1951

Appendix No. 33 ATLANTIC BIOLOGICAL STATION ST. ANDREWS, N. B.

STATISTICS OF THE OTTER TRAWL HADDOCK CATCH

The annual catch of haddock has shown wide fluctuations as is apparent from the accompanying Figure 1. During the 1914-18 war the haddock catch increased to 71 million pounds but since that time only in the years 1926, 1929 and 1948 did catches exceed 50 million pounds. In the years 1921, 1933, 1942 and 1944 the annual catch dropped below 30 million pounds.

Previous reports have shown that landed value, efficiency of capture and exploitation of new grounds all play a part in the magnitude of the haddock catch, but that abundance on grounds already fished is of primary importance as a factor in determining catch.

Although detailed records of effort, growth, year-class abundance and mortalities have been collected only since 1945, short-term biological investigations by Needler and Thompson in earlier years have shown the importance of abundant year-classes in the haddock fishery off Nova Scotia.

Measurements of catch per trip and catch per day at sea are available from Department of Fisheries records for otter trawlers back to 1931. The four largest steam trawlers which have carried out continuous year-round fresh-fishing operations were selected as an index of changes in abundance. Average catch per trip for each year of large and scrod haddock is shown in Figure 1. A high catch per trip of scrod in 1934-35 was associated with a high catch per trip of large haddock in 1935-38. A lesser scrod peak in 1939-41 was associated with an increased catch of large haddock in 1942-43. An increased catch per trip of scrod beginning in 1947 is associated with an increased catch per trip of large haddock in 1948-50.

The total otter trawl catch of scrod and large haddock from 1947 through 1951 for the January to June period is also shown in Figure 1. Total catch of large haddock has remained approximately the same since 1948 with the scrod catch increasing markedly in 1951. Age composition data for haddock from Banquereau, Western Bank and St. Pierre Bank (Figure 2) indicate that the 1946 year-class makes up the major portion of this scrod catch. An increased scrod catch indicates a relatively strong year-class. On Banquereau and Western Bank the indications are that the 1947 year-class will also give good recruitment to the fishery. Data are not available from St. Pierre Bank for the second quarter of 1951.

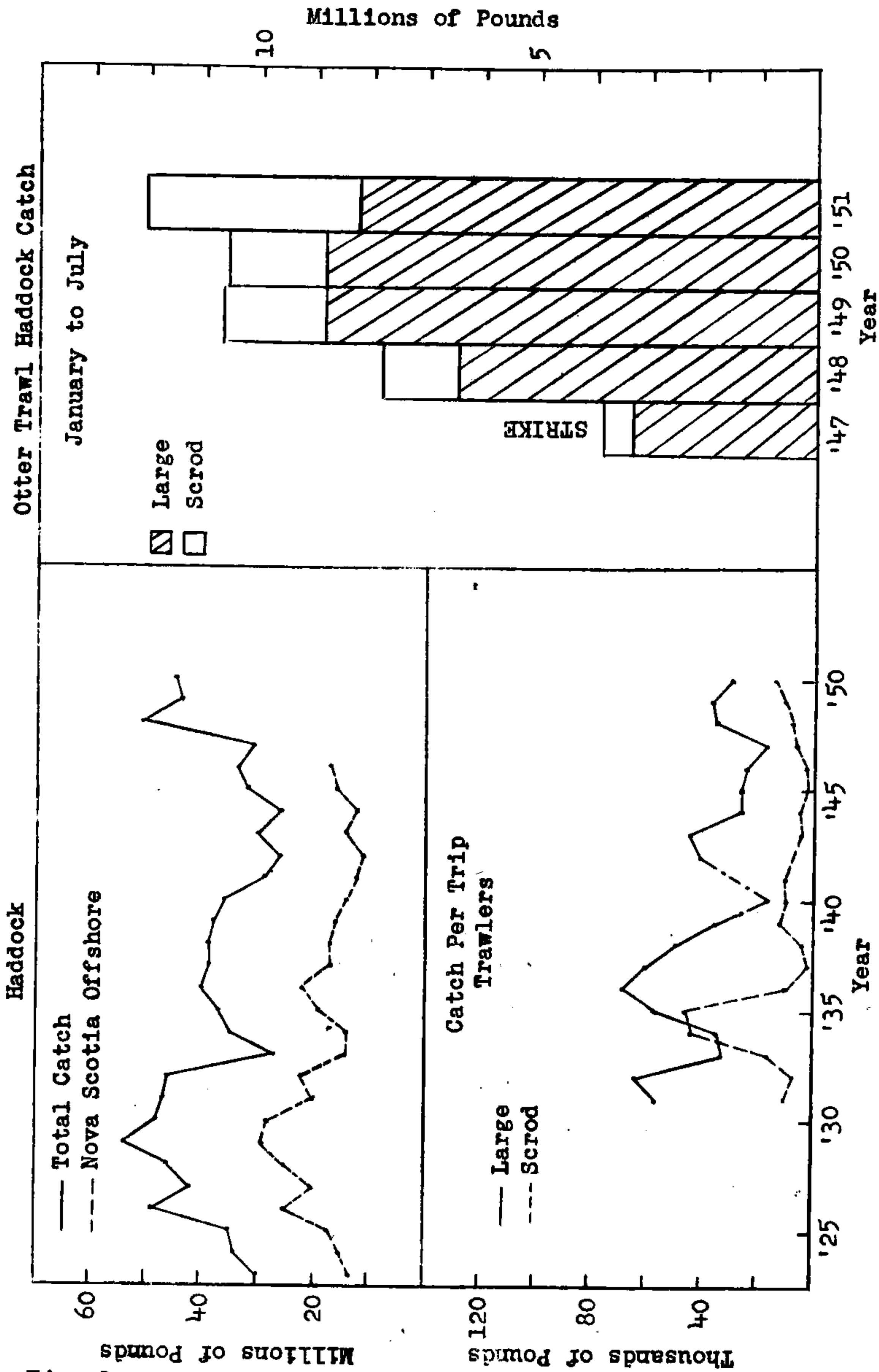

Millions of Pounds
10
5
Otter Trawl Haddock Catch
January to July
Large
Scrod
STRIKE
'47 '48 '49 '50 '51
Year
Haddock
Total Catch
Nova Scotia Offshore
60
40
20
Millions of Pounds
Catch Per Trip
Trawlers
Large
Scrod
120
80
40
Thousands of Pounds
'25 '30 '35 '40 '45 '50
Year

Fig. 1

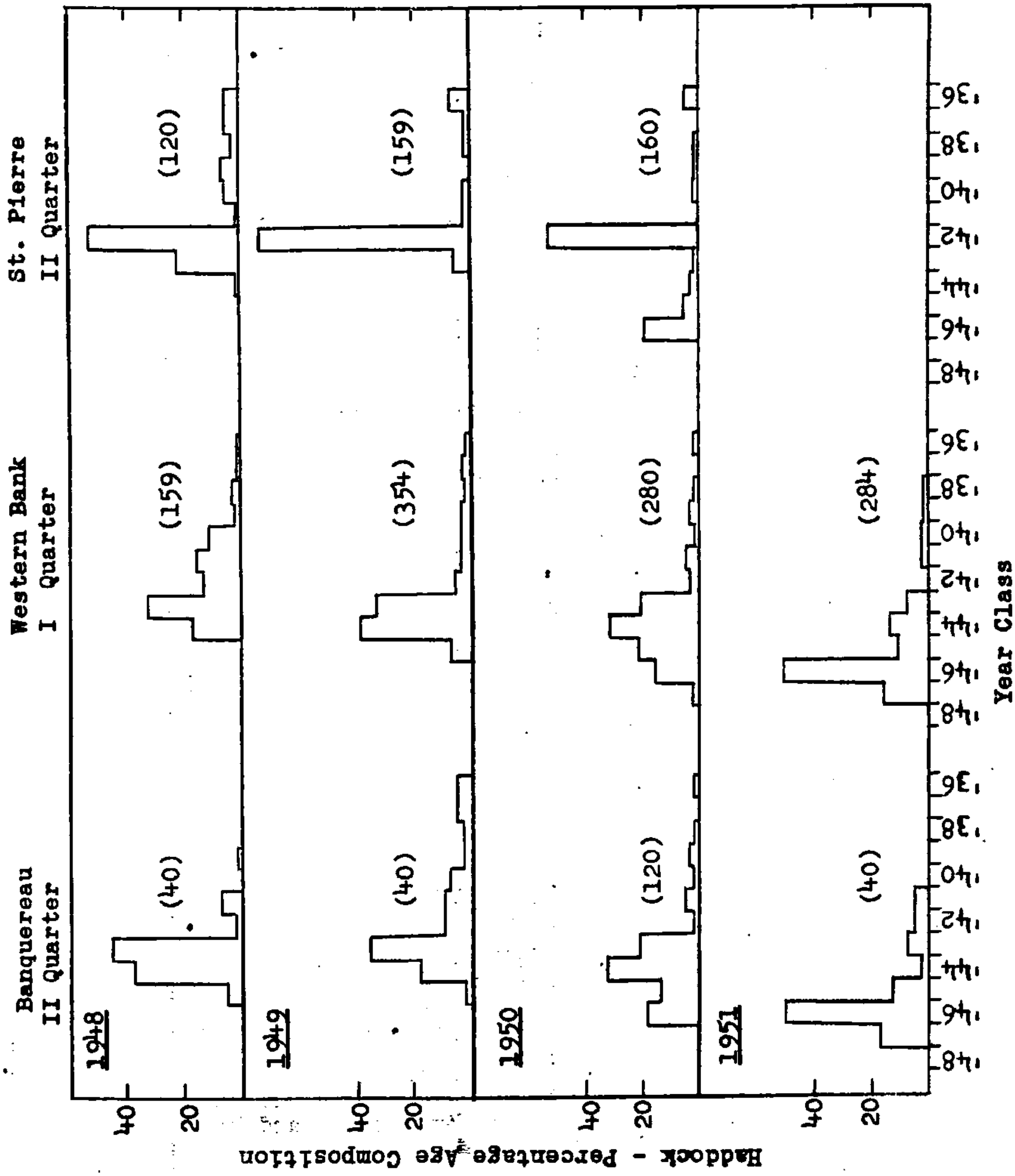

Banquereau
II Quarter
Western Bank
I Quarter
St. Pierre
II Quarter
1948
1949
1950
1951
(40)
(159)
(120)
(40)
(354)
(159)
(120)
(280)
(160)
(40)
(284)
40
20
'48
'46
'44
'42
'40
'38
'36
Year Class
Haddock - Percentage Age Composition

Fig. 2

These data show that a relatively small number of year-classes are represented in the haddock catch and that large fluctuations in year-class strength occur. For example, in 1948 to 1950 the haddock taken from St. Pierre Bank belong mainly to the 1942 year-class. During the same period the 1943 and 1944 year-classes were dominant in the haddock catch from Banquereau and Western Bank.

A summation of the available evidence indicates that the increased scrod haddock catch in 1951 shows a good recruitment of new year-classes which should result in a continuing abundance of medium-sized haddock to the fishery.

Continued collection of special statistics of the groundfish fishery is required in order that fluctuations may be analyzed to give a basis for prediction of changes in abundance.

F. D. McCracken and J. M. Stuart

Appendix No. 34

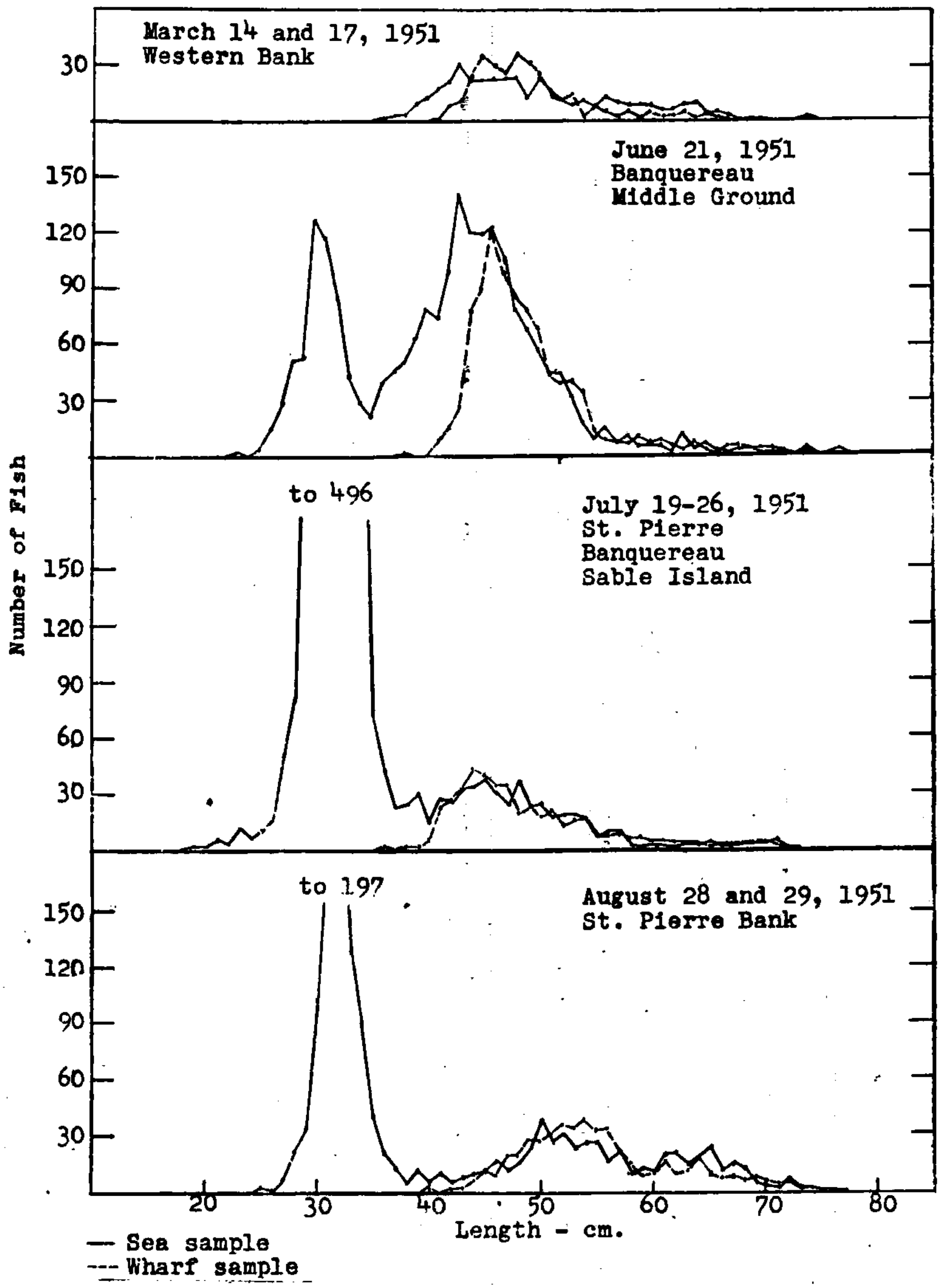
WASTAGE OF SMALL HADDOCK

The increased use of otter trawls on the banks off Nova Scotia and the recent formation of the International Commission for the Northwest Atlantic Fisheries increases the need for data on the portion of the catch discarded at sea as well as statistics of the landed catch. Such information is necessary in order to determine whether restrictive measures, such as minimum mesh sizes for otter trawls, are desirable.

Four sea trips have been made to date in 1951 and a comparison of the actual catch with the landed catch for haddock is shown in the accompanying figure. Random samples were taken at sea and weighted samples of the scrod and large haddock landings were taken for the same trip. On the basis of the cull it is assumed that all haddock 45 cm. and over are landed; the wharf sample was then adjusted so that a direct comparison can be made with the sea sample.

The following table gives the percentage of the haddock catch discarded at sea by numbers and by weight for each of the four sea trips.

Haddock discarded at sea by Canadian trawlers - 1951
Offshore Banks



Month	Banks	Percentage of the total catch of haddock discarded: Number	Weight
March*	Western	21	27
June	Banquereau and Middle Ground	56	37
July	St. Pierre, Banquereau and Sable Is.	84	59
August	St. Pierre	64	30

*March sampling somewhat inadequate for this purpose

These data support the general knowledge that larger quantities of small haddock are taken during the summer months. Variation in the percentage of small haddock discarded, as shown by the summer trips, is presumably due to differences between banks but it is apparent that continued sampling is necessary before drawing definite conclusions.

The bimodal characteristics of the catch curve with large quantities of haddock around 30 cm. in length being discarded may indicate production of a good year-class (see also Appendix 33).

F. D. McCracken

Appendix No. 35

DANISH SEINING COMMERCIAL TRIALS

Fishing operations of a 39 ft. Danish seiner (converted from a flounder dragger) have demonstrated that Danish seining for flatfish is a profitable method of fishing in Chedabucto Bay.

In Danish seining an area of bottom is enclosed by two miles of rope and the seine. The ropes and seine are then hauled, the ropes sweeping bottom fish into a central path and into the net. Trials of this method of fishing, using the M. V. "J. J. Cowie" in the summers of 1948 and 1949, demonstrated good prospects of profitable commercial seining for flatfish in Chedabucto Bay.

The Fisheries Research Board interested the owner of the M. B. "Gay Rover", a 39-ft. flounder dragger, in this method of fishing with the results of the "Cowie" trials. The gear used by the "Cowie" was loaned to him. Assistance was also given in installing the gear and making the first sets. Detailed records of his operations have been received in return (see table).

Seiner landings, landed value, expenses and net profit

Month	Landings - lb.	Value $	*Expenses $	Net $
May	42,000	1289.72	455.60	834.12
June	66,000	1992.00	374.93	1617.07
July	80,000	2365.65	422.40	1943.25
August	101,000	3045.80	796.55	2249.25
to Sept. 9	31,000	1071.50	63.00	1008.50
TOTAL	320,000	9764.67	2112.48	7652.19

* includes wages paid to deck-hand

For comparative purposes there are available sporadic records from a 53-ft. dragger operating in Chedabucto Bay (see table).

Catch per day fished, seiner vs dragger

Period	Danish Seiner Lb. per day	Danish Seiner No. of days	Dragger Lb. per day	Dragger No. of days
May 25-31	4,654	3	4,195	3
June	4,743	14	4,470	8
July	4,436	18	5,060	10
Aug. 1-4	8,680	3	8,095	3

Cost of operation for the Danish seiner is less than for the dragger (one less crew man and smaller running cost), thus in terms of net profit the seining method is even more favourable than in terms of poundage.

It is of interest to note that practically no roundfish were taken by the Danish flounder seine and that witch (Glyptocephalus) made up approximately 78 per cent of his total catch.

The grounds available for Danish seining are more restricted than for dragging since relatively smoother bottom is needed to prevent fouling. Indications are strong, however, that on such grounds where concentrations of flatfish are sufficient to afford profitable small-boat dragging the Danish seining method is more efficient and profitable.

F. D. McCracken

Appendix No. 36

EXPLORATORY DRAGGING AT THE HEAD OF THE BAY OF FUNDY

Exploratory dragging in 1949 by the Fisheries Research Board using the M. B. "Pandalus" resulted in the development of a fishery for the winter flounder

(Pseudopleuronectes americanus) in western Minas Basin between Kingsport and Cape Blomidon and in Scotsman Bay. Further exploration in 1951 at the head of the Bay of Fundy failed to extend the grounds now being fished.

A survey of Minas Basin, Cobequid Bay, Minas Channel and Chignecto Bay was made with a 40-ft. flounder drag using the M. B. "Mallotus" during June and July. Irregular, hard and rocky bottom prevents dragging in eastern and central Minas Basin, Cobequid Bay and eastern Chignecto Bay. Elsewhere at the head of the Bay of Fundy dragging is possible but results indicate that only in the areas now being fished are commercial quantities of either winter flounders or haddock available.

Size and age composition, 1949 vs 1951

In 1949 about 80% of the "Pandalus" catch of winter flounders were fish of over 12 inches (the minimum commercial size) and of these about 80% were seven years or older. In 1951, 62% of the winter flounders taken were larger than 12 inches and of these only about 10% are over six years of age.

These data indicate that the accumulated stock of large old fish has been considerably reduced and are substantiated by the continued drop in catch per unit of effort from 1949 to 1951 (see also Appendix 38). Continuance of the fishery for winter flounders in Minas Basin will be largely dependent upon recruitment to existing stocks.

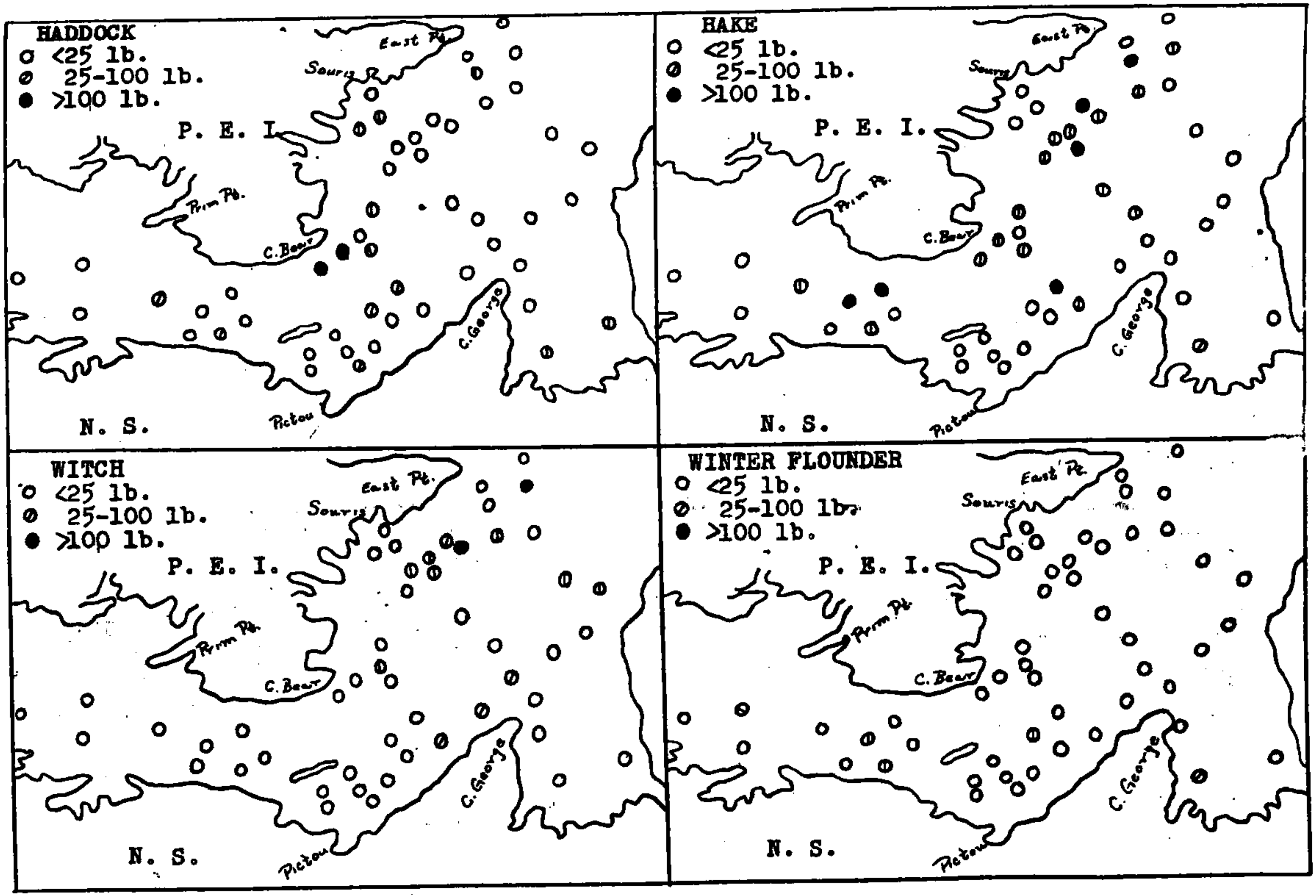
L. M. Dickie

Appendix No. 37

EXPLORATORY DRAGGING IN THE SOUTHEASTERN GULF OF ST. LAWRENCE

The M. B. "Mallotus" began exploratory dragging for groundfish in this region by late August and this exploration was continuing at the time of writing. Drags were made with a 50-ft. flounder drag at stations in the Northumberland Strait as far west as Wallace Harbour, N. S., in George Bay and from Cardigan Bay to East Point, P. E. I.

Echo sounding of the bottom along the north shore of Prince Edward Island from East Point to North Rustico indicates that up to 10 miles offshore the bottom is rocky and not suitable for extensive dragging. Inside 20 fathoms on the northwest shore of Cape Breton Island similar conditions exist. Outside 20 fathoms only a few tows have been made and these produced negligible catches.



Approximate positions of half-hour tows in southern Gulf
See legend for catches

In the other areas noted above half-hour tows were made at 61 stations. The principal species of groundfish taken were hake, haddock, witch and cod. Plaice and winter flounders were taken in many of the tows but only a small percentage were of commercial size.

The best catches were made along the Prince Edward Island shore from East Point to Prim Point in depths of 15 to 21 fathoms. The position, depth and catch in pounds is shown in Table I for all catches over 100 lb. per half-hour tow. Table II gives the weight of each species in this total catch.

Each circle on the accompanying figure represents the approximate position of a half-hour drag. Catches of haddock, hake, witch and winter flounders are shown as indicated by the accompanying legend.

Table I

Position		Depth	No. of	Total
Latitude N	Longitude W	fm.	Tows	Catch
45°40'	61°45'	12-14	1	150
45°52'	62°17'	15-16	1	233
45°56'	62°20'	17-21	1	164
45°59'	62°25'	20	1	312
45°56'	62°28'	23-25	1	321
45°53'	62°50'	18	1	466
45°52'	62°55'	21-23	1	302
45°54'	63°03'	19-20	1	202
46°17'	62°07'	21	1	376
46°13'	62°10'	18	1	193
46°16'	62°05'	22	2	870
46°16'	62°01'	17	1	404
46°19'	61°48'	24	1	207
46°17'	61°53'	20-22	1	180
			TOTAL	4,380

Table II

Species composition of total catch

Species	Weight - lb.
Hake	1,870
Haddock	965
Witch	820
Cod	309
Plaice	295
Winter flounder	121
	4,380

It should be noted that hake made up almost half the total landings and were present in all catches of over 100 lb. per half-hour tow. Hake are relatively cheap fish and are at present being at least partially discarded by the draggers operating in this region.

Of the flatfish species taken, the witch were all of commercial size. In deeper water (12 fm. or more) the winter flounders were of large average size but not numerous in any of the tows. In shoaler water of Northumberland Strait winter flounders were more numerous but a large proportion were below present commercial size. Plaice of commercial size were found only in the deeper water of the Souris region.

Exploration is being continued through October and November to assess possible seasonal movements of the major species.

The better catches of groundfish to date have been taken from grounds already fished by one dragger of the Gloucester type and by several larger draggers. Our data indicate that dragging could be extended further into the Northumberland Strait than is the case at present. In the region sampled, areas not already being fished by draggers do not appear to offer good prospects except on a limited basis. Completion of this survey and critical examination of the data obtained will indicate whether certain areas should be more thoroughly explored.

L. M. Dickie

Appendix No. 38

DEVELOPMENT OF INSHORE COMMERCIAL DRAGGING

Inshore flounder dragging beginning in 1948, on the basis of Fisheries Research Board exploration, included in 1951 two new areas and significant amounts of other species besides the winter flounder. Statistics of the fishery indicate that further expansion can be anticipated only through discovery of new grounds.

Detailed records of catch and effort are being obtained and this relatively new fishery is being followed closely, but the wider scope of dragging operations increases the difficulty of obtaining precise comparable records.

St. Mary Bay

A million pounds of winter flounders were landed from St. Mary Bay by October, 1951, showing no increase over the same period for 1950. Thirty-two small draggers operated, at least periodically, as compared to 24 in 1950 and approximately half the winter flounder landing was taken from a previously unfished region off Cape St. Mary. Haddock landings of half a million pounds and catfish landings of 125,000 lb. both show an increase.

Age composition data for 1948 through 1951 show that a higher proportion of young winter flounders were taken in 1951. The 1941 year-class which made up 30 to 40% of the catch in April, 1950, has practically disappeared from the catch in 1951.

In the early spring fishery the catch per unit of effort was much lower than in previous years but reduced effort during the summer gave a higher catch per unit of effort than in 1950.

The high catch per unit of effort and large average size of flounders on the Cape St. Mary ground suggest an "accumulated" stock.

Tagging

Winter flounders were tagged in St. Mary Bay in October and November, 1949, in May, 1950, and in October, 1950. The number tagged and the number of returns up to September 15, 1951, are given in the following table:

Time of Tagging	Number Tagged	Number Recovered 1949	Number Recovered 1950	Number Recovered 1951
Oct.-Nov., 1949	2,616	114	499	94
May, 1950	1,523	-	512	161
Oct., 1950	2,009	-	232	162

The number of tags retaken indicates a relatively intensive fishery. All recoveries (with one doubtful exception) have come from the St. Mary Bay region. Only three tag returns from the Cape St. Mary ground in a total of 417 shows that this stock is relatively separate from the rest of the bay.

Minas Basin

Seven draggers operating in Minas Basin and Scotsman Bay from late May through July produced the same catch of winter flounders (approximately a third of a million pounds) as five draggers did in 1950. Catch per unit of effort in 1951 decreased to approximately two thirds that of 1950.

Samples of the catch in 1951 confirm those of 1950 in that a greater proportion of young fish were taken than in 1949.

Annapolis Basin

Dragging was more sustained here during 1951 than in either 1949 or 1950. Nine draggers operated in 1951 and six of these for considerable periods of time. As a result the reported catch of winter flounders was approximately half a million pounds as compared to 120,000 lb. in 1950.

Chedabucto Bay

Four small draggers operated in Chedabucto Bay in 1951 where none had operated previously. Explorations of the M. V. "J. J. Cowie" in this bay during 1948 and 1949 showed promising catches of flatfish. Stimulus to dragging in this area was also supplied by the success of the Danish seiner (Appendix 35). The bulk of the catch consisted of flatfish (plaice, witch and winter flounders) which are species not exploited previously in this area.

Expansion

Significant expansion of the inshore flounder-dragging industry can only be anticipated through the discovery of new grounds and may require a lowering of the commercial size limit as set by the industry to utilize slower-growing flounders found in other parts of the Maritimes.

F. D. McCracken

Appendix No. 83-A

SUMMER MINIMUM SALINITIES IN THE MAGDALEN SHALLOWS

The waters of the western sector of the Gulf of St. Lawrence are known to be highly stratified during the spring and summer seasons. The thickness and the salinity of the surface layer reach a minimum during the summer. The thinning surface layer during the period of vernal and summer warming indicates inefficient vertical mixing. On the other hand, the decreasing salinities with the advent of summer would indicate efficient horizontal mixing. The observed minimum salinity along the north coast of Prince Edward Island varied from 25.2‰ in 1947 to 27.7‰ in 1949.

From the variations of salinity and thickness of the surface layer, it is possible to calculate the amount of fresh water necessary to bring about a minimum of salinity. The western Gulf of St. Lawrence has an area of approximately 26,000 square miles, and the drainage basin of the St. Lawrence system is nearly 360,000 square miles.

Run-off figures can be converted to a layer of water covering a given area during a given period. Similarly, too, the layer of fresh water required to produce, by mixing, a layer of certain salinity and thickness can also be calculated.

Accumulated Thickness of Fresh Water (metres)

Year	From run-off	From variations of salinity and thickness of surface layer
1945	1.48	1.12
1946	0.9	0.83
1947	2.02	1.68
1948	1.32	0.97
1949	1.42	1.02

The resultant calculations, on the basis of the average run-off for the months of April, May and June, and the thickness and salinity of the surface layer for the months of June, July and August, are shown in the accompanying table.

A good correlation is indicated which suggests the excellent possibility of forecasting the salinity variations of the surface layer during the summer on the basis of the run-off from the St. Lawrence Basin, and also, to a lesser degree of accuracy, the summer minimum salinity along the north coast of Prince Edward Island.

L. Lauzier

Appendix No. 83-B

RECENT WATER TEMPERATURES IN THE BAY OF FUNDY AREA

Continued daily observations of surface water temperatures since 1921 at St. Andrews, N. B., had revealed unusually warm or cold years at different times.

During the 1940-50 decade the waters of the Bay of Fundy area have shown a fairly definite trend towards higher temperatures with a maximum in 1949 and an appreciable decrease in 1950. The plotted data for the period 1940-50 in twelve-month running averages in degree-months are shown in an accompanying figure. Since 1950, even warmer temperatures have been experienced. From December, 1950, to August, 1951, the monthly averages, with the exception of one month, are the highest average temperatures ever observed during the respective months for the period 1921-1950. They were at least 1.5° C. and as much as 2.4° C. higher than the monthly normals.

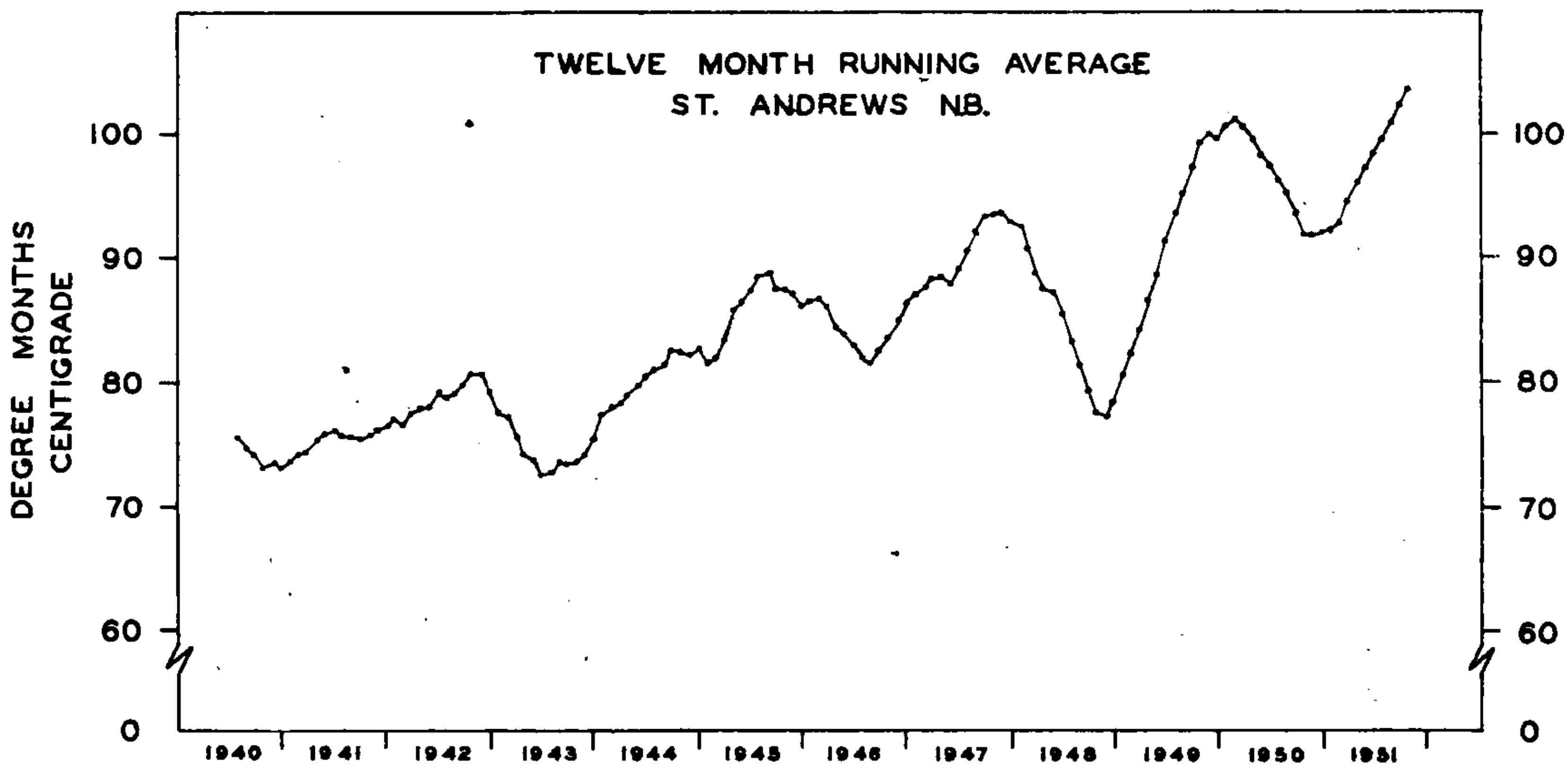
From 1921 to 1940 the variations of the running average ranged between 59.0 and 91.8 degree-months, and since 1941 maxima of 93.5, 100.9 and 103.4 were reached in 1947, 1949 and 1951 respectively. The minimum recorded in 1950 was as high as the maximum of the 1921-1940 period.

For a twelve-month period, the average temperature had reached by September, 1951, the highest ever reported for the area. This twelve-month average is still increasing but it is expected to drop by December, 1951. Moreover, the 1951 average from January to December will be the highest ever recorded.

The accompanying figure shows a certain regularity in the occurrence of maxima and minima which does not mask the general trend. The periodicity of those extremes seemed to be shorter than during the previous decades of 1921-1940.

It is known from previous work that the Bay of Fundy temperatures reflect general water conditions over a large section of the Atlantic coast; hence the high temperatures in the Bay of Fundy area during 1951 are an indication of a general warming of our coastal waters. From the Bay of Fundy to the central southern Gulf of St. Lawrence the surface water temperatures were between 1.7° C. and 2.2° C. higher than the normal; however, this warming was more pronounced during the first five months of 1951 than later in the year.

L. Lauzier



Twelve months running average of surface water temperatures at St. Andrews, N. B. from 1940 to 1951.

Appendix No. 83-C

THE EFFECT OF FREEZING ON THE SULPHATE-CHLORINITY RATIO OF SEA WATER

An investigation into the effects of freezing upon the sulphate-chlorinity ratio of sea water which was commenced at the Scripps Institute of Oceanography in April, 1950, was continued throughout the winter months.

A large tank with insulated sides and bottom was constructed and filled with sea water on which an ice cover was allowed to develop under natural cooling. Analyses of samples taken from the tank before and after freezing, and from the ice cover, confirm the idea that there is a selective retention of sulphate ions in sea ice and a consequent decrease in the sulphate-chlorinity ratio of the waters below the ice. Variations in chlorinity as determined from density and by titration were also studied, but, where they showed any consistency, they were of opposite sign to what would be expected from the abnormalities in sulphate-chlorinity ratios. Further experimental freezings are contemplated.

Water samples from the Scotian Shelf, the Gulf of St. Lawrence and the water around Newfoundland have been examined for sulphate-chlorinity ratio and found to vary in this parameter from 0.1380 to 0.1397. Collection of samples continues and it appears promising that the sulphate-chlorinity ratio may serve as index to the origin and thermal history of coastal waters.

H. J. McLellan

Appendix No. 83-D

THE WATERS ON THE SCOTIAN SHELF - JUNE, 1950, TO MAY, 1951

A report has been prepared on hydrographic data collected on the Scotian Shelf between June, 1950, and May, 1951. Temperature and salinity observations were made during four seasonal cruises of the Atlantic Oceanographic Group. Each cruise occupied twenty-eight stations in four lines running from inshore to well beyond the outer edge of the Shelf. These lines of stations were supplemented by bathythermograph observations between stations and two lines of bathythermographic observations across the eastern banks. Eleven crossings from four cruises of H. M. C. S. "New Liskeard" during the same period were also considered.

The observations permit the development of an unusually warm regime in these waters to be followed. A very mild winter, when chilling of surface waters failed to attain its usual severity, coupled with an incursion of warm bottom waters in the winter months, brought on a period of abnormally high bottom temperatures and almost eliminated the cold "intermediate" layer which is a typical feature of the Scotian Shelf.

In August, 1950, two temperature sections were obtained over the central section of the Shelf separated by an interval of seven days. Two days before the second crossing a severe tropical storm passed along the Nova Scotia coast and completely upset the temperature distribution in the waters. Piling up of surface waters reduced the strong thermocline, where gradients as high as 2° C. per metre had been observed, to one where the maximum gradient was 0.3° C. per metre. The intermediate layer, except for a small volume close to shore, was driven from the area, and a body of water with temperatures as high as 10° C. invaded the deep basin inside Emerald Bank.

The data for this period suggest that the cold water layer on the Scotian Shelf exists in two distinct phases, probably indicative of different origins.

H. J. McLellan and R. W. Trites

Appendix No. 83-E

OCEANOGRAPHIC FEATURES OF THE STRAIT OF BELLE ISLE

The oceanographic features of the Strait of Belle Isle have never been fully described, although tides and tidal currents have been well investigated by the late Dr. W. Bell Dawson, Superintendent of Tidal Surveys. The only extensive study of the oceanographic features in the Strait was made by the Belle Isle Expedition of 1923. This expedition, under the direction of Dr. A. G. Huntsman, was sponsored jointly by the Biological Board of Canada, the Canadian Department of Marine and Fisheries and the Newfoundland Government. It utilized the Canadian Government Fisheries Patrol Steamer "Arleux", and the Motor Boat "Prince" of the Atlantic Biological Station at St. Andrews, N. B.

The oceanographic data from this expedition have been analysed with respect to temperature, salinity and density distribution and are at present being prepared for publication. The oceanographic findings are as follows:

1. A minimum depth of approximately 100 metres and a minimum width of 9 miles (14 km.) are limiting factors in the movement of water through the Strait of Belle Isle.

2. Analysis of temperature, salinity and density distributions indicate the water movements at times as follows:

   (a) A progressive inward movement of water of Arctic and sub-Arctic origin on the north side;

   (b) A progressive outward movement of Gulf of St. Lawrence waters on the south side;

(c) A dominant outward f[illegible] of Gulf water; and

(d) A dominant inward flow of Labrador water.

The latter condition was not observed during the short periods of observations in 1923 but has been described by other observers.

3. The structure of water columns in the Strait of Belle Isle undergo considerable change with time. The differences in time between the appearance of successive maxima and minima suggest that these are related directly to tidal influences.

4. At times some extreme temperature gradients as between the waters of the north and south side of the Strait were observed as follows:

(a) On August 17 the surface temperature gradient was from 3.9° C. on the north to 8.1° C. on the south.

(b) On September 7, when the dominant flow was outward from the Gulf, the surface temperature gradient was from 4.0° C. on the north to 10.0° C. on the south, while the gradient on the bottom was from less than 0.0° C. on the north to -1.0° C. at the centre of the Strait, and 10.0° C. on the south.

5. Three main water masses are found in various proportions in and adjacent to the Strait of Belle Isle as follows:

(a) Gulf of St. Lawrence water from the surface layer with temperature and salinity characteristics of 11.0° C. and 33.3‰, respectively;

(b) Arctic water with temperature and salinity characteristics of -1.6° C. and 33.3‰, respectively; and

(c) West Greenland Current water with temperature and salinity characteristics of 3.5° C. and 34.5‰, respectively.

In addition other water masses whose characteristics have been in part influenced by land drainage and seasonal warming are found in traces within the areas covered by the survey.

W. B. Bailey and H. B. Hachey

Appendix No. 83-F

CUMULATED WATER TEMPERATURES IN THE BAY OF FUNDY AND THE GULF OF ST. LAWRENCE

As growth is, in part, a chemical process, water temperatures constitute a significant factor in the rate of