

ANNUAL REPORT

ON THE WORK
OF THE

Biological Board of Canada

FOR THE YEAR

1930

OPERATING UNDER THE CONTROL OF

HON. E. N. RHODES
MINISTER OF FISHERIES

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OTTAWA
1931

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REPORT OF THE WORK OF THE BIOLOGICAL BOARD OF CANADA

FOR 1930

The Biological Board, which operates under the control of the Minister of Fisheries, was created in 1912 by an Act of Parliament. For a number of years the Board was composed entirely of scientists, and two stations for purely scientific and fundamental research were operated for a few months yearly.

In order to bring the Board into closer contact with the work of the fishing industry and the practical problems which arise from time to time in the industry, it was decided to reorganize the Board by adding to its membership men directly concerned with the practical business of the industry. Consequently in 1923 the Act was amended for this purpose.

The Board as reorganized now employs a permanent staff of scientists and operates four research stations. Two Stations, known as Biological Stations, one at St. Andrews, New Brunswick, and the other at Nanaimo, British Columbia, are mainly concerned with the more purely scientific and fundamental problems, while the other two, known as Fisheries Experimental Stations, one at Halifax, Nova Scotia, and the other at Prince Rupert, British Columbia, deal with practical problems arising in connection with the handling, preservation and marketing of fish.

At Eastern Passage, near the entrance to Halifax Harbour, a laboratory was built three years ago by the Department of Marine and Fisheries for research and instruction in marine biology, mainly in connection with the scientific course in fishery matters established at Dalhousie University. The resources of the laboratory, however, are available to students of any Canadian university. The Board was asked to assume the responsibility of supervising and maintaining the laboratory and to use it for such purposes as may be necessary, but so far it has not been of much direct use to the Board.

In addition to these a field station for the investigation of sockeye salmon is maintained at Cultus Lake, British Columbia, and a sub-station for oyster investigation has been established near Ellerslie, P.E.I.

As a result of the handing over, to the Provincial Governments concerned, of complete control of the natural resources including the fisheries of the Prairie Provinces, no provision is now made by the Federal Government of funds to carry on scientific work in these provinces. Consequently the work of the Board is now confined to the Atlantic and Pacific Provinces.

The Board during the year 1930 was composed of the following:

- Professor J. P. McMurrich, Toronto, Chairman.
- J. J. Cowie, Ottawa, Secretary-Treasurer.
- Professor R. S. Bean, Halifax, Nova Scotia.
- Professor A. T. Cameron, Winnipeg, Manitoba.
- Professor Arthur F. Chaisson, Antigonish, Nova Scotia.
- Professor Philip Cox, Fredericton, New Brunswick.
- John Dybhavn, Prince Rupert, British Columbia.
- Professor A. H. Hutchinson, Vancouver, British Columbia.
- Professor W. T. MacClement, Kingston, Ontario.
- Professor Marie-Victorin, Montreal, Quebec.
- Professor H. G. Perry, Wolfville, Nova Scotia.

Professor E. E. Prince, Ottawa, Ontario.
 J. A. Rodd, Ottawa, Ontario.
 Professor W. P. Thompson, Saskatoon, Saskatchewan.
 Doctor R. C. Wallace, Edmonton, Alberta.
 A. Handfield Whitman, Halifax, Nova Scotia.
 Professor A. Willey, Montreal, Quebec.
 Professor Alexandre Vachon, Quebec, Quebec.

SUMMARY REPORT OF ATLANTIC BIOLOGICAL STATION, ST. ANDREWS, N.B.
 1930

The following constituted the staff of the Station during the year 1930:

Dr. A. G. Huntsman, Director.
 Dr. R. H. M'Gonigle, 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 (Aquiculture).
 Mr. E. G. Rigby, Curator.

SEASONAL

Prof. P. M. Bayne, Scientific Assistant.
 Dr. K. E. Carpenter, Scientific Assistant.
 Prof. A. F. Chaisson, Scientific Assistant.
 Mr. R. B. Kerr, Scientific Assistant.
 Mr. R. R. Langford, Scientific Assistant.
 Mr. J. M. Morton, Scientific Assistant.
 Mr. E. Pentland, Scientific Assistant.
 Dr. D. S. Rawson, Scientific Assistant.
 Mr. J. G. Rempel.
 Mr. H. P. Sherwood, Scientific Assistant.

The Atlantic Biological Station is situated in proximity to the most concentrated, varied and continuously active shore fishery, of which we have knowledge. At the same time it has a remarkably central location for relations with the ten universities of eastern Canada, upon which the fisheries work must depend for much expert knowledge and assistance.

The staff for the year has consisted of (1) five full-time investigators, (2) two employed for the year, but on a scholarship basis, one from Dalhousie, and the other from New Brunswick University, (3) six seasonal investigators, one from England, and one from each of the following universities: Acadia, Dalhousie, St. Francis Xavier, McGill, and Toronto; and (4) twenty-five volunteer investigators connected with the following universities: Acadia, 2; St. Francis Xavier, 1; New Brunswick, 1; McGill, 8; Queens, 2; Toronto, 9; and Western, 2. Of the employed staff four were at the Station and nine were at different points on the coast. Of the volunteers three were elsewhere on the coast, and twenty-three were at the Station. During the autumn an additional investigator has been added to the employed staff, and two additional volunteers (graduate students at the University of Toronto) have undertaken the investigation of Canadian Atlantic problems.

INVESTIGATIONS OF PARTICULAR ECONOMIC SPECIES

Salmon.—Messrs. R. B. Kerr and A. A. Blair have begun a comparative study of the salmon population in three important, widely separated rivers in the Maritimes, the St. John in southern New Brunswick, the Miramichi in

northern New Brunswick, and the Margaree in Cape Breton Island. A more intensive study is being made of the Miramichi fish in an effort to differentiate an early-run from a late-run type.

Lobsters.—Prof. A. F. Chaisson and Mr. W. Templeman made studies of the lobster population on several sections of the coast as the beginning of investigations designed to determine the validity of different regulations for the fishery in the different sections, and to lay the basis for a proper policy of conservation. They also tagged a considerable number of lobsters in order to ascertain the nature of their migrations.

Oysters.—Mr. H. P. Sherwood, Dr. A. W. H. Needler, Dr. A. B. Needler, and Mr. E. T. McEvoy prosecuted their investigations on the oyster from their base near Eglarville, Prince Edward Island. Dr. A. W. H. Needler has carried through a considerable variety of planting and transplanting experiments with oysters of different sizes and in different places, and has also been determining the conditions of spawning and of setting of spat in the Bideford river. Mr. Sherwood attempted tank culture of the oysters and three tanks were used, with the object of determining the conditions that favour spawning and setting of the spat. Dr. A. B. Needler studied the rate of growth in the oyster and the proportions of the sexes in the various ages.

Shad.—Prof. P. M. Bayne experimented with the hatching of the eggs of the shad on the Shubenacadie river in preparation for a large practical experiment next year.

Capelin.—Mr. G. W. Jeffers continued his studies on the capelin in the strait of Belle Isle, finding out what temperatures and salinities are suitable for the development of the eggs, what the conditions are that determine spawning, and how rapidly the fish grow and mature.

Herring.—Mr. W. E. MacFarland has begun a study of the herring of the Passamaquoddy region as to food, distribution of various sizes, possibility of distinct races, and temperatures for successful development of the eggs.

Clam.—Mr. C. L. Newcombe has taken the clam as a type of the animals inhabiting the intertidal zone, and is attempting to disentangle the various factors that limit its distribution, abundance, and rate of growth.

Round Whelk.—Miss M. M. Melville began an investigation of the life-history of this bait animal, which has been much sought after by the bank fishermen under the name of "cockle".

OCEANOGRAPHY

Investigations in this field form a necessary basis for assistance to the industry in the proper prosecution of the various fisheries.

Mr. H. B. Hachey took charge for the Department of Fisheries of an expedition to explore the resources of *Hudson bay*. There was complete failure to find any commercial deep sea fish in the bay. The hydrographical and biological material is being worked up by a number of specialists in order to determine what adverse conditions may be responsible for this negative result.

A start has just been made to definitely assess the resources of the *bay of Fundy*. The general investigations that have been carried on from the Station for a series of years have provided a fair understanding of the complicated series of factors that determine the nature of the variable fisheries of the region. Professor Bayne has been making a detailed comparison of the conditions at the mouth and head of the bay, which exhibit a very great contrast, the reasons for which are not entirely clear. Dr. V. Vladykov has just begun an analysis of the monthly fishery returns from the different districts for the last ten years in order to relate, if possible, the actual takings with the conditions that have

been found to exist. This is to be checked up by direct enquiry of those engaged in the fisheries and by systematic fishery experiments.

A full explanation is being sought of the extraordinary richness of the fisheries of the *Passamaquoddy region*, owing to these being jeopardized by projected power construction. Mr. Hachey has been investigating the mixing at the reversing falls of the St. John river in comparison with that at and near the mouth of Passamaquoddy bay. Dr. E. E. Watson has attempted to analyse the complicated movements at the head of the bay by a novel method, involving the use of depth drags to log the currents. Mr. J. M. Morton and Mr. Hachey have been determining the distribution of the phosphates throughout the region and throughout the year, as these are believed to be responsible for limiting the growth of the vegetable matter that forms the ultimate food of the fishes. Prof. A. Cameron has begun a similar investigation of the silicates. Miss V. M. Davidson has continued her census of the diatoms, which are taken as typical vegetable forms to serve in the elucidation of the fluctuations in the ultimate fish food.

A number of basic studies are in progress, consisting of (1) periodicity of spawning in shell-fish by Dr. H. I. Battle, (2) effects of low temperatures on various marine animals by Mr. M. H. Friedman, (3) effects of various kinds of light on marine organisms, by Dr. A. B. Klugh, and (4) the penetration of light into sea water by Mr. W. R. Sawyer.

FISH DISEASES

Dr. M'Gonigle has had to deal with a considerable variety of diseases and death losses in fish, such as "white spot" in the salmon, ulcers in the flounder, various diseases in the trout, varied losses in the hatchery service largely attributable to unusual climatic conditions, and destruction of salmon through industrial pollution.

Miss A. Alley has continued to investigate and follow the course of the protozoal infection of the young ('sardines') and old herring of the Passamaquoddy region, that has seriously affected the large industry based upon these fish.

FISH PHYSIOLOGY

Fundamental investigations of the functioning of the various systems in the fish have been prosecuted during the year largely as a result of the interest and direction of Dr. B. P. Babkin. These consisted of the following,—(1) the chemical mechanism for the secretion of the digestive juice of the pancreas by Dr. Babkin, (2) the control of respiration by Drs. Babkin and M'Gonigle, (3) the elimination of urea in the gastric juice by Dr. Babkin and Dr. S. A. Komarov, (4) the action of 'hormones' on the circulation, by Dr. M. E. MacKay (in part with assistance of Dr. Komarov), (5) the dependence of digestion on temperature, by Mr. J. V. V. Nicholls, and (6) the action of 'hormones' on the heart, by Miss M. E. Huntsman.

WORK IN RELATION TO FISH AS FOOD

Experiments were conducted in an effort to determine the reasons for deterioration, that had been observed to occur under certain conditions in the cold storage of rapidly frozen fish. Mr. Morton and Dr. D. J. Bowie were associated in this work.

Mr. N. E. Gibbons continued his attempts to differentiate between autolysis and bacterial action in the decomposition of fish, and Mr. A. S. Cook explored various fishes and marine animals as to the occurrence of trimethylamine oxide, which is associated with the objectionable odour in decomposition.

Dr. Komarov compared haddock skin, haddock flesh, and beef in value for causing the secretion of the gastric juice in the dog, as an indication of their comparative value for man, and they were found to range in importance in the order given.

Controversy in the fish industry as to the need of retaining the slime on fish has been responsible for the initiation of work on the biochemistry of the various kinds of slime on the skin in fishes, and in particular those of the haddock and of the slime-eel, by Messrs. J. Campbell and H. W. Lemon.

FISH CULTURE

The *Trout* investigations by Mr. H. C. White have been continued along the following lines,—(1) natural food of larvae and later stages, (2) application of previous results in an effort to lessen the loss of fry in streams with limited control, (3) effect of character of feeding on egg production in fish held to furnish eggs for hatchery purposes, and (4) factors determining successful hatching in nature.

The plans formulated for a thorough attack upon the fish cultural problem have been carried through the initial stages. A hatchery for varied experimental work has been erected on the property of the Station and is being utilized for the first time this winter. Considerable preliminary study has been made of the problem of water supply. Dr. K. E. Carpenter has completed her enquiry into the reasons for the unfavourable character for fishes of the water from the Chamcook lakes as delivered at the Station, and remedial measures are being arranged. Local sources of water supply are being developed for alternative experiment on this most important matter in hatchery practice. Open troughs and pools for carrying and rearing fry have been constructed, and some have been in operation during the season, in particular in experiments by Dr. M'Gonigle on the comparative value of different foods for fry.

For the marine side of the fish cultural problem, a dam has been erected across Tidal cove, near its mouth, which brings into control an extensive area of tidal water for the location of regulated tidal pools to serve in separating out the factors that determine successful culture of forms such as oysters and clams.

The services of Dr. G. C. Embury of Cornell University were secured for a short period for consultation in connection with the general plans for fish cultural investigation.

In Ontario, Mr. E. S. Pentland has conducted surveys and experimental work to serve as a basis for the development of a system of culture of fresh water shrimps (amphipods) for fish food.

LAKE SURVEYS

A proper foundation for a rational system of fish planting is sadly lacking. Fundamental for this is a knowledge of the factors that make lakes suitable for any given kind or quantity of fish.

In Saskatchewan Dr. D. S. Rawson, with the assistance of Messrs. J. G. Rempel and R. R. Langford, has continued his work on the lakes of Prince Albert National Park, dealing this year with the fish food in Waskesiu lake and the fish and life conditions in Sandy lake. Experimental introduction of black bass and speckled trout is projected and the way therefor has been prepared.

In New Brunswick a comparative study is being made of the connected series of four lakes going by the name of the largest—Chamcook. Conditions are being followed throughout the year by Mr. M. W. Smith, and an experimental fertilization of the second smallest (Gibson) with sea mussels has been made. The principal food organisms for small fish are being studied by Mr. C. J. A. Hughes and Dr. K. E. Carpenter.

Six experimental concrete ponds at the Station have been in continuous use in an analysis of the factors that may determine life conditions in relatively quiet waters, such as that of lakes. Two of the ponds have been utilized to determine the efficacy of a relatively small amount of herring meal in increasing the production of plant and animal life. This is to assist in formulating a policy for the fertilization of lakes with fish meal, as projected for one in Jasper Park.

MISCELLANEOUS ACTIVITIES.

Apart from the investigations that form the prime object of the Board's work, the members of the staff are called upon to give assistance in various ways. There is a steadily increasing number of requests (a large proportion coming through the Department of Fisheries) for information and for the examination of material of various kinds, and these can be handled but slowly owing to the exigencies of the main work. There has been a similar increase in the number of individuals (chiefly from the fishing industry) soliciting interviews both at St. Andrews and Toronto for the purpose of securing information at first hand. There has been a marked accentuation in the demand for addresses and written articles in connection with the fisheries and the work of the Board, and many important requests have had to be refused. Only casual attention has been given to this phase of the Board's work, which, if properly handled, would be of most considerable value. The time is ripe for it to receive special attention from the Board, which it has never had.

Reference has already been made to the assistance given to the Department in connection with fish mortality and the Hudson Bay expedition. In addition Dr. M'Gonigle's services have been utilized by the International Fact-finding Commission in its investigation of the fisheries of lake Champlain, involving field work on both the winter and the spring fishery, and extensive laboratory work now in progress.

Reference should also be made to the fact that this Station accomplishes the Canadian portion of the work that is reviewed for cooperative purposes by the North American Council on Fishery Investigations. This definitely links it with the similar attack on the general fishery problem of the high seas that is being made by the United States, by Newfoundland (just being initiated), and by France.

Apparatus in connection with fisheries investigation and fish handling, much of it consisting of specially constructed models, as well as samples of frozen fish, was furnished to form part of a fisheries exhibit by the Department, which was displayed on three different occasions, twice at Montreal and once at Lunenburg. The museum and aquarium at the Station have been put into better condition.

FISH FREEZING

The completion of a satisfactory demonstration of the saleability of frozen fish (Ice Fillets) in the Toronto market, has removed the need for more than a limited amount of freezing, which has been largely confined to flounders and salmon, except for use in the Station residence. Progress has been made with the testing out of the principles involved in the satisfactory operation of the automatic freezer, and the success attained paves the way for the construction of a commercial model.

The experiment in the production and sale of Ice Fillets has revealed many deficiencies in the current methods used by the industry in storing and handling frozen fish, and, in face of these, rapid freezing is in vain except for short storage. Damage in storage results more readily in fat fish such as herring, salmon, and mackerel, than in ground fish like cod and haddock. An attack

has been made on this problem of ensuring adequate cold storage with a minimum of expense, but the factors involved in deterioration of the frozen fish have not yet been sufficiently clarified. It has not as yet been possible to operate the new automatic jacketed cold storage in proper fashion, owing to the lack of a steady and sufficient supply of electric current for automatic operation.

In addition to following the sale of Ice Fillets and investigating the marketing of fish in Toronto, Mr. R. A. McKenzie has conducted experiments in the rate of defrosting of blocks of fish under various conditions, so as to provide definite facts connected with the handling of frozen fish by retailers and consumers.

Experiments in freezing oysters, clams, scallops and lobsters in cakes similar to Ice Fillets have been attended with complete success, which opens up a considerable field whenever proper conditions for storage and marketing are available.

IMPROVEMENTS

A piece of property has been secured on a branch of Richmond bay, near Ellerslie, Prince Edward Island, and a small two-storey laboratory has been erected thereon. This establishes a permanent sub-station, primarily for oyster investigation, but also for the study of all the fisheries and conditions peculiar to the Magdalen shallows, as the shallow southern portion of the Gulf of St. Lawrence is called. Three oyster ponds have been constructed in connection with this laboratory.

A hatchery has been erected and fry troughs in connection therewith constructed on the property of the Station at St. Andrews. A concrete tank has been built on the hillside above to receive local water for winter use in the laboratory and for re-circulation in the hatchery, as a safeguard and an economic alternative to the regular water supply through a long surface pipe from the main of the Algonquin Hotel.

Land bordering on Tidal cove at the head of Passamaquoddy bay has been secured, this also in connection with fish cultural investigation. A dam has been built cross the cove, preparatory to the construction of ponds with tidal control. A start has been made in the construction of pools to utilize the fresh-water of the brook at the head of the cove for rearing fish.

A hot-water heating system has been installed in part of the laboratory in such a way as to make sufficient heated space available for the winter work that is being carried on and to permit of later extension to the whole building.

Under the superintendence of the Curator and the Master of the "Edward E. Prince", a new boat, the "Zoarces", powered with a crude-oil engine and ninety feet in length, has been built at Shelburne, N.S., by the Fisheries Experimental Station and is now in process of equipment. Owing to her small size, the "Edward E. Prince" has been inadequate for the work of deep sea fisheries investigation carried on by the Atlantic Biological Station and the "Zoarces" is to be made available for it.

PARASITES OF THE HERRING

BY

A. ALLEY, *University of Toronto*

From May till September records were made of the number and degrees of herring parasitized. In all 29 lots, with approximately 100 fish in each lot, were examined. From each lot three herring were taken, one badly diseased, one slightly diseased, and one apparently free from parasites. Sections from each fish of the organs involved in the disease were prepared and put on slides, and blood smears were also made from these herring and the stomach contents inspected. For comparison sections were made of tissues from three flounders (two diseased), one skate, and one haddock. The records of the diseased fish are being worked over, and the slides stained and inspected.

FISH RESPIRATION AND DIGESTION

BY

B. P. BABKIN, *McGill University*

1. Investigation of the respiratory mechanism in skate, which was begun in collaboration with Dr. R. H. M'Gonigle during the summer of 1929, was continued with him during the summer of 1930. It was demonstrated that the depression of the peripheral part of the reflex mechanism regulating the respiratory movements by cocaine, or its stimulation by mechanical irritation of the mucous membrane of the mouth, changes the reaction of the animal to the normal stimulus, that is, water. Besides the reflex mechanism the respiration in skate is regulated by the automatic activity of the respiratory centre, which is incomplete, and weakly influenced by the changes in the blood circulation and oxygen supply. Therefore, the respiratory mechanism in skate is two-fold, being due partly to the automaticity of the respiratory centre, and partly to reflex stimulation.

2. The effect of intravenous injection of histamine, acetyl-choline, choline and adrenaline on the spontaneous pancreatic secretion in skate was studied. Histamine ($\frac{1}{4}$ to 50 mg.) produced hardly any effect on the flow of the pancreatic juice, a slight acceleration of the secretion being noted in some cases, in other cases a slight inhibition. The usual effect of acetyl-choline (1 to 10 mg.) in these experiments was an inhibition of the spontaneous pancreatic secretion, and this probably because it greatly increased the blood pressure. Large doses of choline, (from 100 mg. to 1 g.) did not produce any inhibition of the pancreatic secretion, as did acetyl-choline, and it is doubtful if it gave any increase. The conclusion which may be drawn from these experiments is that parasympatheticomimetic drugs which activate the pancreatic secretion in mammalian animals do not stimulate the pancreas in the skate. Intravenous injection of adrenaline (1 cc. 1/10,000; 1/1000) produced a marked inhibition of the spontaneous pancreatic secretion. The action of adrenaline in this case may be explained in the same way as the analogous action of acetyl-choline, i.e., by vaso-constriction and diminished supply of blood to the gland.

3. Since it was known that the products of nitrogenous metabolism are eliminated in skate through the gills and with the bile (urea), it was interesting to determine whether they also pass into the gastric secretion. Conjointly with Dr. S. A. Komarov I investigated the presence of urea in the gastric contents and in different fluids (water, 5% alcohol) introduced into the stomach and kept there for a certain period of time.

Urea was found in all three materials. The maximal figure determined by us for the concentration of urea in the alcoholic fluid (kept in the stomach for 3 hours) was 0.863 gm. %. In general the higher the acidity of the fluid, the greater was the concentration of urea in it. It may be presumed that urea is excreted into the stomach, but further experiments are necessary.

THE SPAWNING OF CERTAIN COMMON BIVALVES

BY

H. I. BATTLE, *University of Western Ontario*

Systematic examinations of the gonads of the following species were made:

- (a) *Yoldia saponilla* (Gould)—Dredged in 20-30 metres, St. Croix Estuary, off Biological Station. July 14th-September 18th.
(Deep sea clam)
- (b) *Mya arenaria* L. —Mud flats at Biological Station. June 17th-September 18th.
(Soft shell clam)

- (c) *Mytilus edulis* L.
(Mussel) —(i) Rocky ledges at Biological Station.
June 18th-September 18th.
(ii) Muddy gravel at Birch Cove.
August 14th-September 18th.
- (d) *Macoma baltica* L. —(i) Mud flats at Biological Station.
July 13th-September 18th.
(ii) Mud flats at Birch Cove. August
2nd-September 18th.

While the data from the preserved material are as yet incomplete the gonads of littoral forms (*Mya*, *Macoma*, *Mytilus*) seem to mature during the new moon spring tides while the germ cells are discharged during the remainder of the tidal cycle (i.e. subsequent neap, full moon and neap tides). This may perhaps be correlated with the fact that during the summer months the low water of the new moon spring tides falls in the early morning or evening, in which case the temperature of the exposed littoral forms will only be raised a very few degrees over that of the water. Low water during the neap tides occurs nearer mid day when the air is heated by the sun. The temperature of the littoral forms on days of strong sunlight may be raised as much as ten degrees Centigrade above that of the water covering them at high tide. It has been shown in the laboratory that an elevation of temperature favours the discharge of the germ cells from a mature gonad. This fact lends weight to the assumption that the increased temperature during the low water of the neap tides (following the new moon spring series) initiates a discharge of the germ cells which have been maturing during the previous new moon springs. The discharge of the ova and spermatozoa once commenced usually reaches a peak prior to the full moon springs and thence falls to a low level by the time of the succeeding new moon spring tides. *Yoldia sapotilla*, the deep water species, appears to have an incomplete spawning during both new and full moon spring tides.

HATCHING SHAD EGGS UNDER ARTIFICIAL CONDITIONS

BY

P. M. BAYNE

Actual hatching of shad eggs at Elmsdale on the Shubenacadie river was carried on May 23-June 24, 1930. Spawning must have commenced on or before May 13, 1930, at some point above Elmsdale. The percentage of dead eggs for catches of one hundred and over was not in direct proportion to the number of eggs caught. It is possible that the larger catches of eggs were spawned by fewer fish and before being caught may have been spawned for a shorter time than the smaller catches. The three largest catches of eggs all occurred within six days after the only freshet of the spawning season. During that time the daily maximum temperatures of the river water ranged from 17°-21°C. The river temperature varied from a minimum of 8.5°C. to a maximum of 26.0°C. during the period of hatching.

Attempts were made to hatch eight series of eggs in salinities of 0.0%, 0.5%, 1.0%, and 1.5% at temperatures of 8°, 12°, 17°, and 22°C. These temperatures actually worked out to be 7-11°, 11-15°, 16-19° and 21-22°C. respectively. Eggs, the appearance of which seemed doubtful, lived longer at 17°C. and a salinity of 0.5% than did apparently normal eggs at the same temperature and salinity. Eggs held at 22°C. were either attacked by *Saprolegnia* species or all died at approximately the same time irrespective of the salinity. The largest number of apparently normal larvae was hatched at a temperature of 12°C. (11°-15°C.) and a salinity of 1.0%. Eggs collected when the temperature of the river water was 17°C. or more produced the most normal larvae.

INVESTIGATION OF THE ATLANTIC SALMON

BY

A. A. BLAIR AND R. B. KERR

Investigations conducted upon the Atlantic salmon during the summer of 1930 consisted chiefly of the collecting of data and material (length, weight, sex, and a sample of the scales) from fish caught in the Miramichi river, New Brunswick, during June, the Margaree river, Cape Breton island, and the St. John river, New Brunswick, during July. About 400 fish were examined from each locality. During August, September and October a trap-net was operated on the North-west Miramichi river, New Brunswick, for the purpose of obtaining material after the closing of the commercial season, and thus to follow the run throughout the whole season. Samples of smolts and parr were also obtained from the Miramichi river. Arrangements were made to have material collected and forwarded from Lake Shubenacadie, Nova Scotia, and from Loch Lomond, New Brunswick, this material being obtained from the so-called land-locked salmon of these lakes.

This material is now being examined at the University of Toronto in an attempt to compare the fish from various localities in regard to length, weight, length of time in fresh water, length of time in the sea, rate of growth, time of maturity, and the proportion of previously spawned fish. The material obtained from the Miramichi river will also be examined and analysed in an attempt to determine any differences in the fish throughout the season.

HISTOLOGICAL INVESTIGATIONS OF FISH

BY

D. J. BOWIE, *McGill University*

1. It was found that solutions or mixtures that require warming before injection are unsuitable for fish pancreas, since the necessary heat coagulates the tissues of fish. After many trials with various cold mixtures containing salts of bismuth opaque to X-rays, a suspension colloid was made up which would penetrate into the minute ducts without becoming diffused into the surrounding tissue. By the use of this colloidal mixture followed by the Spalteholz oil-of-wintergreen method of making tissues transparent and by subsequent radiographs, it was possible to make a comparative study of the duct system in the pancreas of four species of skates.

2. Pancreatic tissues were obtained from many skates and after fixation by various methods were preserved for subsequent examination of the islands of Langerhans and the system of ducts, by means of paraffin sections.

3. Tissues from the stomach of various species of skates were obtained for subsequent study of the secretory cells forming its epithelial lining.

4. Tissues from the duodenum of various species of skates were obtained for subsequent study of certain large eosinophil cells observed near the pancreatic duct in tissue obtained by Dr. Babkin in 1929.

5. The blood supply of the pancreas of skates was found to be from two sources, namely (1) the coeliac axis, and (2) the superior mesenteric artery.

6. A certain amount of time was spent in studying frozen sections of fish muscle, frozen and preserved in the refrigerator under various conditions.

SILICATE CONTENT OF NATURAL WATERS

BY

A. CAMERON, *University of New Brunswick*

An investigation was begun to determine the distribution of silicates in the waters of the St. Andrews region, using the methods developed by Atkins and

King, with whose determination direct comparison was possible by means of a standard sample, kindly supplied by Dr. King. A large number of determinations in Passamaquoddy bay and the St. Croix river showed so little order that the procedure was subjected to scrutiny. While weathered citrate of magnesia bottles had been reported as satisfactory, it was found that they could not be relied upon, giving diverse results with the same samples. The results previously obtained had to be discarded.

Only by September was a satisfactory method of handling the water samples available, paraffined cardboard cans being used. Consistent results are now being obtained and some order is apparent. The most striking result is the finding of more than twice as much silica in the Chamcook lakes as in the salt water.

THE CHEMISTRY OF HADDOCK SLIME

BY

J. CAMPBELL, *University of Toronto*

For an analysis of the components of fish slime, haddock caught on the line trawl were kept alive in a tank of running water till desired to provide material for study; or slime was collected from haddock about to be taken to market.

At first the haddock were placed in tap water immediately after death and the copious loose slime then taken after 2 to 4 hours. Later, however, the slime was scraped from the fish immediately after death as some of the mucoprotein is apparently lost by solution in the tap water.

Three definite fractions were found in the slime, (1) a mucoprotein, (2) a protein which is apparently a phosphoprotein, and (3) lipoid matter. An attempt was made to obtain mucoitin-sulphuric acid from the mucoprotein but the results on investigating the properties of the product were not definite.

The method finally used was to extract the mucoprotein from the slime by distilled water, evaporating down and precipitating by alcohol; and the residue dissolved in 0.01% alkali and precipitated by acetic acid (repeated) gave the phosphoprotein.

The presence of the mucoprotein has been positively shown by the strong reduction of Fehling's solution on hydrolysis in 5% sulphuric acid, and by the preparation of an osazone from the liquid which melted at 172°C, decomposing at 175°C (uncorrected). Dissolved in concentrated hydrochloric acid it gives a blue colour (Liebermann's reaction) which is believed to be the same as the blue colour produced when fish are preserved in carbon dioxide snow.

An attempt to prepare purine bases, which show the presence of nucleoprotein, from the acetic acid precipitate was negative or very slight, and the latter is classed tentatively as phosphoprotein.

FRESH WATER INVESTIGATIONS

BY

K. E. CARPENTER

A. Enquiry into the causes of the harmful action of the Station tap-water on fishes, and experiments in remedial treatment.

Responsibility for the harmful action was definitely fixed upon the presence of metallic substances derived from the galvanized lining of the supply-pipe; such action was found to be strongest in spring, when the rush of water (which has been turned off during the winter) causes old deposits to scale off, exposing a fresh surface of metal to the action of the soft moorland water.

On the basis of experiment and observation, the following recommendations are made.

(1) The ideal course is to instal a cement-lined supply pipe.

- (2) Failing this, there might be great improvement if the pipe could be kept open throughout the year; this would involve burying the pipe, which at present is largely exposed at a sufficient depth to protect it from freezing.
- (3) A third course is to remove the zinc by absorption in a peat or moss-filter and to ensure deposition of colloidal iron by the addition of a sand-filter. This method works well on the experimental scale, but necessitates careful supervision.

B. Examination of the Cladoceran plankton of the Chamcook series of lakes.

Sample-tows taken with the No. 5 net at fortnightly intervals between May and November, 1930, at depths 0-1 and 3-4 metres, have been examined, taking a count of each species and also a total Cladoceran count, with a view to the elucidation of seasonal and local variations in numbers. The work is not yet complete, as the samples of the last two months were only received a week ago (November 21st) and records of temperatures and dilutions are not yet to hand.

LOBSTER INVESTIGATIONS OF 1930

BY

A. F. CHAISSON AND W. TEMPLEMAN

The lobster investigations of 1930 were chiefly concerned with the collection of information regarding the lobster sizes in those districts in which fishing was being carried on.

I. A thorough survey was made of the eastern shore of the Maritime provinces:

- (a) One series of measurements of 45,000 lobsters from 59 key points along the shore began at the head of bay Chaleur, followed along the New Brunswick coastline and the opposite shore of Prince Edward Island and thence along the Northumberland strait shore of Nova Scotia as far as the gut of Canso. From there the measurements were continued along the western coast of Cape Breton island to bay St. Lawrence.
- (b) A second series of measurements of 16,000 lobsters from 22 localities began at bay St. Lawrence, Cape Breton island, and followed the eastern shore of Cape Breton island to the Nova Scotia mainland, where it included Chedabucto bay, Canso and Dover.

II. In western Nova Scotia a series of measurements was made in Shelburne, Yarmouth and Digby counties. The extent of the survey in this district was necessarily limited due to the closing of the season, but the measurements of 6,000 lobsters from 9 important centres were obtained.

III. A size survey was also made in the Magdalen islands, 8,000 measurements from the 10 chief fishing centres being obtained. The data obtained from approximately 75,000 measurements in 100 localities were treated statistically and the average size and standard deviation were determined for each distribution, thus providing a basis for the comparison of local populations. Charts of the Maritime provinces and the Magdalen islands have been prepared for the graphic presentation of this information. The productivity of the different regions during the last three years is also shown graphically by charts. These charts also show the extent to which canning and the shipping of lobster for the market are carried on in different regions.

A comparison of the female populations in northern N.B. and in western Cape Breton indicates that spawning occurs at a smaller size in the former region.

Tagging experiments were carried on in the Northumberland straits, a total

of 500 lobsters being tagged there. Only 17 have been heard from to date, but greater returns are expected in the spring.

With respect to the present season in the Northumberland straits, such observations as were made last summer indicate that it would not be advantageous as a whole to begin the heason earlier than its present opening date. The possibilities of a later, but shorter, season are discussed.

THE CHEMISTRY OF FISH MUSCLE

BY

A. S. COOK, *University of Toronto*

Quantitative estimations of trimethylamine oxide were made on the aqueous muscle extracts of *Salmo salar*, *Salmo salar sebago* (Girard), *Myxine glutinosa*, *Zoarces anguillaris*, *Amedusa*, *Asterias vulgaris*, *Mya arenaria*, *Homarus americanus*, and on the roe of *Raja erinacea*. This work was a continuation of previous work done in the Department of Pathological Chemistry, University of Toronto.

DIATOM INVESTIGATIONS

BY

V. M. DAVIDSON, *University of Toronto*

The determination of the species and the counting of the diatoms in uniform samples from the hauls with No. 18 net were completed for Prince stations 5 and 6 up to August 1, 1930. The graphs made previously to show the results of the counts for five successive years were extended to include the above. Samples from stations in Halifax harbour and Bedford basin are in process of enumeration as to diatom content.

Two experiments were carried out to test the effect upon the growth properties of surface sea water of adding mud for a period of three days. The water, then poured off, was used for culturing diatoms.

Procedure.

Mud from the shore and from depths of 10 and 40 metres was used.

Half of the water with the mud was placed in bright sun-light, the other half in darkness, the temperature being kept as uniform as possible in the two positions.

Phosphate determinations were made by Mr. Morton of the untreated water, the treated water, and the water at the end of the culture period.

Results.

1. Phosphate increased in all the water in which the mud was placed.
2. The increase was much the greatest in that which had contained the shore mud, and about equal in that which had had mud from 10 metres and 40 metres respectively.
3. The counts indicating the rate and volume of growth were quite irregular in the pairs of jars in each set, and no general conclusion as to which mud was most productive could safely be drawn.
4. Remarkable decrease in the phosphate took place as the result of the growth.

EFFECTS OF LOW TEMPERATURES ON AMPHIPODS

BY

M. H. FRIEDMAN, *McGill University*

In numerous instances death by cold is associated with the formation of ice crystals in the cell and consequent rupture of the cell wall. It is believed that these crystals are formed from the "free" water of the cell and that the "bound" water is not involved.

The experiments undertaken were to determine the following points:

(a) The percentage of "free" water in the "active" liquid state that is converted into "inactive" ice crystals at the lethal temperature.

(b) The amount of water an amphipod can lose by desiccating with cold dry air currents up to the point of death.

(c) The relationship, if any, between the amount of water converted into ice crystals and the amount of water removed by desiccating agents.

(d) The amounts of total, free, and bound water in different species of amphipods and their relationships, if any, to the lethal temperature of each species.

Opportunity afforded itself for the investigation of cardiac rhythm-temperature and respiratory rhythm-temperature relations of *Gammarus locusta* L., and also for the investigation of salinity limits of three species of amphipods.

HYDROGRAPHICAL INVESTIGATIONS

BY

H. B. HACHEY

General Hydrography.

The periodic collection of water samples and the taking of temperatures at various stations was continued. Three additional stations in the region of Passamaquoddy bay were organized for monthly attention in connection with an investigation with reference to the seasonal variation in phosphate content of certain waters.

Records of surface temperatures and general weather conditions were obtained regularly from the various coast stations organized in 1929.

Special Investigations.

In the early spring, the problem of the distribution of the mixed waters from the Passamaquoddy region was attacked from the following angle:

The spring freshets are productive of much water which tends to form a fresh and light surface water. Such a light fresh water would be expected to gradually work down the coast of the bay of Fundy from the St. John river. The mixing region at the mouth of Passamaquoddy bay would be productive of a mixture that should be easily differentiated from this light surface water. The problem of the distribution of this mixed water has always been complicated by the difficulty of following it for any great distance. It is hoped that this latest work will be of considerable value in solving the problem of distribution. Drift bottle work was carried on concurrently with the other investigations in this region.

The investigation consisted of the working of various hydrographic sections over an area extending from the mouth of the St. John river to the waters in the vicinity of Grand Manan.

It has been planned to investigate various mixing mechanisms in the bay of Fundy region. In the early part of June work was carried on in the region of the mouth of the St. John river, in order to determine the part played by the reversing falls in supplying mixed waters to the main waters of the bay of Fundy. Simultaneous work was carried on at stations above and below the falls. Various sections were also run to enable us to determine the general mechanism involved. Shortly after this, responsibility for the Hudson Bay Fisheries Expedition was assumed and the hydrographic investigations as planned were abandoned.

Further Organization of Coast Stations.

Coast stations were organized at the following points:

North point, P.E.I.

Cape Gaspé, P.Q.

Entry island, P.Q.
St. Mary's island, P.Q.

It had been planned to organize two other stations, one at Port aux Basques, Newfoundland, and one at St. Paul's island, N.S. These will probably be attended to at a later date.

LAKE PLANKTON INVESTIGATIONS

BY

C. J. A. HUGHES, *University of New Brunswick*

Assistance was given to Mr. Smith in collecting plankton, and in following conditions in the Chamcook series of lakes. Special collections of plankton were made to determine the effect of light on the vertical distribution of the forms of life, tows being made at three depths from surface to bottom at a standard point in Gibson lake, and under different conditions of weather and time of day. Light was found to be a very potent factor in the distribution of the special copepod (*Diaptomus* sp.) studied. A new species or variety of Cladoceran belonging to the genus *Holopedium* was found.

THE ACTION OF HORMONE-LIKE SUBSTANCES ON THE FISH HEART

BY

M. E. HUNTSMAN, *University of Toronto*

Procedure: The skate heart, removed from a spinal preparation, was perfused with the aid of a Straub cannula. The drugs, or "hormone-like" substances, adrenaline, histamine, acetyl choline and atropine, were added to the perfusion fluid and the effect on the heart observed.

Results: Small doses of adrenaline (a concentration of 1 in 1,000,000 in the perfusion fluid) caused augmentation and acceleration of the heart beat. Larger doses caused inhibition. This inhibition may be due to the change in pH resulting from the addition of larger amounts of the drug. In most cases it was found that adrenaline given after atropine had no effect. Histamine in small doses (1-100 mg. in 2½ cc. of perfusion fluid) augmented and accelerated the heart beat. With larger doses the amplitude of the beat was diminished. Acetyl choline caused inhibition of the heart beat. Atropine given after acetyl choline causes the heart beat to return to normal.

THE LIFE HISTORY OF THE CAPELIN

BY

G. W. JEFFERS, *State Teachers College, Farmville, Va.*

In previous years I have hatched capelin eggs under different conditions of temperature, salinity, etcetera, and have shown that development is apparently successful at temperatures between 0°C. and 15°C. but that the latter temperature is a bit too high although 10°C. is favourable. As to salinity the eggs hatched well at all salinities from 7.5‰ to 30‰, and there was an indication that 7.5‰ is as favourable as higher salinities.

Confirmatory experiments were carried through in 1930, and may be summarized briefly as follows:

- (1) Optimum temperatures: 0°C. to 12°C.
- (2) Optimum salinities: 5‰ or 6‰ to 30‰.
- (3) Approximate hatching time: 55 days at 0°C.; 30 days at 5°C.; 15 days at 10°C.

Further observations on the habits of the fish show that spawning on the beaches does not occur until the water temperature is 6°C. and spawning terminates when the temperature is about 10°C. At least, this is the condition

for the three years under observation at Raleigh. The duration of spawning on the beach has varied from 3 days to 12 days.

After beach spawning is over the fish retire into deeper water in the vicinity where spawning is continued. This, too, is in all probability determined by temperature although it is difficult to find out accurately when they are last seen in the vicinity.

Further data on length-frequencies do not reveal the presence of more than a single year group in the spawning school. The one-year fish are plentiful in early spring, at which time they measure around 4.5 cm. These show no indication of scales and we conclude that the first year is passed without scales.

The scales present peculiar difficulties, due first of all to their minute size, and secondly to the unreliability of the yearly checks. On most of the spawning fish there is an indication of two checks and sometimes an imperfect third check. Providing no scales appear during the first year the bulk of the spawning group at Raleigh are in their third year.

ACTION OF LIGHT ON CERTAIN AQUATIC ANIMALS

BY

A. B. KLUGH, *Queen's University*

During the summer of 1930 I continued the work on the effects of the ultraviolet radiation of the sun on aquatic animals to which I have given considerable attention for the past three years. The same apparatus which I used in previous years was employed, with the addition of a new Corning filter which entirely removes the low wave-length red from the ultraviolet filter.

Experiments on young *Asterias vulgaris* showed that this species was not affected by ultraviolet radiation.

The sperm of *Echinarachnius parma* was found to be extremely sensitive to ultraviolet.

The nudibranch *Eolis gymnota* proved to be sensitive to ultraviolet radiation.

Yoldia sapotilla, a pelecypod which lives at depths of about 20 metres, was found to be sensitive to the effects of ultraviolet.

Hyperia galba, a crustacean which lives in the jellyfish *Aurelia aurita flavidula*, was found to be resistant to the effects of ultraviolet radiation.

During the season of 1930 also experiments were begun on the antagonistic effect of radiations of different wavelength upon animals. A special piece of apparatus was constructed under the writer's direction during the winter of 1929-30, and during the past summer this apparatus was brought into use. Experiments carried on with this apparatus showed a very definite antagonistic effect in the case of the sperm of *Echinarachnius parma* and of adults of the copepod *Calanus finmarchicus*.

EXTRACTIVE SUBSTANCES FROM FISH TISSUES AND THEIR EFFECTS ON THE ANIMAL ORGANISM

BY

S. A. KOMAROV, *McGill University*

1. A comparative study of the gastric secretion after ingestion of beef muscle, haddock's flesh and haddock's skin was performed. A dog with a Pavlov pouch was used for the purpose. It was observed that there is a slight difference between the beef meat and the flesh of the haddock in ability to cause gastric secretion, the latter being a little more active. The skin of the haddock was found to be a much more powerful stimulant of gastric secretion than either the flesh of the haddock or beef muscle. Absolutely fresh haddock, taken living from the tanks, then killed and prepared for eating, were used. Two sets of experiments were performed. In one set equal weights of haddock skin and

flesh were boiled with equal amounts of water for exactly the same length of time, and then filtered, and the ability of these broths to stimulate gastric secretion was determined. In another set of experiments equal amounts of fish flesh alone and of fish flesh and skin were boiled with a known amount of water and their secretagogue properties tested. In all the experiments the presence of skin in the food or of those substances which can be extracted from it by boiling with water, produced a gastric secretion from one-third to one-half greater than the corresponding preparations of fish flesh or beef muscle. Further investigation is very desirable. It is important to determine what substances in fish flesh and fish skin are responsible for the activation of the gastric secretion. Is their concentration greater in the skin than in the meat, or are these different substances in the skin and in the flesh?

2. The action of the extractive substances from the skin of the skate on the blood pressure in skate was studied conjointly with Dr. MacKay. By extraction of skin with 80% alcohol a preparation was obtained, which, after removal of fats, lipoids and inorganic salts, was injected intravenously in an amount corresponding to 20-40 g. skin, and produced a tremendous increase in blood pressure of very long duration. Further fractionation showed that this property, as well as that of markedly inhibiting the heart beat, resides in the lysine fraction.

CHEMISTRY OF THE SLIME OF THE HAG FISH, MYXINE

BY

H. W. LEMON, *University of Toronto*

Myxine glutinosa, commonly called the hag fish, or slime eel, produces large amounts of slime from a double row of glands or "slime sacs" on the ventral surface of the body. As taken directly from the slime sacs it has a milky appearance and is adhesive. It can be drawn out in threads. If diluted with water, or as secreted into water, the slime forms a viscid and ropy mass.

Using Reid's method, the granule substance and the thread substance, as described by him, were separated from the slime. A third fraction was also separated. This was dissolved out of the slime by water or by dilute acids. It was precipitated by making the solution alkaline with sodium hydroxide or with ammonia. Besides these three fractions, lipid material was extracted from the slime by hot alcohol, or by ether.

The granule substance was thought to be a mucin, hence samples were hydrolyzed with sulphuric acid for ten minutes and tested with Fehling's solution, which gave good reduction, contrary to Reid's findings. Also crystals resembling those of glucosazone in structure were prepared from the liquid resulting from hydrolysis. On hydrolysis of the thread substance, no reduction of Fehling's was obtained.

THE ACTION OF HORMONE-LIKE SUBSTANCES ON THE CIRCULATION OF THE SKATE

BY

M. E. MACKAY, *Harvard University*

The investigation comprised a study of the action of histamine as well as of two other hormone-like substances, choline and acetyl choline, and the two hormones, adrenalin and pituitrin, on the circulation of the skate. Histamine was without effect on the circulation of the skate, even when given intravenously in doses 500 times as large as that required to produce a fall of blood pressure in the cat or dog. Furthermore, no vasodilator or skin reactions to injury could be observed in the skate, and extracts of the skin of this animal when injected intravenously were without a histamine-like effect. On the other hand, choline and its derivatives, acetyl choline, had a parasympathetic action similar to that

observed in higher forms. Extracts of skate skin, while they had no histamine-like action, contained a substance very similar to acetyl choline in its effect on the blood pressure.

A great difference was noted in the pressor action of adrenalin in skates from that observed in mammals, namely, the duration of its effect. In warm blooded animals adrenalin is destroyed quickly when injected into the blood stream, but in skates its action does not wear off for several hours.

Pituitrin was found to have a stimulating effect on the smooth muscle of skates similar to that observed in other animals.

INVESTIGATIONS WITH FROZEN FISH

BY

R. A. MCKENZIE

An investigation of the drying that takes place in material during storage was begun in May, one of the regular "freezers" of a wholesale fish firm in Toronto being used. Cakes of "Ice Fillets" were used as material and protected by various methods. During the first part of the experiment the temperature ranged from 2°F. to about 4°F., so far as it was possible to obtain records. The cakes were with and without waxed paper wrapping, with and without a carton covering, and within or not within a sealed corrugated paper box, these being part of the packing procedure for a high quality of frozen fish. For the period from May 9 to June 30 the results of weighings showed complex changes, ranging from an actual increase in weight of 1.38% for the uncovered cakes due to frosting to a loss in weight of 0.92% for cakes wrapped in waxed paper and sealed in corrugated paper box. Other conditions of covering showed intermediate changes. It appears that drying out in this freezer occurs only to a slight extent.

An experiment designed to show the rate of defrosting of "Ice Fillets" under different conditions of wrapping, with different quantities and at different temperatures was undertaken. Copper constantan thermocouples were used for determination of temperature. Preliminary study of the results obtained shows that at room temperature the use of a corrugated paper box increases the time of defrosting on the outside of the mass from 17% to 70% and at the centre from 20% to 72%. At refrigerator temperature the time is increased in the one case from 22% to 64% and in the other 34% to 42%. In respect to differences in the mass of the material it was found that at room temperature defrosting on the outside occurred so rapidly that no very consistent results were obtained, although at the centre, where the time involved was greater, there was definitely an increase in time with increase in mass. At refrigerator temperature quadrupling the volume increased the time 68% to 97% for unwrapped material, and 79% to 105% for material in a corrugated paper box.

PATHOLOGICAL AND OTHER INVESTIGATIONS

BY

R. H. M'GONIGLE

Pathology: Work was continued, preparing sections and slides for microscopic study of the pathological material collected during the season of 1929. Suitable means and formulae for rapid, differential staining were investigated. Among the diseased tissues so studied might be mentioned "white-spot" disease of salmon (*Salmo salar*); an ulcerous (protozoan) disease of flounder (*Pseudo-pleuronectes americanus*); an unknown disease of cod (*Gadus morrhua*); and also various types of disease of trout (*Salvelinus fontinalis*) from material collected in hatcheries. Of the material examined, the protozoan disease of the flounder has proved to be of the most immediate value, due to a very similar disease occurring in herring.

Visits were made to three hatcheries which had been reporting excessive losses in the fingerlings from some time in May, and at a time at which it was impossible (on account of other duties) to make the visits. The result was that when the visits were finally made all evidences of the troubles had disappeared, either by reason of death, or distribution, or both. This was true particularly of St. John, and of Florenceville; at Lake George, Yarmouth County, Nova Scotia, the trouble did not develop until later, and the visit was made while it was at its height, and the disease there was diagnosed as furunculosis, on the basis of the tremendous numbers of bacteria found in the blood. Such advice and suggestions for improvement of conditions, both temporarily and more or less permanently, were made as was possible. Another hatchery (at Bedford) was not visited, but investigations were carried on from the Atlantic Experimental Station at Halifax, by Dr. Leim, who kept us informed of the conditions as they varied from week to week. The trouble there seemed to be associated with an exceptionally dry season, and a very low pH; probably very closely associated with the dry season (low water) if not entirely due to it.

An unusually heavy mortality among the salmon in the retaining pond at St. John also occurred this year, and was investigated at some considerable length by us, with the assistance of the employees of the Department of Fisheries there, under the direction of Mr. J. Catt. Very interesting results were obtained, which will be reported upon separately at an early date. This seemed to be associated with an unusual tidal condition, combined with the unusual dry summer previously mentioned.

From time to time during the summer, pathological specimens arrived at the Atlantic Biological Station from various sources, from Quebec, Nova Scotia, and one from the upper Ottawa. The fish submitted were perch (*Perca flavescens*) from Lake Memphramagog; trout (*Salvelinus fontinalis*) from a lake in Quebec; salmon (*S. salar*) heads from a stream in which "white-spot" had been very severe the previous year, collected by request, for the observation of any evidence of healing—only one dubious case appeared to show a healed scar; doré, or pickerel (*Stizostedion vitreum*) from the upper Ottawa river; salmon (*S. salar*) heads and viscera from Saguenay Co., Quebec, which had no apparent lesion; and some pickled herring from Bear river, N.S., with marks on the sides, apparently herring disease. Reports upon these were prepared as rapidly as possible, and submitted.

Information to the Department of Fisheries from the inspectors of the region indicated that there was an excessive mortality among the salmon of the river St. Croix, a greater run of which was occurring this year, than for any year previously, for a considerable number of years. An investigation was accordingly made to determine what might be the unfavourable conditions, acidity and oxygen determinations being made. It seemed to be probable that the dry summer, previously mentioned in connection with other cases of excessive mortality (above), associated with pollution from certain manufacturing plants, and the tremendous number of dams on the river, might be the effective cause.

Experimental: The major problem was the determination of the relative values of certain cheap, and easily secured, marine products, as food for hatchery fish (*S. fontinalis*), as compared with the expensive beef liver. None of the foods was in any respect comparable to beef liver as the only article of diet.

The experimental work upon the respiratory function of fish, as found in clasmobranchs (*Raja* spp.), which was begun in collaboration with Professor Babkin of McGill University in the season of 1929, was continued, employing certain drugs to serve as very delicate instruments to operate upon the various portions of the respiratory mechanism. Much valuable information was secured from the few experiments it was possible to do.

An experiment to ascertain the effect of certain lead mine effluents or wastes was carried out at the request of Dr. Leim, Director of the Atlantic Experimental Station. The material supplied by him was added to pure lake water, and then trout (*S. fontinalis*) were placed in the resulting solution—no ill effects were observed under the conditions of the experiment, in fact, the experimental fish survived two control fishes.

Miscellaneous: The chief problem under this heading was that of the investigation under the International Factfinding Commission in their study of the fisheries of Lake Champlain. This has fallen into three groups, viz: the winter fishery, studied at a base on South Hero Island, Vt., at a fishery ground called Cowbanks, chiefly upon smelt—but some perch, and cisco, carried out from February 10 to February 27; the spring fishery in Missisquoi bay, chiefly for doré or pickerel, from April 14 to May 14, from a base at Phillipsburg, Que.; and the winter investigations of the stomach contents of the yellow perch (*Perca flavescens*), which is now in progress, at the University of Toronto. Two progress reports have been prepared and submitted.

A STUDY OF THE BAY OF FUNDY HERRING

BY

W. E. MACFARLAND, *Yale University*

The vertebrae of herring from Whale cove, Seal cove and Navy island were counted. The small number of forty specimens failed to show conclusively any variation in the number of vertebrae of fish from different localities although the data indicate that the average is lower in Navy island herring than in the Grand Manan fish.

Sixty-five fish from Navy island and Grand Manan were studied for numbers of fin rays and no evidence was found for racial divisions.

The study of the scales made it evident that accurate age determinations by means of the winters rings were impossible. In a few examples of young herring (two or three years old), the rings were quite distinct. This occurred in less than one per cent of the fish studied, but it may be a significant factor.

The stomachs of four hundred and sixty specimens from various parts of the bay of Fundy were examined and twelve different species were recognized in the food masses. These results corroborated work done by former investigators as to the more general feeding habits of the herring and also added several hints to the movements of the herring in this particular vicinity.

The lengths of over six thousand fish were measured in lots of two or three hundreds. These fish were taken chiefly from Passamaquoddy bay, but samples were obtained also from various parts of Grand Manan, from the New Brunswick shore of the bay of Fundy and from Westport on the Nova Scotia shore. The measurements showed that, of the immature fish, there were two distinct groups, namely, the larger fish (16 cms. in June) from the Grand Manan shores and the smaller fish (14 cms. in June) inside Passamaquoddy bay. These two groups tend to fuse into one in the intermediate area off the southern and eastern shores of Deer and Campobello islands. A difference in the time of spawning is the most logical explanation of the difference of two centimetres between the two groups, and the modifications which take place in the fusion of these groups will no doubt have to be explained from certain hydrographical influences. The fish within Passamaquoddy bay must again be divided into various shoals, but the variation of these shoals is linked up with the degree of infection by the Sporozoon, an account of which will be found in Miss Alley's report; consequently the "sardines" of Passamaquoddy bay may be regarded as one large homogeneous shoal which has broken up into smaller shoals for a period of time.

The experimental work consisted of hatching herring larvae at all the temperatures from zero Centigrade to thirty degrees which are multiples of five degrees. Two trips were made to Seal cove, Grand Manan, to collect spawn. The second attempt brought success insofar as time allowed. The eggs were incubated for about seventy-four hours and the development was nearly one hundred per cent normal at ten and fifteen degrees C. At zero and five degrees development was not apparent. At twenty, twenty-five and thirty degrees, development had begun rapidly but the mortality was one hundred per cent.

THE NATURAL HISTORY OF POLYNICES HEROS

BY

M. M. MELVILLE, *University of Western Ontario*

Polynices heros—the round whelk, or "cockle" as it is locally called, occurs in large numbers in the vicinity of St. Andrew's, N.B. It is used commercially as bait for cod, and also as food in Europe.

Specimens were obtained from Brandy cove, Joe's point, Navy island, Waweig and Birch cove from low water mark to seventeen fathoms, the greatest depth previously reported for that vicinity being ten fathoms.

The height and width of each specimen were measured. By plotting the size against the frequency and comparing the peaks with lines on the shells, there was found to be a relationship between size and age.

The type of food, method of eating, both in the natural habitat and in the laboratory, were studied, and the rate of locomotion on a smooth surface and in sand noted. Experiments on migration proved unsuccessful as even when buried in the sand the whelks disappeared within 48 hours.

Mating was observed in the laboratory and one specimen was observed making a sand collar. Embryoes in various stages of development were found in collars collected at low water. Their reaction to the outgoing tide, the temperatures to which they are exposed, their lethal temperature and their enemies were also observed.

COLD STORAGE EXPERIMENTS

BY

J. M. MORTON

An experiment was conducted to determine the effect of variations in cold storage temperature on the state of preservation of fish. Several samples of fresh brine frozen hake muscle were placed at different points in the cold storage plant where they would be subjected to different degrees of temperature variation throughout the day. After a period of about two months the samples were examined and all appeared to have deteriorated to an equally marked degree. It was hoped that the samples kept at a fairly constant temperature would be in a better condition than those which had received the greatest temperature variation, but no real difference could be detected.

PHOSPHATE CONTENT OF NATURAL WATERS

BY

J. M. MORTON

The phosphate content of water samples from five representative stations has been followed at the surface and bottom throughout the year, the winter determinations being made by Mr. Hachey.

Samples from the rivers flowing into Passamaquoddy bay and the lakes in the vicinity show low values and are not a source of enrichment for the region.

A study was made of the distribution of the polluted water in Black's harbour, and it was found to have a negligible effect in increasing the phosphate values beyond the mouth of the harbour.

The peculiar hydrographic conditions found at the head of Passamaquoddy bay formed the subject of a special study at the time of spring tide in late August. The phosphate values showed a decrease with springing tides, with a minimum corresponding almost exactly to the day of maximum tidal amplitude, followed by an increase as the tidal amplitude decreased.

SEX REVERSAL AND RATE OF GROWTH IN THE EASTERN AMERICAN OYSTER,
Ostrea virginica.

BY

A. B. NEEDLER

Until recently it has been supposed that the sexes are quite distinct in *Ostrea virginica*, but recently it has been suggested that a change of sex takes place during the life of the oyster. About 650 adult oysters were examined and the age (as shown by rings on the shell) and sex were noted. In addition over 300 oysters known to be in their second summer were examined for sexual products.

A study of the adult oysters shows that there are very few female oysters in their second or third summers, about half as many females as males in the fourth summer, approximately the same number of each sex in the fifth summer and from that age on there are more females than males. This suggested that a good proportion of the males undergo a change of sex at the end of the third summer and some in subsequent years. Examination of the young oysters in their second summer showed that 16% to 18% contained sexual products and of these 52 were male and 4 were female. This shows that a few of the oysters are female from the beginning, but does not explain the sudden appearance of a number of females in the fourth summer. Finally three oysters were discovered that were definitely hermaphrodite, both ripe sperms and ripe ova being present at the same time. Self fertilization was successfully carried out in the laboratory with one of these oysters and two have been preserved for histological examination during the winter.

As another method of attacking the problem it seemed desirable to keep a number of oysters of known sex for a year or two and see whether any change took place. This is being tried.

In connection with the investigation of the rate of growth some thousands of measurements have been made of adult oysters from several different beds, of 1929 spat from various places and of this year's spat, but these measurements have not as yet been worked over.

OYSTER INVESTIGATIONS, 1930

BY

A. W. H. NEEDLER

Temperature and the spawning of oysters. Records have been kept of the proportion of oysters spawned out or partially so. Quantitative plankton samples have been taken for the larvae. Cultch has been placed in the water at different times and examined in detail. All of the data have not yet been examined in detail but the following points have appeared. The spawning and setting of spat both lasted for about two months in 1930. Although it appears that no oysters spawned before the water reached a temperature of 20°C. or more they did not start spawning suddenly but rather seemed to spawn continually with increases in the warmest spells. It is suggested that this state may have been exaggerated this year by the sudden rise in temperature as a result of which

suitable temperatures may have been reached before the majority of the oysters were yet ready to spawn. These are, however, only tentative suggestions until the data from the various sources can be compared. The results do clearly show that the spawning is influenced by temperature but it may not always be the limiting factor.

Depth of setting of spat. Placing of cultch at different levels has shown that the greatest abundance is in the uppermost two or three feet below an ordinary low tide. Above this a few spat are to be found as far as half tide. They survive best here when shaded and apparently few survive the winter. Below the optimum the abundance decreases gradually until it is about half that of the best at 15 feet.

Time of setting of spat. The time of setting extends over about two months in 1930. Good sets were obtained on shells placed in the water for three weeks after the first good set. It would appear from the results these two years that it is best to place the cultch in the water after setting has started and just before the first good sets as the first shells put out did not collect as many spat as those slightly later. They were, however, bigger before winter. As in heavy sets too many are obtained for practical purposes there is a fortnight or more when quite satisfactory sets can be obtained.

Kinds of cultch. The following kinds of cultch have been used: Shells (oyster, quahaug, and mussel) broadcast on the beds and in wire baskets, brush, cardboard partitions (like egg crate partitions) coated with a mixture of lime cement and sand.

It has been found that oysters and quahaug shells in baskets have collected good quantities of spat. The bags held a bushel and were cylindrical, three feet long and about a foot in diameter. They were piled two on two in piles of six with four slabs to prevent sinking in soft bottoms or stooked like sheaves of grain in stooks of six. Larger numbers became unwieldy or the pile too high for the depth of water. Equal results were obtained from the two methods. It has been found that mussel shells cannot be used satisfactorily in baskets in Bideford river. With them the spat does not penetrate, due probably to the manner in which they fit closely into one another. Those on the surface collect as much spat as the other shells and they are good for broadcasting. The currents at Bideford are apparently much weaker than in those localities where the wire baskets were developed by the U.S. Bureau of Fisheries.

Shells broadcast on beds cannot easily be transplanted, and if the beds are in deep water the quantity of spat is less than on the shells in baskets along the shore. But where the beds are shallow and the spat can be left there to grow, it seems that this method may be better than the placing of shells in baskets. Trials in progress will throw light on this subject.

Freshly cut brush was placed in the water in faggots held down by stakes and by merely sticking the ends in the mud. These were put out in 1929 at the heads of the inlet. So few spat were visible on them late that summer that they were abandoned as unsatisfactory. Two of the faggots were recovered this summer and it was found that there were a few 1929 oysters on them with very good growth and an abundance of 1930 spat similarly well grown. The branches were so eaten by *Teredo* that the spat could be separated, most of them with ease. It is proposed to try brush seasoned before placing in the water and also to try leaving a large number of faggots two years. This may be a very valuable method of collecting spat as brush is cheap and easily handled and it is possible to use bottoms too soft for any other kind of cultch.

The importance of placing clean cultch of some kind in the water is borne out by observations that many times as many spat occur on clean shells placed

in the water a week or so before abundant spat may settle on clean shells when it is difficult to find a single spat on numerous shells lying about.

Planting of spat. There is little difficulty in obtaining large quantities of spat in cultch placed at the heads of the inlets. But this is only the first stage. In the case of shells broadcast on the beds on which they are to grow there is, of course, nothing more to be done than protect them from parasites and enemies wherever possible. But the shells in baskets must be planted. It has been found that almost all of these left in situ over winter are destroyed. The spat collected on shells in baskets this year were planted at different times to find out the best time to plant. Some were planted almost immediately after setting—or rather when setting was still in progress and the oldest of the spat had settled only two weeks. Three more lots were planted at intervals of about three weeks or a month, the last being towards the end of October when the temperature had fallen to the neighbourhood of 5°C. and consequently growth must have almost ceased. The results of this experiment (which has been carried out both above Shipyard point and on Cooper bed) will, of course, not be available until next year.

Transplanting. In the development of an area where there are very few oysters on the beds, as is the case, for example, with Malpeque bay, it is necessary to do some transplanting. It was planned to carry out experiments with transplanting oysters both young and old at different times, but there is this year no stock available which would warrant the risk of loss. It is hoped to do more next year. But in the course of the operations some transplanting of stages older than spat has been done. It has been found that all oysters introduced from the south shore of Prince Edward Island have been unsuccessful. The hundred barrels from Hillsborough river planted on the Gillis point bed in Grand river and the young oysters from Percival river planted in the same place have been mentioned above. Only a small percentage of each were alive the second summer after planting. Before this was known the writer planted about sixty barrels in all on two beds in Bideford river. They came from Percival river and were intended for concentrations for spawning purposes. This autumn one of these two lots is almost entirely dead, while quite a proportion of the other oysters is either dead or dying. They have shown the same symptoms as those in Grand river last year and which bear some similarity to those reported locally for the disease of 1914. The native Bideford oysters which have been planted in deeper waters will throw light on the effects of moving per se. In Hillsborough river those transplanted from the channel to Mt. Stewart last year thrived and small quantities obtained in the upper reaches of Bideford river last autumn and planted on a bed near by have also thrived. It seems, therefore, that oysters from the south shore of the island do not thrive in Malpeque bay, whereas oysters moved from one part of the river to another at Bideford or Mt. Stewart were unharmed except for casualties due to falling upside down, etc. Specimens of the dying oysters have been preserved for histological examination.

Other subjects. Observations and data have been collected on food, enemies and other subjects but have not yet been made to yield definite results.

A STUDY OF THE SOFT SHELL CLAM (*MYA ARENARIA*)

BY

C. L. NEWCOMBE, *University of Toronto*

During the summer of 1929, the writer made a preliminary study of the biotic communities in the vicinity of the Atlantic Biological Station. This problem involved a qualitative and quantitative analysis of community structure involving a consideration of the reactions, being interpreted as the effects that the community of organisms exerts upon its habitat and the changing conditions

therein upon the organisms. An effort was therefore made to evaluate the physical and chemical factors affecting community formation and development in the areas selected for intensive study.

A continuation of this investigation during the summer of 1930 has brought to the fore the importance of *Mya arenaria*, which ranks commercially as one of the leading shellfish of the coast. Furthermore, its dominant position among the animals of the intertidal belt makes a study of its ecological relationships very pertinent at this time.

The problem of growth, the influence of various physical factors governing distribution and the habitat preference of the species are special phases of the study that the writer has investigated.

THE INFLUENCE OF TEMPERATURE UPON DIGESTION IN
FUNDULUS HETEROCLITUS

BY
J. V. V. NICHOLLS, *McGill University*

The purpose of this investigation was to show the relationship, if any, between the rate of digestion in the duodenum and temperature. The fish, *Fundulus heteroclitus*, was chosen for study because of its hardiness and because in it the digestive processes are simple, there being no peptic glands. The experiments were conducted at temperatures ranging from 5.8°C. and 35.0°C.

The fish were fed with about 140 mg. of clam mantle each. At intervals after feeding the contents of the stomach were aspirated and the quantity obtained and the pH noted. In this way it was possible to tell when duodenal digestion had been completed.

At 29.5°C. digestion required 3 hours; at 12.8°C., 10 hours. At temperatures above the former figure and below the latter digestion became irregular; between 5° and 6°C. it completely ceased.

The increase in the rate of digestion that accompanies a rise in temperature may be due to three possible causes:—

- (a) An increase in the secretion of digestive juices (this is hard to prove in so small a fish).
- (b) An increased action of the enzymes (this was shown to be actually the case).
- (c) Increased motility (it was shown that a rise in temperature increased the rate of the rhythmical contractions of the duodenum; thus, at 12.0°C. the rate was 1.1 per minute; at 29.0°C. it was 4.0 per minute).

A STUDY OF GAMMARUS FOR FISH FOOD

BY
E. S. PENTLAND

All localities within reach of Toronto, from which *Gammarus* of either species had been reported were visited, and at each habitat analysis was made of the physical, chemical, and biological factors, which might exert a controlling influence on the distribution of *Gammarus*. Similar analyses were also made of habitats in which no *Gammarus* were taken. Waters in both the southern alkaline region and the more acid waters of the granite regions of Ontario were examined.

The results of field work have shown that throughout southern Ontario the distribution of *Gammarus* is decidedly local. The chemical composition of the water does not seem to be a controlling factor, and there does not appear to be any reason why the introduction of *Gammarus* into trout waters in this area should not be feasible. Maximum temperature seems to be a definite controlling factor, but the maximum temperature of good trout waters is not above the maximum for *Gammarus*.

One of the objects of the field work was the establishment of experimental ponds, into which *Gammarus* might be introduced under controlled conditions. The ideal location which was sought, was one in which two spring-fed streams, one with hard, alkaline water and the other with soft, acid water, occurred in close proximity. Such a location was not available, and for this reason experiments on the introduction of *Gammarus* were not attempted in soft water.

One experimental introduction was made at the ponds of the Glen Major Angling Co. at Glen Major, Ontario. A previous attempt to stock these ponds with *Gammarus* had not been successful, but it was felt that this was due to the relatively small number introduced, since no protection had been given them from the trout.

Accordingly two cages were constructed of wire screening. One was quite large, roughly rectangular, with a total perimeter of forty feet, and consisted of a screen fence around a clump of *Chara*. A few small trout were unavoidably retained in this cage, but no large fish could gain entrance. The second was much smaller, being eight by twelve inches in size. Both of these cages were stocked with *Gammarus* on July 8, and they were alive and mating on September 20.

At it was clear that a successful stocking of the whole pond would require a much greater number than could be obtained from convenient sources, a small pond was constructed to serve as a rearing pond. This pond was originally used as a nursery pond for trout, but had been drained for many years. The dam was repaired and a temporary flume constructed to supply the pond with water. This pond has an area of approximately fourteen hundred square feet and an average depth of two feet. It will be used when it comes into condition.

INVESTIGATION OF GAME FISH SITUATION IN PRINCE ALBERT
NATIONAL PARK
BY
D. S. RAWSON

The survey was continued during the summer (June 2 to September 26) with the assistance of Mr. J. G. Rempel and Mr. R. R. Langford.

Introduction of small-mouthed black bass into Waskesiu lake.

Although the actual introduction of bass was deferred, the opportunity was taken to further the project by collecting complete seasonal limnological data, especially temperatures, in the Narrows bay, the proposed site for artificial culture ponds. These data are such as to greatly strengthen our belief that bass might spawn in the lake.

Fish food in Waskesiu lake.

A large body of data has been collected relative to the question of fish food and particularly the variation in quantity of insect larvae which are the staples of bottom feeding fish. During the season there were taken more than 200 dredgings, many quantitative shore collections, analyses of fish stomach contents, collections of adult aquatic insects and general observations bearing on the problem. The identification of materials and analysis of data is in progress and promises to throw light on several questions of food cycles and food supply for fish.

Weekly series of temperatures, dissolved oxygen and pH were taken at two stations in Waskesiu lake. Data on this subject are now fairly complete for Waskesiu lake and will be made the subject of a special report at an early date.

Possible introduction of speckled trout.

The MacLennan river was made the object of a two weeks expedition and investigation during late July and early August. This is the critical period for streams in the region since at this time the water is usually at its lowest level and the temperature at its summer maximum.

Briefly, we find that a portion of the MacLennan river from Clearwater lake to its junction with Crean creek is some 25 miles in length, of which approximately 75% might be described as a typical speckled trout stream. It has much rapid water, bottom predominantly stone, gravelly or sandy, plenty of deep holes and logs to provide protection and an abundant supply of the food organisms of the speckled trout with aquatic plants to shelter them. Apparently the decision as to the advisability of introducing speckled trout rests on two questions. Is the maximum observed temperature 19.8°C. (probably close to the true maximum) too high for a speckled trout stream? Considering the rapid flow and the high content of dissolved oxygen observed, it would appear that this temperature is not necessarily a strong argument against the introduction of trout. The scarcity of small tributaries to the stream brings up the second question, will speckled trout spawn in the main stream provided that it contains plenty of clean, shallow gravel beds which appear to be suitable for spawning, a question which in the present state of our knowledge of the habits of the speckled trout no one seems ready to answer.

Fish and life conditions in Sandy lake.

A total of three weeks was spent working on Sandy lake during the season extending the general survey begun in 1929. A rough analysis of the data obtained shows that it is essentially similar to Kingsmere lake although the latter is about three times as great in area. The two lakes are remarkably similar in regard to depth, summer stratification, temperature changes and bottom oxygen supply. As for the primary food supply, Sandy lake has a bottom fauna equal to and a plankton slightly greater than that of Kingsmere lake. Such similarity in the life conditions of the two lakes would certainly warrant the previously suggested introduction of ciscoes into Sandy lake as an intermediate food fish. The ciscoes would feed the pike (at present of poor quality due to a scanty and ill-suited food supply), and the perch, and would prepare the way for later introduction either of the lake trout or of a game trout of the Kamloops type.

ABSORPTION OF LIGHT BY WATER

BY

W. R. SAWYER, *McGill University*

The effect of suspended matter on the absorption of light by sea-water was studied and from a visual study of the plates there appears to be a greater effect on the transmission of the shorter wave-lengths than the longer.

For the study of the biotic effects of light and the absorption of light by water a new artificial source in the form of an incandescent lamp with a UV transmitting bulb was tried out and its spectrum compared with that of summer solar radiation. It was found to be the closest approach to solar radiation that we have been able to obtain so far, and should prove very useful for future work.

A new method for integrating the intensity of sunlight from day to day has been tried and the results are promising. Work on its improvement is in progress.

In contrast to the work on animals the results of the experiments on antagonistic effects of radiation of different wave-lengths on photochemical systems were neither definitely positive or negative so far.

OYSTER CULTURE WORK IN PRINCE EDWARD ISLAND

BY

H. P. SHERWOOD

Experiments designed to test the influence of certain factors on the spawning and early stages of the oyster by the use of small tanks constructed for the purpose on the shore of Bideford "river", resulted negatively on account of the failure of the oysters which were placed in the tanks to produce larvae.

In order to obtain larvae in the tanks the following expedients were resorted to, but without success:—

Ripe sperm was added to induce female oysters to spawn.

Partial renewal of the stock of oysters and of water was made.

Embryos from artificial fertilizations were added.

A number of the oysters were warmed by exposure in shallow pans to full sunlight to induce spawning.

Covers were put on the tanks nightly near the end of the season to prevent chilling of the water.

There were no signs of unhealthy conditions in the tanks, nor was there any mortality amongst spat transferred to the tanks from the "river" late in the season.

Of the six tanks, each 15 feet by 12 feet originally planned, three only were built this year, on account of unsuitability of the available foreshore, and difficulties in construction due to small tides and delays in obtaining materials. The three that were put up remained water-tight and the gravelled bottoms were as satisfactory as could be expected. They have been banked up on the outside, and the banks faced with boards to resist the action of waves and frost during the winter.

Late in the summer conditions in the tanks were compared in their effect on the growth of spat from the "river." Two tanks were covered at night, one having a lower salinity than the other, while the third, uncovered, served as a control. During a month there was no significant difference observable in growth.

Quantitative plankton samples taken daily (or nearly so) from the surface and bottom at two stations in the Bideford "river" were examined, and all oysters in the "umbo stages" counted and measured. The record thus obtained indicates the duration and intensity of spawning, and forms a basis for comparison with subsequent seasons. The maximum number of larvae were found on July 24th, and did not exceed three per gallon.

FERTILIZATION OF LAKES AND ARTIFICIAL PONDS

BY

M. W. SMITH

1. Experiments and observations in experimental concrete ponds.

(a) In Series A.

In these three ponds a continuation of the observations made during the Fall of 1929 were carried out. Temperatures were taken twice daily, and determinations of the oxygen content and pH values were made at least once a week, usually at shorter intervals. Light penetration was observed by small Secchi's disc. Samples of the plancton present were taken regularly at different levels.

(b) In Series B.

Experiments were made in this series of ponds to ascertain the effect of artificial fertilization of the water on the production of planctonic forms. Ponds B1 and B3 were drained, cleaned, and filled with water from the same source. Pond B1 was left unfertilized, but one pound of herring meal was added

to pond B3 on June 11. This was suspended in a coarse sack one-half a metre below the surface. In the other respects the ponds were treated as nearly alike as possible. The water in B2 was not drained out, and 20 pounds of live mussels (*Mytilus edulis*) were added. The physical, chemical, and biological conditions were followed as for the preceding series.

2. Investigations of the Chamcook series of lakes.

To follow up the scheme of fertilizing water for plancton production, approximately 14 tons of mussels were put into Gibson lake from May 19 to the middle of October. These were dumped at the shoreline in shallow water and over a comparatively small area.

In order to follow any possible effects of this procedure, stations were established in four of the lakes of this series, namely, Welch, Gibson, Second, and Chamcook, in order from high to low level. Plancton tows of 15 minutes each were taken at the surface in No. 5 mesh and No. 18 mesh plancton nets, and also at a depth of 3-4 metres in these nets where the depth of the water permitted. Temperature was recorded at each station when tows were taken. Oxygen content, phosphate content, silicate content, and pH values were determined at irregular intervals.

Welch lake (one station) being above Gibson, would not be affected by the fertilization of the latter, and is expected to serve as a control for following the effects in the lower lakes of that fertilization. Gibson lake itself (three stations) was at first expected to show a varying effect of the fertilization depending upon the proximity of a particular station to the point of fertilization. However, it was found that the wind circulated the waters to such an extent that there was no consistency in the quantity of plankton taken. In the two lower lakes tows were primarily taken to find if the fertilization in Gibson lake would be potent enough to affect the production, or possibly keep the quantity of plankton greater throughout the season.

3. Temperature of springs.

From the 1st of June until November 12th the temperature was taken in three springs at the head of Chamcook harbour. These were taken each week. The temperature of Chamcook outlet, as well as a small spring-fed stream running into the harbour, was recorded at the same time. One of the springs is submerged under salt water at about three-quarters flood tide, and so at times it was impossible to record the temperature when taken at the other places.

WATER MOVEMENTS IN PASSAMAQUODDY BAY

BY

E. E. WATSON, *Queen's University*

During the summer of 1930 investigations were carried out in three regions:

(1) The main portion of the bay lying between St. Andrews and Deer island.

A hydrographic section taken from Tongue shoal (Sand reef) to upper Green point, at half flood and at half ebb, showed interesting temperature effects. Below 20 metres the temperature changes very little with tide or depth. On the flood tide the water below 10 metres has approximately the same temperature, while that above 10 metres changes rapidly. On the ebb tide the temperature changes take place at 20 metres instead of at 10 metres. At a station in the deep channel off Upper Green point the temperature curves at half flood and half ebb are almost identical. This station is so near Letite passage that the effect of mixing in the remote portions of the bay are not observable, at any rate not until a later stage of the ebb tide.

(2) Chamcook harbour.

It was thought probable that Chamcook harbour, with its shallow entrances

at both ends, would be a likely trap for cold water. Observations show the contrary. The bottom water is much warmer than that at a corresponding level in the deep water between Kilmarnock head and Minister's island (Sta. 1019). The effect of the sloping bottom between Sta. 1019 and Sta. 1020 (in the entrance channel of the harbour) is very marked. The surfaces of equal density conform to the bottom when the tide is flooding. The heavy bottom water is carried up over the sill at Sta. 1020 and falls immediately to the deepest portion of the basin. Within the harbour fresh water streams and favourable conditions produce warming and mixing, producing a surface outflow. By high water the equal density surfaces slope upwards from Sta. 1020 to Sta. 1019, remaining until low water. In the outer basin the cyclonic circulation of the surface water, due to the earth's rotation, causes the heavier water to rise in the centre, producing a "bump". The water of the inner basin is lighter and warmer than that of the outer basin. More observations are necessary to give a true picture of conditions in the inner basin, which are further complicated by the flow of water over the Bar road. The motion of the water in the larger and more important outer basin seems relatively clear.

(3) Bocabec bay.

The most striking feature of the results obtained here is the behaviour of the water at 5 metres depth, which in the eastern channel is still flowing outward at half flood. Here flood water runs most rapidly from the surface down to 3 metres, while in the southern channel it flows at all depths below 3 metres. At half flood the surface water in the latter is flowing outward. The direction of the currents below 15 metres is due to the configuration of the bottom. In the eastern channel at half ebb the set of the 20-metre current towards the ENE means that the current is following the channel. On the other hand there is a decided set of surface water toward Dick island, starting at low water and reaching a maximum at 2½ hours flood, which may be due to coastal mixing. Between the islands and shoals there is much mixing of the water by tidal streams. The surface water near the shore becomes heavier than that further out, producing a shoreward surface current at approximately 5 metres.

The greatest variation in temperatures in this region was found to be at 5 metres.

SPECKLED TROUT INVESTIGATIONS, 1930

BY

H. C. WHITE

- I. The food of trout in Forbes creek as shown by stomach analyses.
 - (1) Fry begin feeding before the yolk sac is completely absorbed.
 - (2) Chironomid larvae form the principal food of very small fry.
 - (3) The food varies
 - (a) with the size of the trout.
 - (b) with the season.
 - (c) with the location in the water system.
 - (d) with individuals of the same size in same habitat (exceptional).
 - (4) The spawning trout eat large numbers of trout eggs.
 - (5) The adult trout are able to secure alevins before they have emerged from the gravel.
 - (6) The principal foods of trout are: Immature aquatic insects, snails, fish (*G. aculeatus*, *S. fontinalis*), aquatic earthworms, and terrestrial insects.
- II. An experiment on planting fry in Forbes creek.

Eighty rods of natural creek was used for this experiment. Fine screen

barriers were placed above and below the section. All fish, excepting minute fry of *G. aculeatus*, were removed by seining. 5000 trout fry were planted in this section, on July 1st. Fish-eating birds were frightened away or shot. The section was completely seined again the first part of October, and 1520 trout fingerlings were found in the section, a survival of 30.4%.

III. Effect of feeding on egg production of speckled trout.

Five similar compartments were constructed and supplied with running water. Ten trout were placed in each compartment.

Lot I. Was starved throughout the summer (Minimum of food):

Lot II. About half fed.

Lot III. Fully fed.

Lot IV. Starved until July 30th, then fully fed.

Lot V. Starved until August 30th, then fully fed.

On November 30th, all in Lot I had spawned. These yielded relatively small numbers of small eggs, many of which turned white soon after spawning. Some fish have spawned in Lots II, III, IV, but none in Lot V. Fish in Lots III, IV, V, have made good growth.

IV. Artificial redds for natural spawning of trout.

Two artificial gravel redds were constructed and supplied with an upward current of water through the gravel.

No. I. Supplied with spring water.

No. II. Supplied with creek water.

Spawning males and females have entered No. I and have been working over the gravel, but by November 30th, no trout had been observed in No. II.

V. Collecting data on egg production of trout.

Numbers of female trout from Forbes creek and pond have been weighed and measured before spawning, their eggs counted and egg diameters determined. Results to date show that small trout produce smaller numbers of eggs, and generally produce small eggs.

PUBLICATIONS

The following publications on work connected with the Station have appeared during the year:

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- Bayliss, L. E., E. Boyland, and A. D. Ritchie.—The adductor mechanism of *Pecten*. *Proc. Roy Soc. Lond.* B 106, 363-376.
- Bere, R.—The parasitic copepods of the fish of the Passamaquoddy bay region. *Contr. Canad. Biol. Fish.* 5 (13), 421-430.
- Chaisson, A. F.—The changes in the blood concentration of *Raja erinacea* produced by modification of the salinity of the external medium. *Contr. Canad. Biol. Fish.* 5 (18), 475-484.
- Duff, D. C. B.—Factors involved in the production of annual zones in the scales of the cod (*Gadus callarias* Linnaeus). *Contr. Canad. Biol. Fish.* 5 (7), 193-202.
- Ellis, M. E.—*Ichthyophonus hoferti*, Plehn and Mulsow; a flounder parasite new to North American waters. *Trans. N.S. Inst. Sci.* 17 (3), 185-192.
- Investigations on the protozoan fish parasites of the St. Andrews region. *Trans. N.S. Inst. Sci.* 17 (4), 268-275.
- Gee, A. H.—Bacteria concerned in the spoilage of haddock. 3. Further observations on the flora of live fish. *Contr. Canad. Biol. Fish.* 5 (14), 431-439.
- Hart, John Lawson.—The spawning and early life-history of the whitefish, *Coregonus clupeaformis* (Mitchill) in the bay of Quinte, Ontario. *Contr. Canad. Biol. Fish.* 6 (7), 165-214.
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- Huntsman, A. G.—Arctic ice on our eastern coast. *Bull.* 13, 1-12.

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- The effect of the ultraviolet component of the sun's radiation upon some aquatic organisms. *Canad. J. Res.* 2, 312-317.
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- Shoemaker, C. R.—The amphipoda of the Cheticamp expedition of 1917. *Contr. Canad. Biol. Fish.* 5 (10), 219-359.
- White, H. C.—Trout fry planting experiments in Forbes brook, P.E.I., in 1928. *Contr. Canad. Biol. Fish.* 5 (8), 203-211.
- Some observations on the eastern Brook trout (*S. fontinalis*) of Prince Edward Island. *Trans. Amer. Fish. Soc.* 60, 101-105.

SUMMARY REPORT

OF

FISHERIES EXPERIMENTAL STATION (ATLANTIC)

HALIFAX, N.S.

1930

The following constituted the staff of the Station during the year 1930:

Dr. A. H. Leim, Director.
 Dr. J. R. Sanborn, Chief Bacteriologist (resigned May 12).
 Mr. Ernest Hess, Assistant Bacteriologist.
 Dr. J. H. Mennie, Chief Chemist (resigned September 30).
 Dr. H. R. Chipman, Scientific Assistant in Chemistry.
 Mr. S. A. Beatty, Associate Biochemist.
 Miss A. M. Wilson, Technical Assistant in Chemistry.
 Mr. A. S. McFarlane, Curator.

SEASONAL

(1) *Inspection of Lobster Canneries.*

Dr. G. B. Reed.

(2) *Scientific Assistants.*

Mr. A. S. Cook.

Mr. D. Leb. Cooper.

Mr. N. E. Gibbons.

Mr. W. W. Johnston.

Dr. G. O. Langstroth.

Mr. W. W. Stewart.

(3) *Instructors, Course for Fishermen.*

Mr. Carl Johnson—Motor Engines.

Professor R. Maxwell—Natural Resources.

Capt. H. M. O'Hara—Navigation.

Mr. Joel Smith—Preparation of Dried and Boneless Fish.

By courtesy of the Department of Fisheries, Mr. George Earl and Mr. Robert Gray gave courses in the Preparation of Dried and Boneless Fish and in the Preparation of Pickled Fish respectively. Similarly by courtesy of the Department of Natural Resources of Nova Scotia, Dr. M. Cumming and Professor W. V. Longley gave courses in Natural Resources.

VOLUNTEER INVESTIGATORS

Miss Margaret R. Butler, Dalhousie University, and
Miss J. R. Panton, University of Toronto.

INVESTIGATIONS

1. *Refrigeration.*

(a) *Storage of Frozen Fish.*—The effect of a sodium chloride dip on fillets before freezing with regard to the "drip" was investigated.

(Mr. Beatty)

Quickly frozen fish were stored at 0°F. and the keeping quality tested by cooking experiments. The general indication was that the frozen haddock could be distinguished from fresh only after three months storage, and that fresh and frozen cod and halibut could not be readily distinguished at the end of five months. Complete protection from the air of the storage room did not materially alter the result.

(Mr. Beatty)

The denaturing of protein in frozen fish stored under various temperature conditions was investigated.

(Mr. Johnston)

The bacterial flora of frozen fillets which had been stored under known conditions was investigated. Further lots of fish were frozen and bacterial counts and determinations made from time to time. The identification of the organisms isolated is being carried on at Yale University during the academic year.

(Mr. Gibbons)

Further work was done on a method of determining the amount of "drip" or expressible fluid in frozen fish. The most promising method was one involving the use of mercury for the pressure exerting mechanism.

(Mr. McFarlane)

(b) *Rate of Freezing.*—Further investigations were carried out on the relation between temperature of brine, thickness of fish, kind of fish and rate of freezing, and an equation was developed embodying these factors.

(Dr. Langstroth)

An equation was derived for the heat capacity of fish muscle, the constants employed being the freezing point and water content of the fish muscle. Assumptions made in the derivation required to be tested for their validity, and it was considered desirable to investigate a simpler system than fish muscle. As a preliminary, heat capacity measurements were made on dilute salt solutions and on four gelatine gels of known concentration.

(Dr. Mennie)

The freezing point of lobster meat was determined to be -2.0°C . (28.5°F .)

(Dr. Mennie)

(c) *Ice Fillets.*—The following quantities of Ice Fillets were shipped to Toronto for sale between January 1 and December 10th, 1930:

Cod	240 lbs.
Haddock	8,373 lbs.
Halibut	1,880 lbs.
Mackerel	576 lbs.
Gray Flounder	1,336 lbs.
Russet Flounder	840 lbs.

13,245 lbs.

A small quantity of these ice fillets were reshipped to Winnipeg. The production at the Station has slightly exceeded the above amounts. There has been some local sale, certain shipments to Montreal and Calgary, and a quantity were used for exhibition purposes. In addition some 500 lbs. of mackerel ice fillets are being held at the Station.

The mechanical cake making machine developed by Dr. Huntsman and Delamere and Williams has been tested out at the Station. Certain mechanical changes have been introduced to improve the action of the machine.

(d) *Miscellaneous*.—A method of rapidly freezing herring in quantity for bait by having brine sprayed on a series of superimposed trays was developed, but the results did not warrant its adoption in preference to the plate method of freezing the same fish.

(Dr. Leim and Mr. McFarlane)

Attempts were made to brine freeze smelt. These could be frozen exposed to the brine in eight to ten minutes with comparatively little salt penetration. A difficulty arose in washing off the adhering brine in that a relatively thick glaze formed which detracted from the appearance of the fish. It would seem preferable to use a method of indirect contact as has to be done with fillets.

(Mr. McFarlane)

2. *Smoking.*

A piece of apparatus for producing smoke from sawdust outside the smoke house was developed and utilized in the operation of an improved type of smoke house. A small smoking compartment was built in the demonstration building and connected to air conditioning apparatus and the smoke producer. It proved possible to carry out the drying and smoking of fillets in from four to six hours. In the industry the period is usually nearly twenty-four hours in conjunction with dye.

(Mr. Cooper and latterly Mr. McFarlane)

The formaldehyde content of the smoke produced by the smoke producer was investigated. It was found that whereas the type of smoke producer used formerly gave a different kind of smoke at different stages of combustion of the sawdust, the new apparatus gave smoke of constant quality. This was attained by controlling the flow of sawdust rather than that of the air.

(Mr. Cooper)

3. *Salting and Drying.*

Several lots of codfish salted late in 1929 with various commercial salts were followed, and ultimately removed from pickle, and compared by the Advisory Committee as to suitability for market. A short report was prepared on the experiment.

(Dr. Leim, Mr. McFarlane, Mr. Darrach)

The microbiological content of the pickle on the above mentioned fish was followed and the forms found were identified and listed (Dr. Sanborn). The general investigation of the effect of sodium chloride and impurities found in commercial salts on fish muscle was continued from the point of view of water and salt exchange.

Attempts were made to treat Malagash salt so as to reduce the amount of insoluble matter which adheres to the fish when salted.

(Dr. Chipman)

Routine analyses have been carried out on fishery salts and the moisture content of dried fish.

(Miss Wilson)

An experiment was set up to test the effect of using reduced quantities of salt in pickling mackerel with mined and solar salt. An explanation has been afforded of certain red mackerel found along the coast. The experiments supported the contention of the buyers that too little salt was used.

(Mr. Beatty, Mr. McFarlane, and Mr. Robert Gray)

4. *Canning.*

At the suggestion of Dr. G. B. Reed the problem of the effect of canning dying lobsters on the quality of the pack was investigated. An attempt was made to determine the way in which sulphur is released during the process of dying. The availability of sulphur is expected to have a relation to the blackening of the can.

(Mr. Cook)

While inspecting lobster canneries at Point du Chene, Mr. Hess packed several dozen cans of lobster with a view to testing the quality of enamel on

the cans, the effect of acetic acid pickle on the enamel, and the effect of acid pickle on crystal formation in the cans. These cans are stored for observation at stated periods.

Experimental packs of lobsters in various stages of low vitality subsequent to death were made, and these are stored for examination.

(Mr. Hess and Mr. Cook)

A four hundred pound lot of mackerel was brine frozen, after being gutted, and is being held for canning.

An equation was developed for the time required for cans of fish to reach a given temperature during processing. This was tested experimentally.

(Dr. Langstroth)

5. *Fish Oils.*

Further investigations were made on the separation of fish liver oil from the chum by means of two types of centrifuge. It was not found possible to obtain more than 72 per cent of the available oil in the livers by this method. Claims have been made for a much higher yield.

(Mr. Stewart)

Following requests from the Advisory Committee and the Department of Fisheries, work was undertaken to place the staff in a position to co-operate in fish oil inspection. Methods of determining the iodine number, the amount of free fatty acid, and certain physical characteristics of the oils were looked into.

(Mr. Stewart)

Monthly determinations of the percentage oil content of cod livers have been continued. The figures vary from 38 per cent in March to 69 per cent in November. Other factors than time of year are indicated in the results.

(Miss Wilson)

6. *Fish Meal.*

Apart from a small amount of work on herring meal (Mr. Stewart) the investigations on fish meal have been purely routine. One of the main difficulties in the way of making a satisfactory herring meal is the high oil content. Mr. Stewart tried a number of methods of cooking and pressing. By boiling twice with a relatively large amount of water he was able to remove enough oil so that the oil content of the resultant meal was reduced 14.4 per cent. Although this is a very appreciable reduction further removal is probably necessary.

Routine analysis of 28 samples of fish meal has been carried out for commercial firms (Miss Wilson). Most of these analyses have been complete for protein, fat, ash, moisture, sodium chloride and phosphate. Under the existing system no charge is made for this work.

With a view to the possible utilization of dogfish for fish meal the oil content of the muscle and livers of a representative lot of dogfish is being determined.

(Miss Wilson, Mr. Beatty, and Mr. McFarlane)

7. *Other Laboratory Investigations.*

Studies on the development of rigor in fish muscle and of the factors influencing the solubility of the soluble proteins of the muscle have been continued.

(Mr. Beatty)

An investigation of the bacterial flora of fish slime and sea water was continued. The influence of temperature on the physiological activities of selected proteolytic bacteria isolated from fish was begun.

(Dr. Sanborn)

Dr. Langstroth attempted to determine the progress of decomposition in fish muscle by measuring electrical conductivity, but was unable to demonstrate any marked changes.

FIELD WORK

1. *Lobster Cannery Inspection.*

At the request of the Department of Fisheries, the Station carried out an inspection and grading of lobster canneries in eastern Nova Scotia, New Brunswick, Prince Edward Island, and the Magdalen islands. The western portion of Nova Scotia was not covered owing to inability to arrange for the services of a qualified man to grade factories there. The grading was carried out by Dr. Reed and Mr. Hess. The former was in the field from May 29th to June 25th, and the latter from May 31st to July 8th, and from August 20th-30th. Dr. Reed graded 66 canneries and Mr. Hess graded 199. The grading was based on a modification of the "Knight" plan. The grading sheets have been submitted to the Department and a summary report has been prepared by Mr. Hess.

EDUCATIONAL WORK

1. *Course for Fishermen.*

January 22 to March 4, 1930. Attended by twenty fishermen and two Fishery Overseers. The course included Science, Motor Engines, Navigation, Natural Resources, Preparation of Dried and Boneless Fish, and Preparation of Pickled Fish. An examination was held at the end of the Course.

2. *Dalhousie Course for B.Sc. in Fisheries.*

During the Academic term the following classes in this Course were given at the Station:

1. *General Fisheries.* Dr. A. H. Leim. Five hours per week.
2. *Physics and Chemistry of Fish Curing.* Dr. J. H. Mennie. Five hours per week.
3. *Fish Culture.* Dr. A. H. Leim. Five hours per week.
4. *Bacteriology of Fish Curing.* Dr. J. R. Sanborn and Mr. E. Hess. Seven hours per week.
5. *Biochemistry of Fish Curing.* Mr. S. A. Beatty. Nine hours per week.

PUBLICATIONS

The following publications dealing with the work of the Station appeared during the year:—

- Chipman, H. Ritchie and Langstroth, G. O.—"Some measurements of the heat capacity of fish muscle." Proc. and Trans. Nova Scotian Inst. of Sc. 17, 1930, p.p. 175-184.
- Langstroth, G. O.—"On the rate of freezing in fish muscle." Proc. and Trans. Nova Scotian Inst. of Sc. 17, 1930, p.p. 206-212.
- Sanborn, J. R.—"Certain relationships of marine bacteria to the decomposition of fish." Jour. Bacter. 19, 1930, p.p. 375-382.

The following *Manuscript Reports of the Experimental Stations* were issued from Halifax:—

- No. 26. Langstroth, G. O.—"On the rate of freezing of fish muscle." II.
- No. 27. Cooper, D. LeB.—"Further experiments on wood smoke in connection with the fish smoking industry." Part II.

Reports received during this period were as follows:—

- Mennie, J. H.—"Investigation of lobster meal."
- Cook, A. Stanley—"Trimethylamine oxide in fish muscle."
- Chipman, H. R.—"Report on accuracy of Winkler method for oxygen."
- Cooper, D. LeB.—"Report for 1929."

Section I—"The estimation of formaldehyde in wood smoke distillates."

Section II—"Preliminary experiments on an apparatus for shortening the time necessary for smoking fish."

Chipman, H. R.—"An investigation into a method of removing or diminishing the insoluble portion of fishery salt."

Chipman, H. R.—"Notes on a salting experiment."

Chipman, H. R.—"A further investigation into a method of diminishing the amount of the insoluble material in fishery salt."

Sanborn, J. R.—"Certain relationships of marine bacteria to fish curing processes."

- Stewart, W. W.—“New methods of obtaining cod liver oil from cod livers.”
- Stewart, W. W.—“Notes on the preparation of fish meals with their chemical analyses.”
- Hess, Ernest.—“Report on the grading of lobster canneries, June-July, 1930.”
- Mennie, J. H.—“Heat capacity of gels.” Preliminary investigation.
- Langstroth, G. O.—“Thermal investigations on fish muscle.”
- Langstroth, G. O.—“An attempt to determine the progress of decay in fish muscle by electrical methods.”
- Stewart, W. W.—“Notes on the preparation of herring meal.”
- Chipman, H. R.—“The effect of salt solutions on the weight of fish muscle.”
- Stewart, W. W.—“Method of determining the iodine number and acid value of cod liver oil.” Preliminary report.
- Hess, Ernest.—“Report on the grading of lobster canneries operating in the autumn season, August 16 to October 15, 1930.”
- Cooper, D. LeB.—“Methods of fish smoking. An attempt to smoke salted undried fish with dried smoke.”
- Cooper, D. LeB.—“A preliminary study of the effect of varying individual conditions in the smoking of fish on a semi-commercial scale.”
- Panton, Jean R.—“Tryptic hydrolysis of fresh and frozen fish muscle.”
- Butler, Margaret R.—“Observations on the chemical composition of *Laminaria digitata* and *Chondrus crispus*.”
- Johnston, W. W.—“The denaturing of fish muscle during storage.”
- Cook, A. Stanley.—“The discolouration of canned lobster.” Preliminary experiments.
- Beatty, S. A. and
- Leim, A. H.—“High acidity in water supplying Nova Scotia hatchery.”
- Beatty, S. A.—“The reddening of salt mackerel.”

Fish Oils.

A mimeographed outline of a method of preparing cod liver oil was revised and extended by Messrs. Chipman and Stewart with the assistance of Mr. R. Frank Eagar of Halifax. This is available for interested firms or individuals.

THE CHEMICAL COMPOSITION OF SEAWEEDS

BY
M. R. BUTLER

- I. The iodine content of *Laminaria digitata* is found to average 0.368% dry weight, and thus contains a percentage of iodine much greater than any of eleven other species examined by the same method.
- II. Carbohydrate samples have been prepared from various seaweeds by extracting with water, precipitating with alcohol, and dehydrating through a series of absolute alcohol, and ether, with final drying in a vacuum desiccator. The kinds have been: — *Rhodymenia palmata* (dulse), *Ascophyllum nodosum* (rockweed), *Fucus vesiculosus* (rockweed), *Gigartina mamilliosa*, and *Chondrus crispus* (Irish moss).
- III. An attempt was made to determine the composition of what is believed to be a comparatively pure sample of the polysaccharide prepared from Irish moss. The sulphur was determined by precipitation as barium sulphate to be 8.22%; the calcium was determined as calcium oxalate to be 2.15%, or 3.44% when precipitated after oxidation. Dialysis in collodion bags reduced the ash content very little. A solution of the sample was found to be dextrorotatory, but a specific rotation could not be obtained.

TRYPTIC HYDROLYSIS OF FRESH AND FROZEN FISH

BY
J. R. PANTON
(Summarized by S. A. BEATTY)

To determine if freezing, or storage while frozen, have any influence on the digestibility of fish muscle, muscle of cod, haddock, and mackerel fresh, recently frozen, and frozen stored for a considerable time were incubated at 37°C. in

the presence of pancreatin. The hydrolysis of the muscle was determined by the rate of formation of amino acids as measured by Foreman's modification of Sorensen's method.

It was found that (1) haddock muscle, fresh, frozen less than 24 hours and frozen 6 months digested at approximately the same rate; (2) cod muscle, fresh, was digested at a slightly faster rate than muscle stored 2 years at -20°C ; and (3) mackerel muscle, fresh, was digested at the same rate as frozen muscle. Therefore, freezing or storing at -20°C . have little or no effect on the tryptic digestion of fish muscle.

SODIUM CHLORIDE AS A PREVENTATIVE OF DRIP IN FROZEN FISH

BY
S. A. BEATTY

The question of the cause of drip in thawed fish and meat has not been solved. The theory of cell rupture, due to the formation of ice crystals, is the most generally accepted. The rupture of cells is not the only factor and is possibly unimportant. The author has made a study of the water binding power of the proteins of live and dead fish muscle. It has been shown that the proteins retain all water present in the living rested muscle, and that a considerable amount of water is released early after the death of the muscle. Evidence has been found showing this release of water to be the result of the development of post-mortem acidity. This released water may all form drip after freezing and thawing. It may escape from the muscle in one or all of three ways. The ice crystals may puncture the cells and allow the water to escape, although the evidence for this is not strong. The high viscosity of the contents of the fibrils may tend to slow up crystal formation within the fibrils. The faster crystal growth in the interfibrillae spaces draws water from the fibrils and opens up the muscle tissue, allowing the water to escape more readily after thawing. The third factor is possibly the most important. All the water is held firmly by the resting muscle because sufficient protein is in solution to produce a large protein water interface binding all the water present. The release of water in the early post-mortem period is due to the partial isoelectric precipitation of the proteins. The freezing of the water of the muscle results in an aggregation of the protein. This still further lessens the protein water interface and lessens the effect of capillary forces which might have retained a great part of this water.

It is obvious that the greatest preventative of drip is a restoration of the proteins as nearly as possible to their original condition. It is impossible to do this for the whole muscle. It is possible, however, to redissolve a surface layer sufficient to form a semipermeable membrane round the muscle, through which the juices can diffuse only at a very slow rate. This may be done in two ways: the reaction of the surface of the muscle can be made sufficiently alkaline to redissolve the precipitated protein, or the salinity of the surface may be increased sufficiently to reprecipitate the precipitated globulins of the muscle. The former principle is used industrially at the present time. The latter principle is much to be preferred, if it is efficient, as sodium chloride can not be considered as objectionable as sodium hydroxide or strongly alkaline salts.

A factor which has hindered a quantitative study of the problem of drip is the great amount of variation among fish receiving supposedly identical treatment. This difficulty has been overcome by treating one fillet of each fish and keeping its mate for a control. The experiment was done in the following manner,—

Haddock were secured from the fishermen as soon as the trawls were hauled, and were brought immediately to the Station. They were dressed and filleted at once. One fillet was placed in a salt solution of definite strength for a definite time. Its mate was placed in tap water for the same period. The fillets were

wrapped in wax paper and brine frozen at the same rate. They were stored side by side in the refrigerator till defrosted. A small number of fillets were thawed after two months. As the effect of the salt was definite the rest were kept in storage six months in order to determine the effect of longer storage. No difference in the effect of the time of storage on the drip of dipped fillets was found. The results are given together to provide a better average. The defrosting was done as follows,—The wax paper was removed and the fillets were weighed in the refrigerator. They were hung in a sling of twine and allowed to drip 24 hours at 10°C. They were reweighed, the difference in weight indicating the amount of drip. Because of the great amount of variation among the individual fish, it is difficult to present the results in a form which shows properly the effect of the salt. The results of each series have been averaged. Each series represents approximately ten fish. The effect of the salt solutions can be seen from the following summary:

TABLE I

Strength of NaCl. Bath	Time in Bath	Loss of weight on thawing	
		Untreated	Treated
5%	1 Min.	18.1	17.2
	3 "	14.9	13.6
	8 "	9.9	12.1
10%	12 "	10.8	11.1
	1 "	11.2	10.8
	3 "	11.1	3.7
	6 "	14.3	7.2
15%	10 "	13.1	3.6
	1 "	16.1	8.0
	20%	16.7	6.0
20%	½ "	14.7	4.4
	2 "	12.3	3.5

In industrial work it is important to speed up processes as much as possible. It would seem best, therefore, to utilize a very strong solution, about 20% NaCl., and dip a short period, about one minute.

THE DENATURING OF FISH MUSCLE ON STORAGE

BY

W. W. JOHNSTON

It is generally known that muscle if stored over extended periods becomes tough and fibrous on cooking. It has moreover been established from microscopical examinations, that this muscle which has been stored for long periods will not regain the appearance of fresh unfrozen muscle on thawing, as does that which has been held in the frozen condition for only short periods. Since both of the above phenomena bear similar time relationships, it was suggested that there might have occurred a conversion of a portion of the soluble protein of the muscle into a metaprotein—a condition which it was believed would account for the above facts—hence the present investigation was undertaken.

The method consisted in the extraction of about 10 gms. of finely minced muscle in 300 cc. of an approximately 4.5% solution of mono- and di-potassium phosphates, adjusted to a PH. of 7.2. Total and non-protein nitrogen determinations were made on the extract and in this manner the amount of protein nitrogen soluble in the salt solutions was obtained. Extracts were made from fillets of cod, haddock and mackerel, and the nitrogen value based on a protein content of 19%, this figure being taken after a consideration of the moisture content of the fillets, and in the case of mackerel also of the fat content.

In all fish no appreciable decrease in the amount of protein extracted by the phosphate solutions was observed until after a period of from 8 to 10 months, at which time the protein becomes more insoluble and after a period of 25 months storage has decreased to a value little greater than one-half of the original.

In order to differentiate and determine whether the albumen or the globulin fraction was being denatured the more rapidly, aqueous extracts of cod muscle were made and the usual nitrogen determinations done. Although the results of this particular phase of the investigation can not be conclusive owing to the insufficient number of determinations made, they indicate that the amount of protein soluble in water before storage was about five-sixths of that extracted by the phosphate solutions, but that this amount rapidly decreased during the first 7-8 months, after which the rate of denaturation became slower.

This seems to indicate that in the early periods of storage the albumen bears the main burden of the denaturation processes, and since it is during this time that the muscle becomes noticeably fibrous, the suggestion arises that this may be due to the increasing insolubility of the albumen fraction.

BACTERIAL FLORA OF FROZEN FILLETS

BY

N. E. GIBBONS

Frozen fillets were sampled and plated using the Weinzirl technique. The plates were incubated at 25°, 10° and 3° C., and counts made at each temperature, with isolations of representative species. After experimenting with several kinds of media, a 1.5% salt-beef-extract agar was adopted for all work.

Six haddock fillets, which had been stored at -18°C. for a year, when examined in this way showed great variation in the counts, not only between the fillets but in different samples from the same fillet. At 25° the numbers varied from a few thousand to hundreds of thousands, while at 3° the counts were at times only in the hundreds.

If the fillets were allowed to thaw and stand overnight protected from contamination, the number of organisms increased considerably, often as much as ten times.

In order to obtain some of the changes in the flora of the fillets a number of fillets were put up in the usual manner, taking samples before and after freezing. One lot was stored at -18°C., the other at -5°C.

Counts were first made on the fish in the holding tanks, and in both cases they were quite low, several being practically sterile. When sampled in the racks just before freezing the numbers were in the hundreds of thousands—indicating gross contamination in the handling process.

After freezing and 24 hours storage at -18°C., there is a considerable drop in numbers and there seems to be little variation up to the present limit of the data (six weeks).

With those stored at -5°C. there is no appreciable drop in numbers. After two weeks there seems to be an increase. However, the present data is insufficient for definite conclusions.

Some five cod fillets which had been stored at -10°C. for two years were also examined. In these the bacterial counts were low when compared with the other samples. In most cases the 25° counts were little higher than the 3° counts. Moulds often predominated.

THERMAL INVESTIGATIONS ON FISH MUSCLE

BY

G. O. LANGSTROTH

(Summarized by DR. CHIPMAN)

The time of freezing of various thicknesses of fish muscle was determined and compared with the times calculated by the equation,

$$t = (-^2LP/2k (T - 0).$$

Where t is the time of freezing, $-$ is the thickness frozen, P is the density, T is the temperature of the bath, 0 the freezing point of the fish and L and k the latent heat and conductivity respectively. Very good agreement was found, and this equation can therefore be used to find the freezing time of any fish whose constants are known and when one dimensional freezing is used.

When the fish is removed from the freezing bath an additional amount of muscle is frozen due to temperature redistribution. This amount increases with lowering bath temperature until it amounts to about one-quarter of the former amount at a temperature of -78.5°C .

HEAT CAPACITY OF GELS

BY

J. H. MENNIE

(Summarized by DR. CHIPMAN)

It was thought that heat capacity measurements on gels might give information which could be applied to fish muscle. Gels made of gelatine of various concentrations were used and the heat capacities were determined in an adiabatic calorimeter. Measurements were made, from which were prepared curves showing the freezing of sodium chloride solution 1.7%, dry gelatine, and gels of 20%, 40%, and 60%. The gels all show breaks at the eutectic point corresponding to that shown by the sodium chloride. In the case of the 20% gel it was found that the curves were the same for it and for cod muscle above the freezing point. They were different below the freezing point. It is suggested that in the gel there is "bound" water which does not freeze, but in the muscle very little water is "bound."

EXPERIMENTAL SMOKING OF FISH

BY

D. LEB. COOPER

(Summarized by MR. BEATTY)

An experimental smoke producer was designed to give intimate contact between sawdust and air in order to make a reproducible smoke, and it is capable of giving a smoke greater in volume in proportion to the amount of sawdust than any previously built. Smoke was produced which was low in acidity, low in phenols, low in tars, but high in aldehydes.

An experimental smoke house was built containing the following units: smoke house proper, smoke producer, and air conditioner. This enabled the control of three factors, the humidity and the temperature of the entering air, and, to some extent at least, the chemical nature of the smoke. Results indicated the possibility of controlling the degree of smoking and drying to suit the needs of different markets.

It is recommended that the smoke density and the concentration of tar in the smoke be brought under control.

THE EFFECT OF SALT SOLUTIONS ON THE WEIGHT OF COD FISH MUSCLE

BY

H. R. CHIPMAN

The muscle was soaked in solutions of different concentration, and of a great variety of salts of sodium, potassium, lithium, etc. It was found that in general there was an increase in weight with pure water. This increase became smaller as the salt concentration was increased, until it passed through a minimum at about the isotonic point. A further increase in salt concentration caused a greater increase in weight until a maximum was reached at about 1 N. Further increases in concentration produced a lessened weight gain and, if the concentration were strong enough, there was a loss of weight.

As an explanation of the shape of the curves obtained with the salts, it is suggested that the osmotic effect of the salt solution caused a lowering in the weight from that due to soaking in pure water until the isotonic point was reached. A further increase in salt concentration produces a greater solubility of the protein causing more water to be taken up by the fish, the two coinciding at about 1 N. In support of this explanation it was found that the greater the amount of soluble nitrogen in the fish, the greater would be the increase in weight at the maximum point. The decrease in the weight gain leading to a weight loss with greater concentrations would be due to the great increase in the osmotic force over that due to the solubility of protein.

Different salts gave different values for the weight change, but the curves were all similar. Varying the pH caused changes in the shape of the curve; a pH below six showing only a straight osmotic effect, while a pH above five giving a curve with maximum and minimum points.

THE DISCOLORATION OF CANNED LOBSTER

BY

A. S. COOK

Does any change affecting the discoloration take place in the composition of lobster muscle, during the gradual loss of vitality by the lobster but before it is actually dead as judged by the practical method of producing? No significant difference was found between the volatile sulphur given off by 10 minutes steam distillation of 10 gms. of lobster tail meat at a pH of 5 between freshly caught vigorous lobsters and those which were at the point of death.

Since in canneries it is often impossible to deal with all the lobsters on hand without four hours, is it advisable to boil them and then hold them on ice or is it better to attempt to keep them alive until they can be processed? Several canning experiments were conducted and the cans examined for discoloration as well as meat for volatile sulphur content at the end of 3 weeks. Both procedures produced discolored cans.

It was found that the process of autoclaving increases the volatile sulphur content of the meat markedly.

WORK ON LOBSTER CANNING

BY

E. HESS

1. *Grading of Lobster Canneries:*

At the request of the Department 199 lobster canneries were graded during June, July and August 1930, including all canneries in operation in New Brunswick, Prince Edward Island and Cape Breton (Richmond, Cape Breton and Victoria Counties), according to a grading form somewhat modified from Dr.

Knight's original scheme. (Dr. G. B. Reed graded the remaining canneries in Cape Breton—Inverness county—the canneries on the Magdalen Islands and in Eastern Nova Scotia, 66 canneries in all). The grading score varied from 45 marks to 110 marks, with an average mark of 72.9 for the whole Maritimes. 20% of the canneries are considered "poor", grading under 60; 34% are "fair", grading from 60 to 74, and 46% of the canneries are termed "good", grading 75 and higher.

Modification of the present grading scheme, in the sense of a wider deviation from the original Knight scheme, is advocated to make the grading score more intelligible, by making 100 marks a "perfect" score, with deductions only (in case of inferior conditions in the canneries), but no bonus-additions, as in the present scheme. Sub-division of the form into "Equipment" and "Operating methods" seems advisable.

The weakest point in the lobster industry to-day (both in the canning and the live lobster trade) is the care of the live lobsters from the time they are removed from the trap until they are ready for packing. As it is impossible to produce canned lobsters of first quality from an inferior raw material, the question of delivery of live lobsters of prime quality at the canneries should be investigated especially in view of the enormous losses from dead lobsters, and the danger of poor quality canned lobsters (black discoloration) from packing lobsters of low vitality.

2. Canning Experiments:

(a) *Crystal formation in canned lobsters.*

Cans packed commercially in various ways (enamel cans, plain cans, without lining, with lining, sea-water and fresh water pickle, acid pickle, 1.25% acetic acid, in all possible combinations), all showed formation of crystals of magnesium ammonium phosphate to a larger or smaller extent, in some cases of considerable size (2-3 mm. diam.), in other cases in the form of a very fine gritty layer on the lining or the meat. The cans packed with sea-water pickle showed most crystals on the whole, while the ones with acid pickle from fresh water showed very few crystals only in each can. The pH of the pickle on opening the cans (after 17 months' storage) was from 7.6 to 7.9 for the non-acid pickles and from 7.2 to 7.5 for the acid pickles, the lobsters being caught in the month of June at the Magdalen islands.

A series of cans packed from lobsters caught in August at Point du Chene, N.B., showed after three months' storage no formation of crystals, whether in pickle without acid or in pickles containing increasing amounts of acid (0% acid: pH 7.1 to 7.6; ½% acid: pH 6.8; 1 to 2% acid: pH 6.6; 3% acid: pH 6.3; 4% acid: pH 5.8) except in one can with a pickle of pH 7.6.

These results agree with Harrison's that fall lobsters have more acid meat than spring caught lobsters, and seem to indicate that for that reason crystal formation in fall packed lobsters is not as frequent, as the crystal formation is influenced by the pH of the medium in which they grow, the crystals of magnesium ammonium phosphate being soluble in acid, but insoluble in water.

(b) *Pink slimy sediment in lobster cans.*

Experiments seem to indicate that the addition of increasing amounts of acetic acid to the pickle causes an increased removal of red pigment from the lobster meat and an increased red discoloration of the pickle, as demonstrated by comparing the sedimentation remaining on filter papers after filtration of the pickle from the different cans.

THE USE OF CENTRIFUGAL EXTRACTORS TO RECOVER THE
OIL FROM COD-LIVERS

BY

W. W. STEWART

In the "Fishing Gazette", May, 1929, Eric Loffler, Fisheries Engineer for the United States Bureau of Fisheries, reported that by using a centrifugal extractor he was able to recover all the oil that the raw livers contained, except about 4% which remained in the chum. In the pressing method about 28% of the original oil is left in the chum, so by the centrifugal extractor Loffler increased the yield of oil by 24%. The oil recovered by this method is a better grade of oil than is obtained by the pressing method because the oil is extracted from the chum while it is still hot before any spoiling action takes place.

Fresh cod livers were used in all our experiments. A sample was taken and the oil content of the raw livers was determined by the ether extract method. The raw livers were cooked with live steam, following the commercial method as closely as our equipment permitted. The cooker was a type similar to those used by the industry, a cylinder with a conical bottom. The steam pipe extended almost to the apex of the cone. An autoclave was used as a steam boiler. The steam pressure during the cooking was kept at 15 lbs. per sq. in. The period of cooking was 30 minutes. Then the chum was allowed to stand for 15 minutes so that the oil would rise to the surface of the chum. This oil was skimmed from the cooker, filtered through cheese cloth and cotton and then weighed, so as to obtain the yield. The chum was then run into a centrifuge. The oil from the centrifuge was filtered through cheese cloth and cotton and weighed. For each run about 25 to 30 pounds of raw livers were used.

Results:

The results show the yield of oil, calculated as the per cent of the original oil contained in the raw livers, that is recovered by these methods.

Experiments using a Tolhurst centrifuge.

Oil content of the raw livers	% yields		Total
	Skimmed oil	Centrifuged Oil	
1. 58.3%	37.3	43.2	80.5
2. 58.3%	28.2	34.3	62.5
3. 57.7%	35.3	25.2	60.5
4. 67.7%	40.3	17.9	58.2
5. 66.0%	39.8	23.7	63.5

The livers used in 1. were frozen livers, so this accounts for the increase yield of 20%. This would be expected from the work that has been done on the extraction of oil from frozen livers at this station.

Experiment using a Fletcher centrifuge.

Oil content of the raw livers	% yields		Total
	Skimmed oil	Centrifuged Oil	
64.0%	48.3	23.2	71.5

From the experiments it was found that about 5% of the original oil was lost due to the handling, filtering, etc. during the process. In all cases the yields are lower than those reported by Loffler in 1929. He claimed to have recovered about 95% of the original oil as he only left about 4% of the original oil in the chum.

METHODS FOR THE DETERMINATION OF THE CHEMICAL AND PHYSICAL
CHARACTERISTICS OF COD LIVER OIL

BY
W. W. STEWART

The Hanus method and the Wijs method are the two methods that are most generally used to determine the iodine value of an oil. They were compared and it was found that the Wijs method gives a higher value than the Hanus method for the iodine value; iodine value for cod liver oil being 171.3 (Wijs) and 170.0 (Hanus). The Wijs method only requires one and one half hours for the reaction to be completed. The Hanus method has an advantage over the Wijs method in that the Hanus solution is easier to prepare.

On the Acid Value of Cod Liver Oil.

The acid value of cod liver oil was determined in the usual way, namely titrating the free fatty acids of the oil with O.I.N. NaOH, using phenolphthalein as an indicator, in a hot alcohol solution. In hot alcohol the end point for the titration is not very sharp—it was found by using a solvent of 1 part alcohol and 1 part of ether or benzene that the end point of the titration was very sharp.

Acid value of cod liver oil using different solvents as above, the alcohol being either pure or denatured and the benzene either C.P. or 90%, ranged from 9.8 to 9.87, giving agreement within the limit of experimental error.

STUDIES ON RIGOR DEVELOPMENT IN FISH MUSCLE

BY
S. A. BEATTY

The work carried on at the Atlantic Biological Station during the summer of 1927 was continued at Halifax during the spring and summer of 1930. In the previous work it was shown that the proteins of the resting muscle hold all the water, and that part of this water is released in the early post mortem period. The problem has been studied further in order to determine the cause of this release of water. Cod were killed, filleted and the muscle of one fillet was ground and pressed as rapidly as possible. The reaction of the first drop of press juice, and of the press juice that later welled up readily was measured. The second fillet was allowed to go into rigor. It was then ground and pressed and the reaction of the press juice was measured. The results are given in table I.

TABLE I

The hydrogen ion concentration of the press juice of fish muscle before and during rigor

Fish	Press juice first to appear	Free welling press juice	Press juice during rigor
Cod 1.....	pH. 7.13	pH 6.72	pH 6.68
Cod 2.....	pH. 6.79	pH. 6.67	pH. 6.68
Cod 3.....	pH. 7.03	pH. 6.94	pH. 6.85
Sea raven.....	pH. 6.92	pH. 6.84	pH. 6.78

The finding that the concentration of the proteins of the muscle is greater during rigor than in the stage wherein the press juice wells up readily was confirmed. The suggestion was advanced that this increase in the solubility of the press juice was the result of a peptization of the muscle globulin by an increased salt concentration in the muscle. This increased salt concentration is probably either lactate or orthophosphate.

The lactate concentration of the free welling press juice and that of the

press juice of rigor was determined. They were found to be approximately equal. The increase in the concentration of protein in the press juice during the onset of rigor is not due to an increase in lactate.

Evidence has been found indicating the muscle globulin to be present in the anisotropic bands of the muscle. Fish muscle, (cod, haddock, flounder) was found strongly doubly refractive under a polarizing microscope. The double refraction disappeared on the addition of a protein coagulant. The double refraction did not disappear on soaking teased muscle in distilled water, but it did disappear on soaking the teased muscle in sodium chloride solution, 5%—10%. These results are interpreted as follows:—

The globulin of the muscle is in a special molecular orientation in the anisotropic band. The addition of a protein coagulant precipitates the protein, disrupting its specific molecular orientation; the addition of salt results in a pronounced swelling which disrupts also the specific molecular orientation.

A theory of rigor has been developed. This theory is based on the salt effect on the globulin of muscle. The presence of salt, probably orthophosphate, increases the solubility of the globulin in the anisotropic segments. The globulin withdraws water from the isotropic segment causing a shortening of the muscle.

Experiments have been made which show the feasibility of this theory. Cunner were used in these experiments. They were killed by a blow on the head. They were kept immersed in water till the muscles did not react to a direct electric stimulus. It was believed that all nerve action was eliminated in this way.

Distilled water, 1 cc. was injected into the muscle of one side in the region of the external anal orifice. The body immediately curved towards the injected side.

Sodium chloride solution 25%, 5—10 cc. were injected into the muscle of one side and an equal volume of water in the opposite side. The body curved very sharply towards the side injected with distilled water. When injections of salt were reduced to 1 cc. or less the curvature was towards the side injected with salt solution.

The fish were injected with varying amounts of hydrochloric acid in an attempt to reach the isoelectric points of the protein concerned. If the contraction be the result of a swelling process, a reaction close to the isoelectric points of the protein about pH 5.5 should prevent the contraction of rigor. No concentration of acid could be found which inhibited the contraction.

In another series of experiments sodium hydroxide in various concentrations was injected into the muscles of one side and hydrochloric acid in the same concentration was injected into the muscles of the other side. The fish bodies curved invariably towards the alkaline side. After about ten minutes, the bodies curved towards the acid side.

These experiments show that,—(1) salt solutions in low concentrations produce contraction, and in high concentration inhibit contraction. (2) Acids in all concentrations produce contraction. (3) Alkalis in low concentration produce contraction more rapidly than acids, but when both are injected in the one fish the final contraction is always towards the acid side. The first conclusion fits in with the proposed scheme of the cause of rigor. Undoubtedly acids can produce a contraction, but the earlier work on rigor shows that it is extremely unlikely that an increase in acidity has a direct bearing on the production of the rigor contraction. The last conclusion is very unexpected. It is explained as follows:

The fish were on the verge of rigor at the time of the injection. The amount of protein in solution, and hence the amount of bound water is determined by two factors, the hydrogen ion concentration and the salt concentration.

In the pre rigor period, two processes are going on: lactic acid is being produced increasing the hydrogen ion concentration, and orthophosphate is being produced increasing the salt concentration. The former tends to lessen the solubility of the protein, and the latter increases it. Injection of alkali counteracts the former. If the rigor contraction be the result of increased solubility of the protein, the muscle should contract immediately on injection of the alkali. The increase in orthophosphate is due to increase in hydrogen ion concentration. Hence in the side injected with alkali the production of orthophosphate is inhibited, while in the side injected with acid the production of orthophosphate is increased. The diffusion of acid and alkali through the muscles will in a short time effect their neutralization. When this has taken place the contraction will be determined by the amount of orthophosphate. Hence the body curves towards the side injected with acid. It would appear, therefore, that the rigor brought on by a small addition of acid is due to an increase in orthophosphate, and rigor brought on by a larger addition of acid is due to the direct action of the acid itself. These studies have been discontinued for the time being. They will be resumed some time during the summer of 1931.

CERTAIN RELATIONSHIPS OF MARINE BACTERIA TO FISH CURING PROCESSES

BY

J. A. SANBORN

(Summarized by E. HESS)

The following species were isolated from pickled fish: *Sarcina subflava*, *Sarcina lutea*, *Staphylococcus albus*, *Micrococcus candidans*, *Micrococcus aurantiacus*, actinomyces-like forms and torulae. The red organism (*Serratia salinaria*) was isolated from sea salt. Under most favourable conditions for pickling actinomyces-like forms and torulae predominated, the fish being in good condition; when putrefactive changes were under way, the micrococci and sarcinae were dominant, i.e. halophilic species of marine origin, which find favourable growth conditions in concentrations of salt as high as 10-20% NaCl. The different chemical constituents of different salts were found to have different influences on the changes in hydrogen ion concentration of the media with increasing salt concentrations. The possibility of inhibiting certain undesirable types by such means should be investigated, as well as the possibilities of brine inoculation with some harmless species in order to suppress the salt tolerant proteolytic types.

SUMMARY REPORT

OF

PACIFIC BIOLOGICAL STATION

NANAIMO, B.C.

1930

The following constituted the staff of the Station during the year 1930:

- Dr. W. A. Clemens, Director.
- Dr. R. E. Foerster, Chief Biologist (Sockeye Salmon Propagation).
- Dr. J. I. Hart, Assistant Biologist (Pilchard and Herring Investigations).
- Dr. A. L. Pritchard—Scientific Assistant in Biology (Pink and Chum Salmon Investigations).
- Mr. C. R. Elsey, Scientific Assistant in Biology (Shellfish Investigations).
- Dr. N. M. Carter, Associate Chemist (Oceanography, etc.)
- Mr. C. M. Mottley, Scientific Assistant in Biology (Trout Investigations).
- Mr. R. W. Whittaker, Scientific Assistant in Biology (Pilchard Investigation).
- Mr. D. C. G. MacKay, Scientific Assistant in Biology (Shellfish, Salmon, Herring Investigations).

SEASONAL

Mr. H. J. Alexander, Salmon Tagging
 Mr. D. Beall, Oceanography.
 Mr. E. C. Black, Oyster Culture
 Mr. L. L. Bolton, Oceanographical Apparatus
 Mr. G. Carl, Oyster Culture
 Mr. R. H. Fleming, Oceanography
 Mr. G. Hern, Pilchard Investigation
 Mr. L. McHugh, Salmon Tagging.
 Mr. T. Wheeler, Salmon Tagging.

This has been the most active year of investigation in the history of this Station. Approximately fifty investigations have been carried forward during the year with about thirty-two workers involved. Problems calling for solutions are being brought forward to such an extent that it has been impossible to attempt to meet them all with the funds and workers available. However, this is a healthy situation and our concern should be for a sound, well-balanced development. The program now being followed gives major attention to those investigations deemed of fundamental importance to the conservation of the fishery resources and requiring continuity of observation, experiment and record over a period of years. The progress in the work of the Station has been facilitated by the appointment of additional members to the permanent staff, by the additions to the equipment and by the extension of living accommodation. The most important needs of the Station in the immediate future are:

- (a) Increased laboratory accommodation with offices or private laboratories for the members of the staff,
- (b) fireproof library and museum building,
- (c) living accommodations for staff,
- (d) improvement in fresh water supply,
- (e) experimental fish hatchery and rearing ponds.

INVESTIGATIONS

I. *Sockeye Salmon Propagation*.—The study of the propagation of sockeye salmon has been continued under the direction of Dr. R. E. Foerster. In continuation of the program at Cultus lake, all the adult fish arriving at the fences in 1929 were stripped, the eggs placed in the hatcheries and the fry liberated in the lake. The following statement covers the operations:

Total sockeye females arriving at fence.....	3437		
Average number of eggs per female.....	4545		
Total eggs contained in all females.....	3437x4545—	15,621,165	
Total eggs contained in females dead on fences.....	472x4545—	2,145,240—	13.7%
Total eggs contained in females spawned.....	2965x4545—	13,475,925—	86.3%
Total eggs collected.....	12,078,633—		77.3%
Losses occurring in hatchery.....	2,434,515—	15.6% of total eggs.	
		—20.2% of eggs collected.	
Fry liberated.....	9,644,118—	61.7% of total eggs.	
		—79.8% of eggs collected.	
Total eggs contained in all females.....	15,621,165		
Total eggs in females dead on fences.....		2,145,240—	13.7%
Total eggs left in spawned females.....		1,397,292—	9.0%
Total losses in hatcheries.....		2,434,515—	15.6%
Total fry liberated.....		9,644,118—	61.7%
	15,621,165	15,621,165—	100.0%

The run of 1930 is being allowed, after enumeration, to pass into the lake to spawn naturally.

At Taft, in the Shuswap lake area, approximately half a million young sockeye salmon were held until large enough for marking. They were marked

during the latter part of October and released in Eagle river. The eggs were collected in 1929 in Adams river, a tributary of Shuswap lake. This experiment is being carried out in order to obtain information for comparison with that of the experiment of the previous year when eggs were transplanted from Cultus lake.

An experiment to test the efficiency of the pond system in artificial propagation is being carried out at Cultus lake. Half a million young sockeye are being retained in artificial ponds. Half the number were marked and liberated in the lake in the fall of 1930 and the remainder will be marked differently and liberated in the spring of 1931. The seaward migrants will be counted and the percentage of survival determined.

There were counted, in the spring of 1930, the seaward migrants resulting from the planting of two and a half million eggs in the small streams tributary to Cultus lake. The total amounted to 38,000 yearlings. With these, 66,000 two-year-old fish, part of the product of natural spawning in 1927, passed out to sea.

II. *Pilchard and Herring*.—These investigations are being carried out under a joint arrangement with the Provincial Fisheries Department and under the direction of Dr. Hart. The pilchard studies have been conducted along much the same lines as in the preceeding year. Dr. Hart was located at Nootka and Mr. Whittaker at Kildonan. The catches have been sampled and analysed as to lengths, weights and sexes of the fish and it is hoped the results will indicate signs of depletion, if any. The data show that the females average longer and heavier than the males, that the females are more numerous than the males, that there is a definite relationship between length and weight, that the condition of fatness may be recorded mathematically. A study has been made of the specific characters of the pilchard with the object of determining the movements and mingling of schools and of determining the relationship between the British Columbia pilchard and the California sardine. An attempt is being made to determine the ages of pilchards by the use of the otoliths, since the scales are not satisfactory. Material has been collected for a study of the food taken throughout the season.

The herring investigations this winter will be conducted along somewhat similar lines as those on the pilchards. An attempt will be made to establish a system of annual inspection of spawning areas to serve as a possible basis for prediction of future supply.

A study of the alleged pollution of herring spawning areas by effluents from reduction plants was commenced by Mr. H. B. Marshall. Samplings of sea water were taken in several linear and vertical series off two plants in Barkley sound, before operation, sometime after commencement of operation, and toward the end of the season. Extensive analyses were made to determine the character, amount, direction of movement, extent of dilution, etc., of the effluents.

III. *Pink and Chum Salmon*.—The study of pink salmon in Massett inlet has been continued by Dr. A. L. Pritchard. Fences were installed in McClinton creek for intercepting the runs of adult fish proceeding upstream and of seaward migrating fry. Approximately 66,000 pink salmon were counted through the fence in the fall of this year. In the spring of 1931, the fry resulting from the spawning of these fish will be counted as they move downstream and data thereby obtained regarding the production of seaward migrants from a known spawning escapement. Large numbers will be marked in order to obtain information concerning the movements of the returning adults, the numbers returning to the parent stream, and the extent of mortality during the growth period in the sea. Plans are being developed for an experimental planting of pink salmon eggs or fry in McClinton creek next year in the attempt to determine the possibility of obtaining a return from a transplantation. It may be mentioned that Massett

inlet produces every other year a pack of pink salmon of the value of \$300,000 or more. It is a resource that should be carefully conserved.

Some work is being carried forward with the life-history of the chum salmon but this year it has been necessary to devote most attention to the pink salmon study.

IV. *Shellfish Investigation.*—Intensive oyster investigations have been conducted in Boundary bay and Ladysmith harbour. In each of these districts there are now three species of oysters, namely, the native, the introduced Eastern and the introduced Japanese. A study of the physico-chemical conditions in relation to the spawning, spatting and growth of these species has been carried out in the two areas. Experiments were conducted with respect to determining the best methods for spat collection and some consideration was given to the question of dyking. Oyster cultivation along the British Columbia coast is increasing and accurate information concerning the suitability of the various species to conditions prevailing in the various localities will be of much value. Mr. C. R. Elsey has been in charge of the investigations and has had two assistants, Mr. E. C. Black and Mr. G. C. Carl.

A study of the distribution, reproduction and growth of crabs has been carried out in the Prince Rupert area by Mr. D. C. G. MacKay. For purposes of regulation of the fishery, information concerning the mating season has been sought particularly.

V. *Skeena River Investigation.*—It has seemed important to make a comprehensive and accurate study of salmon propagation on the Skeena river system with the object of developing working plans whereby this river system may be maintained at a maximum for salmon production. Such a study will involve a detailed analysis of the catch statistics, a survey of the spawning areas, the development of a comprehensive annual system of spawning bed reports, the possible development of measures for the assistance in natural propagation in addition to artificial methods. A commencement in the program has been made this year by Mr. D. C. G. MacKay, who carried out a survey of certain streams in the Babine lake district. He was assisted for a short period by Mr. H. J. Alexander. A camp was established near the mouth of Fifteen Mile creek on August 12th. As this stream represents one of the best spawning areas on this part of the Skeena river system, it was desired to make continuous observations throughout the season. With the exception of one coho, which was first observed on October 8th, the only salmon to appear until the investigation was brought to a close on October 12th were sockeyes. The stream was inspected throughout practically its entire length. In order to determine one aspect of the success of the spawning, several hundred dead female sockeye salmon were opened and the number of remaining eggs determined. The average per fish was thus found to be 171. From this point of view the spawning was reasonably successful but the lowness of the water was an adverse factor.

Other phases of the investigation included the measuring of 778 dead female and 484 dead male sockeye salmon, short trips to adjacent streams, the collecting of plankton and, in general, the accumulation of such data as might prove of present or future value.

VI. *Trout Investigation.*—The trout investigation, which for the past four or five years has been dealing with the identity and systematic relationships of the trout of British Columbia, was continued by Mr. C. McC. Mottley in the Kootenay district. In order to estimate the success of Kamloops trout plantings in waters where native trout are also found it has been necessary to attempt to establish rigid recognition characters for this species under varying conditions of environment. Temperature seems to be the chief factor in determining the time of spawning, rate of development of the eggs, time of hatching, rate of growth,

the amount of available food, and hence many of the body characters of this trout. The effect of temperature on the early stages of Kamloops trout was carried out in the Dominion Hatchery at Nelson, B.C., by means of controlled conditions. Further experiments to determine the effect of transplanting Kamloops trout, that is, the effects on later stages, were carried out by transferring 2,000 marked fry (1½ inches long) to Cottonwood lake (five miles from Nelson and at an elevation of 2,865 feet) and to coastal conditions at the Pacific Biological Station, Nanaimo. Field work consisted in the collection of samples from new localities not already listed in previous work and in a study of summer water temperatures in the various streams tributary to Kootenay lake. Collections of fry from native environments were made for purposes of comparison with artificially reared fry and native fry.

Owing to the importance of the Kokinee (land-locked sockeye) as a food for large trout and owing to its economic importance as a food for local residents when preserved, a study of the life-history of the Kokinee was commenced. Preliminary work consisted in the collection of 1,100 adults from the spawning run for a racial comparison with sockeye salmon. A planting of 85,000 eyed eggs from Kootenay lake was made in a stream near the Pacific Biological Station to determine the effects of changing the environment on this species.

VII. *Oceanography*. The study of the oceanographic conditions in the Strait of Georgia was continued under the general direction of Dr. A. H. Hutchinson. Particular attention was given to the question of silica, phosphate and nitrate production and distribution and its relation to the fertility of these waters. A special study was commenced on the conditions prevailing in three fiords. The coast of British Columbia is a series of very extensive fiords and it seemed important to determine the conditions in several of these in relation to the fisheries. Dr. Hutchinson gave special attention to the phytoplankton and Miss M. H. Campbell to the zooplankton. The chemical analyses of the water samples were carried out by Mr. R. H. Fleming and Mr. D. Beall. Dr. C. M. Fraser commenced an examination of the bottom fauna of the fiords.

Mr. L. L. Bolton took up a special study of the relative efficiencies of various types of apparatus used in the collection of plankton, having in view the possibility of standardization of methods.

Dr. N. M. Carter has been appointed to the staff of the Station as chemist and it will now be possible to carry forward the oceanographical program throughout the year and to commence a program on the west coast of Vancouver island in relation to the salmon, pilchard and herring fisheries.

VIII. *Salmon Tagging*.—Spring and coho salmon were tagged in three localities, namely, around the north-west end of the Queen Charlotte islands, in the vicinity of Porcher island, and in the Goose island area. Pink and chum salmon were tagged again in Queen Charlotte sound and Johnstone strait. The tagging staff consisted of Messrs. L. McHugh, H. J. Alexander and T. C. Wheeler. The results of all tagging work are now being published as bulletins in the series of the Board. All results from 1925 to 1928 inclusive have been or are now in the process of being published. The returns from the tagging of coho, pink and chum salmon in 1929 and 1930 are now being prepared for publication, but those from the spring salmon tagging will be delayed because of the variation in the age of maturity of this species and the recaptures consequently being spread over several years. The data on record at the present time are as follows:

THE TAGGING OF SPRING SALMON

1. *Spring salmon, West coast of Queen Charlotte islands, 1929*

From May 12 to May 31 and at intervals throughout June, July and August, 375 spring salmon were tagged on the west coast of the Queen Charlotte islands. Of these, 188 were taken in Rennel sound, 8 at Hippa island, 2 at Frederick island

and 177 slightly farther north at La Perouse rocks. Because of the similarity of the distribution of returns from all these areas, they have been taken together under the caption given above. The total recaptures to date have amounted to 40 (10.7 per cent.) distributed as noted below:

	1929	1930
North island, Queen Charlotte islands.....	2	2
Skeena river.....	2	
Tofino, west coast Vancouver island.....	1	
Ucluelet, west coast of Vancouver island.....	1	
Straits of Juan de Fuca (B.C. waters).....	3	
Fraser river.....	7	
Straits of Georgia and Puget sound (U.S. waters).....	4	
Coast of Washington.....	4	1
Columbia river.....	6	
Coast of Oregon.....	7	
	<hr/>	<hr/>
	37	3

The distribution of returns is essentially similar to that reported previously for Hippa island for 1925. Fewer, however, were taken in the Columbia (15 per cent. as opposed to 27) and on the coast of Oregon (17.5 per cent. to 32.4), while slightly larger numbers were returned from the Fraser river, Puget sound and the coast of Washington. A total of 55 per cent. of the returns were from American waters.

2. *Spring salmon, West coast of Queen Charlotte islands, 1930*

In 1930, although more attention was paid to the north coast of the Queen Charlotte islands, nevertheless, 179 spring salmon were tagged on the west coast. These were distributed in the following manner: 115 at Rennel sound, 1 at Hippa island, 13 at Port Louis, 12 at Frederick island and 38 at La Perouse rocks, twenty or 11.2 per cent. have already been returned.

	1930
Skeena river.....	1
Millbank sound (St. John's harbour).....	1
Fraser river.....	3
Straits of Georgia and Puget sound (U.S. waters).....	2
Coast of Washington.....	2
Columbia river.....	9
Coast of Oregon.....	2
	<hr/>
	20

These returns are almost identical with those of 1929 from the same area, except that there is an increase in Columbia river recaptures to 45 per cent., accompanied by a slight decrease on the Oregon coast to give a percentage of 75 from American waters.

3. *Spring salmon, North coast of Queen Charlotte islands, 1929*

It happens that the peak of the run of spring salmon on the north coast of the Queen Charlotte islands occurs after that of the west coast is passed. Accordingly in 1929, taggers were able to leave the latter early in June and work at North island in late June, July and August, examining almost the whole run. In all, 402 fish were tagged at North island. Some 41 others were tagged from Shag rock to Rose Spit, but since no returns have been forthcoming, these have not been considered. The returns amounted to 60 fish, or 14.9 per cent. of the total, as follows:

	1929	1930
Alaska.....	1	
North island, Queen Charlotte islands.....	2	
Skeena river.....	5	
Rivers inlet.....	1	
Lennard island, off Clayquot.....		1

Straits of Juan de Fuca (B.C. waters).....	2	
Fraser river.....	17	2
Straits of Georgia and Puget sound (U.S. waters).....	1	1
Coast of Washington.....	12	
Columbia river.....	10	3
Coast of Oregon.....	2	
	53	7

The localities from which these tags have been returned are almost the same as those in which the fish of the west coast were recaptured, but the number distribution in these localities is radically different. The most striking differences are that the returns from the Fraser river were almost doubled (31.6 per cent. as opposed to 15.8), while the Columbia and the coast of Oregon recaptures fell off, the latter reaching the low figure of 3.3 per cent. The probable significance of this is discussed later in this paper. However, 48 per cent. of the returns were from American waters, exclusive of Alaska.

4. *Spring salmon, North coast of Queen Charlotte islands, 1930*

This year, when the numbers in the run off the mainland at the mouth of the Skeena river were decreasing, attention was turned to the northern coast of the Queen Charlotte islands. Throughout June, July, and August, 660 spring salmon were tagged between North island and Tow Hill in the following proportions:—North island, 472; Pillar bay and Jalun river, 60; Shag rock, 41; Virago sound, 18; Massett flats, off Massett inlet, 25; and Tow Hill, 44. As in previous cases, due to the similarity of returns, all are considered together. In all 84 recaptures, amounting to 12.7 per cent., have been made as follows:

	1930
Alaska.....	1
North coast of Queen Charlotte islands.....	5
Qwadzleet anchorage, Stephens island.....	1
Skeena river.....	2
Burke channel.....	3
Rivers inlet.....	2
Tofino, west coast of Vancouver island.....	1
Kyuquot, west coast of Vancouver island.....	1
Swiftsure banks.....	2
Barkley sound.....	1
Straits of Juan de Fuca.....	3
Straits of Georgia (B.C. waters).....	1
Fraser river.....	15
Straits of Georgia and Puget sound (U.S. waters).....	5.
Coast of Washington.....	9
Columbia river.....	21
Coast of Oregon.....	11
	84

In general, the recaptures noted above are similar to those of 1929 for the same area, with a slight decrease in return from the Fraser river (31.6 to 17.8 per cent) and the coast of Washington (19.4 to 10.7 per cent). Since, however, the numbers from the coast of Oregon increased slightly, the returns from American waters still constituted 54.7 per cent.

5. *Spring salmon, Hecate straits off Banks and Stephens islands, 1930*

This heading includes Bell passage, the waters around Porcher island, including those off Cape George, Edye pass and Chearnley pass, the northern end of Banks island including Bonilla island, and Northwest and White rocks. In April, May and August, 182 spring salmon were tagged of which 10 or 5.5 per cent were recaptured.

	1930
Alaska.....	1
Naas river.....	1
Rivers inlet.....	1
Kyuquot, west coast of Vancouver island.....	1
Alberni canal, west coast of Vancouver island.....	1
Howe sound.....	1
Fraser river.....	1
Straits of Georgia and Puget sound (U.S. waters).....	1
Coast of Washington.....	1
Columbia river.....	1
	10

These returns differ radically from those for the areas on the Queen Charlotte islands in the fact that they are widely spread over Canadian areas. Ten per cent were recaptured in Alaska and 30 in United States waters. This indicates that these springs are bound chiefly for Canadian spawning rivers.

6. *Spring salmon, Millbank sound area, 1930*

The destination of the spring salmon which have been taken in the vicinity of Millbank sound has long been a matter of conjecture. Accordingly in 1930 one boat was instructed to confine its operations as closely as possible to this region. In June, July and August, 207 fish were tagged in Millbank sound, chiefly near St. John's harbour, and 95 off Koeeye river and Hakai channel in Fitzhugh sound, making a total of 302. Thirteen of these, or 4.3 per cent, have been returned to date.

	1930
Fitzhugh or Burke channel.....	1
Rivers inlet.....	4
Robson's bight, Johnstone strait.....	1
Kingcome inlet.....	1
Straits of Juan de Fuca (B.C. waters).....	1
Fraser river.....	3
Columbia river.....	2
	13

In this case, the extreme of localization in distribution to Canadian territory is reached since only 15.4 per cent were apprehended in United States waters, viz., the Columbia river. The other returns are spread along the mainland and Vancouver island shores from Fitzhugh sound in the north to the Fraser river in the south, Rivers inlet having the largest number, 4 or 31 per cent.

7. *Spring salmon, Hardy bay, 1930*

As far as spring salmon were concerned, the area around Hardy bay, or the north-eastern end of Vancouver island, had heretofore been given only passing notice while work was being done on the other species of salmon. The numbers handled at these times were not sufficiently large to warrant any definite conclusions. In 1930, however, during April, May and June, 436 springs were tagged. Of these, 23 were taken along the shore from Hope island to Cape Scott, and 413 in the vicinity of Hardy bay. The total recaptures were 24 or 5.5 per cent, distributed as follows:

	1930
Hardy bay.....	1
Bates' pass.....	1
Port John, Fisher channel.....	1
Bute inlet.....	2
Straits of Juan de Fuca (B.C. waters).....	2
Cape Flattery.....	1
Fraser river.....	1
Straits of Georgia and Puget sound (U.S. waters).....	7
Coast of Washington.....	5
Columbia river.....	3
	24

These returns are striking by comparison with those of the last two areas discussed in that there is only one fish or 4.2 per cent from the Fraser river, and 15 or 62.5 per cent from United States waters. This is similar to the results from the west coast of Vancouver island except that the percentage for the Columbia river is lower.

THE TAGGING OF COHO SALMON

8. *Coho salmon, North coast of Queen Charlotte islands, 1929*

During June, July, August and early September of this year, 728 cohoes were tagged on the north coast of the Queen Charlotte islands, over all the area from North island to Hecate strait, off Rose Spit, in the following proportions:—North island, 375; Shag rock, 20; Cape Naden, 2; Seven Mile point, 3; off Massett inlet, 213; and Hecate strait, northeast of Rose Spit, 115. Thirty-one returns (4.1 per cent) have been received to date. All regions are included in one table since the returns from each were similar and it was felt that no benefit would result from further subdivisions.

	1929	1930
Alaska.....	4	1
Queen Charlotte islands (north shore and Massett inlet).....	4	
Bear river and Stewart.....	1	
Naas river area (including Dundas island).....	3	2
Skeena river.....	3	
Porcher island.....	1	
Banks' island.....	2	
Kemano river.....		1
Gardner canal.....	1	
Gribbell island.....	1	
Burke channel.....	3	
Rivers inlet.....	2	
Toba inlet.....	1	
Whidbey island, U.S.A.....	1	
	27	4

The returns from this area indicate a westerly migration chiefly to the mainland north of Queen Charlotte sound. Two only went farther south. Four were recaptured in Alaska. One interesting return (not recorded in the table) was that of tag No. 14271, affixed in Hecate strait, northeast of Rose Spit, and taken from the stomach of a seal in Hudson Bay pass.

9. *Coho salmon, North coast of Queen Charlotte islands, 1930*

In 1930, 983 cohoes were tagged along the whole north coast of the Queen Charlotte islands. The numbers were distributed as follows:—North island, 557; Pillar bay and Jalun river, 74; Shag rock, 101; Virago sound, including capes Edenshaw and Naden, 105; off Massett inlet, including Wiah point and McIntyre bay, 137; and off Tow hill, 9. Of these tags 67 (6.8 per cent) have been returned to date.

	1930
Alaska.....	16
Naas river.....	4
Wales island.....	1
Queen Charlotte islands, north shore.....	9
Dundas island.....	1
Stephens island.....	1
Porcher island.....	1
Lawyer island light.....	1
Kennedy island.....	1
Skeena river.....	5
Banks island.....	2
Gil island.....	1
Whale channel.....	1
Douglas channel.....	1

Finlayson channel.....	1
Fisher channel.....	1
Dean channel.....	2
Fitzhugh sound and Burke channel.....	9
Queen Charlotte sound.....	1
Rivers inlet.....	4
Bute inlet.....	3
Big Qualicum river (Vancouver island).....	1

67

If comparison is attempted with the results of tagging in this area in 1929, it will be evident that north of Queen Charlotte sound the distribution is similar. Recapture in Alaskan waters of 16 or 23.9 per cent of the total is noteworthy. Only 4 or 6 per cent were retaken south of Queen Charlotte sound, and these from two localities, Bute inlet on the mainland and Qualicum river on Vancouver island.

10. *Coho salmon, Banks island area, 1930*

The following is a summary of the tagging carried on in April, May and August, 1930, in the areas included in the above heading:—Hecate strait, off Stephens island, 53; Bell passage, 1; Porcher island at Cape George, Edye pass and Chearnley pass, 44; McCauley islands, Beaver pass and Spicer islands, 13; the northern end of Banks island, Bonilla island, Northwest rocks and White rocks, 429; and Granville channel, at Camp point light, 6. Of this total of 546, 32, or 5.9 per cent, have been returned.

	1930
Wark canal.....	3
Naas river.....	1
Skidegate inlet, Queen Charlotte islands.....	1
Stephens island.....	1
Porcher island.....	1
Banks island.....	4
McCauley island.....	2
Granville channel.....	4
Whale channel.....	1
Douglas channel.....	2
Millbank sound area.....	2
Fitzhugh sound and Burke channel.....	7
Rivers inlet.....	3

32

These returns are slightly more localized than those of the Queen Charlotte islands. The largest number, 7, or 21.9 per cent, appeared in Fitzhugh sound or Burke channel. Seventeen (53.1 per cent) were taken off the stretch of coast between the Skeena river and the southern end of Fitzhugh sound. It is especially noteworthy that one individual was recaptured in Long Arm, Skidegate inlet, Queen Charlotte islands, and that none appeared in Alaska.

11. *Coho salmon, Campania sound area, 1930*

There is included under this heading the following areas:—Wright sound, around Gribbell island and Promise island, 30; Campania sound area, inclusive of Pitt island, Otter and Squally channels, Passage island, Gil island, Surf islands, John point on Princess Royal island, 177; and Laredo sound including Aristazable, and Swindle islands, Princess Royal island near Mount Alice and Surge narrows, 14; a total of 221. From this work, which was carried on during August and September, 1930, 10 fish, or 4.5 per cent, have been recovered.

	1930
Low inlet.....	1
Aristazable island.....	1

Gil island.....	1
Hartley bay.....	1
Burke channel.....	3
Rivers inlet.....	3
	<hr/>
	10

These returns are purely local and merit no comment other than that 60 per cent were captured in Burke channel and Rivers inlet.

12. Coho salmon, Millbank sound area, 1929

In August, 1929, 152 cohoes were tagged in Millbank sound. Nine (5.9 per cent) have been sent in.

	1929
Burke channel.....	4
Dean channel.....	2
Fisher channel (Roscoe inlet).....	1
Fraser river.....	1
Insufficient data.....	1
	<hr/>
	9

Seventy-eight per cent of the returns were recaptured in the nearby area of Fisher, Burke and Dean channels. It is interesting that Millbank sound is the most northerly area on the mainland coast from which cohoes have appeared in the Fraser river.

13. Coho salmon, Millbank sound area, 1930

In 1930, during June, July and August, a comprehensive programme was carried out in Millbank sound, in the vicinity of Purple bluff, Sound point and St. Johns harbour. Four hundred and fifteen cohoes were tagged, from which number 36, or 8.7 per cent, have been returned.

	1930
Alaska.....	1
Naas river.....	1
Seaforth channel.....	1
Squally channel (Gil island).....	1
Dean channel.....	3
Fisher channel.....	3
Fitzhugh sound and Burke channel.....	15
Rivers inlet.....	5
Smith's inlet.....	1
Yuculta rapids.....	1
Bute inlet.....	2
Toba inlet.....	1
Jervis inlet.....	1
Insufficient data.....	1
	<hr/>
	37

As in 1929, the majority (56.7 per cent) of cohoes from this area found their way to Fisher, Burke and Dean channels. More of the areas south of Queen Charlotte sound, e.g. Yuculta rapids, Bute inlet, etc., were amongst the localities of recapture. Only 4, or 10.8 per cent, were taken north of the tagging area, indicating, in the main, the usual southerly migration.

14. Coho salmon, Goose islands, 1929

In August, 1929, operators were able to tag 367 cohoes off Goose islands and Gosling rocks in Queen's sound. Seventeen (4.6 per cent) are now at hand.

	1929
Dean channel.....	1
Burke channel.....	1
Walker lake cannery.....	1
Rivers inlet.....	4
Seymour inlet.....	1
Belize inlet.....	1
Loughborough inlet.....	1
Johnstone straits.....	2
Toba inlet.....	2
Bute inlet.....	2
Denman island, off Vancouver island.....	1
	17

These returns are widely spread to many inlets, all of which are south of the centre of tagging. Rivers inlet received the largest number, 4, or 23.5 per cent.

15. Coho salmon, Fitzhugh sound, 1930

Two hundred and ninety-eight cohoes were marked in this sound, off Koeys river and Hakai channel and the mouth of Burke channel, in the latter part of August, 1930. The largest return of all the coho tagging, 57, or 19.1 per cent, was received.

	1930
Fitzhugh sound and Burke channel.....	48
Rivers inlet.....	8
Knights inlet.....	1
	57

It appears from the distribution of the returns given above, that the run in this area was mainly a local one. It should, perhaps, be pointed out also, that fishing was very heavy off Namu at this time. This probably would account for part of the large return.

16. Coho salmon, Sooke, 1929

In September and October, 1929, Messrs. J. H. Todd and Son at Sooke, tagged 58 cohoes from their traps. We are deeply indebted to them for this assistance. The eight returns (13.8 per cent) were widely distributed as follows:

	1929
Sooke.....	1
James bay (vicinity of Victoria).....	1
Cowichan bay and river.....	2
Fraser river.....	1
Lummi island.....	1
Point Roberts.....	1
Dungeness trap (Washington).....	1
	8

As in the case of cohoes tagged in this area in 1928, the general migration is eastward. The small numbers preclude any further conclusions except that distribution is somewhat similar to that of the previous year.

THE TAGGING OF PINK SALMON

In order to obtain as complete information as possible on the migrations of the pink salmon in British Columbia, it seemed desirable in 1929, the "on" year for the Fraser river, to make every effort to determine the routes of travel of this species in the waters of the southern portion of the province. Accordingly, tagging programmes were carried out in the Johnstone strait area and at Sooke in the strait of Juan de Fuca.

17. *Pink salmon, Johnstone strait, 1929*

In August and early September, 1929, 468 pinks were tagged in Johnstone and Broughton straits from Beaver cove to Adams river. Thirty-seven (7.9 per cent) of these have been returned to date, as follows:

	1929	1930
Alert bay.....	2	
Johnstone strait.....	4	
Kingcombe inlet.....	1	
Lockboro inlet.....	1	
Deep Water bay.....	1	
Sliammon river, near Powell river.....	1	
Bute inlet.....	1	
Jervis inlet.....	2	1
Burrard inlet.....	1	
Fraser river.....	19	
Puntledge river, near Courtenay, Vancouver island.....	1	
Whidbey island, U.S.A.....	1	
Insufficient data.....	1	
	36	1

These returns are very interesting in comparison with those from the 1928 tagging. The conclusions drawn from the latter were that,—“1. The principal migration of pinks in the Johnstone strait area took place in an east and southerly direction. 2. After they had collected in spawning schools, they did not travel far but went chiefly to local streams. 3. Failure to recapture any tagged pinks south of Discovery passage indicates that pinks of Johnstone and Broughton straits did not contribute to the Fraser river run this year.”

In 1929, although the route of travel was still in an “east and southerly direction,” only six of the returns were local in their distribution and 19 (51.4 per cent) were recaptured in the Fraser. Six were taken in inlets on the mainland shore and one appeared on Vancouver island at Courtenay. These results demonstrate indubitably that in the “on” year for southern British Columbia, many pinks do reach the Fraser river from the north end of Vancouver island through the strait of Georgia.

18. *Pink salmon, Sooke, 1929*

We are greatly indebted to Messrs. J. H. Todd and Son for tagging during August and September, 1929, 185 adult pink salmon from their traps at Sooke on the strait of Juan de Fuca. Thirteen, or 7 per cent, have been returned from the following areas:

	1929
Sooke.....	1
Fraser river.....	7
Coast of Washington.....	4
Puget sound.....	1
	13

This experiment demonstrated that pinks as well as springs, cohoes and sockeye, may also migrate to the Fraser river and neighbouring waters around the south end of Vancouver island through the strait of Juan de Fuca.

THE TAGGING OF CHUM SALMON

19. *Chum salmon, Robson's bight, Johnstone strait, 1930*

In September, 351 chums were tagged in Robson's bight. Of these, 20, or 5.7 per cent, have been returned.

Alert bay and vicinity.....	1930
Blinkinsop bay.....	3
Johnstone strait.....	1
Deep Water bay.....	8
Bute inlet.....	2
Jervis inlet.....	2
Ladysmith.....	1
Chemainus.....	2

20

This distribution of returns is somewhat similar to that of 1928 for fish tagged on the west coast of Quadra and Sonora islands. The general migration was in an easterly and southerly direction with one portion of the run reaching Vancouver island and the other the mainland. Particularly noteworthy is the return of 8, or 40 per cent, from Deep Water bay. These fish evidently rest here during their southern migration.

20. *Chum salmon, Deep Water and Granite bays, 1930*

During September and October, 1930, 531 chums were tagged in the vicinity of Deep Water and Granite bays. To date 46, or 8.7 per cent, have been returned.

Deep Water bay.....	1930
Deep bay, Vancouver island.....	2
Puntledge river, near Courtenay, Vancouver island.....	1
Denman island, off Vancouver island.....	3
Comox, Vancouver island.....	2
Qualicum rivers, Vancouver island.....	2
Chemainus river, Vancouver island.....	2
Sliammon river, near Powell river.....	2
Toba inlet.....	2
Jervis inlet.....	10
Howe sound.....	3
Fraser river.....	6
Deception pass, Puget sound.....	3
Nooksack river, Washington.....	2
Insufficient data.....	5

46

These returns are very similar to those from the same area in 1928, in that there are again two main routes, one to the lower mainland and the other to Vancouver island. The mainland run is larger as it was in the previous year. A striking difference is that this year the large number of 10, or 21.7 per cent, appeared in Jervis inlet, and 5, or 10.9 per cent, in American waters.

IX. *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 salmon runs to the Fraser, Skeena and Naas rivers and to Rivers inlet.

X. *Investigations by Voluntary Workers*.—Eighteen voluntary investigators have been at the station during the year, carrying out studies, many of which have direct economic bearings. The list of problems and investigators follows:

SYMBIOSIS BETWEEN CERTAIN MARINE PLANTS AND ANIMALS.—MR. C. BERKELEY

In this study two interesting cases of close association between organisms have been brought to light. In the one case a green flagellate lives in the cells lining the alimentary tract of a polychaet worm, and in the other case a wine-coloured flagellate lives in the cells lining the digestive tract of a deep-water ctenophore.

SYSTEMATIC STUDY OF MARINE WORMS.—MRS. C. BERKELEY

The work of this year brings to completion the systematic study of the marine worms occurring in the strait of Georgia. A detailed record of this group, which enters so largely into the general economy of the shoreward areas of the ocean, is now available.

STUDY OF PIPER'S LAGOON AS A POSSIBLE FISH-REARING POND.—

MR. L. L. BOLTON

Consideration has been given to the possibility of constructing a dam at the outlet of this body of water of some fifteen acres in extent in order to retain water in it at all times and thus create a rearing pond for salmon. The present study was undertaken for the purpose of determining the ranges in the water temperatures during the summer months and the amount and character of food materials available for fish.

QUALITATIVE AND QUANTITATIVE DISTRIBUTION OF THE ZOOPLANKTON OF THE STRAIT OF GEORGIA; TAXONOMY AND LIFE-HISTORY OF COPEPODA.—

MISS M. H. CAMPBELL

It is generally recognised that certain areas in the Strait of Georgia are particularly rich in food materials for fish. A study is being made of the character, amount and distribution of the zoo plankton and of the factors which influence this development. Particular attention has been given to the group Copepoda which is one of the most abundant and important constituents.

BOTTOM FAUNA OF FIORDS; RAZOR CLAMS OF GRAHAM ISLAND.—DR. C. M. FRASER

A study is being made of several of the fiords characteristic of the coast of British Columbia in relation to fish production. Dr. Fraser has undertaken the study in part at least of the animals living on the bottom in these inlets.

A detailed report has already been made on the growth and reproduction of the razor clams of Graham island and the present study is a continuation in the way of examining collections sent in regularly by the Department of Fisheries to determine the variation in the spawning period over a series of years.

LIFE-HISTORIES OF CRABS—MISS J. F. L. HART

A study was commenced of the stages in the development of the local crabs, including the commercial species. The results of this study will make possible the identification of the various species at any stage of the life-history.

OCEANOGRAPHICAL STUDIES IN THE STRAIT OF GEORGIA.—DR. A. H. HUTCHINSON

Special attention has been given to the occurrence and distribution of the phytoplankton which forms the basis of the food cycle in the waters. The relation of the various physico-chemical factors to the production of the phytoplankton has been studied.

TAXONOMY AND LIFE-HISTORIES OF THE FLOUNDERS OF THE STRAIT OF GEORGIA.—

PROF. V. W. JACKSON

In this study a commencement was made in obtaining the necessary and useful information concerning this interesting and important group of fish.

IDENTIFICATION OF DIATOMS AND THEIR IMPORTANCE IN THE FOOD OF COPEPODA AND SCHIZOPODA.—PROF. C. W. LOWE

Diatoms constitute the first link in the food chain in the waters and a study has been made of their importance in the food of the larger animal planktons such as Copepods and Schizopods which are so important as food for fish, especially salmon.

LIFE-HISTORY OF THE DOGFISH.—MISS V. Z. LUCAS

The dogfish is known as a so-called "enemy" fish and as an important source of oil and meal. Much-needed detailed information concerning the complete life-history will be provided through this investigation.

TAPEWORM PARASITES OF COTTID FISHES.—MISS E. M. LYONS

This study formed part of a general study of the tapeworm parasites of our Pacific coast fishes carried out under the direction of Prof. Wardle.

RELATION OF SEA FOWL TO FISHES.—MR. J. A. MUNRO

This investigation will supply detailed information concerning the extent to which sea fowl feed upon fish. Special attention has been given to the relation of ducks and gulls to herring.

NITROGENOUS METABOLISM IN THE DOGFISH.—DR. E. W. OGDEN

It is well known that the flesh of the dogfish has a relatively high urea content. The present investigation was undertaken to provide further information concerning the nitrogen cycle in this fish.

PHYSIOLOGICAL AND PHARMACOLOGICAL STUDIES OF FISH GUT.—DR. M. J. OMEROD

In this study the effects of various poisonous substances on the digestive tracts of fish were studied.

UNSAPONIFIABLE CONSTITUENTS OF THE LIVER OIL OF DOGFISH.—

MR. E. G. V. PERCIVAL

This investigation was carried out in association with the Fisheries Experimental Station, Prince Rupert, and formed part of a larger investigation aiming to produce a commercial product from the liver oil of dogfish.

WATER MOLDS ATTACKING FISH EGGS.—MR. R. W. PILLSBURY

A study of the molds attacking fish eggs was commenced with the object of discovering methods of control.

NITROGEN METABOLISM IN RELATION TO CARDIO-TONUS IN DOGFISH.—

DR. W. W. SIMPSON

This investigation, carried out in association with Dr. Ogden, was undertaken to determine the relation of nitrogen in the body of the dogfish to heart action.

MARINE AND FRESHWATER INFUSORIA.—MR. G. H. WAILES

Through this study information is made available concerning this group of small animals occurring commonly in the waters and forming part of the food supply of small fish.

TAPEWORMS OF PACIFIC SALMON AND TROUT.—PROF. R. A. WARDLE

In this investigation identification of the parasites was made and extent of infection determined.

CREATINE AND CREATINE CONTENT OF FISH MUSCLE AND BODY FLUIDS.—

DR. F. D. WHITE

These two biochemical substances occurring in fish muscle were investigated in detail.

XI. *Publicity*.—A series of progress reports has been issued during the year. These are being issued quarterly and contain reports on the progress of various

investigations being carried out at the Fisheries Experimental Station, Prince Rupert, and the Pacific Biological Station, Nanaimo. Articles dealing with various phases of the work of the Station have appeared in certain newspapers and journals and lectures or addresses have been given from time to time by various members of the staff.

XII. *Visitors*.—A large number of persons has visited the Station museum, including the members of the Cowichan and Burrard Field Naturalists Clubs. There have also been many scientific and official visitors to the Station, including: Professor J. H. Ashworth, Edinburgh; Mr. J. P. Babcock, Victoria; Dr. L. Bishop, California; Dr. R. H. Bonnor, Seattle; Dr. H. Brown, London, England; Dr. A. T. Cameron, Winnipeg; Mr. J. J. Cowie, Ottawa; Dr. J. G. Fitzgerald, Toronto; Mr. Miller Freeman, Seattle; Dr. H. H. Gran, Oslo, Norway; Dr. J. E. Guberlet, Seattle; Dr. A. G. Huntsman, Toronto; Dr. Frank Lillie, Chicago; Mr. D. MacKay, Ottawa; Dr. Max Mason, New York; Major J. A. Motherwell, Vancouver; Dr. D. Rawson, Saskatoon; Honourable E. N. Rhodes, Ottawa; Mr. E. Ricketts, Pacific Grove; Dr. L. G. Saunders, Saskatoon; Mr. W. L. Scofield, San Pedro; Dr. W. A. Setchell, San Francisco; Dr. V. E. Shelford, Urbana, Ill.; Mr. R. P. Sherwood, Lowestoft, England; President L. M. Spencer, Seattle; Dr. W. P. Thompson, Saskatoon; Dr. W. F. Thompson, Seattle; Dr. H. B. Ward, Urbana, Ill.; Mr. A. J. Whitmore, Ottawa.

XIII. *Conference*.—The annual conference of the staffs of the Fisheries Experimental Station and the Pacific Biological Station was held at the latter station during the last week in August. Twenty-five investigators were in attendance and twenty papers were presented. Drs. C. M. Fraser, R. H. Clark, B. H. Eagles and D. C. B. Duff of the University of British Columbia, and Dr. W. F. Thompson of the International Fisheries Commission attended the meetings.

XIV. *Course for Hatchery officers*.—From July 7 to 19, a course of instruction was given to the assistants to the superintendents of hatcheries in the province. The course consisted of elementary physics and chemistry, general biology and fish culture and was given at the University of British Columbia. Fifteen men were in attendance and the instructors were Dr. W. A. Clemens, Dr. R. E. Foerster and Mr. L. F. Smith. At a dinner at the close of the course, Professor R. A. Wardle gave a special address on the relation of research to fish culture. The following gentlemen were present also and spoke briefly: Dr. Hutchinson, representing the Biological Board and the University of British Columbia; Major Motherwell, representing the Department of Fisheries; Mr. Bell-Irving, representing the fishing industry; Mr. Maiden, representing the B.C. Fishermen's Association, and Mr. Sankey, representing the Anglers' Associations.

XV. *Pacific Salmon Federation*.—Drs. Clemens, Foerster and Pritchard attended the annual meeting of the International Pacific Salmon Federation held in April at Stanford University, California. Papers were presented on the progress of the various salmon investigations being carried out under the auspices of the Biological Board.

XVI. *Publications during the Year.*

- Berkeley, A. A.—The post-embryonic development of the common pandalids of British Columbia. "Contributions."
- Berkeley, C.—Symbiosis of *Beroe* and a Flagellate. "Contributions."
- Berkeley, E.—Polychaetous annelids from the Nanaimo district, part 5. Ammocharidae to Myzostomidae, etc. "Contributions."
- Bolton, L. L.—Sockeye tagging on the Fraser river in 1928. Bull. No. XVI, Biol. Board.
- Clemens, W. A.—Pacific Salmon Migration: The tagging of the Coho salmon on the east coast of Vancouver island in 1927 and 1928. Bull. No. XV, Biol. Board.

- Clemens, W. A. and Clemens, L. S.—Contributions to the life-history of the sockeye salmon (Paper No. 15). Rept. B.C. Comm. Fish.
- Cornwall, I. E.—A barnacle (*Scapellum columbianum*) from Departure bay, B.C. "Contributions."
- Fraser, C. M.—The Razor Clam, *Siliqua patula* (Dixon) of Graham island, Queen Charlotte group. Trans. Royal Soc. Canada.
- Hart, J. F. L.—Some Decapods from the south-eastern shores of Vancouver island. Can. Field-Nat., vol. XLIV, no. 5.
- Hart, J. F. L.—Some Cumacea of the Vancouver island region. "Contributions."
- Hutchinson, A. H., Lucas, C. C. and MacPhail, M.—An oceanographic survey of the Strait of Georgia. Contrib. Marine Biol., Stanford Univ.
- Pritchard, A. L.—The Pink salmon of British Columbia. Can. Fish., vol. XVII, no. 3.
- Pritchard, A. L.—A note on the occurrence of Ray's Bream (*Brama raii* Bloch) on the west coast of the Queen Charlotte islands, B.C. Copeia, no. 3.
- Pritchard, A. L.—Pacific Salmon Migration: The tagging of the pink salmon and the chum salmon in British Columbia in 1928. Bull. No. XIV, Biol. Board.
- Wailes, G. H.—Amphipoda from British Columbia. Museum Notes.
- Williamson, H. C.—Notes on the occurrence of Various Animals on the Fishing Grounds on the Coast of British Columbia. Can. Field-Nat., vol. XLIV, no. 7.
- Williamson, H. C.—Notes on the Food of Spring Salmon. Can. Field-Nat., vol. XLIV, no. 9.

SUMMARY REPORT

OF

FISHERIES EXPERIMENTAL STATION (PACIFIC)

PRINCE RUPERT, B.C.

1930

The following constituted the staff of the Station during the year 1930:

Director, D. B. Finn (resigned August 29, 1930).
 Associate Biochemist, Dr. T. Ingvaldsen (deceased).
 Associate Chemist—H. N. Brocklesby.
 Assistant Chemist—O. F. Denstedt.
 Assistant Chemist—L. F. Smith.
 Associate Bacteriologist—R. H. Bedford.
 Mechanical Engineer, O. C. Young.

SEASONAL

Scientific Assistant, P. T. Black.
 Scientific Assistant, R. S. Tipson.
 Scientific Assistant, C. H. Vollum.

Buildings

Building No. 1 on the Government Wharf has undergone practically no alterations during the past year.

The exterior of the new building has been completed and duly taken over from the contractors. The basement in this building has been completed and refrigeration machinery installed. The first and second storey and attic have been left unfinished. It is proposed to finish the second storey in the next fiscal year.

Equipment

The Station now possesses well-equipped chemical, biochemical and bacteriological laboratories. The nutritional laboratory requires redesigning and extending in view of intensive program in this field.

The engineering laboratory is now equipped to carry on investigations involving temperatures as low as -40°F . The essential parts of this equipment consists of ammonia compressors, brine storage tanks, cold storage rooms, and temperature controlling and recording devices.

Library

The library has now about four hundred bound volumes on its shelves. The fields of chemistry, biochemistry, bacteriology, biology, and engineering are fairly well covered by these books. Between thirty and forty volumes are added per year to the shelves. All the more important journals covering chemistry, biochemistry, biology, bacteriology, and engineering are subscribed to. In addition a large number of fish and allied trade magazines are received by the Station.

Boats

The Station is at present without boats of any kind. The launch "Surveyor," which was damaged by a severe storm during the winter of 1929, has been disposed of.

Plans and specifications have been drawn up and tenders called for a new 75-foot schooner type halibut vessel for the Station. It is hoped that this boat will be ready for the opening of the 1931 fishing season when further commercial experiments will be carried on concerning the control of the discolouration of halibut.

Investigations

The investigations of this Station are at present carried on under two main divisions, preservative and by-products.

"Preservation" includes all investigations having to do with the processing and marketing of fish and other marine products.

Under the heading "By-products" are grouped those studies which deal with the utilization of waste material or marine products which may or may not be used primarily for human consumption.

Preservation

The investigations in this field can be listed as follows:

Bacteriological:

- (1) Discoloration of halibut.
- (2) Marine bacteria and their relation to decomposition of fish.
- (3) Preservation of fresh salmon.
- (4) The packing of shrimps.

Refrigeration:

- (1) An examination of the chemical and physical changes which occur in fish during cold storage.
- (2) A continuation of the chemical study of "Rusting". (Preliminary investigation reported in Biological Board MSS. by H. N. Brocklesby, 1929).
- (3) The effect of cold storage on the bacterial decomposition of fish.
- (4) The desiccating effect in the jacketed type of cold storage room.
- (5) The relationship between the area of cooling coils and the temperature of the cooling medium.

THE CONTROL OF DISCOLORATION OF HALIBUT

Date commenced:	Summer, 1928.	Investigator:
Anticipated completion:	End of 1931.	Robt. H. Bedford.

The halibut caught on the Pacific ocean along the coast of British Columbia and Alaska frequently become yellow on the white ventral surface between the time they are landed on the fishing vessel and their disposal to the consumer. This discoloration is caused by a certain chromogenic bacterium, living in the fresh water from which the ice is made, and utilized in preserving fish on the vessel.

The problem was to eliminate this bacterium.

This was attempted by sterilizing the ice and fishing vessel. This method proved unsuccessful because the organism gained access to the fish through uncontrollable channels. This experiment, however, indicated that solution of the problem could only be attained by treating the halibut directly. This meant that the fish must be partially sterilized immediately they are caught.

Partial sterilization of the fish was accomplished by using a solution of sodium chloride. It was found that when halibut were immersed in a 20 per cent solution for 30 minutes, the majority of bacteria were killed and sufficient salt was held by the skin and surface to inhibit the activity of the remaining bacteria, particularly those in the ice and hold of the vessel.

The practical application of this method proved successful in controlling discoloration and incidentally an efficient means of preserving fresh fish.

The investigation is being continued to ascertain whether the concentration and time of immersion may be reduced and also the effect of lowering the temperature of the sodium chloride solution.

MARINE BACTERIA AND THEIR RELATION TO DECOMPOSITION OF FISH

Date commenced: December, 1929. Investigator:
Anticipated completion: 1931. Robt. H. Bedford

The part played by strictly 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 biochemical characteristics of individual bacteria.

A new form of water bottle was devised for the purpose of taking samples.

Samples of sea water have been taken aspectically at different depths down to 200 fathoms. These samples were obtained at a sufficient distance away from shore so that there was no chance of contamination by soil, sewage or fresh-water forms.

About 90 organisms have been isolated and are now being studied.

At the present time the investigation is not sufficiently advanced to permit any conclusion being drawn but a preliminary report will be available next spring.

PRESERVATION OF FRESH SALMON

Date commenced: 1931. Investigator:
Anticipated completion: 1932. D. C. B. Duff

The manner in which fresh caught salmon are handled from the time of catching to delivery at the cannery is one of the most important factors in their preservation. This has a marked influence on quality and is a determinative factor in grading.

The problems to be investigated are:

- (1) The evisceration of salmon immediately they are caught, or left in the "round".
- (2) (i) Effect of icing,
(ii) Effect of partial sterilization.
- (3) Effect of stowage of salmon at different depths on cannery floor prior to grading.
- (4) Disinfection of canneries.

A few questions to be answered by the experiments are as follows:

(1) and (2). When salmon are shipped in the "round", is decomposition taking place from the inside outwards, or if gutted, is spoilage more rapid because of the greater exposed surface to bacterial attack? Is autolysis in the alimentary canal a factor in decomposition? What preservative effect has icing, and partial sterilization by chemical means?

(3) The canneries suffer considerable losses from the more rapid spoilage of those salmon at the bottom of piles on the floors. What is the maximum height of piling desirable commensurate with loss, handling, and space required for storage?

(4) There are certain strategic points in a cannery which might be possible sources of contamination: Storage pens, "iron chink", washing tanks. This applies particularly during heavy runs.

These experiments are designed to indicate probable causes of spoilage.

THE PACKING OF CANNED SHRIMPS

Date commenced:	August, 1930.	Investigator:
Anticipated completion:	1931.	R. H. Bedford.

Considerable losses have been incurred by local packers owing to the putrefaction and blackening of shrimps.

Some preliminary work has indicated that sterilization was incomplete.

This information has enabled the plant to continue packing shrimps for short periods of storage. The company has not yet installed a pressure sterilizer, and consequently the time of cooking cannot be extended to ensure definite sterilization owing to the disintegration of the packed meat. The investigation is proceeding to establish the best conditions for processing shrimps packed in glass jars, i.e.: Temperature and time of preheating, and the interrelationship between pressure, temperature and time, for final sterilization.

The problem of the blackening of shrimps will be attacked later.

THE REFRIGERATION PLANT

Investigator:
C. C. Young.

In May, 1930, the building operations on the new station had reached the stage where the cold temperature equipment could be installed in the basement. The plans and specifications had been prepared previously and the contract awarded to the Linde Canadian Refrigeration Company.

The plant installed is of the *brine circulating* type, employing two ammonia compressors with a combined capacity of about $7\frac{1}{2}$ tons of refrigeration at standard rating. Because of the low temperatures required, calcium chloride brine is used. Thus brine is contained in two tanks in order that different temperatures may be obtained, by mixing. There are two cold storage rooms and an anteroom; these as well as the brine tanks are insulated with eight inches of corkboard.

The entire equipment was designed to operate automatically. The compressors are controlled thermostatically by the brine temperatures, being so arranged that either compressor may be connected to either tank. The room temperatures are controlled by thermostats as well. These thermostats control the brine entering the cooling coils, admitting either warm or cold brine through a three-way valve, depending upon the position of the regulating mechanism.

Tests have been made on the compressors, but in none of them could the specified capacities be obtained. The Linde company is at present reviewing the test data in order to determine whether the installed machines must be speeded up or replaced by larger ones.

THE JACKETED COLD STORAGE ROOM

To commence:	December, 1930.	Investigator:
Anticipated completion:	August, 1931	C. C. Young

The object of this experiment is to determine the desiccating effect in the jacketed type of cold-storage room.

This type of cold storage room is being developed in an attempt to overcome

desiccation which proves so deleterious to stored fish. It is recognized that desiccation results from the presence of the cooling coils in the cold storage rooms themselves or in bunkers, if the rooms are cooled by the circulation of cold air through them. Since heat is conducted from the outside inward, the cold air circulating through the jacket surrounding the cold room will pick up this heat being transmitted through the insulation, before it reaches the room itself, hence no coils are necessary there. It is obvious that to prevent desiccation the air circulating through the jacket must not reach the interior of the room, because it comes in contact with cooling coils somewhere in its cycle and would serve as a moisture carrier just as in the ordinary cold storage room.

This experiment is being done on a small scale. A room 4'x4'x6' high has been constructed of flooring and entirely sheeted outside with tin to make it vapor proof. The door is gasketed to ensure its being airtight. The room rests on 2"x2" sleepers and has a two-inch air space surrounding it. Air is circulated through this space by a fan and is exhausted over cooling coils in a bunker above the room. The exterior side of the air jacket is well insulated with corkboard. The room has a small antechamber to minimize temperature disturbances when the door is opened.

AN INVESTIGATION CONCERNING COOLING COILS

To commence: January, 1931. Investigator:
Anticipated completion: August, 1931. C. C. Young.

Object.—To determine the relationship between the area of cooling coils and the temperature of the cooling medium and note the desiccating effect within the room.

To cool a room to any temperature, almost any amount of cooling area could be used. For any fixed length of coil, however, there should be but one temperature of cooling medium to give the required temperature in the room, once equilibrium has been established in it. Also for a fixed length of coil there will be a certain desiccating effect within the room, and it is quite likely this drying effect will differ for different cooling areas.

This experiment will be conducted on a small scale. A box has been constructed 4'x4'x6' high, insulated with two inches of corkboard. To begin with, just one hank of ceiling coils will be used; and this will be added to from time to time. For each length of coil, the temperature of the brine will be obtained, after the same temperature conditions have been established in the chamber. The desiccating effect for each case will be determined by suspending a weighed piece of ice in the room by means of a wire passing through the ceiling. In this way the loss in weight of the ice can be found from the outside without disturbing the conditions inside.

During the year 1930, the following publications have been prepared by the investigators in this field:—

DEPARTMENT OF BACTERIOLOGY

ORIGINAL ARTICLES

- "Sea Water Sampling Bottle", by R. H. Bedford, O. C. Young and D. B. Finn. Contributions to Canadian Biology and Fisheries.
 "The Bactericidal Effect of the 'Prince Rupert' Sea Water Bottle", by R. H. Bedford. Contributions to Canadian Biology and Fisheries.
 "The Control of Discolouration of Halibut", by R. H. Bedford. Contributions to Canadian Biology and Fisheries.

GENERAL ARTICLES

- Progress Report No. 6—"Discolouration of Halibut", by Robert H. Bedford.
 Progress Report No. 7—"The Control of Discolouration of Halibut," by Robert H. Bedford.
 Pacific Fisherman, December, 1930, "Preservation of Fresh Fish."

ENGINEERING DEPARTMENT

Progress Report No. 7:

- I—The Fisheries Experimental Station, Building No. 2.
- II—The Refrigeration Installation.
- III—Two Problems in Cold Temperature Research.

BY-PRODUCTS

This division is subdivided into investigations on fish meals, fish oils and the utilization of waste liquors as fish glues and fertilizer. The various researches, if not already published, are discussed in the following pages under the titles:

Fish Meals:

1. The effect of the high temperature employed for drying, on the nitrogen partition in fish meals. By T. Ingvaldsen, Ph.D., *Canadian Chemistry and Metallurgy*, April, 1929.
2. Comparative analysis of meals made from non-putrid and putrid materials. By T. Ingvaldsen, Ph.D., *Canadian Chemistry and Metallurgy*, May, 1929.

Fish Oils:

1. Some properties of commercial pilchard oil. By H. N. Brocklesby, *Canadian Chemistry and Metallurgy*, August, 1929.
2. The seasonal variation of commercial pilchard oil.
3. Composition of the mixed fatty acids of pilchard oil.
4. Polymerization and drying properties of component esters of pilchard oil and a comparison with those of other drying oils.
5. Pilchard oil as a protective coating.
6. Properties and composition of dogfish liver oil. (Complete, will be published shortly).
7. Hydroxylation of dogfish liver oil.
8. Refining experiments on fish oils.
9. Hydrogenation of pilchard oil.
10. Unsaponifiable constituents of liver oil of dogfish. (Work done at Nanaimo Station through courtesy of Doctor Clemens.)
11. Miscellaneous.

Fish Glues from Waste Liquor:

The dialysis of fish glue and its industrial application.

Fertilizer from Waste Liquor.

THE NUTRITIVE VALUE OF MARINE PRODUCTS

Investigations completed:

- Vitamin A content of dogfish liver oil. By Horace N. Brocklesby, *Canadian Chemistry and Metallurgy*, September, 1927.
- Vitamin D content of dogfish liver oil. By Horace N. Brocklesby, *Canadian Chemistry and Metallurgy*, March, 1929.
- Vitamin D content of commercial pilchard oil. By H. N. Brocklesby, *Canadian Chemistry and Metallurgy*, January, 1930. Assisted by O. F. Denstedt.
- Vitamin A content of pilchard oil. By D. B. Finn (in press).

Other investigations are being conducted as follows:

1. The effect of the oil content of pilchard meal upon its digestibility and its biological value.
2. The influence of fish meals on growth.
3. The vitamin A content of pilchard meal (preliminary report in press).
4. The effect of ingested fish oils on the nature of the body fat.
5. The effect of storage upon the nutritive value of fish meals.

Note—Results obtained in investigations 1, 2, and 5 are to be left for interpretation by the biochemist who will succeed Dr. Ingvaldsen.

SEASONAL VARIATIONS OF COMMERCIAL PILCHARD OIL

Time commenced:	September, 1929.	Investigators:
Completed:	October, 1929.	H. N. Brocklesby and O. F. Denstedt.

It has been variously reported in literature that the characteristics of oils and fats obtained from animals and fish vary according to various factors, such as the season of the year, sexual cycle, etc. It has also been reported by commercial firms operating on the west coast of Vancouver island that there is a definite variation in the character of pilchard oil as the season advanced. A series of samples were therefore analysed to ascertain if this variation actually

existed. It was impossible for the investigators to obtain these samples personally so the collections were made by a responsible person in charge of one of the largest reduction plants of the B.C. Packers. Samples were taken every two weeks and represented as far as possible the average of all the oil put through the plant within the 14-day period. The data recorded are as follows:

Yield: This increased from 32 gallons per ton on July 2nd, 1929, to 50 gallons per ton on October 7th, 1929.

Colour: Colour varied from light reddish brown to deep greenish brown and no gradual variation noted.

Stearin per cent: This was undoubtedly higher at the very start of the season, being around 31 per cent, but after that it varied so much that no conclusions could be drawn.

Refractive index: Varied in an irregular manner.

Iodine value: The iodine value gradually rose from 172 to 182, showing a gradual increase to unsaturation as the season advanced.

Saponification value: Varied irregularly.

Specific gravities: Steadily rose from 0.9140 (at 40°C.) to 0.9152 (at 40°C.)

It is recognized that it is unwise to rely upon samples submitted by commercial firms, but in the present instance there was no other alternative. The results of this investigation will be reported in a MSS. in the near future.

A series of analyses will be made this winter upon samples which represent each shipment made from Vancouver from the time the industry started in 1925 until November, 1930. It is hoped by this means to be able to ascertain in what respects the oil varies and within what limits.

COMPOSITION OF THE MIXED FATTY ACIDS OF PILCHARD OIL

Time commenced:	July, 1929.	Investigator:
Anticipated completion:	End of Dec., 1930.	H. N. Brocklesby

Researches into the commercial uses of pilchard oil have been hampered by the lack of exact information concerning the composition of this oil. The separation of the mixed fatty acids of pilchard oil has therefore been undertaken.

Two preliminary qualitative separations have been completed. These were undertaken in order to test out methods and to get a rough idea of amounts and nature of the fatty acids present. A final quantitative separation is now being made.

Briefly, the method of separation is to roughly separate the saturated fatty acids from the unsaturated fatty acids by the insolubility of the lead salts of the former in 95% alcohol. The unsaturated fatty acids obtained therefrom are further divided into a highly unsaturated fraction and a less highly unsaturated fraction by reason of the solubility of the lithium salts of the highly unsaturated fatty acids in 95% acetone. These three primary fractions are then methylated and the methyl esters subjected to fractional distillation in a vacuum of between one and two millimeters. Each primary fraction yields about four fractions on the first distillation. These four fractions are then redistilled under a very high vacuum (approximately 5 microns), until every alternate fraction obtained is relatively pure from the standpoint of the carbon content of the acids.

The results indicate that pilchard oil contains fatty acids ranging in carbon contents from C16 to C22 and that the unsaturation may vary from the mono ethylenic to the penta ethylenic type. The distribution of the unsaturation amongst the various series of fatty acids has not yet been completed.

The unsaponifiable matter from pilchard oil is a reddish brown wax-like substance with a peculiarly pleasant odour. Though not enough of this substance has been obtained for a complete examination, a few of its physical and chemical constants will be reported on.

PROPERTIES OF HIGHLY UNSATURATED FATTY ACIDS FROM FISH OIL WITH
PARTICULAR REFERENCE TO THEIR POLYMERIZATION OF UNSATURATED
FATTY ACIDS FROM OTHER SOURCES

Time commenced: September, 1929. Investigator:
Anticipated completion: September, 1931. H. N. Brocklesby.

While studying the utilization of fish oils for protective coatings, many questions of a fundamental character arose which made it difficult to proceed without investigating certain phenomena more thoroughly. To illustrate, protective coatings such as paint, varnish, etc., made from fish oil, have a very objectionable feature in that they are soft and inclined to become sticky with varying changes of weather. Since this defect is not shown in vegetable drying oils, it is necessary to ascertain whether this phenomenon was a peculiar property of the highly unsaturated fatty acids present in pilchard oil. Furthermore, heat treatments and treatments with catalytic driers did not give the same results with fish oils as they did when applied to vegetable drying oils. It was necessary, therefore, that a comparison should be made of the behaviour of the drying components of pilchard oil with the corresponding components from vegetable drying oils.

A series of experiments on polymerization of mono, di, tri, tetra and penta-ethylenic fatty acids and their methyl glycol and glycerol esters has been commenced. These acids represent the drying components of vegetable and fish oils. A mono-ethylenic fatty acid, oleic acid, has been prepared from the impure technical product on the market. A di-ethylenic (linolic) acid has been prepared in a pure state from poppy seed oil whilst a tri-ethylenic (linolenic) acid has been obtained from linseed oil. The tetra and penta ethylenic fatty acids are both being isolated from pilchard oil.

Preliminary experiments on the polymerization of the methyl esters of clupanadonic acid obtained from pilchard oil has shown that this substance can be made to set to a hard resin-like mass and that the polymerization proceeds in well-defined steps which are entirely governed by the temperature employed.

It is hoped that by studying the polymerization of glycol and glycerol esters of these five series of acids, sufficient data will be obtained to enable one to treat pilchard oil in such a manner that it will be a valuable material for protective coatings. Since other investigations on the utilization of fish oils depend to such a large extent upon the properties of the constituent unsaturated acids, this investigation will also embrace some properties other than polymerization.

THE INDUSTRIAL USES OF PILCHARD OIL—PROGRAM OF DRYING RESEARCH

Time commenced: November, 1929. Investigators:
Anticipated completion: September, 1930. H. N. Brocklesby and
O. F. Denstedt.

Pilchard oil, like other fish oils of its class, is notable for its drying properties. When exposed to air in a thin film, it dries as quickly as linseed oil to form a tough elastic "skin". The value of the oil for the manufacture of paints, water-proofing and other materials is as yet known to only the few industrial concerns which have taken the trouble to investigate the product for themselves. The results of such investigations are, of course, not disclosed. Available information is seriously needed to provide a sound basis for the marketing of the oil, and to establish its importance as an industrial raw material. This has made imperative the investigation outlined below. The research aims not only at providing information regarding the drying properties of pilchard oil, but also at endeavouring to overcome certain defects common to drying fish oils which curtail their usefulness to the protective-coating industries.

A preliminary investigation made at this station in 1928 on the general properties of pilchard and salmon oils has afforded much valuable information

as a starting point for the present program of research. Paints were made, using various combinations of these oils with linseed oils and two sets of panels were exposed outdoors for over a year, one set at Prince Rupert, B.C. and the other at Saksatoon, Sask.

(a) *Refining of pilchard oil for use in paint*

Pilchard oil, like other fish oils, contains a considerable proportion of non-drying constituents which at ordinary temperatures solidify and settle out in the form of a pale yellow grease commonly known as "stearine". These components if left in the oil not only retard its drying, but produce tacky, greasy and dull films. To determine the best method of removing the stearine, a number of refrigerating experiments were carried out at different temperatures and the solid matter separated by various methods. Refining experiments were also conducted for the purpose of removing colouring matter and other suspended substances from the oil. These experiments are to be continued further in connection with the hydrogenation program to be commenced in the near future.

(b) *Bodying and blowing experiments*

For certain purposes in the manufacture of paints and varnishes, oils of relatively high viscosity are required. Linseed and other oils are therefore "bodied" or rendered more viscous by heating them in contact or out of contact with air. The same bodying is also produced by blowing air through the oil at fairly high temperatures. A number of bodying and blowing experiments were carried out with pilchard oil, varying the temperature and time of treatment. The changes in drying properties of the oil and characteristics of the resulting films, due to the various treatments, were noted by determining rates of oxygen absorption, drying times of films, and increase in viscosity as well as by studying the surface characteristics of the films themselves.

(c) *The effect of catalysts on the drying properties and film qualities*

This part of the work is now in progress and consists in studying the influence of several metallic catalysts or "driers" on the drying and film properties of the oil, with the object of determining the combination and quantities of driers most effective in accelerating the rate of drying and producing the best films. The work has been limited chiefly to the study of the effect of five common catalysts on oils subjected to various treatments. The study also takes into consideration the influence of different pigments on the action of the driers used.

(d) *Film studies*

The preceding two sections of the work involve a study of films from the standpoint of surface characteristics such as tackiness, toughness and gloss. Having determined the most promising samples by surface tests, film "skins" are to be prepared and tested for tensile strength, elasticity, moisture penetration and other qualities.

(e) *Natural and accelerated weathering tests*

The final section of the drying-research program deals with the testing of painted panels for weathering qualities by artificial and natural means. Preliminary tests are to be made by subjecting panels to relatively severe conditions of temperature, moisture, illumination and abrasion by artificial means in an accelerated weathering device now being designed. Another set of panels made from the more promising samples as indicated by artificial tests will be exposed to actual weather conditions outdoors for a period of several months. Finally, representative samples of paint will be made up by one of the large paint companies which has kindly offered its cooperation. The samples will then be distributed for use locally. In this way they may be subjected to a variety of conditions of application and exposure which cannot be anticipated, or achieved in the laboratory.

Although pilchard oil and other drying fish oils are used very extensively in the manufacture of heat-resistant paints and also to a considerable extent in conjunction with linseed oil, in the manufacture of general-purpose paints, their use in the latter connection is limited owing to certain characteristic defects briefly described as follows:

1. The paint surfaces when dry, "bloom" or turn whitish colour on exposure, thus masking the true colour of the pigment.
2. Dry fish oil films possess a tackiness which is intensified in moist atmospheres.
3. Fish oil films lose their gloss more quickly than linseed oil on exposure and when used in conjunction with the latter, often give a patchy appearance due to variations in the glossiness of the surface.
4. The volatile products evolved in the drying of fish oils are somewhat more unpleasant than those from linseed oil.

On the other hand the combination of linseed oil with a liberal proportion of drying fish oil has been found to increase the durability of the product, especially in damp briny climates where paints deteriorate quite rapidly. The elimination of the above-mentioned defects is one of the main objectives in the present program of research and experiments not referred to in the above outline of work are being carried on steadily in this connection.

DOGFISH LIVER OIL

Investigator:
H. N. Brocklesby.

Although the properties of dogfish liver oil were investigated by the Station in 1926, no report has been issued owing to the fact that certain analytical data were *in need of confirmation*. This extra work has now almost been completed and a report will be prepared in the near future. It was found that the average ratio of the weight of the liver to the total body weight of the dogfish was, for mature individuals, from 10 to 15 per cent. The yield of oil recovered varied from 50 to 60 per cent of the weight of the liver.

The oil was extracted in four ways, namely—cold extraction with solvents, electrolysis, cold pressing and by steaming. The *second* and the last methods were found to be most satisfactory.

The colour of the oil corresponded to about 6.5 yellow Lovibond units, using a one-inch cell.

Dogfish oil has an iodine value of 145 and is therefore not highly unsaturated. The oil, when exposed in thin films, absorbs 6-7 per cent of its weight of oxygen but does not set to a solid film.

On hydrogenation, using a reduced nickel oxide catalyst, the fish odour of the oil was first removed and after about eight hours' treatment the oil would harden when cooled to ordinary temperatures.

The unsaponifiable matter varies in dogfish liver oil from 3-10 per cent. This fact makes it difficult to dispose of the hydrogenated product to soap manufacturers.

On treating with sulphuric acid, a sulphonated product was obtained which compared favourably with Turkey red oil in emulsifying properties.

The mixed fatty acids were partially separated. Palmitic acid was found to be the chief component of the saturated acids. The unsaturated fractions are now being re-investigated.

PRELIMINARY INVESTIGATION INTO THE HYDROXYLATION OF DOGFISH LIVER OIL

Time commenced:	July, 1930.	Investigators:
Completed:	August, 1930.	H. N. Brocklesby and R. S. Tipson.

Several attempts to utilize the liver oil of dogfish have been only partially

successful. The oil has a number of characteristics which make it difficult for any one industry to utilize it in large quantities.

Owing to the large and varying amount of unsaponifiable matter in this oil, its use, after hydrogenation, as soap stock has not been favourably received. Its drying properties are such as to render it impossible for use as a paint vehicle. While potent in vitamin A, vitamin D is present only in very minute amounts and it has been shown that this vitamin D potency varies considerably.

Sulfonated dogfish oil, whilst having valuable emulsifying properties, has not the physical appearance of the well-known emulsifying oil, turkey red oil. It was thought that a valuable lubricating oil might be made from this liver oil to take the place of castor oil which is now used in various high-speed engines. Castor oil is almost entirely the tri-glyceride of ricinoleic acid, which is in turn a mono hydroxyl fatty acid. It was thought that if part or all of the unsaturated bonds in the fatty acids of dogfish liver oil could be saturated with one hydrogen and one hydroxyl group respectively, the resulting product should have some properties similar to those of castor oil. Samples of hydroxylated dogfish oil have been prepared by saturating the oil with dry hydrogen bromide gas, thus adding on H.Br. to the unsaturated bond. A definite brominated product could be obtained, containing some 26 per cent bromine. The removal of this bromine by silver hydroxide was then attempted. The amount of bromine, however, could only be reduced to 20 per cent and this amount could not be removed on treatment with various substances such as calcium oxide, silver oxide, lead oxide, etc. The rate of additions of hydrogen bromide to the oil and the gradual change in properties of the oil in such treatment have been recorded.

The hydroxylation of the oil was then attempted in another manner. The oil was heated at 190° with a mixture of two parts hydrogen and one of oxygen in the presence of a nickel oxide catalyst. After eight hours the hydroxyl content of the oil had increased 100 per cent and the viscosity had risen considerably. It is believed if these methods were utilized with the addition of high pressure that the oil could be hydroxylated on a commercial scale. Experiments have not yet been completed but sufficient data have been obtained to warrant a preliminary publication which will shortly appear.

HYDROGENATION OF PILCHARD OIL

Investigator:
H. N. Brocklesby.

During a preliminary investigation into the properties and possible commercial uses of pilchard oil, this substance was subjected to the well-known hydrogenation process. Briefly, this consists in treating the heated oil with hydrogen in the presence of a catalyst.

Samples taken from time to time, as the hydrogenation proceeded, showed that after the first half-hour the oil was decolorized and at the end of an hour practically all the fishy odour had been removed. As hydrogenation proceeded further, an increasing amount of solid constituents was produced until after the eighth hour, the product was a white, hard solid fat. The melting point of this substance was in the neighbourhood of 65°C.

This final product, when saponified, gave a white sodium soap which had excellent keeping qualities. The hardened fat was odourless and quite tasteless.

These results indicated that by partial hydrogenation, a domestic salad oil might be produced, whilst by total hydrogenation, an excellent shortening could be obtained.

Several important features in the hydrogenation process have to be studied: the temperature and pressure are factors which affect the formation of solid "iso-acids." The preparation and life of various catalysts used for the hydrogenation of pilchard oil must be investigated. Preliminary refining treatments to remove catalytic poisons will also have to be investigated. An extensive program along

these lines has been outlined and, as an investigator has been engaged for this purpose, the work will be commenced in January, 1931.

A PRELIMINARY INVESTIGATION OF THE UNSAPONIFIABLE CONSTITUENTS CONTAINED IN THE LIVER OIL OF THE PACIFIC COAST DOG-FISH (*SQUALUS SUCKLI*)

Commenced: Jul., 1930. Investigator:
Finished: September, 1930. E. V. G. Percival.

Having regard to the interesting theoretical speculations involved and, in view of the possible industrial applications of Pacific Coast dogfish liver oil, it appeared to be of interest to determine the constitution of the unsaponifiable matter that it contains.

The livers were obtained from freshly killed dogfish, and the gall bladders immediately removed. The livers were cut into small pieces and steamed for one hour. Filtration through glass wool and absorbent cotton gave a clear yellow oil. Yield about 50 per cent of the total weight of the livers.

The unsaponifiable content was estimated by methods of the American Chemical Society (average = 5%) and by that of Kerr and Sorber (average 5.6%). The preparation of larger amounts of unsaponifiable matter was carried out as follows: The cold saponification method of Marcus was employed, using ethylene dichloride as a solvent. The unsaponifiable matter recovered was again saponified and re-extracted until no further amount of saponifiable matter was left; 500 cc. of oil yielded 15 gms. of a brownish viscous oil having a pleasant smell somewhat reminiscent of the lemon terpenes. It has $N_D^{25} - 1.5259$.

Cholesterol was determined by the digitonin method of Windaus, modified by Fraser and Garner. The product was identified through its melting point and the melting points of its benzoate and acetate. The mean of three determinations gave 5.1 per cent of cholesterol in the unsaponifiable matter.

Other oxygenated products (batyl, selachyl alcohols) were removed by treatment with phthalic anhydride as suggested by Heilbron and Owens. A yield of 10 per cent of the unsaponifiable constituents was obtained.

The method for the isolation of these higher alcohols was modified, however, and these modifications have been outlined.

The greater part of the unsaponifiable matter appears to consist of squalene which, however, was not obtained pure, because facilities for high vacuum distillation were not available. A yellow hydrochloride M.P. 107° was obtained, however, which is fairly good evidence that the residue from the cholesterol and selachyl alcohol separation was mainly squalene.

(This research was carried out at the Pacific Biological Station at Nanaimo, through the courtesy of Doctor W. A. Clemens, at the request of the Fisheries Experimental Station. Whilst the work forms an integral part of the fish oil research programme of the Experimental Station, all expenses in connection with the investigation were borne by the Biological Station at Nanaimo.)

PROGRESS IN FISH GLUE RESEARCH

December, 1929, to December, 1930. Investigator:
Time commenced: May, 1927. L. F. Smith.
Anticipated completion: February, 1931.

In a previous report it was shown that both dialysis and electro-dialysis of fish glue liquors remove the inorganic impurities and improve materially the quality of the finished glue. Ordinary dialysis does not lend itself to industrial application. Electro-dialysis, however, which utilizes electrical energy to hasten the process has industrial possibilities.

To investigate fully these possibilities an electro-dialysis apparatus of twenty gallons capacity was built. Four gallons of glue liquor were electro-dialyzed until the ash content had fallen to .05%, calculated on the basis of dry glue present.

This electro-dialyzed glue was found to have excellent drying and moisture-resistant properties when compared directly with the original glue and a popular commercial glue—Le Page's. It was found equal to these glues in strength by the jointed strength test. Through the courtesy of the Forest Products Laboratory, Vancouver, which provided the facilities for testing the specimens, an opportunity was afforded for a thorough study of this test. It was found that the conditions under which the glue joints were made seriously affected their strength. Conditions of gluing which produced satisfactory joints with one glue did not suit another glue of different physical properties. The natural variation in the strength of the wood itself made it difficult to obtain uniform results throughout a series of similar test blocks. Over the range of conditions employed the electro-dialyzed glue displayed an average strength of over 2,000 pounds to the square inch when tested on hard maple. This value nearly equals the strength in shear of the wood itself.

Work has recently been commenced on the dialysis and electro-dialysis of fish waste liquors at a reduction plant in the vicinity. The electro-dialysis will be carried out with the apparatus previously used. The ordinary dialysis is being effected by the use of a form of cellulose membrane which has recently appeared on the market and which offers unique advantages as a dialyzer. In both these projects the aim is to produce a glue capable of competing with the present commercial glues in both quality and price.

The period of practical testing will bring to a close the investigation on fish glue. There is good reason to believe that the methods which have been developed in the course of this investigation will be adopted by reduction plant operators and that fish glue recovered from waste liquors will become an additional by-product of the fishing industry.

UTILIZATION OF WASTE LIQUOR AS FERTILIZER

Time commenced:	January, 1931.	Investigator:
Anticipated completion:	1932.	R. H. Bedford.

In the process of extracting oil from fish there is wasted the soluble nitrogenous material when the expressed liquor is dumped into the sea.

This liquor is rich in nutrients suitable for bacterial growth.

Bacteria are the connecting link between the nitrogenous material in the soil and its preparation for plant growth.

The problem is to establish whether this liquor can be utilized as a soil fertilizer or as an adjunct to straw in the production of artificial manure.

A complete chemical analysis will be made of representative samples.

The production of nitrate nitrogen by soil bacteria in different Canadian soils will be measured.

The utilization of this source of nitrogen will be made in the bacterial decomposition of straw. Certain products of decomposition will be measured and correlated with soil fertility and plant growth.

The economics of the problem will be studied: Transportation and concentration of the liquor.

It is thought that if this liquor can be used as a fertilizer there is a probable solution to the continual wastage of the straw produced on the farms of Western Canada.

THE EFFECT OF INGESTED FISH OIL ON THE NATURE OF THE BODY FAT

Investigators:
D. B. Finn and
O. F. Denstedt.

Certain investigators have found that a considerable proportion of the highly unsaturated fatty acids of fish oils fed to animals is ingested and deposited

in the adipose tissue of the body practically unchanged. This fact may account in some measure for the fishy taste said to be imparted to pork and eggs by fish meals and oils used in feeding.

At the conclusion of a number of experiments carried on about a year ago for the purpose of determining the biological values of various diets containing fish meals and oils, it was found of interest to examine the adipose fat of the white rats used in the experiments. Analyses were therefore carried out to determine the characteristics of the fat and especially to ascertain the amount of fatty acids present with more than two ethenoid linkages in the molecule. While not true of all the samples analysed, it was generally found that the percentage of highly unsaturated glycerides varied directly with the amount of meal or oil used in the diet. The results, although generally confirming the finding of other workers, are not submitted as being conclusive since the diets used in the original experiments were not designed to establish these facts. Further experiments will be carried out at a later date for this purpose.

During the year 1930, the following publications have been prepared by the investigators in this field:—

PAPERS

- "Vitamin D Content of Commercial Pilchard Oil." By H. N. Brocklesby and O. F. Denstedt, *Canadian Chemistry and Metallurgy*, January, 1930.
 "Apparatus for Drying Oil Research." By H. N. Brocklesby and O. F. Denstedt. (In press).

PROGRESS REPORTS

- Report No. 4—"The Drying Properties of Pilchard Oil." By O. F. Denstedt.
 Report No. 7—"Progress in Fish Glue Research." By L. F. Smith.
 Report No. 8—"The Properties and Industrial Uses of Fish Oils." (In preparation). By H. N. Brocklesby and O. F. Denstedt

MISCELLANEOUS INVESTIGATIONS

Naas River Pollution

During the summers of 1929 and 1930, complaints were received by the Department of Fisheries and the Experimental Station that a peculiar silt formation was doing a great deal of damage to the nets in the Naas river. It appeared that this silt deposits on the nets to such an extent that they sink, and it was impossible to pull them up again without destroying them. Mr. Finn made a preliminary examination of the situation in the late fall of 1929 and, during the month of July and August, the Experimental Station sent two investigators to the Naas river to make further investigations. It is thought that the smelter, which turns a tremendous quantity of effluent into an arm which joins the Naas river near the location where the phenomenon occurred, might be the cause of the trouble.

Samples of the effluent from the smelter, sludge from the river bottom, the deposit from the nets, and the samples from above the smelter, have been analysed. Results at the present time do not permit drawing definite conclusions as to the cause. Present indications show, however, that the problem is one in colloidal chemistry and it has been recommended that a qualified man be obtained to carry on the investigation during the summer of 1931. The situation is a serious one as many companies have lost large sums of money through the loss of these nets.

PUBLICATIONS

- Determinations of vitamin A content in the liver oil of the dogfish (*Squalus sucklii*). H. N. Brocklesby, *Can. Chem. and Met.* XI, 238, 1927.
 Vitamin D content of the liver oil of the dogfish (*Squalus sucklii*). H. N. Brocklesby, *Can. Chem. and Met.* XIII, 74, 1929.
 Fish Meals I. The effect of the high temperatures employed for drying upon the nitrogen partition in fish meals. T. Ingvaldsen, *Can. Chem. and Met.* XIII, 97, 1929.
 Fish Meals II. Comparative analysis of meals from non-putrid and putrid materials. T. Ingvaldsen, *Can. Chem. and Met.* XIII, 129, 1929.

- Studies in Fish Oil. Some properties of commercial pilchard oil. H. N. Brocklesby, *Can. Chem. and Met.* XIII, 212, 1929.
- Discolouration of Halibut. F. C. Harrison, *Can. Journal of Research I*; 201, 1929.
- Discolouration of Halibut. F. C. Harrison and W. Sadler, *Biological Board of Canada, Bulletin XII*.
- The nutritive value of marine products, vitamin D content of commercial pilchard oil. H. N. Brocklesby and O. F. Denstedt. *Can. Chem. and Met.* XIV, 13, 1930.
- Sea water sampling bottle. R. H. Bedford, O. C. Young and D. B. Finn. *Contributions to Canadian Biology and Fisheries.* (In press.)
- The Bactericidal effect of the "Prince Rupert" sea water bottle. R. H. Bedford. *Contributions to Canadian Biology and Fisheries.* (In press.)
- The control of discolouration of halibut. R. H. Bedford. *Contributions to Canadian Biology and Fisheries.* (In press.)
- Apparatus for drying oil research. N. H. Brocklesby and O. F. Denstedt. *Contributions to Canadian Biology and Fisheries, Industrial Section.* (In press.)
- M.S.S. Reports:
- The determination of the vitamin A content of the liver oil of the dogfish (*Squalus sucklii*). H. N. Brocklesby, 1927.
- The determination of the vitamin D content of the liver oil of the dogfish (*Squalus sucklii*). H. N. Brocklesby, 1928.
- An investigation of the circulation induced by high velocity jets in rectangular tanks of water. I. M. Fraser, 1928.
- A chemical study of the oil in salmon during cold storage. H. N. Brocklesby, 1929.
- The bacterial spoilage of salmon with reference to the source of the organism responsible for putrefaction. D. C. B. Duff, 1929.
- Preliminary investigation into the hydroxylation of dogfish liver oil. H. N. Brocklesby and R. S. Tipson, 1930.
- The seasonal variation of commercial pilchard oil. H. N. Brocklesby and O. F. Denstedt 1930.
- Unaponifiable constituents of dogfish oil. E. G. V. Percival, 1930.