ANNUAL REPORT

ON THE WORK
OF THE

Biological Board of Canada

FOR THE YEAR

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OPERATING UNDER THE CONTROL OF
THE HON. THE MINISTER OF FISHERIES

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THE BIOLOGICAL BOARD OF CANADA

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SUMMARY REPORT ON THE WORK OF

THE BIOLOGICAL BOARD OF CANADA

FOR 1932

By the Chairman, Professor J. Playfair McMurrich

The year 1932 was the twentieth anniversary of the establishment of the Biological Board of Canada. During the score of years of its existence there has been a constantly increasing expansion of the Board's activities and a constantly increasing importance of the results obtained in or in connection with its laboratories, nor does this statement need modification in its application to 1932, notwithstanding the unfavourable conditions under which it carried on.

The constitution of the Board, as outlined in the Report of 1931, has remained unchanged. During the year the four Stations operated by the Board, the Biological Station at St. Andrews, with the accessory station at Ellerslie, P.E.I., the Biological Station at Nanaimo, B.C., with its accessory station at Cultus Lake, B.C., and the Fisheries Experimental Stations at Halifax, N.S., and Prince Rupert, B.C., have shown their usual activity, indeed have surpassed it in the multiplicity of the problems investigated and the importance of the results obtained.

The Board congratulates itself on the reappointment of Mr. D. B. Finn to the directorship of the Prince Rupert Station, he bringing with him a renewed enthusiasm and valuable experience.

There is to be recorded in this report the first serious untoward event in the history of the Stations, namely, the destruction by fire of the laboratory building at St. Andrews on March 9, the result of an explosion of furnace gas. Fortunately the fire did not extend to the other buildings of the Station, but the loss was a severe one, involving the valuable library, important records and the plankton and other collections of many years. Prompt and efficient action by the director and his staff made possible the partial reconstruction of the building in fire proof materials in time for the summer work of the Station to be carried on. Much, however, yet remains to be done in providing necessary equipment and in reestablishing the library. It is a pleasant duty to record the generous offers from several quarters of gifts of books and pamphlets as a nucleus for the restoration of the library.

During the year the work of the International Passamaquoddy Fisheries Commission was continued with the St. Andrews Station as the summer base, its headquarters later being transferred to the Oceanographic Institution at Woods Hole, Mass.

Summaries of the results obtained by the workers at the various Stations will be found appended to the reports of the Directors. Among so many items of interest it is invidious to select a few for special mention and yet the very number and variety of the investigations make some selections advisable.

In connection with the St. Andrews Station attention may be drawn to the continued investigation of the complex problem of the natural history of the Atlantic salmon. A survey of the herring fishery of the bay of Fundy gave evidence of a close relationship of the "catch" to physical conditions, especially temperature and salinity. Experiments on the "fertilization" of fresh water lakes and ponds have been continued, partly in the experimental tanks at the Station and partly, on a larger scale, in the Chamcook lakes. The value of the results obtained from the survey of the bay of Fundy fisheries, brought to a conclusion last year, suggested that a similar survey should be made of the fisheries of the southern coast of Nova Scotia and work was begun in the Halifax area, the

Eastern Passage laboratory affording a convenient base from which the investigation might be carried on. Data on the occurrence and distribution in the area of certain food fish were obtained and hydrographic observations revealed an interesting layering of the waters both inshore and offshore, which requires further study.

At Richmond bay, P.E.I., the study of oyster culture has been vigorously prosecuted. The effects of temperature and salinity on the spat and on the germ cells have been determined, a method has been discovered for rendering objectionable muddy bottoms suitable for oyster culture and evidence has been obtained of the occurrence of sex-reversal in both directions in the native oyster. A survey of Shediac bay as to its suitability for oyster culture was made.

In British Columbia the failure of the Provincial Government to continue its co-operation in the study of the pilchard and its fishery handicapped somewhat that investigation, but nevertheless not a little was accomplished toward working out the natural history of the fish. At Cultus lake continuation of the experiment as to the relative efficiency of natural and artificial spawning of the sockeye salmon was interrupted, the run of fish being so great that the hatchery could not accommodate the available eggs. However, a further attempt was made to restock depleted waters by transplanting eggs to suitable streams farther up the Fraser valley. Another transplantation experiment was inaugurated by transferring approximately a million eggs of pinks from the Tlell river to McAlpin creek. Especial interest centers in this experiment, since the runs of pinks occur in alternate years and the runs to the Tlell river alternate with those of the Masset area. If successful, the experiment will indicate a possibility of producing runs of pinks every year.

The study of the West Coast fiords, begun last year, has been continued, Jervis and Tuba inlets having been examined with results of great significance from the geological and oceanographic standpoints, as well as from the biological. Much attention has been given to the problems of oyster culture on the Pacific coast, where the eastern and the Japanese oysters have been introduced. A study of the spatting and growth of these forms and of the native oyster indicate a greater hardiness of the Japanese form and the advisability of its more extensive culture.

At the Atlantic Fisheries Experimental Station at Halifax, further attention has been given to the problems of refrigeration and smoke curing. A study of the chemical changes produced by the various methods of freezing has been begun and the composition of the smoke used in smoking fish has been investigated. Improvements have been made in the smoke producing apparatus. The apparatus for smoking with conditioned air installed last year at Lunenburg has been in satisfactory operation during the year, with some modifications that experience has shown to be advisable. Attention has also been given to the conditions under which transportation of frozen fish products and of lobsters is carried on.

An outstanding investigation at the Pacific Fisheries Experimental Station, Prince Rupert, B.C., has been that on the composition and utilization of fish oils. It has been found that by mixing certain fish oils, an oil may be produced that equals, indeed surpasses, cod liver oil in its vitamin content. Such a mixture has been standardized under the name *marinol,* and is now being used by the Public Health Board of British Columbia. An examination of the body oils of the west coast salmon has shown that they differ sufficiently in their saturation in the different species to make possible the identification of the species from which they come and, furthermore, since the formation of free fatty acids proceeds at a definite rate after death of the fish, it is possible to determine from the oils the approximate elapsed time since the fish was caught. Further results from the studies on fish oils and summaries of investigations on refrigeration and fish spoilage will be found in the Director's report and its appendices.

The educational activities of the staffs of the laboratories have been even greater than in past years. The fifth course for Fishermen was given at the

Halifax Station January 27 to March 8, twenty-eight being in attendance. The thanks of the Board are due for assistance to Mr. G. R. Earl and Mr. R. Gray of the Department of Fisheries in the courses in Fish Processing, to Dr. M. Cumming and Professor W. V. Longley of the Department of Agriculture of Nova Scotia in lectures on Natural Resources, to Professor A. S. Walker in lectures on Natural Resources, to Mr. R. H. Davison in a course on Motor Engines and to Captain H. M. O'Hara in a course on Navigation.

From March 10 to March 16 a "refresher" course was given at the Halifax Station for the fishery supervisors and inspectors of the Maritime Provinces and members of the Halifax Station have as usual co-operated in the Fishery course offered by Dalhousie University.

On the Pacific coast the staffs of the Stations conducted a course for the fishery inspectors of British Columbia at the Nanaimo Station from February 15 to February 27, twenty-seven inspectors being in attendance. In the summer, July 4 to July 16, a course was given by members of the staff of the Nanaimo Station to seventeen hatchery assistants of British Columbia hatcheries. The course was given at Sorrento on Shuswap lake.

ATLANTIC BIOLOGICAL STATION

ST. ANDREWS, N.B., 1932

The work of the Station is carried on at St. Andrews, N.B., at the Prince Edward Island Marine Station on the Bideford river, Ellerslie, P.E.I., and at such points along the Canadian Atlantic coast as particular investigations in hand may at any time make necessary.

The particular field of work for which the Station is responsible is that including investigations related to fish culture, fish conservation, and fish exploitation, and certain associated educational matters.

The staff of the Station during 1932 included the following:

Dr. A. G. Huntsman, Director.
Dr. R. H. M'Gonigle, Assistant Director and Assistant Pathologist.
Mr. H. B. Hachey, Assistant Hydrographer.
Dr. A. W. H. Needler, Assistant Zoologist.
Mr. A. A. Blair, Scientific Assistant.
Mr. R. A. McKenzie, Scientific Assistant.
Mr. M. W. Smith, Scientific Assistant.
Mr. W. Templeman, Scientific Assistant.
Dr. V. D. Vladykov, Scientific Assistant.
Mr. H. C. White, Scientific Assistant.
Mr. E. G. Rigby, Curator.

SEASONAL

Mr. J. M. Morton, Scientific Assistant.

For part of the year Dr. R. H. Bedford of the Fisheries Experimental Station (Pacific) was a member of the staff of the Station.

The volunteer investigators during the year and their university associations were as follows:

Miss A. Alley (McGill), Prof. B. P. Babkin (McGill), Miss M. C. Baker (Queens), Dr. H. I. Battle (Western Ontario), Dr. D. J. Bowie (McGill), Prof. A. F. Chaisson (St. Francis Xavier), Miss A. E. Clark ((McGill), Miss V. M. Davidson (Toronto), Mr. J. Wallwin Fisher (Toronto), Mr. M. H. Friedman (Western Ontario), Mr. C. E. Kearney (Dalhousie), Miss M. A. Langstroth (Dalhousie), Mr. N. A. McNairn (McMaster), Dr. A. B. Needler, Mr. C. L. Newsombe (Toronto), Mr. J. V. V. Nicholls (McGill), Mr. R. V. V. Nicholls (McGill), Mr. E. S. Pentland (Queens), Dr. W. R. Sawyer (Harvard), Mr. J. A. Stevenson (Queens), Miss H. Tait (McGill).

INVESTIGATIONS

SPECIAL FISHERIES

1. Salmon. The work of Mr. Blair for the year on the life history of the salmon in certain important rivers has been largely confined to the salmon of the St. John river system, principally as caught at sea, 1,158 fish having been examined. Material was also obtained from the Miramichi from 300 salmon so as to follow conditions for comparison with previous years there and with the St. John conditions. Annapolis river fish taken by the Fish Cultural branch in 1931 for spawning purposes have been studied by Miss I. McCracken of the University of Western Ontario, and also material has been available from the Petitcodiac river, obtained by Inspector B. Barnes in 1931. A limited amount of salmon material has been collected by Mr. Forrest Watson of Halls Harbour for a study of the interesting salmon condition that has been found to exist along the Fundy shore of Kings county, N.S.

As the result of requests for permission to fish a run of salmon to the St. John river, which occurs after the spawning is over, an Order-in-Council was passed permitting fishing in St. John harbour during November and December in order to determine the nature and extent of this post spawning run. Mr. McKenzie has had charge of the collection of data and material provided by this special fishery.

Restigouche salmon fry, provided by the Fish Cultural branch, were planted by Mr. White in the east branch of the Apple river, at the head of the bay of Fundy, to follow their behaviour and success in such very different conditions from those to which they are native, as well as to determine whether a stock of salmon can be built up in that branch, which has been without such fish. Mr. White continued his observations of the behaviour of the salmon in the Apple river and neighbouring streams, following the parr and smolt as well as the adult spawning fish. He has attempted to correlate the character of the parr with the physical conditions (temperature and hydrogen-ion concentration) in the streams.

Dr. David L. Belding of Boston University began in 1931 under the Restigouche Riparian Association, an investigation of the natural history of the salmon parr in the Restigouche river. In 1932 he continued this under the Biological Board, extending it to include other rivers emptying into Chaleur bay. Approximately 2,300 parr were collected from the Restigouche, Kedgwick, Upsalquitch, Matapedia, York, Dartmouth, St. John (Gaspé), Bonaventure, and Grand Cascapedia rivers, the collections being made in October at the end of the season's growth, and the fish seined at night, the only time when accurate sampling is possible. This material is being studied together with hatchery specimens of salmon fry and fingerlings provided by the Department of Fisheries of Canada, and by the Quebec Maritime Fisheries Branch.

An attempt has been made to follow the results of runs of salmon into the Digdeguash and Magaguadavic rivers of Charlotte county, N.B., which have had such in the fall of 1932 for the first time in years. The effect on the salmon of three dams on the Liverpool river, N.S., is being followed by the Department of Fisheries, and Inspector J. P. Buchanan has provided material for a study of the unusual conditions that have resulted. The operations of the Fish Cultural branch on the land locked salmon of the Chamcook lakes has given an opportunity to study the stock there as to character and movements.

2. Herring. Mr. McNairn has begun a study of the varieties of herring occurring in the bay of Fundy, particularly of the spring spawning fish on the Nova Scotian side, which show some agreement in character with the spring spawners in the gulf of St. Lawrence. The director has continued the collection of information from fishermen as to the herring fishery of the bay, and has analysed the monthly and annual statistics collected by the fishery officers, as well

as the daily records of weir catches made available by individual fishermen, in an attempt to elucidate the factors governing catches of herring.

3. Hake. Dr. Battle has extended her study of the hake of the Fundy area to include the whole coast and has made special collections of material both at St. Andrews and at Halifax, as well as enlisting the help of various inspectors in providing data and material from outlying points. There has thus been possible a study not only of the fishery as shown by the official statistics, but also of the food, growth and spawning of this fish.

4. Lobster. Field investigations were carried out by Mr. Templeman in Northumberland strait, which has a late summer or fall fishery, in the western part of the bay of Fundy, and on the eastern coast of Nova Scotia between Canso and Liscomb. Special experimental fishing was done during the close season at Pt. du Chene from July 1 to 20, and at Grand Manan from August 1 to 17. Particular attention was paid to (1) spawning, (2) hatching, (3) moulting, (4) size at maturity, and (5) weight in relation to proportions of the body, and the relation of moulting to the fall fishery in Northumberland strait has been considered. Examinations were made of about 5,000 lobsters from Northumberland strait, 4,780 from the waters between Canso and Jeddore, and 1,950 from the bay of Fundy from St. John to Grand Manan. For a study of migrations 71 lobsters were tagged at Pt. du Chene and 65 at Grand Manan.

5. Oyster. Investigations of this form are carried out at and from the Prince Edward Island Marine Station under Dr. A. W. H. Needler. The principal part of the work is the determination of the factors that affect successful reproduction and growth in local waters. The conditions under which (1) the oyster spawns, (2) the larvae develop, (3) the spat settles, and (4) the adults survive and grow satisfactorily, all require to be determined for successful culture. The leasing by the Department of Fisheries for private culture of considerable areas of Malpeque bay and its tributary waters renders rapid progress along these lines particularly important. It is being found possible to devise improvements in current procedure for (a) the collection of the spat, (b) the handling of the young during the first winter, (c) the separation of the young (d) the preparation of bottom suitable for beds, and (e) the subsequent care of these beds (e.g. protection from starfish). The proper procedure for transplantation from successful spatting areas to successful growing areas is also being worked out.

Dr. A. B. Needler has followed further the course of the reversal in sex that the oyster undergoes, as well as the conditions that control it. Miss Clark investigated the effects of various temperatures and salinities on the sperms and larvae, with a view to determining the importance of local variations in these. A demand having been made for work towards the rehabilitation of oyster beds in Shediac bay, N.B., the services of Mr. Fisher were secured to assist in obtaining knowledge concerning such conditions there as might be of importance in initiating successful oyster culture. Dr. A. W. H. Needler has also been in charge of the oyster work carried on by the Department of Fisheries, which has involved his making examinations with a view to suitability for oyster culture of a considerable number of areas in Malpeque bay and also in other parts of Prince Edward Island, applications for the lease of these areas having been made. There have also been rather large scale operations to superintend in the collection of spat, transplantation of oysters, and improvement of beds.

6. Scallop. Mr. Stevenson began a study of growth in the scallop, which might serve as a basis for proper regulation of the fishery. Material for this has been obtained, largely through fishery officials, from L'Etang, Grand Manan, Digby, Mahone bay, Gaspé and Mutton bay. The Quebec Maritime Fisheries Branch has very kindly assisted in providing material from the last two places named, which are on the Quebec coast. This should serve to reveal some of the principal variations in growth that are dependent upon the rather

different conditions to which the scallop is subjected in different parts of our waters.

7. Clam. Mr. Newcombe has continued his work on the growth of this important shellfish, and on the comparative abundance of individuals born in different years. A particular attempt is being made to compare conditions in such different waters as the Passamaquoddy region of southern New Brunswick and Malpeque bay, P.E.I., the former being quite unsuitable, and the latter quite suitable, for oysters. Attention has also been given to the productivity of representative beds, or those of special interest, for example, those on the Sissiboo flats in St. Mary bay, that have been very intensively dug over.

8. Fisheries of the Halifax area. A general investigation of the fisheries of the Atlantic coast of Nova Scotia was begun, taking as the first part for study the Halifax area, considered as extending roughly from Ship harbour in the east to Lunenburg in the west, and offshore to include those of the outer banks most accessible from Halifax. Facilities made available there by the Fisheries Experimental Station, as well as its central position on the coast made this place particularly suitable as a base for the survey. The Eastern Passage Laboratory afforded very suitable quarters for shore work, including a study of the behaviour of cod and haddock in tanks, and the motor boat "Clione" assisted in inshore work. The regular periodical plankton and hydrographic work that has been carried on in the harbour and in Bedford basin for a number of years by the Experimental Station has furnished a start in an understanding of the seasonal and annual changes in the local conditions.

Work for the season was begun in the latter part of June and continued to the middle of October. The M.S. "Zoarces" carried through the greater part of the work at sea, and until near the end of the season the weather permitted the regular collection of material and making of observations, that is so necessary if there is to be an understanding of the conditions in the water, which are always changing, that is, are dynamic and not static. Four hydrographic and planktonic cruises were made at approximately monthly intervals taking in a series of stations, from Ship harbour to Sambro bank and thence to Lunenburg. On the August cruise the work was extended to include a series of stations from Sambro bank to Emerald bank. In so far as possible a series of stations from Bedford basin out to the 100 fathom line off Halifax harbour was worked weekly. In addition special cruises were made both to the east and to the west. A limited amount of experimental fishing with "line trawl" was accomplished in order to determine the relationship of the distribution of the fish to the very diverse types of water occurring at the different depths.

The local fishery officers and the fishermen along the coast were consulted concerning details in the character and conduct of the fisheries, so as to utilize all existing sources of information, which would permit of forming a general preliminary picture to serve as a basis for particular investigations. Mr. McKenzie was responsible for work on the cod, which included study of variable abundance from place to place, from month to month, and from year to year, as well as of the migrations of the fish. Dr. Vladykov studied the haddock fishery, particularly the methods of capture, the seasonal distribution of the catches, the local spawning, and the distribution and food of the younger fish. Mr. McKenzie also obtained information concerning the character of the herring and other fisheries.

Mr. Hachey investigated the general hydrography of the area, with particular reference to the nature, movements, changes, and relationships of the different types of water both inshore and offshore. Mr. McKenzie studied the local fog conditions as being possibly related to definite areas of cold surface water. Mr. Morton followed the changes in phosphate (and also oxygen to some extent) content of the waters, so closely related to the activities of the organisms living therein. Miss Davidson was able to make quantitative determinations of the

plants in the plankton samples, particularly as obtained by centrifuging preserved samples of water from various depths, a method exceptionally important for water as strongly stratified as that of the Halifax area. These plants serve as food for the planktonic animals, the more abundant of which form the food of pelagic fishes, such as the herring and mackerel. Mr. Kearney made a quantitative study of the plankton and of some of the principal animals in it.

The waters of the Halifax area have been known to be markedly affected by incursions from the gulf of St. Lawrence and from the "cold wall" outside the banks, which is of northern origin. It was found that there is also at times a pronounced movement from the tropic water or "Gulf Stream," which is to be found a considerable distance outside the Banks. An extremely complex picture is presented, which will be difficult to develop in detail, and then only by study of adjacent areas east, west and offshore. The Fisheries Experimental Station is attempting to continue certain of the observations and collections of material throughout the winter season.

GENERAL SEA FISHERIES AND OCEANOLOGY

1. Hydrography. The results of quarterly cruises in the bay of Fundy during the year ending in the spring of 1932 were almost wholly lost in the laboratory fire, and the same applies to a considerable part of the material obtained weekly or monthly at standard stations. The latter work is being continued, although the more difficult conditions have made it necessary to limit the stations to three, in the St. Croix river, Passamaquoddy bay, and the bay of Fundy. These include not only the usual temperature and salinity observations, but also determinations of silica content through the courtesy of Dr. E. J. King of the Banting Institute, University of Toronto.

Mr. Hachey nearly completed an account of the hydrography of the Passamaquoddy region, but the manuscript was lost in the laboratory fire. As an addition to his work on the hydrography of the bay of Fundy, he has studied the problem of the extent of replacement of the waters of that bay from the gulf of Maine.

The regular daily observations of conditions in the water and air made at selected points along the coast by officers of the Lighthouse service have been continued. In addition there has been organized during the last two years under the Maritime Fisheries Branch of Quebec the taking of similar observations at Blanc Sablon, Mutton bay, and Natashquan on the north shore of the gulf of St. Lawrence in relation to the summer fishery. Also observations of this character were started in the summer of 1932 at Halls harbour on the south side of Minas channel, where exists a peculiar salmon fishery. Mr. Hachey has analysed the available data on the surface temperature of the coastal waters in order to determine the nature of the more marked local, seasonal and yearly differences.

Hydrographic observations are being made from the Prince Edward Island Marine Station for the determination of the characteristics of the shallow inland waters suitable for oyster culture, chiefly in the Malpeque bay area, but also during the summer of 1932 in Shediac bay, N.B.

The thermograph records obtained by vessels of the Canadian National Steamships in crossing to Bermuda and back again have been continued in order to ascertain the variations in the character and extent of the northward moving tropic water, the so-called "Gulf Stream". Arrangements are being made with the Woods Hole Oceanographic Institution for the regular working up of the data obtained.

2. Light. The very regrettable death of Prof. A. B. Klugh, who developed a considerable field of work in relation to light, has left the burden of its continuance with Dr. Sawyer. The latter has tested out one of the new

Weston photronic cells as to its suitability for measuring light in field work, a satisfactory instrument for which has not been available. The cell was tried both on land and under water and was found to have distinct advantages. Investigations on the penetration of light into natural waters, the relation of the photosynthesis of various aquatic plants to different kinds and intensities of light, and the effect of light on the growth of the barnacle were continued.

3. Temperature. Prof. Chaisson experimented with the effect of various temperatures on the vigour of lobsters under conditions comparable with those under which these animals may be transported to market. Mr. Friedman has extended his experiments on the ability of clams and oysters to withstand low temperatures, such as those to which they may at times be exposed in nature, possibly with unfavourable results.

4. Tidewater cultural experiments. The shortage of funds made it impracticable to proceed with the projected next stage in the construction of tidal pools at Tidal cove. Some work was done in tightening the dam, which has to function both for holding water out from, and holding water in, the cove, and in experimenting to ascertain the best type of opening to have through the dam for proper control of the water level inside.

5. Experimental weir fishing. A simple comma-shaped inter-tidal brush weir was constructed beside the Station in Brandy cove in relation to ledges situated where the water leaves the cove. A pool was constructed at the bottom of the weir to hold the fish when the tide receded. This fishing engine provided a ready means of sampling the local intertidal fish population from early in the season until late. Herring, mackerel, and squid were the principal species taken, but a very great variety of fish were entrapped including small larvae.

6. Flora. Dr. H. P. Bell of Dalhousie University has, with the assistance of Miss Constance MacFarlane, completed accounts on the marine algae, including their occurrence in Hudson bay, their distribution in the Maritime Provinces, and their seasonal changes in Halifax harbour.

7. Bait and food. Prof. Chaisson has investigated the reported bad effects of mackerel gibs as bait for lobsters in weakening or killing the latter. Mr. Stevenson has studied the nature of the local population of "long-tailed" squid of the Passamaquoddy region from catches in the weir operated by the Station.

Mr. Pentland attempted the rearing of various marine amphipods and determined their comparative resistance to various salinities, with a view to their utilization in estuarial culture.

FRESH WATER FISH CULTURAL INVESTIGATIONS

1. Lake surveys. Conditions in the Chamcook lakes, a series which is most accessible from the Station, were followed by Mr. Smith in so far as circumstances permitted, particularly with a view to an assessment of the effect on the amount of life (as shown by the plankton) of the fertilization of Gibson lake with sea mussels in 1930. Opportunity was taken of an investigation trip to the Yarmouth hatchery for a preliminary survey by Dr. M'Gonigle and Mr. Smith of lake George, which furnishes the water supply of that hatchery.

A survey was requested of the important Loch Lomond series of lakes to the east of Saint John. Circumstances permitted only a preliminary survey on August 30 by a party of investigators from the Station. The lakes proved to be of excellent character for high fish production, and plans are being formulated for continuing the survey and for developing means of best utilizing the possibilities for producing in quantity the desired sport fish.

2. Standing water experiments. The greater possibilities of the standing water of lakes and ponds as compared with the flowing water of streams for high fish production have made it desirable to investigate thoroughly the varied conditions that may exist in such standing water, particularly from the standpoint of

the insurance of high fertility. Mr. Smith has continued his study of the effects of various fertilizing materials on the water and contained life of concrete and earthen ponds. He has extended his work to experiments in which there could be greater control as well as a greater number of differing conditions, using on the one hand earthenware pots holding several quarts of water, and on the other hand glass vials of 4-dram capacity.

3. Periodic water culture. The impracticability of adequate control of both the life and the physical conditions in the permanent bodies of water, whose fish populations the public wishes increased, has forced us to explore all possibilities for bodies of water that could be drained at will. The most promising course seemed to be to search for flat areas that could be inundated by the construction of relatively inexpensive dams. In response to local requests for better trout fishing a survey was made of the environs of the Chamcook lakes in the late summer of 1931, and an extensive area (Meadow brook) apparently very suitable for such a purpose was found on the west side of the main lake, and was recommended. Plans for its use as a public experiment in fish production have been held up by lack of agreement of all the persons concerned.

Apart from the control that periodic inundation permits, there is the advantage of being able to provide fertilizer in the form of plants grown on the land when not under water. There is a considerable amount of scattered experience clearly demonstrating the value of such procedure. Experiments have been started to test in ponds the suitability of different types of "land plant" growth for fertilizing water. The limited surveys so far made indicate that areas suitable for both rich plant growth and inundation at small expense are by no means rare in southern New Brunswick, assuring good opportunity for the application of this method of water culture, which has certain points of similarity with irrigation in agriculture.

4. General hatchery conditions. Study of the conditions generally in the Maritime hatcheries has been continued by Dr. M'Gonigle in order to assist the superintendents in keeping the eggs and fry in the best condition. He or other members of the staffs of the two Atlantic Stations, in particular Dr. N. E. Gibbons of the Fisheries Experimental Station, made special trips to the Saint John, Florenceville, Miramichi, Yarmouth, Middleton, Bedford, Antigonish, and Margaree hatcheries in order to investigate troubles with eggs or fry. An analysis has been made of the hatchery reports from the standpoint of the courses taken by particular batches of eggs, and the matter of transportation of the eggs seems to require special attention, if rather serious losses are to be avoided.

5. Water conditions in hatcheries. The use of recirculated water in the experimental hatchery has been continued. Although necessitated by the lack of a supply of running water during the winter, it is preferable to the latter as affording more control of the character of the water. Dr. M'Gonigle has experimented to determine the advantages of brackish water and of filtering in the recirculation method, using three separate systems. Only the filtered system was satisfactory after the hatching of the eggs, and the two systems without filters, one with fresh and the other with brackish (1% salt) water, showed no particular difference up to the time of hatching, when both proved unfavourable. For the first time an attempt was made to carry fry in the recirculated water, and that that had been filtered gave reasonably satisfactory results, although the bad effects of crowding were evident. There were also experiments to test the efficiency of different rates of water flow.

6. Rearing experiments. Funds were not sufficient to complete the circular pond system designed by Dr. M'Gonigle for testing the use by fry of food organisms grown in fertilized water, so that experiments planned could not be proceeded with. The food experiments being carried out by Miss Tait were continued in an attempt to ascertain the nature of the most important materials for rapid growth. Use was again made of a neighbouring spring-fed brook to supply

the necessary water. The arrangements for troughs for the brook trout fry and for a steady and similar supply of water to all the troughs were considerably improved. The upper part of the reservoir dam was reconstructed so as to be unaffected by alternation of wet and dry weather; the flume was enlarged so as to adequately handle floods, and prevent these adversely affecting either dam or rearing troughs; and the entrance to the flume from the reservoir was carried well below the surface of the water to prevent the entrance of floating debris and to procure the cooler (as much as 6°C.) deep water.

7. Planting experiments. Mr. White followed the results of planting of salmon fry in such localities along the east branch of the Apple river, N.S., as observation had indicated were principally occupied by naturally-hatched fry, and reports a good survival. He studied the behaviour of fry transferred from running to still water, and concludes that they require time to become capable of looking after themselves properly under the altered conditions.

DISEASE AND MORTALITY

1. Herring. The "tail" disease that was first observed in 1913 and 1914 in the herring of the southern part of the gulf of St. Lawence, appeared in the herring of the bay of Fundy and gulf of Maine in 1929, affecting a considerable part of the stock in 1930. In 1931 the condition was improved, there being no trouble with it on the Nova Scotian shore, although occasional individuals showed evidence of having had the disease. During 1932 no difficulty was experienced with it in any place, even where there had been the worst conditions previously, although occasional fish would be seen with evidence in the form of slightly marked spots on the sides, or of some distortion of the body, or tail, of having been previously affected. It is not clear that the less abundance of smaller herring during the last year or two has been the result of the disease, although the latter may have contributed. It would seem that this disease affects the herring in a more or less pronounced manner every so often, but that it rarely shows the severity that characterized the two outbreaks to which reference has been made. It would seem also that it is the sea or summer and fall spawning herring(as distinct from the coast or spring spawning) that is affected, and principally those schools that get close inshore.

2. Eelgrass. Alarming reports were made to the Atlantic Stations of the disappearence of the eelgrass, particularly in certain Nova Scotian waters, where its collection for industrial purposes constitutes a not inconsiderable source of livelihood for quite a number of people. Dr. Leim, director of the Fisheries Experimental Station, secured special reports on the matter from fishery officers and others, and the director of the Biological Station investigated the local condition of the eelgrass at as many points along the coast of the Maritime Provinces as opportunity permitted. Dr. Needler followed up the conditions in Malpeque bay. Mr. Friedman conducted low temperature experiments with the eelgrass in order to ascertain whether freezing may have contributed to the condition. Definite evidences of disease appeared late in the season. This matter has called attention to the very definite need for knowledge concerning the general physiology of this plant.

FISH PHYSIOLOGY AND ANATOMY

1. The circulatory system. Dr. Babkin, Dr. Bowie, and Mr. Nicholls collaborated in an investigation of the wall of the artery in fish, in regard to its structure; and its reaction to distension, temperature, and various organic substances in solution.

2. The digestive system. Mr. Nicholls continued his similar studies on the wall of the intestine, and has also determined the survival times at different temperatures of the wall of the stomach as an example of fish tissue.

3. The muscular system. Miss Langstroth has begun a thorough study of the microscopic structure of fish muscle both in the adult and during develop-

ment. This is to provide needed knowledge of this part of the fish, the principal one used for food.

THE HANDLING OF FISH FOR FOOD

1. Experiments in freezing and storage. The long term storage experiments begun in the summer of 1931 were abruptly terminated (with the loss of material already obtained for study) by the destruction of the laboratory by fire in March, 1932. Dr. Bowie began a new series during the summer, the aim being to ascertain what conditions of freezing and storage affect the ability of the muscle to approximate, on thawing, its original condition of water-protein relation.

2. Digestion of sea foods. Miss Alley continued under the direction of Dr. Babkin the investigations of the effect on mammalian digestion of various fish foods, which were started by Dr. S. A. Komarov. She was able to make a comparison of the comparative effect on various phases of gastric digestion of haddock, cod, mackerel, lobster, and clams.

3. Condition and first handling of ground fish. An investigation was requested of the factors affecting the keeping qualities of ground fish taken in the neighbouring region. Dr. Bedford enquired into the conditions surrounding the fish both in the sea and aboard the boats in which they are brought to the shipping port. Attention was given to the possibilities of influence from the water, the surface of the fish, the food, the bottom, and the walls of fish containers on the boats, as well as temperature. Definite evidence was procured of the very great importance of adequate icing and of avoidance of heavy bacterial contamination aboard the boats.

4. Kinds of sea bacteria. Miss Baker, under the direction of Dr. G. B. Reed of Queens University, investigated the possibility of there being in sea water certain primitive forms of bacteria, hitherto not recognized, and also studied the effect of various salt concentrations on form and reproduction in certain salt water bacteria.

5. Yellow condition in clams. Trouble had been experienced with a somewhat pronounced yellowness appearing on the surface of canned clams, such being considered undesirable. Miss Davidson failed to find any relation of this yellowness to the presence of diatoms. Cursory examination indicated that the yellowness came from particular granules in the epithelical cells, and Miss Langstroth was asked to investigate the matter from the histological standpoint and determine, if possible, the nature and occurrence of any materials that might be responsible for the yellow colour.

EXTRATERRITORIAL INVESTIGATIONS

Several outside institutions very kindly offered to help by giving laboratory space and other assistance to certain investigators, whom we might not be able to accommodate in view of the destruction of the Station laboratory. Miss M. H. Campbell, of the University of Toronto, was accepted on the staff of the Woods Hole Oceanographic Institution, and was thus able to study in Atlantic waters, as she had already done in the Pacific, certain copepods ("red feed" of the fishermen), work which had been proposed to be done at this Station. Similarly Dr. F. R. Hayes of Dalhousie University, who has been engaged in investigations of the metabolism of eggs, was given assistance to enable him to continue such work at the Tortugas Laboratory of the Carnegie Institution, where he studied the role of nitrogen echinoid ontogeny.

Miss Davidson was accommodated at the Woods Hole Oceanograhpic Institution for a portion of the summer to enable her to work with Dr. H. H. Gran of Oslo University and obtain benefits from his long experience in the study of diatoms.

INTERNATIONAL PASSAMAQUODDY FISHERIES COMMISSION

The second and final year of investigation under this Commission of possibilities of effects upon the fisheries of the Passamaquoddy region of dams proposed at the mouths of the bay of that name, has been in progress, with headquarters at the Biological Station during the field stage of the work. The upper part of the hatchery building was again made available for the investigators, who were,—Dr. C. J. Fish, Zooplanktologist and Executive Secretary; Mr. Michael Graham, Ichthyologist; Dr. H. H. Gran, Phytoplanktologist; Dr. E. E. Watson, Hydrographer; Mr. T. Braarud, Assistant Phytoplanktologist; Dr. M. W. Johnson, Assistant Zooplanktologist; Mr. Jas. Bates, Fisheries Assistant; and Mr. C. J. A Hughes, Hydrographical Assistant. Their presence was a very decided advantage for the work of the Station, permitting as it did frequent discussions of problems of common interest, as well as providing first hand information of new findings concerning conditions in the neighbouring waters. The M. S. "Edward E. Prince" was loaned to the Commission for the use of its investigators up to the conclusion of the field work in October, 1932.

EDUCATIONAL WORK

A six weeks' course of instruction was given in January and February, 1932, at Halifax to the superintendents of Maritime hatcheries. The course was in charge of Dr. M'Gonigle, and covered the fields of physics, chemistry, general biology, anatomy, physiology, and pathology. Laboratory facilities were made available at the Fisheries Experimental Station and at Dalhouise University, and for assisting in the work of instruction the services were secured of Drs. S. A. Beatty and H. R. Chipman of the former, and Drs. H. P. Bell and F. R. Hayes of the latter institution.

GENERAL FACILITIES

The laboratory was completely destroyed by fire on March 9, but, fortunately, the strenuous efforts of a large number of persons from the town of St. Andrews and such of the staff of the Station as were not away at the time, coupled with favourable weather conditions, prevented the fire reaching any of the other buildings. The library and extensive study collections of marine material were included in the loss, but it proved possible to remove the contents of the offices, where were most of the records. Several of the investigators lost records, notes and manuscripts, with which they had been working.

Connors Bros. of Blacks Harbour immediately offered the facilities of their laboratory, of which Dr. Bedford took advantage. Plans that had been formulated for making simple summer laboratory accommodation in the tank tower were carried through, and other plans were formulated and executed, providing temporary working places in portions of the fish handling building.

On the site of the former laboratory were the connections for gas and salt water, and, owing to the necessity for these services and other laboratory facilities of a somewhat permanent nature, it was decided by the Board to use all available funds in beginning the erection of a new fireproof laboratory. As there seemed to be no possibility of securing any special grant, this reconstruction was proceeded with, owing to the urgency, largely from funds intended for investigations.

Salt water tanks for keeping fish alive and gas for laboratory heating were provided before the summer season was very far advanced, but offices and laboratory rooms were not available till the autumn. It finally proved possible to reconstruct on the old foundations the part corresponding to the small, original laboratory as built in 1907. In appearance, as well as in general plan, the new is very like the original, but the materials have been brick, tile, steel and concrete

in place of wood. The front or east part contains the offices—general office, records' room, director's, assistant director's and curator's offices—and the remainder consists of seven individual laboratories, one laboratory for three investigators, and a general one (open to the hall), which has six working spaces. The attic, as formerly, is being fitted up for storage. The building has been brought into shape, though somewhat late, for the winter work of the staff.

Advantage was taken of the razing of the site by fire to excavate down to the solid rock under the eastern end of the reconstructed part, thus providing more room in the basement. The tile walls of the latter were made better insulators by placing eelgrass in the cavities,—this in order to ensure uniform temperature conditions. The basement is to be used in part for the storage of preserved material, but principally for keeping forms at low temperatures.

The brick reservoir in the north-east corner of the basement was little affected by the fire, and two of the fish tanks also came through in fair condition. New pump and motor have been installed to keep the reservoir automatically supplied with salt water from the tidal pools, mentioned below. Salt water of uniform temperature for use on the main floor of the laboratory is now furnished automatically with motor, pump, and pressure tank connected with the reservoir, a great improvement over the former system of gravity flow from an elevated outside tank, in which the water became warm in summer and cold in winter. It is planned to use a large part of the basement for constant temperature rooms of 15° C. and below, which are so necessary for investigating temperature requirements of fish.

The local sea water is comparatively uniform in temperature, giving suitable conditions for a great variety of forms. To keep such water relatively unaltered in passage to reservoir and tanks so as to permit of all these forms being held in good condition has proved somewhat difficult. A tidal pool situated back of a ledge and at a level just below high tide of neaps has its water renewed twice daily, and permits of easy centrifugal pumping to the reservoir at any stage of the tide. The water in the pool has been found to have its temperature altered rather quickly by radiation, during clear weather, warming from the sun's rays during the day and cooling during the night. To obviate this a cover has been constructed over the tidal pool, and this has been found fairly effective so far. Improvements that may be made in ensuring proper replacement of water at high tide and in preventing change in temperature through radiation will be revealed by experiment.

The library must be built up anew, as only a few volumes, which were out on loan, remain. It seemed inadvisable to make a particular effort to build it up again, until a fireproof building should be available for storing the books. The reconstructed part of the laboratory now provides safe storage space. Some institutions, with which we exchange, have already been so kind as to furnish available back numbers of their publications,—namely Carnegie Institution of Washington, Museum of Comparative Zoology of Harvard University, Ontario Fisheries Research Laboratory, Portland Society of Natural History, Provincial Fisheries Department of British Columbia, Spanish-American Oceanographical Council, United States Bureau of Fisheries, Commission of Inland Fisheries of Rhode Island, and University of Toronto. There have also been donations of library duplicates by Dr. H. B. Bigelow, Fisheries Experimental Station (Atlantic), Museum of Comparative Zoology of Harvard University, and University of Toronto.

PUBLICATIONS

The Fisheries Experimental Station (Atlantic) and this Station have collaborated in bringing out Nos. 3, 4, and 5 of Progress Reports and it is planned to have an issue of sixteen pages appear quarterly.

The following articles on work connected with the Station have been published during the year.

Battle, H. I. Rhythmic sexual maturity and spawning of certain bivalve mollusks. Contr. Canad. Biol. Fish 7. (20) 255-276.

The moon and when to eat mussels. Prog. Rep. Atl. 3, 5-6.

Chaisson, A. F. The use of mackerel gibs for lobster bait. Prog. Rep. Atl. 5, 5-6.

Factors in the shipment of live losters from eastern Nova Scotia. Bull. Biol. Bd. Can. 33.

Huntsman, A. G. Bait preservation. Prog. Rep. Atl. 3, 13-14.

Disease in eel grass. Prog. Rep. Atl. 5, 11-14.

Progress in fisheries research in Canada. In "Fifty Years' Retrospect." Roy. Soc. Can. Jubilee vol.

Relation of biology to oceanography. In "Physics of the earth. V. Oceanography." Bull. U.S. Nat. Res. Coun. 85.

Jeffers, G. W. Fishes observed in the strait of Belle Isle. Contr. Canad. Biol. Fish. 7 (16) 203-211.

McKenzie, R. A. Water temperature and the haddock fishery of the Fundy area. Prog. Rep. Atl. 4, 10-13.

Needler, A. B. Sex reversal in *Ostrea virginica.* Contr. Canad. Biol. Fish. 7 (22) 283-294.

American oysters change their sex. Prog. Rep. Atl. 5, 3-4.

Needler, A. W. H. Oyster farming on the Atlantic coast of Canada. Dept. of Fisheries, Ottawa.

Mud bottoms hardened with sand for oyster farming. Prog. Rep. Atl. 5, 7-8.

Newcombe, C. L. The soft shelled clam, a Fundy fishery resource. Prog. Rep. Atl. 3, 10-12.

Osburn, R. C. Biological and oceanographic conditions in Hudson bay. 6. Bryozoa from Hudson bay and strait. Contr. Canad. Biol. Fish. 7 (29) 361-376.

Rigby, M. S. List of publications in connection with the work of the Biological Board of Canada, 1922-1930. Bull. Biol. Bd. Can. 28.

Smith, M. W. Fertilizing water with herring meal. Prog. Rep. Atl. 3, 7-9.

Oxygen in water affected by fertilizing. Prog. Rep. Atl. 4, 14-15.

Stevenson, J. A. Scallops; a bay of Fundy resource. Prog. Rep. Atl. 4, 8-10.

Treadwell, A. L. *Haplobranchus atlanticus,* a new species of polychaetous annelid from St. Andrews, N.B. Contr. Canad. Biol. Fish. 7 (21) 277-281.

INVESTIGATORS' SUMMARIES

ARMINE ALLEY

THE EFFECT OF DIFFERENT SEA-FOODS ON THE GASTRIC SECRETION

Various sea-foods were fed to a dog which had a gastric fistula and Armour pouch, and the effects upon the nature of the resulting gastric secretion were studied. These were compared with the effects of feeding meat, used as a standard, with the following results and conclusions:

Foodstuff	Peptic values (Mett's tubes)	Output of pepsin	Mucin concentration % glucose	Mucin output	Relation of mucin to pepsin	Total volume	Total acidity
Per fistula							
Haddock...	1915	9000	61.4	314	28.6	20.8	146
Cod.....	1729 (1 exp.)	8861 (1 exp.)	39.5	156	54.2	20.5	146
Beef heart..	1590	7780	44.9	250	31.1	21.2	148
Lobster....	1843	12782	60.6	366	34.9	28.1	150
Mackerel...	1302	8255	43.8	234	35.2	23.5	153
Clams.....	(Dog vomited food)						
Per mouth							
Meat.....	1490	11980	50.6	444	27.2	30.7	153

(1) Fish (cod, haddock, or mackerel) is as strong a stimulant of pepsin, mucin, acidity and fluid of the gastric juice as meat. Lobster is a much stronger stimulus than meat.

(2) Fish remains in the stomach as long as meat and in some instances longer, *e.g.* mackerel.

(3) Haddock is not only a good stimulus for the digestive enzyme, pepsin, but also for mucin, which affords protection to the mucous membrane.

(4) The effect of fat in fish, as shown in the case of mackerel, is to decrease the peptic value, depress the volume of secretion in the first hour and prolong the retention of the fish in the stomach.

(5) After fish feeding there was always a rise in the fluid volume at the end of the experiment.

B. P. BABKIN, D. J. BOWIE AND J. V. V. NICHOLLS

THE REACTION OF THE ARTERIES OF ELASMOBRANCHS TO DISTENSION, TEMPERATURE AND DRUGS

The aim of this investigation was to estimate the properties of the arterial wall in the skate in relation to tension, temperature, and sympathomimetic and parasympathomimetic drugs, and to compare them with the analogous properties of the arteries of warm-blooded animals. This problem is important in contributing to the proper understanding of the position of elasmobranch fishes in the animal scale. Moreover, the peculiarities of the arrangement and functioning of the nervous system in elasmobranchs provide an opportunity for study of the fundamental properties of the blood-vessels and their reaction to different agents. This may lead to a better knowledge of the more complicated relations existing in warm-blooded animals. The structure of different arteries in various species of skate was studied microscopically, and the innervation of these arteries and their reaction to tension, changes in temperature, adrenaline, acetyl-choline, barium chloride and atropine were investigated. It was demonstrated that some of the arteries, such as the ventral aorta, are practically devoid of muscular

sheath, but are rich in elastic tissue, whereas others (*e.g.* the coeliac and superior mesenteric arteries) possess two layers of smooth muscles. The reaction to tension was different in these two types of arteries. The circular layer of arterial muscles reacted to temperature change differently from the longitudinal. Adrenaline, barium chloride and acetyl choline contracted the arteries; atropine paralyzed the effect of the last-named drug.

M. C. BAKER

PRIMITIVE BACTERIA IN SEA WATER

Sherman (*Science*, Dec. 11, 1931; *Journal of Infectious Diseases*, Vol. 51, Jan. 16, 1932) discovered "primitive forms" of bacteria, obtaining these from such sources as soil, hay, milk and faeces. In an attempt to demonstrate the presence of these "primitive forms" of bacteria in sea water, Sherman's methods were followed with a few modifications to adapt them to these conditions. No indication of the presence of these forms in sea water was found.

A study of the morphological and physiological changes induced in bacteria by growth on solid media, containing various concentrations of salt (NaCl), also was undertaken. Morphological variations and a decrease in the tendencies to sporulate were observed.

H. I. BATTLE

DISTRIBUTION AND FLUCTUATIONS OF THE HAKE FISHERY OF THE ATLANTIC COAST

The so-called hake or ling is one of our abundant Atlantic food fishes. The object of this investigation is a twofold one: first, to correlate, if possible, the present distribution of the hake with existing hydrographical factors; and, secondly, to put on record an historical account of the fluctuations in the hake fishery for the past sixty years which may be used as a basis for judging future changes in the conduct of the industry.

About seventy-five per cent. of the total annual commercial catch of hake is made near the mouth of the bay of Fundy and that in a large part off Digby and Charlotte counties, around the fifty fathom line. Smaller quantities are taken along the south shore of the gulf of St. Lawrence from Gaspé to cape Breton and off the southeastern coast of Nova Scotia. Along the latter area the fishery is conducted partially on the offshore banks but for the remainder of the coast it is purely inshore.

Young hake up to ten centimetres in length have been recorded as occurring in shallow brackish water up to 16.5°C. These are found in coves along the coast directly inshore from the commercial fishing grounds. The adults seem to prefer considerably lower temperatures, but have been recorded in experimental fishing in water as high as 11.1°C. and as low as 2.5°C. in the Fundy area. From October to April hake are present in Kennebecasis bay, a fact which indicates that these fish are capable of withstanding a fairly wide salinity range from the open bay to slightly brackish water.

Over the period from 1870 to 1930 the Atlantic coast landings of hake show many fluctuations. Among these the catch of 1,329,489 cwt. for 1904 stands out as the maximum peak year. The first two-thirds of the sixty-year period shows on an average much larger landings than the past twenty years. For example, within recent years the notable catch of 339,212 cwt. (hake and cusk) in 1929 is only one-quarter of that for 1904.

Depressions can be largely attributed to negligent fishing activities consequent upon low market prices, depletion of the number of individuals engaged in the fishery, ravages of dogfish during the prime summer season, inclement weather conditions and scarcity of bait.

THE LIFE-HISTORY OF THE HAKE

The present investigation was undertaken with the purpose of enlarging our knowledge of the life-history and habits of the hake in Canadian waters. It has generally been conceded that there are two closely related species of hake, *Urophycis tenuis* (Mitchill 1815) and *Urophycis chuss* (Walbaum 1792). Owing to the fact that most specimens appear to intergrade, it seems preferable to temporarily classify them by priority as *U. chuss* or as *U. chuss* (*tenuis*).

Spawning. In the summer of 1932 adult fish in the vicinity of Prince Edward Island spawned in midsummer. Specimens taken in July were either full, with large yolk-laden ova (0.5 to 0.7 mm.) filling the lumen of the ovary, or spent. Off the coast of Halifax county spawning is said to take place in September or October. In late July the ovaries of most fish of a commercial size contain a large number of eggs (0.2 to 0.3 mm. in diameter) in which yolk is accumulating. Fish taken off Digby and Charlotte counties at this time possess ova of 0.1 to 0.15 mm. diameter only. Summer appears to be a growth period for the ova in the Charlotte county area; by late August they have attained a diameter of 0.2 to 0.27 mm., but are probably not ready for spawning until the winter.

There is apparently no one spawning period for the Atlantic coast hake. According to popular belief hake migrations are limited. Spawning then would seem to depend largely on the heating of the waters in a particular region, with the result that summer spawners are found off Prince Edward Island, autumn spawners off southeastern Nova Scotia, and winter spawners in the Fundy area.

Age growth determinations. Hake scales do not always prove entirely satisfactory for age and growth studies because of the indefinite nature of the annuli, but the irregularly shaped otoliths were found to be quite unsuitable for this purpose. The combined scale and gonad studies would seem to indicate that spawning occasionally takes place at the end of the third year, but usually not before the end of the fourth year off both Charlotte and Halifax counties.

FOOD OF THE HAKE

Adult fish taken during the summers of 1931 or 1932 off Prince county, P.E.I., Halifax, Yarmouth and Digby counties, N.S., and St. John and Charlotte counties, N.B., had stomach and intestinal contents consisting largely of crustacea, occasional fish (herring, sculpin, rose-fish, etc.), and squid. The crustacean diet was made up largely of euphausiid shrimps (*Meganyctiphanes*, etc.), prawns (*Pandalus*), occasional crabs (*Cancer*, etc.), and amphipods. Hake are captured largely on line-trawls which might indicate that they are in general bottom feeders. Aside from squid, molluscan food appears to be generally shunned.

Off Halifax county hake tend to be more piscivorous than in the Fundy area, although Crustacea still form a large percentage of the food. Young hake up to four inches long were found to feed on smaller Crustacea (shrimps, copepods, amphipods) than adults. At the mouth of the bay of Fundy the abundance of hake would seem to be related in some degree with the unusual quantities of euphausiid shrimps to be found there.

R. H. BEDFORD

PRESERVATION OF FRESH FISH AT SEA

An attempt was made to record the number of bacteria on the fish as soon as they were caught, the increase in the number under practical conditions at the time they were landed at the warehouse at the port of unloading, and to observe the effect of ice, a clean receptacle for stowage, and cleanliness in handling the fish themselves after eviscerating them, in reducing the rate of bacterial growth.

The result indicated that (1) the number of bacteria on the live fish and shortly after death is low, averaging for 16 fish, 450 organisms; (2) the method

of handling is responsible for abnormal contamination—after five hours there was an average of 1,310,000 bacteria on 4 fish; (3) under clean handling and stowage conditions the increase in the number of bacteria was greatly reduced—in one case there was an increase of only 1240 in 15 hours, and in another an increase of only 125 in 9 hours; and (4) when stowed in ice and the fish thoroughly washed before doing so, the increase in numbers was as follows: in 29 hours there were 810, and on 2 fish in 30 hours there were 1040 and 1820 bacteria respectively.

The experiment shows the decided advantages of (1) a clean hold for stowage that is, one that is consistently treated with a disinfectant, and the thorough washing of fish after eviscerating them prior to stowage, and (2) the effect of low temperature conveyed to the fish through the medium of ice.

THE QUALITY OF PASSAMAQUODDY HADDOCK

There are certain haddock fishing areas (principally in the vicinity of the Western banks adjacent to Sable island) where the fish are "soft and flabby" as soon as they are taken from the water. This is a condition recognized by both fishermen and buyers.

Most of these fish are marketed at Boston, but occasionally some are landed at St. Andrews.

This "soft" condition is said by fishermen to be found always where the ocean bottom is muddy, and where the bottom is gravelly or sandy the finest quality haddock are always caught.

The object of the investigation was to see whether any differences could be determined between the firm-textured haddock caught in the vicinity of gravelly areas and those taken from the areas where the sea floor was muddy in the district of Passamaquoddy bay. The stations selected for the experiment were "Prince" Nos. 6 and 848, gravelly and muddy areas respectively.

The indices used for measuring the conditions of "soft" and "firm" muscle were (1) the soluble nitrogen of the muscle after precipitating the proteins with 10 per cent. trichloracetic acid, and (2) the bacteriological flora of the fish, water, and sea floor.

The result indicates that there is no difference in the fish from the two areas, fish from the muddy areas of Passamaquoddy bay being similar to those of the gravelly area in the St. Croix river estuary. In support of this there are the facts that the nitrogen content of the fish muscle, and the bacteriological condition of the two environments, as well as of the fish themselves, are practically identical. The food of the fish would appear to be similar, too, judging from the bacteriology of the stomach, duodenum, and ileum.

In the light of this experimental evidence as well as from visual observation of the fish themselves the conclusion is reached that haddock caught in the "Quoddy" bay area are similar in quality—firm-textured muscle.

A. A. BLAIR

THE ST. JOHN SALMON FISHERY

As the salmon fishery of the St. John is next in importance to that of the Miramichi and yet presents such different conditions (*e.g.* fall run, if any, much later and not so marked), it seemed that many important questions in the life-history of the salmon might be solved by a comparison of the salmon in the two regions.

It has been possible to analyze some records of salmon catches in this district (procured from Mr. Sidney Evans) giving the daily catch (with total weight) in the bay of Fundy of each fisherman at Lorneville since 1919, and with the following results.

(1) Range in average weight with season is from 0.6 (12.4 to 13 lb. in 1925) to 1.8 lb. (11.8 to 13.6 lb. in 1929). Range in average weight with season for all the years together is from 11.7 to 12.7 lb.

(2) The average weight decreases usually from the period ending June 7 to the period ending June 20 (for all years together from 12.3 to 12.1 lb.), and invariably increases (for all years to 12.7 lb. in the period ending July 18) to a peak somewhere from the end of June to the beginning of August. Except in 1919 and 1931, there was a decrease to the end of the fishing season (for all years to 11.7 lb. by August 9).

(3) The average daily catch for all years per fisherman gradually increases from 6.9 salmon in the period ending June 7 to 12 salmon in the period ending July 11, after which there is a gradual decrease to 6.7 salmon in the period ending August 9. The peak of the catch each year is practically always during the middle part of July.

(4) For any one year there is a tendency for the average catch and average weight to increase and decrease together. Also for different years, the average weight and average catch vary together (*e.g.* low weight going with low catch).

D. J. BOWIE

THE BLOOD VESSELS OF FISH

Histological investigation of various organs of fishes has been continued.

It has been found that the blood vessels of skates have in the arteries a well-developed muscular wall, and in the case of the mesenteric arteries a rich network of nerves. The latter has apparently not been previously recorded.

HISTOLOGICAL INVESTIGATION OF FROZEN AND STORED HAKE MUSCLE

Microscopic study of tissue stored only two days before fixing.

(1) Brine-frozen tissue fixed in the frozen state by means of cold alcoholic fixatives showed an abundance of small ice-crystal spaces.

(2) Similar tissue allowed to thaw and fixed in *warm* alcoholic fixatives showed very little evidence of crystal spaces.

The conclusion is that the tissue fibers, when thawed, reimbibe much of the fluid which, during freezing, had separated out to form the ice crystals.

(3) In brine-frozen tissue the crystal spaces are comparatively small. They increase in size directly as the distance from the freezing surface increases.

(4) In air-frozen tissue the crystal spaces are comparatively large.

A. F. CHAISSON

THE USE OF MACKEREL GIBS FOR LOBSTER BAIT

Mackerel gibs (the gills and soft parts removed in gibbing mackerel) are a very effective bait for lobsters but are commonly believed by fishermen to have a weakening effect upon lobsters subsequently kept in air. This effect is said to be readily observed in fishing boats soon after lobsters are taken from the traps.

Feeding experiments showed no diminution of vigour, that could be attributed to nature of bait, in the case of lobsters fed on mackerel gibs (both fresh and putrid) as compared with others fed on fresh clam or starved. All comparative groups were held under the same conditions in sea water at 57.2° to 62.6°F., and in air at 50° to 59°F. and 62.6° to 66.2°F. Since the lobsters used in the experiments were fed mackerel gibs, both fresh and putrid, in much larger quantities than they would be likely to obtain in baited traps, any loss of vigour due entirely to the gibs should have demonstrated itself.

The lobsters used in the experiments differed from those in which weakness due to nature of bait was said to result in that they were not freshly caught but had been kept in a pound for several days. For that reason the change to air was probably not as extreme as if they had been changed quickly from the bottom of the sea to air as occurs on the fishing boats. It may be this sudden change of environment, particularly if it is accompanied by extremes of light and temperature, evaporation of water from the gills and rough handling, that is responsible

for much of the weakness of lobsters occurring on fishing boats and not the nature of the bait used.

CONSTANT TEMPERATURE EXPERIMENTS ON THE LOBSTER

Observations on favourable temperatures for shipping live lobsters had previously been made on a large scale on the boats carrying them between eastern Nova Scotia and Massachusetts ports. Small scale experiments were performed with the object of verifying the conclusions reached in the field.

Vigorous lobsters were selcted and stored in damp air in incubators which maintained temperatures in the range 32° to 66.2°F. No difficulty was encountered in keeping such lobsters in good condition for six days,—a period of time considerably longer than that required for the average shipment, at temperatures between 32°F. and 50°F. This, then, may be regarded as a safe range for shipment in air if ordinary precautions are taken to supply moisture. Within the same time limits, 50° to 55°F. appeared equally favourable. Temperatures above 60°F. should be definitely avoided. Although the lobster will live in well aerated sea water at a temperature as high as 77°F., the problem of supplying adequate moisture becomes increasingly difficult, in air shipments, with increase in temperature, and is probably the factor which sets the l mit referred to above.

A. ELIZABETH CLARK

THE EFFECTS OF TEMPERATURE AND SALINITY ON SPERMS AND LARVAE OF OSTREA VIRGINICA

It was desired to determine to what extent the oyster might be limited in abundance and distribution through extreme temperatures affecting it during spawning and subsequently.

The life of the sperm is prolonged at lower temperatures, the active period being 9 hours at 40°C., and 148 hours at 5°C.

The same temperature range, viz., 40°C. to 5°C., was tried on the developing larvae. 40°C., 35°C., 10°C. and 5°C. did not allow development to reach the swimming stage, but temperatures between 35° and 10° did. 30°C. proved to be the temperature at which the swimming stage was reached most quickly, *i.e.*, in about three hours after eggs and sperms were mixed.

Experiments showed that the life of the egg under normal environmental conditions for Bideford river was between 4 and 6 hours. Also eggs heated to 40°C. were all killed; eggs heated to 33°C. to 39°C. did not produce swimming larvae; eggs heated to 36°C. to 37°C. produced swimming larvae unless heated for 60 minutes; eggs heated to 35°C. for 60 minutes produced swimming larvae.

The life of the sperm was 22 hours at a salinity of 40.68‰, and increased to 42 hours at 23.2‰, then decreased to 21 hours at 4.6‰.

Also swimming larvae were produced at all salinities between 38.8‰ and 14.5‰.

The results of these experiments show that the variations in salinity and temperature, as found under normal conditions in Bideford river, would not have very great effects on the sperm, once it had been released in the water, or on the development as far as the first swimming stage.

V. M. DAVIDSON

THE SUMMER PHYTOPLANKTON IN THE REGION OF HALIFAX

Heretofore, collections have been made with No. 18 net, hauled either horizontally near the surface or vertically from the bottom upward. For the sake of studying the distribution according to depth and obtaining the nannoplankton known to be escaping through the nets, the centrifuging of water samples from various stations at different depths was begun under the direction of Professor Gran of Oslo, Norway, who perfected the method. Material was obtained from stations as follows:

(*a*) Bedford basin, Halifax harbour, and two stations directly seaward from the mouth of the harbour, sampled bi-weekly;

(*b*) Six stations forming two sides of a triangle from Ship harbour and Lunenburg, to the 100-fathom line, visited monthly.

Study of the material permits the following conclusions:

(1) The amount of phytoplankton during July and August is small.

(2) The content was oceanic in character, being chiefly dinoflagellates augmented by neritic diatoms at the inshore stations and the coccolithinea, *Pontosphaera Huxleyi*, at the outer stations.

(3) On August 1, the centre of Bedford basin showed definite stratification with a maximum of diatoms at 10 metres; at the same time, Halifax harbour, although showing more even distribution from top to bottom, had a noticeable maximum at 10 metres.

(4) The deeper stations beyond the harbour were very poor at all depths except for *P. Huxleyi*, which had its maximum near the surface.

J. W. FISHER

HYDROGRAPHY AND OYSTERS IN THE SHEDIAC AREA

To provide a proper basis for development of oyster culture in Shediac bay, a study was made of the hydrography and the oyster population.

The prevalence of small depths and the two considerable streams tributary to the bay make both temperature and salinity variable. Bottom temperatures passed 20°C. (warm enough for oysters to spawn) at all observation stations—at the end of June or early in July in the bay and rivers, later at the mouth of the bay, and in August at the "Farewell buoy" off the entrance. Diurnal temperature changes were more pronounced than tidal.

Bottom salinities of 27 to 29 per mille prevailed in the bay but decreased sharply in the rivers, becoming very variable and falling very low some distance below the head of tide.

Experimental tonging showed three centres of abundance—in order of importance, between Shediac island and the mainland to the west, the lower part of Shediac river, and the lower part of the Schoudouc river. Occasional oysters were present around the entire bay and barren silted beds occur towards the mouth. In the rivers the abundance decreased towards the head apparently limited by salinity. Where salinities were high the oysters were well "cupped", but in the rivers long and narrow.

Spawning occurred in all oysters observed, commencing when the temperature reached approximately 20°C. and increasing during the warm spells. Two weeks after such warm spells cultch was put out, in the form of oyster and quahaug shells in wire baskets, at representative stations; but no spat was caught or found naturally produced during the season.

M. H. FRIEDMAN

THE FREEZING AND COLD STORAGE OF LIVE CLAMS AND OYSTERS

The natural habitat of the soft-shelled clam and of the oyster is such that it is often exposed during winter to very low temperatures. To culture them it is therefore important to know the lowest temperatures which they can survive. Also, it is often desirable to keep these animals alive in storage for some time prior to marketing and the most economic means of doing so is that of cold storage. Experiments were performed with the following results.

(1) Animals which are brine-frozen survived longer exposure at any given temperature than animals air-frozen at the same temperature.

(2) At temperatures below −4°C. the oyster is more resistant than the clam. Above −4°C. both are equally resistant.

(3) In the clam (and probably in the oyster, too) there is a definite gradation of death for each organ. Thus the anterior adductor muscle is less resistant than is the posterior adductor muscle to the same temperature.

(4) In the clam the smaller animal, within certain size limits, is more resistant than the larger.

(5) Mechanical shock to the frozen clam and oyster is injurious; the same degree of shock to the unfrozen is not.

(6) In the frozen clam each organ (adductor muscles, syphon, mantle) has its own point of susceptibility to injury by mechanical shock.

(7) Oysters survive brine freezing and storage in air at −4°C. for more than seven weeks, even when unglazed.

(8) Brine-frozen clams kept in air at −4°C. showed signs of desiccation at the end of about five weeks but survived such exposure for about seven weeks.

(9) Brine-frozen clams, glazed and stored in air at −4°C., did not show signs of desiccation at the end of seven weeks.

(10) After seven weeks such animals (par. 9 above) showed, however, other unmistakable signs of injury. Gas bubbles had formed in the mantle cavity, the tissues were shrunken, and not many survived on thawing. It is possible that respiration continues at even −4°C. and that these aninals died from tissue starvation.

H. B. HACHEY

HYDROGRAPHY OF THE WATERS OF THE HALIFAX AREA

The general hydrographic conditions both off-shore and in-shore are of prime importance to an understanding of the fishery problems of the area. The data obtained form another link in the chain of our knowledge of conditions along the Atlantic coast.

In the area three distinct bodies of water are to be noted. The upper layers (to a depth of 30 m. off-shore and 60 m. in-shore) consisting of water of a temperature greater than 5°C. have a salinity less than 32.00‰. The intermediate layers (between 25 and 120 m. off-shore and between 60 and 150 m. in-shore) consisted of water of a temperature less than 5°C. and a salinity between 32.00‰ and 33.50‰. The deep waters (off-shore only, at depths between 70 and 200 m.) consisted of water of a temperature between 5°C. and 7.7°C. and a salinity between 33.50‰ and 34.72‰.

The upward trend in temperature of the surface or upper layers through the summer was the result of both the absorption of heat and the movement of warmer waters to the area, and was accompanied by the thickening of the upper layers. There was very little change in the salinity. The greatest change in the sub-surface waters took place in the intermediate layer. The coldest waters of this layer gradually disappeared from the area in such a manner as to preclude the possibility of their having mixed with warmer waters, thus indicating considerable movement.

As a result of the marked stratification, bottom and surface temperatures in the in-shore area fluctuated from week to week within fairly large ranges. In September a southwest gale resulted in the piling of surface waters in the vicinity of the coast, causing the bottom waters to recede outwards from the coast. The surface layer thus caused a rise in bottom temperatures from 2.0°C. to 14.0°C. within a week. Later, however, outside bottom waters moved in to displace the lighter surface waters and conditions returned to normal.

COMPARATIVE SURFACE WATER TEMPERATURES

A number of stations were established for the observation of the surface water temperatures at representative points along the Atlantic coast. The monthly means for August and February of 1931 for various points will illustrate the differences observed in general throughout the period of observation, 1929 to 1932.

	August	February	
Bay of Fundy, mouth	11.6°C.	2.2°C.	
head	14.1°C.	−0.3°C.	
South coast of N.S., Sambro	16.3°C.	0.5°C.	
Scatari	17.3°C.	−1.3°C.	(Ice)
Sable island	19.2°C.	1.5°C.	
Southern gulf of St. Lawrence:			
Entry island	17.5°C.		
North point, P.E.I.	20.0°C.		(Ice)
North shore, gulf of St. Lawrence:			
Cape St. Mary	13.8°C.		(Ice)

In general, the monthly mean is the highest for the month of August at all points although there is a tendency for the waters to be warmest in the early part of September in the bay of Fundy region. The waters are coldest in February at all points although where winter ice sets in it is usually hard and fast for the months of January, February and March. Stable conditions are seemingly to be found in the bay of Fundy region, for the plotting of the daily temperatures results in a fairly smooth sine curve. The plotting of the daily temperatures for the south coast of Nova Scotia points out the occurrence of some very abrupt changes. Such changes are to be noted also in plotting the daily temperatures for the north shore of the gulf of St. Lawrence. It is to be noted that the waters at the mouth of the bay of Fundy have the smallest range of monthly means and also the lowest mean for August and the highest mean for February. The main waters of the gulf of St. Lawrence have the greatest range of monthly means though not necessarily the highest monthly mean for August.

A. G. HUNTSMAN

FACTORS DETERMINING HERRING FISHERY

Analysis of the official monthly fishery statistics, of daily sales of fish from weirs, and of information furnished by fishermen leads to the following conclusions for the herring fishery of the bay of Fundy, and in particular of Passamaquoddy bay.

As a whole the weir catches go up with rising temperature and down with falling, and are practically nil during the coldest months—January, February, and March. This rule holds for individual years, taking the temperatures of the upper twenty metres of the water in the inner and outer parts of the Quoddy region. The extent of a definite spring fishery, most evident in eastern and western districts of Charlotte county, depends upon a rapid rise in temperature during April and May.

From growth studies the principal feeding season is believed to be from May to September. Corresponding with this there is evident a low period in the catch, most pronounced in July.

Low salinity of surface water interferes with capture, and absence of spring catches in St. John county is apparently to be attributed to low general salinity resulting from high spring outflow from the St. John river, reinforced by fresh water from coastal streams affected by spring rains.

Winds bring or remove the herring, depending upon the location of the weir, the ease with which the wind can determine movement of the mass of water, and the time of year. Particular sites are greatly dependent upon wind, which may even determine whether the fishery be in spring or in summer.

DISEASE IN EEL GRASS

Reports of a failure of eel grass, as food for certain game birds and as a material of considerable importance for insulation and for upholstering purposes, were made to the Atlantic stations, and a co-operative investigation resulted, in which the fishery inspectors assisted.

Extensive destruction of the root stocks antedating the current year's growth was found generally, except north of a line through Cabot strait, through Prince Edward Island from east to west and thence through New Brunswick. In water of the lowest salinity there was little or no damage anywhere. Winter killing was at first considered as possibly responsible for the destruction, but the facts of distribution failed to fit such an assumption, and experiments by Mr. Friedman designed to test it, were negative. Late in the season, the growth of the year became affected and there was extensive death of the leaves not only in the localities where damage had occurred previously, but also in the northern parts of Prince Edward Island and New Brunswick. Although no causative organism has been discovered, the indications are that a disease, previously existing in the south, and requiring high salinity and summer temperatures, has been spreading north.

C. E. KEARNEY

THE ANIMAL PLANKTON OF THE HALIFAX AREA

The macro-plankton furnishes a direct source of food for mackerel and herring. As the latter are eaten by the large commercial fishes, the plankton occupies an important position in the metabolism of the sea.

A comparison of tows taken monthly off the southeast coast of Nova Scotia, between Ship harbour and Lunenburg, during June, July, August, and the latter part of September and first week in October, showed that the waters of this region contained more plankton in June and less in August than during any other months of the summer, while a greater volume was taken in the September-October tows than in July. Both vertical and horizontal hauls showed the quantity of plankton to be greater in the Sambro bank region than elsewhere; and a greater quantity was found in the deep waters (upwards of 100 metres) than near the shore.

At a series of stations in the entrance to Halifax harbour, the greatest volume was taken in October while the least was taken in August.

Calanus finmarchicus, the dominant species in the plankton, was found to be present at all stations, and formed the bulk of the tows taken in the Sambro bank region. *Anomalocera patersoni* appeared on July 4, and was present along the whole coast from Ship harbour to Lunenburg and in Halifax harbour. *Meganyctiphanes* was found, during July only, north-west of Sambro bank.

Sagitta elegans was present at all stations, while *Sagitta serratodentata* was found only around Sambro bank and in the deep water (200 metres) northeast of the bank.

M. A. LANGSTROTH

A YELLOW COLORATION IN THE SOFT CLAM, MYA ARENARIA

Connors Bros., a large sea-food packing plant on the bay of Fundy, reported that the clams used were affected by a yellow coloration. Boiling increased the colour, which was alcohol soluble. The canning process also increased the colour, probably due to a chlorine oxidation.

The pigment was found chiefly in the epithelial cells of the mantle of the clam as aggregations of brownish yellow spherical deposits. The valve mantle, the siphons, and the groove between the valves ventrally were heavily affected. The gill filaments containing heavy deposits, the foot, labial palps, surface of the gonad and the heart were also affected. All pigment was found in ciliated cells as the parts affected were those exposed to the mantle cavity.

Clams with only a few hours' exposure each day were pigmented, while clams of approximately the same age from high up the beach with only a few hours' submersion would be free from coloration. It was therefore assumed that the time of exposure was a definite factor in the coloration of *Mya*. As the time of exposure regulated the size of the clams, those which were larger than the average

were all pigmented. No clams under four years of age were found pigmented, while seven and eight-year-old specimens were 100 per cent. coloured.

All coloured specimens examined had the mantle cells pigmented, then in decreasing percentages also the gills, foot, labial palps, heart and gonad. Parasites were found in nearly all affected specimens, but were considered commensal and an effect rather than a cause of coloration.

R. A. McKENZIE

SET HOOK EXPERIMENTS IN THE INTERTIDAL ZONE

These experiments were designed to test out at the mouth of the bay of Fundy (Passamaquoddy region) fishing methods found in use at the head.

Hooks attached with lines to stakes driven into the beach near low-tide mark were baited with clams and herring from February to June in Brandy cove and at St. Andrews point.

Until March 8, no fish were caught. Afterwards some were taken but only in Brandy cove and of the species *Pseudopleuronectes americanus*, *Myoxocephalus octodecimspinosus*, and *M. scorpius groenlandicus*, although at the time small pollock, small herring, eelpout, skate, red perch, cod and haddock were known to be in the vicinity in and about the cove as well as in thirty metres of water outside.

COD EGGS IN THE BAY OF FUNDY

This investigation to determine the time and localities of cod spawning, as well as the rate of development of the eggs, was carried on in conjunction with Mr. Michael Graham, who collected the material with another purpose in view.

It seems evident that little cod spawning took place before the middle of March. From that time on until the end of April considerable quantities of cod eggs were picked up in the tows made at certain stations. By that time, there is some evidence that the spawning was falling off slightly, for there were not quite so many eggs, in the earliest stage of development, collected.

The first eggs were collected about the mouth of St. Mary bay and up the outside of Digby neck about as far as Petit passage. Three days later a larger number of eggs was obtained in the Saint John to point Lepreau region where there had been none about a week previous. From then on until the end of April, as large or larger quantities were collected in these two areas every time each region was covered. A certain amount of spreading out occurred as the time progressed. The area inside of the line from the Lurcher to point Lepreau was fairly well covered, but little done close to Grand Manan.

THE HOLDING OF COD IN TANKS

These cod were taken by the investigators off the Eastern Passage Laboratory during the summer of 1932 and were kept in a cement tank about one and a half feet deep in a well-lighted room, east, north and west exposures. The fish were small, ranging in size from twenty-two to thirty-one centimetres in length and it is believed that they were in their second year.

During the two and one-half months (August to the middle of October) they were kept thus, the water temperature ranged from about thirteen to twenty degrees Centigrade. This latter temperature lasted for a day without apparently causing the fish any discomfort. Readings of eighteen were a quite frequent occurrence. The fish ate well even at these high temperatures. However, the temperature at which they seemed to feed best was fifteen. Clams were used as a continuous diet with no apparent bad effects. The normal fish fed by sight (all feeding done in daylight) while the totally blind fish became aware of its food by touch.

These fish were finally transferred successfully from Halifax to St. Andrews on board the "Zoarces". They were fed just before going aboard and they became

seasick within half an hour after. This might possibly have been due to the excitement caused in handling after being fed, but such had been done before without producing sickness.

THE INSHORE COD FISHERY OF THE HALIFAX AREA

Most of the fish are taken by hand-lines since the fishermen seem to find difficulty in finding grounds large and suitable enough for line trawling. This is a very different situation to that in the bay of Fundy.

This inshore cod fishery seems to be confined to the late spring, summer and fall seasons and reaches its height usually in the summer. A large part of the reduction in landings in the winter and early spring may be accounted for through bad weather curtailing the operations of the small boats, but it is also thought that the cod are scarcer in these inshore waters at this time.

Certain evidence and reports point to an eastward migration in May and June and a westward one in the fall, while the so-called "native" fish, which probably make up most of the catch in the early spring, late August, September and early October, as well as the small winter inshore catches, seem to merely move on and off-shore at certain seasons of the year.

East of Halifax cod with ripe and running spawn are exceptionally rare (possibly due to the early cessation of operations in the fall). Some cod with running milt and spawn are taken in November in Halifax harbour, and in St. Margaret bay there seems to be a definite, but not very large, run of spawning fish in late October or November.

WATER TEMPERATURE AND THE HADDOCK FISHERY (PROG. REPTS. ATL. 4)

Comparison of landings of the commercial fishermen and the experimental fishing with water temperatures as recorded for the bottom at intervals in the Passamaquoddy region shows no haddock experimentally and very very few commercially, being caught in water below 2.2°C. during the period 1925-1930 inclusive, irrespective of whether such cold water lasted one or six weeks or whether it occurred in January, February, March, or April. Other possibilities have been considered, but the water temperature relation seems to be the only one to fit all years.

The best catches per unit of experimental gear were made in water having a temperature of 7.3°C. to 10°C. while the biggest commercial monthly landings were made in months when the bottom temperatures varied from 4.5°C. to 8.8°C., or even to 10°C., considering some of the second best months.

While generally the catches decreased above 8°C., no definite upper limit can be set. At high temperatures, besides a general falling off in the catch, there was a tendency towards irregular high catches, although drag trawling revealed the fact that the haddock were still present and eating heartily, but not taking the variety of baits offered on the hook.

THE SALMON RUN DURING NOVEMBER AND DECEMBER IN SAINT JOHN HARBOUR

These fish prove to be Atlantic salmon (*Salmo salar*), possessing 9-11 anal rays, about 120 scales along the median lateral line, and vomerine teeth. They were reported off point Lepreau, Dipper, Chance and Musquash harbours before arriving in Saint John harbour, where the fishing took place (chiefly in the inner part).

Up to December 1 there was apparently only one school of fish, taken over a period of about three weeks (November 8 to 26) with the peak occurring in the second week (highest daily catch November 18). These fish were taken during a very high freshet and from the beginning of a set of moderately high spring tides until almost the maximum tides of the succeeding high spring tides. During the three weeks of fishing, the surface temperatures a short distance below the falls varied from about 4°C. to 7°C.

The fish averaged about 9.3 lb. (6.25 to 18 lb.) with the daily average weight dropping towards the last of the run.

About eighty per cent. of these fish were females; no males at first but latterly constituting about forty per cent. The gonads were in an early stage of development and the ovaries were about ten centimetres long with distinguishable yellow eggs tinged slightly with orange. The fish were very fat, and with empty stomachs (with three exceptions).

THE SWORDFISH FISHERY OF THE HALIFAX AREA

According to landing averages for a recent series of nine years, the season begins about July and reaches its peak in August. In Lunenburg the last fish are landed in September, but in Halifax county it lasts into October and even November. This season corresponds with the idea that they "strike" in towards the gulf of Maine in May or June and work up along the Scotian coast after that. These fish range in size from about sixty pounds up to four hundred pounds dressed.

All reports agreed that spawn had never been seen in a swordfish, except one man reported having taken a female with spawn in it off Ingonish, Cape Breton, in 1932.

THE TUNA (TUNNY) OR ALBACORE FISHERY OF THE HALIFAX AREA

In Lunenburg county west the first fish during the season are landed in July, the peak is reached in August and the last are landed in September. In Halifax county west and Lunenburg county east, the first fish are landed in June, the peak is reached in July and the fishery drops off rapidly to zero by November.

Fish smaller than fifty pounds are rarely if ever taken. There are two classes, "jumpers", weighing from fifty to one hundred or a little better, which are quite numerous, and large tuna (four hundred to seven hundred pounds). None are reported as having spawn.

THE HERRING FISHERY OF THE HALIFAX AREA

In many ports the cod fishery begins in the spring with the arrival of the first run of herring. A run of spawning occurs as a rule in May from Halifax eastward, increasing in magnitude somewhat as one goes towards the east. These fish, about nine to eleven inches in length, run well up into the stream mouths, coves and bays to spawn over soft bottom in shallow water. A similar but very small run occurs at certain points in the head of St. Margaret bay. Westward from Halifax around the Sambro peninsula and up into St. Margaret bay, there is a spring run of small "bait" herring which seems to decrease in size from six to nine inches about Chebucto head, to three to five inches at French Village, where they are said to be too small for bait.

A run of large "bank" herring, which stay off shore about six miles or farther, was reported from Halifax westward.

Throughout July, August and into September as a rule there is a run of fat "number ones" reported from almost all over the area. These fish are thought to spawn in the eastern part the latter part of September and somewhat earlier toward the westward.

From the summer, on late into the fall as a rule, they report numerous schools of small herring to be seen inshore at various places from Halifax west. These fish are just too small for the usual size mesh of net.

N. A. McNAIRN

HERRING RACES OF THE BAY OF FUNDY

Fundy herring for the most part spawn in summer or fall and at the mouth of the bay or on the Nova Scotian side. Spring spawning herring occur in small numbers at the head of the bay, and at the head of St. Mary bay.

Work on racial characteristics shows that there is a slight difference in the numbers of dorsal fin rays and of keeled scales of spring herring from King's county as compared with those from St. Mary bay.

R. H. M'GONIGLE

DISEASES OF TROUT AND SALMON EGGS AND FRY

Outbreaks of mortality in the early spring of 1932 at several of the hatcheries were associated with (1) imported or shipped eggs; (2) pond or native parents.

The first of these comprised the most important outbreaks, and included both Atlantic salmon, brook and lake trout. These outbreaks occurred *only* in eggs shipped "eyed" never in eggs shipped "green". This did not occur only in eggs imported from other countries, but also in "eyed" eggs transferred from one hatchery to the other. It was interesting that those transferred groups which did badly came from apparently healthy stock, which continued to do well in the parent hatchery. Further, all groups so transferred did not do badly. It seems indicated that some unfavourable influence is imposed upon these eggs in the shipping—either chilling, or drying, or both. These outbreaks are nearly all associated with a population curve falling very slowly week by week, but gradually getting steeper (slowly increasing mortality) until finally an almost explosive mortality occurs—always after hatching.

Those of the second group form a quite different type of case. The mortality begins early and is very heavy, gradually decreasing to approximately none. This, it is suggested, is associated with poor parent stock, or with (possibly, not probably) some failure in securing the eggs.

It would appear, for both types, however, that there is no possibility of either of these sorts of eggs ever successfully producing a large proportion of normal fish, no matter how good their later treatment may be.

J. M. MORTON

CHEMICAL INVESTIGATIONS OF SEA WATER IN THE HALIFAX AREA

Phosphate investigations are of importance (1) in connection with the quantitative study of phytoplankton, since the amount of available phosphate may become one of the limiting factors for plant growth; and (2) in the study of water movements and mixing of water.

Owing to the presence of Mr. T. Braarud, of Norway, at St. Andrews, it has been possible through interchange of samples to tie up this work, within the experimental error, with that done on the other side of the Atlantic.

In general there is a decrease in the amount of phosphate in the top layers as the summer advances. This decrease is due, either to depletion brought about by consumption by phytoplankton or to an inward movement of water, poorer in phosphate, from the open sea. This summer the weather conditions were rather uniform throughout the summer and no violent storms were experienced until early in September, at which time there were several very strong gales from a general off-shore direction. The effect of these gales is shown strikingly by the piling up of a large body of characteristic surface water particularly at near-shore stations. Also the water formerly at the bottom (high in phosphate) has been pushed offshore and downwards by this inward surface movement. Two weeks later, on September 26, water low in phosphate was still present at the near-shore stations. At the off-shore stations at the lower levels conditions had begun to revert to normal, *i.e.* the water rich in phosphate was returning.

Some preliminary work has been done on the amount of dissolved oxygen. The results are in agreement with the phosphate determinations, namely, that wherever phosphate was depleted, or nearly so, the oxygen was high, but in places where the phosphate values were highest the oxygen was lowest.

A. B. NEEDLER

SEX REVERSAL IN OSTREA VIRGINICA

Samples of the oysters from a bed near the Prince Edward Island Marine Station, planted with spat in 1929 have been examined each year and it is found that the proportion of females to males has been increasing: Spat settled on

these oysters in 1930 and the proximity of older females seems to have retarded a change of sex in the two-year-old oysters since they have a very small proportion of females. This supposition was supported by examining oysters from other beds planted in 1930 and finding a ratio comparable with that found in 1931 among the oysters planted in 1929. That the difference in sex ratios is not caused by under-nourishment due to overcrowding was shown by comparing the rates of growth on the various beds.

In 1931 some 200 oysters of known sex were marked, 58 survived and the sex could be determined in about 30. Of these, four had changed from male to female and five from female to male. That more changed in the female to male direction may be explained by the oysters having been kept under somewhat unfavourable conditions. Finally, the sex was determined in about 250 oysters which are being kept in various relative positions for examination in 1933.

A. W. H. NEEDLER

HYDROGRAPHY OF MALPEQUE BAY AREA; WINTER CONDITIONS.

A consideration of data throughout the winter from a station close to the Prince Edward Island Marine Station in Bideford river in the years 1930-31 and 1931-32 has shown the following conditions: when the water is cooling in the autumn the salinity and temperature are nearly uniform from surface to bottom. The water cools to the freezing point for the existing salinity (close to 30 per mille), although ice may be formed on cold nights when the temperature is above the freezing point at the bottom and may be maintained, if cold weather continues, when the surface water is above the freezing point. After the ice is formed stratification occurs to a degree never approached (except very temporarily after heavy rains) in the summer, the surface water being often below 5 per mille and the bottom water close to 30 per mille at a depth of 15 feet. The surface water now warms to the freezing point of this lower salinity and the bottom water tends to become warmer—being above its freezing point (though, of course, below 0°C.) sometimes as much as 1°C. for most of the winter. The ice may last in the spring for many days after the surface temperature is above the freezing point, the surface water apparently being warmed in the open spaces towards the heads of the creeks where the ice disappears first.

COLLECTION OF OYSTER SPAT; IMPROVEMENTS OF METHODS OF EXPOSING CULTCH

Brush—In previous trials brush (a plentiful, cheap material) newly placed in the water failed to catch a significant "set", while brush (birch and alder) which had been in the water for a year collected an abundance of spat. This year brush (both green and dry) placed in the water several weeks before the setting time, part of it left in place and part removed for a week just before the time and returned to the water at the same time as near-by shells which obtained a good "set", gave practically no "set". Brush in the water since 1931 collected more spat, but still far from a commercially valuable catch. The unusually luxuriant growth of slime this year probably influenced the results adversely.

Cardboard collectors—developed in United States oyster areas, somewhat similar to egg-crate partitions and consisting of eight pieces 4½ in. square interlocking with three pieces 4½ in. by 13½ in., dipped in a mixture of lime cement and sand, were tried. When placed along sheltered shores just below low-tide level, good "sets" were obtained, but surface was lost by partial burying and there were losses through starfish. When floated below copper-painted boards these losses were avoided. About 1,000 spat from 0.5 to 3 cm. long could be separated from each collector at the end of the season. Cheaper methods of suspending the collectors from floats have been devised and will be used next year.

Floats for shells in wire bags—constructed by fitting a wooden frame over two puncheons, were made to support 65 bushels of shells each. The same bushel

bags of galvanized netting were used as have been regularly in use stooked along the shore just below low-tide level. It was found that a much more abundant "set" was obtained on the bags on the floats. Other advantages include: complete protection from starfish which cause serious damage to spat on the stooked bags; less labour in placing bags on the floats than in stooking and possibility of doing so at any tide; no loss of shells through resting on the bottom; no loss by sanding up in storms; somewhat faster growth leading to better winter survival. These advantages, together with the better "set", combine to make the floats a great practical improvement, if confirmed by a repetition of the comparison.

The advantages of freedom from starfish, from sinking in the bottom, and probably of greater abundance of spat and better growth would apply equally to any floating cultch as compared with the same material put out along the shore. The above floats, which have a buoyancy of about 1800 lb. and cost about $10.00 with a probable life of several seasons, can be adapted to a variety of cultch materials.

IMPROVEMENT OF MUD BOTTOMS WITH SAND FOR OYSTER CULTURE (PROG. REPTS. ATL. 5)

Most of the bottom in those areas in our waters where suitable hydrographic conditions for oyster culture are to be found consists of very soft mud. In the course of early trials it was found that coarse materials, such as shells, sink into the mud which oozes up between them. Sand was tried in the hope that a continuous layer of tough muddy-sand (such as is found in the transition from sand to mud on shores) would be formed.

A plot of mud, soft to a depth of five feet, about 25 feet square was covered with six inches of sand in 1930. Though at first loose, the surface thus formed became firmer until in a few months it was difficult to push a pole through into the soft mud beneath. The bottom remained firm in the summer of 1932 when a layer of clean shells about four inches thick was spread on it. The bottom now felt definitely hard and would compare favourably with average oyster beds. A good "set" of spat was obtained on the shells and showed a normal survival.

Three plots of similar size and of similar soft mud were coated with 3, 6 and 9 inches of sand in 1932. Present indications suggest that the 9-inch layer is not sufficiently better than the 6-inch to pay, and that the 3-inch layer is almost sufficient. Trials of the survival of spat on shells, and of oysters, planted directly on the sand, are in progress.

ELIMINATING STARFISH AND OVERCROWDING IN OYSTER BEDS

It has become apparent that serious losses (up to 100 per cent.) are to be expected in the first year and a half if starfish are not removed before planting spat. A modification of the method of mopping for starfish used in the United States has been used with success, but is expensive. The use of a trough of water heated by the exhaust of the boat's engine has doubled the efficiency by killing the starfish and greatly reducing the time otherwise used in removing them from the mops.

When losses from starfish are eliminated and spat have been planted on firm bottoms late in the season a good survival has been obtained, as in rapid transfer of spat and small oysters from the head of the "river" to beds closer to the open. However, when several spat occur on a shell or on a piece of a cardboard collector, those on the lower side smother usually when planted and those on the upper side grow together into a cluster producing in the oysters a shape of low value. When a good "set", then, is obtained on shells it is necessary to lift and separate the oysters when one (preferably), two or three years old.

When several spat are present on a square inch of cultch surface there is only room for one to grow for a year or more, and without separation all the rest are lost. Unless shells (used as cultch) are in an advanced state of disintegration, such separation is a practical impossibility but it is easy with the cardboard col-

lectors. Trials are in progress in which separated spat from the collectors are to be reared on trays on floats to the end of the second season, thus avoiding loss from overcrowding, or smothering in silt, and from starfish.

THE OYSTER SITUATION IN THE CHARLOTTETOWN REGION

Further exploration of the channels in the Charlottetown "rivers" failed to discover more supplies of small oysters and confirmed the previous findings of almost barren, hard, rocky bottom in the lower reaches and only limited areas towards the head of the deep water with an abundance of small oysters.

Oysters transplanted in the autumn of 1931 from the deep water of Hillsborough river to Savage harbour showed a very good survival and growth to the autumn of 1932. They spawned, although the area where they were planted is in the open bay of Savage harbour; and there is every indication of the efficacy of these oysters for establishing oyster farming in the north shore inlets. The limited quantities, however, will probably eventually force reliance on local production of spat in the north shore inlets.

An attempt was made to collect spat in Hillsborough river for transplantation to Savage harbour, to test the value of this method of obtaining stock for the north shore inlets. But, although temperatures were favourable and the oysters spawned and the cultch (shells in wire bags) was apparently placed in the water at the correct time, only small catches of spat were made and the growth was small. What was obtained was planted in Savage harbour.

C. L. NEWCOMBE

GROWTH OF THE SOFT-SHELLED CLAM, MYA ARENARIA

A. *Bay of Fundy*

(1) The population of the commercial clams beaches is characterized by (*a*) paucity of small clams representing set of 1928, 1929 and 1930, (*b*) an abundance of small clams (1931 set) commonly numbering 200 to 400 per metre square area and, on some flats (*e.g.* Sissiboo river, N.S.) as high as 6000, (*c*) dominant length classes ranging from 40 to 65 mm. (age range about four to eight years).

(2) The fluctuations in number of clams (above 20 mm. in length) observed on normal beaches are from about 100 to 400 per metre square area.

(3) Study of the annual rings shows that growth activity per unit of length exhibits a marked decline with increase in age from a very early period on. Averages obtained from measurements of rings of four samples from widely separated beaches are: ring no. 2, 19.5; no. 3, 31.3; no. 4, 41.7; no. 5, 49.8; no. 6, 56.9; no. 7, 63.0 mm.

(4) During 1931, approximately 90 per cent. of the total growth obtained in planting experiments took place from about May 1 until September 1. The amount of growth during the "spring" seasons of 1931 and 1932 was essentially the same, whereas in the case of the "summer" periods a slight decline was shown during 1932.

(5) Of the plankton constituents of the stomach contents of *Mya arenaria*, diatoms have been found to be most abundant, zooplanktonts, chiefly tintinnids, playing a less important food rôle. The diatoms taken in by the clam are in the main bottom forms which also occur frequently in the plankton, and neritic species.

B. *Bideford river, P.E.I.*

(1) The clam population (apart from the set of 1931) numbers between 200 and 300 per metre square area, thus corresponding with the population of normal clam beaches of the bay of Fundy.

(2) The amount of growth during the "summer" and "fall" seasons of 1932 was approximately the same in contradistinction to the bay of Fundy, where, during 1931, "summer" growth clearly predominated. During the "summer" period the amount of growth was nearly double that occurring at Clam cove,

N.B., where the average daily water temperature was about nine degrees less than in the P.E.I. area, namely, 11 degrees centigrade.

J. V. V. NICHOLLS

THE EFFECT OF TEMPERATURE VARIATIONS AND OF CERTAIN DRUGS UPON THE INTESTINAL MOTILITY OF ELASMOBRANCH FISHES

Raja diaphanes and *erinacea* alone were used, circularly cut strips being taken from the upper and lower ends of the spiral intestine and valve, and from the colon and rectum. The contractions which appeared within an hour or two were recorded on a slowly moving drum. As soon as they were well established, the temperature was lowered slowly until they ceased at the lower limit, and then raised about 20°C. in from six to seven hours.

(1) A rise of temperature causes an increase in the rate of contraction of all parts of the intestinal tract.

(2) The upper temperature limit at which all contractions cease is about 24°C. for all parts and the lower limit is about 2°C. for all parts.

(3) The upper end of the spiral intestine has the same rate of contraction as the lower end, whereas the upper end of the spiral valve has a more rapid rate than the lower end. The colon and rectum only give spontaneous spasmodic contractions at intervals of about half an hour.

(4) Alvarez's theory of gradients in the gastro-intestinal tract is supported by the results of these experiments.

(5) Adrenaline stimulates all parts of the intestine, though on two occasions inhibition occurred in the spiral intestine.

(6) Pilocarpine stimulates all parts except the spiral valve, where the effect is very doubtful.

(7) Acetylcholine stimulates all parts of the intestine.

(8) Atropine has no effect by itself on any part of the intestine, but counteracts the effect of pilocarpine and acetyl-choline.

(9) It is concluded that the intestinal tract of the skate has a well-developed sympathetic and parasympathetic nerve supply.

THE SURVIVAL TIME OF TISSUE KEPT AT VARIOUS TEMPERATURES

In determining physiologically the survival time of fish tissue at different temperatures, skates of the species *Raja diaphanes* and *erinacea* were used because of their hardiness, strips of musculature being excised from the central region of the stomach.

Three series of experiments were carried out. (1) One set of strips of gastric musculature was kept in nutrient saline at 0°C., and others at 5°C., 10°C., 15°C., and 20°C. respectively. (2) Four sets of starved fish were killed, one set being kept at 5°C. and the others at 10°C., 15°C., and 20°C. respectively. (3) Four sets of freshly caught fish were killed and kept at 5°C., 10°C., 15°C., and 20°C. respectively.

The survival time of strips taken from the antrum of the stomach in these three series of experiments was the same for each temperature, viz., at 0°C. 324 hours, at 5°C. 132 hours, at 10°C. 50 hours, at 15°C. 38 hours, at 30°C. 30 hours.

These results were interpreted according to the R.G.T. rule. Thus Q_{10} between 293° and 283° absolute = 1.66, between 288° and 278° absolute = 3.47, and between 283° and 273° = 6.48.

It was concluded that the autolytic process is more important than the bacterial in the causation of tissue death.

There seems to be a very definite critical point in the processes leading to tissue death, after which they become much more rapid.

E. S. PENTLAND

EXPERIMENTS WITH SALT-WATER AMPHIPODS

Solutions of varying salinity were prepared by diluting sea water with fresh water. Tap water was first used for these dilutions but proved toxic, and was

replaced by spring water in later series. In solutions containing tap water it was worthy of note that death of the females occurred considerably sooner than of the males. In solutions prepared with soft spring water, *G. annulatus* showed the greatest resistance to low salinity, *G. marinus* next, and *G. locusta* least. A single experiment carried out with *Calliopius laeviusculus*, a form found in the more open waters, showed it to have much less resistance to low salinity than any of the three species of *Gammarus* studied.

At laboratory temperatures, eggs of *G. marinus* hatched in from thirteen to fifteen days after fertilization, the young remaining in the brood pouch for from seven to twelve days after hatching. At six to eight degrees centigrade the time of hatching was extended to thirty-three and thirty-four days.

In the laboratory the time of hatching of the eggs of *G. annulatus* was nine days, and the young remained in the brood pouch for only one or two days.

Three *G. annulatus* at forty-three days measured 2.9; 2.9; and 3.3 mm. respectively. Young of *G. marinus* varied in length from 2.6 mm. at seven days to 4.1 mm. at fifty-seven days. Sufficient measurements were not obtained to give a smooth curve, but such data as were obtained indicated a fairly uniform growth for the first three weeks, after which greater variation in the size at the same age occurs, although the general trend is still upward.

In two cases the period between moults was determined, for a female *G. annulatus* ten days, and for a female *G. marinus* twenty-eight days.

W. R. SAWYER

LIGHT IN RELATION TO WATER

Light penetration into natural waters. A comparison was made of the absorption coefficients of bay of Fundy water obtained by lowering a photronic cell into the sea and those obtained by measuring the transmission of light passing through the same water contained in a tube in the laboratory.

Heating of natural pool by solar radiant energy. The daily water temperatures obtained by Dr. M'Gonigle with a thermograph placed in McCullough's brook have been studied in relation to total solar radiant energy received, daily measured by means of an integrating solarimeter and the data examined to date show an approximate straight line relationship.

EFFECTS OF LIGHT ON AQUATIC ORGANISMS

Effect on growth in Balanus balanoides. The work of Klugh and Newcombe of the previous summer was repeated in cooperation with Mr. Newcombe, using a more satisfactory method for measuring the light intensities (the Weston photronic cell was employed in place of the Bell-Howell photometer). The previous results were confirmed, namely, that light has an adverse effect on the growth of *Balanus balanoides*.

Photosynthesis of diatoms. With the exception of the light factor most of the requirements for abundant growth of diatoms in the bay of Fundy have been studied and found adequate. In experiments carried out to study the light requirements for photosynthesis, an optimum intensity of light was observed and blue and red light were found more efficient photosynthetically than green.

Photosynthesis of Cosmarium. The rate of photosynthesis (measured by oxygen output) was studied in light of different intensities and different colours. The maximum rate of photosynthesis was observed to take place in a light intensity of about five per cent. of that of June sunlight. The photosynthetic activity was greatest in the red and least in the green.

M. W. SMITH

A BIOLOGICAL SURVEY OF LAKE GEORGE, YARMOUTH CO., NOVA SCOTIA

In cooperation with Dr. R. H. M'Gonigle, a survey was made of lake George on September 10 and 11, 1932. The water of the lake supplies the nearby

hatchery. It has been considered that a reputed richness of plankton in the lake water, and probably its higher temperature, are responsible to a considerable degree for a more rapid growth of fish fry, as compared with other hatcheries of the maritimes. In addition, one or two of the islands in the lake are used by gulls early in the season for nesting sites, and their excreta, etc., are presumed to have a fertilizing effect upon the water.

(1) The water was found to be unstratified with temperatures of 17.0° and 16.8°C. at surface and bottom respectively. The shallowness (12.5 metres was the maximum depth found) and the exposure to wind action give warm water throughout.

(2) The zooplankton was not rich, being below the average found in other maritime lakes, but the phytoplankton was well above the average and was unique, for, upon examination, it was found to consist almost entirely of a desmid, *Xanthidium* sp.

3. The littoral fauna was quite poor. Killifish, sticklebacks, eels (very abundant) and sunfish, but practically no game fish, make up the fish population.

PLANKTON IN THE CHAMCOOK SERIES OF LAKES

A comparison was made in the amount of plankton secured in the early parts of June, July and October for the three years, 1930, 1931 and 1932, and considerable fluctuation was apparent. Welch lake, which is the highest in the series, showed a similar seasonal fluctuation for the three years, the amount of plankton being high in the spring, low in mid-summer, and then increasing somewhat in the fall. In Gibson and Second Chamcook lakes this seasonal fluctuation was more irregular. In contrast to Welch lake, the amount of plankton in these two lakes in mid-summer was more equal to that found in the spring. This may be due to the more or less continual circulation of the water in these two lakes throughout the summer, and possibly to the fertilization of Gibson lake in 1930 (Second Chamcook lake receives the drainage from Gibson lake). There were indications that the marked yearly fluctuations in these two lakes might also be a result of this fertilization.

THE FERTILIZATION OF WATER IN EARTHEN PONDS

One of two earthen ponds, each containing approximately 12 cubic metres of water, was fertilized with one-third of a pound of herring meal on June 27, 1931.

It was shown by both qualitative and quantitative observations that this degree of fertilization was effective in increasing both the plant and animal production in the fertilized pond, as compared to that in the unfertilized in the second season (1932) as well as in the first season, as already reported.

THE FERTILIZATION OF WATER WITH INORGANIC SALTS IN SMALL CONTAINERS

I. Experiments were carried out to determine the effect of various nitrogen (as nitrate) and phosphorus (as phosphate) concentrations (5, 50, and 500 milligrams per cubic metre) on algal growth in water in paraffined and stoppered flower pots, sunk in the ground to within an inch of the top. Some of the pots were shaded from the direct sunlight.

(1) Species of the genus *Scenedesmus* and species of diatoms were the dominant forms.

(2) There was in general a decided increase in the production in the unshaded pots from the lowest to the highest concentrations of salts. This was especially apparent with the growth of *Scenedesmus*.

(3) It was not demonstrated in any of the pots whether nitrates or phosphates were more efficacious in equal concentrations. Neither could a regular difference be shown between their potassium and sodium salts.

(4) There was a decided difference between comparable pots in the open and in the shade in their production. For instance, the unshaded pots produced

approximately 75 times the number of *Scenedesmus* and also approximately four times the number of diatoms found in the shaded pots.

(5) In the shaded pots, also, there was a general increase in production from the lowest to the highest concentrations of salts, but decidedly less in degree.

II. Experiments to determine minimal requirements of algae for phosphates and nitrates in fresh water were conducted in vials containing 10 cc. of solution, and suspended just below the surface of the sea to obtain uniform temperature. Molisch nutrient solution was used, increasing either the phosphates or nitrates from 0 to 500,000 milligrams per cubic metre of these as phosphate phosphorus and nitrate nitrogen in series of 20 vials each. They were inoculated with a species of *Cosmarium*.

(1) The inoculation proved not only to consist of *Cosmarium* but also of *Scenedesmus*, *Ankistrodesmus* and pamelloid forms.

(2) There was considerable production in the lowest concentrations of nitrate used (0.5, 1, 2, etc., milligrams of nitrate nitrogen per cubic metre). This demonstrates perhaps that, in such a nutrient solution, algae are able to utilize a nutrient salt, even when present in very small concentrations, to complete exhaustion.

(3) The highest production of plants was in the vials containing the greatest concentration of salts. The increase in production with increasing concentration of nitrate was not regular.

J. A. STEVENSON

GROWTH IN THE GIANT SCALLOP

During the summer of 1932 samples of scallop shells from L'Etang, Grand Manan, Digby and Chester were examined with a view to determining the growth-rate under the different conditions obtaining in these districts, use being made of the "rings of growth", which, on the basis of the evidence accumulated, would seem to be annually deposited in mid-winter.

(1) On this basis the maximum age reached by the scallop is at Chester 15, at Digby 12, at Grand Manan 12, and at L'Etang 13 years. Generally, scallops with more than eleven rings were rare.

(2) The age at which scallops in different areas attain the legal size of four inches, as shown by the number of rings between the umbo and a point four inches away on the median line of the shell, was found to vary from 6 (L'Etang scallops) to 3.6 (Grand Manan scallaps), but averaged 4.5 years for all areas considered.

(3) The distances between the rings indicate that on the average the growth-rate increased until the third ring was formed, and decreased rapidly afterwards. L'Etang scallops showed the slowest, yet the most sustained growth-rate. Chester scallops apparently grew very fast at first, but later their growth-rate decreased considerably, though not as much as in Digby and Grand Manan specimens. Higher temperature seems to be associated with slower growth.

SQUID (LOLIGO PEALII) AT ST. ANDREWS, N.B.

Advantage was taken of the fact that squid in large numbers were being caught almost daily during the summer in the newly erected station weir to make a study of their occurrence and condition.

The squid first came close enough inshore to be caught in the weir about July 11. The numbers caught daily increased until August 15, then diminished to September 6, after which none was taken. During the whole of this period they were engaged in spawning, a fact indicated by the presence of fully matured ova and spermatophores within the specimens at all times during July, August, and early September. No periodicity in spawning activities, corresponding to the phases of the moon, was observed.

During the summer, 922 squid were opened for sex determination. The ratio of all the males to all the females was found to be 3.13: 1.00.

An attempt was made to determine the growth-rate throughout the summer; but it was found that the length-frequency curve of any one sample showed only one peak, with no definite length-groups. However, it was noted that the peak in a large sample taken on August 26 was approximately 5 cm. ahead of that of another large sample obtained on July 30.

The stomachs of 723 squid were examined for food content. The vast majority were empty; but some contained the remains of fish, particularly herring, and one was crammed with pieces of squid flesh.

A larval cestode parasite, identified by Dr. Baylis of the British Museum as *Phyllobothrium loliginis* (Leidy 1887) was found to be present in the digestive tracts of 18.38 per cent. of 544 males, and of 17.49 per cent. of 223 females that were examined. The infested squids showed no apparent symptoms of distress. Linton (1922) considered that this cestode was the same as one described by him as *P. tumidum*, which occurred in the adult form in certain sharks.

H. TAIT

EXPERIMENTS IN FEEDING LIVER EXTRACTS TO BROOK TROUT

Since fresh meats are the best single food for feeding trout artifically, they obviously contain the essential elements of a complete food, so preliminary fractionations of beef liver, one of the best of these meats, were performed to attempt an isolation of these elements.

Eight diets, as follows, were fed in duplicate to separate groups (30 each) of brook trout (*Salvelinus fontinalis*) for ninety-five days: (1) acetone extract of liver + 75% dry buttermilk, (2) alcohol extract of the acetone residue + 75% dry buttermilk, (3) residue of acetone and alcohol extractions + 75% dry buttermilk, (4) .9% saline extract + 75% dry buttermilk, (5) residue of saline extract + 75% dry buttermilk, (6) untreated liver 25% (estimated dry) + 75% dry buttermilk (control), (7) 40% dried lung, 20% gelatine + 40% dry buttermilk, (8) 80% dried lung + 20% gelatine.

The amounts used in the first five diets correspond to that derived from amount of liver equal to the 25% liver used in the control.

No diet was so successful as the untreated liver control, which suggests that the essential elements are either of entirely different nature and widely distributed, or else extremely labile and intolerant of manipulation.

Three distinct phases, which appear in all curves, have been named preliminary increment, maintenance and terminal decline. An analysis of each diet curve follows in order of favourability of diet, using for the various diets the numbers already given.

(6) Slow increment; rapid maintained incline; slight terminal flattening. (Temperature (?)).
(5) Poor increment; steady increase; slight terminal decline.
(1) Good increment; fair maintenance; slight terminal decline.
(4) Poor increment; slow steady increase; no decline.
(3) Best increment; no maintenance; rapid decline and early death.
(2) Poor increment; bare maintenance; slow decline.
(7) Poor increment; early decline; further increment and second decline.
(8) Almost no increment; bare maintenance; rapid decline and early death.

W. TEMPLEMAN

SIZE AT MATURITY, BODY PROPORTIONS AND WEIGHT IN THE LOBSTER

Departmental regulations for lobster protection are frequently based upon size, and are aimed to ensure maintenance of the stock through protection of at least a proportion of the breeding individuals.

Size at maturity. Maturity is most easily recognized in the females by their carrying eggs, but mating experiments at Pt. du Chene indicated that the sexes are approximately equal in size at first maturity. First female maturity given in the following.

In Northumberland strait (Pt. du Chene) 7.2 in. long (3 to 4 years old, weighing 7 oz.); eastern Nova Scotia (Canso to Liscombe) between 7.5 and 9 in.; Grand Manan (colder water), mouth of bay of Fundy, 14 in. (probably at least nine years old, and weighing 44 oz.).

Body proportions. In mature males the claws are disproportionately large as compared with females and the immature, while in mature females the abdomen is relatively quite wide and deep, and the carapace is relatively short.

As a consequence, large claws make mature males heavier than mature females of same length, and heavier than both immature males of the same length and also mature males that have attained maturity later (*e.g.* 14.5 in. Pt. du Chene male 20 oz. heavier than 14.5 in. Grand Manan male); similarly the Grand Manan female has a considerably narrower abdomen than the Pt. du Chene female; also the shorter carapace in females means that proportionately more of them are returned to the sea than of males, where a carapace size limit is in force as in Charlotte county.

MOULTING AND GROWTH IN THE LOBSTER

The weakness, and the watery condition of the meat in lobsters at, and for a time after, moulting makes the study of this process of particular importance from both fishermen's and canners' standpoints. Also it is the time at which increase in size or growth occurs.

Time of moulting. In Northumberland strait (Medea rock, Shediac bay) immature males and females began to moult on July 5, and a week or two later the mature males, but no mature females even by July 20, when fishing ceased. In retaining floats mature males moult much earlier than mature females and shell conditions at start of fall season indicate several weeks later moulting in the case of mature females compared with males of equal size. A second general moult of 5½ in. to 9½ in. males and 5½ in. to 8¾ in. females occurred in late August and early September.

At Grand Manan moulting was found only by August 15, and by fishermen's accounts of softness of shells of some lobsters on November 15 (opening of season), it is probably not over before at least September 30, which is too late for a second moult among smaller lobsters of commercial size.

Moulting and the fall season (*Northumberland strait*). At beginning of season (August 16), 95 per cent. of the females and 50 per cent. of the males over 9 in. long had shells not well hardened, and the percentages were particularly high in offshore, deep water. The second moult of the smaller lobsters caused decreased catches in early September, and increased catches by middle of September and of soft-shelled lobsters. Catches in offshore and deep waters, with few small ones, are relatively unaffected by this second moult, and the shell condition of the lobsters over nine inches improves as the season advances.

Growth. Determined by carapace measurements before and after (constant length after three hours) shedding the old shell, and considered as percentage increase in carapace length.

At Pt. du Chene 110 lobsters showed growth varying from 9 to 17 per cent. when of the same size. Males showed growth decreasing from 13.5% at 5.6 in. to about 11% at 11 in., while females after maturity at 8 in. showed growth decreasing more rapidly to 7% at 9.6 in. Lobsters held in retaining floats showed less growth than the above, since receiving little or no food.

At Grand Manan about 70 lobsters from pounds showed similarly a greater decrease in growth with increase in size in females as compared with males, but beginning at a larger size than at Pt. du Chene, owing to delayed attainment of maturity.

MATING IN THE LOBSTER

Previous workers have argued that mating in the lobster may take place in the hard-shelled condition, although no definite records of mating when the female

lobster was hard-shelled and only four when the female was soft-shelled are on record.

Mating experiments were carried on at Pt. du Chene in July, August and September, 1932. The mating process was observed 24 times and definite attempts at mating for an additional 29 times. Successful mating was only accomplished by fairly hard-shelled males and very soft-shelled females. Seventy-seven per cent. of the hard-shelled male lobsters placed with females 0 to 3 hours out of the old shell mated with these females. This percentage decreased until with females 11 to 20 hours since moulting only 29 per cent. of the males mated. The latest mating was with a female which had moulted 16 hours previously. Twenty-four hard-shelled males placed with females which had moulted from 18 to 85 hours previously spent an average of 54 minutes in the presence of the females without mating, although in 23 cases of mating of hard-shelled males with females from 0 to 16 hours since moulting, the average time between the placing of the male with the female and mating was 13 minutes.

The greatest percentage of successful matings took place when hard-shelled males slightly larger than the soft-shelled female were used. Males very much smaller than the female were unable to roll the female over while males very much larger than the female rarely attempted to mate.

EGG EXTRUSION AND HATCHING IN THE LOBSTER

The problems connected with the berried lobster and the larval lobster are among the greatest that confront us in the task of increasing or conserving the lobster supply. A general idea of the variations in numbers of berried lobsters and in the time of laying and hatching of eggs on different parts of the coast is a necessary preliminary to more intensive work on the larvae.

Proportion carrying eggs. During 20 days' special fishing at Pt. du Chene, N.B., in July, 1932, among 600 lobsters caught 32 were berried, while during 20 days' special fishing at Grand Manan, August 1 to 20, a catch of about 500 lobsters gave not a single one berried. Fishermen's catches at Grand Manan in early June showed an average of about one berried lobster to every two or three hundred lobsters caught.

Time of hatching. At Pt. du Chene (representing the western and warmer part of Northumberland strait), among 15 berried lobsters taken between July 1 and 14, four had eggs hatching or hatched; among 15 berried lobsters taken between July 17 and 20, 11 had eggs hatching or hatched; on and after August 24 none found with old eggs. At Cape Tormentine in eastern Northumberland strait from deep water, a berried lobster with old eggs ready to hatch was taken as late as September 22.

Time of extrusion. At Pt. du Chene, first lobsters with new eggs were taken on July 17 and July 20. In retaining floats at Pt. du Chene extrusion occurred a month earlier than in pounds at Grand Manan.

Interval between moulting and egg extrusion. At Pt. du Chene both old-shelled and new-shelled (recently moulted) lobsters were found bearing new eggs, while at Grand Manan only those that apparently had not moulted for one or two years were so found.

MIGRATIONS OF THE LOBSTER

Sixty-five returns from the 950 new-shell lobsters tagged in 1931 at the Magdalen islands show that lobsters tagged in House harbour, Grand Entry and Basque harbour lagoons, a mile or more from the entrance to the lagoon, apparently left the lagoons in the fall and were caught on grounds outside of the lagoons in May and June. None of the lobsters tagged in the Magdalen island area were reported caught in any other region of the gulf. Most of the lobsters liberated other than in the lagoons were caught either near their liberation point or within a mile or two of it. In the Magdalen islands group themselves the furthest distances travelled in 9 to 11 months by recaptured tagged lobsters were only five or six miles.

Sixty-seven returns were obtained from 450 lobsters tagged in 1931 in Malpeque bay. Of these, one lobster was recaptured 20 miles in a straight line and 30 miles following the shore line, away from its liberation point, and another about 20 miles, following the shore line, away from its liberation point. Eight were found outside the bay six to twelve miles east, and eight from five to ten miles west of the liberation points. Nine were caught near the eastern entrance to the bay five to six miles from the liberation points, and the remainder were reported from various points within the bay. The returns show no definite migration but rather a wandering with resulting scattering.

V. D. VLADYKOV

SEASONAL DISTRIBUTION OF THE HADDOCK OF THE HALIFAX AREA

(1) *Spring (spawning) run.* Haddock weighing from 3 to 4 lb. spawn in April and May in the entrance to St. Margaret bay, on gravelly bottom in 25 to 35 fathoms, and are taken with gill nets. Subsequently this school has a tendency to move eastward and then is caught near Pennant bay and Ketch harbour not farther than five miles offshore. These fish are as a rule spent, have small livers, and are in poor condition.

(2) *Summer run.* Haddock belonging to another school, and taken from June to September, constitute the second or summer run of this fish. These are larger, weighing on an average from 5 to 7 pounds, and distinguished easily from the spring school by larger size and "good shape". They appear near the entrance to Halifax harbour, from Portuguese cove to Devils island, and, as the season progresses, they penetrate farther into the harbour and are caught also both east and west of Halifax. These large haddock are found on inshore grounds and seem to follow the schools of fall-spawning herring, on whose eggs they gorge themselves. By the end of September, as a rule, they have disappeared from the inshore grounds.

The best catches of haddock, averaging 5 to 7 lbs., are regularly made by steam trawlers on offshore grounds from the second half of February to the end of April. The poorest catches are taken from July to September when the large haddock frequent the inshore grounds. On the other hand, during September of 1932, when an exceptionally strong storm drove away the haddock from the inshore grounds, unusually good catches of large fish were made on offshore grounds by steam trawlers. This suggests that the large summer shore haddock probably belong to the "Bank school" (race), and frequent alternately offshore or inshore grounds. Furthermore, the catches of summer haddock on inshore grounds are more sporadic than those obtained in the spring months.

(3) *Fall-winter run.* During October, as a rule, practically no commercial catches of haddock are taken in the Halifax area on inshore grounds. From the beginning of November until the end of January haddock are caught in large quantities by schooners from 10 to 20 miles offshore (no consideration is given here to catches made by steam trawlers). The fragmentary information available concerning these is not conclusive, but suggests that this run does not represent movement of a separate school, rather the return of spring and summer schools to the vicinity of their respective spawning grounds.

YOUNG HADDOCK IN THE HALIFAX AREA

Occurrence. The Halifax area, in contrast to the bay of Fundy, is characterized at the present time by an abundance of young haddock (2 to 3 years old), 10 to 18 inches in length. These fish usually school over a muddy bottom in depths from 2 to 10 fathoms. They appear near the shore about the middle of May and remain there usually until the end of September. Exceptionally large numbers were present during the summer of 1932 in St. Margaret bay, where the mackerel traps were often filled with these fish. Their abundance indicates good catches of commercial haddock in the near future.

Food. Several hundred stomachs of young haddock (10 to 20 inches in length) from Eastern passage and Bedford basin, near Halifax, were found to contain principally bivalve mollusks (*Cardium*, etc.) of small size. Worms (Polychaeta) were next in abundance. Small crustaceans (amphipods and schizopods) evidently play a minor rôle. Fish were found in stomachs only occasionally. Echinoderms (brittle stars, sea-urchins, etc.) were practically absent. All of the above enumerated animals occur on muddy bottom. On the other hand, examination of the stomach contents of adult haddock from the Halifax area showed the principal food to be brittle-stars, sea-urchins, herring eggs, etc., quite clearly indicating a difference in diet from that of the young.

Ten young haddock (11 to 14 inches in length), caught with hook and line in Eastern passage on July 20, were placed in an experimental tank provided with running sea-water. Four haddock died in September, whereas the remaining six lived until the end of the experiment (October 14, 1932). Temperatures of the tank water varied from 14 to 20°C., and the fish, in spite of the relatively high temperature, appeared to be in good condition.

The haddock were fed, as a rule, with shelled soft-clam (*Mya arenaria*) each second or third day. The fish found their food both by sight and scent. Besides clam, the haddock ate greedily shrimps (*Crangon*), small crabs (*Cancer*), grasshoppers and potato-beetles (*Leptinotarsa*). On the other hand, the haddock did not take any vegetable food (bread, sea-weed, etc.), nor small mussels (*Mytilus*), periwinkles (*Littorina*) and star-fish. It is interesting to note that haddock would not eat hard-boiled eggs, but would eat eggs fried with butter.

H. C. WHITE

OBSERVATIONS ON ATLANTIC SALMON IN APPLE RIVER, N.S.

Apple river is a salmon stream which has depended entirely on natural spawning for the maintenance of its stock of salmon, hence it is a good stream in which to observe native stock under natural conditions.

(1) *Smolts.* In 1932 smolts were found in all stages of transformation from the parr stage, both far up the streams as well as in the brackish water of the estuary, and collections of these were made.

Great numbers of smolts are taken annually by anglers, since in this stage the salmon takes a baited hook very readily. None of the anglers questioned knew that they were killing the young of the salmon, calling them "salmon trout" and "silver trout". An educational campaign is required.

(2) *Spawning.* In the late summer and fall of 1931 many salmon ascended this stream, and spawning occurred during a period of high water, the last of October and the first of November. Practically every suitable area for a distance of seven miles on the stream had been well utilized by the salmon. High water during the winter and spring in some places, especially in the lower region, changed the course of the stream bed, and in late May neither remains of the redds, eggs nor fry could be found. However, by the middle of June numbers of salmon fry were observed on all the rapids and it was estimated that there were two hundred and eighty thousand fry in the area where the salmon had spawned, giving good stocking by natural reproduction.

(3) *Tagging.* Salmon were tagged in various sections in 1931 and again in 1932. Among the few adult fish taken in the river in 1932 (investigations discontinued rather early) was a salmon tagged in 1931. This fish, a male, was taken before spawning in October, 1931, after spawning in November and again in October, 1932. It was seined from the same pool on all these occasions. It had more than doubled its weight since going to sea as a kelt.

SALMON FRY IN STILL WATER

A number of salmon fry which were being retained in running water were transferred to a still pool of stream water. The fry, which had completely absorbed the yolk sac, were unable at first to maintain themselves in the water in a

horizontal position. By expending considerable energy they kept themselves suspended in the water with the head upward and the body at an angle to the horizontal. This condition gradually improved until at the end of ten days they had apparently become adapted to the still water and they maintained a horizontal position with little effort. During the period when they are becoming adapted to a still-water habitat they would appear to be easy prey for their enemies. Thus these observations suggest that when salmon fry are to be planted in still water they should first become adapted to water in this condition in some place where they are secure from their enemies.

SEVERING A GILL ARCH IN BROOK TROUT

Small brook trout are often injured when hooked by anglers and many of these are retained because when injured, especially about the gills, it is generally considered that such injuries are fatal.

A number of trout were taken on hook and line, transported in a pail of water for several miles and placed in a trough of spring water. A fish hook was inserted through the mouth and a gill arch torn from a number of individuals. The fish became sluggish immediately after this operation and did not respond readily to tactile stimuli for several hours and after twenty-four hours they appeared normal. Eight per cent. of the fish died from the results of the operation. Although the number of respirations dropped to fifty per cent. of normal immediately after the operation, in a few days the number was back to normal. The experiment indicates that a high percentage of hooked trout which are injured, even to the extent of severing a gill arch, may be expected to live if returned to the water when released from the hook.

FOOD OF SALMONIDS

(1) *Atlantic salmon in fresh-water stage.* During 1931, a collection of young salmon of various ages was made and analyses completed of some two hundred stomachs. These analyses indicated that the food of the fry consists almost entirely of immature stages of aquatic insects, Chironomid larvae being the most important. The parr feed chiefly upon immature aquatic insects, but also eat a considerable amount of surface food consisting of mature aquatic and terrestrial insects.

(2) *Land-locked salmon in the Chamcook lakes.* Analyses of contents of stomachs of fish taken by anglers during April and May, 1932, indicate that the fresh-water smelt, abundant in these lakes, constitutes the main food of the adult salmon, identifiable smelt remains making up an average bulk of 82% and unidentifiable fish remains (probably smelt) 13%. Aquatic insects were eaten to the extent of 5%.

(3) *The togue (C. namaycush) in Chamcook lake.* Analyses of the stomach contents of twelve fish (43 to 54 cm. long) taken by anglers during April and May, 1932, showed that fish constituted 95% of the food. Fresh-water smelts made up 83.17%, sticklebacks 11.83%, and insects 5%.

These results are very similar to analyses of the stomach contents of land-locked salmon taken during the same period and indicate that the togue is a competitor of the land-locked salmon.

A PLANTING OF SALMON FRY IN EAST APPLE RIVER, N.S.

The salmon of Apple river and vicinity at the head of the bay of Fundy are "late-running" salmon and no salmon ascend East Apple river to spawn, although it appears suitable for salmon. On July 15, approximately 25,000 fry of Restigouche "early running" salmon were distributed on the rapids of one mile of this stream by placing them in small lots in places such as would be selected by naturally-hatched fry. Observations made on these fry up to October 20 showed that the stream was suitable for the growth of fry, as they made a growth superior to that of the naturally-hatched fry in West Apple river. There was a good survival and the part of the stream utilized was well stocked.

FISHERIES EXPERIMENTAL STATION (ATLANTIC)

HALIFAX, N.S., 1932

The work of the Station during 1932 has consisted of the investigations dealing chiefly with the preparation of fish and other marine products for market, and of educational work in conducting classes for fishermen, fishery officers, and university students.

The scientific staff during 1932 has consisted of the following persons:

Dr. A. H. Leim, Director.
Dr. S. A. Beatty, Associate Biochemist.
Mr. Ernest Hess, Assistant Bacteriologist.
Dr. H. R. Chipman, Scientific Assistant in Chemistry.
Mr. A. S. McFarlane, Curator.

SEASONAL

Mr. J. Campbell, Scientific Assistant for Nutritional Investigation.
Dr. D. LeB. Cooper, Scientific Assistant in Chemistry.
Dr. N. E. Gibbons, " " " Bacteriology.
Dr. W. W. Johnston, " " " Biochemistry.
Mr. W. W. Stewart, " " " Chemistry.

During the summer three volunteer investigators were attached to the Station:

Mr. J. W. B. Cox, graduate of the Dalhousie University Fisheries Course.
Mr. T. Thorbjarnarson, Dalhousie University.
Mr. G. Thorsteinsson, Dalhousie University.

INVESTIGATIONS

REFRIGERATION

Dr. Gibbons continued the examination of frozen fillets stored at various temperatures. After lengthy storage, the bacterial count had increased markedly in those stored at −5°C. No changes could be measured chemically in muscle juice stored for 18 weeks at −5°C. and inoculated with *Actinomyces* or *Kurthia*.

A beginning was made on the investigation of temperature conditions in freight refrigerator cars used by the railways for transporting frozen fish. A suspension system for a recording thermograph was worked out so as to overcome car jolting effects, and records were obtained in early September on a car moving from Halifax to Fort William. The results demonstrated a considerable temperature gradient between the top and bottom of the load in the car, but with fair uniformity at a given point. The top temperatures were close to the defrosting temperature of the fish. Further improvements on the suspension of the thermograph were required, and before any further cars were available colder weather had come, when records are less valuable.

Two small trial shipments of ice fillets of haddock, halibut, and scallops, and of lobster and clams frozen in cans, were made in June to hotels in Brockville and St. Catharines, Ontario. These shipments were received in very satisfactory condition.

SMOKING

The investigations in this field may be divided into three parts:

(1) Laboratory work on the chemistry of wood smoke, and on the separation of certain constituents, such as the tars.

(2) Semi-commercial development of smoke producers, and the improvement of the process of fish-smoking as far as present knowledge will permit.
(3) Commercial application at Lunenburg, N.S.

It was very evident when the construction of apparatus for producing smoke had been completed, that the different types of smoke producers gave a variety of kinds of smoke, and the same producer under different conditions offered the same difficulty. Two types of producers which Mr. McFarlane built involved the burning of sawdust by forced draft. Variations in the air rate, the thickness of the sawdust layer, and the temperature of the producer all influenced the composition of the smoke. This could be detected by the colour of the smoke, and, to some extent, by its odour.

In order to obtain more definite information on the variation in the smoke, attention was given to methods of chemical analysis. Dr. Chipman tested out methods of analysis for carbon dioxide, phenols, and tar, and Dr. Cooper applied the Romijin method for the estimation of aldehydes.

Analysis of the smoke produced as uniformly as possible indicated wide variation in its constituents. From a laboratory point of view, the most uniform smoke these pieces of apparatus would provide left much to be desired, and rendered it difficult to test out the effect on flavour of the fish of smoke produced in different ways.

Following these findings, Dr. Cooper and Dr. Chipman have set up in the laboratory a small drying system, and a small smoke-producing system, in which they hope to be able to reproduce a given set of conditions more readily. It is planned to test the chemical constancy of the smoke produced under different conditions, and then to proceed to ascertain the effects of different types of smoke on fish. Some work has been accomplished in this direction.

Mr. Stewart investigated mechanical means of removing part of the heavy tars from wood smoke, with the two-fold object of improving fish flavour, and reducing mechanical difficulties attendant on passing the smoke through fans, ducts, etc. The use of three types of mechanical tar removers, based on apparatus used in coal gas works for a similar purpose, indicated that one of these could be adapted to the present problem with satisfactory results.

Some attempts were made by Mr. Stewart and Dr. Chipman to produce a smoke solution which might be applied to the fish as a spray or a dip. Could such a solution be satisfactorily developed, it would open the way to much greater control of fish smoking than can be assured at present.

Mr. McFarlane has worked on conditions necessary to produce a good sheen on the surface of the fish, and on its permanence after freezing and defrosting.

Mr. McFarlane built several pieces of apparatus for producing smoke outside the smoke-house. The first type involved the feeding of sawdust at a definite rate on to a plate, which was externally heated. The amount of smoke produced in this way was small commensurate with the size of the equipment, and the amount of heat energy provided. Three producers of the forced draft type, with no external source of heat were built, and were capable of adequate smoke production. The smoke produced had a high moisture content, and on cooling deposited a part of this on the fish, making them damp, and necessitating redrying. Consequently the smoke was passed through a water-cooled condenser, and the temperature reduced to 60 to 65°F., or slightly lower than the fish temperature. This removed much water and tar, etc., from the smoke. Fine, removable screens were interposed between the smoke producer and the condenser to eliminate violent explosions which occasionally occurred before these screens were inserted. It was found that under these conditions fish could be smoked satisfactorily in the smoke-house in five to six hours, and that they had a very mild flavour. One troublesome feature, particularly with un-dyed fish, was the occurrence on the upper horizontal portion of the fish, where they hung over the rods, of a dark band, apparently due to the settling out of smoke particles. This is a difficulty which is found in certain smoke-houses, and not in

others. Probably it is related to the vertical draft just being sufficient to overcome this settling. At the Station smoke-house, a strong vertical movement of the smoke induced by a fan did not remedy the trouble entirely.

Recently, trials have been made of another type of smoke producer, in which several trays of burning sawdust, one above the other, contribute the smoke to a common duct, through which the smoke is drawn by a fan. The smoke produced in this way seems to more closely approximate that produced by fires in the old type smoke-house. The smoke is cool enough not to require cooling in a condenser, and is dry enough so that the fish do not become moist when the smoke is applied. Also there is less banding of the fish. Considerable tar is removed in the fan.

At Lunenburg, the commercial installation has been considerably developed during the year. Some changes in the drying arrangements were carried out at the suggestion of the Station, and the drying of the fish seems now to be very satisfactory and uniform throughout the smoke-house. An excellent sheen is produced. Also under the direction of Mr. McFarlane a smoke producer was installed.

SALTING

The control of the reddening produced by a bacterial organism on salt fish is a problem of considerable importance to the fishing industry. An attempt to gauge its importance was made by sending questionnaires to the fishery officers, and by correspondence with dealers handling salt fish, particularly in Gloucester, Mass. Dr. Gibbons carried out laboratory scale investigations on the control of the organism by the use of various disinfectants, including smoke. While it seems possible in some instances to clean up premises which are infected, there is always the danger of re-infection. Investigation was made on the feasibility of adding substances to the salt which would inhibit the growth of the organism, and which would be non-injurious to health. Several substances were found to be effective. Because of easier application, passing the green salt fish through a dip after they were removed from pickle was investigated. A dip in three per cent. solution of sodium benzoate was effective, but in most countries the use of this substance is not permissible.

A study is being made by Dr. Gibbons of the morphology and physiology of the causative organism.

An account is being prepared giving a résumé of present knowledge with regard to the salting of fish.

CANNING

At a meeting of the Canned Fish Section of the Canadian Manufacturers' Association in 1931, the problem was submitted of determining what processing time was required to properly sterilize cans of re-packed lobster. In the inspection of canneries by authorized officers a certain number of cans are opened. These are re-packed. Mr. Hess duplicated this procedure at the Station, and processed the re-packed cans for various times in the retort and open bath. The cans are being held for examination when the minimum time should be apparent. Results so far show that processing for 15 minutes at 240°F., and two hours at 212°F., was insufficient.

Further comparison of frozen and unfrozen canned lobster after ten months' storage showed that the frozen meat was considerably softer on thawing than was that in the unfrozen cans (Mr. Hess).

Changes in the pH of the body fluids of lobsters were measured during the period when the vitality was becoming lowered in the animals.

During the past season prices for fresh tuna on the market have been extremely low; and this, coupled with the fact that canned California tuna is regularly imported into Canada, made it seem advisable to work out methods of canning the Canadian species. Mr. Hess canned a quantity of this fish in various

ways, and produced an appetizing article. The importance of proper bleeding of the fish to produce a light-coloured product was emphasized.

A plan of a model lobster cannery was prepared by Mr. Hess, and requests have come in for a fair number of copies of this plan.

FISH MEAL

Dr. Beatty has developed a method of determining the phosphate in fish meal more readily than that used in the past. The calcium and phosphate ratio was determined in about 20 white fish meals put up by the various Maritime producers.

Dr. Beatty and Mr. Thorbjarnarson have partially developed a method of estimating iodine in fish meal. The process has been developed along the lines of complete combustion of the meal in an atmosphere of oxygen, followed by collection of the products of combustion, and the recovery and estimation of the iodine in the ash and gases produced. The method is not complete, but further work is being carried out on it.

Early in the year a meeting of the Maritime fish meal producers was held at the Station, and they recommended that the Station should circularize poultrymen's organizations and other bodies likely to be interested in purchasing fish meal, pointing out the value of fish meal as food, and that in general an attempt should be made to introduce fish meal to Canadian farmers. This has been done, and some local sales have developed. It is questionable whether they would have without some urging by the Station.

A short Bulletin has been prepared by Dr. Beatty setting out the advantages of white fish meal as a food for poultry. This has been made available in manuscript form to the meal producers, and it is being published.

It may be considered that the education of farmers in the use of fishery products does not lie within the purview of the Biological Board. On the other hand, it seems at present that no other public body is likely to contribute much to this work, which it is believed will be a real benefit to the fish meal producers.

Representations have been made to the Department of Agriculture pointing out that changes in the definitions of fish meal as contained in the Feeding Stuffs Act are desirable. The oil content should be expressed as a maximum value, and not a minimum, and a classification of fish meals into the following groups is suggested.

(1) White fish meal.
(2) Dark fish meal. (?)
(3) Solvent extracted meal.
(4) Fish residue meal.

Routine analysis of 32 samples of fish meal submitted by the industry has been carried out gratis by the Station. Analysis is for protein, oil, ash, and water, and occasionally for sodium chloride and phosphate in addition.

THE NUTRITIVE VALUE OF FISH

The literature has recorded comparatively little on the chemical composition of our various commercial fishes, and where figures are available they usually refer to only a few individuals of a species, and to one particular season of the year. It is desirable to know in greater detail what the food value of the muscle of the commercial fishes is, and how it varies from season to season. Dr. Beatty and Mr. Thorsteinsson have carried on since the early summer a systematic analysis of the muscle for protein, fat, ash, and water in the following species: cod, haddock, hake, cusk, herring, mackerel, Atlantic salmon, halibut, and Canadian plaice. Attention is being paid to seasonal variation, and variation with size of fish. It is proposed to continue this work throughout a complete year. Dried samples are being retained for possible further analysis in the future.

In view of the preceding paragraph, it is not surprising that little is known of the extractives found in the muscle of the commercial Atlantic fishes. Many processes of fish-curing involve little understood changes of flavour in which the extractives are probably involved, as they are with mammalian muscle. The quantity of these nitrogenous extractives present also has a bearing on the calculation of protein content from "total nitrogen". Dr. Johnston was assigned to the problem of determining the amounts of ammonia, urea, creatinine, and uric acid which were present in the muscle, and has determined these for the summer condition in cod, haddock, hake, mackerel, and herring. In all these species creatinine was present in the largest amount, and uric acid in the least.

Mr. Campbell collected extracts of muscle of cod, haddock, salmon, and herring, and of haddock skins during the summer. Extracts were made from both fresh and autolyzed muscle. A study is being made under the direction of Dr. B. P. Babkin of McGill University of these extracts. A partial examination of the nitrogenous constituents of the extracts has been made. This is to be extended, and a study is to be made of the action of these extracts on the digestive secretory processes in dogs.

OTHER LABORATORY INVESTIGATIONS

1. *Bacteriological.* Mr. Hess has continued the investigation of the growth and activity of representative strains of bacteria from fish slime at low temperatures, covering the range from −16 to +20°C. There has been evidence of growth at temperatures as low as −6°C. Organisms belonging to three genera (*Pseudomonas*, *Flavobacterium*, and *Achromobacter*) have been chosen for this work. The effect of freezing and thawing on bacterial cultures is also being studied.

Two halibut which exhibited yellow discoloration of the white side were sent to the Station during the summer, and there were reports that this appearance was not uncommon among halibut which had been iced aboard the boats for periods of over a week. Mr. Hess isolated an organism, which was capable of reproducing the discoloration on inoculated fish which appeared to be identical with that producing yellow discoloration of halibut on the Pacific coast. Several other organisms capable of producing yellow pigments were also found.

Dr. Gibbons continued his study of the classification of bacteria associated with the decomposition of fish, and belonging to the genera *Achromobacter* and *Flavobacterium*. He also studied the amounts of trimethylamine produced in fish muscle juice which was decomposing at temperatures of 0, 5, and 10°C.

2. *Biochemical.* Casein has been extensively used as a source of protein for the manufacture of various hardened plastics, and Dr. Beatty has suggested the possibility of utilizing fish protein, which can be obtained more cheaply, instead of casein. An investigation into the feasibility of such utilization has been undertaken by Dr. Johnston, and preliminary results are promising.

3. *Fish cultural.* Mr. Hess, in conjunction with Dr. M'Gonigle, inoculated healthy salmon fingerlings with cultures of bacteria which had been isolated in 1931 from salmon fry showing "fin-rot" at the Bedford hatchery. Apparently the organism, if one is responsible, causing the disease had not been isolated, as no recurrence of the disease took place in the inoculated fish.

Bacterial cultures were obtained from trout fry at the Yarmouth hatchery, and salmon fry at the Bedford hatchery. These were from fish which were dying, and which exhibited symptoms of furunculosis. No organism resembling the causative bacterium of furunculosis, or capable of inducing the disease in healthy fry, was isolated in either case.

Examination of water samples from the water supply of the Windsor hatchery has been taken up again, as there is evidence of a partial return to a normal reaction in the water.

FIELD WORK

1. *Lobster collection boats.* During the period from the middle of May to the middle of July, Professor A. F. Chaisson accompanied lobster-collecting boats on six trips from eastern Nova Scotia to Boston. These boats were operating under subsidy from the Department of Fisheries. Records were obtained of the hold temperatures, and of the condition of the lobsters when placed aboard the boats, and again when unloaded at Boston. The conditions under which the lobsters are held awaiting shipment were investigated also. The results indicated that conditions aboard the collection boats are quite favourable, and that the treatment accorded the lobsters by the fishermen in their boats and while awaiting shipment is much more important in determining the condition of the animals on arrival at the market.

A Bulletin has been issued by the Board covering this investigation and subsequent experimental studies at the Atlantic Biological Station.

2. *Lobster cannery grading.* While the regular officers of the Department of Fisheries carried out the grading of lobster canneries this year, Mr. Hess visited five new canneries which were being operated by local branches of the United Maritime Fishermen in Guysborough, Richmond, and Antigonish counties, Nova Scotia. In addition to grading these canneries, suggestions were offered to the managers as to how they might produce a more uniform pack.

Mr. Hess attended the annual meeting of the Maritime Canned Fish Section of the Canadian Manufacturers' Association at Amherst in November, and presented a summarized report on the grading of the lobster canneries in the Maritime Provinces by the Fishery Officers in 1932.

3. *Exhibitions.* At the Provincial Exhibition at Halifax, October 17-22, a small exhibit was included in the booth of the Department of Fisheries. No attempt was made this year to include the work of the Fisheries Experimental Station itself, but a series of specimens illustrating the life-history and rate of growth of the oyster was shown. Material for this exhibit was provided by Dr. Needler. An aquarium containing some common invertebrate marine animals was also shown. Owing to the duration of the exhibition, and the lack of any facilities, only very hardy forms could be used.

4. *Miscellaneous.* Dr. Leim visited a new bait freezer erected at Tignish, P.E.I., by the Fishermen's Federation, and demonstrated the proper use of a brine tank in freezing bait.

Members of the staff gave assistance at various points as required. In this connection may be mentioned work by Mr. McFarlane at Lunenburg in connection with the smoking installation; by Mr. Hess at Lower Wedgeport, N.S., where a cannery began to pack tuna in cans; Dr. Gibbons to the Yarmouth hatchery, and Dr. Beatty to attend a meeting of agriculturists in Sackville, N.B., to discuss the use of fish meal.

Dr. Chipman has followed the operation of thermographs on two of the Canadian National Steamships operating out of Halifax. These records are obtained for the Atlantic Biological Station.

Regular hydrographic observations have been continued at the King's wharf, and at three stations in Halifax harbour and Bedford basin. Plankton is taken at two of these stations.

Data have been collected during the different seasons on the relation between round and gutted weights for cod, haddock, pollock, and some other commercial species. While generally useful, these data are primarily for the Department of Fisheries to use in converting statistics from one form to another.

EDUCATIONAL WORK

1. *Course for fishermen.* The fifth in the series of Courses for Fishermen was held at the Station from January 27 to March 8, 1932. Twenty-eight fishermen from the Maritime Provinces attended this course. The courses and instructors were as follows.

(1) Preparation of dried and boneless fish—Mr. G. R. Earl. 35 hours.
(2) Preparation of pickled fish—Mr. R. Gray. 35 hours.
(3) Motor engines—Mr. R. H. Davison. 34 hours.
(4) Navigation—Capt. H. M. O'Hara. 34 hours.
(5) Science—Messrs. Beatty, Chipman, Hess and Leim. 55 hours.
(6) Natural resources—Professor A. S. Walker, Professor W. V. Longley, and Dr. M. Cumming. 29 hours.

The Department of Fisheries supplied the services of Messrs. Gray and Earl. The Department of Agriculture, Province of Nova Scotia, supplied those of Dr. Cumming and Professor Longley. Messrs. Davison, O'Hara, and Walker were engaged for the times indicated above.

At the close of the course six examinations were held, and 22 of the men passed these, seven with honours.

2. *Short course for fishery officers.* Following their annual conference, a short "refresher" course was held from March 10 to 16, 1932, which was attended by the Fishery Supervisors and Inspectors from the Maritime Provinces. Two chief subjects were stressed:

(1) The inspection of pickled fish—Mr. Gray.
(2) The use of the lobster cannery grading sheets—Mr. Hess.

Other lectures dealt with the prevention of "red" in salt fish, the migrations of commercial fish, the value of fish meal, lobster cannery procedure, and new developments in fish smoking. Demonstrations were held in the last two subjects.

3. *Dalhousie fisheries courses.* Four students who are enrolled in the fourth year at Dalhousie University are taking the Courses in Fisheries 1-4, which are offered at the Station. Classes have been in progress during the fall term as follows.

General fisheries—Dr. A. H. Leim. Two lectures and one laboratory period per week.
Physics and chemistry of fish curing—Dr. D. LeB. Cooper. Three lectures and two laboratory periods per week.
Biochemistry of fish curing—Dr. S. A. Beatty. Two lectures and two laboratory periods per week.
Bacteriology of fish curing—Mr. E. Hess. Two lectures and two laboratory periods per week.

4. *Hatchery officers' course.* Dr. Chipman gave the major part of the instruction in physics and chemistry in the four weeks' course for hatchery officers which was held at the Station in January and February, 1932. Dr. Beatty assisted with a part of these courses. This course was under the direction of the Atlantic Biological Station.

DEVELOPMENT OF THE STATION

The constant temperature room (0°C.) was completed, and has been operated most of the year. In the same room, five compartments provide lower constant temperatures down to −16°C. Cold brine to accomplish this cooling is pumped from the new brine cooling tank in the demonstration building.

The Eastern Fisheries Division of the Department of Fisheries has taken over the original laboratory building at the King's wharf. The laboratory tables and fittings were removed and used in part in fitting up the one unfinished laboratory on the third floor of the new building. Some of this equipment was sent to the Atlantic Biological Station to be used in outfitting temporary laboratory quarters there. The Station retains control of two rooms in the basement of the old building. At present these are being used as storerooms.

Following the removal of the piles of the southern half of the King's wharf, a protecting plank wall was erected to protect the stone wall at the end of the

earth fill. Because of a mattress work under the stone wall, the piles for this breakwater had to be driven about 10 feet out from the stone wall. The upper part of the wall was broken away, and has been replaced by concrete. The earth fill has been graded.

The shed covering the boat slip has been torn down and concrete walls placed to hold the earth fill from falling in on the slip.

One wooden shed on the premises has been torn down. The connecting "bridge" between the new and old building has been removed, and the opening in the wall of the new building bricked up. The removal of these sheds has solved the problem of the upkeep of almost useless old buildings, and removed a certain element of fire risk.

Shelving has been built in the attic of the new building to accommodate collections and equipment.

LIBRARY

Accessions to the library for the year amount to 163 entries, in addition to periodicals regularly received. Some binding has been done.

EASTERN PASSAGE LABORATORY

For use by investigators from the Atlantic Biological Station, the Eastern Passage Laboratory was put into running order early in June and was operated until the middle of October. A proper system of hose and pipe connections was installed to carry running sea water to two sets of concrete aquarium tanks.

PUBLICATIONS

Beatty, S. A. Fish meal in relation to maritime farming. Prog. Rept. Atl. 5, 14-16.

Chaisson, A. F. Factors in the shipment of live lobsters from eastern Nova Scotia. Bulletin 33, 1-29. (Partly made up of results of investigations at the Atlantic Biological Station).

Chipman, H. Ritchie The preparation of fish meal from oily fish. Prog. Rept. Atl. 3, 3-4.

Gibbons, N. E. The reddening of salt fish. Prog. Rept. Atl. 4, 5-6.

Hess, Ernest The influence of low temperatures above freezing upon the rate of autolytic and bacterial decomposition of haddock muscle. Contr. Canad. Biol. Fish. 7, 147-163.

The canning of Nova Scotian tuna. Prog. Rept. Atl. 5, 9-10.

Leim, A. H. Recent short courses at the Fisheries Experimental Station. Prog. Rept. Atl. 4, 3-4.

Successful shipment of frozen fish. Prog. Rept. Atl. 5, 10-11.

Leim, A. H. and A. S. McFarlane The smoking of fillets and haddies. Prog. Rept. Atl. 4, 6-8.

SUMMARIES OF INVESTIGATIONS

S. A. BEATTY

FISH MEAL

At the present time, when the fish trade has such small margin of profit, the utilization of by-products is of even more importance than in the past. Fish meal is, at the present time, the most important by-product of the fresh-fish industry. The manufacture of fish meal has been carried out in the Maritimes for approximately ten years. Eight plants of any appreciable capacity are installed, but only five are in operation, a result of the partial collapse of the German market.

This Station has determined the calcium to phosphate ratios of a large number of meals, showing the excellent balance between the two bone-building

inorganic elements, a balance equalled only in milk. Because of the importance of iodine in the feeds of farm stock in the endemic goitre regions of Canada, some attention has been paid to the iodine analysis of fish meals. The variations in the results of the various workers who have analyzed fish meal and fish foods for iodine would indicate that a good method has yet to be devised. This work was undertaken by Thorbjarnarson and the author, but we have been unable as yet to trap the iodine completely.

The Station has made an effort to develop the home market for the product. The producers, knowing little of animal feeding, are not in a position to guide the farmers in the economical use of the meals, while the farmers cannot afford to experiment at present. Approximately eight months ago, the producers were persuaded to make a determined effort to market fish meal locally, and although accurate figures are difficult to obtain, it would appear that before the year is up, about 10 per cent. of the total output will have been marketed in the Maritime Provinces.

Through the efforts of the Station, the Dominion Department of Agriculture is carrying on further feeding tests on its maritime farms.

S. A. BEATTY AND G. THORSTEINSSON

THE DETERMINATION OF THE FOOD VALUE OF COMMON SEA FISH OF THE ATLANTIC COAST

The food values of the fish of the Atlantic coast have not been determined with sufficient accuracy to be of much value, especially in the case of fat fishes, because a very few fish of each species were analyzed, and little attention paid to the seasonal variations that may occur.

Cod varying in weight from 2 to 50 lbs. show a very low oil content, but there is a progressive increase throughout the summer from approximately 0.35% to 0.50%. The other constituents are very regular, with the exception of water content, which in two large fish was 91% and 83.5%, otherwise ranging from 80.8 to 81.7%.

A large number of haddock showed considerable variation, especially in respect to protein and water, the protein content varying from 13.3 to 18.2%, and the water from 80 to 86%. The fat is low, and there seems to be a slight tendency to increase during the summer.

Hake, and also cusk, show little variation among individuals, and little seasonal variation so far as determined.

Herring show a very large variation in the fat content of individuals. While they do get fatter as the summer proceeds, the variations among individuals is always very pronounced. The fattest as well as the leanest fish were taken in June. The oil content and the water content vary inversely, the sum of the two always approximating 80 per cent. of the total weight of the fish.

Mackerel are not so variable as herring in respect to fat content.

Halibut show such large variations in fat content in respect to the size of the fish that, with the number of fish done, seasonal changes would not be shown. Small halibut of about 2 lbs. are almost as low in fat as are haddock, while those of 100 lbs. may contain as much as 5.7% fat. The increase in fat seems to be closely proportional to the increase in the size of the fish.

The Canadian plaice has an oil content about twice that of the haddock. The water content varies between 80 and 85%, the protein between 13.2 and 18.7%, and the fat between 0.3 and 1.1%. While the fat is very variable, the averages show approximately 100 per cent. increase during the summer.

S. A. BEATTY AND T. THORBJARNARSON

THE DETERMINATION OF IODINE IN FISH MUSCLE

The lack of iodine in the food of the inhabitants of the endemic goitre regions of this continent has resulted in the addition to various foods of inorganic iodine

calculated to supply this deficiency. The addition of inorganic iodine, whether because of its inferiority, or because of the tendency to overdosage, is generally conceded to be not as successful in the treatment of endemic goitre as the use of the natural iodine-containing foods. The general lack of agreement in the results of analyses of the same forms for iodine throws considerable doubt on the accuracy of the methods now in vogue, and it seems necessary to revise at least all values obtained before 1924.

The method being developed by the authors consists of three procedures.

(1) Complete ashing of the material in an atmosphere of oxygen in a closed system.

(2) The trapping of all gases of combustion in a collection train, consisting of alkali washers and a Cottrell precipitator.

(3) The recovery of the iodine from the ash and the collection train, and its quantitative determination.

The complete ashing of the muscle has proved a very difficult task, but has been overcome. The apparatuses ordinarily used were not found applicable to fish muscle. In some cases the combustion was not complete, while in others the combustion of the dry muscle resulted in the production of tars that "froze" the apparatus and extinguished the flame. This difficulty has been overcome by use of an apparatus which can be built at almost negligible cost, and which produces a non-smoky flame, and a white ash. The amount of oxygen used is reduced considerably, and the iodine should be trapped with greater ease than is the case with apparatuses previously employed.

The analytical procedure has been tried with known amounts of iodine with excellent results. The combined washings of the ash and the collection train are treated in turn with arsenious acid and nitrose, converting in the process all iodine compounds into free iodine. This iodine is extracted with carbon tetrachloride, and the resulting extract is treated with freshly prepared chlorine water. After the removal of the chlorine and carbon tetrachloride by boiling, the solution of iodine, now in the form of iodate, is titrated after the addition of an acid and an excess of iodide, with thiosulphate.

The part of the work still incomplete is the trapping of the products of combustion.

J. CAMPBELL

THE NUTRITIVE VALUE OF FISH

A knowledge of the value of fish as a foodstuff is of importance to physiology, medicine, and the industry. For this it is necessary to investigate the composition of different tissues of various species of fishes, especially for the partition of nitrogeneous substances in the muscles, and also to examine the properties of these preparations as to their action on the digestive secretory processes and their nutritional value. This should show, in these respects, the relative suitability of these tissues as foodstuffs.

A preliminary examination of the partition of the nitrogenous constituents in the extracts from fresh tissues has been made. The values of non-protein nitrogen are higher in salmon and herring than in haddock and cod. In herring a much higher value for volatile bases other than ammonia was obtained as compared with the other tissues. The values for ammonia are of the same order in all cases. The urea nitrogen values are fairly uniform. The amino-nitrogen of herring was very high, that of salmon, cod, and haddock following in order. The values of creatine and creatinine are in the neighbourhood of 500 mg. per cent. and are highest in haddock, while salmon, herring, and cod followed. The organic solids vary from 2.1 to 2.9 per cent. Of all the extracts, that of herring seems to have quite a different composition as compared with the others owing to its high values for volatile base and amino-nitrogen.

A. F. CHAISSON

HOLD TEMPERATURES ON SUBSIDIZED LOBSTER COLLECTION BOATS

There are three main groups of conditions that must be controlled if live lobsters are to be marketed in vigorous condition. These are involved in (1) care of lobsters prior to shipment, (2) care of lobsters on collection boats, and (3) care of lobsters after being landed in Massachusetts ports.

Care of lobsters prior to shipment is entirely under the control of individual shippers. Care of lobsters after being landed depends on the facilities that dealers in Massachusetts have for handling lobsters landed there in very unfavourable air temperatures. Care of lobsters on the collection boats requires provision of suitable refrigeration and moisture, and it was the object of this investigation to determine the efficiency of the subsidized collection service in this respect.

Six trips to Massachusetts were made on the collection boats between May 13 and July 18, 1932. Hold temperatures were registered with thermographs and maximum and minimum thermometers with the following results:

(1) The temperature of the bottom half of the cargo ranged approximately from 32 to 40°F.

(2) The temperature of the top of the cargo was, in genaral, 50°F. or less during the greater part of each voyage, but increased in June and July with increase in air temperature to between 50 and 60°F. as the Massachusetts coast was approached.

(3) Examination of crates of lobsters carried at different levels in the hold, and consequently at different temperatures for approximately three days, failed to reveal any general weakness that could be attributed to too high a temperature in the case of crates carried on the top of the hold, as compared with those carried half-way down, or on the bottom, at lower temperatures.

(4) The temperature conditions found on the boats were duplicated in the laboratory on a small scale by holding lobsters at constant temperatures within the range found in the holds of the collection boats, and for a period of time considerably longer than that required for the average shipment.

(5) These observations warrant the conclusion that in the case of the collection boats investigated, the hold temperatures were satisfactory, in general, for maintaining the vigour of live lobsters for the period of time required for shipment to Massachusetts. Facilities for providing moisture and protection from freshwater drip were found to be satisfactory.

(6) Great differences were noted in the condition of lobsters shipped by individual fishermen. This appears to be the most variable factor prior to landing of cargoes. Suggestions on the proper care of lobsters prior to shipment and on preparation for shipment are contained in Bulletin No. XXXIII, 1932.

(7) Condition of lobsters on landing in Massachusetts is not necessarily a criterion of condition when finally culled. Lobsters were frequently landed at air temperatures in the vicinity of 80°F., and several hours may elapse between the time crates are landed and culled, the time depending on the size of the shipment and the facilities of dealers for handling it.

(8) If satisfactory temperatures are to be maintained on the collection boats, the amount of vertical icing must not be decreased, and if increased, it will constitute a factor of safety.

H. R. CHIPMAN

THE PREPARATION OF SMOKE SOLUTIONS FROM WOOD DISTILLATE

Wood distillate was obtained from sawdust and was fractionated. Various oxidising agents as hydrogen peroxide, sodium peroxide, and potassium permanganate were added to the different fractions, but no solution having a smoke odour was obtained. These experiments were repeated with fractions which had been adjusted to a definite pH, but no results were obtained.

It was found that if the residual tar from the fractionating of the distillate were dissolved in alkali, and then made neutral by the addition of acid, precipitation occurred, and the supernatant liquid possessed a smoky odour. Attempts were made to concentrate this liquid, but a change in the odour resulted, and attempts to duplicate the solution were not satisfactory.

ANALYSES OF SMOKE SOLUTIONS

It was thought desirable to work out some system of analysis which could be applied to smoke solutions to enable experiments to be carried out on the controlling of the characteristics of wood smoke, and which would permit a quantitative expression of the aldehydes, phenols, carbon dioxide, and tar present in dilute alkali through which smoke had been passed.

For the determination of aldehydes as a group, several methods were tested. Considerable attention was paid to the development of a colorimetric method, but it was finally decided to use the Romijn method as used by Cooper at this Station for the determination of formaldehyde.

A colorimetric method for the estimation of phenols expressed in terms of tyrosine, based on the phenol determination of Folin and Looney was worked out. This method could be used to show the variation of phenols in smoke solutions with changing conditions.

Attempts made to determine carbon dioxide by precipitation methods were not successful, and it was found that carbon dioxide could be satisfactorily determined by the Van Slyke method.

A method for the determination of tar by extraction with chloroform was worked out, and could be used to express the amount of tar dissolved in the alkali.

D. LE B. COOPER

FURTHER INVESTIGATIONS ON SMOKING

The problem of fish-smoking is one that requires a definite generalized solution. This demands particularized investigations covering the chemical nature and physical characteristics of wood smokes of all types, a long and difficult task. The industrial need for an immediate improvement in the present process being recognized, a semi-technical type of experiment was undertaken as likely to yield results of more immediate benefit.

The preliminary work was done in the large semi-commercial smoke-house, previously described by McFarlane and Leim, using a smoke producer triangular in shape (McFarlane). Results of previous investigations (Dauphinee and Cooper) were applied to determine the constancy of the characteristics of smokes produced in this type of apparatus, but such variability was found in Romijin number, acid number, and tyrosine number as to indicate that the triangular smoke producer is not satisfactory for experimental investigations.

Attention was of necessity turned to the development and trial of other types of producers, and one form appeared to be satisfactory, the theory being that hot partially exhausted combustion gases passing through a layer of sawdust maintained at a constant thickness would result in a smoke, the characteristics of which would be invariant and duplication of results possible.

It was soon recognized that the semi-commercial type of experiment left much to be desired in ease of manipulation. For instance, it was impossible to secure sufficiently accurate analytical samples from the producer already mentioned. The experiments were transferred to the laboratory on a much smaller scale, but a suitable system of analysis has not yet been obtained.

N. E. GIBBONS

TRIMETHYLAMINE IN DECOMPOSING FISH

The volatile basic nitrogen in decomposing fish is composed mainly of trimethylamine and ammonia. The trimethylamine nitrogen may be deter-

mined by difference from total volatile basic nitrogen and ammonia nitrogen. On plotting the trimethylamine nitrogen in a series of fish muscle juice samples, contaminated with various bacteria, and decomposing at temperatures of 0°, 5° and 10°C., it was noticed that there was an early rapid production of trimethylamine, then a stationary phase, followed by a slight secondary increase.

The chief source of trimethylamine in fish is trimethylamine oxide. Cook has determined the amount of trimethylamine oxide in a number of fish, and in decomposing cod muscle found that this substance disappeared in 18 days in muscle kept at 0°C. The increase in volatile base was proportional to the decrease in trimethylamine oxide.

The trimethylamine oxide in muscle juice (haddock) was determined by Cook's method, and in a series of seven samples values of 0.75 to 0.90 mg. of trimethylamine oxide nitrogen per cc. were obtained. The average value was 0.79 mg. per cc. It was at about this point that the stationary phase occurred. It would appear that the trimethylamine is produced very rapidly from the oxide until this source is exhausted. The secondary increase is more puzzling. Lecithin, choline and possibly betaine are potential sources of trimethylamine, but the lipoids of fish muscle can hardly account for the secondary increase, whose source and cause are still unknown.

INVESTIGATION OF FISH DISEASES

During an epidemic among trout fry in May, 1932, the fish began swimming with a corkscrew, or end-over-end motion, soon turned over, sinking to the bottom and dying in a short time with the gills distended. On examination, there were no external lesions, and no changes were visible internally. Cultures were taken from the slime, peritoneum, spleen, and blood. A number of strains were isolated. The disease could not be reproduced in other fry, when inoculated with the various organisms. Furunculosis was suspected from the symptoms of the sick fish, but no organism resembling *Bact. salmonicida* was isolated.

An outbreak occurred among salmon fry, the fish dying off rapidly, with 50 per cent. mortality and over. The gills began to open, the fish swam rapidly in a circular path, then turned over and sank to the bottom. Only a few minutes elapsed between the onset of visible symptoms and death. The only pathological finding was that the gills were white and solid in appearance, and mucoid to the needle. On microscopical examination they did not show the divided appearance or colour of the normal gills. The ends were ragged, as if eaten away, and the filaments were indistinct. There were numerous small, round, transparent bodies, but whether these were cells or parasites was not determined. On culturing, no bacteria were found which would reproduce the condition. It is believed the disease was protozoal. It was controlled, to a certain extent, by Dr. Dreyer using a brilliant green bath.

RED DISCOLORATION OF SALTED FISH

Reddening of salted products is due to the growth of bacteria found in sea salts and capable of living in saturated salt media, and not infrequently renders fish unsaleable. To the author's knowledge, no very practical means of control have been offered.

To obtain some idea of the prevalence of the condition in the Maritimes, questionnaires were sent to the Fisheries Inspectors. Forty-eight inspectors, out of a total of fifty-nine, have replied. Twenty-three report that red fish has caused some loss in their districts. Of the twenty-five reporting no red, ten state that no fish is salted in their districts, in several the fish is shipped green salted, and one makes the significant remark, "no producers admit losses". The districts reporting red include Charlotte county, New Brunswick, practically the whole coast of Nova Scotia, and most of Prince Edward Island. Of one hundred and nineteen producers listed, fifty have had red fish. The number of fishermen salting fish is not known, but it is estimated that 20 to 100 per cent. are troubled

with red. No definite information was given regarding the actual loss of fish, or the monetary loss, as no records have been kept. Reddening has occurred when Turks island, Torrevieja, Trapani, Malagash, German mined, and Liverpool salts were used.

Information regarding the occurrence of red in Canadian salt fish imported into their territories was requested from a number of Canadian Trade Commissioners. Their replies contained little real information. Only one had any practical experience with the condition, and his estimate was that 5 to 10 per cent. of the imported fish turned red. However, various fish importers, and men in touch with the industry, inform us that it is a real problem and one causing considerable trouble.

The first measure of control is a thorough cleaning of the salting establishments. The simplest method seems to be the use of soap and water, or some alkali as washing soda or weak lye. This, with the use of red-organism-free salt should be effective, if subsequent contamination is guarded against. The method should be tried on a practical scale, as it is difficult to simulate actual conditions in the laboratory.

As, at the present time, sterilization of the salt is costly and hardly practical, means of preventing growth of the organisms seem to be the simplest means of control. Sodium benzoate, boric acid, and chloride of lime have been added to the salt, and the first two are effective in low concentrations. As considerable labour is involved in mixing, the simpler method of a dip containing the preservative was tried. Dips of sodium benzoate, boracic acid, sodium nitrate, potassium nitrate, 1 per cent. formaldehyde and water have been used. Benzoate and formaldehyde were the only effective agents, benzoate being effective at a concentration of 3 per cent. Both of these substances are prohibited by the Pure Food Laws for use on fish, but none of the preservatives allowed will control the condition.

The study of the organism is considerably complicated by the necessity of working with practically saturated salt solutions. Attempts to stain the organism have not been successful. The pH range of the organisms lies between 5.5 and 8, and the salt range is from 16 per cent. to saturated, as found by earlier workers.

ERNEST HESS

INVESTIGATIONS ON THE CANNING OF LOBSTER

Effect of freezing on canned lobster. Final examination of cans of lobster exposed to freezing temperatures under various conditions (up to 10½ months), showed no further changes from earlier examinations (1 to 5 months). Cans frozen in brine or air at 0°F., and kept in cold storage at 0°F., all showed considerable softening of the meat after thawing, as compared with unfrozen canned lobster meat of the same storage period (40°F.). No definite inferiority of meat, frozen and thawed several times, as compared with meat frozen only once and stored at freezing temperature for a long time, could be observed.

Processing of "re-packed" lobster cans. As in the industry a certain number of cans are always opened for inspection, their disposal is a problem usually solved by re-packing and re-processing them. The question of the length and temperature of processing necessary to sterilize such cans has been brought up, and several tests have been carried out. A series of sterile lobster cans were opened, allowed to remain open for various lengths of time, re-packed into new cans and fresh pickle added. After closing, the cans were processed at various temperatures for different lengths of time. After storage at room temperature, and at 98°F. in an incubator, from 65 to 77 days, none of the cans showed external signs of spoilage. Upon bacteriological examination, two cans (3 oz.) processed at 240°F. for 15 minutes were found to be non-sterile, as were also two cans processed in boiling water for one and two hours respectively. Pending examination

of the remainder of the cans still in storage, no definite minimum processing requirements can be given.

"FINROT" IN SALMON FRY

Strains of pure cultures of bacteria isolated from infected salmon fry (June 1931) were used for inoculation experiments (in collaboration with Dr. M'Gonigle) on salmon fingerlings in February, 1932, using 18 fish and 5 controls. Six of the inoculated fish died within 2 to 5 days, without showing any symptoms of "finrot"; the others survived many days (*i.e.* until the experiment was concluded).

In July, the test was repeated with young salmon and young trout fry. Of 27 inoculated trout fry, 14 died within one week without any definite symptoms of "finrot"; most of the remaining ones succumbed within the second week, as did also most of the controls. Of 17 salmon fry, 10 died within 3 hours (shock of handling?); 3 more died within 9 days without symptoms of "finrot".

The causative agent of "finrot" had apparently not been isolated, or, if isolated, must have lost its virulence during prolonged culture on artificial media.

DISCOLORATION OF HALIBUT

Discoloration of the white skin of halibut, which is so evident in halibut caught and landed on the Canadian Pacific coast, has occasionally been observed on Atlantic halibut, especially on fish that have been held in ice for some time. Following the work of Harrison, Sadler, and Bedford at the Fisheries Experimental Station at Prince Rupert, B.C., bacteriological examinations of two discoloured Atlantic halibut were made, and the same type of organisms found to be present that were considered to be responsible for the discoloration by the above investigators (*Ps. fluorescens*, as well as a number of chromogenic types, producing yellowish pigments). Inoculations of the skin of fresh halibut with such cultures produced typical discoloration. No investigations as to the origin of the organisms were made. Rapid landing of halibut catches and quick disposal seem most essential, and are perhaps more easily possible at the Atlantic coast, where most, if not all, halibut are marketed fresh.

EFFECT OF LOW TEMPERATURES ON MARINE BACTERIA

Representative strains of bacteria (genera *Pseudomonas*, *Flavobacterium*, *Achromobacter*) from fish slime have been chosen for a series of tests regarding the effects of low temperatures on their growth and their activity. Their cultural reactions were tested at the following temperatures: +20°, +5°, 0°, −3°, −6°, −10°, and −16°C. during an incubation period of 120 days. The results indicate that on the one hand the test organisms vary in general in their sensitivity to low temperatures, while on the other hand, different cultural reactions are affected very differently by low temperatures, *e.g.* indol formation being the most sensitive of the tests made, while nitrate reduction was the least sensitive one. With the exception of indol formation all reactions took place at a temperature as low as −3°C., growth on nutrient agar being observed even at −6°C.

The question of adaptation to low temperatures was studied by subculturing strains of the test organisms at +20°, +5°, 0°, and −3°C. respectively, for 3½ to 4½ months, when the cultural reactions again were tested at the four temperatures for each respective temperature strain. Only the *Pseudomonas* strain, adapted to −5° and 0°C., showed adaptation features.

Growth curves for the *Flavobacterium* strain have been established for the different temperatures; they show an increasing "lag" period with decreasing temperature, but also more rapid exhaustion at the higher temperatures, exhibiting the Tammann principle very clearly.

In morphological studies of cultures on agar slants and in broth, both as regards temperature and length of time of incubation, definite variation in size, shape, and staining qualities has been observed in all cases, but no definite sequence has been arrived at, nor any definite correlation of these variations with time and temperature of incubation.

From studies on the effects of freezing on bacterial cultures, it is apparent that the medium in which the bacteria are suspended is of prime importance, sea-water providing a decided protective action, as compared with ordinary laboratory media. Regarding the influence of the rate of freezing and thawing, the results seem to indicate that rapid freezing and slow thawing are more destructive than the opposite processes.

Prolonged exposure of cultures to freezing temperatures shows an increasing destruction of bacteria both with increase in time and with decrease in storage temperature (−6°, −10°, −16°C.).

THE CANNING OF NOVA SCOTIAN TUNA

Low prices and frequent glutting of the market for fresh tuna during the year, opened up the question of the possibility of canning the Nova Scotian tuna, to bring better returns to the fishermen, and increased employment to cannery workers.

A tuna which had been frozen in cold storage for about two weeks was available for experiments. Various methods were tried, especially regarding the length of steaming of the fresh fish (to remove the fish oil), length of cooling of the steamed meat, amount of meat to be packed, amount of salt and oil to be added to each can, and the time and temperature of processing of the cans.

It was found best to steam the fish in large pieces (15 to 20 lb.) rather than whole, to reduce the time of steaming to 3 to 4 hours, as prolonged steaming will dry out the meat too much. The steamed meat was allowed to cool overnight in a cool room, when it was firm and easy to handle. As the meat shrinks considerably in the preliminary steaming, depending mainly on the size of the piece and the kind of meat, *i.e.* the location of the cut from the fish, and secondarily, on the length of steaming, the meat will shrink very little in the can during processing, if at all. A slight gain of net weight may even be observed, as the meat will absorb some of the oil from the can. So-called "half-pound" lobster tins were used for packing the meat, holding 7½ oz. of tuna meat. The addition of not more than ¼ oz. of dry salt and 1 oz. of cottonseed oil (or olive oil) was found to be most suitable. For commercial purposes, the use of a tin holding 6 oz. of meat would be more advisable, with corresponding reductions in the amounts of salt and oil added to the can, *i.e.* cans of the same size as the California pack sold in this market.

Apart from flavour, the main problem is that of the appearance of the canned meat, the arrangement of the pieces of meat in the can, and, especially, the colour of the meat. This should be as light as possible, of a pinkish-creamy shade. This can only be obtained if proper attention is paid to the complete bleeding of the fish before they are steamed. Not only should the blood from the larger veins along the backbone be drained, but from all the smaller blood vessels throughout the carcass, otherwise the canned meat will be of a dark greyish-brown appearance with reddish-brown spots of clotted blood throughout the meat.

W. W. JOHNSTON

FISH MUSCLE PLASTICS

The first protein plastic materials were manufactured about the year 1900 under a patent held by Krische and Spitteler. Less than 30 years later (1925) the casein plastic industry consumed approximately 3,000 tons of casein in Germany alone. The highest price recorded for casein was obtained in 1919, when it sold in New York for 63 cents per pound; an average price would seem to be about 20 cents per pound, but with the further development of the industry this figure will almost certainly rise.

At present large quantities of numerous species of fish (dog-fish, skate, etc.) with little commercial value are obtainable. In addition large amounts of protein matter in the form of fish scrap which are now turned into fish meal, and for

which the present market is limited, are available. At present, this fish scrap in the form of fish meal is retailed at from two to three cents a pound. *A priori* there would seem to be no reason therefore why casein could not be largely replaced by the cheaper and more readily obtainable proteins of fish muscle. Hence if some means could be devised for converting the fish trimmings and protein of non-commercial fish into a hardened plastic material similar to galalith, an important outlet for the supplies of fish protein now available at very low prices would be provided.

In an investigation into the feasibility of thus utilizing fish protein for the manufacture of protein plastics, only preliminary experiments have as yet been completed. However, treatment of dried fish muscle in a manner similar to that used in the manufacture of casein plastics yielded a product which, while somewhat inferior to the latter, has shown signs of great promise. The greatest difficulty met with in this work lies in overcoming the tendency to brittleness of the finished muscle cake, which may possibly be accomplished by treatment of the raw material prior to plastification by some chemical agent, or by its incorporation into the plastified product.

THE NITROGENOUS EXTRACTIVES FROM FISH MUSCLE

Under the term nitrogenous extractive is classed a number of non-protein nitrogen constituents which occur to a small per cent. in tissue, and are extracted by water, alcohol, or ether. Among other substances, this group contains ammonia methylamine, creatine and creatinine, urea and several purine bases including xanthine hypoxanthine, and uric acid.

It is a matter of common knowledge that if muscle is boiled in water the greatest portion of the flavour of fish or meat is extracted; it would appear likely, therefore, that the group of substances known as the non-protein nitrogen extractives were intimately concerned with the characteristic flavour of fish. Hence, since the flavour of muscle largely determines its marketability, knowledge of the factors concerned is highly desirable.

When the nitrogen content of fish muscle is multiplied by what may be termed the "protein factor", and the moisture, fat, and ash content added, the total in certain species of fish adds to less than, in other species to greater than, 100 per cent. This discrepancy must arise from the fact that different species of fish contain different amounts of non-protein nitrogen and hence the "protein factor" must vary from one species to another. Since only the protein and fat of fish muscle have any feeding value, it is imperative that one should know the quantity of non-protein nitrogen and hence the correct "protein factor" for the muscle of each species, in order to properly appraise and compare the biological values of different fish products.

In a study of the total non-protein nitrogen present in fish muscle, the preliminary investigation consisted of a comparison of the quantity of ammonia, urea, creatinine and uric acid present in different varieties of commercial fish. The average values found on analysis of about six fish of each species were as follows.

Species	Ammonia mmg/g.	Urea mmg/g.	Creatinine mmg/g.	Uric acid mmg/g.
Cod	.169	.180	4.80	.0074
Haddock	.154	.036	5.18	.0048
Hake	.130	.083	3.27	.0031
Mackerel	.203	.169	4.44	.0092
Herring	.198	.133	5.40	.0108

In all species examined the quantity of ammonia per gram of muscle was of the same order of magnitude; on the other hand, the quantity of other extrac-

tives studied showed wide variation from one species to the next. There appeared to be no correlation between the quantity of any extractive present and the size or sex of the fish, nor was any relationship observed between different species in the same family.

A. H. LEIM

TEMPERATURE CONDITIONS IN REFRIGERATOR CARS

A beginning was made on the investigation of the conditions under which frozen fish are transported by the railways. An attempt was made to utilize a Cambridge, two pen, seven day recording thermometer, specially suspended by springs, and with a heavy weight attached to increase the inertia. After preliminary trial of the instrument, it was placed in a refrigerator car which was cooled with ice and salt bunkers. One bulb of the thermometer was placed on top of the boxes of frozen fish, and one on the car floor.

The car was shipped from Halifax on September 7, and reached Fort William on September 14, when the thermograph was removed. Examination of the record showed that the suspension of the thermograph had not been adequate to prevent car jolting from moving the pen. Fortunately, periods when the car was not moving were frequent enough to give a fairly clear picture of the temperature conditions in the car. The temperature at the top of the load varied from 18 to 28°F., while that at the bottom of the car was from 13 to 18°F.

On the return of the thermograph, improvements were made in the suspension system, and trials between Halifax and Truro on freight trains indicated that much better records could be obtained, particularly when the pen arms were at right angles to the long axis of the freight car.

The preliminary records obtained previous to the onset of cool weather show that the temperature conditions under which shipments of frozen fish are made in Canada leave much to be desired. While the temperature was not high enough to permit defrosting to occur, it was considerably higher in the upper portion of the car than would be considered good. Probably 15 to 20°F. should be the upper limit for high quality frozen fish. Lower would be better.

A. S. MCFARLANE

FACTORS INFLUENCING THE PRODUCTION OF SHEEN IN SMOKED FISH

The production of a good sheen on the surface of smoked fish adds greatly to its appearance, and thus to its salability. This necessitates experiments to determine how best to produce a good sheen.

Brining fillets in a brine with a temperature of between 45° and 50°F. showed a distinct improvement in the sheen produced over brining fillets in a brine with a temperature between 60° and 65°F., but the brining of fillets for times varying from 10 to 30 minutes in salinities varying from 60 to 90 per cent. showed little, if any, apparent difference in the sheen produced in market cod fillets.

THE SMOKING OF GROUND FISH AFTER DRYING WITH CONDITIONED AIR

The drying of fish with heated conditioned air necessitates the production of smoke outside of the smoke-house, and its subsequent injection and distribution. The production should not be dependent on weather conditions, so that such conditions as good and poor smoking days will not exist. The smoke should be such that it will impart to the fish the characteristic smoke colour and flavour.

The results indicate that fish can be smoked successfully with smoke from a smoke producer mechanically fed and stirred, and placed outside of the smoke-house. Results also indicate that an ordinary smoking fire placed in a hood and the smoke drawn from the hood and forced into the house will give satisfactory results.

The following are some of the days in which smoking was carried on, and show the date, the air temperature wet bulb and dry bulb, and the time necessary to impart to the fish the necessary smoke flavour.

Date 1932	Outside air		Hours necessary to impart smoke flavour to fish	Kind of fish
	W.B.	D.B.		
July 29.....	67	72	5½	(Market cod fillets)
August 12.....	62.5	64.6	6	" " "
August 24.....	59	71	6½	" " "
October 20.....	58	68	6	" " "

W. W. STEWART

THE REMOVAL OF TARS FROM WOOD SMOKE

In using wood smoke to produce a uniform smoked fish, it may be desirable to remove tars from the smoke for two reasons. The first reason is that the ducts carrying the smoke from the producer become foul with these tars, which drip from the pipes, causing a nuisance about the plant. Also the smoke-house becomes extremely dirty from these tars, which in turn may be the cause of a spotted and unattractive food product. The second reason is that these tarry constituents in smoke may be objectionable to the flavour and the colour of the smoked fish.

The first objection is quite evident to those who have been associated with the production of wood smoke. It will be only possible to determine to what extent the tarry matters affect the product, when suitable methods are developed to control the amount of these tars present in the smoke which is introduced into the smoke house.

Hardwood sawdust was used to produce the smoke for the laboratory experiments. A smoke producer, suitable for this problem, was developed, which was assembled from ordinary cast-iron pipe fittings.

A qualitative colour test was developed which gave a comparison of the tar content of samples of smoke. This test depended on the colour produced on a piece of linen after drawing a definite volume of smoke through the linen. By this method a difference in the smoke production and operation of the furnace could be detected. With further study this test may yield a method of controlling the uniformity of the smoke production.

The efficiencies of three tar extractors, based on the design of the P. and A. extractor used in the coal gas industry, were compared by means of the colour test. From this it was found that an extractor consisting of six plates, which had narrow slots cut in them, was more efficient than one with plates which were perforated with small holes, or had openings in them covered with wire gauze.

It was observed during experiments that the heavy tars which were deposited as a heavy black viscous material, separated out in the smoke duct directly attached to the producer. The temperature of this section was between 55 and 65°C. From this observation it seems possible to separate the heavy tars from the smoke by an air condenser.

PACIFIC BIOLOGICAL STATION

NANAIMO, B.C., 1932

The personnel of the scientific staff has remained unchanged. Dr. Foerster has taken on his duties as assistant director, with residence in Nanimo, but continues in charge of the work of the Pacific Salmon Research Station at Cultus lake. Mr. Ricker remains in residence at Cultus lake to carry out and supervise various investigations in progress there. The following constituted the staff of the Station in 1932:

Dr. W. A. Clemens, Director.
Dr. R. E. Foerster, Assistant Director and Chief Biologist.
Dr. N. M. Carter, Associate Chemist.
Dr. J. L. Hart, Assistant Biologist.
Dr. A. L. Pilchard, Scientific Assistant in Biology.
Mr. C. R. Elsey, Scientific Assistant in Biology.
Mr. C. McC. Mottley, Scientific Assistant in Biology.
Mr. R. W. Whittaker, Scientific Assistant in Biology.
Mr. A. L. Tester, Scientific Assistant in Biology.
Mr. J. P. Tully, Scientific Assistant in Chemistry.
Mr. W. E. Ricker, Scientific Assistant in Biology.
Dr. D. C. B. Duff, Consulting Pathologist (Department of Bacteriology, University of British Columbia).

SEASONAL

Mr. D C. G. MacKay, Assistant (Shellfish).
Mr. E. C. Black, Assistant (Shellfish).
Mr. G. C. Carl, Assistant (Trout).
Mr. L. McHugh, Assistant (Salmon).

Fourteen volunteer investigators were provided with accommodation at the Station during the year. The problems of these researchers have direct or indirect economic bearings and are in practically all cases linked with the major problems of the Station.

Mr. D. Beall (University of British Columbia), Mr. C. Berkeley (Nanaimo), Mrs. E. Berkeley (Nanaimo), Mr. H. Fasmer (Pacific Biological Station), Dr. W. Freudenberg (University of Iowa), Mrs. E. Kuitunen-Ekbaum (University of Manitoba), Mr. S. H. MacFarlane (University of Illinois), Mrs. J. C. Mottley (Pacific Biological Station), Mr. J. A. Munro (Okanagan Landing), Dr. W. A. Riddell (Regina College), Mr. G. H. Wailes (Vancouver), Prof. R. A. Wardle (University of Manitoba), Dr. F. D. White (University of Manitoba), Mr. G. V. Wilby (University of Toronto).

INVESTIGATIONS

While the program of research has been curtailed this year in certain directions, the main lines of investigation have been carried forward and substantial progress has been made in the various fields.

Fish Culture

The development of principles, methods and procedures in the care of fish in all possible stages of the life-history must always occupy a large place in a conservational research program. In the case of certain ocean fishes, general fish cultural methods do not appear applicable at the present time, but in the case of those fish which spend a part or all of their lives in fresh water, there is opportunity for bringing into play various fish cultural measures which, if soundly based, should be of great value. In British Columbia investigations have had to do largely with sockeye salmon, pink salmon and Kamloops trout and have had as their chief objectives: (1) the determination of the relative efficiencies of various so-called "artificial" measures; (2) the determination of the relation of production to catch, whether commercial or angling. This brief statement may serve to indicate the connections among the investigations outlined below which otherwise might appear as isolated and unrelated endeavours.

PROPAGATION OF SOCKEYE SALMON

A considerable number of investigations are being carried out at the Pacific Salmon Research Station at Cultus lake by Dr. R. E. Foerster, assisted by Mr. W. E. Ricker. The work is reviewed under the following nine headings:

1. *Relative efficiencies of natural and artificial propagation.* There are in the province of British Columbia, nine hatcheries devoted in whole or in part to the handling of sockeye salmon eggs, 91,490,000 eggs having been taken in 1931. The hatchery product is distributed either as fry in the lakes and streams or as "eyed" eggs in the gravel beds of streams tributary to lakes. The present investigation has been designed to determine the relative efficiencies of these two types of artificial propagation as compared with natural propagation. The methods are applied at Cultus lake in successive years and the efficiency measured by the percentage of yearling seaward migrants produced from the number of eggs involved. For example, in the spring of 1932, 788,000 seaward migrants were counted at the screen fence at the outlet of the lake. These were the product of a natural spawning in the fall of 1930 when it was calculated that 24,939,000 eggs were deposited on the spawning beds. The production in this test of natural propagation is therefore approximately three per cent. This is the sixth experiment of the series in which the three methods, natural spawning, fry planting, and eyed-egg planting will each be tested four times. The results of the previous five tests were as follows: natural, 1.13 and 1.06 per cent.; fry planting, 3.96 and 2.24 per cent.; egg planting, 1.64 per cent.

2. *Factors involved in the high mortality of young sockeye in Cultus lake.* It has been disclosed that a mortality of 90 per cent. or more occurs among the young sockeye during their period of life in the lake. An attempt is being made to determine the factors involved by an investigation of the part played by enemy fish and by studies of the physico-chemical conditions and the food supply. In connection with the latter, it has been necessary to make a critical study of plankton sampling methods.

3. *The return of adult sockeye salmon from a known escapement.* For the development of an adequate conservational program with respect to Pacific salmon, it is necessary to have information concerning the return from the sea of adult salmon from a known yearling escapement. The return of Cultus lake sockeye has been difficult to determine because of the extensive commercial fishery. For several years large numbers of yearling migrants were marked by the removal of various fins but the reports of captures of marked fish in the fishing areas were not satisfactory. In the spring of 1930, all of the yearling migrants from Cultus lake were marked and a special effort was made to obtain complete returns in 1932, with gratifying results. The enumeration of the return to Cultus lake is not complete but it would seem that the complete return from the escapement of 1930 will be approximately three per cent., of which 70 per cent. will represent the capture by fishermen and 30 per cent. the escapement to Cultus lake.

4. *Transplantation.* In order to determine the possibility of establishing sockeye runs in depleted areas of the upper Fraser river by the transference of eggs and fry from the lower Fraser area, 17,000,000 Cultus lake eyed eggs were planted by the Department of Fisheries in the spring of 1929 in Eagle river, a tributary to Shuswap lake, approximately 800 miles distant from Cultus lake. In addition, marked fingerlings were liberated in the river in the fall of the same year from the retaining ponds of the Biological Board at Taft. Since Cultus lake fish mature at four years of age for the most part, a return was to be expected in 1932. A picket fence was constructed in the river well below the planting area and all fish proceeding upstream were counted. While the return of only seventeen fish to December 1 and the recapture of only fifteen marked fish in the fishing area indicates a failure in the experiment, the possibility of some fish returning as five-year-olds next season should be kept in mind.

5. *Retention of young sockeye in ponds.* Since it has been found that there is a very heavy mortality among young sockeye in Cultus lake, the possibility of reducing the ordinary losses by the retention of the young fish in ponds has been considered. The first experiment was carried out in 1930 by holding the fish for five- and twelve-month periods. The two lots of fish were marked at

release and the surviving yearling seaward migrants enumerated at the screen weir in the outlet of the lake. A severe epidemic killed off a large number of the fish in the ponds and rather vitiated the results of the experiment. However, there was evidence that retention in the absence of the epidemic would have greatly increased survival. It was decided to carry out another experiment in 1932 with retention periods of 10, 14, 18, 22 and 50 weeks. Again, an epidemic has interfered. It is evident that in the development of any fish cultural program, involving retention of large numbers of sockeye salmon in ponds, the possibility of severe losses through epidemics must not be overlooked.

6. *Feeding experiments.* Experiments designed to determine the most suitable rations for young sockeye retained in ponds, have been continued during the year. Briefly, the results indicate that of all foods fed singly, beef liver clearly constituted the best food as measured by increase in size of fry and by mortality percentages. However, excellent rations may be prepared with certain substitutes provided the beef-liver content is not less than thirty-three per cent.

7. *Spawning experiments.* In order to obtain data as to the comparative efficiencies and relative merits of the spawning and fertilization methods practised in the salmon hatcheries of British Columbia, an experimental test was carried out at Cultus lake at the request of the Department of Fisheries and with the assistance of a corps of fish cultural officers. The three methods of spawning, namely, expression, expression followed by incision, and full incision were used, followed in each case by the three methods of washing, namely, rinsing, steeping and congealing. In each experiment, twenty-five ripe female sockeye were used, involving over 100,000 eggs. The total number of eggs used was approximately 1,000,000. The detailed results have been published in Progress Report (Pacific) No. 14.

8. *Experimental tests of the safe-carrying capacity of a standard hatchery trough for sockeye salmon eggs and fry.* This experiment was carried out at Cultus lake at the request of the Department of Fisheries and with the assistance of the fish cultural staff. Fifteen troughs, nine with and six without riffles, were used in the investigation. Ninety baskets, each containing from three to nine quarts of eggs, were employed, and over 3,760,000 eggs were thus involved in the experiment. It was found that riffles greatly increased the safe-carrying capacity of the troughs and the maximum capacity for each type was determined.

9. *Hybridization of Pacific salmon.* As a result of extensive cross-breeding experiments with Pacific salmon in 1927 and 1928 at Cultus lake, it was definitely established that hybridization was possible among the five species. As the hybrids from several of the original crosses have come to maturity, they have been crossed among themselves, with normal wild sockeye and with various hybrids. The results so far appear to show complete fertility. An extensive collection of material is being accumulated which, in due time, will be subjected to critical study.

PROPAGATION OF PINK SALMON

1. *Natural propagation.* In view of the importance of Massett inlet, Queen Charlotte islands, as a pink salmon producing area, it seemed desirable to make a study of the life-history of this species and to investigate the production from known escapements to the spawning beds in order that data might be obtained as to what should constitute an adequate escapement for the maintenance of a run at a high level of abundance. Dr. A. L. Pritchard has been in charge of the pink salmon investigations. McClinton creek was chosen for the type study. A counting weir was installed and in the fall of 1930, 32,955 males and 33,196 females were counted as they passed upstream to the spawning beds. In the following spring the 4,855,000 fry went to sea, of which 185,000 were marked by the removal of the adipose fin. In the fall of 1932, 15,600 adults returned to the creek, of which 95 were marked individuals. Fifty records of fish lacking

the adipose fins were received from areas from Alaska to Johnstone strait, evidently indicating that wandering to some extent had taken place.

2. *Transplantation.* In Massett inlet, runs of pink salmon occur only in every other year. In order to determine the possibility of establishing a run in the so-called "off" year, approximately a million eggs were collected at the Tlell river on the east coast of the Queen Charlotte islands and transferred to a temporary hatchery on McClinton creek. Fry to the number of 877,650 were liberated, of which 124,000 were marked by the removal of the adipose fin. Information concerning the return will be obtained in 1933.

TROUT PROPAGATION

1. *The determination of a fish cultural policy for Kamloops trout.* In the area about the city of Kamloops there is a large number of lakes containing Kamloops trout and constituting a valuable economic resource. These lakes are subject to a heavy fishing drain and fundamental information concerning production is necessary for the development of an adequate fish cultural policy. Paul lake near the city of Kamloops was chosen for study. This body of water contains but one species of fish, namely, the Kamloops trout. There is a single inlet stream to the lake and into this the trout run to spawn. A hatchery is maintained on the upper portion of the stream and a trap is operated in the lower portion whereby fish entering the creek may be captured and stripped. The number of spawning fish and their ages can thus be determined in each year. The number of trout caught by the anglers can be obtained with a reasonable degree of accuracy as well as the ages of the majority of the specimens. Finally, quantitative determinations of the natural food supply can be made. The Fish Cultural Branch has agreed to the liberation of a fixed number of fry over a period of years. All the data necessary for the determination of the relation between productivity and fishing drain are here available, and Mr. C. McC. Mottley is carrying out the investigation along the three lines given above, namely, (*a*) a detailed study of the spawning run; (*b*) an examination of the anglers' catch; (*c*) a quantitative study of the food supply at regular intervals.

2. *The natural food of trout.* During the past few years approximately 1,200 trout stomachs have been collected and Mrs. Jean C. Mottley has made the bulk of the examinations. Special attention is being given to the food consumed by the trout in Paul lake throughout the year. This investigation is preliminary to one of the nutritional values of various types of natural foods.

Numerous requests have been received by the Department of Fisheries for the removal of so-called "coarse" fish from many lakes. It is realized that the relation of "coarse" fish to trout and salmon is a complex one and in order to obtain preliminary data, an extensive collection of stomachs of squaw-fish, chub, carp and other minnows, suckers, sculpins, etc., is being made, and Mrs. Mottley has commenced the examination of the material.

3. *Introduction of brown trout.* Early in the year the Department of Fisheries placed 300,000 brown trout eggs in the Cowichan lake hatchery for the purpose of stocking two streams on Vancouver island. This introduction is intended as an experiment to determine if this species will remain in the streams and provide angling during the summer months when native trout are either in the lakes or have gone to sea. The Biological Board was requested to assist in the experiment. Mr. Mottley has made a study of those anatomical characters used in identification of the species and has followed the growth of those retained in ponds. Pond facilities were not available for the retention of all the young fish to a size suitable for marking so that large numbers of fry were liberated in the Cowichan river. Five thousand of the larger fry were marked by the removal of the adipose fin and 60,000 are being retained in ponds until the yearling stage when they will be marked and liberated. Eight thousand fingerlings which had been retained in a pond at Qualicum beach were marked and liberated in the Little Qualicum river.

4. *A study of Lost lagoon.* In 1929, the anglers of Vancouver city decided to attempt to develop Lost lagoon into a trout pond. This body of water had originally been a portion of Vancouver harbour and later a salt-water pond through being cut off by a fill. Arrangements were made to turn a supply of fresh water into the lagoon. At the request of the angling association, an examination was made of the conditions existing in the lagoon and since then more or less periodic examinations have been carried out. From October, 1931, to August, 1932, Mr. G. C. Carl has made a more intensive study. His report indicates that conditions are not yet suitable for trout although considerable improvement has taken place.

5. *Survey of the Nanaimo river system.* The Board of Trade of the city of Nanaimo requested the Department of Fisheries to undertake the introduction of sockeye salmon into the Nanaimo river system in the attempt to establish a commercial fishery for this species on the east coast of Vancouver island. Coupled with this was a request for a biological survey of the river system for the purpose of developing a fish cultural policy. Mr. Mottley, assisted by Mr. Carl, carried out a brief preliminary survey during August. The Nanaimo river is over thirty miles in length and has four lakes in the system. Examinations showed the existence of extensive and suitable spawning areas for sockeye salmon. The food supply as judged by the plankton appeared to be limited in amount. Kokanees (landlocked sockeye) were found to be present in the lakes. As far as sockeye salmon are concerned, three factors appear to be involved: (1) food supply; (2) the possibility of the introduced sockeye becoming landlocked; (3) the possibility of non-return from the sea. The first factor requires a further study of the conditions in the lakes in order to determine to some extent the possible productive capacity of the system. The other two points can only be determined by experimental introductions.

6. *The trout and other game fishes of British Columbia.* At the commencement of the investigation of the trout of British Columbia, the determination of the status of the various species, varieties and races of trout occurring in the province was considered of fundamental importance. Professor J. R. Dymond undertook this phase and prepared a popular account which has been issued during this year in booklet form by the Department of Fisheries. The booklet consists of fifty-one pages and contains seven excellent coloured plates prepared from paintings by Mr. S. Logier of the Royal Ontario Museum of Zoology.

Mr. Mottley has carried out a critical study of the various characters generally used for distinguishing species, sub-species and races.

PATHOLOGY

1. *Toxicity of fish meals to salmon fry.* In 1930, a heavy mortality occurred among sockeye fry in retaining ponds at Cultus lake. In the following year, it was shown that halibut meal kept under certain conditions produced a toxic material but it was considered that effective concentrations were not possible in the retaining ponds. In 1932, the investigation was continued by Dr. D. C. B. Duff as to the effect of the oil content of certain diet combinations. Refined and oxidized herring and halibut oils were used. The results indicate that increasing the oil content of a herring meal ration produces a mortality much heavier than that due to whole herring meal alone but that such a mortality is reduced to the level of the control when fifty per cent. liver is incorporated in the diet.

2. *Furunculosis.* Dr. Duff has continued his studies of furunculosis with special reference to the conditions under which the bacillus thrives. He discovered that numerous deaths among hybrid salmon in a retaining pond at Cultus lake were due to furunculosis. Two areas of infection in British Columbia have therefore been discovered, one in the Elk river, near Fernie, and the other at Cultus lake. Eggs of speckled and brown trout were examined to determine if they carried the bacillus but negative results were obtained.

3. *Some marine bacteria.* A number of years ago Dr. H. C. Williamson discovered a herring spawning bed in Barkley sound on which practically all of the eggs were dead. A sample was forwarded to the Department of Bacteriology of the University of British Columbia, where Miss Helen D. Mathews undertook the cultivation of the flora associated with the eggs. A number of new species and many new varieties have been obtained in the cultures and an account of these has been prepared for publication. The results of experiments in 1929 and 1930 to determine the possibility of infecting freshly-spawned herring eggs from Departure bay were not conclusive and it has not been established that any of the bacteria were responsible for the death of the spawn in the first instance.

Ocean Fisheries

A study of an ocean fishery must of necessity be statistical in character as well as biological. A measure of the abundance of the stock from year to year is one of the essential requirements and since enumeration is impossible, resort must be had to measures of relative abundance. In a set line fishery, where a definite number of hooks is used on definite banks, the catch per given number of hooks provides a very accurate measure, if adequate and accurate data are critically scrutinized and proper statistical procedures applied. In a gill net fishery, the length or area of gill net, or in a hand line or troll fishery, the number of hooks may be used as the "yard-stick". In the case of the pilchard and herring fisheries of the Pacific coast, the catch per seine boat per day is being used with apparently reasonably satisfactory results.

The characteristics of the stock and the nature of any changes or fluctuations are determined by the study of random samplings of the commercial catch. The sampling must be statistically adequate and all numerical data subjected to statistical analyses. In this way a rigid set of measures is applied and the results from year to year are readily comparable.

Lastly, but not of least importance, the biology of the species must be thoroughly studied, not only for the value of the information in itself in relation to the problem of conservation but to provide a basis for the interpretation of the statistical data.

Pilchard Investigations

1. *Statistical analyses.* The study of the pilchard fishery on the west coast of Vancouver island has been continued by Dr. J. L. Hart, assisted by Mr. W. R. Whittaker. Calculations have been made of the catch per boat per day as in other years to afford an indication of the abundance of the stock in 1932 as compared with the previous six years. The catches at Nootka and Ecoole were again sampled throughout the fishing season and the usual statistical analyses made. Mr. Whittaker has continued his investigation of the use of the otoliths for the determination of age.

2. *Biological.* In the early part of the season, Dr. Hart made two trips off the coast in a search for pilchard eggs but none were discovered. It is hoped that a more extensive search may be made next year. Mr. Whittaker has completed an anatomical study of the pilchard, bringing to light a number of interesting features which have bearings on the matter of relationships.

3. *Pilchard plant effluent.* Dr. Hart, with the assistance of Mr. H. B. Marshall and Mr. D. Beall, has brought to conclusion the investigation of the alleged pollution of herring spawning areas by the effluents of pilchard reduction plants. The results show that the effluent material is soon dissipated and that there is no evidence that herring spawning grounds are contaminated. Mr. Beall has continued his chemical analyses of the pilchard plant effluent in order to determine the nature of the proteins in the waste effluent.

HERRING INVESTIGATIONS

1. *Statistical analyses.* Mr. A. L. Tester has continued the statistical analyses of random samplings of the commercial catches of herring in various localities on the east and west coast of Vancouver island and in the Prince Rupert district. Length and age compositions of the catches have been determined and the existence of local populations indicated. Through the kindness of Dr. C. MacLean Fraser, scale samples and length measurements of samples of herring for about 12 years extending back to the year 1917 have been made available for study. A picture of the changes which have occurred in the stock over a considerable period of time is being developed.

2. *Population studies among herring.* By a study of the average number of vertebrae of young herring in various localities, Dr. Hart has demonstrated that definite differences exist among the herring produced in the various regions. This information provides fundamental data for the identification of these groups in the commercial catch in later years and thereby the extent of migration and mixture.

3. *An investigation of the changes in chemical composition of herring in relation to curing.* Dr. Hart and Mr. D. Beall have commenced an investigation of the changes in chemical composition of herring taken in various localities and at different times during the seasons, with particular attention to the fat content in its relation to the salting and reducing of herring.

SOCKEYE SALMON

In each year, the Provincial Fisheries Department obtains random samplings of the sockeye salmon runs to the Fraser, Skeena and Nass rivers and to Rivers inlet, in respect to scales, lengths, weights and sexes. The material for 1931 was studied by Drs. W. A. and L. S. Clemens.

LING COD

Mr. Wilby gave special study to the spawning and early life history of the ling cod. Spawning takes place from late December to early March in the Nanaimo area. The eggs are deposited in masses around rocky reefs and shores below low-tide level, and the male remains on guard. As many as 500,000 eggs may be deposited by a large female. The eggs hatch in about three weeks. Growth is rapid and a length of 10 cm. is attained in three months, and of 20 cm. by the end of the first summer. Expeditions on a trawler provided information concerning distribution and food.

SALMON TAGGING

No tagging of salmon was carried out in 1932 but a number of returns from the tagging of spring salmon in previous years was received. Dr. Pritchard has completed the final reports and is bringing to completion the studies of scales taken from tagged fish.

FOOD OF SEA-FOWL

The study of the food and feeding habits of merganser ducks has been continued by Mr. J. A. Munro and Dr. Clemens and arrangements have been made for the study of the food of the loon. Mr. Munro has continued his investigation of the foods of various sea-fowl in relation to the fisheries.

FOOD OF THE FUR SEAL

In order to obtain preliminary information as to the nature of the food of the fur seal during its northward migration along the west coast of Vancouver island, twenty-five stomachs were obtained by the Department of Fisheries and forwarded to the Station where Dr. Clemens and Mr. Wilby examined the material.

PARASITES OF FISH

1. *Cestodes.* Dr. R. A. Wardle continued his investigations of the cestodes of Pacific fish with special reference to the physiological conditions under which certain species exist in the alimentary tracts of the fishes.

2. *Nematodes.* Mrs. E. Kuitunen-Ekbaum made a general survey of the nematode fauna of Pacific fish and discovered a new genus and species of dracunculoid nematode in the sockeye salmon. A study was made of the life-history of the blood-red nematode, Philometra, infecting the common flounder.

3. *Trematodes.* Mr. S. H. MacFarlane carried out a survey of the trematode fauna of Pacific fish and has apparently found a rich field. Preliminary identification indicates that twelve familes are represented in the material obtained from seventeen species of fish.

A study was commenced of the unique cestodarian parasite, *Gyrocotyle urna*, occurring in the rat fish.

SHELLFISH

In this field, oyster problems have received major attention partly because of the possibilities of expansion of the industry through the improvement and development of cultural methods based upon detailed biological data. Three species are now under cultivation in the waters of British Columbia, namely, the small, though well-flavoured native (Olympic), which serves the "cocktail" demand; the introduced Eastern oyster (Bluepoint), which serves the half-shell trade; and the introduced Japanese oyster (Pacific), which is served in soups and to some extent on the half-shell. It has been necessary to study in detail the life-histories of all three species, determining particularly the optimum conditions for spawning, spatting and growth. Cultural methods have been investigated, such as spat collection, cultching, dyking, etc.

OYSTER INVESTIGATIONS

Mr. C. R. Elsey, assisted by Mr. E. C. Black, continued the studies during 1932. Particular attention was given to the breeding of the Japanese oyster in Ladysmith harbour and the failure of the spatting of the Eastern oyster in the Nicomekl river at Boundary bay. In the first case, an excellent spawning and spatting occurred during the season, apparently largely as a result of certain combinations of hydrographical and climatological conditions. Possibly the now large population of mature oysters, totalling nearly five million, was a factor. In the case of the Eastern oyster, while there was an extensive spawning, there was a complete absence of set. It is evident that an annual crop of spat cannot be relied upon.

An important series of experiments was commenced to determine more exactly the optimum conditions of temperature, salinity and hydrogen-ion concentration for the spawning of the Japanese oyster. These are continuations of various preliminary experiments carried out during the past six years in which it was found that spawning might be induced by the introduction of eggs or sperms, by temperature changes, etc. It was also found that the Japanese oyster could be crossed with the native and eastern oysters but up to the present time it has been impossible to induce the hybrid larvae to set.

The recent introduction of the Japanese oyster to a bed at Pender harbour has been followed closely. Growth there has been good and excellent meats produced. Experimental plantings in Nanoose and Departure bays have shown satisfactory results.

With the native oyster, special attention has been given to the use of efficient methods in the collection of spat and to studies of growth. The "pests" on the beds at Boundary bay have been studied and some determination made of the extent of their injury.

CRAB INVESTIGATIONS

Mr. D. C. G. MacKay carried out extensive studies of the growth and moulting of the commercial crab which in some degree occupies a place in the market on the Pacific coast that the lobster occupies in the market of the Atlantic. Over three thousand crabs and eight thousand exo-skeletons have been measured and the moulting of nearly three hundred crabs in captivity has been studied. Observations have also been made on the relation of moulting to mating. A preliminary experiment was carried out to determine if baited traps are more efficient in catch than unbaited.

Miss J. F. L. Hart has continued her studies of the early life-histories of various species of crabs.

RAZOR CLAM

Dr. A. L. Pritchard made an examination of razor clams collected periodically by Fishery Inspector E. S. Richardson from the extensive clam beach on the north shore of the Queen Charlotte islands in order to obtain further information concerning spawning and general condition of the clams. Spawning commenced late in May in 1932 and as far as could be determined, all individuals over three inches in length were in spawning condition. The commencement of spawning was evidently at least a month earlier than in 1928.

THE BREEDING PERIOD OF THE PILE-BORER

It has been known that the breeding period of the pile-borer, *Bankia setacea*, varies in the regions along the coast. It is obviously of importance to determine these periods in various areas, particularly in its bearing upon the case of boats. Mr. Elsey and Mr. Black have carried forward the investigation by the distribution of wooden blocks.

Temperature and salinity records have been obtained in the various localities and an attempt is being made to correlate the breeding with the physico-chemical conditions.

OCEANOGRAPHY

The aim of the oceanographical program has been to determine the physico-chemical conditions of our coastal waters and the relation of these to the growth and productivity of the organisms of these waters. These conditions not only determine the character and quantity of the life but their changes and fluctuations from season to season and year to year cause corresponding modifications and cycles in the biological conditions. For example, a summer season of low temperature may cause repression of spawning among clams and oysters. Not only will this result in an economic loss directly but the absence of the larvae from the water reduces the food supply of all the organisms which feed on minute plants and animals. Again, it is generally known that the spawning and survival of herring are good in certain years and poor in others. These differences are in large part traceable to the differences in physico-chemical conditions in the various years. It is important, therefore, to have extensive information concerning the oceanographical conditions along the coast and a continuous record of the conditions. The fishery biologist must then interpret the effects of the physico-chemical conditions on the abundance and character of the stock as distinct from the effects of the commercial fishery.

In studies of general productivity of various areas, the quantity of microscopic plants and animals (plankton) in a unit volume of water is used as a comparative measure.

Up to the present time, the oceanographical investigations have been largely confined to the strait of Georgia but there is urgent need for the collection of data along the whole coast-line of British Columbia.

PHYSICO-CHEMICAL CONDITIONS

1. *Strait of Georgia.* As a result of the investigations of the past several years, it was evident that in order to arrive at a reasonably complete interpretation of conditions it was necessary to secure three comprehensive series of observations, one early in the spring, one in summer when the Fraser river was in flood, and one in late fall. In 1932, three circuits of the strait have been made. Four vertical series of samplings have been taken at each of sixteen "key" stations on each voyage. The data are now being analyzed by Dr. N. M. Carter and Mr. J. P. Tully.

2. *Fiords.* The investigation of the fiords so characteristic of the coast of British Columbia has been advanced by Dr. Carter by an extension of observations to Jervis and Toba inlets. Depths of over two thousand feet have been obtained and the physico-chemical conditions studied. A comprehensive report describing the origin and characteristics of the fiords of the southern portion of the British Columbia mainland coast is almost complete.

3. *Analysis of sea-water temperatures.* Records of surface water temperatures for Departure bay and the strait of Juan de Fuca are available over periods of seventeen and twelve years respectively. Dr. Carter has undertaken to analyze this data. A seven-day moving average has been computed and plotted for each day of the available records and the results have shown certain definite trends as, for example, that the annual summer temperature in the strait of Juan de Fuca has increased by several degrees centigrade since 1921, attaining decided maxima in the summers of 1926 and 1931.

4. *Nitrates.* Because of the exceptionally high concentrations of dissolved nitrates and phosphates in the strait of Georgia, an investigation of the applicability of the standard methods of determining these constituents became necessary. The study has been carried out by Dr. W. A. Riddell, and as a result certain modifications of methods have been adopted.

5. *Methods.* As the oceanographical investigations have proceeded, many improvements in apparatus and methods have been developed by Dr. Carter and Mr. Tully, who have now prepared an account of these for publication in the hope that other investigators may find them of value.

PLANKTON

1. *Quantitative investigation of the phytoplankton of the strait of Georgia.* The relation of the physico-chemical conditions to the general productivity of the strait of Georgia is being investigated by a quantitative determination of the phytoplankton. Vertical series of water samples for the determination of the phytoplankton content have been taken at each station and at the same depths as the samples of water for chemical analyses. The number of phytoplanktonts have been counted in a certain part of each sample and calculations made on the basis of a litre of sea-water. The work of correlating the quantity and distribution of the various phytoplanktonts with the oceanographical data is being carried out by Mr. H. Fasmer.

2. *Life-histories of copepods.* While Miss M. H. Campbell has not been at the Station during the year, she has continued her study of the copepods of the strait of Georgia at the University of Toronto and has completed an extensive report.

The Analyses and Food Values of British Columbian Fishes

The investigations in this field have been considered as a logical extension of the oceanographical program. In the latter, determinations are made of the constituents of the sea-water, such as phosphates, silicates, nitrates which provide the chemical elements that ultimately go to make up the living bodies of the plants and animals of the ocean. Man obtains a considerable portion of his food from the sea (particularly in the form of fish) and thus eventually some

of the chemical constituents of the ocean water become a part of his body substance and provide materials for growth and for development of energy. There is thus a connection between the chemical composition of the ocean water and the well-being of man.

CANNED SOCKEYE AND PINK SALMON

This study has been carried out by Dr. Carter as part of a program arranged with the Fisheries Experimental Station. It was desired to know something of the comparative food values of sockeye and pink salmon, canned at intervals during the season. Four samples of sockeye were chosen representing early, medium, late and river runs and three of pinks on a similar basis. Determinations of protein, oil and ash have been made and calorific values computed.

LING COD

Dr. F. D. White determined the average percentage amounts of protein found in the flesh and skin of fresh ling cod taken during the summer and calculated the calorific values. The amount of fat was found to be negligible. The ling cod has become a very important fresh market fish, there having been almost 50,000 pounds marketed in 1929 with a value of 383,000.

CANNED PILCHARDS

It has been generally recognized that the fat content of pilchards taken early in the season is much lower than of those taken late in the season. Dr. White determined the percentage composition with respect to protein, fat, water and ash of the canned product of these two classes and calculated the food values.

A PRELIMINARY STUDY OF THE FOOD VALUE OF THREE SPECIES OF OYSTERS

Dr. W. Freudenberg carried out comparative chemical analyses of the three species of oysters occurring in the waters of British Columbia. Special interest centred in the glycogen content, particularly as related to "fattening" and spawning. The investigation is now being continued by Dr. Carter and Mr. Tully in order to determine the extent of the variation of the chemical constituents throughout the year.

The Physical Processes Involved in the Salting of Herring

THE SALTING OF ROUND HERRING

For the purpose of providing some very definite information for the use of the Fishery Inspectors of British Columbia, Dr. Carter carried out two series of experiments. The first determined the changes in weights of herring over a period of eleven days in various strengths of pickle. The results have been made available in Progress Report No. 13. The second experiment was designed to determine the separate effects of exosmosis and inward diffusion. A complete account of the investigation will be published in the near future.

The Preservation of Fish Nets

PREPARATION OF A BULLETIN ON FISH NET PRESERVATION

A great many investigations of the problem of the preservation of fish nets have been carried out in many countries of the world. It seemed advisable for the benefit of the industry of the coast and as a preliminary step in any investigative program that might be undertaken, that the literature of the subject be synopsized. This latter work has been done by Dr. Carter and some one hundred and forty-five references have been reviewed. The information will form the basis of a bulletin which will be prepared in association with the Fisheries Experimental Station.

FAUNISTIC

It is recognized that the identification of the plants and animals of our coastal waters and the thorough study of their life-histories must constitute one of the foundations for all phases of biological investigation. The recognition of the various species of fish, clams, crabs, etc., is essential to the successful carrying out of investigations in fishery biology and not only of the adult stages but of all the immature forms. Furthermore, when questions of food, food supply, productivity of areas are taken into consideration, it is evident that the identification of species in all groups from the microscopic to the largest is necessary. From the establishment of the Station twenty-five years ago up to the present time, a great deal of attention has been given to the systematic study of the fauna which is rich and varied. Specialists in various groups have described and classified the species so that there is now available an extensive body of information. It is planned to bring together this information, with descriptions, illustrations and "keys", in the form of a series of publications to be known as "The Canadian Pacific Faunal and Floral Series". The progress in this field has been as follows:

PROTOZOA

Mr. G. H. Wailes has examined various fresh-water and marine collections and has prepared an illustrated systematic account of the marine Protozoa of the Canadian Pacific coast.

POLYCHAETA

Mr. and Mrs. C. Berkeley have continued their studies of the Polychaeta of the coast and during the year published two papers containing descriptions of new species and new records. Additional material has come to hand for study from Puget sound and from a number of deep dredgings in the fiords opening off from the strait of Georgia.

AMPHIPODA

A rather large collection of Amphipoda has been collected largely by Mr. Wailes and forwarded to Mr. Charles Shoemaker, who has kindly undertaken to work over the material. Some of the commoner forms have already been reported upon and a list published in Vancouver Art and Museum Notes. The remainder of the material, which contains several species, will be studied as time permits.

MOLLUSCA

Mrs. I. S. Oldroyd kindly identified a small collection of Mollusca from the Nanaimo area and there appear to be four new records for British Columbia waters among the material.

FISH

Professor J. R. Dymond has continued the preparation of check lists of the fresh-water and marine fish of British Columbia. Dr. Clemens and Mr. Wilby have commenced an illustrated account of the marine fish of the Canadian Pacific coast.

GENERAL CHECK LIST

The need has been felt for some time on the part of all the investigators at the Station, of a reference check list of the fauna and flora of the Canadian Pacific coast. Dr. Clemens, with the assistance of a number of workers, has now completed such a list, which, while possibly incomplete in some respects, will serve as a basis to which additions may be made as other records come to light.

EDUCATIONAL

COURSE OF INSTRUCTION TO FISHERY INSPECTORS

From February 15 to 27, 1932, a course of instruction was given to twenty-two coastal fishery inspectors of British Columbia at the Pacific Biological Station. The three district supervisors of fisheries were in attendance also. The course was arranged and carried out jointly as between the two coast Stations. Instruction was given in elementary chemistry, physics and biology, the salting of herring, canning, bacteriology in relation to the preparation of fishery products and the identification of fish. The instructors were Dr. W. A. Clemens, Mr. O. F. Denstedt, Dr. N. M. Carter, Dr. D. C. B. Duff, and various members of the staff gave special lectures. After the conclusion of the session at Nanaimo, visits were made to the factory of the American Can Company and the plant and research laboratory of the Canadian Fishing Company in Vancouver.

COURSE OF INSTRUCTION FOR HATCHERY OFFICERS

From July 4 to 16, 1932, a field course of instruction was given to seventeen hatchery assistants of British Columbia at Sorrento on Shuswap lake. The course was practically identical with that given to the superintendents of hatcheries in the previous summer. The subjects of instruction were mapping, elementary physics, chemistry and biology, meteorology, limnobiology, hydrography, vegetation, plankton, invertebrates of lake bottom, and fish. There were informal lectures and discussions in the evenings. The instructors were Dr. W. A. Clemens, Dr. R. E. Foerster and Dr. N. M. Carter.

MUSEUM AND EXHIBITS

The Station museum has continued to attract a large number of visitors. A special exhibit of shellfish was arranged for convention of business women held in Vancouver.

LECTURES

Members of the staff have given lectures before various organizations in the province.

PUBLICATIONS

The series of quarterly progress reports was issued during the year under the editorship of Mr. D. B. Finn and Mr. H. N. Brocklesby of the Fisheries Experimental Station. Nine reports on the progress of various investigations have appeared. A number of articles have been contributed to fishery journals and newspapers. The following publications, based in whole or in part on work carried out at this Station, have appeared during the year.

Berkeley, E. and C. Berkeley. On a collection of littoral Polychaeta from the west coast of Vancouver island. Contr. 7 (24).

Some Capitellidae (Polychaeta) from the N.E. Pacific with a description of a new genus. Proc. Zool. Soc. London, part 3, September.

Carter, N. M. The oceanography of the fiords of southern British Columbia. Prog. Rep. Pac. 12.

The salting of herring. Prog. Rep. Pac. 13.

Clemens, W. A. Pacific salmon migration. The tagging of the spring salmon on the east coast of Vancouver island in 1927 and 1928. Bull. 27.

A course of scientific instruction for fish cultural officers. Trans. Amer. Fish. Soc. 61.

Clemens, W. A. and N. M. Carter. Sea as nature's laboratory. Western Fish. 4(2).

Duff, D. C. B. Furunculosis or "fish boils" in game fish. Vanc. Mus. Art Notes 7(1).

Furunculosis in British Columbia. Prog. Rept. Pac. 15.

Dymond, J. R. The trout and other game fishes of British Columbia. Dept. of Fish.

Elsey, C. R. Japanese oysters breed in Ladysmith harbour, B.C. Prog. Rep. Pac. 15.

Foerster, R. E. A comparison of the natural and artificial propagation of salmon. Trans. Amer. Fish. Soc. 61.

Experimental tests of the methods used in the artificial spawning and fertilization of sockeye salmon eggs. Prog. Rep. Pac. 14.

Hart, J. L., L. P. Shultz and F. G. Greenberg. New records of marine west coast fishes. Copeia 2.

Hart, J. L. and G. H. Wailes. The food of the pilchard, *Sardinops caerula* (Girard) off the coast of British Columbia. Contr. 7(19).

The food of the pilchard, *Sardinops caerula* (Girard), off the coast of British Columbia. Rept. Comm. Fish. B.C. 1931.

Hubbs, C. L. and L. P. Shultz. A new blenny from British Columbia with records of two other fishes new to the region. Contr. 7(25).

MacKay, D. C. G. The story of the Pacific crab. Western Fish. 3(6).

An additional Brachyuran crab from northern British Columbia. Can. Field-Nat. 46(7).

Description of a new species of crab of the genus Paralithodes. Contr. 7 (27).

Moorhouse, V. H. K. Do fish react to noise? Prog. Rep. Pac. 13.

Mottley, C. McC. and Jean C. Mottley. The food of the Kamloops trout. Prog. Rep. Pac. 13.

Munro, J. A. and W. A. Clemens. The food of the American merganser, *Mergus merganser americanus*, in British Columbia. Can. Field-Nat. 46(7).

Pritchard, A. L. Pacific salmon migration. The tagging of the pink salmon and the chum salmon in British Columbia in 1929 and 1930. Bull. 31.

The return of marked pink salmon in 1932. Prog. Rep. Pac. 15.

Simpson, W. W. and Eric Ogden. The physiological significance of urea. 1. The elasmobranch heart. Jour. Exp. Biol. 9.

Spencer, G. J. The commercial crab, *Cancer magister* Dana, in Clayoquot sound, Vancouver island. Bull. 30.

Tester, A. L. Local population of herring. Prog. Rep. Pac. 12.

Wailes, G. H. Description of new species of Protozoa from British Columbia. Contr. 7(14).

Ecology of Sproat lake, B.C. Vanc. Mus. Art Notes 6(4).

Protozoa and algae from lake Tenquille, B.C. Vanc. Mus. Art Notes 7(1).

Wardle, R. A. The cestoda of Canadian fishes. 1. The Pacific coast region. Contr. 7(15).

On the technique of Cestode study. Parasit. 24(2).

Whittaker, W. R. Finding the age of fish by their ear-stones. Western Fish. 3(1).

Williamson, H. C. and W. A. Clemens. Pacific salmon migration. The tagging operations at Quatsino and Kyuquot in 1927 with additional returns from the operations of 1925 and 1926. Bull. 26.

INVESTIGATORS' SUMMARIES

DESMOND BEALL

WASTE LIQUORS FROM A BRITISH COLUMBIA PILCHARD REDUCTION PLANT

Attention has been concentrated on the nature of the dissolved "protein" in order to discover whether part or all of the dissolved material can be recovered profitably.

Five samples of effluent were collected from fish which had been stored from six to thirty-six hours before processing and analyses were made for total nitrogen, protein nitrogen, proteose nitrogen, peptone nitrogen, and sub-peptone nitrogen, with the following results.

Time of storage hours	Total N g. per l.	Protein N g. per l.	Proteose N g. per l.	Peptone N g. per l.	Sub-peptone N g. per l.
10	9.32	0.59	3.58	2.26	2.89
6	8.31	0.27	3.15	2.35	2.54
12	8.62	0.69	3.08	2.31	2.54
30	9.39	1.05	3.38	2.21	2.75
36	9.58	0.88	3.01	2.68	3.01

E. BERKELEY AND C. BERKELEY

POLYCHAETA OF THE PACIFIC COAST

Specimens of Polychaeta collected by workers at the Station and elsewhere have been identified from time to time. Exceptionally large individuals of *Heteromastus filobranchus* with enormous gill development have been examined from a depth of eighty fathoms in Saanich inlet where the oxygen content is only approximately 3.5 per cent. of saturation.

G. C. CARL

LOST LAGOON, VANCOUVER, AS A TROUT LAKE

The area was originally a part of Coal harbour, but in 1916 was cut off by a seawall and became a salt-water lake. In 1929, an association of anglers decided to convert the lagoon into a fresh-water area and to attempt to make it a trout lake for fly-fishing. The Pacific Biological Station was requested to advise and since July 13, 1929, has followed the development. A more extensive study was made of the lagoon from October 14, 1931, to August 20, 1932, by the writer. On July 13, 1929, examination showed: surface water temperature 23.5°C., oxygen 70 per cent. saturation, salinity 3.4 gr. per litre, pH 7.7 and plankton extremely scarce. Conditions generally improved from this time on although there were several setbacks as a result of lowering of the water level and the influx of large quantities of salt-water. On August 20, 1932, the surface temperature was 20.0°C., salinity .68 gr. per kilogram, pH 7.8 to 8.4, and the plankton while still not abundant had increased considerably in quantity and contained a greater variety of species. Aquatic plants, insects and fresh-water shrimps were introduced by the anglers and these have contributed to some extent to the general improvement of conditions. During the summer of 1932, there was an "epidemic" of the alga *Lyngbya bergei*, which probably may be taken as an indication of improvement of conditions, although a condition of stability has not been reached and may not be attained for some years. A number of marine forms continue to exist in the lagoon, as, for example, Entomorpha and *Neomysis mercedis*.

One hundred full-grown cutthroat trout were introduced in May, 1929, but apparently survived but a short time, and 200 yearlings of the same species also failed to survive. Approximately 100,000 Kamloops trout fingerlings were introduced in July and August of 1929 and they apparently soon perished. In spite

of other introductions, only a very few specimens have been taken by angling. The stickleback, *Gasterosteus cataphractus*, is present in rather large numbers and probably has constituted a food supply for the trout. The bullhead, *Cottus asper*, is also present in some numbers.

Lost lagoon is not yet considered as suitable for trout production, in large part because of lack of abundance of food organisms. It has been suggested that some form of fertilizer be introduced to hasten the developmental process but this has not yet been attempted.

SALT BATH TREATMENT FOLLOWING MARKING OF BROWN TROUT

For the purpose of learning something of the life-history of the brown trout being introduced into the Cowichan river, 5,000 fry were marked from July 7 to 13, 1932, by the removal of the adipose fin. During the first few days of marking, some mortality occurred and it was suggested that the fish be given a salt bath immediately following the removal of the fin. The treatment was instituted as an experiment with the following results:

July 7—No. of fry marked, 850. Mortality, July 8-14 (7 days).....	111
July 8—No. of fry marked, 1000. Mortality, July 9-14 (6 days).....	99
July 9—No. of fry marked, 750. Mortality, July 10-14 (5 days).....	45
July 10—No. of fry marked, 1000. Mortality, July 11-14 (4 days).....	38
July 11—No. of fry marked, 1000. All fish given 10-minute salt bath after marking (2 ounces sodium chloride per gallon water). Mortality, July 12-14 (3 days).....	10
July 13—No. of fry marked, 400. All fish given 30-minute salt bath immediately after marking and again after 24 hours. Mortality, 2 days.	0
July 8—A lot of 100 fry were handled but not marked or given a salt bath. Mortality, July 9-14 (6 days).....	16

From September 7 to 15, brown trout to the number of 8,700 were marked at Qualicum beach. Immediately after marking all fish were given a fifteen- to thirty-minute salt bath of the same strength as used at Cowichan. The mortality was less than two per cent. The mortality among 3,600 untreated fish at Cowichan was eight per cent. There appears to be definite evidence that the salt treatment reduces mortality.

NEAL M. CARTER

FIORDS AND FIORD FORMATION

Jervis inlet, a true fiord, having a length of 55 miles and an average width of 1½ miles, was systematically sounded in order to investigate further the "no bottom" soundings given on the latest charts. A threshold at a depth of 900 feet was located at the mouth, behind which the depth increased rapidly to 2,000 feet, then more gradually until a maximum of 2,175 feet was recorded in a reach approximately half-way up the inlet. A cross-section taken at this point revealed that the precipitous walls of the surrounding 7,000 to 8,000-foot mountains are produced below sea-level at an angle of over 50° until they meet the almost level, silted-in floor of the submerged gorge.

Toba inlet, 32 miles long and the next fiord north of Jervis inlet, was also sounded. At the entrance of the main channel a threshold was located at a depth of 1,000 feet, behind which a maximum depth of 1,690 feet was attained before the inlet gradually shallows towards its head. The tributary Homfray channel, however, deepens rapidly from each end toward its centre, where the available sounding wire (2,340 feet) failed to reach bottom over a longitudinal stretch of eight miles. Such a depth within one-half mile of shore is the greatest depth yet recorded on the inland coast of the province and is seldom exceeded in any inland waters. Oceanic depths of such magnitude are first encountered at a minimum distance of thirty miles off the open coast of Vancouver island.

No evidence of stagnation comparable with that found in the smaller, shallower inlet (Princess Louisa) which opens off Jervis inlet has been discovered in these three depressions which lie some thousand feet below the bounding thresholds. Dissolved oxygen and other chemical constituents exist in concentrations which would be expected from extrapolation of the values found in the open water of the strait of Georgia. Several very small Maldanids usually found only in corresponding oceanic depths were dredged, together with a single specimen of *Myriochele heeri*, from 1,800 feet in Toba inlet.

Distinct evidence of almost corrosive glaciation has been seen at low tide on the Cretaceous granito-diorite threshold at the mouth of Princess Louisa inlet and the slate mountains bordering both Jervis and Toba inlets are strongly glaciated to elevations of 4,700 feet. Deep glacial furrows have been observed on the summits of 8,000-foot peaks lying on the practically unexplored watershed which feeds both inlets. The trend and age of these furrows corroborates the glacial origin of Princess Louisa and Jervis inlets in particular.

VARIATIONS IN ANNUAL SEA-WATER TEMPERATURES

A seven-day moving average was found to be satisfactory for picturization of the temperature changes minus the effect of sudden diurnal variations and personal errors of observation. Such an average has been computed and plotted for each day of twelve years' records at William head near Victoria, obtained by Mr. Ira E. Cornwall of the Quarantine Station, and for those years in which the data taken at this Station are sufficiently complete. By means of mechanical integration an approximation to a quantity representing the annual duration of a temperature above and below the 12-year average temperature has been computed, the resulting figures showing that although the upward trend is not so regular as first supposed, it is nevertheless quite definite.

The annual summer temperature of the oceanic water in the strait of Juan de Fuca as represented at William head, appears to have increased by several degrees centigrade since 1921, attaining decided maxima in the summers of 1926 and 1931. An interesting point brought out is that corresponding winter maxima occurred during the winters preceding these two summer maxima. Personal observations and measurements made by the investigator have shown two corresponding maxima in the retreat of coastal glaciers, indicating some truth in the saying: "The winters are getting warmer".

A very pronounced feature of the plotted results is the recurrence of warm cycles during each year. These are most noticeable from May to September inclusive and occur approximately every lunar month. These cycles simultaneously occur on an exaggerated scale at Departure bay, as shown by records of the Station.

This exaggeration of temperatures in the strait of Georgia waters as compared with those of the more oceanic water is characterized in several ways. Whereas the average summer-to-winter variation at William head is approximately 5°C., that at Departure bay is nearer 15°C.; high summer temperatures at Departure bay occur earlier than at William head and often exceed those of the latter locality by as much as 8°C., while winter minima are lower at Departure bay. The times of annual equal temperatures at the two localities fall in March and close to the beginning of November.

THE ANALYSIS AND FOOD VALUE OF CANNED SOCKEYE AND PINK SALMON

The four grades of sockeye were chosen from localities which would yield representative early, medium, late and river runs of fish, the last two types being gill-netted from near the mouth and at some distance above the mouth of the Fraser river quite late in the season. The three grades of pink were similarly chosen. Six or more tins from each of the seven grades were selected for analysis.

Results show that the average protein content per tin is practically uniform (19.3 to 19.8 per cent.) for all the sockeye and the early pink packs, but falls to 17.7

per cent. in the later run pink. The average oil content per tin varies with the lateness of the run from 10.3 per cent. to 8.2 per cent. in the sockeye packs, and from 7.3 per cent. to 6.9 per cent. in the pink packs. The moisture content bears a similar, inverse relation. No significant variation in ash content is apparent. The average food value of the different packs is better indicated by the calorific value calculated from the protein and oil analyses, the carbohydrate content of salmon being negligible. This calorific value shows a variation with lateness of season from 833 to 740 calories per pound of total tin content in the case of sockeye as compared with a range from 706 to 652 calories in the pink. The intermediate packs give intermediate values, all analyses comparing favourably with American analyses of canned salmon.

Individual variations, particularly in the oil content of different tins of the same grade, frequently far exceed the differences between the averages for early and late packs. Consequently, any conclusions derived from averages based on a sample of six tins must be accepted with caution. The physical characteristics of the contents of the tin are a more reliable guide to the season and locality in which the pack took place than are the chemical analyses.

THE SALTING OF "ROUND" HERRING

The efficiencies of moist salt and concentrated brines ("pickle") as used in the commercial salting of whole ("round") herring have been compared by a study of the rate of dehydration and penetration of salt when whole herring are packed in moist salt or immersed in salt solutions of different concentrations.

At the end of the legal pickling period (five or six days, depending on the season), herring which have been continuously in contact with moist salt lose 30 per cent. of their original weight through dehydration and gain 8 to 9 per cent. by acquisition of salt. On the other hand, herring immersed in saturated brine lose only 24 per cent. of their original weight through dehydration but take up 13 to 14 per cent. in salt. The latter fish have a less shrivelled appearance and a greater internal salt reserve with which to combat access of moisture during shipment than have those fish which were in contact with moist salt. This advantage is partially offset by a slightly greater net moisture content and consequent weight.

Fish in contact with moist salt cease to lose moisture after the fifth day but continue to take up salt at a uniform rate for some days longer. The loss of water and gain of salt practically ceases after the sixth day in the case of those immersed in saturated brine.

In commercial practice, tanks of herring, pickle and salt accumulate an upper layer of brine having a concentration of from 90 to 80 per cent. saturation if left undisturbed for two or three days as frequently happens. The salt content of fish after immersion in experimental brines maintained at 97, 89 and 81 per cent. saturation indicated the lessened efficacy of such 90 to 80 per cent. brines in the commercial tanks. The rate of salt uptake and final content of salt after six days were very similar to those occasioned by the stronger brine, but the dehydration effect was quite dissimilar. The per cent. weight of water removed increased up to the end of a certain period (5½ days in 89, 4½ days in 81 per cent. brine), after which the total moisture content increased fairly rapidly, causing the net weight of the fish to increase quite rapidly.

The fallacy of allowing fish to remain in a weak brine for a long period of time in an effort to achieve the cure effected by a stronger brine was demonstrated by the fact that herring left in 80 per cent. saturated brine for nine days had regained their original weight and all but 10 per cent. of their original moisture content.

Large or fat herring lose water and take up salt more slowly than the smaller herring up to the end of five days. Plotted results have shown several interesting "halts" in the dehydration curve, which indicate this process is of a more complex nature than might be supposed.

W. A. CLEMENS AND L. S. CLEMENS

STATISTICAL STUDY OF SOCKEYE SALMON RUNS

Through the courtesy of the Provincial Fisheries Department, the annual collection of scales and data from random samplings of the runs of sockeye salmon to the Fraser, Skeena and Nass rivers and to Rivers inlet in 1931 was made available for study.

In the Fraser river the four-year-old fish constituted seventy-nine per cent. of the run. In Rivers inlet, the four-year-old fish were slightly in excess over the five-year-old groups and were characterized by their small size, the average length being the smallest on record. Of special note in the two northern rivers were the exceptionally large number of individuals of the five-year-old, three-years-in-the-lake group in the Skeena river and the striking decrease in the four-year-old age group in the Nass river.

W. A. CLEMENS AND G. V. WILBY

THE FOOD OF THE FUR SEAL OFF THE COAST OF BRITISH COLUMBIA

There has been considerable speculation concerning the nature of the food of the fur seal, *Callorhinus alascanus*, during its northward migration each year along the west coast of Vancouver island. Through arrangements made by the Department of Fisheries in 1931, twenty-five full stomachs were obtained from Indians sealing off Clayoquot sound.

The results of an examination of their contents show that herring occurred in 17 individuals (68 per cent.), salmon in 9 (36 per cent.), squid in 8 (32 per cent.), pilchards in 6 (24 per cent.), hake in 1 (4 per cent.), cottids in 1 (4 per cent.), and osmerids in 1 (4 per cent.).

It is evident that the schooling species form the bulk of the food of these seals, no doubt because of abundance and ease of capture. The sample is too small to infer from it that the various species listed always occur in the relative abundance shown above but it can reasonably be concluded that herring undoubtedly form the most important food material and that salmon constitute a very appreciable portion of the food although not forming the sole or even the main item.

D. C. B. DUFF

TOXIC PROPERTIES OF HERRING MEAL AND OIL WHEN USED AS A FOOD FOR SALMON FRY

Work has been continued on the examination of fish meals for the possible presence of a factor toxic to salmon fry,—investigating the effect of the oil content of certain diet combinations. The refined and oxidized herring oil was prepared by Mr. H. N. Brocklesby at the Fisheries Experimental Station, Prince Rupert.

Feedings were arranged containing an added 10 per cent. of refined or of oxidized oil combined with: (1) liver only, (2) meal only, (3) meal and liver. Where rations contained oxidized oil, the oxidation products were added in proportion. All rations—control or experimental—contained in addition a small percentage of starch. Each diet was fed to an experimental batch of 1,500 sockeye salmon fry for a period of 55 days. Batches fed on rations composed of liver, or of liver and meal in equal parts by weight, suffered no appreciable losses. This was true regardless of whether oil was not added, or was present in the refined or in the oxidized state. In the case of rations not containing liver, the proportions of the initial population lost by the end of the experimental period were as follows:—(1) whole meal ration, 27.7 per cent.; (2) meal with 10 per cent. added refined oil, 56.7 per cent.; (3) meal with 10 per cent. added oxidized oil, 55.3 per cent. While the temperature factor requires further analysis, it does not seem on inspection to have contributed significantly to the losses. Such temperature fluctuations as occurred did not register as extra losses in control batches. Results indicate that increasing the oil content of a herring meal ration

produces a mortality much heavier than that due to whole herring meal alone, but that such mortality is reduced to the level of the control minimum when 50 per cent. liver is incorporated in the diet. The effect of added refined oil is significantly the same as that of added oxidized oil.

FURUNCULOSIS

(1) Studies have been continued at the University of British Columbia on the bacterium isolated in August, 1931, from the victims of the Elk river epizootic, Rocky Mountain whitefish, known locally as "grayling". The organism has been found to conform in all cultural and biochemical characteristics with *Bacillus salmonicida* Emmerich and Weibel. Inoculation of the Elk river strains of the organism into goldfish and chub gave rise to typical symptoms, death, and to the postmortem findings characteristic of furunculosis. *B. salmonicida* was recovered, in the majority of cases in pure culture, from the lesions, kidney, and blood of such fish. Kidney lesions containing large numbers of the organism have been demonstrated histologically, and conform in character with the lesions reported by previous workers. It is concluded that the Elk river epizootic was actually due to furunculosis.

(2) During the summer of 1932, numerous deaths occurred among hybrid Pacific salmon kept in a retaining pond at Cultus lake. Postmorten examination of 103 fish showed a high incidence of typical furunculosis lesions; *e.g.* muscle lesions in 66 cases, liquefactive necrosis of kidney in 62 cases, liquefactive necrosis of spleen in 57 cases. Other typical lesions were present in lesser frequency. An organism corresponding culturally and biochemically to *B. salmonicida* was recovered in 94 cases, in 80 of which it was obtained in pure culture from one or more of the typical lesions. Tests on the pathogenicity of these strains are still under way.

(3) In order to obtain information as to the possibility of furunculosis bacillus being transferred on trout eggs, two lots of random samplings were examined. The first consisted of 32 brown trout eggs taken on January 20, 1932, from the Cowichan Hatchery; the second of 58 speckled trout eggs on February 10, 1932, from the Nelson Hatchery. Only one type of brown pigmented colony, composed of gram negative rods was found on these eggs. The brown appeared only in the colony itself and did not diffuse into the surrounding medium. After seven days the brown colonies became bright golden. In both respects the organism in question did not correspond with *Bacillus salmonicida*, and, furthermore, its fermentation reactions were different. In May, brown trout fry at the Cowichan Lake Hatchery were examined but no evidence could be found of the presence of the furunculosis bacillus.

C. R. ELSEY

BREEDING OF JAPANESE OYSTERS IN LADYSMITH HARBOUR

Although seed oysters can be introduced economically from Japan, it is evident that propagation in British Columbia would offer certain advantages.

Observations with a view to determining what is the likelihood of propagation on a commercial scale in Ladysmith harbour have been made each year since 1926. The results prior to 1932 were disappointing since in three of the six years there was no natural spawning and in the other years although partial spawning occurred late in the season there was only a very light set of oysters resulting from it.

In 1932, all of the oysters in the harbour (from three to five million) spawned completely in the first week of August, three weeks earlier than in 1930 or 1931. Larvae of regularly increasing size were taken in plankton samples and approximately one month after spawning a set occurred on experimental collectors. These consisted of chicken-wire bags of oyster shells of half bushel capacity which

were suspended from floats close to the beds. The average number of spat on a bag was twelve hundred. There was no appreciable mortality at the last examination on October twentieth and the young oysters had increased roughly ten times in length.

It appears from a consideration of climatological and hydrographical conditions, that breeding was the result of an unusually warm June which favoured the development of the sexual products, and a week of hot weather coincident with low daylight tides in early August which provided the spawning stimulus. Apparently the early occurrence of spawning was necessary for the normal development of the larvae. Had it taken place at the end of August or in early September, as was the case in the two previous years, the fall drop in temperature would probably have prevented their development.

BREEDING OF EASTERN OYSTERS IN THE BOUNDARY BAY AREA

Continued investigations of the breeding of eastern oysters in the Boundary bay area, particularly the Nicomekl and Serpentine rivers, further emphasize the fact that the occurrence of a set of commercial importance cannot be depended upon from year to year. As was the case in 1931 there was a complete absence of set in 1932 although extensive spawning of both imported and locally bred oysters took place early in the season, June 20 to August 5. (River oysters tend to spawn about one month earlier than those in the bay.)

An apparent reason for the failure of the larvae in the rivers to develop to the setting stage is afforded by the hydrographical conditions which prevailed after the occurrence of spawning. Salinities, under the influence of rainfall in early July of almost unprecedented amount, dropped below the values which are considered fatal to oyster larvae. In addition, the water was coloured a dirty brown and made abnormally acid by peat which was washed in from the neighbouring farm lands. The deadly effects were exercised not only on Eastern oyster larvae but on those of native oysters, clams, barnacles, etc.

An extensive cultching programme which had been organized to determine first, whether the intensity of set could be materially increased by supplying suitable collectors for the spat at the right time, and second, whether the spat could be successfully transplanted in the fall to the beds in the bay, had to be abandoned because of the death of the larvae.

An analysis of the ages of oysters in the rivers, which was undertaken in 1931 and continued in 1932, chiefly with the object of determining what have been the fluctuations in breeding intensity for previous seasons, indicated that sets of commercial importance have been fairly rare. They appear to have been limited to seasons in which the early summer temperatures were slightly higher than average and the precipitation in June and July was low. It indicated further that the sets in the good years have been greatly restricted by the lack of cultch.

It is concluded that any program which might have as its aim the development of the rivers for seed production should be planned with the fact in mind that the addition of cultch from year to year without regard to climatic conditions and without examination of the plankton for larvae would be impracticable. It is reasonably certain, however, that the judicious placing of cultch in years having climatic conditions favourable and larvae consequently present in the plankton, would result in the production of at least a very valuable supplement to the imported oyster supply.

THE PROPAGATION OF THE NATIVE OYSTER

Continued studies of native oysters in Boundary bay and Ladysmith harbour support the tentative conclusion which was reached in 1931, namely, that the production of oysters cannot be materially increased until improved methods of spat collection are adopted. It is evident that even in years which might be classed as "poor" from the standpoint of seed production under natural conditions, good sets can be obtained on shells which are retained in dykes or in wire bags, piled in tiers in deep water or suspended from floats.

The first heavy spawning of the 1932 season occurred in the third week of May. Plankton studies showed that there was relatively little mortality of the larvae resulting from this early spawning. A heavy spatting, amounting in some cases to forty thousand oysters per bushel of shells, occurred in the period from June 15 to June 30. Shortly after attachment, more than ninety-five per cent. of the spat died and practically all larvae disappeared from the plankton. The heavy mortality was experienced by the spat in the dykes and wire bags as well as by that on the natural beds and both Boundary bay and Ladysmith harbour were affected. A somewhat similar occurrence in 1931 was tentatively suggested to be the result of abnormally great precipitation at the time of and following spatting. Such an explanation can hardly account for the mortality in the present case since there was no excessive rainfall during the period. In spite of the heavy mortality there was an adequate set in experimental dykes and on suspended or otherwise continuously immersed shells.

On the other hand, although setting occurred regularly on the natural exposed beds, nearly all of the spat died in the early stages presumably as a result of exposure to the sun. The exceptions were the survivors of the June set which were large enough to withstand exposure, and the September set which, owing to changes in the tidal cycle, was not exposed for long periods during the daytime.

EXPERIMENTS ON THE SPAWNING OF JAPANESE OYSTERS

With the purpose of obtaining additional information concerning the relation between spawning and certain physical conditions, experiments were conducted at Boundary bay with oysters retained in wire cages and in heated aquaria. The following facts have been established. (1) Natural spawning can occur in the sea in water of which the temperature is consistently below 23 degrees centigrade. (2) Oysters taken from high ground late in July and placed where they will be continuously submerged can spawn in August under conditions which do not cause the spawning of oysters which have remained submerged at the same place for the entire season. (3) Female oysters can be induced to spawn by the addition of eggs or sperms, in suitable quantity, at temperatures as low as 22.5 degrees centigrade. Males under the same conditions can be made to spawn at considerably lower temperatures. (4) When spawning has commenced it can continue even after temperatures have been reduced to 19 degrees centigrade.

THE DEVELOPMENT OF NEW AREAS FOR OYSTER CULTURE

There are many bodies of water on the coast of British Columbia which, although they have never been utilized for oyster culture, appear to be suitable for the growing of Japanese oysters. Observations are being made of experimental plantings of Japanese oyster seed in three different places, namely, Pender harbour, Nanoose bay and Departure bay, the last named because records of temperature and salinity are available for it.

In Pender harbour, where approximately eighty acres have recently been leased for oyster culture, plantings of seed oysters were made in both 1931 and 1932. In the former year, relatively high ground (five-foot tide level) was used. In the latter the oysters were planted at several different elevations, the lowest being at the level of a zero tide and the highest at the seven-foot tide level.

The oysters of the 1931 planting, after being on the beds from April, 1931, to November, 1932, have attained the minimum size suitable for marketing, namely, 250 to 280 meats per imperial gallon.

Of the oysters planted in 1932, those at the zero-tide level have grown fastest. The growth rate of the others has varied inversely as the elevation. Present indications are that the fastest-growing oysters will attain the standard marketable size, namely, 200 to 225 per gallon, by November, 1933, and that the slowest growing lot will require an additional season to attain the minimum marketable size. The relatively slow growth of the oysters on high ground is compensated for by their superior shape. They tend to be short and deeply cupped whereas the fastest growing oysters are long and shallow.

In Nanoose bay, where they are roughly two hundred acres of ground which offer possibilities for oyster culture, the growth rate of oysters planted at the five-foot tide level in April, 1932, has been slower than that at the same level in Pender harbour. The minimum marketable size will probably not be attained until the spring of 1934. It is a reasonable assumption that the rate of growth would be considerably faster at lower levels. The oysters are of good shape. Partial spawning occurred in 1932 but there is no record of spawning for 1931.

In Departure bay the growth rate at the five-foot tide level closely parallels that of oysters at the same level in Nanoose bay. The oysters are of good shape. Partial spawning occurred in both 1931 and 1932.

INFECTION PERIODS OF THE WOOD-BORERS, BANKIA SETACEA AND LIMNORIA LIGNORUM

To determine at what time of the year protection of boats and other wooden structures is most necessary, in the different harbours of British Columbia, blocks of Douglas fir, which are changed at monthly intervals, are being used to indicate when and to what extent infection occurs.

To date, blocks have been exchanged for twelve months in Departure bay, Vancouver harbour, Boundary bay and Massett inlet, and for five months at Prince Rupert, with the following results:

(1) Definite proof has been obtained for what was only suspected before, namely, that dangerous infection by *Bankia* can occur at all times of the year. This fact was strikingly illustrated by blocks from Massett inlet.

(2) The periods of heaviest infection of *Bankia* are in the spring and fall. Contrary to what has generally been believed, the fall infection may be much heavier than that which occurs in the spring.

(3) The activity of Limnoria may be greatest in the spring and early summer but wood is attacked by it at all times of the year.

(4) Temperatures and salinities do not seem to be the most important factors influencing the breeding of *Bankia*.

(5) The dates of occurrence of heavy infection in different bodies of water may differ by several months.

H. FASMER

THE DISTRIBUTION OF THE PHYTOPLANKTON IN THE STRAIT OF GEORGIA

Due to the fact that the phytoplankton forms the first link in the food chain for the greater number of the marine organisms, the knowledge of its biology is a matter of fundamental importance for all marine biological studies. Samples of water taken with the usual form of water bottle were centrifuged and the phytoplanktonts counted.

In view of the fact that counting and tabulating of all samples has not been completed, definite conclusions are not yet warranted. However, it can be stated with certainty that the plankton population at different depths varies not only in number but also very much in composition. For instance, a station having a population of about 250,000 phytoplanktonts per liter at 1 meter, 95 per cent. of which are *Chaetoceros*, has, at 10 meters, only 61,000, and there *Chaetoceros* represents only 27 per cent., while *Rhizosolenia* amounts to 40 per cent. Again, at 30 meters, the total number has decreased to 3,000 and now *Skeletonema* dominates with 52 per cent., while *Chaetoceros* and *Rhizosolenia* represent respectively 17 and 13 per cent. The fact that the protoplasmic part in *Rhizosolenia* is relatively much larger than in *Chaetoceros* and the food value correspondingly also larger makes this information of importance in the estimation of the producing power of these waters.

R. E. FOERSTER

THE RELATIVE EFFICIENCIES OF NATURAL AND ARTIFICIAL PROPAGATION OF SOCKEYE SALMON AT CULTUS LAKE, B.C.

During the spring of 1932 the regular annual count of down-stream migrating sockeye from Cultus lake was made. The total count was 788,637 individuals, of which 779,019 were released to proceed to sea, 3,709 were preserved for examination, and 5,909 were recovered dead on the fence. The examination of the preserved specimens is now being completed but it would appear that practically the entire migration consisted of one-year individuals. As these fish were the product of the natural spawning in 1930 of 4,856 males and 5,542 females, with a possible egg deposition of 24,939,000 eggs, the returns would indicate an efficiency of roughly three per cent. for natural propagation, calculated on the basis of down-stream migrants.

TRANSPLANTATION OF SOCKEYE SALMON FOR RESTOCKING PURPOSES

The experiments in transplanting sockeye salmon from the lower Fraser river areas to the upper has been continued, and has now completed one four-year cycle.

During 1929, the Department of Fisheries transferred approximately 17,000,000 eyed eggs from Cultus lake to Eagle river, a tributary of the Shuswap system, and planted them in the gravel beds of the river. Fry to the number of 123,550 were reared in ponds at Taft, B.C., marked by removal of the adipose and left pelvic fins, and liberated during the latter part of October in Eagle river.

These eyed eggs and fingerlings being from the brood year of 1928, a return was expected this fall, 1932, and in order to enumerate the return to Eagle river, a picket-counting fence was erected in the lower part of the river below the planting beds. To December first the returns have been meagre, only one marked (three-year male) and 17 unmarked sockeye having been recovered. Such count would indicate that as far as a return to Eagle river is concerned, the transplantation was a failure. Anticipating the possibility that the transplanted fish might return to Cultus lake, a close watch was kept for such marked individuals. Only one assertedly genuine Eagle river marked individual has been taken to date at Cultus lake. No records of Eagle river marked sockeye have been received from other spawning areas.

From the fishing areas, a number of marked individuals have been recovered, distributed as follows:—Fraser river, 11; Puget sound, 2; strait of Juan de Fuca, 2.

THE RETURN OF ADULT SOCKEYE SALMON FROM A KNOWN ESCAPEMENT

The marking of seaward migrating sockeye by removal of certain fins has been carried on at Cultus lake for a number of years, with but indifferent success. However, by reason of a small migration, 104,061 individuals, in the spring of 1930 an opportunity of marking the entire migration was offered. All migrants were marked by removal of both pelvics. In the year of their expected return from the sea, 1932, efforts were made to procure as high a degree of recovery from the fishing areas as possible. The unsettled condition of the industry, by reducing the number of operating canneries, greatly aided the work and with the very efficient co-operation of the State of Washington Division of Fisheries, whereby an assistant was placed in each of the four operating canneries on Puget sound, and a supervisor on the Fraser river, exceptionally good recoveries were obtained. The recoveries were:

District	Type	Male	Female	Sex unknown	Total
Puget sound.....	C_4	393	618	...	1011
	C_3	7	...	...	7
	E_4	2	...	...	2
Strait of Juan de Fuca.....	C_4	85	117	...	202
	E_4	1	1	...	2

District	Type	Male	Female	Sex unknown	Total
Bellingham	C_4	9	10	...	19
Fraser river	C_4	475	329	32	836
	C_3	4	2	...	6
	E_4	6	5	...	11

("C" refers to Cultus lake; "E" to Eagle river. The number following the letter indicates the age.)

Thus, with a total recovery from the fishing areas of 2,068 C_4 or four-year Cultus lake sockeye, the return, based on the 104,061 migrants, amounted to two per cent.

To this total from the fishing areas must be added the number of marked individuals returning to Cultus lake. In 1931, these numbered 28, 18 males and 10 females. For 1932, the returns are not complete but to date 652 marked sockeye have been recovered.

The data to date, therefore, would show a return of at least 2,748 marked sockeye from a total escapement of 104,061 migrants, or 2.64 per cent. This percentage will be increased as further recoveries at Cultus lake are made.

CROSS-BREEDING OF PACIFIC SALMON

In continuance of the investigation into the fertility of hybrid salmon, which commenced with the crossing of all species of salmon in 1927, the following operations have been carried out and the following results obtained.

In the fall of 1931, the surviving three-year males of the F_1 generation ripened. They were then crossed with normal sockeye females and produced fertilized eggs which subsequently hatched. The hybrids used were sockeye-chum, chum-sockeye, spring-pink, sockeye-spring, pink-chum, pink-sockeye, spring-coho.

In the fall of 1932, the four-year females of the F_1 generation ripened, were crossed with normal sockeye males and produced fertilized eggs which subsequently hatched. The hybrids used were sockeye-spring, sockeye-chum, pink-chum, chum-spring, pink-sockeye.

A number of the original F_1 individuals from the spawning of 1927 matured in the fall of 1932 in their fifth year and the following indiscriminate crosses to test fertilization were made: male sockeye-spring to female chum-spring; male chum-spring to female pink-sockeye; male sockeye-spring to female pink-chum; male chum-spring to female sockeye-chum.

Eyed eggs from the above crosses were obtained, thus indicating that some fertility does exist.

In the fall of 1929, reciprocal crosses of sockeye and chum salmon were made. The fry were hatched and reared in a retaining pond at Cultus lake. On June 23, 1931, the hybrids were counted and it was found that there were in the pond 1,263 individuals of the chum female-sockeye male cross and 1,888 of the sockeye female-chum male cross. In the fall of 1932, some of the three-year males of both crosses ripened and these were further crossed as follows: sockeye female-chum male to chum male-spring female; sockeye female-chum male to pink male-chum female.

SOCKEYE SALMON FEEDING EXPERIMENTS

Further tests of experimental rations for retained sockeye salmon fry were made during 1932. Sixteen experimental lots of fry were fed for three months and the results, based on increases in length and mortality figures, indicate that while beef liver fed alone continued to produce excellent growth, substitutes may be used, provided that the beef liver content is not less than 33 per cent. Such substitutes used were frozen salmon offal, canned salmon, fresh salmon eggs, dried salmon eggs, dried skim milk and halibut meal.

Rations in which beef liver was lacking did not prove generally satisfactory and it was noted, by plotting coefficients of variation, that high percentages of variation in length occurred for rations lacking beef liver whereas low percentages of variation occurred where beef liver was present.

The best non-beef liver rations were in percentages: canned salmon 50 + dried salmon eggs 50; canned salmon 75 + dried salmon eggs 25; halibut meal 50 + dried salmon eggs 50; halibut meal 33 + dried salmon eggs 33 + dried skim milk 33.

TROUGH CAPACITY EXPERIMENTS

In order to obtain data concerning the safe carrying capacity of a standard hatchery trough, 16′×16″×8″, for sockeye salmon eggs and fry, experimental tests were conducted at Cultus lake whereby varying capacities of eggs were carried in hatchery troughs during the season. The experiment was divided to cover troughs equipped with riffles and troughs not equipped with riffles. Water flow was 10 gallons per minute.

The egg-carrying capacity was calculated on the basis of the number of healthy eyed eggs obtained. For troughs equipped with riffles, a capacity of 9 quarts per basket or 411,000 eggs per trough was successfully carried. For troughs without riffles, as high as 7 quarts per basket of 318,000 eggs per trough were safely carried to the eyed stage, but subsequent returns after hatch indicated that heavy losses occurred in troughs where the capacity exceeded 4 quarts per basket of 185,500 eggs per trough. The character of the losses tended to show that such loss was to a great extent caused by subnormal development during the earlier stages, in other words to overcrowding prior to the eyed-egg stage.

Fry capacity was calculated on the basis of the number of healthy fry produced. The fry capacity for troughs equipped with riffles was found to be 7 quarts per basket or 159,600 eggs per trough and for troughs not equipped with riffles, 3½ quarts per basket or 100,000 eggs per trough.

EXPERIMENTAL TESTS OF SOCKEYE SALMON ARTIFICIAL SPAWNING AND FERTILIZATION METHODS

To obtain data concerning the comparative efficiencies and relative merits of the spawning and fertilization methods practised in the hatcheries of British Columbia, tests were conducted during the season 1931-32 at Cultus lake. Three methods of spawning were used, expression or hand pressure, expression followed by incision, and full incision. Three methods of fertilization and treatment of eggs were adopted with each spawning method, namely, rinsing, steeping and congealing.

The results obtained indicate that expression spawning produced a loss of 13 per cent. through eggs being left in the gonads of the female. Total expression of all eggs is not achieved.

The other two methods of spawning show a much smaller loss, approximately three per cent., for incomplete spawning. No other appreciable difference between the three methods of spawning was noted, except that expression followed by incision required the assistance of an extra spawner during the operation.

No conclusive difference in production of fry was noted between the three methods of fertilizing and washing the eggs. Steeping involved less time and labour than the other two methods but requires running water.

WERNER FREUDENBERG

THE FOOD VALUE OF THREE SPECIES OF OYSTERS

Comparative chemical analyses of the three species of oyster (*Ostrea lurida*, or native oyster; *O. virginica*, or eastern oyster; *O. gigas*, or Japanese oyster) which are of commercial importance in British Columbia, have not as yet been available for food value studies. Through the kind co-operation of Mr. C. R.

Elsey of the Pacific Biological Station, samples of the various species were obtained from Crescent, Victoria, Ladysmith, Departure bay and Nanoose bay during July and August.

In all, four separate samples of *O. lurida*, six of *O. virginica* and five of *O. gigas* were analyzed. The moisture content of all three species was approximately uniform during the two-month period. Of the remaining constituents (calculated on a moisture-free basis) the protein showed the least variation. The glycogen content of *O. lurida* varied from 10.4 per cent. to 26.5 per cent. as the season advanced; *O. virginica* showed a variation from 11.7 per cent. to 31.1 per cent. with a similar seasonal increase; in *O. gigas* the values were more irregular, varying from 12 per cent. early in July through 5 per cent. on July 14 (Departure bay) to 24 per cent. on August 18 at Crescent.

The fat content of *O. gigas* was triple that of the other two species and increased noticeably as the season advanced. The ash content of *O. lurida* fell from 11 per cent. to 6 per cent. during the two months. *O. virginica* behaved similarly, while the change in ash content of *O. gigas* was very slight.

These values compare favourably with those of other investigators and appear to show, for example, that *O. virginica* has a higher glycogen and fat content when grown on this coast than when grown in the east, and that *O. gigas* from Ladysmith is as rich in food material as the Japanese product. The increase in glycogen content during August supports the hypothesis that this constituent is generated and stored during the autumnal and winter months to act as a reserve material during the spawning season. The high calorific value of carbohydrates causes this increase of glycogen to assume significant proportions from the standpoint of food values of the oyster during the winter.

J. L. HART

PILCHARD SAMPLING

(1) *For length.* This investigation was undertaken to discover the way in which the pilchard population reacts to the strain placed upon it by the fishery. Since, at present, specific age determinations can be made only with considerable uncertainty, the investigation has concentrated attention upon the length composition of a representative portion of the pilchard catch.

The most noticeable observation made to date is that of the reduction in the size of pilchards taken during the season of 1931 as compared with the two previous years. In 1932 the size of pilchards increased again but not sufficiently to bring the average length as high as in 1929 and 1930.

It was found that each season females are more numerous than males, although the sex ratio varies considerably. As females are also larger it was considered advisable to treat the two sexes separately.

(2) *For race.* This phase of the pilchard investigation has concentrated on the vertebra counts for pilchards captured in various localities in an attempt to determine the extent of the migrations of the species. The results of several thousand counts demonstrate significant differences, not only between California and British Columbia localities, but between the same British Columbia localities in different years. It is evident that vertebra numbers as a racial character in pilchards must be applied with extreme caution.

J. L. HART AND H. BORDEN MARSHALL

INTENSITY AND EXTENT OF THE POLLUTION CAUSED BY PILCHARD REDUCTION PLANTS ON THE WEST COAST OF VANCOUVER ISLAND

This investigation was undertaken as a result of complaints that the effluent from pilchard reduction plants has caused the herring to abandon certain spawning grounds on the west coast of Vancouver island. The extent and permanence of the contamination resulting from the effluent was studied by examining samples of sea-water and sea-bottom taken at different times and places near two repre-

sentative Barkley sound reduction plants. Water samples were examined for pH, organic nitrogen, dissolved oxygen and poisonous decomposition products; bottom samples were analyzed for nitrogen content and oil content.

The results of all analyses agree with general observations in indicating that the area affected was at all times limited to a radius of 200 m. from the effluent outlet pipe and that even in most of this limited area all signs of contamination rapidly disappeared on the cessation of operation. It is concluded that serious deleterious effects to herring spawning or marine life cannot result from the operation of pilchard reduction plants.

J. L. HART AND D. BEALL

CHANGES IN CHEMICAL COMPOSITION OF BRITISH COLUMBIA HERRING

The investigation to date has shown the oil content to be at a minimum about spawning time and has shown it to bear a reciprocal relationship to the water content. Protein and ash content are subject to comparatively slight alterations.

JOSEPHINE F. L. HART

EARLY LIFE-HISTORIES OF CRABS

Following the successful rearing of several species of crabs, attention has been given to the accurate differentiation of the young stages so that means may be found for identifying the species in the plankton. For example, in the first zoea stage a downward-pointing knob on the third segment of the abdomen of *Hemigrapsus nudus* distinguishes this species from *H. oregonensis.* The megalopal stages of four species of *Cancer* may be distinguished by size, hooked spines on the endopodites of the first four pairs of pleopods, plumose hairs on the exopodites and plumose setae on the exopodite of the uropod.

E. KUITUNEN-EKBAUM

THE OCCURRENCE OF DRACONTIASIS IN PACIFIC COASTAL FISHES

(1) In the summer of 1932 a case of dracontiasis was examined in *Platichthys stellatus* from Departure bay, infected by *Philometra sanguinea.* The same species of nematode has been reported from *Lepidopsetta bilineata, Rhodymenichthys dolichogaster* and *Caularchus maeandricus.* This blood-red nematode in flounders is chiefly located under the skin at the base of the fins or between the fin-rays, while in *Rhodymenichthys* the parasite was found mostly in the muscles of the head. In all cases the nematode appeared to be a mature female, with live embryos in the uterus, except in two cases, when young females were found together with males. In no case was the male found in fish which harboured a mature female. Several experiments were made with direct infection and attempts made to rear the larvae directly, but with negative results. The migration of the parasite through the muscles of the fish takes place probably in a very early stage of development, and, after reaching a particular location, fertilization takes place, and then probably the male atrophies and the female continues the life cycle.

The stomach contents of the fish and the plankton from infected localities were examined to find the intermediate host. A species of *Cyclops* was artifically infected with the larvae, but no infected cyclops was found in nature.

(2) The second case of *dracontiasis* was in sockeye salmon caught from English bay infected with a new species of a dracunculoid nematode, *Philonema oncorhynchi,* nov. gen. et sp. The white, mature females up to 360 mm. long, and the males, 35 mm. long, were found freely in the body cavity or tangled among the pyloric caeca, having migrated from the intestine into the body cavity where they had reached their maturity. No case was found where the parasite had migrated into the muscles of the fish, and therefore the commercial value of sockeye salmon is considered not to have been diminished by that infection.

D. C. G. MacKay

GROWTH OF THE EDIBLE CRAB

In the interests of conservation of the crab fishery it is particularly desirable to ascertain the time required by an individual to reach sexual maturity, commercial size and old age.

From observations made in Boundary bay during 1931, it appears that the hatching of the eggs occurs in the spring, that the zoeal stage is reached by about July and that crabs in the megalops stage may be found from July until early September. The examination and measurement of 1,030 post-larval crabs of the same brood during 1931-32 have shown that there is apparently no significant difference in size or numbers on the basis of sex. The approximate sizes of the first four post-larval stages were ascertained from the data. Observations made during the spring of 1932 indicated a retardation of growth during the winter months for the brood of the previous spring. For the most part these appear to have wintered in the fourth and fifth post-larval stages.

MOULTING AND MATING OF THE EDIBLE CRAB

From May onwards large numbers of live crabs were found buried in the sand near low-tide level. Inasmuch as most of these had either just moulted or were on the point of doing so, this was taken to be a related phenomenon. It is also possible that this behaviour may explain the annual decrease in commercial catch at this time of year which is ordinarily considered to be due to migration.

Observations on 298 crabs which moulted in captivity during 1932 indicated that the increase in greatest width ranged from about 10 to 25 per cent. at a single moulting, and that the active sloughing of the old exoskeleton occupied about ten minutes. Only during this short period would the crab be in a state of almost complete helplessness.

Mating is considered to be related to moulting, the male apparently mating before moulting and the female soon after moulting. Six pairs of crabs in the mating embrace were found on the tide flats near Crescent between May 19 and July 5. These observations taken in conjunction with the extensive moulting now known to take place at this time of year make it seem extremely probable that the mating of the edible crab is a vernal event.

THE NEED FOR BAIT IN CRAB FISHING

Crab fishing in Boundary bay is ordinarily carried on with traps which, oddly enough, are not baited. The following experiment was tried in order to see whether the use of bait would influence the catch per trap. Nineteen traps were baited with clams and oysters placed in punctured tin cans within the traps and nineteen were left unbaited, the baited and unbaited traps being arranged alternately. One crab was left in each trap, according to the custom of the region, and the traps were put out in the ordinary fishing grounds. Two days later, on hauling the traps, the following results were obtained. With bait 325 crabs were taken, of which 134 were females and 191 were males; 124 were males of commercial size. Without bait 303 crabs were taken, of which 100 were females and 203 were males; 130 males were of commercial size.

Elsewhere on the coast fresh bait is regularly employed and is considered essential in order to procure even a moderate catch. Why the Boundary bay crabs should congregate in large numbers in the commercial traps without the use of bait has yet to be satisfactorily explained.

C. McC. Mottley

RACIAL INVESTIGATION OF TROUT

The exact identification of the different forms of trout by means of morphological characters is necessary in the development of a program in fish culture and for the formulation and enforcement of regulatory measures.

In order to test the reliability of various characters, approximately thirty thousand fry and six thousand adults of trout from all parts of the province have been examined. Thirty-five characters have been analyzed in greater or less detail as follows: (A) measurements: (1) total and standard lengths and weights; (2) proportions of head and related structures; (3) proportions of body (trunk and tail); (4) proportions of fins. (B) counts: (1) scales; (2) gill-rakers; (3) branchiostegals; (4) fin rays; (5) vertebrae; (6) pyloric caecae. (C) attributes: (1) coloration; (2) colour of flesh; (3) hyoid teeth; (4) maturity; (5) condition; (6) food; (7) age.

The results show that there is little evidence on the morphological side to indicate the existence of races. A few examples may be given. The scale count once considered to be the most useful criterion for the identification of species and subspecies has been shown to be modifiable by temperature and therefore can have no racial significance. The vertebral count has likewise been found to be modifiable by temperature. The proportions of the head and related structures are so modified by condition of size, age, state of maturity and by nutritional factors that they would appear to be of little value for distinguishing races although they may be of prime importance in differentiating species. Colour of flesh is sometimes referred to as of racial value but it has been shown by experiments at the Nelson hatchery that the offspring of red-fleshed trout when reared on a liver diet, had white flesh. Condition is a character determined by food and spawning. It has been demonstrated that a so-called "dwarfed race" developed into a "large race" when supplied with abundant food.

THE SPAWNING RUN OF KAMLOOPS TROUT AT PAUL CREEK, B.C.

The spawning run at Paul creek was counted and scale samples were taken from eighty-three per cent. of the fish. Certain findings of a biological nature are herein reported, the understanding of which seems necessary for the scientific management of trout cultural operations.

(1) Time and duration of the run. The run began about April 27 and continued until June 1. The duration of the run was longer than usual, probably due to the unusually backward season.

(2) Size of the run. Owing to a heavy freshet on the night of May 1 and the lack of assistance, the fence did not operate for twenty-four hours. While four hundred and seventy-six fish were actually counted, the run may be estimated at 500±25 fish.

(3) Proportions of the sexes in the run.

A. Females made up fifty-three per cent. of the run; males, forty-seven per cent.

B. The males tend to run earlier than the females.

(4) Age composition of the run (percentage for each age of total number of each sex,—195 males and 220 females).

Age	II	III	IV	V	VI	VII
Males	38	18	18	15	8	2
Females	0	35	41	16	7	1

THE ANGLING FISHERY FOR KAMLOOPS TROUT AT PAUL LAKE

An understanding of the biological factors underlying the cycle of depletion and restoration of a fishery is essential for its conservation and management. The present report deals with the continuation of the investigation at Paul lake, Kamloops, in 1932, with special reference to the catch and the fry planted in 1931.

(1) The total catch was about 2,800 fish.

The average catch per person for the season was 2.16 fish; the average catch per boat for the season was 4.10 fish.

The maximum catch approached the legal limit (15 fish) and was obtained only three or four times during the season. The maximum catch per boat was 20 fish, obtained by a party of three fishing in one boat.

The average catch per person increased as the season advanced: May, 2.0 fish per person; June, 1.2; July, 2.0; August, 2.4; September, 3.1; October, 4.5.

The increase is directly correlated with the influx of yearling trout (1931 planting) in the catch. The catch of yearlings rose from 0 per cent. in May to 83 per cent. of the total catch at the end of the season.

(2) The numbers and weight of trout of each age-group caught are estimated as follows:

Age	Number	Percentage	Average weight	Total weight (pounds)
I.....	1200	43	0.6	720
II.....	1300	46	1.9	2483
III.....	220	8	3.4	748
IV.....	50	2	3.9	195
V.....	35	1	2.9	102
				4248

The production of trout at Paul lake for the year may be estimated at four to five pounds per acre, or 2.8 fish per acre.

The analysis of the age composition of the catch per month is shown by the percentages in the following table:

	May	June	July	August	September
No. of fish sampled	138	77	138	233	211
Age					
I.....	0	0	28	75	83
II.....	83	84	57	20	11
III.....	13	7	13	3	4
IV.....	1	6	2	1	1
V.....	2	3	0	1	1

(3) The catch was analyzed for the numbers of immature, maturing and mature fish in order to obtain data for forecasting the size of spawning runs. These three categories were present in the sample of 797 fish, as follows.

1. Immature fish (would probably not have spawned in 1933).... 72 per cent.
2. Maturing fish (would probably have spawned in 1933)..... 22 " "
3. Mature fish (have already spawned and would have spawned again)..... 6 " "

It is probable, judging from the trend of the fishery that the 1933 spawning run will have an increased proportion of II males and III females, and that the numbers of spawners and the egg-collection will be greater than this year (1932).

THE NANAIMO RIVER SYSTEM

The Nanaimo river system has been proposed by the Nanaimo Board of Trade as a possible area for the introduction of sockeye salmon. There is no run of sockeye to any stream on the east coast of Vancouver island south of Seymour narrows. If such an introduction did prove successful there are five other similar systems on the east coast besides the Nanaimo river, providing, in all, about 2,700 acres of lake-water for the production of young sockeye. Consequently, it is

possible that the present valuable fishery for sockeye might be extended into a rather large area hitherto non-productive for this species.

A preliminary biological survey was carried out in August, 1932, of the Nanaimo river system, which consists of the main river joining successively three lakes, each about 500 acres in extent. There are numerous gravelly tributaries and beaches and the lakes are comparatively deep. The system seems to present the physical requirements for a sockeye run.

There is a considerable change in the volume of the river from summer to winter. The lowest period is during August and September. This fact might necessitate the introduction of a late-running variety of sockeye. The pH of the water ranged from 6.6 to 7.2. There was a marked thermocline in the First Nanaimo lake. The plankton and bottom fauna appeared to be present in only moderate amounts. The fish fauna of the river system was investigated above the Nanaimo river falls. Five species were observed and three others were reported to be present: sticklebacks, *Gasterosteus* sp.; spring salmon, *Oncorhynchus tschawytscha*; kokanee, *O. nerka kemmerlyi*; coho, *O. kisutch* (reported); chum, *O. keta* (reported); rainbow-steelhead, *Salmo gaerdneri*; cutthroat, *S. clarkii*; Dolly Varden, *Salvelinus malma* (reported).

JEAN C. MOTTLEY

THE FOOD OF TROUT

A study is being made of the food of trout since the nature and amount of food affects the rate of growth, reproduction and feeding habits of fish. The competition for food between trout and less valuable species is also an important consideration.

Kamloops trout is the only species of fish in Paul lake. In 1931, a study was made of the food of four groups, namely, stream type fry, lake type fry, yearlings and adult trout. The samples were collected from April 15 to October 5. The food of the stream type fry was exclusively aquatic insects, Diptera forming 90 per cent. of the total volume of the stomach contents and Plecoptera and Coleoptera making up the remaining 10 per cent. The lake type fry had a more varied diet, Cladocera and Copepoda constituting 68 per cent. of the volume of their stomach contents, while aquatic and terrestrial insects formed the remaining 32 per cent. The average length of the lake fry was twice the average length of the stream fry and the average volume of the stomach contents was 27 times that of the stream type. The lake apparently offers more food for the fry and this condition appears to promote more rapid growth. The variety of food may also be a factor in the increased growth rate. The food of the yearling trout consisted of terrestrial insects 40 per cent., aquatic insects 30 per cent., and amphipods 30 per cent. The yearlings were ten inches to twelve inches long by the end of the summer, at which stage they are readily caught by anglers. The percentage volume of amphipods increased in the diet of older trout and aquatic insects, terrestrial insects, Cladocera, Gastropoda and Hirudinea (in order of importance) made up the rest of the diet. Of the aquatic insects, the Trichoptera, Odonata and Diptera were the most important. Ants were the most important of the terrestrial insects. No small trout were found in any of these stomachs, but in the 1932 season, trout fry were found in the stomachs of four yearling trout.

Fly fishing varied directly with the occurrence of insects. Trolling became effective as the number of insects decreased and as the fish fed more extensively on Amphipoda.

J. A. MUNRO

THE FOOD OF WATER-FOWL

The results of field studies at Departure bay, Nanoose bay and Comox harbour and of examination of stomach contents at the present time appear to indi-

cate that the golden-eyes and scoters take few or no fish. The red-breasted merganser, the murrelet and the guillemot take fish to some extent. The mallard takes salmon eggs and salmon flesh during the salmon spawning period and an occasional small fish during the remaining part of the year.

J. A. MUNRO AND W. A. CLEMENS

THE FOOD OF THE AMERICAN MERGANSER

An investigation of the food habits of the American merganser, commenced in 1930, was continued and the results were used in the preparation of a preliminary paper (see under "Publications").

The specimens available for study, supplied largely through the courtesy of the Department of Fisheries, were collected at various localities in British Columbia where the American merganser is reported to feed largely on trout and on salmon fry.

The results up to the present time indicate that in the coast region sculpins constitute approximately 54 per cent. of the food of the merganser, sticklebacks 16 per cent., salmonoids, including portions of dead spawned-out salmon, 17 per cent., other fishes 13 per cent. In the interior of the province, sculpins and chub each form 24 per cent. of the food, shiners 14 per cent., squawfish 12 per cent., suckers 10 per cent., trout and salmon 12 per cent.

A. L. PRITCHARD

THE TAGGING OF SPRING SALMON IN BRITISH COLUMBIA IN 1929 AND 1930

Spring salmon tagged with a view to establishing their principal routes of migration have given the following returns.

Area of tagging	Year	No. tagged	Per cent. return	Fraser R.	Percentage of returns		
					Columbia R.	Canadian waters	U.S. waters (exc. Alaska)
North coast							
Queen Charlotte I.	1929	402	14.9	31.6	21.6	50.0	48.3
" "	1930	660	15.0	16.2	27.3	40.4	58.6
Hecate st.....	1930	182	7.2	7.7	30.8	46.1	46.2
West coast							
Queen Charlotte I.	1925	274	13.5	10.8	27.0	27.0	70.3
" "	1929	375	10.9	17.1	14.6	43.9	56.1
" "	1930	179	13.4	16.7	41.7	25.0	70.8
Millbank, etc. sound.....	1930	302	5.0	26.7	13.3	86.7	13.3
Vancouver island							
Hardy bay.....	1930	436	6.2		16.7	33.3	66.7
Kyuquot.....	1927	517	14.1	1.4	64.4	12.3	87.7
Ucluelet.....	1925	1,125	10.8	4.1	60.7	17.2	82.8
"	1926	1,353	13.1	6.2	60.0	17.5	82.5

The spring salmon from the areas in northern British Columbia showed a southerly and easterly migration similar to that reported previously for the same species in the southern portion of the province. The distribution of recoveries

indicates that the movement through southern British Columbia was chiefly along the west coast of Vancouver island.

It appears that in general the returns from the United States waters became fewer as the tagging has moved farther northward, those from the west coast of Vancouver island averaging approximately 80 per cent., from the west coast of the Queen Charlotte islands, 65 per cent., and from the north coast of the Queen Charlotte group and Hecate straits, 51 per cent. The spring salmon taken in Millbank sound were evidently bound chiefly for Canadian spawning areas.

Recaptures in Alaska were reported only for springs tagged in the Queen Charlotte island districts and Hecate straits. In each case, however, there was only one or two fish.

THE RAZOR CLAM (SILIQUA PATULA) FROM NORTH BEACH, GRAHAM ISLAND QUEEN CHARLOTTE ISLANDS, B.C. IN 1932

For some years, those in charge of the clam cannery on North beach, Queen Charlotte islands, have observed that at times many of the clams lose their fatty white appearance and become very thin and dark-coloured. The reduction in weight greatly increases the number required per case, and hence raises the cost of production, while the darkened colour reduces the quality of the pack.

During the spring of 1932, Mr. E. S. Richardson, the fishery inspector for the district, procured samples of live clams from the commercial digs for examination, as follows: April 21, 20; May 5, 12; May 7, 26; May 14, 19; May 19, 14; May 24, 24; and May 27, 23. In only two of the smallest clams was it impossible to discover the gonads and distinguish sex. The lengths of the shells of these individuals were $2^{11}/_{16}$ and $2^{3}/_{4}$ inches. All over three inches were ripe and apparently ready to spawn. It is noteworthy that eggs and sperms were being generally liberated as early as May 27, since Fraser reported that the razor clams in this region were only partially spawned early in July, 1928. There is no doubt that physical factors, the chief of which is probably temperature, greatly influence the time of spawning.

These clams taken on April 21 and May 5 were all classed as fat since they contained well-developed ovaries and testes which were quite compact and hard. Thin and darker clams appeared as follows: May 7, 4; May 19, 1; May 24, 10; and May 27, 21. All of the latter had commenced to spawn and some had almost completed the deposition of the sex products, thereby leaving the intestine and other darkly coloured organs exposed. This condition, which is normal and associated with spawning, could account for the change in appearance of the clams as reported by the cannery officials.

THE NATURAL RUN OF PINK SALMON (ONCORHYNCHUS GORBUSCHA (WALBAUM)) IN MASSETT INLET DURING 1932, WITH SUMMARY SHOWING THE EFFICIENCY OF NATURAL PROPAGATION

The experiment discussed herein was begun with the installation of counting fences in McClinton creek, Massett inlet, Queen Charlotte islands, during the spring of 1930. In the fall, enumeration of the spawning adults was carried out and the count of the down-stream fry migrants in the spring of 1931. Since all data at present on hand indicate that the pink salmon matures at the end of the second year, the examination of the adult run in the fall of 1932 was considered as completing the cycle. The results given below include chiefly a discussion of this year's work, but give also for the first time, so far as is known, a fairly accurate résumé of losses suffered by this species during the various stages of its life-history.

In many ways the run of 1932 was similar to that of 1930. At the outset, up-stream migration was confined to the hours of darkness, immediately after high-water slack tide. Later, as more fish became mature, largest numbers reached the fence on the freshets regardless of light. When the water rose to a height of more than four feet, however, the current was apparently too strong

for the pinks to stem, so that they were forced to seek the back eddies and deep pools below the weir.

Males predominated from the beginning, August 4, until September 14, after which time the females were more plentiful. The final disposition of the sexes on the spawning grounds was almost equal as in 1930, viz., 8,003 (51.3 per cent.) males and 7,597 (48.7 per cent.) females.

It is interesting to note the dissimilarity in the time of the two runs. The first individual was taken this year on August 4, but the main migration took place between August 27 and September 16, as opposed to September 8 to September 28 in 1930. It is felt that the chief reason for this early movement lay in the phenomenally heavy rainfall which occurred when the fish began to appear in the inlet. From August 25 to August 31, the measured fall was 2.7 inches, and from September 1 to September 15, 14.0 inches. Thus the salmon which show a very definite tendency to ascend the rivers after a heavy influx of fresh cold water, obtained sufficient incentive to go up immediately and did not "school" off the mouths of the streams. That those of 1932 were not as ripe as those of 1930 was evident from the examination made at the fence.

Throughout the run random samples were inspected in detail to obtain lengths, weights and egg counts. The average lengths of each sex were almost two inches greater than those of the previous year. Probably correlated with this, the average number of eggs per female, determined from the actual count of 73 individuals, was 1,758, *i.e.* 223 greater. There was thus a slight compensation for the smaller number of fish.

The results for the cycle are tabulated below. The percentages recorded therein have been calculated without attempting to allow for the effect of "wandering" described in another report.

	1930		1931	1932	
	Male	Female		Male	Female
No. adult migrants....	32,955	33,196		8,003	7,597
Av. no. eggs per female		1,535			1,758
No. eggs deposited....		50,950,000			13,360,000
No. fry migrants....			5,026,000		
Percentage ratio fry migrants to eggs deposited in 1930					9.9
Percentage ratio returning adults to eggs deposited in 1930					0.03
Losses egg to fry migrant stage					90.1
Losses marine phase					9.87
Total loss					99.97

THE RETURN IN 1932 FROM THE MARKING OF PINK SALMON FRY MIGRANTS IN 1931

The object of removing the adipose fins from 185,000 salmon fry during the down-stream migration at McClinton creek, Massett inlet, in the spring of 1931, was to establish definitely at what age the fish would reach maturity and whether they would return when mature to spawn in the same area.

From the examination of scales, it has been generally believed that thef ry of this species go down to the sea almost as soon as they are hatched and that the adults return to spawn in the autumn of their second year. The recovery, in 1932, at McClinton creek, of fish lacking the adipose fins which were removed from the fry migrants in 1931 has proven that the age as determined from the scales was accurate.

Recoveries in 1932 for pinks marked at McClinton creek in 1931 have been as follows. From Alaska there have been 19, consisting of,—Karluk beach, 8; Olive cove, 10; Anan creek, 1 (for these last two places reported by Dr. F. A. Davidson, United States Bureau of Fisheries, but scars not forwarded with information). From Northern British Columbia (exclusive of Queen Charlotte islands) there have been 7, consisting of,—Wales island, 1; Nass river area, 1; Skeena river, 4; Chatham sound, 1. From southern British Columbia there

have been 24, all from Johnstone strait. From Queen Charlotte island area there have been 133, consisting of,—Otard bay, 2; Naden harbour, 14; Massett inlet, 22; McClinton creek, 95.

The recapture of 95 marked fish (52 per cent. of the recoveries) in McClinton creek definitely shows that there is a strong tendency on the part of the pink salmon in this locality to return to their native spawning area. It is not unlikely that the 22 fish taken in Massett inlet and the 16 in Otard bay and Naden harbour would ultimately have reached the "parent" stream if they had not been taken in the commercial nets. In such an event, the return to McClinton creek would have amounted to 133 or 73 per cent. of the recoveries.

The recapture in other localities of 50 fish lacking the adipose fins (27 per cent. of the recoveries) seems to indicate a certain degree of wandering. Although no fin abnormalities were discovered among 310,000 pink salmon fry and 1,500 adults from McClinton creek and Tlell river, reports from other areas point out that such abnormalities may exist to a very small extent. It is felt, however, that the indications shown by these returns should not be entirely ignored on this account.

W. E. RICKER

FACTORS IN CULTUS LAKE AFFECTING THE DEVELOPMENT AND SURVIVAL OF YOUNG SOCKEYE SALMON

Studies of the factors in Cultus lake which have an effect on the development and survival of young sockeye have been carried on from the inception of the Cultus lake investigation proper but only since the fall of 1931 have they been intensively prosecuted.

(1) General limnology of Cultus lake. Cultus lake is about three miles by one-half a mile in extent. Its shores slope steeply down, so that more than four-fifths of the bottom is a flat plain of ooze, lying thirty-five to forty-two metres below the surface. Because of this uniform configuration, a single station has been selected for bimonthly limnological observations, which should be representative of the whole open-water region.

From January 1 to the middle of March, the water of the lake was of uniform temperature from top to bottom, reaching a minimum of 3.6°C. At no time was the surface ice-bound. As the water warmed up throughout the spring and summer, a thermocline developed in the 5 to 10 metre stratum and in autumn fell to 15 to 20 metres. During this summer period of stratification, the supply of oxygen at the bottom was reduced to 4.5 cc. per litre; at other times it was abundant at all depths. The water was at all times fairly hard (65 mg. per l. of bicarbonate, expressed as $CaCO_3$) and alkaline in reaction (pH 7.0 to 7.8). Its silica content increased throughout the summer, particularly in the lower strata; nitrates, phosphates and bicarbonates showed little variation with depth or seasonally; nitrites could not be detected.

Enumeration of net plankton organisms gave evidence of an abundant but not particularly varied pelagic biota. The only phytoplanktonts of consequence were the diatoms *Melosira* and *Asterionella*, which attained to a maximum in the middle of March, but were very scarce throughout the summer. The protozoans *Ceratium* and *Dinobryon* were present in good numbers in summer and early fall; the several kinds of rotifers seem to have been most common in winter. Crustaceans of four genera: *Epischura*, *Cyclops*, *Daphnia* and *Bosmina*, show variations in numbers which may be to some extent correlated with the growth and migration of their enemies, the young sockeye.

Dredgings of the bottom fauna in deep water reveal a fauna very restricted, as to species, but not unusually so in numbers of individuals. Only four large organisms were found: one tanypine and two chironomid midges, and an oligochaete.

Collections of larger aquatic plants in the few sheltered bays which harbour them reveal *Chara*, *Myriophyllum*, *Ceratophyllum*, *Ranunculus*, and several species of *Potamogeton*.

(2) Natural food of young sockeye salmon. Specimens of young sockeye have been obtained from the lake by means of three fine gill nets, which were respectively, 5/8, 7/8, and 1 1/16 inches stretched mesh. All have been regularly set at the bottom of the lake in various depths of water and the two smaller ones have been suspended at various levels from the surface. On the whole, they are not particularly successful in taking young salmon, so for food studies specimens found in the stomachs of Dolly Varden, charr and squawfish have been chiefly used.

The stomach analyses confirm previous observations by showing that fingerling sockeye eat plankton crustacea almost exclusively. They take all four species but more of the larger forms, *Daphnia* and *Epischura*.

(3) Food of predaceous fishes of Cultus lake in relation to survival of young sockeye. Larger gill-nets have collected many specimens of the more abundant fishes of the lake. The squawfish (*Ptychocheilus oregonensis*) greatly exceeds all others in the catches. Its principal foods are sticklebacks (*Gasterosteus aculeatus*) and young sockeye. The charr (*Salvelinus spectabilis*) is much less common, but individually is more destructive of young sockeye; as many as seventy-five have been taken from one stomach. It also eats large numbers of sculpins (*Cottus asper* and *C. aleuticus*), sticklebacks, and the decaying carcasses of adult salmon. The few specimens of trout (*Salmo* sp.) examined had eaten sockeye, sticklebacks and midges.

A. L. TESTER

THE HERRING OF THE COMMERCIAL CATCH OF BRITISH COLUMBIA

The purpose of this investigation is to examine the variation in age and length composition of the commercial catch of herring in the coastal waters of British Columbia from year to year to detect any decline of the fishery; and to examine statistically herring from the various fishing areas to determine the degree of intermingling or migration which takes place between them. The ultimate object is to explain fluctuations in the fishery and to determine whether or not these fluctuations are related to the intensity of the fishing. During the past season the sampling program included herring from eight important fishing areas: Trincomali channel and Nanoose bay on the east coast, and Barkley sound, Sydney inlet, Nootka sound and Kyuquot sound on the west coast of Vancouver island; and Jap inlet and Pearl harbour in the Prince Rupert district.

(1) Herring from Sydney inlet had the largest average length of the eight districts examined (200.4 mm.). The average lengths of herring from the other three districts on the west coast of the island, while smaller than that for Sydney inlet fish, were larger than those from the east coast. The lengths of fish from the Prince Rupert district averaged about the same as those from the east coast of Vancouver island (about 188 mm.).

Scale examinations showed that samples of herring from Sydney inlet were characterized by the large proportion of fish in their fourth and fifth years with a small proportion in their third and sixth years. All other districts about Vancouver island were characterized by fish in their third, fourth, and fifth years in order of importance with small percentages of older fish. Although the average length of herring from the Prince Rupert district was relatively small, scale readings showed that the predominating ages were fourth, fifth, and third years in the sample from Jap inlet, and fifth, fourth, third, and sixth years, in order of importance, in the sample from Pearl harbour. These two samples contained a relatively large proportion of fish in their seventh to tenth years of age.

(2) In investigating so-called "racial problems", the following characters were considered: age composition, rate of growth, sex ratio, head length, length

to the insertion of the dorsal fin, numbers of total and abdominal vertebrae, and number of keeled scales. Herring from the Prince Rupert district were found to differ from herring in the vicinity of Vancouver island in several of these characters to such an extent as to be classed as a population distinct from the latter. Several other interesting results were obtained which suggested that herring in several of the fishing areas tended to form local populations, but these results are subject to verification in future work. Among these might be mentioned a gradation in vertebral numbers from south to north-west along the coast, a condition which conforms to the general increase from California to Alaska noted by other workers.

G. H. WAILES

PLANKTON STUDIES

(1) Fresh-water plankton. In connection with certain investigations, collections of plankton were made in the series of Nanaimo lakes, Sproat lake, Lost lagoon, etc. The plankton of the Nanaimo lakes as obtained in August, 1932, was not abundant. Zooplanktonts, especially Crustacea, were few in number while Desmids were represented by many species. Sproat lake plankton, as collected largely in early August, was rather rich in forms. Lost lagoon in Vancouver city is a body of water which at one time was salt but which is being changed into a fresh-water area for the rearing of trout. The lagoon has been under observation since the summer of 1929 and it has been of interest to follow the appearance of the fresh-water planktonts. Myxophyceae and Chlorophyceae appeared in some quantity during the summer of 1932 and *Lyngbya bergei* appeared in July in the form of a thick scum. Crustacea are still rare.

(2) Plankton of alpine regions. In 1931, collections of plankton were made from lake Tenquille, 5,300 feet above sea level. Desmids were particularly abundant. A number of new records of both plant and animal planktonts were obtained.

R. A. WARDLE

CESTODE INVESTIGATIONS ON THE PACIFIC COAST

(1) The viability of tapeworms in artificial media. The aim of the investigation was to test the favourability of a range of artificial media toward tapeworms removed from their host habitat, in order to establish a technique for the maintenace of such animals indefinitely *in vitro*. The cestode selected for experiment was a larval tetrarhynchoid, *Nybelinia surmenicola*, sufficiently common to permit of several thousand individuals being utilised. The media tested comprised a series of salines, of antiseptics, and of nutrient media. The most favourable saline media were Ringer-Locke and saline-citrate, survival time values up to 456 hours being obtained in sterilised Ringer-Locke. The most promising antiseptics were thymol, resorcinol and formol. The most promising nutrient media were Locke-glucose, serum-saline gel, and Lockefish bouillon, survival time values up to 408 hours in Locke-glucose, to 192 hours in serum-saline gel, and up to 200 hours in Locke bouillon, being obtained. No increase in growth or development of the cestode larva was observed.

(2) Additions to the recorded cestodes of Pacific Coast fishes. A collection of material made by members of the Station staff, and by the investigator, comprised: *Clestrobothrium crassiceps* (*Merluccius productus*), *Eubothrium* sp. (*Ptychocheilus*), *Schistocephalus solidus* (shores of Upper Nanaimo lake), larval *S. solidus* (*Cottus*, Shuswap L.), larval *Ligula intestinalis* (Chub, Shuswap L.), *Proteocephalus* sp. (fingerling *Salmo clarkii*, Departure bay, and *Oncorhynchus nerka*, Cultus L.), and an unidentified tetrarhynchoid from *Hexanchus caurinus* with a presumed plerocercoid in *Theragra*. In addition, material was obtained of the previously recorded *Gilquinia squali* (Squalus), *Phyllobothrium salmonis* (*O. gorbuscha*), *Nybelinia surmenicola* (*Ophiodon*), and *Bothriocephalus scorpii* (*Hexagrammos*, *Myoxocephalus*, *Apodichthys*).

F. D. WHITE

THE ANALYSIS AND FOOD VALUE OF THE LING COD (OPHIODON ELONGATUS)

Three freshly caught fish were analyzed. In each case the head, viscera, and bones were removed and discarded as "waste" (this amounted to 45 per cent. by weight of the whole fish); the skin was separated from the flesh and analyzed separately. The average percentage amounts of protein found in the flesh and skin were 16.1 and 26.6 respectively, the remainder being mainly water with a small amount of inorganic material (ash): the amounts of fat were negligible. The calculated food values are as follows:

Food values	Flesh (49% of whole fish)	Skin (6% of whole fish)	Whole fish
Calories per 100 gm.....	79.8	114.7	46.0
Calories per lb.....	362.0	520.3	208.6

The high calorific value of the skin is due to its high protein content, but as this is mainly *scleroprotein*, a class of protein which is highly resistant to the action of the digestive enzymes, in one sense the true "food value" is substantially less than is indicated by the calorific value.

The calorific value of the whole fish compares favourably with European non-fatty fishes, although the percentage amount of "waste" is somewhat higher: the calorific value of the flesh alone is rather higher than that of European fish of this category (Plimmer).

THE ANALYSIS AND FOOD VALUE OF THE PILCHARD (SARDINIA CAERULA)

Two cases of canned pilchards, representing early and late runs respectively, were obtained from a canning factory on Vancouver island. Each case contained eight dozen cans with an average content of 250 gm. of fish per can. Analyses were carried out on the total contents of three cans taken at random from one case (early run) and of five cans from the other case (late run). The contents of each can were separated into flesh, bone, and skin, which were analyzed separately. The two classes of pilchards showed marked differences in their percentage composition: the fat content of the late run was almost double that of the early run, while the protein content of the former was slightly, and the water content considerably, lower than those of the latter. Average comparative results and calculated food values are as follows:

Percentage composition per can	Early run pilchards	Late run pilchards
Protein.....	16.9	15.7
Fat.....	9.8	18.1
Water.....	68.0	60.0
Ash.....	1.9	1.5
Calculated food values		
Calories *per 100 gm*.....	160.5	233.5
Calories *per lb*.....	728	1,059
Calories *per can* (250 gm.).....	401	584

These results indicate (1) that weight for weight, late run pilchards have almost 50 per cent. greater food value than the early run; (2) that the contents of one can (about 9 oz.) of early run pilchards and one can of late run are equivalent in food value to rather more than 1 lb. and 1½ lbs. respectively of ling cod flesh; (3) that compared with European fatty fish, early run pilchards have a somewhat greater food value than the corresponding weight of fresh herring, while the food value of late run pilchards is greater than that of the corresponding weight of salmon section, and almost twice that of sturgeon section.

W. R. WHITTAKER

AGE COMPOSITION OF PILCHARD CATCH AS SHOWN BY THE OTOLITHS

The examination of the otoliths of a representative portion of the pilchard catch each year has been undertaken in order to elucidate the causes of such

fluctuations in the abundance of pilchards as may be indicated by changes in the tonnage captured by the fishery.

The results of such an examination for the two years 1930 and 1931 are fairly comparable. In the two fishing areas investigated, namely, Nootka sound and Barkley sound, the bulk of the pilchard catch was found to be comprised of fish in their fifth and sixth years. Fish in their fourth and eighth years were not plentiful while those in their seventh year were fairly well represented. In the catch for 1931 there was a slightly greater percentage of fish in their fourth year than was found in the preceding year.

G. V. WILBY

THE LIFE-HISTORY OF THE LING COD, OPHIODON ELONGATUS GIRARD

During 1932 an intensive investigation was made of life-history phases of the ling cod, particularly those which heretofore had been impossible due to lack of material and opportunity for study.

A number of specimens under one year were taken in seine hauls during the summer. These young forms grow quite rapidly, attaining a length of 10 to 15 cm. in three months and about 20 cm. at the end of the year.

Scale study shows that there is a close parallel between the growth-rate of both sexes until the males mature, about the fourth or fifth year. There is then a pronounced divergence in the growth rates, that of the males becomes decidedly slower while that of the females continues to increase until the females mature, about the eighth or ninth year, at which time the growth-rate also decelerates.

Corresponding to the greater precocity of the males in the matter of maturity, there is a difference in the age to which the two sexes attain, the males seldom reaching the twelfth year whereas the females frequently reach fifteen years or more.

Evidence has been found of a diversity in the distribution of the sexes during the summer months as the largest males are taken in the deepest waters and the largest females in shallower waters.

From a length of 6.5 cm. the ling cod is a fish-eater, although in the first year a large part of the diet consists of Crustacea, chiefly mysids and shrimps.

The food has been found to consist of herring, various flounders, gadids, hake, dogfish and sand lances, although small ling cod, black cod, grey cod, squids, ratfish, skates, etc., are frequently taken. The results are based upon the examination of 248 stomachs containing food remains.

The habits of these fish were studied under natural conditions, in live-boxes and aquaria. The manner of resting on the ventral fins while awaiting their prey, the sudden darting forth, the protective coloration and marking, as well as anatomical observations made, point to a close relationship to the cottiform fishes. Guarding the eggs by the male is also a cottoid habit. In one small area, one male ling cod and two males of cottids, *Aspicottus bison* and *Hemilepidotus hemilepidotus*, were observed guarding their eggs, the behaviours in the three cases being very similar.

Spawning was studied at various places during the winter. This took place only in strong tidal currents with a temperature range of from 5° to 8°C., where there was an oxygen saturation of between 75 per cent. and 80 per cent. The large glutinous egg-masses are laid on rocks below the lowest low-tide levels and are seen only when the surface of the water is smooth and when the sunlight is very bright.

FISHERIES EXPERIMENTAL STATION (PACIFIC)

PRINCE RUPERT, B.C. 1932

The work of the Station during 1932 has been adjusted to meet the reduced budget without seriously affecting the researches of major importance. The temporary staff has been reduced and the usual special assistance during the summer dispensed with. The work in certain respects has suffered through the absence of the Bacteriologist, whose services were required in the east, but who has now returned.

The staff is as follows:

Mr. D. B. Finn, Director and Biochemist.
Mr. H. N. Brocklesby, Associate Chemist.
Dr. R. H. Bedford, Associate Bacteriologist.
Mr. O. C. Young, Assistant Mechanical Engineer.
Mr. O. F. Denstedt (on leave), Scientific Assistant (Chemistry).
Mr. F. Charnley, Scientific Assistant (Chemistry).
Mr. B. E. Bailey, Scientific Assistant (Biochemistry).
Mr. P. A. Sunderland, Laboratory Assistant (Chemistry).

INVESTIGATIONS

Stringent economic conditions have greatly diminished the activity of the fishing industry on the western coast of Canada. The stress of rigid economy in manufacture necessitated by reduced financial returns has re-emphasized the necessity for utmost efficiency in processing operations, while diminished demand for existing products, in spite of low prices, has forcefully turned the attention of the industry towards the manufacture of new products and to securing new uses for old products. These ends have guided the activity of the Prince Rupert Station since its establishment.

In the following paragraphs the more important features of the investigations are briefly set forth. More detailed statements may be found under "Investigators' Summaries", which have been written by the workers concerned.

VITAMIN ASSAYS

Particularly valuable have been the vitamin assays of marine products which have been proceeding during the past five years. These efforts have assisted in establishing a demand for halibut livers, a product formerly wasted, which has increased the earnings of fishermen in the port of Prince Rupert to the extent of $25,500 during 1932. It is expected that this new demand will spread quickly to other products since it has been shown that the liver oils of the ling cod and salmon have exceptional vitamin potencies. Following the investigations made by this Station, pilchard oil is finding new use in supplementing diets of poultry and cattle with respect to vitamin D, some thousands of gallons being used for this purpose during 1932. It has been shown that dog-fish liver oil is potent in vitamin A; recently samples of this oil have been found to contain 15,000 units of vitamin A per gram. Shark liver oils have also been found to be very potent in this vitamin.

By blending pilchard oil with dogfish liver oil or shark liver oil, a product has been made which is equal in vitamin potency to high-grade medicinal cod-liver oil. The name "Marinol" was invented for it in order to overcome the prejudice which might attach to these oils in the public mind. A co-operative experiment between the British Columbia Department of Public Health and the Fisheries Experimental Station has been arranged in which "Marinol" will be tested for human consumption. Under this arrangement the Station prepares oils which are then fed to the pupils of the Indian Schools under competent medical supervision. Since the Indian institutions in question cannot afford cod-liver oil it is hoped that the high incidence of tuberculosis amongst the children

may be combatted by using the less costly "Marinol". Other institutions are using "Marinol" experimentally and the indications are that the demand for pilchard and dogfish liver oil for this purpose will increase rapidly.

FISH OIL RESEARCH

The chemical investigations have also brought to light other uses for unsaturated fish oils. Thus the studies in hydrogenation are making possible the production of frying oils and shortening fats from pilchard oil. The product is odourless and tasteless and can readily supplant some of the imported cottonseed oil now used for these purposes. Other investigations have shown that pilchard oil can, by proper treatment, be utilized in the manufacture of such protective coatings as paints, varnishes, waterproof fabrics and japans.

Such extensions in the utility of marine products must necessarily be preceded by fundamental studies. Without quantitative data as to the extent, rate and character of reactions, commercial production cannot be carried on with proper economy, neither can a full insight into the possible uses of substances be obtained until their chemical properties and characteristics are known. Many of the obscure problems arising from various methods of preparation and preservation, for instance, the appearance of "rust" on fish in cold storage and oxidative rancidity in medicinal fish oils can only be solved after the chemical constitution and behaviour of the oils have been determined. Such studies, amongst which may be placed the work on the composition of pilchard oil, the studies in oxidation and the rate of the hydrogenation reaction, have proven to be of great value in the solution of practical problems. Their importance to the work of the Station cannot be over-emphasized.

Besides the exploration of potential uses for marine products, the Station has been actively engaged in the improvement of existing methods of production and preservation.

FREEZING AND COLD STORAGE

Most fishing companies who have considerable capital investment in cold-storage plants find it impossible to undertake extensive alterations in design and therefore cannot avail themselves of certain improvements that have been developed by the Board and others. Such improvements involving, as they sometimes do, radical departures from standard practice, are of great value to the engineer in the design of new plants. In order to help those who already have cold-storage plants, a series of studies have been made with a view to improving the stored product and at the same time keeping the requisite structural changes in the cold store at a minimum.

Thus it has been found that it is better—with respect to dehydration or "shrinkage"—to cool a room to the desired temperature by means of a large area of cooling coil maintained at a temperature near that of the room rather than by a smaller area of coil at a much lower temperature than the room. In this way by increasing the area of a coil four times, "shrinkage" has been reduced by nearly 50 per cent. The same effect is brought about by increasing wall insulation, since in this way the temperature difference between the air and the pipes may be decreased. It has also been shown that temperature fluctuations in the stored fish may be minimized by using a specially designed storage bin with an air lock. Various methods of glazing and wrapping have been tested and improvements have been made in the method of stowing frozen fish in cold-storage rooms.

Refrigerated railway transport is receiving attention. The work is being undertaken in cooperation with the Experimental Station at Halifax. At Prince Rupert the engineering laboratories have built a small experimental refrigerator car. The bunkers in this car are movable so that their efficiency in various positions can be determined under controlled conditions. The aim of the experiment is, by means of various improvements, to make possible the shipment of frozen fish products by freight during the warmer months, without unduly increasing the

cost. This is particularly desirable since when the fishing industry becomes ready to market properly frozen fish in preference to iced unfrozen fish a cheap and reliable means of transportation will be essential.

Attention has also been paid to the biophysics and biochemistry of freezing. It has been shown that amongst the most important changes which accompany freezing is the denaturation of proteins. This is brought about by change in hydrogen ion and salt concentration accompanying the removal of water as ice. The effect is most marked between −2°C. and −3°C. and diminishes as the temperature is lowered. Data are being collected concerning the constitution of fish muscle at temperatures below its freezing point so that individual reactions may be studied in vitro rather than in the complex system of the muscle itself.

By studying these reactions not only will the optimum conditions of freezing and storage be found, but information will be obtained regarding control of denaturation by means of buffers. This is important since "drip" or the escape of nitrogenous liquids from muscle which has been frozen and thawed is due to the combined effect of denaturation and the rending of tissues by the formation of large ice crystals.

FISH SPOILAGE

The general problem of fish spoilage includes examination of any undesirable deterioration before or after the death of the animal. So far, work has been confined to a study of some of the chemical changes which are accelerated after death. Refined chemical technique has been developed by which it is possible to detect hydrolysis of the oils within minutes after the death of the fish. The influence of temperature on this change as well as various means of preservation have been studied. An examination is now being made of the relation between protein decomposition and oil hydrolysis in the hope that under certain conditions a determination of the degree of oil hydrolysis may be an index of "freshness".

The changes in hydrogen ion concentration of fish in life and death is being reinvestigated by means of a new technique with the glass electrode. An attempt is being made to relate these changes with those occurring in other substances of the muscle.

The temperature range of growth in marine bacteria has been studied and it was found that some grew at as low a temperature as −7.5°C., while all of them studied grew at 0°C. It has been found also that chromogenic organisms other than *Pseudomonas fluorescens* may play a part in the discolouration of halibut.

NUTRITIVE VALUE OF CANNED SALMON

The biological assay of vitamins A and D in canned sockeye and pink salmon from British Columbia rivers has been completed. It has been found that the oil (which is not to be confused with salmon-liver oil) of both varieties is as potent in vitamin D as is high-grade cod-liver oil, but that the content of vitamin A is very low. The physical and chemical constants of the oil have been studied. The problem has not been investigated from the statistical point of view. Such work would involve seasonal as well as geographic variations in the varieties and would be beyond the present facilities of the Station. It has been sought to place the industry, at whose request the investigation was undertaken, in possession of general facts regarding the two varieties, in order that they may be better able to market the canned product.

ANNUAL CONFERENCE

Owing to reduced budgets it was found impossible to hold the annual conference of Pacific Coast workers of the Biological Board for the current year.

PUBLICITY

During the year there has been a quarterly issue of Progress Reports which has served to keep the industry informed of the work undertaken by the Board

on this coast. Members of the staff have given addresses to the general public, service clubs and schools. Articles have been written for industrial journals and the Station has had numerous visitors from many parts of Canada and the United States.

CONSULTATION

The Station has been consulted by many individuals and companies during the year in matters concerning nearly all branches of the fishing industry. Special assistance was given towards the establishment of halibut-liver reduction plants and to firms producing medicinal pilchard oil.

PUBLICATIONS

Bailey, B. E. The vitamin D potency of oil from B.C. canned salmon. Prog. Rep. Pac. 13, 13.

Bedford, R. H. The viability of the bacterium *Pseudomonas fluorescens* in aqueous solutions of formaldehyde. Contr. Canad. Biol. Fish. 7(12) (Series C, 4).

Salt as a control of bacterial decomposition of halibut. Bulletin 29.

Brocklesby, H. N. Vitamin A in Pacific coast fish-liver oils. Prog. Rep. Pac. 12, 3.

The hydrolysis of the body oil of the salmon. Prog. Rep. Pac. 15, 5.

Finn, D. B. Advances in knowledge of freezing. I. Prog. Rep. Pac. 14, 3.

Smith, L. F. Fish glue from fish waste. I. Preparation by dialysis. Contr. Canad. Biol. Fish. 7 (14) (Series C, 6).

Sunderland, P. A. Analysis of Pacific coast porpoise oils. Prog. Rep. Pac. 14 14.

Young, O. C. Dehydration of fish in cold storage. Prog. Rep. Pac. 14, 12.

Relation between coil area, temperature of cooling medium and dehydration in cold storage. Prog. Rep. Pac. 15, 11.

INVESTIGATORS' SUMMARIES

BAILEY, B. E.

THE VITAMIN POTENCY OF OILS FROM B.C. CANNED SALMON

The preliminary program of the canned salmon investigation included, in addition to determinations of physical and chemical constants, a study of the potency in vitamins A and D of the oils from canned B.C. sockeye and pink salmon.

The work on vitamin D has been completed. The oils from all six samples were of a slightly lower potency than that of medicinal cod liver oil.

The samples of pink salmon oil showed as high a potency as the sockeye. However, since the canned pink salmon has a somewhat lower oil content than canned sockeye, the total amount of vitamin D per can is less in the former than the latter.

Considerable difficulty has been experienced in testing the oils for vitamin A by the colorimetric method. Their potency in this vitamin is so low that a comparatively large amount of oil must be used for the test, and other colours are developed which interfere with the measurement of the blue. However, a technique has been worked out which appears to give consistent results. As indicated by this test the canned pink salmon oils contained no vitamin A and the sockeye oils very little.

It has been shown by biological assays that the pink salmon oil contained no appreciable quantity of vitamin A, but that in the Skeena sockeye oil there was present a very small amount. Fraser river sockeye oil is now being assayed biologically for this vitamin. The sockeye oils from Skeena and Fraser rivers were selected for the biological determinations since they showed the greatest divergence by the colorimetric test.

THE VITAMIN A POTENCY OF LING COD LIVER OIL

The importance of fish liver oils of high vitamin A potency is now well recognized. Several prominent pharmaceutical houses have been purchasing halibut livers at all the Pacific coast ports where appreciable quantities of halibut are landed. The oil finds a ready market and greater quantities could be used if they were available.

Preliminary tests showed that the liver oil of the ling cod was as rich in vitamin A as the average halibut liver oil. A biological assay of one sample of ling cod liver oil and colorimetric tests of several others have confirmed this result. A paper embodying some of these data is now in the press.

THE VITAMIN A POTENCY OF SALMON LIVER OIL

As a by-product of the salmon canning industry in British Columbia, large quantities of salmon livers are available. If it could be shown that they contained an oil of high vitamin A potency in appreciable amounts, their potential value would be great.

Preliminary colorimetric and biological tests have shown that some samples of salmon liver oil are relatively rich in vitamin A. Although not as potent as halibut or ling cod liver oils, they contain from ten to twenty times as much vitamin A as cod liver oil.

COMPARISON OF DIFFERENT METHODS OF PREPARING HALIBUT LIVER OIL

The importance of halibut liver oil as a source of vitamin A has already been pointed out. A number of methods of separating the oil from the livers are possible. Experiments have been carried out in order to find the yield and relative vitamin A potencies of oil separated by different methods. It was considered particularly desirable to compare the effect of various solvents on these factors.

The solvents used were petroleum ether, carbon tetrachloride, ethyl acetate, ethyl ether, acetone, and ethyl alcohol.

The efficiency of the solvents judged by vitamin potency of the product in most cases decreased in the order named above. Where variation from this order was found, acetone and ethyl alcohol were always least efficient.

BEDFORD, R. H.

DISCOLOURATION OF FRESH HALIBUT

The discolouration of halibut was at first thought to be due to the greenish yellow pigment characteristic of the bacterium *Pseudomonas fluorescens*. But later it was noticed that the discolouration consisted of other colours, yellow and orange, and not infrequently a red colour was also discernible.

Bacteria that produced these colours were isolated from fresh halibut and sea water.

Pure cultures of these bacteria were seeded onto halibut and stored at 32°F. (to simulate temperature conditions somewhat comparable to that in the vessel's hold) for seven days, where they produced their characteristic colours—yellow, orange and red.

There are then two sources from which discolouration may be caused: (1) the greenish-yellow pigment producing organisms in the ice, and (2) a number of chromogenic organisms in the sea.

THE TEMPERATURE RANGE OF GROWTH OF MARINE BACTERIA

The temperature range of growth of some marine bacteria was established in order to place their position of growth in applied bacteriology in the preservation of fish, more particularly that of low temperature preservation.

Just over 70 organisms were studied. Some grew at −7.5°C.; many others at −5°, and all of them at 0°. The best temperature of growth (optimum) for the majority was from 20° to 25°.

Growth at the low temperatures is important in relation to fish stored in ice, and also it is a factor that must always be considered in any scheme for the storage of frozen fish.

BROCKLESBY, H. N.

HYDROLYSIS OF THE BODY OIL OF THE SALMON

Postmortem changes taking place in fish are very important from the standpoint of preservation of this material as food. Having regard to the very active enzymes present in fish tissues one would expect that among such postmortem changes would be the more or less rapid hydrolysis of the oil. Up to the present no data have been put forward showing that these changes do actually occur.

The matter has been thoroughly investigated and it has been found that the negative results obtained by previous investigators in this field were due to inadequate methods. After a careful study of methods for the isolation of the oil and methods of analysis had been made, the hydrolysis of the oil of salmon under the following conditions was studied: (i) incipient hydrolysis of freshly-caught fish, (ii) during canning, (iii) during cold storage. The following is a summary of the results.

(1) Among the postmortem changes in salmon is the rapid hydrolysis of the oil. (2) The rate of this hydrolysis is greatly affected by temperature. (3) The oil from the absolutely fresh fish may contain a small but measurable amount of free fatty acids. (4) The commercial exhaust treatment to which canned salmon is subjected does not completely destroy the fat-splitting enzymes present in the tissue. (5) The process of retorting increases the acid value of the oil of canned salmon. The effect is proportional to the time. (6) Temperatures now used in commercial cold-storage plants do not sufficiently retard the hydrolysis of the oil of stored salmon, acid values of from 6 to 14 being obtained in specimens stored for periods of from 6 to 12 months. (7) The oil from the outer portions of the fish always shows a lower acid value than that from the inner portion. It is shown that this may be caused by the neutralization of the free fatty acids by the ammonia present in the cold-storage room.

A paper giving the results of the above investigation is in press.

BROCKLESBY, H. N. AND B. E. BAILEY

THE PHYSICAL AND CHEMICAL PROPERTIES OF CANNED SALMON OILS

Recent studies have indicated that some information regarding the species and quality of fish may be gathered by an analysis of the oil. A preliminary investigation into the application of this method as a means of examining canned salmon has recently been completed. This included the analysis of a number of cans of sockeye and pink salmon each from three localities. Although other data have been accumulated, the acidity and unsaturation of the oil has yielded the most information. Briefly, the results are as follows:

1. The acidity of the oil of canned salmon. Solvent extraction of the oil from canned salmon yielded oils of high and varying acidity. By the use of the improved method of extraction, however, constant values could be obtained. In general, the acidities of the oil from pink salmon were much higher than those of the sockeye salmon. This is in keeping with the previous work where it was found that salmon with the smaller amount of oil gave the higher acidities. It was also found that the oil from river-caught fish gave higher acidities than sea-caught fish.

2. The unsaturation of the oil of canned salmon. In 1918, Bailey and Johnson (*J. Ind. Eng. Chem.* **10**, 599, 1918) proposed a method for the identification of the species of canned salmon based on the determination of the unsaturation of the oil. They found that the oils from each species varied in unsaturation within certain definite limits which was more or less characteristic of the species. The conclusions of these authors were based on very few data

and in view of the importance of the matter, further data have been gathered during this investigation. For pink and sockeye oils it has been found that the iodine value, refractive index and octobromide values fall within definite limits and that the ranges do not overlap. Thus for sockeye oil the iodine values ranged from 135.7 to 151.4 and the pink oil from 157.4 to 161.3. The other values were of a similar order. It appears, for these two oils, that this method can be used for differentiating between species.

Within the range of unsaturation of each oil it was found that there was a uniform increase in unsaturation with locality, those fish caught in the more southerly areas showing lower degrees of unsaturation than those caught further north. This corroborates the findings of investigators working on other species of fish.

BROCKLESBY, H. N. AND F. CHARNLEY

RATE OF HYDROGENATION OF PILCHARD OIL

Further experiments with a closed type of apparatus show that under the conditions of experiments the amount of gaseous impurities accumulating in the reaction flask is too small to have any marked effect on the characteristic nature of the rate curve. These results, together with other chemical data, have been reported in the paper (now in press) entitled, "Some observations on the hydrogenation of pilchard oil".

COMPOSITION OF HYDROGENATED PILCHARD OIL

Additional insight into the mechanism of the hydrogenation process has been gained by an analysis of samples of the oil hydrogenated to varying degrees of hardness. By means of these analyses an approximate idea of the kinds of unsaturated glycerides undergoing hydrogenation at different stages of the process has been obtained. During the initial stages of the reaction the greater part of the hydrogen is used up in changing highly unsaturated glycerides into compounds containing only one or two ethenoid bonds in the fatty acids residue and it is not until most of these have been so transformed that solid fatty acids begin to be formed in quantity.

BROCKLESBY, H. N. AND O. F. DENSTEDT

POLYMERIZATION AND OXIDATION OF PILCHARD OIL

The study of the utilization of oils in the protective coating industries involves at least three major phases of oil chemistry, namely, polymerization, oxidation and a study of film properties. A comprehensive study of pilchard oil has been made from these standpoints, with the following results.

Pilchard oil may be polymerized by heating in the presence or absence of air, by heating with sulphur or sulphur chloride, stannous chloride and a variety of other reagents. Polymerization by heat treatment, however, is the only feasible one, for preparation of oils for paint and varnish purposes. When pilchard oil is heated in the absence of air practically no polymerization takes place until a temperature of about 175°C. has been reached. Up to 200°C. the rate of polymerization is slow, but at 250°C. the rate accelerates and at 300°C. polymerization is very rapid and considerable decomposition takes place. Up to 250°C. the free acidity of the oil decreases with time, all values passing through a single point at about the ninth hour of heating. At 300°C., however, the acidity increases almost immediately and at a very rapid rate. Decomposition at this temperature is extensive. Viscosity increases very rapidly at temperatures above 250°C. and at 300 all samples after the second hour set to a gel when cooled. Heating pilchard oil in a vacuum produces a pale oil of low acidity, and when carried out at 275°C. is probably the best method of bodying pilchard oil for paint and varnish purposes.

A polymerization method of considerable merit has been developed in these laboratories which consists in heating the oil while blowing with superheated steam. Decomposition takes place and the non-polymerizable portion distils over. After a certain time the residue polymerizes to a tough rubbery gel. If the process is stopped just before polymerization takes place, the residue is soluble in ordinary organic solvents and this solution, with the addition of a small quantity of drier, constitutes a quick-drying varnish with several valuable properties.

The effect of catalysts, pigments, and polymerization on the rate of oxygen absorption has also been studied extensively. Pilchard oil oxidizes much more rapidly than does linseed oil. The speed of oxidation is much accelerated by the addition of catalysts. A large number of these have been studied and cobalt linoleate in concentrations of 0.05 per cent. (oxide) has been found to give the best results. The influence of various pigments on the oxidation process shows that certain pigments retard oxidation both in the presence and absence of catalysts. Those pigments with the greater adsorptive capacity show the greater retarding effect. Considerable data have been accumulated regarding the more common pigments. Oxidation is retarded by polymerization although it is likely that the amount of oxygen eventually taken up is the same in the two cases. The retarding effect is proportional to the amount of polymerization.

PROPERTIES OF PILCHARD OIL FILMS

A study of the properties of pilchard oil films shows that this oil has many important qualities. The best film is produced by cobalt linoleate. Small amounts of lead or cerium driers in conjunction with cobalt promote uniform drying but detract from the hardness of the films. In general, all fish-oil films are soft, flexible, and when made from the raw oil are more permeable to moisture than linseed oil films. The softness is due to the large proportion of non-drying glycerides present which are only partly removed by refrigeration. Hardness of pilchard oil films may, however, be improved by (1) treating the oil with sulphur dioxide, (2) by the combined polymerization and steam distillation method. The films made by the latter process are hard, flexible, non-blooming and impermeable to moisture. The losses entailed in its manufacture are, however, quite high. Pilchard oil films may also be improved by the use of gums, certain salts and by stoving.

FINN, D. B.

THE DENATURATION OF FISH PROTEINS BY FREEZING

By using the technique employed in a study of mammalian proteins and described elsewhere (*Proc. Roy. Soc.* B. 3, 356) it has been found that fish-muscle proteins are rapidly denatured by certain conditions in the frozen state. The effect is most marked between $-2°$C. and $-4°$C., and diminishes as the temperature is lowered. The phenomenon is being related to changes in hydrogen-ion and salt concentrations and to certain fractions of the muscle protein.

FINN, D. B. AND B. E. BAILEY

THE ICE PHASE IN FROZEN MUSCLE TISSUE

One of the principal effects of freezing is a concentration of solutions originally present in a tissue, by the withdrawal of water as ice. This concentration has a marked influence upon the protein system. In order to study this effect, the amount of water frozen out of fish muscle has been determined by a method which we consider to be more trustworthy in certain respects than the calorimetric or dilatometric technique which are usually employed.

A large quantity of muscle juice is frozen to equilibrium at a temperature a little below its freezing point and the remaining aqueous phase drained away from the ice so formed. The freezing point and water content of this fluid are

accurately determined. These operations are repeated at progressively lower temperatures and further fractions of ice removed. In this way curves of the freezing point and water content are constructed.

Halibut muscle juice—the aqueous phase of the fish muscle—has been studied and it is found that its water content varies with temperature approximately as follows: −2°C., 52.5 per cent. water frozen; −3°C., 68 per cent. frozen; −4°C., 75.5 per cent. frozen; −5°C., 80 per cent. frozen; −6°C., 82.7 per cent. frozen.

YOUNG, O. C.

COOLING COILS

An outline of this investigation was given in the Report of 1931. Work along the lines then indicated has been completed. The results show: (1) that, for a constant cold-storage room temperature, the difference between brine and room temperature, plotted against thermal transmittance U of the walls, is a straight line function; and the effect of increasing the number of coil banks from 1 to 4 is to decrease the difference between brine and room temperatures from 23°F. to 7.2°F., or roughly in those proportions, depending upon the thickness of wall insulation; (2) the dehydrating effect depends upon the coil area and insulating value of the walls, and is decreased from say 100 per cent. with 1 bank of coils to 73 per cent. with 2 banks of coils, to 58 per cent. with 3 banks and to 47 per cent. with 4 banks; or in these proportions, depending again upon the insulation thickness of the walls; (3) that the dehydrating effect per unit area decreases, as the total evaporating area increases, in the following way. The evaporation from 1 sq. ft. = 0.16 lb./week, while that from 4 sq. ft. of surface = 0.11 lb./sq. ft./week; (4) that lowering the temperature level in the room decreases the dehydrating effect by an amount which can be closely estimated by calculating the air capacity for holding moisture at the various temperatures involved (brine and room), providing the change in temperature is compensated by increased wall insulation.

The results have been made as general as possible by referring them to the thermal conductivity of the walls. Consequently they may be fairly accurately applied to any room for which the wall conductivity is known.

ON THE JACKETED COLD-STORAGE ROOM

With the object of placing at the disposal of refrigerating engineers certain information concerning an improved cold-storage room, a jacketed room much like the one originated by Doctor Huntsman, was built at this Station. A description of this room and some of the results obtained with it are given in the Report of 1931.

This year the work on the jacketed room was completed and a paper has been prepared embodying the work of both years.

Summarizing the results of the entire investigation, the experiments show: (1) that the temperature distribution in the jacketed system of cooling is uniform throughout the room and though the brine temperature may fluctuate 4°F., the room temperature remains constant due to the insulating effect of the wood used in the construction of the inner room; (2) that dehydration depends largely upon the rate of exchange between the inside and outside air; and (3) that dehydration (in the room investigated) expressed as a function of exposed area follows the curve $Y = 549\sqrt[3]{X}$, where Y = dehydration in grams per week, and X = exposed area in square metres.

Other factors of importance which evolved from these experiments were: (1) the advantages resulting from the use of hatchways instead of the ordinary type of door, as discussed in the 1931 Report; and (2) the use of boxes equipped with air locks for the storage of fish in ordinary cold-storage rooms.

DEHYDRATION OF FISH IN COLD STORAGE

As a result of recent researches, by the U.S. Bureau of Fisheries, in the reducing of "shrinkage" of frozen fish in cold storage, by the use of coatings of edible oils, some experiments were conducted at the Canadian Fish and Cold Storage plant here, to compare the loss in weight of salmon and halibut treated with crisco, mazola, cottonseed oil, pilchard oil, and ice-glaze.

Using the criterion of the loss in overall weight, the oil treatments gave the best results, since in no case did the loss, in 12 weeks, exceed 1.9 per cent. of the weight of the treated fish, whereas the ice-glazed fish lost 2.5 per cent. On the other hand, the loss in the latter case was due to evaporation of the ice coating, so the fish were unaltered in weight. With the oil-treated fish, however, the loss was due to dehydration of the fish. This being so, the ice glaze would seem to be the best method of protection tried.

Another factor in favour of the ice-glazed fish was their appearance, which was quite normal and glossy, after thawing. Those treated with crisco had dried out in places where the coating had cracked or chipped off, which rendered the specimens decidedly unsightly. The mazola, cottonseed and pilchard oil-treated fish were all discoloured. Oxidation of the oils or a dissolving out of certain pigments from the skin had imparted a brownish hue to the coating which made the fish appear stale and sour. This impression was accentuated in the case of halibut by the noticeable brown colour of the blood around the pokes and napes.

On the whole, then, the experiments show that the new oil treatment methods as recommended by the U.S. Bureau of Fisheries are inferior to ice-glazing, both from the viewpoint of effects on dehydration and appearance.

CELLOPHANE AS A MEANS OF PREVENTING DEHYDRATION

The increasing importance of packaged fish such as ice fillets, where dehydration is promoted by the large proportion of exposed cut surface to volume, lead to some determinations of the loss in weight of fish stored as follows: (1) in plain transparent cellophane envelopes; (2) in moisture-proof cellophane envelopes; (3) heavily glazed with ice; (4) untreated. The experiments were conducted with halibut "chickens", some of which were treated as above before being frozen, others being treated after.

The fish were hung in the Station's 0°F. room for 20 weeks with the following results. (1) Those placed in plain cellophane envelopes before freezing lost 10.2 per cent. of their weight, while those enveloped after freezing lost only 8.7 per cent. (2) Those placed in moisture-proof cellophane envelopes lost nothing in total weight, but it was noticed that ice crystals had collected on the inside of the envelope. Upon removal from the envelopes it was found that the fish had lost 0.8 per cent. of their weight in the 20 weeks. (3) Those heavily ice-glazed lost 18.2 per cent. of their weight. (4) Those left untreated lost about 11 per cent.

The appearance of the fish, at the end of the test period, was dry, scaly and unattractive, with the exception of the glazed fish which appeared unaltered. Even those in the moisture-proof envelopes appeared dried in the frozen state, though they had lost less than 1 per cent. of their weight.

These experiments show that where packaging is necessary with frozen fish, moisture-proof cellophane is very effective in decreasing dehydration, and that the plain cellophane is comparatively useless from that standpoint.

THE EFFECT OF BAFFLE BOARDS UPON DEHYDRATION OF FISH IN COLD STORAGE

The commercial method of storing frozen fish in piles in the cold-storage rooms results in a certain decrease in evaporation from the glaze, due to the increased resistance offered to air circulation. It was reasoned that by placing baffle-boards spaced throughout the pile, and thus offering still greater resistance to the air, that dehydration would be further decreased. The difficulty of making a test with baffle-boards on a large scale was appreciated, so the following labor-

atory experiment was made. Three halibut of approximately the same weight were heavily glazed and suspended in the Station's 0°F. cold-storage room. One fish was suspended *resting upon* a board somewhat larger than the projected area of the fish; another fish was suspended *under* a similar board, and a third halibut was suspended free of any such board. Weighings were taken weekly and the losses expressed as a percentage of the total weight of the fish.

The following results were obtained at the end of seven weeks. The fish resting upon the board lost 5.7 per cent. of its weight in that time; the fish with the board above it lost 7.9 per cent.; while the third fish with no board lost 8.7 per cent. If we take the latter case as 100 per cent., the other two cases represent only 67 per cent. and 89 per cent. losses respectively. It will be recognized that one baffle-board would have the combined effect of the first two results given above, or, expressed in another way, it would offer 33 per cent. protection to the fish above and 11 per cent. to the fish below.

Whether these figures apply to fish in a large pile is doubtful, but they do show that baffles of some kind would decrease evaporation somewhat. To use boards in practice might cause too great a reduction in storage space, but a moisture-proof paper or fabric would not have that objectionable feature, and would be just as effective as the wood in reducing evaporation.

SOMMAIRE DU RAPPORT SUR LES TRAVAUX

DU BUREAU DE BIOLOGIE DU CANADA

EN 1932

PAR LE PRÉSIDENT, M. J. PLAYFAIR MCMURRICH

L'année 1932 marque le vingtième anniversaire de l'institution par Acte du Parlement *du Bureau de Biologie du Canada*. Pendant les vingt ans de son existence, cet organisme n'a cessé d'agrandir le champ de ses activités ni d'étendre la portée de ses travaux de laboratoire. Dans son application à 1932, cet énoncé conserve toute sa valeur en dépit des conditions défavorables au milieu desquelles s'est opéré le fonctionnement du Bureau.

La constitution du personnel du Bureau, telle que donnée dans le rapport de 1931, n'a pas varié. Pendant la dernière année, les quatre stations dirigées par le Bureau, à savoir: la Station biologique de Saint-Andrews, N.B., avec poste auxiliaire à Ellerslie, I.P.E., la Station biologique de Nanaimo, C.B., avec poste auxiliaire au lac Cultus, C.B., et les Stations d'expérimentations appliquées à la pêche de Halifax, N.E. et de Prince Rupert, C.B., ont déployé leur activité habituelle et l'ont même surpassée par la multiplicité des questions étudiées et l'importance des résultats obtenus.

Le Bureau se rejouit de la rénomination de M. D.B. Finn au poste de directeur de la station de Prince-Rupert; il apporte avec lui un enthousiasme renouvelée jointe à une expérience de prix.

Il convient de signaler en ce rapport le premier événement fâcheux survenu dans l'histoire des stations, à savoir: la destruction par le feu du laboratoire de Saint-Andrews, le 9 mars dernier, à la suite d'une explosion de gaz produit dans l'appareil de chauffage. Par bonheur, la conflagration ne s'étendit pas aux autres bâtiments de la Station mais les pertes n'en furent pas moins affligeantes car elles comportèrent la destruction de la bibliothèque, d'importantes archives et de collections de plancton et d'autres matériaux, représentant le travail de plusieurs années. L'intervention prompte et efficace du directeur et de son personnel rendit possible la reconstruction partielle du bâtiment en matériaux à l'épreuve du feu et cela à temps pour la reprise des travaux d'été de la station. Il reste, toutefois, beaucoup à faire avant que n'en soient parachevés l'installation et l'aménagement du laboratoire ainsi que la reconstitution de la bibliothèque. C'est un agréable devoir de rappeler ici les offres généreuses de livres et de brochures qui sont venues de partout et qui forment déjà le noyau d'une nouvelle bibliothèque.

Pendant l'année, les travaux de la Commission Internationale des Pêcheries de la baie de Passamaquoddy furent poursuivis, avec la Station de Saint-Andrews comme base d'opérations pendant la saison d'été, le bureau-chef de cette commission ayant plus tard été transféré à l'Institut océanographique de Woods Hole, Mass.

On trouvera, attachés aux rapports des directeurs, des résumés donnant les résultats obtenus par les travailleurs scientifiques aux diverses Stations. Parmi tant de questions intéressantes, il n'est pas facile de choiser pour faire de quelques-unes une mention spéciale; cependant il convient de faire une certaine selection à cause du nombre et la diversité des recherches.

En ce qui concerne le station de Saint-Andrews, il n'est pas hors de propos d'attirer l'attention des intéressés sur le fait qu'on a continué l'étude du problème compliqué de l'histoire naturelle des saumons de l'Atlantique. Une attention suivie accordée à la pêche du hareng dans la baie de Fundy servit à démontrer l'existence d'une relation étroite entre les prises de ce poisson et les conditions physiques, spécialement la température et la salinité. Les expériences sur la

fertilisation des lacs et des étangs d'eau douce ont été poursuivies, soit dans des réservoirs d'expérimentation à la Station, soit, sur une plus large base, dans les lacs Chamcook. La valeur des résultats obtenus par l'étude des pêcheries de la baie de Fundy, achevée l'année dernière, fit naître l'idée d'une semblable entreprise en ce qui concerne les pêcheries de la côte au sud de la Nouvelle-Ecosse. C'est pourquoi des travaux de recherches furent commencés dans la région de Halifax, le laboratoire du Passage de l'Est constituant une base commode d'operations pour la conduite de l'investigation. Des données sur l'existence et la distribution, dans la région, de certains poissons comestibles furent recueillies et des observations hydrographiques servirent à révéler l'existence de couches d'eau de densités différentes aussi bien près des côtes que plus loin au large et cette intéressante constatation exigera de nouvelles recherches.

A la baie de Richmond, I.P.E., l'étude de l'élévage des huîtres a été poursuivie avec énergie. Les effets de la température et de la salinité sur les jeunes mollusques et sur les cellules germinales ont été précisés. On a découvert un procédé susceptible de rendre propres à la pratique de l'ostréiculture certains fonds vaseux inutilisables dans leur état actuel et on a recueilli des preuves de l'inversion chez l'huître indigène des sexes mâle et femelle. Une exploration fut faite de la baie de Shédiac en vue de s'assurer si cette région convient ou non à l'élévage des huîtres.

Dans la Colombie britannique, la cessation du concours, jusque là fourni par le gouvernement provincial pour l'étude du célan et de la pêche de ce poisson, eut naturellement pour effet de ralentir quelque peu la poursuite des recherches mais on a fait tout de même des progrès dans l'étude de l'histoire naturelle du célan. Au lac Cultus, les expériences sur l'efficacité relative de la fécondation naturelle et artificielle des saumons sockeye furent interrompues; le nombre de poissons qui sont montés a été si abondant que les appareils à incubation n'ont pu suffire à l'abondance des oeufs disponibles. Toutefois, une nouvelle tentative fut faite en vue de réempoissonner certaines eaux dépeuplées en transportant les oeufs à des cours d'eau appropriés dans la région supérieure du bassin du fleuve Fraser. Une autre expérience de transplantation des oeufs fut tentée par le transport d'environ un million d'oeufs de saumon rose de la rivière Tlell au ruisseau McAlpin. On attache une importance toute particulière à cette expérience puisque la migration fluviale des saumons roses se produit tous les deux ans et que la montée de ces poissons dans la rivière Tlell alterne avec celle de la région de Masset. Si l'essai réussit, il servira à indiquer la possibilité de produire une montée migratrice annuelle des saumons roses.

L'étude des enfoncements et échancrures de la côte occidentale, entreprise l'année dernière, a été poursuivie; les baies Jervis et Tuba ayant été explorées avec des résultats d'une grande portée aux points de vue géologique et océanographique aussi bien que biologique. On a consacré beaucoup d'attention aux problèmes relatifs à l'ostréiculture sur la côte du Pacifique où les huîtres de l'est et du Japon ont été introduites. Une étude sur la ponte, l'essaimage et la croissance de ces huîtres et de l'huître indigène a servi à témoigner de la grande vigueur de l'huître japonaise et de l'utilité qu'il y aurait à en généraliser l'élevage.

A la Station expérimentale de Halifax, on s'est de nouveau livré à l'étude des problèmes relatifs à la congélation et au fumage du poisson. Une étude des transformations chimiques provoquées par les divers procédés de congélation a été entreprise et on s'est livré à des recherches sur la composition des fumées utilisées dans le fumage du poisson. Des perfectionnements ont été apportées à l'appareil fumigène. L'appareil de fumage au moyen d'air traité en opération, il y a un an, à Lunenburg a été en opération dans le cours de l'année et a donné satisfaction après certaines modifications jugées nécessaires par l'expérience. On a aussi consacré quelque attention aux conditions dans lesquelles se pratique le transport des homards et celui du poisson gelé.

Une étude importante faite à la station expérimentale de Prince-Rupert, C.B., a été celle relative à la composition et à l'utilisation des huiles de poisson. On a

constaté que par le mélange de certaines huiles de poisson, il était possible de produire une huile d'une qualité non seulement égale mais même supérieure à l'huile de foie de morue en ce qui concerne sa valeur en vitamines. Ce mélange de composition déterminée, désignée sous le nom de *marinol* est actuellement utilisée par le Bureau Public d'Hygiene de la Colombie britannique. Un examen des huiles des saumons de la côte occidentale a démontré qu'elles diffèrent suffisamment en saturation chez les diverses espèces pour rendre possible l'identification des espèces dont elles proviennent; de plus, comme la formation d'acides gras libres procède avec une vitésse définie après la mort des poissons, il est possible de déterminer approximativement, par l'examen des huiles, le temps qui s'est écoulé depuis la capture.

Les travaux éducationels du personnel des laboratoires ont été plus importants encore que par le passé. Le cinquième cours au bénéfice des pêcheurs eut lieu à la Station de Halifax du 27 janvier au 8 mars; 28 ont suivi ce cours. Le Bureau remercie vivement Monsieur G. R. Earl et Monsieur R. Gray, du Département des Pêcheries pour leur aide dans les leçons sur le traitement industriel du poisson; au docteur M. Cumming et au professeur W. V. Longley du Département de l'agriculture de la Nouvelle-Ecosse pour avoir apporté leur concours dans les leçons sur les ressources naturelles; au professeur A. S. Walker pour ses leçons sur les ressources naturelles; à Monsieur R. H. Davison pour un cours sur les moteurs d'engines et au capitaine H. M. O'Hara pour un cours sur la navigation.

Du 10 au 16 mars, un cours de répétition fut donné à la Station de Halifax au bénéfice des surintendants et des inspecteurs de pêche des provinces maritimes et les membres de la Station de Halifax ont, comme d'habitude, coopéré dans le cours de pêche fourni par l'Université de Dalhousie.

Sur la côte occidentale, le personnel des Stations donna à la Station de Nanaimo, au profit des inspecteurs de la Colombie britannique, un cours qui s'étendit du 15 au 27 février et auquel assistèrent vingt-sept inspecteurs. Pendant l'été, du 4 juillet au 16 juillet, un cours fut donné par les membres du personnel de la Station de Nanaimo à dix-sept pisciculteurs adjoints de la Colombie britannique. Ce cours eut lieu à Sorrento sur le lac Shuswap.