BIOLOGICAL BOARD OF CANADA

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OF THE

ATLANTIC BIOLOGICAL STATION

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By

A. H. Leim, Director

With Investigators' Summaries As Appendices

December, 1935

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ANNUAL REPORT OF THE ATLANTIC BIOLOGICAL STATION, ST. ANDREWS, N. B. FOR 1935.

This report is concerned with investigations carried on at the Atlantic Biological Station, St. Andrews, N. B., the Prince Edward Island Biological Station, Ellerslie, P. E. I. and in the field, the latter being mainly in the Province of Nova Scotia.

The investigations fall into two main groups related to fish culture and to the sea fisheries.

STAFF

The following constituted the executive and investigational staff during 1935:

Full-time

A. H. Leim, B.A., Ph.D.	Director
R. H. M'Gonigle, M.A., M.D.	Assistant Pathologist
H. B. Hachey, M.Sc.	Assistant Hydrographer
A.W.H. Needler, M.A., Ph.D.	Assistant Zoologist
A. D. Bajkov, Ing.Agr., M.Sc., Ph.D.	Scientific Assistant in Biology
A. A. Blair, M.A.	Scientific Assistant in Biology
*R. A. McKenzie, M.A.	Scientific Assistant in Biology
M. W. Smith, M.A., Ph.D.	Scientific Assistant in Biology
#V. D. Vladykov, D.R.N., Ph.D.	Scientific Assistant in Biology
E. G. Rigby, Esq.	Curator
Captain A. E. Calder	Master of "Zoarces" and Collector

Seasonal

W. Templeman, M.A., Ph.D.	Scientific Assistant in Biology (May 17 to September 24)
H. C. White, B.A.	Scientific Assistant in Biology (June 3 to December 2)

During the period from June 5 to August 20 the services of Mr. White were loaned to Dr. Huntsman for the Margaree salmon investigation.

Dr. A. G. Huntsman and Miss M. S. Rigby occupied an office at the Station for a short period during the summer.

Under a new arrangement inaugurated by the Board for this year the following persons were associated with the Station as Research Assistants. The dates of such engagement and their respective University connections are given.

Miss A. E. Clark, M.A.,	(~~formerly~~ University of New Brunswick). June 11 to October 14.
R. E. S. Homans, B.Sc.,	(Dalhousie University) May 7 to December 31.
W. H. Johnson, B.Sc.	(University of Toronto) July 3 to September 30.
G. F. M. Smith, Esq., B.A.	(University of Toronto) May 21 to October 14.
J. A. Stevenson, B.A.,	(University of Western Ontario) June 10 to September 23.

* On leave of absence September 9-15; 22-30.
\# On leave of absence September 1 to November 15.

INVESTIGATIONS

A. FRESH WATER FISHERIES

1. Investigations in hatching and rearing of trout and salmon.

The active investigations by Dr. M'Gonigle in this subject have been largely confined to investigations of disease outbreaks at hatcheries with certain laboratory procedures following; to a study of hatchery mortality statistics and to the rearing of one lot of trout in a circular pond at Tidal Cove.

The development of physical equipment at Tidal Cove will be referred to in a later section of this report but it may be said here that the funds available did not make possible the construction of enough ponds to permit nutritive or pathological studies on trout to be carried on this year. One circular pond was completed in 1934 and "yearling" trout were placed in it in November of that year. These have been carried therein until the present time without difficulty. They were fed and have made excellent growth and yielded on an average over one thousand eggs per female when stripped this fall.

An experiment conducted by Dr. M'Gonigle using recirculated water for hatching trout and salmon eggs was initiated in the fall of 1934 and continued into January 1935, when the eggs were all lost. With failure to achieve success in two successive years and at widely different water temperatures it seems clear that this experiment, if taken up again, will require improved filtering equipment or else the provision of a supply of fresh water for "bleeding" in large amounts daily. As neither of these are available at the Station the investigation has been dropped. The ultimate value of the results is chiefly in providing a means of investigating the environmental requirements of eggs and fry. Taken by and large the hatcheries have little difficulty in hatching eggs; the main problems appear to be in rearing and distribution.

Unusual difficulties in rearing were encountered at several of the hatcheries during the past summer and Dr. M'Gonigle was frequently called to investigate losses which were occurring. In the period from mid-May to the end of July he visited the Yarmouth, Middleton, Bedford and Florenceville hatcheries once, the Antigonish hatchery twice, the Kelly's Pond hatchery three times and the St. John hatchery even more frequently. The Director visited the Antigonish hatchery in connection with the outbreak in July and at a later date Dr. N. E. Gibbons of the Fisheries Experimental Station at Halifax was secured to conduct a bacteriological inquiry. An organism which is suspected of being the cause of the deaths was isolated and studied but attempts at inoculation of healthy fish at St. Andrews did not reproduce the disease.

Diagnoses of acute enteritis, gas bubble disease, fin rot, octomitiasis and chilodoniasis resulted from these investigations. At two hatcheries nc diagnosis could be made. Reports on the conditions found, and recommendations wherever possible, were made to the Fish Culture Branch. It is recognized, however, that in this field prevention rather than cure is probably the only satisfactory solution.

At Kelly's Pond the deaths of fry were shown formerly to be associated with the dying of large masses of algae in the supply pond and a concurrent rise in pH value of the water. Last spring Dr. M'Gonigle and Dr. Smith attempted to prevent the algal growth by treatment with copper sulphate. The result at first appeared to be favourable but in a short time the growth returned and the situation was not ultimately remedied. Other methods were then suggested but with the present drainage facilities at Kelly's pond they could not be carried out properly.

As a means of using the temperature data from the different Maritime hatcheries Dr. M'Gonigle has succeeded in developing a formula which fits the data and demonstrates the characteristics of any waters so far studied. Furthermore a relation appears to exist between the characteristics of the water temperature and the losses at the hatcheries.

Dr. Smith carried out an experiment as a continuation of his work on fertilizing small ponds which demonstrated the value of such ponds for the rearing of trout. Three of the concrete ponds at the Station were fertilized with small amounts of fish meal and a few weeks later trout fry were introduced. One pond was a failure due to low oxygen conditions probably associated with early fertilization but in two others over fifty per cent. of the fish survived and made excellent growth. Their food was the plankton which developed in the ponds. The effect of crowding was shown by the experiment to be reduced individual growth rather than reduced survival. The best result was obtained in a pond where five fry were introduced per cubic metre of water. These grew from an average length of 2.8 cm. (1 inch) to an average final length of 8.9 cm. (3.5 inches) in the period from June 18th to September 12th. In this pond fifty-six per cent. of the fish survived. The total rearing cost was that of about five pounds of fish meal. Apart from rainfall no new water was added to the pond during the experiment.

2. Salmon Investigations.

Mr. Blair has continued the experiments which were begun at the time the annual report for 1934 was compiled and which are designed to throw light on the nature of the scale markings for age determination. The work to date has largely consisted of maintaining salmon parr and smolt in both fresh and salt water under different temperature and food conditions in order to study the effects which are produced on the scales. This phase of the work is largely completed and the scale material ready for study. Associated with this work Mr. Blair has investigated the regeneration of scales in injured areas on the fish.

As a side issue from this scale investigation a considerable amount of data has been accumulated on the feeding behaviour of salmon parr and smolt and on the rate of growth of the fish under the experimental conditions. The data secured are also useful in studying the relative rates of growth of fish and scales, a relationship that is of importance in using the scales to compute the rate of growth of individual salmon.

It is of interest to note that some grilse from St. John and local weirs have been kept alive in sea water in the basement tanks at the Station since the fall of 1934.

Mr. White's services were loaned to Dr. Huntsman for the Margaree salmon investigation for the period from June 5th to August 20th. Following this he returned to Apple River, N. S. to follow the movements of the Restigouche salmon which had been planted as fry in the East Branch of Apple River in 1932 and which had gone to sea during 1934 when they were marked by the removal of the adipose fin. During August 1935 marked grilse were first reported in the estuary of Apple River. Traps were installed in both the East and West branches and up to mid-November, when the run was over, 156 marked fish had been taken, or 5.1 per cent. of the number of smolts marked in 1934. Although grilse were taken by both traps no marked grilse were taken in the West branch of Apple River until the season was well advanced. In other words the return of the marked grilse was to the same stream as they were planted in. In the late season when the fish were thoroughly ripe the marked fish ascended both branches of the river. This experiment to date has shown that the introduced fish have behaved like the local fish and not like Restigouche salmon. Whether there will be a further run from the sea next year, which may be either early or late, remains to be seen.

While at Apple River Mr. White also studied the returns of adult fish marked with metal tags which had been used in 1934 and previously. Returns from the sea ranging from eleven to thirty-three per cent. of the number tagged are reported. Only one fish tagged at Apple River has been reported from another river system, namely the St. John.

Dr. M'Gonigle and Mr. Blair have partially worked up the scale material and other data from land-locked salmon which were tagged in the Chamcook lakes in 1931. Many of these fish have been retaken and new scales collected a number of times at the Department's spawning camp. Others have been turned in by anglers. Some of these fish have spawned three times at least. Examination of the scales shows that if one of these salmon spawns for several consecutive years scale absorption obliterates the growth made between spawnings and the scales fail to show more than one spawning mark. This is of importance in using scales of such fish, where the history is not definitely known, for age determination. The fish fail to show sustained increase in weight during the same period.

The Director spent four days in early June on the Margaree river organizing the salmon investigation pending the arrival of Dr. Huntsman.

3. Rearing of Trout in Flooded Areas.

Only one such area is directly under the control of the Board. This is a small flooded pond on the Station property (Moose pasture - so called). This area was flooded in the fall of 1933 and was found to be devoid of oxygen in 1934 to such an extent as to be useless for rearing trout. Dr. Smith has continued to record the conditions in this area throughout the present year. The amount of decomposing material is reduced but the demand on dissolved oxygen still lowered it to such an extent that trout fry did not survive.

A number of much larger areas of water which have been produced by flooding are now available in New Brunswick and Nova Scotia and several of these have been under observation by Dr. Smith and to a lesser extent by the Director. These may be mentioned in order of their construction.

(a) Stephenson's brook pond. An area of some 17 acres of marshy, shrub covered ground, flooded by the St. John Fish and Game Protective Association in 1933. This was planted with 5,554 advanced trout fingerlings in October 1934. Seining before and after treatment with lime in May 1935 revealed a survival of 9.3 per cent. but many of the fish were large and obviously had been in the pond previous to the 1934 planting. The pond was reflooded and early in July 15,000 trout fry were planted. It was drained at the end of October when only three trout could be found. This was not surprising after a survey of the pond made in August had revealed great oxygen deficiency in the cooler portions of the area. Sticklebacks, whose temperature resistance is greater, and which could survive in the warm, oxygenated, surface layers, were found in large numbers indicating the food possibilities of such an area.

(b) Wittenburg pond. An area of 45 acres in Colchester county, Nova Scotia, in which the water level was raised in late 1934 by the Fish Culture Branch. The repairing of a dam flooded a fringe of vegetation on the periphery of a pond which had existed for a long period. The relatively smaller amount of vegetation submerged coupled with the fact that a fair flow of water passes through the pond indicated that better oxygen conditions might be expected. The temperatures observed in mid-summer were so high as to cast doubt on the value of this area. The conditions are believed to be border line for trout.

(c) Bishop's brook pond. A small but relatively deep body of water, of about one acre's extent, created by flooding a pasture and a small amount of shrubbery by the Kentville branch of the Nova Scotia Fish and Game Protective Association. This pond was flooded and planted with trout in the fall of 1935. A fair stream of water flows through the pond steadily. When examined in November conditions were good but the food producing capacity of the pond is probably quite limited.

Dr. Smith assisted in an examination of two other pond sites near Kentville, N. S. and of one near Forest City, N. B., where local Fish and Game Protective Associations are interested in this method of rearing. In view of the results obtained so far it seems wise to restrain such activity until the cycle of events in the ponds is better understood unless the Associations concerned thoroughly understand their experimental nature. In many cases natural configuration of the land makes the cost of flooding very low.

4. Lake Jesse, Nova Scotia.

This lake was treated with copper sulphate in August 1934 with the object of killing undesirable fish with which the lake was over supplied. Dr. Smith has followed the conditions in this lake by the study of plankton tows taken by himself on two occasions in 1935 and at other times by the staff of the Yarmouth hatchery.

Water samples collected in May 1935 and analysed in the Division of Chemistry, National Research Council indicated the absence of appreciable amounts of copper in the surface water but the bottom sample was reported to contain 0.52 parts per million of copper (equal to 2.03 parts per million of $CuSO_4.5H_2O$) or two-thirds of the amount added originally. Experiments made by placing trout fry in samples of the bottom water at this time also demonstrated its toxicity.

Plankton in the lake changed from poor in the spring to very abundant in November, probably indicating the disappearance of the copper in toxic amounts. Water samples taken in November have not been analysed for copper as yet. If these are reported on favourably stocking of the lake with fry next spring will be recommended.

5. Investigations of Lakes and Streams.

The Chamcook lakes (first and second) remain the ones which have received the most attention because of their closeness to the Station. The problem is one of discovering the physical and biological relationships in lakes in the Maritime provinces. These lakes may be taken as types of deep and shallow lakes. Some of the objects of the investigations are to discover the factors which limit the supply of sport fish in these lakes and to ultimately discover the expected productivity of such bodies of water.

Dr. Bajkov has continued the routine observation of temperatures in these lakes and obtained material for the study of seasonal changes in the plankton and bottom fauna. He has obtained specimens of the fishes which occur in the lakes for a study of their food at different seasons, so that the food chains may be understood. Small numbers of togue and land locked salmon were included in these collections. As smelt appear to be an important constituent of the food of these fish and the smelt population of the lake, while undetermined, does not appear to be large a transfer was made of smelt eggs from streams tributary to Lake Utopia to Chamcook lake. While the number transferred was too small to significantly affect the situation it served to demonstrate the possibility of successful transfer. Any large attempts to introduce smelt would seem premature until the food cycles in the lakes are more thoroughly worked out.

Dr. Smith obtained a quantity of eels by trapping the outlet stream from Chamcook lake and by direct fishing in the lake. These were studied for food content. It was hoped to reach an estimate of the number of eels leaving the lake but while the trap operated successfully for the summer and early fall, the greater flow of water and autumn leaves interrupted its use. The purpose of enumerating the departing eels was to learn something of the drain of food materials from the lake which they represent.

Dr. Smith collected plankton in Gibson lake, which is a tributary of the Chamcook series, to replace tows which were lost in the fire before being completely worked up as they seemed to demonstrate the irregularity of horizontal distribution of the plankton in such a lake. The tows taken this year show a similar irregularity to those taken in former years. Obviously the degree of this irregularity is of importance in any studies of lake productivity.

At the request of the Fish and Game Associations and of the Fish Culture Branch Drs. Smith and M'Gonigle examined conditions in Big, Little and Hopper ponds on Deer island and Miller, Bradford Cove and Bel brook lakes on Grand Manan. Reports based on these investigations have been drawn up on the suitability of these ponds and lakes for stocking with trout. Several of these bodies of water proved to be unusual which may make them valuable from an experimental standpoint. Two of the Deer island ponds were deficient in oxygen and Millers lake on Grand Manan, although apparently normal with regard to the ordinary physical and chemical conditions, was almost devoid of plankton when examined on October 11th.

The St. Stephen branch of the New Brunswick Fish and Game Protective Association have been urging the development of the Magaguadavic river as a salmon angling stream. It was agreed to make a very preliminary survey to ascertain in a general way the characteristics of the river. Dr. M'Gonigle, Dr. Smith and Mr. Rigby spent two or three days making such a survey on the lower parts of the main river and some of the more accessible tributaries. The discovery of ample spawning grounds for the few adult salmon, which ascend the fishway at St. George, on the lower sections of the river argues against the need of a fishway at the Flume Ridge barrier at the present time. The survey does not seem to be sufficiently advanced for a definite decision in this matter.

A case of alleged pollution by the Montague Gold Mine washings which flow in to lake Charles near Halifax was referred to the Station by the Department. The Director secured excellent plankton tows in the lake which indicated the absence of any deleterious substances. Samples of the mine effluents have been collected for further testing biologically.

B. SEA FISHERIES

1. Hydrography.

The chief hydrographic investigations have been concerned with the Nova Scotian coast. The offshore cruise involving seventeen stations and touching most of the banks was undertaken by the "Zoarces" in May and August, Mr. Hachey accompanying the boat on the later cruise. Part of this series was repeated in July and December. A line of four stations out from Halifax harbour was occupied seven times from April to December. Other arrangements were made for which thanks are due to the Chief Supervisor of Fisheries at Halifax whereby data were obtained at one station well outside Halifax harbour during each of the months of January, February and March, so that for the first time a full year's data exist for an outside station on the Nova Scotian coast. The "Zoarces" occupied lines of stations in Chedabucto bay, off Glace Bay and off Ingonish in June and December. Some observations were also made in the Bras d'Or lakes and at other places incidental to the cod and haddock work.

On the request of the Woods Hole Oceanographic Institution hydrographic observations were made in Cobscook bay, adjacent to Passamaquoddy bay, at four stations in August and at one station monthly thereafter. The object is to have established the normal as a basis for comparison if and when the power project dams this area off from tidal influence.

Regular hydrographic observations have been continued at two stations near St. Andrews and by the Fisheries Experimental Station at one point in Halifax harbour. The last named station has also handled the routine arrangement whereby thermographs are kept in operation on two Canadian National Steamships plying out of Halifax.

The arrangement of securing data through Coastal Observers has been continued except that observations have been discontinued at North Point, P. E. I. and have been initiated on board the Halifax Lightship, through the cooperation of the Marine Agent at Dartmouth, N. S.

Mr. Hachey has determined the salinities of water samples collected from the foregoing observations and has analysed the data as it becomes available. The analysis of the 1934 data has been completed and the directions of water movement determined. The contrast of conditions in the waters of the Scotian shelf as between 1934 and 1935 has been notable. In 1934 the August cruise found warm oceanic water flooding this area while in 1935 in the spring months particularly an extensive and persistent body of very cold water was in evidence. The relation of these conditions to the fisheries is obvious and unusual distributions of commercial catches of cod and haddock can be explained in part by the hydrographic irregularities of the year.

The rapid changes of temperature which are frequently experienced in summer on the Nova Scotian coast and their relation to offshore atmospheric disturbances continues to receive attention as new data becomes available. A relation has been found to exist between the surface water temperatures in Halifax harbour in September and the amount of precipitation in the preceding August. Based on ten year data heavy precipitation in August has been followed by low mean surface temperatures in September and vice versa.

Mr. Hachey has prepared a chart which brings out the prominent physiographical features of the sea bottom to the edge of the continental shelf for the eastern Canadian coast.

2. Cod investigation.

Mr. McKenzie has carried on this investigation with assistance from the "Zoarces" and has worked partly from the St. Andrews and partly from the Halifax Station.

It was planned to tag cod in the spring off Halifax but the failure of the run of fish to materialize altered the plan to one of tagging in an exploratory fashion chiefly to the east of Halifax. Five hundred and two cod were tagged by the "Zoarces" between May 3rd and June 29th at points near Halifax, on Sable Island, Middle Ground and Banquereau banks and at Ingonish, N. S. In October, with assistance from Mr. C. Darrach of the Atlantic Fisheries Experimental Station Mr. McKenzie tagged about fifty individuals of the autumn spawning group in Halifax harbour. So far only a small percentage of the 1935 tags have been returned in contrast to the results of 1934 cod tagging where about 17 per cent. of the tags were returned during 1934 and the number has since risen to over 23 per cent. The fish tagged

in shoal water in 1934 have shown but little migration, having been recaptured mainly on the same grounds this year. The cod tagged in deeper water moved offshore in winter and tended to scatter, mainly eastward so that few of them were caught on the tagging grounds in 1935. No significant recaptures of autumn spawning fish tagged in either 1934 or 1935 have been reported.

Vertebral counts have been made on some 5000 cod during 1935. These have been derived from a widely scattered series of locations from the Gulf of Maine to the Gulf of St. Lawrence. Significant differences are again found in cod populations of different sections of the coast and while in general the results agree with those obtained in 1934 differences have been found, particularly on the outer coast of Cape Breton. Seasonal differences have become evident which seem to indicate a westward movement of cod during the winter months. For the third consecutive year the autumn spawning school with its distinctly low vertebral count has appeared in Halifax harbour. No trace of these fish during other months has been revealed either by the tagging or vertebral count method of identification.

The "Zoarces" took a series of plankton tows in late October and early November from the Bay of Fundy to Chedabucto bay to determine the presence, in the water at the heads of inlets, of cod eggs and hence of spawning fish. Such eggs were found in Halifax harbour, St. Margarets bay, the LaHave estuary, Green bay, Negro harbour and St. Mary bay with the tows to the eastward of Halifax still to be examined.

Dr. Needler collected plankton during the open water season from a station near Ellerslie in order to obtain information on the presence of spawning cod in that region. These tows have not been critically examined.

Using otoliths Mr. McKenzie has worked out the ages of the 1933 and 1934 autumn spawning group. The 1927 year class was shown to be dominant with the fish spawning at from five to seven years of age.

Cod were kept in the aquarium tanks at St. Andrews and data collected on their feeding behaviour at the low winter temperatures and at intervals throughout the year. The larger cod were shown to cease feeding when the temperature reached 0°C. (32°F.) while the small fish continued to eat at the minimum temperature of -0.6°C. (31°F.).

Otoliths have been collected from a large number of cod for age determination when an opportunity is offered to carry on this phase of the investigation.

As with the hydrographic and haddock investigations the cod work has been hampered by lack of funds to enable the "Zoarces" to continue full time work.

3. Haddock investigation.

A considerable number of haddock were tagged off the Nova Scotia coast in the spring months. The total was 1,897 fish made up of 1,060 tagged from National Fish Company trawlers on the Western bank, 636 tagged from traps in St. Margarets bay and 201 from traps at Ingonish. The "Zoarces" crew and Mr. Darrach carried out the trawler tagging while the inshore tagging was done directly by the "Zoarces". The tagging was carried on from April 21st to June 10th. The returns from this tagging to date have been small, 5 per cent. from the St. Margaret bay tagging and less than 1 per cent. for the Western bank. An eastward movement of the St. Margaret bay fish is demonstrated by the tagging returns; there has been a movement into the Gulf of St. Lawrence of the fish tagged at Ingonish.

Dr. Vladykov has had vertebral counts made on some 6,000 haddock which were caught at various points between Cape Cod and Newfoundland. These counts confirm the existence of three distinct races of haddock on the Atlantic coast as was indicated by Dr. Needler's work. Smaller differences are also seen in the schools inhabiting different parts of the Nova Scotian area. Such tagging returns as have come in agree well with the movements indicated by seasonal changes in the average vertebral count.

The haddock, referred to above as being tagged in St. Margarets bay, were part of an unusually large run which was taken by the traps there in May and June. Racial investigation of these fish indicated a close similarity to Ingonish fish. Whatever may have caused their concentration in St. Margarets bay their presence within a few feet of shore may be attributed to the very cold water which occupied all the deeper portions of the bay at that time.

Scale material has been collected from about 7,000 fish partly by the wireless operator on a trawler and temperature data on the fishing grounds is turned in by the same man. These scales are for study of the age of haddock composing the schools and thus for determination of the relative abundance of year classes.

Mr. Homans has examined the stomach contents of about 6,000 haddock from the Western bank. The organisms chiefly taken were, in order of importance, sand launce, annulates, crustacea, molluscs and echinoderms. Differences were noted in the diet of small as contrasted with large haddock.

It was further found that during the months of February to May the stomachs of trawler caught haddock were relatively empty as compared with the other months of the year. This demonstrates a diminution of feeding activity during the spawning season.

Dr. Vladykov took advantage of the presence of a biochemist at the Trois Pistoles Station during his stay there to have some determinations made of the primary chemical constituents of several of the chief organisms eaten by haddock.

4. Herring Investigation.

The only work carried on in this field was that of Mr. W. H. Johnson who studied the distribution of the food of the herring by taking plankton tows at two points in Passamaquoddy bay, one where tidal currents were strong and one where they were weak. These tows were taken under a wide variety of light conditions.

Laboratory experiments were included in his investigation. The reactions of young herring to light and their feeding behaviour was studied. A number of species of copepods which are important constituents of the food of the herring were studied with respect to their reaction to light intensity and wave length of light.

It may be mentioned that diseased herring were present in Passamaquoddy bay and its approaches during the summer of 1935 after being almost absent in 1934. No special study was made of this matter.

5. Oyster Investigation.

The chief experiments which Dr. Needler had underway at Ellerslie during the past summer had to do with the testing of cheaper methods of rearing oysters in their second summer. None of the methods tried gave as good results in growth as do the floating wire-bottomed trays from which light is largely excluded by wooden covers. Spat from 1934 collections was placed on unimproved and variously hardened bottoms in situations towards the heads of inlets where starfish were absent and wave action non-injurious. While this method was less costly than the use of floating trays poorer growth resulted, algae grew on the shells and favoured the deposition of silt and consequent smothering.

Creosoted lumber for trays as a substitute for the more expensive copper paint proved to be satisfactory.

Experiments were conducted to test the possibilities of leaving the spat on the cardboard collectors to the end of the summer. The method has possibilities for the poorer grades of oysters.

Another modification of the use of hard bottom for planting out spat was tried by taking shells which had been used as spat collectors in wire bags in 1934 and placing the shells on the shores at various levels from just below low tide level to half tide level. Avoidance of starfish attack was the object. A variety of types of bottom and degrees of shelter were involved. The growth of the oysters in this and in the above experiments was followed by Miss Clark. While some favourable results were obtained the growth and survival was not as good as on the better shallow beds, which are totally submerged at all times. Algae and silt replaced the starfish as the injurious factors.

Miss Clark investigated the growth of spat in the second summer under different degrees of crowding and in various locations. Crowding was found to reduce growth and the greatest growth was obtained in the early summer. The growth rate could not be entirely correlated with temperature and the influence of other factors, such as food is indicated.

Mrs. Needler continued her observations on sex reversal in oysters. The sex of a few oysters has been determined each year for five years and of many more for four years. In many of these the sex changed annually. An experiment to test the effect of crowding on the proportions of the sexes did not demonstrate any relationship.

As the starfish is perhaps the chief enemy of the oyster considerable attention was given to a study of the distribution and activities of starfish in the inlets near Ellerslie. Information as to what areas are free from starfish attack is of value in the planting of oysters. Mr. Smith was engaged in this work. The size at maturity, time of spawning, rate of growth and distribution on the various kinds of bottom were determined. An attempt was also made to estimate the abundance of starfish on certain beds where mopping operations were conducted by the Department.

Starfish were found to migrate shorewards in spring and fall and the larger sizes were killed if exposed to the highest summer temperatures. Experiments on the effects of reduced salinity on starfish, carried out in the laboratory and by exposing individuals in cages in various situations, indicate that in summer temperature is a more important factor than salinity in limiting the distribution of starfish.

Dr. Needler visited the oyster areas in the Bras d'Or lakes in Nova Scotia on two occasions in July and October. In an attempt to improve the quality of the oysters growing there in areas of very low salinity some experimental transfers were made to more saline water at Baddeck and Port Hood, N. S., and St. Andrews, N. B. There was definite improvement in flavour after three months immersion in the new locality. The dark mantle edge, which is objected to in the Cape Breton oysters, was not affected by the transfer. Examination of grounds where transfer of oysters to prevent winter injury was thought to be desirable, indicated that this was not likely to be worth while.

Dr. Needler visited oyster research headquarters in New Jersey and Rhode Island during the summer in order to acquaint himself with developments in oyster culture and research methods which are being utilized there.

oyster breeding

See 6th R page 15 last years report. "experimental oyster farm"

6. Scallop Investigation.

Arrangements were made whereby a Digby scallop fisherman collected scallop shells monthly during last winter and spring. Mr. Stevenson was able to demonstrate from this material the annual nature of the main rings on the shells.

Mr. Stevenson was engaged in a study of the scallop fishery off Digby during the summer months. This fishery has increased so markedly in recent years as to give some concern to some of the fishermen and to the authorities regarding its conservation. As the fishery is closed in the summer Mr. Stevenson was unable to collect, on a large scale, data which might be used to estimate the productivity of the beds. He confined his attention to the weekly collecting of scallops from several stations for growth studies, for determination of size at maturity and duration of the spawning season.

Tows were taken for determining the abundance and fate of scallop larvae. It was found that the spawning season lasted from early June to the middle of September and that some of the scallops spawn when three years old. Furthermore the present size limit permits some immature scallops to be caught.

Scallop larvae were found to be very scarce in the plankton. The same tows indicated a high mortality among Mya and Mytilus veligers.

The food of adult scallops was investigated. A commensal relationship between scallops and small hake was discovered.

7. Lobster Investigation.

This investigation was conducted by Dr. Templeman. Some field work was done on the south shore of Nova Scotia between Port Maitland and Lockeport during the closing days of the 1935 lobster season. The purpose was to collect data on the size of maturity of lobsters in that area. There was considerable difference of opinion in this district as to the value of a size limit and the Station did not possess data on the matter. It was found that the lobsters mature in the above region at a length of from 27 to 29 centimetres. the length being measured between the tips of the rostrum and the telson. The comparative figure for Point du Chene is 18 centimetres. The present protection for lobsters in south western Nova Scotia is for animals under 22.5 centimetres only so that immature lobsters are caught legally.

Observations were made in the aquarium tanks at St. Andrews on the egg laying procedure of the female lobster and on the hatching posture. Further experiments on mating confirmed results obtained at Point du Chene in showing that mating only occurs within a few days after moulting of the female. It was observed that a female lobster which has deposited one lot of fertilized eggs on the swimmerets may still carry a large supply of sperms in the seminal receptacle. There is insufficient data to say what the importance of this may be in permitting the fertilization of more than one lot of eggs between moults.

Lobster larvae were reared in several series of experiments. Better growth was obtained by rearing the animals in darkness than in north window light. Cannabilism was pronounced under both conditions but was more destructive in the light.

A number of lobster larvae were reared individually in a constant temperature room at 20°C. The time between successive moults was determined and at the present time, in five months after hatching, seven individuals have moulted 10 times and have reached a length of 4 centimetres as measured from rostrum to telson.

Some data was collected on the rate of early development of the lobster eggs and on the survival of adult lobsters in air.

8. Limnoria Investigation.

The construction of extensive wharves in St. John harbour re-opened the question of possible injury to the timber by Limnoria, a crustacean borer. The matter was referred to the Board and to this Station. The St. John Harbour Commissioners and the Atlantic Sugar Refineries cooperated in placing test blocks and boards on their respective wharves in St. John harbour and at Partridge island. A rather unexpected and moderately severe attack was experienced at Berth 17 which is out of the main stream of river water as it flows down the harbour. The blocks placed at the other wharves were practically unharmed. As the new structure will be in a very similar situation with respect to the river water to the unharmed blocks the Harbour authorities have been advised that there is no reason to suppose that any danger of attack exists.

In order to explain the attack at Berth 17 a hydrographic survey was arranged by Mr. Hachey, involving the cooperation of the above mentioned bodies. Higher salinities were experienced at Berth 17 than elsewhere. The matter should be investigated further when the spring freshet is on.

Dr. M'Gonigle has carried out the examination of the test blocks and boards and Mr. Hachey the hydrographic work.

9. Eel-Grass Investigation.

No active investigations have been carried on in this field during the year but information was collected from the Fishery Inspectors of such districts as gave promise of recovery of the eel-grass in 1934. The reports have indicated that no commercial amounts of eel-grass are available anywhere on our coast and the situation appears to be even less favourable than it was a year ago.

10. Plankton.

Regular collections of plankton at two stations near St. Andrews, one near Halifax and one near Ellerslie have been continued. In addition a monthly collection in Cobscook bay has been instituted. Reference has already been made to special plankton studies connected with several of the investigations mentioned above.

GENERAL ACTIVITIES

The meeting of the North American Council on Fisheries Investigations held at Washington, D. C. on September 17th to 19th was attended by Messrs. Hachey, McKenzie, Needler and Leim.

The Director gave certain lectures in Biology to classes of Fishermen and Fishery Officers at the Atlantic Fisheries Experimental Station during the period of January 30th to February 28th.

The Director assisted at a demonstration booth, arranged by the Department of Fisheries and the Halifax Station at the Pictou Lobster Carnival on July 10th. This was repeated in revised form at Woodwards Cove and Whitehead, Grand Manan on October 3rd and 4th.

Addresses on the work of the Station were given by members of the staff as follows:
To Canadian Club, St. Andrews - Messrs. M'Gonigle and Smith. In March.
To Rotary Club, St. Stephen - Mr. Hachey. In October.
To Annual meeting of the N. B. Fish and Game Protective Association, Fredericton - The Director. September 11th.

In connection with a survey of the problems confronting the fishermen in the Maritime Provinces the Director assisted Dr. Huntsman in the recording of information obtained from Supervisors Barry, Fraser, Gallant, Marshall and McLeod in March. In connection with this survey he interviewed during the course of the summer and fall fish firms in St. John, Blacks Harbour, Grand Manan, Fredericton and Port Elgin, New Brunswick; in Digby, Westport, Yarmouth, Shelburne, Lockeport, Liverpool, Lunenburg, Hubbards, Halifax, Petit de Grat, Port Hood and Margaree Harbour, Nova Scotia; and Charlottetown and Souris, P. E. I.

GENERAL FACILITIES

Lack of funds has prevented any extensive additions to equipment. The furnace room at the Station has been properly walled in and some minor alterations made in order to roof in the gas machine and furnace room.

At Tidal Cove a raceway, 300 feet in length, has been built to serve as a drain from the pond system and to provide in itself twelve ponds for holding fish. Excavation has been largely completed and supplies purchased for the installation of several small circular ponds early next year.

A pump for pumping salt water has been connected to a car engine and installed in a small shed beside the tidal reservoir and has been piped to two hydrants. It may be used for fire purposes or as a standby for the ordinary salt water pumping system. This pump will deliver water at the hose nozzle at greater pressure than the fresh water connection does and it is available at all times of the year.

PUBLICATIONS

In cooperation with the Atlantic Fisheries Experimental Station three Progress Reports have been issued in 1935 and another will appear shortly.

The following articles on work connected with the Station have been published since the last annual report was written.

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Leim, A. H. Cod and haddock tagging. Prog. Rep. Atl. 15, 3, 1935.

M'Gonigle, R. H. Algae, a factor in some hatchery mortalities. Trans. Amer. Fish. Soc. 64, 416-423, 1934.

McKenzie, R. A. More about codfish and water temperature. Can Fisherman, May 1935, 15.
Cod spawning in the Bay of Fundy and about south western Nova Scotia. Prog. Rep. Atl. 13, 10-14, 1934.
Codfish in captivity. Prog. Rep. Atl. 16, 7-10, 1935.

Needler, A.W.H. Rearing separate oyster spat on trays. Bull. Biol. Bd. Can. 48, 1-12, 1935.

Newcombe, Curtis L. A study of the community relationships of the sea mussel, Mytilus edulis L. Ecology 16, 234-243, 1935.

Smith, M. W. The dissolved oxygen content of fertilized waters. Trans. Amer. Fish. Soc. 64, 408-415, 1934.

Templeman, W. Local differences in the body proportions of the lobster, Homarus americanus. J. Biol. Bd. Can. I, 213-226, 1935.
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ATLANTIC BIOLOGICAL STATION REPORT, 1935.

Appendix No. 1 (Fish Culture)

EXPERIMENTAL FISH FARM, AT BIRCH COVE

The construction of facilities at Birch (Tidal) Cove was continued this season, and a long raceway containing twelve smaller partitions for holding various experimental groups of fish (particularly salmon and speckled trout) was completed and put to use this autumn. A large circular pond for retaining brood stock, which had been completed the previous season, was found highly satisfactory for the purpose, being run through the past winter, with no loss to the contained stock, which yielded this year at their second spawning, a total of fifteen thousand eggs, or an average of one thousand per female.

A series of smaller circular ponds was not completed due to the very stony nature of the terrain, making construction work quite slow. Because of the presence of springs, this particular site is felt to be very suitable for the purpose.

A further series of ponds, at the very lowest part of the area, is planned to enable pathological studies to be carried out, without danger of contaminating the area above, which it is proposed to use for physiological, biochemical or genetic studies.

A small shelter was erected this year, to permit the eggs which were secured to be laid down, for development, and hatching in the raceway. It is recommended that a more permanent building to serve as a field laboratory, as well as shelter, be erected close to the pathological ponds, for the various experimental procedures incidental to the operation of the farm. This building should be planned to provide small hatching groups, needed in genetic studies, where the various lots of eggs require segregation.

R. H. M'Gonigle.

Appendix No. 2 (Fish Culture)

TEMPERATURE CHARACTERISTICS OF THE WATERS OF THE MARITIME HATCHERIES

Purpose: To provide a simple comparative measure of the energy content (solar) as indicated by temperature, in each of the Maritime hatchery waters; and a convenient method of comparing bodies of water for suitability for aquiculture; and also to determine alterations of conditions, over longer or shorter periods, of importance in aquiculture.

Investigation: Shortly after pathological work was instituted a request was referred to the Pathologist to report upon certain of rates of hatching from various hatcheries with reference to the 'heat units' at each of these hatcheries. These units were the days multiplied by the change of temperature in degrees Fahrenheit. No exact data were available at the time, and the great discrepancies between the rates of hatching, and the reported heat units could not be correlated.

In addition, it was early found, in the course of pathological investigations that a very important relationship existed between the incidence and progress of an infection, and the temperature of the waters, a phenomenon to be expected in cold-blodded animals, so that a convenient means of determining temperature relationships has become a greater and greater necessity.

Accordingly, the temperature data, which has been supplied by the Department of Fisheries weekly, for the past five years, and in the case of three hatcheries has been supplied by Mr. Rodd for longer periods---to the commencement of operations in two of these, and for a total period of nine years in another, these data have been tabulated so that comparable weeks for the entire period could be averaged. The first part of the study has been confined to the averages of the maximum temperature for each week, for each of the eleven hatcheries, and it has been found possible to fit the observed averages quite accurately with a mathematical equation having the properties of that of a sine curve. This equation in its general form is as follows:

$T = A - B \sin \left[\frac{2\pi}{P} x - \epsilon\right]$; where T is the temperature in degrees, either Fahrenheit or Centigrade; A, B, and ϵ are constants, P is the period, and x fractions of P. A more convenient form of this equation for expressing the data is:

$T = A - B \sin [6.92(x-K)]$; where K is $\epsilon \times 0.14$, when P is taken as 52.

Among other advantages of such a compact method of expressing the temperature cycle, probably the following are the more valuable:

1. Such an equation can be derived from observed data by very simple calculations.

2. Simple inspection of the equation gives immediately (to one acquainted with elementary mathematics) the outstanding features of the temperature variations; for the constants of these equations accurately express the temperature characteristics of the body of water: A is the average temperature; A + B is the average maximum temperature; K denotes the degree of lagging, that is response to the source of heat (the sun).

3. Variations for any body of water between the calculated values from the equation in any part (where the fit is good over the greater part) and the ~~values secured by plotted~~ observed values, point out peculiarities for that body of water which require further consideration and explanation (such as occur after ice and snow blanket the water body).

4. Having knowledge of the suitability of certain bodies of water for the different species or types of crops, the suitability of any other water supply is quite easily predicted, provided sufficient temperature data are available.

5. The heat quantities are readily derived from the equation (by integration).

R. H. M'Gonigle.

ATLANTIC BIOLOGICAL STATION REPORT, 1935.

Appendix No. 3 (Fish Culture)

ALGAE, AT KELLY'S POND, PRINCE EDWARD ISLAND

Purpose: It was necessary to determine the effective dosage of copper sulphate needed to destroy obnoxious amounts of algae in the waters for the Kelly's Pond Hatchery.

Investigation: Previous investigations had indicated gas-bubble disease at this hatchery with a serious mortality at about the same time each year (depending upon the time that the temperature would reach 50°F.). The waters were found to be highly charged with oxygen, the pH rose to exceptionally high values, the algae would die, and float up in great brown flocculent masses.

As copper sulphate has been used for years as an algicide in treating municipal water supplies, it was attempted to destroy the algae prior to its maximal development and death by means of copper sulphate.

The amount required, which would not destroy the fish (determined by preliminary tests) was then applied. This was followed by a rapid clearing of the pond, as the plankton algae died. The filamentous forms turned brown, and were removed as thoroughly as possible. Copper was recovered from some of this dead filamentous algae, (the amount not yet determined). However, a more resistant form of algae replaced quite rapidly, the susceptible forms, so that a concentration of copper sulphate strong enough to destroy this form would also have destroyed the fish. This method therefore was not effective, and the ultimate conditions at this hatchery were as bad, or even worse, than previously.

Recommendations: It has been recommended that the pond be completely drained, and the contained fertilizing materials (phosphates and nitrates) discharged. The bottom should then be completely exposed to the sun for as long as feasible. Treatment with lime has also been advised.

M.W.Smith and R. H. M'Gonigle.

ATLANTIC BIOLOGICAL STATION REPORT, 1935.

Appendix No. 4 (Fish Culture)

FIN-ROT AT ANTIGONISH AND SAINT JOHN HATCHERIES

Purpose: As very little is yet known of this infection, an attempt was made to learn more about it, with a view to proper prevention, and control.

Investigation: About July 1, a loss developed at Antigonish, which became alarming by July 12. Dr. Leim, being in Halifax at the time, went over to the hatchery, and made an investigation. He found severe infestation of the older fish, with copepods (Salmonicola), together with an oxygen value, of about two-thirds saturation. It was found advisable to make a second investigation (July 26), in connection with this outbreak. The indications from Dr. Leim's investigations were that the cause of the mortality was bacterial. This was confirmed, and a request was at once made for a bacteriologist to be associated in the investigation, due to lack of equipment at the Atlantic Biological Station, for the work.

Dr. N. E. Gibbons, from the Halifax station, at once joined in the work, and made cultures and endeavoured to isolate the causative organism.

So far, we have not identified any of the organisms secured as the causative one, as when inoculation experiments were attempted at St. Andrews, from cultures sent over by Dr. Gibbons, the water temperatures were apparently too low.

In any event, according to the literature, no attempt to culture this organism artificially has as yet been successfub.

At Saint John, the course of events was rather similar; identical forms were observed in smears from abscesses, and were recovered in cultures. The conditions were not so severe as at Antigonish. Putting affected fish into much colder water (spring water) seemed to effect a cure, where the usual chemical baths were quite ineffective.

Recommendations: Dr. Gibbons is continuing the sub-culturing of the organisms isolated, throughout the winter, so that further inoculation experiments may be carried out next season, when the waters are warmer.

Acknowledgement is gratefully made to Mr. Rodd, who paid all the expenses incidental to travelling expenses of both Dr. M'Gonigle, and Dr. Gibbons, as the funds allocated for these studies by the Atlantic Biological Station had been exhausted prior to this outbreak.

A.H.Leim, N.E.Gibbons, and R.H.M'Gonigle.

Appendix No. 5 (Fish Culture)

YARMOUTH HATCHERY MORTALITY

Purpose: The purpose of this investigation as for all the various hatchery investigations, was to determine the causes for a sudden severe loss.

Investigation: The hatchery was visited on June 7, when the fish were found to be suffering very acutely from a condition very suggestive of a severe colic in the human.

Careful examinations for parasites revealed rather few, except a form not seen previously. Due to a history of various internal helminth parasites, and the fact that Lake George, which is the source of the water used for the hatchery, is a bird sanctuary, the presence of the infecting stage of some or other of these forms was suspected.

After consultation with Mr. Rodd, it was agreed to refer the matter of additional investigations to Professor Wardle of the University of Manitoba, who had examined material previously from this hatchery. Professor Wardle agreed to carry on investigation, upon material to be sent him. However, owing to the lack of this material (bird guts) this investigation has made as yet almost no progress.

Recommendations: It is recommended that a very determined effort be made to supply Professor Wardle with as much material, regularly, as he require, so that the cause of the infection can be determined, the manner of infection, so that proper preventative measures can be adopted.

R. H. M'Gonigle, (and Prof. Wardle).

Appendix No. 6 (Fish Culture)

MISCELLANEOUS HATCHERY INVESTIGATIONS

Purpose: To determine the causes of increased mortalities in the Maritime hatcheries.
Investigations: In addition to special investigations referred to separately, smaller, or less complete, studies were made at Florenceville, Saint John, Middleton, and Bedford hatcheries. In addition, a serious loss in eggs at the Nepisiguit sub-hatchery was referred for investigation.

At Florenceville, and at Bedford, no gross pathological picture was seen, and no diagnosis was possible. It was learned later that there was a possibility of poisoning at Florenceville, due to the habit of the local farmers washing out their fertilizer bags in the stream supplying the hatchery. No cause for the conditions at Bedford hatchery was discovered.

At Saint John, the parasites Chilodon, and one of the leeches were found, and these seemed to be associated with a subsequent outbreak of a very severe form of a bacterial disease called Fin-rot.

At the Saint John Salmon Pond, blindness of the fish continues to be a serious cause of loss, and it would appear that this may be associated with the handling incidental to the peculiar location of this pond. It has been thought previously that this loss was associated with tidal conditions, but this year's investigation revealed that some additional factor must be operating, which seems to be outside the pond, and is likely the handling referred to.

At the Nepisiguit sub-hatchery, no field investigation was made, but from the character of the pathological material submitted, the presence of much organic pollution seemed indicated. It is recommended that an investigation be made at the corresponding period, next season.

R. H. M'Gonigle.

Appendix No. 7 (Fish Culture)

SALMON SCALE CHECKS

In determining the age of fish from the scales the winter bands are counted. But often there are other checks in the scales which are sometimes difficult to distinguish from winter bands. So fish were subjected to such things as food and temperature changes, injury, loss of a large number of scales etc. in order that the characteristic markings on the scales might be studied.

The fish used in these experiments were parr and smolts about 20 cm. in length. To produce food checks in the scales one fish was fed well for a couple of months and then it was fed poorly for a similar length of time. Another fish was fed poorly for a few months and then fed well for a month or more. One smolt in salt water was fed poorly for one year and then was well fed for four months. Three fish were starved to see how long they would live without food. They lived for eight months then became covered with fungus and soon after died. Also a fish was starved for one month and then fed well for several months. In all cases where fish are well fed after being starved or fed poorly the amount of food eaten per day shows a gradual increase as if the stomach was returning slowly to its normal size. In one case a fish was being fed four pieces of herring a day and then it was given all it could eat. It took twelve pieces in the morning but during the day it brought up eight of these pieces thus showing that the stomach could not yet hold any more than it had been accustomed to.

To produce temperature checks one fish was held at a temperature around 10°C. for two months and then transferred to a temperature ranging from 15°C. to 20°C. Similarly two other fish were held at a high temperature and then transferred to a low temperature. These fish were well fed at both temperatures. To produce an injury check the scales and skin were scraped from an area on the side of the fish.

A peculiar check is often formed in the scale by the scale being dislodged in the scale pocket. If the scale has been dislodged considerably, then the cause of the check is apparent but it would be possible for the scale to be moved about but remain in practically the same relation to the scale pocket. Then a check might be formed and the cause not apparent. To see if this is possible a fish was given ether and in a definite area 10 scales were removed and then placed back in the pockets again. In another area on the same fish the scales were rubbed slightly to loosen them somewhat. This fish is still being fed so that the scales will show some growth after the operation.

A. A. Blair.

Appendix No. 8 (Fish Culture)

REGENERATION OF SALMON SCALES

When scales are removed from the scale pockets new scales take their places. This investigation was undertaken to determine the time it takes for regenerated scales to reach the size of normal scales and the number of ridges they have when this size is reached.

From four parr about 15 cm. in length scales were removed from a small area near the dorsal fin. One fish was killed each succeeding week and it was found that the scales were regenerated on the first fish i.e. during the first week. So ten more parr about 10 cm. in length were scaled in the same way and a fish removed every two or three days. These have not yet been examined. Another method was used on a large parr 20 cm. long. A definite place was selected at the posterior end of a line of scales and the anterior scales in this line were picked out one every other day. The fish had to be given ether each time to prevent the removal of other scales.

A. A. Blair

Appendix No. 9 (Fish Culture)

EFFECT OF FOOD AND TEMPERATURE ON THE SCALE-LENGTH FISH-LENGTH RELATIONSHIP IN SALMON

Once the age of a fish is determined it is often very desirable to know the rate of growth of the fish, i.e. its size at the end of each winter of its life. This can be calculated from the scale growth by assuming that fish growth is directly proportional to scale growth. Food and temperature are two important factors which affect the rate of growth of fish so experiments were devised to test the effect of these two factors on the growth of the fish and on the growth of the scales.

At a temperature around 8°C. one lot (40 fish) of salmon fry was fed all they could eat while at the same temperature another lot was fed just enough to produce a measurable amount of growth. Similarly at a temperature around 16°C. one lot was well fed and another poorly fed. This same procedure was repeated on large parr both in fresh and salt water. These experiments were run for one year and have just been completed so the results are not yet available. However, the average lengths and average weights of the fry show that the high-temperature, well-fed fish (10.0 cm., 11.6 gm.) grew faster than the low-temperature, well-fed fish (9.1 cm., 8.3 gm.). The high-temperature, poorly-fed fish (7.8 cm., 5.4 gm.) grew somewhat better than the low-temperature, poorly-fed fish (7.5 cm., 4.4 gm.). And, of course, the well-fed fish grew faster than the poorly-fed fish at both high and low temperatures. The well-fed fish show a greater variation in size than do the poorly-fed fish. The effect of such differential rates of fish growth on the growth of the scales was, of course, the purpose of the experiment but the data are not yet complete enough to indicate this.

A. A. Blair.

Appendix No. 10 (Fish Culture)

STUDIES ON THE CHAMCOOK SALMON

Purpose: An investigation to determine the characteristics of a small, easily studied, isolated population of Atlantic Salmon, of the landlocked variety.
Investigation: This study was initiated in the autumn of 1931, by Dr. A. G. Huntsman, and has been followed since by R. H. M'Gonigle, and A. A. Blair.

In the autumn of 1931, all the spawning fish, taken in the traps by the Department of Fisheries, in 2nd, and 1st Chamcook lakes were tagged, and scale samples taken. Length and weight were also determined. Each year, the salmon returning to spawn have been studied, and scale samples taken from the fish, and length and weight samples taken, until last year, when only the spawning tagged fish were so treated. This year (1935), due to low water, the salmon were not able to enter the spawning area early enough, and hence no collection of data was possible, as the collecting camp was not operated.

However, all the scale material taken to date has now been mounted (about 673 slides) and is ready to read, for the determination of ages. Some idea (preliminary) of the results of the scale study can be obtained from the few scales that have been examined. In all cases, so far, the first year's growth has been very poor, the growth ridges being quite close together. The second and third years show the best growth. The winter bands are quite distinct and readily determined. First spawning usually occurs after the third year. The scale absorption during spawning is fairly considerable. It is so extensive that fish spawning for three or four consecutive years show very little growth, and no spawning marks after their first spawning. In such cases, it is impossible to determine the age of the fish from the scales.

Other results, apart from the scale readings, may be summed as follows:

Tagging Results:

1931---Tagging:	males 74				
	females 155	(total 229)			100%
Never Heard of Again			83	36%	
Captured by anglers---1932		77	34%		
1933		8	3%		
1934		5	2%		
1935		5	2%		
(Less 5 reported also under "Returned to Spawn)			90	39%	
Fish Returned to Spawn--- once		31			
twice		19			
thrice		7	57	25%	
			230		100%

Length and Weight: So far as analyzed, the average length is 54.2 cms., with the mode about 58.0 cms. The average weight is 3.8 lbs., with a mode about 4.2 lbs. From the results of the 1933 spawning, the following relation was observed: Males---length (cms.) = 4.25 weight (lbs.) + 38.3; females---length (cms.) = 5 weight (lbs.) + 35.

Recommendations: It is recommended that this study be carried on, and developed (to also include other species, if feasible) for the data will have a very important part in determining productivity of bodies of water. This lake is one of the closest to the A. B. S., and so very conveniently located for such studies.

A. A. Blair and R. H. M'Gonigle.

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Appendix No. 11 (Fish Culture)

RETURN OF GRILSE FROM SMOLTS MARKED AT EAST APPLE RIVER, N.S.

"Early-run" salmon are considered to be more desirable than late-run salmon and the fish cultural department has endeavoured to propagate the young of early-run salmon and establish them in rivers which contain only late-run fish. There has been no evidence that these fish have ever been established and consequently it was decided to select a river for a definite experiment in an area where only late run fish were found.

In 1932, 25,000 early-run salmon fry from the Restigouche river were planted in the East branch of Apple river. During May and June 1934, the survivors from these were trapped as seaward migrating smolts and the adipose fin was removed from each smolt. 3,252 smolts were thus marked and liberated below the trap. The two branches of Apple river enter a common estuary but none of the native smolts from the West branch were marked. The behavior of the Restigouche smolts in going to sea after only two years in fresh water differed from that of the Restigouche fish in their native river where they are reported to remain three or more years in the river.

It was expected that at least some of the grilse from this marking would return this past fall and consequently fish traps were installed on the East and West branches. During August, we were informed that marked grilse were being taken in the estuary along with unmarked fish but no salmon had entered the fresh water. By August the 30th a trap was installed to catch the spawning migration on the East branch and by Sept. 11th a trap was placed in the West branch.

The streams were exceptionally low and up until Sept. 17th only two grilse, both marked fish, were taken in the East branch trap and 6 unmarked fish in the West branch trap. By October 22nd 87 marked grilse were taken in the East branch trap and although 162 grilse were taken in the West branch trap not a single marked fish had entered this trap. After this date when most of the fish were ripe there was no further "homing" indicated by the captures. Most of the ripe fish at this time were carrying many sea-lice indicating that they had very recently come in from salt water. As we have pointed out in previous papers, the high tides and the form of the estuary at Apple River tend to confuse the salmon and it would appear that when salmon are ripe, it is the spawning urge rather than their homing tendency which determines their behaviour.

Of the 3,252 marked smolts the return as grilse was approximately (including those taken by poachers) 156 fish or 5.1%. This number of grilse returning and particularly the return of many female grilse is not in accordance with the behaviour of Restigouche fish in their native stream.

Up to this point in the experiment the Restigouche fry planted in East Apple river, to determine whether or not they would return as early-run salmon, show a behaviour similar to that of the native fish of West Apple river. Whether or not any of them are still at sea to return after a two years absence as early-run fish or otherwise can be determined only by further captures.

H. C. White.

Appendix No. 12 (Fish Culture)

RETURNS FROM SALMON TAGGED AT APPLE RIVER, N. S.

Valuable information concerning the migrations, growth etc. of fishes has been obtained by the tagging and liberating of wild fish. In previous tagging operations at Apple river we have shown the tendency of adult salmon to remain in certain pools and also the fact that they may return to the same pool after a summers absence at sea.

In 1934 further taggings were made and 69 salmon were tagged. This past fall 7 returns from this tagging were taken in traps operated on the East and West branches of the river. One return was received from a drift net fisherman and one from a poacher's net in the estuary. This makes a total of 9 individuals or 13% recaptures. Of the 7 fish which returned to the fresh water at Apple River, 5 were taken in the East branch where they had been tagged and 2 which were tagged in the East branch were retaken in the West branch. Seven out of 63 tagged grilse were retaken and 2 out of 6 older fish. This is a return from grilse markings of 11.1% and of older fish 33.3%. Evidently there is a heavier mortality from predators among the smaller salmon. Indications of this were very evident from the number of fish bearing fresh lesions and old scars on their return from the sea. Fish returning for their second spawning had made, during the summer, an average gain in length of 11.2 cms. whereas one fish in for its fourth spawning had made a gain of only 2 cms.

Of all the salmon tagged at Apple River only a single recapture has been reported at any distance from the river. This fish was taken in July in a drift net a few miles South west of St. John harbor. The returns from the Apple river taggings confirm other observations indicating that Apple river fish usually remain within a few miles of the river mouth.

H. C. White.

ATLANTIC BIOLOGICAL STATION REPORT, 1935.

Appendix No. 13 (Fish Culture)

REARING TROUT IN FERTILIZED WATER

Object: Advanced fingerling trout are much more desirable for stocking waters than fry, but to rear trout to an advanced fingerling stage on an artificial diet is costly. The object of this experiment was to determine what success could be attained by rearing these fish upon natural foods produced by fertilizing water in still-water ponds i.e. rearing these fish with little or no cost for food.

Procedure: Water (20 cu.m.) in three experimental concrete tanks was fertilized with herring meal or "white fish" meal at a concentration of 136 gms. per cu.m. One pond, A1, was fertilized on May 7 with herring meal, the other two, A2 and A3, on May 27, A2 with "white fish" meal, A3 with herring meal. Trout fry were introduced into these ponds on June 18, 100 in A3, 200 in A2 and 300 in A1. The fish were removed from the ponds on September 9, 10 and 12. Netting was placed over the ponds to prevent depredation by birds, particularly kingfishers.

Results:

Pond	A1	A2	A3
Initial number	300	200	100
Final number	16	110	56
% survival	5.3	55	56
Total initial weight	57 gm.	38 gm.	19 gm.
Total final weight	73 "	513.5"	479 "
Total gain	16 "	475.5"	460 "
Initial average weight	0.2"	0.2"	0.2"
Final average weight	4.6"(0.16oz.)	4.7"(0.17oz.)	8.6"(0.3oz.)
Average increase	4.4	4.5	8.4
Average initial length	2.8 cm.	2.8 cm.	2.8 cm.
Average final length	7.6 "(2.6in.)	7.4 "(2.5in.)	8.9 "(3.5in)
Average increase	4.8 "	4.6 "	6.1 "

The cause of the high mortality in pond A1 was due principally to a low dissolved oxygen content, caused by the sudden death and decay of a larger algal growth experienced in this pond than in the others. These results indicate that the amount of fertilizer utilized is on the borderline of what can be safely added to still water containing trout.

Future Plans: It is planned that the experiment will be repeated with somewhat smaller concentrations of fertilizer in order to determine the quantity that can be used with no danger to trout. It is also anticipated that experiments will be carried out to find the maximum load of fish that can be carried per unit volume of water and still permit a good survival and growth rate.

M. W. Smith.

Appendix No. 14 (Fish Culture)

OBSERVATIONS UPON FLOODED AREAS

The object of creating flooded areas is to provide habitats in which trout and salmon (other fish if desirable) can be reared from the fry to the advanced fingerling stage, suitable for stocking purposes, away from predatory fish and in waters which contain a plentiful supply of natural foods, the production of which is stimulated by the fertilizers derived from the decomposition of submerged vegetation. In a flooded area where a large amount of vegetation has been flooded and there is a small flow of water, high temperatures and low dissolved oxygen contents are liable to be experienced, although as such ponds age and the amount of decomposition decreases suitable conditions might be expected to develop. On the other hand, if the flow of water is large nutrient materials will be leached out of the pond and, as a result, the production of fish food is prone to be small. Continued observations are necessary to establish criteria which may be used in selecting sites for flooded areas in which the desired balance between the favourable and unfavourable factors will be realized in the shortest time possible.

St. Andrews, N. B. --- Moose Pasture pond (0.1 acre)

Observations were continued for the second year. The water was clearer and had a somewhat higher average temperature and dissolved oxygen content than in 1934. However, during July and August the oxygen content was insufficient to support trout fry. In October the pond became almost entirely dry. Fish foods, particularly chironomid larvae, were plentiful. It is intended that observations will be carried on in order to secure data upon the time necessary for a pond of this character (a small volume of water in relation to the amount of decomposable organic material) to establish and maintain a good oxygen supply.

St. John, N. B. --- Stephenson's brook pond (approximately 17 acres)

Observations have also been continued upon this pond for the second year. On October 5, 1934, 5,554 advanced trout fingerlings were introduced into the pond. On May 16 and 17, 1935, the pond was drained and 504 surviving fish removed, a survival of 9.3 per cent. These fish had increased on the average one inch in length. Lime was added to the stream at this time to make sure that no trout remained. This proved an effective, but rather severe, treatment as quite a number of fish were killed. (The operations on May 16 and 17 were carried out by Dr. A.H.Leim.) On July 5, 1935, 15,000 trout fry were planted. On October 28 and 29, 1935, only three specimens were secured when the pond was drained. The results are not surprising when the conditions found in the pond during the summer are taken into consideration. During the warm weather the surface water which contained sufficient oxygen for trout growth had a high temperature, while the bottom water, although cool enough, had a poor supply of dissolved oxygen. When the pond was drained in October a surprisingly large population of sticklebacks, tadpoles and aquatic insects was found. An indication of the possible trout production when conditions become suitable for these fish would appear to be given by the very large number of sticklebacks. Observations should be continued in the pond. The planting of trout fry should be continued in order to correlate the physical and chemical conditions of the water with trout survival and growth as the pond ages. Extensive plantings are, of course, not necessary. The area should be kept flooded so as to promote the decomposition of the abundant organic materials.

Kentville, N. S. --- Sutton's, Bishop's brook and Cold brook ponds.

On July 19 and 20, 1955, observations were made upon Sutton's pond, and at proposed pond sites on Bishop's and Cold brooks. Sutton's pond was stocked with trout fry in the spring. Observed conditions of the water in this pond were favourable for trout. On November 1, in company with Dr. Leim, Bishop's and Cold brooks were again visited. It was found that a dam had been constructed on the site at Bishop's brook under the auspices of the Kentville branch of the Nova Scotia Fish and Game Protective Association, and that trout had been introduced. Water conditions were suitable for trout at that time. No results are yet available from the planting of fish in either of the above ponds. It is planned that observations will be continued whenever possible.

Wittenburg, N. S. --- Wittenburg pond.

Under the auspices of the Fish Culture branch of the Department of Fisheries a pond has been created by repairing an old dam and flooding a previous mill-pond site. Work has been done on this pond during the last season by both the writer and Dr. A. H. Leim. During the summer months high temperatures and low oxygen values made the pond water apparently unsuitable for trout. On November 3, however, it was found that the water contained a good oxygen content, due presumably to the larger flow of water through the pond. No fish have yet been planted in this pond. As with the other flooded areas it is hoped that observations can be carried on during the coming season.

Forest City, N. B.

The writer and Dr. Leim, at the request of the Forest City branch of the New Brunswick Fish and Game Protective Association inspected a proposed pond site on a brook flowing into Grand lake. The proposed dam would form a long still-water rather than the customary pond. It is the aim of the people involved to rear salmon.

M. W. Smith.

Appendix No. 15 (Fish Culture)

COPPER SULPHATE AND THE ERADICATION OF PREDATORY FISH IN LAKES

Object: Most of our lakes have been heavily fished for trout. The removal of the trout has permitted the other members of the fish population to increase. This condition makes it difficult, or impossible, to successfully stock such waters with trout fry. This is particularly true where the population of fish is dominated by yellow or white perch, or both. The object of this experiment is to eradicate these predatory fish so that planting with fry will prove more successful. It is preferable to use fry, wherever feasible, for stocking purposes due to the trouble and the present expense of rearing them to the advanced fingerling stage.

Procedure: In this experiment, which is being carried out by the Department of Fisheries, copper sulphate (3.06 p.p.m.) was added to Lake Jesse (45 acres), Nova Scotia, on August 3, 1934.

Results: The procedure was effective in killing practically the entire fish population, as well as the invertebrate animal life and plant life. In 1935 observations have been made in early May and early November to determine if the copper still remained in the waters and if the aquatic life was returning. In May the plankton was very poor, and, although the surface contained only traces of copper, the bottom waters were still unsuitable for trout fry, as shown from certain tests made at the time. Plankton samples taken by members of the Yarmouth hatchery staff showed that the plankton remained poor during the summer. In November a good zooplankton crop was found, but the number of species present was small. Water samples for copper, taken at that time, have not yet been analysed.

Future Plans and Recommendations: Observations will be continued at lake Jesse as often as opportunity permits. Another investigations should be made in the early spring to determine the suitability of the waters for fry before any planting is made, although the observations made this fall indicate that conditions may already be suitable. To determine the efficacy of this experiment the lake should be closed to fishing after it is stocked, or rigorously patrolled in order to ascertain the number of fish caught, and then, after three or four years, it should be treated again with copper sulphate so that accurate data could be obtained upon the survival and growth of trout under these conditions.

M. W. Smith.

Appendix No. 16 (Fish Culture)

A STUDY OF THE EEL, ANGUILLA ROSTRATA

Object: It is the ultimate aim of these investigations to determine the status of the eel as a member of our fresh-water communities. The eel is usually considered a predator, as well as a competitor, fish, but to what extent it deserves this reputation is not well known. The eel is definitely a drain upon our lakes and streams since it migrates to sea and takes from the food-cycle of our fresh-waters the organic matter contained in its body. Our knowledge as to how great this drain may be is at present fragmentary. In general it may be said that a study of the eel, as well as other non-game fresh-water fish, is essential for a proper understanding of the productivity of our waters. As a start on these investigations the food of the eel and the extent of the seaward migration are being studied.
Procedure: Eels were captured by hand-lines and set-lines. All of the fishing up to date has been done in the evening. A trap was constructed on the outlet from the Chamcook lakes, New Brunswick.
Results: Most of the eels captured on the lines (from 7:00 to 11:00 P.M.) contained no food in their stomachs. Digested remains in the intestine indicated that the majority fed only late at night. Such food as was found consisted principally of small fish (sticklebacks) and insect larvae.

Unfortunately the trap could not be successfully maintained in the Chamcook outlet due to the clogging of the fence with leaves whenever there was a heavy rush of water. The amount of water flowing in the stream fluctuated greatly as the gates at the lake were opened and closed in order to run a saw-mill. However some 250 eels were taken in the trap. It is planned to determine the length, weight, sex and age, if possible, of these fish.
Future Plans: If time permits it is planned to capture eels at various times throughout the day so as to determine more definitely their principal feeding periods. Since the trap cannot be satisfactorily maintained in the Chamcook outlet, it is recommended that the field of operations be shifted, possibly to Wheaton's lake.

M. W. Smith.

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Appendix No. 17 (Fish Culture)

THE PLANKTON OF GIBSON LAKE, NEW BRUNSWICK

Object: From the limnological investigations carried out in Gibson lake in 1930, 1931 and 1932, it was found that the horizontal distribution of the zooplankton was very irregular. It is important to ascertain the extent of this irregularity in such lakes as Gibson, particularly for investigations aimed at utilizing the plankton crop as one of the indicators of the productivity of the waters.

The samples collected during the above years were unfortunately destroyed before they could be completely examined. It was not determined whether the planktonts as a whole fluctuated in numbers from place to place, or whether only certain species were more plentiful at one station than at another. Thus a series of samples were taken this last summer to determine the point.

Procedure: As before, fifteen minute horizontal hauls were made with a number 5 plankton net at three stations. To determine how comparable the plankton hauls taken in this manner were with each other, a number of hauls were secured one immediately after the other at the same station. It is realized that these plankton samples do not give absolute quantitative data but only comparative.

Results: The irregularity of the horizontal distribution was once again noted. Time has not permitted an analysis of the samples, so additional data are not available at this time.

M. W. Smith.

Appendix No. 18 (Fish Culture)

A SURVEY OF PONDS ON DEER AND GRAND MANAN ISLANDS, N.B. BRUNSWICK

Object: At the request of interested residents on Deer island and of the Grand Manan branch of the New Brunswick Fish and Game Protective Association six ponds, three on each island, were surveyed from the point of view of stocking these waters with trout.

Results: Deer island -- Big, Little and Hopper ponds. May 13 and June 5, 1935.

Temperature records indicate that the waters of Big and Little ponds probably become definitely stratified during the summer, and, since the bottom is composed of organic ooze and there is abundant plankton to decay, that the waters below the thermocline (hypolimnion) lose more or less completely their dissolved oxygen. The oxygen records corroborate this view. The diminution of oxygen in the hypolimnion is probably quicker and more complete in Little than in Big pond, due to the larger volume of water in the latter. Hopper pond, due to its shallowness and abundant submerged rooted aquatic vegetation, probably has plenty of oxygen throughout the summer, but on the other hand might become quite warm. Fish food was found plentiful in all three ponds. Small trout were noted in the outlet from Big and Hopper ponds, but little was determined of the fish life of the ponds as a whole.

Grand Manan island --- Miller, Bradford Cove and Bel Brook ponds. October 11, 1935.

There were indications that the waters in Bradford Cove pond would become stratified and that the hypolimnion would be poor in oxygen during the summer. Physical and chemical conditions in the other two ponds would probably remain suitable for trout throughout the year, although summer observations are needed for corroboration. Bel Brook pond contained a good plankton crop, but it was surprising to find that there was practically no plankton in Miller and Bradford Cove ponds. Bradford Cove pond is reported to contain no fish; none were noted. Killifish were found in Miller pond. It was reported that some trout are caught each year in Bel Brook pond.

Future Plans and Recommendations: Deer island. --- Since the temperature and oxygen conditions in Little pond probably become quite unsuitable for trout, it is recommended that no planting be made there. A moderate planting of brook trout in the Big-Hopper pond system would be worth while since considerable information has already been obtained for these waters, since the waters are on the border-line of suitability for trout, since the waters represent conditions that probably attain in many small lakes of the maritimes, and since the ponds are quite accessible for further observations. If trout are planted in this system, it is recommended that additional data be secured upon the temperature-oxygen conditions of the waters, particularly during July or August, and that persons resident upon the island be asked to keep records of any trout that might be taken.

Grand Manan island. --- Before recommendations could be made for stocking the Grand Manan island ponds, it would seem that additional information is required concerning the summer conditions. The peculiar plankton situation found in Bradford Cove and Miller ponds should be investigated further as being of both scientific and practical interest. If the scarcity of plankton persists at other seasons in Miller pond, this body of water would provide a good opportunity for a practical application of our studies on fertilizing water.

A.H.Leim, R.H.M'Gonigle and M.W.Smith

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Appendix No. 19 (Fish Culture)

BIOLOGICAL SURVEY OF THE MAGAGUADAVIC RIVER SYSTEM

Purpose: To explore the salmon potentialities of the river system.
Investigation: The main body of the stream for about fifteen miles, at about the middle of its course, and certain of the more accessible tributaries were explored. Samples of the bottom fauna, and of the fish fauna, were secured. The character of the bottom, with special reference to gravel beds for spawning were also observed.

It was thought that ample spawning areas for salmon were discovered in the part investigated, while two of the tributaries would make excellent salmon streams due to the rich food supply, as well as the character of the bottom and water-flow.

The presence of black bass in the main stream however, was felt to be a factor which would hinder the proper development of this stream as a salmon river.

The capture in the local sardine weirs of the sea-stage of the salmon was a further factor, which might be a deterrent in attempting to develop salmon in any river tributary to Passamaquoddy Bay, because a sea fishery, such as occurs on other New Brunswick rivers might be stimulated, with the resultant friction between the various interests.

Recommendations: It is recommended that similar (more complete whenever circumstances permit) surveys as this be made whenever or wherever practical, to provide accurate data upon which to base advice for developing the resources of such bodies of water, which requests are being constantly received.

M.W.Smith and R. H. M'Gonigle.

ATLANTIC BIOLOGICAL STATION REPORT, 1935.

Appendic No. 20 (Fish Culture)

CHAMCOOK LAKE INVESTIGATIONS

I. Transplanting Lake Utopia smelt into Chamcook lake.

It has been found that smelt represent the main food for salmon and togue in First Chamcook lake. As smelt is extremely abundant in Lake Utopia, it was suggested that in the spring of 1935 some quantity of smelt eggs should be transplanted from there into Chamcook lake in order to increase food supply for game fish. On the 24th of May about 200,000 naturally spawned eggs were collected in Lake Utopia tributaries and a few thousand were artificially fertilized, transported into a S.W. tributary of First Chamcook and placed apparently under similar conditions as they were collected.
31st of May eggs were examined and found that they are developing normally. Many moving embryos were observed.
6th of June about half of the eggs were hatched.
12th of June all eggs were hatched and only an insignificant proportion (probably not more than it was when eggs were collected) were found dead.

If the introduction is successful, the following distinction of Chamcook lake smelt from Lake Utopia smelt can be made:

a) breeding season of medium size Chamcook smelt is the middle of March, the breeding season of same size variety from Lake Utopia is the middle of May.

b) during the spawning period the head and sides of Utopia smelt, especially in breeding males, are covered by small white epithelial tubercles, which are insignificant in native fish of Chamcook lake.

As there is plenty of food for smelt in Chamcook lake it is suggested that further experiments in larger scale should be carried on in the spring of 1936.

II. Feeding habits of Chamcook lake fish.

A large number of different species of fish were collected during the open season of 1935 from First and Second Chamcook lakes in order to examine food habits and rates of growth. The most common species were suckers and eels. Salmon and togue were collected in small numbers. The total catch of salmon from Chamcook in 1935, both by fishermen and by me, including the gill nets catch is about fifty or sixty specimens. A brief summary of feeding habits of Chamcook fish is as follows: salmon and togue in Chamcook First feed on smelt; salmon in Second Chamcook on stickleback; eels in both lakes feed mostly on minnows and insect larvae; the majority of their stomachs were empty. Large suckers in First Chamcook feed mostly on Chironomidae larvae, sucker fry consume very diverse items of food. A special report was prepared on feeding habits of sucker fry. Report on food and rates of growth of Chamcook fish is in preparation.

III. Biological conditions of Chamcook chain.

In order to obtain more data on distribution and seasonal changes of plankton, bottom fauna, temperatures etc., the routine work on First and Second Chamcook lakes was continued during 1935. It can be mentioned that temperatures and bottom samples collected during this year do not differ much from those of the previous years, but quite a few of planktonic organisms were added to previous list of species from Chamcook lakes. The results will be summarized in order to prepare an extensive report of biological conditions of this interesting chain of lakes this winter.

A. D. Bajkov.

Appendix No. 21 (Sea Fisheries)

HYDRODYNAMICS OF THE WATERS OF THE SCOTIAN SHELF - 1934.

The hydrographic data obtained during the spring (May) and summer (August) cruises over a portion of the Scotian shelf during 1934, have been subjected to the usual hydrodynamic analysis. The aim of the analysis is to work out the topography of various isobaric sheets and thus determine the water movements. The summarized results of the treatment of the 1934 data is as follows:

1. Along the south coast of Nova Scotia there was a tendency for a shoreward movement of the upper fifty metres of water. This tendency was offset somewhat in the western end of the area, where there was a tendency for a west to east movement which partook of a clockwise circulation which was centred, roughly, between Roseway and LaHave banks.

2. The Scotian Gulf (a central submarine basin on the Scotian shelf) tended to delimit an anticlockwise circulation of the upper fifty metres of water.

3. There seemed to be a conflict between a tendency for a general east to west movement, and a tendency for an onshore movement. In the spring cruise, the east to west movement predominated, while in the August cruise the onshore movement was the predominating one.

4. The maximum movements in May amounted to 8.4 nautical miles per day in the surface layer, and 6.0 nautical miles per day at a depth of fifty metres. The maximum movements in August amounted to 7.7 nautical miles per day in the surface layer, and 3.6 nautical miles per day at a depth of fifty metres.

H. B. Hachey.

Appendix No. 22 (Sea Fisheries)

GENERAL HYDROGRAPHY OF THE WATERS OF THE SCOTIAN SHELF - 1935.

Hydrographical investigations on the Scotian shelf were continued during the past year in a further effort to determine the outstanding features of the waters of the area. A cruise of the area extending between Shelburne and Canso has been made in early May and again in August. The western half of the area was investigated also in July. Inshore conditions were followed by six cruises out of Halifax within the period April to December, as well as by the regular weekly observations made in Halifax harbour. Two short cruises were also made off the Cape Breton coast -- one off Glace Bay, and one off Ingonish -- during the early part of the summer. In the previous year, similar cruises were made and our observations have indicated that the area of the Scotian shelf was transgressed by waters of comparatively high salinity. The transgression culminated in a flooding of the area in late autumn by waters of comparatively high temperature and high salinity which were of at least marginal origin (i.e. from the vicinity of the edge of the continental shelf). The observations of the past season indicate that a large volume of cold water (less than 5.0°C.) from the eastward flooded the Scotian shelf and persisted throughout the season. The observations of the 1934 and 1935 seasons therefore present extremely contrasting conditions that may prevail in this area.

A coöperative effort between the Woods Hole Oceanographic Institute and the Biological Board of Canada is planned for the 1936 season, beginning with a winter cruise in January and followed by spring, summer and autumn cruises. The Woods Hole Oceanographic Institute is interested in the seasonal variations of the waters at the edge of the continental shelf (slope waters), and their observations, coupled with those of the Biological Board, should prove to be of mutual benefit.

Continued attention is being given to the reaction of our coastal waters to steep atmospheric pressure gradients over the ocean. The outstanding features of the phenomenon, which bring about sharp changes in the temperature and salinity of the coastal waters of southern Nova Scotia, have been dealt with in various publications. The study is being continued chiefly by means of the weekly hydrographic data from Halifax harbour, atmospheric pressure charts for the North Atlantic, and hydrographic charts containing data on tropical cyclones. During the past season, a tropical cyclone was experienced in August and the usual replacement of waters occurred with the usual sharp changes in temperature and salinity. More recent data have not been analyzed as yet.

The Halifax lightship offers an opportunity for pertinent observations of considerable interest before, during, and after the disturbance caused by a tropical cyclone. If opportunity permits, a series of observations will be made from the lightship during the late summer of 1936.

H. B. Hachey.

Appendix No. 23 (Sea Fisheries)

SURFACE WATER TEMPERATURES -- ATLANTIC COAST OF CANADA 1935

Surface water temperatures are taken twice daily at twelve representative points on the Atlantic coast of Canada in order to follow the daily, seasonal, and annual variations in the water climates in the various areas. In late autumn of this year, similar observations were inaugerated on the Halifax lightship, while those taken at North Point were discontinued. It is also proposed to discontinue the taking of observations at Sambro Island.

The spring and early summer temperatures at most points were generally lower than usual, the exceptions being at those points in the northern part of the Gulf of St. Lawrence. There was an exceptionally large movement of ice and comparatively cold water moving out of the Gulf of St. Lawrence in early spring and this was seemingly responsible for the lower temperatures that prevailed. The removal of the ice from the Gulf allowed more rapid vernal warming of the waters in the northern part. Analysis of the total mileage of wind at Sydney, N. S. indicates that the excess of wind from the north is a factor in the removal of ice and ice cold waters from the Gulf of St. Lawrence.

Five year normals for selected points on the Canadian Atlantic coast are under preparation, and accompanying data dealing with annual and seasonal variations from these normals will enable an early assessment of the value of the observations of the past six years. Further data is available (in the rough) from the U. S. Bureau of Fisheries for various selected points on the Atlantic coast of the United States. If, upon completion of our report, it would be found of interest as well as of value to have the data of the Bureau of Fisheries, arrangements can be made to obtain same. Some expense may be entailed as it is possible that the data would have to be worked up at Cambridge, Mass. where they are on file.

H. B. Hachey.

Appendix No. 24 (Sea Fisheries)

SURFACE WATER TEMPERATURES AND COASTAL PRECIPITATION

A study of the interaction between sea and atmosphere is of considerable importance to certain oceanographical problems. This is particularly true in our study of the waters of the Scotian shelf. It has been shown that water temperatures on the south coast of Nova Scotia are controlled to a large extent, during the late summer and autumn, by the nature of the distribution of atmospheric pressure over the neighboring ocean. The nature of the distribution of atmospheric pressure is to some extent indicative of landward movements of moisture laden air, and, consequently, is a factor in determining the coastal precipitation. An analysis of Halifax data for the period 1926-35 has led to the establishment of an interesting relation between the precipitation at that point in August and the monthly mean surface water temperature for September. Heavy precipitation in August is followed by a low monthly mean surface water temperature in September, and conversely a light precipitation in August is followed by a high monthly mean surface water temperature for September. As there is a rough direct relationship existing between surface and bottom waters in Halifax harbour during these months, it is evident that a similar relationship must exist between the precipitation and the bottom temperatures. Our meagre data upon this point (bottom temperatures taken weekly) indicate that such is the case.

The monthly mean surface water temperature in September undergoes considerable variation from year to year (12.9°C. in 1927, and 17.5°C. in 1934), as does also the precipitation for the month of August (1.6 inches in 1934, and 7.6 inches in 1927). On the basis of the ten year data, a forecast of the average monthly mean surface water temperature would be accurate to within 6 per cent (to within 1°C.). Consequently the result obtained here is a further reliable indication of the important interaction between sea and atmosphere.

H. B. Hachey.

Appendix No. 25 (Sea Fisheries)

THE SUB-MARINE PHYSIOGRAPHY OF THE SCOTIAN SHELF

It has been found that certain features of the sub-marine physiography of the Scotian shelf have an important bearing on the hydrographic problem of the waters of this area. A chart bringing out the prominent physiographical features has been prepared, and in correlating these with the hydrographical features, the following outstanding points are noted:

1. The Laurentian channel and the Fundian channel form the east and west boundaries respectively of an irregular shaped submerged plateau of uneven topography, which extends out from the Nova Scotia coast line to the edge of the continental shelf.

2. The seventy-five fathom contour forms a central submarine basin with a narrow mouth opening to the south, and this central basin is the only part of the area in which is found waters typical of the open ocean. In the autumn of 1934, when a transgression of marginal waters took place, this transgression was an outstanding feature of this central basin.

3. The seventy-five fathom contour forms several small submarine areas opening directly to the Laurentian channel, and in these areas are found the waters of extremely low temperatures. In general, the shallow portions of the eastern part of the Scotian shelf offer considerable resistance in summer to the westward movement of the waters of extremely low temperatures (found in summer at depths greater than 50 metres).

4. It would seem also that the relative water movements set up by the action of steep atmospheric pressure gradients are more pronounced in the western and central portion of the Scotian shelf, Sable Island and the neighboring shallow banks offering considerable resistance to the disturbance.

H. B. Hachey.

Appendix No. 26 (Sea Fisheries)

CANADIAN COD TAGGING RESULTS, 1935.

This cod tagging has been carried out by Captain A.E.Calder. The planned tagging of the spring "run" off Halifax was not accomplished this year owing to the "run" being a failure. Some cod tagging of a more or less exploratory nature (about 550 all told) has been done, however, in various localities to assist in showing the movements of the cod schools.

To date, very few of these tags have been returned, so few in fact as to preclude drawing any conclusions other than that returns from offshore tagging are very small compared to those inshore. Hence correspondingly more fish should be tagged offshore in order to have the same number of returns for determining migrations.

Of the 2476 tags placed on cod in 1934, about 17 per cent. had been returned by January 1935. This percentage has now been increased to about 23 per cent., or 550 recaptures.

The recaptures from the shoaler water tagging in the Halifax region showed that most of these fish remained within the tagging area in 1934, moved just off shore to deeper water in the winter and back on shore into the tagging vicinity again during the summer of 1935.

The recaptures from the deeper water tagging showed that while a great number of these fish moved into shoaler water during the summer of 1934, still quite a number moved long distances (up to 125 miles) both ways along the shore, possibly slightly more in a northeasterly direction. During the late autumn some considerable movement of these fish offshore must have occurred for a number of recaptures were made on the offshore banks during the late autumn and winter, whereas previous to November only one was recaptured offshore.

During the fishing season of 1935 only, several of these fish tagged in deep water were recaptured in the tagging area. A few were recaptured long distances to the westward, Lunenburg to Browns Bank, while the most of them were taken from Port Bickerton eastward to and around Cape Breton, some even off Newfoundland.

These recaptures show that most of the fish tagged in deep water moved out of the tagging area in the autumn 1934 and did not return to it in 1935. This no doubt accounts for the very poor fishery off the Halifax area during 1935, as no spring "run" occurred. However, three large catches in the spring were reported, but from much deeper water than usual, as a thick layer of very cold water covered the inshore grounds. This cold water is believed to have kept the spring "run" off the shore causing them to move on eastward in a body, spending the summer east of the Halifax area altogether as shown by the recaptures.

Thus the cod fishery of the Halifax area is largely dependent on cod which do not winter along shore, and if conditions are unfavourable in the spring this "run" moves right past the area.

Further tagging should be carried out on this school of fish, as well as on the spring run at Cape Breton, Lunenburg to Lockeport and on both sides of the Bay of Fundy, because these are all believed to be separate schools of cod.

R. A. McKenzie.

Appendix No. 27 (Sea Fisheries)

VERTEBRAL COUNTS OF COD

The study of the number of vertebrae in cod from different regions,- instituted to see how good such a character was in differentiating different schools of cod - has been continued, as it has already served to distinguish a number of populations of cod.

Some five thousand counts were made in 1935, but much of this labour and the time required to obtain checked results, could be reduced if samples could be obtained where and when wanted.

The cod of the United States side of the Gulf of Maine show an average count of about 52.4 while those from the Nova Scotian side of this Gulf and the Bay of Fundy have a range of 52.6 to 52.7. The New Brunswick side of this Bay varies from 52.4 to 52.7 seeming to indicate the presence at different times of schools of fish from both of these regions.

Browns Bank checks with southwestern Nova Scotia shore cod in summer but is higher during the winter.

Lockeport - Roseway Bank area shows an average of 52.8 to 52.9 and is somewhat higher also in winter. The summer average for the Lunenburg - Halifax inshore region is 52.8 to 53.0, but this region is decidedly higher in winter.

In the summer, 1934, Sable Island Bank and Middle Ground counts were uniformly 53.0, but during the winter these went up to about 53.55 as did the Lunenburg - Halifax counts. Banquereau shows the highest summer counts of all, 53.25, but no winter samples have been obtained.

The outer or Atlantic Cape Breton coast cod give the most variable counts of all, sometimes being as low as 52.8 and again as high as Banquereau seeming to indicate at times the presence of schools from offshore mixing with the inshore fish which seem similar to the resident cod off Halifax.

The Gulf of St. Lawrence side of Cape Breton checks with Prince Edward Island in having counts of 52.6. This would indicate a population distinct from the outer coast and "bank" cod. However, schools in the deep water of this Gulf have not been sampled.

A temporary explanation of the higher winter counts in certain regions would be that there is a general shift from eastward, where the counts are higher, to the westward. However, to raise the counts in our most easterly regions, cod of a much higher count than found in Canadian waters in summer, would have to move in. Such an immigration seems to have occurred during the winter 1934-35 over the inshore and offshore regions as far west as Lunenburg. However, these fish had all left by the end of May (judging by the counts) with the exception of the Canso region where the counts remained higher in the summer of 1935 than in 1934.

The autumn spawning cod which frequent certain inshore waters of the outer coast of Nova Scotia for spawning have given consistently the lowest count, 51.6 to 52.7, over a three year period.

This study should be continued over the entire coast and at all seasons, as its possibilities for showing the different populations which make up the Canadian cod fishery have been far from completely exploited.

R. A. McKenzie.

Appendix No. 28 (Sea Fisheries)

THE AUTUMN COD SPAWNING POPULATION

A general study of cod spawning has revealed the fact that there are two spawning seasons,- autumn and late winter or early spring. The two populations of cod inhabit the same regions, at least during part of the year, but behave very differently. A detailed study of them will benefit the fishery through showing what factors control the actions of these fish which behave so differently at spawning time.

Investigations on the autumn spawners have shown that these fish spawn during October and November well up towards the heads of such inlets as Halifax Harbour, St. Margaret Bay, LaHave Estuary and Green Bay, Mouton Bay possibly as well as in the vicinity of Negro Harbour and St. Mary Bay. No evidence is at hand to indicate autumn spawning offshore, though no surveys have been made.

In Halifax Harbour spawning begins when the bottom temperature drops to about 12°C. and continues as it goes down to about 6°C. However, most of the spawning takes place at temperatures of about 11°C. to 8°C. The temperature of the upper layers where the eggs develop varies from about 18°C. down to 5°C. by the end of spawning.

These eggs have been found to be smaller than those spawned during the winter.

It is believed that only about 1 per cent. of these eggs live to reach the hatching stage.

These autumn spawners, judging by small samples collected during each of three successive years, possess on the average at least one vertebra less than the winter and early spring spawners.

In 1933 and 1934, the 1927 year-class was the most abundant brood in this population. The 1928 and 1925 year-classes stand next in abundance, being about equal, while the 1926 brood is in 4th place.

One method of investigation shows that most of these cod reach maturity when they are five, six or seven years of age.

These fish are present in the vicinity of the spawning grounds (judging by Halifax Harbour) only from late September until late March. No trace of them in Canadian waters has been found during the remainder of the year, nor has the small amount of tagging done so far, assisted in this respect.

In the future a complete survey of the Canadian autumn cod spawning grounds, both inshore and offshore, should be made. Sufficient tagging should also be done to reveal the whereabouts of these fish during April to September inclusive. Since these fish have such remarkable spawning habits, some investigations should be conducted on their reactions to temperature changes during the period of the year when they feed intensively.

R. A. McKenzie.

Appendix No. 29 (Sea Fisheries)

COD IN CAPTIVITY

Through caring for and observing cod of all sizes kept in tanks in running salt water, much is hoped to be learned of their reactions and habits. Such observations can then be checked in nature and already have explained some of the reported occurrences in the cod fishery.

So far no regulation of the water temperatures has been undertaken, and these temperatures are quite similar to those of the tide-pool and river from which the water is automatically drawn.

The amount of space per fish appears to have a direct effect, within limits, upon the amount of feed consumed.

In very cold water these cod do not seem to be able to take as large pieces of food as they do in warm water.

All the cod over about 50 cm. in length ceased feeding when the water temperatures went below 0°C. The smaller ones ate more sparingly while a very small one, 25 cm., continued to eat at least some at all times, even when the minimum temperature of -0.6°C. was reached.

The respiration rate of all sizes of cod decreases with the temperature. At -0.3°C. the rate is about twelve per minute, while at 15°C. the rate of small fish (20-30 cm.) may be as high as sixty per minute and larger fish (50-70 cm.) only about thirty per minute. Thus, the larger the fish the slower the rate in general.

The respiration rate of all sizes seems to increase regularly up to a temperature of about 4.5°C. A break occurs between 4.5°C. and 5.5°C. then the rate increases regularly, again up to a temperature of about 12°C. at which point another break occurs. Above this temperature the curves are irregular.

These data will be checked during the ensuing year and information on the feeding habits at the two "breaking" points obtained. If these "breaks" are correct, a change in the rate of functioning of the organism is indicated which should be reflected in the feeding habits and in turn in the baited hook catches in waters having these temperatures.

R. A. McKenzie.

ATLANTIC BIOLOGICAL STATION REPORT, 1935.

Appendix No. 30 (Sea Fisheries)

HADDOCK TAGGING EXPERIMENT IN 1935

To ascertain the movements of certain haddock schools around the outer coast of Nova Scotia, and to give additional proof of the reliability of haddock racial investigations, 1899 fish were tagged during the spring months of 1935. The haddock tagging was done in three different localities. During April 22nd and 23rd, and May 6th to 17th, 1050 fish were tagged on board of the steam trawlers (Viernoe and Rayon d'Or) on the Western bank. During May 27th to 31st, 634 haddock, taken in mackerel traps in the St. Margaret Bay area, were tagged, and on June 10th 201 fish caught in haddock traps at Ingonish South were also tagged. At present only 47 fish or 2.5% have been recaptured. Recaptures of the St. Margaret Bay fish rank first, equal to about 5%, whereas the Bank tagging gave the smallest returns (0.8%).

Among the 33 returns of the St. Margaret Bay haddock, there are three of particular interest. These fish were recaptured this year around June 20th at Canso (1) and Petit de Grat (2). The remaining returns would indicate that some of the fish remain in the St. Margaret Bay area until about the middle of August when they as a rule move eastward along the shore as far as Devil's Island and Cow Bay.

The Ingonish tagging this year gives practically the same results as the former tagging done in Cape Breton in 1927 and 1928, namely, during June the fish stay around Ingonish, whereas late in the fall they were caught in the Gulf of St. Lawrence; thus tag No. 34524 was returned from a fish caught on October 29th, 1935 off east point of Prince Edward Island.

Among the very scarce returns from the banks only one is worthy of mention, namely No. 32563, which was placed on the fish on April 23rd, 1935 at Lat. 44° 03' N., Long. 61° 15' W., and recaptured on June 16th, 1935, near the north east bar of Sable Island, which is located about 100 miles eastward from the tagging point.

During the coming fall and next year some additional returns are expected.

V. D. Vladykov.

Appendix No. 31 (Sea Fisheries)

HADDOCK RACES ALONG THE NORTH AMERICAN COAST

About 6,000 haddock obtained from different places from Newfoundland to Cape Cod, and examined for racial peculiarities, give quite clear proof that the haddock population along the North American coast is not uniform. There are at least three distinct haddock races, found respectively in Newfoundland, Nova Scotia and New England regions. These races are separated one from another by the rather deep Laurentian and Fundian channels.

The Newfoundland race is characterized by the lowest number of vertebrae, varying on the average from 52.5 to 52.9. The New England race ranks next with 53.1 and 53.2 vertebrae. The Nova Scotian race possesses the highest vertebrae count, which may vary from 53.5 to 54.3. Among individual schools of the Nova Scotian race there may be mentioned the following principal haddock schools: Shelburne (53.5 vertebrae); Ingonish (54.0 vertebrae); Emerald-Sambro (53.8 vertebrae); Sable Island (54.2 vertebrae; and Quereau (54.3 vertebrae). Additional details are mentioned in Progress Report No. 14, 1935. In this report also parallel information on the number of vertebrae and the results of haddock tagging was given.

V. D. Vladykov.

ATLANTIC BIOLOGICAL STATION REPORT, 1935.

Appendix No. 32 (Sea Fisheries)

INGONISH HADDOCK IN ST. MARGARET BAY

During the last week of April 1935 quite considerable haddock catches were made with gill nets at Peggy's Point, N. S., and later during May unusually large catches of haddock, amounting to about half a million pounds, were taken in mackerel traps in the St. Margaret Bay region. An investigation was made to determine the origin of this haddock school. It was suspected in the beginning that these haddock must have come from "outside", namely from the Ingonish region.

The movements of "Ingonish haddock school" usually are as follows.- During late spring and early summer these haddock are caught in traps along the eastern coast of Cape Breton, late summer and during fall months they spend in the Gulf of St. Lawrence, and around December 1st they are again caught around the eastern coast of Cape Breton. The winter months the Ingonish haddock spend north of Cape Breton, sometimes on the banks, sometimes close to the shore. The tagging of 1927 and 1928 indicate recaptures of Ingonish haddock as far southwest as Shelburne. Ingonish haddock presumably spawn between Emerald and Sable Island banks, where considerable catches of fish belonging to this school are made. This year, however the haddock catch in the above locality failed. On the other hand, an enormous quantity of large haddock were taken in St. Margaret Bay region.

The racial investigation, made on 492 haddock from the St. Margaret Bay region, indicates that the average number of vertebrae 53.98 is practically identical to that of the typical Ingonish fish 54.00. A closer resemblance is hardly possibly because among the haddock taken this year at St. Margaret Bay there were some native fish with lower number of vertebrae.

In addition, a large haddock weighing about 8 pounds caught during the last week of May, 1935 at Seabright (St. Margaret Bay) bore a tag No. 2773. This haddock was tagged in the spring 7 years ago at Ingonish. These evidences substantiate the belief that haddock taken during last spring in St. Margaret Bay were principally Ingonish fish. To give further proof of this statement, about 700 haddock were tagged this spring at St. Margaret Bay (for details see another summary). Among the returns there are three cases where haddock tagged in St. Margaret Bay were recaptured at the end of June at Canso and Petit de Grat, no doubt on their way to the Gulf of St. Lawrence.

V. D. Vladykov.

Appendix No. 33 (Sea Fisheries)

MISCELLANEOUS INVESTIGATIONS ON HADDOCK BIOLOGY

(a) Nutritive Value of Certain Organisms on which Haddock Feed.

During the past summer at the Trois Pistoles Biological Station an investigation was made together with Dr. Gravel to determine the nutritive value of the major animal groups usually found in haddock stomachs. The analyses of protein, fat, carbohydrates, ash and colorimetric value were made. The complete results are not available at present since the investigation is still in progress.

(b) Haddock Spawning Habits.

The proper knowledge of the time when and where different haddock schools spawn, and the physical conditions under which they spawn, are very important to understand certain peculiarities in the haddock biology. The age at which haddock spawn for the first time and relative abundance of different sexes on the grounds is of considerable importance also. To answer these questions an investigation has been undertaken on about 7,000 fish. It is hoped that during the coming spring detailed results will be available.

V. D. Vladykov.

Appendix No. 34 (Sea Fisheries)

DO HADDOCK FEED DURING THE SPAWNING PERIOD?

A proper understanding of how and when haddock feed is of significant importance because considerable quantities of haddock are taken with hook and line during certain seasons.

Through the courtesy of Capt. Frank Tidman (S. T. Viernoe), and Mr. J. Maher, Wireless Operator of the same vessel, the authors had the opportunity of examining 5,500 haddock stomachs removed from fish taken with an otter trawl in different months during the period from September, 1934 to November, 1935. The number of stomachs containing food, and the number of empty ones was determined for each sample, and the results obtained may be briefly summarized as follows: From September to March the number of fish taking food diminished considerably, thus in September about 82% of fish studied had food in their stomachs, while in March only 16% of those examined contained any food. In April and May a very negligible increase in the amount of feeding fish was found. On the other hand in June there was a sudden increase in the number of fish with food in their stomachs amounting to about 66%. The explanation of why during the spring months, from February to May only a very small number of fish continued to take food lies in the fact that the great majority of the haddock studied spawn during this period.

In conclusion, it may be stated that usually failure to catch any great quantity of haddock with hook and line during the spring months of the year is explained by the fact that the majority of haddock spawn during this season and consequently cease to take food. (For details see Progress Report No. 15, 1935).

V.D.Vladykov and R.E.S.Homans.

Appendix No. 35 (Sea Fisheries)

FEEDING HABITS OF THE HADDOCK

This investigation, started in May, 1935, has been undertaken to determine the feeding habits of the haddock which no doubt exert a considerable effect on the haddock fishery. Up to the present about ten thousand stomachs, collected from several areas during the period 1932-1935, have been examined as to contents. The following conclusions have been reached.

The haddock is very definitely a bottom feeder. The great majority of the organisms that make up its diet are forms that live near the bottom; on the bottom; or are forms that actually burrow in the bottom. The great amounts of sand, gravel, and mud found in the stomachs is additional proof of this statement.

The food of the haddock comprises a great many groups of animals. The following is the percentage composition of the stomach contents of six thousand haddock taken from the western Banks Area:

Sand, gravel, mud -------	24.0
Sand-launces ----------	16.7
Worms ----------	14.1
Crustaceans ----------	11.3
Mollusks ----------	10.8
Echinoderms ----------	10.2
Fish eggs ----------	2.0
Miscellaneous ----------	10.9

A study of the food composition of the haddock in relation to the size of the fish, while yet very incomplete, shows that there is some variation in the type of food taken by young (scrod) and adult (large) fish. It may be said tentatively that the young haddock prefers to eat the small, free-swimming Crustaceans, and occasionally small worms. As it grows older it turns to larger worms, Crustaceans, Mollusks, Echinoderms, and the sand-launce.

The analysis of food found in haddock stomachs shows the specific nature of the different feeding grounds. Thus the haddock from the Western Banks contain large numbers of sand-launces and sand-dollars in their stomachs, those from the inshore area of Nova Scotia usually have large amounts of brittle-stars in their stomachs, while haddock from the Bay of Fundy area normally feed on Mollusks (chiefly lamellibranchs).

Due to difficulties in procuring continuous samples of stomachs from the same region no satisfactory progress has been made as regards the problem of seasonal variation in the food composition.

In order to arrive at definite conclusions this investigation is to be continued during the coming year and plans have been formed for a more systematic collection of material.

R. E. S. Homans.

Appendix No. 36 (Sea Fisheries)

THE FEEDING OF THE HERRING

A study of the feeding habits of the herring in Inner Passamaquoddy Bay is of importance in connection with the weir fishery for these fish. Previous investigations by the author showed that the food taken by the herring at any one place may vary from day to day, and as the cause of such a condition is little understood, investigations were carried out to clarify this problem by studying both the movements of the herring and of its food, both under controlled laboratory conditions and in the Bay itself.

The depths at which the food was present at all times of the day and on different days was determined together with the conditions of the water (light, temperature, salinity, and current). The results indicate the outstanding influence of light in controlling the distribution of the food, the specific effect depending on the particular food form in question. Individual forms, retained in the laboratory and subject to (i) the same light conditions as existed in the bay itself, and (ii) complete darkness, moved in a manner which further supported the importance of light as the outstanding factor controlling their distribution.

Further laboratory experiments were carried out to determine more specifically the relation between light and the food forms. Sunlight, on entering sea water, has its components separated from each other, the nature and amount of each component present at any depth depending both on the nature of the water and the depth, so that the light conditions experienced by the food depends upon the latter's location in the water. A study of this question was made by observing the effect of filtered light on their distribution in glass containers.

The movements and feeding of the herring under varying light conditions was studied by keeping them in an out-door tank. The herring tended to avoid bright sunlight by keeping in the shade whenever possible, and when no shade was present (sun overhead) then tended to remain close to the bottom of the tank, only coming near the surface in light weaker than sunlight (cloudy days, dusk, skylight, and moonlight).

Observations by the fishermen in the Bay itself give some evidence for believing that the small "sardine" size herring swim closer to the surface during daylight than do the larger "spawn" size herring, while during weaker light both sizes have been seen together at the surface.

The herring, in the tank mentioned above, were observed to readily accept food during daylight, dusk, and moonlight, when they would feed to capacity, taking no food at all, however, during starlight and complete darkness (cloudy nights), thus suggesting that light is necessary in order to feed, and that the minimum intensity required is considerably less than that of daylight.

The above results throw some light on the problem "Where do the herring get their food?" It is seen essential to continue this investigation during the summer of 1936 in order to verify and round out the suggestions given by the above results. It is proposed that this be carried out by studying most essentially the herring as it feeds naturally in the Bay itself.

W. H. Johnson.

Appendix No. 37 (Sea Fisheries)

REARING OF SEPARATE SPAT IN THEIR SECOND SUMMER

As a possible method of reducing the cost of rearing separate spat, which is so successful on floating, wire-bottomed trays, the use of hardened bottoms in sheltered situations was tried. Spat of 1934 were placed on a number of plots which included unimproved bottom, bottom improved with gravel and wooden floors covered with gravel. The growth of the spat was followed by Miss Clark throughout the growing season.

To avoid starfish and loss of the separate spat by wave action the experiments were necessarily confined to very sheltered situations. It was found that a heavy growth of filamentous algae with accompanying heavy deposition of silt resulted in a very much slower growth than on the floating trays and a much poorer survival and shape of the survivors. The results were not encouraging, in spite of the much lower cost of the plots used as compared with the trays. It is planned, however, to continue experiments along these lines next year extending them to deeper water and trying to reduce the algal growth and smothering by reduction of light.

Preliminary experiments in the exposure of creosoted lumber and the use of creosoted lumber in small shelved boxes for rearing oysters are promising. It is hoped that the expense of the rearing trays can be reduced by substituting creosoted lumber for the more expensive copper paint. The possibilities of open-mesh sacking supported by galvanized netting of a fairly large mesh are also being explored as a substitute for the more expensive galvanized wire cloth.

The retention of the cardboard collectors with spat in the wire netting bundles for a longer time was tried. When the bundles are suspended from floats the spat have a rapid growth but by the end of the season the shape is poor and clustering bad enough to involve losses in separation. The method has possibilities, however, for the production of the lower grades of oysters and possibly for higher grades if the collectors are broken up before the growth has proceeded too far. It is obvious that the rearing of the spat in the same bundles of collectors on which they were collected is very cheap. It offers full protection from starfish, good growth and might be of real value where the "set" is light. It will be tried again.

Modifications of the shelved wire boxes tried in 1932 and 1933 were used in 1935 reducing expense by using varying proportions of wood in construction. Although satisfactory growth, survival and shape can be obtained the expense remains somewhat higher than that of the large floating trays.

Plans for 1936, in addition to items mentioned above, include trial of planting reared spat from the trays at earlier ages to reduce cost, small modifications in the trays and higher concentrations of spat on the trays. It is hoped that by combining the use of trays with the use of firm bottoms a reduction of cost can be made without a commensurate lowering of growth, survival or quality.

A.W.H.Needler.

Appendix No. 38 (Sea Fisheries)

REARING OF SPAT ON SHELLS IN THEIR SECOND SUMMER

As a further attack on the starfish problem the rearing on shores of spat collected in the preceding year on shells in wire bags was tried. When such spat is planted on the majority of beds a high mortality usually results from damage by starfish and if there is any considerable survival clusters are formed which must be lifted and separated when the oysters are two years old or less in order to avoid distortion and further losses.

By spreading the shells with spat on shores, at various levels from just below low tide up, it was hoped that the damage by starfish could be avoided by their natural absence or by the facility with which they could be removed. It was further hoped that the small oysters could be easily recovered by rakes or forks in the autumn when they were about 15 months old and separated. In this way a higher survival and a reduction of the cost of producing single oysters was expected.

The spat were planted on seven different plots giving a range in depth of from about half-tide level to about a foot below an ordinary low tide, and a variety of types of bottom and degrees of shelter. The growth of the spat was studied by Miss A. E. Clark.

The results while sufficiently encouraging to warrant further trials of the method with modifications do not demonstrate the efficacy of the method as an improvement over planting on shallow beds. The growth was on the whole somewhat slower than the growth on beds. The growth of algae on the shells favoured the deposition of silt with the result that there were both losses and distortion from this source. In the most sheltered situations this was sufficiently serious to reduce survival, growth and shape below the levels obtained on the better shallow beds. The results indicated that shores for this purpose should be firm as possible and the ill effects of exposure to wave action were not as serious as was expected.

It is planned to repeat the trials next year using the more promising types of shore used in 1935 and extending the plots to somewhat deeper levels to avoid the heaviest growth of algae. Losses from starfish were reduced and separation of clusters was facilitated and it is believed that these advantages may make this procedure worth while when the firmer and deeper shores are used. It must also be borne in mind that bits of shell and some spat and small oysters are inevitably left behind in the autumn. Some survival of the small oysters over winter and some increased production of spat must be considered as a further valuable result from the rearing of spat on shells along the shores. The method also brings into use shallow areas which are not suitable for maturing oysters. The method is dependent on the movements of starfish on and off the shores and on means of capturing them. Further investigations are necessary before all these factors can be evaluated and the possibilities of the method fully explored.

A.W.H.Needler.

Appendix No. 39 (Sea Fisheries)

SEASONAL GROWTH OF REARED SPAT IN THEIR SECOND SUMMER

As a check on the conditions in the rearing of oysters in which a certain amount of crowding is necessitated by considerations of cost the growth of spat was followed by Miss Clark throughout the growing season under much less crowded conditions and in four representative situations.

It was found that a higher rate of growth occurred than was obtained under the crowded conditions and that the growth was maintained somewhat better throughout the season. In general, however, the results indicated that the most rapid growth occurred in the early summer - a consideration of practical importance in connection with development of a cheaper procedure in rearing of spat through use of trays only up to the time of danger from Teredo.

A great variation in growth was found, the average weight at the end of the season being approximately twice as great in the best as in the worst situation. The factors controlling the growth rates remain somewhat obscure as the highest temperatures did not produce the fastest growth. The importance of other factors and especially food supply is indicated.

A.W.H.Needler.

Appendix No. 40 (Sea Fisheries)

OYSTERS IN THE BRAS D'OR LAKES, CAPE BRETON

Work supplementary to the preliminary survey in the previous year involved visits to Cape Breton oyster areas for three days in July (3rd to 5th) and three days in October (8th to 10th).

Experimental transfers to improve quality. Oysters from waters with prevailing salinities below 20 per mille in the River Denys district were placed in the water at Baddeck, C.B., Port Hood Is. and St. Andrews. At Baddeck (just seaward of the well-populated oyster area) salinities are just over 20 per mille and at Port Hood Island and St. Andrews 30 per mille or more. Transfers were made at the beginning of July and comparison in October with oysters left in place showed no reduction of the darkness of the mantle edge. The improvement in flavour was believed, however, to be sufficient to make the transfer of value in marketing and there were indications of the commencement of improvement in shape. These effects were more pronounced at St. Andrews and Port Hood Is. than at Baddeck, where the change in conditions was much less. Some of the transplanted oysters were left for future examination to indicate the effects of longer exposure to the new conditions.

The problem of overcoming the dark mantle colour characterizing Bras d'Or Lakes oysters remains unsolved and no promising method is in view. The hope (expressed in my 1934 report) of improvement by transfer to saltier waters is not realized by three months' exposure. Further enquiries and examinations of samples did not confirm the possibility that the mantle colour was somewhat lighter in the more saline waters in the "lakes" although a wide individual variation was found. Microscopic examination of the dark mantles is being continued.

Examination of possible picking grounds made it evident in the short time available that some shallow areas are present on which there is good spat production and high winter mortality and from which oysters could be transferred to deeper waters with benefit to the stock as a whole. But the areas are small (owing partly to the small tides and reduced intertidal zone) and widely scattered, making supervision especially difficult. It is not believed that the benefits would over-balance the expense of proper supervision or the ill-effects of possible abuses of picking privileges, unless as part of a greater development of oyster farming in the region.

Educational work was limited to distribution of literature and to discussion of oyster cultural problems with individuals and small groups. Owing to imminence of elections at the time of both visits it was advisable to avoid public meetings on a subject which might easily become highly controversial.

Some additional hydrographic data were obtained and a cursory examination made of oyster areas at Grand Etang and at Long Pond near Port Hawkesbury.

Work to date in the Cape Breton oyster areas has all been of a preliminary nature limited by time and resources. Little further progress can be made without continued investigations throughout a considerable period including further investigation of hydrography and the present oyster population, and trials of oyster cultural methods with a view to modification to suit the local conditions. Plans for future work depend on the effort considered desirable and on the resources available.

A.W.H.Needler.

Appendix No. 41 (Sea Fisheries)

SEX REVERSAL IN OSTREA VIRGINICA

Most of the work was designed to show the effect of crowding on sex determination. In October 1934 some oysters of known sex were suspended in individual wire baskets and some were crowded in bigger baskets either with oysters alone or mixed with mussels. These were examined in 1935. Observations in the field have suggested that crowding produces a higher proportion of males but the experiment did not support this. There was no appreciable difference between the sex ratios of the oysters kept under different degrees of crowding and there was an abnormally high proportion of males throughout. Although the oysters seem to grow normally it is possible that drilling to determine sex may affect them adversely. To test this the experiment is being repeated with undrilled as well as drilled oysters disposed in individual and collective baskets. It is also possible that the experiments have been started after the sex for the next year was determined. It is proposed to set one up again in 1936 during the spawning season in June or July.

The sex of some individual oysters has now been recorded for five years and of many for four. It seems certain that in many the sex is determined afresh every year.

Alfreda Berkeley Needler.

Appendix No. 42 (Sea Fisheries)

SPAWNING, GROWTH, AND DISTRIBUTION OF STARFISH

The investigations begun in 1934 were continued and expanded. The spawning time of starfish was found to be the first week in June, by examinations of gonads and series of plankton tows (No. 5 net). The water temperature at the time of spawning was about 15°C. Gastrulae appeared on June 5 and progressively later stages until about July 2. Between June 21 and July 4 some larvae settled and metamorphosed on slides set out for the purpose. This was in advance of the time that the oyster spat settled.

A preliminary examination of material collected indicates that starfish as small as three cm. in diameter may spawn. These specimens would not be more than one year old.

The size frequencies of samples of various starfish population from oyster beds show only one distinct year class as did the samples of 1934. There are marked differences in the most frequent size class of starfish from different beds. These differences are interpreted not as different ages but as showing greater growth in certain regions, probably correlated with food supply. Fifty starfish were caged in boxes, with an abundance of food, from September 4 to October 12. Starfish 3.3 to 4.5 cm. in diameter grew 1.8 cm. while those from 8.3 to 10 cm. grew only 1 cm. during this time. This indicates that the predominant size class of any of the starfish populations investigated could easily be of one year old individuals. The starfish were in darkness during the experiment and it was noticed that the bright colours of some of these starfish, all of which were obtained from shallow water, became dull greyish or brownish hues.

Exploration of various types of bottom at various depths in the Bay showed a complete absence of starfish at no place which was investigated. By far the greatest number of specimens were, however, obtained from oyster areas and the population appeared to be smallest on soft mud bottoms. In the upper reaches of the inlets of the Bay only the present year's set of starfish were found.

An estimate of the abundance of starfish on a few of the Department of Fisheries' Oyster beds was obtained by counting the total number of starfish, caught by the routine mopping to remove these pests from the beds. The maximum number was 42,400 from Cooper Bed. These starfish were much smaller, however, than specimens obtained from some other beds where the population was less dense. The probable reason is the scarcity of food suitable for a large population of small starfish as most of the oysters would be too large to be eaten. The figures are strictly below minimum population as mopping operations ceased when the catches became markedly smaller.

G. F. M. Smith.

Appendix No. 43 (Sea Fisheries)

STARFISH MIGRATION AND LIMITING FACTORS IN DISTRIBUTION

Migration of starfish near oyster areas at low tide level was observed. Most of the migration took place in the late spring and the fall, the movements toward shore decreasing as the weather became warmer in the summer. It was observed that starfish may travel twenty feet a day and when near oysters, migrate directly toward their prey. The distance from which the starfish may be attracted toward oyster areas has not yet been investigated.

In the latter part of August the water temperature reached 27°C. in inlets of the Bay. At this time dead starfish were found near low tide mark, which were doubtless killed by the high temperature. The small starfish of the present year in the upper parts of the inlets were not killed, however. Both of these observations are in strict agreement with the laboratory experiments of 1934 on temperature as a limiting factor in starfish distribution.

Laboratory experiments on the effect of rate of change of salinity were carried out. A constant low salinity of 14‰, even when the time of decrease from normal salinity was varied from 45 minutes to as long as 98 hours was unfavourable. In the latter case the survival was much longer in the low salinity. However, if the salinity is raised again to the normal level the starfish may be subjected to a salinity of 7‰ for as long as 4 hours. These experiments suggest that starfish may be acclimatized to lower salinities than those in which they are found in Malpeque Bay. Possibly it is not only the salinity of the external environment that must be considered but also the salinity of the coelomic fluid. This assumes that there is a considerable lag of the salinity of the water vascular system when the external salinity is changed. The laboratory results together with caging experiments during the summer of 1934 and 1935 indicate that during the summer, temperature is much more important as a limiting factor in starfish distribution than salinity. Salinity is perhaps an important limiting factor in starfish distribution in the winter when the Bay is frozen over. On this point no observations have been possible as yet.

In the spring an unidentified protozoan (Holotrichida?) was observed in the cavity of the gonads of starfish. The infested specimens were apparently healthy otherwise. There is as yet no evidence that this protozoan is a serious enemy of the starfish but perhaps it should be placed tentatively on the list of limiting factors for starfish distribution and population density.

In the summer of 1936 it is proposed to continue and extend the work on starfish migration and extend investigations on limiting factors to starfish larvae. Experiments on rate of growth will be continued and data on preference and selection of food by starfish will be sought. The use of traps as a method of starfish control on oyster beds would be linked with experiments on food.

G. F. M. Smith.

Appendix No. 44 (Sea Fisheries)

FUNDY SCALLOP INVESTIGATIONS 1935

The scallop investigation was continued during the summer at Digby, N. S., special attention being paid to the factors determining the productivity of the Digby scallop-beds, which are the most extensive ones in Canadian waters. The investigation fell under the following principal headings:

Growth-rate. The final establishment, both experimentally and statistically, of the annual nature of the rings of growth was effected, thus providing a working basis for further growth study. Throughout the summer, samples of scallops were measured; and satisfactory curves were obtained for three different age-groups indicating growth-rate throughout the summer. It was found that the growing period begins about March, and was at its height in early September. In general, the rate of growth corresponded with the prevailing temperatures.

The growth-rate was determined for each of a series of samples taken from localities exhibiting different environmental conditions, and a study of concurrent observations at these localities upon the environmental factors seems to indicate that whereas several factors may influence the growth-rate of Digby scallops, the most important of these are the amount of food present and the prevailing temperature. There is strong reason to suppose that the outwash of detritus from the Annapolis Basin largely explains the concentration of scallops opposite Digby Gut. There is an offshore gradient in growth-rate corresponding to similar gradients in the quantity of detritus and of plankton (during the summer diatom minimum), in temperature, and to a less marked extent in the speed of currents.

Material was collected for a study of the growth-rate of the free-swimming larvae. These proved to be very scarce in the Digby plankton; the material has yet to be studied.

Spawning. The extent of the spawning season was partially determined. Spawning was already in progress at the beginning of June, and continued throughout the summer until about September 10 on the inshore beds, and perhaps a week later on the offshore ones. A tendency for the scallops to spawn on the high spring tides was noted at the end of the summer; but there was no indication of this earlier.

Material was collected for a study of the abundance of the veliger larvae in the plankton at various times during the spawning season, and is to be worked upon.

The age at maturity was determined at approximately three years, since scallops with three rings were found to be spawning. However occasionally a two-year-old scallop was found to be mature, while occasional three-year-olds were still immature. It should be noted that the Digby fishery causes many three-year-old scallops to be caught and marketed before they have had a chance to spawn.

Food. The stomach contents of scallops from inshore and offshore beds were examined and compared with No.18 net plankton from immediately above the latter. It was found that with few exceptions, the scallops consumed the plankton in toto, and there was little evidence of selective feeding. Large quantities of detrital material and grit particles were ingested; but a tendency to eliminate the diatom Chaetoceras was noted. It appears that detritus forms a large proportion of the food of Digby scallops, and probably influences the growth-rate considerably.

Mortality. Evidence was obtained that suggests that the rate of growth, during the second summer, of Digby scallops largely influences their survival, since it is in this year that they attain a size sufficient for protection from most predators. The dominant age-groups on the beds show invariably very rapid growth during their second year.

Scallop larvae were too scarce for a critical study, but a very high and at times actually complete mortality in the Mya and Mytilus larvae during the early summer in the same localities suggests that a similar state of affairs exists among the scallop larvae.

Distribution. Some exploration for new scallop beds was done with the C.G.S. "Arleux", and several new areas were discovered. Data upon environmental conditions were collected that explain largely the distribution of the Fundy scallop beds. It would appear in general that scallops are present in the direct line of water drift, wherever plenty of suitable food, a sandy or gravelly bottom, and a fairly strong bottom current exist. The Digby area exhibits all these characteristics very markedly.

Arrangements have been made for the collection of regular samples of scallops during the coming winter; and with this material it is proposed to continue the growth study and observations on the beginning of the spawning period and on feeding activity in relation to growth. Temperature records are being continued at Digby through the winter, to be correlated with the spawning and feeding activities. Next summer it is hoped to continue the work on spawning and growth rate, and to investigate the mortality and growth rate of the larval stages in greater detail than has been hitherto possible.

J. A. Stevenson.

Appendix No. 45 (Sea Fisheries)

THE INFLUENCE OF THE DIGBY SCALLOP FISHERY UPON ITS HAKE FISHERY

Young hake (Urophycis tenuis) live commensally during their first year within the valves of Fundy scallops. They first enter the scallops when about five centimetres long, during September; and remain within them throughout the winter until the following July, at which time they have gained a length of about eleven centimetres. They then leave the scallops, having presumably grown too large for them.

Up to five young hake may apparently be present within one scallop, and during dragging operations the fish are imprisoned within the scallops when the valves of the latter snap shut, and are landed on the decks of the scallop boats, and ultimately die.

When it is considered that last winter (1934-5) upwards of ten million scallops were landed at Digby (estimate from "Fisheries Statistics"), it is realised that the mortality of these young hake must be exceedingly high. It is probable that several times the number of hake trawled and marketed in Digby County are killed in this way every year.

It is significant that, corresponding closely with the recent rapid increase in the Digby scallop fishery, hake have been becoming increasingly scarce in the Bay of Fundy off Digby Neck, which was the centre of the greatest hake fishery in Canada.

Arrangements have been made for the collection of samples of these young hake during the coming winter, for a study of their growth.

J. A. Stevenson.

Appendix No. 46 (Sea Fisheries)

GROWTH RATE AND MORTALITY IN MYA AND MYTILUS VELIGER LARVAE AT DIGBY, N. S.

A series of No. 18 net tows was taken at intervals of three days, throughout the summer, in the Annapolis Basin, opposite Digby. The width-frequencies of the veliger larvae of Mya arenaria and Mytilus edulis were worked out from these tows, and from them were deduced the growth-rate of the larvae, and their relative mortality. Identification was effected by use of Stafford's criteria of differentiation of the larvae of eastern Canadian bivalve molluscs, viz. careful measurement of length and width, and general appearance (colour, etc.). It was found that the two forms agreed closely both in growth rate and in mortality. The duration of the free-swimming period varied somewhat, but was approximately two and a half weeks.

The mortality of the larvae, as determined by the quantitative estimation of each age-group, was greatest at the beginning of the summer, when age-groups actually disappeared altogether from the plankton long before they had attained spatting size. Successive age-groups attained successively later stages as the summer continued, until they were large enough to spat. The mortality, in general, varied inversely as the prevailing temperature.

Such complete mortality as occurred during the early summer must play a large part in determining the success of the spawning season for these forms, and this success would appear therefore to be largely dependent upon temperature conditions during the development of the larvae.

J. A. Stevenson.

Appendix No. 47 (Sea Fisheries)

SEXUAL MATURITY IN LOBSTERS ON SOUTHERN NOVA SCOTIA COAST

There has been much discussion in southern Nova Scotia regarding the recent imposition of a three and one sixteenth inch carapace (about 22.5 cm. total length) size limit. In a short field trip, May 24 - June 6, information was collected regarding the sizes at sexual maturity of the lobsters in this area. Measurements were taken of the total length and of the width of the second segment of the abdomen in female lobsters. As determined in 1932 at Point du Chene and at Grand Manan the abdomen of the female begins to increase in width relative to the total length of the body at the approach of sexual maturity.

The increase in relative width of the abdomen began in Clark's Harbour at about 29 cm., in Pubnico at about 27 cm., in the Tusket Islands at 28 cm. and in Port Maitland at 27 cm. In our measurements of 1932 an increase in the relative width of the abdomen at 18 cm. at Point du Chene corresponded with an egg bearing female minimum size of about 18 cm., while at Grand Manan where the increase in the relative width of the abdomen occurred at about 33 cm. the smallest egg-bearing female found was about 34 cm. in total length.

Apparently on most of the Canadian lobster grounds west of Clark's Harbour the lobsters mature at sizes above 27.- 28 cm. the smallest egg-bearing lobsters being in general about 10 cm. larger than those of the southern Gulf of St. Lawrence area. At Lockeport on the other hand the measurements apparently show a mixture of an inshore population living largely in the warmer bays and harbours and first maturing at about 22 cm. with an offshore population living mostly in the deeper and colder offshore water and carrying eggs for the first time at sizes up to 30 cm.

W. Templeman.

Appendix No. 48 (Sea Fisheries)

LOBSTER MATING

Additional work has been done on the process of mating. In mating one of the last pair of walking legs of the male lobster is placed across the body in front of the copulatory appendages so as to give them the necessary elevation to penetrate the female annulus. Exactly the same procedure has been observed by E. A. Andrews (1904) in the case of the crayfish Cambarus affinus.

Eight sexually mature females which had recently hatched their eggs, and had moulted between August 26 and September 16 were kept apart from males during and after moulting and were placed in the presence of eleven sexually mature males of suitable size on September 20. Only two of these females, one moulting 12 days and one 6 days after adding the males were fertilized when the females were dissected on September 24. Three other females of similar size to the unfertilized ones were added to the group on September 22. These three females had moulted only 1 to 3 days previously and when dissected on September 24 all three were fertilized. It is concluded that the normal time for the mating of the female to occur is within a few hours or days after she has moulted.

Females carrying fertilized eggs have been shown by Bumpus (1891) by Herrick (1911) and by the author (1934) and (1935) to invariably possess a full supply of apparently normal sperms in the seminal receptacle. Herrick thought the meaning of this was that the female lobsters copulated with males while in the hard shelled condition since the females rarely lay eggs before they are hard shelled. Five females kept entirely apart from males during the course of the experiment laid eggs in a tank at St. Andrews in 1935. A full supply of eggs which were shown to be fertile was laid in each case. Three of the females were dissected 2 weeks and two about 9 weeks after the eggs were laid. In each case the seminal receptacle contained spermatophores with millions of sperm normal in shape. Thus female lobsters can lay a normal supply of eggs fertilize them from the stock of sperm in the seminal receptacle and still have so many sperms left that we were unable to tell the difference between the contents of the seminal receptacle of a lobster which had laid eggs and those of a female in which none of the sperm had been used. Moreover a gelatinous material filling the seminal receptacle and covering the spermatophores is so hard as to prevent any other copulation than the original one soon after the moulting of the female. As observed in eleven cases where the annulus was dissected out from the old shell all females lose the whole inner lining of the seminal receptacle together with all sperm when a moult occurs.

W. Templeman.

Appendix No. 49 (Sea Fisheries)

EGG-LAYING AND HATCHING POSTURES OF THE LOBSTER

During the summer of 1935 we were fortunate enough to observe the true postures assumed during egg-laying and hatching which apparently have never been described previously for the American lobster.

Two lobsters were observed in the process of laying eggs. Unfortunately most of the eggs had been extruded before the lobsters were observed and the total length of time required for egg-laying could not be exactly determined. During egg-laying the lobster remained on its back supporting itself on the first segment of its abdomen and the tips of the large claws which were stretched out in front. The cephalothorax was elevated at an angle of about 35° the hinder border of the cephalothorax being near or on the bottom; the abdomen was completely folded so that the setae fringing the telson and uropods were almost opposed to the bases of the last pair of walking legs leaving a small space through which the first pair of swimmerets could just be observed. Eggs passing from the oviducts flowed downward by gravity and were carried into the abdominal pocket by means of a current created by the first pair of swimmerets which beat at the rate of 15 to 20 times a minute. When egg-laying was completed the cephalothorax was gradually lowered and the abdomen opened, allowing more sea water to reach the eggs. In about 15 to 20 minutes the animal turned over into its normal position and immediately turned over on its back again resuming its normal position after about 1 or 2 minutes.

Hatching was observed on many occasions. The lobster rested on the tips of the four pairs of walking legs with the large claws held out in front one or two centimetres off the bottom. The cephalothorax was held almost horizontally and the abdomen elevated as far as possible, the whole abdomen pointing straight upward at an angle of 20-45° with the horizontal. While the animal was in this position the swimmerets were waved violently creating a current which passing up the inclined plane of the abdomen, carried often hundreds of larvae, which at this time broke out of the egg shells, beyond the extended abdomen and toward the surface of the water. This phenomenon occurs in about half a minute and may be repeated several times at short intervals.

The European lobster behaves somewhat similarly during egg-laying and hatching. We were unable either to verify or to agree with the descriptions given by Knight (Contributions to Canadian Biology 1918) for egg-laying and hatching in the American lobster.

W. Templeman.

Appendix No. 50 (Sea Fisheries)

EXPERIMENTS ON SURVIVAL AND GROWTH OF LOBSTER LARVAE

Effects of light and darkness. Forty-eight newly hatched larvae, hatched at the same time from the same lobster were placed half in complete darkness and half in the light from a north window. The temperatures were approximately similar in both parts of the experiment. The larvae were kept separately in Best Bottles with about 250 cc. of water and fed on plankton, the water being changed every two days. Twenty-three larvae reached the 4th stage in an average of 14½ days in complete darkness and nineteen larvae in 17½ days in the light. In a similar experiment in which twelve larvae were used eleven larvae reached the 4th stage in an average of 19 days in darkness and nine in 23 days in the light. The larvae reared in darkness were also significantly larger than those exposed to the light. In the first experiment the sunlight reached the larvae for not more than a half-hour per day at sunset and in the second experiment the larvae were never in sunlight, merely being exposed to the ordinary light of the laboratory.

Problem of rearing larvae together. Perhaps the greatest problem in lobster rearing on a large scale is that of preventing cannibalism. Seventy first stage larvae hatched at the same time from the same lobster were placed in each of two wash basins with about 4000 cc. of sea-water in each and the larvae were fed on plankton. One basin was kept in complete darkness and the other open to the ordinary light of the laboratory. Ten larvae survived to the 4th stage and seven to the 5th stage in darkness while in the light only two larvae reached the 4th stage and one the 5th. Most of the deaths were due to cannibalism and it was noticed that in the light basin the larvae oriented themselves by the light rays and gathered in a particular area of the basin where being crowded together many chances occurred for one to seize upon the other, while in the dark basin the larvae scattered equally over the basin.

Low Salinity. Twenty-four larvae hatched at the same time from the same lobster were placed separately in 250 cc. of sea water at salinities of about 31, 26 and 21 ‰ and fed on plankton, the water being changed every two days. Nineteen reached the 4th stage at 31‰, sixteen at 26‰ and seventeen at 21‰. There was no significant difference in the times of moulting at the different salinities and growth was slightly greater at the lowest salinity of 21‰ than at 31 and 26‰. These results agree with the results of similar experiments on low salinity in 1934.

W. Templeman.

Appendix No. 51 (Sea Fisheries)

RATE OF DEVELOPMENT OF THE LOBSTER EGG

The most convenient way of determining when egg laying occurs on different parts of the coast is to collect samples of eggs not later than two months after egg laying and from the stage of development of the embryo to calculate the date of egg laying. Until now however a standard has not been available by which these calculations could be made.

It was found possible to keep the newly laid lobster eggs alive for a month or more in sea water kept in wide mouthed bottles and changed at intervals.

Eggs were placed in still water at different temperatures one and one-sixth days after being laid, having been left attached during this time to the female and kept at 12-13°C. At 18.5°C. the 16 cell stage was reached in about 2 days, at 14.5°C. in about 3 days, at 10.5°C. in 4½ days, at 5°C. in 25 days and at 1°C. no sign of division appeared in 60 days.

As a control the parent female with the residue of eggs attached was kept in a tank with running sea water at 12.3°-14°C. Here at 12.3-12.7° the 16 cell stage was reached in about 3½ days, while at 12.3-14.9°C. the egg nauplius with antennae bifid and telson just beginning to fork was attained in 35 days as compared with 15 days at 20-22°C. in Herrick's experiments (1895). The eye pigment at 12.3-14.9°C. appeared in about 53 days as compared with 26 days at 20-22°C. in Herrick's experiments (1895).

W. Templeman.

Appendix No. 52 (Sea Fisheries)

RATE OF GROWTH OF LOBSTER LARVAE AT A CONSTANT TEMPERATURE

An experiment was begun in July 1935 designed to find the relative length of time required between moultings in the earlier stages of the lobster, also the growth at each moult. Larvae were kept at a constant temperature of 19.5°C. the temperature usually not varying more than half a degree in either direction.

At this temperature the first stage lasted about 3¼ days, the second about 4 days, the third 6 days, the fourth about 14 days, the fifth about 15 days and the sixth about 19 days. The experiment is still in progress at St. Andrews, some of the larvae having reached the 11th stage. Growth per moult is being determined by collecting the moulted shells and measuring the carapace. It is hoped that with this standard together with many other experiments on the rate of moulting at various temperatures which we have performed during the past few years, we shall be able to calculate the number of years required for the lobster to reach a certain size in areas differing in temperature.

W. Templeman.

Appendix No. 53 (Sea Fisheries)

EXPERIMENTS ON KEEPING LOBSTERS IN AIR

To determine the survival period in air three lobsters were placed at each of five temperatures, an attempt being made to keep the air moist in each box by sprinkling sea water at intervals on the bottom of the container. Two small lobsters 21-23 cm. long and one large lobster 26-33 cm. total length were used at each temperature. One of the small lobsters was buckle shelled, having moulted several weeks previously; the other two lobsters at each temperature being hard shelled, not having moulted since the previous year.

The lobsters lived on the average less than 1½ days at 20°C., 5 days at 15°C., 9 2/3 days at 10°C., 12 days at 5°C., and 15 days at 0.5°C. In all cases the buckle shelled lobster died first, having lived less than 1 day at 20°, 2 days at 15°, 6 days at 10°, and 8 days at 5° and at 0.5°. At 0.5°C. one lobster lived in air for 22 days.

Since the gills of the lobsters dying in air were almost always dry, experiments were carried on in which the lobsters were dipped in solutions of the deliquescent salt, calcium chloride. However, no lengthening of the period of survival resulted.

The effect on the concentration of the blood of lobsters kept in air was investigated by means of the Beckmann thermometer. The freezing point depression of the sea water from which the lobsters were removed was 1.77°C, while the freezing point depression of the lobster blood immediately after removal from the water was 1.80°C. Other lobsters removed from the water at the same time were kept alive in air at about 15°C. for 3 days and then bled. The volume of blood produced by each lobster was apparently reduced at least one-third and the freezing point depression was now 2.01°C., indicating that a great amount of evaporation of water had taken place and that death in air may result from a loss of water from the body and a concentration of the body fluids as well as from asphyxiation resulting from the drying out of the gills.

W. Templeman.

Appendix No. 54 (Sea Fisheries)

MARINE BORERS IN SAINT JOHN HARBOUR

Purpose: (a) To determine the presence of Marine Borers, if any, the species, and extent of damage produced, if present: and (b) To determine the hydrographic features of the waters, which might be correlated with the presence, or absence of these borers.

Investigation: The Atlantic Sugar Refineries and later, the Saint John Harbour Commission were concerned with possible damage to underwater structures, under construction, or recently completed, in Saint John Harbour, by marine borers. Although advised that previous investigations would indicate the unlikelihood of such damage, a coöperative effort was planned between the organizations concerned and the Biological Board of Canada.

The Atlantic Sugar Refineries arranged for a series of test-blocks at their wharf, and undertook to obtain regular observations of temperature, salinity, and pH. In the series just completed, no borers were discovered until August, 1935, nine months after the investigation began. Two specimens of the borer (Limnoria lignorum) were discovered in each block (six-month exposed and one-month control) of the September series, as well as the August, but none in October.

The Saint John Harbour Commission arranged for a series of test-boards in various parts of the harbour. They were particularly concerned as to the specifications for the new works under construction. The first boards (from the mouth of the harbour) examined in June were quite heavily attacked by Limnoria. At this particular location, Limnoria burrows were found at a level of +8 feet above the harbour low-water datum. Attack at this site was more severe, and extended to a higher level than at Partridge Island, much further out in the Bay of Fundy (where a greater attack would logically be anticipated), or at any of the other locations investigated, in the harbour.

The waters of the harbour during the freshet periods are of sufficiently low salinity to preclude the possibility of survival of borers. At other times of the year, water of salinity, definitely suitable for the existence of Limnoria, is to be found at the greater harbour depths, which depths, however, are generally below the level of the various wharf structures. It would seem however, that a rather fine differentiation between the hydrographic conditions at various points in the harbour was needed in order to determine the factors involved in the existence of the borers at one particularly favourable spot. A coöperative effort on the part of those concerned was made in the month of August. The results bring out differences which in the final analysis, will probably furnish the answer to an interesting ecological problem--one with a most important practical application.

It seems probable that this investigation will have been instrumental (at least in part) in effecting a saving of several hundred thousand dollars to the Dominion Treasury, in obviating the use of expensive treated piling, and lumber in the new structures.

Recommendations: The examination of the test-boards is being continued, and from the hydrographical point-of-view, it is planned to repeat the survey of the harbour, in the early spring, as during the time of extreme differences in salinity between top and bottom, the differences between various points in the harbour will be more easily noted.

R. H. M'Gonigle and H. B. Hachey.