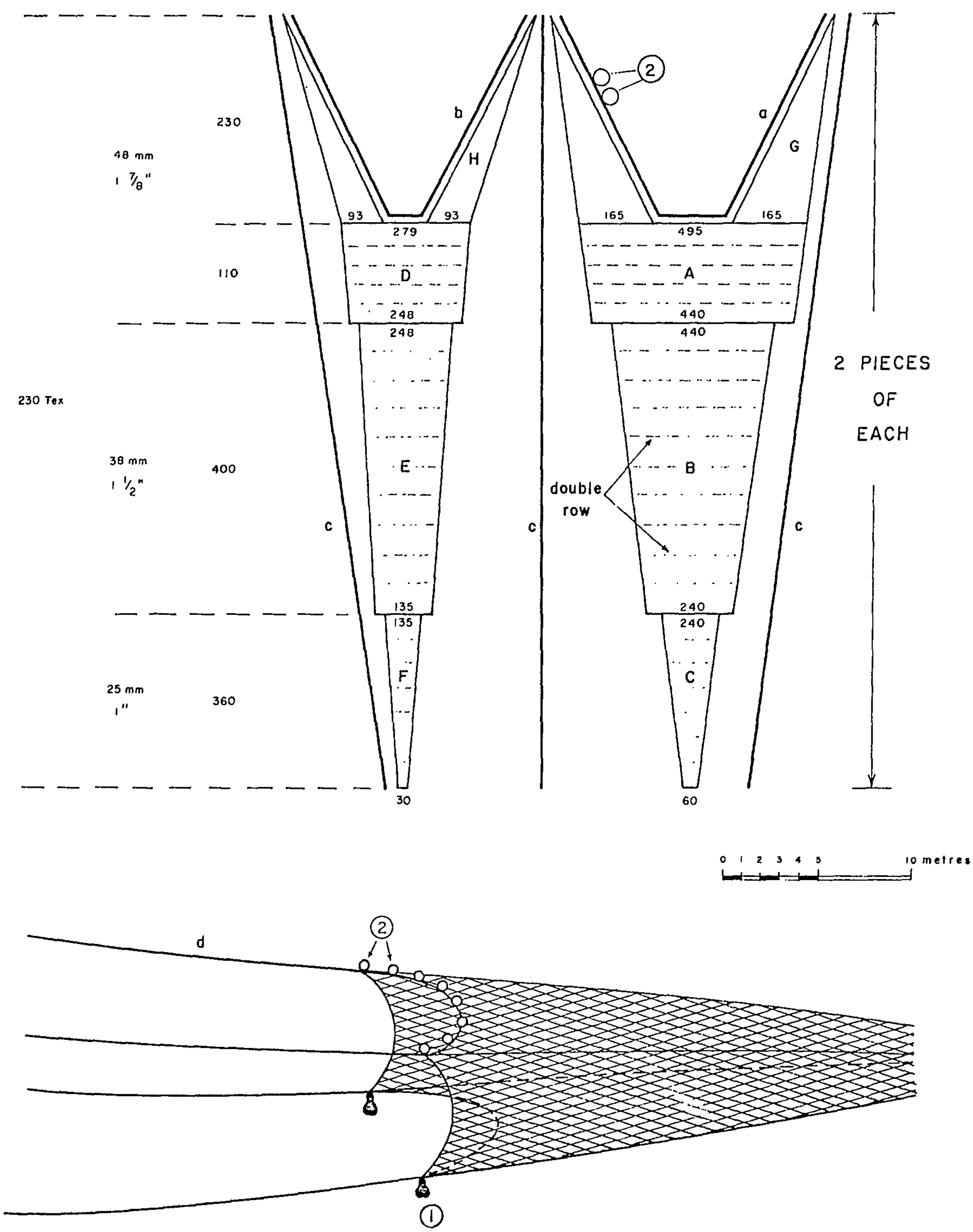


A
a
a1
20
60
40
121 mm
4 3/4"
880 Tex
B
178
138
49
121 mm
4 3/4"
C
206
142
48
76 mm
3"
700 Tex
D
189
117
71
57 mm
2 1/4"
500 Tex
E
176
75
101
38 mm
1 1/2"
4 PIECES
b
F
250
170
300
22 mm
7/8"
700 Tex
G
170
150
200
19 mm.
3/4"
H
150
480
19 mm.
3/4"
880 Tex
I
150
208
19 mm.
3/4"
1050 Tex
2 PIECES

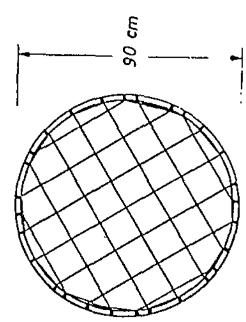


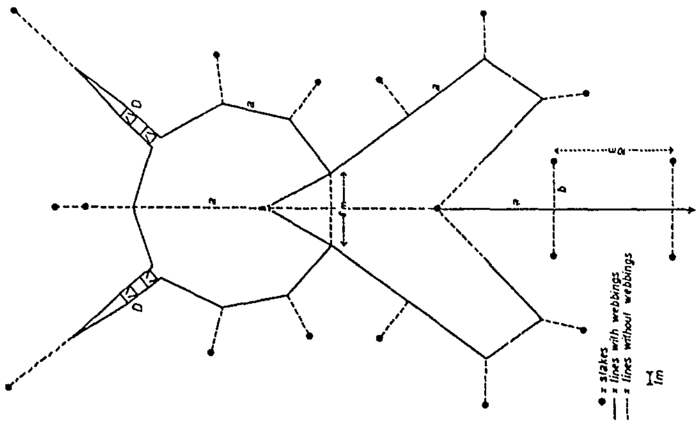
c
c
1
2

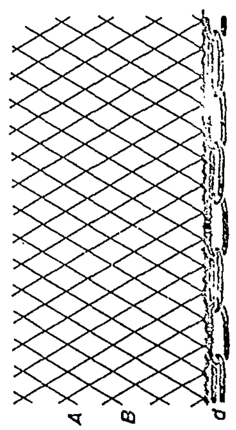
No. 127


230
48 mm
1 7/8"
93
279
93
b
H
2
a
G
165
495
165
110
D
248
248
A
440
440
230 Tex
38 mm
1 1/2"
400
E
B
double
row
c
c
c
2 PIECES
OF
EACH
135
135
240
240
25 mm
1"
360
F
C
30
60
0 1 2 3 4 5 10 metres
d
2
1

No. 505







Session 2

DISCUSSION

During the Session Mr. Alan Glanville, herring trawling specialist of Dunmore East, Co. Waterford, Ireland, showed a film on Irish midwater trawling. He was asked by Mr. Homer Stevens, Secretary-Treasurer, U.F.A.W.U., Vancouver, B.C. if, with the number of vessels from foreign nations fishing in the same area as the Irish vessels, there had been any sign of decline in the herring resource and if so, to what extent.

Mr. Glanville said there had been. He added: "When I heard some people here talking about millions of tons I was rather worried because we had, only ten years ago, a herring fishery of five months' duration, and we could go out – we didn't have to look around at all – we knew more or less from day to day where to go and we could find acres of herring and we could load up and come in just as and when we wanted to. For the last six or seven years, our stocks have been very heavily pinched by foreign fleets. I have counted as many as 150 large trawlers – Dutch, French, Poles, Russians and Slavic, and they have taken out colossal quantities, by our standards. Certainly in the hundreds of thousands of tons, in a very small area, and they have *made a very, very big difference to our fishing. Our season now is down to three months, and sometimes it's down to two months.*

"As I said earlier, I spend 80 per cent of my time trying to find fish, and when I find them I have my eye looking over my shoulder with the hope that nobody else spots me and that I can get to them before he does. I would say whatever resources you've got or whatever laws that you can bring in to protect yourselves, I should get them whacked on as fast as you can, because in our area we've seen our stock absolutely devastated and where eight or ten years ago we also were fishing on stocks of seven-, eight- and nine-year-olds, all the stocks we are fishing now are three- and four-year-olds and maybe some fives."

Mr. Stevens: "As a supplementary question, I wonder if there have been any moves to bring in joint regulations that would apply to all these various nations."

Mr. Glanville: "Yes, as you know, we've had various meetings to try and get all the European nations together to agree on fishing limits. Icelanders who went out on their own shoved it out to 12 miles and got away with it, and we have now agreed upon a six-mile limit, but it does not actually come into force until January 1, 1967, which gives the foreigners in my area another winter at the fish. These fellows fish right up to the three-mile; they fish right up to the two-mile and if you're not looking they fish up to the one-mile."

Mr. W.W. Johnson, Department of Fisheries, Ottawa, asked Mr. Glanville whether the Irish skippers could successfully trawl herring the year around. He also asked about spawning herring, and about summer fish and "wild" herring.

Mr. Glanville: "The easiest time to catch them is when they are busy spawning and you have various degrees of fullness or maziness in the herring, and we begin catching them when they come to our shores – we get them when they're about 20 miles out to sea. With our class of boat and the weather that we have to fish in, we can't really go too far, but we go about 20 miles out and they're up in the water and they're coming in to spawn and from the time that we first get on that show of fish – from the time that it actually spawns, we have difficulty at times in catching these herring in mid-water if, for instance, there is a lot of phosphorous or if there's no moon and it's dark; and if the fish are not very spawny they will get out of the way of a net. Particularly, with midwater trawls, a herring has four ways to go – up, down, and sideways either way. He's got a tail and he uses it.

"As they get more mazy, more full of spawn, they slow down and after maybe a couple of weeks we are taking them in mid-water very, very easily, and as they're lying on the deck, their spawn is running out of them and we know that in another week they'll be on the bottom. Then they go on the bottom and, if we get these shoals of herring to ourselves, we may get about three weeks' fishing before they are spawned and gone. When they go, they seem to go in a flash, overnight. There'll be loads of herring one day and the next day you'll come and the water will be covered with white milk where they've all spawned together and there won't be a fish in sight – they've all gone. If the big foreign fleets get at them, that three weeks that we might have, very often is cut down to about three days.

"Regarding the summer fish. Our fish only spawn in the winter time and the gentleman who asked the question about summer fish – I don't know in your area about spawning times, but as far as I make out you have different spawning in different areas here at different times of the year. If you are trying to catch fish in the summer when they're fast moving and wild, then they are very hard to catch in a mid-water trawl. Mr. Schärfe has told you of the big German single-boat mid-water trawler and they have probably up to 2,000 hp, which is a lot different from ours, and they can tow the most colossal net of light nylon to catch these fast moving fish. Most of

these big German stern trawlers carry two sorts of nets – one of light nylon with a very wide opening, so the fish has a greater distance to go from the centre of the net, one of stronger nylon when the fish are spawnier, and with the class of boats that we have, if the fish are fast and are scattered in mid-water, we cannot take them and at that time even the drift netters, although people think they're out of date, will take herring where we can't."

Dr. Schärfe also commented on the European herring fishery. He said: "We have a North Sea convention which embraces the countries fishing in the North Sea and we have regulations for several species of fish except herring. The reason for that is that overfishing of herring has not been proved, so far, scientifically. Herring is a species which reproduces very quickly. It was mentioned that you don't want herring over 10 years old in your catches, which is correct for ultimate exploitation of the stock. So that if a fisherman now catches six-year-old herring and there are no 16-year-old herring any more may not mean that there is overfishing but that the stock is used properly.

"The other question was can wild herring be caught by mid-water trawls? Well, we can't know what you call wild herring. Non-spawning herring we catch in wintertime with midwater trawls, not only with large stern trawlers but small cutters of 150 - 200 hp., pair trawling quite successfully; not only we, but all the Scandinavians and the East Germans, for instance. Hundreds of vessels catch this non-spawning, recovering herring in the area. Then there is the herring which migrates from Iceland to the Norwegian coast. This was caught by a one-boat mid-water trawl, for the first time last year, from September on. This herring spawns in March-April at the Norwegian coast, so it's a pre-spawner. I showed you echograms of that. So you cannot say that non-spawning herring cannot be caught in mid-water trawls. It can, very well."

Mr. Glanville: "He says overfishing cannot be proved scientifically. Well, we know from our actual financial pocket that we are overfished and that I have to work three times as hard now to make the same money, looking everywhere, and when I go out and see big lots of herring on my meter then I see the whole German-Dutch fleet move in and when there's nothing on meter, then I conclude that something's happened.

"As regards wild herring, I think that the question came from a fisherman who, when he said wild, he meant wild. I know he didn't mean that it was non-spawning. When he said wild, he meant wild as a fish that flies around very fast. When you're purse-seining for them they move so very fast that you can't even get round them when you're going full belt – you can't get your seine around them and you end up with the seine out in a straight line. That is wild herring, probably in the context that it was meant and they cannot be caught, but I certainly agree with what Dr. Schärfe said that herring are caught also not only when they're spawning but when they're recovering and also when they're spent."

Session 3 May 6, 1966 – 9.00 a.m.

Herring Fishing Vessels

Moderator

Eugene M. Gorman,
Deputy Minister of Fisheries,
Prince Edward Island.

Atlantic and Pacific Herring Seiners of Today

by
W.W. Johnson
Industrial Development Service, Department of Fisheries of Canada

FOREWORD

The Canadian herring seiners of both the Atlantic and Pacific coasts did not develop as specific types of vessels for that single method of fishing but rather the method was adapted to existing vessels which were originally designed for other methods of fishing.

Consequently, the vessels which evolved are mainly multi-purpose, particularly in Western Canada, while in Eastern Canada some vessels have been recently designed specifically for herring purse seining. However, these new Atlantic herring seiners are particularly adaptable to such methods of fishing as inshore stern trawling.

It would be quite in order to say that all existing Canadian herring seiners are multi-purpose fishing vessels, which have come to be known both in Canada and the United States as "Combination Fishing Vessels".

It is very probable that the trend to such vessels will continue, although it may be that the herring fisheries of Eastern Canada may prove so lucrative that fishing vessels may engage mainly in purse seining.

However, the style of vessel developed will no doubt lend itself to other methods and the fishermen will in all probability plan their vessels for such future operations should the herring fishery become unprofitable.

This paper describes how the Canadian herring purse seiner has been developed to the present and the probable trends in future vessels.

PART I

HERRING PURSE SEINERS OF THE PACIFIC COAST OF CANADA

INTRODUCTION

Four distinct types of fishing vessels evolved in the early days of development on the Pacific coast of Canada. These were the deep-sea halibut vessel, the inshore salmon gillnetter, the inshore salmon purse seiner, and the open water salmon troller.

The longliner fished the open ocean, sailing long distances such as to the Gulf of Alaska for halibut, while the salmon seiners and gillnetters fished the "inside" waters of British Columbia.

Larger purse seiners, based on the salmon seiner design, were developed for the open water pilchard fishery off the west coast of Vancouver Island and were also used to fish herring in the inside waters of British Columbia in the early stages of development.

Trawling with large steam trawlers was also tried in the early days but this is not relevant as the method and type of vessel did not remain, mainly due to the limited market for groundfish at that time.

The longliner and purse seiner are related inasmuch as they have evolved into a combination fishing vessel which is used primarily as a longliner, salmon seiner, herring seiner or stern trawler, but may engage in one or more of the methods during a year's operation, although not engaging in two methods simultaneously.

During World War II many engaged in sunken gillnetting for soupfin sharks and dogfish, and some carried on until the early 1950s when the price of vitamin oils fell, making the method unprofitable.

After the war, crab fishing with pots was another method to which the combination vessel was put and has become an established, albeit small fishery. It was necessary to line the fish holds and make them watertight, and to install seawater circulating pumps in order to keep the crabs alive.

Salmon gillnetters also became diversified, to a lesser degree, but like salmon trollers, they have no connection with the herring purse seine fleet and therefore no further reference is made.

This paper attempts to illustrate that no specific types of herring seiners were developed especially for that fishery and in actual fact, even though some may engage only in herring fishing during a single year or more of operation, herring seining is actually only one of several methods used by British Columbia combination fishing vessels.

Development of the B.C. combination vessel cannot be considered as solely Canadian, because a great many of the ideas and designs have come from the U.S. Pacific Northwest. Indeed many of the vessels originated in the U.S. and for years the Americans were leaders in the field of development.

After the second World War, however, B.C. began to do her own design and development work and by the mid 1950s began leading the way in many fields of vessel and gear development, but owing to the close contact B.C. fishermen enjoy with their southern neighbours, there is little discernible difference between the vessels, equipment and techniques.

From the Pacific Northwest of the U.S. came such contributions as small stern trawlers, freezing and processing trawlers of a small size, combination trawl-seine winch, trawl drum, power seine skiff and of course the Puretic powerblock which revolutionized all types of purse seining throughout the world.

From British Columbia came such contributions as the refrigerated sea water fish holding system, the gillnet drum, the drum seine, high and medium pressure hydraulic deck machinery and new types of steel as well as fibreglass fishing vessels.

The style and type of fishing vessel, together with the equipment and deck machinery used on the Pacific coast of Canada and the United States, has spread to all parts of the world, much of it to the herring purse seine fisheries of the Canadian Atlantic coast. It is quite possible that the combination vessel will be the herring purse seiner of tomorrow in many countries as it is on Canada's West Coast today.

PACIFIC COAST HERRING SEINERS

In order to understand how the modern Canadian combination fishing vessel evolved, one must consider the history of the U.S. Pacific fishery together with that of British Columbia.

Late in the 19th Century, Atlantic banking schooners were sailed around Cape Horn to ports on the U.S. West Coast. These were vessels such as the "Knickerbocker" and the "Commonwealth", which were typical of this era, fishing with dories and longline gear. They pioneered the halibut fishery in the Pacific and also were engaged in the salt cod trade.

When steamboats carrying dories and longline gear were introduced to the fishery, the sailing schooners suffered the indignity of having to install auxiliary gasoline propulsion motors in order to compete effectively with the coal burners. It was from these auxiliary powered sailing vessels that the halibut schooner evolved and even though modern day longline boats are vastly different from their ancestors, they are still known by the name.

Vessel development on the Canadian West Coast was closely allied to development in the United States. Many new ideas were exchanged and American ports such as Seattle, Tacoma and Bellingham made important contributions, with advancements in the design of gear and equipment.

The transitionary period of the schooners from sail to diesel power was divided into stages. As previously stated, gasoline was the first mechanical power; then came the semi-diesel, the slow speed heavy duty full diesel and finally the medium and high speed diesels of today.

While this was going on, changes were also made in gear handling. The dory was eliminated and the lines were set and hauled from the schooners. These vessels had two masts with a wheelhouse and main propulsion engine aft. The fishhold was forward and this arrangement was not suitable for the early method of purse seining.

Meanwhile, the great Pacific salmon fishery was being developed. In the inshore waters of Washington State, British Columbia and Alaska, two major types of salmon fishing vessels evolved. These were the small two-man gillnetters and the larger seiners which carried a crew of eight.

The salmon seiner was first introduced around the year 1910. It was quite different from the traditional halibut schooner in so far as the wheelhouse, machinery and accommodation were forward with the fishhold and net deck aft. This was found to be the ideal arrangement, as the net and skiff required a considerable amount of deck space, which of course would not have been available on a vessel having a wheelhouse aft. At least this was true for the size of boat used in those days. Another fairly obvious reason for locating the superstructure forward was to facilitate the shooting of the purse seine.

Co-authors Ralph K. Andrews and A.K. Larsen in their book "Fish and Ships" have reproduced some excellent photographs of early salmon seiners, halibut schooners and gillnetters, taken during the days when these great fisheries were in their infancy.

The Americans continued to expand the purse seine fishery on their side of the border, and developed the pilchard and sardine fishery along their coast. They extended their area of operations to include all the coast from California to Vancouver Island, and it was during this period that they began to convert some of the halibut schooners for purse seining. Engines and superstructures were moved forward and the fishhold was moved aft in conformity with the requirements of purse seine handling techniques.

British Columbia followed the American purse-seiner design. They built some vessels and purchased others from the U.S. At this time, the main Canadian consideration was for the salmon and pilchard purse-seine fishery.

It should be noted at this point that the new American seiners were used for halibut fishing, commencing in the early 1920s, clearly illustrating that this type of vessel was particularly adaptable for both inshore seining and deepsea longlining. Stern trawling was also carried out by this type of vessel as early as the 1930s, showing the versatility of the design.

EVOLUTION OF THE COMBINATION FISHING VESSEL

When fishing first began in British Columbia there were two types of fishing vessels, the offshore vessel which pursued the halibut fishery and the inshore vessel for salmon fishing.

The first halibut vessels were steamers and many were brought from Great Britain and the U.S.A. These vessels used the dory fishing method and were quite successful.

The steamers eventually proved too expensive to operate owing to a decline in the halibut fishery. Consequently, they were withdrawn and the fishery was left to smaller vessels, some of which were powered by gasoline engines. Small offshore powered vessels which engaged strictly in halibut fishing evolved. These vessels eliminated dory fishing by working the longline gear from their decks. They were of wooden construction and ranged from 45 to 100 feet in over-all length. The superstructure and engine were located aft and there were forward and after masts which carried riding sails. These are the vessels which, because of the way they evolved, or their appearance, became known as halibut schooners. A great number were built between 1909 and 1929 and a few are still in existence in British Columbia and the State of Washington.

While the offshore vessel was being developed, other vessels were being built for the inshore salmon fisheries.

Two main methods of fishing were adopted, gillnetting and purse seining. Though there were others, these two account for the largest part of the salmon pack today.

The gillnetter was a small open wooden sail boat of approximately 30 feet in over-all length from which the gillnets were manually handled by a 2-man crew.

The first purse seiners were built around the year 1910. They were vastly different from the halibut schooners in appearance and are the forerunners of today's modern combination vessels used for herring seining. They were approximately 50 feet in over-all length with a beam of 12 feet and a depth of 6 feet. Propulsion was by means of a gasoline engine of approximately 25 horsepower and the crew consisted of 7 men. The wheelhouse was located forward of midships in order to allow a large clear after deck on which to handle the purse seine. The living accommodation was located forward of the engine room, which was immediately under the wheelhouse. A single mast and boom were stepped on the deck immediately aft of the wheelhouse while a wooden framed winch with two warping heads was located between the mast and the hatch of the fishhold aft of the engine room. The seine was stowed on a platform located on the stern aft of the hatch. A wooden davit holding two purse seine blocks was located amidships on the starboard side athwartships of the warping heads.

The layout of the salmon seiner was adhered to fairly closely by other seiners that followed in the 1920s. These were the larger pilchard and herring purse seiners which ranged up to 75 feet in over-all length, of wooden construction, powered by diesel engines.

Early editions of "Western Fisheries" indicate that some of the herring fishing off the east coast of Vancouver Island was carried out by what were known as "twin rigs". In this type of operation one-half of the purse seine was carried by each vessel, both making one-half a circle while setting. On the west coast of Vancouver Island, the herring seine was carried by one vessel in the same manner as in pilchard seining. Eventually the twin rig operation disappeared entirely.

The herring and pilchard fishery established a method of operation which employed packers to bring the fish to the plants. The seiners only carried fish on board when all the packers were loaded. The packers were also used as tow off boats, although smaller fishing vessels were usually chartered for this job.

As mentioned previously, vessel development on the Canadian West Coast was closely allied to that of the United States. Many new ideas were exchanged and ports such as Tacoma and Seattle made important contributions with advancements in gear and vessels. It is interesting to note that the seiner type vessel was modified for halibut fishing in the 1920s. It proved very successful; the purse seiner with its forward wheelhouse had become a multipurpose craft.

The purse seine fishery for salmon, pilchards and herring attracted the attention of many owners of halibut schooners who realized that their vessels with engine and superstructure aft were unsuitable for seining. Whether or not seining was totally responsible, very few schooners were constructed specifically for halibut fishing after 1930. In fact, most of the vessels, small or large, intended primarily for halibut fishing, were built with the wheelhouse and engine forward and the hold aft. There was a difference, however, as the schooner hull form was retained in those vessels intended purely for halibuting. The schooner hull form incorporated a hack stern, a high poop deck and a low main deck in order that the fishermen would be close to the water, making it easier to heave halibut on board. The wheelhouse was located on a raised fo'c'sle head. By the mid 1940s, the halibut schooner hull form had almost entirely disappeared and in new construction the seiner type hull was employed almost exclusively.

The early seiners and halibuters had the galley and sleeping quarters combined in the fo'c'sle while the wheelhouse contained nothing more than the skipper's stateroom, the bridge and a toilet. The wheelhouse was short in length and there was almost as much room forward of the house as there was aft. Eventually the wheelhouse was lengthened on purse seiners and the galley was located on deck. The same arrangement was adapted on halibut vessels.

In the early 1940s the top house was added to the seiners, and the crew's sleeping quarters were moved on deck forward of the galley, thus eliminating the fo'c'sle. This allowed the engine to be placed extremely far forward, lengthening the hold and increasing the carrying capacity.

The war years saw the seiner type vessels diverted to such activities as stern trawling, bottom gillnetting for dogfish and crab fishing, all of which were carried out quite successfully. By the late 1940s it was established that vessels engaging in two or more methods of fishing during the year were the most profitable ones. Subsequently, scarcely any vessels in the herring seiner size range have been built for only one purpose. The multipurpose fishing vessel had by 1950 become an established type and had acquired the name "combination fishing vessel".

Construction material in the 1950s was still wood. Some boats were built with sawn frames but most builders used steam bent oak.

The most popular over-all length of combination vessels used for herring seining has remained between 70 and 86 feet from the 1920s to the present day. However, the beam and depth of these vessels has been increased and they are now powered by medium and high speed diesels which are light in weight and compact in size, thus increasing the boat's carrying capacity. A 75-foot vessel built in the 1920s would probably have carried no more than 100 tons of herring, whereas the present day vessels of this length can carry approximately 130 tons under reasonable weather and sea conditions.

All of the seiners had their holds divided into two parts by means of a thwartship bulkhead located about two feet forward of the after side of the hatch. When long, open water trips had to be made, such as crossing Hecate Strait from Queen Charlotte Islands to the mainland, only the forward part of the hold would be filled in order to give sufficient reserve freeboard if bad weather were encountered. When fishing close to the plant and the risk of meeting bad weather was small, both sections of the hold would be loaded.

Until the powerblock was introduced in 1954, all combination vessels carried their seines on a platform called a turntable which was mounted on rollers approximately a foot and a half above the deck. There were no bulwarks around the stern other than a small raised coaming 6 inches in height. This not only allowed the table to be turned but permitted water to drain off the deck very rapidly when the vessel was deeply laden and awash. The table, seine and skiff were secured to the deck, when underway, by means of ½" cables and turnbuckles.

When the powerblock was introduced the turntable was no longer a necessity and was eliminated on new vessels as well as on some of the existing ones. The bulwarks were then carried full height from amidships and around the stern while the seine was stowed on a platform a foot or more off deck. It was soon discovered that ample freeing ports had to be provided at deck level around the stern bulwarks, otherwise water trapped by the seine platform, which is really a box, could not drain off fast enough when the vessel was deeply laden.

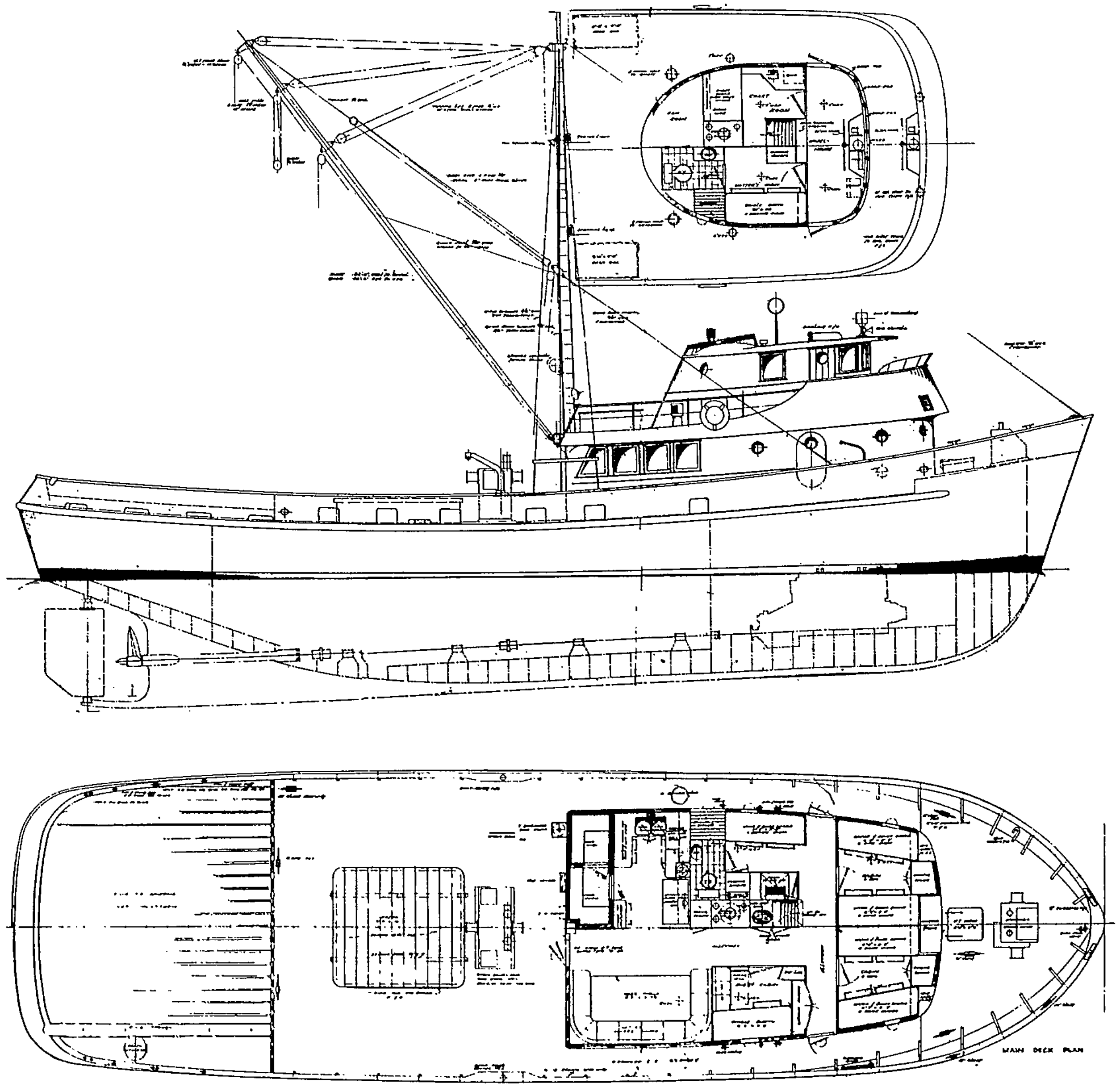
The first steel combination fishing vessels were built in the late 1940s. These were the "David Scott", "Tauranga" and "Treasure Island". The "David Scott" was rigged for trawling as was the "Tauranga", although the latter did engage in tuna trolling and packing as well. The "Treasure Island" was used for salmon seining and towing off in the herring fishery. However, none of these vessels were large enough to be good herring seiners.

It was not until 1957 that a steel vessel large enough to seine herring was built. This vessel was the 75-foot "Pacific Ocean", which was built for Bob Kelly of Nanaimo, B.C.

The trend has gradually increased to a point where any vessel large enough to seine herring is made of steel.

See following pages and page 132.

"WESTERN KING"



"WESTERN KING"

(Courtesy "Western Fisheries", Vancouver, B.C.)

"Western King" measures 87.2 feet over-all, with a moulded breadth of 24.5 feet and moulded depth of 12.7 feet. She is almost seven feet shorter between perpendiculars than "Milbanke," measuring 77.2 feet, compared to 84 feet for the Wachsmuth vessel.

She was designed by naval architect William Reid, who drew the plans originally for Wachsmuth, who later decided to go for the 90' 6" hull Reid had designed for Emil Jensen.

The ship is powered by a 510 HP Caterpillar diesel, model D379, a turbocharged and aftercooled 4-cycle, 8-cylinder unit which develops a rated HP at 1225 rpm. Bore and stroke are 7.25 x 8. It works through 3.03:1 Caterpillar gears, specifically designed to handle the torque and horsepower of the D379. The 3-bladed Osborne wheel is 67" diameter.

On trials in Vancouver harbour, she averaged 11.75 knots over four runs, about the same speed "Milbanke" clocked on her trials.

Her two auxiliaries are six-cylinder Bedford diesels.

She has no hold refrigeration of any type, outside of coils in the bait tanks, but she is designed so that any type of system can be installed easily and without major conversion costs. The hold is insulated.

Accommodations are similar to "Milbanke," and the layout may be seen in the drawings. Navigational and fish finding equipment and instruments are complete and of high quality. Two-station steering gear is Wagner T-15, hydraulically operated. A Sperry electric-lever-controlled power steering system is connected to the two stations at the wheelhouse wheel stand and on the starboard bridge wing. Sperry Gyroscope also supplied a Model 8 auto pilot and an 8" steering compass.

Radar is Marconi model LN47. Radiophone is a Marconi Model CN88, 10 channel unit, and in the skiff a 12-volt Marconi Marcom CN428 is used.

Two AP9 Loran sets were supplied by Sounder Sales & Service, as was the Ekolite ER9B sounder, a 530 fathom unit.

A Bendix automatic radio direction finder, Model 100, with 36" non-rotating loop, was supplied by Aviation Electric Ltd.

"Western King" is one of two B.C. fishboats to be equipped with a sonar, or asdic system. Her Simrad Sonar II gives visibility of an area of sea 3,300 yards wide in front of, and to the side of the ship. A hydraulically operated hull unit is raised and lowered from a cabin control console. The sonar beam is trained from side to side in five-degree steps, and both loudspeaker and earphones are provided to do away with the need to keep a constant watch on the recording paper. The unit was installed solely to hunt for herring, and there will be many skippers watching "King" closely this winter to see how the sophisticated and expensive new fish finding device performs.

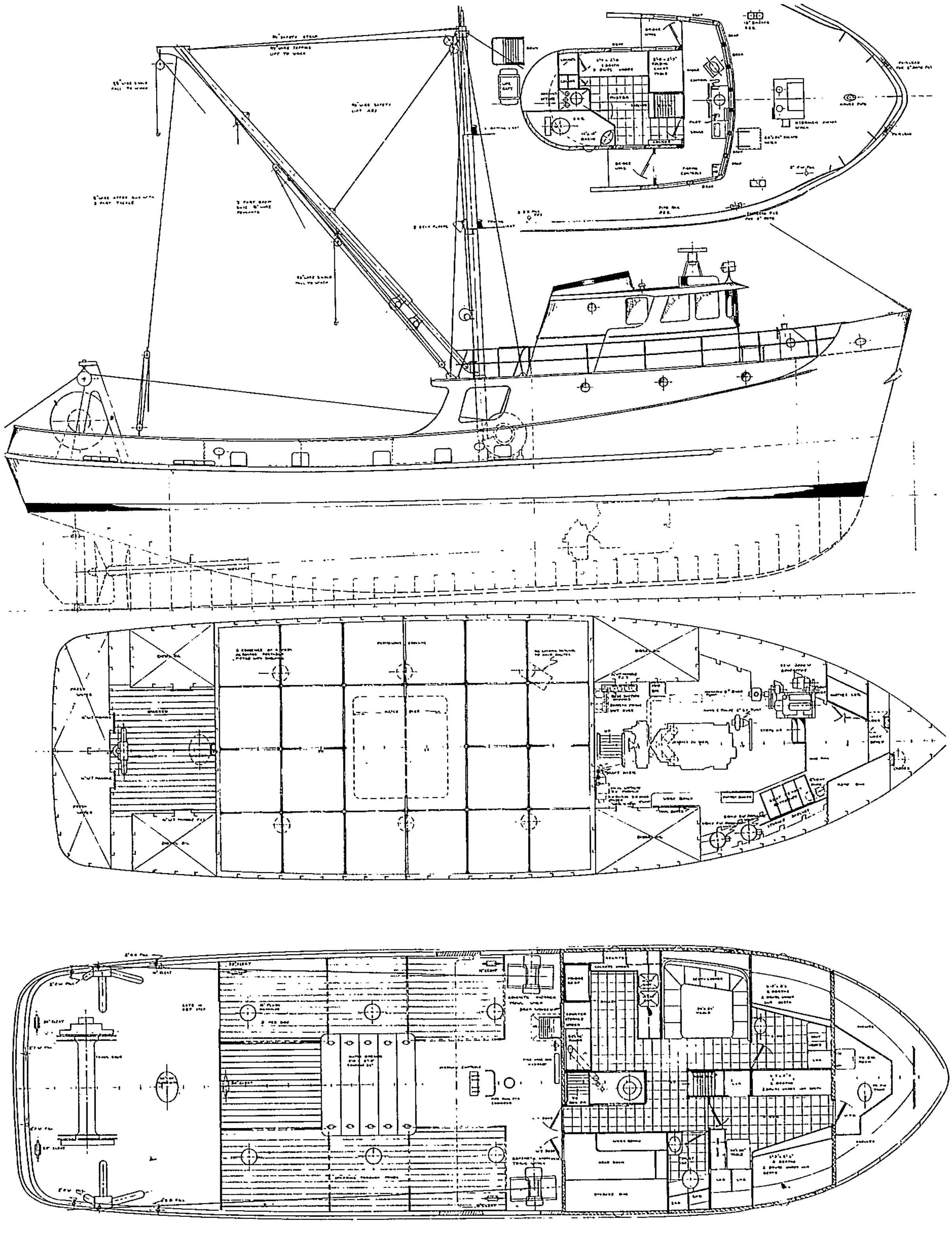
Almost all marine hardware was supplied by Bilmac Marine Ltd., who also supplied the Mathers engine controls, the galley equipment and range, the Plymouth polyprop ropes and the "Blue Strand" wire rope.

Globelite Batteries supplied all heavy duty batteries and William Thomson Ltd. supplied all fire extinguishers.

Electrical installations and wiring were done by May Marine Electric Ltd. A Webasto diesel fuel heating system was supplied by General Engine Sales. A 10-man Beaufort inflatable life raft was supplied by Davidson Manufacturing Co. Pumps to serve the fire and bilge systems were supplied by Pumps and Power Ltd. Exterior coating for the hull, both above and below the waterline, and the deck is Magna Bond, supplied and applied by Western Canada Magna Bond Sales.

The hydraulic system was engineered by Tridel Ltd., and drives the Swann anchor winch, boom topping winch, the Puretic power block, the Swann combination seine-drag winch and the Yeoman fish pump, which was supplied by Grove Processing Ltd.

"SHARLENE K"



"SHARLENE K"

(Courtesy of "Western Fisheries", Vancouver, B.C.)

Measuring 80 feet over-all, 22 feet moulded breadth and 11' 2" moulded depth, the "Sharlene K" is based on William Reid's "Dominator" class of combination boat.

She has a capacity of 200,000 pounds of iced fish, and provides comfortable accommodation for a complement of 8 men.

Designed as a pure trawler, she is different in many ways from the more familiar Reid combination vessels. Her power, for example, is about 25 per cent greater than that specified for the average seiner-longliner, and her deck winches and other equipment were custom designed and built.

Main propulsion engine is a Type JW600 Jenbach marine diesel, a 2-stroke, 12-cylinder unit developing 525 brake horsepower at 1450 rpm. Supplied by New Westminster Marine Sales Ltd., the engine is the first of its size and type in a B.C. fishing vessel. It has a bore of 5.9", stroke of 6.69" and is naturally aspirated. Gear is a Lohmann and Stolterfoht, with a ratio of 4:1, turning a 68" x 48" three-bladed Osborne propeller. A power takeoff capable of producing 250 to 300 HP is attached to the main engine gearbox. The engine is Austrian, and the gear was made in West Germany.

An extensive hydraulic power system operates a total of nine winches, and was installed by Nolan Lowe Ltd. The winches were designed especially for the ship by Gearmatic Ltd. Two 40 HP hydraulic pumps driven from the main engine power takeoff are backed up by an emergency 35 HP hydraulic pump driven by the 50 HP International Harvester auxiliary diesel, also supplied by Nolan Lowe. The two large trawl winches, mounted amidships and outboard just aft of the main bulkhead are Gearmatic Model 30 with a capacity of 700 fathoms of 5/8" wire at 250 f.p.m. at 9,000 lbs. line pull. The trawl drum was made by Bensons, and is powered by a Model 22 Gearmatic winch. A small whipping drum or niggerhead is mounted on the boom and was made up by Nolan Lowe. A hydraulically powered winch was also installed to handle the raising and lowering of the stabilizer poles. The anchor winch, boom topping winch and two cargo winches, which take the place of a single and double fall on the boom, round out the list of hydraulically powered line-hauling equipment.

Kitzul went to great lengths to ensure that his fish would be of the highest quality. The hold was sprayed with a special Urethane foam, which provides insulating qualities. Then wire mesh was laid, and Uniplast cement was troweled on. "Other materials—wood, fiberglass, etc.—are easily scratched by fish pughs," explains Kitzul. "With this lining, the aluminum pen boards and hatch covers, and the ice-holding coils, our fish will be in prime condition." The cement hold lining ranges from ¾" to 3" thick, and was supplied and applied by Foamcoat Products Division of C.T. Brown Coatings Ltd., Vancouver. Coils were installed by Rice & McIntosh Ltd.

The raised deck configuration gives so much added room that Kitzul had a working gear room placed on the starboard side, handy to those working on deck. It contains spare lines, deck tools, web, floats, shackles and anything that could be needed on deck. The room is located just forward of the large central control console under the shelter roof, which ranges the breadth of the ship and covers an area about six feet out from the after bulkhead. The console operates the hydraulic power for the niggerhead, main trawl winches and brailing winches.

Wheelhouse equipment is extensive, and complete for this type of operation. Wagner Engineering supplied the power steering and automatic pilot system, involving a portable power steering unit which can be carried around the ship, and a new rudder angle indicator. Also a departure from common practice is the mounting of the steering compass on top of the wheelhouse, to avoid magnetic problems associated with a steel ship. A "periscope" compass, also mounted on the wheelhouse top, is the ship's main compass, and was supplied by Frederick Goertz Ltd. Controls were by Kobelt.

Radar is a Decca D316, also supplied by Goertz. Supplied by Canadian Marconi was the CH-25 Marconi radiotelephone, the Simrad SK2A sounder, the DX Navigator Loran, with A and C receivers, and the ship's intercom system. May Marine Electric did all electrical wiring, and General Engine Sales supplied the Webasto diesel furnace.

Fire fighting equipment was supplied by William Thomson Ltd., and Davidson Manufacturing supplied the Beaufort 10-man liferaft and the five-man fiberglass lifeboat. Deck stores were supplied by Western Marine Supply, and 3" Monarch pump and other gear by W.G. McWilliam. A 2½" pump was supplied by Pumps & Power.

On trials in Vancouver harbour, the boat showed excellent handling characteristics, with an easier roll than former ships of this class. "We've been trying to get an easier rolling motion into these beamy boats" says designer Bill Reid, "and with this raised foc'sle head, we are getting a much better motion".

Speed of 11 knots was attained with all fuel tanks full, and this was slightly better than expected. As a trawler, the boat is primarily a towing boat, and a towing type propeller was installed.

(continued from page 127)

DECK MACHINERY OF THE PACIFIC COAST

The first purse seine winch was relatively simple. It consisted of two warping heads for pursing, set in a wooden frame and driven by a line shaft from the main engine. The warping heads were on a common shaft, spaced approximately one foot apart – the shaft being exactly over and parallel to the ship's centre line.

Herring and pilchard seining required a heavy lift, coupled with a fast tackle haul-back for fleeting the seine and brailing the catch. Consequently a cast steel winch was developed which had two warping heads for pursing plus a small integral drum fitted with a cable tackle. The small drum, known as the brailing winch, was equipped with a friction clutch, activated by a hand lever and a band brake actuated by foot. It greatly speeded up and made safer the operation of handling the seine.

The original rope purse lines as used in salmon seines were replaced by cable purse lines in the pilchard and herring fishery and as a result, a third winch was developed on which the purse line was wound as it came off the warping heads. This winch was at first manually operated but eventually became power driven. It was equipped with a hand brake to control the purse line tautness when setting.

During the war the vessels were engaged in diversified methods of fishing, such as trawling for groundfish and gillnetting for dogfish and sharks. The purse seine winch was either removed to make way for a gillnet sheave or in some cases the sheave was fitted to the seine winch from which it was driven.

When trawling, the vessels had split winches installed to handle the trawl warps while the seine winch was used to handle the tackles.

Installing and removing winches to engage in two or more methods of fishing during a year proved laborious and time consuming. As a result, an American firm developed a combination winch suitable for longlining, gillnetting, purse seining for various species and trawling. The main drums could be used for the warps when trawling or could take the wire purse line when purse seining. It also had warping heads and auxiliary drums for handling tackles. The only extra attachments were the longline or gillnet sheaves which were light. These could be bolted to and driven from the winch itself. Consequently the necessity to remove and install heavy deck winches when changing from one method of fishing to another has been eliminated. The first winches were mechanically driven by line shafts. However today, as a result of the pioneering efforts of J. Swann Ltd., Vancouver, nearly all are driven by medium pressure hydraulics (1200 – 1600 P.S.I.). Virtually every new vessel of sufficient size to seine herring is equipped with a combination winch.

When hydraulic power became generally used to drive deck machinery, special winches were developed for topping and vanging the boom, eliminating the necessity of doing so with ropes to the warping heads of the main winch. Nearly all combination craft are now equipped with hydraulic anchor winches which are a necessity for herring seining.

The biggest advancement of course for all types of seining was the invention of the power block by Mario Puretic of San Pedro, California. It was first introduced to the Canadian herring seiners in the fall of 1955. The power block greatly reduced the time required to retrieve the seine, simplified the operation and made it much safer. The power block made it possible to develop and handle seines of a much larger size than would have been feasible previously.

Deck machinery for hauling purse seines cannot be discussed without mentioning the drum seining. This method is practised by many vessels which are smaller than those normally engaged in herring seining. It was originally developed from the gillnet drum and is now used by inshore salmon seiners, where it has proved to be an even more effective method of handling the seine than the power block. Not only is the seine hauled faster but the number of crew may be reduced.

Drum seining was tried on a large Canadian seiner, Mr. Bob Kelly's "Pacific Ocean", and on an American seiner operating in the Strait of Juan De Fuca, but apparently it did not prove satisfactory and the vessels reverted to the power block and table method.

Because of the difference in hanging ratio between the cork and leadline, the latter being much shorter in hung length, it was found that even spooling on the drum was almost impossible. The seines had to be hung in such a manner, however, in order to create the bag which is required for open tow sets in the Juan de Fuca salmon fishery. The smaller inshore drum seiners have their seines hung square, thus even spooling is not a problem. No doubt because the herring seines used on larger seiners are also hung in considerably on the leadlines coupled with the fact that the vessels also seine salmon, the drum has little appeal. The smaller seiners have proved the drum to be successful for herring seining and it could be just as successful on larger seiners. It may be thought that the necessity of hanging the seine square with more or less equal lengths of cork and leadline will prevent the seine from fishing. However, this does not appear to be true as the Norwegians and Icelanders have great success with seines which have longer leadlines than cork lines.

It seems that drums have a great potential and the writer has been informed of such a system which may be tried by a Vancouver fisherman on a proposed 100-foot combination vessel. There is little doubt that the drum seining method will be improved upon and even though development may be slow there is the possibility that it could be accepted by larger herring seiners.

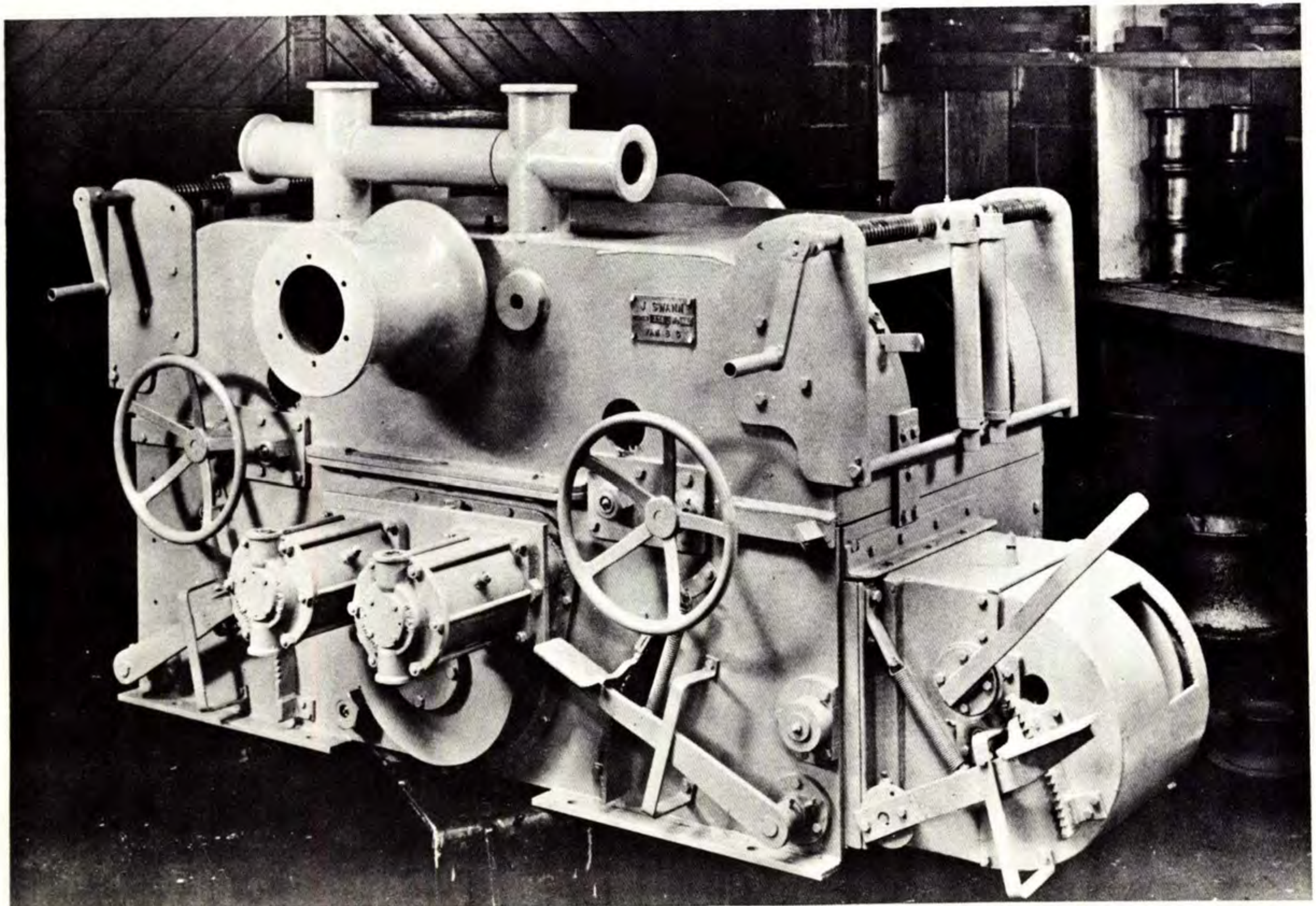
Below deck machinery for removal of the catch must also be considered. The standard method of removing the catch in herring seining as in salmon fishing has been by brailing. Despite the fact that B.C. fishermen were aware that pumps were being used successfully for catch removal by Canadian Atlantic herring seiners and American Atlantic coast menhaden fishermen, they were slow to adopt this method.

Pumping was tried and discarded in the mid 1950s and has really only come into general use during the past three years.

The old method of brailing the catch was probably the most pleasurable operation of herring seining, requiring skill and teamwork. It may be speculated that this made the fishermen rather reluctant to accept pumping, which was obviously faster and more practical. Most of the pumps used are mounted on deck and are hydraulically driven. They create quite an obstruction on deck as does the heavy rubber siphon (usually 8 inches I.D.) which is cumbersome to handle. In order to circumvent such problems an American firm has designed and developed a unit which has the pump and its motor (hydraulically driven) attached to the intake end of a light weight collapsible hose. The pump is lowered into the seine and the herring are pushed up the hose to the water separator on deck and thence to the hold. The pump can be stowed in any convenient location on deck and its hose rolled up when not in use, leaving the deck far less obstructed than is possible with the present pumps and hoses. It also makes it possible to put the intake end deeper into the seine, which is a great advantage when herring swim down or if they are dead, making them hard to dry up. It would seem that such a pump could become almost as popular as the power block with the B.C. fleet.

Most of the deck machinery which has been developed is powered by medium or high pressure hydraulics. Consequently hydraulic power packages for driving such machinery has evolved. Because of the performance characteristics and compactness of hydraulic systems, it seems that this type of drive will be developed much further for the deck machinery of combination fishing vessels.

References: Personal contact as participant in industry, "Western Fisheries" Magazine, and "Pacific Fisherman".



SERIES NO. 275 HYDRAULIC TWO DRUM BEAM TRAWL WINCH

SPECIFICATION

TWO DRUM HYDRAULIC BEAM TRAWL WINCH
SERIES NO. 'BT' – 275

Drum Size:	32" x 10" x 16" wide.	
Drum Capacity:	3,600' of ½" wire. 2,850' of 9/16" wire.	
	Line Pull	*Line Speed*
Mid-Drum:	7,500 lbs.	100 fpm
Oil Required:	50 gpm at 1,200 psi. (Input-40 H.P.)	
Frame:	Fabricated steel, hot-dipped galvanized.	
Drums:	Cast steel, mounted on Timken tapered roller bearings. The drums may be de-clutched by means of a handwheel or hand lever to allow free-running.	
Bearings:	Best quality bronze bushings.	
Gearing:	Cast steel, machine cut teeth.	
Warping Head:	Cast steel, running independent of the drums. Removable to clear one side for long lining.	
Drive:	Two Swann 1061 piston type hydraulic motors having constant torque characteristics. When the winch is used for dragging, only one motor is required. The other motor may be removed and used to drive the stern dragger roller.	
Brakes:	Self-energizing band types, fitted with woven asbestos lining, operated by foot pedals with ratchet releases. A hydraulic brake is fitted to hold the load under operating conditions.	
Control:	By means of a 3 position single lever valve; raise, lower and spring centered hold.	
Spooling:	Two sets of hand operated hardened steel rollers. When the winch is used for seining both sets of spooling rollers may be moved to one end and operated by one handle.	
Weight:	Approximately 4,500 lbs.	
Options:	Brailing Winch secured to end of main winch, having a capacity of 140' of 5/8" wire and a line pull of 6,000 lbs. at 100 fpm, complete with hand lever operated clutch and foot pedal operated brake.	

Bollards on both sides of winch.
Long line attachment.
Slip ring arrangement for electrical pick-up.
Mechanical drive in lieu of hydraulic motors.

THE POWER SKIFFS

The power skiff was first developed in the State of Washington for making open tow sets in the salmon seine fisheries of Alaska and the Strait of Juan De Fuca, and was adopted by British Columbians when they began seining salmon on a large scale in the Strait of Juan De Fuca in the late 1940's and early 1950's.

The skiff was subsequently tried in the herring seine fishery where it naturally replaced the tow off boats or packers which previously did this job.

Eventually, packers were almost totally eliminated from the fleet, in order to cut down production costs and power skiffs took over completely.

The power skiff is for all practical purposes a miniature tug made of plywood, aluminum or steel, measuring 22 by 8 feet and powered by diesel, ranging from 85 to 150 h.p., or gasoline engines developing up to 300 horsepower.

A few skiffs were also made of fibreglass which proved to be a good material.

Many of the skiffs have a semi-tunnel stern which not only allows the use of the largest diameter propeller possible but also increases propeller thrust.

The propeller is usually protected from entangling the seine by two deep skegs on each side of the propeller which are connected with rods or plating forming a protective bottom between the skegs.

The rake of the stem is continued below the water and the forefoot rounded slightly which, together with a shallow draft forward or bow high trim, allows the skiff to steam over the corkline and netting of purse seines without entanglement.

All power skiffs are fitted with a well secured towing post located about 2/3 of the way aft of the stem usually just aft of the engine.

Most skiffs are flat bottom and sufficiently heavy to allow abrupt course alterations under full tow condition without capsizing the skiff. Good stability is also essential in bearing the weight of a seine full of fish when it is tied to the gunwales.

As a safety measure, most power skiffs are fitted with flotation tanks or buoyant sections.

Echo sounders and radio telephones are fitted into nearly all skiffs.

ECHO SOUNDERS IN THE HERRING FISHERY

Prior to the introduction of echo sounders, the conventional method of finding herring was by feeling with a piano wire. It had a lead weight attached to it, was appropriately marked and was contained on a reel which was hand operated. Nearly every seiner was equipped with a feeler wire and many had a small power boat which located the herring and directed the seiner as to where and when to set. Some fishermen specialized in finding herring and operated small boats which were chartered by fishing companies during the herring season just to feel for herring. A great deal of skill was required to locate and assess the herring schools by feeling and men who had that skill were highly respected.

Echo sounders were suggested as early as 1937 by Captain R. F. Bovey of Vancouver, B.C., who was then the agent for British Admiralty Recording Echo Sounders, as a navigational aid and a means of locating herring. The March 1937 issue of "Western Fisheries" contains an excellent article by Captain Bovey. (Note: this article is reprinted at the end of Part 1.)

It was not until 1943 that the first echo sounder was finally introduced into the herring fishery, when one was installed on B.C. Packers' packer-seiner "Nishga", where it proved to be a lasting success.

Some vessels were fitted with echo sounders and used solely for scouting herring during the herring season. No doubt the cost was such that it did not appear feasible to equip all of the seiners with echo sounders.

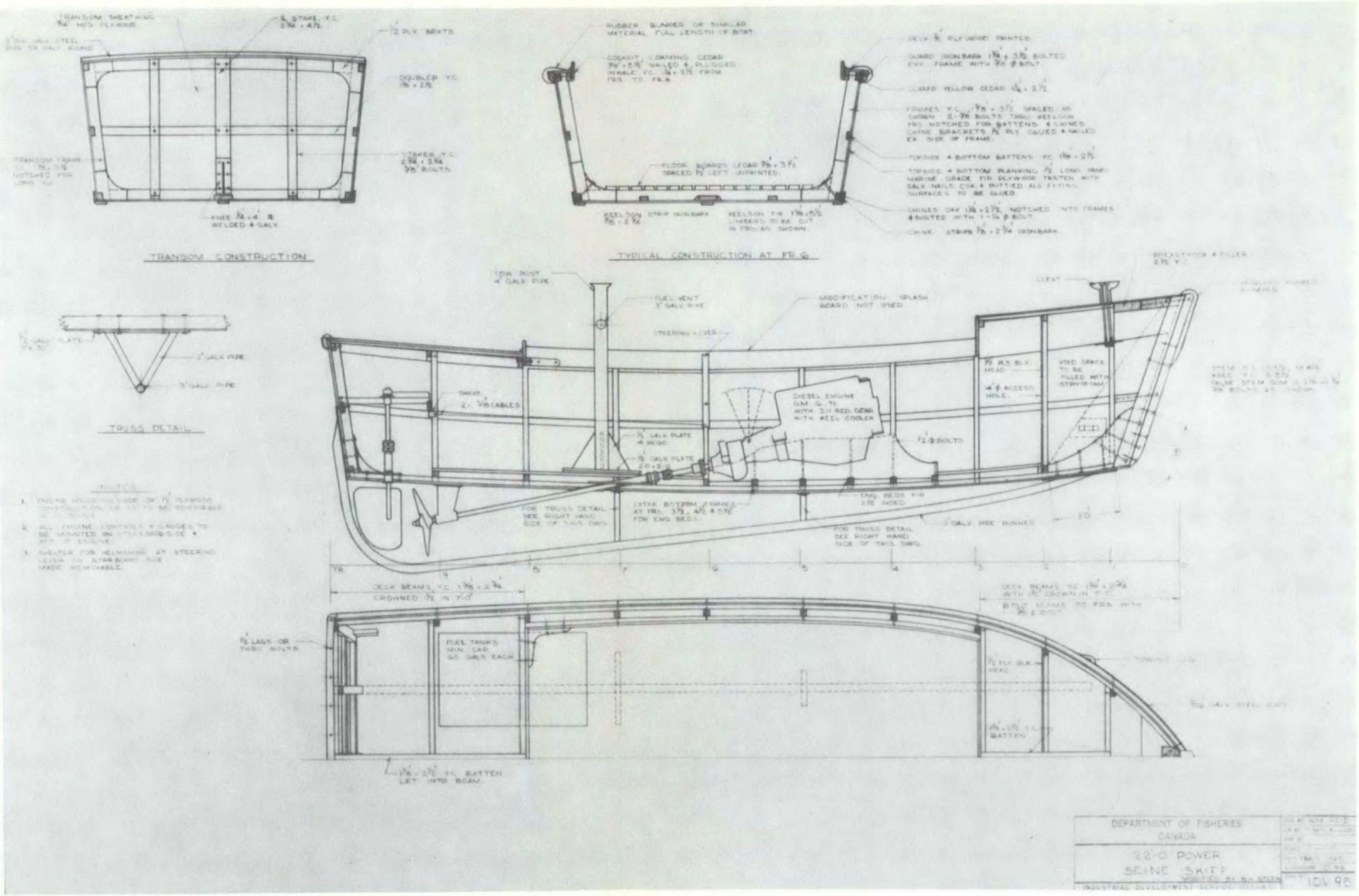
It is interesting to note that the April 1945 issue of "Western Fisheries" carried an advertisement from R. F. Bovey Ltd., agents for British Admiralty Husun Echo Sounders, which showed the following vessels to be equipped with echo sounders: "Nishga, "Skedans", "Norma N," and "Cape Blanco", all of which were engaged in scouting during the herring season; "A.P. Knight", a Fisheries patrol vessel; and "Western girl", "Wamalo" and "Dollina", which were herring purse seiners.

The Bendix dry paper echo sounder was introduced to the fishing industry in 1946 and the cost fell to a level where all herring seiners were soon equipped, as were most other vessels engaged in longlining, trawling and salmon fishing.

In 1955 a sonar set called the Mineapolis-Sea Scanar was installed on the "Pacific Sunrise", skippered by John Dale and owned by the Canadian Fishing Company. However, this experiment did not prove successful and sonar was not tried again until 1963, when a Kelvin Hughes set was installed on Norman Sigmund's "Sea Prince" and 1964, when a Simrad set was installed in skipper George Seter and partners' "Western King". The latter set aroused much interest and, realizing the success of sonar in the Norwegian and Icelandic herring fisheries, other B.C. fishermen began purchasing sonar sets. There can be little doubt that the sonar set is in the fishery to stay and will become as indispensable as the echo sounder.

See following Page

22 FT. POWER SEINE SKIFF



THE ECHO-SOUNDER AS A NAVIGATION AID

By Capt. R.F. Bovey in "Western Fisheries", March 1937.

In addition to being a general navigation aid, echo-sounding equipment is a valuable aid in hydrographical surveying, for the automatic tracing of the recorder gives a picture of the sea-bed more easily, and more accurate, than the graph plotted from odd soundings under the old surveying system.

All B.C. coastal waters are being surveyed by the aid of the Admiralty type Echo-Sounder, for Chief Hydrographer Parizeau has four sets of these instruments to aid him aboard the Canadian hydrographic craft "Wm.J. Stewart." The snag-boat "Sampson" also has an instrument of this nature in order to keep check of the changing bars of the Fraser River.

In depths of three, four or even five thousand fathoms, the accuracy of the echo is undoubtedly far superior to that of a sounding obtained by a dead weight at the end of a long wire, however carefully done. One takes 8 seconds, while the other takes anything up to 5 hours. It used to be a tedious task to lower and raise sounding weights from great depths during hydrographic surveys. The new echo system is checking and correcting old wire soundings.

The risk of a ship grounding is practically eliminated, because all the dangerous ocean bottom tracks will be known and easily identified on the Echo Sounder, and thus ample warning given if the ship, due possibly to foggy weather, were to find herself on one of these courses. This means that the ship need not delay or anchor until weather clears in order to proceed into harbour.

An automatic recorder provides the navigator with a continuous scaled profile chart of the sea bed, an aid which has been a great aid to mariners and fishermen. A stylus moves across the paper. The stylus travel speed is proportional to the speed of sound in the water, having regard to the scale for which the machine is calibrated. A strip of sensitized paper passes slowly beneath the reciprocating stylus. The paper, which is automatically moistened, is sensitive to the passage of a small current, the latter causing the appearance of a sharply defined sepia stain.

The remaining parts of the equipment comprise a "contactor unit" mounted in the engine room, and two magneto-strictor oscillators in small tanks attached to the inner surface of the ship's plating.

The sequence of operation is as follows: the control switch in the recorder closes and operates the transmitter relay in the contactor unit, allowing a range of current to pass from a charged condenser through the windings of the transmitter, thus causing the emission of a sound impulse.

The impulse returns from the sea bottom as an echo, and after reception is applied, after amplification, to the recording stylus, leaving on the paper a mark at the point in the travel of the stylus proportional to the echo-time.

The successive marks on the slowly moving paper form into a continuous contour chart showing the smallest variations in depth, and even affording an indication of the constitution of the sea-bed. These rolls of paper last 60 hours, and the machine may be run continuously for any convenient length of time.

If I were asked to describe the operation, I should say that echo-sounding consists of two main features, namely, sound and time measurement. The time a vibration, made by magnetic hammer transmitter, takes to return to the hydrophone receiver is automatically recorded on the graph, as seen in the sketch. How this is brought about might only make for a confusing description. But the reader will begin to see light when we state that an echo-foot occupies 1/2400 of a second. Five fathoms takes 1/83 of a second. So the recording apparatus changes its recording, actuated by the differences of time taken by the echo to travel up from the ocean bottom at different depths. If you look at the chart sketch the rest will be simple to understand.

The actual number of soundings that can be taken per minute must depend to a certain extent on the depth of water in which the ship is working. In very shallow water, as many as 350 soundings per second can be taken with the British Admiralty Boat pattern recording Echo sounder. For deep sea work, where a scale of 0 to 90 fathoms is provided, soundings are taken at the rate of about 90 per minute.

Echo-Sounding for Schools of Fish

Our Pacific fishermen have always been interested in "listening" for the sounds or echoes from fish schools as a means whereby new schools might be located. A large school of herring, swimming near the surface, may be heard with the naked ear, and resembles the pattering of rain. When the schools are swimming deeper, a fine wire, attached to perhaps a telephone set, would be dropped down into the water, and the bodies of the herring touching the wire might be sensed. Slow-swimming schools are hard to detect by these modes. For years our captains and fish scouts have been seeking a more scientific way.

It will be of interest to many fishermen to learn that a large number of trawlers across the Atlantic are fitted with echo-sounders, which are found a great value in locating fish and the best fishing spots. There were no less than 66 British trawlers fitted out with echo-sounding gear up to January 1935, and numbers have been installed since. Where shoals of fish are detected by the echo-sounder, it is thought that the echo really comes from the air contained in the fish.

Echo-sounding records the position of shoals of fish between the surface of the water and the depth at which the fish are schooling around or swimming.

Therefore it becomes an interesting speculation as to what might be accomplished out on the fishing grounds with regard to the prospecting of halibut banks; the location of salmon and herring, not forgetting the pilchard schools.

If trawlers and trollers could only make such charts of the ocean bed it would save them a good deal of lost fishing gear. Perhaps the same might be said of halibut and cod-fishing gear.

PART 2

HERRING PURSE SEINERS OF THE BAY OF FUNDY REGION OF THE CANADIAN ATLANTIC COAST

INTRODUCTION

Unlike the Pacific coast, where herring purse seining evolved as one of the operations of a combination fishing vessel, there has been a definite trend in the Bay of Fundy region which has led to the development of a pure herring purse seine vessel. The trend now, however, appears to be in the direction of combination fishing vessels.

Wooden purse seiners of a specific type measuring from 50 to 65 feet in over-all length have evolved and these are being used by New Brunswick and Nova Scotian fishermen in the Bay of Fundy region for trawling or purse seining. They had their origin with the open Cape Island type lobster boats, which were the first herring purse seiners. Following these open vessels came the decked vessels, the fish holds of which, however, remained very shallow and not designed to carry herring. This part of the operation was carried out by carrier vessels. The pilot house, accommodation and engine on these Cape Island type vessels are located forward and they have a generous freeboard, a broad transom stern and a good turn of speed.

While this particular type of vessel was being adapted for purse seining, exactly the same type and size of vessel was being used for inshore stern trawling and as there was no fish hold in which to ice the catch it was usually delivered fresh every day.

Eventually the growth of the herring fishery and inshore trawling demanded a seiner and a trawler capable of carrying its own catch; in bulk in the case of the former and in ice in the case of the latter. Consequently, the Cape Island hull was abandoned in favour of the deeper inshore dragger type hull form, which gave the vessels an ample carrying capacity with a good freeboard. Most of the features of the Cape Island seiner were retained, such as the forward pilot house with its offset starboard wing bridge and the galley located in the fo'csle. There was, however, a departure in the location of the engine room of some early purse seiners in that it was located aft.

Up to this point in development, the same type of vessel was used for stern trawling and seining, but none were used for both methods during the same year and they could therefore be classed as single purpose vessels.

It is interesting to note that the profile of these vessels is somewhat similar to that of the Pacific combination vessels and newer designs are even closer in resemblance. Both favour the forward location of the accommodation, pilot house and engine room but differ in the galley location and pilot house layout. Pacific vessels commonly have their galley located on deck aft of the pilot house, separate from the sleeping quarters. The wheelhouse with its wing bridge on the Atlantic vessel affords the skipper a good fore and aft view and also allows him to remain indoors when setting the seine during the winter months. Lastly the Atlantic vessel has a planked transom stern while most Pacific vessels have a timbered compromise stern which is rounded at the quarters, a fast rise on the horn timber and a flat rim which is usually out of the water when the vessel is in the light condition.

Within the last 3 years the trend in the Bay of Fundy region of New Brunswick has swung to the true combination fishing vessels of steel construction and of a larger size than the usual seiner or inshore trawler.

The first of these vessels were the 92-foot sister ships called the "Blue Waters," owned by the Mathews brothers of Campobello and the "Green Waters," owned by the Savage brothers, also of Campobello. These were truly the first combination craft in all of Eastern Canada and they engaged very successfully in tuna and herring seining as well as trawling in a single year's operation. They were also a departure in design, having the engine aft and the galley and sleeping quarters forward, while the bridge, which was of the ferry boat type, was located about amidships.

A third vessel, the 79-foot "Quoddy Bay", also owned by the Mathews brothers, has recently been put into operation. It is of steel construction and is a Pacific type combination vessel built in Vancouver, B.C., with modified accommodations and bridge which have many of the features of the smaller Atlantic purse seiners. Although the vessel is equipped with a combination trawl and seine winch and can rapidly convert to trawling, it is quite likely that the skipper, Ivan Mathews, will engage mainly in herring seining.

Undoubtedly, these vessels will have a great effect on the design of future Atlantic herring purse seiners or combination fishing vessels and credit must go to the men who developed them.

The fishermen of Campobello, N.B., particularly the Mathews and Savage families, did much of the pioneering and their success started the trend which has been closely followed by other herring seiners in the Bay of Fundy region of New Brunswick and Nova Scotia.

THE BAY OF FUNDY FISHERMAN AND THE SARDINE AND HERRING PURSE SEINER

Medford and Burris Mathews' story is worth telling as it clearly indicates the effect they had in the development of the herring fishery. They first started by purse seining sardine weirs in 1934, using dories and a cotton seine which had a 1-inch mesh and measured 35 fathoms in length by 50 feet in depth.

During the same year, they began pure herring purse seining with their father, Mr. Clarence Mathews, who together with his partners, Mr. George Justason of Black's Harbour and Mr. Jess Cook of Back Bay, N.B., were the first to purse seine herring in the Bay of Fundy region. They operated out of 15-foot oar-powered dories, fishing a cotton seine which had a 1-inch mesh and was 70 fathoms in length by 60 feet in depth.

Others who began at about the same time were William and Aubrey Mathews, together with their father Emery Mathews, a brother of Clarence Mathews.

All the herring, which were really juvenile fish packed as sardines, were carried to the plant by sardine carrier vessels. Purse seining was only permitted during the winter months and was carried out during January, February and March in an area bounded approximately by a line drawn from Black's Harbour to Grand Manan and then to Saint John. Purse seining was allowed after weir fishing ceased in the fall until about April 20. However, actual fishing operations were only carried out in the months previously mentioned.

It is interesting to note that scales were also saved in those days and that scaling began with the weir fishery. In return for the scales, men in that business helped remove the sardines from the purse seines into their dories, which had slat work floors. They then rowed to a carrier where the sardines were discharged and the scales recovered from the bilge.

It is obvious that the scalers must also have been of considerable assistance to the seiners in drying up and removing the catch. Apparently the first man to begin collecting and saving scales was Mr. Neil Fry, Paispearl Company,Black's, Harbour, N.B.

In 1936 Clarence Mathews and his sons Medford and Burris built and rigged out the first powered sardine purse seiner on the Canadian Atlantic coast. It was a wooden Cape Island boat 46 feet in length by 2 feet in breadth, powered by a 40 h.p. Palmer gas engine and was named the "Elizabeth and Jewel." The seine was made of 1-inch cotton netting and measured 120 fathoms in length by 15 fathoms in depth. They recall with amusement that they were prosecuted and fined $300 for extending their seine to 120 fathoms from the then legal limit of 100 fathoms in length by 100 feet in depth. Fortunately they were able, with the assistance of Connors Brothers of Black's Harbour, to get the fishery regulations amended to accommodate longer seines.

The "Elizabeth and Jewel" was very successful and the Mathews' caught more sardines than they could sell during the winter and as they were not allowed to seine during the summer, they operated stop seines, shutting off herring and sardines in coves as well as weirs.

The war created a demand for canned herring and sardines and as a result the seine fleet of Campobello and Grand Manan grew to about 40 boats between 1943 and 1945. These seiners were Cape Island boats between 40 and 45 feet in length, powered by gasoline engines. After the war, the demand for canned sardines and herring fell off and the fleet began to decline.

The Mathews brothers built a new seiner about every 4 years, each slightly larger and of improved design. In 1946 they owned a seiner called the "Whiz".

During the same year they acquired the first echo sounder and radiophone to be installed on a seiner in their area. They were working together with Bill and Aub Mathews who had a seiner called the "Winlass" and the radiophone proved its worth when the Bendix, DR I sounder was used to direct the "Winlass" onto schools of sardines.

In 1948 they built a new seiner called the "Rokadon" which was powered by a 671 series General Motors diesel. This was the first diesel installed in a sardine seiner in their area.

In 1950 they installed the first sonar set, a Minneapolis-Honeywell Sea Scanar, on a Canadian seiner and most of the Bay of Fundy seiners eventually became equipped with similar sonars which proved invaluable in the sardine fishery. During the same year Mr. Stanley Savage acquired the first radar to be installed on a sardine seiner.

In view of the inconvenience of having to rely on carriers to act as tow off vessels while handling their seine, the Mathews brothers installed what was probably the first side thruster on any sardine or herring seiner in the world in an effort to handle the seine without assistance. These thrusters, called "Hydra – Jets", were installed amidships in a new seiner called the "Waveguide" built in 1952. The jet thrusters proved so effective that about 8 other seiners in the area were eventually equipped with them.

The Mathews brothers recall that the first fish pump was installed in 1953 or 1954 aboard a sardine carrier and it proved so effective that all scalers and seiners eventually installed them. The scale collectors were quick to realize their worth in salvaging scales and as a result many Cape Island vessels of 40 feet or so in length, powered by gas engines, were rigged for pumping and collecting scales. The pump thus modernized the scale collector boats and the sardine fleet then had 3 distinctive types of boat, the seiner, the pumper and the carrier. The pumper made a living on the scales alone which were obtained by pumping a seiner's catch into a carrier.

In 1954 the fishery regulations were amended to allow summer sardine purse seining in an area bounded approximately by a line drawn from Black's Harbour to Grand Manan and then to Saint John. However, the market was very limited and only 2 or 3 seiners could engage in the summer operations. The winter fleet at the time numbered about 9 seiners, which was all the market could sustain. The Mathews brothers seined during the winter and operated stop seines during the summer.

Stop seining was a profitable business and in 1955 the Mathews brothers caught a record 14,000 hogsheads of sardines and herring. Much of their summer catch consisted of herring which went to pet food, kippers and canned kipper snacks.
Note: a hogshead is 1,248 pounds.

In 1955 the Mathews brothers introduced the first power block to the Canadian Atlantic coast. This was a home made block which they installed on the "Waveguide".

In 1957 Burris Mathews made a trip to Vancouver, B.C., where he viewed vessels engaged in herring seining and as a result built the first decked seiner, named the "Sea Scanar". The vessel still retained the Cape Island hull but the pilot house was modified to include an offset starboard wing to give good fore and aft visibility. This layout has been incorporated in all seiners in the Bay of Fundy region since that time. The "Sea Scanar" was also the first to be equipped with a hydraulic ram to top and lower the power block boom.

The Mathews' also designed and installed on the "Sea Scanar" the first overhead seine davit which has been copied on most of the seiners built in the Bay of Fundy area.

In the same year, 1957, they gave up stop seining and began purse seining on a year-round basis and on taking delivery of the "Sea Scanar", the "Waveguide" was turned over to their younger brother, Ivan Mathews.

In 1958 they introduced the first complete nylon seine to the area and also a new invention called a "skirt", a narrow strip of netting attached to the lower edge of the seine, serving as a tear strip to prevent rips occurring near the leadline from running up into the body of the net.

By 1962 a fair number of purse seiners were being built in the Bay of Fundy region and they all followed the style of the "Sea Scanar". Many were decked but they still retained the shallow Cape Island hull form with no depth of hold suitable for carrying herring.

The first seiner with a hull form and hold deep enough to carry herring was the "Sarah and Stewart" built in 1962 by Mr. Judson Guptil of Grand Manan. This boat was about 58 feet in length, had the engine located aft, and could carry approximately 65 hogsheads of herring.

The next seiner built to carry her own catch was the 65-foot "Polly B" built by Bill and Aub Mathews.

The "Polly B" was built in 1963 and had a deep dragger type hull form with the pilot house and accommodations located forward and engine room aft. It was also the first seiner to be equipped with a medium pressure hydraulic combination trawl and purse seine winch on the Atlantic Coast of Canada.

In 1963 the Mathews and Savage brothers took a giant step forward and built the first truly combination fishing vessels on Canada's Atlantic coast. These were the 92-foot steel sister ships "Blue Waters" owned by the Mathews brothers, and "Green Waters" owned by the Savage brothers.

They not only successfully pioneered the first tuna purse seining venture out of Eastern Canada but were also successful in herring seining and trawling, all of which was engaged in during a single season.

These were the first vessels to be equipped with brine spray refrigeration and two water jet side thrusters. The vessels are radical in design, having the galley and sleeping quarters located separately on the main deck under a raised fo'csle head, while the engine room is located aft and a ferry boat type of bridge straddles the deck amidships.

Late in 1965 Ivan Mathews took delivery of his new combination trawler seiner "Quoddy Bay", which is a 79-foot steel vessel built in Vancouver, B.C.

Although the hull of the "Quoddy Bay" is similar to the Pacific seiners "Pacific Dominator" and "Pacific Harvester", the accommodations and the pilot house are arranged differently.

In typical Fundy Bay fashion the wheelhouse is laid out to give a good view both fore and aft and enables the seine to be set with the skipper remaining indoors.

The steps from the bridge to the deck are arranged so that the skipper can make an easy and rapid descent to the deck.

Not mentioned previously is the fact that the "Blue Waters" and "Green Waters" were equipped with powered side rollers fitted to the bulwarks to assist in drying up the bunt when purse seining. Similar rollers have been used on smaller wooden seiners of the Bay of Fundy region for some time and were introduced about 1955 by Mr. Stanley Savage.

There can be little doubt that the pioneering efforts of the men concerned will continue to have an effect on future seiners in the region.

Reference: Personal contact with Medford and Burris Mathews.

THE HERRING PURSE SEINERS OF NEWFOUNDLAND

Herring fishing in Newfoundland has been carried out since the time of the first settlers. Dories and small open boats were used first to fish gillnets, bar seines and herring traps to produce cured and frozen herring for human consumption as well as for salted and frozen bait.

The first large, powered herring seiner, the "Western Explorer", was introduced to Newfoundland about 1939. This was an 80-foot wooden Pacific type herring seiner built about the same year for the Santa Cruz Oil Company especially for herring seining in Newfoundland.

The Santa Cruz Oil Company brought a floating factory ship, the "Lake Miraflores" to Newfoundland to process herring into fishmeal and operated her in the summer of 1939 off Labrador and in the Bay of Islands area during the winter of the same year.

Apparently the company was able to get all the herring it wanted from local sources and as a result the "Western Explorer" was only used as a packer.

The "Lake Miraflores" was lost off Saint John, N.B. in the winter of 1939-1940 and the "Western Explorer" was put into military service in the Bahamas as a harbour boat. She was returned to Newfoundland for the late Mr. Chesley Crosbie in 1945 to be used as a herring seiner for his curing and fishmeal operations.

Mr. Crosbie began fishmeal operations with a small plant which he built at Summerside in the Humber Arm of the Bay of Islands around 1941. The plant burned to the ground between 1942 and 1943 and was replaced by a new plant of large capacity which was completed in 1945.

The "Western Explorer" began purse seining in 1946 and was also apparently still used as a packer, as the Crosbie Company was able to get a substantial volume of herring from local sources.

The early attempts at seining were not as successful as was hoped and late in the 1940's, Mr. Crosbie obtained the services of two British Columbia herring purse seine skippers, Mr. John Gamon and Mr. Martin Skog to demonstrate the B.C. method of herring seining aboard the "Western Explorer".

The vessel was subsequently successful and as a result the "Eastern Explorer", similar to the "Western Explorer", was built in Newfoundland to fish for the Crosbie plant.

The skipper of the "Western Explorer", Mr. Wallace Smith, had a smaller but somewhat similar seiner built in Newfoundland; this vessel, called the "Veteran Explorer", was eventually acquired by Mr. Crosbie.

In the meantime Mr. Alex Dunphy and his sons, who operated a herring curing plant at Curling in the Humber Arm, had converted a wooden tug, the "Dunville", of approximately 70 feet in length, to a Pacific type herring seiner.

All three seiners operated in the Bay of Islands and Port au Port Bay areas, particularly the latter in which the best seine catches were made.

These vessels were equipped with echo sounders and the "Western Explorer" and "Veteran Explorer" were equipped with fish pumps while the "Dunville" brailed her catch. All three had nylon purse seines by the late 1950's.

Mr. Les Winsor, who skippered the "Western Explorer" after Wallace Smith, told the writer a number of years ago that the "Western Explorer" was an able and good sea boat both loaded and light and although they had caught herring in other places on the south coast of Newfoundland, they did most of their fishing in Port au Port Bay and had made some heavy catches there.

Port au Port was an excellent bay to fish as it was shallow and landlocked on the east, south and west sides and only a short run to the plants in the Bay of Islands.

Unfortunately the herring "run" in the Bay of Islands and Port au Port Bay area ceased some time in the late 1950s and although it was known that there was herring off Bonne Bay and unsuccessful attempts were made to capture them, it was felt that the herring remained in too deep water to be captured consistently by purse seine. As a result Mr. Crosbie shut down his plant. This was most regrettable as he had been closer than anyone to promoting a permanent herring operation which could have established Newfoundland and the other Atlantic provinces in the business at least 10 or more years earlier.

Alex Dunphy and his sons, operating their pickling plant at Curling, were about the last remaining "spark" and it was their request for assistance from the provincial and federal Governments which is reviving the herring fishery in Newfoundland. It is of course hoped that production will continue to increase and that a lasting fishery will develop.

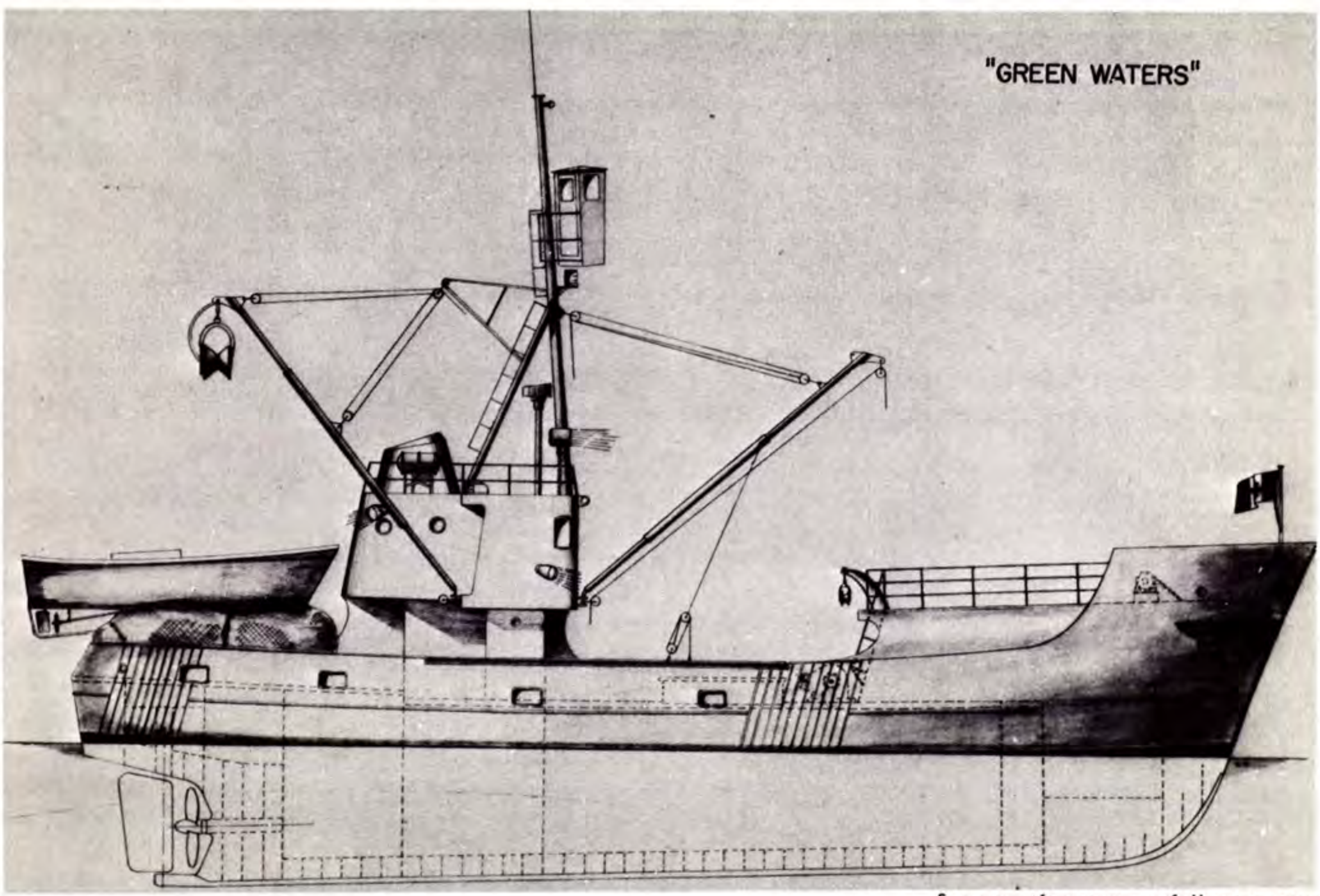
Although no specific type of purse seiner evolved in Newfoundland, some worthwhile observations can be made from the experience gained with the aforementioned vessels.

In proportion to the capital investment in a meal plant, a great deal more must be invested in purse seiners to supply the raw material than is invested in fishing vessels, such as trawlers which supply a ground fish processing plant.

Small boats such as dories operating gillnets, bar seines or traps should never be relied on as suppliers when planning the location of a fish meal plant; even though there may be a good annual inshore run in the area and many such craft making the cost of the herring reasonable to the plant operator. Plants have in the past been located in relation to a stock of herring which could be caught by small boats. Subsequently the run failed; the boats were incapable of ranging farther afield for herring and consequently the plants went out of business.

The plant should be located so as to be central to more than one stock of herring with a long season in mind, even though it means hauling the herring somewhat farther, that is possibly 400 miles or more. The vessel should therefore carry a cargo of perhaps 250 tons of herring or more and be large enough to cope with severe winter weather conditions.

References: personal contact with Chesley Crosbie, Less Winsor, and Noel Tibbo.



See specifications on following page

THE "GREEN WATERS", PURSE SEINER AND TRAWLER

Vessel particulars:

Length over-all	91 ft. 10 in.
Length between perpendiculars	80 ft.
Registered length	84 ft. 7 in.
Breadth moulded	22 ft.
Depth moulded	12 ft.
Draft aft (moulded)	10 ft. 2.5 in.
Draft forward (moulded)	7 ft. 5.5 in.
Draft mean (moulded)	8 ft. 10 in.
Rise of keel	2 ft. 9 in.
Rise of floor	4 ft. 4 in.
Camber (at frame 26)	6.5 in.
Main engine	G.M. 2 cycles, tandem twin 24 cyclinder in "V" Series 71 Max. BHP 1,008 at 2,300 rpm Net continuous SHP 665 at 1,800 rpm
Fuel oil capacity	6,000 gallons imp.
Speed (max.)	6,000 R.P.M.
1 Kent clear view screen	
2 electric bilge pumps	
Operating range	2,000 nautical miles
Fish hold capacity	(150 tons of frozen tuna)
Auxiliary engines	2 GM 3 cyl. series 71 30 kw. generators operating on FPTO, the refrigerating compressor, and hydraulic pump for winches

1 Puretic power block (hydraulic)
1 3 drum Norwinch hydraulic
2 Hanley water jet nozzles of 1,000 pounds thrust each.

Electronic equipment:
1 Simrad EH2A type 516-64 fishfinder, 0-600 fathoms
1 Simrad fathometer 0-200 fat.
1 Honeywell Minneapolis sea scanner
1 Bendix Lr 200 Loran receiver
1 Kelvin Hughes type 14/a marine radar
1 Canadian Marconi type CN86, 60 watt radio telephone
1 Hallicrafter model CB3A littlefone short range radio telephone
1 Sea Slave automatic fog horn and 7-System station inter-communication system
1 Bendix transistorized type ADF 162 automatic direction finder
1 Sperry Gyroscope steering automatic pilot
1 J. Lilley & Gillie magnetic compass with auto pilot setting compass
1 Tenfjord electric hydraulic steering system with two push button and one handle remote controls
2 small transistorized radio telephones for skiff operation
2 Smith "Astral" marine clocks
1 Television
1 Decca navigator (not yet installed)

Purse Seining Skiff—all aluminum with following particulars:
22 ft. over-all length
12 ft. beam
4 ft. depth

powered by a G.M. 4 cyl., 71 series 140 H.P. 3:1 reduction gear.

General Seaworthiness of Herring Seiners

by

Robert F. Allan

Naval Architect, Vancouver, B.C.

SYNOPSIS

The author discusses in general terms the design of herring seiners, particularly with respect to considerations of buoyancy, stability and general seaworthiness.

INTRODUCTION

There is a good possibility that the West Coast type of seiner as developed during the last 25 years will be adapted to the Atlantic Herring Fishery. With this in mind the writer wishes to make some critical observations on these vessels and some suggestions towards possible improvement. Most of the remarks will deal with basic naval architecture and will not refer to details or arrangements.

The West Coast seiner was not originated by naval architects but by wooden shipwrights in collaboration with working fishermen. In some cases fishermen built their own vessels. To this day, the West Coast naval architect has only attempted to put on paper what the fisherman wants and has only made minor contributions by way of modifications to hull form and some control over displacement and stability. The present class of steel boats stemming from the *Bering Sea* built in 1959 are widely accepted principally because they follow the essential features of the later wooden craft. This type of vessel has some basic features, dictated by the fishing arrangements which make it, from a strictly naval architect's point of view, less desirable than certain other types of fishing vessel. These features are:

(a) In most cases the hold size is based on maximum volume available between engine room and aft peak, a volume which carries a load of herring in excess of the reserve buoyancy available.

Several wooden vessels have been lost in this condition reportedly because of taking water in steering compartment through rim timber leaks. Whilst the leak may have triggered the accident, the prime fault is a lack of reserve buoyancy. A very small amount of water in the stern compartment will submerge the main deck aft of the hatch with a consequent loss of supporting waterplane.

When the hold is too large for the corresponding reserve buoyancy as described, control of freeboard is entirely up to the master and it is to be expected that overloading will occur.

(b) Most of the wooden and steel boats have initial stability which appears to be adequate by usual standards yet several vessels have capsized when travelling light. The wooden boats in particular have a light ship centre of gravity which is fairly light above the waterline and adequate G.M. is obtained by a corresponding high Metacentre. The steel boats represent an improvement because the hulls have been lighter and have contained more concrete to cover bottom structure. In most cases they have not had raised decks and their superstructure has been correspondingly lower.

(c) The general type has a wide stern to provide a platform for net and maximum buoyancy for load carrying. In a following sea the type has a strong tendency to broach. This tendency is most marked when vessel is in condition for arrival at fishing grounds. Usually the aft tanks are empty and vessel is by head relative to designed W.L. possibly with fore and aft drafts about equal.

I have dealt principally with the British Columbia vessels with which, of course, we are most familiar. The same remarks apply to a certain extent to the Peruvian and Chilean vessels, but there are some significant differences. The South American vessels are more specialized and are not required to serve in other fisheries as are the British Columbia boats. They are constructed very lightly, have light engines and a minimum of superstructure and auxiliary gear. As a consequence they can carry a greater load on same dimensions. In most cases a minimum freeboard of 10" or 12" with hatch full is attainable with this type, although I understand that they are often seen with a deck load.

Now that we have defined some of the faults, we should consider what measures of improvement are feasible. We shall deal with the various points in same order as mentioned above.

(a) RESERVE BUOYANCY

It is to be expected that, if the industry does not take adequate measures to preserve a reasonable margin of freeboard in loaded condition, the DOT may impose an arbitrary freeboard which will severely restrict the capacity of many existing vessels. The proper procedure in my opinion, is to balance hold more exactly in respect to position and size. Towards this end, owners should obtain in a preliminary stage from builders or designers, fairly complete sample loading conditions showing distribution of tankage and trimmed waterline on a sketch profile.

(b) CENTRE OF GRAVITY

I look for an attempt to lower VCG and Metacentre. I believe this will improve the typical seiner in seakindliness as well as in safety.

Various details contribute to a relatively high or a low centre of gravity. Position of engine is an important one. It is considerably higher in the engine forward type as compared to the conventional East Coast dragger or side trawler. Weight of engine is also important. The present trend to high speed engines need not be harmful provided some or all of the weight saving is converted to ballast. Weight, size and position of deck houses is important. The use of aluminum in these areas is very useful, as was demonstrated in the combination vessel *Attu*. This measure has been generally avoided because of cost, but in certain yards familiar with working aluminum the cost increase has been quite moderate.

(c) TRIM

The trim of these vessels, both in light and loaded condition has always been a most critical point. In the days of the heavy duty engine the aft engine room bulkhead was a little forward of amidships and it was necessary to sail with an excessive trim by head to avoid putting stern under when loaded.

Now we have, particularly in steel vessels, better opportunity to control this. The high speed engine allows a short engine room and the use of stern tanks of high capacity permits a departure trim approximately on designed waterline.

Apart from such details as tankage, the position of hold bulkheads and longitudinal centre of buoyancy should be carefully coordinated to obtain the most desirable loaded trim which is slightly by stern in relation to designed departure condition in order to maintain good freeboard forward. With the high load displacement ratio this matter of hold position and LCB must be controlled fairly precisely.

GENERAL HULL DESIGN

One other field of improvement which should be followed more than it has in the past is the one of resistance. Although the general class of steel vessels built in the West during the last 7 years have been in general considered as good in this respect, no work has been done to establish actual numbers for power vs speed in various conditions of loading. In fact trials have always been of most elementary nature, usually consisting of one or two runs on a dubious measured mile in light condition immediately prior to delivery. It is possible that present models may be quite good but I feel that naval architecture, of the standard now established in the towboat industry, requires a background of tank testing and subsequent service follow-up.

RECENT DEVELOPMENTS

Finally, some remarks in relation to recent developments and improvements in detail may be offered.

The Kort nozzle has now been accepted by the British Columbia towboat industry and has shown remarkable improvements in performance apart from the well known increase in bollard pull. The nozzle offers the combination fishing vessel a much flatter curve of thrust vs speed. This means that a significant increase in loaded speed or trawling speed and power may be achieved along with maximum light running speed, without the harmful lugging down of propulsion engine which is now considered a necessary evil.

The Kort steering nozzle also offers a remarkable manoeuverability, it has a significant effect in reducing tendency to broach and it has the added advantage of being an excellent net guard.

Another contemporary development which is reaching out into larger vessels every year is the use of fiberglass. We now have designs in the 50-foot class approved by C.S.I. using a method of construction not requiring the expensive female mould, nor committing the owner to a design which it is not possible to modify for improvement or individual prefences.

This system appeals to me for smaller seiners where the choice between steel and wood may not be too clear cut. A feature of this construction is the minimum plant required. A certain amount of technical know-how may be acquired fairly rapidly, therefore the transition from wooden boatbuilding is not too difficult.

In conclusion may I add that it is my hope that the East Coast industry may develop boats according to precise needs of their fisheries and not adopt either European or West Coast design unless there should be good reasons for so doing.

Herring Fishing Vessels of the Future

by
JEAN FRÉCHET
Chief, Fishing Operations Branch,
Department of Fisheries of Canada

There is very strong evidence that the largest herring resource in the world today occurs in waters off the Canadian Atlantic coast; yet we harvest an infinitesimal part of the potential yield. As we learn more about the immensity of this stock of herring, we begin to realize that here, on our doorstep, lies an unexploited source of a valuable commodity which is in great demand throughout the world, due to its recognition as one of the richest protein foods known to man.

In early days, this fish was considered to be unimportant and was eaten only by poor people. Today, however, herring is an established delicacy, which has tremendous popularity.

There are other important ways to make use of the herring such as for animal food and yet here in Canada, the bulk of the catch, small as it is in relation to the potential yield, is processed and sold at a price which is necessarily very low, in view of the highly competitive nature of the international market for fish by-products.

On most boats of the Canadian Atlantic coast, which prosecute this fishery, there could be improvements in design, in equipment and gear to increase efficiency. There is also room for many more herring boats, using every new technique and invention available to take advantage of this great opportunity.

A move in this direction is already apparent and this conference will no doubt bring about progress in this field.

Certain factors will be of great concern to all those who may consider either building a herring fishing vessel or acquiring one already constructed. The most obvious questions that come to mind are:

a) What *size* should the vessel be?

b) What *type* would be the most efficient?

c) What *materials* should be used in construction?

d) What *machinery* is required?

e) What *equipment* is needed?

f) What *method of fishing* should be used?

Please do not expect to find exhaustive answers to all these questions within the confines of this brief paper. It is the writer's intention only to impart a few opinions and comments in order to stimulate discussion from which it is hoped that the real value of this conference will emerge.

In the concluding section of this paper, an effort has been made to foresee what shape the fishery could take in the not too distant future if man's ingenuity and inventive genius continue to remove the seemingly unsurmountable obstacles which are being conquered with increasing rapidity in the last few decades.

It is not inconceivable that fishing operations may be carried out with entirely new concepts in fishing vessels, gear and techniques. Your credulity may be taxed to the limit at this juncture, but achievements of the world's most reputable marine scientists and technologists now make it possible to expect vessels and gear to be eliminated from this fishery.

SIZE

Some herring boats like the small seiners of the Bay of Fundy do not hold fish aboard, but operate jointly with pumpers and collectors. However, the trend is towards self-sufficient vessels which will catch, haul and carry herring.

The most important criteria for a profitable venture in herring fishing is *capacity*.

It is of prime importance that the hold of a herring vessel be of a maximum capacity in relation to length, therefore, it is recommended that vessels have a prismatic coefficient well above 0.7 in the loaded condition.

In the near future, sound economic commercial operations on the herring stocks of the North West Atlantic can hardly be achieved with vessels of extreme lengths, however, Coastal vessels below 65 feet in length have too many limitations to be considered here. For instance, they lack mobility to follow the herring stocks from Georges Bank to Labrador banks, they are subject to weather conditions and cannot operate safely offshore in all seasons. Their size is not commensurate with the stock potential. On the other hand, vessels above 150 feet in length may be economic for distant operations but are hardly practical or economic in the Canadian offshore operation. It is therefore in the lengths between 70 and 145 feet that we should seek the answer. Climatic conditions of the North West Atlantic could eliminate vessels of less than 100 feet, but it is felt that an even greater limiting factor would be their hold capacity which is directly related to their earning potential since herring seiners will require about the same crew complement whether they are 70, 90, 120 or 140 feet in length. The hold capacity will be about 150, 250, 400 or 600 short tons of herring respectively. On this basis, it is clearly seen that there are definite advantages to be found with vessels over 100 feet in length. We are thus left with a range of 100 to 140 feet. We could again eliminate the extremes and be left with a 120 ft vessel, however more justification is needed.

The most profitable fishing vessels on our Canadian East coast from the capital investment point of view have been those constructed of wood. Reference is made to the economic studies of John Proskie and to the contribution of William Hines. Mr. Hines established a comparative evaluation of wooden versus steel vessels, at the Second FAO World Fishing Boat Conference, last year. These clearly establish that definite advantages are derived from the use of wood. The maximum overall length of wooden vessels appears to be 120 feet before complex structural problems arise.

Whether wood is used to keep construction cost at its lowest, or steel to provide a more lasting investment, it appears that the 120 ft size of vessel is indicated for the immediate future on the basis of present experience and trends.

Such a vessel would have a water line length of 110 feet. A beam-length ratio 1:4 is recommended thus giving a beam of 30 feet. Considering that green herring weighs sixty pounds per cubic foot and that such a vessel should have a hold volume of 12,500 cubic feet, her carrying capacity would be about 375 tons.

The depth, namely the distance from the top of the deck to the bottom of the keel (rabbet line on wooden vessels) would be 16.25 feet and to insure a wide cruising range, the fuel capacity would be 20,000 imperial gallons.

Since the pay-load of a fishing vessel is of prime importance, it seems desirable to limit water tanks to drinking and cooking water requirements and to evaporate sea water for all other purposes. One thousand gallons would thus constitute an ample reserve.

TYPE

There are definite advantages in investing capital in a vessel that will be capable of using various kinds of fishing gear and methods of fishing with minimum changes in machinery and layout. Thus it would be possible to catch any fish species at peak concentration, but also when market values insure maximum returns.

The general tendency with North American seiners is to locate the wheelhouse, accommodations and engine room well forward. Such an arrangement permits a good clear working deck and the use of the widest part of the hull for holding the maximum quantity of catch. However, the ferry boat type with the engine room and the wheelhouse aft of the midship section also has advantages. It is more adapted to the climatic conditions of the North West Atlantic and reduces the danger of spray icing and provides added protection on deck. It gives better balance of the superstructure in the wind and reduces engine noises and fumes in the living area. There is no need for a long propeller shaft and shaft tunnels. It is not possible, however, to use a single power block to bring the seine forward for repairs.

MATERIALS

A word has been said about possible lowering of capital investment through the use of wood in hull construction. Should difficulties be experienced in finding the necessary quality of wood in long lengths or particular shapes, the use of modern glass and laminating techniques would provide additional strength with minimum cross section.

The use of metallic superstructures in conjunction with wooden hulls offer many benefits which have not been explored extensively in the construction of Canadian fishing vessels. Aluminium would be particularly suitable to reduce top weight and lower the center of gravity, and should also considerably reduce maintenance. Aluminium would be less subject to icing and since it is an excellent heat conductor, new ways of eliminating icing risks might be developed.

In maintenance, one cannot overstress the advantages of plastic materials in covering inner surfaces. They are easily washed and kept sanitary with minimum effort. In the fish hold a layer of insulation covered with mastic and plywood could be covered with reinforced fiberglass and finished with white epoxy. Synthetic materials will even serve as fire retardants in the engine room.

MACHINERY

The propulsion system should occupy as small a space as possible so as not to infringe on carrying capacity. In a 120 foot combination vessel, 900 horsepower is required for efficient fishing operations. Fish behavior is too young a science to permit definite statement as to whether a slow turning four stroke engine is preferable to a high speed two stroke engine to ensure the lesser disturbance of herring schools. On this subject, ideas are too varied to form opinions that could add to the arguments for or against slow or fast turning engines.

The combination vessel, and particularly the seiner, needs maximum manoeuvrability. Presently it is mainly the skiff's work to push or pull the seiner. Water jets and even air propellers have been tested. The latest development in this field has been the introduction of the bow thruster and an active rudder which uses a small propeller on the after tip of the rudder. It appears that there would be definite advantages in the introduction of the steerable right angle drive unit with attached Kort nozzle. Such units are already available in the 900 horsepower range. The variable pitch propeller which is so useful in combination vessels is not yet used in seining in Canada.

Such systems would permit the location of the main engine in the most desirable place aboard, even in the lazarette, thus allowing the advantage of the largest possible hold in the widest part of the vessel. Such systems would ensure maximum bollard pull and excellent manoeuvring ability, enabling turns of 360 degrees in seconds.

In Germany, the stern ramp trawler has been happily married with the seiner by constructing a seine net box on the stern trawling gantry above the ramp. The skiff is handled on the regular stern trawling ramp. On a 120 ft vessel with a limited freeboard, it would seem desirable to use a hinged transom, hydraulically controlled, to form a stern trawling ramp.

Aboard a combination vessel, a combination winch is desirable. Hydraulic power gives the necessary flexibility. Such a winch could easily combine the drums and warping heads necessary for seining, trawling, long lining, gill netting etc.

The hydraulic side roller which is a long pipe covered with rubber and located on top of the bulwark permits drying out the bunt or hauling any net with ease. It seems a most desirable addition, particularly aboard seiners which operate in cold climates. The returns derived from faster emptying of the net offset the slight additional cost.

There is a need for a powerful herring pump to empty the bunt as rapidly as possible. Particular attention must be given to the selection of a pumping system that will not scale the herring or break the backbone. Air pumps may even become more efficient for this operation, especially in the retention of the quality of the herring.

Shipboard freezing systems may become mandatory in the developing of the marketing of herring for human consumption. Even now a precooling system to lower the temperature of the herring to 28 or 30° Fahrenheit would be an asset. Refrigerated sea water or brine solutions are indicated.

The skiff aboard the herring vessel should be light but powerful. Aluminium here presents an excellent material for construction while free piston gasifiers for propulsion may have great potential, being light and compact propulsion units, particularly if used in conjunction with a water jet turbine. As a matter of fact, recent developments in water jet propulsion systems indicate the possibility of achieving high thrusts while insuring ease of operation around nets.

EQUIPMENT

Modern navigational and fish finding equipment is now well established aboard fishing vessels. Selection of the most efficient equipment is important. A powerful somar system is a necessity aboard a seiner and care should be taken to obtain the best possible definition. A frequency of not less than 40 Kilocycles is desirable for a good herring scanner. The smaller the fish, the higher the frequency should be. Frequencies as high as 200 kc. have been successfully used. The powerful unit aboard the seiner is not always handy for scouting operations in closed bays, rocky creeks, etc. It is therefore advisable to equip the skiff with a small manual scanning sonar system and to use the skiff for scouting in confined waters.

We have already referred to the need for further behavior studies of herring in relation to noise and light. However, light attraction systems are already in use aboard seiners. The use of submerged lights appears to be most valuable in attracting deep schools to upper water layers within range of seine nets. The biological station at Grande Rivière is presently engaged in such experiments under a joint federal provincial project. There also appears to be advantages, in certain circumstances, in having the skiff equipped with light attraction systems.

Experimental work may lead to the introduction of attracting devices using noise or electrical fields or impulses but such systems are not yet fully developed for commercial operations. Development work is also needed in the field of color, its intensity, wave length, etc., in relation to light attraction systems.

TECHNIQUES

Fishing gear and techniques are being covered by other authors at this conference. Therefore, I will simply mention that a 120 foot vessel with 900 HP would be able to use the largest knotless seine nets known at present which are nearly 500 fathoms in length and 65 fathoms deep. Similarly, the boat would have the thrust to tow large herring trawls. Her size would definitely permit offshore operations which are foreseen as a next step in the herring fishery development program on the Atlantic coast.

Finally, we are convinced that her facility to operate various types of gear and her mobility would permit year round fishing operations.

THE FUTURE

The ever increasing pace of man's scientific achievements make it possible for us to project our thoughts into the future with the knowledge that the fantasies of today are the accomplishments of tomorrow.

By the time that our grandchildren enter the fishery, space travel may be a commonplace occurrence. During their time, one could expect fully automated vessels remotely controlled from shore based "brain centers". A skeleton crew of three men will be carried on board to service the electronic, mechanical and fishing equipment. As incredible as this may seem, plans for such an operation with a mothership as the control centre have already been completed by the U.S.S.R.

Herring fishing would lend itself admirably to such an operation, so possibly the day is not too far distant when such systems will be in use on our coasts.

The next logical step would be to relieve the catching vessel of the responsibility for handling the fish on board. This would mean that the whole of the ship could be given over for space for fuel and all the highly sophisticated equipment which such a system would require.

Detachable cod-ends are being used by some countries. Here, the bag of fish is released from the trawl with an attached radar reflector buoy, or radio homing signal device, to be picked up by the mothership. The addition of a similar cod-end to the bunt of a purse seine would achieve the same purpose.

Herring fishermen have already investigated the possibility of utilizing long rubber pipes called "dragons" which are currently being used for transport of oil or fuel. This method makes it possible to move fantastic volumes in relation to the horsepower of the towing vessel due to the low resistance and positive buoyancy of the pipes or "dragons".

Radio controlled underwater vehicles have been proposed, four of which would tow a giant pelagic trawl from each of its four corners. These vehicles would tow on courses, predetermined by a nuclear powered submarine equipped with powerful fish detecting sonar which would locate the dense schools of herring.

Since we have embarked on this flight of imagination let us proceed to the ultimate which is the harvesting of fish from the sea in an era when fishing vessels and gear as we know them are things of the past.

Men like Commander Cousteau and American aquanauts have shown conclusively that men can survive for extended periods at great depths in undersea "houses" which they can leave and return to at will. This points the way to the establishment of vast fenced-in areas of the sea which would contain hybridized, fast growing herring and other fish. Pipe lines would connect these "submarine ranches" to shore establishments. Herring would be pumped through these pipelines in accordance with the demand of the market.

I was asked, when preparing this paper, to give some indication of herring-fishing trends in the near and distant future, however the request failed to stipulate at what point to stop. It is now time to come back to earth and to work on our urgent common goal; the future of the Canadian Atlantic Herring Fishery which is expected to become perhaps the most important fishery on this coast.

The goal can only be realized through the co-operation of all concerned: industrialists, administrators, scientists, naval architects and ship-builders, through a well planned, coordinated and vigorously prosecuted effort. Conferences such as this will give impetus to this development. Any plodding or failing on our part will see the harvesting of this rich resource on our doorstep by the vessels of competing fishing nations.

Session 3

DISCUSSION

Mr. Robert F. Allan, in reply to a question about the Kort nozzle and controllable pitch propeller, said: "In my opinion, the use of the Kort nozzle makes the use of the controllable pitch propeller much more necessary. If you were to draw a curve of thrust versus speed, for an open propeller and a nozzle propeller on the same diagram, you would find that the nozzle gives you a much flatter curve. This means that you can design the fixed propeller for say some compromise speed, seven knots, and the engine will not be overloaded at slower speeds. At the same time, a greater proportion of power will be available for free running. If you do the same for the controllable pitch propeller, you will find that at the lower speeds the controllable pitch will give you less thrust than the fixed propeller because of its slightly lower efficiency due to the warped form of the blade in other than the optimum pitch, and the only advantage of the controllable pitch propeller is that it will be able to give you 100 per cent of the power at higher speeds – at free running speeds. The result of that is not very significant. Perhaps you get 25 per cent more hp of free running speed on the propeller, but the increasing speed of the vessel may be only a quarter of a knot."

There was a remark from the floor that, in catching herring, it was extremely desirable to have a variable pitch propeller. "If you want to slow the boat down you're better to slow it down *with a variable pitch propeller than changing r.p.m's, because changing r.p.m.'s undoubtedly spooks the herring."*

Mr. Allan said: "There's one other point in favour of the controllable pitch propeller. Many high speed engines will not idle below 40 per cent of the normal r.p.m. Consequently it is very difficult to get a precise slow movement of the ship for exact positioning. The adjustable pitch propeller, of course, allows you to do this. Many of the Norwegian and Icelandic controllable propellers are, in a sense, not controllable pitch propellers but rather adjustable pitch propellers. One has to unwind the wheel, and it is not something you can do off and on. You set the thing for the fishing condition."

Mr. Homer Stevens: "I just want to say that I believe if we want to call a conference of all the widows and children of the fishermen that have been lost as a result of accidents in the Canadian fishing industry we would certainly have a larger gathering than we have here. In view of the interests and safety of men that are working on boats, I would like to ask Mr. Allan a few questions, if I may. In view of the fact that the fishermen's lives are at stake why do you abhor the introduction of stiff government regulations over stability and other measures designed to prevent sinking and capsizing? The second – the vessels that you describe – are they designed to maintain adequate stability with the seine and power skiff aboard? and the third, Mr. Allan, are you in favour of government training of captains and engineers, with a view to improving operational safety at sea?"

Mr. Allan: "Well, may I say in a general way that I'm not in favour of government regulation of anything. You seem to infer that government regulation of stability and so forth would be good. We have more regulations in the marine industry than you have in your automobile on the road. There are quite a few widows and orphans from automobiles, too; we would get quite a large meeting out of them. Many government regulations which we have now result in a false approach; there is an effort to get to the borderline of these conditions without overstepping. I'll give you instances of this. There is a 15-ton gross limit below which inspection is not required. How many vessels are built to this limit in which everything is strained to the utmost – the load carrying capacity, the stability and so forth? Would it not be better if that were raised and we had liberty to design our vessels properly? I could point out to you that many drum seiners are just 15 tons – 14.9 tons. They're carrying a fairly large drum on deck. They're limited in size to about 40 feet x 12 feet. I've pointed out many times that it would be much better if we were to make that boat a 20-ton boat or a 22-ton boat, for very little more cost, but no, we have to avoid that government regulation. It's the same thing with many of these barriers. There's a 150-ton limit, there's a 50-ton limit, and so forth. Every one of them introduced some choice which is not the proper naval architect's choice, but one which is dictated by economic consideration.

"Now the other part of your question, as to whether these vessels are designed to contain adequate stability with the seine and skiff on deck. Well, I tried to introduce a point there that the definition of stability is not a simple thing. The normal criterion of stability, as used by most, say the C.S.I. to a certain extent, and many builders, is the figure of the value of G.M. The value of G.M. does not give the total picture at all. The position of the centre of gravity is equally important, and of course this requires a very complete analysis to really get it down to figures, and say we make cross curves of stability, we have righting lever curves for various loading conditions. Then we come up with the question of what is the minimum. No one is going to stick his neck out and say that the G.Z. figure should not be less than so and so. They're going to make that very, very safe and you're going to get again a barrier which is not necessary in many cases. I would much rather rely on the wisdom of sea-going types. Most fishermen – most skippers – are pretty adequate types. It eventually boils down to a matter of seamanship. Sure, some seamen take a

chance with a boat that's not too good, but you could get a trained man, you could get one through a college or school of navigation and put him out there – he could overturn or founder the best boat.

"If we do not have a training scheme in private industry, I think then it is necessary for the government to provide this training. I would much rather see the industry provide its own training."

Mr. Jean Frechet: "Mr. Chairman, I would just like to add a word to this – that many nations, including Canada, are presently working on a very simple formula which could be used by fishermen at sea to analyze their rolling period and thus avoid, in certain circumstances, the dangerous accidents that occur so often, and I think that before long such a formula will be published and will be available internationally, to all fishermen, and once a rolling period beyond which they should never go is established, either by naval architects or by an inspector, on a sound formula for his boat, I think he could make sure that he need never exceed such a rolling period. Many accidents at sea could thus be avoided."

Mr. Walter Scott, Naval Architect, Department of Fisheries, Ottawa: "I would like to ask a specific question of Mr. Allan and to make some remarks. There are many instances on record where stock plans are offered by a naval architect in answer to a fisherman's specific wants. Instances are known where a West Coast design using West Coast timbers is offered as a design for construction and operation on the Canadian East Coast to be built out of local (therefore East Coast) materials.

"My suggestion would be that the purchaser of a design should advise the naval architect of his place of building, type of timber available, propulsion motor and equipment preference, rather than being sold a stock design which then requires great alteration, which generally is uncontrolled and then, on acceptance, or in fishing operation, find that the design is useless because of these departures from the stock plan.

"A second question I would raise is that load lines were observed on the film which was shown yesterday of a Dutch trawler. This particular aspect of vessel safety is being intimately discussed between all government organizations at an international level. I would like to know if Mr. Allan in his design investigation, combined with the potential design changes previously referred to, gives any allowance in his design for sheer profiles, effective superstructure lengths, deck chambers, etc., as would be part of a regulatory load line calculation on a larger vessel.

"I maintain that this is very necessary, as in this current conference on a fluid cargo, namely herring, there can be an over-abundance of possible trouble due to the combination of three surfaces, insufficient temporary bulkheading, and mixups during pumping."

Mr. Allan: "Your remarks, Mr. Scott, are well taken. In the matter of stock plans, this is a wide subject. You must remember that it is only in recent years that the naval architect has become involved in fishing boat designs at all. When my father started the business, the Steamboat Inspection Service required plans to be submitted, and he was often commissioned to make some drawings after the boat was built. It's in a state of evolution. Many fishermen come to us and to other naval architects, I am sure, wanting a model. All they care about is a lines plan. They're not too interested in fine details – they're going to do this themselves. I think this is probably more prevalent on the West Coast – you have more enterprising individualists there, particularly Scandinavians. They are a very selfsufficient type. I would agree with Mr. Scott that as far as a major vessel is concerned, if it were built far away from home, I would hesitate to sell a stock plan. I have actually come across this situation and have refused this without having adequate information as to what was the end purpose of the ship – what was the choice of machinery and so forth. With regard to the question of the load line – if we have load lines on vessels under

150 tons, we'll have another increase in bureaucracy to enforce it, and goodness knows, I think in Canada we're getting enough of that as it is without encouraging it. I still believe in trusting to the seamanship of the fishermen to a certain extent, but I don't want to design a vessel of which they will come back and tell me they can't fill the hold because they're going to put the deck under water. This is what I want to regulate, and it's where I'd give it nine, 12 or 15 inches of freeboard. This is something I would judge myself as a result of experience.''

Mr. Stevens: ''I was listening to Mr. Allan, and perhaps his antipathy for regulations stems from the fact that he is a naval architect. In any case we have the example of the auto industry and accidents, and it's only very recently that we've noticed a feeling that the auto industry itself should be regulated or do its own job, and apparently there will be a lot of money spent in looking after the safety features rather than the tail-fins, and recently we have the example of the building collapsing in Ottawa; one man was killed and there was quite an investigation to find out why that building collapsed. Now, there are a lot of regulations designed to prevent industrial accidents. I feel that I must express this opinion, that it is not a good answer to say that it's all a matter of seamanship. On the other hand, it could be said that good seamanship would involve the man himself knowing or ensuring that every possible safety feature was designed into his vessel, not only for when it's running loaded, but when it's running light. It may be necessary to regulate the builder, the owner and the architect in this respect. Do we have in this gathering, any representatives of government, or otherwise, who are in favour of regulations designed to prevent death at sea; in other words, who are in favour of increasing government regulations on stability, load lines, seamanship, and everything else?''

Session 4 May 6, 1966 – 2.00 p.m.

Trends in the Utilization of Herring

Moderator

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

The Nutritive Value of Herring Meal

by

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During the last war condensed fish solubles and good fish meals were the best available source of the then uncharacterized growth factor for poultry which was loosely termed "APF" – or animal protein factor– by nutritionists. With the discovery of vitamin B_{12} in 1948 and the almost simultaneous recognization of its important role in stimulating growth of young poultry, cheap industrial sources of the vitamin became available. This in turn threatened the favourable price situation previously maintained by fish meal and related fish by-products. It was at this juncture that the then Canned Salmon Operating Committee (now the Fisheries Association of B.C.) requested that the Vancouver Laboratory investigate the situation and report back to the Industry. This was done, and as a direct result a collaborative research program was initiated on a contract basis between the Fisheries Research Board and the Poultry Science Department of the University of British Columbia. This was in 1950, and the arrangement has continued for almost 15 years since the Industry has demanded new research in this area and we have ourselves initiated new programs as the need became apparent. It is my intention to discuss briefly some of the results that have been obtained during these years.

It was first realized that there was a lamentable lack of knowledge regarding the effect of commercial drying procedures on the nutritive value of herring meal for chicks, and extensive studies were carried out to determine the effect of heat. Herring meal was prepared by drying press cake in warm air (about 100°F) and grinding the dried cake to the consistency of normal meal. This was subjected to controlled heating in a rotating stainless steel drum at 300°F (149°C). The results obtained when chicks were fed the "ideal" meal, commercial flame dried meals and meals heated for 1, 2 or 3 hours at the above temperature were rather unexpected. Thus, when the meals were fed at a high level in chick rations only those heated 3 hours supported poor growth of young chicks when the ration contained a reasonable proportion of vitamins of the "B complex", including very heat sensitive folic acid. However, *in absence of added vitamins,* overheated commercial herring meal and meals heated at 149°C for 2 or 3 hours exhibited poor nutritive value. It was concluded from these studies that only *excessive* heating destroys the nutritional value of herring meal protein, and that normal commercial drying procedures are not harmful when vitamins of the "B complex", some of which are readily destroyed by mild heating, are added to the rations. Subsequent studies carried out in Great Britain verified these early findings. These results were of considerable commercial significance since they indicated that commercial drying procedures were not harmful if carried out without undue heating. In connection with this work other research showed that 3-hour heating seriously impaired availability to chicks of essential amino acids of the herring meal. This was interpreted as indicating that the digestability and availability of the protein were not significantly impaired unless the meal was subject to serious overheating.

The effect of the natural oil (lipid) of herring meal on nutritive value when herring meal was subjected to heat was then examined. As long as the rations were well-fortified with B-complex vitamins, the nutritive value of meals, heated in different ways before and after extracting most of the oil with hexane, was not significantly affected. Later, further studies were made on this general problem and will be described presently.

Considerable concern was evidenced by B.C. herring meal producers concerning lack of knowledge regarding the availability of data on the nutritive value of their products to the feed industry. As a result of a request for information on this subject, this reporter prepared a Circular in 1960 entitled "The Known Nutritional Properties of British Columbia and Related Herring Meals." This was merely a review. It pointed out that herring meal was outstanding among most other fish meals in that it appeared to be more stable and retained its nutritional properties better during processing and prolonged storage. Available evidence, which was summarized, indicated that where information was available, Pacific and Atlantic herring meals exhibited similar properties.

One point that should be emphasized is that whole meals definitely contain a slightly lower content of available essential amino acids than do press cake meals. However, so far as this reporter is aware, the differences are not great enough to be reflected in poorer chick growth when conventional biological assays are used. Presently the real value of herring meal is reflected in its high content of essential amino acids.

What is the present value of the vitamins in herring meal? Since the fat soluble vitamins (A and D) are largely destroyed during processing, only B complex vitamins remain of which thiamine (B_1) and folic acid are also destroyed by heating. The remaining B vitamins account for a value of somewhat less than $14 per ton of meal, assuming that the vitamin B_{12} is worth $9.30 and the choline $3.00. Available data indicate that Pacific and Atlantic herring contain similar amounts of these vitamins. The role of the lipid (oil) fraction will be described later.

Since vitamin B_{12} was discovered, extensive searches have been made by nutritionists to locate another such growth factor in natural products, so far without really positive results. There is no doubt that fish meals and related products cause slight growth stimulation in chicks that cannot be entirely accounted for by known nutritional factors. However, this is thought by many reputable nutritionists to be due to a favourable effect on the bacterial flora of the digestive tract, and is due to some uncertain secondary effect. Perhaps the term "uncharacterized growth effect" should supplant the term "uncharacterized growth factor" that is often used.

The above Circular indicated the deficiencies in our knowledge of the nutritional properties of B.C. herring meal. For this reason a collaborative study (Research Board, I.D.S. and Industry) was undertaken to determine the nutrient composition of B.C. whole herring meal. This led to publication of a Circular outlining in detail the nutritive value of six representative samples of herring meal taken at six different periods in 1960 and 1961. These samples were of whole meal containing condensed fish solubles since by this time reduction plants were adding solubles back to the press cake before drying.

The seasonal variations were in general rather minor (Nov.-Feb. samples) and the averages were 71.57% protein, 7.9% ether extractable lipid, 11.04% ash and 7.74% moisture. The essential amino acid composition was reported in detail, and the results indicated close agreement between samples, and the values were reasonably high. Available lysine averaged 7% of the protein and in vitro analyses indicated 92.4% digestability. Biological tests with chicks indicated an average supplementary protein value of 122 (with no statistically significant differences between samples) in comparison with a "reference protein". The mineral and vitamin contents were also reported, and the values were very consistent between samples. The results permitted the conclusion that B.C. herring meal was of excellent nutritive value and of reasonably constant composition. A survey of the available literature and certain comparisons carried out in connection with the above programs has shown that herring meals are almost invariably superior in nutritional properties to meals prepared from sardine, menhaden and anchovy. The reasons are almost certainly due to several factors including the greater stability of herring lipids, the fact that the fish meal plants are perhaps a little more careful in preventing overheating of the meal and do not follow "curing" practices.

Herring and other similar meals prepared from pelagic comparatively fatty fish are characterized by a rather high lipid content. In spite of the fact that this often accounts for some 8-10% of ether soluble lipid, and 10-14% of total lipid, no nutritional studies had been carried out on this fraction until a research program was initiated at the Vancouver Laboratory about 1960. It should be mentioned here that in general the ether extractable lipid fraction is largely composed of neutral tri-glyceride oils – "depot lipids". The remaining 3 or 4% of lipid extracted by such solvents as boiling ethyl alcohol or chloroform-methanol is largely phospholipid. This total lipid then accounts for a very significant fraction of the meal – say 200-250 lb per ton. A fairly thorough study of the nutritional properties of this lipid fraction was therefore carried out.

Herring meal freshly prepared, stored 7 months or antioxidant treated (0.11% BHT), were extracted with a 2:1 mixture of chloroform-methanol, a solvent that extracts most of the lipid. The solvent was removed in vacuo and the lipid fractions were fed to chicks at a level of 10% of their ration. The lipid fractions were dark and very viscous and were difficult to distribute in the rations. Rather similar experiments were carried out using other herring meals with and without antioxidant, some of which had been held at about 80°F for over 12 months. The outstanding results of these experiments can best be summarized as follows.

The lipid fraction from antioxidant-treated meals was more readily extracted and was more "fluid" than that from non-antioxidant treated meals, and was somewhat better utilized by chicks. The extracted lipid, when fed at a 10% level in the chick rations (equivalent to that in hypothetical rations containing 75% herring meal) caused absolutely no toxic reactions so long as the ration was well supplied with vitamins. All lipid fractions suppressed growth in absence of added vitamins. The lipid fraction was about 80% utilizable by chicks when compared with added fresh herring oil. This value dropped to 67% after storing meals for 11 months. When the antioxidant BHT was used, the extracted lipid was 91% utilizable in comparison with fresh herring oil, and this value decreased to 82% in 11 months. These results show that antioxidant treatment definitely protects the nutritive value of the lipid fraction.

As our knowledge of animal nutrition has increased, it has become recognized that poultry has a higher tolerance for lipids than was hitherto thought, provided that they are maintained on rations adequately supplied with vitamins and proteins containing desirable levels of essential amino acids. Thus fats are now used in poultry rations since they have high combustible energy, much of which is nutritionally available. However, not all this "combustible energy" (heat energy) is nutritionally available and it is customary to refer to that fraction of the caloric value of feedstuffs that is available to the animal for transformation to heat energy or tissue energy as "metabolizable energy". For determination of metabolizable energy of foodstuffs such as herring meal, specially-designed rations are used.

The results of a number of experiments showed that the metabolizable energy of the extracted lipid fraction of both freshly-prepared and stored herring meals was significantly higher when antioxidants were used (BHT and ethoxyquin were employed). Tests in which high levels of herring meals (25%) were fed in chick rations showed that the metabolizable energy of 5 commercial whole and press cake herring meals was considerably higher when antioxidants were used in the meals. Growth response experiments indicated that the protein quality of herring meals was protected by antioxidant treatment.

We now feel that the nutritive value of the lipid fraction in herring meals has been amply demonstrated, especially where antioxidants are used to protect the lipid. However, more work remains to be done and we have recently formulated a further series of experiments designed to improve nutritional quality of herring meals. The Industry on the West Coast is aware of the fact that bulk handling, which may save several dollars per ton in the bagging operation alone, is the coming method for handling this meal. The Vancouver Laboratory has conducted numerous trials on bulk handling in close collaboration with the Industry, and the method offers considerable promise. Some problems remain to be overcome, but herring meal by and large does not heat as badly as sardine, menhaden or anchovy meals so the heating problem is less acute. Presently the effect of prolonged (e.g. 7 months) storage of meals at temperatures between 90 and 120°F is being examined, since this condition might arise commercially in bulk handling under extreme conditions. It is considered mandatory that all bulk meals be antioxidant-treated, and ethoxyquin is undoubtedly the most effective and cheapest antioxidant presently available.

It is often asked whether vegetable or other proteins such as those made by yeasts when fortified with "synthetic" amino acids are likely to offer serious competition to fish meals. There is no clear cut answer to this question. Certainly there is a danger here, for *very cheap* essential amino acids, particularly lysine and methionine, when added to vegetable proteins could offer serious competition. So far the synthetic amino acids have been too expensive to compete with those in fish meals, and from the point of view of the fish reduction industry it is to be hoped that this situation remains static, at least until better outlets develop for herring. The preparation of a nutritional standard for Atlantic herring meal is recommended.

Effects of Various Reduction Processes on Quality of Herring Meal and Oil

by
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Edible Oils Section, Food Products Branch
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INTRODUCTION

A glance at the figures dealing with the utilization of marine oils in margarine and shortening in Canada, Table I, shows a steady consumption of about 44 million pounds for the past two years. However, in 1963 we used nearly twice this quantity, 87 million pounds, and 46% of all fats used in margarine were of marine origin.

To offer price changes in competing oils as the explanation for these fluctuations is too superficial. The Department of Industry, established more than 2 years ago to aid Canada's manufacturing industries, set itself the following two tasks:

(a) to study the causes influencing the demand and supply of marine oils, and

(b) to promote the expansion of the production of marine oils, if economically justified.

In the past virtually all domestic marine oil used for edible purposes in Canada, was B.C. herring oil. The size of the annual catch determined the volume

Table I

Use of Marine Oil in Margarine and Shortening

Year	Used in margarine (000 lbs.)	Per cent of total fats in margarine	Used in shortening (000 lbs.)	Per cent of total fats in shortening	Total marine oils in margarine and shortening (000 lbs.)
1960	12,386	9.1	7,526	4.5	19,912
1961	31,568	21.3	16,938	10.2	48,506
1962	48,292	32.2	21,553	11.9	69,845
1963	64,555	46.6	22,885	12.4	87,440
1964	29,734	21.0	13,486	7.0	43,220
1965	30,026	22.1	14,726	7.7	44,752

USE OF SOYBEAN OIL IN MARGARINE AND SHORTENING

1960	91,436	67.4	62,353	37.9
1961	65,287	44.1	42,248	27.9
1962	55,193	36.8	52,180	28.7
1963	46,933	33.9	55,324	29.9
1964	81,069	57.2	62,596	32.5
1965	67,196	49.4	59,685	31.2

TABLE II

World Fish Oil Production 1958-1965
(INCLUDING FISH LIVER OIL)[3]
(1,000 Tons)

Country	1958	1959	1960	1961	1962	1963	1964[1]	1965
Canada	30	28	14	26	27	32	29	29
United States	81	92	103	127	124	92	89	95
Chile	1	2	7	7	15	14	19	22
Peru	11	26	53	131	166	171	176	160
Dennark	19	22	20	19	27	31	38	45
Germany, West	27	34	32	30	32	27	25	23
Iceland	22	41	34	51	75	61	100	122
Norway	56	64	78	85	75	71	103	197
Portugal	6	6	7	9	8	9	10	10
United Kingdom	15	21	21	17	16	25	21	22
U.S.S.R.	13	19	23	26	30	33	35	44
Angola	10	5	8	4	4	4	8	7
Morocco	5	4	6	5	5	6	6	6
South Africa, Rep. of	15	18	32	47	40	32	25	23
South West Africa	12	19	17	20	26	21	54	39
Japan	41	53	39	46	56	35	31	41
Others[2]	20	23	20	20	18	20	20	42
WORLD TOTAL	384	475	511	669	743	682	789	927

[1] Preliminary; includes estimates for countries for which data are not available.

[2] Includes estimates for minor producing countries.

[3] Based on USDA and Oil World, Hamburg, data.

TABLE III

World Production of Marine Meals
(000 TONS)

	1959	1960	1961	1962	1963	1964
Meat Meals, Liver Meals and Soluble From Whales	94	101	105	97	101	86
Fish Meals from "White Fish"	480	528	570	650	570	690
Fish Meals and Solubles from Oily Fish	1,590	1,747	2,255	2,615	2,700	3,400
Miscellaneous Meat Meals and Solubles of Aquatic Animal Origin	14	12	13	14	11	12
Total	2,178	2,388	2,943	3,376	3,382	4,188
Canada, Total	–	45	79	78	85	76

Source: Fao, Yearbook of Fishery Statistics, vol 18, 1964 of oil and meal produced. However, in some years, the domestic consumption was heavily supplemented by imports of U.S. menhaden oil and Icelandic herring oil, Table VI.

Canada's Atlantic Provinces, Table IV, contributed very little oil to this market. Whatever did come, turned out to be of rather low quality. Most of the Atlantic marine oils consisted of liver and offal oils. They were mainly sold as feed supplements and for industrial uses.

It is rather astonishing that until recently no serious attempt has been undertaken to exploit the herring potential of Canada's Atlantic coast. Since 1963 herring oil production in the Maritimes increased five-fold from 1.4 million pounds to 7.1 million pounds. Compared with the annual output of 40-50 million pounds on the West Coast, this development still appears modest, but all forecasts indicate that the day is close, when it can be stated that most Canadian herring oil is produced on the Atlantic coast.

A similar development has taken place in the fish meal area, Table V. White fish meal, produced from offal, was the standard Maritime product. The herring meal largely stemmed from the sardine industry. Again, since 1963 the herring meal output has doubled in Eastern Canada from 6,200 tons to 12,800 tons.

Being closer to the Ontario and Quebec markets, this new industry is in a good situation to compete with British Columbia. Similarly its location is favorable for the traditional Canadian markets in Britain, Tables VIII and IX.

As proven by this Conference, the stage is set for a significant new Canadian industrial development. The expanding Canadian and world markets are ready to buy the products, Tables II and III.

In order to succeed, the new herring reduction industry must not only be aware of the existence of modern reduction technology, but must utilize it to the fullest possible extent. This industry should no longer be regarded as a by-product operation, but as the most efficient way of meeting the nutritional needs of men and animals.

TABLE IV

Canadian Production of Marine Oils by Type and Area
(THOUSAND POUNDS)

	1962	1963	1964	1965
Atlantic Coast				
Groundfish				
Body and Offal ..	890	1,366	1,437	1,970
Liver	6,500	7,360	5,810	4,560
Herring...........	1,545	1,400	4,730	7,140
Seal	1,740	1,534	1,270	2,350
Other[1]............	53	94	605	1,015
Atlantic Total	10,728	11,754	13,852	17,035
Pacific Coast				
Herring............	40,750	52,800	44,500	41,750
National Total.......	*51,478*	*64,554*	*58,352*	*58,785*

[1] Includes "Other Fish Liver Oils" starting in 1964.

TABLE V

Canadian Production of Fish Meals by Type and Area
(SHORT TONS)

	1961	1962	1963	1964	1965
Atlantic Coast					
Groundfish.......	(1)	33,392	28,371	25,342	42,794
Herring..........	(1)	4,375	4,667	6,247	12,783
Other...........	(1)	–	611	636	930
Atlantic Total....	38,838	37,767	33,649	32,225	56,507
Pacific Coast					
Herring	39,794	40,478	51,818	44,040	40,129
National Total ...	78,632	78,245	85,467	76,265	96,636

Source: Based on DBS No. 24-002

[1] No Breakdown Available. At a Later Date (DBS No. 24-201 for 1962), DBS Revised the Atlantic Coast Total For 1961 to 33,599 Tons.

TABLE VI

Canadian Imports of Marine Oils by Types
(THOUSAND POUNDS)

	1961	1962	1963	1964	1965
Fish Liver & Visceral Oil	–	–	–	105	261
Fish & Marine Animal Oil	31,387	42,124	24,165	980[1]	7,911
Whale & Spermaceti....	1,139	887	648	–	–
Cod Liver Oil	917	893	1,039	–	–
Total	33,443	43,904	35,852	1,085	8,172

Source: DBS No. 65-007

[1] Includes Whale Oil, Previously Included in Class 2297; Change in Classification.

TABLE VII

Canadian Imports of Fish Meal
(SHORT TONS)

Country of Origin	1961	1962	1963	1964	1965
Peru	5,521	–	2,666	–	–
United States of America	897	151	66	90	71
Rep. S. Africa	–	–	250	4,800	–
Total	6,418	151	2,982	4,890	71

Source: DBS No. 65-007

TABLE VIII

Canadian Exports of Marine Oils by Types
('000 LBS.)

	1961	1962	1963	1964	1965
Herring Oil	959	88	947	23,291	7,578
Cod Liver Oil, Sun Rotted	7,004	5,885	10,047	6,965	5,112
Fish and Marine Animal Oil, N.E.S.	524	146	1,302	1,113	2,477
Whale Oil	129	1,260	4,918	3,161	4,526
Fish Liver & Visceral Oils	12	34	12	162	(1)
Total	8,628	7,713	17,226	34,692	19,693

Source: Based on DBS No. 65-004

[1] Fish Liver and Visceral Oil Not Listed Any More in 1965.

TABLE IX

Canadian Exports of Fish Meal and Condensed Solubles
(SHORT TONS)

	1961	1962	1963	1964	1965
Herring Meal and Pilchard Meal	32,111	36,680	45,149	50,497	40,112
Fish Meal, N.E.S.	7,864	10,699	10,404	11,991	18,832
Fish Cond. Homogenized Solubles	1,296	1,658	2,237	1,871	1,838
Total (Meal Only)	39,975	47,379	55,553	62,488	58,944

Source: Based on DBS No. 65-004

You will be aware that much progress has been made in the understanding of feedstuffs and their utilization. The conversion ratio for chicken has been reduced in tests to below two. No doubt, the quality requirements for fish meal will become more rigorous. The same applies to herring oil. The reduction technology will have to be geared to the market of tomorrow.

The Department of Industry is fully prepared to help industry to meet this challenge. We try to help by improving the channels of communication and cooperation between all the parties interested in this development. In addition, the Department plans to commission a consultant study to establish what type of equipment is best suited to process the variety of fish supply at the lowest possible cost into meals and oils of the highest possible quality.

SURVEY OF CANADIAN FISH REDUCTION CAPACITY

A little more than one year ago, a survey of the Canadian fish reduction industry was still fairly simple. Ten large plants on the West Coast produced the bulk of Canada's herring oil and meal, Table XII. Approximately 49 plants in the Maritime Provinces served the fish processors for the purpose of by-product disposal. Only a few of them produced herring oil or meal. The refiners of edible oil showed not too much confidence in the quality of East Coast herring oil. Refining losses were about 2% higher than for the competing B.C. herring oil, and prices correspondingly lower.

Herring meal from the East Coast was also of uneven quality and not in continuous supply. Feed manufacturers can formulate their rations only when being assured of a continued supply and of a uniform quality.

All the British Columbia plants had daily capacities in excess of 300 tons of herring. Their oils and meals had developed fairly adequate standards, which have enjoyed the confidence of the refiners and feed manufacturers for many years. The West Coast plants are old. Many look back to 40 years of service, and some of this often in the now defunct California sardine industry.

East Coast fish meal plants produced primarily a white fish meal, low in oil and protein content, compared with herring meal. Oil content often ranges down to 2%, and usually did not reach the 8–10% found in herring meal. Edible oil production was restricted to a few plants, such as sardine canners, and in small volume. The protein content of the offal meal ranged from about 58–66% compared with 72–75% for herring meal.

TABLE X

Canadian Supply and Disposition of Marine Oils
(MILLION POUNDS)

	1961	1962	1963	1964	1965
Production	53	51	65	58	59
Imports	33	44	36	1	8
Exports	9	8	17	35	20
Apparent Domestic Disappearance	78	88	83	25	47

Source: Based on DBS Data.

TABLE XI

Canadian Supply and Disposition of Fish Meal
(SHORT TONS)

	1961	1962	1963	1964	1965
Production	78,632	78,245	85,467	76,565	96,636
Imports	6,418	151	2,982	4,890	71
Exports	39,975	47,379	55,553	62,488	58,944
Apparent Domestic Disappearance	44,075	31,017	32,896	18,967	37,763

Source: Based on DBS Data.

TABLE XII

Fish Reduction Plants in Canada

	Pacific Coast	Atlantic Coast	Total
1) Number of Plants	10	52	62
2) Capacity Range, Tons of Raw Fish:			
Per Hour	13-47	1-25	–
Per Day	310-1,100	18-600	–
3) Total Raw Material Capacity:			
Tons Per Day	7,000	5,435	12,435
4) Number of Plants Producing Edible Oil	10	approx. 8	–
5) Number of Plants With Oil Producing Capacity	10	approx. 26	–
6) Number of Plants with Stickwater Recovery	6	approx. 13	–
7) Number of Plants with Flame Dryers	10	approx. 20	–
8) Number of Plants with Steam Dryers	–	approx. 12	–
9) New Plants Planned or Under Construction	–	approx. 8	–
Estimated Total Raw Material Capacity of These Plants, Tons/Day	–	3,700	–

The rising demand and prices for fish meal, as well as the realization that the herring resources of the North-West Atlantic waited to be exploited, have combined to transform the pattern of the industry on the Atlantic Coast. The total daily capacity has risen by more than 2,000 tons within less than 2 years. Some new plants are at present under construction. Others are in the planning stage. All large plants, i.e. from 250 tons per day up, intend to concentrate on herring reduction. The estimate is, that of the 52 plants at present operating in the Maritime Provinces only about 8 produce edible oil, i.e. primarily herring oil. Seal oil producers have not been included.

Many of the old plants and most of the small new plants have equipment for oil separation. Their production volume, however, is too small to meet the requirements of the edible oil industry, and their oil is shipped in drums for industrial utilization.

The simplicity of the steps of the reduction process seems to have misled many companies to neglect the study of the effects of the multitude of differences in the properties of the raw material on the methods required to produce a good oil and meal.

The Norwegian industry actually maintains a research institute, complete with a pilot plant, to study all the variables of fish reduction.

Briefly, herring reduction involves the following steps:

(1) cooking the fish,

(2) pressing the liquids out of the cooked fish,

(3) drying the press cake,

(4) separating press liquor into oil and stickwater,

(5) concentration of stickwater by evaporation.

Each step is beset with problems. Cooking conditions are vitally important in influencing the property of the final meal as well as the effectiveness of the pressing step. Partial decomposition of the fish due to lengthy or improper storage prior to processing will lead not only to processing difficulties, but will also lower oil and meal quality.

Equipment manufacturers have come out with many designs to meet all these variations, including cost considerations. The final decision rests with the reduction plant management. They must know what equipment is best suited to perform all the required tasks. Thus, it is not sufficient just to buy a press. The consistency of the cooked fish must be known, and it must be known what can be done to control this consistency. For example, this step will greatly affect the oil yield. Further, whether the press cake contains 50 or 60% moisture will have a bearing on the drying operation and its costs.

When stickwater is evaporated, the capacity must be sufficient to meet all the demands. Obviously, a direct steam cooker will add a great deal more stickwater for evaporation than an indirect cooker having an outer steam jacket. Some operators find it difficult to cook a fish without addition of water, but return some stickwater instead of adding steam. And when direct steam is used, the purity of the steam bears watching.

While all Western plants use exclusively various designs of flame dryers, in the East we are witnessing a trend to use more steam dryers, especially in the smaller and medium sized plants.

Suffice it to stress the real intricacies involved in the reduction process. The present high margins between raw material costs and product prices may become again much narrower. A careful choice of equipment is essential for efficient and economical operation.

Many new plants are under construction or are being planned. Old plants are being replaced by new equipment. Especially the smaller plants are generally of high quality and sophistication, and it is hoped that the large plants will meet this challenge.

ASPECTS OF OIL QUALITY

The larger East Coast plants are increasing the supply of herring oil to the refining industry. Without going into the details of various reduction processes, one significant technical change should be mentioned. The trend among some of the new East Coast plants is to pass the press liquor straight through a centrifuge to separate oil and stickwater. The oil may even be passed through a second polishing centrifuge to remove practically all remaining moisture. This procedure should contribute to a higher oil quality. In fact, it seems that the free fatty acid content of a well-processed herring oil, which often dips to 0.5%, may partly be traced to this procedure.

In contrast, all West Coast herring plants pump the press liquor first into a series of usually four settling tanks. The oil and stickwater "break" and the oily top layer flows by gravity from one tank to the next one. This process is aided by steam coils in these tanks, which heat the press liquor. When the two phases tend to emulsify and are difficult to "break", direct steam is used to promote the separation. Obviously this procedure, carried out in open iron tanks, facilitates the oxidative breakdown of the highly unsaturated acids, which are so characteristic for marine oils. These oxidative changes are irreversible. While it is possible to bleach such an oil to an acceptable color standard, it is, however, reasonable to assume that non-volatile precursors are formed, which are partly responsible for poor flavor stability in the final products, such as shortening and margarine.

Another word on oil quality in this connection. Apart from oxidative changes, hydrolysis is likely to be promoted. In the West Coast plants, this oil is obtained by gravity separation, in settling tanks, is not centrifuged, but considered to fully meet the specifications as shown in Table XIII outlining the experience of an Eastern refiner. True, this oil has met so far with fair acceptance, but it is considered inferior to vegetable oils. If better production methods can keep the free fatty acid content consistently between 0.5 and 1.0%, the refiners will notice the difference. Instead of a generally accepted standard of 2% FFA, new standards may be developed which may lead to a premium for a better oil.

TABLE XIII

Quality of British Columbia Herring Oil 1965[1]

	Average	Range
FFA, %	1.31	0.45 – 1.95
Bleached Color, Lovibond Red (5¼" Column)	2.0	1.2 – 3.5
Moisture, %	0.30	0.06 – 0.80
Impurities, %	0.02	0.01 – 0.06
Refining Loss	approx. 3%	

[1] Data Supplied by Eastern Canadian Edible Oil Refiner.

A practice, which is understandable, but rather disturbing for the refiner, is the mixing of oils of high FFA with those of low FFA in order to remain below the 2% limit. In practice, this results in an oil regarded as inferior by the refiner. Despite the lower free fatty acid content, he finds that his final product suffers in flavor stability or shelf life. Consequently he will tend to include less herring oil into his formulation.

Another area of concern to the refining industry is the occasional difficulty encountered in the hydrogenation of herring oil. This phenomenon may at least partly be related to the same causes leading to high free fatty acid contents. Just as the time that elapses between the catching of the herring and its reduction, as well as the temperature at which it is kept, are crucial to the smooth functioning of the reduction process, this period also vitally determines the properties of both oil and meal. Sulfur compounds, phosphatides, etc. have been blamed for the trouble. It is an area requiring investigation also by the herring producer. However, if the refiner finds that the oil hydrogenates unevenly, or if he is required to hydrogenate to a higher solids content, he is compelled to blend more vegetable oil with the marine oil in order to meet the specifications of his final product.

In summary it can be said that many refiners judge most of the properties of a herring oil by just one criterion: free fatty acid content. If it is low, i.e. below 1%, the oil is assumed to possess good stability. In fact, many refiners believe that herring oil can be improved sufficiently to be fully interchangeable with vegetable oils, and that they would be able to make a shortening of good quality from 100% herring oil.

As far as margarine is concerned, it is rare that a manufacturer is prepared to use more than 70% herring oil in his formulation. Even at that level there seems to be a sacrifice in quality. It is often observed that some herring oils show iodine values around 110, even down to 105. If it should become possible to produce this type of oil in good quantity and of good quality, theoretical considerations indicate, that it would be well suited to be hydrogenated into a good margarine oil.

YIELDS OF OIL AND MEAL

Dr. Idler and co-workers (McBride, MacLeod, Idler, Fisheries Research Board, Canada, 16 (5) 1959) showed that the 5:1 ratio of raw fish to fish meal does not hold too well. Protein content of herring fluctuates with the sexual maturity of the fish, just as the oil content.

Figures for oil and meal yield of Atlantic herring are as yet very sketchy, except that a lower oil recovery is indicated. This may prove to be wrong.

Tables XIV and XV report the experience gained in British Columbia. Looking merely at annual averages, meal yields varied from 17.7 to 18.2%, a very narrow range. It should be remembered that these results are all based on flame drying operations. A 2% increase in yield resulting from steam drying (and the simpler and cheaper deodorization) might be brought up as a strong argument against flame drying.

TABLE XIV

British Columbia Herring Production and Processing Results (CUMULATIVE TOTALS FOR END OF FISHING SEASON)

	1966	1965	1964	1963	1962
Total Catch, Tons	180,365	240,580	262,045	265,647	224,161
Production					
Bait, Tons	848	893	1,128	886	575
Meal, Tons	32,163	43,062	46,778	48,035	39,535
Oils, ('000 LBS.)	35,600	50,300	45,100	44,100	43,250
Average Yields					
% Meal	17.9	18.0	17.9	18.2	17.7
% Oil	9.9	10.5	8.7	8.3	9.7

Based on Department of Fisheries Data.

TABLE XV

Meal and Oil Yields of a British Columbia Herring Reduction Plant (PER TON OF WHOLE HERRING)

1965/66	Meal		Oil	
	LBS.	%	LBS.	%
2/6	320	16.0	203	10.2
12/7	382	19.1	268	13.4
4/8	380	19.0	272	13.6
17/8	372	18.6	284	14.2
31/10	322	16.1	207	10.4
14/12	373	18.7	207	10.4
31/12	392	19.6	215	10.8
28/1	425	21.3	161	8.1
1/2	430	21.5	161	8.1
15/2	417	20.9	154	7.7
1/3	429[1]	21.5	122	6.1
15/3	429[1]	21.5	70	3.5

[1] At End of Season Some Stickwater Was Discarded, Due to Lack of Evaporation Capacity.

Average oil yields in the same period varied from 8.3 – 10.5%. This is a good return, especially in view of frequent interference through strikes during the peak period. A slight suspicion may be cast on these values. Most producers record their yields in U.S. gallons and the Department of Fisheries as well as D.B.S. report in Imperial gallons. If a conversion is omitted somewhere during the reporting chain, the yields may turn out higher than they actually are.

It is the experience of all companies, that during the summer season, July to August, oil yields are very high (Table XV) rising to 14-15%. Meal yields, reflecting the lower protein content of herring, can dip as low as 300 lbs. per ton of fish during the summer. In winter the meal yield rises. Table XV shows a peak of 21.5% and this would have been higher had the stickwater evaporator not been of insufficient capacity to cope with the increased water as the oil content was dropping. The yield might have been 23%.

ASPECTS OF HERRING MEAL QUALITY

Professor March of the University of British Columbia recently stated that today's herring meals are of such high quality that very sensitive methods of analysis must be applied to differentiate them on the basis of nutritional value. Many methods are being tested to properly assess the biological value of the protein for various types of livestock. Mrs. March claimed a good correlation to exist between the pepsin digestibility and biological assay.

Many feed manufacturers, too, test fish meals for available protein, but a standard specification has apparently not yet been developed. The meal still continues to be sold on a protein content (N x 6.25) basis. However, most nutritionists contend that the day is not far off, when fish meals will be judged on protein content plus protein value.

In the meantime, we can expect a continuation of the debate on the relative merits of steam and flame drying, and their effect on the nutritional value of herring meal. Many Canadian and other nutritionists deny that there is any difference between a carefully flame-dried and a steam-dried meal. As long as the outlet temperature of the flame dryer remains below 212°F a high quality meal is said to be the result. Many manufacturers will agree that the actual temperature is usually above this maximum.

When discussing yields, operators of flame dryers tend to attribute losses to burning of fine meal particles. Estimates for this type of loss, together with the disappearance of fines, range from 3-10%, although good evidence is difficult to locate. The hot gases are assumed to scorch just the surface of meal and remove burned particles.

Since especially in large-scale reduction plants flame drying is more economical than steam drying, there is a great inducement to favor this process. However, I rather expect that with the development of more rigorous specifications, especially for poultry feeding, steam-dried meal will become more desirable.

A glance at Table XVI will indicate the high level of nutritionally valuable amino acids which must be preserved to be available; otherwise, competing protein supplements will replace fish meals. Synthetic amino acids are beginning to be offered at competitive prices and can improve the value of oilseed meals sufficiently to persuade a feed manufacturer to drop fish meal from a ration.

In the past considerable excitement has been created by the presence of so-called unknown growth factors in fish meals. The trend is to discount their presence, although at times nutritionists are at a loss to explain beneficial effects of fish meals.

TABLE XVI

Content of Selected Amino Acids in Herring Meal and High Protein Feed Supplements

(VALUES GIVEN AS % OF CRUDE PROTEIN (N x 6.25))

% Protein	Lysine	Methionin	Cystine	Histidine	Tryptophan
Herring[1]	8.3	2.6	1.4	1.9	0.8
Presscake	9.1	2.7	1.6	2.0	0.8
Stickwater	4.6	1.3	0.4	1.2	0.2
Meal Without Stickwater Recovery....	9.1	2.7	1.6	2.1	0.8
Whole Meal....	8.2	2.5	1.3	1.8	0.7
Soybean Meal..	6.6	1.4	1.7	3.7	1.3
Rapeseed Meal	5.6	1.5	1.3	2.5	1.4

[1] Norwegian Winter Herring, G. Boge, J.SCI. Food Agric., 11, 362 (1960)

When comparing production of white fish and herring meals in Canada with the export of these commodities (Tables V and IX) the evidence supports the claim that Canadian feed manufacturers prefer to use white fish meal to an oily meal. Freight rate advantages must also have affected this attitude.

This attitude can probably be explained by a short review of the improvement achieved in the quality of herring meal.

Herring meal of a high oil content – say 8-11% – used to come off the dryer in a rather hot condition. To avoid ignition, the meal was matured. This process represented a slow oxidative polymerization of the fats present in the meal. Not only did the fat become largely unavailable to the animal, but reactions occurred between breakdown products of the fat and protein, lowering further the digestibility and value of the meal.

Steam drying, of course, partly overcomes the problem of a hot meal and generally has a milder effect on the fat.

Furthermore, methods were developed to rapidly cool the meal. It was found that the addition of an antioxidant, BHT, effectively curtailed the heating of the meal. In all West Coast plants herring meal is today packed in multi-ply paper bags with a polythene lining. These bags are fairly airtight and prevent oxidation of the fat, and thus heating of the meal. Antioxidants are generally only added to bulk shipments of herring meal.

In other words, it has become possible to produce a herring meal which is considered wholesome, fresh and fairly stable upon storage by feed manufacturers. They are, in fact, going a step further. The oil content of the meal has become a desirable characteristic, which the feed manufacturer finds included in the price paid for the protein content.

Computer formulation of feeds will particularly assess the following characteristics of herring meal before deciding whether or not to include it into a ration:

Protein content,
Fat content,
Phosphorus content,
Calcium content.

Herring meal may contain 3-6% calcium, and 1.5-3.5% phosphorus, both elements of great value in poultry rations. Naturally, the feed manufacturers demand that a meal be free of salmonella contamination, but they no longer regard the vitamin content as very important, since synthetic products have simplified matters.

Attention must be drawn, however, to the desirability of producing whole herring meals. Not only will the meal yield be raised by 20-30%, which offers an economic advantage beyond the cost of stickwater concentration, but the minerals and minor elements would otherwise be largely lost too.

It is interesting to note that the protein content of the stickwater solids, however, is somewhat lower than that of the herring cake, and will slightly reduce the protein content of the whole meal. On the other hand, in the case of stickwater from an offal process, the protein content is somewhat higher and, therefore, may slightly raise the protein level of whole offal meal.

In both cases, the nature of the protein and of the other nitrogen compounds of the stickwater is nutritionally inferior to the muscle protein, because these soluble substances are derived partly from collagen, whose composition lacks a number of the essential amino acids.

A matter of importance to the developing Atlantic herring meal industry will be the need to guarantee a continuous supply and a uniform quality. Up to now the inability to meet these essential requirements has caused feed manufacturers to hesitate to buy East Coast herring meal despite freight advantages.

Many herring meal as well as feed manufacturers have welcomed the proposal of the Plant Products Division of the Canada Department of Agriculture, to drop the definition of "Oily Fish Meal", and instead require meal manufacturers to declare the minimum and maximum fat content of their product. This decision represents not only a compromise between the demands of the producers of the different meals, but may lead to a better appreciation of the value of the fat content of a meal. Let us hope that this compromise has positive aspects.

ECONOMIC ASPECTS OF HERRING REDUCTION

Wide fluctuations, particularly in the world market price of herring meal, but also in the price of herring oil, have in the past greatly influenced the stability of the oily fish reduction industry. International agreements among associations of fish meal manufacturers have since then helped to avoid these extreme price declines, and the price of fish meal is now ranging at economically attractive levels.

It is not yet clear to what extent the experience gained in British Columbia is applicable to the Atlantic Coast. For example, the average oil yield of 9 – 10% in B.C. may be lower on the East Coast, perhaps as low as 6%. In order to establish a firm competitive position, it seems wise to instal equipment which will give the best possible meal yields. An average yield of 20% should be attainable, and these may rise to 21 – 22%. Losses, especially those indicated to occur upon flame drying, will have to be avoided. In other words, a high-quality reduction operation will offer distinct economic advantages.

ECONOMIC ASPECTS OF OFFAL REDUCTION

The average Atlantic fish meal plant was established to solve the offal disposal problem for a filleting or canning enterprise. To move offal out to the sea, far enough away to prevent local pollution, presented a considerable expense without any return. A fish meal plant, designed to process a relatively steady flow of waste material, was the answer. Often, smaller fish plants in the neighbourhood sell their offal and contribute to the efficiency of such a reduction operation.

The choice of equipment was – at least in the past – influenced by the price as much as by the nature of the raw material. Stickwater recovery had either not yet been developed or usually did not form part of the process. Since the bulk of all fish was low in oil content, oil recovery played a rather insignificant role. It is fair to state that the aim was to dispose of a by-product of low economic value with the least effort and the least expense. Even today, many companies do not attach a definite price tag to their offal. It is regarded as worth anywhere from no value to $12.00 per ton. The advent of modern reduction technology and the demands of the modern feed industry are forcing fish processors to adopt a completely new approach. While relatively few innovations have been introduced into the Pacific herring industry, a number of small and medium-sized fish meal plants of up-to-date design have been installed on the Atlantic coast during the past few years. Having steam dryers, these plants can produce a meal of high quality. They can handle oily fish and can often produce an oil of good grade. Their size will not permit the processing of large volumes of whole herring at the peak of the season. However, they can profitably supplement their offal operation with herring reduction, provided they produce oil in large enough quantities to be of value to the edible oil refiners.

Many of the present offal plants may produce from 1,000 to 2,500 tons of white fish meal a year, but only approximately 200,000 lbs. of oil. Under these conditions, it is impossible to produce an oil of either uniform or of the high quality required by the edible oil industry. Moreover, this oil has over the years found a ready market in such industrial applications as leather treatment, sulfonation, paints, etc. It commands a price of about 8¢ per pound at the present time.

The following estimate indicates the economics of modern offal reduction plants based primarily on white fish waste.

Cost

Cost of raw material per ton:	$10.00
Cost of reduction per ton:	$12.00
Total cost	$22.00

Revenue

Meal yield: 19%, 65% protein, at $2.50 per protein unit, i.e. approx. $160. per ton of meal:	$30.40
Gross profit per ton waste:	$ 8.40

An annual output of 2,000 tons of meal could be obtained from approximately 10,500 tons of offal. This represents the waste material from the filleting of about 30 million pounds of fish. If the meal plant has a capacity of 100 tons of raw material per day, this represents 105 days of operation. Most offal plants have a capacity between 50 and 100 tons, and operate often for 100-200 days per year in terms of their total capacity. The approximate profit of this type of plant would amount to between $80,000 – $90,000 per year, plus the return on any oil produced, which could be in excess of $10,000.

The problem of the co-existence of an offal and a herring reduction industry on the Atlantic coast may be described as follows:

(a) The offal plants enjoy a captive raw material supply in relatively small volume for a long period of the year. They can supplement their revenue by a modest herring reduction operation. Many such existing companies are at present cautiously expanding their plants or are building new ones with various modifications of this idea in mind. Some people with experience in herring reduction have criticized this approach as impractical and uneconomical. The future will show whether a carefully designed plant of this nature can survive.

(b) Herring reduction plants are built for handling large volumes of fish for short periods of time. No plant on the West Coast, and none of those now being built on the East Coast has a capacity of less than 300 tons of raw material per day. In fact, the tendency is towards 500-1,000 tons per day plants. Obviously such plants can handle offal only as a sideline. The average operating period in terms of total capacity has been between 30 and 40 days per year, i.e. around 10% of their capacity on the West Coast. Indications are that on the East Coast, this period may be extended to 75 or more days. The result would be a more efficient plant utilization and the opportunity to invest in superior equipment in order to be able to produce a higher quality oil and meal.

Both types of operations: herring and offal, should each have a fairly independent place in the expanding fish reduction industry along the Atlantic coast.

Use of Herring for Fish Protein Concentrate and Low Fat Meal

by

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INTRODUCTION

Herring meal is sold primarily on a protein unit basis. When it is processed by conventional procedures, 30-40% of the fat remains in the meal. Thus, when fatty herring are employed a low protein meal is obtained, or, looking at it another way, oil is being given away. Meals with a high fat content are also undesirable for use in many feed rations. Finally, better markets would probably open up for oil if it were available in quantity and on a continuous basis.

The presence of oil in fish meal will increase the metabolizable energy available in the meal provided the diet is adequately fortified with vitamins and provided the proportion of protein and of essential amino acids to protein was controlled. However, oxidative changes in the fat fraction are well recognized as conducive to a decline in nutritive value during prolonged storage. As other speakers have mentioned, antioxidants can be added to the meal to retard this rancidity, and another possibility would be the removal of the fat by solvent extraction. Although adding to the cost of the meal, the advantages of this process may justify the higher price. When used as an animal feed, a defatted herring meal could be incorporated in the diet much closer to slaughtering time without imparting off-flavours to bacon or meat. For human consumption a high protein, essentially tasteless and odourless meal would be valuable as a protein supplement to the diet.

For the above and other reasons it is important to know the oil content of herring and to develop processes for reducing oil in meal (i.e. fish protein concentrate).

PROCESSES AND CHARACTERISTICS OF PRODUCTS

Several methods are available for producing low fat, high protein meals from herring. The Food and Agriculture Organization of the United Nations (F.A.O.) is very interested in these developments with a view to supplying protein to the millions of undernourished people in underdeveloped countries. Specifications for fish meal for human consumption, established by F.A.O., are shown in Table 1.

Table 1

F.A.O. Specifications for Fish Protein for Human Consumption

	Type A	Type B	Type C
Protein (N x 6.25) at 10% moisture	min. 67.5%	min. 65%	min. 60%
Available lysine	min. 6.5% of protein	min. 6.5% of protein	min. 6.5% of protein
Moisture	10% max.	10% max.	10% max.
Fat content	0.75% max.	3% max.	10% max.

Type A fish protein concentrate should have no more than a faint taste and odour, while Types B and C will show a wide range of taste and odour.

The process developed by the Halifax Laboratory of the Fisheries Research Board of Canada and recently adapted by the United States Department of the Interior, Bureau of Commercial Fisheries, was designed to produce the highest possible quality of Type A fish protein concentrate. Studies on extraction of fat and water soluble materials from cod muscle had shown that a mixture of 70% isopropyl alcohol and 30% water gave the maximum extraction of these materials with a minimum loss of protein. This process was modified for use with raw herring as follows: The fish is ground and treated with polyphosphoric acid to partially hydrolyze the connective tissue and neutralize odours. The material is then extracted once with hot 70:30 isopropanol:water mixture followed by two extractions with hot 99% isopropanol. This procedure reduces the final fat content to a satisfactory level.

In Table 2, the proximate composition of fish protein concentrate made from whole herring is compared to F.P.C. from cod fillets. Both products greatly exceed the F.A.O. specifications for Type A edible meal with respect to protein and fat content. In fact, the Type A edible meal has an extremely high fat and low protein content.

The Protein Efficiency Ratio, determined by feeding protein to rats, for F.P.C. produced from herring is 2.74 as compared to 2.97 for F.P.C. from cod fillets. On the same scale casein, the protein in milk, has a P.E.R. of only 2.50.

The lysine content of F.P.C. from whole female herring at spawning time is lower than from male fish, Table 3.

Instead of starting with whole herring, the presscake can also be used as a raw material for F.P.C. and existing plant facilities for the recovery of oil and solubles could be utilized. However, the protein content of the resultant F.P.C. is considerably lower than if prepared from whole herring due to the loss of water soluble proteins.

A second method for producing a low fat meal from herring would be by solvent extraction of the dried meal. Many fat-solvents have been suggested for this process. When meal is overheated in flame dryers, oil will polymerize and is difficult to extract. The odours and flavours would have to be removed in a separate step with a water soluble solvent, such as isopropanol.

Other possible processes include azeotropic distillation of the ground herring or the presscake; by this method the water is distilled off with a suitable solvent and the oil recovered from the solvent.

The final criteria for judging all these methods would have to include the costs of processing and the price of the meal. Commercial or large scale pilot plants for producing low-fat meals for animal feed or human consumption are presently in operation in Morocco, Chile and New England (New Bedford). The

TABLE 2

F.P.C. from Whole Herring and Cod Fillets

Raw Material	% Protein (dry basis)	Moisture (%)	Ash (%)	Fiber (%)	Fat (%) ether extract	Fat (%) Chloroform-methanol extract
Cod fillets................	92.9	4.64	1.89	0.50	0.02	0.033
Whole herring	89.7	8.24	7.13	0.94	0.09	0.18

TABLE 3

Lysine Content of F.P.C. Prepared from Herring and Cod

Raw Material	Lysine (%)	Lysine (% of protein)	Available Lysine	Available Lysine (% of proteins)
Herring..........................	11.6	14.1	5.82	7.07
Male herring prior to spawning.......	11.2	15.03	6.28	8.43
Female herring prior to spawning.....	9.63	11.3	5.13	6.14
Cod fillets.......................	12.6	14.2	8.49	9.58

Morocco plant produces partially defatted and deodorized flour made from trimmed and gutted sardines. The New Bedford plant, operated by Viobin Corporation, uses an azeotropic distillation method with ethylene dichloride as the solvent. As far as we know, only a limited amount of the output of these plants is used as a dietary supplement in human nutrition with the balance of the production incorporated into animal feed rations.

It is planned to undertake a cost analysis of the isopropanol process at Halifax next year.

OIL CONTENT OF HERRING

Southern Gulf Area

The majority of herring in this area spawn in May and June and the fat content is low and variable. For example, near Shediac the herring averaged only *ca* 7–8% fat (A.H. Leim. Report of the Atlantic Herring Investigation Committee. F.R.B. Bulletin No. 111. 1957). During July and August herring taken at Caraquet and North Rustico were much fatter (10–15%) with an average of 12–13%. By September the fat content had dropped to *ca* 8–10% at Caraquet, North Rustico and Cheticamp.

Northwestern Gulf of St. Lawrence

Most of the fish were collected from L'Ile Verte to Bonaventure, P.Q. Sampling was mostly carried out during May and June when the fish were spawning.

The fat content, *ca* average 8% (5–10%) is comparable to that found for the Southern Gulf area. From August to October the fat content increased to an average of *ca* 13%.

Outer Coast of Nova Scotia

Sampling was done at St. Ann's Bay, Madame Island, Halifax, Lunenburg, Lockeport, N.S., and from Sable Island Bank. May samples from St. Ann's Bay averaged only 5% fat. From July through August herring from the other areas generally ranged from 11–15% and averaged 12–13%.

West and South Coast of Newfoundland

The fat content of herring taken in February and March average 10–11% fat over a 4-year period in Bay of Islands. This was almost identical to the fat content of Fortune Bay herring in March, 1948. Herring from Port au Port Bay averaged nearly 46% in November, 1948.

Bay of Fundy

Quite a thorough study, conducted over 10 years, was made of the fat content of the "sardine" herring from the Quoddy region of the Bay of Fundy (see Table 4) (A.H. Leim. J. Fish. Res. Bd. Canada *15*, 1259. 1958). The average fat (2.4–8.2%) was low for the small fish (less than 14 cm) except during the fall of 1945 when it reached 11–14%. Fish over 14 cm frequently exceeded 10% fat in the fall, but in the fall of 1949 the fat content of all fish averaged only *ca* 5%.

It was noted that herring from Harbour du Loutre were always very fat by comparison with those from other sources. In June these fish averaged about 13% fat (2 years) and in September-October values of 14.8, 19.4 and 27.4% were reported.

COMPARISON OF FAT CONTENT FOR EAST AND WEST COAST HERRING

A few generalizations can be made providing it is appreciated that variations can be quite large from year to year and area to area.

From July through December, West Coast (South East of Vancouver Island) herring had uniform and high fat content (16–18%) with the exception of November when it dropped to 13–14% (see Table 5) (J.R. McBride, R.A. MacLeod and D.R. Idler. J. Fish. Res. Bd. Canada *16*, 679. 1959) (J.L. Hart, A.L. Tester, D. Beall and J.P. Tully. *Ibid. 4*, 478. 1940). Spawning is earlier on the West Coast and herring contained the least fat (5%) in March and by June the high point (24%) was reached. The analytical procedures employed for the analysis of East Coast herring give values which are 10–15% higher than that used on the West Coast. It may therefore be concluded that West Coast herring contain more fat for a longer period of time than do those of the Atlantic area. It should be emphasized, however, that data is available only for Bay of Fundy herring on a month by month basis over one entire year. More data are required on the seasonal variation of fat in Atlantic herring.

TABLE 4

Fat Content of Small Herring, September 1943 to July 1952[b]

Month and year	Number of samples	Highest fat content	Lowest fat content	Average fat content	
				7.0-14.0 cm.	14.5 cm. and up
1943		%	%	%	%
September	4	20.4	8.3	11.6	15.7
October	2	8.7	7.3	8.0	...
November	3	9.8	6.5	7.2	9.4
December	1	6.0	6.0	6.0	...
1944					
January	4	12.5	4.6	7.4	9.6
February	1	4.1	4.5	4.5	5.1
March	1	3.5	4.2	3.5	4.2
April	2	1.6	2.0	1.8	1.7
May	2	6.9	2.5	2.5	5.1
June	5	13.9	4.2	6.9	9.6
July	9	17.3	3.8	8.2	13.8
August	4	14.6	2.9	4.4	9.8
September	3	12.7	6.8	7.6	12.0
October	4	13.1	6.4	8.5	11.6
November	2	11.4	5.3	5.3	9.8
1945					
January	1	7.0	5.7	5.7	7.0
February	1	3.2	3.2	3.2	...
March	3	4.1	3.4	3.7	...
April	3	3.7	2.5	2.8	3.6
May	5	5.0	1.6	2.4	4.2
June	2	6.8	5.5	5.7	6.8
July	4	11.8	4.6	5.5	8.6
August	2	15.1	11.0	...	13.0
September	3	11.0	7.8	10.9	9.4
October	2	27.4	11.2	11.2	27.4[a]
November	1	17.8	14.3	14.3	17.8

[a] High value; fish from Harbour du Loutre. [b] 1943-1945 shown here. Data from A.H. Leim. J. Fish. Res. Bd. Canada 15, 1259-1267 (1958).

TABLE 5

Proximate Analyses of Pacific Herring (Clupea pallasii) Caught at Monthly Intervals for a Year[b]

Month	Sex	Gonads[a]	Water	Fat	Ash	Protein
1957			%	%	%	%
January	Male	15.30	70.10	9.47	2.47	17.59
	Female	9.99	70.37	9.50	2.36	17.38
February	Male	16.41	72.09	7.76	2.35	17.84
	Female	16.20	72.00	8.04	2.28	17.00
March	Male	20.81	76.43	4.90	2.43	16.79
	Female	19.15	76.70	5.40	2.78	16.68
April	Undetermined	—	71.90	10.91	2.30	14.81
May	"	—	74.77	8.09	2.41	15.13
June	"	—	57.69	24.35	2.65	14.25
July	"	—	66.49	16.53	2.36	15.00
August	"	—	65.31	18.06	2.29	14.31
September	Male	3.68	64.20	17.61	2.34	15.44
	Female	2.40	63.40	18.01	2.37	15.31
October	Male	5.73	65.00	16.20	2.46	15.94
	Female	2.91	64.75	16.70	2.37	15.94
November	Male	10.60	66.80	14.40	2.41	16.90
	Female	4.02	68.30	13.05	2.45	16.61
December	Male	12.80	64.6	16.55	2.31	17.62
	Female	7.29	64.0	16.60	2.47	17.00
1958						
January	Male	18.15	69.1	11.66	2.28	17.69
	Female	14.69	68.6	11.72	2.39	17.75

[a]Expressed as percent of total body weight. [b]J.R. McBride, R.A. MacLeod and D.R. Idler. J. Fish. Res. Bd. Canada 16, 679-684 (1959).

Herring Oil Research at Halifax

INTRODUCTION

Herring oil is composed principally of triglycerides, which means that it contains three molecules of fatty acid for each molecule of glycerol. Basically there are three types of fatty acids; the saturated, monounsaturated and polyunsaturated. These are linked with a glycerol molecule in the following manner:

$$H_2\text{-C-O-CO-}(CH_2)_x\text{-}CH_3$$
$$|$$
$$H\text{-C-O-CO-}(CH_2)_y\text{-}(CH\text{=}CH\text{-}CH_2)_m\text{-}CH_2\text{-}CH_3$$
$$|$$
$$H_2\text{-C-O-CO-}(CH_2)_z\text{-}CH\text{=}CH\text{-}(CH_2)_n\text{-}CH_3$$

This arrangement has been shown by Dr. Brockerhoff, at Halifax, to be a common one in fish oils, with a saturated and a monounsaturated acid in the outside positions, and a polyunsaturated acid in the middle position.

The properties of the three different types of fatty acids are quite different. The saturated fatty acids are usually solid and quite stable. The monounsaturated fatty acids are commonly liquid and oxidize very slowly. Butter and olive oil are two fats which are rich in these respective acids and you will be familiar with their properties. The polyunsaturated fatty acids are also liquid, but the number of their double bonds makes them oxidize very readily. Linseed oil is rich in a fatty acid with three double bonds, and you may compare this with almost all fish oils which contain chiefly unsaturated fatty acids with either one double bond, or acids with five and six double bonds.

Composition and Properties

In almost all fish oils there are eight fatty acids which make up over 80% of the total in the oil. The fatty acids in a typical herring oil are:

myristic	5%	16% saturated
palmitic	11	
palmitoleic	12	60% monounsaturated
oleic	12	
eicosenoic	16	
docosenoic	20	
eicosapentaenoic	7	11% polyunsaturated
docoahexaenoic	4	
Total	87	

Many of you are aware that iodine values are an important consideration in marketing oils. You might be interested in the proportions of the major components of these types of acids in three different types of oils covering the iodine values encountered in commercial fish oils:

	Herring Oil	Cod Liver Oil	Anchovy Oil
Iodine value	130	165	190
Fatty acids			
Saturated	16	24	30
Monounsaturated	60	48	29
Polyunsaturated	11	19	26

It is clear that as iodine value increases there is, surprisingly, an *increase* in saturated acids and a *decrease* in monounsaturated acids. However, the changes are offset by an increase in polyunsaturated fatty acids. Since the latter have five or six double bonds in each molecule, even a small change has a marked effect on iodine value.

There are, of course, some seasonal changes in the properties and composition of our local Atlantic herring oils. These have recently been investigated in the Halifax Laboratory. The first step in this programme was to collect a dozen samples of oil at random from various plants in this area in order to obtain the widest possible variation in oils. These have been analysed and a paper will appear soon in the Board's Journal describing the results. The iodine values ranged from 112 to 140, which was more or less in agreement with results for herring oils published from other areas. It was therefore surprising to subsequently learn that herring oil from the Baie des Chaleurs area can have iodine values of the order of 95 to 100.

Iodine values are of particular interest when the oils are intended for edible fat products; such is the case with herring oils. The oils are hydrogenated to assure that the polyunsaturated fatty acids are reduced completely to saturated or monounsaturated fatty acids. If reduction is not sufficiently complete, there is a risk of flavour reversion to produce an undesirable flavour. Hydrogenation is a relatively expensive step in edible oil processing, and if the edible fat manufacturer can start with a low iodine value oil then his production expenses may be kept down, Low iodine value herring oils should therefore command a small price premium. However, it is first necessary to convince the edible fats manufacturer that these are pure herring oils and are not adulterated. The Halifax Laboratory is in a position to do this with the aid of modern techniques such as gas chromatography.

A further interest in iodine values also arose from this preliminary survey of our local oils. With the aid of gas chromatography the proportions of the saturated, monounsaturated and polyunsaturated fatty acids in any marine oil can be determined quite accurately. In looking over the herring oil analyses it was discovered that the percentage of the polyunsaturated fatty acids is given by a simple formula:

$$\% \text{ polyunsaturates} = 10.7 + 0.337 (\text{iodine value} - 100)$$

It was even more interesting to find that this formula works as well for other marine oils, such as cod liver oil. The iodine value is simple to determine and gives, with the aid of the formula, the percent polyunsaturated fatty acids. Our local herring oils contain, on the average 20% saturated fatty acids; this value is not affected very much by iodine value and the monounsaturated fatty acids can therefore be calculated by any difference. In the past, purchases of local herring oils have been based on general quality with little attention to composition. It is now possible to select the oil most suitable for a given purpose; modern technology needs this sort of information for efficient operation and usually financial benefits accrue to all concerned. On this subject it is worth mentioning that the beach-spawning capelin in Newfoundland are relatively lean (3-4% oil). Since males are found on the beaches and the females in off-shore schools, it should be possible to handle oils from the two sexes separately. Oil from males had an iodine value of 125 while that from females was 144. Capelin oil has been shown in the Halifax Laboratory to be similar in most respects to herring oil.

A detailed study of oil from migratory mackerel is underway and samples of herring oil are being collected from plants in Nova Scotia and Newfoundland, as well as from the West Coast, in order to study seasonal variations in the chemical composition of oils produced in different areas.

Process for Utilization

New means of utilizing marine oils are under investigation. Several years ago the Halifax Laboratory carried out a study which showed the feasibility of recovering the various types of fatty acids from herring oil. You will recall that at the beginning of this section I mentioned that the various fatty acid types tend to occur in mixtures in each triglyceride molecule. One simple means of obtaining the component fatty acids is to transesterify with methanol:

$$\begin{array}{l} H_2C\text{-}O\text{-}CO\text{-}R_1 \\ \;| \\ HC\text{-}O\text{-}CO\text{-}R_2 \\ \;| \\ H_2C\text{-}O\text{-}CO\text{-}R_3 \end{array} \xrightarrow[\text{Alkali}]{\text{Methanol}} \begin{array}{c} CH_3\text{-}O\text{-}CO\text{-}R_1 \\ + \\ CH_3\text{-}O\text{-}CO\text{-}R_2 \\ + \\ CH_3\text{-}O\text{-}CO\text{-}R_3 \end{array} + \begin{array}{l} H_2C\text{-}OH \\ \;| \\ HC\text{-}OH \\ \;| \\ H_2C\text{-}OH \end{array}$$

This is an economical and convenient process but it is only suitable for use with oils which are low in free fatty acids. The resulting methyl esters are still a complex mixture of some sixty different fatty acids. A process has been developed at Halifax to separate this complex mixture into the component parts. The process is based on countercurrent extraction, and the various types of esters are pumped in one direction through a column while nitromethane flows in the other direction. The nitromethane dissolves the more highly unsaturated fatty acid esters, which can be used in drying oils. The saturated acid esters may then be separated from the monounsaturated esters by distillation if desired. The monounsaturated acid fraction could be particularly useful in certain industries after chemical modification. Uses which show promise are as plasticizers in some plastics or as sources of some rare dicarboxylic acid esters of interest in special grades of nylon and other materials. An economic study carried out some years ago showed that the entire oil production on this coast was insufficient to support a single plant large enough for economical operation. Since this situation is now changing, the Halifax Laboratory is maintaining an interest in exploring details of the methyl ester production and segregation processes so that the facts will be at hand when future developments require utilization of marine oils in other than the present markets.

FREEZING AND FROZEN STORAGE OF HERRING

Increasing amounts of herring are being frozen each year for human consumption as such, as raw material for canning and smoking, or for use as bait. Numerous studies have been carried out to find the best methods of freezing and storage conditions to avoid deterioration, especially rancidity, which has placed severe limitations on the utilization of herring.

Methods of Freezing

Many types of freezers are currently in use for herring, including brine freezers, blast-freezers and plate freezers.

1. *Brine freezing*

This method is especially useful when large amounts of herring are to be frozen in a short season. A typical installation in a freezing plant (in the center of the herring fishery in Norway) operates as follows: The herring are washed as they are unloaded from the vessels, and packed in 50 kg (110-lb) wooden boxes. The boxes are placed on a slow moving conveyor belt and brine at -19°C (-2.2°F) is sprayed over the boxes. The freezing time is 2 hr; the boxes are then washed to remove the brine and placed in coldrooms. The capacity is 3600 boxes (396,000 lb) per 24 hr.

2. *Blast freezing*

Large amounts of herring are also dry-frozen by circulating air over finned plates or in blast freezers. These freezers are more expensive to construct than brine freezers for equal capacity, but indications are that they produce a better product.

3. *Plate freezers*

Herring can also be frozen in plate freezers, although due to the lower capacity of these freezers, higher priced consumer packs would be most suitable for packing. One important recent development has been the use of vertical plate freezers for freezing sprats and small herring as raw material for the sardine industry (in Norway). The fish are frozen in water and it has made possible an extension of the packing season by several months.

Rancidity and its Prevention

Since herring is a fatty fish, the chief limitation to prolonged storage is the development of rancidity. Numerous studies have been carried out to eliminate this problem, and it essentially boils down to a question of economics.

The storage at very low temperatures, -20°F to -30°F (-29°C to -34°C) or below, checks rancidity quite well for periods up to 7 months (E. Heen and O. Karlsen. The Technology of Herring Utilization, Fiskeridir. Skr. Ser. Fisker: Vol. II, No. 1. 1953). It has been found that thin films of ice are almost completely impervious to oxygen at low temperatures and glazing will protect herring from rancidity during cold storage. The effectiveness of an ice glaze will depend very much on the extent of desiccation occurring in cold storage. It has been observed that the glazed herring retain their ice glaze for 4 to 5 months during storage at about -13°F (-25°C) under commercial conditions (A. Banks, *Ibid.*).

The method of freezing has also been found to influence the development of rancidity. Brine-frozen herring has been reported to turn rancid much sooner than dry-frozen herring, possibly due to the catalytic effect of the salt (Heen and Karlsen, *Ibid.*). Traces of metals such as copper have been shown to accelerate rancidity and should be avoided. Antioxidants have been used with varying degrees of success. Both Canadian (Tarr) and Norwegian workers have reported on the beneficial effect of ascorbic acid, especially in conjunction with a glaze. Coating the herring with a gel, such as alginate or methyl cellulose, protects against dehydration and oxidation, especially if an antioxidant is incorporated. This again is a question of economics.

Fillets of herring can also be successfully frozen subject to suitable precautions, including low temperature storage and proper glazing or packaging in alginate jelly.

Research at Halifax on Natural Antioxidants in Herring

Studies are presently underway at the Halifax Laboratory to determine the amounts of naturally occurring antioxidants in herring. The variations due to size, sexual maturity, season and area are being studied and the results should be of interest to packers as a guide to the keeping time which may be expected in storage. Antioxidants of various types will also be evaluated.

THE LIQUEFACTION OF BRITISH COLUMBIA HERRING BY ENSILAGE, PROTEOLYTIC ENZYMES AND ACID HYDROLYSIS

The wet reduction process currently used in British Columbia to bring about the conversion of herring to animal feed yields oil, solubles, meal and whole meal.

Herring meal is of high nutritive value and is used as protein and growth factor source in animal feeds. There are certain advantages, however, to having a supplement to animal rations in a liquid rather than in a solid form. In a liquid form it can be more readily transported in bulk in tank cars than is the case with the dry product. Secondly, there are certain advantages to having such a substance as a binder in otherwise dry rations. Thirdly, it should be possible theoretically to prepare a liquid product more cheaply than a dry one since less steam would be required for its preparation. One disadvantage to a liquid product would be the transportation of the water in the final product.

Three methods have been proposed in the past to liquefy fish. In the ensilage process, first introduced in Finland in 1920, minced fish is acidified to pH 2.5 to 4.0 and allowed to stand for a period of approximately 2 weeks during which time liquefaction occurs. This process, although referred to loosely as ensilage, is actually, as will be shown in this report, a liquefaction of fish resulting from natural enzymes present in the fish. This has been a popular product in Europe, especially the Scandinavian countries, for many years. Published reports indicate that the process is cheap and the product is of good quality.

True ensilage differs from this in that the breakdown is accomplished by the action of lactic acid bacteria in a process strictly comparable to the fermentation which takes place in a silo. The true ensilage procedure as applied to fish has been studied to a limited extent in France. In another patented process, fish and fish waste is liquefied by the application of steam under high pressure. The use of proteolytic enzymes to digest the fish has also been suggested.

TABLE 6

Effect of Temperature and pH on the Rate of Solids Breakdown in the Production of Whole and Eviscerated Herring Ensilage

Sample No.	Ensilage Treatment	Stormer (viscosity) values during ensilage[a] Time (days)								
		0	1	2	3	4	5	10	15	20
1A	Whole herring, pH 4.5, 25°C.	*	*	*	29.6	17.8	17.1	15.5	14.8	14.1
1B	Whole herring, pH 2.0, 25°C	*	32.8	16.5	15.5	15.4	14.2	14.0	13.1	13.1
2A	Whole herring, pH 4.5, 37°C	*	21.2	16.8	15.1	14.8	14.2	13.4	13.3	13.3
2B	Whole herring, pH 2.0, 37°C	*	15.1	13.1	13.1	13.0	13.1	13.1	13.1	13.1
3A	Whole herring, pH 4.5 rom temperature (21°C)	*	99.0	28.6	24.5	21.1	20.0	17.0	16.5	15.1
3B	Whole herring heated to 95°C for 15 min before incubation conditions same as 3A................	*	*	*	*	*	*	*	*	*
4A	Whole herring pH 4.5, 25°C	*	*	*	76.1	32.1	21.1	15.5	15.0	14.0
4B	Eviscerated herring pH 4.5, 25°C	*	*	*	*	46.4	27.7	17.2	16.1	15.5

[a] Sec/100 revolutions at 25°C. * In excess of 150 seconds. From J.R. McBride, D.R. Idler and R.A. MacLeod. J. Fish. Res. Bd. Canada *18*, 93 (1961).

I. *Ensilage*

In these procedures the herring were ground and blended with one-fifth volume of water.

The data in Table 6 illustrate the ensilage process at pH 2.0 and pH 4.5. When the sample is preheated there is no change in viscosity and the ensilage is therefore caused by the natural enzymes of the herring (samples 3A and 3B). The rate of this process is difficult to predict, probably because the enzyme content of the herring varies (samples 1A and 4A). When the viscosity value is less than 30 the product is satisfactory by this criterion, but, unfortunately, ensilage preparations have other demerits. When the products mentioned in Table 6 were filtered and concentrated to 50% solids, only samples 1A, 2A and 2B were sufficiently fluid to be acceptable. In all cases there was a considerable loss of solids due to filtration (ca 30-50%) and the oil content of the samples ranged from 3.7 to 10.2%. The length of time required to obtain adequate digestion would necessitate large tank capacity in order to obtain a reasonable through-put.

II. *Proteolytic Enzymes*

In the previous section the use of naturally occurring proteolytic enzymes of the herring has been shown to give rise to a product which has some very desirable characteristics. Unfortunately, however, the process is slow. The most obvious way of increasing the rate of digestion is to add more enzymes. The amout of acid required to maintain the pH of the digestion mixture constant is a measure of proteolysis. Preheated herring homogenates are more smoothly digested by commercial proteolytic enzymes than are non-heated homogenates (Table 7).

Table 7

Effect of Several Commercial Proteolytic Ezymes in the Reduction of Pre-Heated and Not Pre-Heated Whole Herring to Liquid Fish

Sample No.	Enzyme[a]	Substrate treatment	Protein in filtered solids
			grams
1A	Protease	Pre-heated	2.97
1B	Protease	Not heated	3.07
2A	Rhozyme B-6	Pre-heated	17.2
2B	Rhozyme B-6	Not heated	22.2
3A	Pepsin	Pre-heated	1.67
3B	Pepsin	Not heated	3.87

[a]Enzyme digestion at the following pH and temperature: Protease pH 8.0, 50°C; Rhozyme B-6 pH 6.0, 60°C; pepsin pH 2.0, 37°C.

The data in Table 8 show that pepsin gave rise to the highest percentage solubilization while Rhozyme B–6 and bromelin were about equally active. While both pepsin and bromelin achieved maximum solubilization at the end of 48 hours of digestion, Rhozyme B–6 required an additional 24-hour digestion period to reach its highest level of solubilization.

The oil content should not exceed 5% on a wet weight basis to be acceptable as an animal feed supplement. It proved to be extremely difficult to remove oil from these digests prior to concentration to the finished product. Chilling and scraping off the solidified emulsion was effective but would be both cumbersome and uneconomical. Boiling with or without KH_2PO_4 was not entirely satisfactory. When the ground herring was precooked, pressed, and the free oil removed prior to enzymic digestion, the situation was improved, but there was still an oil-emulsion problem. Commercial equipment would be capable of pressing out somewhat more oil than we could but the product would still be on the borderline of acceptability. Pepsin was most effective at pH 2.0 and there was no noticeable increase in proteolysis above a concentration of 0.3%.

III. High Temperature Acid Hydrolysis

Scraps from non-fatty fish have been liquefied for some time at pH 2 to 4 with the aid of steam under high pressure.

This process was applied to whole herring homogenates diluted with 20% water. Processing at 50 psi (300°C) for 3 hours resulted in 70% solubilization, 66% free oil and 7.5% free fatty acid. *The most significant difference between this product and that prepared by proteolytic enzymes was the complete absence of any oil-protein emulsion in the pressure cooked sample.* While the percentage solubilization achieved in this steam-cooked sample was somewhat lower than that achieved in the maximum solubilized pepsin sample, it is, however, higher than that achieved in the maximum solubilized bromelin and Rhozyme B–6 samples. Furthermore, the percentage of the total oil existing as free oil in the pressure sample was approximately 4.5 times as great as in the enzyme-solubilized products. The free fatty acid level of 7.5% obtained in the free oil of the pressure sample did not differ significantly from the levels obtained for the corresponding enzyme products. The steam pressure prepared liquid fish did, however, have a much darker colour than the finished enzyme sample, as well as a slightly burnt odour.

Table 8

The Effect of Several Commercial Proteolytic Enzymes on the Reduction of Whole Herring to Liquid Fish

Enzyme	Enzyme digestion conditions			Insoluble solids (dry wt.)	Maximum solubilization	Free oil	Free fatty acids in free oil
	pH	Temp	Time[a]				
		°C	hours	grams	%	%	%
Pepsin	2.0	37	48	56.14	77.8	15.0	10.80
Bromelin	4.5	60	48	88.47	64.6	18.0	7.6
Rhozyme B-6	6.0	60	72	92.34	65.5	12.0	9.7[b]

[a]Time required for maximum solubilization or point experiment terminated.

[b]Free fatty acid level following 48-hr digestion 7.2%.

Comparison of Acid Hydrolysates, Proteolysates and Commercial Meal

Each product was prepared in a pilot plant from the same batch of herring.

When the data from the two liquid fish products listed in Table 9 are compared on a 100% total solids basis to the corresponding results obtained for the meal and whole meal products, it is evident that the protein content of the two meal samples is somewhat higher than found in the two liquid products. On the other hand, the ash values of the two liquid fish products were approximately equal and about double the ash levels found in the two meal products. While the oil levels of the two meal samples were about equal, *the oil content of the pressure-solubilized liquid fish sample was about one-half that found in the two meals and approximately one-quarter that present in the enzyme-solubilized liquid fish concentrate.*

It is unlikely that herring reduction by either liquefaction process would be competitive with a fish meal operation. The acid process could, however, provide a low fat fish meal.

STUDIES ON THE CONVERSION OF HERRING STICKWATER TO SOLUBLES

Bacterial Decomposition at High-Temperature

This problem was investigated at Vancouver (R. A. MacLeod, D. R. Idler and W. A. B. Thomson. Applied Microbiol. *3,* 202, 1955).

Fish stickwater, also referred to as press water, is a by-product of the fish-processing industry. It consists of the fluids expressed from cooked fish or fish waste materials when the latter are converted to meal. After removal of the greater part of the oil by centrifugation, the stick-water can be condensed to a product called solubles which contains, usually, about 50 percent solids. If no further treatment than evaporation were involved in the preparation of solubles, the product would be too viscous and would contain too much oil to be suitable for commerce. This unsatisfactory viscosity and oil content results primarily from the presence of suspended and dissolved protein in the original stickwater. Various methods have been devised to overcome the effects of this protein. In one process, the protein is coagulated with acid and removed by centrifugation (S.H.

TABLE 9

Analysis and Viscosity Tests of a Pressure and a Pepsin Solubilized Liquid Fish Concentrate and Comparison of the Analyses with that of Commercial Meal and Whole Meal

Analysis (wet weight)	Acid-pressure liquid fish (Station product)		Pepsin-solubilized liquid fish (Station product)		Meal (commercial)		Meal (whole)
	Actual % total solids[a]	100% total solids[a]	Actual % total solids	100% total solids	Actual % total solids	100% total solids	100% total solids
Water (%)	57.00	0.00	65.0	0.00	7.70	0.0	0.00
Total solids (%)	43.00	100.00	35.0	100.00	92.30	100.0	100.00
Protein (%)	32.90	76.60	22.10	63.10	74.00	80.10	81.00
Oil (%)	1.91	4.45	5.60	16.00	8.94	9.69	10.20
Ash (%)	8.22	19.10	6.80	19.40	9.10	9.85	9.05
Viscosity test							
Stormer[b]	17.90	–	16.4	–	–	–	–

[a] Analyses are given both for the actual solids content of the product as well as for a product calculated to contain 100% solids for ease of comparison with the results for meal.

[b] Seconds/100 revolutions/200 g weight. Test after sample held for 2 hours at 25°C.

TABLE 10

Effect on the Loss of Total Solids of Holding Stickwater at Various Temperatures for 48 Hours

	Experiment A			Experiment B		
Storage temperature, F..........	140	160	180	140	150	160
Total solids, grams per liter						
0 hr	90.5	90.5	90.5	88.1	88.1	88.1
48 hr	78.1	85.6	88.2	76.2	80.6	83.8
Loss of total solids, percent.....................	13.7	5.4	2.5	13.6	8.6	4.9

Lassen. Process for treating fish press liquor. U.S. Patent No. 2,372,677. 1945); in another, the protein molecules are converted to small fragments using proteolytic enzymes (J. K. Gunther, and L. Sair. Process for treating fish press water. U.S. Patent No. 2,454,315. 1948).

To treat stickwater with commercially available proteolytic enzymes, the temperature must not exceed 140°F (60°C). Inasmuch as stickwater leaves the previous stage of processing at temperatures above 200°F (93°C), it must be cooled to 140°F. Without special cooling facilities and with the large volumes of stickwater involved, cooling to the desired temperature can take as long as 48 hours under plant conditions. During this time, as much as 15 to 20 percent loss in solids from the stickwater has been found to take place. In spite of the relatively high temperatures involved, this solids loss has been found to be due to the action of bacteria. The data in Table 10 show that a temperature of 140°F (60°C) results in serious losses but that losses are significant up to 180°F (84°C). Further experiments established that the increase in bacterial population with time paralleled the decrease in solids in the stickwater and there was very little decomposition in the first 10 hours. The pH rose progressively from 6.5 to 7.5. When the stickwater was autoclaved there was no loss in solids in 48 hours, but boiling for 5 minutes gave no protection (Table 11).

Thermophilic aerobic, anaerobic and facultatively aerobic spore-forming bacteria are widely distributed in nature, even in environments unfavorable for their development (Mary B. Allen. The thermophilic aerobic spore-forming bacteria. Bact. Rev., *17*, 125-173. 1953). Both sea water and ocean bottom mud have been found to be sources of these forms. Fish stickwater provides an excellent nutritive environment for the growth of microorganisms. One would expect, then, that because stickwater, during its production, is maintained for various periods at temperatures suitable for the growth of thermophiles, large populations of these forms would develop in it. Because of their ability to form spores capable of lying dormant in the processing equipment under unsuitable conditions, relatively large inocula of thermophiles would thus be available to bring about decomposition of subsequent batches of stickwater.

Because of the wide distribution of thermophiles in nature, one would not expect contamination of stickwater by thermophilic organisms to be a purely local problem. In support of this conclusion is the fact that stickwater samples from the two plants producing this by-product in the Vancouver area all decomposed in much the same way at high temperatures. Furthermore, stickwater obtained at different seasons of the year from these plants displayed the same pattern of decomposition. In addition, it has been reported that decomposition of stickwater at a point far distant from Vancouver occurred at temperatures up to 85°C (*Lassen et* al., 1951).

Table 11

Effect of Various Heat Treatments on Subsequent Loss of Solids from Stickwater upon Storage at 140°F for 48 Hours

Treatment Before Holding Period	Total Solids (g per L) 0 hours	Total Solids (g per L) 48 hours	Loss of Total Solids* Percent
None......................	88.3	75.5	14.5
Boiled for 5 min............	88.9	75.8	14.7
Autoclaved for 30 min at 120°C (248°F)............	91.2	89.3	2.1

*After storage for 48 hours at 140°F.

Prevention of Bacterial Decomposition in Herring Stickwater

Studies described above have revealed that 15 to 20 percent loss in solids can occur in herring stickwater held at 140°F (60°C) for 48 hours. Smaller losses can occur at even higher temperatures. These solids losses have been shown to be due to the action of spore-forming thermophilic bacteria.

Stickwater is processed by two different methods. In the one case, in which stickwater is acidulated in order to remove protein and facilitate the separation of "bound oil," the acid used also acts as a preservative. In the other, in which proteolytic enzymes are used to treat stickwater prior to condensation to solubles, an essentially neutral medium is required and under these circumstances decomposition by thermophilic bacteria can be serious.

Antibiotics have been successfully employed to preserve fresh fish and meat (H.L.A. Tarr, B. A. Southcott, and H. M. Bissett. Experimental preservation of flesh foods with antibiotics. Food Technol., *6*, 363. 1952).

The following studies were carried out at the Vancouver Laboratory of the Fisheries Research Board of Canada (D.R. Idler, R.A. MacLeod and W.A.B. Thomson. Applied Microbiology *3*, 205. 1956).

Preservatives were added to the stickwater at 140°F with thorough mixing, after which the mixture was stored without agitation at this temperature for 48 hours. Sodium nitrite, versene, and sulfanilamide were each tested at levels of 1000, 100, and 10 parts per million (ppm). All three prevented solids loss only at the 1000-ppm level. Sodium acid pyrophosphate was effective at a concentration of 0.25 percent based on weight of the stickwater, that is, at a level of 2500 ppm. This observation confirmed the finding of McFee who used rosefish stickwater (E.P. McFee, personal communication). In separate experiments, sulfathiazole was found to have a considerable though quite variable action in preventing the decomposition of stickwater. On one occasion, 10 ppm of sulfathiazole completely prevented solids loss while on another occasion, 100 ppm was only partially effective.

When antibiotics were tested, these were added to the stickwater at two levels, 1 ppm and 10 ppm, for preliminary screening purposes. Penicillin G, Achromycin, hygromycin and erythromycin were each found to be completely effective at 1 ppm. A great variation in effectiveness was observed with Aureomycin. On one occasion, Aureomycin was completely effective at 10 ppm and on another, 20 ppm permitted 50 percent of the total decomposition of an untreated sample to take place.

The results obtained in the preliminary screening revealed penicillin G to be the most promising antibiotic for preserving stickwater under the conditions employed since it was the most effective of those tested, and from the economic standpoint is the least expensive. For this reason, the preservative action of penicillin G was considered in more detail. The minimum concentration of penicillin G which would completely inhibit bacterial action at 140°F was determined.

A temperature of 140°F, which was used in preliminary screening experiments, would be the final temperature in the cooling process and some bacterial decomposition is known to take place above 140°F. It was therefore necessary to determine if penicillin G would still be effective at higher temperatures. It was considered unlikely that the antibiotic would be subjected to any one of the higher temperatures chosen for lengths of time exceeding 10 hours. Penicillin G was thus added to stickwater at 160, 180, and 200°F and held at these temperatures for 10 hours. At the end of this time, all flasks were cooled to 140°F and incubated for 48 hours. Solids loss at the end of the 10- and 48-hour periods was determined. Even 1 ppm of penicillin G retains its effectiveness in preventing decomposition when stickwater is maintained at 160°F for 10 hours prior to incubating at 140°F for 48 hours. At 180°F, on the other hand, 1 ppm is only partially effective, though 10 ppm still gives complete protection.

Cooling and agitation are frequently effected by bubbling a stream of air through the stickwater. This practice greatly enhances the loss of solids (2x) from the stickwater when no preservative is used and the effectiveness of penicillin G is reduced if the aeration is carried out for 10 hours at 180°F.

A drop of only 10°F (140 to 130°F) brings about a fourfold increase in the amount of solids lost from stickwater stored for 48 hours. At 120°F the loss was 40% of the total solids. This loss can be completely eliminated or reduced to negligible proportions by the addition of 1 ppm of penicillin G to the stickwater.

The addition of penicillin G at a level which would prevent the decomposition of stickwater at high temperatures would increase the cost of condensed solubles (50% solids) by 0.06 cents per pound.

THE GEL FACTOR IN HERRING SOLUBLES

Identity and Seasonal Variation

To prepare a *fluid* concentrate (solubles) of herring stickwater, the suspended and dissolved proteins must be either removed by acid or destroyed by proteolytic enzymes.

On the West Coast it was noted that solubles produced by the acidulation process were fluid from summer herring but gels were encountered when late fall and winter herring were employed. The problem is illustrated in Table 12 where the extremely high viscosities (stormer values) are apparent for solubles prepared from herring caught from September through January (J.R. McBride, R.A. MacLeod and D.R. Idler. Agriculture and Food Chemistry 7, 646. 1959). The gel sets up within 24 hours as reflected in the results from the pour residue test. The solubles produced from November through January were not fluid at 50°F.

The increasing severity of the gel paralleled the development of the gonads. However, removal of gonads did not improve the fluidity of the solubles. Further investigation of this problem established that the material causing the problem in solubles was gelatin. The data in Table 13 establish the correlation between gelatin content of the solubles and fluidity.

TABLE 12

Comparison of Physical Properties and Analytical Data on Samples of Herring Solubles Prepared at Approximately Monthly Intervals

Month Caught	Properties of Solubles					
	Insoluble solids, %	Stormer 2 hr.	Values[a] 24 hr.	Pour Residue Test[b] 77°F. 2 hr.	77°F. 24 hr.	50°F. 24 hr.
July	1.42	15.7	16.1	0.5	0.7	1.5
August	2.64	29.6	80.4	9.1	14.5	28.3
September	6.72	107.0	268.0	19.8	32.0	45.6
November	8.83	c	c	54.9	34.1	100.0
December	6.47	279.0	c	36.1	41.5	100.0
January	7.36	236.0	350.0	14.1	27.7	100.0

[a] Seconds/100 revolutions/200 grams at 77°F. Values determined at indicated times after preparation of solubles.

[b] Percent of solubles retained in beaker at indicated temperatures and times after preparation of solubles.

[c] Too strong a gel for Stormer test to be applied.

TABLE 13

Relation between Gelatin Content and Viscosity of Herring Solubles Prepared from Herring Caught at Approximately Monthly Intervals

Month Caught	Gelatin in Solubles %	Viscosity of Solubles: Stormer Values 2 hr.	Stormer Values 24 hr.	Pour Residue Test, 50°F. 24 hr.
August	1.18	20.8	21.8	6.74
September	1.62	28.0	42.1	100.00
November	2.26	63.0	94.0	100.00
December	2.31	128.0	136.0	100.00
January	2.68	>150.0	>150.0	100.00
February	2.56	138.0	>150.0	100.00
March	2.42	>150.0	>150.0	100.00
April	0.99	23.0	23.6	7.85
May	0.99	20.3	20.7	6.35
June	0.91	23.3	24.2	7.10

TABLE 14

Comparison of the Contribution Made by the Various Tissues to the Total Collagen Content of a 100-g Herring Caught in June and in February.

Tissue	Collagen Content: June	February Male	February Female
	mg	mg	mg
Head	240.65 ± 2.85	312.30 ± 10.66	301.9 ± 9.40
Tail	29.35 ± 2.49	37.70 ± 7.00	33.30 ± 2.62
Skin + scales	110.09 ± 2.84	336.10 ± 27.30	332.12 ± 7.51
Bone	69.29 ± 4.14	67.90 ± 2.39	68.90 ± 7.40
Viscera	62.88 ± 5.97	34.31 ± 3.09	26.42 ± 3.37
Flesh	130.03 ± 6.02	152.50 ± 14.37	126.05 ± 9.25
Milt	—	5.85 ± 0.52	—
Roe	—	—	7.61 ± 0.76

The source of the gelatin was established to be collagen, which is present in connective tissue and is a protein of skin. Collagen breaks down to gelatin under the influence of acid and heat used in preparation of stickwater and solubles. Analyses of the collagen content of herring taken in June and February are given in Table 14 (J.R. McBride, R.A. MacLeod and D.R. Idler. J. Fish. Res. Bd. Canada *17,* 913. 1960). It will be noted that most of the extra collagen in February herring is located in the skin. This is because, like the salmon, the herring's skin greatly increases in thickness prior to spawning.

Destroying the Gel Factor

Several commercially available proteolytic enzymes were effective in destroying the "gel factor". Treatment of the stickwater with Rhozyme B-6 at 0.5% for 1 hour resulted in satisfactory solubles. Other enzymes also gave products with suitable viscosities (Table 15).

ACKNOWLEDGEMENTS

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TABLE 15

Effect of Treating Primary Stickwater with Proteolytic Enzyme Preparations on Viscosity of Resulting Solubles

Enzyme Used[a]	Enzyme Concentration[b]	Pour Residue Test on Solubles[c]	a-Amino N Released in Stickwater[d]		
			0.5 hr.	1 hr.	2 hr.
Control.......	0	100.00	0	0	0
Rhozyme B-6..	0.5	7.7	0.0470	0.0470	0.0504
	0.05	23.0			
	0.005	26.3			
Ficin	0.5	27.5	0.0924	0.1064	0.1288
	0.05	37.2			
	0.005	100.0			
Bromelin	0.5	12.0	0.1400	0.1428	0.1484
	0.05	37.4			
	0.005	25.4			
Protease	0.5	14.8	0.1456	0.1652	0.2184
	0.05	17.0			
	0.005	25.1			
Papain	0.5	26.0	0.0010	0.0212	0.0500
	0.05	39.7			
	0.005	100.0			
Collagenase ..	0.5	13.30	0.0200	0.0414	0.0506
	0.05	26.60			
	0.005	31.00			

[a] Stickwater treated with each enzyme for 2 hours under following conditions: rhozyme B-6, pH 6.0, 140°F; ficin, pH 5.0, 104°F; bromelin, pH 5.0, 140°F; protease, pH 8.0, 104°F; papain, pH 5.0, 98°F; collagenase, pH 6.5, 98°F.

[b] Expressed as percent of total solids present in stickwater.

[c] Determined at 50°F, 24 hours after preparation of solubles.

[d] Expressed as mg/ml and determined at indicated times during digestion.

Present and Future of Fish Meal and Oil World Supply and Consumption

By

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World production of fish meal and oil has increased steadily and rapidly over the course of the last 20 years and although tapering off somewhat in 1965 it is safe to predict that with new developments in finding and catching available resources fish meal and oil production will increase over the course of the forseeable future. More precisely, total world production of fish meal has soared from 579 thousand metric tons in 1948 to 1 million 374 thousand metric tons in 1958 to a record high of over 3 million metric tons in 1964. Although fish oil has not increased proportionately, due to more extensive fishing on non-oily species, world production has risen from 350 thousand metric tons in 1955 to 750 thousand metric tons in 1965.

Certainly a large part of the increase in fish meal and oil production is attributable to the rise of the Peruvian anchovy fishery which presently accounts for over 35% of the total world production. And certainly modern developments in fish catching technology have made larger catches possible with a result of higher outputs of fish meal and oil. But the first cause behind increased production has been a steadily rising demand and subsequent boost in value for these products. The fish meal and oil business has become more economically attractive to the investor. To more fully understand the role of fish meal and oil today we should take a look at exactly what each of these products is used for and why.

Fish meal is used almost exclusively today as a complementary protein feedstuff in the poultry and swine industries. In the more advanced nations of Western Europe and North America almost all large poultry producers and feed mills – and this is where the majority of fish meal is sold – use a method of least-cost ration formulation in their determination of poultry feeds. Using broiler chickens as an example we can see the producer formulating the least cost broiler ration which will fulfill the required levels of several amino acids, or protein, and the required energy levels. These amino acids and energy requirements are usually met by a combination of fish meal and corn, or a combination of soybean meal, meat and bone meal, and fat, with the addition of synthetic methionine. The extent to which fish meal is used in broiler rations therefore is determined by the competitive price level with the other feed ingredients, that is, meat and bone meal and soybean meal. In 1965 with fish meal prices at U. S. $170 plus per ton the competitive price relationship was not favorable and we saw a serious cutback in its usage, particularly in the United States. However, it should be remembered that world production was down in 1965, a factor in itself contributing to the high value, and almost all production was utilized even at the record prices.

Once it is seen that fish meal does not enjoy an isolated economic position but that the price is influenced by other high protein feeds, the question may be asked, "why does fish meal command the highest price of all meat or vegetable proteins and will this high price continue in future years?" In short, with soybean meal at $70 per ton and meat and bone meal at $90 per ton, how can the fish meal industry continue to sell their product for over $150? The answer in part lies in

Tables I and II where we can see how fish meal enjoys a high protein percentage and the best possible amino acid balance. With soybean meal relatively low in methionine and most other plant proteins low in lysine, methionine, and tryptophane, the proper use of fish meal in rations for poultry and swine offers great value in improving their efficiency of protein utilization. Fish meal also contains an unknown growth factor which stimulates rapid growth unlike any other feed ingredient. Also its digestibility is considered excellent. Thus when the total factors of fish meal are taken into account, we can see that it is attractive to the feed producer even at the premium of over $150 per ton. It is important to those in the fishing industry that fish meal has the added benefits that make it a premium product for it is more expensive to produce than the other proteins. But, I think, we can now see why it would be safe to conclude that fish meal will enjoy a high consumption at premium prices in the forseeable future. Although prices have been settling somewhat since last year, barring gross overproduction, the general picture can be viewed with somewhat reserved optimism.

* * * * *

Although prices for fish oil, unlike fish meal, declined after 1945 we have in recent years seen a solidification of price and a generally slightly upward trend. The reasons for an upward trend in fish oil values are directly attributable to its use in margarine production. Aside from the United States where fish oil does not yet have clearance for use in foods almost all is consumed in margarine production. In the United Kingdom, Germany, Holland, and the Scandinavian countries 95 to 97% of the fish oil produced and imported goes to the production of edible fats.

It is generally known that under a higher standard of living there will be a higher per capita consumption of edible fats and oils. This is exactly the situation we have seen in Western Europe and Canada; that with a rapidly elevating standard of living has come a greater consumption of edible fats; hence the demand for fish oil.

It should be mentioned that consumption and demand of soybean oil and groundnut oil, the chief competitors of fish oil, are both on the rise. In addition, the production of whale oil is decreasing, thereby creating a vacuum to be filled by the other products.

TABLE I

Animal Origin	*Percent Protein*
Fish Meal	60 – 70%
Meat and Bone Meal	50%
Hydrolized Feather Meal	85%
Dried Blood	84%
Plant Origin	*Percent Protein*
Soybean Meal	44 and 50%
Cottonseed Meal	43%
Sesame Meal	48%
Corn Meal	9%
Corn Gluten Meal	41 and 60%
Groundnut (Peanut) Meal	47%
Dried Brewers Yeast	45%

TABLE II

Amino Acid	Percent by Weight of Dried Product			
	Fish	Beef	Soybean	Cottonseed
Lysine.................	6.6	8.3	6.8	4.1
Tryptophane	1.6	1.0	1.4	1.2
Methionine	3.2	2.8	1.7	1.6

Also, due to increased catches of lean fish to South American anchovy has shown sizeable declines in oil yield in recent years with related reductions in fish oil exportations from Peru and Chile.

Here in Canada the fish oil consumption amounts to approximately 700 – 800 tank cars per year with a percentage being imported. As the Northwest Atlantic herring fishery develops, most fish oil will probably be sold in this Canadian market. However, I think it is safe to say that if herring reduction develops to the point where domestic consumption cannot absorb production, fish oil can readily be exported and sold to the Western European countries.

* * * * * *

No discussion of the future of the fish meal and oil business would be complete without mention of the production of fish protein concentrate, or fish flour, for human consumption. Fish protein concentrate is a defatted and deodorized dry powdered fish material that can be used as a supplemental ingredient with cereal products to help alleviate starvation and malnutrition throughout the world. With presently known methods FPC can be readily made from most stocks of industrial fish throughout the world, including herring. Considering the wholesomeness of FPC the Food and Agriculture Organization of the United Nations has said, "Fish proteins contain all of the essential amino acids in combinations well balanced for the needs of the human diet; they are particularly suitable for the enhancement of the biological value of cereal proteins. In addition, fish protein concentrates are rich in calcium, phosphorus, and trace elements required by the human body as well as containing notable amounts of vitamins in the B complex. Other animal proteins also contain all these amino acids, but are not so readily available in adequate amount." (Food and Agriculture Organization of the United Nations, *Future Developments in the Production and Utilization of Fish Meal, Rome 1961)*

It has been calculated that it would take approximately one ton of fish protein concentrate to meet the annual protein dietary requirements of one hundred people. Roughly, that is one ounce per person per day. Or if we calculate in terms of a total of 500 million people suffering from protein deficiencies in the world today, probably a conservative estimate, we can assume that right now, this year, the world needs could absorb 5 million tons of fish protein concentrate.

Considering value and cost of FPC most estimates today run in the neighborhood of $300 to $400 per ton. On the level of the individual we would see an FPC cost of about 1 to 1½ cents per person per day.

But Fish Protein Concentrate is not as easy as it sounds. A general acceptance of the product as made from whole fish must first come about. Then testing the various different processes of producing FPC from both an economic and product acceptability standpoint. Finally there must be training programs in the usage of fish protein concentrate.

Nevertheless, in the long range the fish meal reduction business will slowly convert to producing this more valuable and higher quality product. After all, it is more biologically economical to feed the fish directly to the man rather than the fish to the chicken and then the chicken to the man.

The world is getting very hungry. With the rapid growth of world population today there will come a natural demand for the fish reduction products; fish meal, fish oil, and fish protein concentrate. Of course, the market for these products is sometimes volatile due primarily to fluctuations in the fish resource. But I would say that most information indicates a bright future for both the fisherman and fish processor.

TABLE 111

1965 World Fish Meal Production*

Country	*Thousand Metric Tons*
Peru	1,282
Norway	309
South Africa	272
United States	242
Iceland	172
Denmark	112
Canada	82
United Kingdom	80
Germany	68
Chile	70
Angola	44
Sweden	7
Total (as yet reported)	2,740

* Includes major producers only. Japan and U.S.S.R. not yet reported.

Herring Products for Human Consumption - Technology of Herring Processing

by

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(Mr. Biegler's paper was read by Dr. Hans Baasch, Hamburg, Germany)

Herring are free-swimming pelagic ocean fish, keeping to depths of up to 800 feet. They are found particularly in that region of the North Atlantic where the warm waters from the south (Gulf Stream) mingle with the cold arctic currents. Their schools frequently reach huge proportions. Best known among the Atlantic herring breeds are those originating from the White Sea, the Murman Coast, from Norway, Iceland, and the Baltic region, from England, Scotland and Newfoundland.

Because of its high nutritional value and extreme abundance, the herring has since early times been a favourite catch wherever people have used it as food, be it as fresh fish or, commercially utilized, as salt herring or smoked herring whether canned or pickled, or as deep-freeze herring.

Only since the 'twenties of this century, however, can we speak of a technology of herring processing. As its founder, I would like to give the following definition of *commercial fish technology:*

"Due to the findings resulting from my extensive systematic research and years of practical experience, I was able to gradually eliminate the hitherto practised empiricism which had solely been based on superficial practical experiences without the aid of science. Purposeful and practical techniques based on experience were incorporated into the technological and rational framework of this field of technology, in mechanical as well as manual respects. My constructive logical development work laid the scientific and technological foundation for methods of fish processing based on a striving for perfectionism from the points of view of accuracy and a systematic, concrete approach in the proper perspective. Because of the many temporary and natural imponderables of the herring, its processing becomes a difficult but interesting challenge. In this respect, fish processing and the technology of fish packing differ considerably from other branches of industry. In short, shelf-life and quality of the final products are the result of building accidental discoveries into a system".

The principles of preservation and the resultant processing methods and technology are as follows:

SALTING OF HERRING

By salting the fish, a large quantity of water (approx. 30%) is removed, thereby depriving the bacteria of a suitable culture medium. Commercial salt in large quantities has a bactericidal or bacteria-inhibiting effect. Aside from its general bactericidal effect, salt may also be credited with a specifically selective action. According to the theory of plasmolysis, the body of a bacterium consists of the inner protoplasm and the outer semi-permeable membrane. If the bacterial cell is subjected to an osmotic pressure significantly higher than that present inside the cell, water is removed from the cell until balance of pressure has been achieved. This results in a shrinking of the cell content which becomes detached from the cell wall. This affects its basic vitality.

Early man who lived near the sea, or lakes and rivers, knew the value of fish as a food and knew how to use salt as a preserving agent. He obtained salt either by pouring saltwater on red-hot charcoal or by extracting it from the ashes of certain plants. Salt has been obtained and is still being obtained commercially by drying salt lakes or by mining in salt mines. Today we distinguish between salt obtained by evaporation and mineral salt. Fineness of grind is of importance.

Trade in salt fish, especially salt herring, occurred as early as the 7th century A.D. Fishing off the south coast of Sweden goes back to the 13th century. After the Dutchman William Beukelsz from Biervliet had pioneered the process of gutting and invented the salt measuring bushel around 1400, Hanseatic businessmen did a brisk trade in salt herring packed in oak casks, during the 15th and 16th centuries. These two inventions were responsible for largely eliminating production errors in the salting of herring. The boom period of the Dutch salt herring trade lasted for 200 years – from approximately the year 1500 until the Treaty of Utrecht in 1713. Then England and Norway started exploiting these vast schools of herring. German herring fishing started only at the time of the foundation of the German Empire in 1872 (Emden, Elsfleth, Glückstadt, Leer, Vegesack and Bremerhaven), with the City of Bremen as the center (D.H.G.).

Later, the methods of mild salting (White herring), medium salting (Scottish method), strong salting (Norwegian method: especially for cut-up herring and salt-herring strips), cold salting (Russian method), and the sugar-herb salting-anchovies, fish tid-bits – (Scandinavian method) became known. I introduced (canned) white-herring fillets in 1924. At around 1950, cans of boneless salt herring with milter were brought on the market by the D.H.G. Since about 1960, a type of white-herring fillet in cans or window-packs has gained acceptance.

Vacuum-canning and backed-aluminum-foil vacuum-packs of white-herring fillets or high-grade herring processed according to the "Enzymo"-technique, will be the future methods of packing herring.

The following salting procedure, which was used previously, is still being used:

1. *Salting at Sea.* The freshly caught herring is gutted immediately, i.e., gills and viscera are removed, and with them the food contained in them (plankton) as it would quickly decay in dead fish, particularly in warm weather. This also prevents the herring blood from coagulating since all the blood is allowed to drain out. This assures a snow-white tissue color. The gutted herring is immediately mixed with sea-salt and packed in barrels. A cooper on board ship closes the filled barrels after the herring itself has developed sufficient brine. A barrel packed on board a "logger" (herring cutter) is called "sea pack" or "Kantje". Once the "logger" has a sufficient number of "sea packs" on board or if it terminates its run for any other reason, it heads home. Not until it reaches there, does the actual processing into salt herring of the catch begin. Hundreds of workers in large, well-aired rooms first sort the herrings according to size, and into fish with and without roe.

The fish is repacked in barrels, salt is added, the barrels are closed, and more brine is then added through the bung-holes.

2. *Salting on land.* Upon arrival on shore, the herring is gutted and sorted. The girls who do this work are given the boxes filled with herring, which they then distribute according to size into other boxes around them, from which again only certain sizes are salted and packed. Gutting is done by sticking the so-called gutting knife into the herring close behind its head, and pressing the blade of the knife against the neck, which is held with the left hand. The girl now presses her thumb against the gullet of the fish and twists her wrist forward. With this practised movement she at once removes gills, gullet and viscera. The fish are sorted by size, the various sizes being the number of fish per barrel: 6-700, 7-800, 8-900, 900-1,050 and 1,050 to 1,200 and more.

For salting and packing, the packers select certain sizes. The salt should preferably be measured in barrel portion of 25-30 kg. Salt of medium granulation is used. Hardly any salt is placed on the bottom of the barrel. The herring are packed as follows: At first, one herring is put on its back against the staves. It is important that the fish are packed tightly and upright as the resultant flattened back gives the herring a fuller appearance. Next, two herrings are placed close to the first with their heads facing out. Rows of herrings are added until there is too much space, and three herrings can be fitted in instead of two. This eliminates the danger of round packing. This way the herrings lie in the barrel in straight rows, sprinkled with salt, their undersides facing up. Packing is continued in this way until one layer is completed. One or two handfuls of salt are then sprinkled over the layer. The herrings packed on the outside are covered with two herrings each, taking care to fill up the empty spaces. The next layer is packed at right angles to the previous layer.

Care must be taken to sprinkle the salt evenly. Packing is now continued at right angles until the barrel contains two layers more than its capacity. Salting between the layers must be done in such a way that the tips of the undersides are kept free of salt. In order to allow the brine to form in the barrels, they are then placed, lids off, in the shed, to be filled up again the next day from barrels containing herrings of the same size, packed on the same day. The added layers are again sprinkled with salt, and now the barrels are closed. After approximately 4-6 weeks, the process is finished; the barrels are now ready to be topped up. A hole is drilled into the opened barrels, about three fingers above the barrel center, in order to collect the mother brine. The herrings to be used for topping-up are rinsed in the brine (after sorting of the milters). Then, the barrels are packed above their rims, are closed, placed on their sides, and the mother brine is then added through the bung-holes. Finally, the barrels are marked with stencils.

Today, this procedure seems outdated, but this is not the case. Large numbers of barrels are still being packed this way and brought on the market.

At the same time, however, technology has led to improvements in efficiency and mechanization.

Upon arrival at the plant, the herring is washed and mixed with "Viturin" salt in mixing drums. From there, the herrings drop into wooden barrels, where they are packed tightly and covered with brine. After the barrels have been closed they are stored in a cool place. The fast-curing process being completed, the herrings are boned in the Baader-machine, vacuum-packed in view packs (in brine). The retail store, too. must store the packed herring in a cool place.

According to another procedure, the fresh herrings are boned, mixed with "Enzymon" extract according to the "Pebemazett" method and dry-packed in barrels. They are then steeped in brine, the barrels are topped up and closed. After a few weeks, the process is complete and the herring can be vacuum-packed in bags. This ensures that salt-herring and white herring fillets are brought on the market in a sanitary, first-class condition. Manual handling has been almost completely eliminated.

SMOKING

We may assume that in earliest times man, having discovered fire, used the thick smoke rising from his fires to preserve fish. The incomplete combustion or the smoldering of plant matter (wood) improves the keeping-ability, firmness, and the taste of the fish. This process produces a large number of different substances like formic acid, acetic acid (wood vinegar), formaldehyde, acetone, phenol, cresol, tannin, catechol, guaiacol, pyrogallol, toluene, xylene, methyl alcohol, etc. The majority of these substances contained in the smoke are germicidal. The bactericidal action of the smoke at first affects only the surface, and only after longer exposure does it penetrate deeper into the fish. The bacteria-inhibiting action is greater in the adipose tissue than in the muscle tissue. The action of the salt, and the concurrent reduction of water content further improves keeping ability, which can be seen most clearly in salt fish processed by the cold-smoking method (salmon herring or "Bokkings", reds, bloaters).

It is important that the smoke has a certain degree of humidity in order to increase the bactericidal action of the smoke (empyreumata). The smoke protects the fatty portions of the fish against rancidity. The heat of the smoke and the draught of air moving through the smoke-house result in a 10-30% loss of water in the fish. This fact is of crucial importance for the keeping ability of smoked fish.

Commercial production of kippered herring (salmon herring) dates back to about 1800, and was carried out in smoking establishments particularly in Holland, England and Germany.

High-temperature smoking was extensively employed at about the turn of the century (1896).

The Elbe-Biegler smoke tower embodies modern smoking technology. After pickling, the herrings are arranged on spits and placed on holders in the smoke house. The tower has a height of approx. 52 feet and a length of about 26 ft. It is divided into three sections, which are separated by suspended partitions. An endless chain picks up the two or three suspended parts, situated side by side, under which tip-type pans are fastened to receive dripping fat. The heating plant of the tower is located in the basement below the lift system. Each batch is uniformly dried, cooked, and smoked. After smoking, the spits are placed in a cooling tower where the fish is cooled to a temperature which will allow immediate aseptic and sanitary packing in boxes without the danger of condensation forming in the packages. In this tower, the Biegler *continuous* method was first used in the year 1927. This process has been successfully used for day and night operation until the present time.

Although the public will continue asking for kippers (herring smoked at high temperatures), technological progress in smoking points towards the production of fillets of kipper and salmon herring.

By using the Elbe-Biegler smoke tower, various types of fillets can be produced on a production line. Even today we have smoking equipment in which herring fillets can be smoked at low and high temperatures on a production line. After the fillets have been cooled and oil has been added, they are vacuum-packed in view-packs. They should only be stored in coolers from where they can then be sold.

Not only fresh fish but also round herrings, frozen according to the contact-method, and frozen herring fillets can be used for production. In thawing the frozen fish, it is important that the method employed prevents structural changes and oxidation of the fish.

STERILIZATION

Preservation of canned herring was made possible by the sterilization process, an invention by the French cook Nicolaus Apperts (1806). His method is based on the use of bottles and glasses. By boiling the content of a hermetically sealed vessel, it was rendered sterile, all bacteria having been killed. In the course of further developments, fire-tinned sheet-iron cans were used, and pressure cookers instead of the open water baths. This made it possible to sterilize at temperatures above 100° Centigrade (boiling point of water). This also shortens sterilization time and noticeably improves quality.

The use of cans to pack preserved foods became dominant. To a small extent, animal products were also packed in glass jars. The cans were manufactured in all shapes and sizes. The process of fire-tinning has been completely abandoned since the advantages of the electrolytic method of tinning were recognized, and with it the practice of varnishing.

The machines used to close the cans developed from simple bending devices to modern, fully automated equipment with or without provision for vacuum sealing.

The pressure cookers used for sterilizing have undergone numerous modifications. Thus, the upright pressure cooker developed into a horizontal model. It was followed by the high-pressure cooker, the rotation pressure cooker, the tower pressure cooker, and finally the horizontal continuous sterilization system.

In canning herrings of various sizes, the following methods can be distinguished:

(1) The Norwegian method. After pickling, the herrings are sorted by size, then arranged on spits after the "Kloster" method and placed on frames (racks). They then pass through a drying and smoke tunnel according to the Quärner-Bruck system. The method operates on the counterflow principle. After the herrings have passed this system, a cutting machine cuts off their heads, and the bodies drop on to conveyor belts from where they are manually packed into cans which already contain pure oil or tomato sauce. After the oil or sauce has been topped up, the cans are closed and immediately sterilized in pressure cookers.

(2) In the Belgian method, small herrings or sprats are placed on grills after their heads have been removed; these grills are then placed on carts and moved through a drying system. The racks completely covered with small herrings subsequently pass through an air blancher which is heated by gas. After cooling, the small herrings or sprats are canned in oil, and the closed cans are then sterilized.

(3) Another method is the French (Toquer) method.

(4) The German method, particularly the original method after Biegler sen., represents a completely new approach to herring processing. This method differs from all previous methods in that the herrings are processed completely boneless. Also, instead of using oil or tomatoes, sauces were added of a quality which is insurpassable in culinary art. Herring fillets are canned in cream of tomato, Mediterranean-wine sauces, cream of paprika, rich cream with horseradish, cream with horseradish, cream of mushroom, beer sauce and in a large variety of other gourmet sauces. This assortment of canned fish products has acquired international fame, and enjoys world-wide popularity. Other products are the smoked and fried herring fillets in special Biegler sauces.

The procedure briefly is this: Immediately after rinsing and washing, the herrings move into the Baader deboning machines, i.e. after the Biegler continuous method, then pass through the blanching equipment, to be packed immediately in sauces into cans which are closed automatically and sterilized in the high-pressure "Rotomat". Sterilization control data must be rigidly adhered to because they determine the juiciness and meatiness of the fish as well as the homogeneity and the flavour of the sauce.

Culinary perfection is possible only by achieving a perfect balance between the fish product and the ingredients of the sauce, and by perfect harmony of the material used for packing and the content.

The basic technological requirements must be closely linked with the development of the production method, be it by means of the continuous principle introduced by Biegler, be it by means of strict rules within the chemical enzymological mechanical habitus within the effects of the agents by heating and coagulation or by microbiological effects and physiological reactions. In mechanization, the *continuous* principle is combined with the natural characteristics of the herring. Mechanized processes include cooling, washing, boning, blanching, steaming, smoking and frying, automatic vacuum-sealing, vacuum-homogenization of sauces, and finally treatment in the high-pressure cooker, and rotation.

MARINADES

Marinading is one of the most interesting methods used in the processing of herring. It was perfected especially in Germany, and originated in home-cooking and in hotels and restaurants. It was discovered long ago that vinegar acts as a preservative, particularly when salt is added.

The bacterioscopic and bacteriostatic effect of the vinegar-salt action can be seen from the "Skelett" figures and the "Pebea" figures (Biegler-system) given below.

In the middle of the 19th Century, small establishments appeared around the Baltic, which at first only marinated salt herring and later on also fresh herring. The marinade, consisting mainly of vinegar and salt, is known to have preservative properties. Marinade also contains spices and sugar. At first, the salt herring, after having been soaked in water, or later on, the fresh herring, were immediately packed in barrels together with a mixture of spices, sugar, and herbs (onions, tarragon, dill, bay-leaves etc.); then vinegar-salt solution was poured over it. After the herrings (round, with oblique nose-cuts, or with grills removed) were fully cured (after approx. 8 - 14 days), they were packed in smaller containers and shipped. Small wooden casks, kegs or wooden buckets were used.

In the 'eighties, production of cold marinades began in the ports along the western Baltic and along the North Sea. The industry did not begin to expand until after 1900. Initially, salmon barrels (capacity 400 liters) were used for curing for many years. Some establishments were already using rectangular wooden vats. Earthenware vats or concrete vats, lined with tiles, were also being used.

When in the 'twenties, however, the production of cold marinades for future consumption became customary, the Pebema method invented by Biegler generally prevailed.

The industry thus progressed from an empirical approach to technological methods, thereby developing a system of manufacturing techniques. In order to assure uniform products with good keeping qualities, Biegler introduced extensive innovation into the manufacture of cold marinades, among them hexammine, sweetening agents, spices, vinegar-salt concentrates, and prophylactic measures. Further to be taken into consideration are the "Pebeatus" and "Stagnatum" infection and numerous other factors.

An important indicator for keeping quality are the Pebea figures established by Biegler and compiled in his Pebeagram (*Allgem. Fischwirtschaftszeitung*, No. 20, 1965).

The Pebea figure ("Skelett" figure) is based on the vinegar and salt contents of the finished marinades:

Pebea figure = % vinegar x % salt

Example:

I.	2.2 x 5.6 = 12.32	(keeping qualities in the tropics) export
II.	*2.0 x 5.0 = 10.0*	(general figure - average storage at 10°C)
III.	1.8 x 4.6 = 8.2	(normal - *cool* storage at 6°C)
IV.	1.6 x 3.8 = 6.0	(*freezer* storage at ± 0°C)

Example

Pebema Bath: 7-8% vinegar
15-18% salt
Ratio: 80-84 kg fish halves
40-36 1 solution

Introduction of the Pebemaro method which is characterized by a special curing method.

A Pebema bath contains the following ingredients:
7- 7.5% vinegar - 70-75 liters vinegar (10%)
15% salt - 15 kg salt with addition of "Vitosan"

Pebea figure -% vinegar times % salt

Fish halves prepared in the above way may be used for mayonnaise and similar sauces as well as for other types of sauces.

The Pebemazett method is based on the "contra principle" of the curing method for round herring.

1% vinegar and 10% salt

(In conjunction with the "Gusto-Enzymo" principle and the "Vitosan" method).

Fish halves prepared in this way may be used for fish tid-bits and fish snacks according to the anchovies method.

Pebea figure - *water content* % x degree of acidity or
salt content % x % salt x % acid

Cold marinades are prepared as follows:

The fish are boned with the Baader boning machine, washed, put through preliminary pickling, weighed, and put down for curing with the aid of the Hoppe and Krooss equipment according to the Pebema method. They are then stored in coolers. Then follows continuous further processing without in-between storing. Machines fill special sauces into the cans, which are then closed by an automatic process. The product is then stored in a cool place.

The Biegler *continuous method* and the Pebeagram established by him were also applied to the production of cooked and fried marinades which became popular at the same time. The pebea figures for the cooked and fried marinades can be shown as follows:

Pebea figure - % vinegar times % salt
in the finished marinade.

Table of Pebea figures (cooked and fried marinades)

Vinegar %	Salt % 4.5	4.0	3.5	3.0
1.7	7.6	6.8	5.9	5.1
1.6	7.2	6.4	5.6	4.8
1.5	6.7	6.0	5.2	4.5
1.4	6.3	5.6	4.9	4.2
1.3	5.8	5.2	4.5	3.9
1.2	5.4	4.8	4.2	3.6

Evaluation of Pebea figures (cooked and fried marinades)

Cooked marinades

Pebea figure	3.0-3.5	3.6-3.9	3.9	3.9-5.1	5.2-6.7
	Medium keeping quality	Limited keeping quality (to be kept cool)	Normal keeping quality (to be kept cool, 1.3% vinegar and 3.0% salt)	Very good keeping quality	Keeping quality suitable for export quality

Fried marinades

Pebea figure	3.9-4.2	4.2-4.9	5.0	5.1-6.0	6.0-7.5
	Low keeping quality (to be kept cool)	Limited keeping quality (to be kept cool)	General figure 1.5% vinegar 3.2% salt, to be kept cool	Good keeping quality (to be kept cool)	Keeping qualities suitable for exports (to be kept cool)

The firm W. Wilkes deserves particular credit for developing the cooking and frying equipment. The requirements of the *continuous method* have been met to perfection. This has made it possible to prepare the finished product without adding any preservatives whatsoever.

The technology of herring processing begins with the slicing or filleting of the fish by the Baader boning equipment. The very nature of machine processing ensures a high degree of cleanliness in this production process.

The following continuous operation system is employed in the production of cooked marinades: The pieces of fish are placed on a wire-mesh conveyor belt in the cooking chamber. The conveyor belt is advanced by chains on both sides. Steam coils on the bottom of the tank or a gas or oil heating unit underneath the cooking tank heat the cooking bath. Control instruments keep the temperature in the cooking bath at a steady 95° C to ensure that no damage is caused by overheating. The fillets are kept in place in the bath by a hold-down arrangement which advances at the speed of the conveyor belt; this prevents the fillets from leaving the belt. The pH value of the cooking bath is kept constant at 3.8-4.0. The sides of the cooking tank are fitted with removable doors to allow cleaning of the tank. After the fish have passed through the cooking bath on the mesh conveyor belt, they proceed to the washing section where they are again subjected to fine jets of water. Then they pass on to the packing line where they are packed by hand in cans, plastic packs, or in glass jars.

Special equipment feeds jelly into the packs which are then closed and transferred to cool storage areas to await shipping.

Before the herring is placed into the frying equipment, it passes through a solution which removes the blood, and through a pickling solution, an accurately proportioned vinegar-salt solution. The total length of the continuous frying equipment (manufactured by W. Wilkes) is approximately 65 feet. Heat is provided by gas or oil. The wire-mesh conveyor belt does not touch the bottom of the tank, but is kept almost an inch off the bottom by an arrangement of scrapers. The temperature in the frying chamber is 185° C. Pure oil, or oil mixed with tallow, bone fats, hard fats etc., is used for frying. Sanitary principles call for a constant changing of the frying fat and for the removal of impurities that accumulate in the fat. Scrapers and suction filters are provided for this purpose. Efficient operation of this machine is possible only with the help of an attached, fan operated system to cool the fried fish. Next follows a work table on which the cooled fried product is packed as quickly as possible. Sauces are then added by machine, and the containers are closed immediately to avoid delays during which the product might be exposed to bacterial contamination. This continuous frying equipment can maintain its important, uniform function only if adequate control devices and recording thermometers are provided.

A fourth type of marinade is the extra-fine marinade. These are marinades using herring halves processed by the Pebemaro method, packed in mayonnaise or salad-cream. These oil-containing sauces are produced in vacuum homogenizing equipment designed by Biegler.

The Pebea figures are calculated from the ratio (2:1) between fish and mayonnaise.

Extra-fine marinades

Pebea figures - % vinegar times % salt plus % fat

All marinades are gastronomically excellent fish products – without claiming classification as foodstuffs produced for future consumption. The exception is herring produced for storage purposes according to the Pebema, Pebemaro, or the Pebemazett methods. But if herring produced according to these methods is packed in cans or any other packs, they must be labelled: "Keep in a cool place. For immediate consumption!"

Deep-frozen herring

The last method of preserving herring, applied to *round or filleted herring,* is *deep-freezing.* Keeping time, however, is limited, depending on the herring's fat content, and does not exceed 6-9 months. Deep-frozen herring is subject to the danger of turning oily fairly soon. This would quickly deprive it of its quality. It must be stored at temperatures around minus 30° C.

Contact freezing has been found especially suitable for herring. This method consists of placing the fish in contact with low-temperature surfaces. The method is used to freeze both unpackaged and packaged fillets and round fish. Freezing equipment comes equipped with cells or plates; its structural design provides further distinctions. Basically, it can be built for step-by-step or for continuous operation. The contact surfaces of the equipment are cooled either by direct evaporation of the coolant, or by brine.

The Protan method is especially suitable for fat herring. In this method, herring or herring fillets are dipped into alginate solution which contains certain salts and lactic acid; the herring is then placed in boxes or similar containers, covered with solution, and frozen in multi-plate freezers. The alginates form a jelly and cover the frozen fish with a film, which prevents an oxidizing and drying-out of the fish.

When heated to approximately -6° to -8° C, the fillets can easily be separated without having to be thawed first. The firm Nordischer Maschinenbau, Lubeck, is now selling equipment for thawing the fillets which is being successfully used. This makes it possible to use even herring fillets frozen for many months for further processing into marinades and canned products. Frozen round herring is suitable also for producing kippered herring.

By way of conclusion, we should think of the aspects and perspectives which in future will have an important bearing on herring processing at sea. It is clear that in one way or another the technology used will be a continuation of the disciplines we have just discussed.

The Utilization of Herring for Pet Food

By

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The Canadian market provides a yardstick for the assessment of the opportunities for the utilization of herring in pet foods, both at home and abroad.

THE MARKET (1)

In 1965 the total Canadian pet food volume was slightly in excess of 202,000,000 pounds, representing a consumer sales volume of $32,000,000. This volume includes the following categories.

1. Canned Dog Food
2. Canned Cat Food – Maintenance & Luxury Type
3. Dry Dog Food
4. Semi-Moist Dog Food
5. Dry Cat Food

The volume of dog food in 1965 was in excess of 155,000,000 pounds compared to 47,500,000 pounds of cat food. Within the dog food category canned dog food accounts for 78% of the total pound volume with dry dog foods accounting for virtually all the remainder. The newer semi-moist products are, as yet, a relatively small percentage of the total.

Canned maintenance cat foods account for about 92% of the total (43,700,000 pounds) with dry cat food and luxury cat foods (as typified by the salmon cans) each contributing 4%.

The Canadian pet food industry has been recording strong volume growth with 1965 showing about 7% in pounds and 10% in dollars over 1964. It is anticipated that volume will continue to increase over the next five years and the dollar volume growth will continue with the acceptance of the "new concepts" such as luxury cat food, dry cat food, semi-moist dog food, to mention a few.

While the export of pet foods is in its infancy we should not lose sight of the potential available in the United Kingdom and European Common Market. In both areas the market is strong and warrants careful consideration. The volume potential dwarfs the Canadian figures.

HERRING

While it is true that meat and meat by-products are the major components of canned dog foods, it is likely that fish will play an increasingly important part in formulation. The rising cost of meat and meat by-products will force manufacturers to consider fish and the advantages offered by herring are numerous. In canned cat foods, herring is the principal ingredient. Selection of herring as a canned pet food ingredient may be attributed to the following factors.

(1) *Palatability* – Fresh or frozen herring based pet foods provide a degree of acceptability, particularly with cats, that is difficult to surpass. Good acceptability is the first prerequisite in the development of any pet food and herring based cat foods provide a standard of excellence in the trade.

(2) *Size* – The size of herring throughout the life span (7½"-8" at two years to 12½"-13½" at nine years) provides optimum bone size that completely softens with normal retort cycles.

(3) *Analyses* – While analyses reflect seasonal variation the herring taken in any month in a given area

are reasonably uniform. The following figures represent several hundred analyses of Atlantic herring.

Protein –	16.0% Av. (13.5%-18.0%)
Oil –	8.0% Av. (3.0%-18.0%)
Calcium –	.43% Av.
Phosphorous –	.42% Av.
Salt (Na. Cl.) –	.71% Av.
Moisture –	72.3% Av. (65%-79%)
pH –	6.34 Av.
Vitamin A (Herring Oil) –	33,000 i.u./lb.

(4) *Otoliths* – otoliths of herring are very small and do not require extraction before processing in order to provide a safe product. In larger species this bone must be removed with expensive equipment in processing.

(5) *Storage Life* – The low pH of herring contributes to stability in a frozen state. Many of the bottom feeding fish show a higher pH and relatively short frozen storage life.

(6) *Thiaminase(s)* – The thiaminase(s) present in herring are relatively heat stable and at temperatures beyond 170°F rapid destruction of thiamine occurs. Deficiencis must be overcome by supplementation of maintenance canned products with Vitamin B1.

HERRING MEAL

Fish Meals are an important pet food ingredient and the quality factor is the prime consideration. While Canadian fish meals enjoy an enviable reputation both at home and abroad, there is room for improvement in the industry. Research dollars spent on quality improvements should show handsome dividends.

With the antioxidants and processing knowledge available today the derogatory factors such as objectionable odour, excessive fat acidity and poor palatability should be no problem.

Bland, mild fish meals processed to provide a maximum level of digestible protein will find increasing acceptance both in Canada and the export markets.

Increasing emphasis is being given to protein quality. A minimum of 92% pepsin digestible protein is considered a reasonable standard. While low fat (below 5%) fish meals are most attractive it should be possible to obtain stable fish meals at higher fat levels that have similar acceptability patterns.

Herring meals present an opportunity to the industry to meet the quality requirements of the pet food manufacturers. As new concepts and techniques are applied to dry pet foods, there will be a continuing demand for improved ingredients. The fish meal industry should be able to meet this challenge and there is no question that products that meet the needs or fit the concept will command a premium in the market.

THE CHALLENGE

The current usage of herring in the pet food industry represents a small fraction of the total Atlantic tonnage. However, the pet food potential for the utilization of herring and herring meals is sizeable.

Quality standards in the pet food industry are in most respects similar to foods for human consumption. Customers are particular about the food that is fed to pets and the presence of trash of any kind is not acceptable. Care must be exercised from the time fish are caught until canning to prevent contamination of any kind. The condition of box cars assigned for the movement of frozen fish is particularly important. Every car should be carefully inspected before loading to make sure that floors and side walls are clean and in sound condition. Wood chips are by far the source of most canned cat food complaints and present a difficult removal problem in processing.

Research in pet foods is continuing at a rapid pace and there is evidence that consumers are willing to pay for quality products with convenience features. Dry cat foods, luxury type dog and cat foods and semi-moist dog foods are typical of recent developments. Many of the products bear a close resemblance to human consumption foods and no doubt some of the concepts applied to pet food will be followed by the food industry. At the same time new concepts in human foods will be carefully screened for possible application to the pet food field.

The extent of the utilization of herring and herring meal in pet foods will depend to a large extent on co-operative research and development between our industries.

SESSION 4

DISCUSSION

During the fourth session the Honourable H.J. Robichaud, Minister of Fisheries of Canada, invited to address the participants, remarked that this was the first conference of its kind to be held in the Atlantic provinces, but he recalled that the first Federal-Provincial Conference on Fisheries was held in Ottawa in January 1964. He said: "For many years, probably for the last decade, we had been told that there was, if I can use the expression, misunderstanding between the governments of the different provinces and Ottawa, and one of the first decisions which I had to take after assuming the responsibilities of the administration of the Department of Fisheries was to find out if really there was such a minunderstanding. However, I can assure you that as a result of that conference, we laid the basis for really good understanding between the provinces andOttawa, so far as fisheries are concerned.

"Early this year, in Montreal, we had the first Canadian Atlantic Fishing Vessel Conference, which, as you all know, was a tremendous success and I am impressed, since arriving in Fredericton an hour or so ago, to learn that this one, the Canadian Atlantic Herring Fishery Conference, like the vessel conference sponsored by the Federal-Provincial Atlantic Fisheries Committee, is also a tremendous success. We all together understand the objectives of this conference, to draw together the owners and operators of herring catching vessels and processing plants, biologists and technologists specializing in the behaviour, finding and catching of herring. I want to take this opportunity to assure each and every one of you that the Federal Department of Fisheries is giving its full support to the development of the herring fishery, both inshore and deepsea, here in the Atlantic provinces and on the Pacific coast. It might be a coincidence that only a week or two ago Parliament approved the Fisheries Development Act. It is the first legislation of this kind introduced by the Federal Government, and I think that it is time to have an Act giving the Minister of Fisheries certain authority in order to join with the provinces, with the industry, even with individual fishermen, for the development of our fisheries. We recognize the importance of the herring fisheries to the industry.

"There may be at present more concern for the processing of herring as fish meal, but with the increased demand for protein food, I think we are approaching the time where we will have to give much more attention and consideration to the processing of herring for human consumption, and in this regard I want to assure you of the full co-operation of the Fisheries Research Board of Canada. As most of you know, you may have been told at the opening of this Conference, we will be launching, in July, a new research vessel for operation off the Atlantic coast. It will be stationed at St. Andrews and one of its assignments will be research into the herring fisheries. I am hoping that with the co-operation of the industry and the departments concerned with fisheries of the different provinces, and with the co-operation that we are prepared to give from Ottawa, there is a bright future ahead of us in the development of this fishery."

In response to a question about herring as food for lobsters, Dr. D.R. Idler said: "Herring is frequently fed to common lobsters. We have carried out some studies at Halifax on herring as a sole source of food for lobster. The lobsters were brought in and held in tanks in the laboratory. One group was starved and the other group was fed herring as the sole food source, and for a while, a matter of a few weeks, the group being fed herring did do better than the group which was being starved, as measured by the number of blood cells and also the blood protein levels which have been correlated to the indexes of the nutritional status of the lobster, but within a few weeks they had fallen considerably and when the herring diet was supplemented with beef liver the blood counts rose rapidly and the blood protein levels did also. It is not to *say that herring couldn't be used, but certainly I think it should be investigated further, before it was considered as a sole source of food."*

Mr. Garth R. McKenzie, Fredericton, N.B.: "My question is to Dr. Weinberg. You didn't have sufficient time to read all parts of your paper and one of the missed parts was on page 13, where you said 'In all West Coast plants herring meal is today packed in multi-ply paper bags with a polyethylene lining. These bags are fairly airtight and prevent oxidation of the fat, and thus heating of the meal.' My question is, over and above this oxidation prevention benefit, would you say this type of container has qualities which allow the meal to arrive in a better or more valuable condition at the end user's plant as compared to the cheap bag which, until recently, has been used almost exclusively on the Atlantic coast?"

Dr. B. Weinberg: "Actually, probably Dr. Tarr is much better qualified to answer this question. The fact is that on the West Coast I haven't seen jute bags used any more, and there has been the problem of the heating of the meal where the fat content, about eight per cent plus, was responsible for this heating. Now they get the meal off at a relatively low temperature and when it is packed in bags, apparently there is no need to add antioxidants if you pack it in the four-ply paper bag with polyethylene lining and the air is fairly well excluded, so that the oxidation at that temperature is reduced to such an extent that there's no heating going on under practical conditions of storage, and this meal retains its full quality of digestibility by the time it reaches the consumer."

There was some discussion of the costs referred to in Dr. Weinberg's paper, and the manner in which they were arrived at. Mr. Homer Stevens then said that it had been interesting to find a table of the costs and revenue in terms of the reduction of herring, but he found himself very much in agreement with the statement made by the Minister of Fisheries that perhaps there should be more emphasis on the utilization of herring for food purposes. He wondered if anyone could provide an over-all outline of the costs and revenue in terms of processing herring for human consumption.

Dr. Weinberg: "I would fully agree and I should say, also, that our Department (Industry) probably looks at the fish reduction business as, in a sense, a necessary evil. We would very much prefer to see herring made available for human consumption and we are working actively to see what the possibilities are and, optimistically, for fish protein concentrate, but Dr. Needler and other gentlemen here are much more aware of the difficulties of selling let's say 250,000 tons of herring from the East Coast, plus 250,000 to 500,000 tons or more from the West Coast for human consumption anywhere."

Mr. Stevens: "I am in agreement that it may be a necessary evil, but my question was, and I don't know, perhaps Dr. Baasch or someone else might be able to get some information, as to the actual values of herring processed for human consumption and the costs involved in that type of processing."

Dr. Hans Baasch: "I don't know how informative this will be – I can just give you a few figures. A kilogram of herring to the German manufacturer costs between 7¢ and 10¢. The kilogram is 2.2 lb. Now, only 50 per cent of this is used so the actual sales price for 1 kilogram, which takes, of course, two kilograms, is between three and six marks. For a kilogram, that is between 80¢ and $1.60. This, of course, depends on the wage situation in Germany – it is different from that in Canada – and on various other things, machinery, etc. The turnover of the German fishing industry is a little over $110 million a year.

Mr. Richard I. Nelson, Vancouver, B.C.: "For the benefit of the conference we could explain our west coast experience in canning herring. Our company has canned herring for quite a few *years; we canned a lot during the war. Since the war we've had very poor success in marketing our canned herring in Canada, mainly because it's impossible for us to produce a product at a low enough cost to compete with our competitors on the east coast and in other countries. On a limited scale the cost of the containers and the cost of our labour in British Columbia and the cost of the tomato puree on top of the fish just makes it impossible to produce a can at a price that can be sold in Canada. We've also investigated different ways to do it in some mechanized bulk way, canned in the most inexpensive containers we can find without the addition of any other material that would add to the cost, and we still find that we come up against a blank wall in that the cost of production is more than we can sell it for. As I say, that is our experience in British Columbia on the canned herring. We certainly hope that conditions will improve and that we can finally process all our herring in some form for human consumption, but for the present time it doesn't seem to be feasible."*

Dr. Baasch was asked what was the minimum fat content in herring which the German market uses for the operation that he spoke of, and also if frozen herring lends itself to this type of operation.

Dr. Baasch: "Aside from other factors, herring should not be too large. The minimum fat content is generally eight per cent. As to freezing, the manufacturers themselves do not freeze, but to an increasing extent the fisheries themselves freeze herring and deliver it in the dry periods to the manufacturers, and they can manufacture with frozen products, too."

A question from the floor asked for further elaboration on the subject of processing herring for human consumption, in terms of the volume used for this purpose, the marketing of the product, etc., in Germany, Canada and other countries.

Dr. Tarr, answering the question, said: "Our station, over the years, has done a lot of work on herring by-products. From the time I joined the station in 1938 and even before that, on to the present time, a lot of experimental work has been done, some with the industry. As Mr. Dick Nelson was saying, it's very regrettable that when these things have been done in the industry, and the industry has struggled to make some sort of profit they have always failed. A typical example was the production by B.C. Packers of what I consider just as good or perhaps better kipper snacks than were produced elsewhere. They had quite a good product. This was produced for something like 15 years and finally taken off the market, presumably because they didn't make a go of it. It's a curious economic situation. Certainly I don't think it would be at all possible for the amount of herring that we put in herring meal presently, to go in production as a human food; even if a small fraction of it went that way it would be a good thing. I would like to see it and most of our research people would like to see it, but the situation is a very peculiar and difficult one. We have not the continental population, we have not the continental liking for these specialty products, unfortunately. There are a few people who like them, but this is the difficulty."

Mr. Don Millerd, Vancouver, B.C.: "I might just mention another thing that on our coast, at one time previous to the war, a total of 50,000 tons of herring was dry salted and the vast majority of this went to Mainland China. There is no longer any dry salt herring done in British Columbia. That is, this year. There was a little done last year – we did a little that went to Hong Kong, but the main market was Mainland China and this is now dried up."

Session 5 May 7, 1966 – 9.00 a.m.

Current Canadian Developments in the Herring Industry of the Atlantic Coast

Current Canadian Developments in the Herring Industry of the Atlantic Coast


Mr. McArthur

by
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Mr. Sametz

(Note: In the absence of Mr. McArthur, This paper was read by Z.W. Sametz, Director, Regional Development, Economics Service, Department of Fisheries of Canada, who explained that it was an attempt to set up a direct confrontation between the three elements of the situation, firstly the resource stocks, secondly the marketing possibilities and thirdly, the industry production plans as summarized by the individual provinces. Mr. Sametz said it was felt that this confrontation was necessary to a rational public and private investment policy. He added: "What is happening today is a revolution when considered against the long history of the herring fishery of the Atlantic Area".)

The basic material for this paper, "Current Canadian Developments in the Herring Industry of the Atlantic Coast", has been derived from two sources. First, contributions were received from the Deputy Ministers of the five provincial Departments of Fisheries summarizing their appraisal of current developments in each province and secondly, from a study carried out by Mr. Carl Mitchell of the Economics Service of the Department of Fisheries.

If there is one word which would summarize current developments in the herring industry of this coast that word is "*revolution*". This, I think, is apparent from the very fact that this Conference has been called and the discussions which have already taken place. What is happening today represents a revolution when considered against the long history of the herring fishery of the area.

The beginnings of this new emphasis on the potential of the herring industry began less than two years ago. The existence of large herring resources in the area has been well known for many years. Although attempts have been made to stimulate development in the fishery from time to time, generally speaking, there was little or no response from the fishing industry. Developments which are now taking place appear to arise from the simultaneous emergence of several favourable factors: (1) emphasis which is being directed to the world food and population problem; (2) the desire of all governments to stimulate economic activity; (3) the availability of adequate investment capital and (4) the apparent opportunity for profitable investment in this branch of the industry.

About a year ago Mr. Hart of the Industrial Development Service of the Department visited each of the five provincial capitals. He discussed with fishery officials the probable trend of fishery development over the next 10 years. Specifically, he sought the opinions of the Deputy Ministers and their staffs regarding trends in catches of the major species as well as estimates of the manpower, plant and equipment which would be needed to catch and process the estimated production. Detailed estimates were made for 1968 and 1975.

It should be borne in mind that the estimates to which I will refer were made more than a year ago. The situation at that time was less clear than it is today. It should also be borne in mind that each provincial estimate was made independently of estimates made for other provinces. In view of the known total catch of 312 million pounds of herring for the year 1964 one is somewhat startled to find that the estimated total herring catch for 1968 was just over 1 billion pounds and for 1975 approximately 2 billion pounds. Achievement of catches of this magnitude would mean a three fold increase between 1965 and 1968 and a 6 or 7 fold increase between 1965 and 1975.

These estimates were reviewed briefly at the Federal-Provincial Atlantic Fisheries Committee meeting in September last. The consensus of the representatives of the provinces at that time was that the estimates were, if anything, on the conservative side.

The most optimistic of the provinces has been Nova Scotia where increase in catch from 143 million pounds in 1965 to 500 million pounds in 1968 and to 1 billion pounds in 1975 was suggested. In support of these estimates Mr. Meagher points to a substantial increase now taking place in the offshore herring fleet with some 20 purse seiners and converted draggers and trawlers in sight for 1966 and 1967. It is pointed out that plant capacity is also being expanded rapidly in Nova Scotia and will soon reach 3,000 tons of raw fish per day. Mr. Meagher also expresses the view that although most of the increased catch will be reduced into meal some increase in food herring production can be anticipated.

For Newfoundland the percentage increase in catch suggested is also very great, that is, from 28 million pounds in 1965 to 190 million pounds in 1968 and 210 million pounds in 1975. Mr.Gosse has indicated that the initial seining operations have been very successful with the catch exceeding 15,000 tons during the 1965–66 winter fishery. A further expansion of the fleet is anticipated in the near future. Mr. Gosse also points out that two additional plants are planning to engage in production of herring meal. It should be noted that the Newfoundland catch of herring during and just after World War II was at a very high level.

For Quebec the projected catch for 1968 is placed at 100 million pounds and for 1975–150 million pounds. These estimates compare with a 1965 catch of 46 million pounds. Dr. Jean anticipates an increase in the trawler-seiner fleet from 3 to 12 vessels although he anticipates a reduction in the number of gill-netters. It is anticipated that the number of meal plants will increase from 1 to 3. The number of plants producing canned and fresh and frozen herring products is also expected to increase. Some decline in bloater production is suggested but an increase is expected in the output of pickled herring. These changes will require substantial capital investment both for vessels and plant facilities.

Herring catches in Prince Edward Island have been small relative to the other provinces. In 1965 the catch was 4.5 million pounds. Modest increases to 6 million pounds in 1968 and 10 million pounds in 1975 are suggested. This year it is proposed to study the feasibility of seining operations.

New Brunswick has been the major producer of herring for many years and landings of 182 million pounds in 1965 represented 45 per cent of the total for the five provinces. For this province the suggested increases are to 300 million pounds in 1968 and 650 million pounds by 1975. Over the period 1965 to 1975 Mr. Chenard predicts an increase in inshore seiners from 23 to 60 and of offshore seiners from 5 to 46. At the same time some increase in inshore gill-netters is forecast although a decrease in weirs is anticipated. During this same period it is suggested that the number of meal plants will increase from 6 to 18; canning plants from 15 to 18 and fresh and frozen plants from 8 to 12. A decline from 88 to 60 is suggested for smoking plants. Much of fleet expansion suggested above is being financed by the New Brunswick Fishermen's Loan Board.

The realization of catches of the magnitude suggested by the provincial Deputies will depend on:

(1) the stock of fish in accessible waters and

(2) continued opportunities for profitable exploitation by industry.

The question of available stocks of fish I leave to Dr. Tibbo. He has suggested to me that while definite quantitative figures are most difficult he believes a total figure of the order of 1 billion pounds by 1975 would perhaps be more realistic than the 2 billion pound total of the provincial estimates. Dr. Tibbo is inclined to support the estimates made by Quebec, Newfoundland and Prince Edward Island from the point of view of resource availability. However, he expresses some doubt regarding the physical possibility of achieving the long-term objectives set for Nova Scotia and New Brunswick.

With respect to the opportunities for profitable exploitation by industry either for food or meal production this will depend on a number of economic factors. These include: (1) the strength of the markets to absorb the additional products without serious price reaction; (2) the capital cost of the necessary vessels and other facilities to increase the catch substantially; (3) the capital cost of processing facilities and (4) the trend of operating costs per ton of fish caught.

It appears that while an increase in production of food products is probable in the long run the great bulk of the increased utilization of herring in the immediate future will be for reduction into meal and oil. I shall therefore concern myself mainly with the economics of the meal situation as we see it. As I have indicated the Economics Service of the Department has carried out a fairly comprehensive study of the current and short-term future meal situation both for Canada and the world.

The trend of world production and consumption of fish meal over the past 10 years is I am sure well known to everyone here. The spectacular increase in production by Peru has dominated the picture. We all recall the temporary collapse of the meal market in 1959 and 1960 and the concern expressed at the time over the future of the industry. Fortunately, market demand showed remarkable strength and within a matter of months the world price was restored to economic levels.

World production of meal continued to increase up to 1964 when it reached 4,092 thousand tons. Some decrease appears to have taken place in 1965 due to a decrease in Peruvian output, but towards the end of the year Peruvian production again reached record levels. The hesitation in production early in 1965 was reflected in higher world prices. There is little doubt that, despite what may happen in Canada, the overriding influence in the world fish meal picture for the short-term future will depend on Peru and perhaps to a lesser extent Chile where production has been increasing sharply.

High prices of meal will continue to induce greater production efforts by all producing countries. At the same time high prices, relative to substitutable sources of protein, may also tend to reduce the proportionate use of fish meal in feeding rations. The interaction of these two factors could lead to a levelling off or even some reduction in fish meal prices.

In Canada, and particularly for the Atlantic coast provinces, the effect of the new interest in herring meal production is just beginning to be reflected in statistical data. In 1965 the output of herring meal on the Atlantic coast doubled from 6,000 tons to over 12,000 tons. At the same time the output of groundfish meal also increased substantially so that the overall output of meal increased to 56,500 tons bringing the Canadian total including the Pacific coast to 96,600 tons. As has been pointed out by the provincial Deputies, a rapid expansion in both catching and processing facilities is currently taking place. Undoubtedly meal production will reach record levels in 1966 and will continue to move upward.

Looking ahead for the next 5 years, that is, to 1970, our economists see a generally favourable demand picture based on both domestic and export prospects. The export prospects will, of course, be most important as Canada has for many years been a net exporter of meal. It is encouraging, however, to note that domestic retention of fish meal did increase significantly in 1965. Most of Canada's export of meal goes to the United States with lesser amounts to the United Kingdom. Increased demand in both of these markets appears probable.

Based on current investment trends in the herring reduction industry and market prospects our economists suggest an increase of 15 per cent per year over the next five years may be expected. This would result in output for the Atlantic area of about 110,000 tons by 1970. Since most of this increase will come from herring rather than groundfish this will require over 400,000 tons of raw herring by 1970.

In my remarks regarding fish meal I have drawn heavily on a report prepared by Mr. Carl Mitchell of our Economics staff.

The Canadian Fish Meal Industry 1958-1964: Short Term Prospects with Particular Reference to the Herring

by
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(Note: This is the Background Report referred to in the final paragraph of the preceding paper, "Current Canadian Developments in the Herring Industry on the Atlantic Coast".)

I. ECONOMIC ASPECTS OF FISH REDUCTION

Fish reduction is an important part of the fishing industry in many countries. Three main products are produced from this process, viz. fish meal, solubles, and fish oil. The first two products, i.e. fish meal and solubles, will be referred to throughout this paper as fish meal which is the most important product produced; fish oil being essentially a by-product. For this reason in the analysis to follow emphasis will be placed primarily on the economic factors influencing fish meal production.[1] This analysis will take into consideration the properties and uses of fish meal, the reduction process, and the factors influencing its demand and supply.

Properties and Use of Fish Meal

Fish meals are rich in protein and other nutrients. "Properly processed fish meals are one of the main sources of high quality protein. They also supply important quantities of phosphorous, vitamin B_{12}, niacin, choline, other minerals and vitamins, and unidentified "fish factor".[2] Despite these properties fish meals at present are not accepted generally for human consumption but are utilized mainly as an ingredient in the preparation of balanced feeds for livestock, particularly poultry and swine.[3] In this respect however, although fish meals are richer in essential nutrients than most of the other ingredients of balanced livestock feeds, they are not exclusive sources of these nutrients, which can be obtained from other meals, such as vegetable and animal meals (Table I).

The foregoing considerations have marked economic significance in relation to their implications with respect to the demand for fish meal. A discussion of these implications follows later in this analysis.

The Reduction Process

Fish reduction into meal and oil is accomplished mainly by mechanical processes. The meal processing

[1] The economic factors influencing the production of fish oil as a by-product or joint of fish meal production are also of some significance but these will not be discussed in any great detail.

[2] Combs, E.F. "Nutritional Aspects of Importance in the analysis of the Market for Fish Meal", F.A.O. International Meeting on Fish Meal, 1961.p.1.

[3] Fish oils which are primary sources of vitamins A and D are utilized for both human and livestock consumption; they are used in the production of margarine and shortening and for industrial purposes.

TABLE 1

Approximate Composition of Selected Feed Ingredients Employed in the Production of Balanced Feeds

Ingredient	Ribo-flavin mg./lb.	Panto-thenic Acid mg./lb.	Niacin mg./lb.	Choline Equiva-lents* mg./lb.	Vitamin A Activity I.U./lb.	Methi-onine $%	Cystine %	Lysine %
Soybean oil meal (44% protein) ..	1.30	6.0	12.0	1200	–	0.62	0.66	2.90
Soybean oil meal (50% protein) ..	1.20	6.0	9.5	1300	–	0.71	0.78	3.30
Corn gluten meal	0.70	4.5	20.0	150	2900	1.00	0.60	0.70
Meat meal	1.50	1.8	21.0	750	–	0.65	0.64	3.40
Fish meal	4.00	3.0	30.0	700	–	1.80	1.10	5.50
Blood meal	0.70	0.5	14.0	300	–	1.00	1.50	7.60
Feather meal (hydrolyzed)	0.80	3.5	8.0	400	–	0.52	2.30	1.50
Distillers dried solubles (corn)..	8.00	10.0	54.0	2200	–	0.48	0.32	1.20
Dried whey	12.00	20.0	5.0	900	–	0.15	0.31	0.90
Dried buttermilk...............	12.00	13.0	4.0	550	–	0.74	0.40	2.20
Dehydrated alfalfa meal	6.5	13.5	14.0	2000	66000	0.29	0.40	0.90

* Includes total choline, plus betaine hydrochloride divided by 1.26

Source: *Poultry Feed Formulas, 1964*, Dept. of Poultry Science, Ontario Agricultural College, Ontario Dept. of Agriculture, Table 2.

industry is essentially resource-based dependent on ample supplies of low-priced raw materials, either whole fish or fish wastes including offal.[1] These materials determine to a great extent the type of plant, the processes employed, and the products produced.

The industrial aspects involve heavy investment in plant and equipment and the type of plant required depends on whether low-oil content or high-oil content fish are to be reduced. However, there are some plants which are equipped for both low and high-oil content fish. There are four basic operations in the processing of low-oil content fish, namely groundfish. There are: disintegration of raw materials; cooking; drying; and grinding. For the reduction of high-oil content fish such as herring, the fish is first cooked and pressed mechanically and a liquid containing some water and oil is extracted. The pressed material, the presscake, is then dried to produce the meal. The liquid, containing water and oil, extracted from pressing is passed through a separator where most of the oil is retrieved. The remaining liquid, "stickwater", which contains mainly water but also small quantities of solids and oil, is put through a further evaporating process to remove the water and is sometimes re-introduced into the drier with the presscake to increase the yield of meal.

The Demand for Fish Meal

Since fish meal is used primarily as an ingredient in the production of balanced livestock feeds the demand for fish meal will depend on the demand for these feeds which originates from their use in certain types of livestock production. As such this demand is related to the standards of living as reflected in the composition of the human diet and the development taking place in agriculture. This limits the demand for fish meal mainly to the highly developed countries of the world with progressive agricultural sectors, where balanced livestock feeds are widely used.

Specific factors relating to the demand for fish meal, however, all relate to its suitability and efficiency as an ingredient in the production of balanced feeds in comparison to the other ingredients used. These factors are: (a) present and expected prices;

[1] "Fish meal produced from whole fish has often been thought to be of higher quality than that produced from filleting and canning wastes; but evidence indicates that many meals produced from such wastes – including whitefish, redish, mackerel and herring types – are equally high in protein quality as those produced from whole fish, though usually of lower protein content". Dusterhout, L.E. and Snyder, D.E. "Effects of Processing in the nutrivite value of Fish Products in Animal Nutrition". *Fish in Nutrition*, F.A.O. International Congress, Washington, D.C., 1961, p. 304.

(b) the composition and regularity of supply; and (c) institutional factors. These institutional factors (c), which will not be treated in any detail, refer to the different regulations governing the production, quality and use of fish meals in various countries.

(a) *Present and Expected Prices:–* Prices are the most important factor affecting changes in output of fish meal. The two aspects of prices are the prices for fish meal in relation to its cost of production and the prices of the meal in comparison to the prices of competing nutrients. The price criterion for using fish meal has been pointed out by Peterson as follows: "when fish meal can supply certain necessary components in a balanced feed cheaper than by the use of other feedstuffs, minerals and synthetics, then it will be economically advantageous to use fish meal to fill these requirements."[1] Prof. Allen also pointed out that the long term use of fish meal in animal feeds must be justified primarily on its known contribution in relation to its cost.[2]

The most important competitors of fish meal are vegetable and meat meals. At the F.A.O. conference in 1961 it was pointed out that at given relative prices fish meal faces far greater competition from high protein vegetable feeds than it did years ago, especially from soy bean, and from meat meal which should be regarded as a close substitute for fish meal. It is indeed paradoxical that increased livestock production, which would increase the demand for fish meal, will also improve the competitive position of meat meal in the future.

Essentially it seems that the price elasticity of demand for fish meal is high; especially at price levels which are above those of alternative nutrients on a comparative basis, i.e. per protein unit. In other words, since the ingredients used in the mix can be varied depending on their supplies and prices, high prices of fish meal in relation to the prices of other ingredients would lead to a reduction in the quantities of fish meal used in production and lower prices will exert the opposite effect. These results might not be instantaneous since, as Allen points out, for various reasons there is a lag in the response of buyers to price change.[3] However, their effects on the industry should never be underestimated.

(b) *The Consistency of the Product and Regularity of Supply:–* Consistency in the composition of a feed and regularity of supply are important factors in making decisions on its use in the production of balanced feeds. Regularity of supply insures the meeting of production schedules, and consistency in the composition of the feed facilitates mixing and the production process. Here again, the decision to use fish meal will depend to a great extent on how well it would meet these two requirements in comparison to other alternative feeds. For this reason, it is important in the fish meal industry that high and exacting standards of quality be met and maintained.

Supply Factors

The supply of fish meal and oil is directly related to the supply of fish, the nature of the fishery, and fish prices. There, as is the case with demand, the prices and supply of alternative vegetable and animal feeds exert considerable influence on the quantities of fish meal that would be produced. If, for example, some feeds such as soybean meal were in short supply, balanced feed producers would increase their take of fish meal, which would result in higher prices and increased fish meal production. The opposite effect, lower prices and decreased fish meal production, could result if there was an over supply of soybean meal. The essential point is that the many forces affecting the demand for and supply of fish meal are interrelated and should be taken into consideration.

The supply of Fish and the Nature of the Fishery

The importance of steady supplies and consistency in the composition of fish meals to the fish meal industry was pointed out earlier in this analysis. This however, is often impossible because of the variability in fish catches. Due to ecological and climatic conditions the supply of fish and the species caught are highly variable, even on a seasonal basis. These

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[1] Peterson's "Fish Meal Production and Trade in the World", F.A.O. International Meeting on Fish Meal, Rome, Feb. 1, 1961, p. 3

[2] Allen G.R., "The World Outlook for Fish Meal", F.A.O. International meeting on Fish Meal, Rome, Feb, 1, 1961, p. 1.

[3] Ibid. p. 6.

variations bear upon the disposition of the catch, thus affecting the supply of fish and offal for reduction purposes and the inherent composition of the fish meal produced.

Competing Uses for the Catch and Fish Prices

There are many competing demands for the use of whole fish, which are reflected in prices paid to fishermen for the different species caught. Fluctuations in prices for different uses can affect the quantities of whole fish which will be available for reduction purposes.[1] This is extremely important since the establishment of fish reduction plants pre-supposes an adequate and cheap supply of fish. However, while prices for fish used for reduction may reflect generally prices paid for fish in other uses, when reduction becomes the major use supplies are often purchased in bulk at less than average prices.

II. WORLD PRODUCTION FISH MEAL AND OIL 1958-1964

Due to increasing fishing effort in many countries the world catch of fish increased from 36.1 million tons in 1958 to 56.7 million tons in 1964; an increase of 57 per cent at an average rate of growth of 8 per cent a year.[2] (Table 2)

The largest proportion of the world's catch was marketed for human use, which increased by 27 per cent during the period. The most significant change, however, was the increasing proportions of the catch which were utilized for reduction purposes. In 1958, four million seven hundred thousand tons of fish, or 13.2 per cent of the world's catch, were used for eduction purposes. In the following years, the quantities used increased rapidly, with the exception of 1962 and 1963, to 16.9 million tons which accounted for 28 per cent of the world's catch.

World Production of Fish meal and Oil 1958-1964

As a result of the increased quantities of fish used in the production of fish meal and oil,[3] world production of these two products more than doubled during the period (Table 3.).

Table 2. World Catch and Disposition - 1958-1964

	1958	1959	1960	1961	1962	1963	1964
			(In millions of short tons)				
Total World Catch	36.1	39.9	43.5	47.2	50.9	52.1	56.7
(index)	(100)	(111)	(120)	(131)	(141)	(144)	(157)
For Human Consumption	30.3	31.9	34.0	35.4	36.6	37.8	38.7
(index)	(100)	(105)	(112)	(117)	(121)	(124)	(127)
Marketing fresh	16.0	16.9	17.9	18.1	18.6	18.8	19.1
(index)	(100)	(106)	(112)	(114)	(116)	(118)	(120)
Freezing, Curing & Canning	14.3	15.0	16.1	17.3	18.0	19.0	19.6
(index)	(100)	(105)	(112)	(121)	(126)	(133)	(137)
For Other Purposes	5.8	8.0	9.5	11.8	14.3	14.3	18.0
Reduction[a]	4.7	6.9	8.4	10.7	13.2	13.2	16.9
(index)	(100)	(147)	(179)	(228)	(281)	(281)	(360)
Miscellaneous	1.1	1.1	1.1	1.1	1.1	1.1	1.1
(index)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

a Only whole fish destined for the manufacture of oils and meals is included. Raw material for reduction derived from fish primarily destined for marketing fresh, freezing, curing, canning and miscellaneous purposes is excluded; such waste quantities are included under the other disposition channels.

Source: F.A.O. *Yearbook of Fishery Statistics*, Vol. 19, 1964.

[1] This is not the case with offal which has a market price only for reduction purposes. In fact, some fishermen and fish processing companies, under certain circumstances, may sometimes pay for its disposal.

[2] In comparison, The average annual rate of growth in the five years previous to this, 1964-1958, was around 4 per cent.

[3] Fish oil throughout this paper refers to fish body oils only.

Table 3. World Production of Fish Meal and Oil 1958-1964

	1958	1961	1962	1963	1964
		(Thousands of Short Tons)			
Fish Meal					
White Fish	451	594	652	575	690
Oily Fish	1,133	2,222	2,601	2,685	3,402
(a) Herring (Est.)	271	323	346	383	498
(b) Other	862	1,899	2,255	2,302	2,904
TOTAL	1,584	2,816	3,253	3,260	4,092
Fish Oil					
Herring (Est.)	91	151	181	171	247
Other	224	440	486	423	523
TOTAL	315	591	667	594	770

Source: F.A.O. *Yearbook of Fishery Statistics,* Vol. 19, 1964

In 1958, the relative magnitudes of fish meal and fish oil production were 1,584 thousand tons of meal and 315 thousand tons of oil. By 1964, production of fish meal had increased to 4,092 thousand tons and fish oil to 774 thousand tons. These great increases were due mainly to the increased use of high-oil content fish during the period, from which were derived most of the fish oil and over 70 per cent of the fish meal produced.

Production of fish meal from herring increased during the period but declined in relative importance due to greater use of other fish species, the most important of which was anchovy. In 1958, two hundred and seventy-one thousand tons of herring meal and 91 thousand tons of herring oil were produced, which accounted for 17 and 29 per cent respectively of total world production of fish meal and oil during the year. In the other years of the period herring meal production fluctuated somewhat but the general trend was one of increased production. In 1964, four hundred and ninety-eight thousand tons of herring meal and 247 thousand tons of herring oil were produced, accounting for 12 and 13 per cent respectively of world production of fish meal and oil.

Major Producing Countries

The impressive growth in world production of fish meal was due mainly to the tremendous expansion in fish meal production in Peru during the period. This growth was the result of heavy investment in boats, plants and equipment, for the exploitation of the rich anchoveta fisheries off Peru's coast, which started in the early 1950's.[2] Statistics revealing the magnitude of this growth and its effects on world production are given in Table 4.

In 1958, the largest fish meal producing countries in order of importance were the United States, Japan, Peru and Norway. United States production, based mainly on the menhaden fisheries, was 366 thousand tons or 23 per cent of world production in that year. Production in the other major producing countries was as follows; Japan, 237 thousand tons, Peru, 140 thousand tons and Norway, 139 thousand tons. By 1964, Peruvian production had increased to 1,709 thousand tons, which accounted for over 40 per cent of world production in that year. In comparison, Japanese production had increased to 466 thousand tons and Norwegian production to 185 thousand tons. United States production, however, declined to 316 thousand tons. Some countries such as the Union of South Africa, Chile[1] and Iceland experienced great increases in production. In 1964, the Union of South Africa produced nearly 300 thousand tons of fish meal and was the world's fourth largest producing country.

The major fish oil producing countries are shown in Table 5.

[1] This development began in 1952 with the collapse of the pilchard fisheries of California resulting in a substantial movement of fish meal plants from the United States to Peru.

[2] Chile also exploited the anchoveta fisheries and the rate of increase in fish meal production in this country was almost as great as that of Peru.

Table 4. Fish Meal Production by Major Producing Countries 1958 & 1961-1964

	1958	1961	1962	1963	1964
		(Thousands of Short Tons)			
Africa					
Angola	82.3	60.8	36.3	36.1	60.2
S.W. Africa and the Union of South Africa	107.3	206.4	233.6	270.1	292.2
Morocco	18.3	20.9	17.6	22.0	24.0
Asia					
Japan	236.8	398.4	430.0	351.0	466.1
North and South America					
U.S.A.	366.0	410.0	421.7	361.2	316.0
Canada	69.5	75.9	83.4	91.1	84.3
Peru	140.0	923.8	1,229.1	1,244.7	1,708.7
Chile	20.2	63.8	100.7	118.1	191.5
Europe					
Denmark	72.2	63.7	96.9	105.7	136.4
Fed. Rep. of Germany	84.2	75.2	89.5	89.6	89.6
Iceland	52.1	78.2	113.4	101.0	139.4
Norway	139.2	166.7	118.4	146.9	185.5
United Kingdom	86.1	80.3	79.6	82.7	87.1
Soviet Union	44.0	92.5	100.7	124.0	159.1
Other Countries	65.8	99.4	103.0	116.2	151.9
World Total	1,584.0	2,816.0	3,253.9	3,260.4	4,092.0

Source: F.A.O. *Yearbook of Fishery Statistics*, Vol. 19, 1964

Table 5 Major Producing Countries for Fish and Body Oils 1958 & 1961-64

	1958	1961	1962	1963	1964
			(Thousands of Short tons)		
Africa					
S.W. Africa and the Union of South Africa	25.2	64.3	64.8	52.3	78.2
Asia					
Japan	29.3	32.7	40.8	23.2	20.9
North America					
Canada	29.0	25.9	27.7	32.9	29.3
United States	83.2	131.0	123.5	91.5	88.3
South America					
Peru	11.3	130.8	165.9	170.4	233.3
Europe					
Denmark	18.7	19.0	26.8	30.7	38.3
Fed. Rep. of Germany	20.1	24.2	25.1	21.1	31.4
Iceland	11.4	43.2	66.9	51.9	88.8
Norway	38.1	65.3	64.4	60.2	92.0
Other Countries	48.3	54.3	60.7	59.8	69.5
World Total	314.6	590.7	666.6	594.0	770.0

Source: F.A.O. *Yearbook of Fishery Statistics*, Vol 19, 1964.

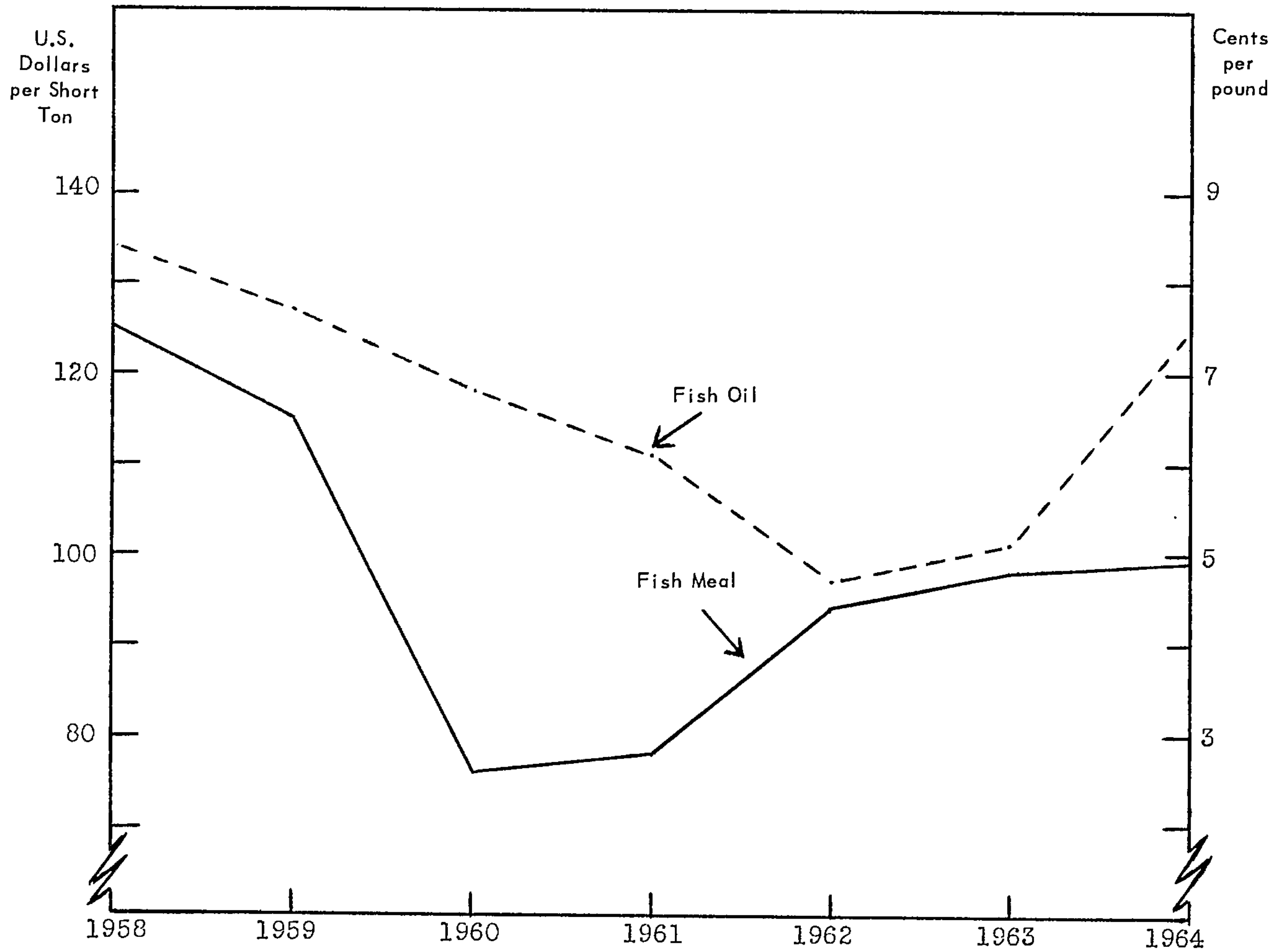


Fig. 1. Price Trends of Fish Meal and Oil, 1958–1964

The main oil producing countries during the period were Peru, the United States, South Africa and Iceland. Peru was by far the largest producer. In 1964, production in Peru was 233 thousand tons, which was 31 per cent of world production in that year. The statistics show that the magnitude of oil production does not necessarily depend on the magnitude of fish meal production and is in fact more directly related to whether low-oil content or high-oil content fish are processed. For example, a country like Japan, which was the second largest fish meal producing country in 1964, ranked quite low in the scale of major fish oil producing countries.

III. THE WORLD MARKET SITUATION 1958-1964

General trends in world market prices for fish meal and oil from 1958-1964 are demonstrated by export prices per ton of fish meal and per lb of fish oil (Fig. 1). Fish meal prices in 1958 and 1959 were highest for the period but decreased by about 40 per cent to a low for the period in 1960. Since then, however, the trend in fish meal prices has been upwards. Price increases by 1964 were about 30 per cent higher than those of 1960. The trend in fish oil prices was different from that experienced for fish meal in the respect that relatively steady price decreases occurred from 1958 to 1962. In 1963 and 1964 prices increased substantially especially in 1964.

These price changes especially in the case of fish meal, exerted considerable influence on the world's fish meal industry. The high market prices for meal and oil in the late 1950's indicated that world demand for these products had increased substantially. These prices led to the expansion of fish meal and oil production but also induced a search for cheaper sources of nutrients and to the substitution of vegetable and animal feeds for fish meals in the production of balanced livestock feeds. The effects of these conflicting economic forces, increased production and a decreasing demand due to the substitution of other feeds, were responsible for the extensive and sharp price decreases for fish meal which started in the late months of 1959.

By 1960, prices had fallen considerably and the declines were accentuated by financial crises in the Peruvian fish meal industry and indiscriminate selling practices which created great problems for the world industry generally. In many countries fish reduction plants experienced great financial losses and many were closed down. International attempts were made to control production, world trade and stabilize the industry. In 1960, the first meeting of the International Association of Fish Meal Manufacturers, which was formed in 1959, representing the industry in each of the main manufacturing countries, was held in Rome to discuss the problems faced by the industry[1]. At this meeting a Fish Meal Exporters' Organization was established which introduced voluntary quotas for all exporting countries. This was followed in 1961 by an International Meeting on Fish Meal in Rome, sponsored by F.A.O., which discussed in detail many of the problems facing the industry, measures to combat these problems, and the outlook for the industry.

The world fish meal industry emerged from the crisis in 1960 better organized internationally; more

Table 6 Exports of Fish Meal and Oil by Major Countries 1958 & 1961-1964

		1958	1961	1962	1963	1964
			(Thousands of Short Tons)			
S.W. Africa & the Union of S. Africa	Meal	98.3	186.2	228.1	235.4	280.1
	Oil	17.6	49.5	49.8	35.0	49.0
North America						
Canada	Meal	31.3	41.1	49.0	57.6	64.3
	Oil	3.4	0.7	0.1	1.1	12.2
United States	Meal	–	–	–	–	–
	Oil	47.0	61.2	61.4	130.9	75.6
South America						
Peru	Meal	116.4	779.2	1,161.5	1,142.0	1,569.0
	Oil	1.8	112.5	140.8	138.1	121.7
Europe						
Denmark	Meal	59.0	43.5	62.2	66.1	67.0
	Oil	12.5	10.3	17.4	23.2	33.7
Iceland	Meal	60.7	79.0	78.7	114.2	138.6
	Oil	16.6	28.6	66.6	61.5	57.6
Norway	Meal	117.6	141.3	65.9	113.8	138.6
	Oil	7.1	17.6	15.2	14.6	14.5
Sub-Total	Meal	483.3	1,270.3	1,645.4	1,729.1	2,320.1
	Oil	106.0	280.4	351.3	404.4	364.3
World Total	Meal	639.1	1,408.0	1,808.4	1,888.7	2,583.9
	Oil	150.7	331.1	402.6	460.9	418.0

Source: F.A.O. *Yearbook of Fishery Statistics*, Vol. 19, 1964.

[1] There are 16 member countries. These are: Belgium, Canada, Chile, Denmark, France, Germany, Holland, Iceland, Morocco, Norway, Peru, Portugal, South Africa, Sweden, United Kingdom, and the United States.

aware of the economic forces in operation in the industry such as those resulting from price fluctuations and competition from alternative meals, the necessity of maintaining regular supplies and high quality, and the need for greater promotional activity to increase demand. As a result of the implementation of some of these measures, world demand for fish meal improved to such an extent that prices increased in 1961, 1962, 1963 and 1964 despite substantial increases in world production of fish meal during these years.

World Trade in Fish Meal and Oil 1958-1964

Due to increased world production of fish meal and oil there was a considerable expansion in world trade during the period. Data on world exports of fish meal and oil by major countries are given in Table 6.

World exports of fish meal increased fourfold during the period, from 639 thousand tons in 1958 to 2,584 thousand tons by 1964, and fish oil exports threefold, from 157 thousand tons to 418 thousand tons.

Peru was the largest exporting country of both fish meal and oil. In 1964, fish meal and oil exports from Peru, which were 1,569 thousand and 122 thousand tons respectively, accounted for over 60 per cent of world exports of meal and about 30 per cent of world exports of oil.[1] The United States did not export fish meal in any appreciable quantity but was a larger exporter of fish oil, being second only to Peru in this respect. South Africa was the world's second largest fish meal exporting country and in 1964 exports from South Africa were 280 thousand tons of meal and 49 thousand tons of oil. The European countries of Norway, Iceland and Denmark, which are large herring meal producers, were large exporters of both fish meal and oil.

The major fish meal importing countries during the period were the United States, the Federal Republic of West Germany, the United Kingdom and the Netherlands[2]. These countries received 70 per cent of world exports in 1958 but only 56 per cent in 1964 (Table 7) indicating a considerable expansion in fish meal markets in other countries during the period.[3]

United States imports of fish meal increased from 100 thousand tons in 1958 to 425 thousand tons in 1964. Much of this increase was due to decreasing United States production of fish meals. The Federal Republic of West Germany, the United Kingdom and the Netherlands also experienced substantial increases. In 1964, the Federal Republic of West Germany, which was the largest importer of meals for the period,

Table 7 Imports of Fish Meal by Major Countries 1958 & 1961-1964

	1958	1961	1962	1963	1964
			(Thousands of Short Tons)		
North America					
United States	100.0	192.6	248.3	330.0	424.7
Europe					
Germany Fed. Rep.	113.0	249.4	365.6	288.2	406.2
United Kingdom	123.3	266.3	302.2	298.4	291.1
Netherlands	112.6	268.5	347.4	242.0	324.6[a]
Total	448.9	976.5	1,263.5	1,158.8	1,446.6
Total World Exports	639.1	1,408.0	1,808.4	1,888.7	2,583.9
Total as percentage of World Exports	70.2	69.4	69.9	61.3	56.0

[a] Includes quantities destined for the Fed. Repub. of West Germany

Source: Import figures derived from Exports statistics on Fish Meal F.A.O. *Yearbook of Fishery Statistics*, Vol. 19, 1964.

[1] The anchovy is not a very oily fish and has a smaller oil content than either herring or menhaden.

[2] All those countries with the exception of the Netherlands are among the world major producing countries (Table 7).

[3] Other countries showing significant increases included Japan, France, Italy, Belgium, Czechoslavakia, Poland, Spain and Yugoslavia.

imported 406 thousand tons of meal, the Netherlands 325 thousand tons and the United Kingdom 291 thousand tons.

The Main Markets for Fish Meal 1958-1964

The United States, the Federal Republic of West Germany, the United Kingdom, and the Netherlands are the main markets for fish meal. During the period 1958-1964 the quantities of fish meals marketed in these countries accounted for about one-half of world production during the period (Table 8).

The quantities of fish meal consumed in these countries increased from 906 thousand tons in 1958 to 1,948 thousand tons in 1964, at an average rate of about 16 per cent a year. Much of this increase is attributed to the United States, where domestic consumption increased from 376 thousand tons in 1958 to 741 thousand tons in 1964. Fish meal consumption in the other countries in 1964 were as follows: 496 thousand tons in the Federal Republic of West Germany, 378 thousand tons in the United Kingdom, and 326 thousand tons in the Netherlands.

Fish meals were used primarily in poultry feeds in the countries mentioned above but their use in swine feeds increased during the period 1958-1964. Their output of poultry meat and pork during this period was quite extensive (Table 9).

Production of poultry meat and pork in the United States, the Federal Republic of West Germany, the United Kingdom and the Netherlands increased from 12,272 thousand tons in 1958 to about 15,000 thousand tons during the period 1958-1964. The rates of increase in this production however, were well below those of fish meal consumption, indicating that the use of fish meals in these countries had increased substantially during the period.

IV. CANADA'S FISH MEAL AND OIL INDUSTRY 1958-1964

Compared with many countries in the world, the volume of Canadian production of fish meals has been relatively small (Table 4). This situation prevailed despite the fact that Canada is a large fish producing country by world standards, has a highly developed agricultural sector, and is the next door neighbour to the United States, the largest fish meal consuming country in the world.

Canadian landings of fish by selected species and by areas from 1958-1964 are shown in Table 11. Total landings of fish in Canada, excluding molluscs and crustaceans, increased from 961 thousand tons in 1958 to 1,078 thousand tons in 1964 at an average rate of 1.7 per cent a year.[1]

Table 8 Quantities* of Fish Meal Used by Major Consuming Countries 1958 & 1961-1964

	1958	1961	1962	1963	1964
	(Thousands of Short Tons)				
North America					
United States	376.0	602.6	670.0	691.2	740.7
Europe					
Germany Fed. Rep.	197.2	324.6	454.1	377.8	495.8
United Kingdom	209.4	346.6	381.6	381.1	378.2
Netherlands	116.5	272.0	247.2	246.8	325.6
Total above Countries	899.1	1,545.8	1,752.9	1,696.9	1,940.3
World Production	1,584.0	2,816.0	3,253.9	3,260.4	4,092.0
% of World Production	56.8	54.9	53.9	52.0	47.4

* These consist of the summation of production and import statistics for these countires. Data on fish meal exports which should be deducted from these figures were not available for the U. S., Germany and the United Kingdom. These exports, however, were very small.

[1] This rate of growth in Canadian landings is not very impressive and was considerably smaller than the average rate of growth in world landings during the period which was around 8 per cent a year.

TABLE 9

Production of Pork and Poultry Meat, Selected Countries 1858 & 1961-1964

	1958	1961	1962	1963	1964
		(Thousands of Short Tons)			
Poultry					
North America					
United States	3,959.7	4,792.4	4,674.7	4,855.3	5,026.9
Europe					
Germany, Fed. Rep.	96.8	119.9	124.3	133.1	156.2
United Kingdom	232.4	383.7	381.1	384.5	401.3
Netherlands	54.0	91.6	108.6	115.3	—
Total Poultry above countries	4,342.9	5,387.6	5,288.7	5,488.2	5,584.4
		(Thousands of Short Tons)			
Pork					
North America					
United States	5,218.4	5,698.0	5,905.9	6,206.2	6,249.1
Europe					
Germany, Fed. Rep.	1,643.4	1,780.9	1,908.5	1,919.5	2,021.8
United Kingdom	769.9	763.4	850.3	871.2	920.7
Netherlands	298.1	370.7	374.0	382.8	—
Total Pork above countries	7,929.8	8,613.0	9,038.7	9,379.7	9,191.6
Grand Total Poultry and Pork	12,272.7	14,000.6	14,327.4	14,867.9	14,776.0

Source: F.A.O. *Bulletin of Fishery Statistics*, No. 9, 1964.

TABLE 11

Canadian Landings of Fish,* by Selected Species and by Areas
1958 – 1964

	1958	1959	1960	1961	1962	1963	1964
			(Quantity in Short Tons)				
Total Landings	961,317	988,930	841,828	933,278	1,028,821	1,095,294	1,077,817
Atlantic Coast	586,275	631,876	630,761	562,040	629,968	660,771	704,637
Groundfish	437,295	485,843	481,903	442,624	481,550	501,314	512,855
Cod	265,466	319,569	302,311	258,430	292,693	304,774	287,851
Other	171,829	166,274	179,592	184,194	188,857	196,540	225,004
Pelagic	148,980	146,033	148,858	119,416	148,418	159,457	191,782
Herring	116,522	119,458	123,165	96,685	123,251	126,342	156,302
Other	32,458	26,575	25,693	22,731	25,167	33,115	35,404
Inland Fisheries	57,307	58,606	52,651	61,537	68,516	58,740	55,041
Whitefish	12,012	12,398	13,546	13,592	13,289	10,281	11,467
Other	45,245	46,208	39,105	47,945	55,227	48,459	43,574
Pacific Coast	317,735	298,448	158,416	309,701	330,337	375,783	318,139
Herring	202,561	222,016	93,838	224,217	222,638	286,101	252,643
Salmon	90,659	52,840	37,577	60,817	81,954	59,662	62,110
Other	24,515	23,592	27,001	24,667	25,745	30,020	3,386

* Excluding molluscs and crustaceans

Source: D.B.S. *Fisheries Statistics of Canada*

The increase in Canadian landings can be attributed to the fisheries of the Atlantic Coast, where landings rose from 587 thousand tons in 1958 to 705 thousand tons in 1964. Groundfish landings accounted for most of the increase. Cod landings, the main groundfish species landed, fluctuated during the period between a low of 258 thousand tons and a high of 319 thousand tons. Landing's of herring, the main pelagic fish species caught, varied during the period from a low of 97 thousand tons in 1961 to a high of 156 thousand in 1964. The average annual landings of herring on the Atlantic Coast for the period were 123 thousand tons.

On the Pacific Coast total landings of all fish were 318 thousand tons in 1958 and were at this same level in 1964. Extensive fluctuations in landings were experienced on this coast during the period, from a low of 158 thousand tons to a high of 376 thousand tons. These fluctuations were due mainly to sharp year to year changes experienced in the herring fishery. Herring has been the major species by weight landed on this coast and herring catches amounted to over 200 thousand tons a year, with the exception of 1960 when only 93 thousand tons were landed as a result of a crippling strike which tied up most of the herring fleet for the major part of the fishing season.

Large quantities of Canadian fish landings are utilized for reduction purposes (Table 12).

In 1958, two hundred and thirty-five thousand tons of whole fish, accounting for 20 per cent of the weight of total Canadian landings, were utilized for reduction purposes. In 1960, only 93 thousand tons of fish were utilized for reduction and this decline in quantity followed upon decreased world prices and the low level of herring landings on the Pacific Coast. From 1961, with increased landings, the quantities of fish used in reduction increased to a high of 312 thousand tons in 1963 but dropped to 286 thousand tons or 22 per cent of total landings in 1964.

Production of fish meal and oil in Canada 1958-1964

Fish meal and oil production in Canada from 1958-1964 were subject to fluctuations arising from factors such as the world situation and prices of fish meal and the volume and nature of fish landings in Canada.[1] For the period on the whole, no great increases in production of either fish meal or oil were experienced (Table 13).

Fish meal production in Canada increased from 69,662 tons in 1958 to 79,934 tons in 1964, at an average rate of growth of 2 per cent a year. Fish oil production, on the other hand, decreased from 62 million lb to 55 million lb during the same period. There were extensive fluctuations in the production of both these products. In 1960, due to a conjuncture of unfavourable circumstances, such as falling world fish

TABLE 12

Disposition of Canadian Fish Landings* 1958-1964

	1958	1959	1960	1961	1962	1963	1964
			(Thousands of Short Tons)				
Canada							
Marketing Fresh	208.6	236.7	207.5	210.8	203.7	237.3	247.3
Freezing	286.3	279.3	299.4	290.1	343.1	380.5	449.9
Curing	225.3	285.6	309.7	259.5	269.5	240.5	202.7
Canning	99.1	76.3	72.7	80.6	116.9	88.3	82.3
Reduction	234.6	228.1	93.5	205.9	235.3	312.1	286.4
Miscellaneous Purposes	29.5	35.0	24.0	51.5	32.3	27.3	40.6
Offal for Reduction	(25.4)	(25.9)	(30.3)	(32.8)	(29.8)	(21.6)	(17.1)
Total	1,083.9	1,141.0	1,006.8	1,098.4	1,200.8	1,286.0	1,309.2

* Includes molluscs and crustaceans.

Source: F.A.O. *Yearbook of Fishery Statistics*, Vol. 19, 1964.

[1] Oil production is particularly affected by the nature of fish landings since the oil-content in particular species varies during the year or the fishing season.

TABLE 13

Canadian Production of Fish Meal and Oil, Quantity and Value 1958-1963

		1958	1959	1960	1961	1962	1963	1964
				(Quantity in Short Tons) (Value in Thousands of Dollars)				
Fish Meal								
Atlantic..........	Q	31,085	29,749	26,457	33,599	38,022	33,649	32,525
	V	$ 4,046.8	$ 3,617.4	$ 2,377.4	$ 3,602.9	$ 4,743.8	$ 4,018.8	N. A.
Pacific	Q	38,577	43,239	18,506	42,486	43,130	54,887	47,409*
	V	$ 5,848.5	$ 5,955.9	$ 1,946.0	$ 5,197.3	$ 6,329.7	$ 7,847.6	$ 7,280.0
Total	Q	69,662	72,988	44,963	76,085	81,152	88,069	79,934
	V	$ 9,895.3	$ 9,573.3	$ 4,324.4	$ 8,800.2	$11,073.5	$11,866.4	—
				(Thousands of Pounds and Dollars)				
Fish Oil								
Atlantic..........	Q	13,936	12,915	13,209	7,288	10,941	11,439	13,489
	V	$ 1,911.1	$ 1,816.4	$ 951.3	$ 398.6	$ 524.5	$ 877.3	$ NA
Pacific	Q	48,288	44,490	18,573	43,382	42,200	51,487	41,355*
	V	$ 3,615.3	$ 2,911.4	$ 1,302.0	$ 2,826.5	$ 2,282.9	$ 3,953.2	$ 3,992.3
Total	Q	62,224	57,405	31,782	50,610	53,141	63,226	54,844
	V	$ 5,526.4	$ 4,727.8	$ 2,253.3	$ 3,225.1	$ 2,834.6	$ 4,830.5	—

Source: D.B.S. *Fishery Statistics of Canada*

* Source: *B.C. Fisheries Statistics*, (1964)

[1] Oil production is particularly affected by the nature of fish landings since the oil-content in particular species vary during the year or the fishing season.

meal prices and poor herring landings on the Pacific Coast, production of fish meal and oil in Canada fell to a low of 44,963 tons of meal and 32 million lb of oil. The peak year of the period was 1963 when 88,069 tons of fish meal and 63 million lb of fish oil were produced.

From Table 13, the relative importance of the reduction industries on the Pacific and Atlantic Coasts can be realized. The Pacific Coast industry relied primarily on the herring fishery as its source of raw materials while the Atlantic Coast industry depended mainly on offal from groundfish landings. This dependence was responsible for the differences in the production of meal and oil between these coasts, that were experienced during the period. On the Atlantic Coast, production remained at relatively stable levels throughout, averaging around 32 thousand tons of fish meal and 12 million lb of fish oil a year. On the Pacific Coast, which was the major producing area during the period, production of fish meal increased from 38 thousand tons in 1958 to 47 thousand tons in 1964 at an average rate of growth of 3.2 per cent a year; while fish oil production was over 40 million lb a year for every year of the period with the exception of 1960. The level of production on this coast would have been considerably higher during the period had it not been for a series of price disputes in the herring fishery, leading to strikes which curtailed herring fishing operations in five of the seven years covered by the period[1].

The fish meals produced on the Atlantic Coast are mainly white fish meals (Table 14) which are produced primarily from cod but may also contain other

[1] Herring prices have been negotiated annually on the Pacific Coast by the United Fishermen and Allied Workers Union which represents the majority of herring fishermen and fish meal producers before the commencement of the herring season in the middle of October. Strikes due to the failure of these negotiations to reach a settlement before the commencement of the fishing season were experienced in 1958, 1959, 1960, 1961, and 1962 and tied up 79 to 80 fishing vessels for periods of up to 6 weeks.

TABLE 14

Production of Fish Meal by Main Species
Atlantic and Pacific Coasts 1958-1963

	ATLANTIC COAST				PACIFIC COAST				
	SPECIES				SPECIES				
	(Short Tons)								
Years	Offal & Liver	Herring Body	Other	Total	Herring Body	Salmon Offal	Other	Total	Canada Total
1958	*	*	31,085	31,085	36,115	2,024	438	38,577	60,662
1959	*	*	29,749	29,749	41,696	1,362	181	43,239	72,988
1960	*	*	26,457	26,457	17,634	724	148	18,506	44,983
1961	*	*	33,599	33,599	40,817	1,281	388	42,486	76,085
1962	33,392	4,375	27	37,794	41,299	1,536	295	43,130	81,152
1963	28,371	4,667	611	33,640	(a)53,271	1,157	459	54,887	88,069
1964	25,342	6,247	936	32,525	46,071	929	409	47,409	79,934

* No breakdown available, included in Other,

(a) (*B.C. Fisheries Statistics*, 1964)

Source: D.B.S. *Fishery Statistics of Canada.*

species such as haddock, flatfish and redfish. Herring meals were not of any great importance during the period and were classified separately only from 1962, when 4,375 tons of herring meal were produced out of an Atlantic total meal output of 37,794 tons, thus constituting approximately only one ninth of this output in that year. By 1964, herring meal production had increased to 6,247 tons, or by nearly 40 per cent, and accounted for over one-fifth of total output on the Atlantic Coast for that year.

On the Pacific Coast herring meal predominated, accounting for 96 per cent of total fish meal production on this coast during the period. Only small quantities of salmon meal and other meals were produced. For Canada on the whole, herring meal production in 1963 accounted for 53 per cent of total Canadian production.

The great dependence on the herring fishery for reduction purposes on the Pacific Coast in comparison to the Atlantic Coast accounted for the much greater output of fish oil from the Pacific Coast (Table 15).

Herring oil production on the Pacific Coast accounted for over 70 per cent of total Canadian production and was over 40 million lb a year for most of the period. In comparison, the main fish oil produced on the Atlantic Coast, cod oil, was less than 10 million lb a year. Herring oil output, however, showed signs of increasing in importance with increased herring meal production. In 1964 herring oil output on the Atlantic Coast was 4 million lb, which was about 34 per cent of total oil production on this coast for that year.

The Structure of the Reduction Industry in Canada, 1964

There are extensive differences in the structure of the fish reduction industries on the Atlantic and Pacific Coasts. On the Pacific Coast there are fewer plants but these are much larger than their counterparts on the Atlantic Coast. From 1958-1964, there were ten plants in operation on the Pacific Coast. This indicated that the increased production in fish meal and oil which were realized on this coast during the period was brought about not by increased capacity but by the more effective utilization of existing plants. All the Pacific Coast plants are oil producing since they are primarily herring reduction plants and operate mainly in the three months of the herring season.

The Atlantic Coast industry is characterized by many small plants which utilize mainly offal from groundfish in their operations, with the result that less than half of them are equipped for oil recovery (Table 16). There is little evidence that there were any great changes in the industry on the Atlantic Coast until 1964 when a few new plants were built and old ones renovated. These developments are geared mainly to the exploitation of the herring resources on the Atlantic Coast which have not been fully exploited by Canadian fishermen.

In 1964 there were 60 fish meal plants in operation in Canada; of these, 49 were situated on the Atlantic Coast (Table 16).

The great difference in capacities between Pacific and Atlantic coast plants is evident in the above table. The ten plants on the Pacific coast had an estimated capacity of nearly 7,000 tons a day in comparison to 3,000 tons for the 49 plants on the Atlantic coast. Total reduction capacity in Canada in 1964 was around 10,000 tons per day. Canada's fish reduction industry has not been operating at anywhere near full technical capacity. It has been pointed out that existing capacity was sufficient to produce even 1963's record yield of meal in little more than 40 working days.[1]

TABLE 15

Production of Fish Oil by Main Species
Atlantic and Pacific Coasts 1958-1963

(In Thousands of Pounds)

	ATLANTIC COAST					PACIFIC COAST				
	SPECIES					SPECIES				
Years	Cod	Herring	Seal	Other	Total Atl. Coast	Herring	Salmon	Other	Total Pac. Coast	Canada Total
1958	5,163	2,369	4,089	2,315	13,936	38,301	9,757	230	48,288	62,224
1959	6,831	1,244	2,734	2,106	12,915	43,102	1,293	95	44,490	57,405
1960	6,762	735	4,130	1,582	13,209	17,918	546	109	18,573	31,782
1961	4,585	1,203	—	1,440	7,288	41,672	1,390	320	43,382	50,601
1962	9,440	—	—	1,501	10,941	40,243	1,476	481	42,200	53,141
1963	8,494	1,361	1,493	91	11,439	50,037	1,069	381	51,487	62,926
1964	7,060	4,602	1,238	586	13,486	44,902	710	338	45,950	59,436

Source: *Fishery Statistics of Canada (B.C. Fisheries Statistics,* 1964)

TABLE 16

Fish Reduction Plants* in Canada, 1964

	Pacific Coast	Atlantic Coast	Other	Total
Number of Plants	10	49	1	60
Number of Plants with Oil Capacity	10	20?	n. a.	
Capacity Range, Tons of Raw Fish				
Per hour	13-42	1-9	n. a.	
Per day	310-1000	18-200	n. a.	
Total Raw Material Capacity Tons/Day	6,770	3,000	n. a.	9,770

* 24 hour operation.

Source: Dr. Weinberg "The Use of Marine Oils and their Future Prospects". Dept. of Industry, Chart X.

[1] ibid. p. 10

V. THE MARKETING OF CANADIAN FISHMEAL AND OIL 1958–1964

The greater part of Canadian production of fish meal was marketed abroad during the period 1958-1964 while most of the fish oil produced was marketed in Canada (Table 17).

There was a distinct upward trend in fish meal exports, which increased from 27 thousand tons in 1958 to 62 thousand tons in 1964 despite fluctuations in the level of production in Canada. The domestic disappearance of fish meals in Canada varied quite extensively during the period from a low of 12 thousand tons to a high of 42 thousand tons. For fish oils, both the domestic disappearance and exports fluctuated during the period; the range in these fluctuations for exports were from 155 thousand lb to 24 million lb and for the domestic disappearance from 9 million lb to 60 million lb. The domestic disappearance was greater than exports in every year of the period except 1960.

Market Prices for Fish Meal and Oil

Fish meal and oil prices in Canada follow United States prices closely. These in turn, since the United States is the world's largest market for fish meal and oil, reflect the world situation and prices for these two products. Price quotations in the United States for domestic menhaden meals and imported Peruvian anchovy meals for selected years were as shown in Table 18.[1]

TABLE 17

Production, Exports and Domestic Disappearance of Fish Meal and Oil in Canada 1958-1964

	1958	1959	1960	1961	1962	1963	1964
Fish Meal				(Short Tons)			
Total Production	69,662	72,988	44,963	76,085	81,152	88,069	79,934
Exports..................	27,233	44,722	35,020	39,975	47,379	55,523	62,489
Imports..................	—	—	2,058	6,418	150	298	4,889
Domestic Disappearance ...	42,429	28,266	12,001	42,528	33,923	32,844	22,334
Fish Oil				(Thousands of Pounds)			
Total Production	62,224	57,405	31,782	50,001	53,141	61,809	54,844
Exports..................	6,759	21,821	22,590	1,483	155	2,249	24,403
Imports..................	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.
Domestic Disappearance ...	55,465	35,684	9,192	49,218	52,986	59,620	30,441

Source: D.B.S. *Trade of Canada* — Exports by Commodities

TABLE 18

Mid-June Price Quotations, New York Market, Selected Years

	1959	1960	1962	1963	1964
			(Price per Ton: U.S. Dollars)		
Domestic menhaden (60% protein)................	131	96	124	125	130
Anchovy (65% protein)................	145	80	119	117	124
			(cents per lb: yearly average)		
Menhaden oil-crude	7.4	6.5	4.6	6.2	8.7

Source: *Fishery Products Report,* U.S. Bureau of Commercial Fisheries.

[1] Actual prices received for Canadian herring meals (70% protein) and groundfish meals (60% protein) differed by only a few dollars a ton.

These prices show that there were some differences in the prices of these two meals. Before 1959, anchovy meals were more expensive in the United States than menhaden meals but from 1960 onwards the situation was reversed. The result has been that on menhaden meal there was almost a complete recovery in prices in terms of current dollars in 1964, since the price per ton in 1959 and 1964 was almost at the same level, $130. For the imported anchovy meals, due no doubt to the great supply, prices in 1964 were still below those of 1959.

Included in the Table were prices for crude menhaden oil. These give some idea of the magnitude and change in fish oil prices in the years mentioned. Menhaden oil prices declined from 7.4 cents per lb in 1959 to a low of 4.6 cents per lb in 1962, increasing again to a high of 8.7 cents in 1964. The rather great increases in the price of menhaden oil and other fish oils since 1962 have been brought about by the increased use of fish oils in the production of margarine and shortening.

There is a great deal of hedging, forward buying of meals, and other speculative activities in the fish meal industry, which is subject to highly seasonal variations in output with the result that prices fluctuate quite substantially during the year. Mid-monthly price quotations in 1964 in the United States for fish meals were as shown in Table 19.

Canadian fish meals, white fish and herring, were marketed at Boston and Seattle respectively. Prices of these meals fluctuated during the year from $127 to $142 a ton for whitefish and from $133 to $154 a ton for herring. In comparison, prices for menhaden meals ranged from $128 to $141 a ton and for anchovy meals from $125 to $143 a ton.[1] The availability of stocks for these various meals can be obtained from these quotations, which show that Canadian meals were not available in each month throughout the year. White fish meals were marketed mainly from March to August while herring meals were marketed mainly from October to March. This latter period corresponds with the herring fishing season on the Pacific Coast.

TABLE 19

Mid-Monthly Price Quotations, Fish Meals, U.S. Markets, 1964

	Boston		New York				Seattle	
	White Fish (60% Protein)		Menhaden (60% Protein)		Anchovy (65% Protein)		Herring (70% Protein)	
	Per Ton	P.P.U.*	Per Ton	P.P.U.*	Per Ton	P.P.U.*	Per Ton	P.P.U.*
	(U.S. Dollars)							
January	—	—	135	2.25	138	2.12	133	1.90
February	—	—	135	2.25	133	2.05	133	1.90
March	135	2.25	128	2.13	133	2.05	133	1.90
April	133	2.22	128	2.13	127	1.95	—	—
May	130	2.17	128	2.13	128	1.97	143	2.05
June	127	2.11	130	2.17	125	1.92	143	2.05
July	132	2.20	131	2.17	130	2.00	—	—
August	130	2.16	130	2.17	133	2.05	—	—
September	—	—	132	2.20	134	2.06	—	—
October	—	—	140	2.33	140	2.15	147	2.10
November	—	—	140	2.33	143	2.20	147	2.10
December	142	2.37	141	2.33	143	2.20	154	2.20

* Per Protein Unit.

Source: *Fishery Products Report,* U.S. Bureau of Commercial Fisheries.

[1] On a per protein unit basis, which measures the relative protein richness of the various meals and accounts for the various prices per ton, Canadian meal prices were quite competitive with the other meals marketed in the United States.

TABLE 19A

Fish Meal Exports of Canada 1958-1964

Main Countries	1958	1959	1960	1961	1962	1963	1964
				(Short Tons)			
1. *United States*							
Herring Meal	11,779	24,180	22,760	28,821	32,709	42,474	48,346
Other Meals	5,640	1,980	961	37	2,992	2,675	2,082
Total	17,419	26,160	23,721	28,858	35,701	45,149	50,428
Value in $'000	$ 2,524	$ 3,962	$ 2,746	$ 3,168	$ 4,968	$ 6,529	$ 7,243
2. *United Kingdom*							
Herring Meal	22	5,327	–	2,821	3,921	1,675	2,131
Other Meals	8,478	10,600	9,578	6,611	6,849	7,409	9,299
Total	8,500	15,927	9,578	9,432	10,770	9,048	11,430
Value in $'000	$ 1,147	$ 2,340	$ 884	$ 1,164	$ 1,425	$ 1,104	$ 1,521
3. *Other Countries*							
Herring Meal	1,236	2,581	1,670	470	50	–	20
Other Meals	78	54	52	1,215	859	321	611
Total	1,314	2,635	1,722	1,685	909	321	631
Value in $'000	$ 179	$ 394	$ 197	$ 187	$ 116	$ 44	$ 86
Total Exports of Canada							
Herring Meal	13,037	32,088	24,430	32,112	36,680	44,149	50,497
Other Meals	14,196	12,634	10,591	7,863	10,700	10,405	11,992
Grand Total	27,233	44,722	35,021	39,975	47,380	55,554	62,489
Value in $'000	$ 3,850	$ 6,696	$ 3,827	$ 4,519	$ 6,509	$ 7,677	$ 8,850

Source: D.B.S. *Trade of Canada* – Exports by Commodities

Export Markets 1958-1964

Canadian fish meals are exported mainly to the United States and the United Kingdom, two of the world's largest fish meal importing countries. Small quantities of Canadian meals are exported also to other countries in Central America (Mexico) and the Caribbean. The United States has been by far the main export market for Canadian fish meals, and exports to this country increased from 17 thousand tons in 1958, valued at $2.5 million to 50 thousand tons in 1964 valued at $7.2 million (Table 19A), which constituted about 80 per cent of total exports by quantity and value for that year.

Exports to the United Kingdom did not experience any great increases during the period with the exception of 1959, when 16 thousand tons of fish meal valued at $2.3 million were exported to that country in comparison to only 8 thousand tons valued at $1.1 million in the previous year, 1958. In 1964 exports to the United Kingdom were in the magnitude of just over 11 thousand tons which were valued at $1.5 million. Exports to other countries declined during the period from over one thousand tons in 1958 to six hundred tons in 1964.

Canada's fish meal exports by species show that herring meals have been the main meals exported and increased from 13 thousand tons in 1958 to 50 thousand tons in 1964. Other meals, i.e. white fish or groundfish meals, declined from 14 thousand lb to 11 thousand lb during the same period. The marketing distribution of these meals showed that herring meals were marketed mainly in the United States and groundfish meals in the United Kingdom.

The geographical pattern of the trade in fish oils is quite different since most of the oils are exported to the United Kingdom and other countries, very little being exported to the United States. (Table 20).

Total fish oil exports increased from 6 million lb in 1959, valued at $618 thousand to 23 million lb in 1960, valued at $1.1 million. Of this, 21 million lb were exported to the United Kingdom. Total fish meal

TABLE 20

Fish Body Oils Exports of Canada 1958-1964

Main Countries	1958	1959	1960	1961	1962	1963	1964
			(Thousands of Pounds)				
1. *United States*							
Herring Oil	–	529	58	444	9	36	3,807
Total	55	534	327	963	135	1,338	4,919
Value in $'000	$ 26	$ 26	$ 17	$ 62	$ 17	$ 87	$ 410
2. *United Kingdom*							
Herring Oil	2,688	19,956	21,080	515	–	911	19,459
Total	2,724	19,956	21,080	515	20	911	19,459
Value in $'000	$ 255	$ 1,383	$ 1,350	$ 38	$ 1	$ 81	$ 1,743
3. *Other Countries*							
Herring Oil	3,965	1,323	1,171	–	–	–	25
Total	3,980	1,331	1,183	.5	–	–	25
Value in $'000	$ 337	$ 105	$ 109	$ –	$ –	$ –	$ 3
Total Exports of Canada							
Herring Oil							
Other							
Grand Total	6,759	21,821	22,590	1,483	155	2,249	24,403
Value in $'000	$ 618	$ 1,514	$ 1,147	$ 100	$ 18	$ 168	$ 2,156

Source: D. B.S. *Trade of Canada* – Exports by Commodities

TABLE 21

Total Production of Poultry & Meat by Categories in Canada 1958-1964

	1958	1959	1960	1961	1962	1963	1964
				(millions of pounds)			
Beef & Veal	1,346	1,273	1,391	1,426	1,419	1,536	1,690
Mutton & Lamb	31	32	32	35	33	30	29
Pork	974	1,238	988	967	978	978	1,060
Poultry							
Foul and Chicken	356	365	358	416	412	453	483
Other	124	137	114	151	154	154	171
Total Poultry	470	502	472	567	566	607	654
Total Production of Meat	2,821	3,045	2,883	2,995	2,995	3,152	3,434

Source – D.B.S. *Agriculture Division*

exports then fell off substantially in the subsequent years until 1964, when 24 million lb, valued at $2.2 million, were exported.

The Domestic Market 1958-1964

The magnitudes of the domestic market for fish meals from 1958-1964 were obtained from the domestic disappearance (Table 17). This disappearence was not greatly affected by imports since only small quantities of foreign fish meals were imported into Canada during the period. On the whole, the market for fish meals in Canada from 1958-1964 has been quite small. This would appear to be so in view of the indications that the market for balanced livestock feeds in Canada has been buoyant under the impetus of increased Canadian output of livestock and livestock products.

The total production of poultry and meat in Canada from 1958 to 1964 has been as shown in Table 21.

TABLE 22

Production of Primary Concentrates and Complete Feeds in Canada

1960-1964	1960	1961	1962	1963	1964
			(Short Tons)		
Primary or Concentrated Feeds					
Swine Service Concentrates	141,928	147,061	147,160	160,809	141,510
Poultry Concentrates	184,909	198,728	192,696	195,627	185,863
Calf & Cattle Concentrates	141,684	145,298	154,252	151,859	125,012
Total Concentrates	468,521	491,087	494,108	508,259	456,385
Secondary or Complete Feeds					
Swine	625,306	734,819	755,151	822,273	1,395,724
Poultry	1,150,001	1,434,391	1,430,648	1,476,300	2,049,199
Calf & Cattle	689,514	665,258	678,541	655,016	1,342,465
Total Secondary Feeds	2,464,821	2,834,468	2,864,340	2,953,589	4,787,388
Other Animal Feeds	731,578	474,581	439,214	447,007	473,673
Total Animal Feeds					
Swine	767,234	881,880	902,311	983,082	1,537,234
Poultry	1,334,910	1,633,119	1,623,344	1,671,927	2,235,062
Calf & Cattle	831,198	810,556	832,793	806,875	1,467,477
Other	731,578	474,581	439,214	447,007	473,673
Total Production	3,664,920	3,800,136	3,797,662	3,908,891	5,713,446
Domestic Disappearance of Fish Meal	12,001	42,528	33,923	32,844	22,334
Fish Meal as % of Total Production	0.3	1.0	0.8	0.8	0.4

Source: D.B.S. *Shipments of Prepared Stock and Poultry Feeds*

Total output of meat in Canada increased from 2,821 million lb in 1958 to 3,045 million lb in 1964 at an average rate of growth of 3 per cent a year. Production of pork increased from 974 million lb to 1,060 million lb and poultry meat from 470 million lb to 654 million lb during the period.

The production of primary concentrates and balanced livestock feeds in Canada in the last five years of the period were as shown in Table 22.

Total production of primary concentrates and secondary or complete feeds in Canada increased from 3,664,920 tons in 1960 to 5,713,446 tons in 1964, at an average rate of growth of 11 per cent a year. This rate was greater than the average rate of growth for poultry and meat in Canada during the same period (1960-1964) indicating increased use of these feeds in the livestock industries.

The magnitude of Canadian production of primary concentrates and secondary or complete feeds in relation to the quantities in the domestic disappearance of fish meal suggests that the use of fish meal in Canada has been minimal. It is understood that uses of fish meal are confined mainly to the production of starter feeds for poultry and swine. Only small quantities of fish meals have been used in the production of these starter feeds however, (generally from 50-100 lb of fish meals are used in the production of one ton of starter rations), which constitute less than 10 per cent of the poultry and swine concentrates produced. The main factors responsible for this limited use of fish meal have been the availability of and competition for soybean meal in Canada.

The production of soybean meal in Canada increased from 396 thousand tons in 1961-1962 to 465 thousand tons in 1964-1965 at an average rate of growth of 4.5 per cent a year (Table 22A). The apparent disappearance of soybean meal in Canada fluctuated from year to year. The high for the period was in 1962-1963, when the domestic disappearance was 468 thousand tons, and the low was in the following year 1963-1964, when the domestic disappearance amounted to only 434 thousand tons.

Canadian soybean meal (45% protein) prices in U.S. dollars increased from $84.6 a ton in 1959/60 to

TABLE 22A

Canadian Soybean and Soybean Products, Supply and Disposition

	(August 1 – July 31) ('000 Bushels)			
	1961-62	1962-63	1963-64	1964-65
Soybeans				
Production	6,631	6,608	5,002	6,976
Imports	13,329	14,711	15,656	15,827
Supply	19,960	21,319	20,658	22,803
Domestic Crushings	16,916	17,862	18,606	19,541
Exports	3,617	2,445	1,614	3,179
	(thousands of pounds)			
Soybean Oil				
Domestic Production	176,821	183,592	192,655	201,057
Imports	17,062	27,182	34,261	33,660
Supply	193,883	210,774	226,916	234,717
Exports	49,039	51,076	28,163	33,164
Apparent Disappearance	144,744	159,698	202,753	201,553
	(thousands of Tons)			
Soybean Meal				
Domestic Production	396	419	442	465
Imports	247	282	203	261
Supply	643	701	645	726
Exports	192	233	211	267
Apparent Disappearance	451	468	434	459

Based on D.B.S. Data

$104.7 a ton in 1964/65 at an average rate of increase of 4 per cent a year. In comparison Peruvian anchovy fish meal prices in the United States during the same period increased from $94.4 a ton to $155.9 a ton at an average rate of 10.5 per cent a year. The trends in soybean meal and fish meal prices during the period 1959/60 to 1964/65 are shown in Figure 2.

The trends reveal that soybean meal prices displayed greater stability than fish meal prices, since price increases were steadier and were much less subject to annual fluctuations. The gap between the prices of these two products has been widening, especially in the last year 1964/65, when there was a substantial increase in fish meal prices. The competitive position of fish meal in relation to soybean meal appears to have been decreasing in the United States and Canada.[1] If these trends continue the use of fish meal in these two countries could be curtailed sharply and could lead to a substantial alteration in the fish meal situation in the future.

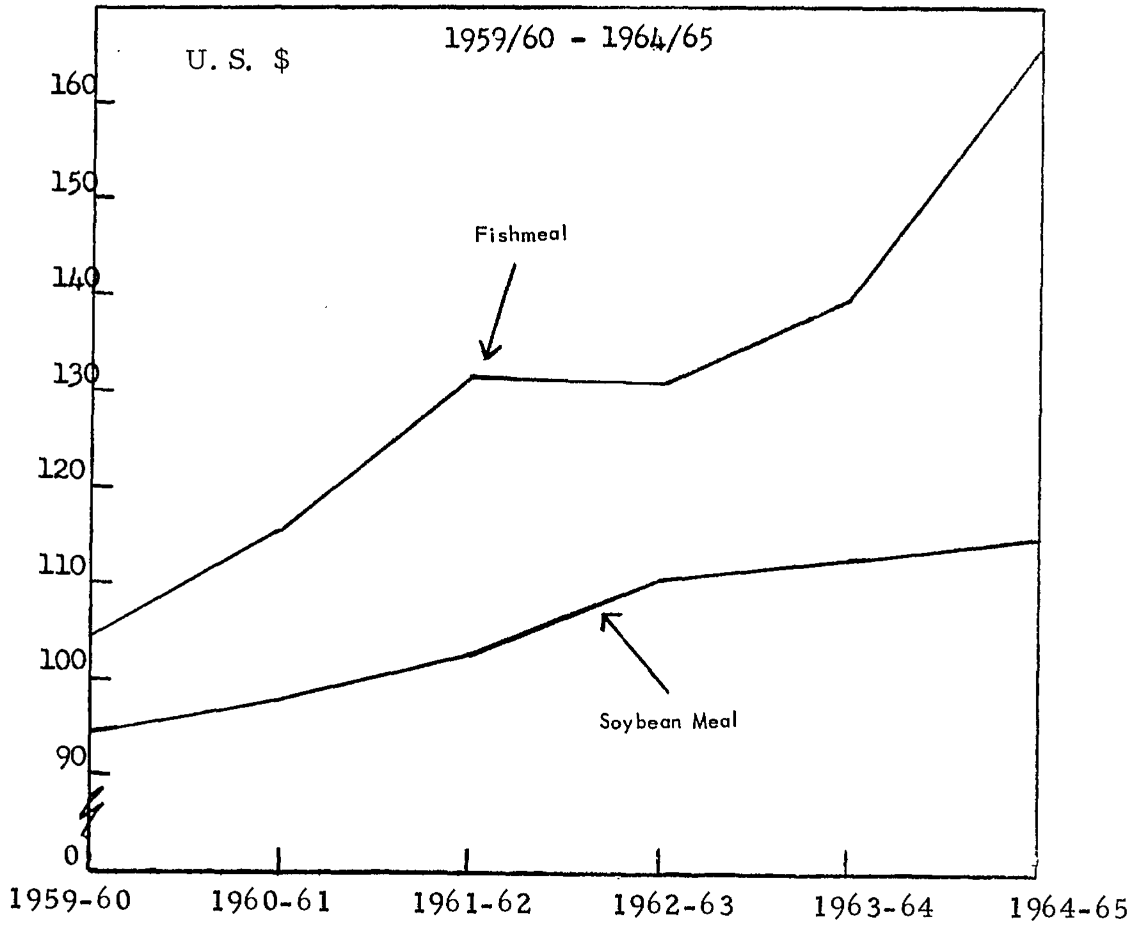
VI. RECENT DEVELOPMENTS AND PROSPECTS OF CANADA'S FISH MEAL INDUSTRY[2]

In this section recent developments and short term prospects for Canada's fish meal industry will be analysed. This analysis will first take into account however, the world fish meal situation and outlook up to 1970 since the prospects for Canada's fish meal industry will depend very much on this.

[1] Since the United States and Canada are large producers of soybean meal and other meals fish meals can maintain their share of the market only if their prices are related appropriately to the prices of soybean and other meals.

[2] No special attention will be paid to the production and prospects for fish body oils in this analysis since they are directly dependent on the production and prospects for fish meal.

Fig. 2 Price Trends; Fish Meal and Soybean Meal



Source: U.S. Dept. of Agriculture, *Foreign Agriculture Circular,* March 1966.

The World Fish Meal Situation and Outlook

Figures are not yet available on world production in 1965. World production in 1965 however was probably lower than the 4,092 thousand tons produced in 1964, because production in Peru fell off in the first half of the year as a result of unusually low landings of anchovy. It has been estimated that Peruvian production was around 1,385 thousand tons in 1965, which was 300 thousand tons less than production in 1964.[1] In the United States fish meal production in 1965 is expected to be slightly larger than in 1964 since menhaden landings were moderately above their 1964 level. These landings, however, were still considerably below the more than two billion pounds annual catches of the early 1960's.

World fish meal prices increased quite substantially in 1965. In the United States, high and low prices of 1965 quoted for the various fish meals were as shown in Table 23.

There was a range of about $40 per ton between high and low prices during the year. High prices ranged from $180 a ton for whitefish to $192 a ton for herring. Price quotations in the early months of 1966 were substantially above prices quoted in the

[1] Dept. of Trade and Commerce "Annual Fisheries Review – Peru", 1966.

Table 23 Range in Price Quotations of Fish Meals, U.S. Markets

	1965			
	Low		High	
	Per Ton	P.P.U.	Per Ton	P.P.U.
Boston-Whitefish (60% Protein)..........	$140	$ 2.37	$180	$ 3.00
New York-Menhaden (60% Protein)	$142	$ 2.37	$184	$ 3.12
Anchovy (65% Protein)	$140	$ 2.15	$184	$ 2.83
Seattle-Herring (70% Protein)	$157	$ 2.25	$192	$ 2.75

Source: *Fishery Products Reports,* 1965. U.S. Bureau of Commercial Fisheries

early months of 1965.[1] This may indicate that prices for 1966 on the average will range above those of 1965.

The outlook of the world's fish meal industry up to 1970 depends to a great extent on the outlook for Peruvian production and the behaviour of world prices. Fish meal prices are already quite high and will probably result in inducing greater world production and some decrease in world demand, because higher prices could result in some reduction in quantities of fish meals used in various countries. The interaction of these two forces could conceivably lead to either a levelling off of prices or to actual price decreases, and there is a distinct possibility that either the former or the latter would be experienced before 1970.

The recent decrease in anchovy landings in Peru in 1965 caused great concern in that country, since it was thought that the anchovy fisheries were over exploited and that decreasing returns had set in. There were indications however, in the late months of 1965 and the early months of 1966, that anchovy landings had increased above their former levels with the result that marked increases in fish meal production are expected for 1966. There is some evidence though, that the fishery is being over exploited by the present fishing effort since over 60 per cent of the fish now caught are immature. Although it is too early to come to any definite conclusions about the prospects for Peru's fish meal industry in the next few years it seems likely, with the introduction of measures to regulate the fishery and bring about greater efficiency,[2] that production in Peru will probably level off by 1970 at slightly over 2 million tons a year.

The outlook situation for world production of fish meal up to 1970 based on a linear projection from world production data for an eleven year period 1954-1963,[3] is shown in Fig. 3.

On the basis of this projection world production of fish meal might be in the magnitude of 5.2 million tons by 1970. This constitutes an increase of nearly 26 per cent over world production in 1964, which was 4 million tons. This increase might be a bit on the conservative side, especially if production in Peru in particular and in a number of other countries such as Japan, the Union of South Africa, Chile, and the U.S.S.R. increases as rapidly in the late years of the 1960's as they did during the 1958-1964 period.

Recent Developments, Canada's Fish Meal Industry

Significant developments have been taking place in Canada's fish meal industry since 1964, which

[1] Price quotations for March 1966 were as follows: $165 a ton for whitefish, $156 a ton for anchovy and $185 a ton for herring. In comparison, prices for these meals in March 1965 were as follows: $143 a ton for whitefish and anchovy and $161 a ton for herring.

[2] Fishing season and size limitations have been established for regulating the fishery. There is also a great deal of consolidation in the financial structure and plants in the industry to achieve greater efficiency.

[3] A logistic curve might be more adequate for this purpose but in view of the short period involved it is thought that a least-square regression line would suffice.

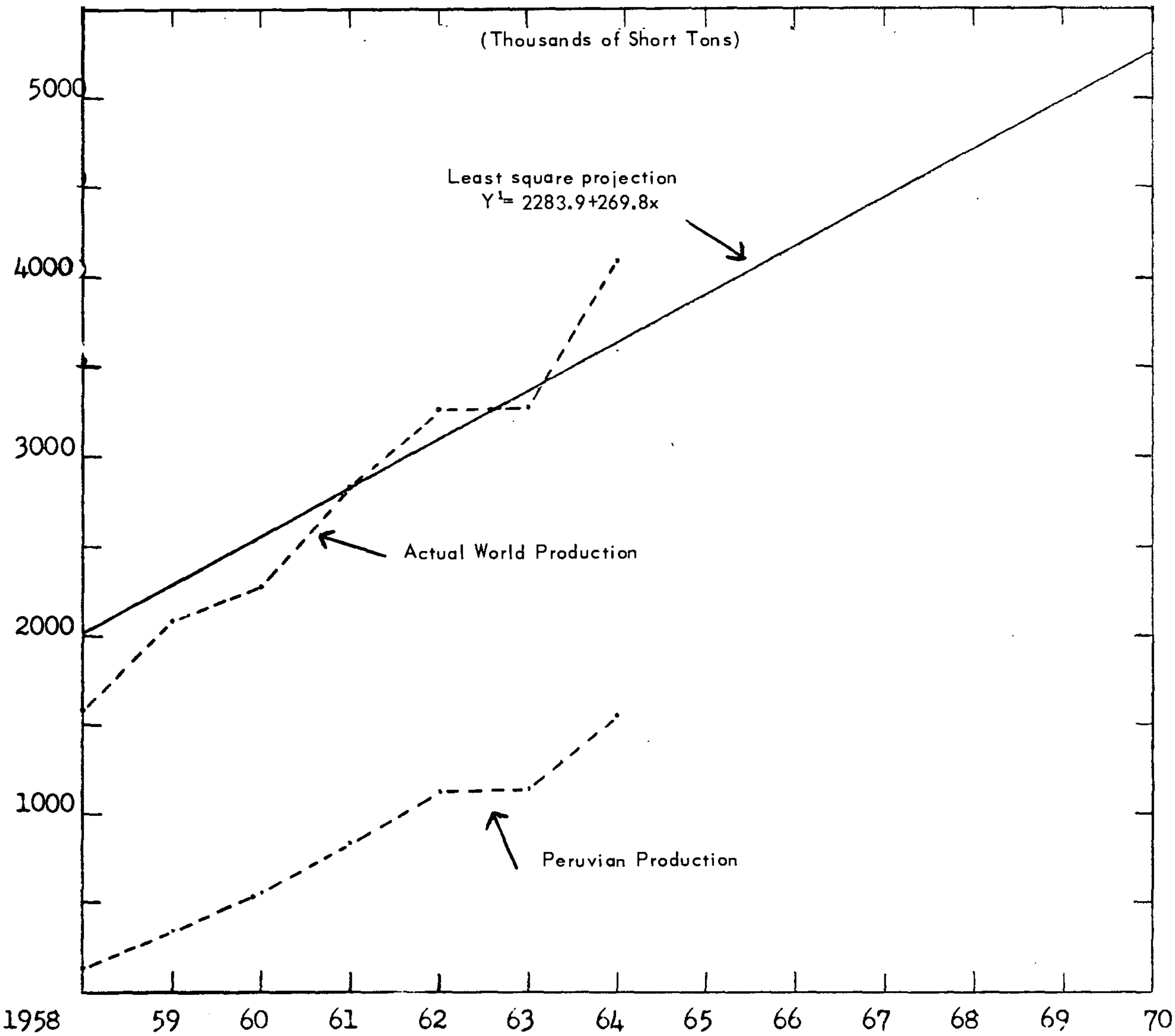


Fig. 3. World Fish Meal Production 1958–1970

Table 24 Canadian Production of Fish Meals 1964-1965

	Atlantic Coast		Pacific Coast		Total	
	1964	1965	1964	1965	1964	1965
			(Short Tons)			
Groundfish	25,342	42,794	–	–	25,342	42,794
Herring	6,247	12,783	46,071	40,129	54,007	52,912
Other	936	930	838	–	1,774	930
Total	32,525	56,507	47,409	40,129	79,934	96,636

B.C. *Fisheries Statistics*, 1964.

Source: *Monthly Review of Canadian Fisheries Statistics*, December 1965.

have exerted considerable influence on fish meal production in Canada since that time. These developments, however, have been restricted to the Atlantic Coast industry and have resulted in making this area the main area of growth in Canada for the industry.

Canadian production of fish meal increased by 21 per cent from 1964 to 1965.

In 1965, total fish meal production in Canada was the highest ever, when 97 thousand tons of fish meal were produced. This increase was entirely due to increases in Atlantic Coast production since production on the Pacific Coast declined to 40 thousand tons resulting from a decline in herring landings to 222 thousand tons, Atlantic Coast production of fish meal in 1965 was 56 thousand tons which constituted a 75 per cent increase since 1964. This production accounted for nearly 60 per cent of total Canadian production in 1965.

The great increase in production on the Atlantic Coast was brought about by extensive increases in plant capacity on this coast. At present, there are 54 fish meal plants on the Atlantic Coast with an estimated capacity for processing over 5,000 tons of fish a day. This constitutes an increase of 65 per cent since 1964 when there were 49 fish meal plants on this coast (Table 16.) This great increase in capacity was brought about not only by the new plants which have been built but also by the extension and renovation of old plants which have been taking place. In comparison there were no increases in plant capacity on the Pacific Coast with the result that Atlantic Coast capacity has increased from 30 per cent of total Canadian capacity in 1964 to 42 per cent in 1965/66.

The new developments on the Atlantic Coast have been geared mainly to the herring fishery and these developments, by providing new market outlets for herring, have been responsible for the increased herring landings and herring meal production. Herring landings increased from 156 thousand tons in 1964 to 202 thousand tons in 1965 and herring meal production from 6 thousand tons to 13 thousand tons in the same period.

The marketing pattern of Canadian fish meals also experienced some change in 1965, since exports declined to 42 thousand tons while the domestic disappearance increased to 45 thousand tons, which has been the largest retention in Canada to date. Although it is too early to arrive at any general conclusions on the potential for the domestic market it is significant that this increased retention for Canadian use occured during a year of extremely high fish meal prices.

Short Term Prospects: Canada's Fish Meal industry 1966-1970

The short term prospects for Canada's fish meal industry will be analysed with respect to the trends which are evident from the past and more recent performance of the industry. The recent performance, especially for the Atlantic Coast, indicates that the foundation on which rapid expansion in the industry can take place in the future is now being made. Despite great optimism that this expansion will take place almost immediately it will be well to remember that this is not normally the case. For example it took Perù some 6 to 7 years to become a major world producer under conditions which are much more favourable than are experienced herè in Canada at the present time. Great and sustained growth in Canada's fish meal industry will depend on factors such as: world prices for fish meal; the abundance of the herring fishery; and whether increased fishing effort could be accomplished without greatly increasing costs. These factors, which will only be known with time, all point to the desirability for an ordely and rational development for the industry.

Projections have been made for levels of output in Canada's fish meal industry from 1966 to 1970. These projections are confined to a short period because recent developments render the making of longer-run estimates of output extremely intricate and difficult. They are intended to indicate, therefore, output levels that are technically possible for the industry and take into account, to some extent, anticipated increases in demand for Canadian fish meals during the period.

The Demand for Canadian Fish Meals 1966-1970

The demand for Canadian fish meals is expected to increase during the period in both export and domestic markets. On the basis of present evidence it would appear that the demand for Canadian fish meal for export is likely to increase during the period. The increased export demand is expected to come primarily from the United States, where domestic production of fish meals has declined in recent years. If this trend continues, greater reliance will have to be placed on imports of fish meals from Canada and Peru to fullfil final demand for fish meal in the United States. The extent of demand for Canadian meals in the United States will, however, depend a great deal on production in Peru. Since expansion of Peruvian fish meal production shows signs of levelling out there are good long term prospects for sustained increases in Canadian fish meal exports to the United States.

Demand from the United Kingdom will probably increase steadily during the period since fish meal production in the United Kingdom remained at relatively stable levels for sometime and no great increases seem likely for the foreseeable future. This means that increased demands for fish meals in the United Kingdom will have to be met by increased imports. Some of these imports are likely to come from Canada.

Domestic demands for Canadian fish meals are also expected to increase during the period, 1966-1970. This is based on the assumption that production of poultry and meat will increase; that the trend towards increased use of concentrates and feeds, which was evident during the period 1960-1964, will continue; that greater use will be made of fish meals in production and, most important of all, that price relationships between fish meal, soybean meal and meat meal will not alter appreciably during the period.

Canadian Production of Fish Meal 1966-1970: Some Projections

The projected increases in the production of fish meal in Canada from 1966-1970 are based on the expected performance and output of the fish meal industries on the Atlantic and Pacific Coasts.

On the Atlantic Coast, judging from the present interest in the expansion of facilities and plans for the development of the fish meal industry, extensive investment in new plants and equipment and fishing vessels to exploit the herring fishery should be forthcoming in the period 1966-1970. There are plans by four large companies, three of them Canadian and one American, to build four large plants in the next two years with a total processing capacity of over 2,000 tons of raw fish a day. Plant processing capacity should therefore be over 7,000 tons a day by 1968, and if this trend continues should increase to 10,000 tons a day by 1970. This will constitute an increase of 100 per cent over the present processing capacity on this coast. The projected rate of increase in fish meal production for the Atlantic Coast rests on the assumption that this increase in plant capacity will be realized.[1]

Fish meal production on the Atlantic Coast should be in the vicinity of 112 thousand tons by 1970 (Fig. 4). This constitutes an average rate of growth in production of over 15 per cent a year during the period.

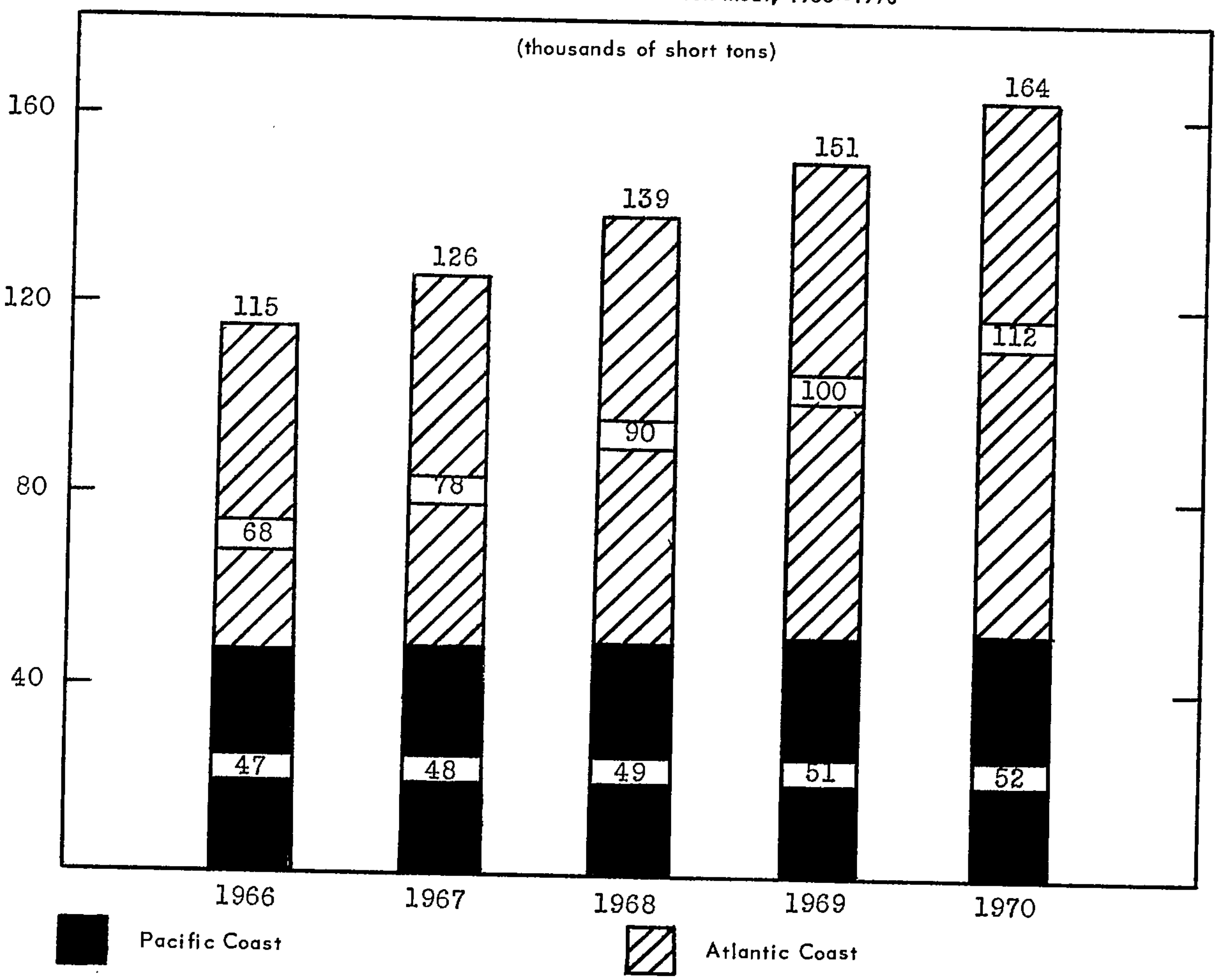
On the Pacific Coast there are no indications at the present time that any great increases in investment in plants and equipment or any great changes in the fish meal industry on this coast are to be expected during the period 1966-1970. In fact, many Pacific Coast fish meal companies are switching their attention to the Atlantic Coast and investing in new plants and equipment there. Because fish processing capacity on the Pacific Coast will probably remain at its present level, no great increases in fish meal production can be expected. This production is likely to fluctuate during the period, depending on herring landings. The estimated production on the Pacific Coast by 1970, based on the extrapolation of a linear regression line, should be around 52 thousand tons. (Fig. 4.)

The projections for the Atlantic and Pacific Coasts fish meal industries during the period 1966-1970 were combined to obtain the Canada total which is given in Fig. 4.

In Fig. 4, Canadian production in 1966 should be over 100 thousand tons and should increase to around 165 thousand tons by 1970.

[1]This is on condition that the seasonal pattern of operations on this coast will not change appreciably. If, for example, reduction operations are carried out for longer periods in 1970 than they are now then production levels would be higher than those projected.

Fig. 4. Canadian Production of Fish Meal, 1966–1970



Implications of Fish Meal Projections for Canada's Herring Fisheries 1966-1970

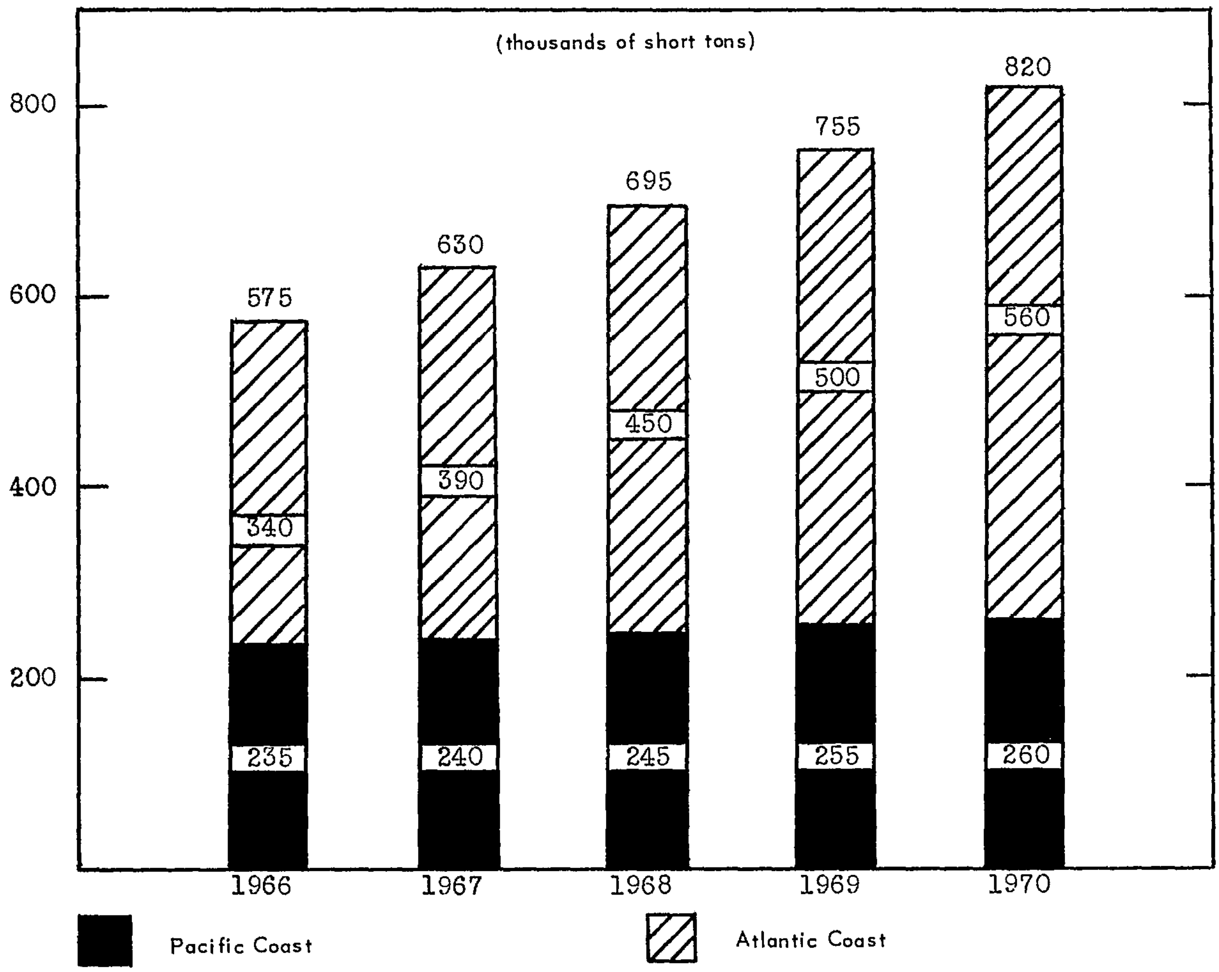
The demands which the increases in fish meal production projected for Canada during the period 1966-1970 will impose on the fishing sector can be established on the basis of an average requirement of five tons of raw fish or offal for the production of one ton of fish meal. The requirements of raw material for Canada and for the Atlantic and Pacific Coast industries are shown in Fig 5.

In Fig. 5, the volume of fish and offal required for fish meal production in Canada should increase to over 800 thousand tons by 1970. Of this, 560 thousand tons will be required from the Atlantic Coast fishery and 260 thousand tons from the Pacific Coast fishery.

In the light of these prospects the demand for herring for reduction purposes in Canada in the years to come should be quite substantial. On the Pacific Coast, where the industry depends essentially on the herring fishery, the 260 thousand tons required by 1970 is close to the maximum catch thought possible for herring on this coast, which is around 300 thousand tons. Any further expansion in reduction capacity on this coast beyond this limit will have to depend on other fish species for raw materials.

On the Atlantic Coast the herring potential has not been fully tapped, due to the inadequacy of market outlets. Fishery biologists point out that it is quite possible to increase landings nearly three-fold in many areas without any danger of overexploitation of the herring resources. Because of this, the proposed developments for the fish meal industry on the Atlantic Coast are based mainly on the development of this fishery. If production of fish meal from groundfish offal remains relatively stable during the period 1966-1970, using about 200 thousand tons of groundfish offal a year, then by 1970 about 400 thousand tons of herring will be required by the fish meal industry on the Atlantic Coast.

Fig. 5 Projected Demands, Fish & Offal for Resuction in Canada
1966–1970



Session 5

DISCUSSION

Dr. Needler: "I think it might be properly explained that these projections by the representatives of the Provincial Governments were made on request in order to get some over-all assessment of the situation, and I don't feel that any one of the people making these projections considered them very firm. I think that they were conjectures rather than firm projections, so none *of the gentlemen who made them should really be held to account. It does show, however, that in general there is a feeling among the representatives of Provincial Governments on the Atlantic coast and indeed, this is shared by the Federal Government, that we are not merely on the verge of a major expansion – a major expansion has already started.''*

Mr. Brian Meagher: ''Mr. Chairman, I would suggest that it should be pointed out that, in making a record of the statements made by the various provincial deputy ministers, this does not necessarily reflect the opinion of the government that each deputy represents; on a provincial basis the government of Nova Scotia has not authorized this statement. It is a personal statement from which, incidentally, I would not retract anything or any of the projections that we've made. As a matter of fact in Nova Scotia most things we do are on a conservative basis. We use a small 'c' when we say that, but I'd just like to point out that this, when it is written into the record, should be expressed as the opinion of the Deputy Minister rather than the Government.''

Session 6 May 7, 1966 – 10.15 a.m.

Industry's Approach to the Development of the Canadian Atlantic Coast Herring Fishery

Moderator

Dr. Yves Jean, representing
Maurice Lessard,
Associate Deputy Minister,
Department of Industry and Commerce,
Quebec, P.Q.

Our Future Supply of Herring in the Bay of Fundy

by

D.A. McLean, Jr.

CONNORS BROS. LIMITED, BLACK'S HARBOUR, N.B.

In introducing the following submission, we appreciate this opportunity for the East Coast Canadian sardine fishery to submit its views.

There always has been a tendency to underemphasize the importance of this industry to the area and its people, so we feel it is important that some understanding be given to those whom we employ and also the population of the whole area which is dependent on the sardine industry.

The fish processing industry in general and the sardine industry specifically play a very important role in the economy of Southern New Brunswick.

The East Coast sardine fishery, for the main part, is centered in the Bay of Fundy and in and around the Passamaquoddy area of Charlotte County and is the second largest canned fish industry in Canada. With nine operating plants in Charlotte County, annual production runs well over 1,250,000 cases per year. As a result of this production, the direct outlay for fish and manufacturing wages would run to over $6,500,000.00 per annum. Added to that, would be the cost of cans, which are manufactured in the local area, plus, a substantial quantity of other New Brunswick products used in the process. Additional investment of many millions of dollars has been made in weirs, seines, boats, canneries and other equipment. At the height of the season, employees in the canning industry alone amount to over 2,000 people.

According to statistics, there has been fishing for sardines in the waters of the Bay of Fundy for over 75 years. During these years, there have been years of plenty and years of scarcity but, up until now, no one has yet been able to make any predictions as to the volume of catch available or the areas in which they could be caught. This uncertainty of the supply has always been of grave concern to the industry as well as the fishermen of the area.

This current increase in the herring fishery of the Bay of Fundy is naturally of great interest to us. We view with grave concern the increase in the use of herring for direct reduction into fish meal and oil without the thought of controls or restrictions. This concern stems from the fact as to what effect this uncontrolled fishery will have on the supply of sardine size herring. This interest in herring for reduction is obviously sparked by, first of all, heavy government subsidization of boats, plants and machinery with additional tax concessions and also the present market situation for herring meal. It should be pointed out that one ton of herring bought for canning purposes will contribute approximately $80.00 to the economy of the area in direct wages and payments to fishermen. The same amount of fish purchased for reduction into fish meal and oil would contribute $23.00 to the economy. One must remember that fish canning remains a very high labour content industry whereas fish meal can be produced almost entirely mechanically. We mention these points, not to reflect unfavourably towards those concerned with the fish reduction industry, but only to point out some significant points concerning the canning industry.

The fish meal fishery in the area of Southwest Nova Scotia is based on the inshore migration of mature herring which results in their spawning sometime during the months of August, September and October.

It is reasonable to assume that the supply of sardines, which maintain our business, originate from the eggs left by these mature herring.

The fishing effort has steadily increased during the past few years. The herring landings in the Bay of Fundy in 1963 were 161,000,000 pounds. Landings increased in 1964 by 15% and, again in 1965, the increase was a phenomenal 38% over 1964. It is of increasing concern to us that this steady increase cannot continue without seriously affecting the herring population.

Age and length characteristics prepared by the Department of Fisheries on the herring caught for reduction in Southwest Nova Scotia during the past few years show a marked trend toward young fish being caught. In 1962, the results showed that 31.4% of the fish caught were in the four-year-old class or first year spawners. Since that time, the quantity of four-year-old fish caught has increased to 37% in 1963 and to 55.3% in 1964. The percentage of herring caught in the five to eight year class decreased from 40.2% in 1962 to 28.1% in 1964 (1965 figures were not available when this report was written). These are very alarming figures and would indicate the age of the school is becoming younger which points possibly to an over-fishing condition.

At the present time, there is a great deal of incentive for any one with a limited amount of capital to establish direct reduction plants, mainly at government expense, with the anticipation of quick and attractive monetary profit. It is, therefore, the direct responsibility of the Federal Government of Canada to ensure that any such endeavours do not have a direct bearing on loss of supplies to industry already established and existing on its own capital contributions from earned income over the years.

The trend has been the same in other world fish meal areas established in recent years. Both Peru and South Africa have been forced to take belated conservation measures and, in each case, solely for the continued existence of the fish meal industry itself rather than, as could well happen here, to eliminate a threat to long established industry with a large investment in physical and human assets. Even on the Canadian Pacific Coast, the reduction industry has established safeguards to ensure the supply of herring.

We submit that the fishery of Southwest Nova Scotia and the Bay of Fundy requires a complete evaluation to make possible the maintenance of a maximum sustained catch from the fisheries which will support the existing sardine industry as well as the fish reduction industry. Any conservation or management measures will consist of restricting present catches in some way in order to ensure better catches in the future.

We submit that we require immediate action by the Federal Department of Fisheries to provide important research into the herring populations and habits in order to provide the information needed to formulate recommended levels of fishing effort. Following this, we require legislation and action to control fishing and catches at the recommended levels.

It is wise for us to remember that action may have to be taken before absolute certainty of the state of the stocks is known, otherwise, events may have gone too far. There is rarely any such thing as painless conservation and almost always there is immediate sacrifice to be made to achieve the long term gain. If this immediate loss is small, then all parties are less affected. Therefore, action should be taken early.

We submit that the following general conservation methods should be considered: –

1. Protection of herring for a short period before they spawn.
2. Protection of spawning area and spawning beds from the fishery, especially the trawler fleet.
3. A limit on the quantity of mature herring taken from the water to ensure ample population remaining for spawning.
4. A limit on the size of the fish taken for reduction.

The 1966 outlook for the fish meal industry certainly is not as bright as this time last year. The price of meal on the American market has dropped between thirty and forty dollars per ton in the last few months. The present world market for fish meal is weak because of the large inventory stocks on hand in Peru. Naturally, developments in the Peruvian production will be the key to future world prices. The excessive high price of meal reached in 1965 has had a lasting effect on the market. Feeders have reformulated to compensate for this high price and have used as low as 2% fish meal where at one time the amount ranged between 7% and 10%. With the introduction of substitutes for fish meal on the market, the sales situation is going to be tough. There is currently an aggressive sales program underway for such substitutes as "Octaferm", "Methionine", "Fermacto", "Solulac" and others. This sort of program is producing results, namely reformulation by feed manufacturers and consequent lower volumes of fish meal in demand.

It has been claimed that in most years far more herring are caught than can be marketed profitably. It was Alexandre Dumas who made the statement "Herring is an excellent fish that would have a great fuss made over it if it were expensive". Unless new methods are found to make herring more attractive and convenient to prepare from the consumers' point of view, prospects for increased sales of canned products to the affluent society of the Western World are not particularly bright. Demand, therefore, lies in areas where there is a great demand for protein for its own sake but production costs must be kept extremely low to make up for the high cost of transportation and lack of economic ability to pay by the underdeveloped areas concerned.

The sardine industry in the Bay of Fundy suffers, not from a selling program, but from the production difficulty in obtaining sufficient suitable fish for packing. The encouragement, therefore, of any additional form of industry, which will tend to decrease sources of supply, can only lead to the eventual decline of an industry which has built up its reputation around the whole world over the past 75 years.

We must, therefore, appeal to the Department of Fisheries to establish immediate and extensive facilities for proper research into fishing for herring to ensure that proper conservation measures are instigated and strictly enforced.

To put it bluntly, a short-term view for a "quick dollar" could well prove disastrous over the long haul to the fishermen of this area and the land workers dependent on their skills.

Industry's Approach to Development

by

Laurie Delaney

Gorton-Pew Limited, Havre Aubert, Magdalen Islands, P.Q.

(Mr. Delaney's paper was read by L.C. LeBlanc)

During the past twenty years, we who have been engaged in the fisheries have viewed with pride the great strides that have been attained in research and development. These achievements have been the result of a co-operative effort between industry and government. However, our look into the past must be brief for, in setting our goals for the future, we must be fully cognizant of the complexity of the problems that will confront us. We must accept the fact, and the challenge, that we are becoming more and more involved in a field that is international in scope. Our competition will not only be met in the market place, but also on the oceans where our raw material must be harvested.

There are many of us here who have become financially dependent upon the herring fishery off our Atlantic Coast. At times we have a tendency to become complacent; but we soon face reality and realize that we are engaged in a fisheries that is cyclic by nature. We admit that our success, to a great degree, becomes more dependent upon the guidance and advice of the biologist with each passing season. We must propose and adopt programs which will prove most beneficial for the entire industry in the years ahead. Fish populations of the "inshore fishery" must continually be observed. An increase in fishing effort and new plant construction must be accomplished, but in an orderly manner so as to provide a barrier against the possibility of over-fishing our supply.

The seiner-trawler type vessel offers more flexibility to the boat owner; it also has the possibility of yielding greater financial returns. However, we will have to continually depend upon the marine architects to provide us with vessels that are faster, larger, more efficient, and more economical to operate, if we are to pursue fish that swims further from our shore. More time and effort will have to be exerted toward perfecting midwater trawling. Seines will have to be utilized which may be longer in length and deeper in depth. Chemical preservatives and refrigerated salt water offer new horizons for research in the preservation of fish.

The fisherman of the future will have to be skilled in the usage of modern electronic equipment. His accuracy in operation and interpretation will determine the degree of success he experiences in his daily endeavors.

Fish reduction plants will have to establish sanitation and maintenance programs that are on a higher level than exist today. Although equipment fabricators have provided the industry with machinery that satisfies our needs at present, they will have to modify equipment to produce a better grade of product for the future, especially in that part of the process that relates to the cooking, pressing, and drying of fish. Electronic controls in all probability will become more popular as a means to achieve greater efficiency. As automation gains a stronger foothold, the demand for semi-skilled and skilled personnel will increase.

Even though we are suppliers of an ingredient that is used in the animal feed trade, we will have to voluntarily modify our standards on quality, thus upgrading our product on an industry-wide basis. We must develop a constant demand for "*Canadian* herring fishmeal." Some segments of the feed industry have publicly acknowledged that Canadian herring fishmeal when properly processed is the best fishmeal available in the market. We must take advantage of these praise-worthy comments and aim to co-operate on joint research projects with the feed industry.

At the present time, unfortunately, almost all of the markets that herring are sold into are limited in quantity and at times highly competitive. New uses, therefore, must be sought. It appears as though world-wide demand and interest for a fish protein concentrate is gaining momentum. We must continue in our endeavors to develop a process that is practical and economical. International demands for protein will continue to expand. However, the purchasing power of the individual in such areas as South America, Africa, the Mid-East, and Far-East must be taken into consideration as the prime factor in developing a product that will meet their needs.

In conclusion, I want to re-emphasize that the future does hold great opportunity for our industry. There is just cause for optimism. However, in order to take full advantage of these future prospects, we must act now, jointly and in unison, to establish standards and goals that will be second to none.

The Vinegar Cured Herring Industry in Eastern Canada

by
F.K. Spencer
Booth Fisheries Limited, Chicago, Ill., U.S.A.

The remarks as contained in this paper are directly related to a cured herring operation since it is this phase of the industry with which our company has been most intimately associated. Others attending this meeting have been exposed to other phases of the herring fishing industry and will undoubtedly comment on those aspects of the industry with which they themselves have had experience.

Booth Fisheries' primary interest at the present time in the Canadian East Coast herring fishery is as a supply source of raw material for its Cured Fish Division which is located in Chicago, Illinois. Likewise it is felt that other processors of cured herring products in the United States consider the East Coast of Canada as their primary source of raw material.

Collectively the United States cured herring processors will, it is estimated, annually use some 65,000 barrels of either salted or vinegar cured herring; the latter type representing the greatest volume. It is further estimated that of this 65,000 barrels, approximately 65% will originate in Eastern Canada. Approximately 10% of the United States' requirements are purchased from foreign sources other than Canada and the remainder will be purchased domestically. It is thought that perhaps 3,000 barrels are used annually in Canada, but no figures are available to support either U.S. or Canadian usage. Booth has purchased salted and vinegar cured herring in Canada for well over 30 years and themselves have operated herring curing plants in Nova Scotia and New Brunswick for at least 19 years. I hasten to point out that during the time we have operated company-owned plants, we have, in addition to the production obtained from these plants, purchased considerable quantities of herring from other producers. Our plant in Nova Scotia was closed in 1965 when simultaneously we commenced operations in a plant which we acquired at Caraquet, New Brunswick.

Pickling with vinegar and spices is a very ancient form of food preservation dating back to prehistoric times. Some believe that it probably antedates even the method of pickling with salt. It is mentioned frequently in the writings of the Greeks and the Romans, indicating that certain of these fishery items so prepared with vinegar and spices were considered great delicacies, selling at such high prices that they were reserved for the banquet tables of the very rich. One dish, popular in Spain and in Latin American Republics of Central and South America today is "escabeche". It is prepared by frying fish in oil with bay leaves and spices, then marinating in vinegar and oil. This particular dish can be traced directly to the Romans who had earlier acquired it from the Greeks. Vinegar pickled fish played a very important role in the food economy of the Northern European nations down through the 17th Century and still, to a lesser degree, continues to do so today. Spicing and pickling is one of the methods of food preservation employed in North America today and at its inception was directed primarily at satisfying the food habits of early immigrants, particularly those from Scandinavian and Northern European countries. While the consumption of cured herring products is not growing commensurate with the population growth in the United States, it is interesting to note, however, that it is steadily growing and items prepared from herring are very acceptable, particularly to children. We may conclude, therefore, that the market will continue to expand and that there will be a continued need for these items.

Vinegar differs from salt as a preservative agent in that it does not preserve by osmosis, extracting water from the food but, instead, enters into chemical combination with the product itself, thereby reducing or by inhibiting bacterial growth. Some 30 years ago practically all of the herring caught in Eastern Canada was salt cured; however, a method was later devised whereby salt and vinegar were combined to provide a product not so susceptible to oxidation and with a vastly improved colour characteristic.

A straight salt cured herring is usually very tough, whereby with a salt and vinegar combination cure the texture is much more tender and more acceptable to the buying public. Spices used in the finished product are intended for flavour and are not, as was thought in older times, used as a preservative. Quite to the contrary, the spices used oftentimes contain bacteria and by their introduction there is a chance of accelerating bacterial growth. For this reason most herring processors today use essential oils of spice for these are much more sterile and therefore the chance of introducing a deteriorating factor into the product is reduced.

In considering the possible potential of a given area as a source of supply for the necessary raw material needed in a herring curing processing plant, there are many factors to be considered. For example, the market preferences in different areas, and I am thinking particularly of the United States, will demand a different type of raw material. The "matjes" herring, which originates in Iceland, which has a very high fat content, is acceptable for some products, while lean spring herring obtained during April and May along the New Brunswick Coast and the more preferable fall herring caught from July to September in New Brunswick and Nova Scotia will supply another taste need. Fortunately for the Canadian herring industry it is the fall caught herring which has gained the widest acceptability in the markets of the United States and Canada.

SPRING HERRING

Generally speaking, the spring caught herring are smaller, have a much lesser fat content, darker meat, and are slightly tougher than those taken in the autumn. For the above reasons they are used principally as a "fill in" and at a time when the inventories of the more acceptable fall caught herring are usually depleted, or at best, very low. For quality reasons it is not desirable to hold the fatter fall herring for periods exceeding six to eight months. The cost of holding an inventory of fall caught herring to cover the needs for a full year is alone substantial and this reason, coupled with that of quality, will dictate the use of spring caught herring, in the herring curing industry. It may well be that scientific research will uncover populations of herring now unknown to us which will provide a year round supply of prime herring similar in all respects to those which we now commonly designate as fall herring. It should be pointed out, however, with respect to this latter, that any such population of herring must be capable of being delivered into a processing plant within a period of twenty-four to thirty-six hours after catching. Boats of better design with revolutionary holding techniques may, however, permit us to reach more distant grounds and at the same time land fish of high quality. It is essential that good, firm fish are delivered to a processing plant so as to facilitate filleting, which is the method applied in processing about 90% of the raw material destined for subsequent curing.

ALEWIVES

We have above discussed the spring herring which represents the first phase of a seasonal pelagic fishery for the Canadian East Coast under the present method of operation. Immediately following the spring herring run alewives are taken and processed, thus enabling any processing plant to operate on a continuous basis between the spring herring run and the fall herring run, the latter commencing in New Brunswick during the second week of July. They are, therefore of prime consideration in regulating the flow of product through a plant. This species usually appears late in May and the run continues until late in June. These fish are much more susceptible to deterioration due to extended storage in the raw state and have a tendency to soften much faster than does the true herring. It is, therefore, of prime importance that any processing plant engaged in handling this species be located as close as possible to the source of supply. They are inferior to the spring herring for discoloration and principally yellowing occurs at a much faster rate than it does in the spring herring, demanding that they be used as early as possible after pickling, and as earlier mentioned, they do fill a need in keeping a New Brunswick herring pickling plant operating on a continuous basis.

FALL CAUGHT HERRING

Continuing with the season, fall herring fishing begins in New Brunswick about July 15, continuing until the middle to the end of September and on rare occasions well into the month of October. During the initial stages of this run the fish are not too acceptable for a fillet product, the texture being soft, and as a consequence thereof, when possible, filleting is delayed until at least the second week of the run. Whether or not improved handling techniques would permit utilization of the species during the first week of the run can only be determined by experimentation. It is thought that better education of, and a willingness on the part of the fishermen to take better care of the catch may make this possible. It should, however, be pointed out in the case of New Brunswick that drift nets caught the fish, with fishing being done at night in poorly lighted boats, resulting in the fish oftentimes being abused by inefficient handling techniques. In the matter of gill net caught fish, there are two distinct techniques applied in New Brunswick and Nova Scotia. In New Brunswick, the "drift net" system is applied, while in Nova Scotia the "set net" method is used exclusively. In the former, the fish have a longer period of time on board the boat and as a result are exposed to the warm summer temperatures for greater periods, whereas in Nova Scotia the nets are tended early in the morning with a lesser time interval between catching and landing. Also, the layout of the small inshore herring fishing boats in Nova Scotia is, in our estimation, superior, permitting the fishermen the opportunity to tend his nets without stepping on the fish removed from the nets and on board the boat. This is a most important feature and quality factor in landing good, firm, undamaged and unbruised herring, which are required for a cured herring product. Furthermore, in Nova Scotia, the herring are protected from the sun by wet canvas coverings during the transport to shore, whereas in New Brunswick this practice is not employed. There is a wide area for improvement in the handling of herring and a program should be instituted whereby fishermen are made aware of the delicate nature of the product they are handling, particularly when it is intended as a food item. Perhaps acceptance of the better handling practices has been slowed due to herring being used as well for fish reduction purposes, which does not require the careful handling of the raw material. It has been noted in our Caraquet operation that on days when fishing is good and herring are plentiful, as much as 50% of the catch is sometimed rendered unsuitable for a pickled herring operation due to the abuse to which the fish have been subjected following removal from the nets and subsequent transportation to the shore based plant. It has been suggested that the fishermen would be well advised to have two holds in their boat when drift fishing for herring, so that in working their gear it is not necessary for them to wade knee deep through herring all night, thus spoiling much of their catch and, as a result, they lessen their earnings through having to sell their fish to a meal reduction plant.

MARKETING

While we ourselves market a number of different cured herring items, there are basically just a very few items which are processed in Canada and the United States in a volume which would provide a reasonable profit for those investing in the industry. We are well aware of the fact that there are a number of specialty items made available by foreign sources and marketed in the United States and in Canada. These, however, are of minor importance but perhaps they could conceivably play a part in a complex cured herring processing plant which would specialize in every possible item, thereby permitting it to operate throughout the year on a continuous basis. Also, thought should possibly be given to the idea of salt processing of herring products, for these might find a market in other areas of the world now deficient in a high protein food. Industry is not, in my estimation, in a position to invest monies in these very minor items carrying with them their high cost of processing equipment and possibly a low margin of profit, since they will have to compete with products originating in countries such as Japan, and others which do not have the high cost of labor which we here in Canada and the United States experience. Perhaps government will see fit to undertake some comprehensive research and assistance to ascertain whether or not the specialty items herein referred to could be of importance and play a major part in extending the herring processing season over a greater period. While the inshore herring fishery is of significant importance to the economy of the Atlantic Provinces and particularly to New Brunswick and Nova Scotia, we have seen in the last two years that the potential of the offshore fishery is much greater than the inshore fishery. With the advent of larger boats and the ability to fish with seines, the catch of herring has increased beyond our wildest expectations. Certainly a part of this fish can be and will be devoted to the pickling process, particularly if our techniques of handling are improved, permitting us to land good quality fish at the plants. Unfortunately, the schools of herring are oftentimes quite removed from the present processing areas and therefore, this without some advancement in handling techniques, will be a detriment to any progress which we can visualize.

MANAGEMENT

With respect to management, this too is one of the curtailing factors in the expansion of the pickling industry. Traditionally, the handling and processing techniques have been handed down from generation to generation and, in some cases, from father to son, and as a result of this there is but limited knowledge and ability available. Here again, perhaps the governments of both countries can further the expansion of the industry by making a concentrated effort toward introducing new talent and ability into the industry. Unfortunately, as is the case throughout the fishing industry generally, many young men are unwilling to choose the fishing industry as a profession, for it does not carry with it the security that perhaps other more minor industries have.

THE NEWFOUNDLAND INDUSTRY

The Newfoundland herring industry historically has played a major role in supplying herring products as a food item. In recent years, however, possibly due to an offshore migration of herring population during the traditional fishing season, we have seen a reduction of processing. While pickled herring continues to be produced in some areas, the industry as a whole has suffered a reduced volume. Intensified fishing efforts by inshore and, more particularly, by offshore seiners may well influence the industry in Newfoundland and most certainly a part of the fish landed by offshore seiners will be utilized in pickling and subsequently into cured herring products. As a company we are intensely interested in the development of not only the Newfoundland herring fishing industry, but that of Eastern Canada in general, and optimistically look to it as a continued source of raw material for our Cured Herring Division, and as a means of increasing our production of fish meal and other related products.

Industry's Approach to Development of the Canadian Atlantic Coast Herring Fishery

by

W.R. Murdoch

B.C. Packers Limited, Dartmouth, N.S.

It gives me a great deal of pleasure to be addressing this conference today, and I must congratulate the speakers of the last two days for the wealth of information presented to this very attentive audience. Certainly the mention of herring on Canada's Atlantic Coast has caused quite a stir in the last year. The Secretariat provided this section of the conference with a variety of topics so that each speaker could present his thoughts but stay within the same "wave lengths." Unfortunately, these wave lengths cover a wide frequency, so my remarks will be limited to those topics that I am closer to.

Our enthusiasm was aroused in 1958, after meeting two pioneer seiners from Campobello Island, N.B., Captains Medford Matthews and Stan Savage. At this time, there was only a handful of small seiners, and their fledgling herring seine industry was struggling with shrinking markets, discriminatory gear policies and a lack of enthusiasm from other segments of the fishing industry. Those acquainted in the East Coast industry were primarily concerned with fishery products for human consumption. Herring meant sardines, smoked, salted or vinegar cured products and bait in several forms. The traps, weirs and gillnets could usually fill the market, but there were always years of gluts and scarcities with the usual hue and cry from the fishermen of not enough markets or not enough fish.

During the next few years, considerable time was spent by our company in assessing the possibilities of establishing a herring reduction plant in the Bay of Fundy region. From 1958 to 1963, the herring seine fleet expanded considerably, and with this expansion, marketing problems became evident. Production facilities did not keep pace with catching effort. A large pet food plant moved from Maine due to increasing costs of transportation of other materials and the proximity to their consumer market. The sardine market for seiners at certain times of the year was conversely related to the catch of sardines from weirs. The bait, smoking and curing markets required only limited quantities of particular sizes and qualities of herring. In summary, herring seining in the Bay of Fundy had proved itself over a period of years, yet no plant operator was prepared to supply the processing facilities needed to fill this gap. In 1964, our company chose to build a plant at Pubnico in South Western Nova Scotia. This was the beginning of recent increased interest in the East Coast herring fishery.

Past statistics of catches in no way indicate the potential of our herring industry in many areas, but rather show trends or patterns of limited market conditions or limited fishing activity. True, some areas have experienced declined landings in some years due to disease, and poor year classes due to changes in spawning and environmental factors. But in retrospect, these setbacks could probably have been less significant had the total base of the herring industry been broadened and more diversified in terms of catching gear and areas fished, since there are at least 6 distinct groups of herring population. I think these points must be the foundation for any future expansion, and can only be attained through complete co-operation of an integrated program between industry and government.

RESOURCE RESEARCH

A considerable amount of effort and funds was put into the Atlantic Herring Investigation Committee from 1944 to 1950. This was a joint venture between the Federal Government and the Atlantic Provinces, brought about by the increased need for food during World War II. Its purpose was to develop a greater utilization of herring for both ordinary usage and for new types of products. This expanded utilization depended upon the quantities of herring that could be taken in perpetuity as well as devising more efficient methods of catching. Conclusions were reached regarding divisions of herring populations, growth rates, spawning behavior and other biological data, as well as suggestions regarding catching methods. It provided a firm basis for future studies, but not all aspects have since been followed up, probably because the demand and interest for herring products diminished after the war years. With the recent revival of interest in this fishery, certain portions of this publication have been taken for granted, while some conclusions, notably those pertaining to methods of fishing, have been disproved in recent commercial ventures.

It would, therefore, appear that there is an urgent need for an immediate revival of research and exploratory fishing to guide and control the planned expansion of this resource. Possibly a good example of a parallel is the build up of the Russian fishing effort in I.C.N.A.F. sub areas 4 and 5. Since 1961, a huge mobile fishing fleet of over 500 vessels, ranging up to 3100 ton factory trawlers has moved into the North West Atlantic and during the last two years a definite shift to sub areas 4 and 5 has been evident.

Russian catch statistics of herring reported to I.C.N.A.F. for sub areas 4 and 5 were:

1962 – 160,404 metric tons
1963 – 100,036 " "
1964 – 133,195 " "

This fluctuation is probably based on changes in units of effort, rather than sustained yield fishing, as much of the same fishing effort was switched to silver hake fishing with the following catch statistics for the same sub areas:

1962 – 50,725 metric tons
1963 – 230,380 " "
1964 – 248,455 " "

This is a phenomenal increase of catch in just 4 years, and one must assume that research and exploratory fishing played a leading role in establishing this fishery on our historic fishing grounds, for species with we showed a complete lack of interest in.

It is interesting to note two observations reported in the I.C.N.A.F. Soviet Research Report, 1963, document #59. Decreased herring catches in sub area 5 were attributable to a decline in their drift net fishery, and considerable changes were noted in both size and age groups, not only during the 1963 season but also as compared to 1961/62. In 1961 and 1962, the predominant year class was 1956, while in 1963, the 1960 and 1958 year classes accounted for over 2/3 of the catch. They also reported in 1963 that the total herring mortality for herring of age 5 or older, on Georges Bank, based on age composition and fishing effort, was now 80%. I know Canadian scientific information and our commercial fishermen reported Georges Bank stocks as being large old herring, which would indicate a low mortality rate, and this has probably held true up until a few years ago. Does this mean that present herring fishing on Georges Bank has reached a sustained yield level, or that the stocks are being exploited beyond a reasonable level?

Another example of our limited knowledge of herring populations is our experience over the last two years fishing on the South Coast of Newfoundland. According to past research reports, this body of herring is reported to be a separate population, spawning locally in the spring. Yet from our limited fishing experience, these fish disappear or scatter in April and we found little evidence to indicate mass spring spawning from our commercial catches even though a seiner was maintained on the South Coast until late June in 1965.

I mention these examples to illustrate that a little knowledge can be dangerous when taken out of context, or used by itself. Similarly, single statements or conclusions drawn from information collected 15 or 20 years ago does not necessarily hold true today unless proved or verified over a long period of time or is based on current knowledge. The point to be made here is that research and exploration on herring is needed immediately, and is necessary for orderly expansion and optimum utilization of a fishery resource.

MARKETING AND PRODUCT FORM

Some people within the industry still claim it is a shame to reduce herring to meal and oil, and lament that herring should deserve a more sophisticated end product. I cannot agree more fully with these exponents, in that any fishery product should end up in a product form that commands the highest product return; but should we forsake a possible staggering increase in total landed value for the sake of up-holding the average landed value per pound? I think not. Our historic markets for food herring products have been limited, and generally speaking herring in North America has been considered as a cheaper type of food in our affluent society. In a report entitled, "The European Market for Herring," compiled by the Organization for Economic Co-operation and Development in April 1965, eleven European member countries reported catch and product statistics for the years 1957 to 1963. In 1963, herring landings totalled 1,771,700 tons, and of this 783,700 tons or 43.2% was processed into food products as follows:

Salted	– 31.2%
Fresh	– 30.1%
Canned	– 15.9%
Marinated	– 13.7%
Smoked	– 9.1%

The percentage of herring for food products in relation to total landings ranged as follows:

	Total Catch (Metric Tons)	% Human Consumption
Norway	510,000	17.1
Denmark	290,800	22.4
Iceland	396,200	29.5
West Germany	104,700	81.3
Netherlands	114,300	88.2
Sweden	193,000	98.1
France	33,400	100

It can, therefore, be readily seen that the countries with extensive herring fisheries and limited home markets must depend on meal and oil markets for the bulk of their product return, even though they are in close proximity to an immense market that historically considers herring as a food item in many forms. Further, a trend has been evident in recent years, and the proportion of salt herring is decreasing due to more sophisticated tastes due to increased prosperity in European countries. It is, therefore, doubtful if our expanding industry could look forward to receiving a substantial share of this market in a volume that would materially help a large segment of our expanding industry, unless we could sell primarily on a lower price basis. Even so, it is yet to be established if our herring have the particular quality and specifications that will meet their rigid market requirements.

Even our present food herring industry, serving markets already established, is limited by natural factors such as fatness, size, texture, and area and season of catch. It would, therefore, seem logical to assume that meal and oil plants will form the core of any intense expansion, and food production facilities will follow as demand and product requirements become known. Also, not to be overlooked in assessing the type of expansion is the regularity of volume and the cost of catching and transportation. In Norway, herring for human consumption dropped from 33% in 1959 to 17% in 1963. Food herring markets were lost due to unfavorable composition and migration of stocks, and unpredictable cyclical changes in volume. Norway is now content to assume the role of a meal and oil producer.

THE FUTURE

One of the questions posed was if industry considered landings of 1,000,000 tons of herring in the Canadian Atlantic area a reasonable target by 1975. I certainly would like to think in such terms, but I think the scientists and biologists are far more competent to assess the future potential. Certainly this fishery has experienced expansion to date, increasing from between 100,000 and 125,000 tons from 1950 to 1960, to over 200,000 tons in 1965, with the fishing effort still predominantly centred in the Bay of Fundy area. This is a 100% increase in 10 years; can we look forward to a 500% increase in the next 10 years? One popular theory assumes that the present rate of catch is 5% of the population, and the rate of fishing mortality can increase to at least 15% without any depletion in spawning stocks. I don't think this can be used as a rule of thumb for all known stocks, as some are fished more intensely than others. The Georges Bank Fishery is a good example of the unknown factors involved, and the same could hold true for many of the population groups reported but that have not been subject to an intensive fishing effort.

This fishery has the earmarks for expansion, but the final analysis will rest on the development and success of actual commercial fishing enterprises, both of catching units capable of exploratory fishing in areas not presently fished to any great extent, and also processing facilities strategically located to provide a broader base of operation. The incentive to attract fishermen has been demonstrated for a number of years by crew earnings aboard many of the Bay of Fundy seiners, and more recently by seiners operating in Newfoundland. The development of gear and fishing techniques, and the type of vessels and equipment will evolve as our experience broadens. Similarly, reduction processing equipment is bound to improve as customers require better quality controlled products, and more stringent controls are applied against water and air pollution. In all of these fields, I am sure that industry is aware of its obligations, but will no doubt require continuing support and co-operation of government agencies as has been appreciated in the past. No doubt the information presented at this conference will leave an impact on all of us, and will be a valuable contribution in furthering the growth of our fishery resources.

SESSION 6

DISCUSSION

Mr. Jean Frechet said he had been interested in Mr. Spencer's proposals made for improved designs and better handling practices for the inshore boats of the Gulf of St. Lawrence and Nova Scotia. He felt that a lot of improvements could be made on the mechanization of this operation. Mr. Frechet added that he had noticed that the Russians had developed a new class of 45-foot drifter similar to those used on the Great Lakes in Canada and the United States. He also asked Mr. Spencer if he could provide a little more detail about the proposals for two holds in the herring boats.

Mr. Spencer: "Actually, I don't know much about herring boats. My interpretation of the problem, however, is this, that in the case of the New Brunswick boats the fish are mixed, or the man stands in the middle of the boat and, taking the fish from his net, he drops them into the centre of the boat, whereas Nova Scotia boats have two separate compartments and the man stands in the forward or after compartment, I'm not sure which, removing the fish from the net and throwing them into the area where he's not working. I am sure there are many people here who could answer this question much more thoroughly than I myself can."

Mr. R. Simmons, of Computing Devices of Canada, Ottawa, commenting on the development of new techniques, better midwater trawls, training in electronics, etc., wondered whether Mr. LeBlanc would consider the advisability of developing equipment specifically for the herring industry, rather than the adaptation of existing equipment.

Mr. L.C. LeBlanc, Caraquet, N.B., replied that his company's experience with the herring industry had been mostly in inshore fisheries, but last winter it had had a seiner-trawler built at Paspebiac, P.Q. He understood this boat was fishing from the Magdalen Islands, and that it was using the same type of sounding equipment as was used in trawlers. He thought it possible that specialized equipment could be used to advantage in the herring industry.

Mr. Simmons asked whether the industry would consider the establishment of a research and development organization similar to that established in Great Britain by the White Fish Authority, where G.C. Eddie and his team had developed some equipment aimed specifically at the fishing industry. If the electronics industry knew exactly what was wanted and had a reasonable guarantee of a market, it could go ahead with production.

Mr. LeBlanc commented that after a year or two of experience with these boats, better suggestions as to specific needs could be made. "At the moment, I don't know if we know what we want."

Mr. Frank Spencer asked Mr. Johnson if any thought had been given to the development of a midwater trawl for use in the herring fishery of the North Atlantic. He understood from the experiences of the Germans that, in the heavy winter weather which might be experienced off the coasts of Newfoundland and Nova Scotia, a midwater trawl would be more effective than a conventional purse seiner. "With a midwater trawl one would not experience the damage I referred to earlier in broken backs on herring that were intended for filleting."

Mr. Johnson: "As you know, we tried midwater trawling in the Atlantic in the past but always with small vessels, and we felt that this was perhaps the reason they were never too successful. I have seen tows as high as seven to eight tons working with very small boats from Newfoundland – 60 feet, 160 horsepower. I could not feel 100 per cent enthusiastic about midwater trawling for herring until we got the opportunity to rig out a fair size trawler and try it, and then we'd be prepared to make an assessment. Certainly what Dr. Schärfe says is correct; they have caught a lot of herring, and I don't see why we shouldn't be able to do the same thing over here. It's just a matter of getting the ship and going at it, and during the winter, I'm not so sure that we would find herring on all the grounds on which we trawl; for example, in Newfoundland the herring are close to the shore. It may not be so easy to trawl them in that area, but then, on the other hand, I've heard that there's quite a lot of herring on Georges Bank in the winter. If this is so, then the chances of trawling herring might be pretty good during the winter months, but the gear efficiency of the midwater trawl and bottom trawl – you've got to combine the two – is still pretty low as compared to that of the purse-seiner, even with the best of gear I've heard described and seen any details of. In the end, I think that something should be done in this area with a boat rigged up and tried both winter and summer, but it's got to be a big enough ship to do something with. Say 500-600 horsepower at least."

Mr. Z.W. Sametz, Regional Development Economics, Department of Fisheries of Canada: "I am particularly interested in the effects of prices on the reduction industry. We seem to think the prices are already inordinately high in the industry. What I would like to find out in particular is that if prices do stabilize or decrease, whether this will have a dampening effect on the plans that are presently going forward in increasing reduction capacity?"

Mr. McLean: "If I understand your question right, should the price of meal stabilize or decrease, what effect will this have on the proposed expansion? Speaking for our company, we don't plan any expansion next year, or this summer. We're going to hold pat. From my point of view that's about all I can say to that question."

Mr. Murdoch: "We have a plant expansion under way in Newfoundland and I think basically that there is a fishery we feel can be exploited over there. I think certainly that with prices at their present level there is ample margin for the fishermen to make a good dollar out of it, and there's margin there for us to take a gamble to put in a million dollar expansion in a development that is, as yet, unproven."

Mr. Stevens: "Mr. Chairman, mention has been made of the earnings of the fishermen and I take it from various material that's been presented so far that the earnings, if they are improving or have improved, are based upon the higher tonnage landed per man per boat. Have you looked at the situation from the viewpoint of retaining a high level of catch so that the earnings of the fishermen based on the tonnage landed per year, as well as on the matter of price per ton paid to the fishermen, will be maintained or increased?"

Mr. Murdoch: "Well, I can only say that we're among those who are expanding, and with expansion we're looking forward to providing a much larger market for this large body of fish which we think is off our shores, and as such, I would think that for the years to come, as far as we can see into the future, anyway, that the catch per vessel should maintain, or, if anything, it should increase because of the number of plants that we hope will be provided throughout a much larger area. Therefore I think that this expansion should provide added markets for the fishermen, and providing there are resources there, then I feel that the level of catch will be maintained for some years to come."

A conference participant asked if Dr. Tarr, who had participated in a meeting of the International Association of Fishmeal Manufacturers, held in Cape Town, South Africa, April 24-30, would present a brief report on the meeting.

Dr. Tarr: "I have been asked to report on this meeting, length of time 5 minutes, that is one minute per day of meeting, so I can't give a very precise summary.

"I will report largely on the scientific sessions because the Fisheries Council of Canada and other people get a report on the more economic aspects from Mr. Garland who is with the Trade Commissioner's office, and usually attends these meetings.

"There are a number of interesting points which came up in the scientific sessions. I'll try to go through those that might be most interesting to you. One that I think is probably of interest to everyone is the advances that are being made in attempts to obtain biologically synthetic proteins from yeast grown on mineral oil concentrates, that is on the hydrocarbons in these oils. A considerable amount of progress is being made in this field, but by and large, these proteins are deficient in methionine and certain other essential amino acids, and at the moment I don't think the picture is a very serious one – it is something that has to be considered and is definitely being considered. So far all these yeast proteins have not been nutritionally nearly as valuable as those in fish meal, but we must watch this development because there is a lot of work going in attempts to make mutants of these yeasts that will make much better proteins.

"There's another aspect which received considerable discussion and this has a similar bearing on the value of fish meal as has yeast protein concentrate. This is the development of synthetic amino acids that can be added to fortify vegetable proteins. Now this is not a new development. Monsanto and Du Pont have been making synthetic methionine for many years. Presently though they are making a lot; there is such a demand that they can't satisfy it, so you can see that this amino acid is being made in sufficient quantity for feed use, and production may increase. If methionine becomes cheaper it may be a very serious competitor to high protein concentrates such as fish meal. The Japanese, several years ago, developed a microbiological process for synthetic lysine (another essential amino acid) and this, they claim, is now being sold for $1.50 pound. It is also apparent that the Russians are very interested in getting essential amino acids cheaply because they are short of good proteins. They claim that they may be able to develop a process for producing lysine at about 90 cents per lb. I don't know whether this is a fact or not; we must watch its development.

"There was, of course, the perrennial discussion of fish protein concentrate and I won't go into this. So far as I can see from what various delegates said, including two very capable ones from the United States, there does not at the moment seem to be any very definite market for this product. As you know, there has been a very large study of this in the United States, the method used being based on that developed by the Fisheries Research Board's Halifax Station.

"There was a long discussion concerning antioxidants and their use in fish meals. One or two delegates even wanted to make their addition mandatory. This was not approved. We ourselves feel that for many uses antioxidants can be very valuable; for bulk handling, of course, they are almost mandatory. The South Africans are very cautious about this because their meals are more reactive. They all go through what they call a 'curing' process, so that the present situation is one which I think we have to watch. As far as herring meal bulk-handling is concerned, I think antioxidants are necessary. Of course the usual procedure on the Pacific coast has been to bag the meal in multi-wall paper bags and, normally, heating hasn't been too much of a problem. There are occasions of runaway heating when the plant produces the meal too hot. I think at the present time there is a very strong indication that antioxidants will be used. We certainly hope that modifications of present antioxidants or development of new antioxidants, will enable them to be added before drying of the press cake. At the moment they're added after drying and unfortunately the oil in the meal has undergone an induction period and is somewhat unstable, and of course the antioxidant does not work so effectively. I did learn from Dr. Mead, who spearheaded the whole use of antioxidants in fish meal, that they have found in their work that the addition of the antioxidant to the condensed solubles before it goes into the dryer is preferable. We intend to try this ourselves; this would, perhaps, improve the situation.

"There were several discussions on the uncharacterized growth effects in fish meal and the actual value of fish meal in promoting chick growth. Few nutritionists now feel that new 'growth factors' exist. There is a lot of work being done by practical nutritionists in the United States, people who raise as many as 40 million chicks per year, and several of these feel strongly that fish meal is worth putting into practical rations. Certain dollar figures were given – I won't go into these – but they're quite impressive, and these people who really live by producing very large numbers of broilers believe that fish meal is a valuable additive to their feed formulations. Not all people feel the same way – some people claim that fish meal is not necessary and as you know, in Europe in general, there has been quite a setback in the inclusion of fish meals in chick rations. I think this is temporary. I hope it is occasioned by the rather high cost of fish meal to the feed processors. There is a very delicate balance, and anything that could happen to suddenly raise the price of fish meal might create a very serious situation, not only in Europe, but on this continent, so that I will leave that with you. There is nothing much we can do about this at the moment except to try and stabilize fish meal prices.

"There were some discussions on the use of complete polyethylene bags. South Africans are most interested in this. They are experimenting with the use of 9-mil. polyethylene bags which have some advantages and some disadvantages. I have no time to discuss these. I might say that the proceedings of the meeting will be completely available to the Fisheries Council and to certain other people. There is not very much else that is important except one or two little items. One is pelleting, and it was concluded that pelleting would not be a very profitable procedure. Some people have talked of pelleting fish meal. This would involve the cost of pelleting and possibly the cost of depelleting, and I don't think there is any particular advantage in this for most purposes. There was a discussion on bulk handling, of course. I think this is a method that can be used in certain areas to great advantage.

"There was one final item and I don't know how serious this is. Certain German investigations have been made and there is supposed to be a panel of quite competent people studying it. It is claimed that in the direct flame drying procedures the flue gases in some cases may contaminate the meal with carcinogens from the oil burners and with vanadium. This has been the subject of studies by a competent panel, and at the moment there are no available conclusions. It is something one has to watch; I rather hope that nothing much will come of it. It seems

to be extraordinary that people have used fish meal for years at quite high levels in poultry and other rations without ever having experienced trouble from this."

Mr. W.A. Moore, Fredericton, N.B., Chairman of the New Brunswick Fishermen's Loan Board, suggested the establishment of a co-ordinating committee on the financing of fisheries enterprises. "New Brunswick is just as interested in industrial expansion as any province on the Atlantic seaboard;" he said, "but from the Loan Board's point of view it must remain orderly, and the time has long since past when some sort of co-ordination should be established between various government agencies in Ottawa and elsewhere, and loan boards particularly."

CLOSING REMARKS BY CHAIRMAN

Dr. Needler: "I think I am an optimist on the expansion of the herring industry on the Atlantic coast, and that the basis for optimism is very firm. It lies in the undoubted fact that we are not even approaching the full exploitation of the herring resource. I'd like to make it clear that at this stage I would not pretend or presume to summarize the views of the conference but I would like to make a few comments which are, really, just my own. First, about the resource itself. There are some components of the herring stocks on the Atlantic coast which are undoubtedly pretty well exploited; however, these are only, according to our best knowledge, a small proportion of the stocks available. Other stocks are very grossly underexploited.

"Those of us who laboured on the Atlantic Herring Investigation Committee to look at the Gulf of St. Lawrence and its approaches actually felt a little bit impatient at times regarding the slowness with which development came. I feel sure that there is room for great expansion, but there are two words of caution I'd like to give. One of them is that it is impossible to estimate stocks and particularly impossible to estimate what annual production can be maintained, without a well developed fishery. The fishery is necessary in order to provide the scientists with material on which to make such estimates, and this state of affairs does not exist for a great many of our herring stocks, so the quantitative estimates that you have heard must be regarded simply as estimates. We can be sure that we can catch a lot more than we are catching now, but we can't be sure how much more until we start substantial exploitation of those stocks about which we don't know too much. There's another word of caution. When people start exploiting stocks of herring, like, for example, those in the Gulf of St. Lawrence or on the south shore of Newfoundland, which have a whole lot of ages present, it must be plain that for every thousand fish which have just joined the concentration – in general they are pre-spawning concentrations of adults – there are 900 that have just joined a year ago. If you're thinking of a ten per cent mortality rate, 810 have joined the year before and so forth, and there are thousands for every thousand that have just joined. If the mortality rate gets up to the level of the Pacific coast, about 80 per cent in all except the far northern areas, or the 80 per cent that the Russians report on Georges Bank, but even if they get up to say 50 per cent for every thousand recruits, there will only be a total of 2,000 instead of maybe 10,000 and as soon as there is substantial exploitation of any one of these stocks in which there is an accumulation of old fish, the abundance is going to go down, catch per effort is going to go down and the best guess is that after you have a substantial fishery the catch per effort will certainly not be half what it is now. It mightn't be a third.

"Now this is just a word of caution. In spite of this, there is only one thing for all of us to do and that is to go ahead and expand. On the other hand, as many speakers have said, the Government must see that there is enough research, both to guide the development, indicate

prospects, and also to be sure that we don't damage existing industries. And this will be done. My minister said yesterday that there was a large research vessel being provided this year for the study of the pelagic fishery. This is just one aspect of the sort of expansion in research – biological research – that is in mind, and that must and will be carried out.

"Now about fishing methods, it is quite clear that we have had in Canada a pretty good development of certain fishing methods over the years. We have had fixed gill-netting for some centuries. It is still one of our major means of production, and we have had a weir fishery for close to a century, which has a good deal of advantage in providing a controllable and high quality supply for canning. It is also clear that in the last few years, there has been really active development of purse-seining in Canada. This has come about partly through an active pioneering local development, especially in Charlotte County, N.B., or based there, and partly through more recent industrial and federal-provincial activities. We have assisted in this to some degree through federal-provincial assistance in explorations and demonstrations, conversion of draggers to purse-seining and so forth. Some of these things you have already heard about.

It appears to me that so far there has been some real neglect of trawling for herring, and one of the things that I think should come out of this, as a federal-provincial or as a departmental activity, is the support of some experiments in trawling. We have quite a large number of trawlers of the 100'-110' class with several hundred horsepower, up maybe to six or seven hundred in some cases, and we have even some larger ones. These boats would be quite capable of switching in one day between herring trawling, groundfish trawling and scallop dragging, and I think that one of the things that we shall do in the near future is make an active attack on trawling – on the problems of trawling. In this we shall have to enlist the co-operation of those who are really experienced, and they are mainly in Europe. They already have especially designed gear and they already have other equipment which is specially designed for the herring fishery.

" I think, too, some of the speakers mentioned drift-netting. It is rather interesting that drift-netting in Europe was at such an intensity as to cause government concern in England 200 years ago. It still is an important source of high quality food herring and we have to keep an open mind on this, especially if the food herring industry expands, as I think it should. When one comes to vessels, it is pretty obvious that about all you can say about herring vessels is that we're going to have to be open-minded and experimental. We in our Department in co-operation with the provinces from time to time have had some experimental types of vessels constructed to test them out and when successful, demonstrate them. This is another field that really must be continued in.

"I am so far from being an expert on marketing, or on processing that I have very little comment myself to make. However, if you can take this as an unskilled and distant view, it seems quite clear that the days when we were really worrying about the long-term trend in fish markets seem to be gone, and I think they may be gone for good. This doesn't mean that there won't be real difficulties. For example, somebody mentioned the real difficulty in making the herring meal industry pay next year; maybe there won't be any, and maybe there will, but marketing in the long run shows undoubtedly an improving trend. Up until a few years ago economists were saying on this continent that the food fish consumption was increasing only in proportion to the increase in population. Recently they haven't been so sure. There seems to have been a tendency both for consumption to go up faster than the population and for fish prices to the consumer to go up faster than the prices of other commodities. I would think that the development of a larger fish meal industry on the Atlantic Coast will take place. It probably will be profitable to all concerned but maybe in the long run one of its main advantages will be that it establishes a knowledge of

the supply; it establishes the supply itself, and provides a firm base from which industry can develop even more valuable forms.

"I should like to end my comments as Deputy Minister of Fisheries by saying that the Department is determined to do everything it can, both to assist in the development and to see that the development does not outrun the resource to the damage of existing industry. However, I don't like to end up on the last clause, because it doesn't sound as optimistic as I feel. I am sure that there will be a major and profitable expansion.

"I would like, before closing, to express my thanks, and I am sure in a number of cases, your thanks to a number of people who have made this Conference the success I think it has been. I'd like to start with the people who have done the work. I'm not thinking only of those who have guided the initial arrangements – my colleagues of the Federal-Provincial Committee and the Industrial Development Service of the Department, but the men and women who have been working here in the office of the Secretariat, they come, some of them, from our own Department's local offices, but also from another Federal Department, the Department of National Health and Welfare and from the Government of New Brunswick. I'd like to thank the Federal Fishery Officers for their contributions. We had excellent co-operation from the Queen's Printer, which has a branch at Camp Gagetown, in preparing last minute papers and I think that we all owe a debt of gratitude to these various people – I hope I haven't forgotten any, who have actually carried out the work of seeing that this Conference proceeds smoothly. We are glad to have had the press and radio people with us because a conference of this kind loses some of its value if it isn't well reported. I think that perhaps the most important group to thank are those who prepared and presented papers, and I have been impressed by the quality of the papers presented. I don't agree with everything they all said, of course, nobody does because they don't even agree with one another, but the papers have been excellent. And finally, I would like to thank my colleagues on the Federal-Provincial Atlantic Fisheries Committee because this Conference is a Federal-Provincial Atlantic Fisheries Committee effort, and especially I thank the Minister and Deputy Minister of Fisheries for New Brunswick and the members of their staff who have been called on to do a bit extra because we're meeting in the beautiful city of Fredericton. I think we have had a good conference and I think that we must all now digest it, do our best to separate the facts from the fantasy and the wheat from the chaff, and I think if we do this as I know we all will the industry will benefit. Thank you."

Mr. A. Cunningham, Halifax N.S.: "My remarks are going to be rather brief. I would like, Mr. Chairman, on behalf of all those gathered here from all segments of the fishing industry and from allied trades, to express thanks and appreciation to the Federal-Provincial Atlantic Fisheries Committee for arranging this conference. We have spent a most useful three days in discussing the herring potential in the Atlantic Coast area. The very large attendance shows the great interest that is being displayed in the development of the herring industry and I am sure we can look forward to great things in the future, not only in the reduction of herring into meal and oil, but the greater use of herring for food purposes. I must confess I am a bit overcome by the intense enthusiasm, but we must be positive thinkers. I would hope that as time goes on we can see the future potential in the herring fishery in the Atlantic coast area without using a magnifying glass. Forecasting is unavoidable, because every decision we make involves some kind of judgment of the future. We just hope we are right more often than we are wrong. The meetings here have been well arranged, well conducted and the participation has been outstanding. Those presenting papers are to be congratulated. Again, Mr. Chairman, on behalf of those present, our very grateful thanks."

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