ANNUAL REPORT

ON THE WORK
OF THE

Biological Board of Canada

FOR THE YEAR

1931

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

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The Biological Board of Canada, which serves as the scientific division of the Department of Fisheries and is under the control of the Minister of that Department, was established by Act of Parliament in 1912. As at present constituted it consists of two representatives of the Department of Fisheries, two representing the fishing industry, and fourteen scientists selected from the staffs of various Canadian universities. The present membership is as follows:—

Professor J. P. McMurrich, Toronto, *Chairman.*
J. J. Cowie, Ottawa, *Secretary-Treasurer.*
Professor R. S. Bean, Dalhousie University, Halifax.
Professor A. T. Cameron, University of Manitoba, Winnipeg.
Professor A. F. Chaisson, St. Francis Xavier University, Antigonish.
Professor Philip Cox, University of New Brunswick, Fredericton.
John Dybhavn, Prince Rupert.
Professor A. H. Hutchinson, University of British Columbia, Vancouver.
Professor W. T. MacClement, Queen's University, Kingston.
Professor Marie-Victorin, University of Montreal, Montreal.
Professor H. G. Perry, Acadia University, Wolfville.
Professor E. E. Prince, Ottawa.
J. A. Rodd, Ottawa.
Professor W. P. Thompson, University of Saskatchewan, Saskatoon.
President R. C. Wallace, University of Alberta, Edmonton.
A. Handfield Whitman, Halifax.
Professor A. Willey, McGill University, Montreal.
Professor A. Vachon, Laval University, Quebec.

This Board meets annually for a review of the work of the year, the discussion of future undertakings and the election of officers, its various enactments being subject to the approval of the Minister. In the interval between the meetings of the Board its business is carried on by a Central Executive Committee consisting at present of the Chairman and Secretary-Treasurer of the Board *ex officio,* Professors Cameron, MacClement, Marie-Victorin and Mr. A. H. Whitman, and to facilitate the work of this Committee, two Sub-Executive Committees have been established, one for the Atlantic coast and one for the Pacific. Recommendations from the Sub-Executive Committees must be approved by the Central Executive and its decisions are subject to the approval of the Minister.

To carry on its work the Board has control of four Stations—two, at St. Andrews, N.B., and Nanaimo, B.C., for the investigation of problems connected with the culture, conservation, and capture of fish; and two, at Halifax, N.S. and Prince Rupert, B.C., for the investigation of problems in connection with the handling, preservation, and marketing of fish. With the extension of the work of the Board to special lines of investigation, two substations have been found necessary,—one at Cultus lake, B.C., in connection with extensive and intensive studies on the life history of the Sockeye salmon, and another at Ellerslie, P.E.I., for the study of the oysters of Richmond bay. Further a

biological laboratory situated on the Eastern passage into Halifax harbour and intended to supply opportunities for the training of men for the fisheries service has been placed under the control of the Board.

Application having been made for a permit to erect a dam across the mouth of Passamaquoddy bay with the object of utilizing the tidal waters as a source of power, the question arose as to what effect such a dam would have upon the valuable fisheries of the region. The governments of the United States of America and Canada appointed a Joint Commission to investigate the matter; the representatives of the United States being Mr. O'Malley, U.S. Commissioner of Fisheries, and Mr. Sette of the U.S. Fishery Service; those for Canada being Dr. W. A. Found, Deputy Minister of Fisheries, and Dr. A. G. Huntsman, Director of the St. Andrews Biological Station. The services of experts were engaged by the Commission and accommodation was found for them at the St. Andrews Station, those engaged in the work being Dr. C. J. Fish of the Buffalo Museum of Science, Mr. Michael Graham of the British Fisheries Service, Lowestoft, Dr. H. H. Gran of the University of Oslo, and Dr. E. E. Watson of Queens University.

A record of the work done under the auspices of the Board at its various Stations during the year 1931 will be found in the reports of the Directors and the summary reports of the members of the staffs and voluntary workers which follow, but it seems desirable to emphasize some of the more important investigations that have been in progress.

A noteworthy accomplishment of the year has been the completion of a survey of the fisheries of the bay of Fundy, from which much important information has been obtained, and may be made the basis for future observations. The variation in the periodicity of the salmon in different areas may be mentioned as of special interest, introducing as it does fresh complexities into the already complex life-history of the Atlantic salmon. On the west coast important experiments were begun with both Sockeye and Pink salmon, looking to a testing of the parent stream theory and the possibility of materially improving the runs of poor years. In co-operation with the provincial government an intensive study of the pilchard fishery has been begun.

Oceanographic studies have been continued on both coasts to ascertain the source and distribution of the silica and phosphate contents of the waters as influencing the growth and distribution of the plankton. On the west coast work has begun on the oceanography of the fiords with a promise of important results, and on the east coast the study of the physical conditions in Malpeque bay have revealed the air temperature as a most important factor influencing the development of oyster spat.

The standardization of the lobster canneries has been completed and as the result of the experience gained a new programme of standardization has been drawn up and forms prepared. Explanation of the fatal effect of "drip" on lobsters has been obtained and attention has been given to their rate of growth and their migration. A successful spatting of oysters has been obtained in Richmond bay and the growth of the young oysters is being studied. On the west coast the rate of growth of plantings of Eastern and Japanese oysters has been compared with that of the native form, the Japanese oyster seeming to show the greatest hardiness. An ecological study of the soft shelled clam has been carried out with the view of determining the optimum conditions for its growth and reproduction and an investigation of the life-history of the commercial crab of the west coast has been made.

Much attention has been given to the effects of refrigeration on fish muscle, and to improvements in the methods of smoking fish, and these improved methods are being tried out on a commercial scale in a plant installed at Lunenburg on

plans worked out at the Halifax Station. Investigations of methods for improving the preparation of fish-meals and of the purification of fish-oils by hydrogenation have been continued. A beginning of investigations to determine the nutritional value of fish as food has been made and a bibliography of the subject has been compiled.

ATLANTIC BIOLOGICAL STATION

ST. ANDREWS, N.B., 1931

The work particularly associated with this Station consists of the general investigations of the fisheries of the Atlantic coast, and investigations and educational work in connection with fish culture. A substation for oyster investigation, the Prince Edward Island Marine Station, is situated near Ellerslie, P.E.I.

The following constituted the staff of the Station during 1931:

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 (Zoology).
Mr. R. A. McKenzie, Scientific Assistant (Zoology).
Mr. M. W. Smith, Scientific Assistant (Limnobiology).
Mr. W. Templeman, Scientific Assistant (Zoology).
Dr. V. D. Vladykov, Scientific Assistant (Zoology).
Mr. H. C. White, Scientific Assistant (Zoology).
Mr. E. G. Rigby, Curator.

SEASONAL

Mr. J. M. Morton, Scientific Assistant (Technical Processes).
Mr. C. L. Newcombe, Scientific Assistant (Zoology).
Mr. E. S. Pentland, Scientific Assistant (Limnobiology).
Mr. J. A. Stevenson, Museum Assistant.

There were the following volunteer investigators during the year with university associations as shown:

Prof. B. P. Babkin (McGill), Dr. H. I. Battle (Western Ontario), Prof. P. M. Bayne (Acadia), Prof. H. P. Bell (Dalhousie), Dr. D. J. Bowie (McGill), Mr. J. Campbell (Toronto), Prof. A. F. Chaisson (St. Francis Xavier), Mr. J. W. B. Cox (Dalhousie), Miss V. M. Davidson (Toronto), Mr. M. H. Friedman (Western Ontario), Mrs. A. M. Jeffers (State Teachers College, Virginia), Dr. G. W. Jeffers (State Teachers College), Dr. E. J. King (Toronto), Mrs. H. M. King, Prof. A. B. Klugh (Queens), Dr. S. A. Komarov (McGill), Mr. H. W. Lemon (Toronto), Miss I. McCracken (Western Ontario), Dr. A. B. Needler, Mr. J. V. V. Nicholls (McGill), Mr. R. V. V. Nicholls (McGill), Dr. M. E. Sawyer (Harvard), Dr. W. R. Sawyer (McGill), and Miss H. Tait (McGill).

INVESTIGATIONS

SPECIAL FISHERIES

1. Salmon. Mr. Blair continued his study of the life history of the Atlantic salmon in certain rivers of New Brunswick and Nova Scotia. It was decided that work should be concentrated for a time on the Miramichi river system, which might serve for the elucidation of certain general problems. From Loggieville, N.B., as a base, operations were carried on throughout the season, these involving the collection of data and material from (1) the open gulf, (2) the tidal portion of the river, and (3) certain of the fresh-water branches. The regular fishing

provided the material, for the most part, as only for a limited period was it necessary to resort to special fishing.

Miss McCracken investigated the life history of salmon obtained in 1930 for spawning purposes by the Fish Cultural branch from a mackerel trap at Port Maitland, N.S. It is desired to extend this work to include all the principal groups of salmon of the Fundy area, and for this purpose officers of the Department have assisted by collecting samples of scales and data from salmon of the Annapolis, Petitcodiac, and other rivers.

The Fish Cultural branch has planted fry from Matapedia salmon in the Maccan river at the head of the bay of Fundy, as an experimental measure at the request of the Atlantic Biological Station. Mr. White followed up this planting, and at the same time carried through a field study of the salmon in certain other rivers (Apple, Eatonville, and Advocate) in the same region in order to establish knowledge of the local fish, with which the introduced fish could be compared.

Dr. Huntsman analyzed the statistics of the commercial catches of salmon in the Maritime region for the last sixty years in an attempt to determine the possible factors causing fluctuations in the salmon in the various districts.

2. Lobster. Mr. Templeman, with the assistance of Mr. R. V. V. Nicholls, carried through the season's investigations principally in the Magdalen shallows, the warm southern half of the gulf of St. Lawrence, where the breeding of the lobster is so uniformly successful. During the early part of the season (May and June), 32,000 lobsters taken by the fishermen in various districts of Nova Scotia and Prince Edward Island, were examined and measured in continuance of the work begun the previous year in determining differences between the various local stocks. During July and the first half of August attention was given to conditions for the lobster as found in the Magdalen island waters, and in Malpeque bay, P.E.I. 4,400 individuals were examined and measured in the former locality, of which 2,400 were from fishermen's catches. The balance, as well as 1,500 in Malpeque bay, were secured by special fishing. Over 1,400 lobsters were tagged before liberation in the two localities. The conditions in House Harbour lagoon were compared with those in Pleasant bay, outside, and the former place was particularly studied from the standpoint of the importance of lagoons as sanctuaries for breeding lobsters.

During the latter part of August and September operations were conducted in the western part of Northumberland strait, where there is a fall fishing season, the chief places visited being Point du Chene, Summerside, and Cape Tormentine. About 800 lobsters were tagged, and 12,000 were examined and measured. During the present year special attention was given to measurements of berried lobsters in order to ascertain the minimum size at spawning on various parts of the coast.

3. Oyster. The oyster investigations are largely confined to the region of Malpeque bay, on the west side of which on the Bideford river is situated the Prince Edward Island Marine Station, in charge of Dr. A. W. H. Needler. The latter was assisted by Dr. A. B. Needler and Mr. J. W. B. Cox, volunteer investigators. In addition to the scientific investigations Dr. A. W. H. Needler has had charge of various cultural operations for the Department of Fisheries.

The oyster being in our waters at the northern limit of its range, the matter of suitably high temperature for reproduction is of particular importance. Consideration was given to this as well as to other conditions needed for successful spawning and spat-fall, so important for the oyster farmer to know as a basis for setting out his spat collectors at the proper time. The use of brush as such collectors is being tried, and the conditions under which it is most effective determined. The growth of the spat after setting has been studied as of importance in determining survival through the first winter; also material for

following the later growth of the oyster for different localities and seasons was obtained. Cultural operations have consisted in (1) an attempt to grow as many oysters as possible on experimental beds in the Bideford river as a basis for commercial operations, (2) experiments with the transplantation of small and apparently stunted oysters from deep water near Charlottetown to shallower water where they might make beds of commercial value, and (3) a preliminary examination of Shediac bay with a view to future operations.

Dr. A. B. Needler has paid particular attention to the change in sex of the oyster during its life, and the conditions that may determine it. Oysters have been collected regularly at different places in Bideford river for a study of the comparative rate of growth in different situations, of the season of most rapid growth, and of the comparative amount of growth in successive years. She has also done preliminary work in a disease found to kill off in two years' time all of a certain lot of oysters transplanted from the south side of the Island to Malpeque bay. Dr. A. W. H. Needler has studied the oyster disease that wiped out the fishery in Malpeque bay subsequent to 1914, so that such a catastrophe may be avoided in the future.

4. Clam. The conditions surrounding the occurrence and growth of clams have been the subject of intensive study by Mr. C. L. Newcombe. Various beds in the Passamaquoddy region have been under survey and experimental plantings in different situations have been made not only in this region, but, for comparative purposes, also near the head of the bay of Fundy. Growth studies form a prominent part of the work, and with particular relation to the question of depletion of the beds by overdigging. On request from the Department an investigation was made of certain beds in St. Mary bay from this same standpoint.

5. Fisheries of the Fundy area. On request an attempt has been made to complete a survey of the fishery resources of the bay of Fundy in a year's time. To accomplish this it has been necessary to make use of all the available personnel of the Station, and the response of the volunteers to an appeal for assistance in this work was all that could be desired. The assignment of parts of the work was as follows,—hydrography—Mr. Hachey; processes of handling fish—Mr. Morton; shad and general study of statistics—Mrs. Jeffers; herring—Dr. Huntsman; cod, smelt, tunny, and swordfish—Dr. Jeffers; haddock and gaspereau—Mr. McKenzie; pollock, halibut, skates, and flounders—Dr. Vladykov; hake, cusk, and mackerel—Dr. Battle; salmon—Miss McCracken; lobster—Mr. Templeman; clam—Mr. Newcombe; scallop—Mr. Stevenson; mussel, periwinkle, sea urchin, squid, eel, trout, and bass—Prof. Bayne; and sea weeds—Prof. Klugh and Prof. Bell.

The area included in the survey has been taken to extend from the international boundary at the St. Croix river to cape Sable, including the bay of Fundy proper with its tributary waters, and the north-east portion of the gulf of Maine stretching from the mouth of the bay to Browns bank along the north side of the deep Fundian channel. There have been available from the historical side the account of the fisheries of the bay of Fundy by M. H. Perley, which appeared in 1850, and the fishery reports of the Dominion Government for the more than sixty years since Confederation.

The supervisers and inspectors of fisheries for the various districts in the area have been brought into frequent consultation, both in groups and individually, and have given great assistance with their expert knowledge of conditions. Public meetings for information and discussion were held at Saint John, Yarmouth, and Woodwards cove, Grand Manan. A very large number of men in the industry at place after place along the whole coast have been interviewed as to their experiences in the fishery, and an exceptionally large amount of information has been obtained in this way.

The Department of Fisheries operated the M.S. "Nova IV" during the season in scallop-dragging experiments and co-operated with the survey in covering the whole area in very comprehensive fashion. The new M.S. "Zoarces" proved of great service in enabling investigators to visit outlying points expeditiously, and was also employed in certain systematic fishing experiments designed to show the comparative distribution of bottom fish throughout the bay.

The background for an understanding of the rationale of the various fisheries has been provided to a considerable extent by the hydrographical and biological investigations of past years throughout the area. It has been thought necessary to supplement this by a series of quarterly cruises, covering the area at crucial times in the year in as adequate a manner as proves feasible for showing the changes in hydrographic and planktonic conditions with the seasons. The M.S. "Zoarces" is carrying these through, the times being (1) the latter part of August (midsummer in the water), (2) November, (3) the latter part of February (midwinter), and (4) May. In addition an attempt is being made to ascertain the location of any schools of winter-spawning gadids (cod, haddock, and pollock) in the area, making systematic plankton tows to locate the floating eggs.

GENERAL SEA FISHERIES AND OCEANOLOGY

1. Hydrography. The weekly and monthly observations at standard stations in the Passamaquoddy area have been continued and the number of stations extended to six, of which four are outside the bay proper. The Fundy area is being given special attention in the quarterly cruises already mentioned, and Mr. Hachey is bringing together the results of the investigations of recent years.

The waters in the vicinity of the Prince Edward Island Marine Station are being studied by Dr. A. W. H. Needler, an attempt being made to determine the play of the factors governing temperature and salinity. Data for a study of the seasonal changes in conditions in Bedford basin and Halifax harbour continue to be collected by the Fisheries Experimental Station there.

Daily observations of temperatures are being continued at the series of stations established at lightships and lighthouses along the coast from Grand Manan to the north shore of the gulf of St. Lawrence. One at Gaspé has had to be discontinued, the work being abandoned by the observer. The thermographs of the Meteorological Service, which the Station operates on vessels of the Canadian National Steamships on lines running to Bermuda and the West Indies, have suffered some interruption in service owing to changes in the routing of vessels, but it is hoped to have shortly a resumption of the series of observations crossing the "Gulf Stream" from Montreal and Halifax. Temporarily a line from Boston to Bermuda has been utilized. Mr. Hachey has subjected past records to analysis and furnished a report upon the same. The results have been made available to the Woods Hole Oceanographic Institution, which is making a particular and extended attempt to investigate thoroughly the waters of the Atlantic off the coasts of Canada and the northern states of the Union.

The hydrographic material obtained on the expedition sent by the Department of Fisheries to Hudson bay in 1930 has been worked up by Mr. Hachey and a report published.

2. Chemistry of the water. Mr. Morton and Mr. Hachey have continued to make regular determinations of the phosphate content of samples of water taken at selected stations in the vicinity of the Biological and Experimental Stations. During the summer season weekly samples from two places at the head of the bay of Fundy were examined, one series being secured through the

agency of Prof. Bayne, by the steamer "Kipawo" in Minas basin halfway between Kingsport and Parrsboro, and the other by Mr. White off the mouth of Apple river. Additional observations were made for working out the order in the vertical and horizontal distribution of phosphates in the Passamaquoddy region, and this was extended by analysis of a series of samples obtained by the Passamaquoddy Commission for the work of Dr. H. H. Gran in relation to the growth of diatoms.

The work on silicates in the waters of the region, begun in 1930 by the late Dr. A. Cameron of the University of New Brunswick, has been continued and extended by Dr. and Mrs. King. Imperfections in storage of the samples and in method of estimation, which largely vitiated the first season's work, have been corrected, and what appears to be a very satisfactory procedure developed. Dr. King reports upon a more accurate "compensating" method of making the determinations, which has been used by Mrs. King in surveying the region, both fresh water and salt, as to the horizontal and vertical distribution of silica. Very interesting experiments have been carried through by Dr. King and Miss Davidson, showing that large amounts of silica added to the local sea water greatly increase the growth of diatoms, and that on death of the diatoms the silica goes back into solution rather rapidly.

3. Light. The important experimental work on light in relation to water and its contained life by Prof. Klugh and Dr. Sawyer has been continued. A new quartz spectrograph, purchased by funds furnished to Prof. Klugh by the National Research Council, was designed by these two investigators and was built by the Gaertner Scientific Corporation and the Research Workshop of Queen's University. Apparatus for its under-water operation is under construction at the latter place. In its present state it was brought into successful operation during the summer and was calibrated so as to be used by Dr. Sawyer in determining the degree of penetration of light into various waters of the region and the effect of certain kinds of plankton on such penetration.

The facilities for light investigation were greatly improved by the construction near the laboratory on a solid ledge of rock of a cement platform, so that the delicate galvanometers, which must at times be used, may be quite free from vibration. Over part of the platform a small building was constructed to house such instruments as might be used in the work. The cost of the interior fittings for the present set-ups was met with funds provided from a grant by the National Research Council. The site was selected with a view to the best light exposure and the installation designed to make the best possible use of limited space. The investigators consider that the results are entirely satisfactory and much better work is made possible.

Experiments were conducted by Prof. Klugh as to the nature of the light required for the growth of the commercial sea-weed, dulse. Prof. Klugh and Mr. Newcombe collaborated in studying the effect of light on the growth of barnacles.

Prof. Klugh tried out the Bell-Howell photometer, recently placed on the market, with a view to its utilization in light work in shallow water. The results of careful tests made were satisfactory enough to warrant devising a portable apparatus for the use of this instrument in obtaining light values in such waters as fish ponds and trout streams, and the same has been made available to Mr. Smith for his investigations. Prof. Klugh was able to construct, with filters from the Corning Glass Company superior to those previously available, an improved type of "moonlight" lamp similar to that made previously for the work of Miss Odell in studying the reactions of copepods to lights of various intensities. This was calibrated and made available to Dr. C. J. Fish, who desired to extend the work of Miss Odell in his investigations for the Passamaquoddy Commission.

Also Prof. Klugh has arranged with Dr. H. H. Gran, who is associated with that Commission, for some cooperative experiments on the relation of light to the growth of diatoms, which it is hoped to carry out during another season.

4. Temperature and salinity. In our climate clams and oysters may be exposed to freezing temperatures in nature, and as well refrigeration is at times used for holding both these shellfish. In this connection Mr. Friedman has studied the abilities of both of these animals to withstand sudden or prolonged lowering of the temperature below the freezing point.

Prof. Chaisson, who had investigated the reaction of the skate to low salinities for the water in which it lives, turned his attention to the lobster for this same feature. This is of importance owing to fresh water from ice used in shipping not infrequently dripping upon or running over the lobsters. An extension of the work to cover the conditions generally met with by the Department of Fisheries in transporting lobsters to market is being planned.

5. Fauna. The material collected by the Department's expedition to Hudson bay in 1930 was distributed to a number of specialists in Canada and the United States for identification and report. Dr. A. Willey of McGill University handled the copepods and Dr. C. McLean Fraser of the University of British Columbia the hydroids. Through the courtesy of the United States National Museum members of its staff have identified a variety of materials, namely, the mollusks, and among the crustacea, the crabs (Dr. Mary J. Rathbun), other decapods (Dr. Waldo L. Schmitt), and amphipods (Mr. Clarence R. Shoemaker). Miss I. Gordon of the British Museum of Natural History has identified the Cumacea and Nebaliacea. Dr. Vladykov of the staff of the Station has prepared a very full account of the fishes of the expedition. Other groups of animals are also being handled by specialists.

6. Flora. The diatoms of the Hudson Bay Expedition have been studied and reported upon by Miss Davidson, and Prof. Bell has the seaweeds in hand.

The regular collections of microplankton throughout the year at selected Stations in the waters in the vicinity of the Biological and Experimental Stations have furnished material for determining the fluctuations in the abundance of the plant life of the waters from season to season and from year to year. Miss Davidson has paid particular attention to the diatoms in these collections from the Passamaquoddy area at two principal stations and is completing work covering seven years of collections. In addition in connection with the work of the Fundy survey she is studying the differences throughout the bay of Fundy in the various seasons.

Prof. Bell has continued his survey of the seaweeds of the Canadian Atlantic coast, and during the past season with assistance in transportation provided by the National Research Council he travelled nearly ten thousand miles in visiting 77 points from Grand Manan to the Gaspé peninsula, collecting material at all points.

7. Bait. The North American Council on Fishery Investigations at a meeting in November, 1930 put on record its belief in the importance of conducting experiments with preserved bait for cod and other demersal fish. This Station initiated simple experiments at the end of that year, and these were continued with amplifications during part of the season of 1931. The crew of the M.S. "Zoarces" has carried these out whenever opportunity was afforded.

GENERAL FRESH WATER FISHERIES AND LIMNOLOGY

Principal attention is being given to the Chamcook series of lakes, situated near the Station and showing very considerable diversity in character, in the belief that these may be taken as sufficiently typical of the lakes generally in the

Maritime provinces to serve for fundamental and preliminary study. Mr. Smith has for another year followed up the conditions in three of these lakes throughout the season and finds Welch lake (the uppermost in the series) to be markedly different from Gibson and Second lakes, which are very similar in character. Chamcook lake proper, the largest and lowest, is again a distinct type. A study has also been made of the changes in the distribution of the plankton in Gibson lake as shown by tows taken at two specially selected stations with the object of determining the adequacy of limited tows properly revealing the plankton wealth of any given lake.

Dr. M'Gonigle during the winter of 1929-30 assisted the International Fact-finding Commission for Lake Champlain in an investigation of that lake. He has continued with a study of material then obtained and now reports fully upon it. During the past season, with the assistance of Mr. Smith, he investigated the Chiputneticook lakes in the St. Croix system, primarily in connection with fish mortality, but conditions in general were surveyed.

Mr. Smith has had in hand a series of experiments in water fertilization. The original series of three cement pools, protected from surface drainage, were heavily fertilized in 1928, one with sea mussels, another with barnyard manure, and the third merely by overflow from the two former. They are still showing rather marked changes from year to year as well as from season to season, and study continues to be made of the striking differences in conditions of all kinds that have resulted from such fertilization.

Proposals for the fertilization of a lake in Jasper National Park, Alberta, called attention to the desirability of ascertaining the value of small amounts of fish meal in fertilizing fresh waters. A second year's trial of the effect of adding one pound of herring meal to 10,000 gallons of water in one of a pair of cement pools has shown definitely that such an amount very greatly increases the quantity of life in the water as well as altering conditions otherwise. Two ponds of the same size each holding approximately 3,300 gallons of water were excavated in a marshy spot, with heavy clay subsoil, and these were protected from loss of water through their walls and bottoms by ditches on the outside, kept filled with water. One of the two was fertilized with one-third of a pound of herring meal and the conditions in both followed throughout the season. There was a much greater production of plankton and of various aquatic plants in the fertilized pond.

Opportunity was taken in 1930 of the visits for investigation made to the Chamcook lakes to fertilize Gibson lake with fifteen tons of sea mussels. The duration and extension of the fertilizing effect has been followed during the current year.

Mr. Pentland has continued his study of the conditions required by certain fresh-water amphipods, suitable for fish food. The work for the season was carried out under controlled laboratory conditions.

FISH CULTURE

1. Water conditions in hatcheries. The experimental hatchery of the Station is located on a hillside on the grounds of the Station far from any stream that might provide a full supply of water. It had been expected to use the system, which brings water from the Chamcook lakes a distance of four or five miles to the town of St. Andrews, and upon which the Station depends for its supply of fresh water during the summer. Available funds were, however, insufficient to put the entire pipe line belonging to the Station below frost, and this left the hatchery without a supply of running water during the winter, the season for which trout and salmon eggs must be carried. Advantage was taken of this

situation to work out a method of providing proper conditions both in character of the water and in temperature without reliance upon a natural flow of suitable water. The marsh at the top of the hill, used for the construction of the clay ponds, was utilized as a source of water, which was stored in a cement tank used during the summer as a salt-water reservoir. This water was run into a cement tank built on the rock below the hatchery. The space between the tank and the floor of the hatchery was enclosed with wooden walls, and insulated with eel-grass; and a jacket-heater designed to provide hot water for bungalows was used with a water system consisting principally of two series of pipes, which acted as radiators to keep the temperature from dropping too low. A small electric motor and a centrifugal pump kept the water in circulation from the tank through filters and the egg-containers, and back to the tank. This system gave complete success without renewal of the original supply of water. In this way suitable conditions were provided for the experiments conducted by Dr. M'Gonigle as to the importance of any given temperature, salinity or water-flow in the development of trout eggs.

Dr. M'Gonigle has further tested the water from Chamcook lake as delivered at the Station through the long metal pipe line, by placing trout fingerlings in it at the end of the season when it was believed to be in the best condition. The initially heavy death rate observed is attributed to the weeding out of individuals not fitted for the new habitat into which they were introduced. He has also studied the course of events in each of the various hatcheries in the Maritime provinces from the time of stocking with eggs in the autumn to distribution of the fry the next spring or summer, with a view to ascertaining causes for losses and formulating procedure for their avoidance.

2. Water conditions in retaining ponds. At times considerable difficulty is experienced in carrying salmon from the time of capture till they are ready for stripping. There are ponds for holding the salmon at different points along the coast. That at Saint John was investigated in 1930 by Dr. M'Gonigle and was found to undergo very great changes with the tide. During the present year he has extended this study to include the pond at South Esk on the Miramichi, which is also tidal.

3. Food of young fish. Experiments on the relative effectiveness of various kinds of food for small brook trout were begun by Dr. M'Gonigle in 1930, utilizing a spring-fed stream situated near the Station to supply water to a battery of wooden troughs in which the fish were kept. Under his direction Miss Tait continued the experiments in 1931 with an improved installation of troughs.

Mr. White has studied the stomach contents of artificially hatched trout fry that had been held a long time before planting. In a few hours' time after planting these secured an abundance of food, quite comparable with that taken by the native trout fry of the stream. He has also compared the food of brook trout fingerlings and sticklebacks occurring together in Forbes creek, P.E.I., and has found that the latter fish secure classes of food organisms not readily available to the former, and at the same time serve as food for large trout.

4. Artificial spawning beds for trout. Mr. White has constructed and operated a spawning box for brook trout to be placed in a stream. He has followed the result and finds not only that trout enter the box and spawn, but also that the eggs hatch out satisfactorily and provide healthy fingerlings. This method provides a means of supplying spawning beds to streams, which are deficient in bottom suitable for trout spawning.

FISH MORTALITY AND DISEASE

1. Herring disease. During 1929 and 1930 it was known that a certain percentage of the herring of all sizes in the bay of Fundy and neighbouring part

of the gulf of Maine showed more or less definite evidence of the presence of certain microscopic parasites, which were to be found in considerable numbers in the dark muscle of the side of the body just beneath the skin. Miss A. Alley had studied the condition in previous years, but was not an investigator at the Station in 1931. It was decided that it was of importance to continue collecting data as to the prevalence of the condition, and the services of Mr. N. A. McNairn of McMaster University were secured for the examination of lots of herring taken at various places and times.

2. Fish mortality in fresh water. An extensive mortality of the fish in the Chiputneticook lakes of the St. Croix system was investigated by Dr. M'Gonigle, but its cause was not certainly determined, apparently being no longer in operation. Acting for Dr. M'Gonigle, Dr. A. W. H. Needler investigated the circumstances surrounding the death of brook trout in Campbell's pond, extensive decomposition of finely shredded potato pulp from a starch factory being found to be responsible. Remedial measures were proposed.

FISH PHYSIOLOGY AND ANATOMY

1. The digestive system. Dr. Babkin and his associates have continued their studies of the digestive system of the fish, the skate being used as most convenient for experimental purposes. Dr. Babkin himself studied the effect of distension of the oesophagus and stomach on muscle action and gland activity and with Dr. M. E. Sawyer traced the distribution of the sympathetic nerves to the alimentary canal and the effects of their stimulation in comparison with vagus stimulation. Dr. Sawyer investigated the relationship and functioning of a peculiar muscle attached to the large intestine and apparently related to the spiral valve. Mr. J. V. V. Nicholls carried out experiments to determine the effect of temperature and drugs when acting directly upon the muscle of the stomach wall. Dr. Bowie has continued his work on the histology of the pancreas of the skate and has prepared to determine the nature of the peculiar muscle attached to the large intestine.

2. The respiratory system. Dr. M'Gonigle has investigated the effect of varying temperature upon the rate of respiration in the brook trout in order to obtain evidence of unfavourable behaviour at high and low temperatures and so to establish the limits of the range of most suitable temperature for this fish.

THE HANDLING OF FISH FOR FOOD

1. The surface slime. The slime on the surface of the fish is frequently considered of particular value during handling or curing. Mr. Lemon has continued his study of the nature of this slime, this year confining his attention to that found on the skin of the haddock.

2. Autolysis of the muscle of fish. Mr. Campbell has determined the comparative rate of automatic decomposition of haddock muscle at different temperatures from the freezing point to that of the warmest weather and has done the same for beef muscle, revealing a distinct difference between the two.

3. Extractives of skin and muscle. Following up his discovery of the effectiveness of fish skin in particular in causing a marked secretion of the gastric juice, Dr. Komarov has prepared extracts from the skin of the haddock and the skate and from the muscle of the haddock, and is attempting to determine the nature of the extractives and their action in the living organism.

4. The histology of frozen fish. The problem of the alteration of the fish flesh by freezing and cold storage is being attacked by an extension of the work done by Jackson at this Station and by Weld at Halifax. A clearer picture of the state of the tissue is being obtained by fixation without change in temperature,

which Dr. Bowie has demonstrated. Experiments are in progress to determine the extent to which the tissue can on thawing return to its original condition after certain freezing and storage procedure.

5. Handling and curing methods in the Fundy area. As part of the survey of the Fundy area Mr. Morton has extended the work of Mr. E. E. Daggett, who reported upon the methods used in handling fish at Beaver Harbour, Wilson's Beach, and Grand Manan, and is preparing to report upon the differences to be found throughout the area.

6. The sales of fish in Ontario. Mr. McKenzie has analyzed the sales data of a leading wholesale firm in order to determine the nature of the varying demand (or supply) and the possible reasons therefor.

MISCELLANEOUS ACTIVITIES

TECHNICAL SERVICES

A considerable variety of technical services is rendered by members of the staff to the Department of Fisheries and to the public. Material of varied character, principally fishes, is received for identification, and Dr. Vladykov in particular is called upon frequently for expert report. Dr. M'Gonigle answers personally or arranges otherwise to handle all calls from the Maritime hatcheries. Mr. Smith has assisted in this work, and Dr. Leim of the Fisheries Experimental Station kindly visited hatcheries that were readily reached from Halifax.

EXHIBITIONS

A museum with aquaria is maintained at the Station and this attracts a considerable number of visitors. A request came for an exhibit at the Charlotte County Fish Fair, an institution started over eighty years ago and recently revived. A varied and successful exhibit was arranged. This included still water aquaria cooled with ice, in which various kinds of fishes and other marine animals remained in excellent condition in spite of the crowding and lack of moving water to which they were subjected.

EDUCATIONAL WORK

Plans have been made by Dr. M'Gonigle for a resumption of the courses to hatchery officers, one of four weeks' duration to be given early in 1931 at the Fisheries Experimental Station, Halifax, where class room facilities are available.

GENERAL FACILITIES

Improvements in the general facilities of the Station, that have been in progress, have been carried to a further stage.

1. Salt-water system. The difficulty involved in providing at all times a full supply of fresh salt water in the face of a tidal rise and fall of over twenty feet was met by the construction of a pool just below high water level, for which the rock ledges in front of the Station afforded very suitable conditions. For supplying water at low pressure and in considerable volume for the many tanks and aquaria, in which fishes are held by experimental purposes, a centrifugal pump driven by an electric motor has been installed, and the motor equipped for the automatic filling of the storage tank. The pipe line has been placed below frost so that experimental animals can be held throughout the year. This low pressure system is used for cooling in the light experiments and for the condensing coils of the refrigerating machinery. The water in this system suffers little change in temperature after removal from the sea, but, when in the tidal pool, is considerably heated even at the bottom on clear days during the

summer. Steps are being taken to prevent this, which makes the water fatally warm for many of the local forms during the summer season.

The capacity of the cement storage tank, used for the salt water delivered at high pressure in the laboratory and hatchery, has been very considerably increased and a cover provided for protection from the heating effects of the sun, but the pumping equipment is not yet in satisfactory state.

2. *Fresh-water system.* Winter use of the laboratory and hatchery have rendered it necessary either to put the pipe-line below frost or to provide a supply of fresh water in some other fashion. It has been possible to put only a small part of the line below frost as yet, so that temporary measures have been adopted, which provide a limited supply of fresh water for winter laboratory use. As has been described under hatchery experiments, water accumulating in a pool in a marshy spot situated at the top of the hill behind the Station, and draining an area of woodland of moderate size has been piped into the reservoir that is used during the summer for storing salt water for high pressure delivery. In addition the fresh water main has been put below frost as far as a small stream (crossing the Station's road), which had been dammed to furnish an additional amount of water.

3. *Refrigeration.* During the course of the year the available supply of electric current from the local power company has been so improved as to meet sudden demands. Not until this took place was it possible to operate the jacketed cold storage automatically and maintain the desired constant temperature of 0°F. for experimental work on cold storage. Automatic electric incubators are placed in the anteroom of the cold storage to provide any desired temperature above 0°F. and below the freezing point.

A one-ton ammonia refrigerating machine, no longer needed for freezing temperatures, has been put into service to maintain a cold room under the laboratory at a constant temperature of 32°F. (the freezing point). As automatic equipment has not yet been available, this has been accomplished by placing in the room many metal vessels filled with water, which freezes and thaws alternately, preventing significant lowering or raising of the temperature from the desired point. Incubators in the room provide any desired temperatures from the freezing point up to the highest summer atmospheric temperature. Still higher temperatures are provided by incubators placed in the laboratory. In this way there are now available for experimental purposes constant temperatures for any desired levels from 0°F. upward.

4. *Heating.* A hot-water system for heating the laboratory was in part installed late in 1930, and gave satisfactory service during the following winter. During the autumn of 1931 the installation was completed, the remaining rooms being provided with radiation, use being made of certain steam radiators in the possession of the Station, which were made suitable for hot water use by horizontal installation. Satisfactory conditions are now provided for the winter work, which is increasing in extent.

5. *Rearing ponds for fry.* Under Dr. M'Gonigle's direction a rearing pond for fish fry, subdivided for the growth of food organisms, is being constructed in a suitable spot at the top of the hill for ready supply with Chamcook water, water from the woodland drainage area, and salt water from the high level reservoir.

6. *Tidal control ponds.* The dam across Tidal cove at the head of Passamaquoddy bay has been tightened with earth filling, and caulking on the inside. It will now be feasible to construct with a minimum of expense a series of ponds with variable tidal exchange, in which can be worked out the conditions suitable for oysters and other estuarial forms.

7. M.S. "Zoarces." The new ninety-foot motor ship "Zoarces," which replaces the "Edward E. Prince" for open water investigations, has been fitted up and put into commission. She has been found very sea-worthy, and eminently serviceable for the work. She is not yet fully equipped for dragging, nor has the refrigerating equipment been installed in the commodious centrally-placed hold, which is to be used for the experimental carrying of fish.

8. Road. In recent years road transportation has become increasingly more important in the work of the Station. The handicap in this connection of the very steep hill, which must be surmounted in leaving and reaching the Station by land, has been in part overcome by an alteration in the road, giving a very much easier grade. The new part has been brought into use, and during the autumn of 1931 widened so that vehicles may pass each other, and ditched so that the surface may be kept from guttering. Some further widening and improvement in grade of parts of the road will need to be made.

INTERNATIONAL PASSAMAQUODDY COMMISSION

This Commission, appointed by the Governments of Canada and the United States to arrange an investigation which might furnish a basis for predicting the effects of the Passamaquoddy dams on the fisheries of the region, chose St. Andrews as a base for the investigation. The Biological Board decided to afford the Commission every possible facility not involving an outlay of money.

The upper part of the hatchery building, not being required for the time being, was made available for the use of the employees of the Commission during the summer season as office and laboratory. For the same season insofar as available living and boarding facilities in the residences were furnished to these employees as to supernumeraries. They were likewise given the use of the library and of laboratory equipment.

As the motor boat "Edward E. Prince" was not at once required by the Fisheries Experimental Station, it was turned over for the use of the Commission in its investigations.

PUBLICATIONS

During the year there have appeared the following publications on work connected with the Station.

Babkin, B. P.—Further studies on the pancreatic secretion in the skate. Contr. Canad. Biol. Fish. 7 (1) 1-10.

Effect of haddock flesh and skin on gastric juice. Prog. Rept. Atl. 2, 3.

Babkin, B. P. and S. A. Komarov.—Note on the urea content of the gastric juice in the skate. Contr. Canad. Biol. Fish. 7 (2) 11-15.

Babkin, B. P. and R. H. M'Gonigle.—Studies on the respiratory mechanism in skates. Contr. Canad. Biol. Fish. 6 (11) 315-329.

Chaisson, A. F.—The toxicity of fresh water on *Pseudopleuronectes americanus* (Walbaum). Contr. Canad. Biol. Fish 7 (7) 67-72.

Davidson, V. M.—Biological and oceanographic conditions in Hudson bay. 5. The planktonic diatoms in Hudson bay. Contr. Canad. Biol. Fish. 6 (26) 495-510.

Fraser, C. McLean.—Biological and oceanographic conditions in Hudson bay. 3. Hydroids of Hudson bay and Hudson strait. Contr. Canad. Biol. Fish. 6 (24) 475-481.

Hachey, H. B.—Biological and oceanographic conditions in Hudson bay. 2. Report on the Hudson Bay Fisheries Expedition of 1930. A. Open water investigations with the S.S. "Loubyrne." Contr. Canad. Biol. Fish. 6 (23) 463-471.

Biological and oceanographic conditions in Hudson bay. 6. The general hydrography and hydrodynamics of the waters of the Hudson bay region. Contr. Canad. Biol. Fish. 7 (9) 91-125.

Huntsman, A. G.—The processing and handling of frozen fish, as exemplified by ice fillets. Bull. 20, 1-58.

The maritime salmon of Canada. Bull. 21, 1-99.

Biological and oceanographic conditions in Hudson bay. I. Hudson bay and the

determination of fisheries. Contr. Canad. Biol. Fish. 6 (22) 455-462.
Preserving scallops. Prog. Rept. Atl. 1, 5.
Canning brine-frozen mackerel. Prog. Rept. Atl. 1, 6.
Metal in water kills fishes. Prog. Rept. Atl. 1, 12.
Fillet skinner. Prog. Rept. Atl. 1, 13-14.
Fish hatching investigations. Prog. Rept. Atl. 1, 15-16.
Brine freezer, using ice and salt. Prog. Rept. Atl. 2, 4-6.
Temperature and the Passamaquoddy fishery. Prog. Rept. Atl. 2, 14-15.
Periodical scarcity in salmon. Prog. Rept. Atl. 2, 16-17.
Big catch of Miramichi salmon every three years. Prog. Rept. Atl. 2, 18-19.
Huntsman, M. E.—The effect of certain hormone-like substances on the isolated heart of the skate. Contr. Canad. Biol. Fish. 7 (4) 31-43.
Jeffers, G. W.—Observations on the cod fishery in the strait of Belle Isle. Bull. 18, 1-9.
King, E. J.—On the colorimetric estimation of silica. Contr. Canad. Biol. Fish. 7 (10) 119-125.
King, H. M.—On the occurrence of silica in the waters of the Passamaquoddy bay region. Contr. Canad. Biol. Fish. 7 (11) 127-137.
Komarov, S. A.—Comparative study of gastric secretion in the dog after ingestion of haddock flesh and skin and of beef meat. Contr. Canad. Biol. Fish. 7 (6) 57-65.
MacKay, M. E.—The action of some hormones and hormone-like substances on the circulation in the skate. Contr. Canad. Biol. Fish. 7 (3) 17-29.
McKenzie, R. A.—The fish trade of southern Ontario. Bull. 23, 1-37.
M'Gonigle, R. H.—Brook trout and temperature. Prog. Rept. Atl. 2, 20-21.
Needler, A. B.—The haddock. Bull. 25, 1-28.
Needler, A. W. H.—The oysters of Malpeque bay. Bull. 22, 1-35.
Three haddock populations in North American waters. Prog. Rept. Atl. 1, 10-11.
Disappearance and return of Malpeque oysters. Prog. Rept. Atl. 2, 9-11.
Nicholls, J. V. V.—The influence of temperature in *Fundulus heteroclitus*. Contr. Canad. Biol. Fish. 7 (5) 45-55.
Sawyer, W. R.—The spectral absorption of light by pure water and bay of Fundy water. Contr. Canad. Biol. Fish. 7 (8) 73-89.
Walker, S. J.—Biological and oceanographic conditions in Hudson bay. 2. Report on the Hudson Bay Fisheries Expedition of 1930. B. Investigations at Churchill, Manitoba. Contr. Canad. Biol. Fish. 7 (23) 472-474.
Willey, A.—Biological and oceanographic conditions in Hudson bay. 4. Hudson bay copepod plankton. Contr. Canad. Biol. Fish. 7 (25) 483-493.

INVESTIGATORS' SUMMARIES

B. P. Babkin

Investigation of gastric secretion in Raja. The investigation of the structure and physiological activity of the gastro-intestinal tract and its appendages in fishes is important because nutrition in marine forms is a fundamental function. A thorough knowledge of the physiology of the alimentary canal will be a key to the interpretation of the nutritional habits of different fish and will also help us in understanding such complicated processes as seasonal migration of marine animals. The science of nutrition will form a scientific basis for the breeding of fish under artificial conditions.

(1) With a spinal preparation (spinal cord cut below the medulla) the influence of distension with food masses (pieces of herring and pieces of skate muscle) and the effect of pilocarpin on the gastric secretion were studied. The distension of the stomach did not activate any marked secretion of the gastric juice. A somewhat better result was obtained with intravascular injection of large doses of pilocarpin. Under the influence of this drug the neutral reaction of the gastric mucous membrane turned acid. However, in this case also, no marked gastric secretion ensued. Whether the absence of secretion was due to the inability of pilocarpin to stimulate the endings of the secretory nerves in skate or whether the effect of operation was not favourable for the functioning of the gastric glands, further investigations will show.

(2) An attempt was made to activate the gastric secretion in skate by distension of the oesophagus with a balloon. The distension activated swallowing movements. In one case repeated distension of the oesophagus provoked a scanty secretion of gastric juice.

B. P. BABKIN AND M. E. SAWYER

The vagus and sympathetic nerves in the skate. An anatomical study was made of the course and distribution of the sympathetic nervous system in supplying nerves to the alimentary tract and related glands.

Different nerves—vagus and sympathetic—were stimulated and the motility of the stomach observed. It could be demonstrated that both nerves activated movements especially of the pyloric part of the stomach. The cardiac part was less affected by the stimulation of these nerves.

H. I. BATTLE

1. The Fundy hake and cusk fishery. Hake and cusk have been classed together since 1911 in the Canadian Fisheries Statistics. Within the period from 1920 to 1929 inclusive, the Fundy area has contributed 75.6 per cent. of the total Atlantic catch. The hake fishing season for the most part lasts from April or May to October, and most of the catch is dried for export. It is sold only to a limited extent as fresh fillets in the home market, although practically undistinguishable from haddock, and this trade might be increased, in which case a constant supply will be required.

Two species of hake, *Urophycis tenuis* (Mitchill), the White hake, and *Urophycis chuss* (Walbaum), the Squirrel hake, are taken. Most seem to be referrable to the former species and indeed very few fishermen recognize the existence of more than one kind.

Hake are found to be concentrated near the mouth of the bay of Fundy about the fifty fathom line. On the New Brunswick shore they inhabit a muddy bottom north of Grand Manan, about the Wolves and Campobello, extending in fair quantities to point Lepreau. The catches diminish rapidly passing northward along the St. John county shore line and are practically negligible at the head of the bay, although occasional specimens are taken in weirs off Albert, Westmorland, Cumberland and Colchester counties. On the Nova Scotian side of the bay, the hake inhabit a fine gravel bottom and for that reason are considered superior in quality to those taken on the New Brunswick muddy bottom. Very few are caught off the coast of Yarmouth, but the catch is large off Digby county, and diminishes gradually along the Annapolis and Kings county shore line.

The history of the fishery from 1870-1929 as outlined in the statistical and fisheries reports shows wide periodic fluctuations with 1899 as a peak year. Some of the depressions are attributable to ravages of dogfish; others to a diminution of fishing activities consequent upon low market values, depletion of number of men engaged in the industry, unfavorable weather conditions, or scarcity of bait.

Some fishermen are of the opinion that hake migrate to the offshore banks in the winter, while others are inclined to hold that they merely go out to deeper water in the bay. In either case more seaworthy craft will be necessary to provide for a winter catch.

The cusk is a deep-water form occasionally taken on rocky ledges about Grand Manan (less than 1 per cent. of hake and cusk recorded in statistics), but it constitutes the greater part of the "hake and cusk" catch of Yarmouth county and about 2 per cent. of that for Digby county. The Yarmouth county landings (amounting to 4 per cent. of the total Fundy area hake and cusk for 1929) are taken by hand-line and trawl off Lurcher shoal and the northern limit of Seal Island ground.

2. The Fundy mackerel fishery. Many years ago it seemed questionable whether the fish that are found schooling along the United States coast travel northward and are those found in Canadian waters or whether the latter belong to schools which migrate in from the deeper coastal waters to spawn. The latter view is now held in the light of evidence from tagging operations and since

trawlers have taken adult mackerel on Georges banks in February.

The mackerel catch of the Fundy area represents only about 5 per cent. of the Canadian Atlantic total for the period from 1920 to 1929 inclusive. For the past decade the catch has been negligible or lacking on the New Brunswick shore, and at the head of the bay. With the exception of 1912 and 1913, for about forty years no great quantities have been taken in these localities, and indeed the whole Atlantic catch has shown a definite depletion since 1893. This year, however, as predicted by Mr. Sette of the U.S. Bureau of Fisheries, the catch has been exceptionally large all over the bay. Mackerel strike Yarmouth usually in May; the peak of the catch comes in June and diminishes gradually until October.

P. M. BAYNE

1. The Fundy sea mussel fishery. There is little or no attempt made to use the sea mussel as food or for bait in the Fundy area. Digby and Kings county alone are reported in the statistics as using the sea mussel commercially and then only from 1915 to 1924. Only one attempt has been reported of canning the sea mussel. It yet remains to be seen whether prejudices can be overcome and a demand created that will make a market worth while.

2. The Fundy periwinkle fishery. There are suggestions from the fishermen that the periwinkles have not recovered from the two large catches of 1922 and 1924. As a side line the marketing of periwinkles would be quite profitable for many fishermen if the supply and a suitable market price could be maintained. In addition to developing the trade by opening up markets there should at the same time be steps taken against the possible depletion of the beds.

3. The Fundy sea urchin fishery. The supply of sea urchins seems unlimited. The annual shipment seems to be determined by the demand on the Boston and New York markets and by the trans-shipment charges. Unless the fishermen are so close to steamships that they can ship by freight their profits are used up in the payment of trans-shipment charges.

4. The Fundy squid fishery. Squid are used as a fertilizer to a limited extent, and as bait in Charlotte, Digby and Yarmouth counties. Since 1863 the percentage of the Canadian Atlantic catch caught in the Fundy area has only been between 25 and 30 on three occasions. There is an opening for the development of a dried squid market in China and amongst the Orientals of British Columbia, which would last as long as the present strained relations exist between China and Japan.

5. The Fundy eel fishery. The catch is limited more by the fact that eels are not much in demand as a food than by the available stock. With the exception of four years the maximum catch has been from Yarmouth county and has been uniformly high. This is probably correlated with better facilities for the shipment of eels to the Boston and New York markets. Canadian live eels find a ready market in Holland and Germany.

H. P. BELL

1. Algae of the Canadian Atlantic coast. Collections were made at 77 different points along the coast from the Gaspé peninsula along the Northumberland straits, around the Atlantic coast of Nova Scotia to the head of the bay of Fundy and west to the island of Grand Manan. At present the list of species includes 30 greens, 38 browns and 47 reds, making a total of 115 identified species, and, in addition, 7 species regarding which there is doubt. A large part of the information collected is absolutely new for the region.

2. Observations on Hudson bay algae. Material from expeditions of 1927 1928, 1929 and 1930 included 40 species, of which 2 were blue greens, 7 greens, 18 browns, and 13 reds.

The only greens found inside the bay were estuarial forms. The typical ocean forms were found outside in the strait only. The browns showed the same tendency but not to such a marked degree. Practically all the browns found inside were deep-water forms, and the few typical marine browns found inside were stunted specimens. The only healthy intertidal browns from the inside were estuarial or tide pool forms. With the reds, typical marine forms were found both inside and outside and showed normal growth in both places.

This suggested that the surface water and environment inside was decidedly different in some way from that of typical marine or ocean conditions; that the deep water inside was more like the ocean and the intermediate zone graded between these two.

In addition to the above the assemblage of species was not like that found on the Atlantic coast of North America, but more like the north Atlantic, or northern Europe. There was at least one species which has never been reported for North America, but is quite common in Europe.

A. A. BLAIR

Miramichi salmon investigation, 1931. Anglers, set-net fishermen, and drift-net fishermen have been in dispute as to the proper regulations for conserving the salmon fishery of the Miramichi system. Also it has been claimed that the hatching of eggs from fish taken in the fall does not help the stock of fish that supplies the commercial catch that is confined to the early part of the season. An intensive study of the salmon at all stages seemed necessary as a means of throwing light on the matter.

Out of 1,533 scale samples from salmon caught in the river by set-nets and in the bay by means of drift-nets, 579, that have been examined to determine the life-history, show that in June and July the 3_2 group (3 winters in river and 2 in sea) forms bulk of catch. The 2_2 group is poorly represented although showing some signs of increase in July. Other groups found in smaller numbers are 2_3, 3_3, 4_2, 4_3, and 5_2. Most of the scales with spawning mark are from salmon which have spawned previously as grilse. Erosion, which accompanies development of sexual organs, of scale material at periphery begins about middle of July; it is more common and more extensive in males.

Grilse were secured, examined as to sex, and found to be 95 per cent. males. As also most of the adult salmon are females, it seems definite that the males mature earlier.

D. J. BOWIE

The histology of frozen fish muscle. It was believed, as a result of the finding of Weld that frozen fish muscle on thawing rapidly reabsorbs water from the ice crystals, that a truer picture of the condition of the tissue at any stage could be obtained by cutting and fixing it, or merely fixing it, without alteration in temperature, *i.e.* by treating the material with a fixative with the same temperature as the material. It was also believed that such a method would permit of a direct study of the ability of the tissue to reabsorb water after different procedures in freezing and storage, such ability being of prime importance in making frozen fish the equal of unfrozen fish in consistency.

Sections were cut in the refrigeration room (−12°C.) so that they remained frozen after being cut. Some sections of rapidly frozen tissue were placed in cold (−12°C.) alcoholic fixatives, so that the sections were not thawed before fixing took place. Sections so treated showed a shredded appearance of the rapidly frozen muscle fibres. This condition was not observed in sections of the same tissue, which were allowed to thaw in aqueous solutions before fixation could take place, so the spaces in the tissue left by the ice crystals are larger when the section, or the material before sectioning, has been fixed without change in temperature.

J. CAMPBELL

Control of autolysis of haddock and beef muscle by cooling. Autolysis of fish muscle is of great importance in itself, and also because it accelerates subsequent bacterial decomposition. Lowering the temperature is the chief means used in industry to control autolysis and bacterial decomposition, and therefore deserves accurate investigation. In this regard haddock muscle has been compared with beef muscle for the reason that the haddock is a cold-blooded animal and lives at low temperatures, so that its body processes must act at temperatures about 28° C. lower than those of warm-blooded animals such as the cow.

Haddock muscle autolyses with decreased rapidity from 35°C. to 0°C., there being a decrease of nearly half in the rate at the lower temperatures (Q_5 ranging from 1.42 to 1.88). Beef muscle shows a similar condition but the decrease is not so great (Q_5 ranging from 1.39 to 1.60 within the range 40°C. to 15°C.).

At the same temperature beef muscle was found to autolyse more rapidly than haddock muscle (at 25°C. in 48 hours, calculated from tangents to the curves, beef muscle gave an increase in non-protein nitrogen of 1.1 per cent. of the total nitrogen as compared with an average of 0.7 per cent. for haddock).

Different specimens of haddock muscle had different activities, *e.g.*, at 25°C. in 48 hours an increase in non-protein nitrogen of 0.2 per cent., 0.7 per cent., and 0.9 per cent. was found in three different specimens. In an experiment where ground haddock muscle was incubated at 0°C. for 60 days the average autolysis gave an increase of 17 mg. non-protein per 100 g. wet weight muscle.

A. F. CHAISSON

The effect of low salinities on the lobster. In connection with the exposure of the lobster to drip from melting ice during shipment, it was considered desirable to ascertain the extent and mechanism of any resistance to low salinities that this animal might possess.

In the lobster as in the skate, death in fresh water does not seem to be brought about by a lowering in concentration of the general blood volume, but by failure of the respiratory mechanism, which results in asphyxiation after very short periods of immersion, which lower the blood concentration very little. Similarly both animals are able to withstand a very considerable lowering in concentration of the general blood volume without ill effect, provided that the water to which they are exposed is in part sea water.

In various dilutions of sea water and within the time limits of the experiments (24 hours) no new balance between the blood concentration and the water, such as occurs in the skate, was noted; for there was a steady, uninterrupted drop in the blood concentration with time. Also, unlike the skate, the lobster's mechanism for maintaining the concentration of the blood above that of the water in which it is living, is not destroyed by lowering the blood concentration to $\Delta 1.212$°C. or even lower, and the normal blood concentration level is restored if the animals are then returned to full sea water. In fact, it would appear that this mechanism survives the death of the animal through asphyxiation.

In experiments to determine the effect of drip from melting ice on lobsters under shipping conditions, the drip was found to affect the lobsters in the same way as immersion in fresh water though the time required was greater. It produced failure of respiration and decrease in the concentration of the blood. Death occurred in all cases of drip.

V. M. DAVIDSON

1. Seasonal variation in diatom abundance in the Passamaquoddy region. Diatoms, as the chief component of the phytoplankton, play an important rôle in the nutrition of the sea, being the food of copepods, which in their turn are eaten by the fishes. Physical and chemical factors favorable to the production

of an abundance of diatoms are, therefore, indirectly responsible for a good supply of economic food fishes.

The diatoms begin to multiply in March, or even in February, reach their maximum in May or June, and then decline with, in some years, a tendency to recover in the autumn, usually September or October. The total production in the estuary of the St. Croix river (Station 6) exceeds that just outside the mouth of the bay (Station 5), the two places that have been steadily investigated since July, 1924.

Phosphate and silica values in the sea-water reach their minimum towards the close of the spring flowering, but it is not thought that they ever fall to the minimal quantity required for plant propagation as shown by cultural experiments.

Production begins before the water warms up appreciably, and is complete before the sun reaches its maximum heating and lighting effect. The curve of light intensity follows more closely than any other the curve of plant abundance, at both stations.

2. Diatom production in the Fundy area. Seasonal variation in diatom production is important for correlation with the hydrographical studies and the results of the fishery investigations to give a more detailed picture of the conditions of the Fundy area.

It was found that neritic species of diatoms are characteristic of all regions except the southern part of the bay which feels the influence of Atlantic water, and that species such as *Biddulphia regia* dominate the warmer waters at the head of the bay in summer while the genus *Chaetoceras*, especially *C. debile* and *C. sociale*, hold sway in the colder waters at the mouth.

M. H. FRIEDMAN

Resistance of clams and oysters to freezing temperatures. The clam and the oyster are often exposed at low tide to the very low temperatures of winter, and also it is at times of advantage to keep them in cold storage prior to marketing. Therefore it is important to determine their "cold-hardiness," the ability of an organism either to withstand extreme low temperature (intensity factor) or to withstand long periods of low temperature (time factor).

It was found that the lethal temperature of each kind can be correlated with the environmental temperature of each, and that the lethal temperature is lower the more rapid the cooling. With regard to the problem of storage for varying lengths of time, the rate of cooling probably is also a determining factor. The oyster will keep much longer at −6° C. than will the clam. At −4° to −5°C. both survive exposure for weeks. The author confirmed the phenomenon first viewed by Mr. J. Richard Nelson of Bivalve, N.J.; whereas the animal might recover after being frozen if it is treated gently during the defrosting process, it will not recover if it is subjected to mechanical shock.

H. B. HACHEY

1. The general hydrography of the waters of the Fundy region. The Grand Manan region is seemingly the receiver of waters from various sources, and as a dispenser of these same waters it enters as the prime factor in determining the conditions in the bay of Fundy.

The water in one or another of the other regions may, by a definite change in character (either from one season to the next or from one year to another), bring about a considerable change in the relative conditions in the Grand Manan region. As an example, the great variation from season to season in the volume of drainage water from the St. John river region results in marked differences in the character of the waters proceeding to and from the Grand Manan region.

Waters are carried into the bay of Fundy between Nova Scotia and the

region of Grand Manan bank. Between the Grand Manan bank and the coast of Maine the outflowing waters are to be found. The inflowing waters are of oceanic origin and as they proceed up the bay they undergo progressive changes as they mix with other waters. The waters at the head of the bay of Fundy are fairly well mixed. The waters from the head of the bay, from the St. John region, and from the Passamaquody region reach the Grand Manan region, proceeding there at depths determined by the respective densities. These waters are carried along the eastern coast of Grand Manan and there divide to supply a body of surface water which is carried to the Nova Scotia shore and another which rounds the southern point of Grand Manan to proceed along the coast of Maine. The southern region of Grand Manan is productive of much tidal mixing and upwelling which is productive of heavy surface water which must sink as it proceeds from the region.

Movements of comparatively heavy water from the Passamaquoddy region result in an indraft of lighter surface waters from the St. John area. The rough and rugged coast of eastern Nova Scotia is productive of much upwelling.

2. Analysis of sub-surface temperatures between Halifax and Bermuda. A knowledge of the surface temperatures of the waters off our coast is of importance both to problems in hydrography and meteorology.

Analysis of the thermograph records for the past three years taken between Halifax and Bermuda has revealed that the physical character of the waters along this route varies from year to year and from season to season. Three different bodies of water are determinable from the records: (1) coastal water, (2) intermediate water, and (3) Gulf stream. The variations that occur are accompanied by a displacement of the boundaries of the various bodies of water. These variations may be said to be cyclic in character. Extreme conditions are to be found in the late summer and late winter.

3. The general hydrography and hydrodynamics of the Hudson bay region. The hydrographic investigation in connection with the Hudson Bay Fisheries Expedition of 1930 was of particular importance in explaining the results of the fishing operations.

The waters of Hudson bay differ markedly from the waters of Hudson strait and the waters of the open ocean. Intense stratification in the upper twenty-five metres, decreasing as the waters of the open ocean are approached, gives Hudson bay the character of a large estuary. Below fifty metres the waters are for all purposes dynamically dead, thus resulting in a cold saline body of water which probably undergoes very little change from season to season. The deduced movements of the waters at various levels show that the inflow of waters from Fox channel and the many fresh-water drainage areas control the hydrographic conditions as found. The main water movement is from the James bay area to Hudson strait and thence to the open ocean.

A. G. HUNTSMAN

1. The maritime salmon of Canada (Bulletin 21). The various fishing interests concerned with salmon have been much exercised from time to time over decreased fisheries, and various restrictions have been urged as necessary for conservation. It has seemed advisable to determine any order that might exist in the fluctuations in the quantities of salmon taken from year to year, so as to be able to suggest possible factors responsible for the changes.

A study of the statistics of the salmon catches of the various districts for the period since Confederation, during which statistics have been collected, has revealed a complex order in fluctuations in abundance of the salmon. There are evidences of (1) depletion, (2) conservation, (3) general competition between different ages giving a periodicity of the length of the life of the average spawning fish, (4) competition in fresh-water giving a periodicity of the length of the life in

fresh-water, (5) a periodical scarcity on the average every 9.6 years, and (6) a 48-year complex fluctuation.

2. Fishery resources of the Fundy area. Information has been desired as to the possibilities of increasing any or all of the fisheries of the waters extending from the international boundary at the St. Croix river to cape Sable. The very greatest diversity is to be found in the nature and extent of the various fisheries throughout the area, and it was questioned whether the small quantities obtained in certain localities were in reality due to a dearth of fish.

It is found definitely that the same fishing effort is not equally productive in all parts of the area, and that in fact very great differences exist, which are correlated with the physical conditions in the water. These differences involve (1) the kinds of fish, (2) the abundance of particular kinds, (3) the sizes of particular kinds, (4) the lengths of the seasons for particular fisheries, (5) the elaborateness of the fishing gear employed, (6) the efficiency of the boats employed, and (7) the amount of time devoted by the individual to fishing as compared with other occupations. In general all these tend to decrease going from the mouth to the head in the whole bay of Fundy, as also in St. Mary bay, and the lesser bays and estuaries. Possibilities of considerable increase in the catch are largely confined to forms for which there is at present either (1) no market, (2) only a limited market, or (3) only a low-priced market. Instances of these three classes are (1) dog-fish and silver hake, (2) sea urchins, periwinkles, and mussels, and (3) hake and herring.

The area as a whole is divided more or less definitely into a series of parts showing a steady gradation in physical conditions and in fishery from ocean to river,—(1) Yarmouth shore with swordfish, albacore, cusk, and abundant mackerel and lobster fisheries; (2) mouth of bay with pollock and large summer herring fisheries; (3) lower bay with hake, scallop, and sardine fisheries; (4) upper bay with many sea fisheries of definite value but reduced, such as lobster, mackerel, pollock, cod, haddock, and spring herring; (5) Minas basin with most sea forms few, and very limited fishing of a general nature; (6) Cobequid bay with sea forms rare, and fishing virtually confined to anadromous fish; (7) tidal portion of Shubenacadie river with sea forms very occasional and dying owing to reduced salinity; and (8) non-tidal portion of Shubenacadie river without sea forms, but fishing for the anadromous salmon, shad, and gaspereaux of definite value.

3. The Fundy herring fishery. Herring are by far the most abundant fish in the whole area and are very generally distributed throughout, failing only in the rivers above points where the salinity is greatly reduced. The catch is largely concentrated at the mouth of the bay on the New Brunswick side, where they are utilized for canning purposes, chiefly the young as sardines. It has been claimed by some that the comparatively small catches elsewhere are due to lack of proper facilities for making use of them and not to any lack of the fish themselves. Are the herring at other points than in the Passamaquoddy region in sufficient abundance, of the proper size, and available throughout a sufficently long season to warrant the establishment of canning factories and curing establishments?

On the New Brunswick side there are weirs from Grand Manan at the mouth of the bay of Fundy to Hopewell cape in Shepody bay at the very head. There was a failure to find evidence of the weirs in the upper part of the bay ever taking the quantities of either small or large fish that fill the weirs at the mouth of the bay where the herring strike. Above Saint John they speak of bushels of herring rather than hogsheads, and finally at Hopewell cape a half-bushel is a good catch. Herring and other fish for mink food and sardines for lobster bait are in some cases regularly procured from Saint John or points farther to the west. On the Nova Scotian shore the evidence shows a somewhat similar difference between the outer and inner parts of the bay of Fundy, though less pronounced than on

the New Brunswick side. There is a decrease in the availability of herring (as revealed by weir catches) from the outer bay to the inner bay, Minas basin, and Cobequid bay, and occasional herring enter the tidal portion of the Shubenacadie river. Since fishing is not equally intensive throughout, the possibility of increased catch would seem to be comparatively greater in the inner part of the bay than in the outer.

The spring spawning fish deposit their eggs at the head of the bay of Fundy on the south side of Minas channel, and at the head of St. Mary bay, while the summer spawners have extensive spawning beds off the southern end of Grand Manan, and at Brier island, Trinity rock, Lurcher shoal and other points off the neighbouring shore of Nova Scotia. These seem to be two distinct races with different salinity and temperature relations not only at spawning time, but throughout life.

4. The Fundy lobster fishery. Very considerable differences in the number and average size of the lobsters throughout the area are known to exist. Are there basic local differences in the fishery as making desirable the present or new local regulations of the fishery, in order to maintain its present level or carry it to higher levels?

On the New Brunswick side of the bay the smallest lobsters found, and also the average size, increase from Maces bay eastward to the head of the bay of Fundy, and westward to the mouth of Passamaquoddy bay, indicating the former bay as an important centre of the dispersal of lobsters, this corresponding with the presence of a fairly deep inshore body of warm water in that bay during the summer.

On the Nova Scotian side of the bay of Fundy there is a steady decrease in abundance of lobsters from the mouth to the head, and with this there is an increase in the average size and in the size of the smallest. This shows no evidence of successful breeding on that side. In St. Mary bay, which is a small replica of the bay of Fundy, and beside it on the south, there is a similar decrease in abundance and increase in average size from the mouth to the head along the south side, but very small lobsters are found at the head. This indicates a dispersal or breeding centre at the head of the bay, but one that is not very successful in comparison with that farther out towards cape Sable.

In the parts of the area that become coldest in winter, that is in the inshore waters and in the inner part of the bay generally, lobsters are not to be caught during the period from the middle of January to the middle of March when the temperatures are lowest. They would seem to remain in retreat or even bury themselves in the mud during this period. In such cases the spring fishery is governed by the warming up of the bottom water, and this shows a complex tidal effect, fishing being better at the springs or at the neaps, or the same for both, depending upon the local conditions.

5. The Fundy salmon fishery. It has been proposed that the salmon fishery be extended, particularly the drift-net fishing in the open bay, which is least likely to be overdone, as it ceases to pay long before the stock is exhausted.

The Saint John drift-net fishery extends from the harbour out into the bay to the southwest nearly to Grand Manan in a strip of water roughly between one mile and eight miles off the coast, and only occasional salmon are taken in the weirs of that coast outside the harbour. The salmon apparently congregate in the surface layer of the strip because it is occupied by water of low density issuing from Saint John harbour, and good catches are not to be expected outside it. The Minas channel fishery is confined to the intertidal zone on the south shore from cape Split or Scotts bay southwestward. It is most productive about Halls harbour and drops out before Parker cove to the westward is reached.. Yearly success in this fishery is the reverse of that inside in Minas basin and tributary waters, as if a common stock of fish were caught chiefly in one or other district. A severe winter with a great quantity of floating ice is credited with causing good

outside fishing and poor inside fishing during the following season. In the channel the salmon are considered to very closely hug the south shore so that drifting is unnecessary, and in fact useless offshore. It would appear that the salmon are driven in large numbers from Minas basin in severe winters and that the hook formed by cape Split coupled with their shore-keeping habits effectually prevent their return, thus explaining the markedly isolated character of this fishery unrelated to any salmon rivers.

No basis is found for the belief that there are elsewhere in the area quantities of salmon comparable with those taken in the Saint John drift-net fishery, although less lucrative drift-net fishing of varying value can be found elsewhere. In the main the sea fishery for the salmon is definitely related to the rivers, which they ascend.

6. Bait experiments. On certain sections of the coast fresh bait may be unavailable at times when fish are comparatively plentiful. Nearly everywhere preserved bait is, or may be, of very considerable value for the fishermen.

Herring and clams were used in the experiments. Comparison was made between fresh (or recently frozen), salted, and formaldehyde-treated bait. In addition to differences depending upon (1) the condition of the bait at time of preservation, (2) the nature of the preservative, (3) the strength of the preservative, (4) the time of storage, and (5) the temperature of storage, there were evident also differences depending upon (1) the kinds of fish, (2) the numbers of the fish, and (3) the season of the year.

In certain cases bait treated with formaldehyde gave the best catches, particularly with hake. In other cases salt bait gave the best results, reaching its extreme for certain flatfish, which were caught on no other kind. At the end of the season certain fish, *e.g.* the haddock, would not take any bait offered, though present in quantity as shown by the otter trawl.

A. M. JEFFERS

The Fundy shad industry. Of the shad taken in Canada, the average per cent. caught in the bay of Fundy and its tributaries for the years from 1921 through 1929 was 59.

Compared with the total commercial fisheries of the Fundy area the shad fishery is relatively unimportant. In sections where it is abundant enough to support a fishery it has considerable local value. The majority of the shad taken in this area are taken in the Saint John river and harbour. They are also caught in the Petitcodiac river, in Shepody bay, in Cumberland basin, in Cobequid bay, in Minas basin, in the Shubenacadie river, and a few in the Annapolis river and basin.

When the shad catch was at its peak, from 1874 through 1886, this industry was of sufficient importance to compare favourably with other commercial fishes. In the year 1879, for example, shad made up 4.5 per cent. of the total value of the fisheries of this region. The story of the shad fishery in the Fundy area since 1872 is one of general decline. Previous to 1904 this fish was plentiful enough to be of considerable commercial importance. Since that date the size of the catch has been so small as to be practically negligible. This decline is evidently due to depletion as a result of overfishing and lack of protection during the spawning season. It is gratifying to report that the shad seemed more plentiful during the season of 1931 than it has been for many years.

Drift nets, set nets, and weirs are the three principal means of taking shad. Due to the extreme scarcity of these fish during late years they are not fished for to any great extent in many sections, but are taken only incidentally with salmon.

G. W. JEFFERS

1. The Fundy cod fishery. This, the most prominent commercial fish on the Atlantic coast of Canada, was surpassed in importance only by the herring (in-

cluding sardines) and the hake (including cusk) in the Fundy area for the ten years 1920 to 1929 inclusive. At that, the Fundy catch of cod represents only about 6 per cent. of the catch of this fish for the whole Atlantic coast.

Long-line trawls and hand-lines are the principal methods of capture, and herring constitute the staple bait.

By far the greatest proportion of the commercial catch is taken toward the mouth of the bay, particularly on the Nova Scotian side and out toward Grand Manan at the mouth. This fishery is practically negligible toward the head of the bay although there is no sustained effort to capture cod in this region.

The cod fishery has shown a pretty definite decline during the last forty years both in the Fundy area and along the Atlantic coast of Canada. In the former this is perhaps due to the almost extinction of schooner-fishing and to the fact that haddock has to some extent supplanted cod in the fresh-fish market, with the consequent lower prices for salt cod and hence a decline in the number of cod fishermen.

2. The Fundy smelt fishery. Of the total Canadian catch the Fundy area produces only about one per cent. in quantity but considerably more in value due to the proximity to the American markets.

Smelt are practically absent about the islands at the mouth of the bay. Yarmouth is the leading smelt county with Charlotte a poor second. The fish is rare toward the head of the bay, doubtless due to the absence of streams suitable for spawning and the general turbidity of the water.

There is no noticeable decline in the fishery and the lack of suitable spawning rivers precludes the possibility of greatly increasing the catch although there is no good reason why it could not be rather noticeably increased.

Fishing is done mainly during the fall and winter months, gill nets being the principal method of capture. In Yarmouth county the fishermen have restricted themselves to hook and line fishing only, and we find that the method works so well that there is little likelihood of its being abandoned.

3. The Fundy tunny (albacore) fishery. Very little is known of the life-history of the tunny or albacore beyond the fact that it is a resident of the high seas and a summer visitor to our coasts. Where it winters or breeds is not known; the smaller fish—less than 20 pounds—do not appear in our waters. The tunny is found off the outer coast of Nova Scotia and, less frequently, on the Nova Scotia side of the bay of Fundy. On rare occasions it is seen in Passamaquoddy bay but the commercial catches are restricted to the counties of Yarmouth and Digby. Since 1926, Digby county has not reported any.

For the last ten years the Fundy catch has averaged over 6 per cent. of the catch for the Atlantic coast of Canada although this percentage varies from less than 2 to over 11.

4. The Fundy swordfish fishery. Like the tunny the swordfish is a species belonging to the open seas. It is essentially a southern fish that wanders north in spring. In summer it is fairly abundant sporadically along the outer shores of Nova Scotia and rarely enters the bay of Fundy. Consequently it, too, is confined to the counties of Yarmouth and Digby.

In 1929, Yarmouth was the only county in the Fundy area reporting swordfish. Twenty-three hundredweight were reported for the Fundy area, whereas 6,336 hundredweight were taken in all Canada.

Possibilities of increasing this fishery in the Fundy area are therefore slight beyond the fitting out of boats suitable to hunt them off the outer Nova Scotia shores.

E. J. KING

On the colorimetric estimation of silica. Many natural waters possess a yellow tint which must be allowed for in the silica estimations. This is usually done by making a "blank" reading on a 100 cc. sample of the water, without the addition

of the reagents, against the picric acid standard. The value found in this way may be subtracted from the value obtained with the sample plus reagents, the difference representing the true soluble silica content of the water.

As the taking of "blank" readings is always a bothersome proceeding due to the uncertainty and difficulty of matching, an apparatus was designed for overcoming this difficulty by means of "compensating" tubes of water mounted below the ordinary Hehner tubes used in the estimation.

A series of determinations using this apparatus was made on waters from several different localities. In most cases there was excellent agreement between the compensated value and the corrected value obtained by subtracting the blank reading from the non-compensated.

E. J. KING AND V. M. DAVIDSON

Relation of silica to the growth of phytoplankton. With the purpose of obtaining more information on the part played by silica in the production of diatoms, the diatom population was followed in different concentrations of silica in sea water held in glass jars coated with bakelite to prevent solution of silica from the glass. Jars A, B, and C contained sea water treated with modified Miquel solutions and with concentrations of 0.92, 4.92, and 10.92 mg. of silica per litre, respectively.

During a week of cloudy weather there appeared to be no increase in the diatoms, but with the advent of much sunshine, growth became very luxuriant. This was especially marked in C, with B also showing a fair amount, and A a little as well. The gradation in opacity of the contents of the jars became very marked during the next week. The soluble silica content of the jars fell rapidly with this burst of growth and after several days had fallen nearly to the vanishing point in all the jars.

There was a steady decrease of the silica in solution which ran parallel with the growth of diatoms, and after the cultures were dead and re-solution of the forms had commenced, there was a steady increase of soluble silica until the original values had almost been reached.

H. M. KING

The occurrence of silica in the waters of the Passamaquoddy region. A study of the occurrence of silica in the waters of the Passamaquody bay region has been undertaken with a view to determining the distribution of this chemical constituent, its variation in amount with depth and location, its seasonal variations with their possible relation to the growth of phytoplankton, and the possible relation of its regional concentration to the movements of the waters of the bay.

In localities where the turning over of the water was very marked there was little difference in the silica values from top to bottom, but in other localities where the water movement was not so marked the values varied considerably with depth. During July the values found were fairly high, but with the August profusion of diatom life there was a marked falling off of the silica values of the top layers at the stations least subject to overturning of the water. The water of the bottom oozes in these places was very high in silica.

Waters tributary to Passamaquoddy bay had a much higher silica content than the waters of the bay itself. A possible relation between the silica content and the movement and origin of the waters at stations 5 and 3 (in the bay of Fundy) has been noted. In one of the fresh water lakes tributary to Passamaquoddy bay a marked difference in silica content of the water, corresponding to a sharp thermocline, was observed.

A. B. KLUGH

1. The utilization of algae in the Fundy area. The dulse industry is the only algal industry of any importance in Canada, and it is confined to the bay of Fundy. It is practically confined to the island of Grand Manan, and to its north side, though there is a small and somewhat sporadic development in Annapolis county. There is at present only a limited market for it. In addition to dulse, some of the larger algae—the rockweeds, are used, namely as fertilizer for farm lands; but the seaweeds of the bay of Fundy form a potential resource, which as yet has scarcely been tapped.

2. Photosynthetic rates of dulse in light of different wavelengths. Experiments on the photosynthetic activity of dulse (*Rhodymenia palmata*) in red, green and blue light showed that it had its greatest photosynthetic activity in green light, and this fact seems to account for its distribution, which, in the bay of Fundy is at, and below, low-tide level.

A. B. KLUGH AND C. L. NEWCOMBE

Light as a controlling factor in the growth of Balanus balanoides. Areas on different sides of the wharf block, denuded in the spring, were selected with different degrees of illumination, and the growth of barnacles thereon followed during the course of the season. There was no appreciable set of young after June 6. On August 4 the area exposed to sunlight from 8.00 a.m. to 8.00 p.m. showed 1,100 barnacles from less than 1 mm. to 4 mm. diameter each way, and 220 from 7 mm. diameter, while the area exposed only for about one hour in early morning showed 700 from 5 to 6 mm. high and 2 to 3 mm. wide, and 600 from 8 to 13 mm. high and 4 to 7 mm. wide. Other exposures were intermediate. There is thus shown an inverse relation between light intensity and growth, indicating an adverse effect of the former on the latter.

S. A. KOMAROV

1. The extractive substances of fish skin. Haddock skin and extracts prepared from it are strong stimulants of gastric secretion. Also substances isolated from the skin of the skate greatly influence the blood circulation in that fish. It is important to determine the nature of these extractive substances and details of their action.

Extracts of skate and haddock skin were submitted to fractionation by the method of Kossel and Kutscher. The protein and inorganic matter in the free extract of skate skin injected intravenously in cats under ether anaesthesia was found to be quite effective in causing a fall of blood pressure and inhibition of the heart beat. Atropine (1 mg.) abolished the inhibitory action on the heart beat and to some extent diminished the depressor action of the extract, but did not abolish the latter altogether. Thus, a choline-like effect on the circulation and also a histamine-like action could be demonstrated in cats. These observations suggest the idea that histamine-like and choline-like substances present in fish skin may be responsible to some extent for the high secretagogue effect of fish skin on the gastric secretion.

2. Extractive substances of haddock muscle. The high secretagogue effect of meat extracts, especially in the case of gastric and intestinal secretion, was thought to be attributable to their content of carnosine, methylguanidine and histamine, all of which greatly influence the blood circulation. As to fish muscle, no adequate study of this has been made, and in connection with the evaluation of fish as a food such an investigation is considered very desirable.

Two adequate samples of muscle were taken from freshly-killed haddock and crude extracts prepared. The process of purification of the extracts is being carried out with a view to obtaining their constituents in a pure chemical state. Some crystalline organic substances have been isolated but not yet identified.

3. Deep aseptic autolysis of haddock muscle. The autolysis of fish muscle is of great importance commercially because it evidently takes place in many industrial processes such as smoking, salting and freezing. Nothing is known regarding the fate of such substances as carnosine, carnitine, guanidine, choline, histamine and urea when the tissue is autolysed. It is a very interesting question also how the autolysis of fish muscle would be reflected in the secretagogue properties of the tissue.

Extracts from haddock muscle autolysed in the presence of thymol and toluene at room temperature for four weeks were purified and fractionated according to the method of Kossel and Kutscher. As compared with extracts from fresh muscle, there was found by analysis to be very considerable increase in ammonia, amino nitrogen, and non-protein nitrogen, and decrease in urea. Thus with the formation of ammonia decomposition of urea evidently takes place during autolysis. Probably urease, which was found recently to be present in some tissues of warm-blooded animals, is present also in haddock muscle and plays its part during autolysis.

H. W. LEMON

The mucus secretion of the skin of the haddock. Many fish have a covering of slime on their skins. It is believed by some that this slime or mucus should not be removed from the fish during the process of handling. They say that the fish has a better appearance when marketed if the slime is intact. Also its presence may be of importance in the preserving of the fish.

The solubility of the mucus in distilled water, sea-water, dilute solutions of sodium hydroxide, and dilute solutions of acetic acid was found by determining the amount of nitrogen dissolved from one gram of mucus by 100 cc. of the solvent. In 100 cc. of distilled water or of sea-water the nitrogen content was 4.5 mg. In dilute alkali the nitrogen content rose from 4.5 mg. at zero concentration to 11.3 mg. at 0.1 per cent. concentration of sodium hydroxide at which concentration solution was complete. In dilute acid the nitrogen content rose from 4.5 mg. at zero concentration to 7.4 mg. at 3.0 per cent. concentration of acetic acid, beyond which no further solution was obtained.

In order to get some idea of the composition of the mucus, the following determinations were made. The water content was found to be about 90 per cent. of the total weight. The inorganic material, largely from the sea-water held by the mucus, was 13.0 per cent. of the dry weight. Total nitrogen was 10.9 per cent. of the dry weight. The amount of material extracted by ether and alcohol, largely lipoid material, was about 27.6 per cent. of the dry weight. Thus the organic material remaining is about 59.4 per cent. of the dry weight. This is largely protein. The mucus gives all of the usual protein colour reactions.

I. MCCRACKEN

Salmon of the Fundy area. Microscopic examination of the scales of salmon from Allens lake retaining pond (1930) showed that the majority, both males and females, remained three years in the river before descending as smolts; the majority of males returned as grilse; and more than half the females returned after two years in salt water. These data concerning male fish are based on a relatively small number of specimens.

R. H. M'GONIGLE

1. The herring disease of Passamaquoddy bay. On the whole, the disease was not nearly so acute this season as in either of the two preceding. From the limited number of lots examined, one would conclude that the most severely affected fish appeared in the St. Andrews and western shore region.

Such results as have been secured tend to indicate that the percentage of

infected fish decreases with the advance of the season, although the percentage of severely infected fish apparently increases. The explanation suggested for this phenomenon is that the mortality of infected fish is greater, and only unaffected, or relatively unaffected fish, survive the summer.

2. Lake Champlain investigation. Facts were desired, which might make it possible to settle the international controversy concerning the fisheries of the lake, particularly of Missisquoi bay. The pike-perch is the species chiefly in question. The winter and spring fisheries for various fishes were both investigated and material from each secured. In the subsequent studies, the food of the yellow perch has been the main assignment for Canada.

In the region which we investigated during the winter portion of the study, the value of the smelt fishery (minimal) was estimated. How it compared with other regions is not known. However, as far as yellow perch are concerned, it is a very poor region, for the stomach contents were much smaller than all other regions (except one). Perch from the shallow regions of the south of the lake and of Missisquoi bay had much greater content.

During the last few days of April, the stomachs of almost every perch taken in certain parts of Missisquoi bay were very full of pike-perch eggs. Three-quarters of the yellow perch diet proved to be made up of insects and of fish, in about equal proportions. During the period of egg diet, it was the fish portion which was mostly replaced, insects being affected to a less degree. Younger perch have a slightly greater proportion of insects than the older ones, which have a considerably greater fish proportion. Crustacea and molluscs form irregular proportions of the diet. *Hybognathus regius* and *Boleosoma nigrum* (fish), *Hexagenia* and *Sialis* (insects) and *Asellus* and *Cambarus* (crustacea) were probably the more frequently occurring organisms identified.

3. Fish mortality in the Chiputneticook lakes, St. Croix river system. The extensive nature of the mortality indicated the cause to be a poison. There was a very definite possibility for such poison, for the water-level of the lake had been suddenly raised by about six feet in the early summer, over an area which all the previous summer, fall and winter had been exposed, so that there was much dead vegetation, and so forth. It is probable that the *sudden* flooding of this extensive area would dissolve ample deleterious materials to account for the wholesale death of the fish, of which the white perch (*Morone americana*) seemed to be the chief victim.

The absence of any land-locked salmon among the dead fish seemed to cast some doubt on this theory, and seemed to suggest that some other factor might be operating, possibly a wholesale poaching for salmon. Dynamite, or set-lines would be the implements employed for this purpose, and the "cull" fish being discarded, would account for the dead specimens found. Against this idea was the fact that there was no evidence of torn mouths indicating set-lines in the dead specimens examined though dynamite was not ruled out. The apparently extensive nature of the mortality rendered the poison theory the more probable.

4. Factors affecting successful development of trout eggs. As a result of certain experiments in which trays of eggs were placed in the outflow of springs in nature, so that the water had to pass through the trays (and eggs) instead of over them, with almost perfect results, experiments were devised to ascertain the amount of water required for such type of hatchery outfit, the results of which might be determined by the comparative success of such trials. In addition, as controls, various other types of apparatus were employed, still water of varying depths, and surfaces, water agitated by rocking, and so on. The water supply for flowing water experiments was secured by means of recirculation; and a temperature of about 5°C. maintained by a small heating system with water circulation.

"Eyed" brook trout were used, and they received no care or attention from the time that they were set up until the experiments were discontinued. Occa-

sionally they had to be examined to see when hatching occurred.

The effect of salinity, and temperature, employing incubators with still water, was determined, and showed 12½°C. and 15°C. to be unfavourable, and that about 7½°C. was the optimum. A salinity of 3 per cent was unfavourable, 2 per cent. not good, and one-half per cent. only fair. One per cent. was good.

An experiment in which surface varied, and also the depth (for the total amount of water was constant), was unfavourable in the smaller surfaces, and greater depths. It required a surface of 18 sq. in. (112 sq. cm.) for 67 eggs as a minimum. Since there were 600 cc. of water used, the depth was 5 1/3 cm., or about two inches.

An experiment in which the water was passed downwards through the eggs gave just as good a yield of sac-fry as a similar trial, in which the water, with the same rate of flow, passed upwards through the eggs.

Water-flow varying from rates of 1¼ gallons per minute per square foot cross-section, up to 105 gallons per minute per square foot cross-section seemed to all yield equally good results. In five different rates, the maximum dead eggs out of 250 was seven, or about 2.8 per cent.

5. Lethal temperature, and respiratory rhythm of brook trout. Further investigations during this past year have been made concerning the causes of mortality in salmonoid fishes. The brook trout was employed as the experimental animal, as observation has shown that it is the least resistant in the majority of cases of the hatchery fishes.

Fingerling trout parr were taken, three or more, in a flat, shallow pan with water enough for them to swim in easily. By heating slowly, at a standard rate of 1°C. for every five minutes, and keeping the water constantly stirred, it was found that the lethal temperature was 28° to 29°C.

By plotting the logarithm of the respiratory rate, which was measured by taking the interval (by means of a stop-watch) required for fifteen respiratory movements of the operculum, or mouth (mandible), against the reciprocal of the absolute temperature for the range of temperatures studied, three straight-line curves were secured, intersecting at about 9° to 10°C., and about 23°C.

The uppermost curve had a slope of negative value. It was assumed that the curves indicate physiological ranges, of varying degrees of favourableness the uppermost being a temperature region of unfavourable physiological influence. The middle one appears for various reasons (chiefly the rate of growth) to be the optimum. The significance of the lower range is not apparent, and while not unfavourable, seems to be of quite a different character.

6. Salmon retaining-pond investigation. The study, begun last year at the Saint John salmon retaining pond, was extended this year to include two other ponds. One of the new ponds, at Nictaux Falls, N.S., was entirely fresh-water, and the fish entered the same without netting, by a fish-way. The Saint John pond is one subject to extreme changes in salinity, depending on the phase of the tide, and also, the fish have to be trapped, and transported to the pond. Intermediate between these is a new pond, being constructed on the Miramichi. It has been suggested that a study of these ponds, and the fish in them, may throw some light upon the causes for occasional severe losses which are experienced in them.

At Saint John, the water in the pond is practically fresh for the greater part of each day at all times, but when the tide is more than 23 feet above low-water datum, the salinity reaches that of Courtenay bay (25 parts per mille, or higher, depending upon wind, etc.), for about three hours. The water in the pond is very thoroughly mixed, and is the same in temperature, salinity and oxygen content throughout. The salinity then falls at a rate varying with the concentration of salt water (cooling curve).

On the Miramichi, the pond had not been constructed, so samples were

collected from the river. All of the samples have not yet been received, and analysed, but from so many as have been handled, it is evident that the surface water varies considerably in salinity, depending upon the phase of the tide and the amount of the rainfall. At neap tides, the water was about 1 part per mille, with moderate precipitation, and about 4 parts with dry weather. At the same time, neaps, there was remarkable stratification, the bottom salinity being much higher. As the tidal cycle approached the spring tides, mixing became better and better, and the salinity of the surface water became higher, and the bottom lower, until at spring tides the surface and the bottom were equal, about six parts.

7. Is the nature of the water a factor in mortality of fingerlings distributed from hatcheries? A large number of trout fingerlings left after the conclusion of certain feeding experiments, were transferred into certain troughs, fed by water which it was known was contaminated in the first part of the season by metallic salts (or colloidal solution of the metal itself) from the pipe-line through which the water was conducted. It has been thought that this contamination decreased progressively with the advance of the season, and in October, when this transfer was made, that the water was free of pollution.

However, within twenty-four hours the trout began to die, and continued to do so for five or six days, the number of deaths decreasing daily, from an initial rate of 86. The survivors, which did not appear different from those which died, were active and splendid-looking specimens.

It is suggested that this type of factor operates, to a greater or less degree, in every transfer of fish from one environment to another. Some unfavourable factor, no matter how diluted, seems to affect certain of the new inhabitants so seriously that they succumb, but those that survive are "the fittest" for that particular environment, and this "weeding-out" may be an inevitable, and more or less desirable, process.

8. Analysis of hatchery reports. Weekly reports have been supplied by the Fish Cultural branch of the Department of Fisheries. From these there have been plotted the maximum and minimum weekly temperatures, the residual population weekly, of each group, or race of each kind of fish in each institution (the investigation has been confined to the eggs, and resultant fry of the current year as yet); and the percent mortality of the residual weekly population. It would be premature to make very definite conclusions from one season's study, yet the following points may warrant attention.

(1) Sudden increases in the mortality of young fry, and fingerlings, appear to be associated in practically every case with an increase in the temperature of the water. It appears to be the *rate* of increase, rather than the actual temperatures, or even range of temperature. Enough data are not yet to hand to state what this rate may be, but it appears to vary also with the species, and probably several other factors affect it.

(2) One of the most striking points evident quite early was a difference in the population curves of eggs, secured locally, and of eggs sent in from elsewhere. This was true for every case, and for every institution. It is thought that this difference in behaviour of these eggs is due to the shipping, for all eggs shipped "*eyed*", both brook trout and Atlantic salmon, showed this very characteristically. This does not appear to hold, however, for eggs shipped "*green*".

(3) The rate of mortality for each species tends to be different—the population curves fall at characteristically different rates. This holds only for local eggs, or for eggs shipped green. There were some interesting exceptions, apparently associated with differences in temperatures.

(4) The hatching period does not cause any change in the rate of mortality. The population curve continues without any break, or change of slope through, and beyond this period. This seems to apply to all species, salmon, and eastern and western trout.

(5) Atlantic salmon, with interesting exceptions, hatch "explosively". With brook trout, this period may be spread over a very considerable period.

(6) Two groups of the same strain of "native" Atlantic salmon taken from different ponds, but by the same personnel, showed a very interesting difference in rate of mortality. This appeared to be associated with the slight difference in salinity.

R. A. McKENZIE

1. The Fundy alewife fishery. There are apparently two species (*Pomolobus pseudoharengus* Wilson and *P. aestivalis* Mitchill) included under the name of alewife or gaspereau. Since they are usually considered to be the same by most people, it has been found necessary to treat them together until such a time as samples can be obtained from all about the region throughout the whole spring and summer fishery.

The alewife fishery is restricted to the Atlantic coast and the principal supply comes from the Maritime provinces. Of this, about fifty-five per cent. comes from the Fundy area, where the St. John river and harbour fishery produces about five times as much as any other county bordering the bay. Yarmouth county stands second with about one-fifth as much landed per year. All the other counties about the bay produce much smaller quantities of alewives. The Gaspereau river, and the Shubenacadie and St. Croix rivers (Hants county) are probably the most important centres in these other counties.

This fishery depends on the fish running up the rivers at a certain time of year. In St. John county the height of this run occurs in March or April, in Yarmouth county it is in April, in Hants, Colchester and Annapolis it is usually in April, in Kings and Digby it is in May, as a rule, and in Cumberland it is almost always in June.

The greater proportion of them are taken in weirs built in the lower stretches of the St. John river. However, some drift-net fishing is done in and about the mouth of the river, as well as in the Shubenacadie, Gaspereau and Avon rivers. Set nets, square nets and dip nets are also used at various places in this fishery.

It appears from a rough survey of the statistics that the landings since 1869 have been very irregular, but have held up on the whole.

2. The Fundy haddock fishery. The entire Canadian haddock catch is made in the Atlantic, and of this about one-fifth is taken in the Fundy area. Within this area it ranks fourth in point of quantity landed. About twenty per cent. of the catch in this area is made on the New Brunswick side and eighty per cent. on the Nova Scotia side. A brief survey of the landings since 1869 reveals the fact that very few haddock were landed or reported so at the beginning of the period. Following this two very high peaks in the landings are found, one in 1883 and the other in 1897, but after the latter the reported landings decreased to a very low level by 1921. However, there has been considerable increase in the landings since then.

On the New Brunswick side almost all of the haddock fishing is done between cape Spencer and the mouth of the bay, with most of it being done about the islands at the mouth of Passamaquoddy bay. The fishery on the other side of the bay extends from cape Sable as far in as Scotsman bay with most of it being concentrated about the mouth of St. Mary bay and Digby neck. By far the greater proportion of the haddock is caught on ground trawls while fishing on hard bottom, and herring seems to be the most generally used bait.

Generally speaking, there are two haddock fishing seasons at the mouth of the bay, spring and fall. This is more pronounced on the New Brunswick side. The farther into the bay one goes the less distinct these become, the change being towards a short summer season with the haddock being taken more or less incidental to other fisheries. This seems to be correlated to some extent with the temperature of the water.

3. The fish trade of southern Ontario (*Bulletin 23*). The investigation consisted of working up the sales statistics, for a period of two years, of one of the leading wholesale fish dealers in the district, which is bordered by large fresh-water lakes, which afford a supply of fresh-water fish.

A consideration of these statistics revealed the fact that only thirty-five per cent. of the fish sold were of fresh-water origin, while forty-one per cent. came from the Atlantic and twenty-four from the Pacific. A great variation was found in the sales of each species from year to year, but the total quantity sold remained fairly constant for the two years. It was found that about sixty per cent. of the year's business was done from November to April inclusive—January, February and March being the best. The maximum sales were found to occur about the end of April or the first of May. During the latter part of May, and June, July, August and September, the sales of fresh-water fish were about twice as great as either those from the Atlantic or Pacific. The rest of the year the sales of Atlantic fish predominate with the fresh-water fish following a close second. Throughout the year these two groups vary tremendously, whereas the Pacific fish sales are more regular, but not so great.

It was found that twenty per cent. of the fish were sold in the cured condition, chiefly smoked, while the other eighty was divided between frozen and unfrozen. Only about six per cent. of the unfrozen was found to be sold as fresh fillets while the remainder of the uncured fish was sold either in the round or dressed. Some eighteen of the more important fish were discussed in detail as to origin, form and seasonal variation in sales.

J. M. MORTON

1. Plant fertilization in sea water. In the sea, the abundance of plant forms is often determined by the amounts of phosphate and nitrate present. The amounts of nitrate follow the phosphate values closely and hence the phosphate values have been taken as an index of the fertility of a water sample. The source of phosphate in the sea is found to be the decaying material on the bottom, large quantities being found in proximity to such. The results of determining samples from places where the water is well mixed show that the values are the same at the top and at the bottom.

2. Fish processing methods of the Fundy region. In connection with the general survey of the fishery resources of the bay of Fundy, about forty fish-processing plants were visited and the methods in use observed.

Large quantities of hake, cod and haddock are salted and dried chiefly for markets in southern countries. Herring and alewives are the principal species which are pickled. Herring are smoked as bloaters and kippers and finnan haddies and smoked fillets are prepared at many places. Brine freezing is carried on at Yarmouth and St. Andrews while large cold-storage plants are located at both Saint John and Yarmouth. Canneries for clams, kippered herring, sardines, lobsters, haddock and finnan haddies are found around the mouth of the bay, some on the Nova Scotia side and some on the New Brunswick side. In fact, the distribution of plants for all the operations mentioned shows that all of these are concentrated between Saint John and the United States border on the New Brunswick side of the bay and between Digby and Cape Sable island on the Nova Scotia side.

A. B. NEEDLER

1. A disease found in the oysters of Malpeque bay. In 1929 a number of oysters from the south side of Prince Edward Island were brought over and planted in two beds in Malpeque bay near the Biological Station. During 1929 these oysters seemed to be fairly healthy but throughout the summer of 1930 diseased specimens were found on the beds, by the autumn they were dying in

considerable numbers and by the spring of 1931 it was impossible to find a live oyster on either of the beds. The diseased oysters were thin and generally had yellow spots containing pus-like matter somewhere about the body. It seemed probable that these oysters were infected with the same disease which destroyed most of the oyster population in the bay some years ago and that they had caught it from the native Malpeque oysters which are now immune but are still carrying the disease.

With the idea of throwing some light on the organism responsible for the disease, several of the sick oysters were preserved and sectioned. Cells that appeared to belong to the infecting organism were found in various parts of the body but particularly in the liver and muscle. It is suggested that the organism may be a mycetozoan but much more work will be necessary before its exact nature can be determined.

2. Sex reversal in Ostrea virginica. Oysters were examined from several beds in Bideford river, P.E.I., from Long island, N.Y., and from Bivalve, N.J. Some of the beds in all three places had been planted with spat so that the age of the oysters was definitely known while other beds had oysters of various ages. In the latter case the age of each oyster was determined by counting the annual zones on the shell. As a result of these investigations the following conclusions were reached. The majority of oysters in any one population mature as males and later change to females. The bigger an oyster is by the first winter of its life the more likely is it to be mature and the more likely is it to be a female in the next spawning season. The females tend to be larger than the males of the same age until they reach their fourth summer after which the advantage is somewhat lost. The change from male to female may be hastened by an environment favourable to growth or retarded by the proximity of older females. A few oysters may mature as females without first passing through a male phase.

Of the oysters of known sex marked in 1930, only five remained to be examined in 1931, but amongst these was one that produced sperms in 1930 and eggs in 1931.

A. W. H. NEEDLER

1. Hydrographical investigations in the Malpeque bay area. Hydrographical investigations have been continued in Bideford river and Malpeque bay in an attempt to study the changes in conditions (especially in temperature, which seems to be of the greatest importance) and the factors producing these changes, with the end in view of knowing what to expect as general conditions in different places and of predicting the conditions in particular cases.

The results to date have shown the relatively very great importance of weather conditions in the air (air temperatures, sunshine and rainfall) as compared with the importance of tidal changes and the conditions in the open gulf outside. The latter do, of course, play an important part in the production of the conditions in the inlets where there is, as it were, an equilibrium between these forces, but in the shallow inlets of this region, where the depths are less than fifteen feet on the average, the atmospheric conditions can produce very great fluctuations which are often of very great importance. For example, changes of over 10°C. in the prevailing temperatures in the inlet may occur in less than a week when the air temperatures change suddenly. It is found that the temperature changes due to the rise and setting of the sun are much greater than those due to the rise and fall of the tide. Tidal changes, on the other hand, are of greater importance in relation to salinity, and the rapidity with which the normal salinities reappear after a spell of heavy rains.

2. The use of brush for the collection of oyster spat. The possible importance of brush for the collection of spat is very great, as it is available in very large quantities, can be used on bottoms too soft for any other material as yet found practical, and as materials for cultch will probably be in great demand in the

near future. Although green alder and birch brush planted in 1929 failed to catch spat that year, it was well covered with spat next year after being left in the water. White birch and alder brush, of which half was green and half had been cut and exposed to the weather for two years, collected very few spat in 1931, although nearby shells planted at the same time were well covered, suggesting that soaking in the water is necessary before the brush will catch spat.

3. Growth of oyster spat. It was found that there was a greater survival of spat which were well grown before winter than of those which were still small. Those which were less than 0.5 cm. in length showed a very high proportion of deaths in their first winter. The very late catches of spat are therefore likely to be quite unprofitable. It is important from a practical standpoint to know the probability of a sufficient growth being obtained before winter by late spat. This is of particular importance here at the northern limit of the oyster's range, where late spawning is probable. It would be quite inadvisable to plant cultch at all in the late years except in particularly well-sheltered places, as the expenses are considerable and the supplies of good material for cultch far from unlimited.

The results to date have shown that there is a considerable variation in the growth attained in different places (faster growth towards the heads of the inlets), in different years (faster growth in the warm years) and in different situations (effects of crowding, current, etc.). These differences have been sufficiently great to keep the growth near the minimum for a profitable survival in the case of certain lots of cultch even in the last three years (1929 to 1931) which have been warm and in the sheltered waters where the observations were made.

4. The oyster situation in the Charlottetown region. In the vicinity of Charlottetown the presence of large quantities of small and apparently stunted oysters in deep water out of reach of the present tong fishing has been considered a possible source of stock for the establishment of oyster farming in the near-by waters. Investigations there have been designed to determine the best method of using this body of oysters of which no use is now made.

The investigations have yielded a preliminary picture of the oyster situation in the area. The points of greatest interest are as follows:

(*a*) Exploration of the deep water has shown that the bottom of the channel in the lower reaches of the Charlottetown "rivers" supports no oysters and little of anything else, the bottom being hard, clean and rocky. In limited areas towards the head of the deep water abundance of oysters obtains and they are slow-growing and at present, at least, small.

(*b*) When transplanted to shallower water in the same inlet these oysters survived well and grew much more rapidly than those left in their original situation.

(*c*) The topography of the Charlottetown rivers, with deep channels separated by a steep slope from large tidal flats, is such that very little level hard bottom suitable for oyster culture is available. The neighboring bays on the north shore of the island have smaller tides and more gently sloping shores and level hard ground is present. There is, moreover, little fishing now carried on in them.

(*d*) The hydrographic conditions in the north shore inlets are comparable to those in the Malpeque area and present no apparent great difference in temperature or salinity from the areas of the channel where the small oysters occur.

(*e*) Oysters transplanted from the channel of Hillsborough river to Savage harbour on the north shore survived for some time after the transplantation but it remains to be seen whether they survive the winter and grow well in the following summer.

(*f*) It is considered probable that the small oysters could be successfully used to establish oyster farming in the bays of the north shore.

5. The disease among the oysters of Malpeque bay in the years 1914 to 1916. A preliminary picture of the oyster disease of 1914-1916 has been based in part on observations by the writer and in part on the history of the disease as obtained from local sources. Evidence is given for the following conception of the disease. It appears that the disease was brought to the bay from areas in the United States with oysters brought in for planting. The disease was new to the oyster community of Malpeque bay and a very high death rate resulted. The mortality appeared first in one part of the bay and in the course of two years spread to the rest and then was carried to neighboring inlets. The mortality was very high—undoubtedly well over 90 per cent.—but although successive crops of spat were decimated enough survived to re-establish the oyster community at the heads of the inlets where the temperature conditions were most favourable and even in 1929-1931 a very few old oysters could be found on the beds in the open bay where, however, the reproduction was very slight. In the last few years several transplantations of oysters were made from bays on the south shore of Prince Edward Island where the disease did not occur, in an effort to quicken the re-establishment of the oyster population. These all survived for a year after planting and then died with symptoms similar to those of the oysters which died in 1914-1916. Also about one in one thousand of the present native oysters of the area show similar symptoms. It is concluded, therefore, that a population resistant to the disease has been developed. As a result of a recommendation based upon the above facts, the transfer of oysters from Malpeque bay to other areas has been prohibited.

C. L. NEWCOMBE

1. An ecological study of the soft-shell clam, Mya arenaria. In this investigation there have been considered the physical conditions operating on the clam during all seasons of the year, factors most significant in determining distribution, the rate of growth throughout each season at different levels on the beach, and a comparison of the rate of growth on the various commercial clam-beaches of the bay of Fundy. The results so far obtained are as follows:

(*a*) The growth and abundance of clams is very largely dependent on the time of exposure.

(*b*) Clams submerged constantly at a depth of one metre below the surface exhibited a growth of 5.88 mm. per clam during a period of 44 days. This amount exceeded that which took place at any level in the intertidal belt, so that we can conclude that the clam is not dependent on bottom detritus for food.

(*c*) The maximum growth of clams in the intertidal belt under experimental conditions took place near the extreme low-tide mark in a region submerged practically all the time.

(*d*) Clams placed at a level of about 21 feet above datum level exhibited a growth of 1.44 mm. per clam during a period of 44 days.

(*e*) In general, clams are found in greatest abundance at a level halfway between the mean high and the mean low-water mark.

(*f*) Clams kept at a constant temperature of 30°C. were not found to survive for a period of over three days. Those kept at temperature around 2°C., 5°C., 10°C., 15°C., and 25°C. for 29 days all survived although the amount of growth was very slight, never exceeding 0.1 mm. per clam.

(*g*) Specimens planted in an area where the salinity is known to range from 8.51 to 17.22 per mille during exposure all survived with the exception of two and exhibited a growth of 1.8 mm. per clam. Those subjected to a salinity of about 1.0 per mille did not grow to any appreciable extent although the lethal effect was not particularly high, eleven having survived.

(*h*) The maximum amount of growth of clams takes place during the spring and early summer in the St. Andrews region. Growth in this season practically ceases after the first or second week in October.

2. The Fundy clam fishery. The yearly average quantity of clams dug in the Fundy area during the six-year period, 1925-1930, constitutes nearly 50 per cent. of the total number for Canada, and is nearly two-thirds of the number reported from the entire Canadian Atlantic coast. The Fundy area clam fishery is centered at the mouth of the bay, principally Charlotte, Digby, and Annapolis counties.

During the period 1900-1905, no clams were canned in Digby and Annapolis counties, whereas in the year 1927 about 89 per cent. of the total number dug were canned. Of all the clams taken in the Fundy area during the period 1900-1905, only 14 per cent. were canned as compared with about 70 per cent. during the recent period, 1925-1930. In general there has been a considerable increase in the percentage canned throughout the entire Fundy area during the period 1922-1929. However, since 1930, when the U.S. tariff regulations came into effect, the output of canned clams has been materially reduced to the extent that many factories have closed and others are operating only during certain months of the year.

In Charlotte county, N.B., there are about 800 acres of commercial clam beaches. On certain beaches excessive digging has resulted in partial depletion, whereas other beaches possess potentialities for the development of a large commercial fishery as yet not appreciated.

In Digby and Annapolis counties approximately 1,000 acres of flats are suitable for commercial digging. In these counties, conditions are favourable for digging and marketing fresh clams.

J. V. V. NICHOLLS

The effect of temperature variations and of certain drugs upon the gastric motility of elasmobranch fishes. Excised strips of the stomach of *Raja diaphanes* and *Raja erinacea* alone were used. Spontaneous contractions appeared in almost every case within an hour or two. As soon as they were established the temperature was lowered slowly until they ceased, and then the temperature was very slowly raised, until they ceased at the upper limit. The temperature was raised about 20°C. in from six to seven hours.

It was found that:—

(1) A rise in temperature causes an increase in the rate of spontaneous contractions of all parts of the stomach, the rate at the lower temperature limit being about 0.7 contractions per minute, and at the upper temperature limit about 2.1.

(2) The upper temperature limit at which contractions exist is about the same for all parts of the stomach, viz., about 24.5°C. The lower temperature limit varies for different parts, being for the cardia 7-8°C., for the fundus 3.0-5.5°C., for the antrum 1.5-4.0°C., and for the pyloric sphincter 1.5-3.0°C.

(3) The rate of contractions at any one temperature is different in different parts of the stomach. The parts, named in the order of the descending rates, are, —the pyloric sphincter, the antral and fundic regions of the lesser curvature, fundic region of the greater curvature, antral region of the greater curvature, and the cardia.

The actions of adrenaline, atropine, pilocarpine, and acetylcholine were also investigated. It was found that:—

(1) Adrenaline stimulates all parts of the stomach except the antral region near the pyloric canal, where it stimulates in concentrations of 1:2,000,000, but inhibits in concentrations of or greater than 1:1,000,000. Adrenaline administered after pilocarpine has an additive effect.

(2) Atropine has no effect upon the normal contractions of any part of the stomach, but antagonizes the effect of pilocarpine and acetylcholine.

(3) Pilocarpine and acetylcholine stimulate all parts of the stomach.

E. S. PENTLAND

The basis of successful culture of Gammarus. In a study of *Gammarus* under laboratory conditions, at the University of Toronto, various experiments to determine their reaction to temperature, pH, food, and rate of flow of the water were carried out, and a number of attempts were made to secure definite data on the rate of reproduction.

Of the various factors studied, temperature is by far the most important. It was found to be practically impossible to keep *Gammarus* alive for any length of time in standing water at laboratory temperatures, but no difficulty was experienced when the temperature was kept between ten and fifteen degrees centigrade.

Within the range of natural waters, the pH appeared to be of only slight importance.

Various types of food were tried, including several kinds of aquatic plants, and organic detritus. The most satisfactory food tried was dead elm leaves, which, when well soaked, were readily taken.

At laboratory temperatures the use of standing water appeared detrimental, although better results were obtained if it was changed frequently. The use of running tap water was tried, but was found to introduce several serious difficulties, and did not prove satisfactory.

M. E. SAWYER

A mechanism controlling the movements of the large intestine in elasmobranchs. A sheet of muscle in the mesentery attached to the large intestine of the dogfish, first discovered by Cannon, appeared to be related to the spiral valve and its contraction caused the rotation of the intestine.

Experiments on this muscle were carried out on dogfish and skates (spinal preparation). In both of these animals the muscle takes origin in the oesophagus just above the cardiac sphincter and passes posteriorly, spreading out fan-like in a very thin sheet to be inserted on the right lateral margin of the large intestine. Contraction of the muscle causes, in addition to a rotation of the intestine, a pulling of the pylorus, duodenum and large intestine anteriorly toward the cardia. Frequently contraction of the muscle was followed by an active peristalsis-like movement in the large intestine.

The muscle responded with maximal contraction to mechanical or electrical stimulation. It also responded to sudden stretching and to a slow increasing tension when the latter reached a certain degree. In both dogfish and skates this degree of tension was found to be that produced by a weight of 5 to 7 grams. The response to this form of stimulus was frequently a series of rhythmic contractions.

Sympathetic and parasympathetic drugs also produced a positive effect on this muscle, in the intact animal as well as in the isolated state. On the other hand, no evidence of an extrinsic nerve supply could be demonstrated. Electrical stimulation of the various nerves and plexuses in the abdomen while producing good contractions of the stomach, pylorus and duodenum had no effect on the muscles. Histological investigations for the presence of nerves are being carried out.

W. R. SAWYER

The spectral absorption of light by natural waters. The work of the previous summer on the penetration of light into natural waters was continued with a number of improvements in equipment and technique.

(1) A laboratory study was made of the spectral absorption of light by the water from various habitats at or near the Atlantic Biological Station.

(2) The spectral absorption of light by sea-water containing known concentrations of plankton was determined and the relationship between the number of

planktonts and the absorption obtained.

(3) The vertical distribution of the plankton in a given habitat was determined from the absorption curves of water samples taken at various depths down to 20 metres (obtained just after sunset), the maximum concentration being found at 10 m.

The method used was to pass a parallel beam of light from an incandescent lamp horizontally through a sample of water contained in a pyrex tube. The transmitted light was picked up by a quartz spectrograph. The standard plates were made by means of a new screen method.

M. W. SMITH

1. A comparative study of the conditions in the Chamcook lakes. A study of the physical factors shows that the conditions in Welch lake were quite different from those in either Gibson or Second Chamcook. Whereas the water in Welch lake became strongly stratified in the summer, a strong wind circulated the water of the other two at this season. Since the bottom of Welch lake is composed of a richer organic ooze than is found in the others, and also since the water is much more definitely stratified, the lower strata of this lake became depleted of oxygen, and the acidity, expressed as pH, reached a comparatively low value.

On the whole, the same plankton species occurred in all three lakes, but in varying abundance, as exemplified by the very large production of *Holopedium gibberum* in Welch lake during the early summer. All the lakes showed a sudden increase of plankton in spring, but the quantity was maintained at a higher level during the summer months in Gibson and Second lakes than in Welch. This is likely due, in part at least, to the continued mixing in the former bodies of water.

2. The distribution of plankton in Gibson lake. When a comparison is made in the quantities from station to station on the same day, and from week to week, a great irregularity is noted.

(1) The horizontal distribution was very uneven. Surface tows show that generally, when the amount was high in shallow water, it was high in the deeper.

(2) The plankton taken at 3-4 metres at station 2 exhibited a fluctuation in amount similar to the surface on many occasions. This substantiates the idea of a general irregular horizontal distribution.

(3) However, in some instances, the quantity for the deeper water was high, when that for the surface was low. A vertical movement in that area is indicated.

(4) A periodicity in the plankton was demonstrated. The cycle was approximately monthly. However, as noted above, when a maximum occurred in shallow water, a minimum was found at the deeper station.

A demonstration of this irregular distribution is important, since it illustrates the inadequacy of a few tows in order to draw conclusions as to the plankton productivity of a lake. Also it indicates that a study of the shallow water is essential to ascertain what amount of plankton is available for plankton-feeding organisms which, on the whole, are found in those areas.

3. The effects of small amounts of fertilizer upon the plankton growth in experimental ponds. One pound of herring meal was added to one of two similar experimental concrete ponds (B series), and also a comparative amount to one of two similar earthen ponds (N series). The water supply for all was the same. An equal number of plankton organisms was added to each of the B series. The members of the N series also received a comparative number.

In the B series, the beneficial effects of fertilization were evident. A larger amount of plankton and a greater variation in the physical factors occurred in the fertilized pond. A scarcity in the number of species of plants and animals indicates that certain factor, or factors, were limiting. The pH value, since it was consistently high, may have been the most restrictive.

In the N series, the effect of the fertilizer was very pronounced, as shown by both a greater plankton production and variation in the range of the physical

factors in the fertilized pond. Although numbers of entomostracans were taken in the unfertilized pond, their rate of increase was much slower. Plant growth, especially filamentous Algae, was notably larger in the fertilized pond.

4. The effects of large amounts of fertilizer upon the plankton growth in experimental concrete ponds. This investigation was carried out in the A series of concrete ponds, A1, A2, and A3. Ponds A1 and A2 were heavily fertilized during the summer of 1928, the former with 1,000 pounds of salt-water mussels, the latter with 1,000 pounds of cow manure. Pond A3 has received overflows from these two ponds on various occasions, but no fertilizer has been added directly. The effects of this procedure are still very marked, but as might be expected, are least pronounced in pond A3. The conditions during 1931, as a result of this fertilization, may be summarized as follows.

(1) There was an immense production of both plant and animal growth. This production was irregular, one or two forms producing a maximum growth at any one time.

(2) Great variations occurred in the physical factors, depending, aside from various outside meteorological influences, upon the plankton growth and the stage and rate of decomposition.

(3) The number of species in the fauna was quite limited. This indicates that, although the forms that were present gave large quantities, the conditions were unfavourable for the production of many species of plankton organisms that might be expected to occur.

It is concluded that such a heavy fertilization was beneficial for producing large numbers of any species which might occur, but, that this production was very irregular and subject to marked fluctuations.

5. The effect of fertilizing Gibson lake. During the season of 1930, Gibson lake was fertilized with about 15 tons of salt-water mussels (*Mytilus edulis*). This material was confined to a restricted area at the shore and in shallow water.

A comparison of the quantity of plankton taken during the two seasons, 1930 and 1931, in Welch, Gibson and Second Chamcook lakes shows: (1) that Welch lake, which lies above Gibson in the series, gave approximately the same results in both seasons, (2) that Gibson lake exhibited a greater production in 1931, especially during the late spring and the summer, (3) that Second Chamcook lake, which receives the drainage from Gibson, produced a marked increase in quantity, also especially during the late spring and the summer.

Since the amount found in Welch lake remained nearly the same, while the other two lakes showed increases, it is inferred that the fertilization was effective.

J. A. STEVENSON

The Fundy scallop fishery. The Giant scallop (*Placopecten grandis* Solander) is the subject of an important fishery, the economic value of which is high to the Fundy area, up to 84 per cent. of the total Atlantic Canadian scallop catch being yearly taken there.

The capture of scallops is effected by specially constructed scallop-drags drawn along the sea bottom by a powerfully-engined boat, which at Digby is in many cases also specially designed for the work.

The main areas of distribution are from southwest of Brier island to Parkers cove, in Nova Scotia; and south and southeast of Grand Manan island in New Brunswick. Less extensive areas exist off Lurcher shoal and along the northern shore of the bay from Campobello island to point Lepreau, including the Wolves.

The history of the Fundy scallop fishery dates from 1895, and from 1895 to 1920 scallops were landed in small quantities solely from the northern shore of the bay. In 1920, the Digby fishery began. and very large quantities were landed in Digby and Annapolis counties, increasing till 1927, but since then, due to the state of the market, decreasing considerably.

The future possibilities of the scallop fishery lie chiefly in the creation of a

better market, by advertisement and wider distribution of products. The waste portion of the flesh should be utilised for food, possibly by the manufacture of "scallop-paste."

H. TAIT

Food for brook trout. Fish hatcheries are faced with the problem of finding a cheap adequate diet for brook trout which can be conveniently fed. Fifteen combinations of foods were fed to trout kept in separate troughs with fifty fish in each, and a comparison made upon the basis of weight increase and mortality. Each ration was incorporated in a jelly made from either animal gelatine or the seaweed Irish moss.

Provisional results are as follows. Feeding the food in jell form kept the troughs cleaner and ensured that the food did not immediately separate on entering the water. The inert bulk provided by the Irish moss when added to fresh beef liver or lung appeared to be beneficial. The fish had a better appearance and were more active than those fed only upon beef liver. Dried buttermilk or dry lactalbumin with either Irish moss or gelatine is inadequate. Animal gelatine shows no evidence of providing any valuable food material. Dry lung can largely replace fresh meat with no bad effect. Variety of foods in one ration is beneficial. Dry lung, dry buttermilk and gelatine appear to be an adequate food. This will require confirmation in future work.

W. TEMPLEMAN

1. Growth rate of lobsters. Theoretically the best time to catch lobsters would be at the end of the rapid growth period. In imposition of size limits it is also necessary to know how many years it will take the smallest lobsters that can be caught, to reach the size limit. If it takes too many years the decrease due to natural causes may counterbalance the increase in size and weight and no good result from the size limit except to allow more lobsters to mature.

The percentage increase in length on moulting was determined from carapace measurements for four lobsters in the Magdalen islands (first moult for the year) as from 10.1 to 18.4 per cent., and for 19 lobsters at Point du Chene, N.B. (small lobsters at least second moult for the year) as from 4.5 to 14.5 per cent. The average increase was slightly less than 10 per cent.

In five cases where both carapace and total length measurements were taken, the increase as determined by carapace measurement was always greater, ranging from 2-6 per cent. greater than that as determined by total length. A certain amount of growth in length thus probably occurs between moults, especially during the weeks previous to moulting, by stretching of the joints of the abdomen, thus the existing growth tables based on individual moults and total length measurements before and after moulting may need revision. In Northumberland strait during the past summer the lobsters over 9 inches moulted once and those under 9 inches at least twice.

2. Lagoons of the Magdalen islands as lobster sanctuaries. Since 1894 the lagoons of the Magdalen islands have been reserved by law as lobster sanctuaries. Since fall fishing was prohibited there has been no fishing in these lagoons. Statistics show that the catch of lobsters in the Magdalen island waters has kept up as well as, or better than, on any other part of the coast. If these sanctuaries are directly responsible for preventing depletion in this area, the idea of sanctuaries may be applied on other parts of the coast.

The temperature over the whole of Pleasant bay was found to be suitable for successful lobster breeding and the temperature of House Harbour, Grand Entry and of Harbour Basque lagoons even more suitable. Salinities inside the lagoons were apparently similar to those outside.

Lobsters were plentiful over a large part of House Harbour lagoon, a catch

of 13 to 14 lobsters in a trap was not uncommon. Of the 1,500 lobsters caught in House Harbour lagoon, July 11 to August 10, below 23 cms., there were about three times as many males as females, and above 23 cms. over ten times as many males as females (23 cms. is about the general size at first egg extrusion in this region). This occurred to a lesser extent in the catches of new shelled lobsters in Malpeque bay and in Northumberland strait.

A small percentage of females with eggs hatched or hatching were found in the lagoon and one with new eggs. No definite evidences were discovered of movement of lobsters to and from the lagoon, and if those in the lagoon had entered it, they must have done so early in the year.

This was also indicated by the condition of the shell. From the time we started fishing in the lagoon on July 11, all the lobsters except an occasional large male or a berried female had new shells of such character as to indicate that moulting must have occurred in the majority of cases at least a week previously and probably two weeks. In Pleasant bay outside the entrance to the lagoon moulting was just beginning by July 11 and it was only by July 25 that any large percentage of lobsters had moulted, moulting being practically over by August 5.

3. Shell condition of lobster during fall fishing season. There has been much argument regarding the suitability of the period, August 16 to October 15, for fishing in the western Northumberland strait region. Neighbouring districts are asking for a similar season, claiming that they will catch more lobsters, more easily, and that an addition to the fall district will relieve the pressure in the live lobster markets during the spring. Shell conditions were noted in 12,000 lobsters, August 20 to September 22.

(1) When the first measurements were taken on August 20, from 50 to 70 per cent. of the market lobsters (over 9 inches) were buckle or rubber-shelled and totally unfit for shipment. The small lobsters were new shelled and hard shelled. About the end of August all the lobsters under nine inches moulted a second time in the Point du Chene - Summerside area, while only from 50 to 70 per cent. of the small lobsters had moulted a second time in the West point and Port Howe waters, by September 12 and 22. Those new shelled lobsters had little meat in their claws and were thus not very remunerative to the canner.

(2) The exact weights of 500 lobsters in the period August 27 to September 1 and of 500 in the period September 15 to 19, together with other information, indicate that at least 30 per cent. more lobsters of the same size were required to pack a case of lobsters this year at Point du Chene from, say, August 27 to September 15, than during the first week of the fall season, August 16 to 23, or than in almost any locality during the spring season.

(3) Also, in a district where the smaller lobsters moult twice during the year, the fall season results in the capture of a large number of small lobsters after the first moult, whereas in the case of a spring season they would have increased 10 per cent. in length by the second moult, in the fall.

4. Lobster measurements. To determine the best lobster-breeding areas by the comparative abundance of small lobsters. An area with little successful breeding would need a high size limit, while in areas with very successful breeding the lobsters may be overcrowded with regard to food supply and a lower size limit would be necessary. The measurements also show what percentage of the total catch would be affected in various localities by the application of any particular size limit, and afford a statistical basis for future work on decreases in size due to more intensive fishing.

About 50,000 lobsters were measured. These measurements were spread over 60 localities, the average sizes calculated in the different localities having a probable error of about 0.1 cms. Measurements were divided into male and female. Measurements of 231 berried lobsters indicate that in southern Nova Scotia, from Clarkes harbour west, the smallest size at egg extrusion is in general at least 11 inches, while the comparative smallest size in the gulf region would be about 8 inches.

5. Lobster tagging. In all lobster conservation programmes it is most difficult to persuade the fisherman that by illegal actions he is injuring his own fishery and not some fishery hundreds of miles away. The tagging should give an idea of the extent of the lobster's movements. Other problems which last summer's tagging is expected to help to solve are (1) movement of lobsters from the lagoons in the Magdalen islands, (2) relative activity of male, non-berried female, and berried lobsters, (3) movement of lobsters into deep water in late fall, and (4) size attained when moulting occurs only once a year.

About 2,200 new shelled lobsters were tagged, 950 in the Magdalen islands, 450 in Malpeque bay, P.E.I., 450 in Northumberland strait, 140 off North cape, P.E.I., and 140 six miles east of Pugwash, N.S. Most of these lobsters were placed so as to be captured during the spring season of 1932. About 70 to 80 tags already returned fail to show migrations greater than 6 to 8 miles, although individual lobsters have travelled from two to four miles in a single night.

V. D. VLADYKOV

1. Fishes from the Hudson bay region. This investigation was based on a study of six collections of fish (about 4,000 specimens) made from 1919 to 1930 by Messrs. W. G. Walton (1919), Frits Johansen (1920, 1927, 1929), B. W. Taylor (1928), H. B. Hachey and S. J. Walker (1930).

This material is composed of 42 different forms, 39 species, 33 genera, and 16 families of fishes.

It was found that the most important commercial fish for this region are principally anadromous and rarely marine:

(*a*) whitefish, tullibee, and sturgeon all around James bay,

(*b*) brook trout chiefly on the east coast of James bay,

(c) arctic trout and Greenland cod in Hudson strait and Hudson bay.

2. Pollock fishery in the Fundy area. Pollock in this region stand in the ninth place as regards market value, but in the sixth position with regard to quantity "caught and landed." During the ten years, 1920-1929, the average yearly pollock catch was 5,513,400 pounds which represents 63.2 per cent. of the whole Canadian catch, or 35 per cent. of the total pollock catch in Canada and United States.

The best catches were taken on the east coast of Grand Manan and between Campobello and Deer island on the New Brunswick side, and near Brier island on the Nova Scotia coast.

It is suggested that pollock in the Fundy area are divided into two independent groups:—(*a*) New Brunswick side, and (*b*) Nova Scotia side. For the first group, the chief month of capture is September, while for the second, July and August.

The New Brunswick fish probably spawn near the entrance to Massachusetts bay. However, the Nova Scotia pollock seem to have other spawning grounds which are south and southwest on, or near, Georges bank.

During the five years, the pollock catch in New Brunswick waters has greatly decreased, but on the Nova Scotia side the decrease has not been appreciable.

3. Halibut fishery in the Fundy area. The halibut taken in this region during the last ten years, 1920-1929, represent only 2.5 per cent. of the total Canadian catch of this fish. Ninety-two per cent. were taken on the Pacific coast. The fishery in the Fundy area during 1928 occupied the seventh position as regards market value, but the eighth with regard to the quantity "caught and landed."

The average catch of halibut in the Fundy area for the ten-year period, 1920-1929 inclusive, was 816,700 pounds, which represent 32 per cent. of the average catch for the whole Atlantic coast of Canada.

The halibut in the Fundy area possess different sizes, indicating that this region represents a virgin condition.

The chief catch of halibut in the Fundy area is made on the banks at the entrance of the bay (Browns and Cape Sable island). Pubnico, Yarmouth and Digby are the principal landing ports for halibut.

H. C. WHITE

1. Is there danger of artificially hatched trout fry starving after planting? The fate of fry after planting is an important phase of fish cultural operations. It has often been stated that trout fry starve after planting.

Several small lots of fry were retained until the yolk sacs were completely absorbed as well as the fat reserves in the body. These fry were then planted in streams where it was known that suitable food was available. Some hours after the fry were planted they were seined from the different streams and preserved for stomach analyses. When these were later examined it was found that the fry had secured an abundance of food and that the food organisms taken were comparable with those taken by naturally hatched fry in various streams.

This experiment shows that there is no danger of trout fry starving when properly planted in a suitable stream, even though they have been retained without food for a long period before being planted.

2. Artificial spawning beds for brook trout. In a previous summary it was stated that an artificial gravel redd in a box had been supplied with spring water and that trout had entered the box and spawned in the gravel in the fall of 1930.

This past spring it was found that the eggs had hatched in the box. The first free-swimming fry were removed on March 22 and a further lot was seined from the box on April 1. After this no further removals were made. When we visited the box on June 19 we found 27 healthy fingerlings in the box.

This experiment demonstrates the possibility of supplying spawning beds along streams or ponds which have no spawning beds or have spawning beds which are subject to silting or other unfavourable factors.

3. Food of brook trout fingerlings and sticklebacks in Forbes creek, 1930. Fish food in a body of water may be abundant and yet a large part of it may not be available to a particular species of fish. Different fish have different feeding habits and secure different food organisms.

At the conclusion of the Forbes creek experiment, trout fingerlings and sticklebacks were removed for stomach analyses. Having previously determined the abundance of the various food organisms in the stream it was desired to know to what extent the fishes were feeding upon these organisms. The analyses of the stomach contents of these fish indicate that many of the most abundant organisms were not available to the trout. However, the trout had secured a considerable number of terrestrial insects which had fallen into the water. The sticklebacks seem to be better foragers for most aquatic food and had secured plankton organisms, none of which had been taken by the trout fingerlings.

Since other analyses have shown that adult trout may feed to a large extent upon sticklebacks and since the sticklebacks are able to secure classes of food organisms not readily available to the trout, it would seem that the stickleback (*G. aculeatus*) is not an undesirable fish in trout waters.

4. Fish food in Forbes creek, P.E.I. The amount of fish food in a body of water is an important factor in determining the number of fish which the body of water can support. In the Forbes creek planting experiments it was desirable to know to what extent the fish in the experimental section had depleted the food.

At the conclusion of the planting experiment in 1930, quantitative samples of the food organisms of the stream were collected. The organisms from these samples were identified, sorted and weighed. This analysis showed that the gravel rapids were exceedingly rich in food, yielding over five thousand organisms per square foot with a weight of 26.31 gms. The pool bottoms, among algae, yielded a somewhat smaller number of different organisms but with approximately

the same weight. Large stone surfaces yielded over one thousand per square foot.

This analysis, although it does not represent the entire food of the stream since it does not take into account terrestrial forms falling into the water, shows that there was abundance of food in the stream after it had supported the planted trout throughout the summer.

5. The salmon of certain streams of Cumberland county, N.S. Salmon fishing in the bay of Fundy is one of the important industries. There is an abundance of food suitable for adult salmon and therefore many more salmon could mature in the bay than at present. Plantings of salmon fry and natural reproduction in the streams have not been sufficient to increase the numbers of adult salmon. Since the young salmon spends a number of years in the stream and the adult salmon ascends the stream to spawn it is necessary to have a knowledge of this part of their life-history before logical recommendations can be made concerning measures to increase the numbers of salmon going to the sea.

Observations indicate that during the first summer salmon fry remain near the places where they were hatched. They were found most frequently among stones in the *shallow parts of the rapids*. They were not found in the deep pools or sluggish parts of the stream.

Salmon parr one year or older frequent both the swift parts of the streams and the deeper pools and apparently migrate considerable distances up or down the stream. By the middle of August the spermaries of the male parr have developed to a stage where they distend the abdomen and the parr begin to take on a spawning coloration. Parr may be found milting from mid-September to late November.

The smolt stage was not found in any of the streams examined but large parr apparently approaching the smolt stage were taken in the channel pools of the estuary. Silvery male parr from the estuary ascended the river with the spawning run of adult male and female salmon from the sea.

Adult salmon were taken in a weir near the mouth of Apple river from July 18, when the weir began to operate, to August 30, when operations ceased. By August 4, salmon were following the tides in and out of the estuary of Apple river. The first adult salmon in the river, above tide water, were observed on August 14. Tagged salmon which were retaken gave information regarding their migrations in the stream. Many of the female salmon did not ascend the river until ripe and a few days after depositing their eggs, dropped down stream to the head of tide water.

Although salmon entered the estuaries of streams which appear suitable for spawning they do not ascend above tide water in many of the streams.

FISHERIES EXPERIMENTAL STATION (ATLANTIC)

HALIFAX, N.S., 1931

The work of the Station in the main consists of investigations of problems in 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 staff during 1931 consisted of the following:

Dr. A. H. Leim, Director.
Dr. S. A. Beatty, Associate Biochemist.
Mr. Ernest Hess, Assistant Bacteriologist.
Dr. H. R. Chipman, Scientific Assistant (Chemistry).
Miss A. M. Wilson, Technical Assistant (Chemistry).
Mr. A. S. McFarlane, Curator.

SEASONAL

Mr. D. B. Finn, Scientific Assistant.
Mr. N. E. Gibbons, " "
Mr. W. W. Johnston, " "
Mr. W. W. Stewart, " "

INVESTIGATIONS

During recent years, while it has been impossible to concentrate completely on one subject of investigation, the tendency has been to stress refrigeration problems. During 1931, smoking problems were given more attention, and the year has seen a gradual transfer of major attention from refrigeration to smoking. At a meeting of the Advisory Committee in August, it was recommended that considerable attention be given to problems in connection with salt fish. Up to the present it has not been possible to go far in this direction.

1. Refrigeration. Dr. Beatty elaborated on the work of Mr. Johnston in 1930, which had to do with the changes in solubility of the protein of frozen fish muscle under different conditions of storage. This was in an attempt to throw further light on the increase in "drip" or liquid exudate on thawing, which is noted for longer periods of holding frozen fish. The problem was attacked by determining the amount of dissolved protein in muscle press juice removed from frozen fish after various periods of storage. The period of time of storage ranged from a few days to two years.

A further attack on this problem of the changes which occur when frozen fish are stored was made by investigating the bound water in fish muscle, and attempting to find whether it changed in quantity during storage. This work was undertaken by Mr. Finn, who used the dilatometric method of estimating bound water, and by Mr. Stewart with calorimetric methods. Mr. Finn's method involved measurements of volume change when the muscle froze and calculation therefrom of the quantity of water frozen as compared with the total quantity of water known to be present from moisture determinations. Mr. Stewart used measurements of heat changes which occurred when the fish muscle passed from a temperature below its freezing point to one above as a means of calculating the quantity of water frozen. Using these methods he investigated the stability of this bound water during storage.

Frozen brines are often of value for refrigerating small compartments such as may be desired for holding frozen fish. It was desired to know something more about the heat capacity of such brines, and the temperature range where the change in heat capacity was most marked in order that these brines could be utilized to the best advantage in holding frozen fish. To this end Dr. Chipman made some determinations of the heat capacity of a eutectic mixture of sodium chloride, using calorimetric methods.

Mr. Gibbons continued the investigations which he started in 1930, on the growth of spoilage bacteria in frozen fish stored at −5°C. and other temperatures. This work is being continued over a long storage period. In addition to determining changes in the bacterial content of the frozen fish, the chemical changes are also being followed by determinations of non-protein nitrogen, volatile base and ammonia nitrogen.

Mr. Hess has compiled a bibliography of papers concerning the effects of low temperatures on bacteria, having in mind the effects of cold storage temperatures on bacteria which cause spoilage of frozen fish. A survey of the literature is being made pending the completion of suitable constant temperature incubators for use in carrying out investigations on the viability and activity of type organisms under these conditions.

Although not an investigation, it may be mentioned here that ice fillets of haddock and cod were shipped to Toronto during January and February in order

to provide a retail firm with a standard product. Slightly over a thousand pounds were put up and shipped. Later in the year, in co-operation with the Department's officers, small introductory shipments of ice fillets were made to Prince Edward Island.

2. Smoking. The smoking of fish by the industry has been attended with certain difficulties in securing uniformity of product from day to day. At certain seasons smoking by the old methods was virtually impossible. This was due to high humidity and temperature of the atmosphere. These conditions required the heating of the air to a point beyond temperatures that the fish would stand without losing tensile strength, if drying was to be accomplished.

The solution of these difficulties seemed to lie in the conditioning of the air so as to produce uniform drying from day to day. The question arose as to whether the sheen which the trade demanded could be produced on the surfaces of the fish in the absence of the radiant heat and possibly the smoke which the drying fires ordinarily used produce.

An air conditioner, steam heater and fan were connected in series with a compartment which was built in the demonstration building, and in which several hundred pounds of fillets could be hung. Tests were carried out by Mr. McFarlane, Mr. Hess and Dr. Leim in the drying of the fish by using warm dry air, such as could be produced at any time by the equipment. The effects on the rate of drying and the sheen were studied. Various methods of introducing the air into the drying compartment were tried, and the effect on the economy of operation and uniformity of drying studied.

It was soon evident that there was no difficulty in producing a suitable sheen with steam-heated air. This is of some importance, even apart from air conditioning, because of the difference in cost of heating the air by wood fires and by steam.

Following this result, experiments were carried out by Mr. McFarlane on the production of smoke outside the smoke house, and its injection and distribution in the house. Three types of smoke producers have been tried, the simplest being a large metal box open at the top, containing sawdust, which is ignited and kept burning by means of an air stream blown down on top of the sawdust. While this box worked well in the initial stages, eventually a great deal of heat was produced, and combustion became too complete to produce much smoke. The construction of a larger model, somewhat modified from one devised by Dr. LeB. Cooper, has been commenced. In this machine the sawdust will be continuously fed and ignited.

In an effort to demonstrate the practical application of air conditioning to the drying of fish for smoking, the Department of Fisheries undertook to install at the plant of the Lunenburg Sea Products, Ltd., Lunenburg, N.S., air conditioning equipment connected to one of the smoke houses. The equipment procured consisted of an air washer, aerofin heater and fan capable of handling 20,000 cubic feet of air per minute. In addition, there was the necessary duct work to make connections to and in the smoke house. Mr. McFarlane supervised the installation of the equipment and also its operation in the initial stages, making such changes as were necessary to produce uniform results throughout the smoke house. The general result was satisfactory, but some problems are still presented in the drying of large haddies where there is more difficulty in obtaining uniform drying than with fillets.

3. Salting and drying. Several experimental lots of split cod fish were salted with representative fishery salts, including the newest Lucas vein salt produced by the Malagash Salt Company. The progress of the curing was followed, and the appearance of the resultant fish compared. These experimental lots provided material for the experiments mentioned in the next paragraph.

Dr. Chipman devised two laboratory boxes in which the temperature and humidity could be controlled. Information was obtained from the meteorolog-

ical offices of Porto Rico and Brazil as to the average temperature and humidity conditions prevailing in these countries where dried fish are marketed. Similar conditions were produced in the boxes, and samples of fish and salt were exposed to them. It was thought that some of the salts might produce a product which would not take up moisture as readily as others. No significant differences were found between the behaviour of the fish which had been cured by means of the different salts available. The result is not considered to be conclusive and possibly a better type of experiment would show different results.

4. Canning. Mr. Hess examined from time to time experimental cans of lobster which he had packed in 1930 for the purpose of determining: (1) the resistance of the different types of enamelled cans to plain and acid pickle; (2) the development of magnesium-ammonium-phosphate crystals; and (3) the development of pink sediment and slime in the cans. He also investigated the effects of freezing on canned lobster during storage.

Mr. Johnston continued the investigation of the effect of canning dying lobsters on the blackening of the product. He studied the amount of volatile sulphur present in the muscle both before and after cooking and at different stages of the process of dying of the animal. He investigated the pH changes which go on in the lobster muscle during the dying process, and the effect of differences in pH on the blackening of the cans.

Mr. Hess investigated the condition, after 13 months' storage, of cans of lobster put up by Mr. Cook and himself during the summer of 1930 in a study of blackening and the effect of canning weak or dying lobsters.

5. Fish meal. Dr. Chipman gave some attention to the production of meal from oily fishes such as the herring and dogfish. Previous attempts to remove oil from these meals by mechanical means had failed to reduce the oil content as much as seemed necessary. Dr. Chipman attempted to remove the oil from meal made from both of the above fishes by solvents. In this connection he used acetone and naphtha as oil solvents, combining their use with various periods of cooking the raw material. He also investigated the removal of water by acetone.

Dr. Beatty has collected information from the federal and provincial Departments of Agriculture dealing with the value of fish meal in the feeding of animals, with a view to assisting firms in advertising and selling their product in Canada at the present time when the foreign market situation is so difficult. As it seemed desirable to be able to determine the calcium content of fish meals with some rapidity, methods were looked into by which this might be accomplished. A satisfactory method was found. The iodine content should also be known, and a suitable method of determination is being sought.

Routine analysis of numerous samples of fish meal submitted by the trade has been made by Miss Wilson and Dr. Beatty.

6. Other laboratory investigations. Mr. Gibbons has continued his investigations of organisms present in the digestive tracts of marine fishes and has made a bacteriological study of some 115 samples.

Experiments are being undertaken to ascertain the most economical and satisfactory methods of sterilizing premises where salt fish are handled. The "red" organism has been increasingly important in causing losses in recent years and information should be available as to how it may best be eradicated from infected buildings and equipment.

On a request from the Atlantic Biological Station, Mr. Hess made cultures from affected fish during an outbreak of "fin rot" at the Bedford hatchery. The various organisms found were isolated and are being cultured pending their use by Dr. M'Gonigle.

On a similar request Dr. Beatty studied the isoelectric point of salmon egg proteins. It had been suggested that the death of fish eggs in some of the acid waters found in the Maritime Provinces was due to the pH of the water causing precipitation of the protein. The work done was only of a preliminary nature.

7. Bulletin on the nutritive value of fish as food. Dr. Beatty collected a bibliography of papers dealing with the value of fish as food. Some 175 references have been included in this bibliography. Following this, an effort was made to consult as many as possible of these papers. A bulletin giving a resumé of the subject as presented in these references has been prepared.

FIELD WORK

1. Lobster cannery inspection. Mr. Hess inspected and graded 20 lobster canneries in western Nova Scotia which had not been covered during the preceding year.

On the completion of this first uniform grading of the canneries, Mr. Hess drew up a new grading form in which inspection of canning operations would form a part. The previous form only took equipment into account.

The new form was discussed by the Maritime lobster canners at a meeting held in Charlottetown in early December and some amendments were made on the basis of this discussion. The form as it now stands will be used for further grading of the canneries by the Fishery Inspectors.

2. Investigation of lobster collecting boat. At the request of Departmental officers, arrangements were made to have Mr. McFarlane accompany one of the lobster collecting boats on a trip in June from Canso to Boston. On this trip he took temperatures of the live lobsters in different parts of the hold of the collecting boat and followed the condition of the animals from loading to unloading. It was found that, under the conditions of icing which were in use, the temperature of the lobsters was between 40 and 50°F. and that there was considerable variation in different parts of the hold.

3. Fishermen's bait freezer, Marie Joseph, N.S. Dr. Leim visited Marie Joseph in late July at the request of the Department to aid in correcting the operation of an ice and salt cold storage which had been erected there. Following this visit, Mr. McFarlane spent over a week at Marie Joseph following up the operation of the storage and of the brine freezing tank. He succeeded in getting proper storage temperatures and instructed the local men in the proper procedure to follow in using the freezing tank.

4. Exhibitions. The Station took part in the Department of Fisheries exhibit at the exhibition held in Halifax from August 29 to September 5, and at Lunenburg from September 15 to 19. At Halifax the exhibit featured the origin of the vitamin content of cod liver oil, "red" bacteria of salt fish, canned brine-frozen mackerel and fish meal. At Lunenburg fish meal and the life-history of the oyster were featured. Dr. Needler of the Prince Edward Island Marine Station provided the material for the oyster exhibit.

5. Miscellaneous. Dr. Leim carried out a few minor examinations at the Middleton and Bedford hatcheries at the request of the Atlantic Biological Station.

Dr. Chipman has followed the installation and operation of thermographs on two passenger boats operating out of Halifax. This work is for the Atlantic Biological Station.

Hydrographic observations have been continued at the King's wharf and at three nearby stations. At two of these regular plankton tows have been made.

EDUCATIONAL WORK

1. Course for fishermen. Following the custom of several years past, a course for fishermen was offered at the Station from January 28 to March 10, 1931. This course was open to bona fide fishermen between the ages of 17 and 35. Twenty-three fishermen attended the course. In addition four men sent by the Newfoundland Department of Marine and Fisheries were in attendance. The courses and instructors were as follows:—

(*a*) Preparation of dried and boneless fish—Mr. George R. Earl and Mr. James Coolen (part time).
(*b*) Preparation of pickled fish—Mr. Robert Gray.
(*c*) Motor engines—Mr. C. Johnson.
(*d*) Navigation—Capt. H. M. O'Hara.
(*e*) Science—Messrs. Beatty, Chipman, Hess, Leim and McFarlane.
(*f*) Natural resources—Professor A. S. Walker, Professor W. V. Longley and Dr. M. Cumming.

The services of Messrs. Earl and Gray were given by the Fisheries Department, and those of Dr. Cumming and Professor Longley by the Provincial Department of Agriculture. The others mentioned and not on the regular staff of the Station, were employed for the requisite time.

An examination was held at the end of the course. Nineteen men passed the examination, four of them obtaining honors.

2. Dalhousie course for B.Sc. in fisheries. During the spring academic term, the following classes in this course were given at the Station, there being three students:—

Bacteriology of fish curing—Mr. Hess (seven hours per week).
Biochemistry of fish curing—Dr. Beatty (eight hours per week).

No courses were given in the fall term as there were no fourth year students in fisheries.

3. Course for Departmental officers. A course of four weeks, from November 17 to Deecember 14, was held at the Station for new officers of the Department of Fisheries, and certain others who failed to pass the examinations at the earlier courses. Eighteen officers were in attendance. In this course instruction in the preparation of pickled fish and inspection methods were particularly stressed in view of the application of these subjects to the work of the officers.

The courses and instructors were as follows:—

(*a*) Preparation of pickled fish—Mr. R. Gray.
(*b*) Preparation of dried and boneless fish—Mr. G. R. Earl.
(*c*) Biology—Dr. A. H. Leim.
(*d*) Physics and chemistry—Dr. H. R. Chipman.
(*e*) Bacteriology—Mr. E. Hess.
(*f*) Principles of canning—Mr. E. Hess.
(*g*) Principles of smoking—Mr. E. Hess.
(*h*) Refrigeration—Dr. A. H. Leim.

An examination in these subjects was held at the completion of the course.

DEVELOPMENT OF THE STATION

During the early part of the year, all but one of the laboratories in the new building were fitted up for use with the usual equipment of cupboards, tables, fume cupboards and plumbing.

An air compressor was installed and compressed air was made available to the laboratories.

A gas-fired steam boiler with automatic control has been installed in the demonstration building, and steam made available for the cannery and smoking experiments.

The large brine freezing tank, which was constructed in 1927, was not built to withstand corrosion for long. It began to leak so badly this year that repairs were out of the question. It was therefore dismantled and a smaller steel tank has been installed to serve as a brine cooler. The ammonia coils from the former tank were utilized in the new one. The new tank is heavily insulated and provides a ready source of cold brine at all times. Arrangements are being made to conduct brine from this tank to an insulated constant temperature room in the main building. Mr. Hess has developed a series of constant temperature boxes in this room for operation at sub-zero temperatures.

PUBLICATIONS

Anonymous—Methods of handling fish. II. Instruction in curing and packing pickled mackerel Bull. 19, 1-17.
Beatty, S. A.—The cause and prevention of drip in frozen fish. Prog. Rept. Atl. 2, 12.
Hess, Ernest—The canning of brine-frozen mackerel. Bull. 24, 1-13.
Langstroth, G. O.—Thermal investigations on fish muscle. Contr. Canad. Biol. Fish. 6, 375-389.
Leim, A. H.—Prevention of drying in cold storage. Prog. Rept. Atl. 1, 7-8.
Preparation of cod liver oil by freezing. Prog. Rept. Atl., I, 9.
Cold storage changes in frozen fish. Prog. Rept. Atl. 2, 7-8.
Course for fishermen. Prog. Rept. Atl. 2, 13.
Preventing freezer burn during storage. Fishing Gazette 48, 23 and 26.

INVESTIGATORS' SUMMARIES

S. A. BEATTY

1. Water exchange in fish muscle. The following is a continuation of the study of the "drip" or exudation of water from fish after freezing and thawing, and deals with the solubility changes that go on in the muscle proteins during the storage period. When the fish are frozen, the water and the proteins are separated. If the proteins are soluble when the ice crystals melt, a great deal of the water will be taken up as the proteins pass into solution. If, on the other hand, the proteins are rendered insoluble during the storage period, the amount of "drip" will be materially increased.

The first material examined for changes in solubility of the proteins was the muscle press juice. Stored fillets, the storage period of which ranged from two years to a week, were minced and pressed, after which the protein in solution in the press juice was determined. It was found that the differences among individual fillets of the same lot were greater than the average of the lots stored at various intervals. The protein in the press juice from fillets stored two years was only slightly less than that from the freshly-frozen fillets. Either there is no change in the solubility of the proteins in fish during storage, or there is a store of soluble, undissolved protein that enables the press juice to remain always saturated in protein.

The solubility of the proteins in stored fillets was the subject of an investigation by Mr. W. W. Johnston during the summer of 1930. Because of the importance of this data, the work was repeated and enlarged. There is a progressive lessening in the solubility of the myoalbumin, starting as soon as the fish are frozen and measurable after two or three days. This drop reaches practically a maximum after about four months. The drop in the solubility of the myoalbumin agrees with the data we have on the increase in drip, on the falling off of the flavour of the stored fish, and of the toughening of the tissues.

2. The salts in fish meals. The investigation of the salts in fish meals was undertaken because of the slump in the sales of fish meals due to the collapse of the German market. The value of a meal is usually determined by the concentration of protein and that of phosphate as well as by the low value of salt (NaCl) and of oil. This seems inadequate for at least two reasons. Stock foods are mainly of plant origin, and are usually about ten times as high in phosphate as in calcium. It has been shown that a 1:1 ratio of calcium to phosphate provides for the best bone development, and acts as a deterrent of rickets, even in the absence of vitamin D. It is clear, therefore, that the calcium content of stock foods is of more importance than the phosphate content.

Calcium is ordinarily determined gravimetrically, a very tedious and time-consuming process. The phosphate determination is also slow, tedious, and of doubtful accuracy. No dependable figures are available as to the iodine content of fish meal, as all have been obtained by ashing the meal in the air. This has possibly resulted in the volatilization of the greater part of the iodine. The chemists should supply to the industry:

(1) An accurate rapid method for the determination of calcium.
(2) An accurate rapid method for the determination of phosphate.
(3) Data as to the calcium to phosphate ratio to be expected in fish meals.
(4) Data as to the iodine content of fish meals.

The first and third of these requirements have been fulfilled. A titrimetric method has been adapted to fish-meal analysis that fits in well with the general procedure and that permits an accuracy of within about 1 per cent.

The calcium to phosphate ratio in fish meal is the nearest to the ideal of that of any stock food, with the possible exception of milk. There is a considerable variation in different batches, and while neither the farmers nor the food blenders at the present time realize its importance, the calcium content should be stated on all guaranteed analyses.

3. The proteins of salmon eggs. The appearance of the eggs killed by the uncommonly highly acid water of the Windsor hatchery strongly suggested an isoelectric precipitation of the proteins of the egg yolk. The deaths of eggs at the Bedford hatchery have been somewhat higher than the average of the other hatcheries, and here, too, an acid water is encountered. The dead eggs were invariably white and the proteins of the yolk were precipitated. It was thought probable that the immediate cause of the death of the eggs was the isoelectric precipitation of the yolk proteins.

An attempt was made to determine the isoelectric points of the proteins of the yolk. The yolks of a large number of eggs were separated from the embryos, and added to approximately an equal volume of 5%NaCl solution. This solution was dialysed in a collodion sac until salt free. The whole of the proteins were precipitated showing the absence of albumin. The precipitated protein was brought into solution with the aid of salt and the solubility was measured at various concentrations of pH. A minimum value was found in the neighbourhood of pH 5.4, but the results were very inconclusive because of the effect of the salt used to keep the protein in solution. Undiluted egg yolk does not precipitate over a range between pH 4 and pH 8. The ease with which the proteins are precipitated in the presence of pure water shows that the white colour of freshly-killed eggs is due to the loss of salts resulting from an increase in the permeability of the egg membranes.

H. RITCHIE CHIPMAN

1. The heat capacity of a eutectic mixture of sodium chloride. Some thermal data for a eutectic mixture of sodium chloride were required, and as no values were available, it was decided to determine them experimentally.

The adiabatic calorimeter which had been used for the determinations of thermal data of fish muscle was used. The eutectic mixture was made by dissolving 23.6 gms. C.P. sodium chloride in 76.4 gms. distilled water. The method used was similar to that used in finding the heat capacity of fish muscle.

The following values were obtained:—

Temperature (°C.)	20	0	−10	−20	−23	−24	−25	−30	−40
Heat cap. (cals./gm./C.°)	0	15.9	24.1	41.5	42.6	70.3	83.3	92.9	97.1

2. The preparation of meal from oily fish by naphtha extraction. Some experiments were carried out to test a process for making meal from dogfish by naphtha extraction. A frozen dogfish was cut up and cooked in a steam-jacketted kettle. Portions were removed after 30 minutes and 45 minutes cooking, and extracted with naphtha of boiling point below 90°. The solvent was decanted off and the meal dried. Three extractions were used. The meal, which had been cooked for 30 minutes, gave a final oil content of 14.5 per cent. The meal, which had been cooked 45 minutes, had the solvent filtered off instead of decanted and the final oil content was about 4 per cent.

This was repeated with herring and the final meal had an oil content of about 3 per cent. The meal was of good appearance, though slightly dark.

Experiments were carried out to determine the rapidity with which the oil was removed. A frozen herring was ground by a meat chopper, and cooked on a water bath for 30 minutes. 100 gms. were extracted by 200 gms. solvent with mechanical stirring. Six extractions were made and each lasted for ten minutes. The filtrate from each extraction was analysed for oil content. The six extractions removed about 92 per cent. of the oil, the first extraction removing about 72 per cent. To see if the absence of water made a difference, some of the original ground fish was dried in an oven at 105° over night, and the water-free material extracted by naphtha as before. It was found that four extractions removed about 92 per cent., and the first extraction about 76 per cent.

These results showed that a very satisfactory meal could be made with naphtha extraction from oily fish. The extractions were only of ten minutes duration, and no doubt fewer extractions of longer duration would remove the oil with the use of a smaller amount of solvent. This was found to be the case with another solvent.

3. The preparation of meal from oily fish by acetone extraction. Meal was prepared from herring which had an oil content of 18 per cent., and after acetone extraction the final meal showed an oil content of about 4 per cent., or, in some cases, less than 1 per cent. It was found that it was not necessary to cook the fish prior to the extraction, as the acetone coagulated the protein, as well as removed the water and oil. By drying the meal at 70°C., a meal was prepared which was almost white. The uncooked meal seems to be more flaky than the cooked material.

The rapidity with which acetone removed the water and oil was determined. Frozen herring was either extracted after being ground or was cooked on a water bath for 30 minutes. Some experiments were made with cod fillets so as to extract water without oil; and some were made with dehydrated ground herring to extract oil without water. The analyses could not account for all of the water or oil present, but there were several sources of error and the results gave a sufficiently good approximation.

Working with 100 gms. fish and 10-minute extractions of 200 gms. acetone, it was found that when water was present alone, 90 per cent. was removed in 3 extractions: water and oil present and fish cooked, 94 per cent. of the water after 2 extractions: water and oil present and fish raw, 80 per cent. after 4, and 90 per cent. after 6 extractions. Oil removal was as follows:—oil alone, 80 per cent. after 8 extractions; oil and water, fish cooked, 91 per cent. after 4 extractions; oil and water, fish raw, 93 per cent. after 4 extractions.

An experiment under similar conditions but with extractions lasting 30 minutes, both water and oil present and fish cooked, gave 94 per cent. water and 73 per cent. oil removed after 2 extractions, and 98 per cent. oil removed after 3 extractions.

N. E. GIBBONS

1. A bacteriological study of frozen fillets. The drip from frozen fillets (muscle juice) was used as a medium. This was passed through a Seitz filter to sterilize, then incubated at temperatures of 5°, 0° and −5°C., either with or without inoculation with bacteria. Determinations were made at intervals of non-protein, volatile base and ammonia nitrogen.

With sterile muscle juice there is no increase in any of these constituents after 6 to 8 weeks at 0° or −5°C. Nor is there any change in contaminated juice at −5°C. up to nine weeks (limit of experiment). However, at 0°C. there is a decided change in three weeks, all giving a putrid odour at this time. Some organisms will give a very bad odour in a week. In nine weeks the amount of N.P.N. almost doubles. At the same time the volatile base N. increases 4 to 15 times, the ammonia N. from 6 to 16 times, depending on the organism present. At 5°C., the increase is much greater, being in the same length of time over twice

for N.P.N., about 30 times for volatile base N., and 40 times for ammonia.

Counts made on fillets frozen in July, 1930, and stored at −5°C., show a decided increase (three to nine times as numerous in a year) in the number of organisms present. After one year colonies of red, yellow and white bacteria could be seen scattered over the surfaces. Actinomyces are present in large numbers, giving the fillets a characteristic earthy smell.

2. Lactose fermenting organisms in the feces of marine fishes. While of little significance either from a practical or sanitary point of view, it is of interest to determine whether fish in the sea harbour organisms in their intestinal canals similar to man and warm-blooded animals. The presence of *B. coli* and related organisms in the intestinal contents of fresh-water fish has always been a factor complicating the sanitary examination of water.

There were examined the feces of 31 haddock, 36 cod, 2 pollock, 2 sculpin and 1 catfish, all taken on hand lines or trawls two and a half to three miles off shore; and of 24 cunner and 17 mackerel that had been netted but handled as carefully as possible in their removal to prevent contamination. The cunner were obtained just inside Herring cove, which is lined with human habitations on either side. The mackerel were taken about two miles south of this point. These were fall mackerel, and according to the fishermen, had probably "been playing along near the shore most of the summer." The feces were inoculated into lactose broth and incubated at 37°C. Those showing gas were streaked on Endo agar.

In the original cultures gas was obtained from 23 haddock, 13 cod, 2 sculpin, 16 cunner and 12 mackerel. However, pure cultures of organisms fermenting lactose were obtained from 1 haddock, 4 cod, 10 cunner and 13 mackerel. Five strains were obtained from the 2 sculpin. Two cultures were obtained from two flounder taken off City Point, New Haven, Conn., at the opening of the city sewer, a favourite fishing ground. From the data it seems that marine fishes will harbour coli-like forms if living in contaminated waters.

E. HESS

1. Magnesium-ammonium-phosphate crystals in canned lobster. These crystals occur very frequently in enamel cans, the pickle of which is between pH 8.0 to 6.6, and occasionally in pickle with pH as low as 6.4, especially after prolonged storage. Although these crystals are formed in cans, which upon cultivation show absence of viable bacteria, it is interesting to note in this connection that similar crystals are formed during the growth of certain bacteria in media containing beef-heart hormone, or lobster meat infusion with 0.5 per cent. agar, 1 per cent. peptone, pH 7.0 to 7.2; e.g. *Ps. fluorescens: B. alcaligenes.*

2. Pink sediment and yellowish-pink discoloration of white meat. Occurs often in cans with acid pickle. Experiments with the dried (100°C.) and powdered pigmented tissues connecting the muscles with the lobster shell (claws and tail) showed no relation between the colour of an emulsion of the powder in different buffer solutions, and the pH of the buffers, before and after autoclaving the emulsions (pH 8.0 to 5.2). Similarly no relation between emulsion in different NaCl solutions (0.0 to 6.0 per cent.), and the colour of the emulsion, seemed to exist. The pigment in this powder is slightly soluble in distilled water and n/5 NaOH; very soluble in 95 per cent. alcohol, in acetone and ether (at least a yellowish-orange fraction of the pigment); and extremely soluble in chloroform, turning the latter to a bright red colour, while the remaining powder becomes creamy-white. If chloroform is added to different powder-buffer mixtures (autoclaved), shaken and centrifuged, the colour of the chloroform in buffers pH 8.0 to 6.8 appears as a yellowish-red shade, while in buffers with pH 6.6 to 5.4 the colour is bright red. Experiments on raw pigmented muscle juice showed certain relationships both between pH and salinity of mixtures and their colour, after autoclaving and centrifuging. In mixtures of pigment-muscle juice with

buffer o 8.0 to 7.0, no coagulation of proteins took place, but the whole mixture was turbid and had a pink colour; at pH 6.8 the muscle proteins were coagulated and included the pigment (the coagulum had a pink colour), with clear supernatant liquid; at pH 6.7 and lower, coagulation had also taken place, but the coagulum remained white, and the pigment was fully thrown to the bottom of the tubes by the centrifuging.

Similarly, pigment-muscle juice, when autoclaved with distilled water and in 0.5 and 1.0 per cent. saline will yield a white coagulum, with red sediment; if autoclaved in 1.5 to 6.0 per cent. saline (NaCl) the whole coagulum of muscle proteins will assume a pink colour, and there is only a very small red sediment, the same results being obtained also when the saline is buffered to pH 6.5. If the different saline solutions are buffered at 7.0, the coagulum will become pink even in the 0.5 per cent. solution.

Considering that in the canning of lobsters two processes have to be dealt with,—first, the initial boiling of the live lobsters in water of different salinities and pH, or the steaming of the lobsters in live steam, and second, the processing of the boiled lobster meat in the cans in presence of pickle of different salinities and pH; further investigation of the effects of both salinity and pH of the media in which both the live and the boiled lobster meat are cooked, upon the red pigment of the lobster meat seems necessary.

3. Effect of acid pickle on the enamel in "C-enamel" cans. As the C-enamel cans are produced especially for the canning of non-acid products such as fish, shell-fish, lobster, etc., the effect of acid pickle (2.0 per cent. acetic acid), as used in many lobster canneries, was investigated by canning lobsters in three different commercial makes of C-enamel cans, both with acid and non-acid pickle. Examination of the cans after storage up to 14 months showed that the effect of acid pickle upon the enamel as compared with non-acid pickle is negligible, the effect, if any, being very small in either case.

4. Effect of freezing on canned lobster during storage. Several lots of one batch of canned lobster were frozen in different ways and kept in cold storage or at room temperature for various lengths of time. After three months the pigment in all cans was practically the same, except for the brine-frozen lot, where the pigment was a slighfly brighter red. The only difference between frozen and unfrozen samples, so far, is that the meat in the former cans is quite soft to the touch, while in the latter ones it is firm (especially noticeable in the body of the claws).

5. "Smut" (iron sulphide) formation in canned lobsters. Black discoloration was never observed in cans with pickle, the pH of which was 6.60 or less, examination covering a large number of cans over several years and of different origin.

In test tube experiments, when 5 cc. of saturated aqueous solution of hydrogen sulphide was added to 5 cc. of different buffer solutions, precipitation of iron sulphide upon addition of a few (3-5) drops of ferrichloride solution was always definite and immediate at pH 6.65 and higher, and always absent or appearing only on standing at pH of 6.0 and lower. There is no doubt that the iron sulphide formation is closely related to the reaction of the medium, although, in experiments where ground up, boiled lobster meat was autoclaved (after different periods of storage) in buffers and in the presence of ferrichloride solution, the border line of the reaction was not as sharp. However, the meat in buffers from pH 7.0 to 6.8 was always darker (grey) after autoclaving, than the meat in buffers of pH 6.6. to 6.4. The changes became evident only after the ground meat had been standing (in 1.5 per cent. saline) for 24 to 48 hours at room temperature.

Experiments made in collaboration with Mr. Cook on the influence of the vitality of live lobsters on the smut formation in the canned product, showed, on examining the experimental pack after 13 months' storage, that the longer the *live* lobsters had been kept out of water (in dark, cool room) before canning them, the higher was the pH of the pickle in the can (ranging from 6.9 when canned

immediately to 7.7 when canned after 36 hours out of water), and the black discoloration of can (non-enamel) and meat was evident to an increasing degree. Lobsters that were dead after 24 hours, on the other hand, when canned, were found to have a pickle of pH 6.3 only, after 13 months' storage. This is no doubt due to the formation of lactic acid in the dead lobster, previous to the proteolytic changes therein.

W. W. JOHNSTON

The discoloration of canned lobster muscle. Reed and co-workers reached the conclusion that the sulphur (which unites with iron from the container to form the black iron sulphide) was liberated from the muscle by bacterial action at some time intermediate between shelling and sterilization and accordingly recommended to the packers that not longer than four hours should elapse between these processes. The canners claim that they have followed these instructions carefully but have occasionally found discoloured packs. This led to the suggestion that some change might have occurred in the muscle during the gradual loss of vitality of the lobster, which resulted in an increase in volatile sulphur and hence in an increased proportion of discoloured cans.

The lobster's condition was not found to result in any significant differences in the amount of volatile sulphur present in the muscle both before and after cooking. As a general rule it was found that the more highly discoloured cans had higher pH values. They also contained about twice as much volatile base as the former, but it is doubtful if this correlation is of great significance.

An experiment designed to determine the effect of increasing the pH of muscle prior to sterilization was not decisive, but indicated an injurious effect. The effect of prolonged sterilization was found to be definitely injurious to the appearance of the muscle, and, in addition, to its flavour. The pH of these cans on opening was considerably higher than the controls. The results from a limited number of lobsters in a statistical experiment suggest that the pH of muscle increases when the lobster is held on ice and becomes inactive. This could not be correlated with any increase in volatile bases present in the meat.

Accordingly, the tentative conclusion is drawn that the discoloration of canned lobster will be increased by a higher pH. Under factory conditions this increased pH may result from holding the lobsters for long periods before boiling and processing. Increases in pH may also result from unnecessarily long periods of sterilization.

A. S. MCFARLANE

Experiment on drying fish for smoking, using air conditioning apparatus. The object of this experiment, conducted at the plant of the Lunenburg Sea Products, Ltd., Lunenburg, N.S., was to prove:—(1) that fish could be dried uniformly in a commercial smoke house using heated conditioned air; (2) that a quantity equal to almost twice the quantity ordinarily put in could be dried in the same time as was necessary for drying by wood fires under favourable conditions; (3) that drying could be done under unfavourable weather conditions; (4) that conditions known as burned tails and cooked fish, which are sometimes obtained under unfavourable conditions with wood fires, could be eliminated; (5) that the appearance of the fish as to sheen would be equal to the appearance of the fish when wood-drying fires were used.

For this work, an air-conditioner capable of cooling and conditioning 20,000 cubic feet of air per minute was installed. Water was used as a cooling agent, which, with an adequate supply, and low temperature, was sufficient. Connected to the air-conditioner was an aero-fin steam heater which heated the air to the desired temperature. A fan attached to the aero-fin drew the air through the air-conditioner and the aero-fin, and forced it into the drying chamber through a 34-

inch duct, which duct was connected to a header. The header, so made as to distribute the air uniformly in the drying chamber, extended along one side of this drying chamber, and had sixteen 7¼-inch openings. This header was placed near the top of the house. The air was returned to the air-conditioner by a duct which opened into the bottom of the drying chamber. Thus a closed circuit of air could be obtained if desirable. The inside diameter of the drying chamber was 17′ 0″ deep, 13′ 0″ wide and 12′ 0″ high.

In one test with an entering air temperature of 85°F. Dry Bulb and 65°F. Wet Bulb, giving a relative humidity of 33 per cent., 4,300 lbs. of large cod fillets were dried satisfactorily in 2 hours and 30 minutes. With wood-drying fires, 2,400 lbs. of large cod fillets were dried in 3 hours. The temperature of the outside air was W.B. 31, D.B. 33, which would be considered a good drying day. In another test of medium cod fillets, with an average entering air temperature of 65 W.B., 84 D.B. giving a relative humidity of 35 per cent., the time taken to complete drying was 1 hour and 30 minutes, and with wood drying fires small cod fillets took 2 hours. On this evening the outside air was 53 W.B., 55 D.B., a day when drying conditions were not good. Provided the temperature of the fish was kept below 65° or 70°., depending on the variety of the fish, no indication was noticed of cooking or of burned tails. The sheen in all cases was equal to the sheen produced by wood-drying fires, and in some cases superior to it.

W. W. STEWART

The estimation of bound water in cod muscle. Lyophilic colloids play a large part in the make-up of biological tissue. This group of colloids, which includes the proteins, have a strong attraction for water. This is evident from the fact that a certain part of the total water in the colloid is bound up with the colloid particle. The mechanism of the forces which cause this binding is not exactly understood. To determine the state of water in cod muscle, the amount of water present in the muscle as ice is determined by measuring the heat necessary to melt this ice. Knowing the total amount of water, the bound water is given by the difference between these two quantities. The heat measurements were carried out in a Richard's adiabatic calorimeter.

By using this method from 92 per cent. to 94 per cent. of the total water in fresh cod muscle could be accounted for as ice at −20°C. Therefore, 8 per cent. to 6 per cent. of the water in the cod muscle can be considered as bound water. This is in agreement with Moran (Proc. Roy. Soc. B, Vol. 107, No. B749, p. 182), who found by a dilatometric method that not more than 6 per cent. of water in beef tissue could be considered as bound water.

No change in the amount of bound water in cod muscle could be detected by this method after storage at −20°C. for six weeks. Also it was found that the rate of freezing did not influence the amount of bound water.

PACIFIC BIOLOGICAL STATION

NANAIMO, B.C., 1931

The general programme of investigation has been carried forward at the Station during the year. There have been curtailments such as the elimination of salmon tagging, and certain projects have had to be postponed. However, some forty more or less distinct problems have been attacked, grouped about a number of major investigations. Reports on certain results have been published during the year and many others are in the course of preparation.

The scientific staff during the year was as follows:

Dr. W. A. Clemens, Director.

Dr. R. E. Foerster, Assistant Director and Chief Biologist.

Dr. J. L. Hart, Assistant Biologist.
Dr. A. L. Pritchard, Scientific Assistant.
Mr. C. R. Elsey, Scientific Assistant.
Dr. N. M. Carter, Associate Chemist.
Mr. C. M. Mottley, Scientific Assistant.
Mr. R. W. Whittaker, Scientific Assistant.
Mr. A. L. Tester, Scientific Assistant.
Mr. J. P. Tully, Scientific Assistant.
Mr. W. E. Ricker, Scientific Assistant.

SEASONAL

Dr. D. S. Rawson.
Dr. D. C. B. Duff.
Mr. D. C. G. MacKay.
Mr. G. C. Carl.
Mr. D. Beall.
Mr. E. C. Black.

PROPERTY AND ACCOMMODATION

Arrangements have been completed for the purchase of the land upon which the Station buildings are located and some additional land including that surrounding the source of the fresh water supply. The Board will own outright twenty-four acres on Departure bay.

Some additional laboratory accommodation for the staff has been provided in an old building on the premises through some alterations and repairs, including the installation of a heating system.

The residence building was filled to capacity during the summer and additional accommodation was provided in a near-by cottage.

INVESTIGATIONS

PROPAGATION OF SOCKEYE SALMON

1. Relative efficiencies of natural and artificial propagation. A considerable number of researches centred about the propagation of Sockeye salmon are being carried out by Dr. R. E. Foerster at Cultus lake. The main investigation has for its object the determination of the efficiency of artificial propagation as compared with natural propagation. The experiment is being carried out by using the three methods, namely, (*a*) natural, (*b*) artificial with fry planting, and (*c*) artificial with egg planting, in successive years over a considerable period of years, using the number of yearling seaward migrants as the measure of productivity. With the data of this year, the results of five experiments are now available for comparison.

An investigation of the factors involved in the high mortality of the young fish during the year in fresh water has been commenced by Mr. Ricker.

2. Pond retention. The value of pond retention in the propagation of the young of Sockeye and Coho salmon has been investigated by holding the young for certain periods and then marking and liberating into Cultus lake. The survival in terms of seaward migrants was determined by enumeration at the counting weir in the outlet of the lake.

3. Transplantation. The experiment in the transplantation of Sockeye salmon from the lower portion of the Fraser river to the upper portion has been continued. In alternate years eggs have been transferred from Cultus lake to Taft on Eagle river, a tributary of Shuswap lake, where they have been

hatched, the young retained in ponds until the fall, when they have been marked and liberated in Eagle river. In the intervening years, eggs have been collected in Adams river, a tributary of Shuswap lake, and handled in the same manner as those from Cultus lake. In the first case, the transfer has been from a locality approximately eight hundred miles distant, and in the second, approximately ninety miles. The returns of adults will be determined by the installation of a counting fence in Eagle river.

4. Feeding experiments. In many fish-hatching establishments, the practice of liberating the fry as soon as they have reached a free-swimming and free-feeding stage has been superseded by the procedure of retaining the young fish in ponds until they have reached a size where they are more able to fend for themselves. In any such system the feeding in quantity of foods not natural to the fish is necessary. Raw beef liver has been found universally to be the best food. However, with increase in price has come a search for a cheaper fish food, but as yet there has been no agreement among fish culturists as to the best substitute food. It seemed desirable to test out various foods and combinations at the ponds at Cultus lake. Beef liver, frozen salmon offal, canned salmon and halibut meal were used separately and in various combinations. Halibut meal alone proved to be the poorest food, producing the smallest growth and the heaviest mortality. Canned salmon and frozen offal were but little better. Beef liver gave excellent results. In the various combinations, liver was essential. A reasonably good combination was found to be one-third liver, one-third canned salmon and one-third halibut meal. A report on the first season's results has been given in progress report No. 9. Further experiments are being carried out.

5. Hybridization of salmon. Four years ago successful crosses were made among the various species of Pacific salmon. The fertility of these when crossed with normal Sockeye salmon is being determined.

6. Spawning experiments. At the request of the Department of Fisheries, there are being conducted certain experiments in which three methods of spawning, namely, expression, expression followed by incision, and full incision, are being tested. The eggs taken by each method of spawning were washed in each of three ways,—rinsing, steeping and congealing. The eggs so obtained are now in the hatchery.

7. Trough capacity experiments. To provide the Department of Fisheries with definite information regarding the optimum capacity of a standard hatchery trough, experiments are being carried out in which troughs with riffles are loaded with from three quarts of Sockeye eggs per basket to nine quarts, and troughs without riffles from three and a half quarts per basket to seven quarts.

8. Tests of the period of fecundity of Sockeye salmon eggs and milt. Experiments are being carried out to determine the periods over which eggs and milt may be held before mixing and still remain perfectly fertile.

PILCHARD AND HERRING INVESTIGATIONS

These investigations have been continued under the joint auspices of the Provincial Fisheries Department and the Biological Board, and under the direction of Dr. J. L. Hart with Mr. W. R. Whittaker and Mr. A. L. Tester as assistants. The catches throughout the pilchard fishing season have been sampled and analyzed as to lengths, weights and sex, thus, among other things, providing data for the discrimination of age classes. Mr. Whittaker has successfully used the otoliths of the pilchard for the determination of age. The food of the pilchard has been carefully studied and a report has been completed for publication by

Dr. Hart and Mr. G. H. Wailes. An investigation of the waste liquors from the reduction plants has also been completed by Mr. D. Beall.

The investigations of the herring have been designed largely to determine the causes of fluctuation in abundance. Statistical analyses of the catch records and regular analyses of the catches as to length, weight, age and sex are being made. Studies of the spawning and subsequent mortality during incubation and early life-history have been carried out.

In order to provide definite information as to the biological and chemical condition of herring in relation to the methods of curing, an investigation in co-operation with the Fisheries Experimental Station has been commenced. Samplings are being made at various localities during the season, and it is hoped that definite information will be obtained which will lead to improvements in curing methods.

Certain phases of the study of the alleged pollution of herring spawning areas by effluents from reduction plants have been completed and a complete report is in preparation.

PINK AND CHUM INVESTIGATION

Dr. A. L. Pritchard has continued this investigation, devoting practically all his attention to the Pink salmon of Massett inlet and in particular to a study of propagation. In the spring the seaward migrating fry from the spawning of 66,000 adults in McClinton creek were enumerated. The migration took place between February 8 and May 8 and consisted of 4,855,000 fry, of which approximately 185,000 were marked by the removal of the adipose fin in order to obtain information in regard to returns.

During the summer, the Fish Cultural branch established an eyeing station on McClinton creek and transferred to it approximately 978,000 Pink salmon eggs taken in the Tlell river on the east coast of Graham island. Dr. Pritchard then took charge of the material. Most of the fry will be liberated immediately upon the absorption of the yolk sac, but some 300,000 will be retained until they are large enough to be marked so that definite information concerning the returning fish may be obtained. This experiment is designed to determine the possibility of establishing a run to McClinton creek in the "off" year. No adult Pink salmon appeared in McClinton creek in 1931.

SALMON TAGGING

While no tagging of salmon was carried out in 1931, returns from operations of previous years have continued to come in and the final reports of the results of the six years' operations are being assembled.

IDENTIFICATION OF YOUNG SALMON

Certain anatomical characters such as number of gill rakers, number of scales in the lateral line, number of rays in fins and number of branchiostegals are used for the distinction of the five species of Pacific salmon. Drs. Foerster and Pritchard are examining young fish at short age intervals with respect to the above characters to determine what changes take place in the early life-history: in other words, to determine to what extent adult specifications may be applied to young. From this, exact information will be available for the separation of the five species at all stages in the life-histories.

SHELLFISH INVESTIGATION

Mr. C. R. Elsey, with the assistance of Mr. G. C. Carl, studied intensively the spawning, spatting and growth of the native and eastern oysters in the

Boundary bay area, particularly in the Serpentine and Nicomekl rivers. Considerable attention was given to the problem of establishing a method of measuring accurately the actual amount of growth. The problem of dyking has received some consideration. Conditions were followed in Ladysmith harbour where native, eastern and Japanese oysters are propagated.

Japanese oysters have been distributed to new localities and continue to demonstrate their ability to grow under conditions more or less unsuited for the growth of the native and eastern oysters.

A bulletin on the oyster situation in British Columbia is almost completed.

A study of the crabs in the Boundary bay area was carried out by Mr. D. C. G. MacKay. Data concerning abundance, distribution, food, proportion of sexes, sizes, growth, etc., were obtained. A large number of individuals were tagged.

Dr. Edith Stevens commenced a study of the importance of diatoms in the food of oysters, identifying over one hundred species from the mantle cavity and the digestive tract.

TROUT INVESTIGATION

This investigation has been concerned in large part with the biological factors underlying the propagation and conservation of trout, and intensive studies have been carried out on Kamloops trout at Paul lake by Mr. C. McC. Mottley. This lake was chosen in part as a type where the natural balance has been upset by the spawning streams drying up and by a heavy fishing drain. The problem in part is to determine how many young fish should be planted in the lake in order not to overtax its nutritive capacity and yet to "farm" it to its fullest extent. The causes of depletion have been largely determined and recommendations for certain remedial measures made. An attempt is being made to determine accurately the population of the lake through accurate enumeration of all spawning fish, determination of fry production and out-take by anglers. A study of the life-history of the trout has also been made with special reference to growth, food, age, spawning, etc. In addition general studies of conditions in relation to trout have been made in Summit, Victor, Three Valley and Griffin lakes near Revelstoke and in Shuswap, Knouff, Pinantan, Fish, Nicola and Penask lakes. Also a survey was made of the beaver dam situation at Penask creek.

Dr. D. S. Rawson made a general study of the limnobiological conditions in Paul lake and of its productive capacity. Several near-by lakes were studied for comparative purposes and it is hoped to establish a basis and procedure for the assessment of the productive capacity of all lakes in British Columbia. In connection with the determination of the ages of trout, Miss Gladys Clandinin commenced a study of the development and growth of scales in steelhead and cutthroat trout, for the purpose of establishing a sound basis for the age determination of these species. Mrs. Jean C. Mottley has commenced a study of the food of Kamloops trout as a first step in an investigation of the comparative values of natural and artificial diets in the rearing of young trout.

SOCKEYE SALMON STATISTICS

Drs. W. A. and L. S. Clemens continued their analyses of the data collected annually by the Provincial Fisheries Department on the Sockeye runs to the Fraser, Skeena and Nass rivers and to Rivers inlet. During leave of absence at Stanford university, they commenced a summary review of the reports of the past twelve years and considered certain refinements in statistical presentation.

FISH SYSTEMATICS

Professor J. R. Dymond has described two new races of trout in British Columbia. He has also prepared a popular account of the trout of the province with coloured illustrations. Arrangements are being made for publication as a bulletin. He is now preparing check lists of the fresh and marine fishes of British Columbia.

Dr. C. L. Hubbs has discovered, among some fish sent him for examination, a new genus and species of blenny. This is being described under the name *Allolumpenus hypochromus*.

THE FOOD OF THE FUR SEAL

There has been considerable conjecture as to the nature of the food of the fur seal during its northward migration off the coast of British Columbia. In the summer of 1931, the Department of Fisheries collected the stomachs of twenty-five fur seals taken by the Indians of the west coast of Vancouver island. The material is being carefully examined by Dr. Clemens and Mr. Wilby and will be reported upon at a later date.

NUTRITIONAL VALUE OF CANNED SALMON

Under instructions from the Executive Committee, Dr. W. A. Clemens organized an investigation of the nutritional value of canned salmon. The first phase of the work has been limited to Sockeye and Pink salmon and to representative samples of early, middle and late packs. Studies of the oil and vitamin contents are being carried out by Mr. H. N. Brocklesby at the Fisheries Experimental Station. The general chemical investigation is being conducted by Dr. N. M. Carter at the Pacific Biological Station.

OCEANOGRAPHY

The general study of the oceanographical conditions in the strait of Georgia has been continued. The investigation has been planned with the object of obtaining data concerning the effect of tidal, meteorological and topographical conditions upon the source, concentration, distribution and utilization of the chemical substances, their relationship to the seasonal fluctuations in growth and availability of plankton and consequently their effects on growth and movements of fish and other marine products.

In addition, a special study has been made of several of the fiords that open off the strait of Georgia in order to provide information as to the extent to which they contribute to the general productivity of the coastal waters.

Dr. N. M. Carter, assisted by Mr. E. C. Black and Mr. J. P. Tully, has carried out extensive physico-chemical analyses involving the determination of temperature, density, transparency, salinity, hydrogen-ion concentration, nitrate, nitrite, phosphate, silicate and oxygen values. Considerable research has been expended on improving methods, technique, graphical calculation and representation of analysis. Over 1,200 samples have been examined during the year. Experiments have been carried out on the use of various types of drags on drift bottles. In the study of the fiords several very interesting results have been obtained. In some of the fiords extensive stagnant areas occur at the bottom where there is entire absence of oxygen. Strata of very high nitrite values have also been found.

Dr. A. H. Hutchinson has continued the study of the phyto-plankton and the relation of the physico-chemical factors to its production. Particular study is being given to the relation of the phosphate cycle to the plankton production.

Results of an investigation of the layer of water in the strait of Georgia from the surface to a depth of fifty yards has been recently published by Dr. Hutchinson and Mr. C. C. Lucas. Miss M. H. Campbell has made detailed studies of the life histories of the common copepods of the plankton of the strait of Georgia. These are the forms which constitute the bulk of the food supply of young fishes and such large fish as the herring, etc. Studies have also been made of the vertical and horizontal distribution in quantity of these animals. Mr. H. Fasmer carried out a study to determine the efficiency of the closing plankton net as used at the Station, and of the centrifuge used in the concentration of the plankton.

PATHOLOGY

1. Cultus lake. In the late summer of 1930, a severe epidemic appeared among the Sockeye fry in the retaining ponds at the Smith Falls hatchery. *Costia necatrix* was isolated, and while it was suspected as being a causative agent, direct proof was lacking. The disease did not appear in 1931, but Dr. D. C. B. Duff carried out an investigation of halibut meal as a possible carrier of pathogenic organisms and as a possible source of poisonous decomposition products. Micro-organisms isolated could not be shown to be pathogenic, and, while the meal gave rise to a diffusable poison, observations indicated that effective concentrations were not possible in the retaining ponds.

2. Elk river. In the summer of 1930, the deaths of considerable numbers of trout and whitefish were reported in the Elk river near Fernie. Mr. Mottley made a preliminary survey of the situation and made certain recommendations. In 1931, reports of further deaths of fish were received and Dr. Duff was detailed to make an investigation. He found that the epidemic was caused by the bacterium, *Bacterium salmonicida.* The source of the infection should be sought and steps taken to prevent transference into other areas.

INVESTIGATIONS BY VOLUNTARY WORKERS

Thirteen voluntary investigators have been at the Station during the year carrying out a variety of important studies. A number of the researches have already been referred to and the following additional are recorded:

1. Symbiosis between certain marine organisms. Mr. C. Berkeley. A study has been commenced of the symbiotic algae occurring in *Ascidia* with the possibility of tracing a connection between the presence of the alga and the cellulose constituent of the test.

2. Systematic study of marine worms. Mrs. C. Berkeley. An extensive collection of polychaet worms from the Friday Harbour region, Washington, and another collection of littoral forms from the west coast of Vancouver island have been studied and two papers describing several new species have been completed.

3. The early life histories of crabs. Miss J. F. L. Hart. Little of the early life history of Pacific coast crabs has been studied. The free-swimming larvae are exceedingly abundant in the waters throughout many months of the year and serve as food for many larger animals, especially fish. The larvae are so unlike the adults and in some cases so like one another that it is necessary to rear the stages in the laboratory in order to establish identities. The complete life history stages of some half dozen species have been obtained and some of the stages of the commercial crab. Oyster larvae have been found to be a very satisfactory food material for the crab larvae.

4. Diatoms as the food of copepods and phyllopods. Professor C. W. Lowe. Diatoms constitute the first link in the food chain in the waters and this study was carried out to determine the significance of these plants in the food of

copepods and phyllopods which in turn constitute an important food for fish. In order to obtain data on the food chain, the stomach contents of a number of species of fish were studied.

5. The algal flora of Spider lake, Vancouver island. Professor C. W. Lowe. Small-mouthed black bass have been introduced into Spider lake and have successfully established themselves. This study is a commencement of an investigation of the food supply of the lake.

6. Reactions of fish to noise. Professor V. H. K. Moorhouse. Complaints have been received that the noise of outboard motors was driving fish away from their usual haunts. It was necessary to carry out the investigations with fish in aquaria and the surf perch was found most satisfactory for experimentation because it adapted itself so readily to aquarium conditions. The results of the experiments were interesting in demonstrating definitely the establishment of conditioned reflexes.

7. An investigation of the life histories of waterfowl. Mr. J. A. Munro. The presence of many waterfowl on the sea coast has given rise to the general belief that such congregations are detrimental to man's interests in that these birds are serious competitors of the fishing industry. Observations of the habits of these birds has been undertaken and examinations of stomach material.

8. The food of the American merganser. Mr. J. A. Munro and Dr. W. A. Clemens. This study was undertaken because fishermen, especially anglers, have demanded the destruction of the merganser on the grounds that it is responsible for serious losses of important fishes. Material for study has been supplied chiefly by the Department of Fiheries.

9. The Protozoa of British Columbia waters. Mr. G. H. Wailes. A study of the Ciliata has been completed and a report submitted for publication. A complete review of the marine Protozoa of British Columbia waters is being prepared with keys and numerous illustrations. This will provide a very useful reference.

A collection of algae, invertebrates and plankton made in Sproat lake in connection with a survey of conditions following some mortality among salmon is being examined and reported upon.

10. The life history of the Ling cod. Mr. G. Van Wilby. During the year this investigation has been advanced particularly by the study of specimens in the first year, by the examination of stomach contents of specimens obtained by a commercial trawler, by obtaining much additional length-weight-age data and by a study of the catch records of the past thirteen years.

ANNUAL CONFERENCE

The fifth annual conference of the staffs of the Fisheries Experimental Station and the Biological Station was held at the latter station on August 27 and 28. Professors C. M. Fraser, A. H. Hutchinson and W. Sadler of the University of British Columbia, and Dr. W. F. Thompson and staff of the International Fisheries Commission were present, taking part in the programme and discussions. Twenty-five investigators were in attendance and over twenty reports were given of investigations carried out during the year.

EDUCATIONAL

COURSE FOR HATCHERY OFFICERS

From July 13 to 25 a course of instruction was given to the superintendents of hatcheries in British Columbia. It was decided that instruction should be given in the field, and Sorrento on Shuswap lake was made the headquarters.

The Inspector of Hatcheries for British Columbia and nine superintendents took the course. The instructors were Dr. Clemens, Dr. Foerster and Dr. Carter.

Courses were given in the following subjects: mapping, physics, chemistry, meteorology, limnobiology and hydrography, vegetation, invertebrates of lake shore, lake bottom, and stream, plankton, and fish. There were also lectures and informal discussions in the evenings on a variety of subjects and a special lecture by Dr. D. S. Rawson on the productivity of lakes.

INSTRUCTION IN THE SALTING OF HERRING

In October, Dr. N. M. Carter gave a lecture on the physical and chemical principles underlying the process of salting of fish to certain officers of the Department of Fisheries. Arrangements are being made by the Pacific Biological Station and the Fisheries Experimental Station for giving a two weeks' course of instruction to Departmental inspectors at the former station.

PUBLICITY

The series of quarterly progress reports were issued during the year. By means of these, popular accounts of investigations have been presented to the persons in the fishing industry and to others interested in the progress of fishery research. A number of short newspaper articles have appeared. Lectures and addresses have been given at various points in the Province by various members of the staff. In addition, reviews of the work of the Board on the coast have been given by the Director at the Universities of British Columbia and Washington, and at Leland Stanford Junior University. The Station and its museum have been visited by a large number of persons, including various groups such as the Boy Scouts of Vancouver island and members of the Cowichan and Burrard Field Naturalists Clubs.

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Wailes, G. H.—*Amphipoda* from British Columbia. Vanc. Mus. Art Notes. 6.
White, F. D.—The occurrence of creatine in the muscle, blood and urine of the dogfish, *Squalus sucklii*. Contr. Canad. Biol. Fish. 6.
Williamson, H. C.—The white Spring salmon. Canad. Fisherman, 18.

INVESTIGATORS' SUMMARIES

D. Beall

Waste liquors from pilchard reduction plants. Due to existing methods large losses of oil and meal are incurred in the separation of the meal from the liquid portion of the cooked fish and subsequently the oil from water fraction.

From the study of the waste liquors from the oil separation tanks it was found that these liquors contain, on the average, 1.1 per cent. oil, 1.9 per cent. meal (dry oil free), and 3.6 per cent. dissolved protein by weight. However, there is a great variation in their composition according to the conditions of the fish processed. A meal recovery machine manufactured by the California Press Company was found, on the average, to recover forty-seven per cent. of the meal and eight per cent. of the dissolved protein. It was also found that the meal losses were halved when the perforations in the press were reduced from one-sixteenth of an inch to one-thirty-second of an inch in diameter. The oil losses in the fish storage tanks (containing fresh fish) were found to be negligible.

C. Berkeley

Symbiosis in marine organisms. In an investigation of algal symbionts in ascidians cells which appear to be of an algal nature are frequently found in quantity both in the test and in the ectoderm of *Ascidiopsis paratropa*, but not in any other tissues, except possibly in the circulatory fluid, and only in young individuals. In mature specimens a very remarkable condition was found in the egg cells, the nuclei of some of these being heavily pigmented with brown granules. These granules are a more or less regular spherical or oval shape and it seems possible that they are infective bodies connected with the supposed algae in the young animals.

C. and E. Berkeley

Polychacta. A large collection of dredged Polychaeta from Friday harbour, Washington, consists chiefly of species already recorded from the Nanaimo region, but a few interesting types have been found amongst the material, including some fragmentary specimens of a Capitellid of which only one example had been known previously and had not been recorded. This, with some other interesting and undescribed Capitellid material at hand, forms the subject matter of a paper being submitted for publication. A collection of littoral Polychaeta from the west coast of Vancouver island has proved interesting from the distributional standpoint, and a paper in press giving an account of it includes the description of a new species of Sabellid.

Mildred H. Campbell

Life histories of copepods. The life cycle of *Calanus tonsus* is economically important as this species constitutes the predominant constant element of the

zooplankton in the strait of Georgia, and forms the bulk of the food supply of young fishes and herring. *Euchaeta japonica,* one of the largest species of the entire copepod group, is a deep cold water species.

During the summer of 1930 some of the developmental stages were obtained by artificial rearing in the laboratory and the remainder have been isolated from plankton hauls collected throughout the year. During the summer of 1931 the examination of plankton was continued and the complete series for both species obtained, consisting of six nauplius stages and six copepodid stages. It is found that when compared with *Calanus finmarchicus* Gunnerus, *Calanus tonsus* has a very similar life history. It appears to have a definite spawning time in the early spring months. All the nauplius and early copepodid stages are passed through rather rapidly. The great part of the year is spent in the fifth copepodid stage and the species probably only exists in the adult stage over a short period—January and February.

Euchaeta japonica seems to breed more or less all the year round and all stages may be found in the same plankton sample.

N. M. Carter

An oceanographical investigation of certain types of fiords. The coast of British Columbia is intersected by many long inlets or fiords which greatly add to its effective length, but these have been so little investigated from an oceanographical viewpoint that it is impossible to state at present whether the fishing and other marine industries do benefit, or could benefit, to an extent proportional to this increased area of coastal water. An extensive and comparative study of fiords, with the object of ascertaining their scientific and economic potentialities, was therefore considered advisable. Of three fiords, chosen to represent three distinct, representative types, and observed monthly over a ten-month period, one (Saanich inlet) was found to have a large basin of stagnant water underlying the normal, tidal water back of a comparatively shallow bar which stretches across the mouth of the inlet. The physical and most chemical properties of the water in this basin seem to remain fairly constant throughout the year, independent of tide or seasonal effects. Two other fiords with similar stagnant basins have been found, and this condition should be described in view of the fact that certain chemical constituents are present having concentrations two to ten times those recorded for normal sea water.

Gladys Clandinin

On the development of scales in Cutthroat and Steelhead trout. Since scales are used extensively in the determination of the age of many fish, it seemed desirable to obtain definite information concerning the appearance, distribution and development of the scales in these species.

The first appearance of scale papillae seemed with few exceptions to depend upon length rather than age of the fry. The first papillae make their appearance when Steelhead fry are about 2.6 centimetres in length, and Cutthroat 2.8 to 3 centimetres in length.

The papillae appear as a single row of circular plates along the lateral line extending almost from the pectoral fin to the adipose fin (Steelhead 2.6 cm.). On larger specimens (Steelhead 3 cm.), there are two to three rows of papillae along the lateral line from just behind the operculum to the caudal region and five to seven rows in the region of the dorsal fin. Development proceeds more rapidly in the ventral direction.

When the scale papillae begin to develop in the Steelhead (2.6 cm.) an aggregate of deeply staining cells appears in the dermis, which spreads itself out

horizontally, the cells becoming arranged in two circular plates (Steelhead 2.8-3 cm.). Between these two layers, a layer of highly refractive substance appears, the scale substance, which starts at the centre. In further development it spreads throughout the entire length and width of the papillae.

At first the scales lie entirely in the dermis and in a plane parallel with the surface of the body. They pass into an oblique position (Steelhead 3.7 cm.) before they are large enough to crowd each other. This change in position of the scale appears to come about through a proliferation of epidermal cells beneath the posterior end of the scale and development of connective tissue between the epidermis and the anterior end of the scale.

W. A. AND L. S. CLEMENS

Statistical study of Sockeye salmon runs. The examination of the collection of scales and data of Sockeye salmon running to the Fraser, Skeena and Nass rivers and to Rivers inlet in 1930 made by the Provincial Fisheries Department has been carried out.

The almost phenomenal run to the Fraser river was very largely composed of four-year-old fish (seventy-six per cent.). The run to Rivers inlet was composed of equal numbers of four-year-old and five-year-old fish and together these age groups comprised ninety-six per cent. of the run. The Skeena river fish were also almost entirely comprised of four- and five-year-old, the latter forming fifty-two per cent. and the former thirty-nine per cent. of the run. The run to the Nass river is always interesting because of the number of age-groups represented. In 1930, there were eight age-groups with the five-year-old group (two years in fresh water) forming fifty-four per cent. of the run.

The runs to these rivers were large, providing excellent catches and satisfactory escapements.

D. C. B. DUFF

1. Investigations on causes of disease in Salmonida. In the late summer of 1930 a severe epizootic appeared among Sockeye fry in the retaining ponds of the Smith Falls hatchery, Cultus lake. Microscopic examination of scrapings from side and gills of affected fish showed the presence in nearly all cases of *Costia necatrix,* but it was possible that the epizootic was due to some other and primary cause, and that the Costiasis was a secondary condition, or that other factors, such as physical conditions, improper food or a concurrent infection, may have aggravated the course of the disease.

Halibut meal is used as part of the feed in the ponds, and was suggested by Dr. Foerster as a possible factor. When mixed with water, with or without previous ether extraction, and held at room temperature for twenty-four hours or longer, it gives rise to a diffusible poison which kills Sockeye fry. An amount of forty-eight-hour meal filtrate equivalent to 0.08 gm. meal, added to each litre of water in the experimental jars, consistently kills Sockeye fry in twelve to eighteen hours, but infusions held at the temperature of the hatchery water supply require one week or over to produce a poison comparable in strength to the room temperature preparations. Liver and canned salmon produced poisons slightly less potent than those from halibut meal.

A consideration of capacity and rate of flow in the retaining ponds, together with the amount of food given daily and the cleaning routine, makes it clear that a concentration of decomposition products immediately harmful to fry could never be attained. Exposure for three weeks to continuous doses just below the level required to produce definite symptoms, failed to give a cumulative injurious effect, such as might conceivably come from the film coating the sides and bottom

of the ponds, and a direct test of this possibility on a small scale showed nothing unfavourable.

Of twelve species of micro-organisms isolated from samples of halibut meal, none produced any evidence of disease in Sockeye fry when added in large quantities to experimental jars.

2. Elk river investigation. Following a request for an investigation of an epidemic among the game fish of the Elk river, this stream was inspected, on August 12, over a stretch of about forty miles, from below Elko to about fifteen miles above Fernie. The stretch of stream in question does not appear to differ from other portions of the stream, except in receiving sewage, etc., at and near Fernie, and in the location of a power dam at Elko, twenty miles below Fernie. Even at low water the river is of a good size, swift of current, and is quite deep in many places. There are few, if any, places between Fernie and Elko where stagnant water or sewage could collect. From these considerations it is my opinion that even in midsummer the possibility of damage to fish from sewage or from the weekly pumping out of the comparatively small chlorinated swimming pool is exceedingly small. All the dead fish found were grayling, and with the exception of two which had obviously died from wounds, all bore characteristic "marks," consisting of a hemorrhagic, roughly circular area, about one square centimetre or more in diameter, nearly always situated directly between the pelvic fins, and often involving the bases of the fins. Examination of the body cavity showed the peritoneum and omentum heavily infiltrated with blood, and in most cases the kidney had become a fluid mass. Cultures from the muscle, the dorsal blood vessel, and the kidney, gave in nearly every case a bacterium with characteristics like those of *Bacterium salmonicida,* which causes the well-known infectious disease of salmonids, furunculosis. As this disease is also characterized by exterior sores or "boils," and also intestinal inflammation and peritonitis, it would seem almost certain that the Elk river fish are attacked by furunculosis. Complete proof would, of course, depend upon the final identification of the bacterium obtained, together with evidence of its infectivity.

C. R. ELSEY

The oyster investigation of British Columbia. British Columbia, though boasting an important fishery, imports most of the oysters which are consumed. The price at which they are sold places them beyond the reach of the average citizen. This condition suggests either that the coastal waters are unsuited to oyster culture or that the industry has been neglected. Observations which have led up to the making of this investigation have indicated that the latter supposition is the correct one.

The high water-temperatures which prevailed throughout the winter and early spring caused the bulk of native oysters to spawn three weeks earlier than in the average season, in the period between May 10 and June 1. All cultch was by June 5 thickly set with young oysters and continued to catch them until June 13, but the remainder of June was characterized by wet weather with a general lowering of water-temperatures and densities, and on July 1 all of the spat was dead and the plankton contained no larvae. A small proportion of oysters developed spawn in July and August, but no set of commercial importance accumulated on the materials of the natural beds.

Similar material, however, which at regular intervals throughout the season had been placed in experimental dykes (previously without oysters) at Ladysmith and suspended in wire sacks, from floats, both at Ladysmith and Crescent, collected a satisfactory set, evidently because the very young set which became attached at the time when the lowest daylight tides of the year were accompanied by hot

weather, was protected in the dykes and on the suspended cultch from subjection for any long periods to the direct heat of the sun.

Eastern oysters in the rivers and on the beds at Crescent spawned in the interval between May 25 and June 15. Presumably as a result of the rain which followed, the larvae did not develop and no spatting occurred. A survey of the rivers showed that they contain more than two million eastern oysters, all of which have set there, during the past fifteen years. A study of the material indicates that the heaviest set occurred in 1926 and that the present year is the only one of the past five in which no setting occurred.

Japanese oysters have been distributed to new localities and continue to demonstrate their ability to grow under conditions entirely unsuited to the growth of the other two species. There is evidently no limit to the quantity of this species which can be matured on the coast. Spawning occurred in the latter part of August, but no larvae were taken. A half-dozen species of marine organisms have been introduced from Japan with the seed, but there is no evidence yet that any of them can be classed as oyster pests. The ability of the above organisms to survive, however, indicates that there is a potential danger of introducing drills, sponges or mud-worms which might prove injurious to the native oyster. The advisability of seed inspection is being considered.

H. FASMER

Experiments on plankton methods. The main object of the experiments was the determination of the filtration coefficient for the plankton net in use at the Biological Station. Comparison of the volume of plankton in one cubic metre of water obtained by the Bolton plankton bucket and from samples obtained by the net showed the efficiency of the net to be between eighteen and fifteen per cent. The filtration coefficient for the same net calculated according to the tables of Hensen is approximately 0.31. This result indicates what already several investigators suspected and, in the case of fresh water plankton, already has been proved; namely, that the efficiency of the plankton net requires to be determined for quantitative investigations and that the net collections should be supplemented by collections with self-closing plankton buckets.

Experiments on the influence of different fixing agents on the plankton volume of the same sample, determined immediately after the fixing agent had been added and again later. when the sample had remained standing for approximately three weeks, showed that there was sometimes a very considerable shrinkage, somewhat different for the different agents.

R. E. FOERSTER

1. The relative efficiencies of the natural and artificial propagation of Sockeye salmon at Cultus lake, B.C. To test out thoroughly the relative efficiencies of natural propagation and the two standard methods of artificial propagation, a twelve year programme was drawn up and work commenced in 1925. In each subsequent year one particular method of propagation has been investigated and the success of the method determined on the basis of the number of seaward migrating individuals produced.

The general programme of the investigation called for natural propagation in 1930 and accordingly all Sockeyes were allowed to pass to the lake. During the migration 10,395 adults were counted of which 4,856 were males and 5,553 were females. The sexes were thus fairly evenly represented. Conditions on the spawning grounds during the spawning season were considered very good. The natural spawning of 1930 represents the third test of this type of propagation

and should form a good example of what might be called moderate spawning. In 1925 only 5,426 Sockeye spawned naturally and in 1927, 81,228 individuals were released into the lake.

In the spring of 1931 there were counted 355,149 young Sockeye migrants passing out of Cultus lake. An analysis of the migration disclosed that 349,993 of the migrants were yearlings, thus providing, for the artificial propagation with liberation of fry test of 1929, a return of 2.24 per cent. of the total number of eggs contained in all the female Sockeye arriving at the counting weir in 1929. Of two-year-old individuals there were 5,156 which represented a return of 0.19 per cent. of the total number of eggs contained in all females enumerated in 1928, thus increasing the efficiency of the egg-planting method of artificial propagation conducted in 1928 to 1.64 per cent. Aside from the 3,526 individuals preserved as a sample of the migration, all migrants were marked by removal of both pelvic fins and the adipose fin prior to liberation from the counting traps.

While a second test of artificial propagation with planting of eggs was proposed for 1931, the possibility of a large run necessitated a change in plans and artificial propagation was conducted to the limit of hatchery accommodation after which the remaining Sockeye were to be allowed into Cultus lake for natural spawning.

2. Pond retention of Sockeye salmon. At the request of the Department of Fisheries an experiment was undertaken to determine the value of pond retention of Sockeye salmon in comparison with the standard system of liberating Sockeye from the hatchery as free-swimming fry.

In ponds constructed at Smith Falls hatchery in the spring of 1930 five hundred thousand Sockeye fry were placed and one-half of this number were liberated in the fall as five-month-old fingerlings. It was intended that the remaining half should be held for one year, but toward fall a very disastrous infection swept the ponds and wiped out ninety per cent. of the retained fish. The survivors were used, however, in the manner previously planned, some being liberated at the end of September and the remainder carried through to the end of twelve months.

The retained individuals were given a distinguishing mark at the time of liberation into the lake and these marked fish were enumerated at the counting fence as they endeavoured to migrate from Cultus lake to the sea. For the five-month-old fingerlings the data show a return of 10.6 per cent. of the total number liberated or 1.7 per cent. of the total number of fry in the ponds. For individuals retained for a year the returns are 63.1 per cent. of the total number liberated from the ponds or 3.8 per cent. of the total number of fry held originally. It is conceded that the returns are too high on the one hand and too low on the other but in cmparison with the 3.6 per cent. return that has been found for fry liberation, the value of retention is quite evident.

3. Cross breeding of Pacific salmon. The possibility of hybrid salmon appearing among salmon catches has been a debatable point among fishermen and canners and certain reports of the appearance of such fish have been circulated. In order to test out the possibility of such cross-breeding taking place, breeding tests were made at Cultus lake in 1927 when the appearance of the five species of Pacific salmon made such an effort possible.

In the fall of 1930 the males of the Fl generation ripened and were crossed with normal Sockeye females, and gave fertile eggs. This fall, 1931, the hybrid females, Fl generation, ripened and the eggs obtained from them have been subjected to milt from normal Sockeye males. It would appear that some of the eggs were fertilized but whether the embryos will hatch satisfactorily remains to be seen.

J. L. HART

1. Pilchard investigation. The pilchard fishing has in recent years experienced a very rapid growth and in consequence some doubt has been felt as to whether the supply of fish is sufficient to withstand the drain placed upon it by the fishing.

The races of the pilchard have been investigated by making a study of certain body proportions and meristic characters of pilchards taken at Nootka sound and Barkley sound in 1930 and 1931, and at Monterey, California, in 1930. The results have been positive. The ages of pilchards have been studied by making length measurements of a representative sample of the pilchard catch for the last three seasons. Certain changes have been found to have taken place in the size of pilchards which appear to be related to fluctuations in the fishing. For pilchards of the size range taken in British Columbia waters the weight appears to be proportional to the length.

2. Investigation of the food of pilchards. The food and food supply of pilchards are of economic interest, since (1) fish are more often caught in localities where food is abundant, (2) when food organisms are absent, the water is clear and the fish are wild with the result that they are difficult to catch in a purse seine, and (3) the oil for which the pilchard is reduced is dependent upon the fat of the fish and that in turn is dependent upon the extent and quality of the pilchards' food supply.

Pilchards were found to eat one hundred and forty-nine different kinds of plants and animals of which fifty-one different kinds were plants and ninety-eight animals. The diatoms, usually referred to as green feed, constituted about forty-five per cent. of the food. The second most important group in the pilchards' food is the copepods which together with the other Crustacea constitutes the red feed. In 1930, red feed was more abundant in the digestive tracts of pilchards than in the three previous years and this may be related to the high oil content of the pilchards during that season.

3. Herring investigation. The herring fishery in British Columbia is a very important one but it has been made less profitable by uncertainty as to its location, season and magnitude. The object of the present investigation is to determine whether the fluctuations are due to natural causes or the effect of the fishing. First of all, an attempt is being made to find out what fluctuations are occurring in the abundance of the herring and what changes in the herring stock are accompanying these fluctuations.

Scale readings for herring from Barkley sound, Nootka sound and the east coast have been made and the age composition of the catch calculated from the results. For purposes of a general statement the different districts resemble one another sufficiently to justify the results from all the samples about Vancouver island being grouped together in one average. Forty per cent. were third year, thirty-nine per cent. fourth year, five per cent. fifth year and ten per cent. unreadable. In general, these results resemble those obtained for the previous year. The differences between these results and those obtained in Alaska and Europe emphasize the necessity for a complete investigation of the British Columbia herring fishery.

JOSEPHINE F. L. HART

Early life histories of crabs. Little of the early life history of Pacific coast Decapods has been studied. The larvae are common in plankton at all times of the year and serve as food for certain of the macro-plankton as well as fish. The larvae are so unlike the adults and in some cases so like one another that it is necessary to rear the stages in the laboratory to be sure of assignment to the

right species. This work of identification is necessary before problems of a more direct economic bearing can be attempted.

Complete series of the larval stages of three species of Brachyura and two Anomura, as well as several incomplete series, were obtained from eggs hatched in the laboratory. *Hemigrapsus nudus* was reared through five zoeal stages, one megalopal and killed in the sixth young crab stage, age four months. *Hemigrapsus oregonensis* was kept through similar stages until the fourth young crab stage. *Lophopanopeus bellus* went through four zoeal stages, a megalopal and two young crab stages. The one megalopa of *Pugettia producta* obtained from the egg died before reaching the crab stage, after passing through two zoeal stages. Four zoeae of *Pinnixa faba* and some post larval stages of different species of *Cancer* were obtained. Series of four larval stages and one glaucothoë before the young crab stages were reared of *Pagurus granosimanus* and *P. hirsutiusculus*.

A. H. Hutchinson

Oceanography of the strait of Georgie. (1) Some of results of the study of the oceanography of the strait of Georgia may be summarized as follows. The strait of Georgia is a great basin, connected with the sea by narrow passes, which receives water from a number of large rivers, notably the Fraser river. The river water is conserved during the summer and forms a marked upper layer, epithalassa, which is characterized by low salinity and high temperature. The increase in temperature as compared with sea water may amount to 10°C. or 18°F. Throughout the greater part of the region this epithalassa has a stability which is sufficient to resist tidal and wave movements. Since time is a factor, the heating effect of the sun, insolation, upon the epithalassa becomes most evident at regions some distance from the river mouth. In the case of a large river, as the Fraser, this distance may exceed ten miles. Abundant fish food in the form of plankton is present and the amount is greatest at the regions where the most complete mixing of the river and of the sea water takes place. Evidently each water source contributes certain conditions or factors favourable for plankton growth. Mass movements of the epithalassa accompany tidal changes, resulting in variations of salinity, temperature and plankton at any point according to the source of the translocated water and the phase of the tide.

(2) The investigation of the *seasonal changes in phosphate* particularly in relation to plankton has been continued and coordinated with the results obtained during four previous years. In the strait of Georgia at a distance of 22 miles NW of the Fraser river mouth (Station 1), there is a definite seasonal cycle consisting of the following phases:—"a general minimum" of phosphate at all depths during May to early June; an "epithalassal minimum" of phosphate accompanied with a "depth maximum" during late June, July, and August; an "epithalassal maximum" accompanied by intermediate values at greater depth during September to January; a uniform column of intermediate phosphate values during late January to early April; a transition period during April to early May. The relation of these phosphate changes to the occurrence of plankton is being studied.

C. W. Lowe

1. Diatoms as the food of copepods and phyllopods. The investigation of diatoms as the food of copepods, begun a year ago, was continued during the past summer and extended by determining the food chains between the diatoms and the larger fishes of economic importance. One instance of this work is as follows: a Ling cod twenty-eight inches long, weighing nearly eight pounds, was found to contain a number of young herrings in its stomach. These herrings in turn

were found to be filled with numerous copepods and from these were obtained over twenty species of diatoms. Other fishes examined in this manner were the Rock cod, *Sebastodes caurinus;* the Starry flounder, *Platichthys stellatus;* the Yellow perch, *Damalichthys argyrosomus;* the Dogfish, *Squalus sucklii;* Dog salmon, *Oncorhynchus keta,* and herring, *Clupea pallasii.* From the stomach contents of these fishes no less than eighty species of diatoms have been identified. Copepods were obtained from all of them with the exception of the flounder which contained only a number of small Mollusca, chiefly young *Patella,* and in these some twenty-five species of diatoms were found. The greater part of these diatoms were littoral forms and not plankton forms as in the other examinations.

Another observation concerning diatoms as food for the copepods was one in which two living species of the Harpacticideae, *Harpacticus uniremis* and *Diosaccus spinatus* were seen to devour large numbers of *Melosira nummuloides, M. roperiana, Biddulphia aurita,* and *Licmophora lyngbei.*

2. The algal flora of Spider lake, Vancouver island, B.C. Spider lake near Van Horne lake is of particular interest because of the fact that the introduction of small-mouthed, black bass some years ago has been very successful. Large numbers of fry can be seen around the shores in June of each year and the bass fishing is improving year by year.

It seemed advisable to make a study of the plant life forming the basis of the food supply of the lake. The algae identified from this lake total one hundred and sixty-four species (an increase of one hundred and fifty per cent. over the number found last year), with the following groups represented by the number of species indicated: Myxophyceae, 19; Peridineae, 5; Flagellata, 3; Bacillarieae, 27; Desmidiaceae, 76; other Chlorophyceae, 34. In addition to these there are a few unidentified species which are either rare or new. One of these is a desmid with the zygospore which probably has never been observed before. The large number of desmids in proportion to the other algae shows the purity of the water. The lake is interesting in the fact that it is the only lake known to the investigator to contain the three fresh-water species of *Ceratium, C. Hirundinella, C. cornutum,* and *C. curvirostre.*

D. C. G. MacKay

A study of the commercial crab, Cancer magister. Inasmuch as existing knowledge concerning the life-history, growth and migrations of the Pacific coast edible crab is surprisingly limited in consideration of the importance of the fishery, the study commenced in the spring of 1930 was continued throughout the past summer. The capture of apparently healthy, edible crabs at, and adjacent to, the docks of the Anyox Copper Smelter at Granby, where concentration of waste materials would be relatively high, was considered indicative of a lack of serious effects on the crabs of the region from this source.

In Boundary and Semiahmoo bays, adjacent to the town of Crescent in southern British Columbia, of 6,155 crabs caught in the commercial traps, 6,043 or 98.2 per cent. were males and but 112 or 1.8 per cent. were females, while at Prince Rupert, as found in 1930, 76.3 per cent. were females and 23.7 per cent. males, and at Nass harbour to the north, 65.4 per cent. males and 34.6 per cent. females. No definite explanation of this unusual condition can at present be offered.

Egg-bearing females were not encountered at Crescent from the middle of June to the latter part of September but, due to the appearance of large numbers of the zoea and megalops stages it would appear that hatching of the eggs probably occurred during May or June. Samples of these crabs were taken

whenever possible and their volumes as groups ascertained for the study of growth. The average volume in cubic centimeters per hundred crabs increased from 6.8 on July 16 to 13.0 on August 7, and to 22.9 on September 21.

Catch per trap in Boundary and Semiahmoo bays where, strangely enough, bait is not employed, was found to be 19.8, both sexes included, on June 17, with a more or less steady decline, possibly due to migrations, until August 6 when only 4.6 were taken. This may be compared with six to seven crabs per trap as taken at Nass harbour and Prince Rupert with the aid of bait during 1930—including a larger proportion of females, as already observed.

During the season approximately eight hundred crabs (as far as possible, newly-moulted) were tagged with a view to the study of migratory movements. Preliminary returns show migrations of as much as three miles in as many weeks.

V. H. K. MOORHOUSE

Reactions of fish to noise. Complaints had been received that the noise of outboard motors was driving fish away from their usual haunts, and it was planned to study the response of available species of fish to noise. As noise producers, a tapper, bell, buzzer and motor horn were used.

Flounders (mostly small, a few large specimens), rock cod (mostly small, a few large specimens), and dogfish embryos (twenty cm. with yolk sac three cm.) and adults (ranging from forty to eighty cm. in length) gave little or no sign of being affected in any particular fashion by noise.

Small perch, up to ten cm., for a short period of time after being caught, were repelled by noise and grouped at the opposite end of the tank, but rapidly became accustomed to the noise, so that in about two weeks very little sign of repulsion by the noise could be detected.

It was found that the perch, while becoming accustomed to noise in the sense that they showed none of the repulsion first evidenced, were still markedly responsive, because a conditioned reaction was built up. On combining the stimulus of noise with feeding, it was found that after about eight repetitions, a fairly strong surface reaction could be elicited by the noise acting alone, *i.e.*, a conditioned reflex had been formed. This response increased in intensity on reinforcement, until after about fifty-seven repetitions practically all the perch would rise at the sound, break water at the surface and produce an effect which in photographs cannot be distinguished from the actual feeding response.

Some effort was made toward the end of the time available, to develop a protective response to certain noises. Darkness or shadow causes these fish to dive and remain near the bottom. By combining darkness with the noise it was found possible to develop a short-lived protective response after a series of quick repetitions, but time and material were too deficient to test the matter very thoroughly.

An outboard motor produces quite a surface disturbance as well as noise and a small machine was tried for the purpose of imitating this characteristic. A water mill fitted with paddles was adjusted so as to rotate and splash the surface water. On trying this with any fish of group 1, *i.e.*, fish accustomed to feeding, the result was a strong surface response. The perch would collect directly below the water mill and would constantly be struck by the paddles. This response is also a conditioned one—the fish evidently associating any surface agitation with food poured on the surface from the tip-bucket.

C. McC. MOTTLEY

Investigation of trout in British Columbia in 1931. Owing to (1) the economic value of angling, (2) the fact that regulations governing angling require

specific biological bases, and (3) the fact that fish cultural operations present many problems for investigation, it was decided to extend the investigation to the biological factors underlying the propagation and conservation of trout.

Depletion has occurred in Paul lake, as shown by the fact that anglers' catches are reduced, consisting largely of yearlings and two-year-olds, and that the egg-collections since 1928 have been below average, although the effort to obtain eggs has been doubled.

One cause of the depletion is that the fishing effort has been gradually increasing since 1921. This year, although the legal limit was fifteen fish per day, not a single angler using legal methods caught more than eight fish per day. The depletion has allowed food organisms to increase and the condition of the trout is improving. Another factor is that Paul creek goes dry in August, and water is diverted for irrigation, so that plantings of eggs in riffles may go dry or pools may dry up and the fry die. Owing to the creek drying up each summer, salvaging operations in Paul creek have been necessary and have been carried out since 1916, with the exception of 1928. Observations on fry plantings made this year in the lake would point to the fact that the fry method is more successful for Paul lake.

J. A. MUNRO

An investigation of the food habits of the American merganser. This study, commenced in 1930 in association with Dr. W. A. Clemens, was undertaken because fishermen and anglers have demanded the destruction of the merganser on the grounds that it is responsible for serious losses of important food fishes. In the extensive literature of economic ornithology no information of value on this subject is to be found, therefore an attempt to remedy the deficiency seemed desirable.

The American merganser is a duck and is protected by the Migratory Bird Treaty to the same extent as other species of ducks. The Dominion Government having the responsibility for the protection of this species, it is of considerable importance that full information as to its economic status should be made available.

Through the co-operation of the Department of Fisheries, 36 specimens were available for study. These were collected at the following localities, viz: Little Shuswap river, 2; Babine lake, 26; Sooke river, 3; Cowichan river, 1; Tlell river, 2; Seymour creek, 1; Quamichan lake, 1.

The following items of food were identified in the stomachs of specimens taken in the interior of British Columbia, viz: *Cottus asper, Ptychocheilus oregonensis, Leuciscus balteatus, Oncorhynchus nerka kennerleyi, Mylocheilus caurinus,* salmon ova, stone fly larva, lepidopterous larva, crane fly, carabid beetles, dipterous insects and miscellaneous vegetable matter.

Specimens taken on Vancouver island contained salmon ova, *Cottus asper* and miscellaneous vegetable matter. The two specimens from Tlell river, Queen Charlotte islands, contained salmonoid fry.

ANDREW L. PRITCHARD

Report on investigation of the natural run of the Pink salmon (Oncorhynchus gorbuscha (Walbaum)) during the year 1931. By the use of counting fences installed in McClinton creek, Massett inlet, during the spring of 1930 it was planned to determine for the Pink salmon (1) the efficiency of natural propagation, (2) the age at maturity, and (3) the validity of the parent stream theory.

In beginning the programme which was calculated to yield definite data on

the first problem, the mature Pink salmon migrating upstream in 1930 were accurately counted and an estimate was made of the total number of eggs deposited. In the spring of 1931, it was necessary in continuation of the plan, to count the fry, which were the progeny of this run and which were migrating downstream to sea.

This run of fry was similar to the adult run in that it consisted of three species, Coho, Pink and Chum. It was possible to separate these accurately and obtain counts for all.

The first Pink salmon fry arrived at the fence on February 8 but the run did not really begin until February 14. Gradual increase followed to a daily total of approximately 10,000 on April 6. The main migration occurred between April 21 and May 8 when over 71 per cent. of the total or 3,460,000 fish were handled.

The total number migrating between February 8 and June 10, the end of the run, was 4,855,000. 66,155 mature male and female Pink salmon ascended the creek in 1930, and it is estimated that 50,900,000 eggs were deposited. The number of fry migrants amounts to only 9.5% of the number of eggs, which gives a loss during spawning, incubation and early fry period of 90.5%.

D. S. RAWSON

The productivity of lakes in the Kamloops region, B.C., as related to the production of Kamloops trout. A study has been begun of the ecology, and especially the food producing capacity, of Paul lake (chosen as particularly favourable for population studies) and of other lakes in the region for comparison in deciding to what degree, if any, the estimate of fish productivity in Paul lake, as determined by Mr. Mottley, might be applicable to other lakes.

Paul lake is a small (2 square miles), deep (maximum 55 m., average about 30 m.) lake situated near Kamloops at an altitude of 2,500 feet. It is fed by two small streams, one of which comes from Pinantan lake and is used for irrigation purposes. The lake is now several feet lower than in former years and has little or no outflow. The shallow shore area is small, heavily covered with Chara down to a depth of 11 metres. From this point depth increases rapidly to 25 or 30 metres.

The surface temperature rose as high as 20°C. in August but the bottom (50 m.) temperature was always less than 5°. While a marked stratification existed the large volume of cold water retained its oxygen (4.5 p.p.m.) throughout the summer. This condition is quite unlike that in shallow lakes of the vicinity (*e.g.* Pinantan, where summer stagnation is complete and bottom organisms are almost absent below the lower limit of the thermocline, 12 m.).

The bottom fauna contained an abundance of Amphipods (*Gammarus limnaeus* was found at the unusual depth of 50 m.), insects (Odonata and Trichoptera in shallow, Chironomidae in deep water), molluscs (*Physa* and *Lymnaea* in shallow, Sphaeriidae in deep water), and many leeches in shallow water.

The plankton was not rich, quite variable, and the phytoforms seemed unduly scanty. *Daphnia pulex* was most abundant.

The food of the Kamloops trout was quite variable, including chiefly, *Gammarus*, insects (damsel and dragonfly nymphs, caddis and chironomid larvae, as well as the adult insects when they were emerging), the larger gastropods, *Daphnia* and leeches. It was surprising to find many trout up to 1 pound in weight (13 inches) gorged with *Daphnia*.

EDITH STEVENS

Role of diatoms in the food of oysters. In this investigation it was hoped to find whether diatoms are used for food as much as is usually thought—and if they are used, what relationship this might have to the fattening of the oyster. It is known that certain localities are more desirable for this fattening process, but the reasons are not definitely known.

The diatoms were, with a few exceptions, the same in all three species of oysters (*Ostrea lurida, O. gigas,* and *O. virginica*). Besides the ninety determined species found in the digestive tract, there were many smaller species not determined. It was found by actual count of the unbroken specimens that about eighty per cent. of them had protoplasm within the cells before entry. It seems that too much emphasis may be placed upon the use of diatoms as food for the greater part of the content is detritus of some form. A large amount is composed of particles of multicellular plants and sand. By actual count of the unbroken specimens over fifty per cent. of the diatoms found in the digestive canal contained protoplasm. These results need to be checked very carefully. The fact that many of these plants might become crushed in the process of digestion makes for a possible error in the count.

G. H. WAILES

The Protozoa of British Columbia waters. The following new species have been discovered and described,—

Order Amoebaea; *Vexillifera vacillans*
„ Radiolaria; *Challengeron depauperatum*
„ Chromomonadina; *Distephanus octangulatus*
Distephanus pentagonus
„ Peritricha; *Zoothamnium candelabrum*
Subclass Acinetaria; *Trichophrya columbiae*
Podophrya elongata.

W. R. WHITTAKER

Age composition of the pilchard catch as shown by the otoliths. The age composition of the catch is necessary for conclusions concerning depletion, races or racial distribution of the species. In 1929 it was found that determination from the scales was not satisfactory, and otoliths (or ear bones) have since been collected for this purpose.

Otolith material collected during the season of 1930 gave the following results. In Barkley sound the bulk of the pilchard catch was found to be comprised of fish in their fifth, sixth, and seventh years, with approximate average standard lengths of 9.7, 9.8 and 9.9 inches respectively. Fish in their fourth and eighth years were not plentiful. At Nootka the majority of the fish examined for age appeared to be in their fifth and sixth years.

FISHERIES EXPERIMENTAL STATION (PACIFIC)
PRINCE RUPERT, B.C., 1931

INVESTIGATIONS

FRESH FISH INDUSTRY

Further work has been done regarding the characteristics of marine bacteria and their relation to the decomposition of fish by Dr. Bedford. It has been found that some which are active in decomposing fish muscle may grow at temperatures as low as —5°C. Among these are a number of chromogenic

bacteria. The activity of these bacteria at lower temperatures is now being investigated. The practical application of the sodium chloride treatment for the control of the bacterial discolouration of halibut at sea was not carried out, since no satisfactory arrangement could be made with any member of the halibut fleet. The small boat possessed by the Station is wholly inadequate for such experiments. Further laboratory work indicates that when the temperature of the brine is lowered the penetration of the salt into the skin of the fish is reduced. It is the intention to try this modification on a large scale during the next season.

The relative numbers of bacteria existing in various concentrations of salt water such as occur at the mouth of a river flowing into the sea are important from theoretical and practical considerations. Such data are necessary as a basis upon which to elaborate any future work. Investigations carried out at the mouth of the Skeena river and out at sea indicate that the numbers of bacteria decrease rapidly with the increasing salinity.

In order to investigate the change in temperature of fresh fish when stowed in the holds of vessels, special resistance thermometers have been constructed in these laboratories by Mr. Young. A preliminary experiment has been carried out with these instruments on salmon kept under conditions similar to those which obtain in actual practice. Both iced and un-iced samples were used. The above system was found to be satisfactory for this type of work, much of which has to be done at sea under trying conditions.

FROZEN FISH INDUSTRY

Investigations relative to the improvement of cold storage rooms have been continued by Mr. Young with encouraging results. By increasing the cooling coil area the total efficiency of the refrigeration plant is increased whilst the dehydrating effect decreases. These important results are now being checked and extended to include the storage of fishery products. The "jacketed cold storage room" has been found to be very efficient in that it permits of almost constant temperature within the room but at the same time it was found that the ordinary vertical door cannot be made sufficiently air-tight to eliminate exchange of air and hence desiccation still proceeds. Experiments are being made with a horizontal oil-sealed hatch which, at least in experimental work, shows great improvement over the standard refrigerator door.

In connection with the engineering aspects of the preservation of fish by cold storage it was desirable to obtain more data on the thermal properties of fish muscle and insulating material at freezing temperatures. A modified "hot plate" of original design has been constructed. By this device the thermal conductivities of commercial fishes of this coast and a variety of common insulating materials are being determined.

As a result of the study of the growth of marine bacteria at low temperatures by Dr. Bedford it was decided to find the effect of the sodium chloride treatment found so efficient in the treatment of fresh fish. Halibut treated with a 20 per cent. brine solution and kept in cold storage in the usual manner for eighteen months, proved to be in good condition at the end of that time. The oxidative type of rusting which occurs around the napes and cut surfaces is not prevented by this method and further investigations are being made concerning this.

The susceptibility of fish oils to rancidity is of importance in the preservation of fish. This is emphasized in a further study of the chemical changes taking place in the oil of frozen salmon by Messrs. Brocklesby and Denstedt. It appears that oxidation and also a reaction with a nitrogenous substance are involved in the production of "rust." Ammonia hastens the onset of "rusting" and also turns the red pigment of salmon oil to a rusty brown colour. Studies of the

biological and chemical rancidity of salmon oil are in progress. The activity of ammonia-producing bacteria at low temperatures is also being investigated.

SALMON CANNING INDUSTRY

At the request of the industry preliminary experiments have been commenced on the nutritive value of canned salmon, pending the approval of a more extended programme. The preliminary work by Messrs. Brocklesby and Bailey involves the vitamin A and D potency of canned Sockeye and Pinks each from three producing areas. This work is being done on the extracted oils. The physical and chemical properties of the oils are also being found. Since the work may be extended to include a larger number of samples some study is being given to the colorimetric test for vitamin A as applied to salmon oils.

FISH OIL INDUSTRY

The refining of fish oils is a prerequisite to their industrial use. Decolorization is an important process in such refining. At the present time plans are being made for the establishment of a refinery on the Pacific Coast. Information was desired concerning the process as applied to Canadian fish oils. As a result of an investigation carried out this last summer by Messrs. Brocklesby and Moore it has been found that several B.C. deposits of diatomites and bentonites can be used economically to decolorize fish oils. Furthermore, the poorer grades can be cheaply activated by a simple acid treatment.

To form a basis for the industrial investigations concerning the utilization of fish oils the composition of pilchard oil has been determined. The work is completed and will soon be ready for publication.

Industrial applications of fish oils are still being investigated. The investigation by Messrs. Brocklesby and Denstedt regarding the use of pilchard oil in the protective coating industry is almost complete and many valuable data have been accumulated.

It is possible that a fish-oil, edible-shortening plant may be erected on the Pacific coast in the near future. Apart from the general economic depression, there are two reasons why the plans for this new industry have been delayed. First, the Government regulation necessitating the labelling of fish oil products with the words "Made from fish oils," and secondly, the fact that no reliable data were available concerning the hydrogenation of pilchard oil. Through the efforts of the Fisheries Department, the regulation has been amended and the necessary information regarding the hydrogenation of pilchard oil is being furnished by a comprehensive series of studies by Messrs. Brocklesby and Charnley. The rate of reaction and the effect of catalytic poisons which may be met with in fish oils has been determined. Information regarding the correlation of analytical constants has also been accumulated. The research is now concerned with the change in composition of the oil as hydrogenation proceeds.

BY-PRODUCTS INDUSTRY

The investigation by Mr. Smith concerning the possibility of the manufacture of fish glue on this coast has been completed. A simple method of making fish glue from fish waste liquors has been found. Samples of liquid glue have been prepared from the waste liquor of reduction plants and subjected to chemical analysis and joint strength tests. Glues as strong as the best commercial liquid glues can be produced. Three papers have been submitted for publication and a popular bulletin is in preparation.

Several oils from commercial fishes of this coast give high values for vitamin A when tested colorimetrically. These tests are being checked by biological

assays and if confirmed, such oils should constitute a valuable source of vitamin A.

A bacteriological investigation is in progress regarding the utilization of the waste liquors from pilchard reduction plants as a fertilizer. A chemical analysis has been made of the liquor and the action of the material on various types of earths is now being investigated.

MISCELLANEOUS

1. Nass river investigation. The factors involved in the depositing of Nass river mud on the nets of salmon fishermen in the Nass river area have been found by Dr. Martin. Silt particles from the river, precipitated by the sea water, are held together and on the nets by marine organisms killed by the fresh water. The smelter at Anyox (originally suspected of being the cause of the trouble) has been proven to be free of any responsibility in the matter.

2. The phenol co-efficient of some commercial disinfectants. Enquiries are being received concerning the efficiency of commercial disinfectants. Eleven such substances are being tested for the information of the industry by Dr. Bedford.

STAFF

The following comprised the staff of the Station during the year 1931:

Assistant Bacteriologist—R. H. Bedford.
Assistant Chemist (and Acting Director)—H. N. Brocklesby.
Assistant Chemist—L. F. Smith.
Assistant Chemist—O. F. Denstedt.
Assistant Chemist—F. Charnley.
Mechanical Engineer—O. C. Young.
Scientific Assistant (Biochemistry)—B. E. Bailey.
Laboratory Assistant (Chemistry)—P. A. Sunderland.
Laboratory Assistant (Bacteriology)—J. A. Potts.
Laboratory Assistant (Engineering)—D. A. Ross.

SEASONAL

Special Investigator Nass River Problem—W. H. Martin.
Scientific Assistant in Bacteriology—P. T. Black.
Scientific Assistant in Chemistry—L. P. Moore.
Scientific Assistant in Engineering—J. E. Dyck.

BUILDINGS AND ACCOMMODATION

The Station now possesses two well-equipped buildings which should provide sufficient accommodation for some years. The second storey of the new building was completed this spring.

EQUIPMENT

The transfer of the bacteriological laboratories to the new building has necessitated the purchase of considerable new equipment. These laboratories are now well established in the new quarters. All laboratories are now well equipped. In connection with the canned salmon experiments it has been found necessary to obtain a large autoclave and small steam boiler. These were purchased locally and are proving satisfactory. Several new pieces of microscopical apparatus have also been acquired for the above investigation. Other equipment purchased has been largely to replace broken or worn stock.

LIBRARY

About 60 new volumes have been added to the Station library during the past year, bringing the total up to about 500 volumes. In addition, new journals have been subscribed for, 52 now being received by the Station. A subdivision of the library has been made between the two buildings thus relieving to a considerable extent the congestion in the library of the old building.

CONSULTATION

The Station has been consulted by many firms on a variety of fisheries technological subjects. This is becoming a very important part of the duties of the Station and seems to be very much appreciated by the industry. When in Vancouver, members of the staff spend a great deal of their time on this sort of work. The Experimental Station does not undertake commercial analysis.

PUBLICITY

Addresses have been given by various members of the staff before organizations both in Prince Rupert and in Vancouver. The Acting-Director has had several conferences with the Canadian Manufacturers Association, officials and technologists of various fishing companies and brokers handling fisheries products. He has also conferred with technologists and fisheries research workers of the south Pacific coast.

The quarterly Progress Reports, (now published at Prince Rupert) have been issued regularly. The mailing list for this publication is steadily growing, it now being necessary to print 1,000 copies of each issue.

PUBLICATIONS

Progress Reports

No. 7. The control of discolouration or yellowing or halibut. By R. H. Bedford.
The large scale production of fish glue. By L. F. Smith.

No. 8. The new low temperature research laboratory and projected refrigeration research. By O. C. Young.

No. 9. Fish oils as foods. By H. N. Brocklesby.
Marine bacteria. By R. H. Bedford.
Fish glue from fish waste. By L. F. Smith.

No. 10. The Fifth Annual Conference.
The hydrogenation of pilchard oil. By F. Charnley.
The use of pilchard oil in protective coatings. By O. F. Denstedt.
The study of the mud deposits on the gill nets in the Nass river district, British Columbia.

No. 11. The decolorization of fish oils. By H. N. Brocklesby.
Investigations in refrigeration. By O. C. Young.
The growth of some marine and other bacteria at low temperatures. By R. H. Bedford.
Composition and vitamin potency of oils from canned salmon. By B. E. Bailey.

Contributions to Canadian Biology and Fisheries

(series industrial)

No. 1. The nutritive value of marine products. IV. A note on the vitamin A content of commercial pilchard oil. By D. B. Finn.

No. 2. Apparatus for drying oil research. By H. N. Brocklesby and O. F. Denstedt.

(series a general)

No. 18. A deep sea bacteriological water bottle. By O. C. Young, D. B. Finn, and R. H. Bedford.

No. 19. The bactericidal effect of the Prince Rupert water bottle. By R. H. Bedford.

INVESTIGATORS' SUMMARIES

R. H. BEDFORD

1. The control of bacterial discolouration of halibut. In continuing this experiment from the previous year it was intended to ascertain whether the concentration of the NaCl and time of immersion may be reduced and also what would be the effect of lowering the temperature of the solution.

The laboratory work indicated that when halibut was treated with either 15 or 20 per cent. NaCl at 0°C., the quantity of NaCl in or on the skin was about the same, and slightly less in the 1 cm. layer, than when the temperature of the solution was maintained at that of the room. The next step—its practical application—was not carried out for the reason that no satisfactory agreement could be made with any member of the fleet.

Since it was found that NaCl could be used for controlling discolouration and for its partial sterilizing properties, a modification of the method is being used in a practical manner in Great Britain. This is called the "Sterilac" process; the halibut are dipped in brine and then immediately frozen.

An examination of 500 lbs.—about 150 fish—of frozen halibut first treated by our method for controlling discolouration has just been made after the fish had been in cold storage for 16 months. This examination was made in the presence of the general manager, comptroller, superintendent, and a grader of the Canadian Fish and Cold Storage Company, Prince Rupert. There was no discolouration; the white side had remained white, while those that had not been treated were distinctly yellow. Around the poke, *where the glaze had disappeared,* there was slight rusting. It was the unanimous opinion that this method of controlling the bacterial discolouration of halibut was a success.

2. Marine bacteria and their relation to decomposition of fish. The part played by marine bacteria in the decomposition of fish is not known. This information is desired as a foundation upon which to elaborate any bacteriological investigation regarding the decomposition of fresh fish, and the changes that take place in fish in cold storage.

The problem involves a complete classification of the morphological, cultural, and physiological characteristics of individual bacteria, and a tentative classification has been made.

It has been established that numerous marine forms grow at as low as – 5°C. (23°F.). This is of practical importance in regard to iced fresh and cold stored fish. It has also been established that certain marine bacteria can grow over quite a wide range of temperature, as for example – 5° to 37°C. with an optimum of 20° to 25°. Some qualitative work indicates that they are active in decomposing fish muscle. These two factors together indicate that marine bacteria must be considered in any scheme of preservation and shows the necessity for proper stowage and insulation of vessels' holds both for fish intended for fresh and frozen markets.

3. Effect of fresh and salt water upon bacterial numbers and nitrate reduction. In this oceanographical problem the information desired is as to what effect the mixing of fresh and salt water has upon bacterial numbers, whether the reduction of nitrate takes place under any of the conditions presented, and whether the numbers of bacteria in the sea rise and fall with season.

In six months' work it has been found that the mixing of fresh and salt water causes a decided decrease in the number of bacteria. No seasonal fluctuation is at present discernible, and denitrification has not yet taken place.

4. Pilchard effluent as a nitrogenous fertilizer. A preliminary investigation indicated that chemically, the effluent from pilchard reduction plants is rich in nitrogen (10 per cent.) and phosphorus (1.5 per cent.), both calculated on

moisture-free sample, two important constituents for plant growth; and bacteriologically, it is a suitable medium for the production of nitrate nitrogen. This fact has been established by treating a number of different soils with the effluent and measuring a plant food (nitrate nitrogen which may be used as an index of the value of nitrogenous fertilizers), which is made available for the plant by certain groups of bacteria.

It is now intended to measure its effect upon peat soil and other cellulosic material and see whether an artificial manure can be made.

H. N. Brocklesby

The properties of some miscellaneous fish oils. Tests have been made of samples of oil from one or more of the head, body and liver in each of the commercial fishes, halibut, Ling cod, Black cod, Red cod, Grey cod, herring and ratfish. Considerable variation was found in (1) colour in Lovibond units (Y, 0.6—29.9; R, 0.1—9.9), (2) iodine value (86.3—171.5), (3) saponification value (145.5—195.2), (4) unsaponifiable matter (0.20—22.2) and (5) vitamin A in Lovibond blue units with 10 per cent. solution of oil (0—294). The outstanding features were the high vitamin A potencies of halibut, Ling cod, and Grey cod liver oils, such not having been reported for the latter two fishes, though known for the halibut.

H. N. Brocklesby and B. E. Bailey

Determination of the vitamin potency and the chemical properties of oils from B.C. canned salmon. Knowledge of the vitamin potency of B.C. canned salmon is important both to the producer and consumer. Few data are available relative to the vitamin potency of canned salmon in general, and none whatever concerning B.C. products. Samples of oils of canned Sockeye and Pink salmon have been obtained from the Fraser river, Rivers inlet and Skeena river areas. The results of preliminary tests show that vitamin D is present in both species in an amount comparable to that found in cod liver oil. The vitamin A potencies, however, are low. In administering doses for the latter test it has been found necessary to feed the unsaponifiable matter since the low vitamin A potency necessitated feeding of very large doses of oil.

The most interesting facts so far produced by the chemical analyses have to do with the free fatty acid content of the oil. Oils recovered by cold pressing canned salmon always give lower acid values than those prepared by solvent extraction. Furthermore, the acid values of solvent extracted oils vary to a far greater extent than do those of pressed oils. Oils from Sockeye salmon have lower acid numbers than those from Pink salmon, irrespective of the method of extraction. Pink salmon oils are more highly unsaturated than Sockeye salmon oils and preliminary experiments would seem to indicate that the fish of both species caught in the more northerly waters are more highly unsaturated than those caught in the south.

H. N. Brocklesby and F. Charnley

Hydrogenation of pilchard oil. A promising field for the pilchard oil industry of the Pacific Coast is in the manufacture of fats for edible and other purposes. No hydrogenating plants, however, have yet been erected in British Columbia, but there are prospects of one being built in the very near future. Successful hydrogenation depends very largely upon the conditions under which the reaction is carried out, and, since oils vary considerably in composition and properties, the optimum conditions for each oil will be different. Consequently

an accurate knowledge of the effects of all the different factors which influence the reaction must be obtained.

The velocity of hydrogenation of refined pilchard oil in the presence of simple nickel catalyst has been studied by determining: (1) the hydrogen absorption, (2) the change in refractive index, and (3) the change in iodine value during hydrogenation. From these data curves showing the relation between each of the following were drawn: (1) hydrogen absorption and iodine value, (2) hydrogen absorption and refractive index and (3) iodine value and refractive index. The relation in (3) has been expressed in the form of an equation, $n_D^{60} = 1.4474 + 9.6158 \times 10^{-5} + 7.7998 \times 10^{-8} I^2$ where n = the refractive index and I = iodine value.

It was found that very small quantities of organic sulphur (cystine), or organic phosphorus (lecithin), organic phosphorus (lecithin), organic nitrogen (glycine and also the ether extract from decayed cod-fish), fatty acids (total fatty acids from pilchard oil) exercised a very pronounced retarding effect on the velocity of hydrogenation.

H. N. Brocklesby and O. F. Denstedt

1. A chemical study of the rusting of frozen fish and a study of the oxidative rancidity of fish oil. Investigation of the "rusting" of salmon in cold storage, commenced in 1927, but postponed until suitable cold storage rooms were available, has now been resumed, and the following information obtained.

(*a*) The free fatty acid content of the oil of frozen salmon is greater towards the centre of the fish.

(*b*) The acid value (free fatty acid content) is no criterion of the "rusted" condition.

(*c*) Oils from fresh fish are neutral.

(*d*) "Rusted" fish, when extracted with ethyl ether, give oils which appear to be oxidized. Such oils give positive results when tested for rancidity. They also contain large amounts of nitrogen.

(*e*) Oils extracted from "rusted" fish by cooking with water and pressing do not appear to be oxidized. They do not react towards peroxide indicators. They have normal iodine values. It is supposed that the oxidized oil is absorbed by the tissues of the fish and is therefore not extracted by this method.

(*f*) An atmosphere of ammonia hastens the onset of "rusting."

(*g*) Salmon oils stored in ammonia also give a rusty coloured product.

(*h*) From analysis of the "rust" it appears that it is not composed of oxidized oil alone but that nitrogen is present in some form or other.

2. The drying properties of Canadian pilchard oil. It has been desirable to improve certain qualities of pilchard oil films with a view to extending the usefulness of this oil in the paint industry. It has also been desirable to determine the utility of pilchard oil in the waterproofing, patent leather, leather, linoleum, printing ink and other industries, as well as to investigate new fields of usefulness.

The hardness of films has been improved considerably (*a*) by using cobalt linoleate drier alone in concentration of 0.05 to 0.1 per cent., depending on the pigment (cerium preferable to lead); (*b*) by treating the raw pilchard oil with sulphur dioxide gas; (*c*) by incorporation of pigments and fillers such as calcium and barium carbonate; (*d*) by the incorporation of synthetic gums; and (*e*) by the admixture of linseed or China wood oils. Impermeability of moisture has been improved by the incorporation of gums and pigments. Adhesiveness has been improved by decreasing permeability to moisture, and treatment with sulphur dioxide. Yellowing of white pigments in the dark has been overcome by sulphur

dioxide treatment and slight polymerization of oil. Gloss has been improved by (*a*) proper refrigeration of the oil; (*b*) use of polymerized oils; and (*c*) use of cobalt drier alone. Permanence of gloss has been improved by increasing the hardness of the film.

H. N. Brocklesby and L. P. Moore

The decolourization of fish oils. Before they are suitable for industrial use, fish oils must be refined by such processes as alkali treatment, wintering, decolourizing and deodorizing. Little work has been published regarding decolourization, and it has therefore been thought desirable to ascertain the efficiency of standard decolourizing earths and carbons when used with a fish oil (*i.e.* Canadian pilchard oil), and also to investigate the decolourizing power of certain British Columbia earths.

Using a commercial sample of pilchard oil, about 150 experiments were made on a semi-commercial scale. The results may be summarized as follows: (1) None of the domestic earths (such as B.C. diatomite, Bentonite, and volcanic ash) were as efficient as imported activated earths; (2) domestic earths are cheaper and can therefore be used in larger quantities; (3) by a simple acid treatment domestic earths were made as active as imported earths.

W. H. Martin

Study of the mud deposits of the gill nets in the Nass river district, British Columbia. The sinking of gill nets by depositing mud near the mouth of the Nass river was a serious loss to fishermen and cannery operators during the 1929 and 1930 seasons. During those two seasons preliminary studies were made by the Experimental Station but no definite conclusions were made as to the cause of the phenomenon.

During 1931 a microscopical analysis of the silt from the Nass, and deposits from the nets were made. It was found that they were identical in character but entirely different from the material discharged by the Anyox smelter, which had previously been suspected of being the cause of the trouble.

The mud on the nets was found to be attached by means of gelatinous strands of jellyfish and other marine organisms. The trouble occurred when the marine life in the sea was most abundant.

Furthermore the phenomenon was always preceded by exceptionally high tides which caused rapid mixing of large amounts of silt containing Nass water with sea water containing abundant sea life. The sea water precipitated the river silt which deposited on the marine organisms which were killed by the fresh water.

L. F. Smith

1. The joint strength of fish glue. A study was made of the adhesive strength of liquid fish glue in wood joints. Commercial samples and samples prepared in the laboratory from fish waste were tested. The procedure developed by the U.S. Forest Products Laboratory was employed. Strips of maple wood were glued together and then broken in shear in a testing machine, the load at failure being calculated in kilograms per square centimetre of glued area. The majority of the glues were stronger than the wood, strength values up to 200 kg. per sq. cm. being recorded.

High viscosity and concentration of the glue solution and lengthened assembly time were effective in producing strong joints when joining pressures of 3-14 kg. per sq. cm. were employed. The effect of atmospheric humidity

was slight below 75 per cent. relative humidity; at higher humidities joints were seriously weakened by softening of the glue.

2. The examination of fish glue. A study has been made of the methods of evaluating liquid fish glue. The joint-strength test is considered the one thoroughly reliable test by which the value of a glue as an adhesive may be determined. The viscosity of a glue measured under standard conditions bears little or no relation to the strength of joints the glue is capable of producing. Low hygroscopicity indicates a glue which is faster drying and more resistant to atmospheric conditions. The determination of the gel-point gives no information of assistance in judging the adhesive properties of a glue. A test for the speed of set is shown to lack sound theoretical foundation. The ash, chloride and solid contents are the most important chemical data. The hydrogen-ion concentration is of little value in practical glue testing. Result of protein precipitation analyses by use of magnesium sulphate cannot be correlated with the behaviour of glues in actual service.

3. Preparation of liquid fish glue by the dialysis and electro-dialysis of fish waste liquors. The waste effluent liquors of plants engaged in the manufacture of fish meal from fish waste contain glue. The purification of these liquors to make glue involves the separation of salt and diffusible substances from the glue colloid. Simple dialysis using viscose tubing and electro-dialysis using membranes of parchment paper are effective in removing impurities and producing glue of good quality from waste liquors. Both methods can be used on an industrial scale, the dialysis process being the simpler and more efficient.

O. F. YOUNG

1. Cooling coils. It seemed desirable to determine interrelationships between (1) area of cooling coils in refrigeration of a cold storage room, (2) temperature of the cooling medium, (3) outside temperature, and (4) dehydration. One to three "banks" of cooling coils have been used, and outside temperatures of 60°, 70°, and 80°F., with a temperature inside of 10°F. For example it was found that with an outside temperature of 60°F., and with one, two, and three "banks" of coils, the temperature difference between the circulating brine and the inside air was 16.4°, 10.0° and 8.0° respectively, and the dehydration 0.050, 0,036, and 0.030 lbs. per square foot per day respectively.

2. Improved cold storage rooms. To obtain a non-dehydrating cold storage room, for the storage of frozen fish, a jacketed cold storage room was constructed having a metal-covered inner compartment, surrounded by a 2-inch air space in the form of a continuous duct which commences at the discharge of a circulating fan, spirals about the room, passes under the floor and ends at cooling coils situated in a "bunker" overhead. An anteroom adjoins one side and is so arranged that the fan may be made to circulate the air in the anteroom as well as about the room itself before the door into the inner compartment is opened. The main insulation encompasses both the room and the anteroom but only the jacket separates the two chambers.

It has been found: (1) that the temperatures at the top and the bottom of the room do not differ from each other more than half a degree Fahrenheit; (2) that small fluctuations in the temperature of the cooling brine do not perceptibly affect the temperature in the room; (3) that opening and closing the doors between anteroom and jacketed room have no perceptible effect upon the temperature of the jacketed room; (4) that slight dehydration still proceeds due partly to leakage about the door (verified by taping with rubberized tape),

and partly to leakages in the metal covering elsewhere than the door; (5) that with an absolutely air tight inner compartment dehydration does not take place (verified by constructing a small metal airtight box having oil seals for all openings); and (6) that a horizontal hatchway lends itself well to the employment of an oil seal, and presents a means of access that facilitates securing absolute air-tightness when closed.