C O N F I D E N T I A L

ANNUAL REPORT

of

THE ATLANTIC FISHERIES EXPERIMENTAL STATION

THE FISHERIES RESEARCH BOARD OF CANADA

1949

REPORT OF

THE ATLANTIC FISHERIES EXPERIMENTAL STATION

HALIFAX, N.S.

1949

By S. A. Beatty, Director

The research staff of the Atlantic Fisheries Experimental Station has been concerned for some years with the very early spoilage of fish during that period before actual methods of preservation, such as salting, canning or freezing can be applied. Since the longest storage period, before preservative measures, other than temperature control in the region of the freezing point are taken is in the fresh fish trade, the research program has been most directly applicable to that branch of the industry. But while little attention has been paid of late to such preservative measures as salting or freezing, we believe that definite progress has been made, and that while this series of investigations now appear to be reaching a stage that for the time being will permit of lessened activity, they will enable us to transfer our efforts to other phases of fish preservation with greater certainty that the foundation has been well laid.

We know now the general trend of events that occur during the early stages of fish spoilage. We know the types of organisms concerned, and where they come from. We know considerable about their optimum environment and something of their respiratory activity. We know the actual stowage conditions at sea and means of correcting the gross errors in procedures. We know the main weaknesses in our butchering techniques although we have gone only a short distance in their correction.

Insofar as the fresh fish trade is concerned we have unearthed serious errors in shipping methods, and are now undertaking commercial tests which we hope will correct these. We have considerable information as to the state of preservation of the fish as it reaches the consumer.

This information has been released to the fish trade as it has been obtained through our Progress Reports, through personal contacts with members of the trade, and through conferences with plant foremen. Not only is the industry aware of the findings of the laboratory, but members have been most co-operative in their own efforts to better their product (one firm reduced the bacterial contamination of their fillets by about 90%). They have given every assistance in the way of trial shipments. Reports reaching the laboratory from distributors in the interior indicate a definite improvement in the quality of the fish reaching them.

We believe the foregoing is proof that it pays in a small laboratory to concentrate our efforts on a small number of researches. But the time has come when a large part of our staff must investigate the problems of the salt fish trade. A good start was made in this field several years ago when physical chemical studies of the drying of heavily salted fish resulted in the artificial drying of practically all our heavily salted fish. This was worthwhile stop gap work, but it was not a systematic investigation of the problem. We have now started to study the bacteria concerned with the salt fish industry, the action of salt on them, the definitely halophilic organisms, and the action of salt on the muscle proteins. As with the fresh fish investigations there must be a definite lapse of time between the start of the investigation and practical results, but we believe that, if our present capable trained staff remains intact, results of practical value will develop rapidly.

While this transfer of our main activity from fresh to salt fish was due anyway, the addition of the Province of Newfoundland to Canada makes it more imperative that these researches be pursued vigorously.

The main contributions made during 1949 are as follows:-

FRESH FISH

We have known for a very long time that fish iced in the laboratory, where considerable care is taken will keep perfectly fresh at least twice as long as fish iced aboard ship, and we know that this difference in keeping time must be due to differences in the temperature of the fish. Last year we reported studies on the preponderance of phychrophilic bacteria in fish stowed in ice. It was shown that these organisms grow rapidly at temperatures only slightly higher than that of melting ice. This fact raises two important questions (1) What difference does a few degrees near the freezing point make in the rate at which these bacteria can spoil fish, and (2) How much above ice temperature are fish normally stowed at sea, in the plant, and during transit to market?

Mr. Castell has shown the very pronounced difference a few degrees make in the keeping time. Lowering the temperature from 37°F to 32°F just about doubles the keeping time; that is cod fish stowed at 37°F keeps about 5 days, while at the temperature of melting ice between 8 and 11 days.

Mr. MacCallum's measurements of the actual stowage temperatures aboard ship have shown that there are marked differences in various parts of the hold. He has shown that the fish in the middle of the pens, where the cooling should be best, require about 3 days on the average to reach the temperature of the ice. This means that some of the fish probably never do reach 32°F.

He found that cooling was particularly poor along the back walls of the pens. In fact some of these fish never get below 40°F and the fish in the tops of the pens are only slightly better cooled.

What effect have these very poor stowage conditions on the state of preservation of the fish? We have shown previously that stale fish can be found not more than 3 days old in summer weather aboard schooners, and not more than 5 days old aboard trawlers.

Why are stowage temperatures so poor? The fault is in part the construction of the fish holds and in part the poor or careless icing done by the crew. It is impossible, no matter how a fish hold is insulated or refrigerated to bring in good fish with our present stowage procedure and it would be very difficult with proper stowage procedure to land fish, all of it in a good state of preservation, when stowed in our fish holds as they are now constructed.

We have demonstrated to our own satisfaction that the present stowage procedure can be greatly improved, and in our opinion it is time that our icing techniques were given a full scale trial in commercial practice. We wish to take charge of the actual icing operations aboard three ships next summer from June through September. One of these is a typical trawler, one a schooner with an insulated hold, and the other a schooner with no hold insulation.

We have made no survey of the actual storage temperatures in our fish processing plants because the practices vary so much from plant to plant that little information generally applicable could be obtained unless the whole industry were surveyed. But it is common practice, as far as we are aware, in every plant to permit fish to stand on the filleting lines too long, for example over the noon hour.

The stowage of fresh fillets in ice was shown last year to require more than 24 hours to cool, and particularly in L.C.L. shipments the fish sometimes did not reach the ice temperature at all.

During the present year work was done on the precooling of fillets. It was shown that precooling in water or dilute brine before packing is impracticable not only because the fish take too long to cool but because they may warm up considerably before the packing is complete.

Dr. Dyer has shown that rapid freezing has no noticeable effect on cod or haddock fillets, and that the objectionable characteristics of frozen fish are the result of long storage or poor storage conditions or both. Hence, freezing or partial freezing followed by almost immediate defrosting should do no harm.

Mr. MacCallum has found that ordinarily 20 pound metal fillet boxes of cod or haddock fillets can be frozen to a depth of 1/4" in about 30 minutes either in air flow freezers or in

Birdseye freezers, that these fillets are normally defrosted in about 3 hours and the temperature of the whole box lowered to the freezing point of fish (about 30°F, Dr. Carter 1948). Small lots of fillets precooled in cardboard containers were shipped by one firm to Montreal, and while the cardboard containers were not satisfactory the fish arrived in excellent condition. It is planned to expand these trial shipments during 1950 to full scale operation, if larger trial shipments prove satisfactory.

This brings us to a study of conditions, particularly temperature conditions, in wholesale and retail stores. Since our study of the state of preservation of fish in wholesale and retail stores in the interior in 1937-1938, we believe there has been a definite betterment in the quality of the fish shipped from the Atlantic coast. But we have never made a thorough study of the actual holding facilities and distribution techniques. This is an essential study that should be undertaken during 1950.

We have previously reported the very great importance of fish slime as a medium for the growth of spoilage bacteria, and as a means of spreading these organisms through a fish plant. Our studies have shown that the thorough removal of slime from the fish before filleting has a marked effect on the keeping time of the fillet. It was shown that this removal of the slime before filleting results in a very much lower bacterial load on the fillet. But desliming has little or no effect on the keeping time of the round fish. In some way bacteria are continuing to act. Mr. Richards showed that bacteria can and do penetrate the skin and act on the muscle tissue beneath.

Studies started in 1948 were continued this year. It was shown that organisms do penetrate to the cellular tissue of the muscles beneath the skin. Here penetration is very slow, the bacteria do not seem to be able to penetrate the muscle cells but, given time, they work their way into the intercellular spaces.

We do not know as yet the practical significance of this penetration. The greatest part of the work was done on fish which had already spent several days at sea. What data we have would indicate that the penetration is not significant for the first 4 or 5 days with properly cooled fish. This should be definitely settled during 1950.

Our investigations into the reduction of trimethylamine oxide have given us the most reliable single index of spoilage for cod and haddock. They have been of definite importance as well in working out the course of events during the early stages of spoilage. We have shown previously that during this period lactic acid is oxidized to acetic acid and carbon dioxide. Mr. Kastner has measured the volatile acid production in spoiling fish flesh and has shown that the oxidation of lactic acid parallels the reduction of trimethylamine oxide.

This oxidation will be studied in greater detail. We shall determine if this reaction occurs during the period of rapid bacterial proliferation both in fish that do and do not contain trimethylamine oxide. If this is true we should have a possible measure of the state of preservation for all fish. The various degradation products will be determined as accurately as possible, and if one constituent, eg. acetic acid, is invariably present, we shall endeavour to obtain a rapid method for its determination.

The bacteriological laboratory has shown the importance of the elimination of slime previous to filleting. Last year we reported abortive attempts to develop fish washers capable of cleaning fish on a commercial scale.

This year Mr. Foley and his assistants have developed a washer that does remove the slime satisfactorily, and if this equipment stands up in commercial operation the problem seems reasonably well solved.

The basic problem was to remove all the slime from every fish, because, if an occasional dirty fish were to get by, the whole filleting line would be contaminated. Hence, every fish must be assured of satisfactory individual treatment.

The apparatus consists of an inclined shute down which the fish travel by gravity. The bottom of the shute consists of a roller that gives the fish a rotary motion and expedites its travel down the shute. As the fish travels along it is brushed by rapidly rotating wipers made of rubber belting, the whole shute being sprayed with water to carry away the slime. The removal of contamination is about 99 percent, and the machine has a throughput of about thirty steak cod per minute.

We have had no success in developing a satisfactory semi-automatic filleter, and the effort that must be put into it when compared with the chances of success seems to make it difficult to justify our efforts. We have decided to turn to other work that bears greater promise.

FROZEN FISH

Our work on this branch of the industry has gono in two directions. We have continued our work on air-flow freezing in an endeavour to develop equipment cheaper in operation, and more versatile than the plate freezers. We have made exhaustive studies on the effect of cold storage on packaged fish.

The work on air flow freezers consisted in the main of the installation of proper refrigerating equipment, and of the design of a suitable tunnel. These are both done. We are now working on three further phases of the problem. We hope to be able to reduce materially the floor space occupied by the tunnel. We have yet to work out a suitable rapid defrost mechanism. We have not yet been able to evolve a suitable car light in weight and with sufficient flexibility.

The second series of experiments were concerned with the effect of storage on fish.

Dr. Dyer has previously shown, as well as have many others, that there is a definite relationship between storage temperature and quality; the storage period for cod and haddock being quite short except at -10°F. This work is being repeated for halibut. The results are not at all convincing but it would seem that at 0°F or lower frozen halibut is good for at least 6 months.

All the work we have done on the storage of frozen fish indicates the importance of protein denaturation. We believe if we could prevent this latter change we would overcome the most serious single difficulty in the storage of frozen fish.

SALT FISH

Since salt is a preservative, one essential study is the bacteriology of salt fish. We have confined our attention in the past to a study of red halophilic organisms, and most of our work has been mainly a systematic study of these bacteria and attempts to circumvent their growth by means of bacteriostats that could be used on a food product. A proper study of the field should include a study of growth over all ranges of salt, and investigations of the metabolism of the organisms concerned, and conditions determining their growth limits. A start has been made in this work.

One of our most important investigations on the halophiles is the determination of lethal temperatures in relation to time. It was felt that possibly the easiest and cheapest way of cleaning up the solar salt, which is probably almost invariably the primary contaminant, is by heat. Mr. Castell has shown that it requires about 9 minutes at 212°F to kill the growth in salt and that it is more resistant to heat when growing on fish. We shall endeavour to determine the cost of sterilizing salt in bulk by heat.

The only practical method of control of growth of red on contaminated fish has been by refrigeration. Almost all larger processors of heavily salted fish have cool storages capable of holding the fish at about 40° to 45°F. It has been found that red is much more thermophilic than we had thought. They grow very rapidly at 45°C (113°F). By incubating at these higher temperatures we can now complete counts in 2-6 days that used to require as many weeks.

On the other hand, unless fish are very heavily contaminated growth is not likely to occur at 45°F.

Pigment formation seems to be related to bacterial respiration. The development of colour is dependent on the contact with air, on temperature, and on water content of the medium. It is easily possible that there can be a fairly heavy growth under certain conditions before the development of colour reveals this growth. Red has been shown to be generally distributed throughout one fish plant examined. All storages and utensils were found to be contaminated. The lowest contamination was found in the dryers and the dry storages. This is probably due to the drier air in these portions of the plant.

Dr. Dyer has made a good start on the physical chemistry of salting. This work has been continued this year by Mr. Duerr, working under Dr. Dyer's direction. The penetration of salt into fish muscle is probably greatly affected by the state of the proteins. Hence, the effect of salt on the rate of denaturation has been determined not only on the proteins in situ but as well on isolated proteins. The proteins in situ denature above about 10% salt. This is of importance in the brining of fillets previous to freezing. Salt solutions over 10 percent should not be used. With isolated myosin the results are different. There is a gradual denaturation paralleling the increase in the strength of the salt solution, this denaturation being related as well to the temperature.

There has been a continual request from a branch of the industry for a very rapid means of determining the moisture content of salt fish, a method that would leave the fish intact.

This is almost an impossible task, mainly because the sampling of the fish is very difficult unless reasonably large samples that would destroy the fish were taken.

But this is not the primary problem. No one has devised a chemical or physical test rapid enough to grade any small product such as fish except for such characteristics as size and weight. Hence, apples, potatoes, eggs and similar products are all graded by visual inspection, and almost certainly the same will always be true for salt fish. Therefore, the limiting factor is the accuracy of the inspector, and we have methods for determining water content of salt fish satisfactory for the determination of the accuracy of the grader.

During the summer we investigated the ability of skilled officers to estimate the water content of fish. We found that for very moist or very dry fish these inspectors had no accurate idea of the water content.

It was found that over the ordinary commercial range at which fish are usually exported they would probably be out about $1\frac{1}{2}$ percent. This seems to be acceptable accuracy, but it is possible only when inspectors and graders are under continuous laboratory supervision. It would appear that neither graders nor inspectors should be asked to grade fish much beyond the range 35-42 percent.

MARINE OILS

The research in this division of greatest immediate importance is the separation of cod liver oil from cod liver residue. If this work can be pushed through to a stage of economic commercial development it will be very timely indeed.

Before the last war the Maritime cod liver oil industry was poorly developed, partly due to the competition of the Norwegian cod liver oil producers, but during the war the Maritime cod liver oil industry was worth about $500,000.00 annually, The greater part of the medicinal oil trade was lost rather early in the post-war period. Our cod liver oils ran barely more than the required 85 D, but they averaged over the whole Maritime area somewhere between 3000 and 4000 A. Most processors found it more profitable, as the price in medicinal cod liver oil declined, to sell this relatively high vitamin A oil to the feed blendors. Recently the price of this oil has declined very markedly, particularly because of the competition of alfalfa meal and alfalfa leaf meal, and because of the devaluation of European currencies. Our cod liver oil processors now find themselves in much the same position as they were previous to the war, with costs of production as high as, or higher, than the selling price of the oil. We are now responsible as well for a considerable production of cod liver oil from Newfoundland, and the Newfoundland industry is finding itself in possibly worse circumstances because, by and large, Newfoundland oil is not nearly as high in vitamin A. It is obvious that unless some other product can be marketed the cod liver oil industry of the Atlantic coast will remain ailing or die.

The separation of oil from the other constituents of the cod liver achieved by Dr. Vandenheuvel last year has been fully patented, and we are now in a position to attempt to make the separation on a full commercial scale. We have reached agreements with one of the purveyors of centrifugal equipment and with one of the largest producers of cod liver oil, which will enable us to operate on a full commercial scale, and we hope to be in operation early in January 1950. Except for the capital cost of an expensive centrifuge this method should be cheaper than the present methods and should yield a recovery approximately as good as any process now in operation. At the same time it makes available a relatively concentrated protein residue which might be of considerable value. Dr. Guttmann, who is on loan from the Nova Scotia Research Foundation, has spent considerable time in determining the best use that can be made of these liver residues. He has found that they are equivalent in the important vitamins of the B group to mammalian liver. At the present time pork liver is selling for about 18 cents wholesale in Halifax, and beef liver for about 30 cents. Presupposing a net selling price of this liver residue of 15 cents the gross intake from the sale of the liver residue from one of the larger trawlers would be somewhere between $10,000.00 and $15,000.00 annually, the oil at the present price about $7,500.00, or a total value of somewhere around $20,000.00. This is about equivalent to the total value of the oil alone at its highest wartime price. Actually it should be worth more than the wartime value because practically no method used on the Atlantic coast recovers more than 75 percent of the oil present.

The long range problem of the oil research laboratory is to find a market for fish body and liver oils, which will be dependent not on other materials, such as vitamins which may be contained in the oil, but on the oil itself. One of the most fruitful fields of research in this direction is the hardening of oils by the addition of hydrogen. This procedure, which has yielded foods, such as vegetable shortenings and butter substitutes from some vegetable oils, has not been applicable generally to other vegetable oils and marine oils. We believe that hydrogenation will not be applied successfully to marine oils until we have more knowledge of the hydrogenation process. Dr. Vandenheuvel and Mr. Nickerson have been carrying on researches in this field for approximately 1½ years. They have developed a quantitative procedure which has yielded very satisfactory results with simple unsaturated organic compounds. They are now applying this method to esters of longer chained fatty acids, and eventually they hope to be able to determine exactly what goes on during hydrogenation in the more complex oils.

Research is also being carried out on the polymerisation of marine oils. This work has been in progress only a few months. One of the problems which is now under investigation in this field is a moderate polymerisation of fish oils to slow down their rate of oxidation sufficiently to allow their use in canning of fish products as a substitute for vegetable oils.

GENERAL

One of the miscellaneous researches carried to practical completion this year was the development of an emergency dory transmitter. The work was started during 1948 by Mr. Ellis and could not be completed before he took up his graduate studies. During the past summer Mr. Whitely, under the direction of Prof. G.H. Burchill has developed a battery powered dory transmitter with a range of about 2 miles, which appears to be satisfactory. The equipment is being redesigned so that it can be packaged in a container of the same size as the dory emergency rations. Prof. Burchill, with the assistance of one of the students, is also undertaking to develop a mark buoy with the somewhat longer range of 10-15 miles that can be used to mark bodies of fish, enabling the boat to be navigated to the area irrespective of visibility. We wish to take this opportunity to express our thanks to Prof. Burchill for his assistance.

One of the most important functions of this station is the maintainence of proper contacts and relationships with the trade, with governments, and with similar research organizations.

We believe that our best contact with the trade is the direct contact made by the Director and the staff. When I took over the direction of the laboratory practically the only direct contact with the industry was through the Director. I have made every effort to widen this contact, and now practically the whole staff of the laboratory is known to and used by the industry.

It will be possible here to refer only to a small number of successful installations made by the industry acting on the advice and with some technical assistance from the staff. Our work on vessel refrigeration has been accepted by the industry. Our refrigeration engineering branch is working with producers in the design of fish holds for new vessels. Of the 15 larger fresh fish processing plants in Nova Scotia 3 have been entirely redesigned and rebuilt from flow sheets drawn up by the engineering staff. The part played by the laboratory in the development of salt fish dryers and tunnel smokers has been referred to in previous reports. During the past year we have assisted the trade in the trial shipment of pre-cooled fresh fish to the interior. We have assisted in the purification and recovery of fish liver oils.

As the station expands and as our fund of information becomes more valuable to the trade this field of work will expand. This expansion is in line with the wishes of the Department. However, such work must be a product of the research and not an end in itself. Some work aimed at direct application to the industry is of value to the research staff but unless care is taken the research staff will be given little opportunity to do anything else. Hence, some years ago we decided to assign one engineer directly to field work. With the enlarged field which now includes Newfoundland we have been forced to increase our field staff and we now have two men engaged in this work; a third, to be assigned direct to Newfoundland, will join our staff on January 1st,1950. I believe that we will have to have another man concerned directly with fish refrigeration. In our opinion it is the only way that we can do that work which the trade are demanding from us, and which they will continue to demand from us, and keep our research staff at their appointed tasks.

Our Progress Reports are assuming continuously greater importance in the eyes of the trade. Some years ago we received requests for information that had been supplied in recently published Progress Reports. This sort of thing has almost entirely disappeared and our discussions with processors indicate that the Progress Reports are well read.

During the present year we have written a number of radio shorts to be included in the CBC Fishermens' Broadcasts. We have no way of determining the value of these shorts, and at least for the present we question whether they are of much value.

During the year we wrote the preliminary script and planned a major part of the sequence of a moving picture produced by the National Film Board for the Department of Fisheries on the Production of Boneless Codfish. While the cost of this type of work is high we believe that moving pictures can play a very important part in placing before the trade, and the public in general, information about the scientific side of fish processing, and distribution. However, we wish to stress that these pictures should fall very definitely into two classes (1) instructional pictures to be shown to the trade alone (2) documentary films that will increase the interest of the public in general in fish, and possibly indirectly influence fish consumption.

As our list of publications show, the staff has endeavoured as the work develops to record their findings in publications in scientific journals. We have taken an active part in local scientific organizations and in the Chemical Institute of Canada. We have endeavoured to maintain a very close relationship with other research organizations in the Maritime area and elsewhere. We are guiding thesis problems for students who in the near future will graduate from Dalhousie University, Acadia University, Queens University and the Nova Scotia Technical College. As was agreed approximately 2 years ago, we are now giving a course in Bacteriology to Dalhousie students who are registered in the course of Food Technology. This work is interfering quite definitely with our research programme, and while we believe that the step was necessary to institute a course which should be of value to those engaged in the fishing industry, Dalhousie University should have had ample time by the time the course will be repeated to provide its own teaching staff.

We wish to express our thanks to Prof. Burchill of the Nova Scotia Technical College for his guidance and assistance in the development of a dory emergency transmitter, and for his offer to assist in the development of other radio beacons of benefit to the industry. Also, we record our thanks to the Nova Scotia Research Foundation for the services of Dr. Guttmann, who has done the bio-assays on cod liver residues.

Plans have been finished, and have gone to the Central Office for the addition to, and changes in the present building which we hope will be completed in the reasonably near future. The size of a laboratory such as ours is limited by work space and, when the new building programme is completed the size of the research staff will be fixed for some years to come. Therefore, a great deal of thought has been given to the organization that will maintain a staff of a sufficient number of high calibre senior research people and a correct proportion of junior people. An army cannot exist of either all generals or all privates.

There is a very close working relationship among the various members of the staff, and it is impossible to divide our work into water-tight compartments. But for the purpose of organization the research staff has been separated into 6 divisions:-

(1) Bacteriology:- Our bacteriological studies will concern problems of fish preservation, and also the beneficial role of microorganisms in certain fish cures, such as light salted cod fish and Scotch cured herring.

(2) Biochemistry:- will be concerned with studies of basic constituents of fish and the biochemistry of fish preservation, such as fish freezing and frozen storage.

(3) the new division of Nutrition and By-products will be concerned with fish as food, vitamins, proteins, essential fats, amino acids, salts, etc. It will also have charge of the work

on the utilization of fish and marine animals for either nutritional or industrial purposes.

(4) The division of <u>Marine Oils</u>, organized two years ago, will concern itself with the physical and organic chemistry of marine oils as concerns their industrial utilization. This work will include studies in hydrogenation, polymerization, blowing, etc.

(5) The division of <u>Physical Chemistry</u> just being organized, will undertake studies of the physics and physical chemistry of various preservation processes, such as freezing, salting, smoking, etc.

(6) Our <u>Engineering Division</u> will be concerned with the application of results of laboratory investigations in general to the processing of fish. This engineering division will be divided into 4 branches: <u>Refrigeration</u>, under charge of W.A. MacCallum, <u>Chemical</u>, under charge of D.G. Ellis, <u>Mechanical</u>, under charge of M.A. Foley and <u>Field</u>, under charge of A.L. Wood.

Each of these divisions or sub-divisions will be headed by a senior investigator. The provision of skillful assistants causes us considerable concern. The divisions of Bacteriology, Biochemistry and Nutrition can be staffed, at least to a considerable extent, with well trained, intelligent female workers. The value of female workers in Marine Oils and Physical Chemistry is somewhat doubtful. We believe that these divisions will have to be staffed to a great extent by junior temporary university graduates, or perhaps better by students working towards graduate degrees. Our junior engineering staff must be of a somewhat permanent nature. Field engineers must be permanent employees because each will require a number of years to make him entirely familiar with the division of fish engineering with which he will be primarily concerned. We believe it will be possible to build our junior engineering staff with young men, who will wish to learn something of engineering research as it applies to fisheries, and that after 2 or 3 years with us these junior people will be passed on.

At the end of this section is given a list of the present staff. The following is the staff that, in our opinion, will be required to carry on properly the research programme of the laboratory and for which adequate space arrangements can be made in the new building.

ADMINISTRATIVE STAFF

Supervising Clerk	W.D. Cossaboom
Stenographer Grade II	I.J. Rattray
Stenographer Grade II	P.C. Kinsman
Stenographer Grade II	M. Kenney

RESEARCH STAFF

BACTERIOLOGY

Senior Bacteriologist	C.H. Castell
Assistant Bacteriologist	N.C. Cuthbertson
Assistant Bacteriologist	D.C. Willoughby
Senior Research Assistant	D.P. Smith
Assistant Technician Grade II	E.G. Mapplebeck
Junior Lab. Assistant Grade II	M. Greenough

(Complete)

BIOCHEMISTRY

Biochemist	W.J. Dyer
Junior Biochemist	M.E.J. MacMillan
Senior Research Assistant	J.D. Duerr
Senior Research Assistant	J.W. Kestner
Assistant Technician	M.R. Douglas

(Complete)

NUTRITION

Nutritionist	P.L. Hoogland
	3-4 Junior assistants 1 technician

(Only Dr.Hoogland on staff at present)

OIL CHEMISTRY

Organic Chemist	F.A. Vandenheuvel
Organic Chemist	A. Guttmann
Senior Research Assistant	J.D. Nickerson
Senior Research Assistant	E.R. Hayes
Assistant Technician Grade I	R. St.C. Hiltz

(Complete)

PHYSICAL CHEMISTRY

Associate Chemist	J.R. Dingle 2-3 assistants
Physical Chemist	D. Dickinson 2-3 assistants

(Only Dr. Dingle on staff at present)

ENGINEERING

Engineer	A.L. Wood
Associate Engineer	W.A. MacCallum
Associate Chemical Engineer	D.G. Ellis
Associate Engineer	M.A. Foley
Assistant Engineer	H.E. Power
Assistant Engineer	F.H. Theakston
Junior Engineer	C.G. Oldershaw
Assistant Engineer	W.C. Angevine
Assistant Engineer	R.P. Hunt
Assistant Technician Grade III	R.C. Edmonds
Assistant Technician Grade II	D. Casavechia
2 technicians to be appointed	

MAINTENANCE STAFF

Maintenance Superintendent Grade IV	U.R. Demone
Maintenance Superintendent Grade III	R.C. Palmer
Caretakers: Caretaker Grade IV	J.D. Groat
Caretaker	To be appointed

Staff of the Atlantic Fisheries

Experimental Station

1949

Administrative

S.A. Beatty, M.A., Ph.D., F.C.I.C.	Director
W.D. Cossaboom	Supervising Clerk
Miss M. Kenney	Stenographer Grade II
Mrs. P.C. Kinsman	Stenographer Grade II
Miss S.J. MacGregor	Stenographer Grade II (to July 13,1949)
Miss I.J. Rattray	Stenographer Grade II (from Sept.15,1949)

Scientific

W.C. Angevine, B.E.	Assistant Engineer
Mrs. I.R. Brownlee, M.Sc.	Junior Bacteriologist (to August 1,1949)
C.H. Castell, M.S.A.	Senior Bacteriologist
N. Cuthbertson, M.Sc.	Asst. Bacteriologist (from October 1,1949)
J.R. Dingle, Ph.D.	Associate Chemist (from October 1,1949)
J.D. Duerr, B.Sc. (Arts)	Sr. Research Assistant
W.J. Dyer, M.Sc., Ph.D., M.C.I.C.	Biochemist
D.G. Ellis, B.Sc., M.C.I.C.	Associate Chemist (Educational Leave)

M.A. Foley, B.E.	Associate Engineer
A. Guttman, Ph.D.	On loan from Nova Scotia Research Foundation
E.R. Hayes, B.Sc.	Sr. Research Assistant (from June 7,1949)
P.L. Hoogland, Ph.D.	Nutritionist (from December 15,1949)
J.W. Kastner, B.Sc.	Sr. Research Assistant (from May 16,1949)
W.A. MacCallum, B.Sc.,B.E., M.Sc.	Associate Engineer
Miss M.E.J. MacMillan, B.Sc.	Junior Chemist
J.D. Nickerson, B.Sc.(Chemistry)	Sr. Research Assistant
C.G. Oldershaw, B.E.	Junior Engineer
H.E. Power, B.E.	Assistant Engineer
F.C. Read, B.A., B.Sc.	Assoc.Chemical Engineer (to April 1,1949)
Miss D.P. Smith, B.Sc.	Sr. Research Assistant (from October 1,1949)
J.M. Snow, B.Sc., M.Sc.	Assistant Biochemist (to September 8,1949)
F.H. Theakston, B.E.	Assistant Engineer (from May 16,1949)
F.A. Vandenheuvel, Ph.D.	Chemist
D.C. Willoughby, M.Sc.	Asst. Bacteriologist (from October 14,1949)
Miss N.J. Wilson, B.Sc.	Sr. Research Assistant (to Sept. 1,1949)
A.L. Wood, B.Sc., B.E.	Engineer

Staff (continued)

Technical

Miss S.J. Bendell	Lab. Technician Grade I (up to June 1,1949)
D. Casavechia	Asst. Technician Grade II
Miss M.R. Douglas	Asst. Technician Grade II (from June 15,1949)
R.C. Edmonds	Asst. Technician Grade II
Miss M. Greenough	Jr. Lab. Assistant Grade II (from July 1,1949)
R. St.C. Hiltz	Asst. Technician Grade I (from April 11,1949)
Miss E.G. Mapplebeck	Asst. Technician Grade II (from July 4,1949)
R.C. Palmer	Asst. Technician Grade III
Mrs. B.M. Zwicker	Asst. Technician Grade I (up to July 1,1949)

Maintenance

U.R. DeMone	Maintenance Supervisor Grade IV
J.D. Groat	Caretaker Grade IV

S E C T I O N   I

F R E S H   F I S H

Appendix No. 1

STORAGE TEMPERATURE AND SPOILAGE RATE

In the first appendix of last year's report it was shown that as the storage temperature reaches a range close to freezing, the difference of a few degrees has a very significant effect on the keeping time of cod fillets.

During the current year these studies have been continued. A large number of tests have been made with fillets of cod and haddock and a few tests have been made with whole gutted round cod.

These accumulated results confirm the initial observations. It has been shown that the keeping time for the fish at 37°F can be approximately doubled by reducing it to 31.5°F. That is, a reduction of $5\frac{1}{2}$°F (from 37° to 31.5°) adds to the keeping time the same amount as a reduction of 40°F (77° to 37°) at the higher range. Results which were obtained from a group of 6 boxes of fillets representing a normal selection from the cutting rooms of a local fish plant are shown in Table I.

TABLE I

The keeping time (up to a trimethylamine value of 15) for commercial, untreated fillets taken directly from the cutting lines of a local fish plant.

STORAGE TEMPERATURE		KEEPING TIME
31.5°F	(-0.3°C)	11 to 12 days
33° F	(0.6°C)	6 to 8 days
37° F	(2.8°C)	5 to 6 days
45° F	(7.2°C)	2 to 3 days
77° F	(25°C)	22 to 30 hours

Other tests were run with groups of fillets having pronounced differences in their initial quality before going into storage. The results from these tests show that, although the keeping time at any one temperature is determined by the initial contamination, a reduction in the storage temperature from 37° to 31.5°F almost invariably double the keeping time at 37°F (Table II).

TABLE II

The number of days required for 7 lots of cod fillets to reach a trimethylamine value of 15 when stored at 37°F (2.8°C), 33°F (0.6°C) and 31.5°F (-0.3°C). These fish were purposely chosen with a wide difference in their initial quality and arranged in decending order

LOT NO.	DAYS AT 37°F	DAYS AT 33°F	DAYS AT 31.5°F
1	7½	9½	13
2	5¼	7½	12
3	5	6½	8
4	3¾	4¼	5¼
5	3½	4	4¾
6	3	4¼	5
7	1½	2	2¾

If the fish are in a reasonably good condition to begin with, even the reduction from 33°F to 31.5°F adds several days to the keeping time.

Very similar results were obtained with the gutted round cod.

The significance of these observations when applied to fish in the boats at sea, in the fish plants, during transportation and in the wholesale and retail outlets, becomes very apparent. It would also indicate how quickly early care of the fresh fish could be counteracted by poorly controlled storage in the wholesale and retail stores.

C.H. Castell

Appendix No. 2

FURTHER STUDIES ON STORAGE TEMPERATURE AND BACTERIAL ACTIVITY

The spoilage of fish by the natural mixed cultures at different temperatures is a very complex affair. If we consider the problem only in terms of trimethylamine oxide reduction, we have the following things to consider (1) the influence of temperature on the growth of cells; (2) the influence of temperature on the activity of the enzymes; and (3) the influence of temperature on similar enzymes from organisms having different temperature requirements for growth.

Attempts have been made to study each of these different phases, although this work has not been confined wholly to the reduction of the oxide. Some of the results are condensed in the following notes:-

(1) Ps. putrefaciens is a psychrophilic organism isolated frequently from fresh fish; it grows readily at freezing temperature; it reduces trimethylamine oxide, nitrate and nitrite and it also breaks down proteins. An active culture of this organism was inoculated into a 5 percent peptone solution and into nutrient solutions containing nitrate, nitrite and trimethylamine oxide. These were incubated at 31.5°, 33°, 37°, 45°, 77°F, and periodic tests were made to determine the amount of chemical change that

occurred. Some of these data are given in Table I.

TABLE I

Rate of chemical changes brought about by Ps. putrefaciens at different temperatures in broth cultures

Chemical Change	°F Temperature	Time-Days
50% reduction of nitrate	37° (2.8°C)	7
	33° (0.6°C)	11
	31.5°(-0.3°C)	14
50% reduction of trimethylamine oxide	37°	11
	33°	16
	31.5°	18
50% reducte of nitrite	77°	6
	45°	16
	37°	34
	33°	55
	31.5°	78
25% breakdown of peptone	77°	7
	45°	24
	37°	35
	33°	65
	31.5°	90

It is evident that, with the growing cultures under the conditions that were used, the reduction of the oxide and the nitrite were slightly less affected by reducing the temperature from 37° to 31°F than the reduction of the nitrite, or the breakdown of the peptone. But once again this reduction of 5½ degrees approximately doubles the time required to bring about a given change in the substrate.

(2) The next set of tests was designed to determine the rate of trimethylamine oxide reduction at 25°C and 2°C by stock cultures of mesophilic bacteria compared with cultures of <u>Ps. putrefaciens</u> which grew readily at temperatures near freezing. The oxide broth was prepared using 0.5 percent oxide and pH 7.0. Table II shows the results obtained.

(3) In the two preceeding tests the results were obtained with <u>growing</u> cultures in nutrient media. In this case we observe the effect of temperature on growth and enzymatic activity combined. In order to determine its effect on the enzyme activity, apart from cell growth, some tests were made using mass inoculations of resting cells in a substrate containing oxide, sodium acetate, and buffered at pH 7.1. These were made with cultures of <u>E. coli</u>, <u>A. aerogenes</u>, <u>S. marcescens</u>, <u>P. vulgaris</u>, <u>Ps. putrefaciens</u>, and unidentified organisms from fish. Details of these results will be given later in the Board's Journal. In general they indicate a reduction in enzyme activity as the temperature is reduced from 37°C down to -0.3°C. But even the cells of <u>E. coli</u> slowly reduced the oxide at -0.3°C, which is below the growth range of this organism. Figure 1 shows the oxide reduction-time curves for <u>S. marcescens</u>. <u>Ps. putrefaciens</u> was the only culture of those tested where the oxide was reduced more slowly at 37° than at 25°C.

TABLE II

The effect of temperature on the reduction of trimethylamine oxide in a nutrient broth, by nine non-psychrophilic strains of Entreobacteriaceae and nine psychrophilic cultures of Ps. putrefaciens

Name of Culture	Mg. trimethylamine per 100 ml of broth 2 days at 25°C	8 days at 2°C	15 days at 2°C
Ser. marcescens	52.2	0.19	0.2
Prot. vulgaris	7.6	0.30	0.4
Esch. coli	35.2	0.35	0.6
Esch. coli	53.6	0.43	1.2
Aer. aerogenes	30.5	0.47	7.3
Aer. aerogenes	46.0	0.42	9.3
Aer. cloaceae	40.0	0.32	13.2
Aer. cloaceae	45.0	1.06	10.6
	2 days at 25°C	4 days at 2°C	8 days at 2°C
Ps. putrefaciens	20.4	28.5	46.3
"	20.4	26.9	37.6
"	24.7	23.8	42.0
"	22.8	40.2	43.1
"	19.0	40.2	44.1
"	20.4	35.1	35.6
"	23.0	26.9	35.3
"	28.0	35.0	36.0
"	32.0	14.9	23.3

Figure 1

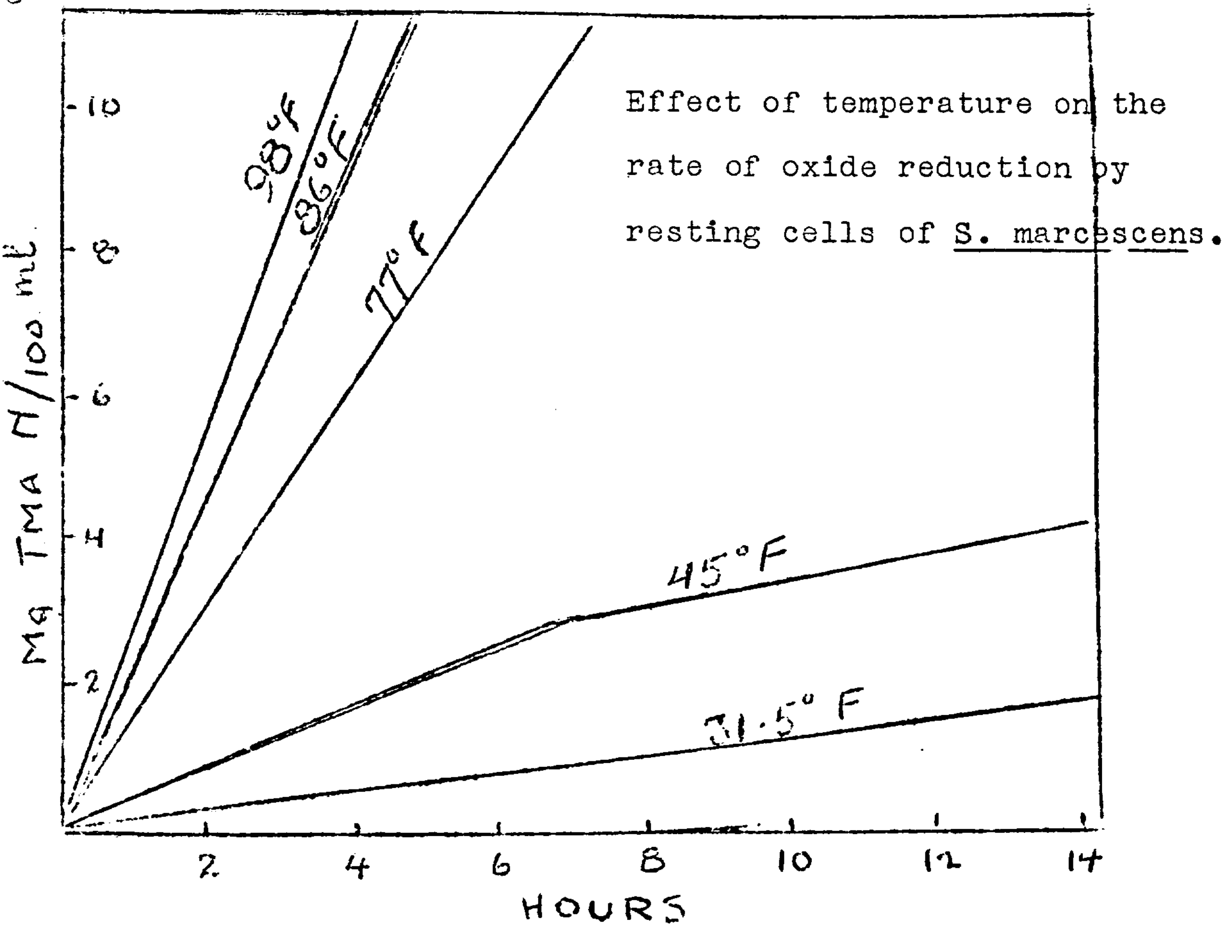


Table III shows the time required to produce either 10 or 2 mg. of trimethylamine from approximately similar weights of resting cells at 5 different temperatures by six cultures. Two points are worth noting: first, the difference in the rate of oxide reduction by the various cultures at any of the temperatures; those isolated from the fish are much more active than stock cultures. Second, even with these psychrophilic organisms from the fish, there was a considerable difference in the rate of reduction when the temperature was reduced from 7.2°C to approximately freezing (-0.3°C).

(5) Observations on the growth rate of psychrophilic bacteria, isolated from fish and grown in four different culture media, have shown that lowering the incubation temperature from 2.8°C to -0.3°C retarded growth to a greater extent than a reduction from 25° to 2.8°C.

TABLE III

Hours required for approximately similar weights of resting cells of 6 cultures to produce trimethylamine at different temperatures

Culture	Source	10 mg at 37°C	10 mg at 30°C	10 mg at 25°C	2 mg at 7.2° C	2 mg at -0.3°C
Achromobacter 176	fish	2.1	2.5	omitted	4.2	9.0
Ps. putrefaciens	fish	9.0	omitted	6.3	5.1	15.5
Ser.marcescens	fish	3.5	4.3	7.0	4.5	15.0
Esch. coli	stocks	13.0	18.0	35.0	20.0	29.0
Aer.aerogenes	stocks	20.0	29.0	42.0	19.0	33.0
Prot. vulgaris	stocks	14.2	25.5	57.0	75.0	75.0

Therefore, from these observations we can conclude that a difference of a few degrees above freezing in the storage temperature of ice is of importance because it inhibits the growth of many species of bacteria; it retards the growth of the psychrophilic species; and it reduces the activity of the enzyme systems that the bacteria have already formed. We believe that next to the prevention of gross contamination, strict attention to the storage temperature is one of the most important factors in the production of good quality fresh fish.

With the publication of the papers giving the details of these tests, this work will cease, as far as the laboratory is concerned. Already the application of the data to commercial practice is being undertaken by the refrigeration engineers. We have yet to make a survey of the storage facilities and practice of the wholesale and retail fish dealers in eastern and central Canada.

C.H. Castell
J.M. Snow

Appendix No. 3

FACTORS AFFECTING THE REDUCTION OF OXIDE BY RESTING CELLS

During the past year further studies have been made on the effect of various factors on the enzymatic reduction of trimethylamine oxide. This has been done using mass cultures of "resting cells" as the source of the enzymes and standard conditions throughout the whole series of tests. The results have been recorded in the form of graphs of which there are far too many to even record representative samples in this report. In brief the results are as follows:-

(A) pH: The pH of the substrate has a very marked effect on the rate of reaction. For some of the organisms tested the enzyme had an optimum pH of 7.2-7.4, but for most of the fish spoiling organisms the optimum pH was above 8.0. The activity was retarded as the pH was reduced below 7.0 and for some, but not all cultures, when it was raised above 8.0. Below pH 6.0 the reduction of the oxide was very much slower for all cultures.

(B) Salt: Increased salinity decreased the rate of oxide reduction.

(C) Temperature: With all the cultures tested, except *Ps. putrefaciens*, the activity of the enzymes increased as the temperature was raised from -0.3° to 37°C. The cells of *Ps. putrefaciens* reduced the oxide faster at 25° than at 37°C. There appeared to be little if any correlation between the temperature requirement for growth and the effect of temperature on the rate of oxide reduction by resting cells. The oxide-reducing organisms isolated from fish reduced the oxide much more vigorously than transfers from stock cultures. With resting cells of these psychrophilic bacteria from fish it was observed that a reduction from 7.2°C to -0.3°C more than doubled the time required to produce a given amount of trimethylamine.

(E) Storage: If cells of bacteria are "harvested" and stored they gradually lose their ability to reduce the oxide. The higher the storage temperature the sooner their activity is diminished.

(F) Adaptation: Cultures of oxide-reducing bacteria were continuously transferred in parallel on both solid and liquid media with and without oxide. Two things have been observed: First, that the cultures continuously cultured in liquid medium reduce the oxide much more rapidly than similar cultures grown on the surface of agar slants. Second, that the addition of oxide to the liquid medium further enhances the rate of the enzyme activity after continued transfers.

(G) Nitrate and Nitrite: Both these substances interfere with the reduction of the oxide by the resting cells. But their rate of inhibition differs very much with different species of bacteria. The reduction of oxide by *E. coli*, for example, is strongly retarded by both nitrite and nitrate, while other unidentified organisms isolated from fish showed no change from added nitrate and others considerably less change from added nitrite.

In *growing* cultures, it was found that most of the organisms tested rapidly reduced the nitrate but very slowly reduced the nitrite and that at -0.3°C its reduction was almost brought to a standstill even though the bacterial cells continued to multiply.

C.H. Castell
J.M. Snow
I. Brownlee
N.J. Wilson
E.G. Mapplebeck

Appendix No. 4

THE MECHANISM OF NITRITE PRESERVATION UNDER NEUTRAL OR ALKALINE CONDITIONS

It seems very probable that in acid solutions, nitrous acid ions combine with the amino groups or other groups in the proteins and destroy the enzyme activity. Under these conditions the nitrite acts as a bactericide as well as an enzyme inhibitor. Under neutral or slightly alkaline conditions the bactericidal properties disappear, but the nitrite continues to inhibit the activity of certain bacterial enzymes, and among these are those responsible for the reduction of trimethylamine oxide. We have been trying to determine the mechanism of this latter reaction, and the work is still in progress.

Using a group of 5 cultures of bacteria, all of which reduce trimethylamine oxide, but differ in their ability to reduce nitrite and nitrate, the following tests were made:-

(1) Rate at which they reduced equimolar concentrations of sodium nitrite, sodium nitrate and trimethylamine oxide when each of these compounds was added to a similar basic culture medium.

(2) Rate at which they reduced these compounds when they were added to the culture medium in pairs.

(3) Similar tests using resting cells in place of growing cultures.

These tests revealed that for all these organisms the reduction of nitrate was very much more rapid than that of the nitrite. With organisms of the Colon-Aerogenes group, the nitrate was reduced faster than the trimethylamine oxide; but with certain unidentified fish-spoiling bacteria the reduction of the oxide was as fast or faster than the nitrate.

When these compounds were added together, it was found that for the Colon-Aerogenes species, the nitrate was almost all reduced before any perceptible reduction of the oxide. With the fish-spoiling group oxide and nitrate were reduced simultaneously.

Similarly, the nitrite had a very strong inhibiting action on the reduction of the oxide by the Colon-Aerogenes group (which are comparatively rapid nitrite reducers), but much less effect on the organisms which very slowly reduce the nitrite.

It had been previously observed by Dr. Dyer that nitrite produced by the reduction of nitrite in fish muscle had no inhibiting action on oxide reduction. Although this was the case with some fish-spoiling bacteria, it was not so with the cultures of E. coli and A. aerogenes. With these organisms both the sodium nitrite that was initially added and the nitrite formed through the bacterial reduction of the nitrate stopped the reduction of the oxide.

These observations would indicate that both the nitrate and nitrite inhibit the oxide reduction by some sort of competitive action, but that the results differ with different organisms. It would appear that the ability of either nitrate or nitrite to inhibit oxide reduction is at least partly associated with the rate at which the organisms reduce the nitrate or nitrite.

It was found by Mr. Richards that nitrite also inhibited the reduction of certain sulphur containing compounds to form hydrogen sulphide.

Miss Wilson found that the inhibition of oxide reduction by nitrite was lessened by the addition of certain reduced redox indicators. Both these observations suggest that the nitrite may interfere with the dehydrogenase which releases the hydrogen from the carbohydrate, rather than the reductase (triammeoxidase) which reduces the oxide.

Because it is probable that the use of nitrites for fish preservation may be officially sanctioned in the near future and because we believe this to be the type of work that may lead to a better understanding of other methods of fish preservation, the work will be continued during the coming year.

C.H. Castell

Appendix No. 5

EFFECT OF NITRITE ON PROTEOLYSIS

Although the evidence continued to point to the conclusion that, under conditions that permit bacterial growth, nitrite interferes mainly with the respiratory enzymes, tests are being made to ascertain its action on various hydrolases.

When 5 percent peptone was used as the only source of nutrients it was found that nitrite changed the shape of the growth curves for Ps. putrefaciens, grown at various temperatures between 0.3°C and 25°C. In every case it prolonged the lag phase, more than doubled the maximum cell count, and straightened out the phase of decline. Biuret estimations were carried out to determine the rate at which the peptone was broken down in the presence and absence of nitrite. In every case the number of days required to bring about a 25 percent breakdown of the peptone was increased in the presence of the nitrite. But when consideration was given to the increased lag phase for the initial bacterial growth the actual breakdown of the peptone by corresponding numbers of bacterial cells was approximately the same in the presence and absence of nitrite.

More direct results were obtained by measuring the proteolytic activity of resting cells of bacteria in gelatin at 7.2° and 25°C. The organisms used were B. subtilis and Ps. putrefaciens and the rate of decomposition was followed by measuring the progressive increase of the free amino acid content. From the results obtained there was nothing to indicate that the nitrite had any effect on the breakdown of the gelatin.

J.F. Richards
J.M. Snow

Appendix No. 6

PENETRATION OF BACTERIA THROUGH SKIN

The work of the previous summer has been continued on the rate of bacterial penetration through the skin and into the muscle beneath. This year's work has consisted of making sections and following the migration of the bacteria by means of direct microscopical examination.

It has been shown that the organisms readily penetrate the epidermis and increase in the inner layers of the dermis and outer muscle cells. After four days storage at 7.2°C (subsequent to their arrival at the fish plant) they are present in these areas to the extent of many hundred millions per sq. cm. Attempts to make corresponding plate counts have shown that only a small fraction can be estimated by this method, compared to those visible under the microscope.

For some time, depending upon the temperature, the bacteria do not penetrate into the deeper layers of the muscle, but were most numerous in the connective tissue between the outer muscle fibers and the 3 or 4 muscle layers directly under the skin.

The mode of entrance through the skin remains unknown, but the theory that the skin itself acts as a barrier to bacteria seems without much foundation. Once through to the cells beneath the dermis their progress is slow and seems to consist of the production of enzymes which allow the cells of the tissue to separate, rather than by breakdown of the cells. There were abundant instances of bacteria in large numbers funnelling their way between the separated cells.

These observations not only agree with those of Aschebourg and Vesterhus (1947) on winter herring, and Schwartz and Zeiser (1939) on various fresh and salt water fish, but they give a rational explanation to our own observations that the removal of surface bacteria and by washing and mechanical means, and the application of disenfectants to the surface of slime carried fish adds little or nothing to the keeping time of round fish. These treatments apparently do not affect the bacteria immediately beneath the skin. As washing and disenfecting may easily remove up to 90 percent of the surface bacteria it would indicate that these heavily populated sub surface areas may be more important in the development of spoilage than has been formerly considered.

At first these observations might give the impression that our attempts to reduce the heavy contamination on fish fillets by thoroughly washing and desliming the round fish are going to be of limited value. It must be realized, however, that the penetration of bacteria through the skin is limited by time and temperature. If fish are kept near the freezing point there is no significant penetration of bacteria through the skin for at least 5 or 6 days. The tests recorded here were done with fish that were several days out of water at the start of the experiment. In this connection it is important that we determine the significance of the time and temperature of exposing the fish on the deck of the vessel before icing them down in the hold. It would seem that this is still another reason for temperature control of the fish in the boats at sea.

In the immediate future it is hoped that we will be able to take photomicrographs of a series of permanent mounted sections that have been prepared this summer.

C.H. Castell
J.F. Richards

Appendix No. 7

INFLUENCE OF BACTERIAL SPOILAGE OF COD ON PROTEIN DENATURATION

Preliminary to studying the effect of the initial quality of fish on the changes in frozen storage, the influence of initial quality on the denaturation of the protein was studied.

Fresh cod fillets were stored at 6°C and soluble protein and myosin determined as described previously. It is evident from the results of a typical experiment (Table) that there is only a negligible decrease in the soluble protein and myosin extracted by 5 percent sodium chloride at 0°C until significant proteolysis reduces the protein content. After 10 days storage the soluble protein nitrogen decreases about 50 percent, while the myosin decreases to about 20 percent of the total protein. The non-myosin fraction is thus doubled. This indicates the extent of proteolysis since the decomposed protein would be measured by the Biuret reagent as occuring with this fraction.

TABLE

Days Storage at 6°C.	Trimethylamine mg. N/100 g.	Protein SPN percent	Myosin as percent of total protein
Initial	0.23	96	76
1 day	.3	94	80
2 days	2.6	95	70
5 days	66.	92	69
6 days	100.	92	69
7 days	100.	60	20

We conclude that the protein extraction is not affected by early spoilage. Previously we have shown that a decreased protein extraction results if the extractant solution is above 5°C. The above results, of course, do not mean that the proteins of spoiling fish will not have an increased susceptibility to freezing denaturation.

W.J. Dyer
M. Douglas

Appendix No. 8

THE EFFECT OF NATURALLY OCCURING MUSCLE CONSTITUENTS ON PROTEIN EXTRACTION

Trimethylamine oxide and urea are two compounds which occur widely in fish muscle. Urea has been shown to be a significant factor in maintaining the osmotic pressure of body fluids of marine fish. This has not been shown in the case of trimethylamine oxide, although some evidence exists favouring this possibility.

The effect of these substances on protein extraction was determined by extracting fresh cod muscle with various solutions of trimethylamine oxide and urea in water, as well as five percent sodium chloride. Soluble protein nitrogen and myosin were determined colorimetrically.

The results using urea as an extractant show little variation from normal (Table I). In the absence of salt, the water soluble fraction, and not the globulins were extracted. When used with five percent sodium chloride both fractions were extracted, and the values obtained are not significantly different from the normal values of 90 percent soluble protein nitrogen and 64 percent myosin nitrogen. These results were not unexpected since urea is a non-electrolyte and should therefore have no effect on the peptization of myosin.

TABLE I

Extraction of Protein and Myosin by Urea

pH	Extraction Solution	Soluble Protein Nitrogen (as percent of total Protein Nitrogen)	Myosin Nitrogen (as percent of total Protein Nitrogen)
7.2	1% Urea	23.8	0
7.1	3% Urea	28.5	0
7.2	5% Urea	23.8	0
7.2	10% Urea	23.8	0
6.9	5% NaCl + 1% Urea	75.6	52.0
7.0	5% NaCl + 3% Urea	64.0	48.8
7.0	5% NaCl + 5% Urea	75.6	55.2
7.0	5% NaCl + 10% Urea	88.8	57.6

The results using trimethylamine oxide as extractant are more difficult to interpret (Table II). Although the values in the absence of salt agree with the normal values for water extraction there appears to be a lessening in the amount extracted with increasing trimethylamine oxide concentrations. In the presence of five percent sodium chloride the values are definitely lower than normal and decrease with increasing trimethylamine oxide concentration. This effect is not confined to the myosin fraction since when the myosin nitrogen value is subtracted from the soluble protein nitrogen the resulting figures are less than the normal twenty-five percent value for the albumin fraction.

TABLE II

Extraction of Proteins and Myosin by Trimethylamine Oxide

pH	Extracting Solution		Soluble Protein Nitrogen (as percent of total protein Nitrogen)	Myosin Nitrogen (as percent of total protein Nitrogen)
	Sodium Chloride percent	Trimethylamine Oxide percent		
6.8	0	1	31.0	0
6.4	0	3	23.9	0
6.4	0	5	19.9	0
6.4	0	10	19.9	0
6.5	5	1	55.0	40.2
6.3	5	3	40.1	28.5
6.4	5	5	32.2	19.9
6.5	5	10	19.9	4.4

This effect is not brought about by pH since this value remains approximately constant regardless of concentration. One possible explanation is that the trimethylamine oxide forms a non-peptizable complex with protein through its coordinate covalent oxygen linkage. The trimethylamine oxide is not ionized at pH 6.5 and probably does not form a salt with the protein at this pH.

J.D. Duerr

Appendix No. 9

VOLATILE ACIDITY AND SPOILAGE

The investigation into volatile acids produced during fish spoilage was carried out to determine the correlation between volatile acid production and the spoilage of fish muscle. Cod and haddock fillets were chosen since we know that with unfrozen fillets the trimethylamine value is our best indication of the stage of spoilage.

Sigurdsson (1947) followed volatile acidity and trimethylamine production in herring, and showed that the rise in volatile acids paralleled the increase in trimethylamine. We have now extended this investigation to cod and haddock. The use of trimethylamine as a spoilage test has definite limitations when applied to canned or frozen fish and to fresh fish of several varities, and a more universal criterion of incipient spoilage is needed.

The method of Friedmann was used to follow volatile acidity. This consisted in the steam distillation of the volatile acids contained in a 10 gram sample of muscle mince in a magnesium sulfate solution which is maintained at a constant volume (30 mls.). Recovery of known amounts of acids by this method was 98 percent of the theoretical value.

The average value of the initial volatile acidity for "fresh" cod fillets obtained from a fish plant during the summer was of the order of 18 ml. of 0.01 N. acid per 100 grams of fish. This value rises to about 180 ml. when the trimethylamine nitrogen is 44 mg. per 100 grams. The rise in volatile acidity parallels the trimethylamine nitrogen production in untreated cod fillets and in fillets containing sodium nitrite, and in haddock fillets. The investigation was carried out at 0°, at 7.2° and at 25°C. Results of typical experiments are shown in the tables.

TABLE I

Volatile Acid and Trimethylamine Production of Untreated Cod Fillets

0°C			7.2°C			25°C		
Age (days)	Vol.A.	TMA	Age (hours)	Vol.A.	TMA	Age (hours)	Vol.A.	TMA
0	18.5	0.5	0	18	0.7	0	18.5	0.5
1	42.5	1.4	7	15	0.6	4	18.1	0.5
2	17	--	18	19	1.5	9	37.3	1.26
3	31	4	28	14	1.0	12	27.5	1.7
4	39	3.7	48	62.5	6.3	16	67.7	5.0
5	41	5.8	43	31	3.2	21	66	13.5
6	144	30.1	62	123	12.6	25	116	13.5
7	165	34.5	85	145	44	31	185	27.6
						45	760*	--

* There was a very pronounced odor of hydrogen sulfide at this point.

Vol. A. -- volatile acidity as ml. of 0.01 N. acid per 100 grams of fish.

TMA. -- trimethylamine nitrogen as mg. per 100 grams of fish.

TABLE II

Volatile Acid and Trimethylamine Production in Treated (nitrite) Cod Fillets at 0°C

Age (days)	Vol. A.	TMA
0	28.5	0.9
1	19	0.8
2	26.5	0.5
6	46	2.9
7	58.5	2.3
8	42	3.0
9	54	2.1

From the results obtained it would appear that continuation of this work may well prove fruitful. A program with the view of developing a more universal test for spoilage based on volatile acid production might follow along the following lines:-

(1) a comprehensive survey of the total volatile acidity of fishery products of economic significance, including those in which the trimethylamine value is not a satisfactory spoilage indicator.

(2) coupled with (1), the determination of the component acids. Neish (1949) has modified a technique for the quantitative determination of the volatile acids produced during 2, 3-butanediol fermentations. This technique, that of partition chromatography, was in part examined during the course of the above investigation and it would appear that it could be applied to the determination of the volatile acids produced during the spoilage of fish muscle.

J.W. Kastner

Appendix No. 10

THE STOWAGE OF FISH AT SEA - THE ROLE OF ICE AND OF ARTIFICIAL REFRIGERATION

This is a continuation of the work reported in Appendix No. 7 of the 1948 report. In all, the data herein presented represents the results of observations and research made during the past summer in the course of eight schooner trips and one trawler trip. On some trips Station observers iced certain fish pens in a manner thought to be scientifically sound. The remainder of the pens were iced by the fishermen according to established custom. The comparative results of these icings are given here as is other information gathered in the course of many investigations made during unloadings at the dock.

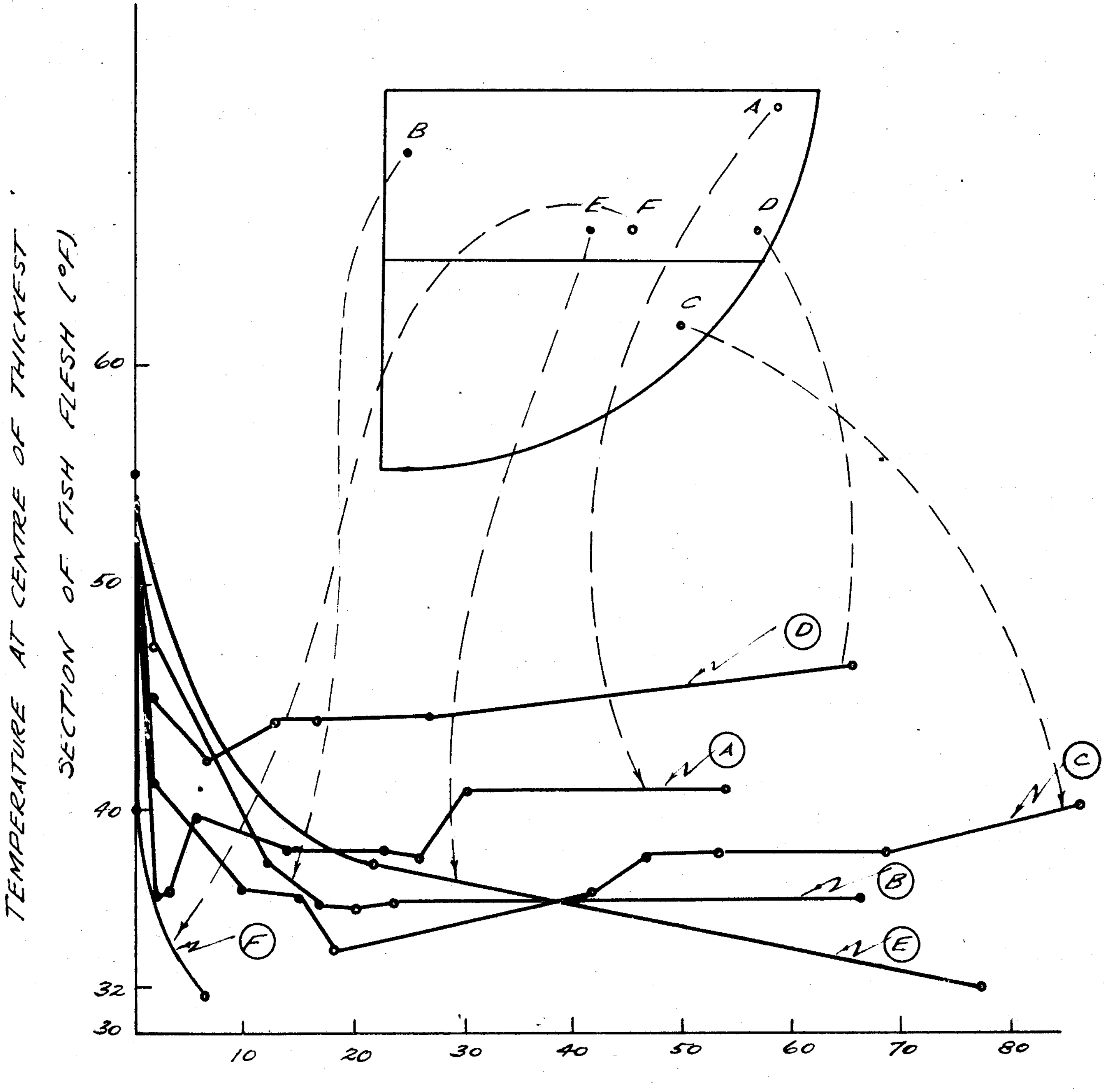
The investigation aboard schooners was concerned with two types of vessel: one in which the hold was insulated and not refrigerated, the other in which the hold was neither insulated nor refrigerated. The accompanying cooling curves for fish iced aboard these vessels point out some of the serious errors which occured in the stowage of fish during these trips.

Curve A shows the cooling rate of a fish situated at the top of a pen in a fish hold possessing well insulated deck, end bulkheads and back walls. This fish was buried in ice when initially stowed and cooled rapidly at first, dropped from about 50°F to 35°F in approximately three hours. At the end of this time the ice had melted from the fish and its temperature began to rise, reaching over 40°F two days later. This type of cooling has been encountered many times. It is the result of placing fish too close to the deckhead to permit the laying down of a sufficient thickness of ice at the time of original stowing. Warm air which is present for at least five months of the year at the top of a fish hold not artificially refrigerated, melts a thin layer of ice very quickly. If periodic "topping off" or reicing proves to be too little and/or too late, then adjacent fish are lost as were the fish in this particular pen.

Curve B shows the cooling rate of a fish next to the pen boards in an uninsulated vessel. In this case the fish was not iced adequately because it took almost 20 hours to bring it down to 35°F and this was as cool as the fish ever got.

Curves C and D show the cooling rates of fish stowed along the back walls of the same pen. Fish C started to cool rapidly, but within about three hours most if the ice was gone. It took almost a day for the fish to reach 34°F. By this time the ice was gone completely and the fish proceeded to warm up to 40°F. Curve D shows the same thing in a much more pronounced form. The ice was gone within a couple of hours. The fish never got down as low as 40°F.

These four curves show very plainly that danger areas are the bounding ends, top and bottom of the fish pen. The worst location for spoilage, particularly in uninsulated pens, is along the back walls, next, under the deckhead, and third, next to the pen boards at the front of the pen. Trimethylamine determinations subsequently made showed all above samples, except from the fish at location B, to be spoiled at time of landing.



COOLING CURVES FOR GUTTED COD FISH ICED ABOARD SCHOONERS

Fish under investigation were located in pen as shown in diagrammatic sketch above

The human factor is of greatest importance in the stowage of fish at sea. Curve E is an average of the cooling rates of a very large number of fish stowed in the centre of the pens from both insulated and uninsulated holds. For the purpose of cooling fish in the centre of pens it does not matter whether either artificial refrigeration or insulation or both are installed aboard a vessel. The quality of the icing job is all important. Curve E indicates very poor icing. The fish in the centre of the pen did not get down to temperature in less than three days. The curve is an average one and therefore in a very large number of cases the fish in the centre of the pen cool much more slowly than this. Even by the time they reach shore they never will have reached 32°F in many cases. This points out that the stowage as it is now carried on will not bring in fish of consistently good quality, no matter how the boat is equipped. At the present time the fish are stowed in layers as much as fifteen inches thick and the trickle of ice water through these layers is the only means by which they can be cooled. It is obvious from our results that this is entirely too haphazard a procedure, and that many of the fish pack closely together, thus allowing little or no ice water to reach adjacent fish. The fact that eventually the fish (Curve E) did get down to 32°F indicates that enough ice was used.

It is obvious that if the fish and ice are intimately mixed the fish must cool much more rapidly. Curve F shows the cooling rate in a pen where this was done. Four fish so investigated reached 32°F in about 7 hours, instead of in about three days. In this icing, layers of fish were restricted to the depth of one fish, that is about three inches, About one and one half inches of ice separated the layers of fish.

Previous discussions with fishing skippers about this method of icing has brought out the possibility of damage to the fish by the ice due to a shifting as the vessel rolls. This was not observed in the pen iced by this method. On the contrary, the ice and fish tended to solidify so that there could have been no movement.

The one trawler trip supported the wisdom of paying particular attention that the ice and fish are laid down in intimate contact. The best quality fish unloaded from the trawler was, judged by company inspection and A.F.E.S. trimethylamine determinations, taken from the A.F.E.S. iced pen and these were the first fish caught. There was one exception where a few bad fish were found in a trapped pocket of ice water at the bottom and back of the fish pen next to an insulated wall. A full pen of more recently caught fish iced in customary fashion was rejected by company officials as spoiled.

The same trip yielded further information on icing techniques. The crushed ice used on the vessel had a large proportion of excessively large chunks. It was impossible, therefore, for each layer of fish to be covered with ice without requiring the use of much more of the latter than was required for the actual cooling job. Hence in addition to better icing, it would appear cheaper to use finely crushed ice aboard fishing vessels.

The effect of the large chunks of ice on fish appearance was observed. At the time of unloading, the fish from the well iced A.F.E.S. pen were held compactly by the remaining ice. The ice had not indented or marked the sides of the fish, possibly because the flesh had remained firm as a result of the low storage temperature. On the other hand, large indentations were observed in the sides of many of the fish taken from inadequately iced pens.

Practical information was obtained regarding the effect of ensuring protection of the fish at the top of the pens. The top layer of fish was kept well below the deckhead to allow ample space for icing and "topping off". The excessive air temperatures (45°F recorded above the A.F.E.S. pen) for which the uninsulated steel deck was mainly responsible, caused sufficient melting of the top ice to cause the latter to crust over in a more or less rigid mat. This was removed only with some difficulty at the time of unloading. If this pen had not been so well iced, the top fish would have been exposed and would have spoiled. However, for the man who has to dig out the top fish from the midst of a mass of almost solid ice, it appears to be a stiff price to pay for good quality fish. It is suggested that this matting can be eliminated and good fish landed if these top fish could be well iced beneath an insulated deck where some means is provided to keep a slow movement of cold air between the top fish and the deckhead.

A comparison of present icing technique adopted on schooners and trawlers is worthy of note. Five to six men are available for work in the schooner hold for the transfer, stowage and icing of fish which come to them already sorted. One man alone may be required to do all of this work on a trawler and at the same time attend to sorting. As a result he works practically unspelled. It is only natural to expect that he has little time left to take on the extra work which would be required if a more comprehensive program of handicing were instigated.

The results of our work can be summarized as follows:-

(1) Fish iced in layers of a foot or more in thickness in any vessel, insulated or non-insulated, cannot be cooled rapidly enough to prevent spoilage during a normal trip at sea.

(2) The intimate mixing of ice and fish in the hold produced very rapid cooling; the fish reach the temperature of the ice in about 7 hours. Trimethylamine determinations supported visual inspection as to the excellent quality of fish landed from pens so iced.

(3) Particularly in uninsulated vessels, but even in insulated vessels, the ice tends to disappear from the back of the pens and the fish may warm up. There will always be a risk of bad fish along the back wall both in uninsulated and non-refrigerated vessels. This indicates the need for artificial refrigeration in this region of the vessel.

(4) Artificial refrigeration of the space between the top fish in the pen and the deckhead is required to prevent melting and subsequent solidify of the deep layer of crushed ice which should be stowed in this region. It would also prolong the storage life of fish in this area if through one circumstance or another icing were inadequate.

(5) Fish should not be stowed close enough to the deckhead to prevent the proper icing of the top of the pens. Fish in this region have normally about as poor a temperature condition as the fish along the back wall. Provision of about fifteen inches clear space between top fish and the deckhead should permit

proper icing and "topping off".

(6) There is a need for artificial refrigeration of the air in the central part of the hold to eliminate wastage of the ice stowed with the fish next to the pen boards.

(7) Fine crushed ice should be used in order to promote rapid cooling and to reduce the quantity of ice required.

(8) Decks, end bulkheads and pen back walls should be well insulated.

(9) In the case of the trawler, a more liberal allotment of manpower to the highly important job of stowing fish seems warranted.

Observations appear to indicate that the practical approach to the problem of fish stowage is to consider the insulation and artificial refrigeration of vessels as imperative. With this as a foundation, an attempt should be made to imporve icing methods to a degree which can be coped with on board ship.

One suggested approach is the installation of a mechanical ice crusher and slinger in the hold of a vessel as an experimental project. These machines have many important applications ashore where they are used to ice products in locations inaccessible to icing by hand. With this in mind, we are now investigating available sizes, costs and delivery, of a machine of a size nearest to our estimated requirements. It is expected that some reduction in size of available machines may have to be made by our staff. Furthermore, a study of technique and application aboard ship will be required. The choice of a suitable power supply is also necessary. It is hoped that the pioneer work can be started in our laboratory and then the chosen apparatus can be transferred to a vessel. Installation aboard a trawler would have the advantage that the scientific study of results should be simplified if we are dealing with fish known to be still kicking when stowed.

A solution to the problem of fish stowage which can be acceptable to the fisherman, the shareholder and the scientist must be found; otherwise complete success will not have been achieved. The study is of such magnitude and has so many influencing factors, both natural and man made, that quick results are not anticipated. The first season's investigation, which may get under way during the warm months of 1950 will require the services of at least two investigators prepared to remain at sea with their ships. They must be prepared to investigate all reasonable angles and to direct a complete icing program aboard a vessel when this is required.

W.A. MacCallum
G.H. Cook
R.W. Wilson
C.G. Oldershaw
W.J. Dyer
H.E.J. MacMillan

Appendix No. 11

THE STOWAGE OF FISH AT SEA - THE RECORD OF THE "LILA B.BOUTILIER"

An extensive investigation of the effect on the keeping time of fresh fish of the refrigeration installation on the fishing schooner "Lila B. Boutilier" did not materialize as planned for the summer of 1949. Only one trip was made aboard this vessel.

During the one trip investigated, the total period of compressor operation was a small fraction only of the total time spent at sea. The unit was not operated at all during the trips from port to the Banks and return to port. It was used sparingly during fishing operations, and then on "Manual" rather than on "Automatic" control. Icing up of evaporator coils was experienced on occasion. Our observers log shows the engineer to be at fault in his operating procedure which accounts for the icing. In the latter's defence he asserts that this technique is forced on him as a result of insufficient generating capacity provided in the unit's design.

As in the trip aboard other schooners described in Appendix No. 10, our observer iced one pen according to the A.F.E.S. plan, and recorded temperature readings of the fish throughout the trip. He took parallel readings in an adjacent pen which was iced as described by the crew. The cooling curves obtained fall into two distinct groups, one group for the fish which cooled rapidly in the A.F.E.S. iced pen, the other for the fish iced by the crew and which never cooled properly. Trimethylamine determinations indicated that all fish samples from both pens were of good quality. In the case of the crew iced pen this could have been due to

(1) the fact that the fish were iced and gutted immediately after reaching the schooner.

(2) the cooling provided by the evaporator coils for a short time before the vessel headed for home.

(3) the shortness of the time which elapsed between the stowing of the fish and their unloading at port (less than two days).

Apart from the fact that it was demonstrated again that intimate mixing of fish and ice is a guarantee of quickly cooled fish, nothing concrete can be found from a study of this trip. As a result we are not yet in a position to say exactly what benefits have accrued from the installation on the "Boutilier" over say the simple job of insulating the hold of the schooner "Theresa E. Connor". The intensive study in icing made on the insulated "Theresa E. Connor" and on the uninsulated schooner "Marjorie and Dorothy", reported in Appendix 10 does indicate the necessity of a measure of artificial refrigeration. Whether we are getting this in the quantity and in the places required from the installation on the "Boutilier" still remains to be answered.

Information based on practical results, rather than scientific determinations, indicate, however, that the overall picture of the quality of fish landed by the "Boutilier" has improved tremendously. This is based on company reports to this station. This vessel, which in pre-installation days was credited with one of the poorest records for quality fish is now credited with the highest record by the same judges. We have been approached by the company and captain within the past few months regarding the installation of an artificial refrigeration unit on the "Boutilier's" sister ship, the "Theresa E. Connor". We were, in fact, urged to supply a design for this schooner. The view was taken at that time, however, that we could not recommend certain features incorporated in the "Boutilier's" design until it was shown to our satisfaction that their adoption would assist the "Connor" in bringing in better fish, assuming the crew on the "Connor" were doing their utmost to ice their fish properly. For this reason the icing investigation, reported in Appendix 10, was conducted on the "Connor" to determine the maximum ability of the vessel to bring in good fish as she is fitted out presently. In our judgment the investigation of the "Connor's" catches indicated that a measure of artificial refrigeration aboard that vessel would be of decided advantage. However, as shown earlier, we did not then, and still do not know with absolute certainty, whether the system installed on the "Boutilier" would be the logical choice. There are indeed several features of this first design which it is thought could be changed to increase the usefulness and efficiency of the installations. No recommendations have been given therefore regarding a unit for the "Connor" pending a study of the "Boutilier's" performance record.

Should we continue to meet with difficulties in conducting our investigation on the "Boutilier" it may be advisable that we return to laboratory investigation and experiment with the cooling of fish in a limited number of pens treated exactly the same and located in the same environment known to be found on the "Boutilier". After this, we could alter the treatment as dictated by experience already obtained aboard the "Boutilier" keeping the environment the same. Lastly, the environment could be altered, while maintaining original treatment. As refrigeration facilities for such a project are presently available we should be able to proceed with little additional expense other than some loss in the fish required for the experiment.

It is significant that the results of this work which was pioneered in Canada by the Fisheries Research Board of Canada is now being incorporated into the design for a new class of trawlers to be built by a large Canadian company. We have been most happy to co-operate with the American firm of architects retained by the company in their examination and resolution of the problem. The urgency with which management is requesting information based on practical experience concerning all phases of the refrigerated hold and ice stowage problem makes this work appear more important than ever and should indicate the necessity for pursuing the additional investigations proposed above.

W.A. MacCallum
G.H. Cook

Appendix No. 12

ROUND FISH WASHER

Work on the washing of round fish for the removal of bacteria from the gut cavity and surfaces, has been progressing for some time (Annual Reports 1946, 1947 and 1948).

At present the fish goes to the filleting tables unwashed and the surface slime with its high bacterial count is inadvertently rubbed off on the cutting boards and allied equipment, hence spoilage is given added impetus from the start. It has been the aim of the station to rid the fish of this bacteria-bearing slime before actual processing begins and so reduce the incidence of contamination throughout the plant. A fish washer is to be the first step in the "Fresh Fish Production Line" currently being developed by the station.

This "Round Fish Washer" is the latest of a series of machines developed during the past three years (Annual Reports 1946, 1947 and 1948). The first ones (Annual Reports 1946 and 1947) were of the cylindrical screen type in which the fish were tumbled and scraped against the screen, so removing the slime which was removed by a water spray. It worked well during preliminary trials but was not satisfactory when loaded to capacity. The next washers employed a chain conveyor with attached clamps to pull the fish through a series of rubber scrubbers or flappers to remove the slime which was carried off by means of a water spray (Annual Report 1948). This type washer did not handle enough fish, mainly because of clamping difficulties; it did not penetrate the gut cavity and was rather complicated mechanically.

Simplicity and ease of maintainance were the guiding principles in the development of the latest washer. It uses a modification of the same type scrubbers as in the previous washers together with the water spray to aid in desliming and to carry it off. Gravity is utilized rather than the chain conveyor to move the fish through the machine.

The washer consists essentially of an aluminum alloy cylinder rotating in the opposite direction to an aluminum alloy hexagon which carries the desliming mechanism, the scrubbers or flappers (Plate I). These two members are so positioned and rotated, the scrubbers at 350 R.P.M. and the roller at 35 R.P.M. as to support the fish and produce a turning moment on it which allows all surfaces and the gut cavity to be cleaned by the scrubbers. A sloped aluminum plate guide board (Plate I) is fitted the length of the rollers to stop the fish from being flipped away from the scrubbers. The whole arrangement is sloped about 1 inch to the foot which gives a rate of travel, through the

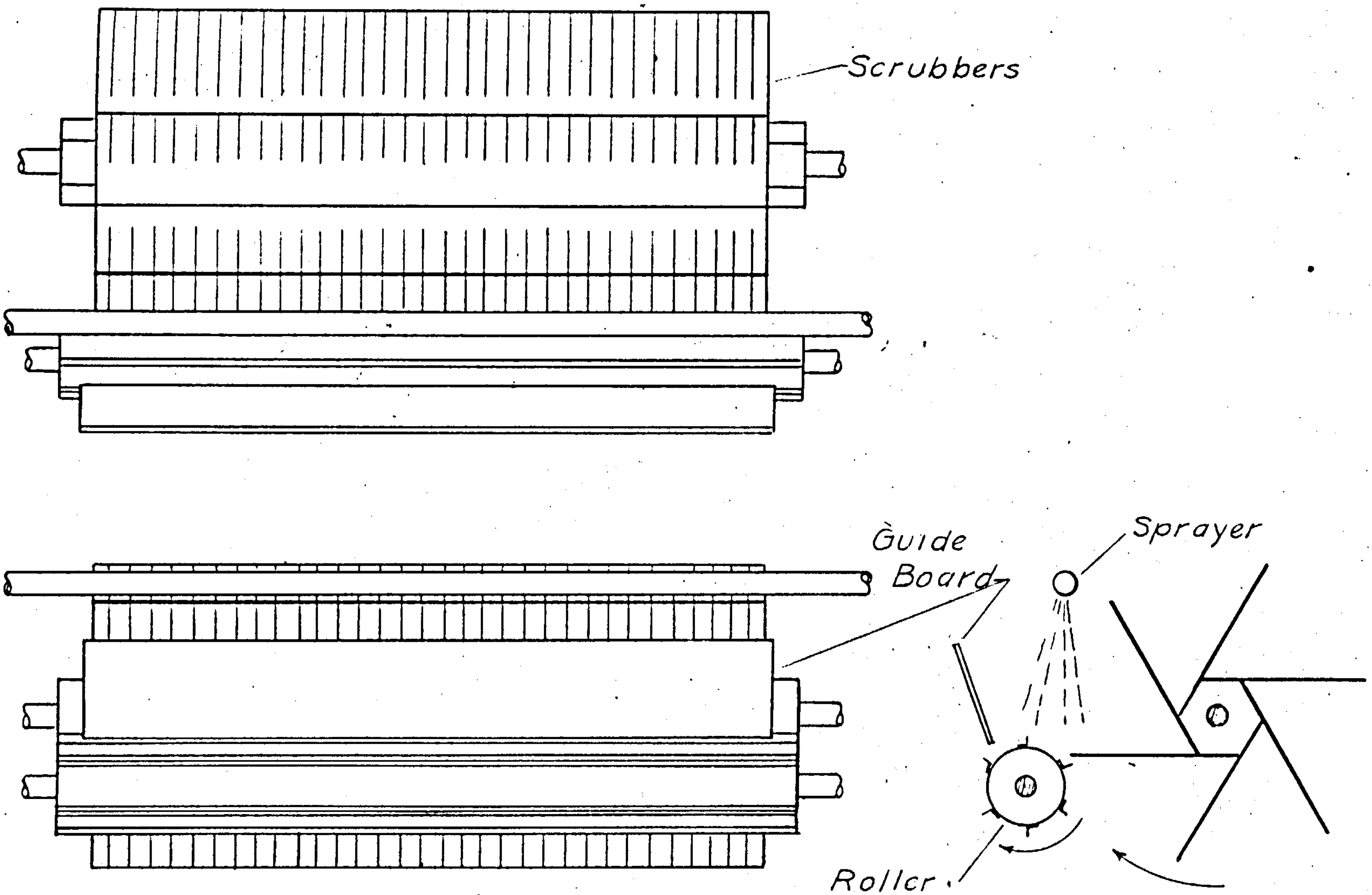


Plate I ROUND FISH WASHER

C.G.O.

washer, of from 10 to 15 seconds depending on the size and condition of the fish.

The complete washer consists of two sets of scrubbers and rollers mounted side by side so as to give a washing rate of about 2 to 5 seconds, with an average of six fish in the washer at a time. It is fitted with loading and discharge chutes to facilitate handling, a cover to reduce flying spray and a trough to remove slime and water.

The washer is constructed entirely of corrosion resistant aluminum alloy, the frame being of channel covered with 1/4 inch plate and 0.040 inch sheet. The rollers and scrubbers are cast aluminum made up in 2 foot sections, and joined to give a total length of about 8 feet. The scrubber castings are hexagonal and carry 6 laminated rubber flappers. The roller castings are fitted with ½" x ½" x 8 feet aluminum angles spaced equally about its periphery. The scrubbers and rollers are carried on a steel shaft with bearings at the centre and ends. All bolts are cadmium plated to keep corrosion to a minimum. The washer occupies a floor space of about 55 square feet, being approximately 13 ft. long and 4 ft. wide. At present the drive is carried on one end of the machine itself, but may be moved overhead in actual plant operation.

Test runs on this type washer have given consistently good results in that bacterial counts were reduced by about 99% and there is reason to suppose that this can be maintained in commercial operation. It is proposed to pass the washed fish through a chlorine solution spray to rid the fish of part of the remaining bacteria.

Modifications in the drive mechanism may be undertaken in the future but otherwise the washer is ready for trials on a commercial scale. The policy of the station is to install a "Fresh Fish Production Line" as a whole so neither the washer or any other single piece of equipment will be put into commercial operation before that time, the reason being that no single machine or practice can improve the quality greatly, the problem being one of general improvement throughout the processing chain.

C.H. Castell　　M.A. Foley
H.E. Power　　C.G. Oldershaw

Appendix No.13

SEMI AUTOMATIC FILLETING

For some time now the station has attempted to develop a method of filleting cod, haddock, and mackerel by mechanical methods. The advantages of mechanical methods of filleting over manual methods are numerous. The most important of these is that the cutting of the fish will take place under more sanitary conditions, as the machine will have to be built of non-corrosive metal which will be continually washed with a disinfectant. There will be no "build up" of slime and bacteria as there is now on the present wooden cutting boards of the filleting table. If the fish flesh is sterile when it enters the machine the fillets will be much less contaminated. Other advantages of the mechanical method might be lower production costs and smaller space requirements, both of which would be welcome by the fish processing industry.

The first attempt at mechanical filleting of the larger fish was made by W.H. Bowes after extensive study of herring filleting methods and manual methods of filleting cod and other large fish. The machine which he built was a larger version of the common herring filleting machine. It consisted of two circular knives mounted side by side about one-half inch apart and a metal trough to feed the fish tail first and belly up into the turning blades. (See Figure 1). The test of this machine did not prove too satisfactory as it was impossible to feed the fish into it properly, the tail could not be made to enter between the blades. Also the fish were thrown from the machine at a very high velocity.

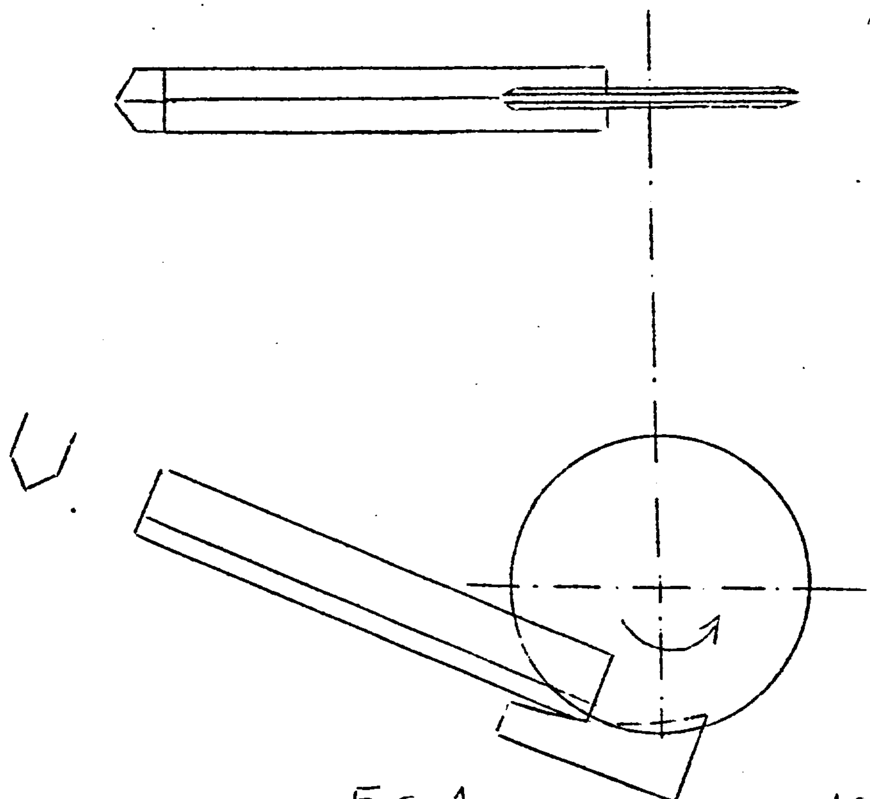


FIG. 1 J.E.P.

A second machine was a modification of the above fitted with guides to guide the tail of the fish between the notching blades. These guides did not work satisfactorily. A third machine was built with the feed trough horizontal, and a pair of guiding rollers powered by a motor used along with spring guides, to feed fish, tail first and belly up into the two parallel blades. This proved better. The two sides of the fish were split away cleanly from the backbone, however too much flesh was left on the backbone at the tail end and if blades were adjusted to remove this the blades cut into the backbone at the head end. In an effort to remedy this two sets of blades were mounted on the machine as shown in Figure 2, but they were not successful due to a tendency of the fish to turn as it went through the blades. A similar machine was constructed using smaller blades. However, this was not the cure as the fish still turned in the machine.

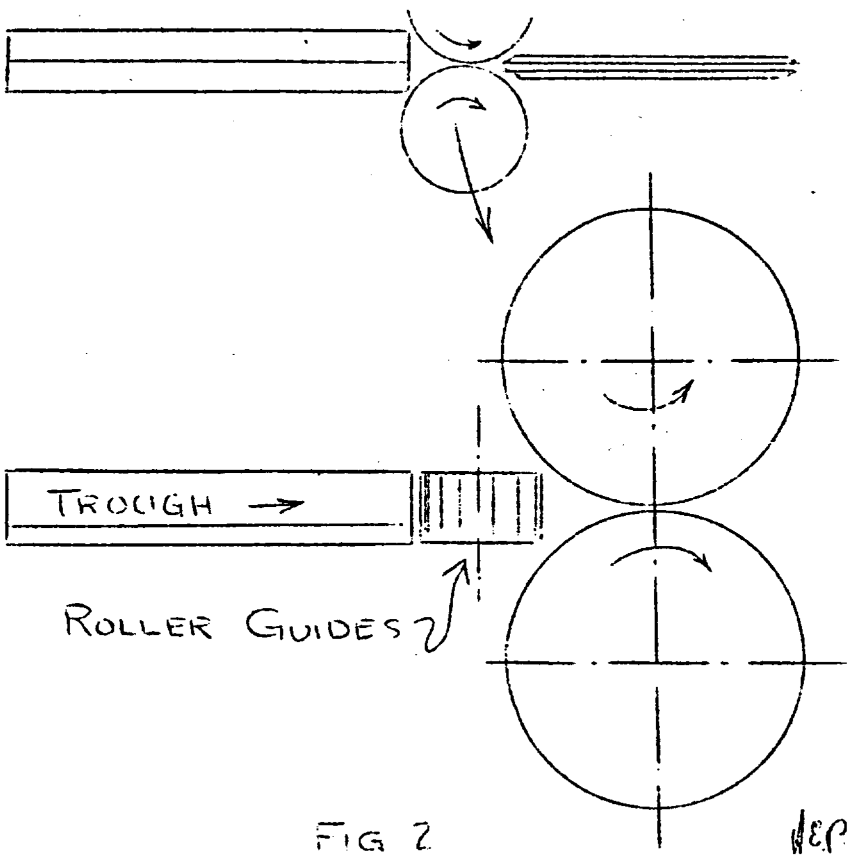


FIG 2

HEP

It was decided that the solution of this problem would require more time and effort than we are able to devote to it at present. In view of this, further work on this machine is being postponed until greater effort can be allotted to the problem. The problem is by no means insoluble and much valuable knowledge has been gained from work with the above machines.

H.E. Power

Appendix No. 14

PRE-SHIPMENT CHILLING OF FRESH FISH

Certain investigations have been carried out to determine the most effective and commercially practicable method of routing and refrigerating the fresh fish fillet from the time it leaves the filleter until it is ready for transportation to our North American inland centres. The trade has exerted considerable effort to evolve a handling technique to ensure a maximum keeping time for fresh fish. While some of the means adopted have been novel, and some more or less successful, none appear commercially sound for large scale fresh fish production.

We propose to discuss those methods which we have been called upon by the trade to investigate, and to give the preliminary results of work carried on at our Atlantic Technological Station in an effort to provide an answer to some of the existing problems.

A. Chilling by Immersion

Those using this method combined with ice cooling at a later stage expect that in a dual purpose bath through which the fillets pass upon leaving the filleter, temperatures will be reduced materially while the fish are being treated. Investigation has shown the following to be true.

1. Due to the danger of freezing the bath, a temperature of dip below 32°F cannot be obtained. Thus extremely rapid chilling of fillets to 32°F is not possible.
2. Remote cooling of the bath may result in a waste of refrigeration due to poor design which permits warming up of the liquid before it reaches the treatment tanks.

The following are typical observations made of temperatures at the various stages between filleter and final icing.

TABLE I

Season	Temp.Fish Fillet Before Bath	Temp. Bath	Temp.Fish Fillet leaving Bath	Temp. Fish when packed	Elapsed Time
Early spring	35.6°F	45°F	—.	41°F	20 min.
Early spring	32.5°F	41°F	34°F	39°F	20 min.
Early autumn	42.5°F	47°F	43.5°F	--	10 min.
Early autumn	39.5°F	46.7°F	39.7°F	--	10 min.
Early autumn	43.0°F	47°F	43.8°F	--	10 min.
Early autumn	45.7°F	47°F	46.5°F	48.2°F	8 min.

In all cases the fillets were being warmed, rather than cooled.

What possibilities are there for the success of the immersion method providing an efficient design were provided? To answer this question we have developed a series of cooling curves determined experimentally for each of three weights of fillets. Each series consists of three curves, each of which is for a specific temperature difference between cooling liquid and fish fillet at the time of immersion. By using the series of curves applying to that size fillet, the time required for the fillet to cool through a desired temperature range may be estimated. For example, suppose we could be satisfied with a product chilled to 33°F, the 2 lb. fillet recorded last in Table I would have to be immersed for over $2\frac{1}{2}$ minutes , while smaller 13 oz. and 10 oz. fillets would be reduced in temperature by equal amounts in 1 1/4 minutes and 65 seconds respectively. The first two requirements are out of line in that treatment at accepted concentrations is not recommended for these periods.

All three requirements are out of line in that:-

(1) the physical length of immersion tanks would have to be extended three and four times over present lengths (a reduction in the speed of belt travel through the tanks in order that presently used tanks could be retained would not be possible without a corresponding reduction in production rate which would not be acceptable).

(2) a multiplicity of tanks and hence cutting lines would be required if all sizes of fillets and all temperatures of fillets at time of immersion were to be taken into account.

(3) the refrigeration requirements for such tanks would be very high. This in itself might be justified if fillets could be packed quickly enough to prevent an appreciable subsequent temperature rise. Table I shows that the shortest elapsed time from bath to icing or cooler was 8 minutes. It appears improbable that this will be reduced much more. The temperature rise in the fillet during this interval was 1.7°F. A rise of 5°F over a 20 minute interval is noted for No.2 fillet in Table I. Inevitable production delays can always be counted upon to produce similar situations. This results in a 38°F fillet providing the latter left the bath at 33°F. This temperature, translated in terms of time, labour and cost required to gain back these precious few degrees by subsequent refrigeration indicates a wastage of original cooling. The whole study indeed would appear to indicate that the proper time and place to apply refrigeration is immediately after packaging is completed.

B. Chilling by Ice

Most producers, whether or not users of the refrigerated bath, use ice as the refrigerant subsequent to packaging. Ice for stowing and for transport has one great advantage, that is, dependability. There are several reasons, however, why other techniques for chilling fish are receiving attention.

1. Ice cools fish slowly

Fillets packed in wooden boxes may be packed as a body in larger cases along with a quantity of ice, and shipped by refrigerated freight immediately, or in individual boxes may be held in a 32°F holding room. Demand governs procedure. The net result is a slowly cooled product (Note No.107 -No.45 Progress Reports of the Atlantic Coast Stations). The last fish recorded in Table I will be cooled to 32°F in a little more than two days after being iced. During the first day and a quarter of this time the fish will never be below 37°F. Castell (Report of the Atlantic Fisheries Experimental Station- 1948) has shown that untreated lightly contaminated fillets begin to spoil after four days when stored at 37°F. On the other hand a storage temperature of 31.5°F will prolong the keeping time of the above fillet to 10 or 11 days. Melting ice is incapable of cooling this low or better still to around 30.5°F at which temperature fish start to freeze.

2. Restriction in use

The construction of Canadian Railway Refrigerator cars is such that melting ice from iced and boxed fish is no problem. However, this is not true for all refrigerated truck transport. The tendency is for truck transport in North America to go to mechanically operated compression systems, or to secondary refrigerant principles involving few moving parts. These trucks are considered to be fairly foolproof holding rooms on wheels. Essentially, they are to carry frozen products or chilled products, not products in the process of being cooled by ice.

Air transport of fish, economically possible for the more expensive seafoods, also precludes the use of ice.

3. Production problems

The great diversity of products from most of the fresh and frozen fish plants is such that packing and shipment of a proportion of fish in ice has not extended plant resources to the point where the task cannot be accomplished. Necessarily, this will not be true in the future should the expected great increase of fresh fish sales materialize. The problems of space requirements and handling costs may then be such that alternative refrigeration facilities will be required.

4. Transportation costs

Fresh fish are shipped in refrigerated carload lots on the basis of net weight plus an estimated percentage for icing and packing. This percentage could be greatly reduced if chilled fillets were shipped without ice in the cases.

C. Chilling by Artificial Refrigeration

The preliminary to this work is noted in Appendix No. 13 of the Annual Report of the Atlantic Fisheries Experimental Station, 1948 and in Note No. 107, No. 45 Progress Reports of the Atlantic Stations. The use of metal fillet boxes in place of wood, the chilling of each box separately in a blast of cold air, and finally the packing of these boxes tightly together in a conveniently sized outer box without the addition of ice, and finally the shipment of the refrigerated fish by refrigerated truck and rail facilities holds attractive possibilities. Much of the ground work for the development of required technique has already been done at this station. The development of a large air blast freezer described in detail in Appendix No. 10 has been carried out with this important application in mind. Valued information regarding control conditions, production rates, truck construction, and truck movement has already been obtained through the use of this unit and should be transferable directly to full scale commercial production.

How does this method of cooling compare in speed with others investigated?

Assuming equivalent initial and final temperatures, the following representative results have been obtained.

TABLE II

Chilling Method	Nature of Pack	Time in Blast	Associated Temperatures of Cooling Medium
Air Blast	20 pound metal container of fillets (4" thick)	40 min.	Air blast at -42°F
Air Blast	20 pound metal container of fillets (4" thick)	65 min.	Air blast at -10°F
Air Blast	20 pound metal container of fillets (3 1/4" thick)	35 min.	Air blast at -10°F
Plate Freezer	10 pound cardboard carton of fillets (2½" thick)	60 min.	Refrigerant Temperature of -30°F within plates

TABLE II (continued)

Chilling Method	Nature of Pack	Time in Blast	Associated Temperatures of Cooling Medium
Low temperature Holding room (box is placed directly on brine coils)	20 pound wooden box of fillets (3" thick)	about $3\frac{1}{2}$ hours	Coil temp. -10°F Room temp. +2°F
Cooling by ice in conventional packing cases placed in equivalent to iced (15% salt) refrigerator car.	8-20 pound wooden boxes each 3" thick cooled as a block	about 55 hours	32°F

As the investigation stands to date the following points can be summarized with respect to pre-shipment chilling of fish.

1. Chilling by immersion at any stage in the production line does not appear to be warranted.

2. Chilling by ice is slow, giving a large scope for bacterial action. Chilling by the blast method is rapid. Bacterial action is reduced at the resulting low temperatures which can be lowered to 30.5°F very rapidly. Keeping time is increased.

3. Chilling by blast air in large scale fresh fish production where 30 to 32°F storage facilities are provided should make for reduced labour costs, space requirements and a smoother production line than is possible using any of the other conventional methods.

4. Chilling by blast air is most efficient and practicable for the production of fresh fish for air cargo and refrigerated truck transport.

5. Transportation costs by refrigerated railway and truck transport carload lots should be greatly decreased by pre-transit chilling in the blast which permits subsequent shipment being made without ice being added to packing cases.

There remains several aspects which must be investigated.

1. No producer should be encouraged to use this method unless he has a suitable 30 to 32°F holding room to handle his chilled fish for whatever period may elapse between chilling and transit.

2. A strict check should be maintained to ensure that equivalent facilities or icing facilities are available and are being used immediately upon unloading of pre-transit chilled fish from railway refrigeration car or refrigerated truck transport.

3. A more rugged, better designed metal container for pre-shipment chilling than that presently used is required. Cost of this container is also to be considered (present cost is about twice that of corresponding wooden box). If it is not possible to produce lower priced containers, an alternative would be to have rugged combination packing and pre-transit chilling cans, which could be used over and over again in the fish plant. Wooden boxes could be used for transporting the chilled fish once it was transferred from the chilling cans. This would involve additional research in both wooden and metal box construction.

4. The use of metal boxes for fillets would require a study of packing room production flow and technique.

W.A. MacCallum

SECTION II

FROZEN FISH

Appendix No. 15

THE DESIGN OF AN AIR BLAST FREEZER

Design and construction of a blast freezer to incorporate the results of research, referred to in Appendices No. 16 and 17 of the 1948 Annual Report, has proceeded with satisfactory speed.

We have completed the insulation of a room of sufficient size to house a blast unit which in its first form occupies a floor space of 18 x 12 feet and a height of 8 feet. Additional ammonia refrigeration equipment has been installed in our engine room. All evaporator and all mechanical installations have been completed.

The complete system has been tested without product load. The installed equipment proved capable of maintaining a blast air temperature of minus 47°F within the freezer ductwork. A regulator is provided for the purpose of maintaining any desired temperature higher than this. This gives the plant great flexibility and should permit the carrying out of freezing experiments at any temperature thought to be practicable. Fan performance checks closely with design specifications. Air flow is very regular. It is apparent from information already gathered that a reduction in the floor space now alloted the unit is entirely possible without adding to fan motor power requirements. Fan installation is of flexible design which will permit much further experiment with air flow. Final decisions on the merits of various air flow schemes cannot be made until the unit is tested under refrigeration load for each scheme.

The work on truck development has proceeded in parallel with freezer construction and testing. Three wood and aluminum trucks, which appear to be suited to pre-shipment chilling of fresh fish, have been constructed. The development of a metal truck for quick freezing parcelled fillets has proceeded more slowly. However, results achieved to date are encouraging. A restraining mechanism has been designed to maintain evenness of pressure on the product during freezing. Another mechanism is being developed for control of the plates separating packages placed within the truck.

The problem posing the greatest difficulty appears to be one of reducing the present weight of the truck while still maintaining required strength and retaining the desirable operating features already developed. Items of design have been rechecked, piece by piece. A worth while reduction in weight ap ears possible. Hence a truck based on this design will be built and checked for performance under load and at low temperatures. Providing performance is satisfactory, a still lighter truck will be designed.

In the event that the truck weight cannot be reduced sufficiently in this way, the next step will be to erect fish package adjusting and restraining mechanisms as a part of the tunnel itself, rather than as part of the truck.

When air flow measurements are completed and suitable freezing trucks are available, the unit will be tested under full load. Then the performance of the freezer will be made available to the trade.

The work with respect to pre-shipment chilling has already reached the advanced stage where at this moment facilities are available for putting fish through the unit on a commercial basis.

The brine defrost system incorporated in the design offers considerable scope for performance investigation. As yet this defroster has not been operated. Power requirements for fan motors may vary to a great extent, this variance depending on brine elimination features. The variance appears to be of such ma nitude that a complete study of defrosting equipment appears to be justified. Inquiries placed with refrigeration companies show the lack of a fund of information on defrost problems. These will constitute some of the features upon which we will be asked to give recommendations by any one in the trade interested in freezing and chilling by the air blast method.

W.A. MacCallum
F.H. Theakston

Appendix No. 16

SOME EFFECTS OF LOW TEMPERATURE ON MYOSIN

The investigation of the properties of proteins would be greatly enhanced if myosin could be extracted and stored in a powder form from which solutions could be made in a short time. It has been shown that many proteins can be stored in dried form for indefinite periods of time. There are presently available two methods of drying myosin, both of which lead to considerable denaturation. The first involves spray drying the extracted protein, the product being 60 percent peptizable by 5 percent sodium chloride. The second method is drying the muscle tissue in a vacuum dessicator, and extracting the dried material with salt solution. This procedure has not been shown to be of value in storing protein. A third method which has not been applied to myosin is freeze drying, in which the solution is rapidly frozen (usually at dry ice temperature) and then placed in a high vacuum until dry. Before this method can be applied some information regarding the rapid freezing of myosin is required.

It has been shown that myosin solutions frozen slightly below the eutectic point of the peptizing salt will be denatured, the extent of denaturation depending on the time of exposure to the freezing temperature. The results of these experiments (Table I) show that myosin solutions frozen far below the eutectic temperature are also partly denatured.

TABLE I

Salt Concentrations % while frozen	Undenatured Myosin (as percent of unfrozen)
0	76.5
1	74.2
2	69.0
3	73.1
4	75.5
5	77.6

They also show that the concentration of salt is relatively unimportant.

It was further shown (Table II) that myosin solutions frozen above the eutectic point were not appreciably denatured by subsequent exposure to dry ice temperature (-80°C). The effect of rate of thawing was found to be of negligible importance.

TABLE II

Freezing Temperature	Temperature of Subsequent Exposure	Time Thawing	Thawing Temperature	Undenatured Myosin (as percent of unfrozen)
-15°C		24 hours	3°C	89
-15°C	-80°C	24 hours	3°C	88
-15°C		10 min.	20°C) till)melted	91
-15°C	-80°C	10 min.	20°C)	94

These figures were obtained by using isolated myosin systems and it should be noted that results obtained by similar treatment of myosin in situ will not be comparable. It seems likely that undenatured dried myosin can be prepared by freeze drying providing the system is frozen above the eutectic point.

The determination of myosin is carried out by precipitating myosin (usually by dilution to less than ½% salt) and dissolving the resultant gel in 1 N sodium hydroxide. It was found that normal sodium hydroxide would dissolve denatured as well as undenatured myosin. If 5 percent sodium chloride solution was used as extractant only the native protein would be soluble since insolubility in 5 percent salt solution is our criteron of denaturation. In several experiments previously performed it was found that there were considerable differences between the values obtained when salt solutions were used and when normal sodium hydroxide was used. The sodium hydroxide values were invariably higher. This lead to the belief that the salt had not completely peptized the protein. This was shown to be the case by making four identical myosin gel preparations dissolving one in normal sodium hydroxide and the remainder in 5 percent sodium chloride solution. Myosin in aliquot portions of each were determined at intervals. The results show that native myosin must be allowed to stand for some time in a finely subdivided state in 5 percent salt solutions or low values will result in the determination.

TABLE III

Time in peptizing Solution	Peptizing Solution	Myosin N (as mg/g fish)
10 minutes	N NaOH	15.4
10 minutes	5% NaCl	10.4
3 hours	5% NaCl	13.8
24 hours	5% NaCl	15.1

J.D. Duerr
M.R. Douglas
W.J. Dyer

Appendix No. 17

CHANGES IN THE PALATABILITY OF FROZEN HALIBUT

In March of this year, taste panel experiments to show the effect of temperature and length of storage were begun on frozen halibut. Fresh gutted fish of approximately thirty pounds were obtained. These were sliced to pack in one pound cans. The cans were frozen in a brine spray at -27°F for two hours and left in a room at -20°F overnight. The following day they were stored in constant temperature cabinets at +10°F, 0°F and -10°F.

The printed form used by the tasters for marking the halibut ratings was adapted from that used for similar tests on frozen cod fillets. At each taste panel the stored fish was compared with fish freshly frozen in brine at -27°F. Unfortunately the quality of the control varied considerably and it was not always a good standard of comparison.

Halibut has a much higher fat content than cod and from similar experiments on frozen cod it was expected that early rancidity, especially at the higher temperature +10°F, would cause a rapid decrease in palatability as ascertained by the taste panel. Up to 26 weeks this effect has only begun to be observed for the stored fish has compared very well with the control. The halibut has been continually graded "fair" by the tasters and if the control were considered perfect would in proportion rate much higher. This can be noted from the following table of taste panel results.

Taste Panel Ratings of frozen halibut as % of perfect grade

Weeks of Storage	Control 24-28 hours 27°F	-10°F	0°F	+10°F
1	75	77	69	74
3	66	68	73	72
5	64	67	66	49
7	65	65	70	67
8	81	65	71	53
11	77	56	52	51
14	41	68	73	53
16	78	68	73	53
21	69	64	67	62
26	72	64	62	56

The fish is judged on appearance, texture, odour and taste and on the basis of these a grade is given. The above table represents the average grades on the fish samples. The change in grade at present corresponds very closely to the loss of "sea fresh" taste but it is expected that after a very few weeks it will be more influenced by the objectionable texture developed in frozen fish on long storage.

Although there is some protein denaturation as shown by the decrease of myosin and total protein solubility as recorded in the following table, it has not affected the texture of the frozen halibut sufficiently to cause any considerable reduction in palatability rating.

Percent of total protein N

Weeks of Storage	-10°F Sol.Prot. N	-10°F Myosin	0°F Sol.Prot. N	0°F Myosin	+10°F Sol.Prot. N	+10°F Myosin
0	90	64	90	64	90	64
1	68	44	76	54	74	53
2	72	52	76	49	73	52
5	83	54	77	47	57	36
11	70	40	80	48	71	44
21	73	54	70	61	62	40
26	51	26	78	36	60	24

Determinations of free fatty acid and peroxide values were also made, the fat being extracted with chloroform. As shown in the table there is a steady increase in free fatty acids, much more so at the higher storage temperatures.

Storage Time Weeks	Free fatty acids % -10	0	+10°F	Peroxide value m. eg/100 g fat -10	0	+10°F
Fresh		2.8			0.4	
1 week		2.0			0.7	
11 weeks	3.9	10.3	13.5	0.4	0.6	0.75
18 weeks			13.4			0.8
23 weeks	4.4	11.0	17.3	0.6	1.3	1.8
29 weeks	7.5	12.8	19.1	0.4	1.5	1.4

The peroxide values have not changed at -10°F but show a considerable increase at the storage temperature of 0° and +10°F.

Summarizing, after 6 weeks there has been a small decrease in palatability of frozen Atlantic halibut, much less than with cod and haddock stored under the same conditions.

W.J. Dyer
M.E.J. MacMillan

S E C T I O N   I I I

S A L T   F I S H

Appendix No. 18

BACTERIOLOGY OF SALT FISH

In spite of the fact that for over seventy years scientific papers have been published on the red halophilic bacteria that discolor salted fish, we appear to be little nearer to the control of this defect than they were seventy years ago.

In conjunction with our other work on salt fish we are trying to find some further details about these red organisms.

Temperature Relationships

A. Commercial red contaminated solar salt was heated in the hot air oven to determine the times and temperatures required to render it sterile by hot air. As shown by Figure 1, these organisms are very resistant to dry heat, surviving 7 but not 9 minutes at 102°C, and 15 but not 23 minutes at 92°C, and 40 but not 45 minutes at 82°C. Below this temperature they may be heated hours without any effect. At 52°C they were quite active after 26 hours continuous drying.

On dried contaminated cod fish they were even more resistant to dry heat. On 50 gram portions of dried fish they survived 15, 20, 30, 40 but not 50 minutes at 92°C.

In contrast to this, when contaminated salt was placed in boiling water the red organisms were unable to survive for even one minute.

B. Up to the present time we have considered 37°C as the best incubation temperature for culturing these organisms, and when testing solar salt, etc., for the presence of red bacteria the plates have been incubated at least 4 or 5 weeks before terminating the test. Using pure cultures, contaminated brine, salt and fish as the source of the organisms it has been found that they are much more thermophilic than we had formerly believed. Even from small numbers of cells they grow more rapidly and turn red much faster at 44° to 48°C than at 37°C, and extremely slow at 25°C. By combining these higher incubation temperatures with an improved medium and other changes in our former technique we are able to complete the analysis of salt, etc, for red bacteria in from 2 to 6 days in place of the former 4 or 5 weeks.

TABLE I

The effect of temperature and the size of the initial number of cells in the inoculation on the development of red coloration on the surface of halophilic culture medium in petri dishes using pure culture.

Approximate Number of Cells in inoculum	Days to Develop Red Coloration on surface of medium			
	At 45°C	At 37°C	At 25°C	At 7.2°C
10^{10}	1	2	6	8
10^{9}	2	3	8	>50
10^{8}	3	4	9	50
10^{7}	3	5	12	50
10^{6}	4	5	13	50
10^{5}	4	5	14	50
10^{4}	4	5	14	50
10^{3}	5	6	14	50
10^{2}	5	6	18	50
10	5	6	18	50

C. It has been frequently observed that potentially "red" organisms do not always develop the familiar red pigments. The growth at 25°C is much slower than at 37° or 45°C, and often colorless except after very lengthy periods of incubation. If the organisms are exposed to air, subjected to moderate drying or grown at higher temperatures (37° to 48°C) they form the pigment very rapidly. These and other similar observations are leading us to believe that the <u>development of color</u> and the <u>presence</u> of these organisms on fish are not synonimous; and that a fish may develop a heavy crop of these organisms, which may become pigmented with increased temperature, lengthy holding, drying or some other subsequent change in their environment. This is being followed up and may lead to a modification in our methods of attacking the problem.

D. We are also being continuously confronted with the fact that as well as temperature, the initial size of the inoculation (i.e. the number of bacteria per gram weight of fish) plays a very important part in the growth of the organisms and the development of the red pigment. The following tests illustrate this point. A large number of sterile plates containing the culture medium best adapted for growing halophiles, were inoculated with decreasing dilutions of a heavy suspension of a pure culture of "red" organisms, and sets were incubated at 45°, 37°, 25° and 7.2°C. A similar test was run using a lightly contaminated commercial salt as the source of the bacteria. The results are given in Tables I and II. When the inoculatum consisted of the pure culture and the plates were incubated at 25°, 37° or 45°C even a very small initial number of cells sooner or later developed in typical red surface growth. But when the temperature of incubation was 7.2°, except where the inoculum contained ten billion cells or more there was no evidence of growth or red coloration up to 50 days. With the lightly contaminated salt as the source of bacteria the results were somewhat similar. As a group these organisms grew more slowly. And up to 50 days there was no red coloration and no indication of growth at 7.2°C.

TABLE II

Similar to Table I, except that a commercial salt, lightly contaminated with red bacteria, was used as the source of the organisms.

Approximate Number of Cells in inoculum	Days to develop red coloration on medium			
	At 45°C	At 37°C	At 25°C	At 7.2°C
10^3	5	7	24	50
10^2	7	11	30	50
10	17	30	35	50

This culture medium is a better substrate for these organisms than salted fish, and therefore the periods for the development of red colour would be very much greater under natural conditions in the plant. From this it can be seen that only fish that are grossly contaminated at the beginning of storage are likely to turn red if the temperature is at or near 7.2°C (45°F).

E. To what extent is a plant handling solar salt contaminated with red organisms? Most of our so-called knowledge concerning this question is based on suppositions rather than facts. One plant very kindly offered us complete facilities to get the answers. Several hundred plates of sterile medium were placed throughout the plant to determine the presence and distribution of these organisms in the atmosphere. The walls, floors, beams, pillars, ramps, conveyers, shovels, carts, etc, were examined by means of contact plates. The results are rather startling. 92% of the plates exposed to the air in the salt storage sheds and bagging rooms showed developed red organisms. In the dryers and in the rooms used to store dried salt fish the corresponding figure was just under 40%. As these latter rooms were dusty and the floors in many places had a cover of dried pulverized fish dust, these results were most unexpected. Almost 100% of the contact plates in the sheds, containers, conveyors, etc, showed heavy contamination. Even surfaces which had been recently treated with a formaldehyde spray produced a crop of red halophiles.

This type of work has not been carried out extensively in the past because of the difficulties and the length of time required in culturing the organisms. Now that they can be grown almost as quickly as common non-halophilic bacteria we intend to enlarge our picture of their distribution in all phases of salt fish processing and storage.

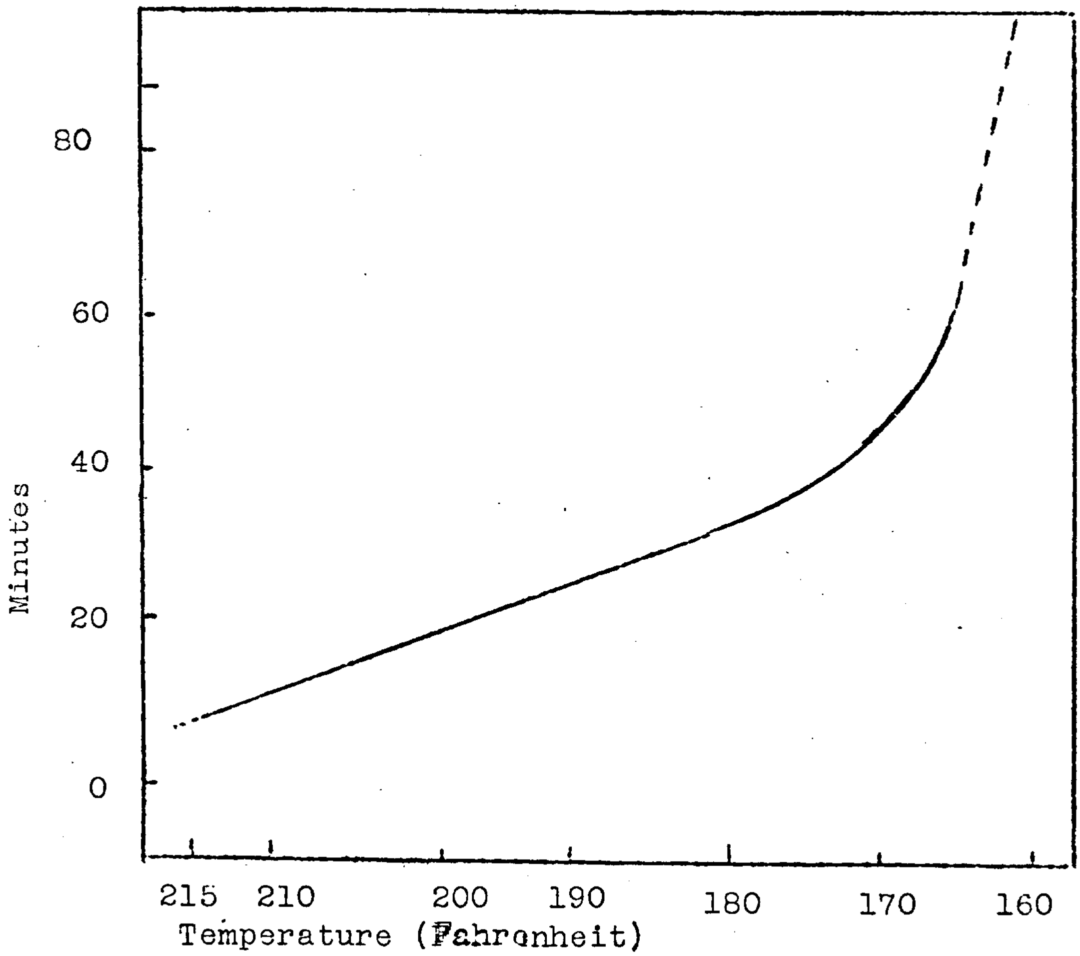


Figure 1

Time required to destroy red halophiles in contaminated commercial solar salt by heat.

F. Subjecting contaminated salt to a series of freezing thawings had relatively little effect on either the activity or the survival of the red halophiles. There is not much to support the practice of freezing "red" contaminated fish, except that the accompanying washing, brushing and handling will temporarily reduce the numbers of organisms on the surface and lighten the colour of the fish. When conditions are later suitable for growth these fish will again develop a red color.

C.H. Castell

Appendix No. 19

MYOSIN DENATURATION IN SALT FISH

The inter-relation between salt uptake and myosin denaturation reported last year (page A57) has been confirmed. Cod fillets were placed in brines of various strengths at 0°C. Percent soluble myosin and salt were determined on samples taken periodically. In all five cases (brines of 5, 10, 15, 20 and 25 percent sodium chloride concentration) denaturation began when the salt content of the fillet had reached approximately 8 percent as shown in the figure. The extent of denaturation depended on the final salt concentration.

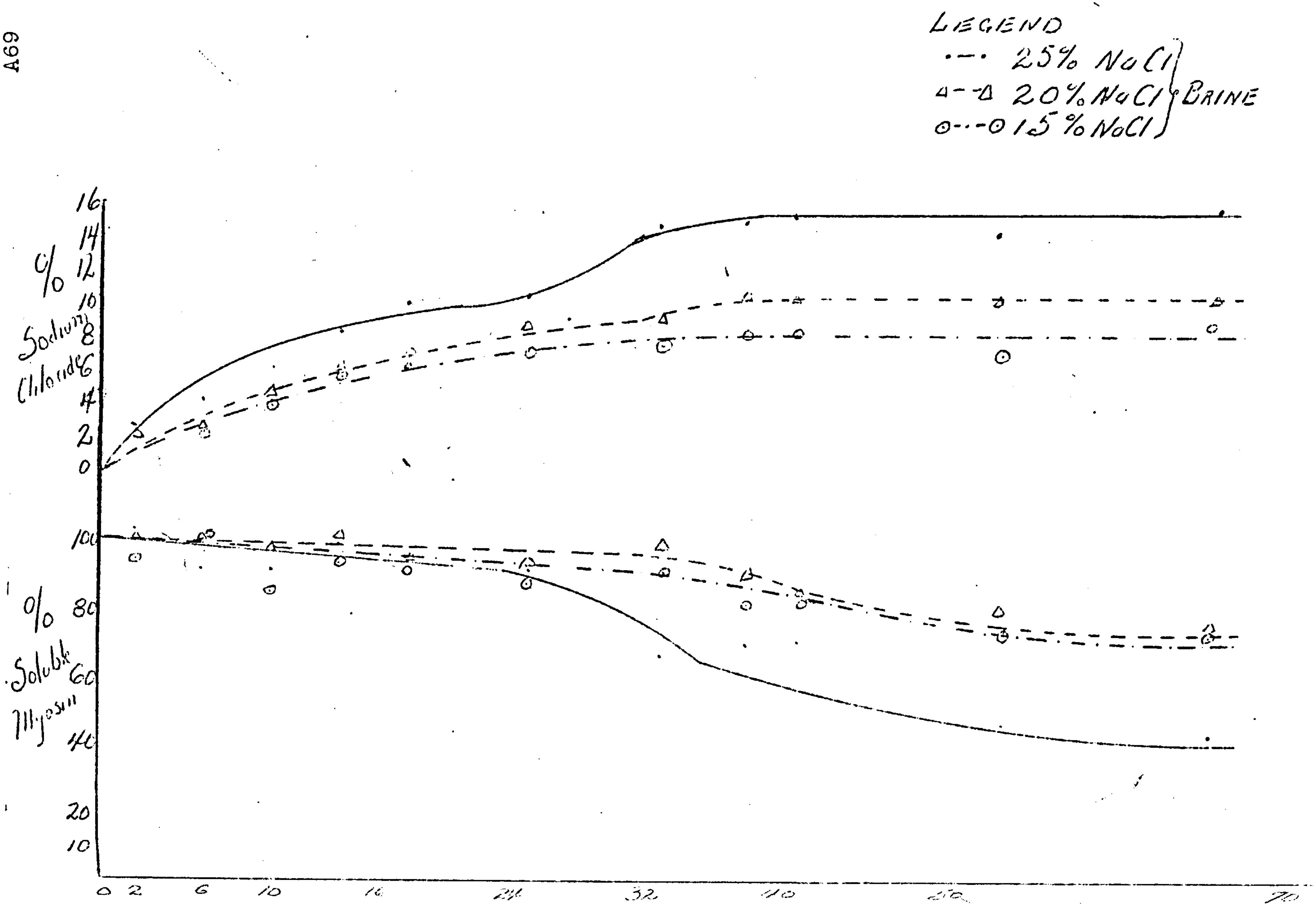
TABLE I

Brining Solution percent NaCl	Time Hours	Soluble Myosin N (as percent of Initial)	Salt Concentration percent
25	65	55.6	15.9
20	65	77.0	10.7
15	65	82.4	9.0

The fillets brined in 5 and 10 percent salt solutions did not reach the critical value of 8-10 percent salt so that very little denaturation occurred.

Attempts were made to duplicate these results using isolated systems. In this case the protein solution was made up to various salt concentrations by the addition of salt. Myosin was determined by dilution precipitation and extracting the precipitated myosin with 5 percent sodium chloride in the cold. Unfortunately it was not found until recently that the peptization of myosin by salt is an equilibrium so that the absolute

A69



LEGEND
25% NaCl
20% NaCl
15% NaCl
BRINE
% Sodium Chloride
% Soluble Myosin
0
2
4
6
8
10
12
14
16
10
20
40
60
80
100
0 2 6 10 24 32 40 70

numerical values of many determinations may be in error.

However, certain differences between the isolated system and myosin in fillets appear. There is no sharp break in the denaturation curve with increasing salt concentration. Rather there is a gradual decrease in soluble myosin which increases with increasing salt concentration.

TABLE II

Soluble myosin after 4 hours exposure to salt concentration.

Percent NaCl	Soluble Myosin (as percent of Initial Soluble protein)
4.6	70.5
5.3	68.0
6.3	64.5
7.2	60.2
8.0	59.5
9.9	57.1
10.7	54.5
11.8	47.5
12.7	47.5

It was found also that exposure to 5 percent salt causes denaturation of part of the myosin although this was not extensive and was possible due to incomplete peptization.

The effect of temperature was determined by carrying out these experiments at various controlled temperatures. Results obtained are in agreement with those already reported by Dyer (1947 and 1948) in fillets. That is both the rate and extent of denaturation are increased by increased temperature at any constant salt concentration. The greatest temperature effect appears to be between 5° and 10°C.

TABLE III

Percent Salt	Soluble Myosin N after 4 hours (as percent initial soluble protein N)			
	0°C	5°C	10°C	15°C
5	70.5	65	22	26
10	52.8	65	26	24

J.D. Duerr

Appendix No. 20

MOISTURE CONTENT EXAMINATION OF SALT COD

Tests were carried out at this station in co-operation with the Inspectors of the Department of Fisheries in an attempt to determine the accuracy with which these inspectors could determine the water content of salt fish, and to find out the relative reduction in weight loss of shipments of fish due to inaccuracy of these estimates.

In our tests fish were taken in lots of approximately twenty, graded individually by each of three inspectors and dried to constant weight.

The results are summarized briefly as follows:-

(1) Between the ranges of 35-42%, the accuracy being on an overall average of 1.65% for the three inspectors on all tests, the estimates are considered favourable.

(2) Over 42%, their estimates being from 4.38%-6.50% in error, and with an individual test error range from 1.8-12.5% per fish, leads us to believe they are unable to give satisfactory estimates in this range.

(3) Under 35% moisture we again find an error of 2.6-3.5%, and with assorted ranges of moisture content being judged at one test the error rises to 5.56%, thus fish under 35% moisture are not being satisfactorily estimated.

This would indicate that care in sorting the fish as to size before drying would eliminate drying the smaller fish to a much lower moisture content than the larger ones; the fish apparently being passed as of a much higher moisture content than they possess.

Further tests to indicate the relative moisture contents of each fish in a shipment might be carried out to advantage.

E.A. Lawson

SECTION IV

SMOKED FISH

Appendix No. 21

BACTERIOLOGY OF SMOKED FISH

During our smoking experiments of the previous year (Appendix No. 30, 1948) it was found that fish smoked in the station's experimental smoker and stored at 0° and 3°C had a keeping quality that was very much superior to corresponding fresh fillets kept under the same conditions. This was shown by organoleptic examinations, trimethylamine values, pH changes and bacterial counts. The smoked fish were in a good condition after 5 or 6 weeks at 0°C, while the unsmoked fillets were spoiled in 9 to 12 days.

These results do not coincide with the experience of the trade (where the older type of "loft" smoker is used). They look upon smoking chiefly as a means of adding flavour and colour to fish, rather than a method of preservation. It may be, and often is, that only the worst of the fresh fillets are smoked, and that this is the explanation of the relatively poor keeping quality of commercially smoked fillets. However, there is also the question of the quantity and effectiveness of the smoke itself. Until the chemists can provide us with a method of measuring the changes that take place on the surface of the fish during smoking, our spoilage curves and bacteriological data is of a very limited value. Furthermore, it has been shown that the pH of the substrate has a marked effect on the activity of enzymes reducing trimethylamine oxide. In the past we have tried to follow the spoilage of smoked fish by means of the trimethylamine values. We believe it quite possible to develop a considerable surface slime on smoked fish and occasionally to have the commencement of putrid odours without necessarily having a sharp rise in the trimethylamine values. More work is required to determine the value of trimethylamine as a measure of spoilage in smoked fish or a new criterion of spoilage must be developed before work along these lines can be accurately followed.

For these reasons, any extensive work on the bacteriology of smoked fish has been temporarily shelved. In spite of this decision curiosity has prompted us to carry out a few additional experiments and the results seem to be worth recording briefly.

A. Cod fillets were removed from fresh round cod as asceptically as possible, brined and then inoculated by brief immersions in suspensions of various pure cultures of bacteria. These were then smoked in the station's tunnel smoker for three hours. By means of plate counts made before and after smoking a rough estimate was formed of the percentage of bacteria that survived.

Organism	% Survival
Green Pseudomonas A	1.4
Green Pseudomonas B	6.0
Green Pseudomonas C	1.7
Ser. marcescens A	0.5
Ser. marcescens B	0.2
Flavobacter sp. A	24.0
Flavobacter sp. B	76.0

Organism	% Survival
Mic. aureus	23.0
Mic. pyogenes	16.0
Mic. roseus	9.0
Mic. cinnebareus	14.0
Mic. citreus	4.0
Mic. aurantiacus	1.0
Mic. varians	31.0
Mic. candicans	80.0+

From this it would seem that smoking is less destructive to the gram positive micrococci and Flavobacter than to those gram negative rods that were tested.

C.H. Castell

Appendix No. 22

NEW TUNNEL SMOKEHOUSE

The "New type" tunnel smokehouse (Annual Reports 1947, 1948) was installed commercially in 1948 and was exhaustively tested during that year and part of 1949. It was found that the smoking period was far longer than had been anticipated.

After much investigation, in which air flow and smoke density closely approximated that obtained in the Linton-Wood tunnel, it was found that the fish required a smoking period of from 4 to 6 hours before the desired color was obtained. Despite changes in velocity, smoke density, brining, draining and in handling methods the smoking rate was never improved significantly.

This smokehouse was finally replaced by two of the Linton-Wood units. It is interesting to note that with these standard tunnels the smoking period was somewhat longer than that of the same type of tunnel in various other localities, which would seem to suggest that the fish, climatic conditions or these and a combination of some unknown factors may be the cause of the lengthening of smoking time.

However, until the complete chemical and physical process of smoking is determined, little can be done, from an engineering point of view, to shorten, improve or modify the present smoking process in the fishing industry.

M.A. Foley
A.L. Wood

S E C T I O N   V

M A R I N E   O I L S

Appendix No. 23

THE PRODUCTION OF COD LIVER OIL

Final steps have been taken in order to industrialize the new rendering process developed at the station for fish livers (see Annual Report 1948). Considerable delay was encountered in selecting the proper type of centrifuge that is to be used in the process. It will be recalled that the process consists in treating comminuted livers, without addition of water and at low temperatures ($<70^{\circ}C$) with a small amount of alkali in order to bring the pH near 8. Centrifuging of the resulting product affects the separation of the oil from the protein residue. A basket type centrifuge would affect this separation but more advantage would result from a continuous operation. Finally a suitable type of continuous centrifuge was found and it is planned to have the installation in working condition by the middle of the winter.

The advantages of the new process over other methods have been thoroughly weighed. One of the greatest is the total recovery of the protein part of the livers substantially undenatured.

The study of this protein residue has formed the subject of an investigation undertaken a year ago. A more complete account will be found further in this report (see liver residue) but it is of interest to underline under this heading the importance of liver protein residue recovery for the vitamin oil industry.

Recovery of these valuable residues will bring in revenue to the cod liver oil industry in the Maritime Provinces and Newfoundland at a moment when general adverse circumstances have rendered the position of the cod liver oil producers rather difficult. Full details of the process itself will appear in the next Progress Report.

F.A. Vandenheuvel

Appendix No. 24

MARINE OILS IN GENERAL

Hydrogenation - Work has progressed on the basic study of hydrogenation. The programme of this study was outlined in the 1948 Annual Report. Part of the results so far obtained have been communicated at the Chemical Institute of Canada meeting in Halifax this spring when it formed the subject of two conferences.

A new method of investigation of the hydrogenation mechanism was described along with the results obtained with simple organic compounds. It was shown that the method was very accurate and was yielding promising results. Since then the study has been extended to single unsaturated fatty esters, again successfully and it is felt that very useful information will be obtained as the study develops itself, as regards practical hydrogenation of oil in general, and particularly fish oils.

As outlined in the former Annual Report, the aim of this work is to secure optimum conditions of hydrogenation in order to obtain maximum selectivity in the hardening of marine oils. It is planned, however, to undertake hydrogenation work on a larger scale and on practical oils in order to apply the information obtained in the course of this basic work.

F.A. Vandenheuvel
J.D. Nickerson
W. Singh

Appendix No. 24 A

ANALYSIS

This summer a complete review of the methods of analysis related to marine oils was undertaken.

One of the interests in the study was to show the relative merits and limitations of the methods. It showed also that, in specific cases, the general standard methods of analysis for oils and fats can be modified with advantage when they apply to marine oils.

At the same time Messrs. Hayes and Cann were as a result of this investigation well equipped to undertake their thesis work with analytical tools of ascertained value.

The raw materials used were several different grades of marine oils of various origin (seal, cod liver, halibut liver, whale, herring) at various degrees of freshness. We also used for comparative purposes oils and fats of vegetable or animal origin (olive oil, corn oil, linseed oil, lard, shortening, margarine, butter) and pure compounds (such as pure fatty acids, esters)

The methods of analysis studied were for the most part those of the American Oil Chemists' Association which were then compared with recently published methods.

Acid number, Saponification number, Iodine number, Peroxide number, Acetyl number, Unsaponifiable matter, titer, and diene value were the principal analyses studied.

We also determined the physical constants, such as density, viscosity, refractive index and colour.

F.A. Vandenheuvel
B. Cann
E. Hayes
P.M. Jangaard

Appendix No. 25

SYNTHESIS OF FATTY ACIDS

In the Annual Report of 1948 the necessity of securing pure specimens of fatty acids for comparison purposes in future work was underlined. This led to the application of the Arndt-Eistert reaction, and it was found that it constituted a valuable method of synthesis for the purpose. The first findings were communicated to the Canadian Journal of Research under the title "The application of the Arndt-Eistert reaction to the synthesis of fatty acids of high molecular weight".

Further results have been submitted to the Canadian Journal of Research. These papers have not as yet been issued.

Furthermore, the same method has now been extended to unsaturated acids of high molecular weight with equal success

F.A. Vandenheuvel
P. Yates

Appendix No.26

POLYMERISATION OF OILS

The study of the polymerisation of marine oils has just started. Herring oil will constitute the material for this research which will be later extended to seal and whale oils.

Primarily interested in one phase of this work is the canning industry. The Norwegians have been using mildly polymerised herring oil (sild olje) for some time with success and a good deal of work has been achieved by the Norwegian Fisheries Research concerning the properties of this oil. The literature concerning this work shows, however, that further study is desirable in the field, especially in the processing methods which are not described.

Another phase of this research "Solvent segregation of polymerised marine oils" will interest the paint industry.

F.A. Vandenheuvel
E. Hayes

Appendix No.27

FISH LIVER RESIDUE

The programme outlined in the 1948 Annual Report has been fulfilled by the analysis of the protein residue of fish livers submitted to the new recovering process and the study of the various possibilities of this material for industrial purposes.

As it is separated from the oil the protein residue is a paste, 66% of which is water. The rest is mainly protein.

But it is as rich as beef liver in vitamins of the B complex including B_{12} the anti-pernicious anaemia factor.

For example, one of the principal vitamins, riboflavin (B_2) is present at an average of 15 micrograms per gram of material which is the average potency for beef liver.

As for B_{12}, the average is around 450 micrograms per pound.

When the livers are originally fresh the resulting paste can be canned yielding a palatable as well as highly vitaminized product analogous to mammal liver paste. Hydrolysed, it yields a product very similar to beef extract.

The paste can also be extracted (water) and the resulting solution evaporated (spray dried) to a potent liver extract rich in all the vitamins of the B complex including B_{12}.

In any case the paste can be dried (drum dried) yielding a meal perfectly suitable for feed supplement.

It is probably under this last form that most of the residue will be used although it is no doubt the least profitable form. Nevertheless, it would, as such, bring a 25% increase in revenue from cod livers. There is no doubt on the other hand as to the salability of such a product which would be entirely welcome by the milling industry for the purpose of feed manufacture, as a recent enquiry has shown. The high vitamin content of the meal and particularly that of B_{12}, probably closely related to the "Animal protein factor" makes it of unusual value.

Meanwhile, the study of the protein residue has still several interesting points to cover and these will be the object of next year's research. They are principally:

(a) Quantitative determination of the essential amino acids.

(b) Methods of processing the crude fish liver extracts in order to obtain clinical concentrate at B_{12}.

(c) Feed test using the meal as material.

F.A. Vandenheuvel
A. Guttmann

S E C T I O N VI

M I S C E L L A N E O U S

Appendix No. 28

TECHNICAL SERVICES TO THE INDUSTRY

During this last year, it was earnestly anticipated that more time and assistance would have been available for the extension of this station's contacts with the fishing industry. However, once again it has been barely possible to keep pace with the requests received for essential industrial assistance.

Such activity does not lend itself readily to publication. Many problems, which are undoubtedly serious handicaps to efficient operation are solved by such ridiculously simple procedures that reporting them would seem to be supercilious. Therefore, a certain portion of the work done by this station's engineers has, of necessity, been done cursorily -seldom is it recorded and often not even remembered.

Rather than submit a long report filled with masses of apparently trivial and unrelated details, it is deemed preferable to select some few contributions made to the industry to serve as examples. As for the value of the general routine work, we prefer to refer the reader to the industry for its evaluation.

Salt Fish

A.F.E.S. Salt Fish Dryers have continued to multiply in spite of our hopes and predictions. During 1949, 23 new units were installed, raising the number of units in the Maritimes and Quebec from 64 to 87, an increase of about 35%.

Eight new salt fish plants have been built from layouts made by this station and put into operation under supervision of our engineers.

Two hybrids have resulted from this abnormal growth, One is an A.F.E.S. Tunnel Type smokehouse with a standard salt fish dryer located on the floor above, both units using the same hot air supply equipment. Conversion from smokehouse to dryer operation is accomplished by throwing a switch and shifting a damper.

The second combination is a dryer designed for both salt fish and Irish moss. Some time ago, basic data on the drying of Irish moss were determined by this station's scientists, but the initial cost of a dryer for moss alone seemed too high to tempt the industry to experiment. Finally, one company, which wished to process both products, utilizing our design for a salt fish dryer as a basis, risked its ability to dry the moss, with such assurance as we could offer. The result has been satisfactory. This is not a standard A.F.E.S. salt fish dryer, but is a completely new design. It may also be suitable for the production of lightly salted fish.

Another new salt fish dryer has entered the field. A commercial consulting engineering company has designed this dryer, in collaboration with this station's engineers, for one of the larger companies. Drying salt fish during the warm summer months is most difficult in any dryer not equipped to dehumidify the inlet air. Unfortunately, the known mechanical or chemical methods of accomplishing this are too expensive to justify their use economically. For some time, it has been felt that increasing the drying potential during summer months may extend the range of dryer operation. If successful, this dryer may produce dried fish during all but those days where dewpoints exceed 65°F. In any case, the design should prove satisfactory for lightly salted fish. Its cost is expected to exceed that of the standard A.F.E.S. unit, but should be less than a unit equipped for dehumidification.

Considerable interest is being shown by the smaller producers in the construction of cooled storage rooms for salt fish. At least six shore fish processers have requested drawings and specifications. If these initial installations prove to be economically sound, more inquiries may be expected. Such holding rooms are in general use by the large producers where schooners fish is kenched. The shore fisherman normally pickles his fish, largely because he may wish to make "boneless" and he has no cool storage available.

Fish Meal

Two new fish meal plants have appeared. One was designed by a local engineering company and installed with this station's engineers acting in a consultant capacity.

The second plant is of somewhat unusual design, and the engineering staff of this station was consulted only after the plant was actually in operation. Unfortunately, major changes, which appeared to be desirable were restricted by the primary design, but it was finally found possible to greatly increase the daily production with a relatively small additional investment.

The production of fish meal is very alluring to the engineer, especially the possibilities it could offer to the small fish producer. Thousands of dollars are spent annually to dispose of fish offall, when it is not inconceivable that it could be turned into a source of revenue. At least, the cost of dumping it may be saved.

Smoked Fish

Only four new A.F.E.S. Smokehouses have been installed this year. Two of these replaced the larger experimental unit in North Sydney. This larger unit, which was reported last year, did not match the standard model in quality of the product processed and has been abandoned. The other two units were installed by a local company in a new venture, based on the performance of their own duplex installation at Halifax.

Considerable more basic data on smoking fish must be obtained before any new design is presented to the industry. Standard A.F.E.S. smokehouses continue in successful operation, on cod fillets, finnan haddie and kippers.

Frozen Bait

The scarcity of frozen bait during 1948 has awakened a great interest in bait freezers and storages. Requests for layouts and estimates have ranged from large community projects to supply Prince Edward Island and Grand Manan, to smaller individual enterprises for a limited number of fishermen.

Although it is difficult to demonstrate the economic possibilities in such undertakings, several layouts have been prepared, many requests have been investigated and some general surveys made to determine frozen bait requirements and installation costs. Only two plants (Prince Edward Island and Cheticamp) have actually been built.

The freezing of bait is a relatively high investment for a single fisherman or small community. Transportation and holding frozen bait, when obtained from a central freezer has been a problem. This station has designed a possible solution in an insulated box, which may be carried by truck to the central freezer, loaded there, and returned to the fishing site. It may be kept cold by an ice-salt mixture or, where electricity is available, by a small compressor, thus holding the frozen bait until used. Drawings are available but it is unlikely that this unit will be adopted by the fishermen until one is actually built and demonstrated in practical use.

Newfoundland

At the entry of Newfoundland into the Dominion of Canada, this station's engineer, in company with Dr. H. Fougere of the Gaspe Experimental Station, visited Canada's tenth privince. The purpose of this trip was to familiarize ourselves with the fishing industry there.

Five large salt fish plants were visited including both indoor and outdoor drying procedures. Representative small shore fishermen were interviewed. Practically all varieties of Newfoundland salt fish were examined, special attention being paid to the lighter cures.

Five of the largest frozen fish plants were included in this tour. These plants are highly mechanized, compared with the Maritime fresh fish plant with which we are familiar. Apparently no expense has been spared on equipment in this branch of the industry, and production efficiency should be high.

Typical bait freezers and storages, cod liver oil, seal oil, fish solubles, white and oily fish meal plants were examined.

Technically and in general the Newfoundland Fishery impressed this writer as including both the oldest and most modern production methods. This is particularly evident in the salt fish industry.

The producers, who are actually the people, are most courteous, friendly and industrious. The shore fishermen and small salt fish producers have learned their methods by experience and have learned well. These men know their business thoroughly.

The frozen fish industry furnishes the examples of the most modern in processing. Practically every known variety of equipment may be seen in one plant or the other. However, this writer was conscious of a certain wanting of sound, fundamental engineering practice. Without citing concrete examples the picture would appear similar to that of a large, modernly equipped hospital, operating without the presence of either a qualified physician or surgeon. Every one is exercised in producing a first class product. Packages are attractive and the time between the landing and freezing of the fish is remarkably short. The freezers in use are all far superior to any but the best in the other Maritime provinces. The resulting product must be excellent, although it is suspected that production costs may be relatively high.

Miscellaneous

With over 80 dryers in operation, some of which are four years old, breakdown of equipment is to be expected. We are continually called upon to service these plants, as well as various other production equipment. Inquiries for information on various processes, new machinery, materials of construction, etc., are encountered continually and it is difficult to keep well enough informed in this field to submit intelligent replies.

Practical consultant engineering companies are becoming more interested in assisting the industry and some few of the larger producers are availing themselves of such assistance, particularly in regard to new installations. Of course, the multitide of small producers cannot afford the present cost of these services and in almost every case where the practicing engineer is engaged he consults this station, usually at the producers' request. This means that this station almost invariably finds itself actively engaged in most industrial operation and design, although are often spared the preparation of final drawings and specifications for some of the larger enterprises.

Every request has received serious attention, even to the design of an original brand label for one company's packages.

A.L. Wood
W.C. Angevine

Appendix No. 29

HERRING REDUCTION PLANTS

The possibility of establishing one or more herring reduction plants for the utilization of the surplus fish on the North Shore of New Brunswick was investigated.

It was determined that the erection of two profitable plants might be possible, one in Gloucester County and the other somewhere between Westmoreland and Kent Counties due to the large quantities of waste herring in these localities, approximately 3500 tons of fish and offal in each. As the herring season lasts only from 25 to 30 days it means that each plant must have a daily output of about 20 tons of finished meal. The initial outlay and operating expenses are high for such a plant as it would remain idle for 11 months of the year unless sufficient white fish offal can be obtained to extend the period of operation. In addition to the value of the oil and meal produced a further income might be derived from the drying of the stickwater.

One small plant of doubtful vintage and efficiency is now operating in the area but is of little value in view of the large quantity of waste. It might be possible, with certain modifications, to use this as a pilot plant to determine the economic possibility of a larger layout, the management being very co-operative and interested in the problem.

A.L. Wood
M.A. Foley
W.C. Angevine

Appendix No. 30

LOBSTER MEAL

In addition to the ordinary fish scrap, lobster bodies, a by-product of both canneries and chilled meat production, are available for the production of meal. We were requested to prepare a quantity of lobster body meal to be utilized by Officials of the Dominion Department of Agriculture in feeding tests. While this was being done the drying characteristics were determined. The scrap was dried in the laboratory pilot plant dryer. It was found to be practically a free drying material, drying much more readily than ordinary fish scrap.

H.E. Power

Appendix No. 31

DORY EMERGENCY TRANSMITTER

During 1948 Mr. D.G. Ellis produced an emergency transmitter for dory fishermen for the purpose of sending a signal that could be picked up by the direction finder of the schooner. This was built from surplus war equipment and it demonstrated that such equipment has a real use in the industry, not only making fishing safer, but enabling fishermen to work in foggy weather and so increasing the catch. The original transmitter was operated by a hand cranked magneto.

During the present year Mr. Whitely working under the direction of Professor G.H. Burchell of the Nova Scotia Technical College developed a battery-operated dory transmitter that is now undergoing tests at sea.

If this equipment is shown to fill a real need, the plans will be turned over to several producers of radio equipment in order that an adequate supply at reasonable cost may be assured.

This transmitter was designed for emergency use in dories when separated from the schooner in fog, snow storms, etc. It consists of a single tube oscillator and amplifier which feeds into a twelve-foot antenna. It is intended that the antenna should be supported by the mast of the dory. The antenna radiates slightly less than 0.1 watts power on a frequency of 2134 kilocycles. The direction-finding equipment in the schooners cover this frequency and the power radiated should be sufficient to ensure reliable bearings up to two miles or greater. The transmitter emits a steady unmodulated note when the button is pushed and it will be necessary for the direction-finder operator to switch on the beat-frequency oscillator on his receiver in order to hear the signal. The bearing is taken in the normal way.

It is planned to develop a modification of this equipment with a somewhat longer range to act as a mark buoy for trawlers, scallop fishermen and others that may need to locate readily and accurately specific areas at sea.

We wish to express our appreciation of the assistance of Professor Burchell in this work. Without him the work would have gone much slower and a useful apparatus might not have been developed.

S.A. Beatty

SECTION VII

LIST OF PUBLICATIONS

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