INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

REDBOOK 1962 PART III

SELECTED PAPERS FROM THE 1962 ANNUAL MEETING

From Serial Numbers:

1013, 976, 967, 968, 1007, 1006, 1008,
989, 955, 1005, 988, 991, 1022, 1001.

NOTE: Following a decision by the Commission in its 1962 Annual Meeting this year's Redbook includes in addition to the Proceedings of the Standing Committee on Research and Statistics and Selected Papers from the 1962 Annual Meeting also the Research Reports for the year 1961 (the research reports up to and including the year 1960 are published in the Annual Proceedings Vols.3 -11). Summaries of Researches, hitherto included in the Redbook, will now appear in the Annual Proceedings.
Due to this great increase in the volume to be included, the 1962 Redbook appears in 3 parts:

PART I	Proceedings of the Standing Committee on Research and Statistics
PART II	Reports on Researches in the ICNAF Area in 1961
PART III	Selected Papers from the 1962 Annual Meeting.

Erik M. Poulsen,
Executive Secretary.

Issued from the Headquarters of the Commission

Halifax, N. S., Canada

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1. RESULTS OF SOVIET HYDROLOGICAL INVESTIGATIONS IN THE ICNAF AREA DURING 1961

I. Hydrological Conditions in Subarea 1

by V.V. Burmakin and I.I. Svetlov

In 1961 hydrological investigations in ICNAF Subarea 1 were carried out aboard the research vessel "Topseda" during May-June and August-September, and aboard the RT "Novorossiisk" during September (see Fig. 1). The r/v "Topseda" made two detailed hydrological surveys, whereas the RT "Novorossiisk" took only trawl hydrological stations -- completing a curtailed program. In addition, some hydrological observations were made aboard the RT "Stalingrad" during April.

In 1961 the ice situation in the Davis Strait was quite favourable which affected the distribution of temperatures in the 0-50 m layer (see Figs. 2 and 3). Warming up was observed earlier than in the years 1959 and 1960. Early in May the temperature of surface water along the coastline north of Frederikshaab was from 1° to 2° (see Figs. 2 and 3).

Negative temperatures associated with accumulation of ice brought by the West Greenland Current, were observed locally at that time in the southwestern sector of the area. The cold waters of the Canadian Current (-1° to 0°) were closest to the area at a point north-west of Holsteinsborg; hence their boundary extended south-westwards. The warm waters of the Irminger component of the West Greenland Current prevailed over the rest of the area with temperatures of 3° to 4°. Fig. 3 shows the waters of this current flowing in a wide stream towards north-west.

The Arctic component was not as well developed in 1961 as in previous years. Its waters occupied a rather narrow zone fringing the coastline with temperatures in May from 0° to 1°, in September from 3° to 4°.

The temperature of waters of the Irminger component of the West Greenland Current in September reached 7-8°. These waters invaded the banks, flowing up their slopes toward the tops. The 6° isotherm, (Figs. 2 and 3), reached the area of Godthaab, whereas the temperature along the coastline was uniformly about 4°.

The following is a description of the hydrological conditions observed on various fishing banks in 1961.

Fig. 4 shows the temperature distribution in the sections across Store-Hellefiske and Lille-Hellefiske banks. In April and May, despite advanced surface heating and thin intermediate cold layers, the temperature of the warm stream of the current on Lille-Hellefiske bank was lower than that observed in the same period of 1959 and 1960. This, apparently, due to the fact that the warm waters flowing up the slope had not reached the top, or that these waters had already

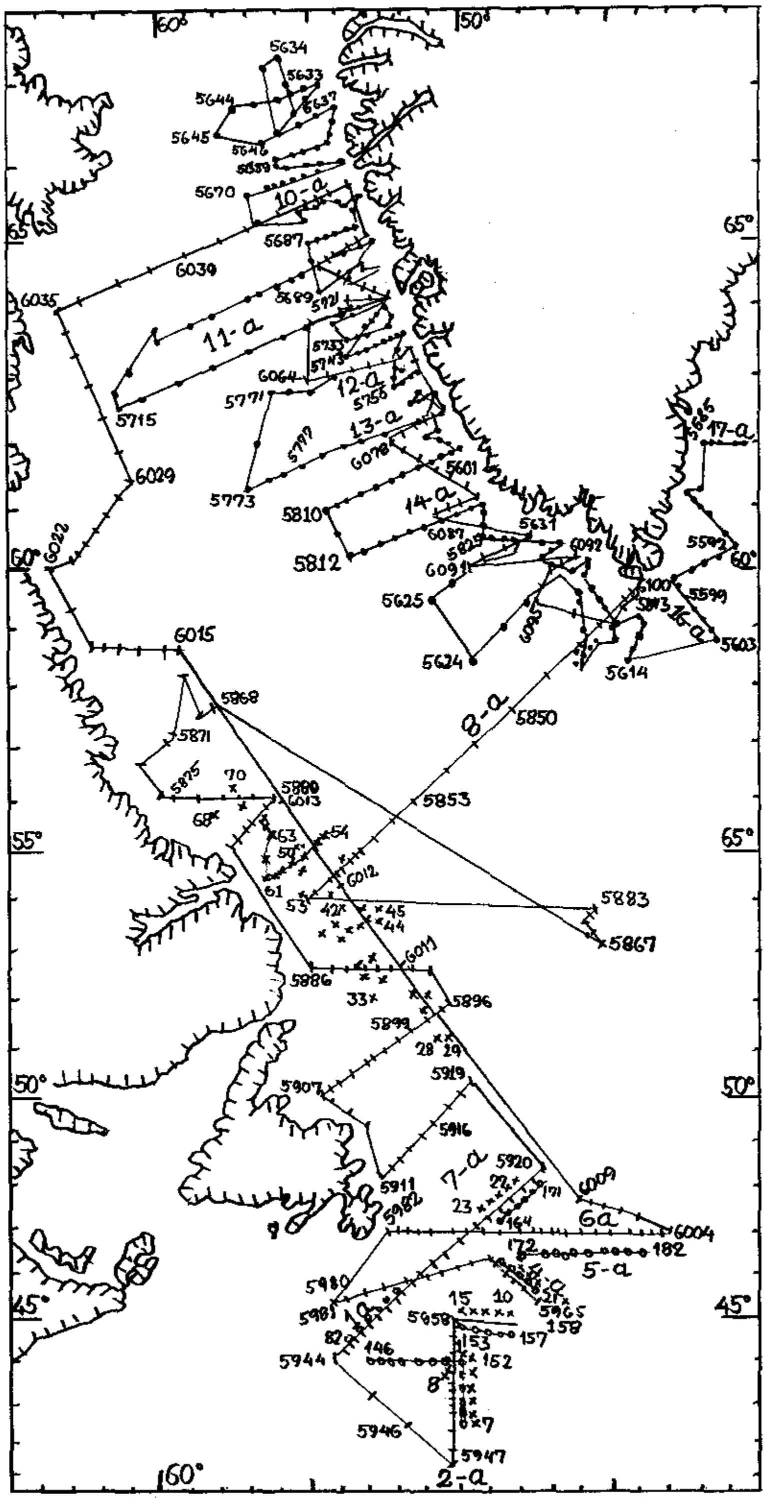

Fig. 1. Sketch map of the hydrological sections and stations in ICNAF Subareas 1, 2 and 3, worked by Soviet vessels in 1961.

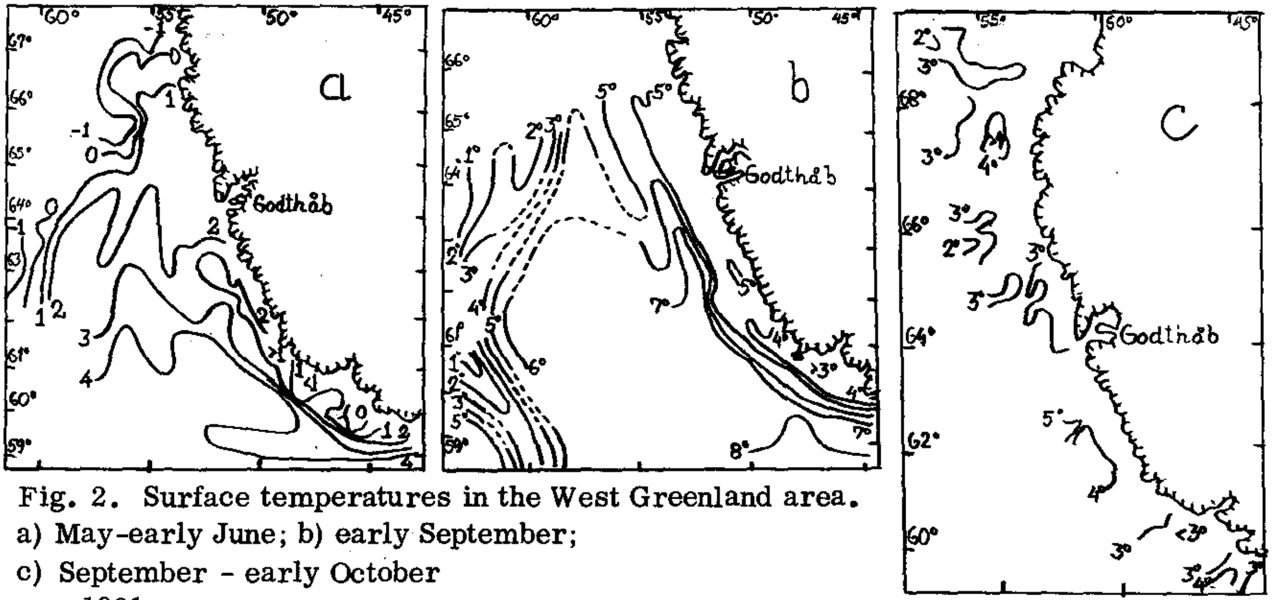

Fig. 2. Surface temperatures in the West Greenland area.
a) May-early June; b) early September;
c) September - early October
1961.

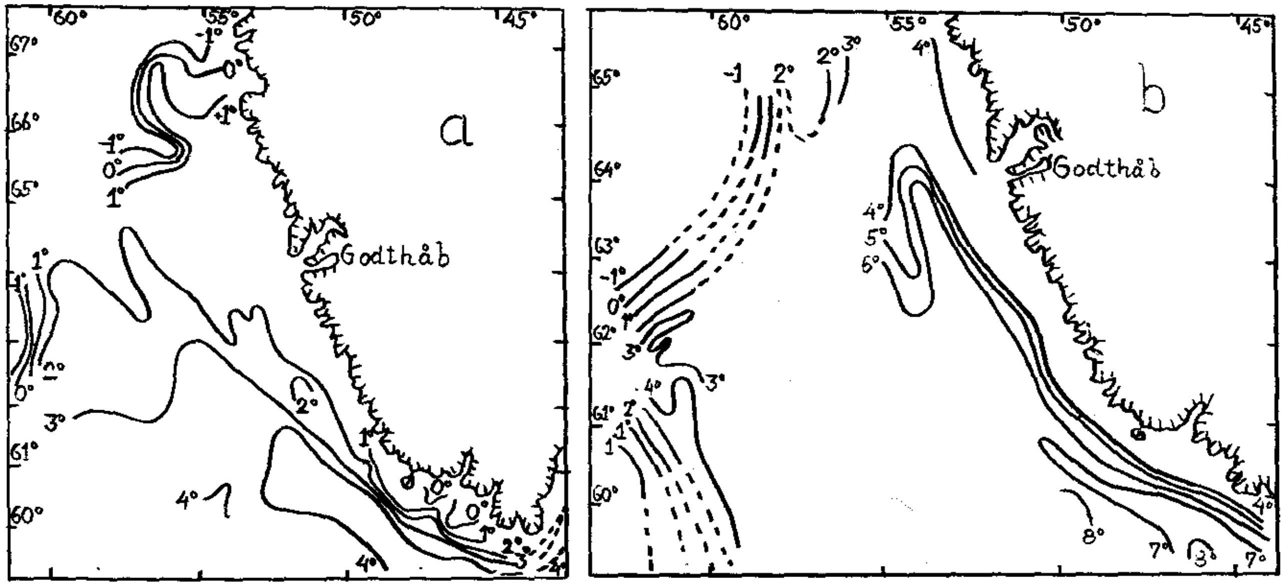

Fig. 3. Temperatures at 50 m depth
a) May-early June; b) early September 1961.

warmed up the cold intermediate layer and lost temperature as a result of heat transfer. Unfortunately, there are no data available for February and March.

In 1961 the cold waters on these banks could be tracked down to 50 to 100 metres. On Lille-Hellefiske bank the average temperatures of the 0-50 metre layer were 0.63° in April, and 1.04° in May, or 0.5°-0.6° above those observed in previous years.

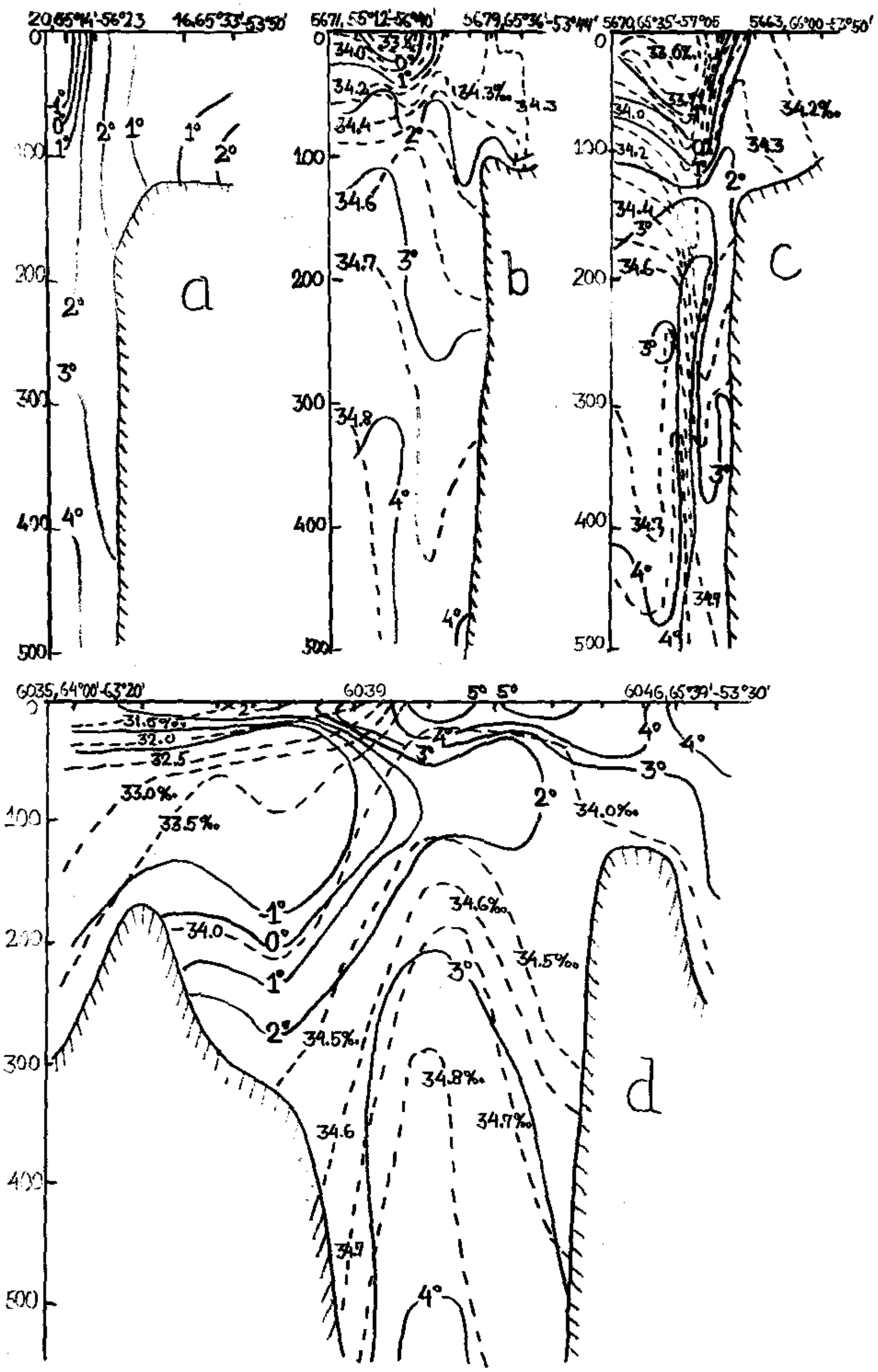

Fig. 4. Temperature and salinities

a. Section across Lille Hellefiske Bank (10a), April 23;
b. Section across Lille Hellefiske Bank (10a), April 24;
c. Section across Store Hellefiske Bank, May 20;
d. Section across Lille Hellefiske Bank and the strait (10a), Sept. 3-5.

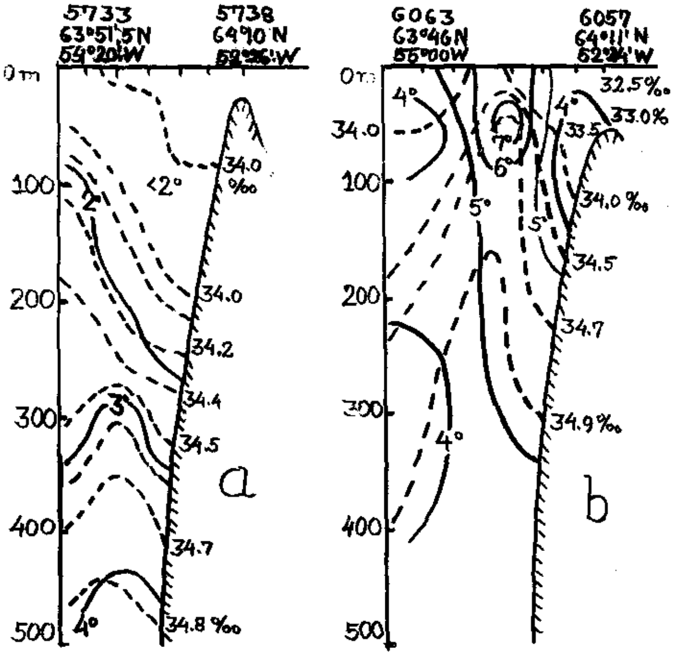

Fig. 5. Temperatures and salinities in the section through the Fyllas Bank (11a)
(a) June 1; (b) September 6-7.

The surface temperature over the tops and slopes of these banks was (Fig.4) from 0.5 to 1.5°, and reached 2° at 150-200 m, whereas in 1959 and 1960 the corresponding temperatures observed in the same season and at the same depths were 3° to 4°.

On the Fylla Bank (Fig. 5) the temperature of water alongside the slope, 150 m, was (in June 1961) 1.5°, rising above 3° only as deep as 300-400 m. In September 1961 the temperature over the slope and the top of this bank reached the level of 3° to 5°, exceeding the June temperature by 2°. The 4° isotherm appeared at 300 m in June, and shifted to 50-150 m in September.

In 1961 the temperature conditions on Fiskenes Bank were formed, as usually, under the influence of the waters of the West-Greenland Current. On the slope of Fiskenaes Bank (Fig. 6) the temperature was (in June 1961) below 2°; in September it went up to 3°-4°. In 1961 the flow of the Irminger component approached closer to the slope than in previous years.

On Frederikshaab Bank (Fig. 7) the surface waters were (in June 1961) heated to only somewhat above 1°, whereas they in 1960 exceeded 2° as early as in April. In September the temperature of the near-bottom layers increased to 4°-5°.

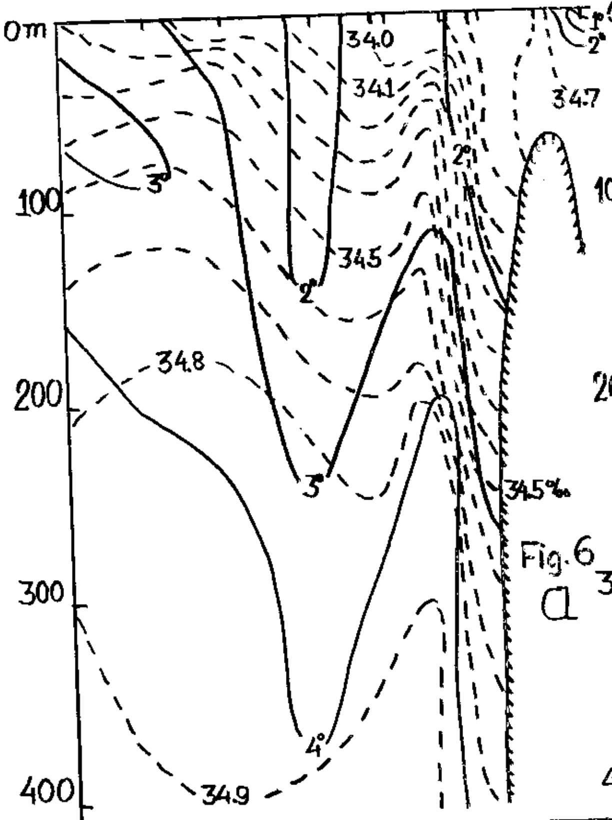

Fig. 6
a

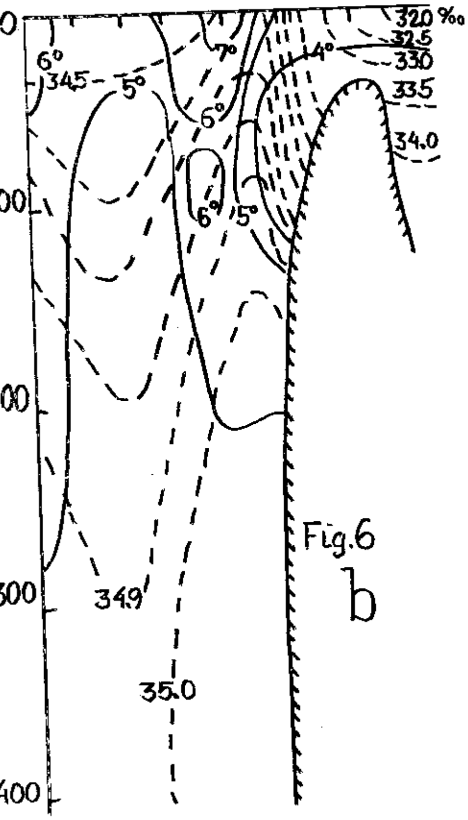

Fig. 6
b

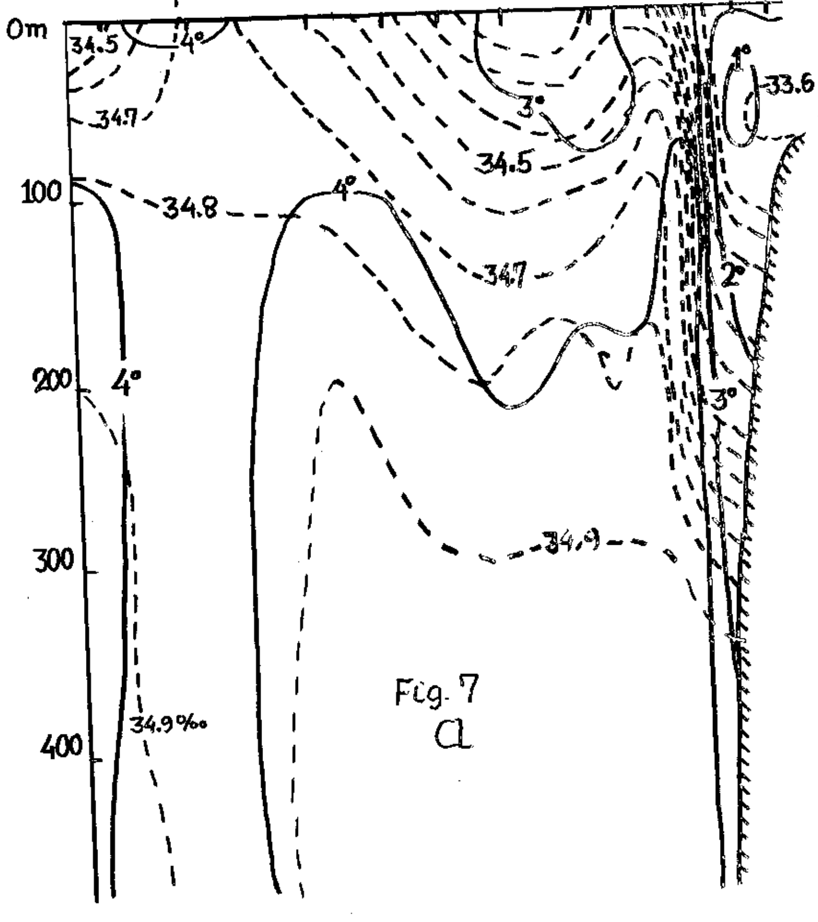

Fig. 7
a

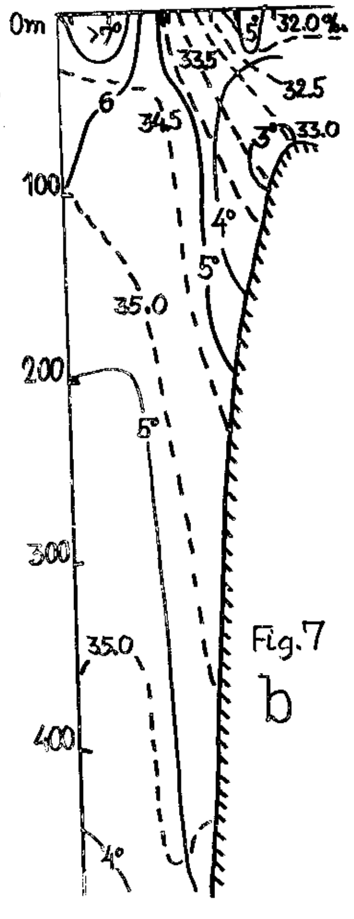

Fig. 7
b

The course of the temperature increase from May to September 1961 can also be traced on the maps of temperature distribution near the bottom (Fig. 8).

In May the coastal zone from Cape Farewell to Godthaab was occupied by waters of 0.5° to 2.0°. At that time the warm Atlantic waters did not yet advance far up the banks, whereas in September they had almost reached the shores. In September the temperature on the banks increased to 4°-5°, and in the southwestern sector to 6°.

Thus in autumn the temperature of water over the banks increases with the increase in the influx of warm waters, reaching its maximum in winter time. The lowest temperature in the near-bottom layers was observed in spring and early summer. In 1961 the minimum summer temperature on Lille-Hellefiske Bank was somewhat lower than in previous years, while on the other banks it remained within the normal range.

The salinity of the waters of the West Greenland Current ranged from 34.1 o/oo to 35.08^{o}/oo during 1961. In May 1961 the salinity of waters over the slopes and tops of the banks, at depths of 50 to 100 metres, was from 34.2^{o}/oo to 34.3^{o}/oo (see Fig. 4). With the increase in depth the salinity increased up to 34.7^{o}/oo. The salinity of the waters of the cold intermediate layer varied from 33.5^{o}/oo to 33.7 o/oo.

The salinity of waters along the shore from Cape Farewell to Godthaab during May and June 1961 varied from 33.0^{o}/oo to 33.5 o/oo (see Fig. 9). The 34.0 o/oo isohaline which, according to Kiilerich, is the conventional boundary of the Arctic current, extended along the banks up to the area north of Godthaab. A concentration of low-salinity waters (33.6 o/oo), formed as a result of thawing of ice and inflow of cold waters of the Canadian current, was observed northwest of Store-Hellefiske Bank.

In September the surface salinity decreased throughout the entire area. It was particularly low (less than 32 o/oo) along the coast from Cape Farewell to Godthaab. During May and June 1961 salinities below 34 o/oo in the near-bottom layer were observed only in the area of Godthaab and Ivigtut. Over the rest of the area it ranged from 34.2 o/oo to 34.9 o/oo.

In September 1961 maximum salinities, up to 35.08 o/oo, were observed in the south, in a warm current stream, and minimum, 31.5 o/oo, at the surface of the narrow coastal strip between Ivigtut and Godthaab.

Headings for Figures on Page 8:

Fig. 6.(above). Section, Fiskenaes Bank; a-June 4-5, 51°39'W to 56°20'W; b-Sept, 7-9, 51°34'W to 55°00'W.

Fig. 7.(below). Section Frederikshaab Bank; a-June 6-7, 50°31'W to 51°05'W; b-Sept. 9, 50°28'W to 52°28'W.

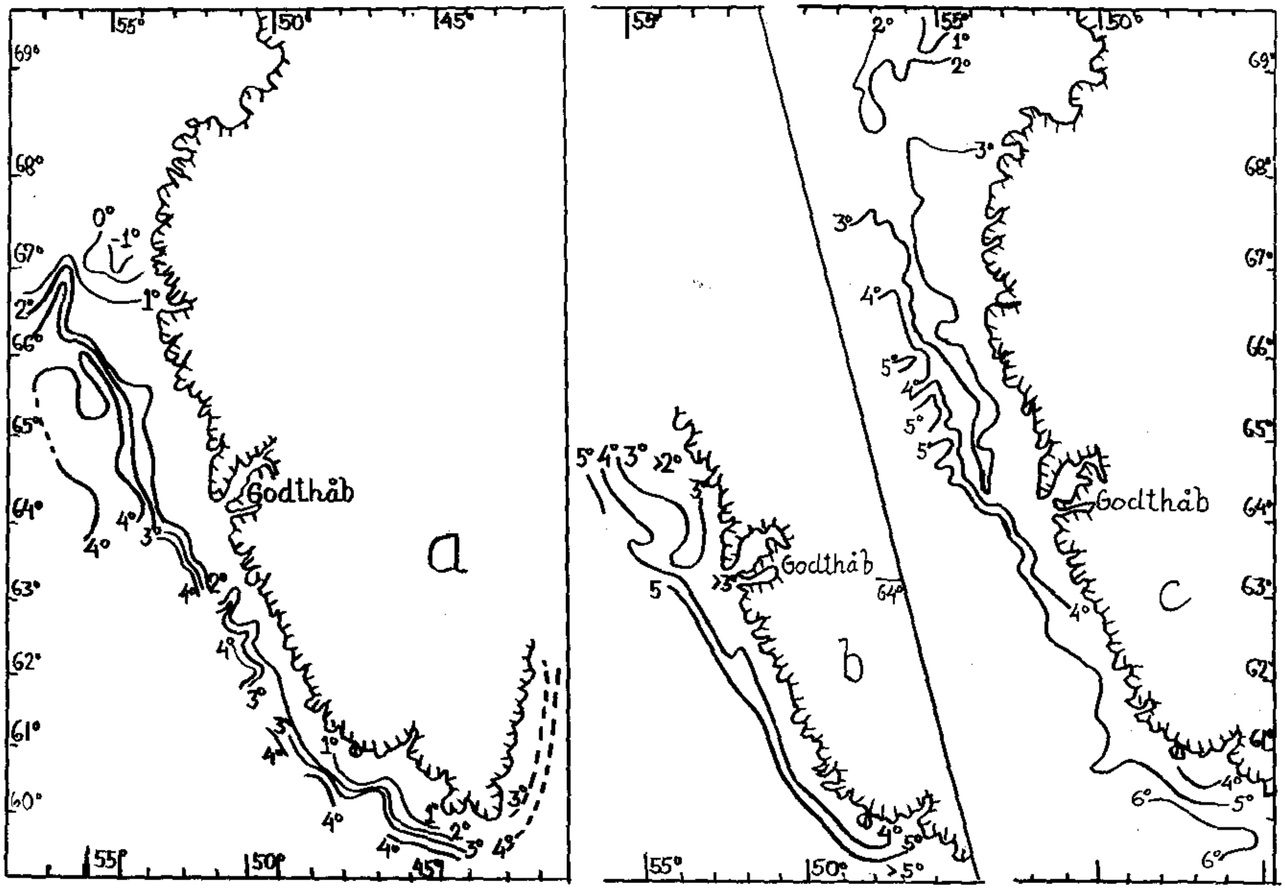

Fig. 8. Near-bottom water temperatures in the West Greenland area
a. May-early June; b. early September; c. September-early October.

Data from the two oceanographic surveys made by the research vessel "Topseda" permitted to construct dynamic topographies for 0-200 m layer. Dynamic horizontals on the maps are spaced at intervals of 10 dynamic millimetres (see Fig.10). The figure indicates that in September 1961, when the temperature stratification took place, the West Greenland current became steadier than during May and June 1961. In September current lines were more strictly directed northwards. Dynamic horizontals became denser within the coastal strip on the banks off Cape Farewell, in the area of Ivigtut and Godthaab, indicating places of increased velocities of currents.

A cyclonic eddy was observed west of Godthaab, with its centre in latitude 63°20' N and longitude 55°00' W. Its appearance was, probably, caused by the configuration of bottom and wind current. The velocities in the eddy were low, from 2 to 5 cm/sec.

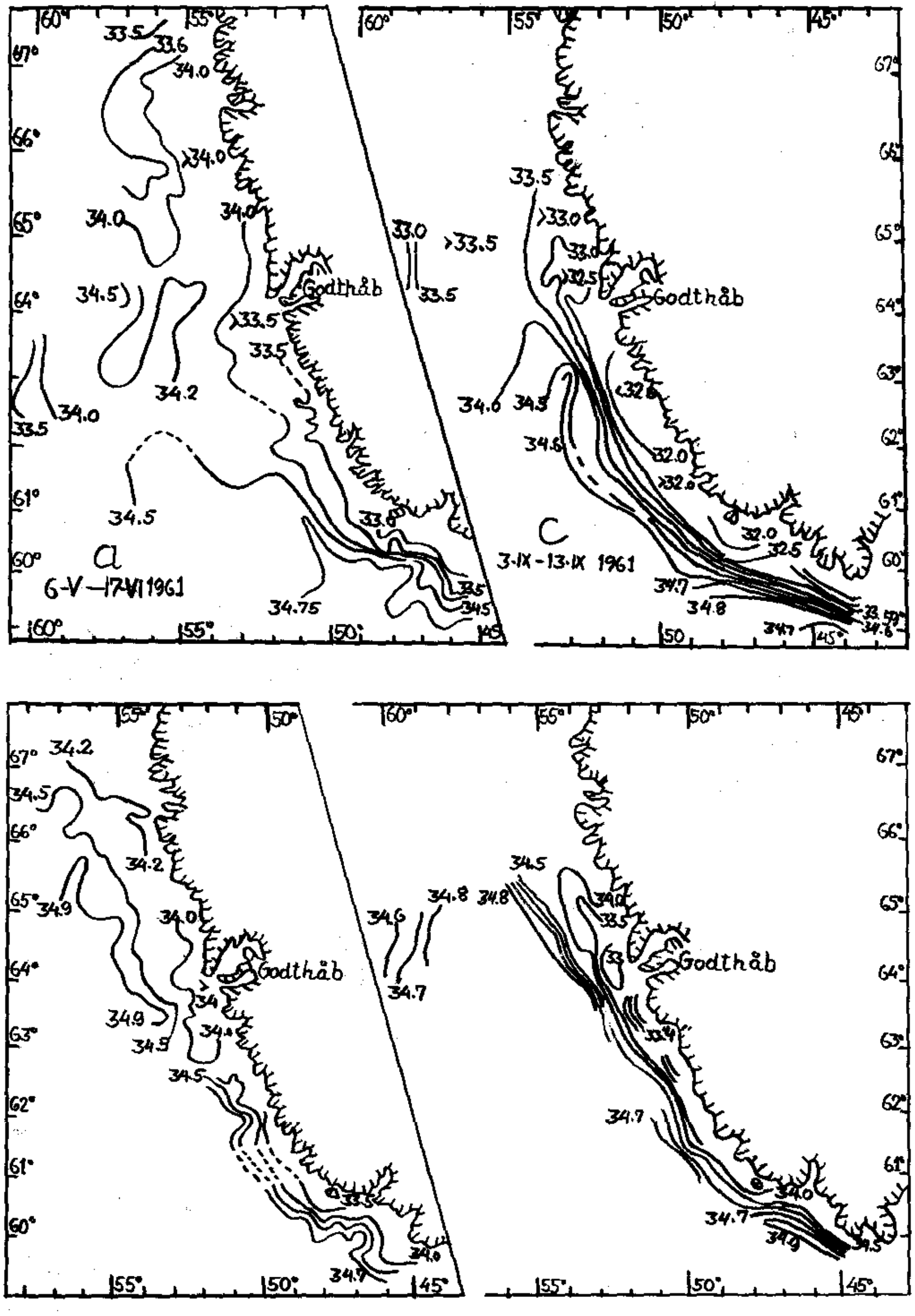

Fig. 9. Salinities in the surface (a,b) and near-bottom (c,d) layers in the West Greenland area.

In early spring, a comparatively steady current could be tracked on the map only in the area between Cape Farewell and Ivigtut, and northwest of Store-Hellefiske Bank where the cold Canadian current made its way to the south invading the shallow regions on the banks.

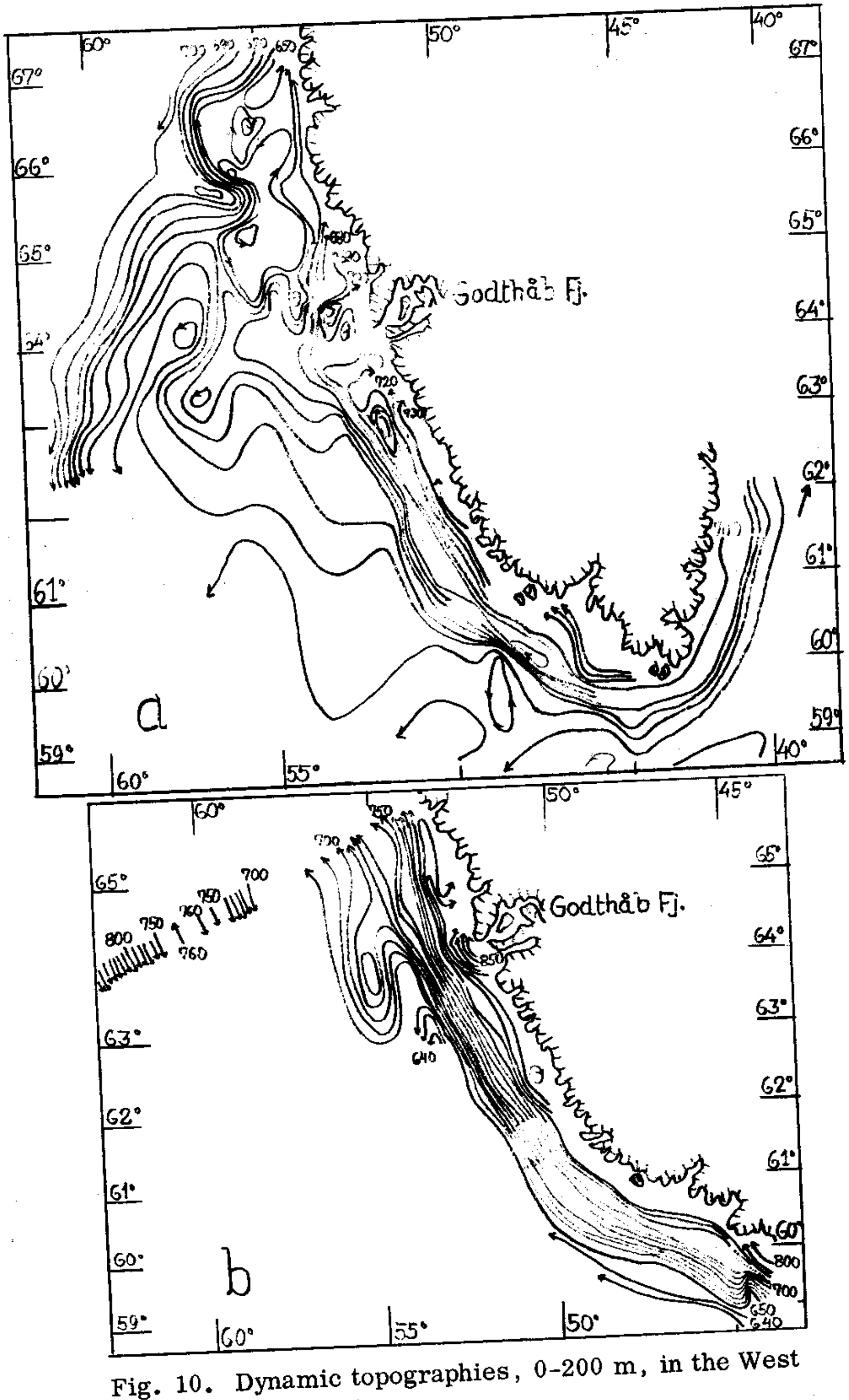

Fig. 10. Dynamic topographies, 0-200 m, in the West Greenland area.
a. May-early June; b. September.

Observations carried out at the stations for 12 hours provided data on velocities and directions of the residual currents. The analysis of the velocities by different methods shows that velocities assessed using the dynamic method are on the average 3-4 times lower than those calculated from the treatment of the instrumental observations.

The latter showed that on Banan Bank velocities of the surface currents ranged from 17 to 27 cm/sec. On the western slope of the bank they increased near the bottom and reached 32 cm/sec., while on the eastern slope they decreased to 13 cm/sec.

Maximum velocities of the residual currents of 36 cm/sec. were recorded in the 15m layer in the southern part of the Greenland coast in the moment of big tides (syzygial). The lowest velocities of the residual currents were found to be on Fiskenes and Dana Banks and made up 6-7 cm/sec.

The cyclonic eddy in the Fiskenes Bank area registered in May was not observed when September survey was done; but the dynamic horizontals in this area being scarce, there is every reason to suppose that insignificant horizontal movements of water masses do take place at this time.

The observations showed that strong tidal currents occur in the West-Greenland area. The velocity values of these currents on Fiskenes Bank, for example, range from 20 to 30 cm/sec. reaching occasionally to 40 cm/sec.

Vectorial-progressive roses (Fig. 2) demonstrate an increase in the velocities from the surface down to the bottom of the Banan Bank.

The bottom configuration distorts the character of the currents. On the Banan Bank the northern and western slopes are smooth, the eastern and southern slopes being steep. Evidently, the current rests on the steep slope, is reflected from it and enters a shallow hollow, and when it meets a smooth slope it moves on steadily almost not distorting the general picture of the current.

On the banks off the southern coast of West Greenland the velocities of the tidal currents on the surface reached 40-50 cm/sec. which considerably exceeds the velocities of the residual currents.

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II. Hydrological Conditions in Subareas 2 and 3.

by Yu. I. Buzdalin and A. A. Elizarov.

In 1961 hydrological investigations in Subareas 2 and 3 were carried out aboard the "Odessa", during July - August, and aboard the "Topseda", during July-September (see Fig. 1). In addition, scouting trawlers kept taking near-bottom and surface temperatures at trawling stations, throughout the year.

In Subarea 2 (Labrador) the standard hydrological section 8A (Cape Farewell - South Wolf Island) was taken late in July. On July 15 average temperature of the 0-200 m layer, calculated from the Labrador current section, at stations 5855/5865, was 0.90°. That was very close to the average temperature for this section for 15 successive years, (1936, 1938-1941, 1948-1957, and 1961), i.e. 0.91°.

In July 1961 the waters of the coastal branch of the Labrador current were heated to a somewhat higher temperature than the waters of its main stream. An analysis of distribution of specific volumes of seawater over the shelf, and results of dynamic treatment of section 8A, indicated that the velocities of the Labrador current in Subarea 2 off the shelf were not high in the year 1961. On the surface they varied from 5 to 20 cm/sec; in a few cases inconsiderable counter-currents, whose velocities never exceeded 2 cm/sec, were observed. The highest velocities, up to 50 cm/sec, were noted over the continental slope, over the depth of about 500 m. Such velocities are distinctive of the warmer water zone of the Labrador current (Elizarov, 1960).

In the summer of 1961 the temperature of these waters was abnormally high. The waters of the cold core of the Labrador current in July 1961 were colder than usual, which later on affected the hydrological conditions in the area of the Newfoundland banks. Hydrological investigations carried out in Subarea 3 (the

Newfoundland banks) revealed that in the summer of 1961 the Labrador current was not as well developed as in 1960.

In July 1961 the current velocities in section 7A, across the northeastern slope of the Grand Banks, calculated by use of the dynamic method, never exceeded 23 cm/sec, whereas in the summer of 1960 they reached 33 cm/sec, and in 1959 -50 cm/sec. The average temperature of the 0-50 m layer in section 3A, across the eastern slope of the Great Newfoundland Bank, on July 5, 1961 was 5.00°, as compared to 4.74° on July 31, 1960.

The average temperature of the 0-200 m layer, calculated from three stations in section 3A, which are supposed to define the cold core of the Labrador current (A. A. Elizarov, L. A. Zotov, 1960), on July 5, 1961 was 1.83°. Although information on July temperatures are not available for comparisons, it can be concluded that the intensity of cold water transport by the Labrador current had considerably decreased. The average temperature for the three stations on July 15 was 0.83°, and the rate of seasonal changes of average temperatures never exceeded 0.02°-0.03° a day.

A number of other hydrological observations confirmed the assumed decrease in the intensity of the cold Labrador current in the summer of 1961.

In the beginning of August 1960 the temperature in the near-bottom layer of the shallow waters on the Grand Banks, at 50 m depth, was 1.8°, whereas in 1961 it exceeded 2° as early as on the first days of July. In July 1960, water with a near bottom temperature below -1° extended down the eastern slope of the bank southward to latitude 45°N; in 1961 no such phenomenon was observed even in the northeast of the Grand Banks.

The absolute oxygen content in the summer of 1961 was lower than in the summer of 1960, hardly ever exceeding 9 ml/l. As it is generally known, colder waters, as a rule, are associated with higher oxygen contents.

Late in July an intensification of transport of the cold waters of the Labrador current within the Newfoundland banks area appeared. On the eastern slope of the Grand Banks near-bottom temperatures were, early in July, above -0.97°; but a month later the area was largely covered by waters below -1°.

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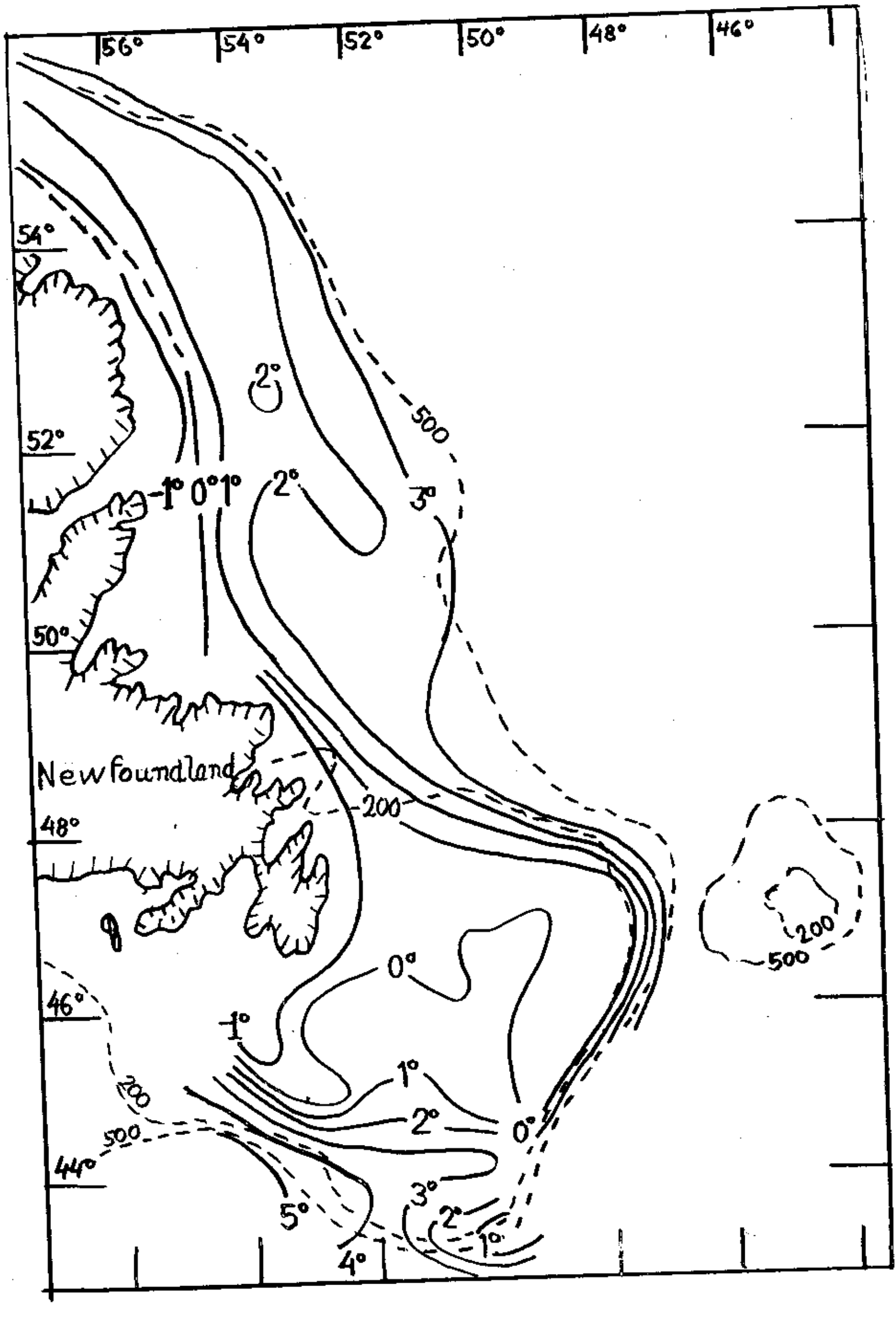

Fig. 11. Near-bottom temperatures in June, 1961.

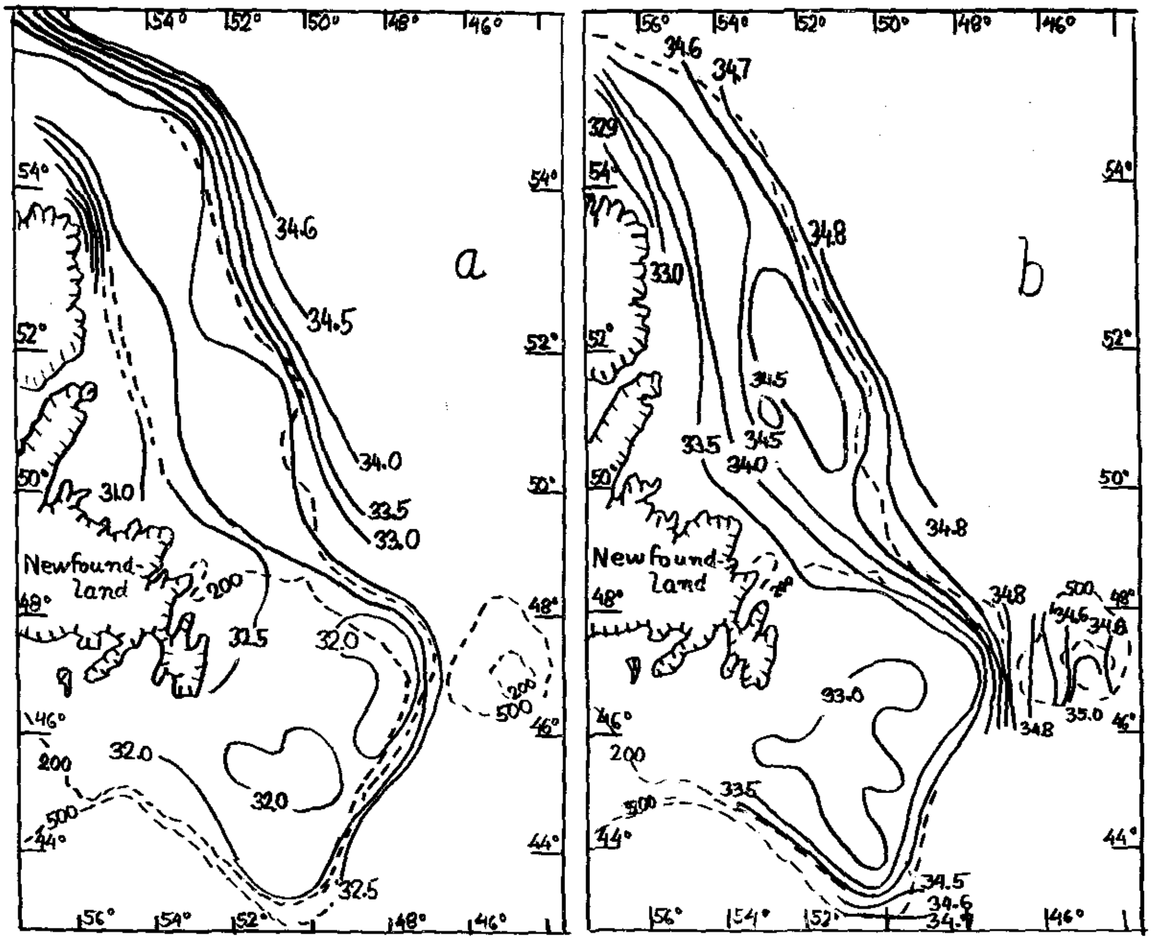

Fig. 12. Salinities a) surface; b) near bottom. June, 1961.

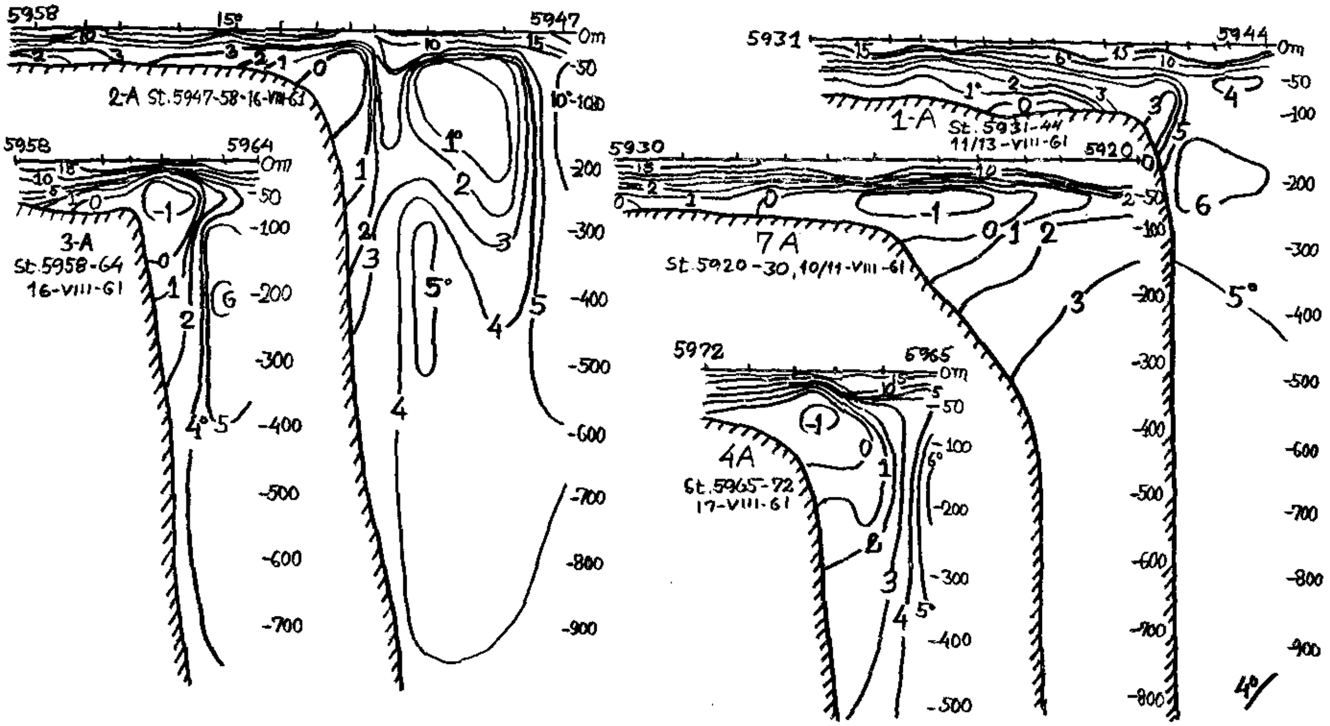

Fig. 13. Temperatures in standard hydrological sections in the area of Newfoundland Banks. Middle of August, 1961.

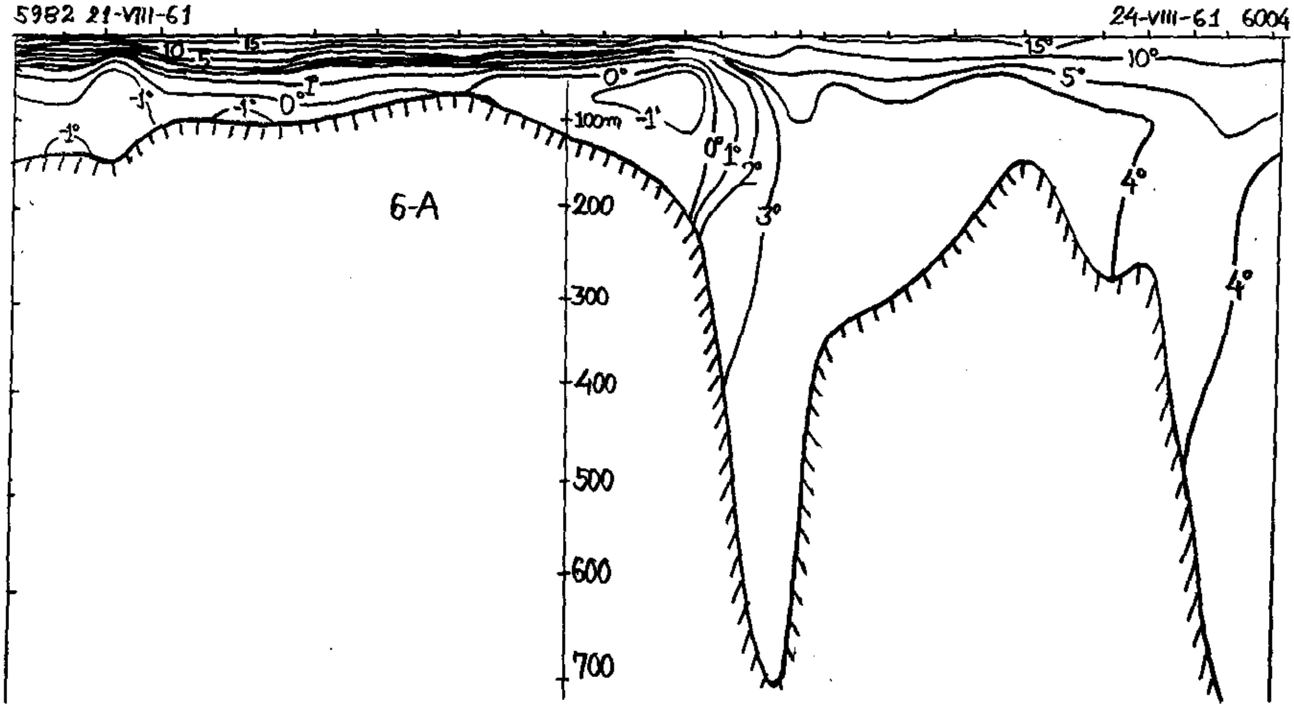

Fig. 14. Temperatures in standard section 6a. August 21-24,1961.

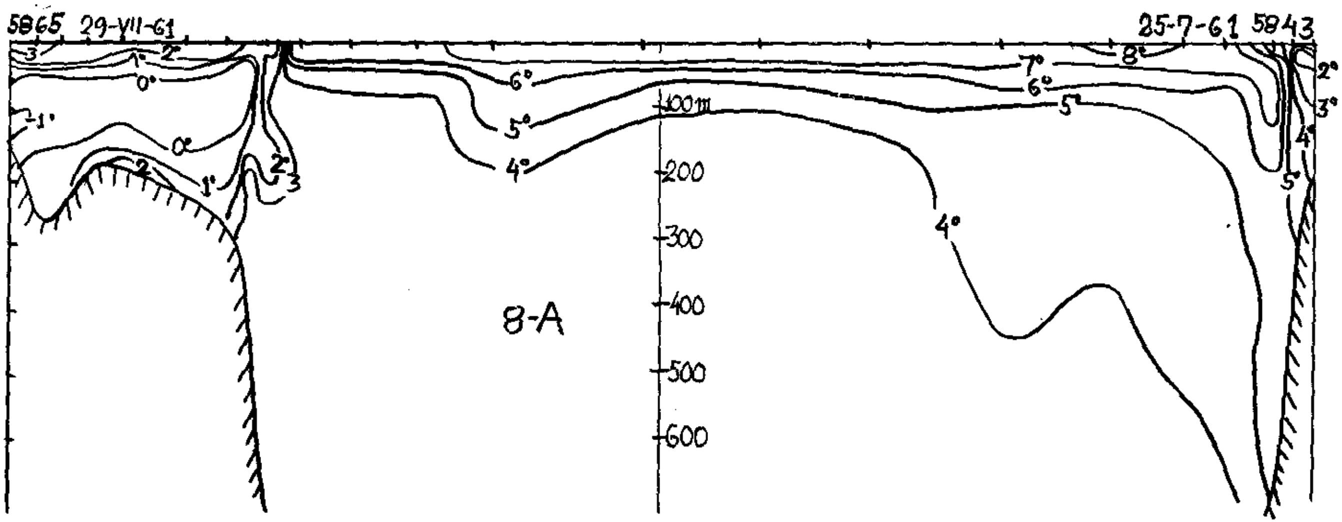

Fig. 15. Temperatures in standard section 8a. August 25-29, 1961.

III. Distribution of Dissolved Oxygen in the Water Masses in the Newfoundland Area.

by M. A. Istoshina

Hydrochemical studies were carried out in all sections (see Fig. 1)in the area of the continental shelf, between 41° and 53° N, as well as beyond the continental slope over

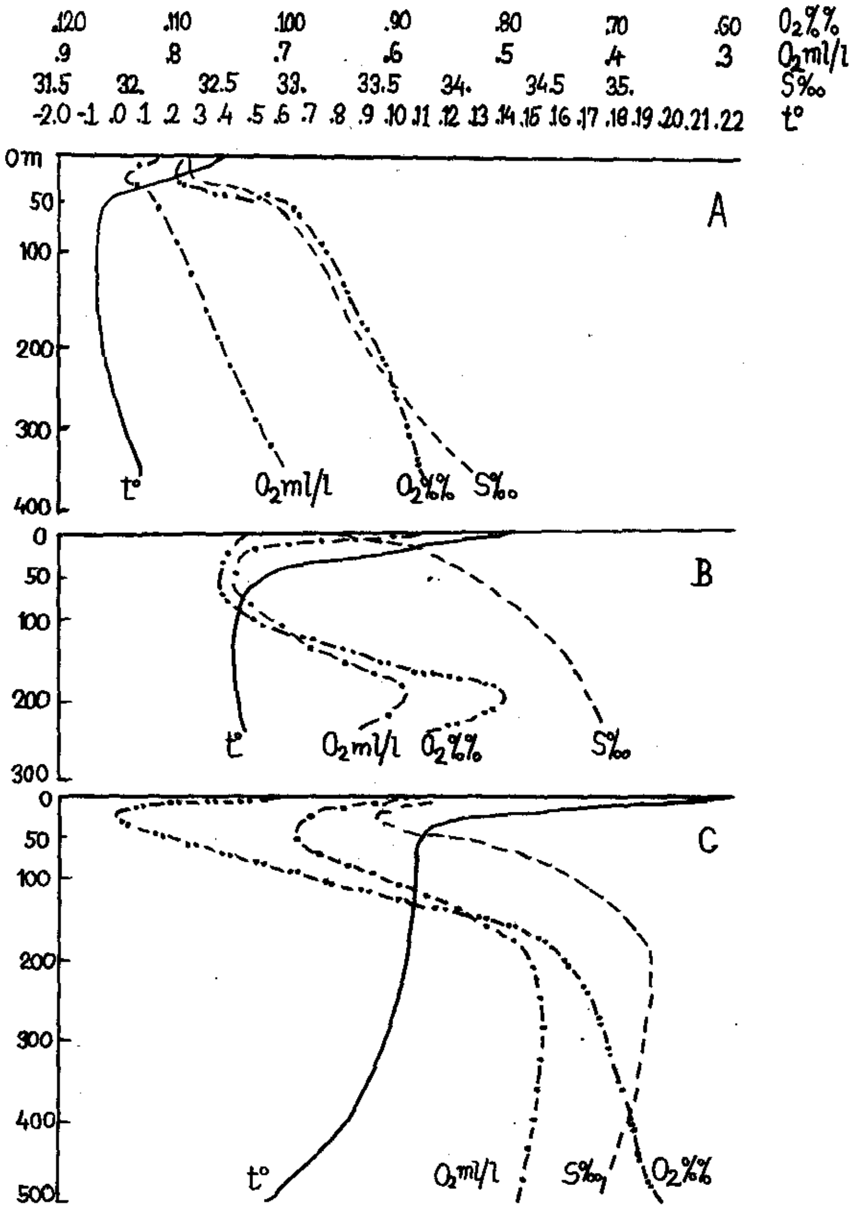

Fig. 16. Vertical courses of temperature, salinity and oxygen content. August, 1961.
A. Labrador Current; B, mixed waters;
C. Atlantic waters.

greater depths, aboard the research vessels "Topseda" and "Odessa", during July and mainly August, 1961. The methods described by Bruevich (1), were employed for analyses of the hydrochemical samples obtained.

It is common knowledge that the hydrological regime in the Newfoundland area is determined by interaction between the arctic waters of the Labrador current and the waters of the North Atlantic current. As a result of their interaction a third mixed type of water is produced. The three types of water differ in contents of hydrochemical elements. The cold waters of the Labrador current have a high content of dissolved oxygen, from 8.0 to 8.5 ml/l. In the warm waters of the North Atlantic current the content of 0_2 is around 5 ml/l. Mixed waters are characterised by the intermediate values of 0_2 content (see Fig. 16). The figure shows the distribution of dissolved oxygen in the surface layer during summer.

The bulk of the surface waters in the area investigated should be classified as mixed waters, except for the northeastern sector where the isoxygen outlines distinctly the narrow wedge of the Labrador current extending down to 51°30' N. Farther southward the Labrador waters gradually lose their original characteristics. The course of isoxygens on the map indicates, however, their presence along the eastern slope of the Grand Bank, up to the zone of their junction with warm Atlantic waters (43° N - 49° 50' W) which have an oxygen content of 5 ml/l and influence the areas of southwestern and southern slopes of the Grand Banks, as well as the southern slope of the Flemish Cap.

Gradual decrease in oxygen content caused by physical and biochemical processes is illustrated by the following figures:

Latitudes	52°40' N	50°20' N	47°00' N	44°56' N	43°10' N
0_2, ml/l	8.05	7.11	6.23	5.98	5.87

The content of dissolved oxygen in the surface waters over the Grand Banks never exceeds 5.7-6.1 ml/l, and in the waters over the Flemish Cap bank it ranges from 6.1 to 6.5 ml/l.

The relative 0_2 content in the surface layer varies between 100% and 108%, except for the cold Labrador waters where oxygenation reaches 118%, which, apparently, should be explained by later phytoplankton "flowering". "Flowering" of phytoplankton in the cold waters of the Labrador current, apparently, begins earlier farther south and moves gradually northwards.

The summer season is characterised by a higher content of dissolved oxygen, reaching 9 ml/l, at the depth of the discontinuity layer which in most cases is located at 25 m level, being formed as a result of powerful radiation heating (see Fig. 16). It can be assumed that the high oxygen contents obtained in the process of phytoplankton "flowering" are maintained in the zone of the discontinuity layer, since the processes of exchange between this zone and underlying layers are impeded, whereas on the surface the 0_2 content naturally decreases with the progress of heating.

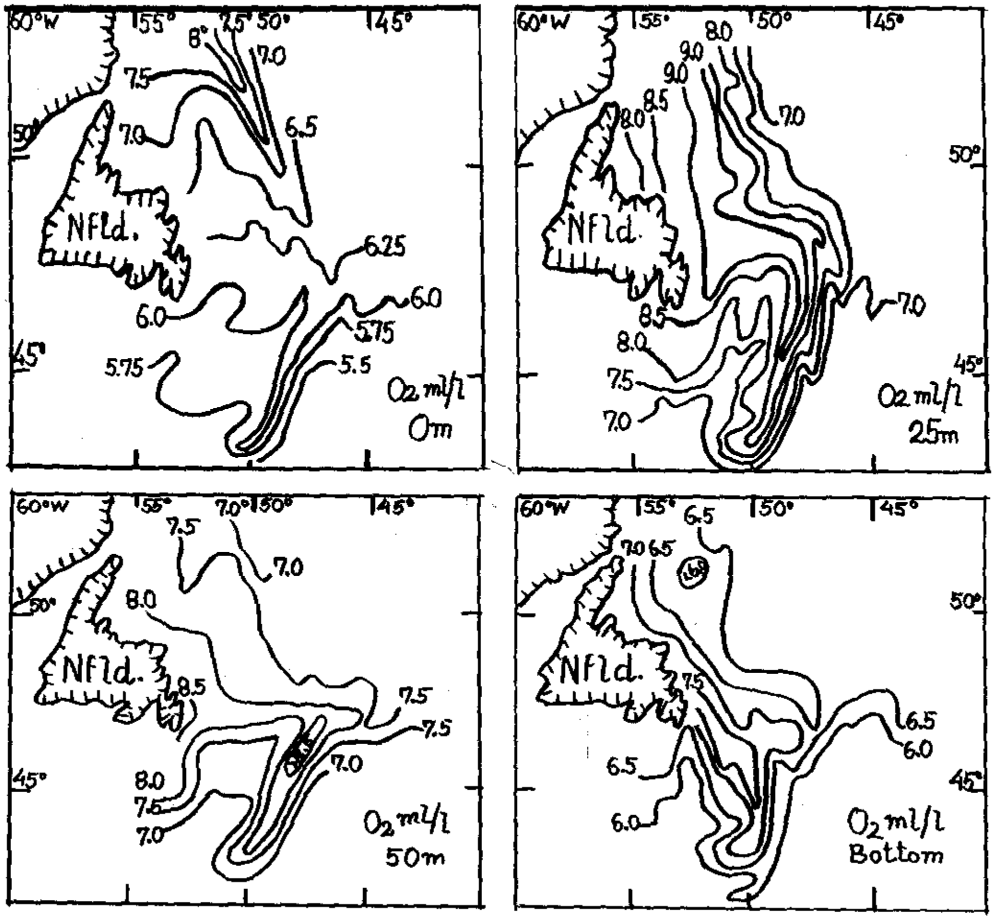

Fig. 17. Horizontal oxygen distribution, ml/l, in the area of Newfoundland Banks. August,1961.

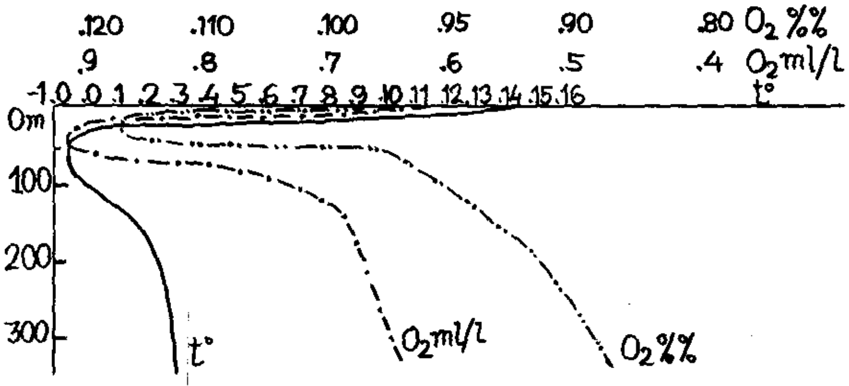

Fig. 18. Vertical courses of temperature, salinity and oxygen content, ml/l, station 5922. August 1961 (see Fig. 1).

A similar picture of oxygen distribution was observed in the year 1960. In the near-bottom waters the oxygen content usually varies between 5.7 - 7.5 ml/l (71-93%). In the southwestern area of the Great Banks the O_2 content is from 5.9 to 6.8 ml/l (71-84%), in the south-east - from 6.6 to 7.1 m ml/l (84-90%), in the southern portion of the bank - from 7.1 to 7.3 ml/l (87 - 92%), and over the Flemish Cap - from 5.7 to 6.3 ml/l (77-88%). (See Fig. 17).

The picture of the vertical distribution of dissolved oxygen during summer reveals the following peculiarities:

a. Relatively low O_2 content in the surface layer as compared to that at the 25 metre level.

b. Maximum oxygen content in the zone above the discontinuity layer.

c. Abrupt decrease in oxygen content below the discontinuity layer. (See. Fig. 17).

d. Minimum oxygen content at 200-500 m levels (from 4.5 to 5.9 ml/l, or 64- 82%) in the areas influenced by the North Atlantic current, see table below:

Position	44°00' N 54°20' N		44°14' N 53°59' W		44°24' N 50°15' W		44°53' N 48°30' W		45°20' N 47°22' W	
Depth	O_2		O_2		O_2		O_2		O_2	
m	ml/l	%	ml/l	%	ml/l	%	ml/l	%	ml/l	%
0	5.71	101.8	5.92	104.2	5.45	100.0	5.73	102.2	5.56	98.6
25	7.67	114.3	6.52	113.4	6.77	115.3	7.32	116.6	8.19	115.2
50	6.66	92.2	7.29	102.8	6.85	108.7	8.06	103.6	7.05	95.5
200	5.56	79.0	4.95	71.3	4.69	74.1	5.69	81.5	4.46	64.4
500	5.71	79.5	-	-	4.83	68.7	5.93	82.0	5.57	77.9
1000	6.16	85.0	6.12	84.2	6.48	88.0	6.36	86.5	6.08	83.6

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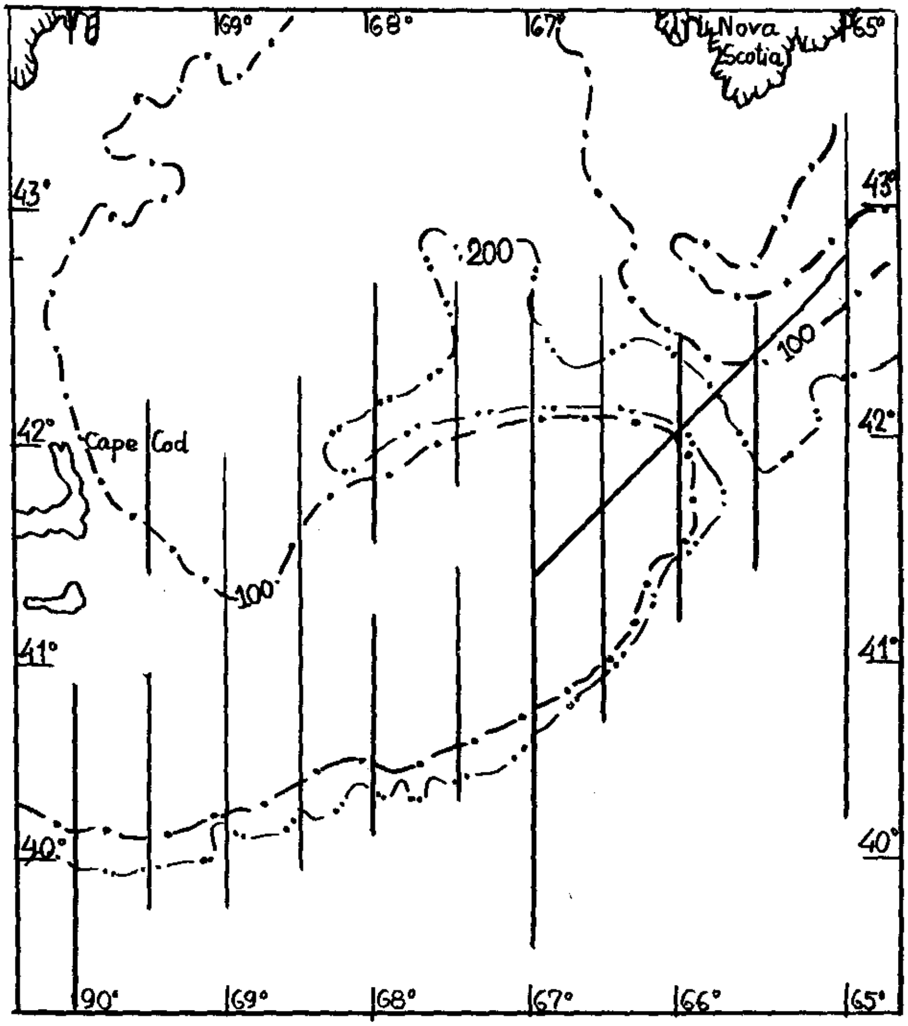

Fig. 19. Oceanographic sections in ICNAF Subarea 5 worked by the r/v "Balaklava" and the r/v "Boguchar" in 1961.

IV. Hydrological Conditions in Subarea 5

by A.A. Klimenkov and V.I.Pakhorukov

Three oceanographic surveys were made in the area of the Georges Bank during the year 1961. In June and December observations were carried out aboard vessels of the Polar Research Institute, and in October in co-operation with vessels of the Baltic Research Institute. The surveys covered the oceanographic stations in standard meridional sections 10' apart. The area from the central part of the Gulf of Maine in the north, to the warm Atlantic waters south of Georges Bank in the south, between longitude 65° and 70° W, was surveyed (see Fig. 19). As the hydrological data are inadequate, a detailed description of the hydrological regime in the area is not possible. Therefore the present paper is limited to the discussion

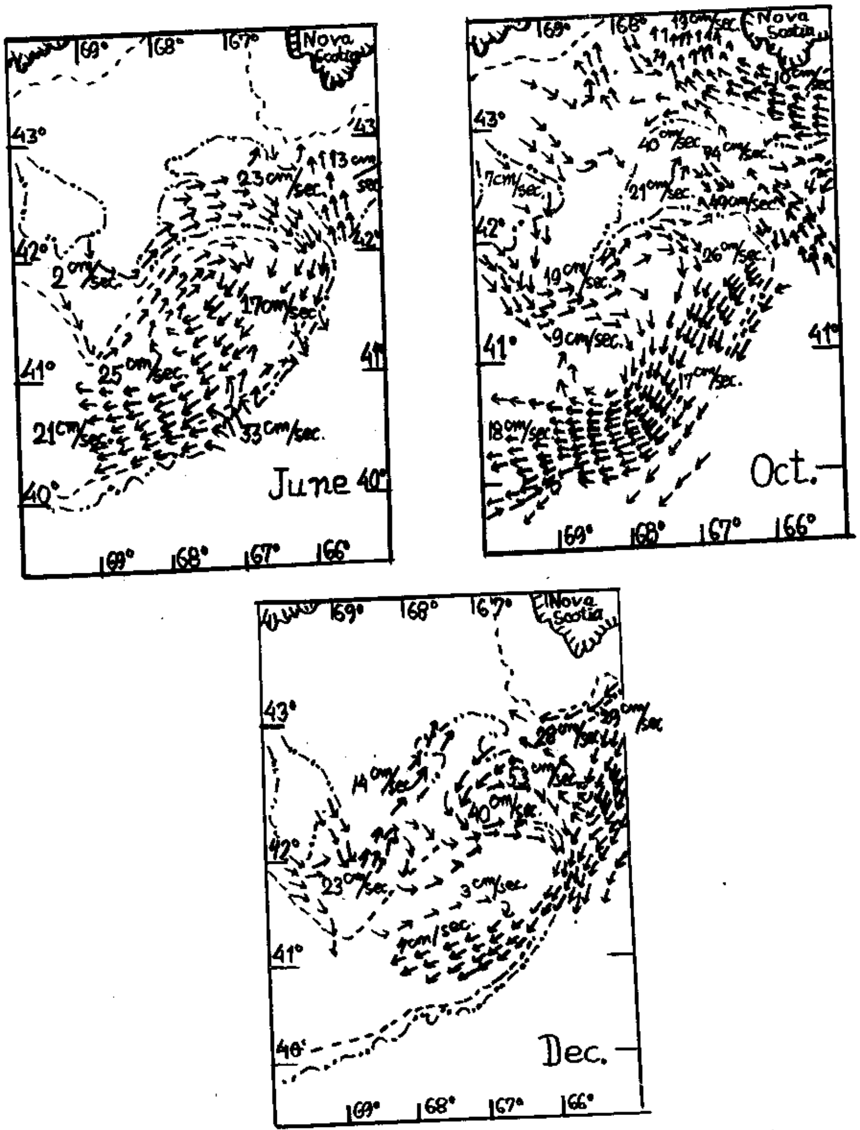

Fig. 20. Sketch maps on permanent surface currents over the Georges Bank for June, October and December, 1961.

of the hydrological conditions as observed in the summer and autumn-winter seasons of 1961.

Sketch maps of surface currents for the summer and autumn-winter seasons, based on the results of dynamic treatment of hydrological observations, were constructed (see Fig. 20). These maps represent only qualitative characteristics of the water masses movement in the area investigated. The quantitative indices for permanent currents are liable to be questioned, as they were produced without considering the effects of the heavy tidal currents. The sketch maps, however, appear to be in good agreement with the results of drift-bottle experiments conducted by the US research vessel "Atlantis" in June 1933 (see Fig. 21).

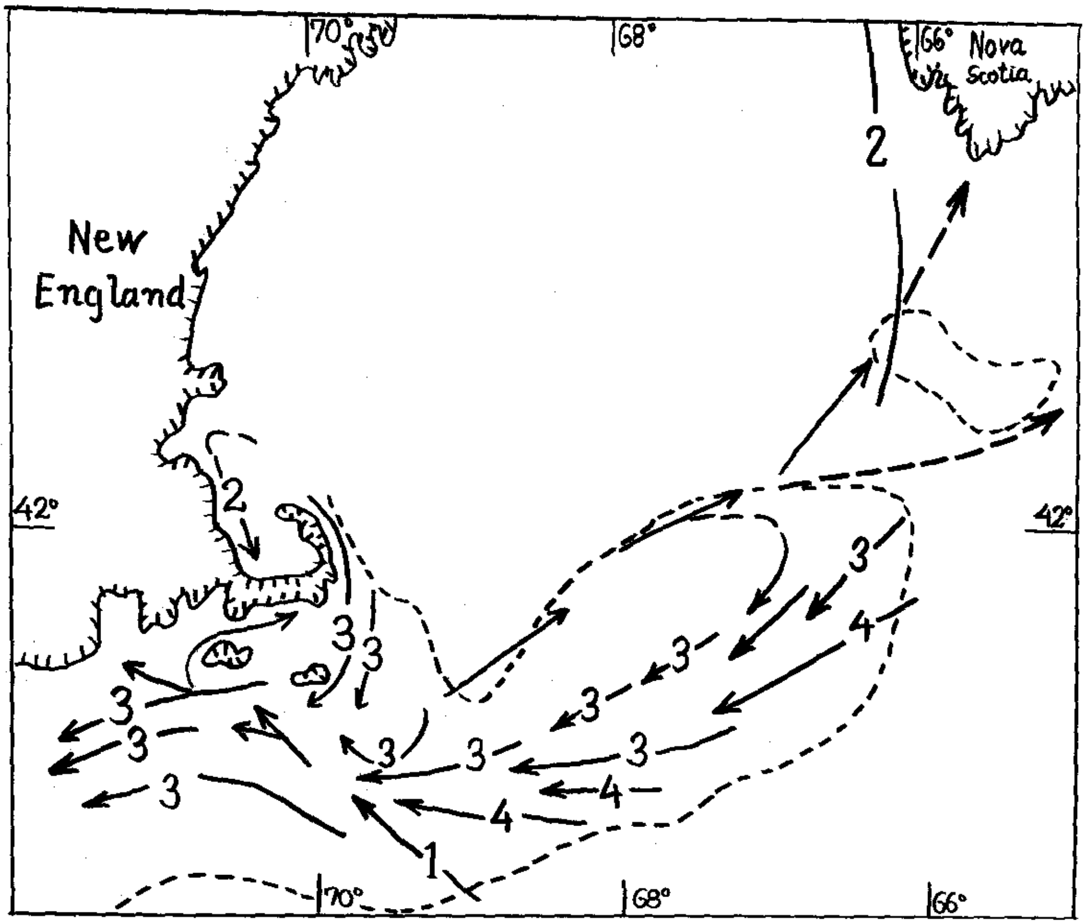

Fig. 21. Course of drift bottles on the Georges Bank in June, 1933, as observed from the US r/v "Atlantis" (velocities in miles/day).

An analysis of the maps on permanent surface currents revealed: 1) the currents over the bank were of anticyclonic nature and followed the contour of the bottom; 2) a complex interaction of water masses took place in the area of the Georges Bank.

The centre of anticyclonic movement of waters was observed over the shallower northern part of the bank. Its location changed with the season. In June, e.g., it was observed over the northern part of the bank; in October it shifted a little southwestwards; in December it shifted southwards and was poorly defined. The changes were caused by the prevailing northern wind. According to Day, 1958, the system could be even completely destroyed by long-lasting north-western winds.

The velocities of the anticyclonic movement over the Georges Bank were also subject to seasonal changes. The results of dynamic treatment of the observations revealed, that the velocities in the central part of a radius of the gyral were 18 cm/sec in June, 9 cm/sec in October, and from 3 to 4 cm/sec in December. In the peripheral zone of the gyral, where the waters interacted with waters of diverse origin, the velocities increased. In the northeastern sector they were 32 cm/sec in June, 50 cm/sec in October, and 40 cm/sec in December.

Waters of diverse origin interacted in the area. There were slope waters formed as a result of mixing of the cold Labrador waters with the diluted waters from the Gulf of Saint Lawrence, and with Atlantic of high salinity. They arrived from the direction of Browns Bank. A portion of the slope waters, fringing the Browns Bank from south-west, entered the Gulf of Maine through the trench between Georges Bank and the Browns Bank, at 0-100 m depths. Within the Gulf of Maine it joined the stream fringing the northern slope of Georges Bank. Another portion of the slope waters extended alongside the southern slope of the Georges Bank. With north-eastern winds, the bulk of the slope waters flowed along the continental shelf. A branch of the Gulf Stream was observed over the south-western slope of Georges Bank.

The northern and northwestern slopes of Georges Bank, from 0 to 50-60 m depth, were covered with waters from the Gulf of Maine. The layer from 60 m depth to bottom was composed of water resulting from interaction between transformed Atlantic waters and the waters from the Gulf of Maine. The central part of the bank was covered with bank waters proper, - a mixture of Atlantic slope waters and waters from the Gulf of Maine, produced by the action of the anticyclonic system.

Hydrological and hydrochemical observations were conducted before the surveys began, from April 17 to June 28, and after their completion, from October 12 to December 28, 1961. From the middle of April till the end of June the surface temperature increased from 3.7° to 12°. In summer, on sunny days, the temperature increased sometimes with 0.5°. Recurrent thick fogs with southern component winds impeded the process of warming. Maximum surface temperatures (up to 19°) were observed from fishing vessels on sunny calm days in August. In the autumn-winter season, with cold northern winds, abrupt falls of the temperature of air, from 6° to -3°, and of surface water to 0.3°, were occasionally observed in the course of one day.

Figs. 22 and 23 represent horizontal distribution of temperature and salinity, for 0 m, 50 m depth and near-bottom layer, as calculated from the data of three oceanographic surveys. They show that hydrological and hydrochemical characteristics of various sectors of the Georges Bank were not uniform.

In the central sector of the bank waters were mixed all way down to the bottom in June, October and December. The temperature was from 7° to 8° in June, 12° in October, and 7° in December; the salinity from 32.2 to 32.6 o/oo in June, 32.4 o/oo in October, and from 32.6 to 32.7 o/oo in December.

In the area off the southern and south-western slopes of the bank the presence of Atlantic waters, rising in several homogenous tongues up to the 80 m isobath, was

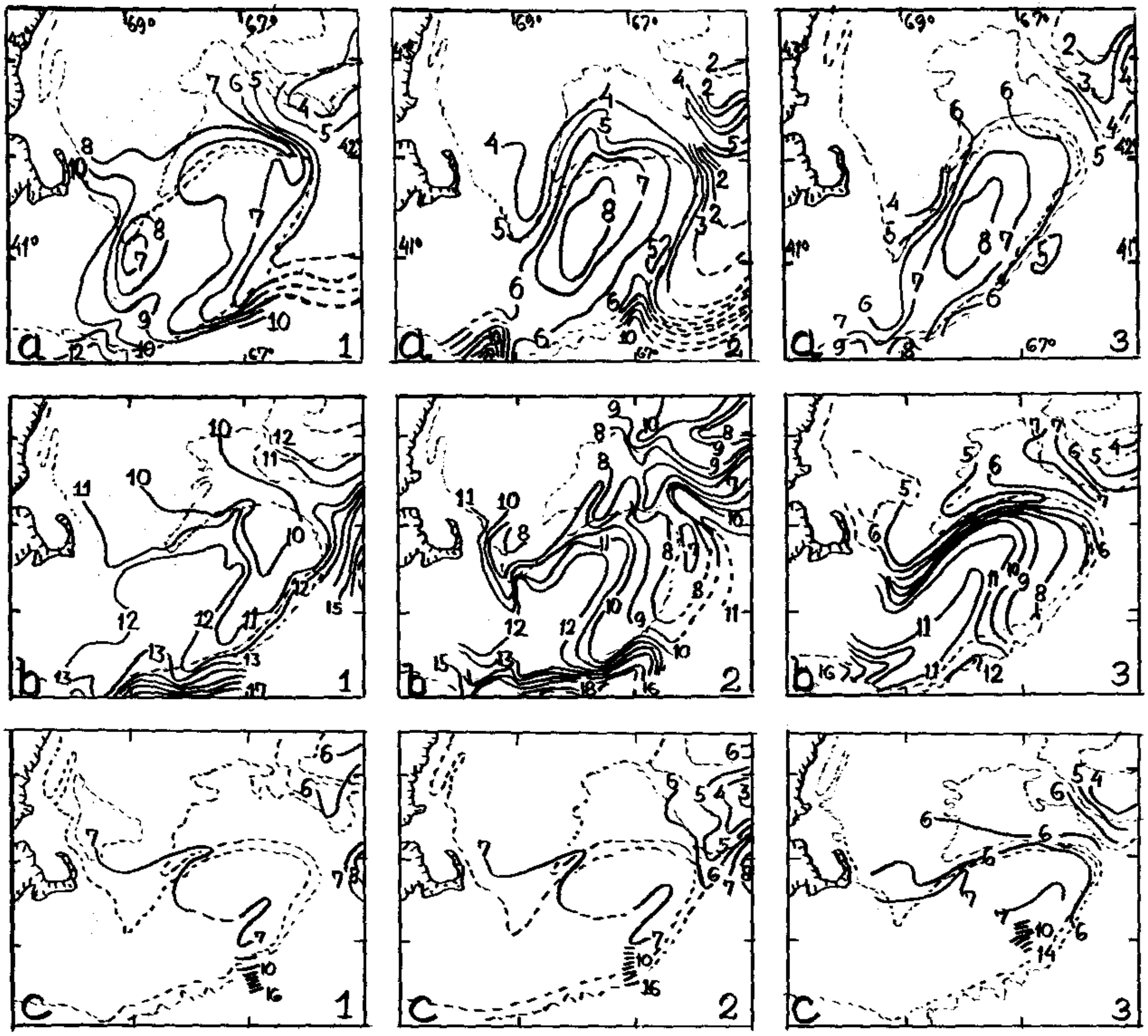

Fig. 22. Isotherms for various sea levels in the area of the Georges Bank.
a. June; b. October; c. December, 1961.
1. o m; 2. 50 m; 3. near-bottom layer.

observed. South-western winds assisted the intrusion of Atlantic water masses. The temperature of the Atlantic waters was from 10° to 13° in June, from 16° to 18° in October, and from 14° to 16° in December; their salinity was subject to slight seasonal changes within a range from 35.0 to 35.8 o/oo. High temperature (up to 0.3° per mile) and salinity (up to 0.2 o/oo per mile) gradients, caused by convergence of heterogenous waters, were observed in this area.

The eastern and southeastern slopes of Georges Bank were fringed with rather cold circumfluent slope waters, extending southwestwards from the direction of the Browns Bank and from the Gulf of Maine, along the continental shelf (see Fig. 24). The temperature in the Gulf of Maine was from 6° to 7° in June, 10° in October,

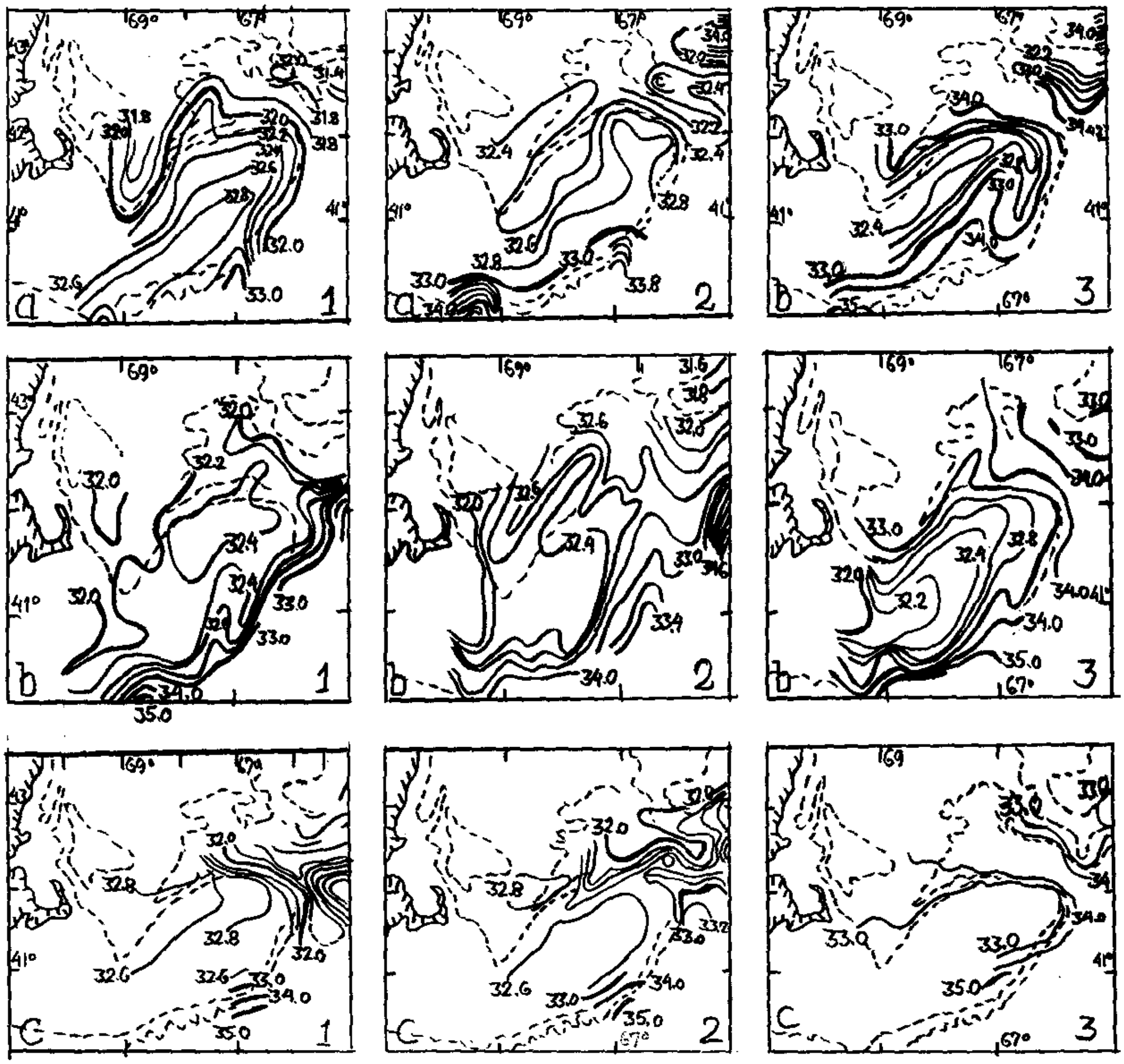

Fig. 23. Isohalines for various sea levels in the area of the Georges Bank in June, October and December, 1961, a, b, and c respectively. 1) 0 m; 2) 50 m; 3) near-bottom layer.

and 6° in December; the salinity during the summer and autumn-winter seasons ranged from 32.0 to 32.3 o/oo. The temperatures and salinities of the slope waters were somewhat lower; at 50 m the temperature in June was 1°, in October 6°, and in December 2°. The upper layer in the summer-autumn season was heated to the depth of 25 m (up to 6° in June, 12° in October, and 6° in December). The salinity of slope waters, up to a depth of 50 m was 31.44 o/oo in June, 31.14 o/oo in October, and 31.53° in December; in the near bottom layer the salinity varied from 32.05 o/oo to 32.99 o/oo.

The greatly transformed Atlantic waters extended northwestwards along the near-bottom layer (150-200 m) of the trench between Georges and Browns Banks, filling the deep in the central sector of the Gulf of Maine. The extension of these waters was limited by, approximately, the 200 m isobath.

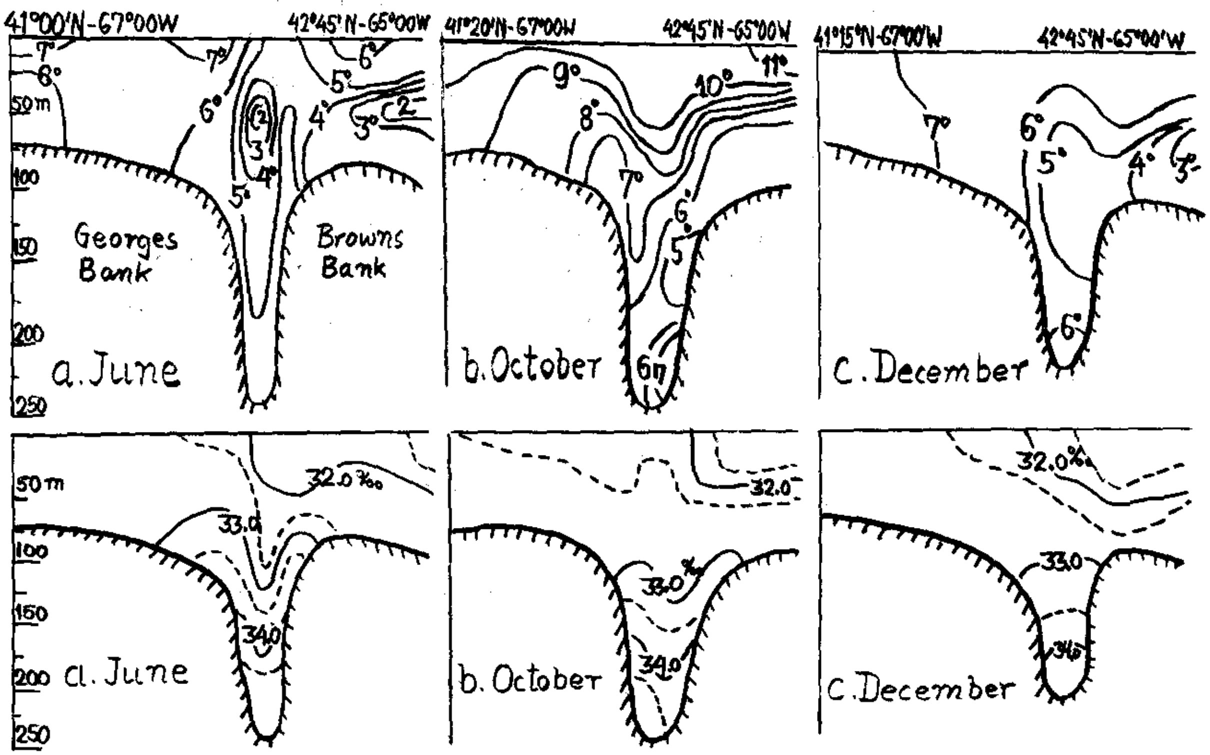

Fig. 24. Temperatures and salinities in the section across the trench between the Georges and Browns Banks, 1961.

On the northern slope of Georges Bank the waters of Atlantic origin, interacting with the waters from the Gulf of Maine, formed a frontal zone with temperature gradient of 0.1° per mile, and salinity gradient of 0.1° o/oo per mile. The slope waters entering the Gulf of Maine through the trench on the side of Browns Bank, differ only inconsiderably from local waters in temperature and salinity ranges in the 0-100 m layer (their temperature was from 4° to 5° in June, from 8° to 10° in October, and from 5° to 6° in December; the salinity-from 32.0 to 32.8 o/oo in June, from 32.3 to 33.0 o/oo in October, and from 32.4 to 33.0 o/oo in December.

CONCLUSIONS
(Summary)

1. The Georges Bank area is an area of complex interaction of three water masses: The Atlantic waters, the waters from the Gulf of Maine, and the slope waters.

2. The central sector of the bank is covered with bank waters proper, which are derivatives of the waters named above. The anticyclonic gyral in the centre of the bank is, apparently, the mechanical force assisting in formation of these waters.

3. The water dynamics in the Georges Bank area are most strongly influenced by northeastern, northwestern, and southwestern winds. The north-

eastern winds intensify the flow of slope waters along the line of the continental shelf and can completely destroy the anticyclonic gyral over the bank. The southwestern winds intensify the intrusion of the high-salinity Atlantic waters into the Bank area.

4. For the recurrence of fogs in summer time the area is second only to the Newfoundland Bank. The highest rate of recurrence and duration of fogs is observed in May and June, with southern winds, in the zone of junction of warm and cold currents. During the first half of summer thick fogs impede the process of warming up of waters.

5. The surface temperatures on the bank are varying in the course of a year from 2° to 19°, the maximum degree of heating being observed in August and September.

6. The maximum degree of freshening of waters in the area was noted in the second half of summer (32.18 o/oo).

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2. CONTINUOUS PLANKTON RECORDS:

The Distribution of Plankton off Newfoundland

by V. Bainbridge and L.T. Jones
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In a previous paper presented to the environmental working party of ICNAF at Aberdeen in 1961, Bainbridge and Robinson (1961) gave a preliminary account of the plankton along the Plankton Recorder route ('Z') between Iceland and Newfoundland, up to October 1960. Sampling along this route has been continued and a further route across the Atlantic, from Liverpool to St. John's ('D') was started in June 1961. It is now possible to give a more detailed account of the distribution of plankton in that part of the ICNAF area covered by these two Recorder routes. In this region the cold Labrador Current meets the warm waters of the Gulf Stream System and wide differences in sea temperature over short distances are well known. Consequently, marked differences may be expected in the plankton of this area. The Plankton Recorder, which is towed by commercial ships, obtains a continuous sample of plankton from a depth of 10 metres. It has proved useful in the detection of the sharp boundaries between plankton communities in the area and a number of examples are presented in this paper.

Phytoplankton and Calanus

Some obvious differences between the plankton of the cold waters of the Labrador Current and the warmer waters further offshore can be seen in the distribution of phytoplankton and in the population structure of *Calanus finmarchicus*, the dominant copepod. This is illustrated by Figs. 1a - d in which the western parts of the Recorder Routes from Iceland have been arranged in order of months regardless of the year of sampling. (Results from the new route from Liverpool are omitted because this route has been in operation for only six months.) The numbers of the early stages of *Calanus* (copepodites I - IV) and the later stages (V & VI) are plotted along the routes. The intensity of any green colour is also shown; this provides a rough measure of the amount of phytoplankton present. The colour is estimated visually in four categories which are transferred to a numerical scale based on acetone extractions of standard Recorder samples. Temperature data have been extracted from the charts showing mean sea surface temperatures which are published each month by the U. S. Navy Hydrographic Office. When available, temperatures in °F are given along the Recorder routes and indicate the approximate positions where the isotherms on the chart for the month cross the route.

It is convenient to consider first the plankton along the route running towards the Straits of Belle Isle. This is generally ice-free from July to December and Records are now available covering all six months (Figs. 1c and d). The effect of the Labrador Current can be seen in the temperature minimum over the shelf and the temperature gradient further offshore. During July, August, September and October phytoplankton was clearly most abundant in the cold water over the continental shelf and slope. There were also distinct differences in the population structure of Calanus along the routes. During July, August and September Calanus copepodites I - IV were found, usually, in the cold water of the Labrador Current, whereas stages V and VI were most abundant in the warmer water offshore. In later months, from October to December, highest numbers of Calanus stages V and VI were found in the region directly influenced by the Labrador Current.

The drift of pack ice generally reaches the northern part of the Grand Banks by January and from this month until June the ship's track from Iceland runs south of Cape Race. The western portions of four Recorder routes taken during this period are shown in Figs. 1a and b. Phytoplankton was detectable by colour estimation on the records of February, April and May and was again most abundant in the colder water. Calanus stages V and VI were also more numerous in the colder water during February and March while the converse was true during May.

After this paper was circulated by ICNAF, we read the paper by Semenova (1962) who describes the zooplankton in the area of the Newfoundland Banks during the period 1 March to 9 April, 1960. She observed that the reproduction of Calanus finmarchicus was taking place in March in warm Atlantic waters, while zooplankton was still at its winter minimum in the Labrador Current over the Grand Banks. However, it appeared that the spring development of diatoms had started in the Labrador Current. Along Recorder routes in the vicinity of the Grand Banks, fluctuations in the numbers of Calanus and the amount of phytoplankton appear to follow surface temperature but may also be related to other factors, such as depth. The Recorder route for May, 1961, extended over the Banks and, the distribution of phytoplankton and Calanus (Fig. 1b) appears to be similar to that observed by Semenova during March. The results from Recorder routes running towards the Straits of Belle Isle give a clearer picture of plankton distribution in relation to surface temperature and are in general agreement with Semenova's conclusions. The results emphasize the difference in timing of the development of plankton in the cold Labrador Current and the warmer Atlantic water.

Warm and Cold Water Species.

The distribution of several zooplankton species shows an interesting pattern which appears to be related to the two major current systems. Species normally associated with warm and cold water conditions on the 'D' and 'Z' routes have been listed in Table I, with the months of occurrence; and the distribution of members of these two groups is shown in Fig. 2. The grouping of the Copepoda in Table I is similar to that given by Kusmorskaya et al. (1960) with the exception of Metridia longa which they consider a boreal species. The euphausiids Thysanoessa *gregaria*, *Nematoscelis megalops* and *Euphausia krohnii* are associated with warm water in other regions of the Recorder survey, though *E. krohnii* is considered to be a boreal species by some authors. Bainbridge (1961), and Bainbridge and Robinson (1961) noted the presence of warm-water species off the north-eastern slope of the Grand Banks. The introduction of the new route from Liverpool to St. John's has augmented our knowledge of distributions. As shown in Fig. 2, extensive patches of warm-water species have now been found north-east of the Banks during August and September and during December, January, February and March. The presence of these species may be associated with a current filament of the Gulf Stream System. One such filament is indicated north-east of the Grand Banks on the chart given by Fuglister (1951).

The distribution of species of the warm-water group and of *Calanus glacialis*, the most prominent member of the cold-water group, have also been plotted on the Recorder routes from Iceland shown in Figs. 1a - d. A good correlation with surface temperatures is evident.

The size distribution of furcilia larvae of *Thysanoessa longicaudata*.

The furcilias of the dominant euphausiid, *T. longicaudata*, were numerous in August and September 1961. For the purpose of the present work six furcilia stages are recognised. The first has no pleopods, the second has five non-setose pleopods and the third five setose pleopods. Following this stage the seven spines on the end of the telson are reduced in number in successive moults, so that the fourth stage has five spines, the fifth has three spines and the sixth has one terminal spine, but still has the long lateral spines on the telson common to all the furcilia stages. These lateral spines are then lost, after which it is not possible to recognize definite stages.

Measurements of the overall length of the furcilias, from the rostrum of the carapace to the end of the telson, showed that the furcilias from the oceanic part of the 'D' route were smaller, stage for stage, than those from the continental slope part of the same route. In August there was a particularly sharp boundary between the small and large furcilias and in September there were two populations of quite distinct sizes. The larger furcilias in both months had the same size characteristics as those from the 'Z' route, further north, in August (Figs.3 and 4; Table II). There was no 'Z' Record in September. Although temperature data are not available for August and September, the different size distributions suggest that the environmental conditions in the vicinity of the Grand Banks in these months were comparable to the conditions in part of the Labrador Current further north. The distribution of warm-water species of plankton overlapped that of the small furcilias but no warm-water species were found in the parts of the Records bearing the large furcilias (Fig. 3).

Concluding remarks.

There are, therefore, easily distinguishable differences between the plankton of the two main current systems. Waters of the Labrador Current appear to support a much higher standing crop of the phytoplankton than do the warmer waters more offshore. Also, the seasonal cycle of *Calanus* shows a considerable time lag in this current compared with adjacent regions. Certain species are restricted to either the Labrador Current or the Gulf Stream System. One widespread species, *Thysanoessa longicaudata*, has been shown to have populations with distinct size differences which appear to be related to these two major currents.

Spatial and temporal variations are known to occur in the Labrador Current (e.g. Soule and Murray, 1957) and in the Gulf Stream System (e.g. Stommel, 1958). We hope to be able to study long and short term variations in the plankton of this area and possible relationships with hydrography and the fisheries. The new Recorder route from Liverpool to St. John's is likely to be most useful in these studies and it will be interesting to compare the results from this area with those obtained from the route between Newfoundland and Boston which was also started in July 1961 under a contract between the Scottish Marine Biological Association and the United States Office of Naval Research (62558-2834, NR 104-601).

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TABLE I.

Warm and Cold Water species found on the 'Z' and 'D' Recorder routes, December '59 to January '62.

The distribution of the two groups is shown in Fig. 2.

Date	Dec.59	Feb.60	Mar.60	Apr.60	Sept.60	Oct.60	Mar.61	May 61	Aug.61	Sept.61	Nov.61	Dec.61	Jan.62
Route	Z	Z	Z	Z	Z	Z	Z	Z	D	D	Z	D	Z
Warm-water species													
Calanus helgolandicus									+	+			
Nannocalanus minor		+							+	+			+
Clausocalanus arcuicornis		+											
Lucicutia flavicornis		+											
Pleuromamma borealis		+					+		+	+			+
P. gracilis		+					+		+	+			
P. abdominalis							+		+	+			
Heterorhabdus spinifrons		+											
H. papilliger							+						
Nematoscelis megalops									+			+	+
Thysanoessa gregaria		+					+		+	+		+	+
Euphausia krohnii		+					+		+	+	+		+
Cold-water species													
Calanus glacialis	+				+	+	+				+		+
C. hyperboreus				+				+					
Metridia longa		+	+	+							+		+
Sagitta maxima			+										

Heading for Figure No. 1. (a,b,c, and d).

Calanus, phytoplankton colour, and surface temperature along Recorder routes ('Z') off Newfoundland. Numbers of Calanus per sample are shown on a logarithmic scale, above the route. Stages V-VI are given as histograms and stages I-IV as a line graph. Estimates of phytoplankton colour using an arbitrary scale are shown by histograms below the route. Temperatures in °F are taken from the charts published monthly by the U.S.Hydrographic Office and indicate the positions at which isotherms cross the Recorder route. G. indicates the presence of Calanus glacialis and W the presence

TABLE II. The size distribution of stages of furcilia Thysanoessa longicaudata.

From the oceanic parts of the 'D' route in August and September, (stippled in Fig. 3.)

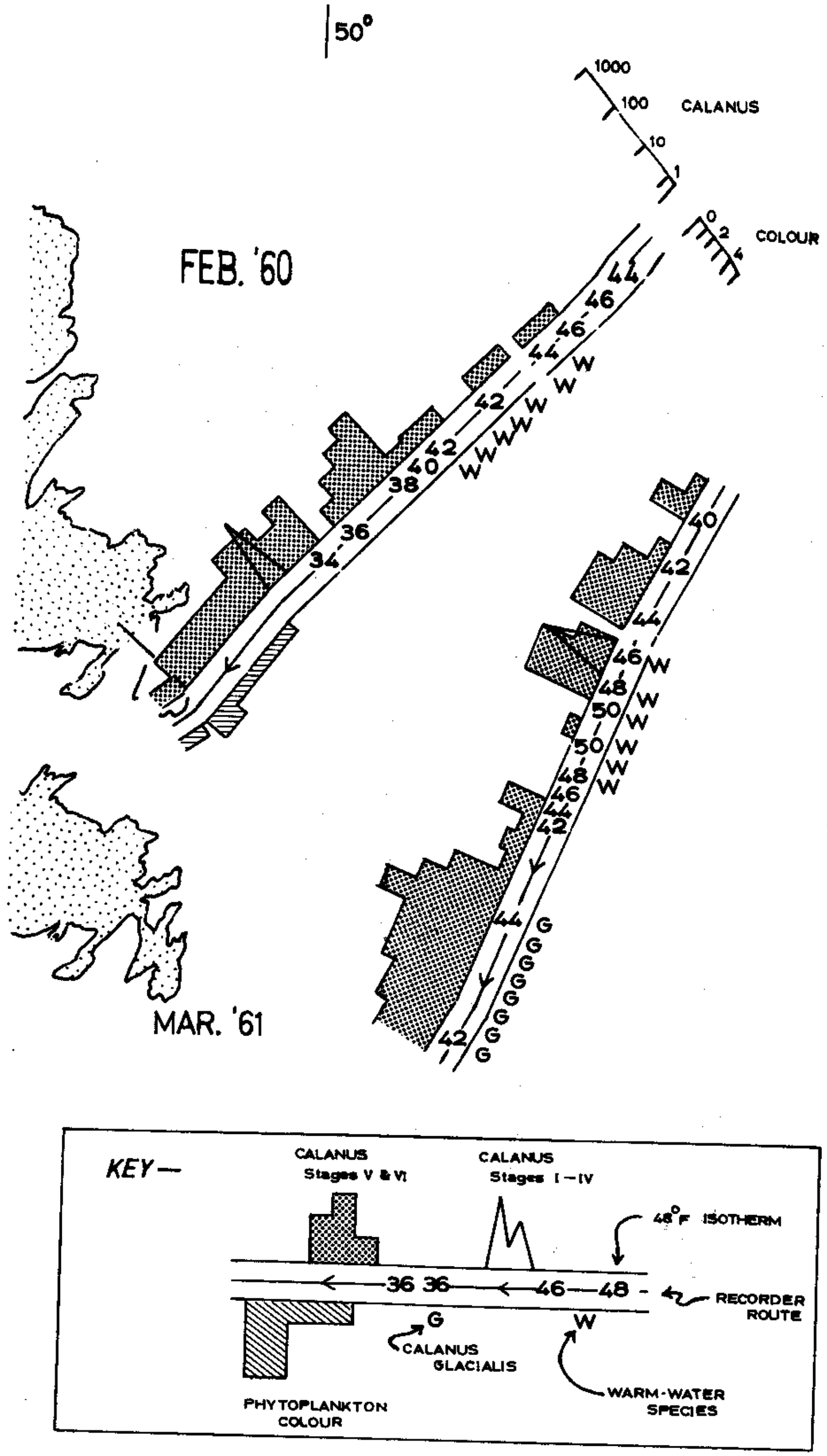
Size mm	2.0 2.4	2.5 2.9	3.0 3.4	3.5 3.9	4.0 4.4	4.5 4.9	5.0 5.4	5.5 5.9	6.0 6.4	Mean
Stages										
I	2	2								2.45
II		2								2.70
III		2		3						3.30
IV			2	8	2					3.70
V			1	7	12	4				4.06
VI				1	42	50	8			4.52

From the continental slope parts of the 'D' route in August and September, (hatched in Fig. 3).

Size mm	2.0 2.4	2.5 2.9	3.0 3.4	3.5 3.9	4.0 4.4	4.5 4.9	5.0 5.4	5.5 5.9	6.0 6.4	Mean
Stages										
I		1	1							2.95
II			1							3.20
III				4	16	2				4.15
IV					4	9	6	1		4.80
V					1	4	5			4.90
VI						2	10	14	1	5.46

From the 'Z' route in August (hatched in Fig. 3) .

Size mm	2.0 2.4	2.5 2.9	3.0 3.4	3.5 3.9	4.0 4.4	4.5 4.9	5.0 5.4	5.5 5.9	6.0 6.4	Mean
Stages										
I			1							3.20
II										-
III					2	1				4.37
IV					3	6		2		4.74
V					1	3	7	1		5.03
VI						3	8	13	3	5.49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RECORDER ROUTE
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WARM-WATER SPECIES
PHYTOPLANKTON COLOUR

Fig. 1 a.

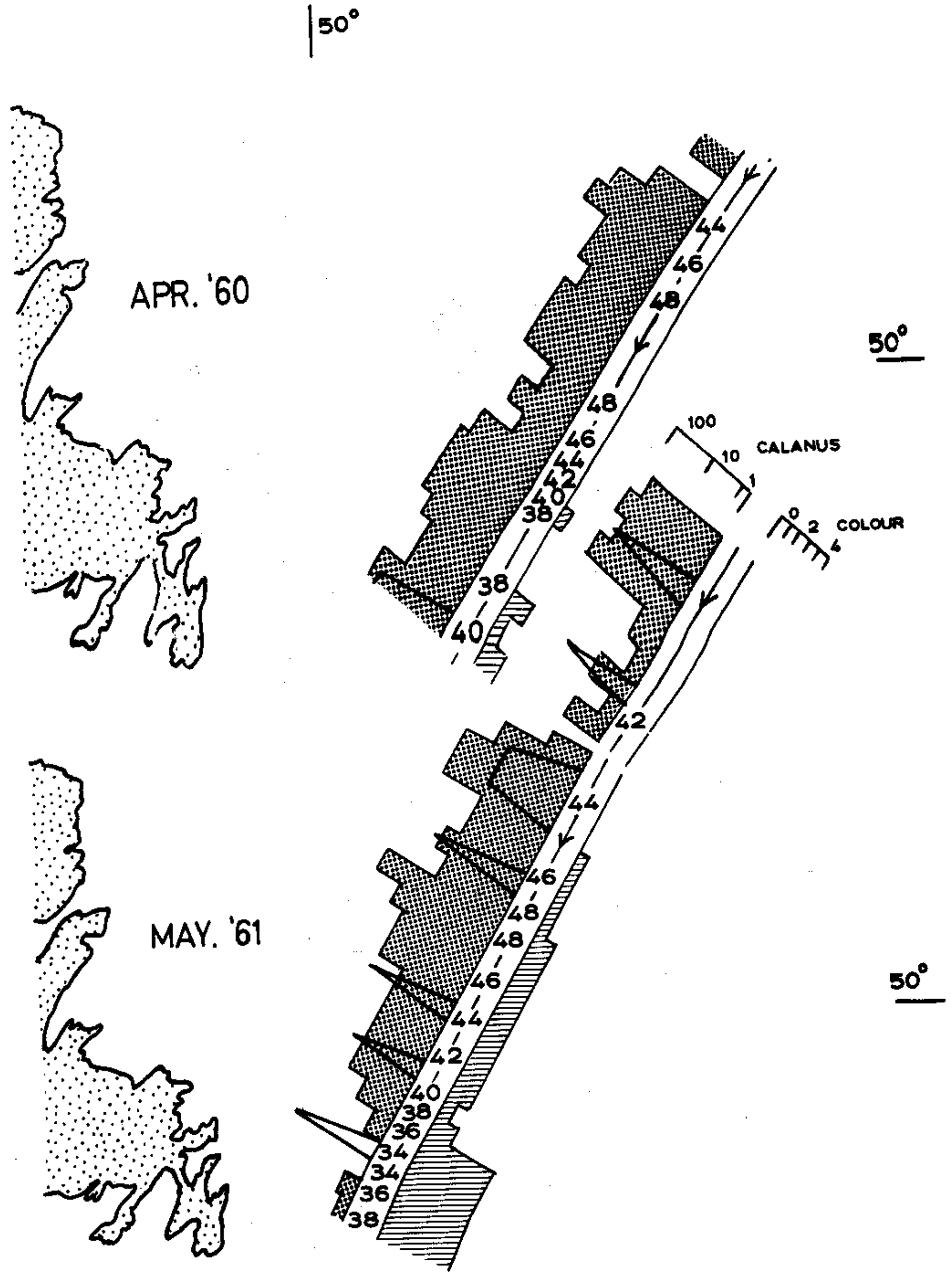
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Fig. 1 b.

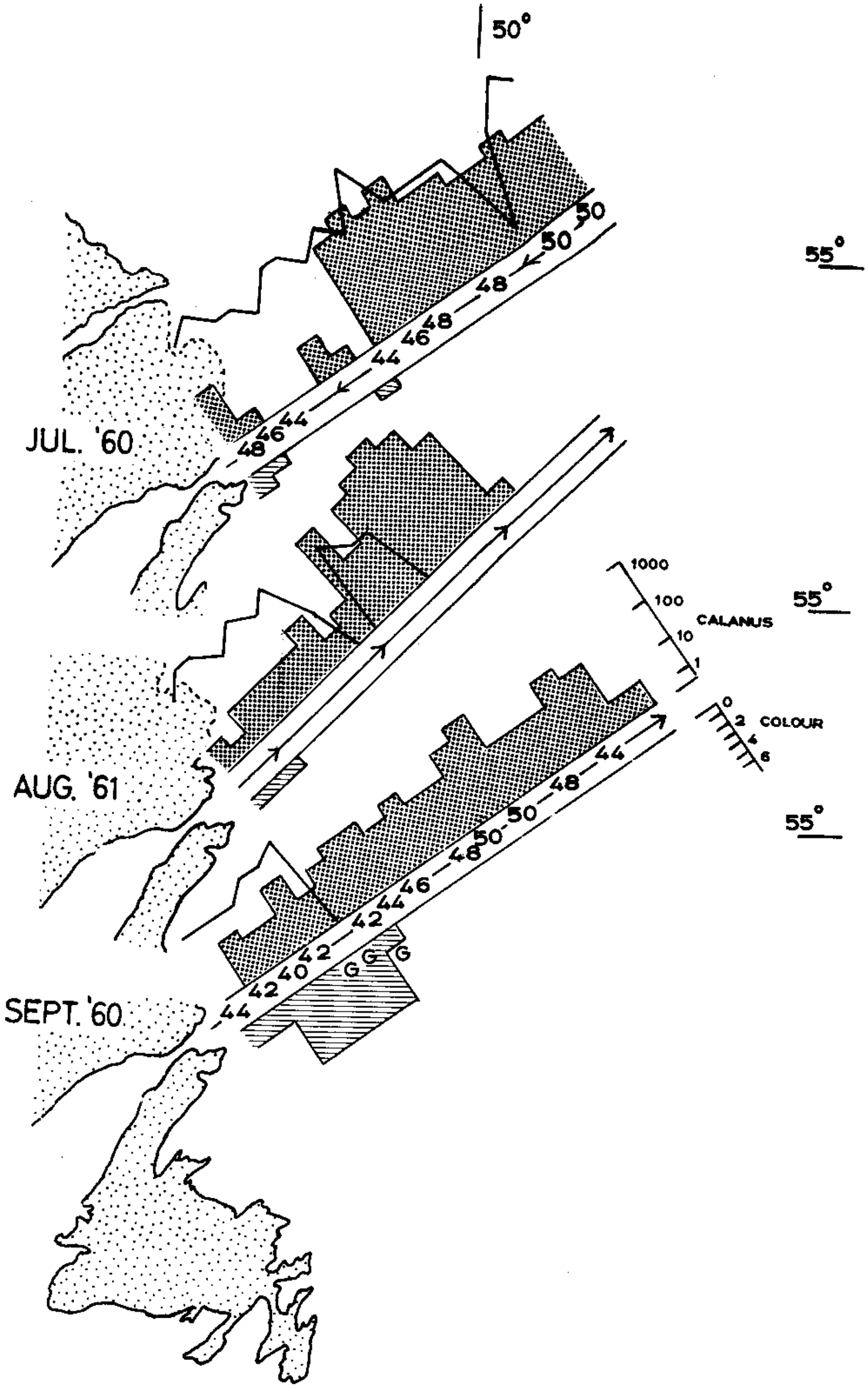
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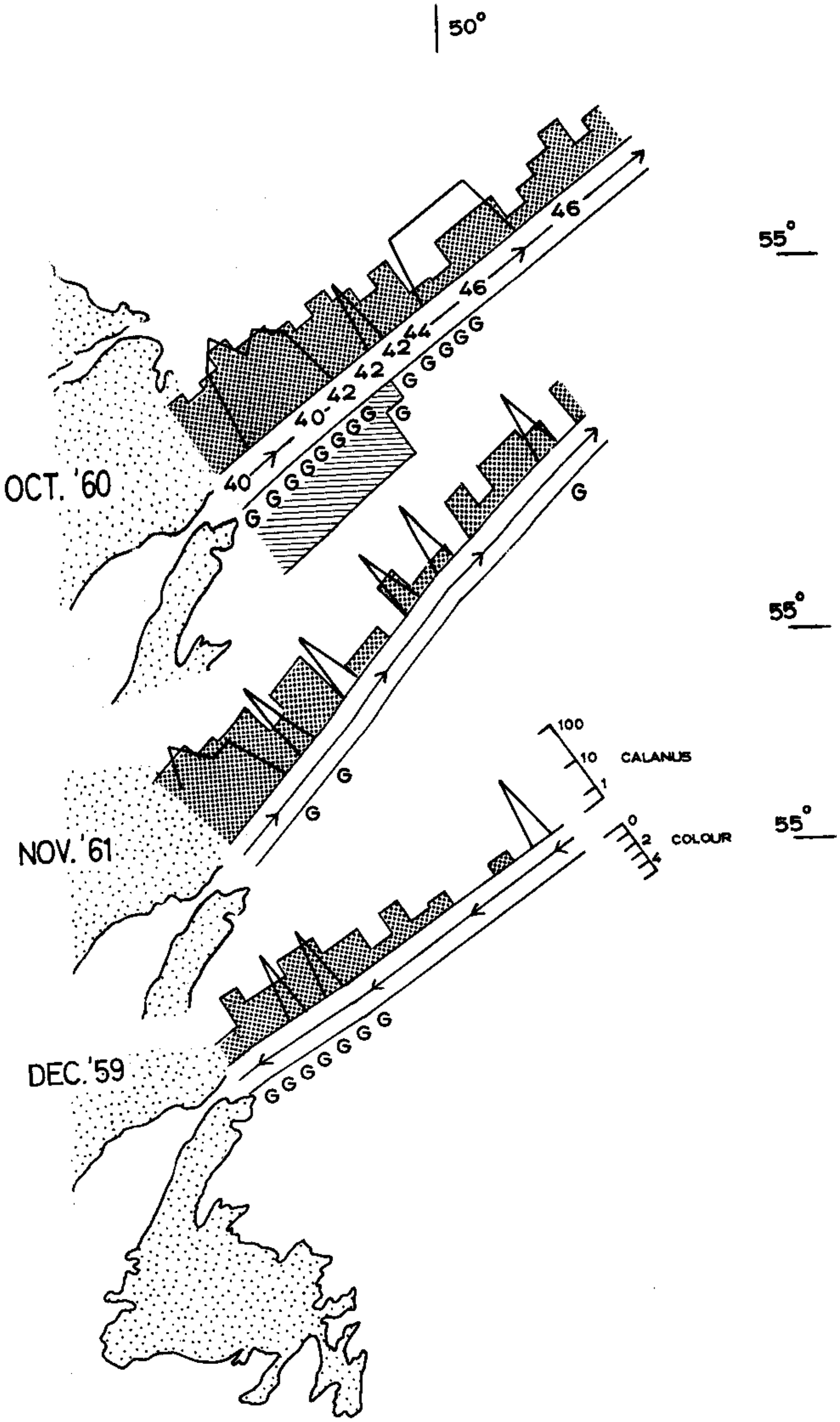
Fig. 1 c.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2
4
COLOUR

Fig. 1 d.

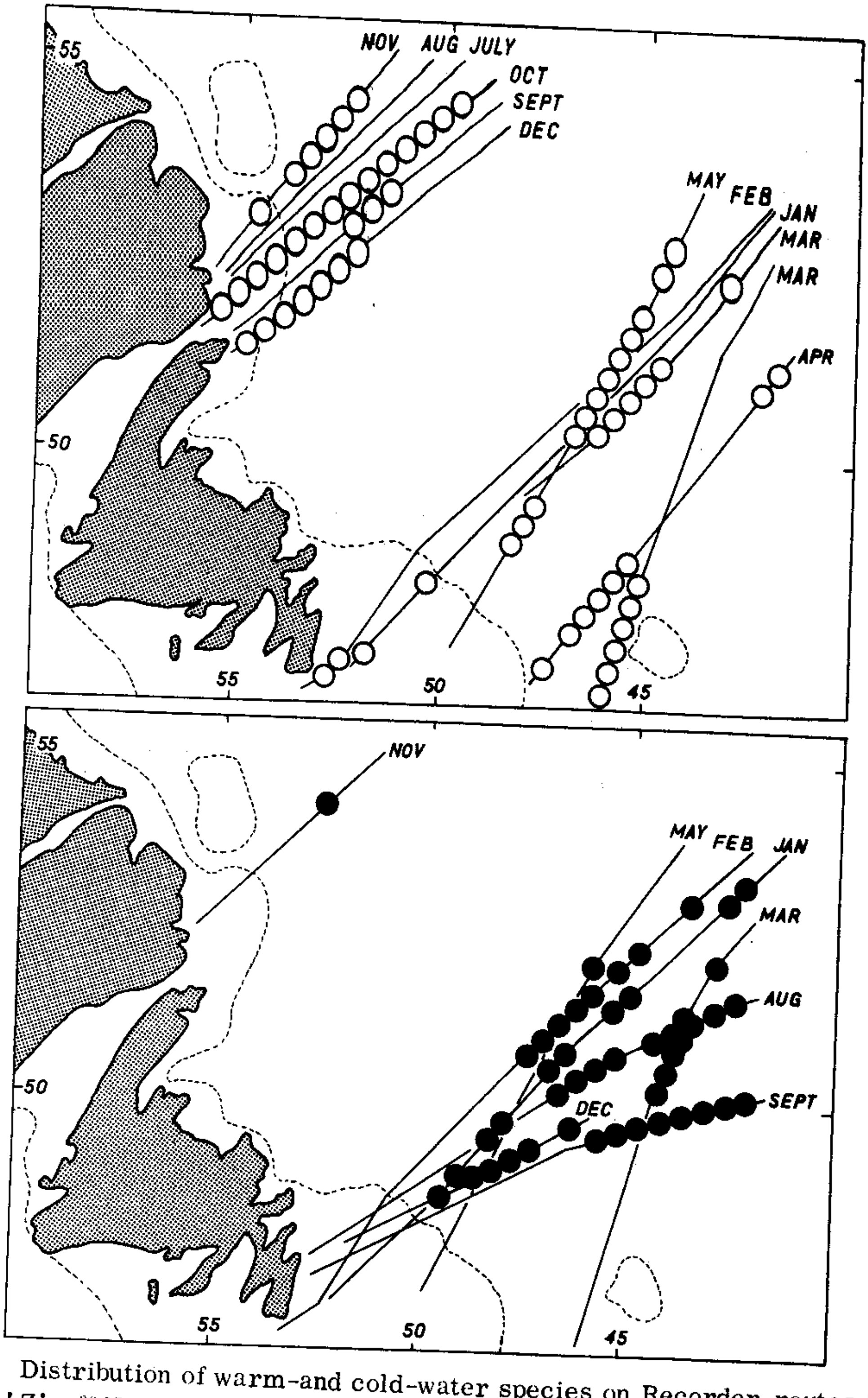

Fig. 2. Distribution of warm-and cold-water species on Recorder routes 'D' and 'Z' off Newfoundland, December 1959 to January 1962 (See Table I). Open circles: cold-water species; full circles: warm-water species.

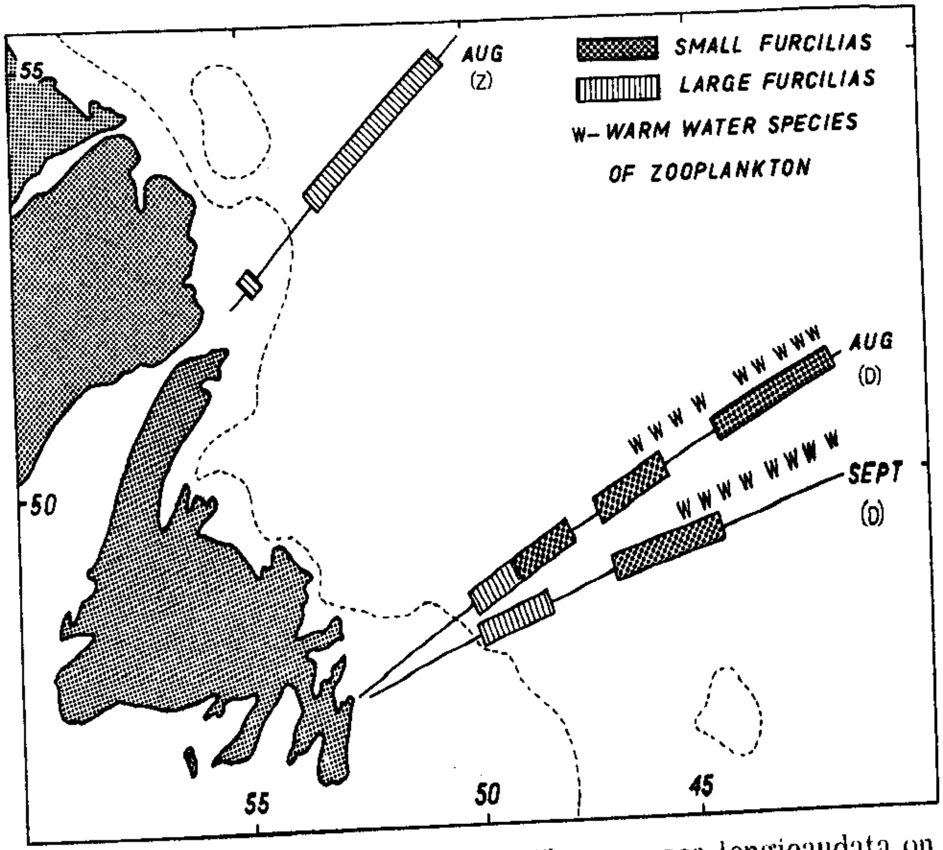

Fig. 3. Distribution of furcilia larvae of Thysanoessa longicaudata on Recorder routes 'D' and 'Z' in August and September 1961 (See Table II).

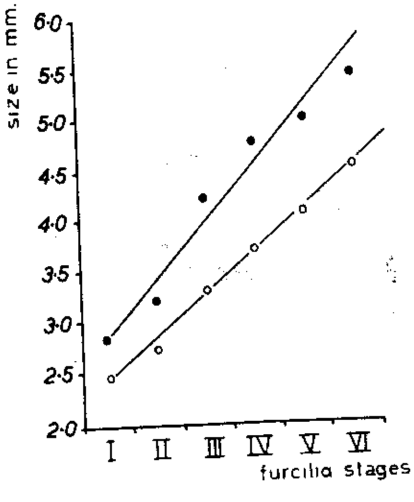

Fig. 4. Mean sizes of Thysanoessa longicaudata furcilia stages. Dots represent furcilias from the hatched areas in Fig. 3. Open circles represent furcilias from the stippled areas in Fig. 3.

3. CONTINUOUS PLANKTON RECORDS:

The distribution of young redfish in 1961

by G. T. D. Henderson,
Scottish Marine Biological Association,
Oceanographic Laboratory,
Edinburgh.

The following account is based on a report submitted to ICES for the Annales Biologiques for 1961. Most of the material was collected outside the ICNAF area but it seemed undesirable to separate the results for this area from the wider context of North Atlantic sampling.

Plankton Recorder sampling in the oceanic areas of the north Atlantic was continued in 1961 on the standard routes previously operated, and was extended in June by the addition of a route between Liverpool and St. John's, Newfoundland ('D' route) and in July by routes from St. John's to Halifax, Nova Scotia ('Ea') and from Halifax to Boston, Mass., ('Eb')*. Extra sampling was carried out on the 'Z' route (between Iceland and Newfoundland) and on weather ship routes to Ocean Weather Station 'ALFA' (in 62°N. Lat. 33°W. Long) in April and May to complement the joint Icelandic-German redfish survey cruises in May. In June and July sampling on the 'Z' route was temporarily suspended, as a strike of dock labour in Reykjavik prevented the delivery of Plankton Recorders to the vessels normally towing on this route.

As in previous years, the young stages of the redfish were found in the areas south and southwest of Iceland, across the Irminger Sea, and from southeast to south of Cape Farewell, Greenland. The specimens taken in these areas from April to July, and, exceptionally, one large individual in August, all appeared to be of the *Sebastes marinus* type, none being noted as exhibiting any of the pigment or opercular spine development characteristics attributed to the *mentella* type or to *S. viviparus*.

The occurrences of these young stages were apparently a little later than in some of the preceding years, as none were taken before mid-April, and only 5 in the second half of this month. They were, however, very abundant throughout May; fair numbers were also taken across the Reykjanes Ridge area in about Lat. 61° - 62° N. in June. Very few were taken in July, but the area in which catches have been most regular in this month in earlier years, the vicinity of Cape Farewell, was unfortunately not sampled. The numbers caught in the Irminger Sea area in May were generally higher than had been noted previously, reaching levels of 35 to 38 per

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* The 'Ea' and 'Eb' routes are sampled as part of a contract (62558-2834, NR 104-601) between the Scottish Marine Biological Association and the United States Office of Naval Research.

$10m^3$ in three rectangles west of the centre line of the Reykjanes Ridge, and exceeding 10 per $10m^3$ in several other adjacent rectangles. The overall abundance, south and southwest of Iceland, in April and May was 15% higher than the previous best year, 1959, and was over twice the mean level for the period 1955 to 1960; they were even more abundant in June than is usual in this month, but sampling was not adequate for a precise estimate. From a comparison between the Recorder material and preliminary results from other sources, it appears that there is a general agreement as to the broad pattern of larval redfish distribution in 1961. The distribution at 10 metres is shown in Figs. 1 and 2, where the samples for April and May and for June and July are combined into two charts.

The percentage size composition is shown, in Fig. 3, with blacked-in histograms for the 1961 material superimposed on the open histograms representing the combined size frequencies for the 1955-60 period. There is some increase in the representation of the 6.0 mm size group in May, suggesting, perhaps, that release of the young was later than usual; a suggestion borne out by the size-frequency distribution in June and by the late appearance of _Sebastes_ in the Recorder samples (see above).

The first Records on the 'D' route in June and July did not take any young redfish between the British Isles and the Newfoundland Banks but, on Records taken in July and August between St. John's and Boston ('Ea' and 'Eb'), a small number of young redfish were found. These specimens all had the sub-caudal melanophores stated to be characteristic of the _mentella_ type, and were of a very much smaller size range than those taken in these months in the open Atlantic where specimens with sub-caudal melanophores have never been found during 7 years of sampling with Plankton Recorders. Their distribution in July and August is shown separately in the chart in Figure 4, on which is also shown the size composition by numbers caught. These occurrences, from the later part of the season, cannot offer more than a fragment of the distribution pattern in this area, but it is hoped that sampling in 1962 will provide information throughout the season.

Headings for Figures 1,2,3 and 4.

Fig. 1. Chart showing the distribution, at 10 metres depth, of the young stages of the redfish, _Sebastes marinus_, in April and May, 1961. The boundary of the ICNAF area is shown with a dotted line.

Fig. 2. Chart showing the distribution, at 10 metres depth, of the young stages of the redfish, _Sebastes marinus_, in June and July, 1961. Symbols as in Fig. 1. The boundary of the ICNAF area is shown with a dotted line.

Fig. 3. Histograms showing the percentage size composition, month by month, of the young stages of the redfish, _Sebastes marinus_, taken at 10 metres depth by the Plankton Recorder. Open histograms show the combined results from the years 1955-60 and the superimposed black-in histograms represent the 1961 results.

Fig. 4. Chart showing the distribution at 10 metres depth, of the young stages of the redfish, Sebastes, taken on July and August Recorder tows between Cape Race, Nfld.,

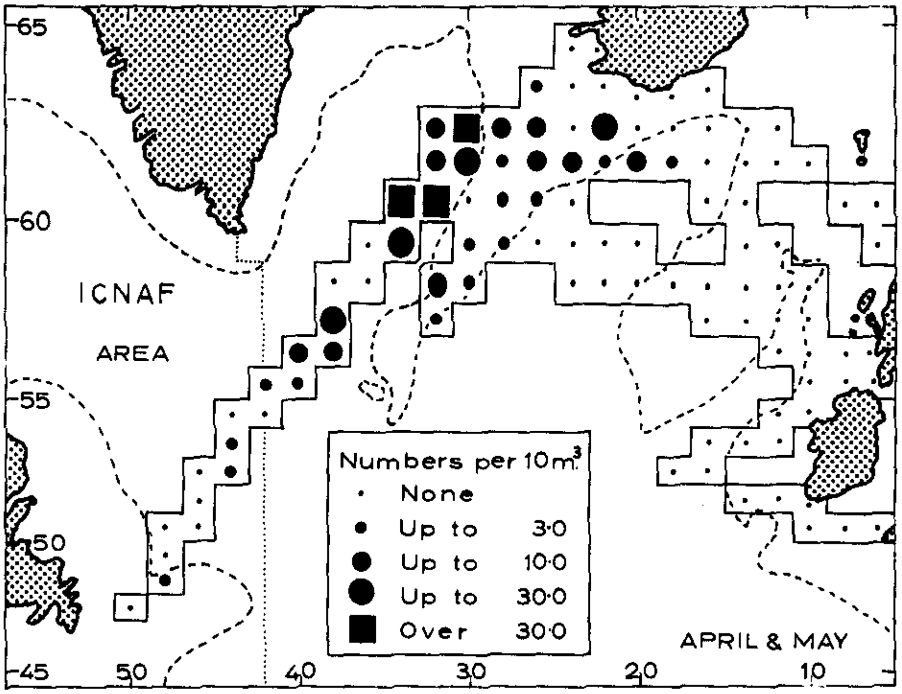
65
60
55
50
45
50
40
30
20
10
ICNAF
AREA
Numbers per 10m³
None
Up to 3·0
Up to 10·0
Up to 30·0
Over 30·0
APRIL & MAY

Fig. 1.

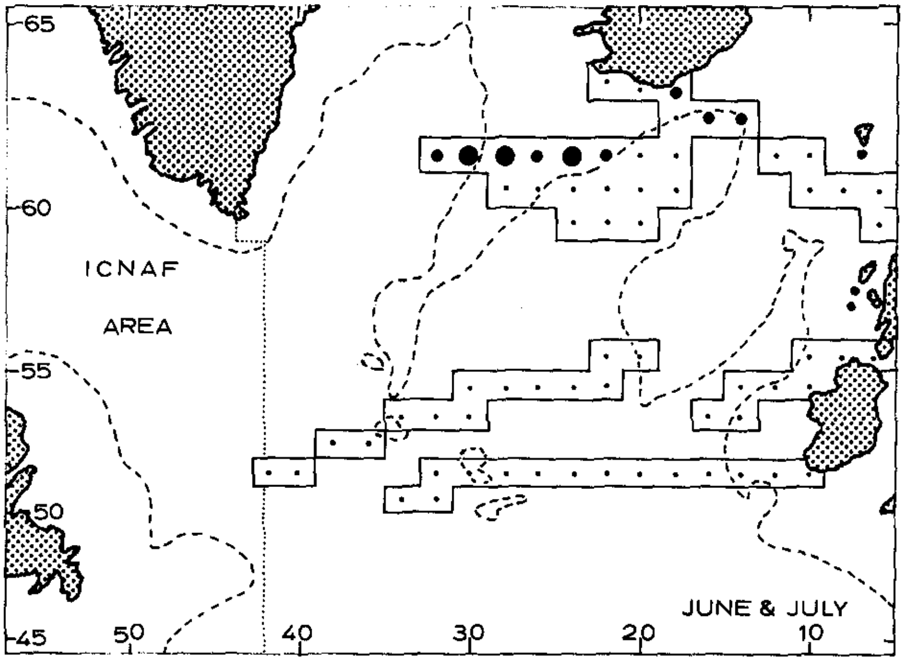
65
60
55
50
45
50
40
30
20
10
ICNAF
AREA
JUNE & JULY

Fig. 2.

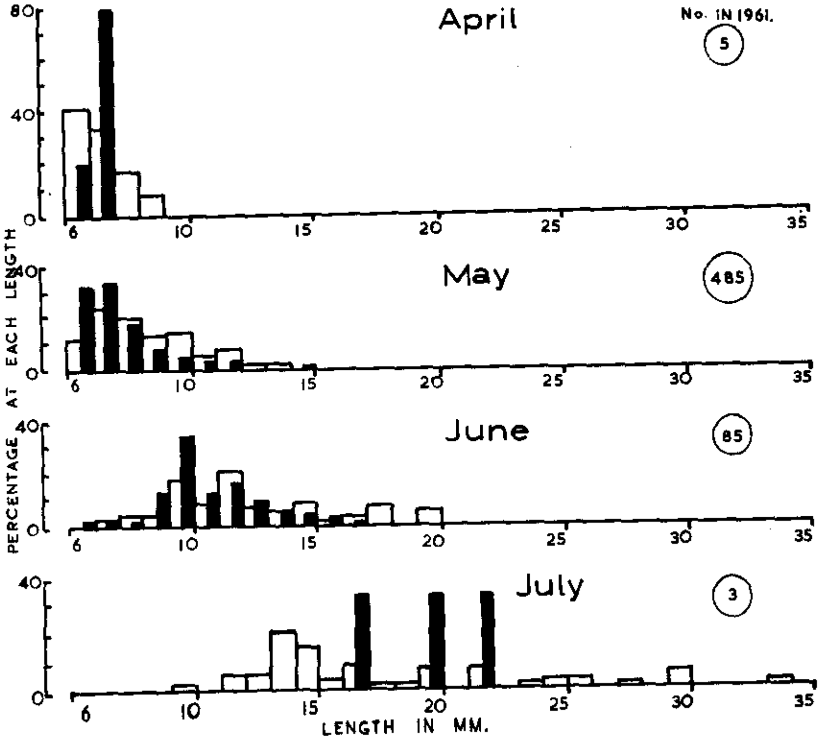
April
No. IN 1961.
5
May
485
June
85
July
3
PERCENTAGE AT EACH LENGTH
80
40
0
6
10
15
20
25
30
35
LENGTH IN MM.

Fig. 3.

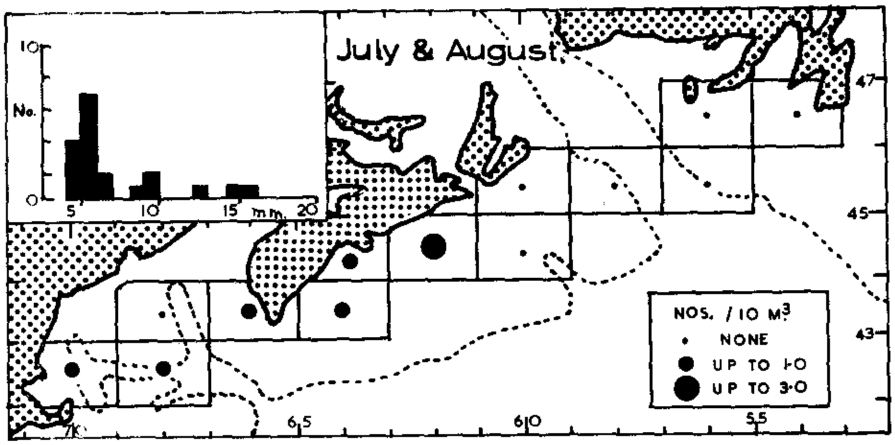
July & August
No.
10
0
5
10
15
mm.
20
47
45
43
NOS. / 10 M³
• NONE
● UP TO 1·0
● UP TO 3·0
70
65
60
55

Fig. 4.

4. CONTINUOUS PLANKTON RECORDS:

Preliminary notes on sampling between St. John's, Newfoundland and Boston, Mass.

by R.S. Glover
Scottish Marine Biological Association
Oceanographic Laboratory, Edinburgh.

During the last two years the Continuous Plankton Recorder survey has been progressively extended across the Atlantic to North America. In 1961 this extension was assisted further by a contract (62558-2834, NR 104-601) between the Scottish Marine Biological Association and the United States Office of Naval Research.

In July, 1961, as part of the contract programme, two new routes were started from R.M.S. NEWFOUNDLAND (by permission of Messrs. Furness Withy and Co. Ltd.) The Recorders are towed at the depth of 10 m which has always been the standard throughout the survey; the methods of analysis of the material are the same as those used since 1948 during the survey of the eastern North Atlantic and the North Sea. The new routes are:

Ea - from St. John's, Newfoundland, to Halifax, Nova Scotia.
Eb - from Halifax to Boston, Mass.

The mileage sampled so far is as follows:-

		Ea	Eb	
1961	July	361	451	
	Aug.	449	358	
	Sept.	0	356	
	Oct.	440	344	
	Nov.	331	347	
	Dec.	260	339	
1962	Jan.	0	0	(Ship did not visit U.S.A. in this month)
	Feb.	463	349	(Not yet analysed)
Totals		2,304	2,544	miles
Grand Total		4,848		miles

One of the major objectives of the Plankton Recorder survey is the study of fluctuations in the abundance, distribution and composition of the plankton. Results from the European part of the survey, since 1948, have shown the danger of attempting this kind of analysis from material collected over a short period of time. In general, three years sampling appears to be the barest minimum required and after five years the value of the results begins to increase in a striking way.

It would be most unwise, therefore, to attempt to generalize about the plankton on the new routes, Ea and Eb, on the basis of 6 months' sampling. These preliminary notes are offered here so that members of ICNAF may be aware of the kind of material which is being collected and analysed.

Figure 1 shows the positions of the Recorder routes during the last six months of 1961. Each route is divided into 10 mile "samples" which are numbered, consecutively, from the eastern ends of the routes. Alternative, odd-numbered, samples are subjected to a form of routine analysis, the remaining samples being used for specialist purposes only (e.g. for fish larvae and eggs). Two Records were treated as "qualitative" as a result of malfunctioning of the Recorder mechanism; in November because there was an escape of plankton; in December because the positions of the 10-mile samples are rough estimates.

Figures 2-5 show the distributions of a few selected organisms. It should be remembered that the Recorder samples at a depth of 10 metres. The broken line in the charts shows the position of the 100-fathom depth contour.

In Figure 2, the green colour of the filtering silks provides a rough measure of total phytoplankton which was most abundant off the southern tip of Nova Scotia (in July, August, October and December) and off southern Newfoundland (in October and November). Young fish and eggs were found mostly in July and August. We were specially interested in the specimens of young redfish (*Sebastes*) which were the first collected by the Recorder with the caudal pigment spots said by some workers to characterize the *mentella* type. All the *Sebastes* collected in the open Atlantic during the last seven years have been without this pigment and have been identified as the *marinus* type.

Figure 3 shows the numbers of "total copepods" and of *Calanus finmarchicus*. These charts show a feature which is seen also in Figures 4 and 5; a scarcity of plankton over the deep channel of the Cabot Strait connecting the Gulf of St. Lawrence with the Atlantic Ocean. In many of the charts the region of scarcity is flanked by a zone of abundant plankton over the shallow waters of the shelf on both sides of the channel; see, for example, the distribution of "total copepods" in August, or *Ceratium fusus* in October. Of the organisms plotted in the charts, only *C. fusus* in August was more abundant over the deep channel than over the continental shelf. This kind of sharp contrast at the edge of the continental shelf has been a constant feature of Plankton Recorder sampling in European waters.

Figure 4 shows the scarcity of *Temora longicornis* in the Gulf of Maine, compared with its relative abundance between Halifax and Newfoundland. In the European part of the Recorder survey this species is abundant in the North Sea but relatively rare over the Atlantic shelf and restricted to the colder northern waters of the oceanic Atlantic (Colebrook, John and Brown, 1961). Another copepod, *Centropages typicus* (Fig. 5), was more abundant in the Gulf of Maine than elsewhere on the 'E' routes although it extended eastwards along the Nova Scotian shelf in October. In the European survey this species is common in the oceanic waters of the Atlantic but it is widespread in the North Sea where it is sometimes regarded as an indicator of the inflow of mixed oceanic and coastal water. Frost (1938) associated Ceratium fusus with mixed or Atlantic water (but not with Arctic water) off the Newfoundland coast. In the Recorder material (Fig. 5), it was found in October and November over the north-eastern part of the Nova Scotian Shelf and off the southern coast of Newfoundland. In the European part of the survey it is common throughout the North Sea and in the oceanic waters of the Atlantic (Robinson, 1961).

One of the advantages of sampling across the Atlantic using a standard technique is that it provides special opportunities for comparative studies of the plankton in European and American shelf waters and over the deep ocean. In general the plankton of the American shelf is similar to that of European waters but the present limited sampling suggests that there may be large differences in the seasonal cycles of production on the two sides of the Atlantic. The full oceanic survey has been in operation for a very short time but it has confirmed that the plankton over the shelves is quite distinct from that over the deep ocean with a rich standing crop and few species in the cold northern water and a lower crop and a great variety of species in the warmer water between Newfoundland and the United Kingdom.

PLANS FOR THE FUTURE

With the continued assistance of H. M. Treasury and the U. S. Office of Naval Research, it is hoped that the Plankton Recorder survey of the North Sea and the eastern North Atlantic will be continued, as previously, together with the cross-ocean routes introduced during the past two years. The new sampling over the North American shelf ('Ea' and 'Eb' routes) will be continued and it may be possible to add other routes in the western North Atlantic.

In March 1962, a new route (G) was introduced between Scotland and Greenland from M. V. UMANAK (with the permission of the Royal Greenland Department of Trade). This route will be financed partly from British funds and partly from the O.N.R. contract.

Figure 6 shows the routes which will be sampled, at monthly intervals where possible, during 1962. Requests for information concerning these routes should be addressed to the Officer-in-Charge, Oceanographic Laboratory, Craighall Road, Edinburgh 6, Scotland.

This survey of the North Atlantic would not be possible without the assistance of colleagues in other laboratories who supervise the equipment and arrange for the return of the collecting silks to the Edinburgh laboratory. We are particularly grateful to Mr. David Miller of the Woods Hole Laboratory of the U. S. Bureau of Commercial Fisheries and to Mr. Ingvar Hallgrimsson of the Reykjavik Fisheries Laboratory.

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Frost, Nancy. 1938. The genus *Ceratium* and its use as an indicator of hydrographic conditions in Newfoundland waters. *Nfld. Dept. Nat. Res., Res. Bull.* No. 5, pp. 12.

Robinson, G. A. 1961. Contribution towards a plankton atlas of the north-eastern Atlantic and the North Sea. Part I: Phytoplankton. Bull. Mar. Ecol., *5:* 81-89.

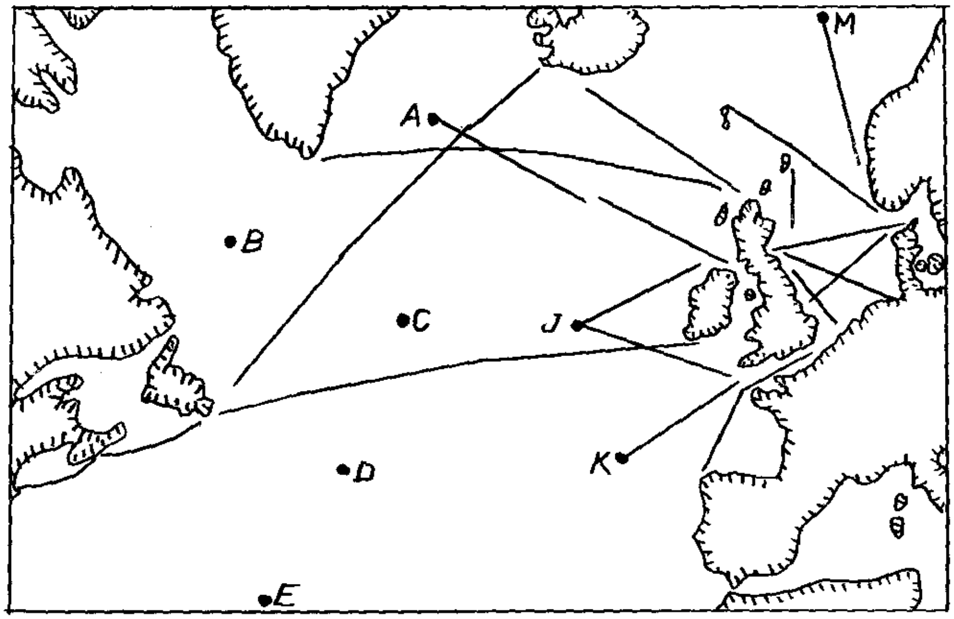

Fig. 6. Edinburgh Plankton Recorder Survey in March 1962. Capital letters indicate the position of Ocean Weather Stations.

For Figures 1-5, see the following pages.

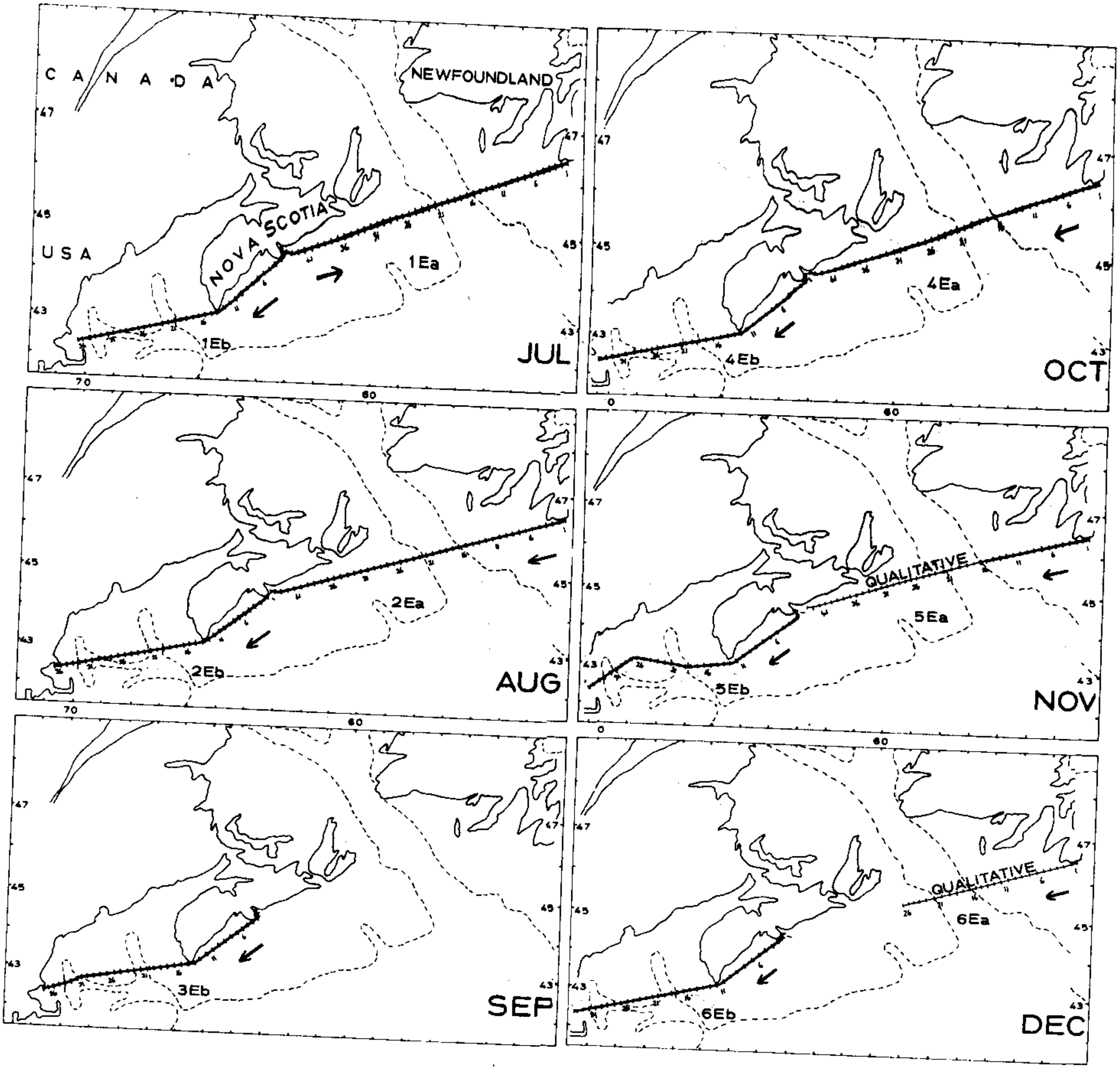

Fig. 1. Positions of the Recorder routes, July-December, 1961.

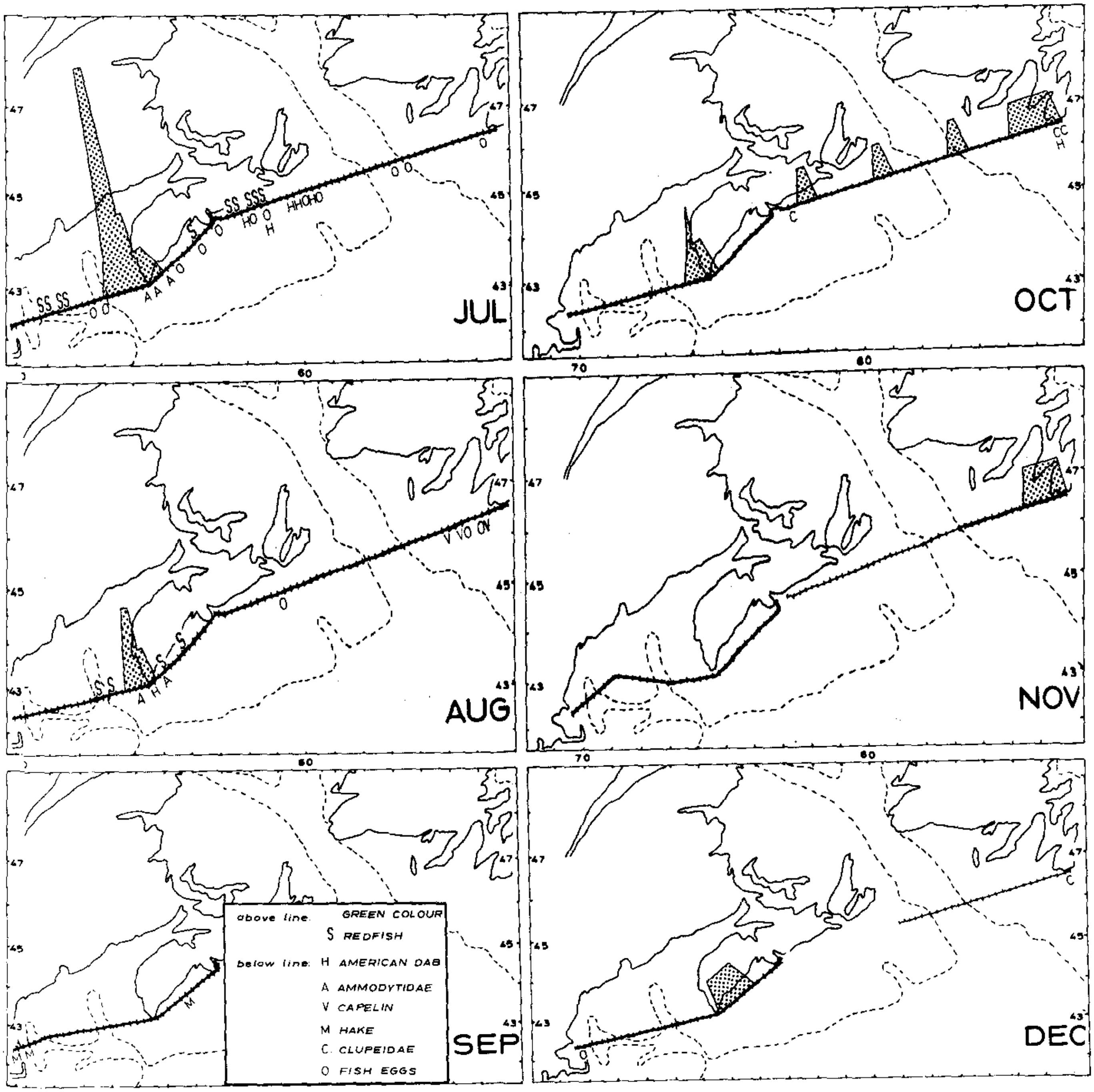

Fig. 2. Distributions of a few selected organisms along Recorder routes, July-December, 1961.

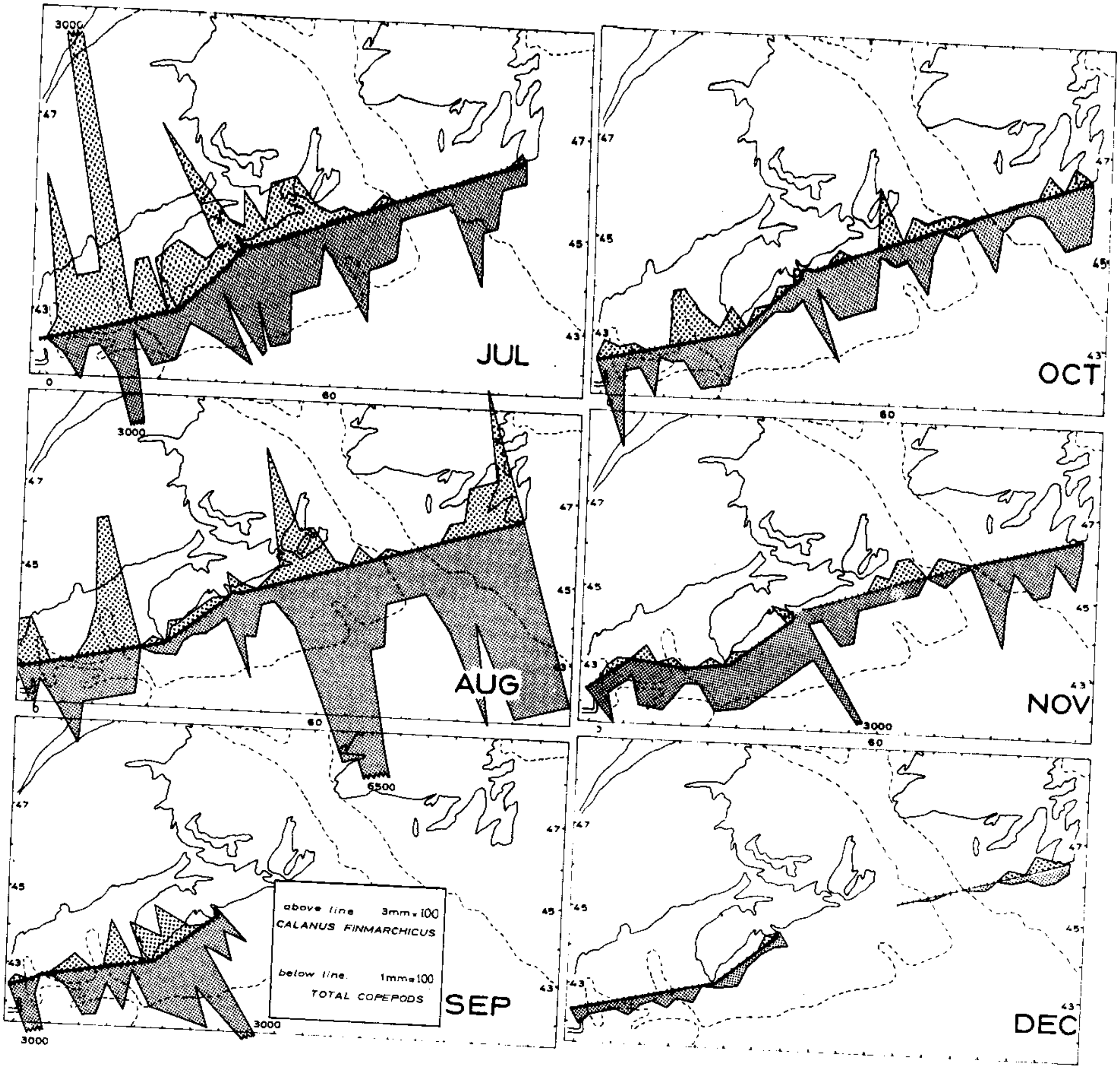

Fig. 3. Numbers of "total copepods" and of *Calanus finmarchicus* along Recorder routes, July-December, 1961.

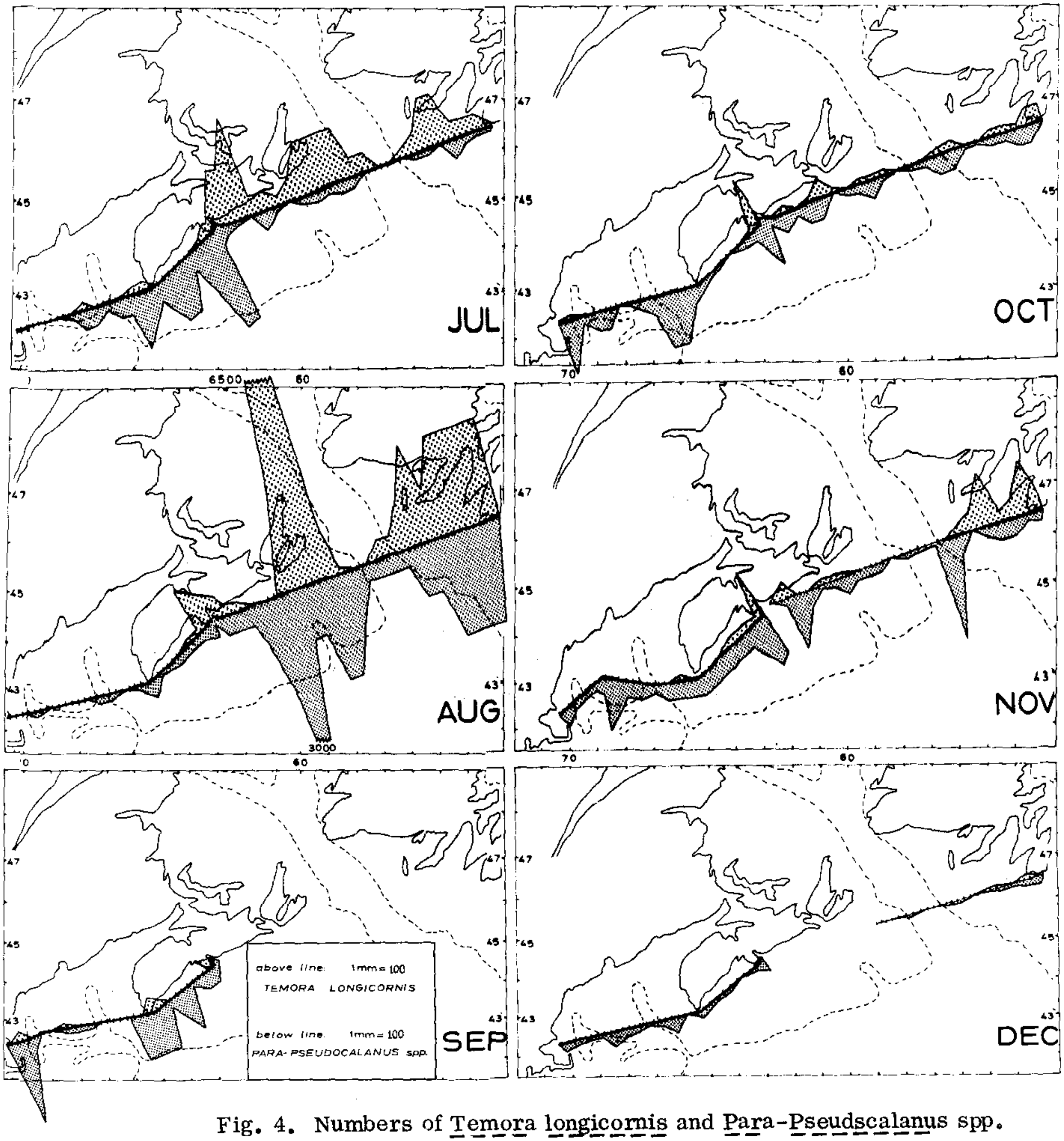

Fig. 4. Numbers of *Temora longicornis* and *Para-Pseudscalanus* spp. along Recorder routes, July-December, 1961.

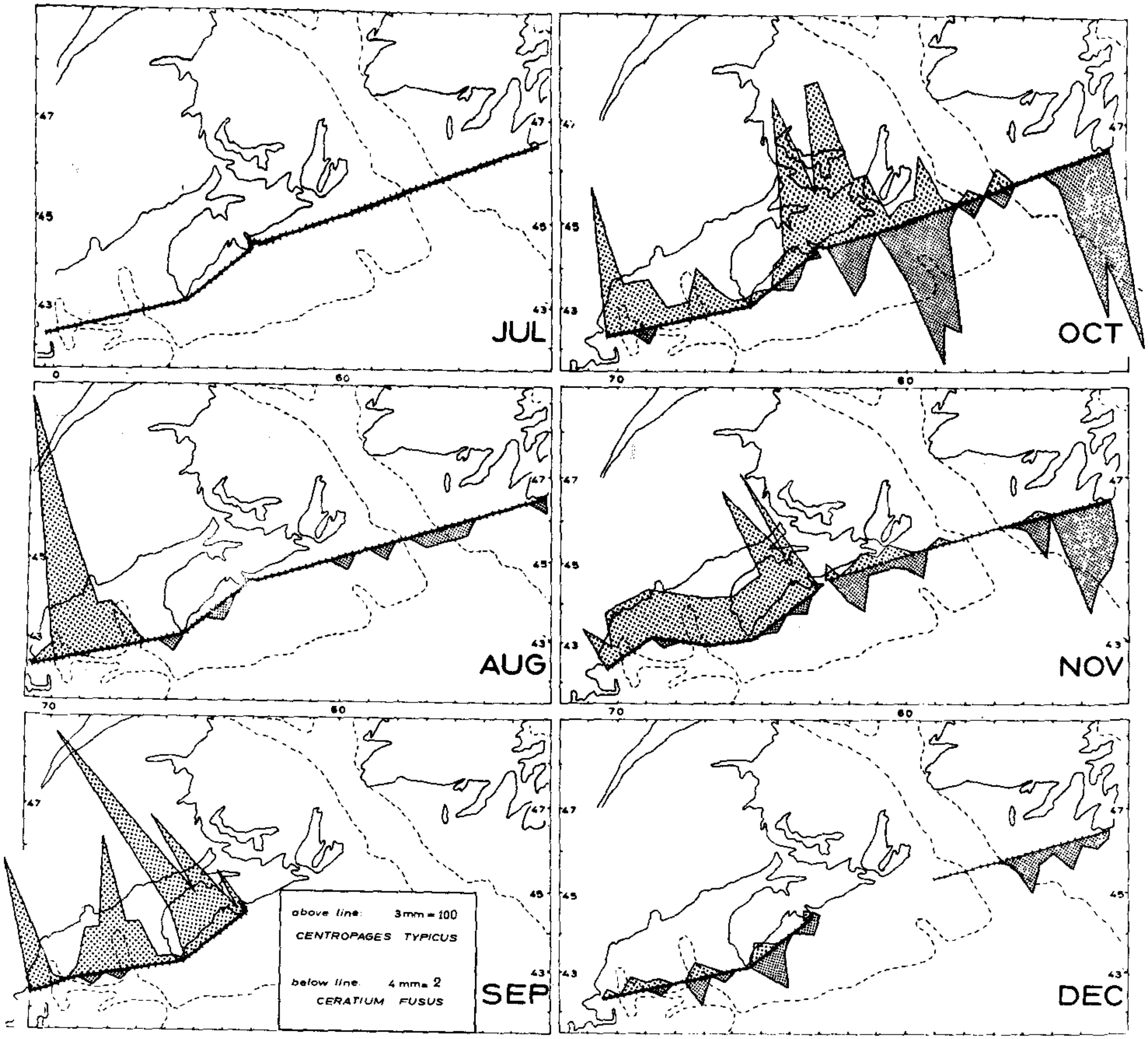

Fig. 5. Numbers of Centropages typicus and Ceratium fusus along Recorder routes, July-December, 1961.

5. PLANKTON INVESTIGATIONS CARRIED OUT BY THE PINRO IN THE ICNAF AREA DURING 1960 and 1961.

by E.A. Pavshtiks, T.N. Semjonova, and S. S. Drobisheva.

Since 1959, plankton sampling has been carried out by the scientific staff of the Polar Institute during expeditions to the Northwest Atlantic. In 1959, 50 plankton samples were taken in the Grand Bank area. In 1960, a large area from South Labrador and Newfoundland to Bermuda was covered by the Investigations; 1156 samples of zooplankton were collected. In 1961, the main attention was paid to the continental shelf waters and some of its fishing grounds; 859 samples were taken.

A 37 cm diameter Juday net of silk gauze No. 38 was used. Samples were taken from 500-200, 200-100, 100-50, 50-25, 25-10 and 10-0 m. The Euphausiacea distribution in the near-bottom layers was studied through hauls with special nets with the reverse cone (50 cm in diameter) of silk gauze No. 0. The nets were attached to the trawl headline; 105 samples were collected.

Studies of the quantity and composition of the plankton in different water masses were the main purpose. Such information is necessary for estimation of peculiarities in the hydrological regime of some areas and for the determination of the food basis of plankton-eating fish.

In 1960, the plankton investigations covered Subareas 3, 4, and 5, in 1961, Subareas 3 and 5.

Subarea 3.

The data from 1960 showed that Copepoda predominated in the Newfoundland waters, namely: *Calanus finmarchicus*, *Pseudocalanus minutus* and *Oithona similis*. In the coastal waters *Temora longicornis* and *Pseudocalanus elongatus* were abundant. Besides, *Eukrohnia hamata*, *Limacina retroversa*, *Thysanoessa longicaudata*, *Oikopleura labradoriensis* were common.

In the cold Labrador Current in the Grand Bank area and northward, the following arctic and subarctic species were recorded: *Aeginopsis laurentii*, *Euphyse flammea*, *Calanus glacialis*, *Metridia longa*, *Apherusa glacialis*, *Limacina helicina*. Species of tropic origin (*Nannocalanus minor*, *Mecynocera clausi*, *Clauso-calanus arcuicornis*, *Calanus* spp., *Aegisthus mucronatus* etc.) were observed in the warm Atlantic waters north and east of the Grand Bank and in the Flemish Cap area. At the same time boreal forms (*Metridia lucens*, *Pleuromamma robusta*, *P. abdominalis*) were recorded.

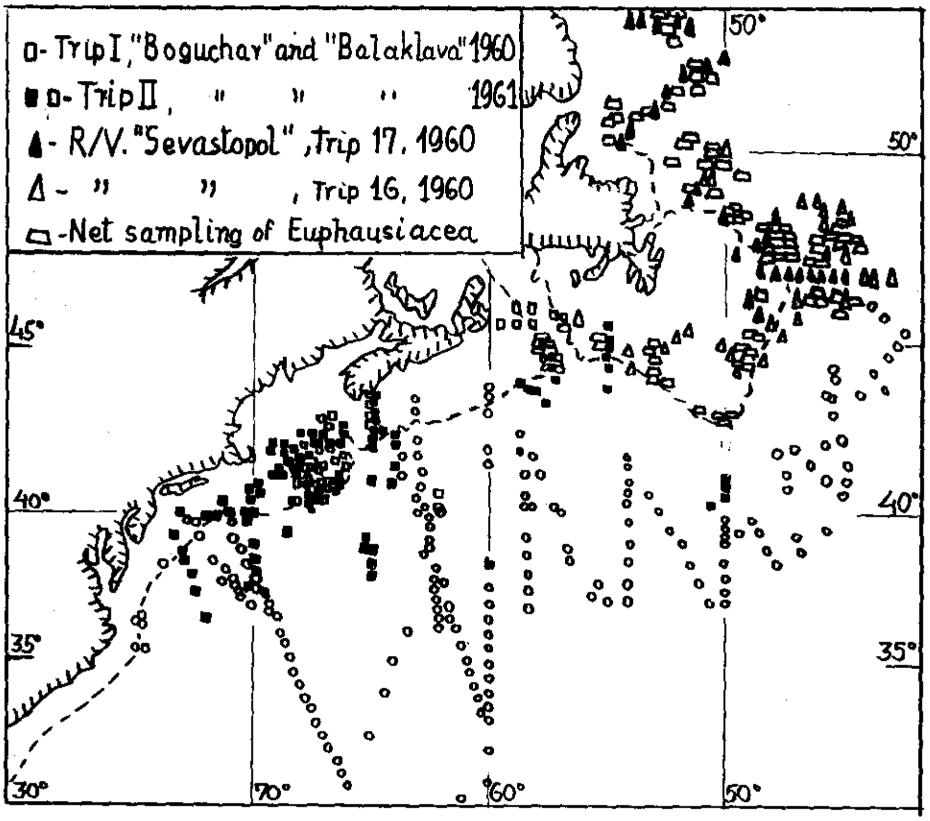

Fig. 1. Chart of plankton stations worked in 1960 and 1961.

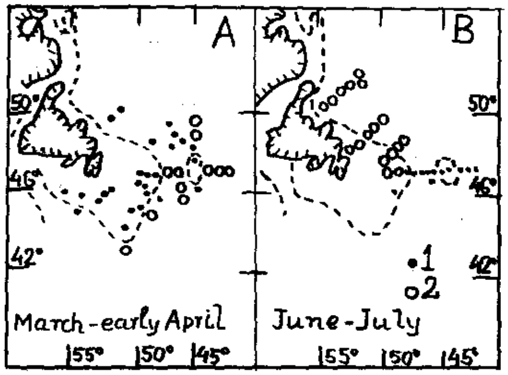

Fig. 2. Spawning of Calanus finmarchicus in the Newfoundland waters (according to the data of 1960). 1. Stations where spawning Calanus finmarchicus were not observed. 2. Stations where mass spawning of Calanus finmarchicus occurred.

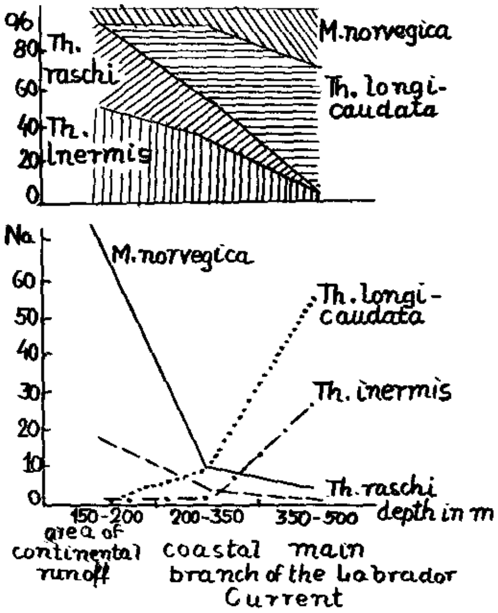

Fig. 3. Composition and quantity of Euphausiacea on the section to the north-east of the Gulf of White Bay (R/v "Sevastopol", trip 14, July, 1959.).

The spring development of plankton started much earlier in the Atlantic water than in the cold Labrador waters. Thus, in the warmer Flemish Cap water and east of the Grand Bank *Calanus finmarchicus* spawns as early as March, while in the Labrador water its mass spawning is recorded only in June (Fig. 2), which means that there the onset of biological spring takes place about two months later than in the Atlantic waters.

The cold Labrador waters of the Grand Bank are characterized by an active and prolonged spring development of Diatomeae (*Thalassiotrix longissima*, *Chaetoceros* spp.). A mass development of Diatomeae was, however, not observed in Atlantic waters, in contrast to Labrador waters. Peridineae (*Peridinium depressum*, *Ceratium* spp.) prevailed in phytoplankton.

From June to August 1959 and 1960, the study of Euphausiacea distribution in the Newfoundland shelf area was carried out by means of a net, attached to the trawl headline. The stations where Euphausiacea samples were taken, are shown in Fig. 1. *Thysanoessa inermis* and *Th. raschii* dominated in the land drainage, while *Meganyctiphanes norvegica* and *Thysanoessa longicaudata* were met in the main stream of the Labrador Current.

Euphausiacea were found in the inshore stream of the Labrador Current in small numbers and all species were almost in equal proportion (Fig. 3).

South and east of the Newfoundland Shallows at 1500-2000 m *Nematoscellis megalops* and *Thysanoessa ambliops* were observed.

The standing crop of Euphausiacea on the slopes of the Newfoundland Bank is formed under the influence of the surrounding water masses. On the northern slopes where the current velocity of the main Labrador branch is higher than on the southern, the fauna typical for the Atlantic waters maintained its oceanic character. On the southern slopes where waters of the main current loose their speed and mix with Bank waters, neritic species prevail.

The largest quantities of Euphausiacea (90800 specimens per one hour) were observed in the centre of the eastern slope of the Newfoundland Bank. On the northern slopes Euphausiacea were present in smaller numbers (20-50 specimens per one hour).

A great quantity of *Th. longicaudata* was caught in the Flemish Cap area (10,000-11,000 specimens per one hour).

On the northern slopes of the Newfoundland Bank the abundance of different species of Euphausiacea changes from season to season. In early spring (March) *Th. longicaudata* prevailed, while by the end of summer (August) the importance

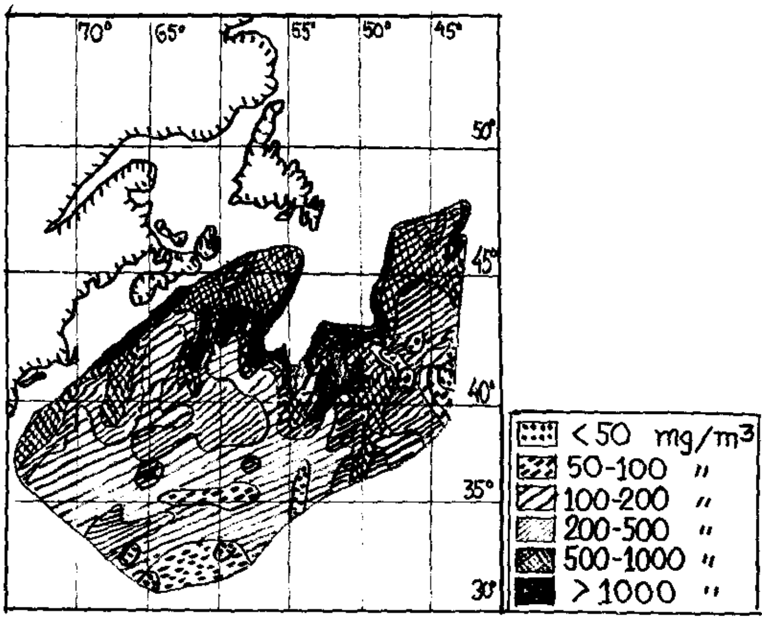

Fig. 4. Quantitative distribution of plankton in the Northwest Atlantic in May-June, 1960 (Luca, Pavelko, 1961).

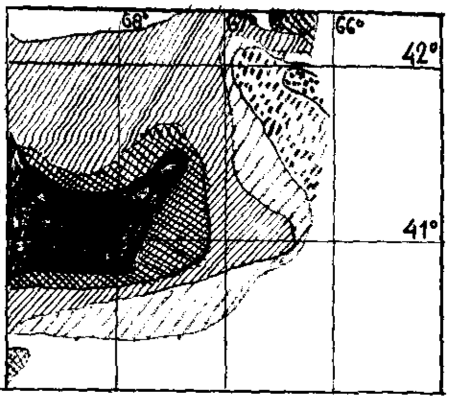

Fig. 5. Quantitative distribution of the plankton on Georges Bank in the 0 - 100 m layer in June, 1961.

of *Th. inermis* increased. Apparently, these changes depend upon the seasonal variation of the strength of the Labrador Current. Seasonal quantitative variations of the different species of Euphausiacea were not observed on the eastern and southern slopes of the Newfoundland Bank. The neritic species (*Thysanoessa inermis* and *Th. raschii*) constantly dominated in plankton.

Subareas 4 and 5.

According to the data from May-June, 1960 (Chart I) the bulk of plankton in water of 15°-23°C, consisted of warm-water (subtropic) organisms: *Rhincalanus cornutus*, *Calanus tenuicornis*, *Mecynocera clausi* etc. They were observed southwest of the Grand Bank and the Flemish Cap and in the open ocean (50°-65° W, 40°-30° N). Representatives of the tropic fauna (*Corycaeus* sp., *Copilia*, *Sapphirina* and *Euclio*) dominated in the plankton west of 65°W between the continent and the Bermudas at the end of July with temperature up to 28°C.

Plankton is poor in the Gulf Stream waters both in composition and in quantity (Luca, Povelco, 1961).

Large standing crops of food plankton (Calanoida, Euphausiacea, Hyperiidae) were observed in the summer 1960 along the continental shelf near the mouth of the Gulf of Maine and near Nova Scotia (Subarea 3).

During the spring-summer season of 1961 the status of the plankton on the fishing grounds of Banquereau, Artimon and Georges Bank was studied to clear up its suitability for the fattening of herring. A rich development of phytoplankton occurred in April on the fishing grounds of Banquereau and Artimon. Diatomeae (Chaetoceros sp., Thalassiothrix longissima) were dominating. Peridineae were rather poor. Zooplankton was also scarce. Calanus finmarchicus (copep. stages III, IV and V), Pseudocalanus minutus, Sagitta sp. and Limacina retroversa were the most abundant species.

On the slopes of the banks, at 100-200 m, plankton became more varied. Calanus hyperboreus, Metridia sp., Euphausiacea and Hyperiidae appear in plankton catches.

The increase of total biomass of plankton on the banks till 1000 mg/m^3 is caused by the mass development of Diatomeae. The biomass of Copepoda at the same time did not exceed 200 mg/m^3.

Calanus finmarchicus, Euphausiacea and Hyperiidae were the main items of food for herring in these areas.

On Georges Bank, April 18-28, Diatomeae (Thalassiotrix sp., Thalassiosira sp., Rhizosolenia sp.) and Peridineae were abundant. The total biomass, chiefly phytoplankton, was 327-840 mg/m^3. In May the development of Diatomeae is over, while Peridineae continue to develop and their number increased in June. Holosphaera viridis was frequently met in June on Georges Bank.

Calanus finmarchicus and Pseudocalanus minutus were the most abundant species on Georges Bank. Calanus finmarchicus spawns here in the second half of April when its nauplii were numerous in the plankton. In May, specimens of all stages of development (I-V) were met (the total biomass of plankton was 500-1000 mg/m^3.). A small number of nauplii was also observed. Calanus finmarchicus and Pseudocalanus minutus dominated in the plankton of Georges Bank, and constituted in June the bulk of the standing crop of plankton.

A patch of high zooplankton biomass (up to 3000 mg/m^3) was observed in the centre of the Bank in June, 1961.

The biomass of plankton varied in the south-west part of Georges Bank from 500 to 1000 mg/m^3; phytoplankton (Ceratium focus and Peridinium sp.) constituted the main portion.

On the northern and eastern slopes of the banks the number of plankton species was less. Approaching the Gulf Stream (in June), the biomass of plankton decreased from 1000 to 50-100 mg/m^3 (Fig. 5). In May and June, 1961, herring on Georges Bank were feeding intensively on Calanus finmarchicus, Hyperiidae and young fish (Klimenkov and Pahorukov, 1961).

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6. PRELIMINARY ESTIMATION OF YOUNG COD, HADDOCK AND REDFISH FOUND IN THE NORTH-WEST ATLANTIC OCEAN.

by Nevinsky, M.M.

In December, 1961, to March, 1962, the Polar Institute (PINRO) carried out its first estimation of young cod, haddock and redfish in the areas of Labrador, Newfoundland, and Nova Scotia. The investigation was aimed at a long-term forecasting of fish stock and sources with a view to organize trawling in the above areas. The estimation of young fish was made on board the vessel POBYEDA in accordance with the technique suggested by the PINRO for the Barents sea.

A commercial bottom trawl with a 12-metre long net of a fine-meshed (8 mm) cotton cloth was used. The estimation was based on all cod and haddock up to 36 cm long and redfish up to 12 cm long taken by the trawl. The fish taken during one-hour trawling were considered to be an index of the relative numbers of young fish at various ages.

During the voyage 204 trawlings were made. The data give an idea of the relative number of young cod, haddock, and redfish and serve as a basis for describing the yield of the separate year-classes.

TABLE 1. AVERAGE CATCH OF YOUNG COD AND HADDOCK PER ONE-HOUR TRAWLING IN DIFFERENT REGIONS FROM DECEMBER, 1961, to MARCH, 1962.

Regions	Cod			Haddock		
	Number of trawlings	Total young fish	Average catch per one-hour trawling	Number of trawlings	Total young fish	Average catch per one-hour trawling
2J	31	1848	60	-	-	-
2K	26	1009	38	-	-	-
3L	27	701	26	-	-	-
3M	13	181	15	-	-	-
3N	12	162	13	-	-	-
3O	13	24	2	13	1189	91
3P	15	229	15	15	1	<1
4V	9	238	26	9	78	9
4W	10	58	6	10	98	10
5Z	25	2	<1	25	435	17

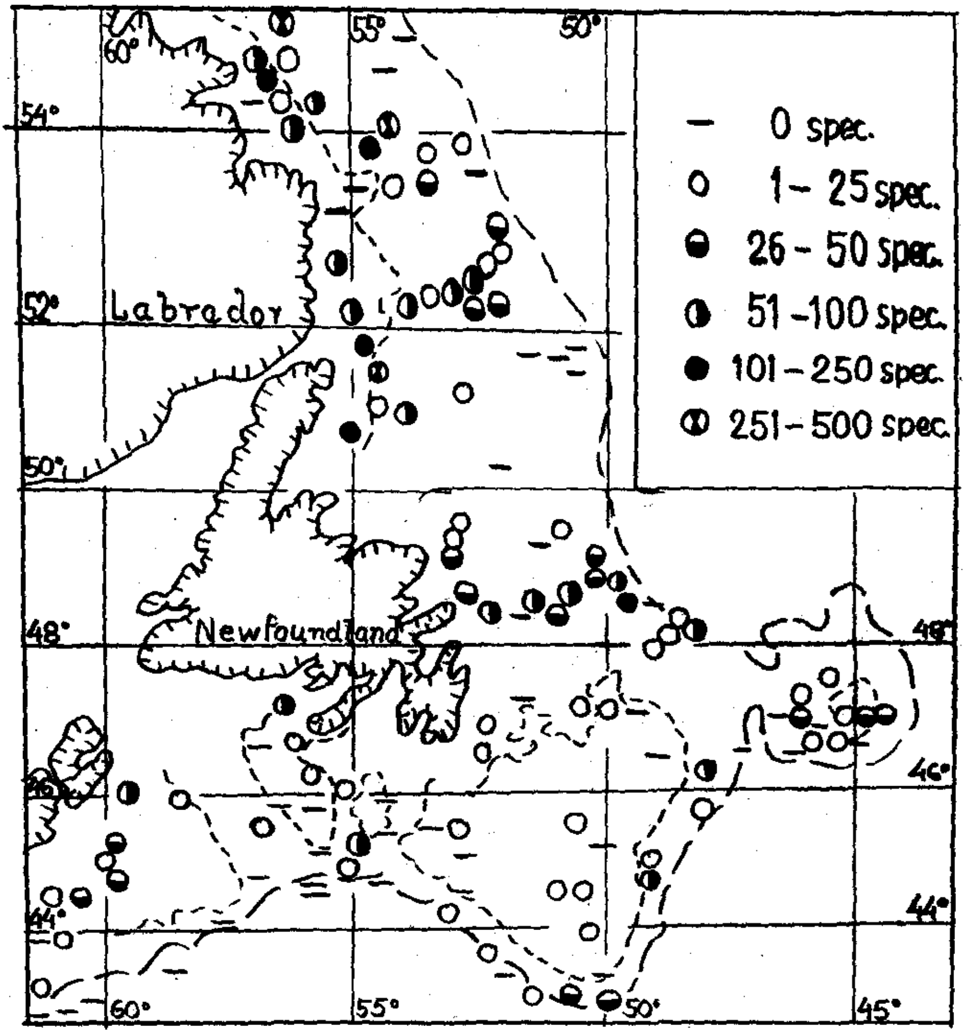

Fig. 1. Distribution of young cod of up to 36 cm size.

Young Cod (Fig. 1).

Main concentrations of young cod were located as follows: (1) the South Labrador region (2J) - North and South of the Hamilton Bank; (2) shallow waters of the Hamilton Bank; (3) the region of the North Newfoundland Bank (3K) near Belle Isle; (4) at the North-East slope of the Grand Bank (3L); and (5) the southern section of the shallow waters at the Flemish Cap (3M).

The bulk of young cod was found in the areas of South Labrador, North Newfoundland Bank and North-East slope Grand Bank (Table 1). A pronounced drop was observed in the regions of the Flemish Cap, St. Pierre (3P), and at the southern slopes of the Grand Bank (regions 3O and 3N).

Off Nova Scotia (4V and 4W) the yields of young cod are also rather poor.

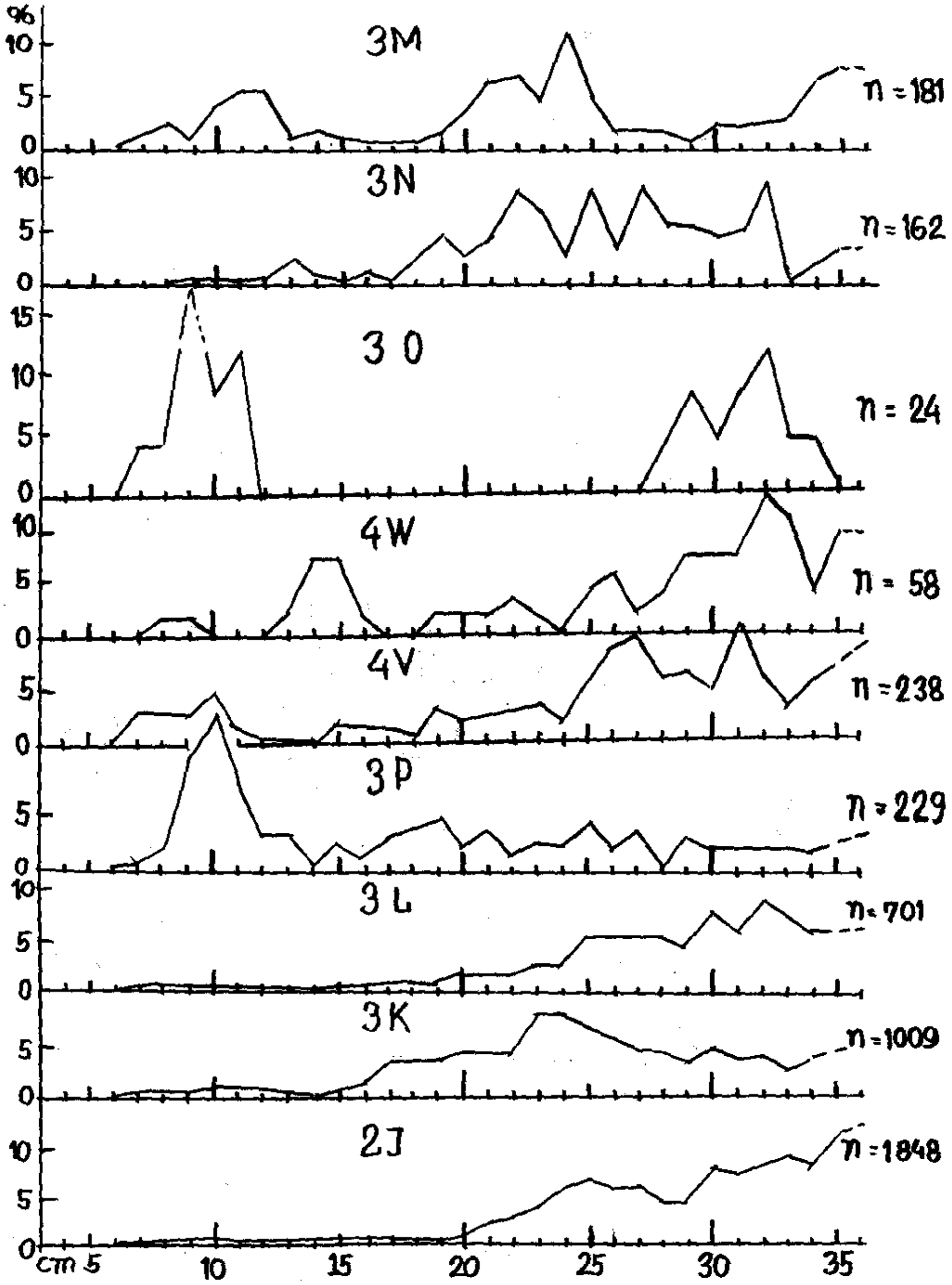

Fig. 2. Sizes of young cod, by divisions.

There are almost no young fish in the region of Georges Bank.

The young cod mainly concentrate between 50 to 350 m depths; below 400 m only occasional specimens were observed.

Sizes of Young Cod (Fig. 2).

Since the young cod have not yet been aged, their sizes are used for estimating the year-class strength.

The sizes of young fish in the regions investigated indicate cod up to 36 cm are 3 year old or younger, i.e., belong to the 1961 (0+), 1960 (1+), and 1959 (2+) year-classes. Fig. 2 shows that the sizes of young cod in various regions differ.

To cite an example, in the region 2J, in 1962, the bulk of the young cod caught was 20-35 cm. Bearing in mind that young fish of that size are 2 to 3 years old we can conclude that the region is characterized in the main by 1960 and 1959 year-classes. The size curve in the chart drawn for the Newfoundland Bank (3K) shows that there the larger part of cod specimens belong to the 1960 brood, the peak being at 24 cm.

The North-East slope of the Grand Bank (3L) reveals a prevalence of young fish of 24-35 cm, perhaps of the 1960 and 1959 broods.

In the southern regions - at the St. Pierre Bank (3P) the greater quantity of young cod measured 7-13 cm which proves the predominance of the 1961 year-class; at the Flemish Cap (3M) the 1960 year-class appeared more common, with sizes ranging from 19 to 26 cm, 24 cm being the most common one. The curve for the South-East slope of the Grand Bank (3N) indicates that here the 1960 and 1959 year-classes are the most numerous.

The Labrador-Newfoundland area, as a whole, is clearly marked by the predominance of the 1960 and 1959 year-classes, except for the St. Pierre Bank where 1961 is abundant. The areas of Nova Scotia (4V and 4W) reveal similar lengths of young cod, in the main from 14 to 35 cm. It is assumed that these young cod belong to the 1960 and 1959 year-classes. The 1961 year-class is scarce in these regions.

Distribution of Young Haddock (Fig. 3).

Unlike cod, the area of young haddock is very limited. Young haddock were not found farther north than 46°00 N. Lat. Most young fish were located at the Grand Bank South-West slope (3O). A clear concentration of young haddock was also observed on Georges Bank (5Z).

The remaining regions of Nova Scotia are far from rich in young haddock. Young haddock were here caught at depths of 50-250 m; no haddock were found deeper than 300 m.

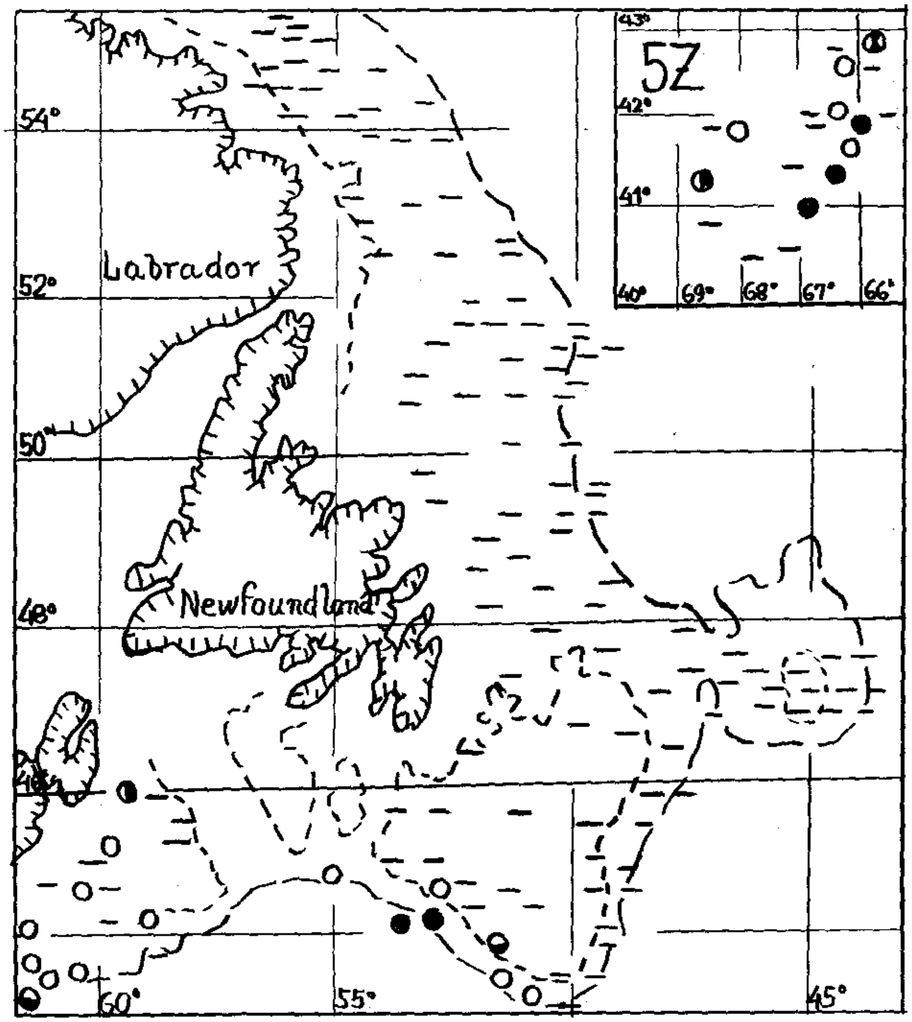

Fig. 3. Distribution of young haddock of up to 36 cm size.

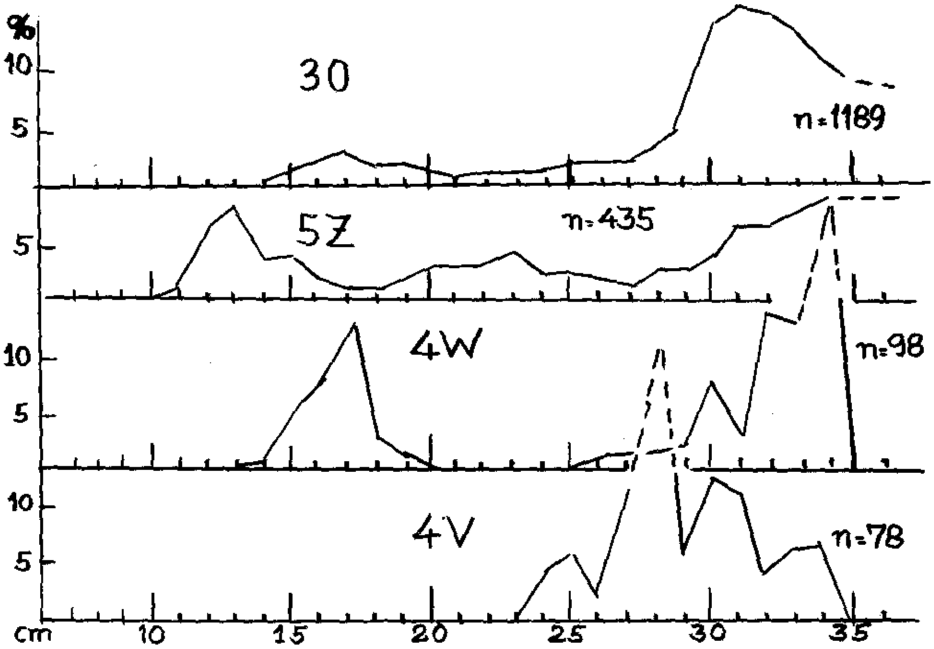

Fig. 4. Sizes of young haddock as found in different regions.

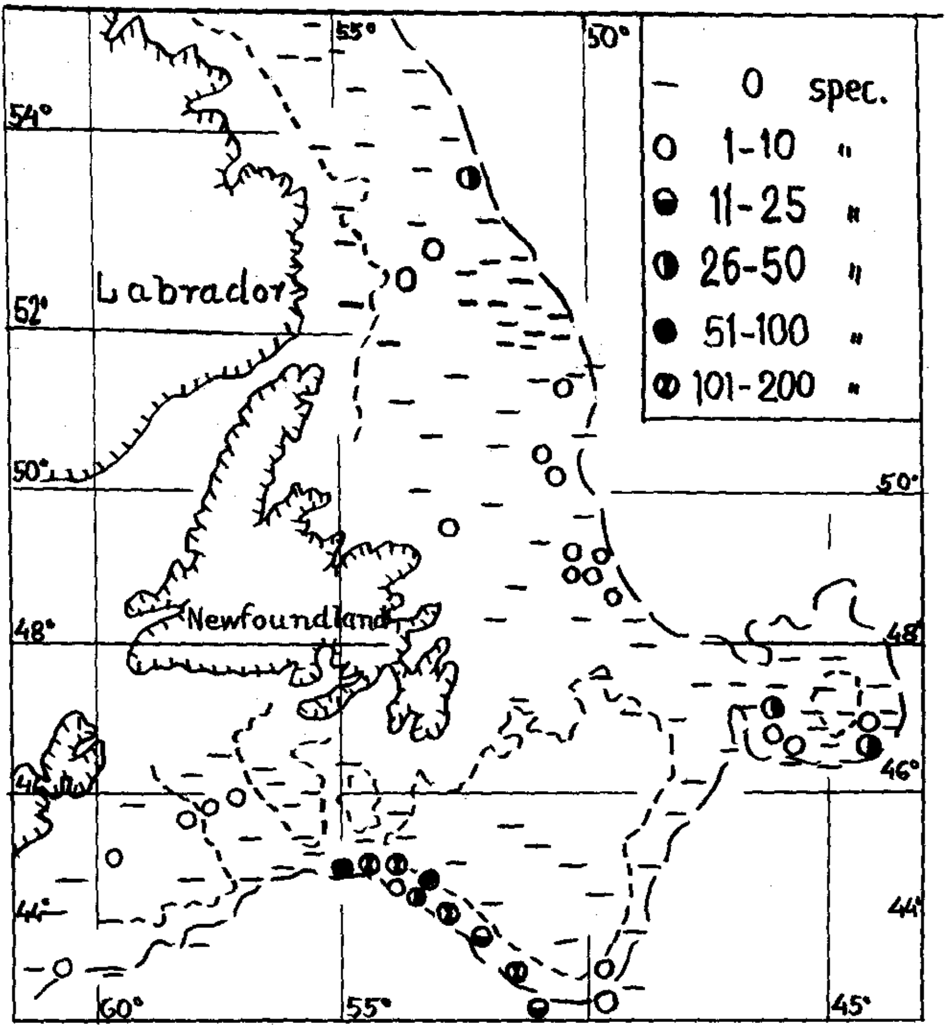

Fig. 5. Distribution of young redfish of up to 12 cm size.

Sizes of Young Haddock (Fig. 4).

Data on sizes of young haddock were collected from the regions of the South-West slope of the Grand Bank and Georges Bank. Data from the Barents Sea may indicate (PINRO) that the bulk of young fish of 28-35 cm size caught on the South-West slope of the Grand Bank belong to the 1959 brood, 31 cm being the most common length.

Judging by the lengths of haddock caught on Georges Bank this region is populated by the three broods 1961, 1960, 1959, the 1959 brood may prevail slightly.

Regions 4V and 4W cannot be adequately described due to the scarcity of data. It is here impossible to estimate year-class strength without age determinations.

Distribution of Young Redfish (Fig. 5).

Main concentrations of young redfish were found on the Grand Bank South-West slope (regions 3O and 3P), where young are numerous at 175-260 m depth. At the South slope of the St. Pierre Bank in February, 1962, up to 5,000,000 young redfish were caught per one-hour trawling (86% of the total amount of the 20 cm redfish caught).

In the remaining regions either very few or no young redfish were noticed. The maximum catch of young redfish east of Hamilton Bank and on the southern slope of the Flemish Cap was only 50 specimens per one-hour trawling.

7. SOME DATA ON DISTRIBUTION OF YOUNG COD AND HADDOCK OFF LABRADOR AND NEWFOUNDLAND.

by A.Yu. Bulatova

INTRODUCTION

This contribution is based on 1636 hauls by bottom trawl from 50 research cruises off Labrador and Newfoundland conducted by the Polar Research Institute from March, 1954 to October 1961. Young cod and haddock (17-20 cm and higher) were only caught as a bycatch, and, therefore, the distribution of the young during their first year cannot be shown. In order to present the differing distribution of young fish of various sizes the young under 25 cm and the young from 26 to 36 cm are considered separately in the autumn, winter and spring, and summer periods.

COD

Labrador and North Newfoundland

The first investigations off Labrador took place in October, 1957. That year the scouting vessel "Odessa" fished up to 59°40' N and single specimens of cod 25-35 cm occurred in catches from the northern Labrador regions. Young cod probably penetrate even farther north in the region.

South of Hamilton Inlet Bank on the slopes of the channel, 200-300 m, a concentration of young cod was noticed in all years investigated (Figs. 1 A-D). This concentration south of the Labrador spawning area is relatively constant. Its borders and density vary slightly by seasons. In the eastern part of the channel, 220-300 m, from 25 to 100 young specimens were taken per one hour trawling in August-September, 1958. In October-December, 1958 the area with the same density was smaller, but in 270-290 m catches of young increased to 432 per one hour. The abundance of young in the channel varies by years. It was at its lowest in the cold year 1959. In the warmer years 1960 and 1961 about 200 young cod were caught per one hour at depths of 200-260 m and temperatures just above 2°C.

In 1961 more than 100 young cod were caught per hour trawling, on the southern part of Hamilton Inlet Bank, 160-180 m temperature 1.6°C. and on the south-east slope, 200-380 m, temperature 2.7°C.

Considerable concentration of young cod in the region of the North Newfoundland Bank was not observed during the investigation. Only in the north-eastern part of the bank, 270-340 m, temperature 3-3.5°C the hauls contained 20-30 specimens (in 1961 60 specimens) per one hour.

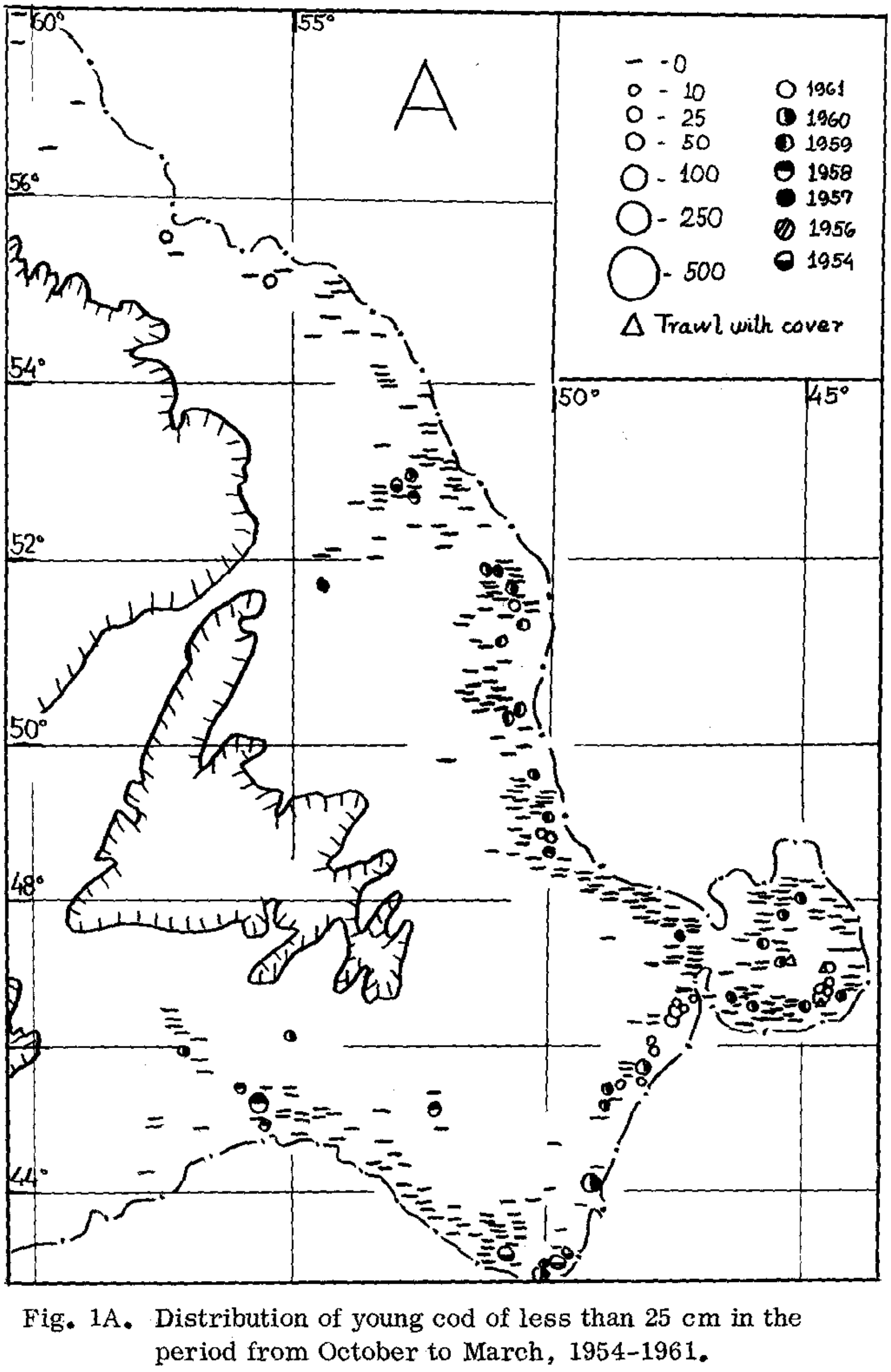

Fig. 1A. Distribution of young cod of less than 25 cm in the period from October to March, 1954-1961.

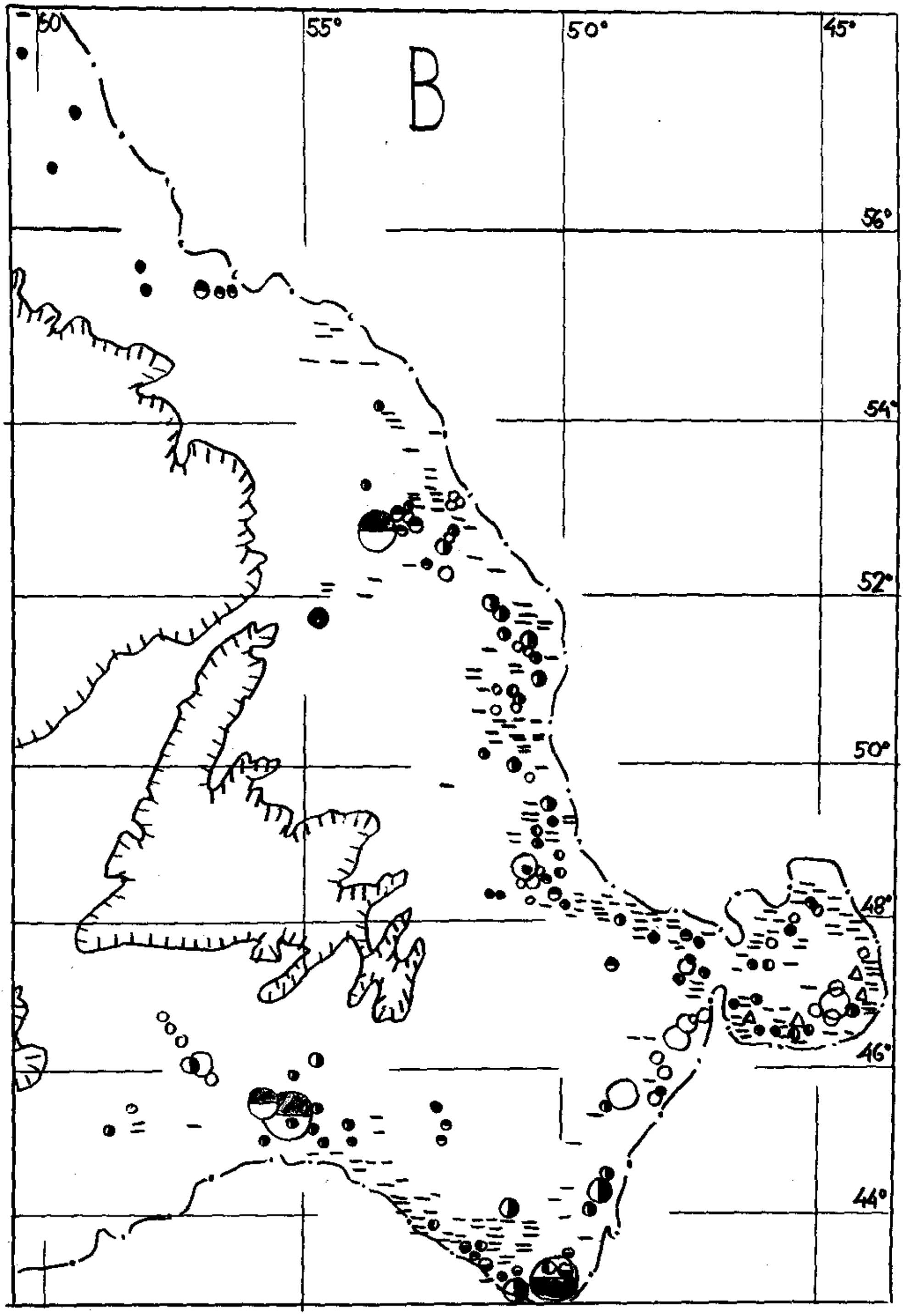

Fig. 1B. Distribution of young cod of 26-35 cm in the period from October to March, 1954-1961.

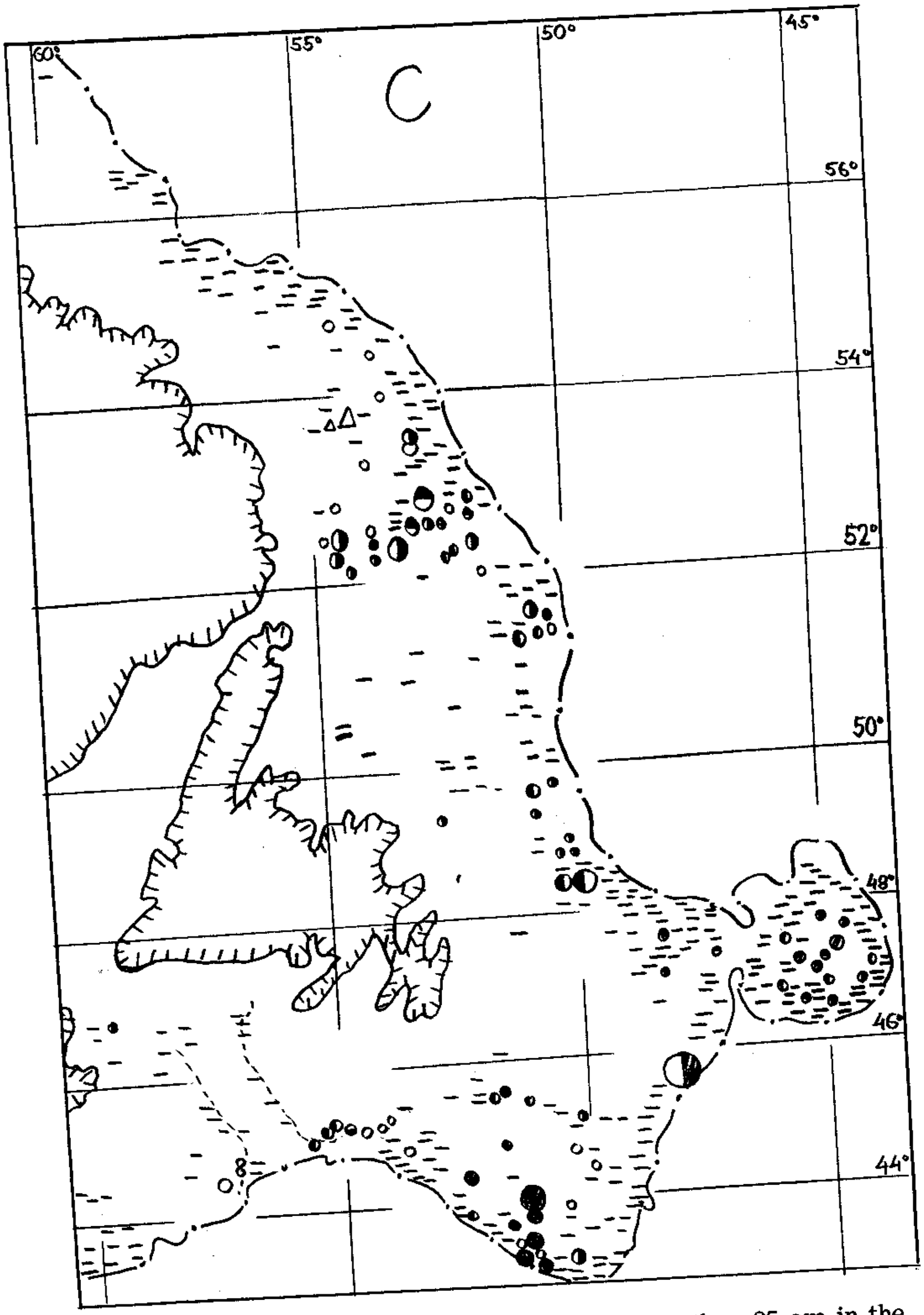

Fig. 1C. Distribution of young cod of less than 25 cm in the period from April to September, 1954-1961.

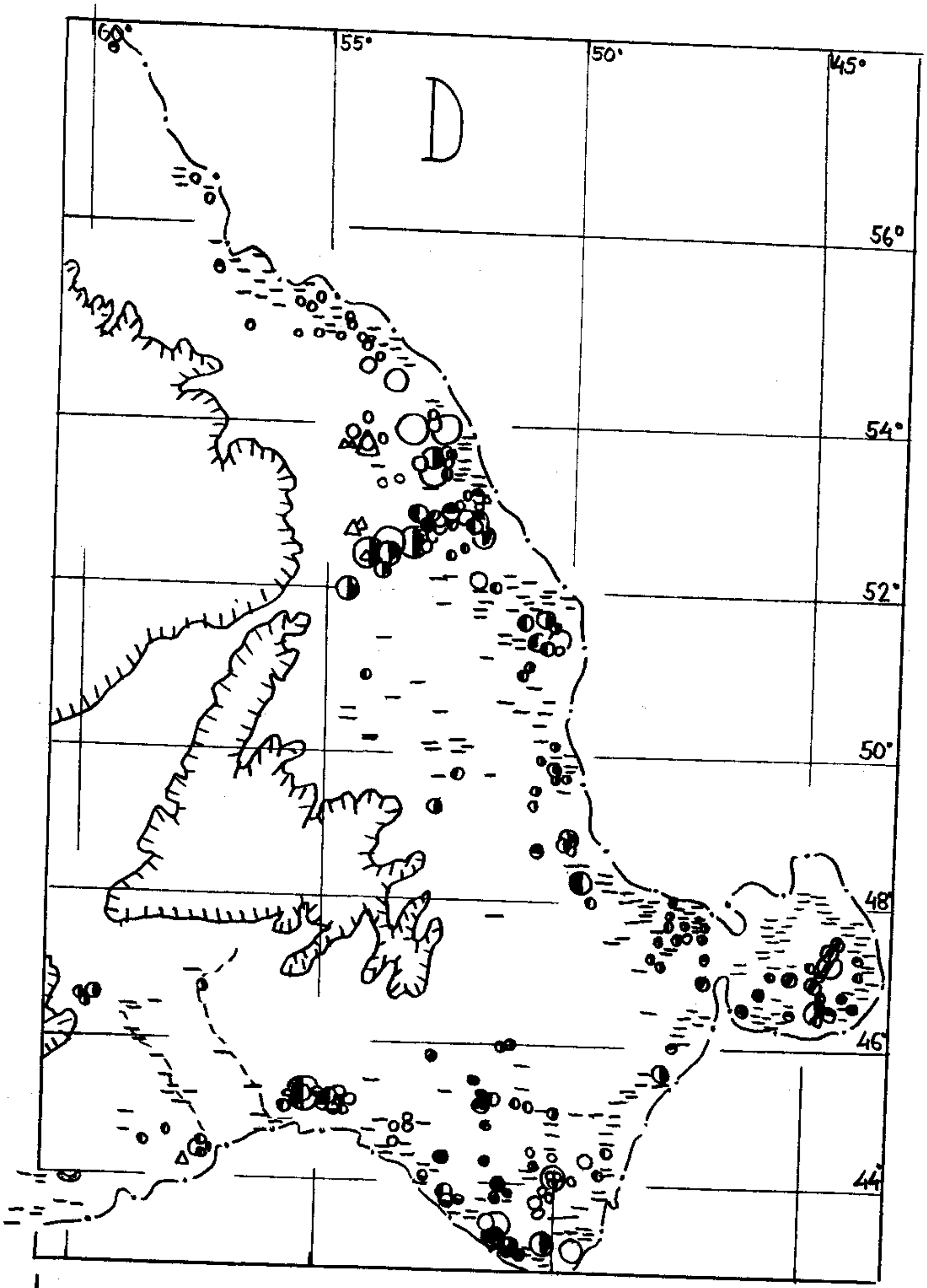

Fig. 1D. Distribution of young cod of 26-35 cm in the period from April to September, 1954-1961.

Flemish Cap

The young are concentrated on the shallow part of the bank and on its eastern slope at depths of 170-250 m. The greatest numbers were caught in 1956, 1960 and 1961 (up to 116 per one hour). On the northern slope of the bank at depths over 300 m young did not occur in the catches. On the southern and western slopes in the same depths only few young were caught.

Grand Newfoundland Bank

On the north-eastern slope of the Bank where the Labrador current forks into two branches trawl catches of 10-153 young cod were made at depths of 200-300 m with temperatures below 2°C. At more than 300 m the young were not found despite numerous hauls.

On the eastern slope of the Great Newfoundland Bank, according to the 1960 and 1961 data the young were distributed between 200-300 m (up to 117 per one hour) during the winter. In summer the young were distributed on the shallow part of the bank where, as a rule, temperatures were rising due to the summer heating.

The concentration of the young in the "tail" region of the Grand Bank is appreciable; between 100-200 m from 40 to 278 specimens were caught by a trawl.

St. Pierre Bank. Green Banks.

According to data from several years, the young were distributed in the warmer southern parts of St. Pierre and Green Banks. Especially large amounts (up to 2000 cod per one hour) were caught in 45-70 m, November, 1958. The young were in 1961 found on the south-western slope of St. Pierre Bank at 100-180 m with catches of 27-107 individuals per one hour.

A peculiar feature of young cod is that in almost all regions they concentrate near the spawning grounds. Location of these grounds is presented in papers of the meeting of the "Environmental Working Group" of the International Commission for the Northwest Atlantic Fisheries.

Investigations have with rare exceptions shown that young are not found at depths over 400 m. The young of small sizes more often occur in less deep water, e.g., in 2J the young of 25 cm were taken in trawls at depths less than 300 m, the young of 26-35 cm at the depths less then 400 m; on St. Pierre Bank the corresponding depth limits were 200 m and 300 m.

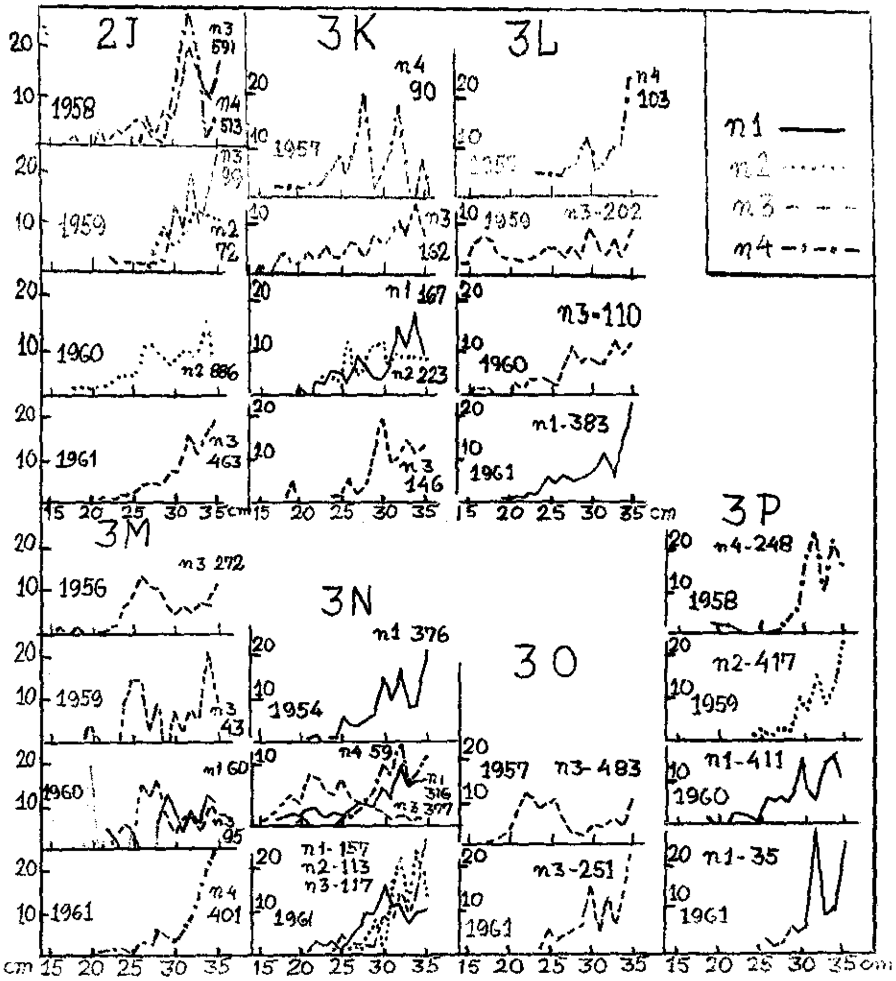

Fig. 2. Sizes of young cod by regions in different years, n_1 -January-March; n_2 - April-June; n_3 -July-September; n_4 -October-December.

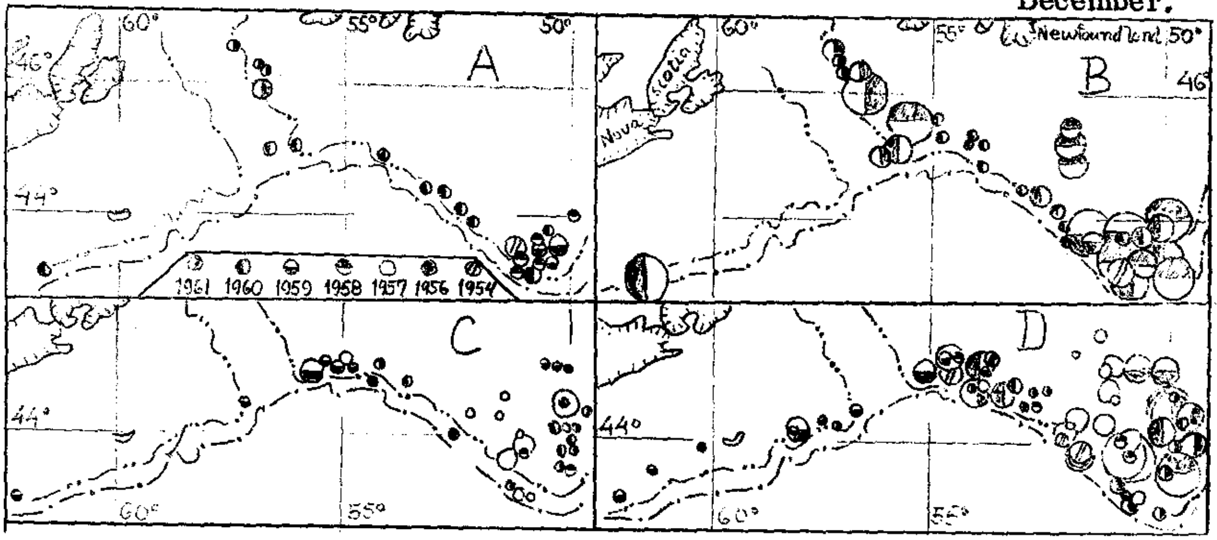

Fig. 3. Distribution of young haddock of less than 25 cm (A and C) and of 26-35 cm (B and D) in 1954-1961.

Data from several years testify that in summer young cod migrate from the slopes to shallow water. No seasonal changes in the depth distribution were observed on Flemish Cap, probably in connection with the relatively constant temperature regime.

The depth distribution of the young varies from year to year. Thus in Division 3O in December of the exceptionally warm 1958 year young cod were caught at 250-275 m; also in August, 1959, the young were distributed rather deeply, at 125-200 m.

Size of Young Cod

The size composition by regions in 1954-1961 is shown in Fig. 2. The data from the separate months are summarized (for better comparison) by three months periods.

Taking into account size composition of the young and comparing it with the not numerous age determinations the dominating year-classes can be approximately estimated. In Divisions 2J and 3K the 1954, 1955 and 1957 year-classes are predominant. This is also noted for commercial catches in the paper by A.I.Postolaky (1). On Flemish Cap the 1958 year-class was well represented.

For St. Pierre Bank 1955 and 1958 year-classes appear as good ones, judging from average sizes for cod of different age-groups given in the papers by Fleming (2) and Postolaky(1).

Haddock

Distribution of haddock under 35 cm is shown in Fig. 3. In the autumn-winter and spring-summer periods young haddock were located in the southern part of the Grand Bank and on its south-western slope, and also in the southern part of St. Pierre and Green Banks. Young haddock were distributed in shallow waters wider in the summer than in the winter period. More often young haddock were taken in the catches at depths from 50-150 m and up to 200 m. In the southern part of the Grand Bank at the depth of 70 m up to 7000 specimens of young haddock could be taken per one hour. Investigations showed that the young haddock inhabit this region constantly and in great amounts.

On the southern slope of St. Pierre Bank, at 160-200 m, up to 183 specimens were taken per one hour trawling. In 1961 the young were found on the south-western slope of St. Pierre Bank (from 20 up to 374 specimens per one hour).

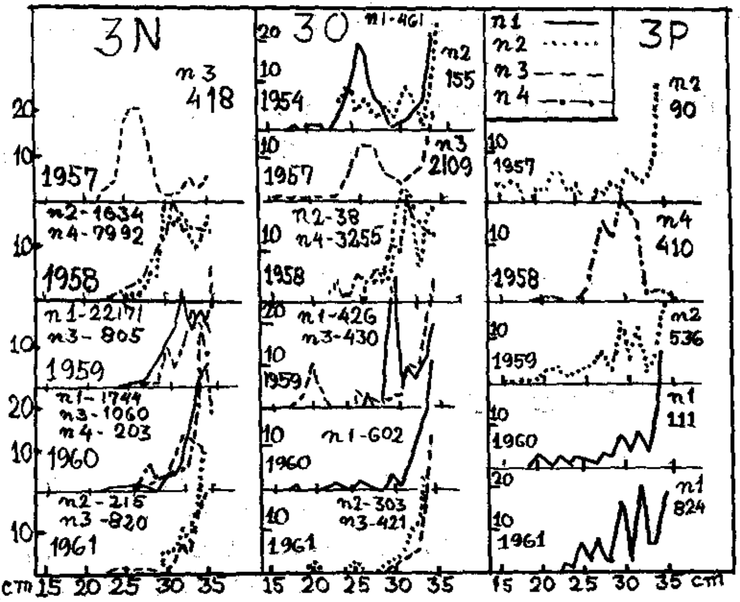

Fig. 4. Sizes of young haddock by regions in 1954-1961. n_1 - January-March; n_2 - April-June; n_3 - July-September; n_4 - October - December.

Sizes of Young Haddock

The size curves for the same years in Divisions 3N, 3O and 3P follows one another rather closely; this indicates a fairly similar composition of haddock in these Divisions (Fig. 4). From size composition and age data it can be assessed that the young of 25-28 cm (in 1957) and of 30-32 cm (in 1958) which were dominating in the above mentioned regions belonged to the 1955 year-class.

Conclusions

1. Five regions with concentrations of the young cod can be distinguished in the investigated area off Labrador and Newfoundland.

   a) Region of the gut south of Hamilton Inlet Bank;
   b) Northern part of the north-eastern slope of the Grand Bank;
   c) Shallow part of Flemish Cap and its eastern slope;
   d) Southern part of Grand Bank;
   e) Southern and south-western slopes of St. Pierre Bank.

2. Young haddock was found only in the southern part of the Grand Bank and St. Pierre Banks and on their south-western slopes.

3. Young cod and haddock of up to 25 cm inhabited less deep waters than young fish of 26-35 cm.

4. In the summer period the young of both species were caught in large amounts in shallow water of the banks and in the winter period closer to the slopes.

5. From the size composition of young cod it can be assumed that for Divisions 2J and 3K the 1954 and 1957 year-classes and for St. Pierre Bank - the 1955 and 1958 year-classes are abundant.

6. The 1955 year-class of haddock was abundant.

A. Bulatova.

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1. Postolaky, A. I.	Some data on biology of Labrador and Newfoundland cod. Soviet Fish. Inv.,in North-Western Atlantic, VNIRO, PINRO, Moscow, 1962.
2. Fleming, A. M.	Age, Growth and Sexual Maturity of Cod in the Newfoundland Area, 1947-1950. Journ. Fish. Research Board of Canada, Vol. 17, No. 6, 1960.

8. DIVISIONS OF COD STOCKS IN THE NORTHWEST ATLANTIC

by Wilfred Templeman, Fisheries Research Board
of Canada, Biological Station, St. John's, Nfld.

Contents

Introduction

The available information from which divisions in stocks of cod, *Gadus morhua* L., of the Northwest Atlantic can be deduced consists mainly of vertebral numbers, migratory studies, growth, year-class strength, spawning times and places and time and location of pre-spawning and other concentrations.

Much of this information is unpublished and has been supplied in a general form by various cod investigators so that detailed information is not available. Also a detailed presentation of vertebral and migratory data etc. is beyond the scope of this paper. Much of the basic information, therefore, will have to be discussed on its face value but in many cases the pattern is clear enough that this method of examination will be sufficient for the present purpose.

The basic vertebral and migratory data leading to hypotheses or beliefs in stock divisions will be presented first and this will be followed by an attempt to unify this material and add other pertinent knowledge for purposes of preparing diagrams of and discussing the divisions in cod stocks.

Figure 1 shows place names and Danish zone divisions for the Greenland area and Fig. 2 the many place names of this paper for the Labrador-Cape Cod region.

Figure 3 shows total cod landings from the various ICNAF divisions in 1959. Information on the Canadian Atlantic offshore cod fishery east of Halifax is found in McKenzie (1942) and on the distribution of cod in the Newfoundland inshore fishery 1947-49, in Templeman (1958). These and the many statistical publications of ICNAF will provide some information on the relative quantities of cod available from certain stocks and areas and will serve to supplement the information provided in the present paper on divisions of cod stocks.

In this paper the word "population" refers to the cod occupying any defined area at a particular time. The word "stock" is used to denote more unity in the group with regard to its greater degree of intermingling within itself and considerably less mixing with other groups, or a withdrawal to its own territory during some part of the year, whether for spawning or feeding, etc. A stock is a recognizable unit in which most of the fish have a similar area-occupying and migratory pattern. Along with this partial isolation of a stock from neighbouring stocks there are often other physical differences such as in growth, vertebral numbers, etc.

In addition to published information the author has had the benefit of stock division maps, spawning and other information provided for the Greenland area by Paul Hansen, for Subarea 4 by Yves Jean and for the Gulf of Maine by Albert C. Jensen. He has also through W. R. Martin been able to consult a very great amount of original data on cod vertebral averages (each sample usually about 100 fish) gathered by R. A. McKenzie of the St. Andrews Station during the period 1933-41 and forming the basis of the paper by McKenzie and Smith (1955). Much unpublished data from the St. John's Station on cod vertebral averages, cod spawning and the results of tagging experiments at the St. John's Station have also been used.

Vertebral numbers

Introduction

Apart from possible genetic differences, a discussion of which is impractical at the present time, and although any factor affecting the rate of egg and possibly early larval development can have an important effect on vertebral number, differences in vertebral averages of cod in the North Atlantic are apparently produced chiefly by different temperatures in the upper layers of water during early development. High temperatures produce low and low temperatures high vertebral numbers. This in turn is related to the time of spawning in relation to the area and the year. Consequently stocks having spawning times related to similar surface temperatures may have similar vertebral numbers.

Different stocks may have similar vertebral averages but adult stocks having very different vertebral numbers cannot be the same stocks.

Consequently vertebral averages can often give the broad picture of stocks which either must be or are likely to be essentially distinct without much intermingling, and stocks which may be the same or may intermingle widely but are not necessarily one stock and require other methods of attack to define the stock divisions.

As a rule the discussion of the reasons for vertebral differences is outside the scope of the present paper.

Although we have found no statement on the matter in Schmidt (1930) and Hansen(1949) it is evident by comparing Schmidt's cod vertebral averages for the Northwest Atlantic with our more recent vertebral averages that Schmidt (and Hansen) followed the common European practice of including the urostylar half-vertebra as a vertebra. We do not include the urostylar half-vertebra in our vertebral counts and consequently in using Schmidt's and Hansen's vertebral averages we have subtracted 1 vertebra in each case.

Greenland and Iceland

Vertebral numbers from cod collected between 1924 and 1937 (Schmidt, 1930; Hansen, 1949) show that, omitting some local fjord stocks, vertebral averages off West Greenland increase from south to north (in this period 52.11-52.42 south of Frederikshaab to 52.31-52.86 from Godthaab to Sukkertoppen and 52.67-52.93 in the Christianshaab to Disko area). The vertebral averages at East Greenland (Angmagssalik), 51.93-52.14 (if we combine Schmidt's small sample with his large one as he has done in his chart), are lower than those of southern W. Greenland but still higher than at West Iceland, 51.29-51.96. The vertebral numbers, therefore, indicate the lack of complete intermingling between the northern and southern West Greenland stocks and between southern West Greenland and East Greenland and West Iceland stocks. They also indicate the possibility of more intermingling between southern W. Greenland, and still more East Greenland stocks, and West Iceland stocks than between the stocks of the latter two areas and those of northern W. Greenland. There are also, at least in certain years, strong drifts of cod larvae from Iceland to Greenland (Tåning, 1934, 1937; Hansen, 1949).

Local fjord stocks may have widely different vertebral averages from those of the neighbouring outside stocks. The single vertebral average from Ikertok Fjord (53.01) is the highest and the single average from Kangia Fjord (51.95) the lowest in West Greenland.

Greenland and Labrador

On the Canadian side cod do not extend as far north as in West Greenland, the most northerly individuals found in the A. T. Cameron 1959 cruise from off Cape Dyer, Baffin Island (Lat. 66°47' N) southwards being at 125 and 150-160 fathoms (230 and 275-295 m) at Lat. 63°N and the first significant but small numbers off Frobisher Bay at Lat. 62°14' to 62°20' N in 150-200 fathoms (275-365 m) and in Ungava Bay (Templeman, 1960).

From the area of central and southern West Greenland which are the most likely regions of immigration of cod from Greenland to the Baffin Island-Labrador area the vertebral averages are approximately 2 vertebrae higher in Labrador than in West Greenland. Thus it is unlikely, as both cod populations are large, that there is any very considerable migration of adult cod from Greenland to Labrador or vice versa. This has been noted previously by Schmidt (1930), Thompson (1943) and Hansen (1949).

Labrador-Newfoundland region

Between northern Labrador and the southern part of the east coast of Newfoundland as far as St. John's, both coastal and offshore vertebral averages in different samples usually range between 53.8 and 54.6 and vertebral averages as high as 54.4 may be found south as well as north. There is consequently no reason, based on vertebral numbers, for believing that there are basically different stocks of cod in this large area. Moreover, in the deep water over or close to 100 fathoms (185 m) on the northern and northeastern parts of the Grand Bank there are large shoals of cod with vertebral numbers very similar (53.8 - 54.3) to those of the coastal and offshore populations of the east coast of Newfoundland and Labrador. Again, with some slight admixture from local and shallower-water Grand Bank stocks, these stocks may be considered to be basically part of the northern high-vertebral-number stocks.

The plateau area of the Grand Bank shallower than and enclosed by the 50-fathom (90 m) contour together with the deeper areas, also to the southward including the southwestern slope and the southern two-thirds of the eastern slope, are occupied by cod with vertebral averages between 52.2 and 53.3 with almost all the averages below 53. There is a small area of mixture of the northern and southern types lying near the 100-fathom (185 m) contour on the eastern slope of the Grand Bank between 45°30' and 46°N.

The vertebral numbers of Flemish Cap cod during the summer are on the average slightly lower than those on the neighbouring northeast corner of the Grand Bank from which Flemish Cap is separated by the Flemish Channel over 600 fathoms (1,100 m) deep.

Cod on or near the northwestern border of the 50-fathom (90 m) contour of the Grand Bank and in the Avalon Channel between the bank and the coast show vertebral averages of 53.2-53.7, usually intermediate between the generally-below-53 vertebral number of the surface of the bank populations and the vertebral averages of 53.9-54.2 usually found on the northern part of the Avalon Peninsula and near the 100-fathom (185 m) contour of the northwestern Grand Bank, but very much like the vertebral averages of the southern part of the Avalon Peninsula.

Farther west the vertebral averages of St. Pierre Bank are variable, between 52.7 and 53.7, but usually 53.3 or lower, overlapping the 53.0-53.7 averages of the neighbouring coastal Fortune Bay, Placentia Bay, Burgeo Bank and Ramea areas but with some averages lower than in these latter areas.

Gulf of St. Lawrence

In the Gulf of St. Lawrence on the Newfoundland side vertebral averages are usually below 53 to beyond the southern entrance of the Strait of Belle Isle where high vertebral averages (53.9-54.5) similar to those of the east coast of Newfoundland and southern Labrador are encountered. There is, however, 1 record of a 53.7 vertebral average together with another of 52.7 from off Port au Choix near the northern end of the deep Esquiman Channel which suggests the possibility that some schools of east coast cod pass somewhat farther into the Gulf than the Strait of Belle Isle.

A vertebral average of 52.4 on Centre Bank in the middle of the Strait of Belle Isle and vertebral averages between 52.4 and 53.0 at the western entrance to this Strait on its northern side show no evidence of penetration of high-vertebral count Labrador cod inward on the northern side of the Strait of Belle Isle. On the North Shore of the Gulf of St. Lawrence west of the Strait of Belle Isle vertebral averages (from the offshore part of the coastal shelf) rise somewhat and lie between 53.10-53.70, enough higher than the 52.3-53.0 averages of the west coast of Newfoundland south of Port au Choix to suggest some separation between the stocks.

Somewhat similar vertebral averages to those of the North Shore of the Gulf (usually 53.0-53.6) are typical of most samples from the Gaspé area and in the vicinity of the 100-fathom (185 m) contour marking the southern border of the Laurentian Channel as far as off eastern Cape Breton, and also Banquereau.

Lower vertebral averages, however, of 52.1-52.8, are generally present in the Gulf of St. Lawrence south of the Laurentian Channel over the central and southern areas of the Magdalen Shallows and some samples in this vertebral range occur in Bay Chaleur and off its mouth while others in the Bay Chaleur area, especially near the northern entrance to the bay, are in the lower part of the range of the Gaspé type.

The very large number of vertebral averages, all between 52.0 and 52.8 and almost all between 52.2 and 52.6, taken by McKenzie almost entirely from June to August, mainly north and west of Prince Edward Island and near the Magdalen Islands with a single average from each of Bradelle and Orphan Banks, indicate that these Magdalen Shallows cod are essentially a separate stock from that near Gaspé (or a number of stocks related to the various banks and island areas.)

The cod population north of the Gaspé Peninsula from Cape Gaspé west possesses high vertebral averages between 53.0 and 53.7 (and usually 53.3-53.6) in 10 averages by McKenzie. This population, with slightly lessened vertebral numbers, 52.9-53.2, in McKenzie's original averages, extends southward to near Cape d'Espoir and outside the mouth of Bay Chaleur while the population in Bay Chaleur has vertebral averages mainly but not entirely, in McKenzie's original records, between 52.4 and 52.8. Presumably outside the mouth of the bay is an area of intermingling between the Gaspé and Bay Chaleur stocks with the Gaspé type predominating.

A few vertebral averages taken by the St. John's Station in random samples of southern Gulf cod in 1950-51, about 10-15 years after McKenzie's samples, agree generally with McKenzie's results: 2 samples on Bradelle Bank west of the Magdalen Islands, 52.8; 1 at the mouth of Bay Chaleur, 52.5; 3 off Bonaventure Island, Gaspé, 52.9, 53.0 and 53.1; and 2 farther west off Cape Gaspé, 52.9 and 53.4.

The main cod population of the Gulf, quantitatively, is the Gaspé-Bay Chaleur population at and off the mouth of Bay Chaleur from northern New Brunswick to Gaspé and northward around the Gaspé Peninsula.

The western Cape Breton population has vertebral averages (in 11 averages in June-August by McKenzie) of 52.4-53.0 (8 averages between 52.8 and 53.0), slightly but definitely higher than those of the neighbouring Prince Edward Island and Magdalen Islands and hence has the vertebral characteristics of a population somewhat separate from the populations of these 2 areas.

Nova Scotian Shelf

For the Scotian Shelf the usual 52.9-53.6 vertebral averages of the northern part of the Shelf are similar to those of the cod populations of the Gaspé-southern contour Laurentian Channel populations. Across the Laurentian Channel the vertebral range of the St. Pierre Bank population, 52.7 - 53.7, includes the range of the northern Scotian Shelf vertebral stock but has a wider range of vertebral averages.

Passing southward along the Scotian Shelf the vertebral averages gradually decline. The Sable Island Bank-Emerald Bank population is slightly lower in vertebral number than the Banquereau population. South of the Scotian Gulf there is a continuing slow decline in vertebral numbers, accentuated south of Lockeport so that from Cape Sable west to the Bay of Fundy the usual range is between 52.3-52.7.

In the northern Scotian Shelf area McKenzie and Smith (1955) noted that vertebral averages increase off Cape Breton during summer months and on the Nova Scotian banks during winter months indicating a northerly (westerly) movement of higher-vertebral-count fish than the resident stock of these areas in summer and a southerly (easterly) movement in winter.

Gulf of Maine

For the Gulf of Maine there is little information. Judging by the few averages available the vertebral averages on the northeastern tip of Georges Bank, 2 samples each 52.7, are not much different from those on the neighbouring Browns Bank on the Nova Scotian Shelf, 52.5-53.0. In the western coastal area a vertebral average of 53.0 has been recorded by Schmidt (1930) for Mt. Desert I. Schmidt's Nantucket Shoals vertebral average of 51.9 is lower than any of the vertebral averages from the Gulf of Maine and evidently represents a different stock from those in the coastal Maine area and on northeastern Georges Bank.

Additional Stocks

In addition to the large stocks of cod providing the great bulk of the fishery and whose vertebral numbers have already been discussed, there are certain small stocks which because of their isolated spawning or spawning-time situations have vertebral numbers widely different from those of neighbouring stocks. For example the autumn-spawning cod of Halifax Harbour and the neighbouring St. Margaret Bay (McKenzie, 1940) had low vertebral averages, 51.6-51.8 compared with 52.9 for spring spawners caught in the same general area off Halifax.

In the landlocked Ogac Lake located at 62°52' N and 67°21' W at the head of Ney Inlet on the southern side of Frobisher Bay on Baffin Island there is a relict population of cod with a very low vertebral average of 52.1 (in information supplied by Ian A. McLaren of the Fisheries Research Board of Canada Arctic Unit, Montreal, Que., sample size, 121 fish) compared with the vertebral averages of close to or over 54 found in the open-sea cod population just southward of this lake.

Similar to this but less extreme is Hansen's (1949) highest vertebral average for Greenland, 53.01, from Ikertok Fjord, from small fish presumed to be produced from spawning in the fjord.

Doubtless many other small stocks will be found which, spawning in isolated locations or in different seasons and surface temperatures from the main stock of an area, will be found to have vertebral numbers distinctly different from the main stock of the area.

Caution in dealing with vertebral numbers

Extreme caution must be exercised in combining vertebral samples. An adequate random sample of 100 or more fish should be used as a basic unit, and in areas where 2 stocks overlap as on the eastern edge of the Grand Bank what appear to be separate schools of the 2 stocks may sometimes be found, for example, proceeding southward on the eastern slope of the Grand Bank, vertebral averages of (nautical miles between adjacent averages in parentheses) 53.9, (14) 53.1 and 52.8, (8) 53.8, (24) 54.3, (29) 52.7 have been found in our samples.

Great care must be taken in combining samples from different depths because, apart from the usual size and year-class differences, the deep-water stock may be a separate stock from that on the top of the bank, migrating into the area from elsewhere.

Thus, on the northern fringe of the Grand Bank the fish in the deep water in summer are usually of the northern high-vertebral-average stock, 53.8-54.4, whereas in shallower water, 15-70 nautical miles (30-130 km) distant, vertebral averages as low as 53.0-53.1 are found. A similar but not so clear-cut example is seen in the many low vertebral averages of Bay Chaleur and the higher but variable vertebral averages of cod from the nearby Gaspé area and in part at least from another stock.

At the southern entrance to the Strait of Belle Isle on the Newfoundland side vertebral averages of 54.1-54.5 from cod of the Newfoundland east coast stock and averages as low as 52.4-52.7 for cod of the west coast Newfoundland vertebral stock may be as close as 10 nautical miles apart or, for different years plotted on the same map, may overlap.

McKenzie (1939) says that off eastern Cape Breton in the deeper water 60 or 70 fathoms (110-130 m) and deeper, cod possess vertebral averages of 53.2 or higher (i.e. the Gaspé-southern border Laurentian Channel-Banquereau vertebral type) while those taken from the shallow inshore waters of eastern Cape Breton as well as those of southern and northwestern Cape Breton have vertebral averages of 52.6-52.8.

Combining any of these groups of which many more examples could be given will often hide a great part of the data.

Migration

Introduction

Tagging experiments produce evidence on the dispersal of spawning and feeding populations of cod and on the amount of intermingling with neighbouring populations. A number of tagging designs are worthwhile. A population of cod is often closest to being a well-defined stock when it is concentrated for spawning. The reduction of feeding at this time reduces the tendency for dispersal and because over most of the area January-June spawning predominates, the colder water and the winter descent into deeper water also promote concentration of the stocks. Tagging of these pre-spawning and spawning concentrations allows a study of the amount of intermingling with other spawning stocks in the summer feeding dispersal. On the other hand, tagging during the summer feeding dispersal when many stocks are intermingled should show to which spawning stocks these feeding stocks are related. These ideals are seldom attained. Most tagging has been done in the months of June-September when temperature conditions are favourable for the tagger but often not for the fish. At this time cod are readily caught in shallow water which is a favourable factor but the high temperatures of the latter part of the summer and early autumn are detrimental to survival. Over much of the northern part of the area the amount of winter fishing on the spawning grounds is negligible due to ice and weather conditions and hence the tagged fish are not caught in the spawning areas.

In an area such as the southern part of the Gulf of St. Lawrence, for example, the big fishery is near Gaspé-northern New Brunswick in summer and on the southern edge of the Laurentian Channel off eastern Cape Breton in early spring. Most tags from Gulf types are therefore likely to be returned from these areas. However, if great concentrations of cod existed throughout many summer months elsewhere in the southern Gulf they would very likely be fished. On the other hand returns are somewhat lower than they should be from areas of low concentration which are only fished lightly if at all.

In discussing tagging papers we are usually handicapped by lack of knowledge of whether the relative lack of migration is due to the immaturity of the fish or to the fish belonging to a resident stock. Much of the tagging has for the present to be accepted on its face value and we may make some errors in discussing the mobility of the stock. In the Newfoundland tagging we have removed some of the difficulty by tagging only cod 50 cm and over in length. Much of our discussion also refers to the years after the tagging year and thus more of the fish included in the discussion are likely to be mature.

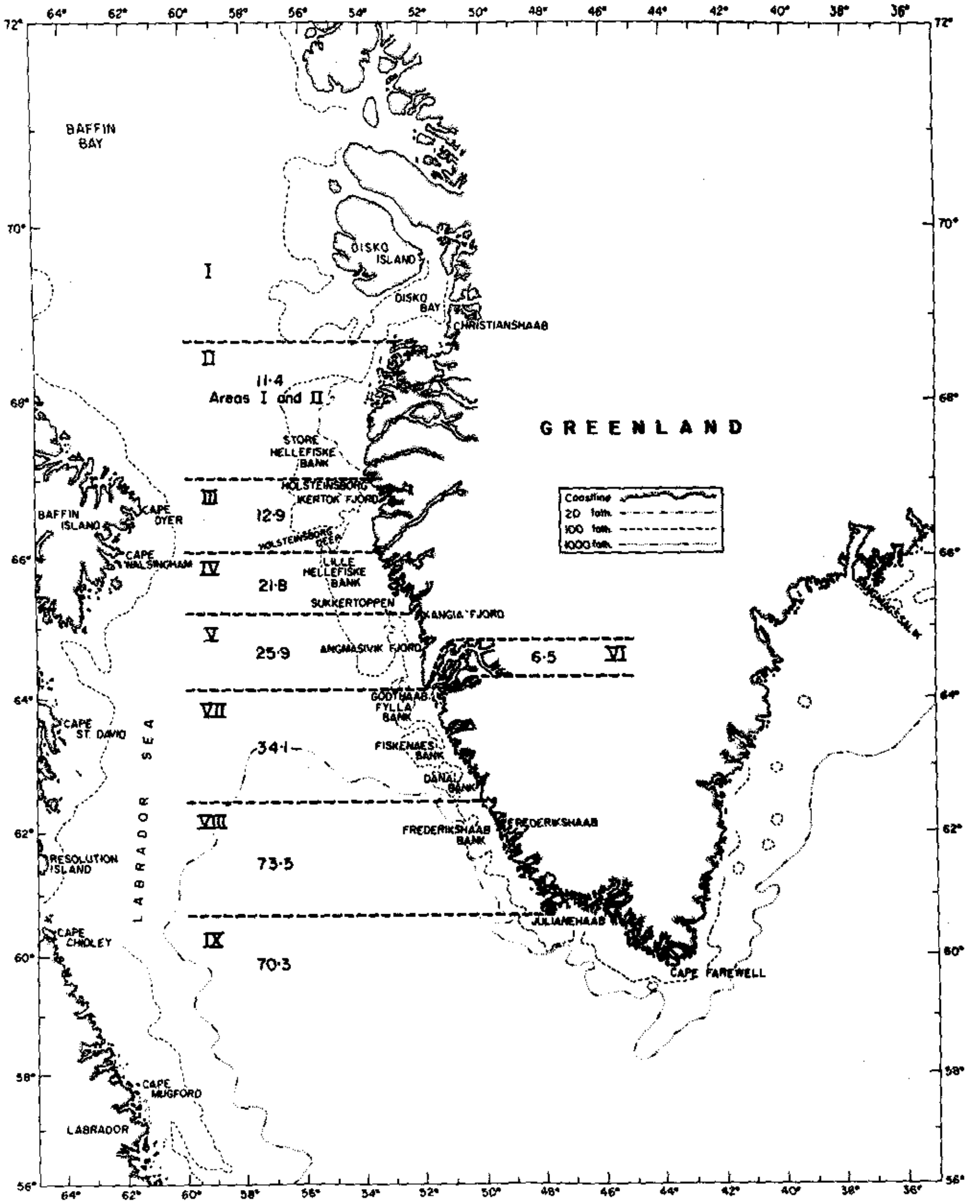

Fig. 1. Place names for Greenland area and Hansen's (1949) Zones I-IX in West Greenland, ICNAF Subarea 1. (Numbers in zones indicate percentages of total recaptures of cod, from taggings in each zone, recaptured in Iceland.)

Greenland

Hansen (1949) has summarized the results of cod tagging in Greenland from 1924-39 and Hansen, Jensen and Tåning (1935) in more detail the tagging from 1924-33.

According to Hansen (1949) the great spawning migrations of cod from West Greenland to Iceland take place mainly from the southern zones. For the 2 northern zones I and II (Fig. 1) 11.4% of all recaptures from the 1924-39 tagging were made in Iceland. The percentage recaptured in Iceland increases slowly southward to 12.9 in Zone III, 21.8 in Zone IV, 25.9 in Zone V and 34.1 in Zone VII (but only 6.5 in Zone VI, including only Godthaab Fjord), but increases rapidly and abruptly in Zones VIII and IX, the southernmost districts of West Greenland, to 73.5 and 70.3 respectively (Fig. 1). Excluding Zone III where many fish were tagged in fjords and Zone VI which is entirely a fjord area, both fjord areas having intensive fisheries and consequently high recapture rates, total recaptures in Greenland are fairly uniform in the northern Zones I-VII (3.9-5.5% of the numbers tagged) but lower for the 2 southern Zones VIII and IX (1.6 and 3.2%). For the recaptures at Iceland the reverse is the case, low but rising slightly southwards for the northern zones I-VII (0.4-2.0%) and higher for Zones VIII and IX (4.4 and 7.5%).

More recently Paul Hansen (personal letter, February 1961) says that from the tagging experiments 1924-1939 and since 1946 there is evidence of a strong interchange of cod between the banks in ICNAF Divisions 1A, 1B, 1C and 1D of Fig. 3 and N in Fig. 4 (approximately Zones I-VII of Fig. 1) whereas very few migrations in each direction have been recorded between these banks and the southern area, ICNAF Divisions 1E and 1F of Fig. 3 and S in Fig. 4 (approximately Zones VIII and IX of Fig. 1). In the cod-tagging experiments of 1929-39 a large spawning migration to Iceland occurred mainly from Divisions 1E and 1F. In more recent cod taggings from 1946 to the present time very few recaptures from Iceland have been reported compared with the 1929-39 period and cod tagged in Divisions 1A-1D and Divisions 1E-1F are reported in nearly equal numbers.

Rasmussen's (1958) summary of the results of Norwegian cod tagging, 1948-57, in West Greenland waters recorded many results very similar to those of Hansen above. From the Norwegian tagging, carried out in the Holsteinsborg Deep just north of Lat. 66°N from 1953-56, most cod were recaptured on the southern banks between Lat. 62° and 65°N in May and June and almost entirely northward between 66° and 68° N in August-September. Of 227 returns only 2 were from West Greenland south of 62° N (61-62°N), 7 from Iceland and 1 from Newfoundland (the Grand Bank). Thus Rasmussen believes that the West Greenland area north of 62°N is dominated by a true West Greenland stock of cod with a more or less closed migration pattern.

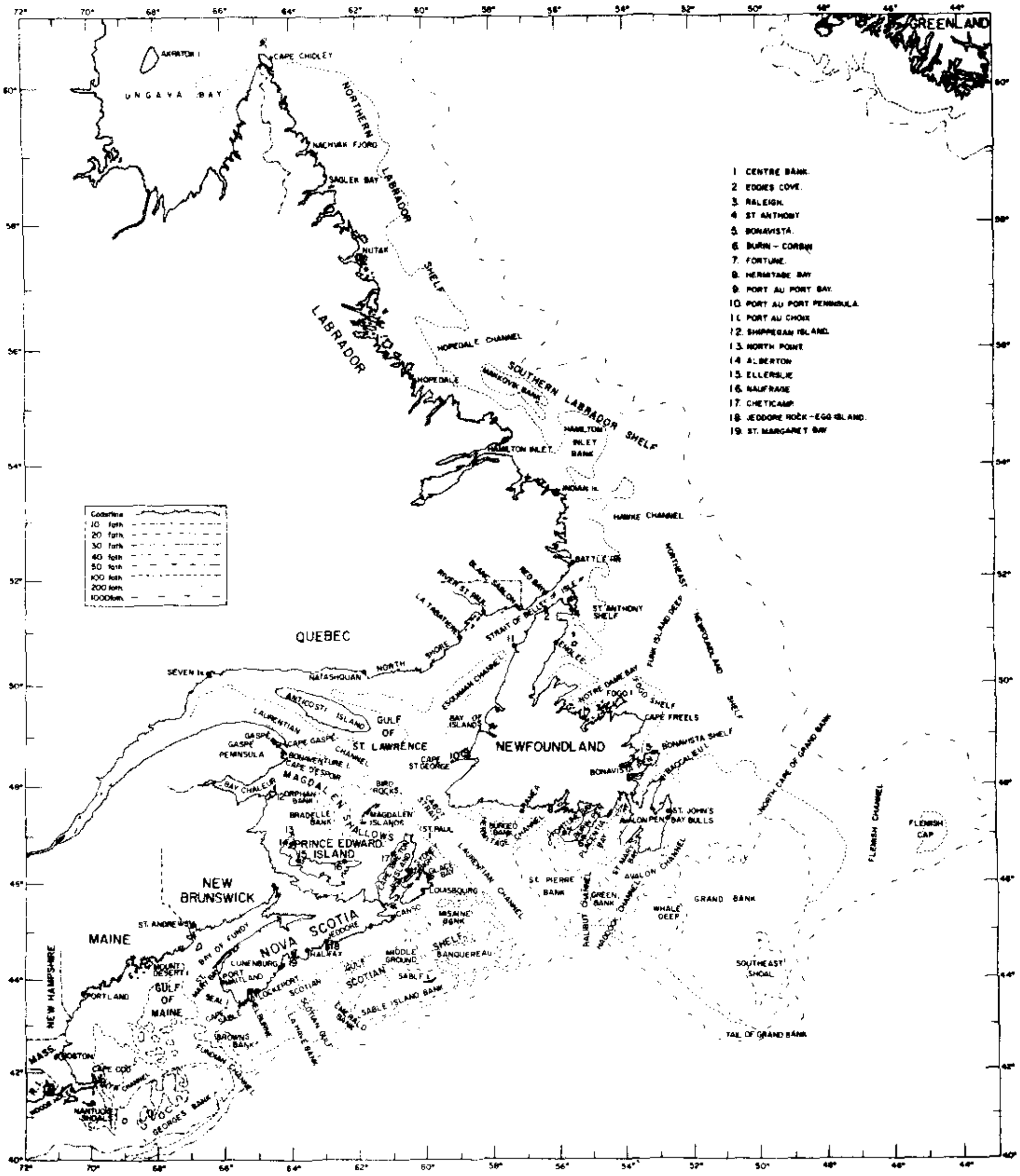

Fig. 2. Place names, ICNAF Subareas 2-5.

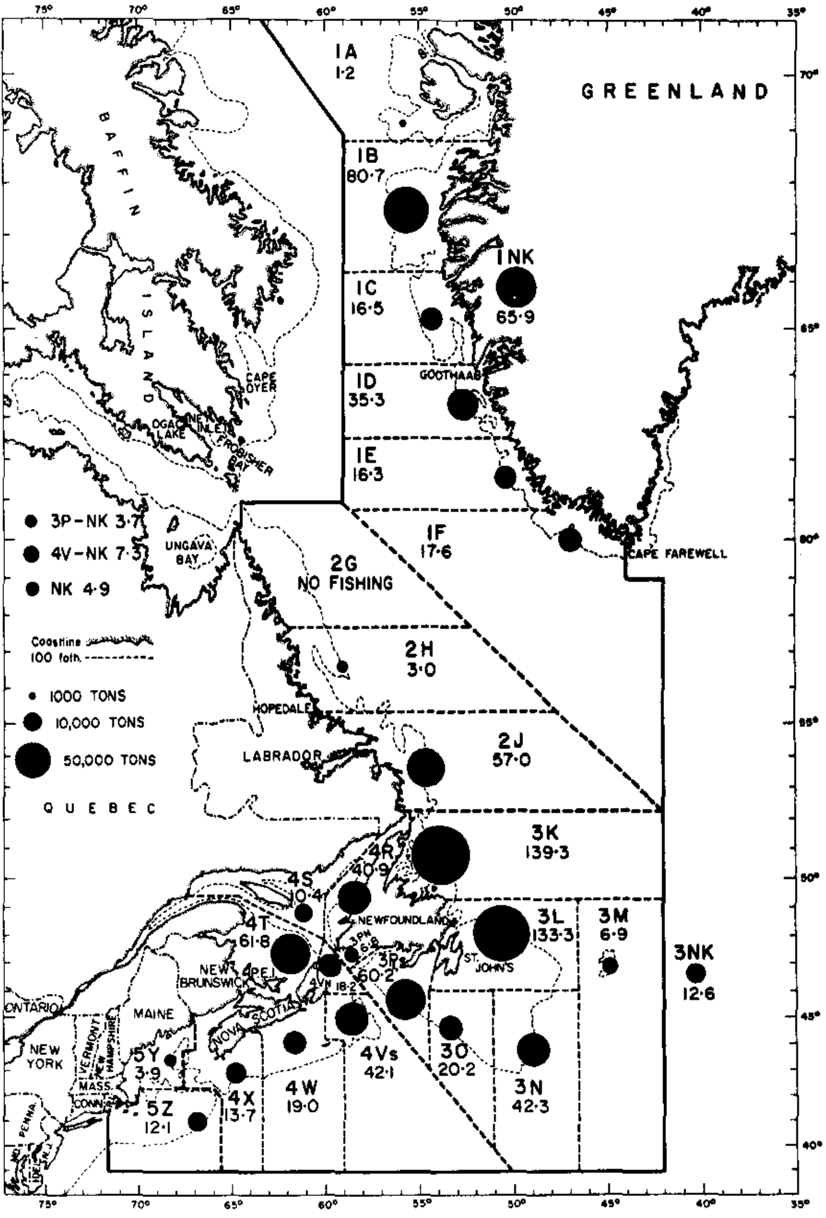

Fig. 3. Relative quantities of cod caught in 1959 in ICNAF Divisions. (Circle area is proportional to metric tons caught. NK = not known. NKI = in Subarea 1 but Division not known. Data from ICNAF, 1961.) Total catch in metric tons: whole ICNAF area, 953,517; Subarea 1, 233,542; Subarea 2, 59,994; Subarea 3, 425,261; Subarea 4, 213,468; Subarea 5, 16,350; unassigned, 4,902.

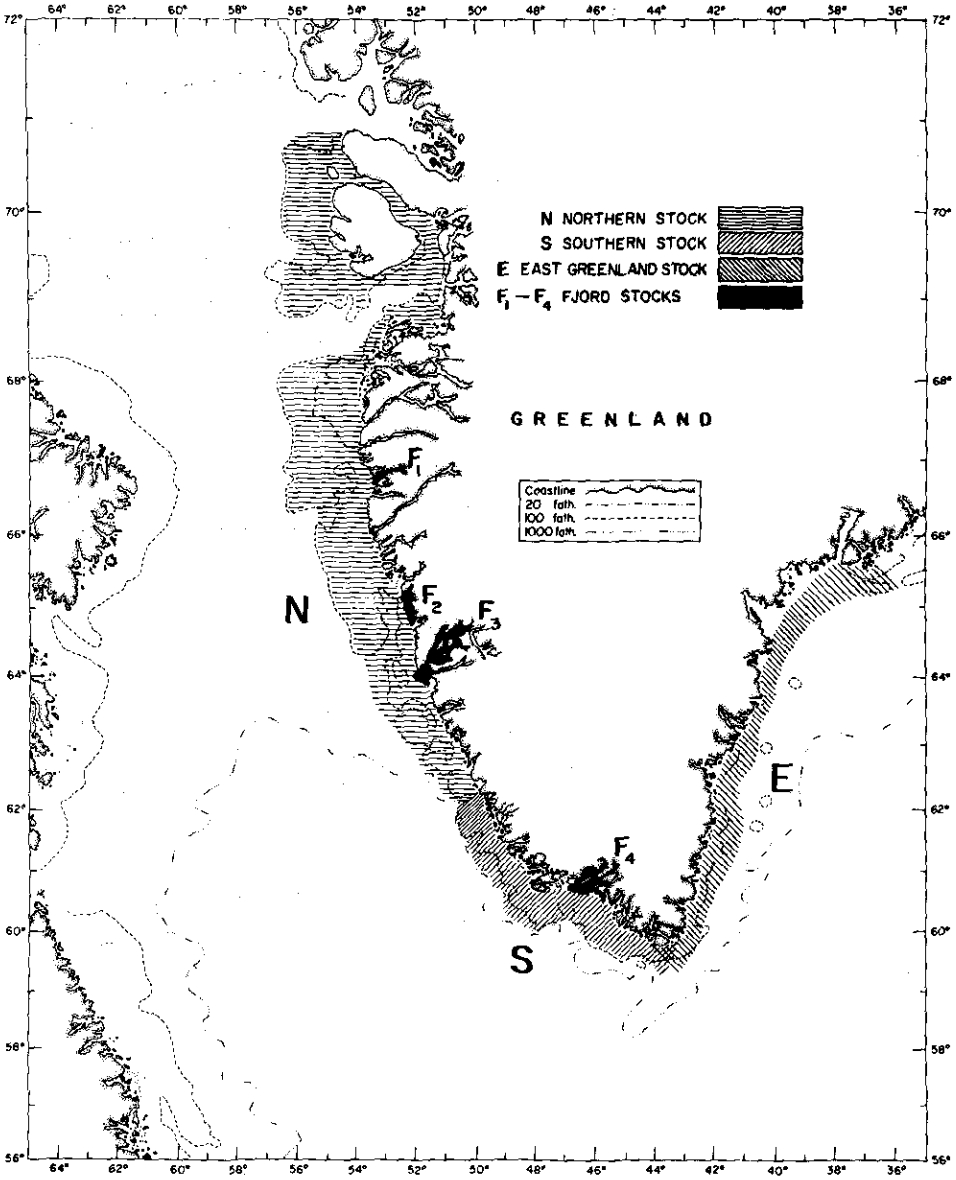

Fig. 4. Cod stocks of the Greenland area.

Trans-Labrador Sea movements

Tåning (1934) reports the capture in northern Newfoundland in 1933 of a cod tagged in the Westmanna Islands off South Iceland in 1931. Presumably this cod reached Newfoundland via West Greenland. Hansen (1949) says that so far no cod marked in West Greenland has been reported from Newfoundland. In 227 returns from Norwegian cod tagging in West Greenland in 1953-56 one was from Newfoundland (Rasmussen, 1958). This individual, tagged on Dana Bank in June 1955 was recaptured April 1956 on the Grand Bank (Rasmussen, 1957). Paul Hansen (Feb. 27,1962) has supplied a list, prepared by Mr. S. A. Horsted, of 7 recaptures in the Newfoundland area, 1954-59, from the Greenland Administration's cod tagging in West Greenland, 1951-59.

In the other direction Thompson (1943) in 984 returns from Newfoundland and Labrador tagging had only 1 return from West Greenland from a cod tagged at Indian Islands, Labrador on July 7, 1934 and recaptured in August 1938 just south of Disko Bay.

In our more recent tagging, from 670 recoveries (Templeman and Fleming, 1962) there were no recoveries in Greenland, but from more than 5,000 recoveries from 23,000 cod tagged during 1950-55 in the Newfoundland area by the St. John's Station there have been 2 recaptures reported from West Greenland, 1 from Greenland (presumably West Greenland), 1 from the North Sea and 2 from the Barents Sea.

It is often impossible to authenticate these distant recaptures and since trawlers move rapidly between the Newfoundland, Labrador and West Greenland areas and more itermittently to the eastern areas such as the Barents Sea the possibility of error in reporting is great. At least some of the recorded movements to and from West Greenland are probably authentic.

Labrador

Cod tagged inshore in southern Labrador south of Hamilton Inlet both in tagging by Thompson (1943) and Templeman and Fleming (1962) showed most of the long-distance recaptures to be southward along the east coast of Newfoundland. There appears to be no barrier to movement and from the depth of recaptures in the spring it was indicated that most of these long southward migrations were during the winter in the deep warm water beneath the below -0°C intermediate layer.

From cod tagged in northern Labrador at Nutak in 1948 (Templeman and Fleming, 1962) very few recaptures were reported, 1 fish only migrating as far as southern Labrador and none south of Labrador. In the opposite direction, apart from fish tagged near the northern extremity of Newfoundland, cod tagged in the Newfoundland coastal and bank areas east, south and west only rarely migrate to Labrador (none in Thompson, 1943; and Templeman and Fleming, 1962). The reason for this is probably that cod in this area move into deep water and have a tendency to migrate southward over winter hence bringing some Labrador fish to Newfoundland while the early summer movement of coastal fish though pelagic is most likely toward the coast following schools of capelin. The coastal break at the Strait of Belle Isle leading Newfoundland fish into this Strait close to the coast on the southern side tends to interfere with movement of Newfoundland coastal fish to Labrador during their summer feeding migration.

Newfoundland east coast

Tagging at Raleigh at the northern extremity of Newfoundland in July 1934 (Thompson, 1943) showed migration northward along the Labrador coast, southward on the east coast of Newfoundland and some movement into the Gulf of St. Lawrence on the southern side of the Strait of Belle Isle.

Tagging at Englee on the northeast coast of Newfoundland about 60 nautical miles (110 km) south of Raleigh in September 1947 (Templeman and Fleming, 1962), resulted in intermediate to long movements southward, mainly in the deep water over winter and shorter movements northward with some movement into the Gulf of St. Lawrence along the southern side of the Strait of Belle Isle.

Cod tagging at Fogo on the northeast coast of Newfoundland, August 1950 (St. John's Station unpublished data) with 447 returns showed that considerably more than half of the fish, even after 2 years at liberty, returned during the summer to the tagging area or areas only a few miles away. There was significant movement northward along the Newfoundland coast and some entrance into the Strait of Belle Isle where there were 7 recaptures on the southern side but only 2 on the northern side of the Strait and only 1 in southern Labrador. There was an equally significant coastal movement southward but not beyond St. Mary's Bay on the southern side of the Avalon Peninsula. Some fish, but a much smaller proportion than from the St. John's tagging, moved over winter to the slopes of northwestern Grand Bank where they were caught in March-June.

Tagging at Bay Bulls, 16 nautical miles (30 km) south of St. John's in 1933-37 (Thompson, 1943) and at St. John's 1948 (Templeman and Fleming, 1962) gave migrations all along the east coast of Newfoundland as far north as the entrance to the Strait of Belle Isle but no migrations to Labrador. There were southward and westward coastal movements only as far as the eastern shores of the Burin Peninsula. An occasional fish migrated to the western and northwestern edges and slopes of the Grand Bank and southwest to the Haddock and

Halibut Channels. Tagging at St. John's, August-September 1950 (St. John's Station unpublished data) gave the same coastal migrations as the previous tagging except that 2 our of 784 returns were from southern Labrador (1 inshore, 1 offshore) and 1 was on the south coast of Newfoundland west of the Burin Peninsula. Almost all the many offshore recaptures from this latter tagging were in March-June on the northwestern slope of the Grand Bank between Lat. 46°20' and 48°40'N. It appears that by far the greatest movement in winter from the St. John's region is toward the northwestern slope of the Grand Bank. Judging also by the large number of northward coastal captures in the year following the tagging year there is likely to be some over-winter and spring migration northward in the deep water. Also it is possible to take small numbers of cod throughout the winter in the deep water of the Avalon Channel several to 20 or more miles off St. John's and Bay Bulls. Thus all the cod do not move during winter to the slopes and channels of the neighbouring banks.

In migrating pelagically in the surface layers toward the coast in June there is a much-greater-than-random return to the general area of tagging but a great deal of movement also following the capelin more directly toward shore.

Grand Bank

Tagging on the southern Grand Bank in July 1935 (Thompson, 1943) and in May 1947 (Templeman and Fleming, 1962) gave some movement inshore to the southern part of the Avalon Peninsula and the Burin Peninsula, mainly from the fish tagged on the northerly half of the southwestern slope of the bank, but most fish migrated eastward, northward or northwestward to occupy the less-than-50-fathom (90-m) area of the bank during the late spring and summer.

Tagging on the northwestern slope of the Grand Bank at about 46°30'N on June 4-5, 1948 (Templeman and Fleming, 1962) gave mainly inshore recoveries entirely from the eastern part of the Avalon Peninsula in the year of tagging and coastal migrations as far northward as Notre Dame Bay in ensuing years. There was significant summer movement also to the northern slope of the Grand Bank.

Additional taggings in the same area of the NW slope and in the Avalon Channel at about 47°N about half-way between the Avalon Peninsula and the Grand Bank on April 12-17, 1951 (unpublished data, St. John's Station) gave inshore recoveries mainly from the Avalon Peninsula but several as far as the Bonavista Peninsula and Cape Freels on the east coast of Newfoundland. Most of the remaining returns were from neighbouring areas to the tagging area in the Avalon Channel and on the western Grand Bank in April-June.

St. Pierre Bank

Tagging on St. Pierre Bank (southern plateau, Thompson, 1943; southwestern slope at about 45°20' N, June 8, 1947, Templeman and Fleming, 1962; and on the northern plateau from May 20-June 2, 1954, unpublished data, St. John's Station) gave recoveries, apart from large numbers on the bank itself, chiefly in the inshore area to the northeast, mainly from Hermitage Bay and the Burin Peninsula to the Avalon Peninsula south of St. John's. A very few recoveries were from the western half of the south coast of Newfoundland and from the Gulf of the St. Lawrence as far as the Port au Port Peninsula on the west coast of Newfoundland and from the Scotian Shelf and the Grand Bank. (This assessment depends largely on the unpublished results of the 1954 tagging from which much larger numbers of returns were obtained than from the 2 previous taggings).

Newfoundland south coast

Tagging at Fortune in June-July 1935 (Thompson, 1943) on the western side and at Burin and Corbin from June 19 to July 10, 1948 (Templeman and Fleming, 1962) on the eastern side of the Burin Peninsula produced recaptures along the south coast of Newfoundland both east and west of the tagging localities, but not in the Gulf of St. Lawrence, and along the whole east coast of Newfoundland with only a few fish passing northward beyond the Avalon Peninsula. Some fish moved over winter to the Halibut and Haddock Channels and some occasionally to the northwestern Grand Bank.

Burgeo Bank

Tagging on Burgeo Bank, April 22-May 14, 1954 (unpublished data, St. John's Station), apart from the large numbers caught on the bank itself, gave returns chiefly between May and September and mainly from the coastal region from Hermitage Bay to Cabot Strait. There were smaller numbers of returns from the west coast of Newfoundland and from the eastern part of the south coast of Newfoundland as far as the Avalon Peninsula. There were also small numbers of returns, but more than usual from taggings in the Newfoundland area, from across the Laurentian Channel and the other deep channels of the Gulf of St. Lawrence and on the Scotian Shelf. There were a few returns from St. Pierre Bank and occasional Grand Bank returns.

Newfoundland west coast

Tagging off Port au Port in July and September 1934 and 1935 (Thompson, 1943) and off Bay of Islands on Oct. 7-20, 1948 (Templeman and Fleming, 1962) gave some winter but mainly March-April returns from outside the Gulf of St. Lawrence along the western part of the south coast of Newfoundland. The farthest eastward recovery was from west of the mouth of Hermitage Bay, and very few fish, 1 from each tagging, were recovered from Burgeo Bank and none from St. Pierre Bank. The recaptures and the decline of the fishery indicated that by late April, May and June the cod were migrating northward again along the west coast of Newfoundland.

Trans-Laurentian Channel movements

In 984 recoveries of cod tagged in the Newfoundland area (Thompson, 1943) only 2 trans-Laurentian Channel migrants were reported, to Banquereau and Sable Island Bank from St. Pierre Bank and Fortune respectively.

Templeman and Fleming (1962) in 670 recoveries from cod tagged in the Newfoundland area also had 2 recoveries from across the Laurentian Channel to the Scotian Shelf, 1 from tagging at Port au Port on the west coast of Newfoundland and 1 from the southern Grand Bank.

Out of 2,200 recoveries of cod tagged between the Laurentian and the Fundian Channels (McKenzie, 1956) there were 33 trans-Laurentian Channel migrants to the Newfoundland area. Northward migration across the Channel naturally occurred more frequently from the taggings nearest the Channel.

McCracken (1957) in 277 recoveries from tagging at Louisbourg near the southern edge of the Laurentian Channel had 3 trans-channel migrants to the Newfoundland area, whereas in 215 recoveries from tagging a little farther south at Canso there were no returns from the Newfoundland area.

Out of 1,022 recoveries of cod tagged in northern New Brunswick in June-September 1955-56 (McCracken, 1959) 18 returns came from across the Laurentian Channel to the Newfoundland side between Hermitage Bay and the northern slope of St. Pierre Bank and Cape St. George.

From cod tagged at the Magdalen Islands in July 1957 and May, 1958, Martin (1959) in his diagrams shows, out of 185 recoveries, 5 from across the Laurentian Channel in the Newfoundland area between Fortune Bay and the Bay of Islands. Crossings of the Laurentian Channel, therefore, are chiefly from populations bordering the Channel, and occur in only small numbers.

Gulf of St. Lawrence south of the Laurentian Channel

On the whole the recoveries from tagging in the Gulf of St. Lawrence (McKenzie, 1956) support the hypothesis that there is at least 1 Magdalen Shallows stock of which in summer most of the same individuals year after year are separate from the Gaspé stock but with some mixing in and off Bay Chaleur.

This hypothesis is supported by the tagging off Naufrage, P. E. I. in August, 1940; off Ellerslie, P. E. I. from July to November 1930-36; on the eastern edge of Bradelle Bank, Aug. 6-7, 1936; and off North Point, P.E.I. and west of Bradelle Bank, Aug. 5 and 8, 1936. The only southern Gulf of St. Lawrence summer tagging in McKenzie's paper showing an unusual amount of intermingling with the Gaspé fish is that off Alberton, P.E.I. in July 1939 (McKenzie's fig. 42). It may be significant that in this year (McKenzie, 1939) during the spring migration the higher-vertebral-count Banquereau-Gaspé cod passed through the eastern Cape Breton area in the shallower water instead of the usual migration track in offshore waters over 60 fathoms (110 m) deep. It is possible that these cod went pelagically south of the Magdalen Islands instead of north and thus mingled with the Alberton population.

Almost all the cod entering the Gulf of St. Lawrence from tagging on Banquereau and eastern Sable Island Bank (McKenzie, 1956) were caught near the Gaspé Peninsula and north of Cape Breton Island at the entrance to the Gulf. Of 4 Gulf recoveries from cod tagged on Misaine Bank, however, 2 were caught in the Magdalen Shallows area, 1 in Bay Chaleur and 1 at Gaspé.

Recent tagging (McCracken, 1959), from June to September, mainly in or close to the mouth of Bay Chaleur gave almost all recaptures in winter on the southern edge of the Laurentian Channel, mainly about the 100-fathom (185-m) depth, in the region from Bird Rocks but chiefly St. Paul's Island to north of Misaine Bank with a few recaptures from eastern Banquereau. In summer these fish were concentrated near the area of tagging in and off Bay Chaleur and northern New Brunswick and southern Gaspé. There were not many captures elsewhere in the Gulf, a few north of the Gaspé Peninsula and around the Magdalen Islands and very few near Prince Edward Island.

Tagging at the Magdalen Islands in July (Martin, 1959) gave the same winter distribution as the Bay Chaleur-northern New Brunswick tagged fish. In the summer of the year after tagging, recoveries south of the Laurentian Channel, according to Martin's diagram, were Gaspé, 8; Orphan Bank, 6; northern New Brunswick 3; Prince Edward Island, 1; Magdalen Islands, 12. Thus, although movements to Gaspé are significant, the large proportion recovered in the year after tagging in the Magdalen Islands area is in great contrast to the very small proportion of recoveries in this area, from McCracken's tagging off and near the mouth of Bay Chaleur (McCracken, 1959, fig. 2), 16 in the Magdalen Islands area compared with 293 in the vicinity of the tagging areas off southern Gaspé and northern New Brunswick, for a year after the tagging year. This Magdalen Islands summer stock therefore has some of the characteristics of a local stock.

Tagging off Cheticamp, on the western side of Cape Breton Island in July 1937 (McKenzie, 1956, fig. 38) gave in the years after the tagging year the following returns from Gulf of St. Lawrence: 4 from Gaspé, 1 from the Magdalen Islands and 14 from near Cheticamp. Again this western Cape Breton stock is essentially a local stock with (allowing for the lack of fishing along the slopes of the Laurentian Channel during the period of McKenzie's tagging) probably a strong movement out of the Gulf in winter and return in spring.

The earlier Gulf of St. Lawrence tagging in 1930-36 (McKenzie, 1956) showed very little evidence of the strong outward winter migration from the Gulf of St. Lawrence because no large deep-water winter fishery existed at that time on the slope of the Laurentian Channel at the southern entrance to the Gulf. Martin (MS, 1961) from winter compared with summer otter-trawling surveys showed that most commercial-size cod had migrated outward from the southern Gulf by January and were concentrated in greatest numbers between 100-125 fathoms (185-230 m) at bottom temperatures of 2 to 4°C along the slope of the Laurentian Channel at the southern entrance to the Gulf of St. Lawrence off St. Paul's Island-Sydney Bight. These surveys, however, also showed that small immature cod of pre-commercial sizes were present in small numbers in winter off northern New Brunswick and Gaspé and that very small cod of the 0 and 1 age-groups were still present in shallow water off Shippegan Island in January at bottom temperatures of -1°C and lower.

Martin (MS, 1961) reported on the movements of cod tagged in 80 fathoms (145 m) off Sydney Bight in early February 1960. Of 52 recoveries from June to December 1960, 50 were taken from the western Gulf of St. Lawrence, mainly off northern New Brunswick and Gaspé. It would be interesting to tag at various depths and localities along the winter distribution of the Gulf cod between Bird Rocks and Misaine Bank to find if any of the smaller Gulf stocks related to other summering areas are to some degree localized in their winter distribution.

Scotian Shelf

The following notes are after McKenzie (1956) and refer to cod taggings in the years 1935-38: cod tagged at Misaine Bank March 1-2, and northern and eastern Banquereau April 18-20, showed a fairly large percentage of the migrants (apart from those captured near the tagging area) recaptured in the Gulf of St. Lawrence (especially in the Gaspé area), or near northeastern Cape Breton probably on their way to and from the Gulf. Tagging on eastern Sable Island Bank, March 28-April 6, showed less but still significant movement to the Gaspé region of the Gulf. Small numbers of cod tagged on Banquereau April 23-26, April 30-May 3 and larger numbers tagged on May 4-5 and May 28-29 and cod tagged on Sable Island Bank April 20 and May 30 and on or near Middle Ground north of Sable Island Bank on May 13 and June 15-29 produced little or no migration into the Gulf - none beyond the eastern perimeter of the Gulf. Tagging south of Emerald Bank March 5-26, gave returns mainly from the neighbouring southwestern half of Sable Island Bank with some spreading farther northward, especially in summer.

From both Banquereau and Sable Island Bank some cod migrated in summer to the neighbouring outer coast of Nova Scotia. These cod could either be coastal cod which had spent the winter on these banks or bank cod on feeding dispersal after spawning. Probably both of these alternatives occur.

Cod tagged mainly in May-September in the inshore areas of Nova Scotia, at St. Mary Bay, and near Seal Island, Shelburne, Lunenburg, Halifax, Jeddore Rock to Egg Island, Canso and Glace Bay produced recaptures mainly within a few miles of the tagging areas in ensuing years, with some intermingling with adjacent populations and some seasonal movement, offshore in winter and return in summer, between the Halifax-Glace Bay area and the neighbouring offshore banks. There was a little scattering to the Gulf of St. Lawrence and Newfoundland regions. Movement to the offshore banks in winter increased from south to north.

Similarly tagging off Lockeport, Nova Scotia, May-October 1953, off Louisbourg near Glace Bay, Nova Scotia in June and July 1954 and off Canso in July and August 1954 (McCracken, 1956, 1957) gave essentially the same results as McKenzie's tagging in the same or neighbouring inshore areas of Nova Scotia. The Canso fish moved little and the Louisbourg fish more than those of Canso. There was little intermingling between the 2 stocks. Most recoveries were from within the tagging region and recoveries from outside the tagging region were mainly from neighbouring inshore grounds and in the Canso and Louisbourg tagging during the winter-spring from neighbouring offshore banks of the Scotian Shelf. There was some winter movement to neighbouring deeper water.

Trans-Fundian Channel movements

In more than 2,200 recoveries of cod tagged between the Laurentian and Fundian Channels (McKenzie, 1956) there were only 11 from across the Fundian Channel on New England fishing grounds. From 757 recoveries of cod tagged off Lockeport, Nova Scotia (McCracken, 1956) there were only 7 from across the Fundian Channel about 80 nautical miles (150 km) distant, 6 of these from the neighbouring Georges Bank.

However, Wise (MS, 1962) found that the eastward trans-channel movement was much greater in tagging on northeastern Georges Bank in March-April 1957 from which, in the summer and early autumn after tagging, 20 returns were from Georges Bank and 16 from Browns Bank and the coast of southwestern Nova Scotia. Of subsequent returns 18 were from west and 8 from east of the Fundian Channel.

From tagging on Browns Bank in March 1957, there were 41 returns from Browns Bank and other localities east of the Fundian Channel and 5 west of the Channel. From tagging on Browns Bank in October 1957, 7 returns were from east and 4 west of the Fundian Channel (Wise, MS, 1962).

Gulf of Maine and southward

Tagging on the northern side of the Gulf of Maine in the Nova Scotian region has already been discussed. Smith (1902) reports the results of the tagging of over 4,000 mature cod caught at Nantucket Shoals and liberated near Woods Hole, about the end of January 1898-1901. Schroeder (1930) discusses the information on the migrations of southern New England cod obtained from the tagging of over 23,000 cod on and near Nantucket Shoals, southeast of Cape Cod during 1923-29. He also reviews Smith's results. Schroeder concluded that a large part of the Nantucket Shoals cod population migrates southward in autumn to the Rhode Island-North Carolina region where most of them remain until spring. Only a small proportion of the cod from north and east of Cape Cod make this southward migration. The cod return eastward in spring, most of them summering on Nantucket Shoals, but some of the larger fish, which probably before the tagging occurred had migrated southward from north and east of Cape Cod, continue northward and eastward to deeper water. Although in the winter the cod catch between Rhode Island and Delaware ranged between 3 and 5 million pounds, in the summer relatively few cod were caught off Rhode Island and cod were caught only rarely west of Rhode Island. During some summers part of the Nantucket Shoals cod move eastward to the Chatham-South Channel region.

Wise (1958) discusses the results of his tagging of 448 cod off southern New Jersey in the winter of 1955-56 and of Schroeder's (1930) winter cod tagging in the same area. He concludes that the cod which range mainly from Long Island (and Block Island) to North Carolina in winter and spring should be regarded as a separate wintering and spawning population which in summer feeding migration moved northward to Nantucket Shoals and in individual cases (Schroeder, 1930) probably to the Gulf of Maine and Georges Bank. This is the southernmost stock of cod.

Wise and Jensen (MS, 1960) say that returns of several hundred tagged fish, from cod taggings in the Gulf of Maine region since 1955, indicate that the eastern Georges Bank population is of most importance and apparently mixes little with the more westerly and northerly groups, but some of the older fish wander to the southwestern Nova Scotian area. West of about 68°W Long. on Georges Bank there is another cod population which spends the summer in South Channel, about 69°W, especially on the western side of this Channel and which spends most of the remainder of the year inshore in the Nantucket Shoals-Chatham area. North of this stock are 1 or more largely sedentary stocks living on the coastal shelf and banks along the northwestern border of the Gulf of Maine.

It is apparent from Wise (MS, 1962; see also previous discussion) that, presumably after spawning, there is a large amount of eastward movement of the eastern Georges Bank stock in spring and summer to intermingle with cod of the Browns Bank and southwestern Nova Scotia stocks, but not nearly so much movement of these latter stocks occurs, at least in spring and summer, in a westward direction to intermingle with the eastern Georges Bank stock. There is apparently some residual eastward migration of the eastern Georges Bank stock. Although the small number of returns give only an indication, there may be in autumn-winter a significant movement of Browns Bank cod to Georges Bank or a return of migrating Georges Bank cod from Browns Bank to Georges Bank. Thus another or additional explanation may be equally plausible, namely that part of the Browns Bank stock migrates westward across the Fundian Channel in autumn and winter, returning eastward again in spring to spawn.

Divisions of cod stocks

Introduction

The question of division of cod stocks in the ICNAF area has been discussed in recent years especially by Hansen (1949) for Subarea 1; by Templeman (1953), and Fleming (1960) for Subareas 2, 3 and Division 4R; by Martin (1953), McKenzie and Smith (1955) and McKenzie (1956) for Subarea 4; by Wise and Jensen (MS, 1960) for the whole ICNAF area; and by Wise (MS, 1962) for the western part of Subarea 4, Subarea 5 and southward. Meanwhile, new information has accumulated, especially from tagging and although for all stocks much information is still needed it is now possible to give a more complete but in many respects still tentative picture of the identity and the degree and season of intermingling of many of the chief cod stocks of the ICNAF area.

In the divisions between cod stocks discussed here research papers and unpublished information related to vertebral and migratory studies and already discussed will not be referred to in detail again and whenever general statements regarding these matters are made the reader is referred back to the reviews in the earlier parts of this paper.

Although it is necessary in a chart to draw rather definite lines between stocks it must be understood that generally stocks are not so clearly divided as the maps show and the lines are meant only to include the major part of the stocks.

Almost every part of the cod life-history has a bearing on the reasoning regarding distinctions between stocks but we have only had time here to review in detail the vertebral and migratory patterns which are on the whole of broadest importance and available in greatest amount for the reasoning. Other life-history patterns bearing on stock divisions will be included piecemeal in this discussion as they are needed.

Greenland stocks

Figure 4 and information regarding it have been provided by Paul Hansen, rather reluctantly in view of lack of clear divisions between the stocks other then some of the fjord stocks. (See also Hansen,1949). The stocks have been divided into: N, northern West Greenland stock; S, southern West Greenland stock; E, East Greenland stock; and some fjord stocks (small in numbers compared with the outside stocks): F_1 , Ikertok Fjord stock; F_2, Sukkertoppen stock (from Kangia Fjord and Angmasivik Fjord); F_3, Godthaab Fjord stock; and F_4, the Julianehaab stock (from fjords of this area). The divisions have been based mainly on differences in migratory pattern. There are also some differences in vertebral averages, these being lower for southern than for the northern West Greenland stock and still lower for East Greenland. Vertebral averages of fjord stocks taken at a time when the fjord stock is not intermingled with the offshore stocks may sometimes be considerably different either higher or lower than those of the neighbouring coastal and offshore stock. The growth rate is lower for the southern than for the northern West Greenland stock and the growth of the East Greenland stock is similar to that of northern West Greenland. There are often some differences between N and S in year-class strength.

The stock of N is to a great degree self-contained and in the years of large migrations to Iceland these largely took place from S. Relatively little tagging has yet been reported on from E.

Tagging experiments have shown that very few cod belonging to F_2, F_3 and F_4 migrate to the offshore area. Tagging experiments with young cod in F_1 have shown that cod when 7 years old leave the fjord and migrate to the offshore banks.

All the fjord stocks have growth rates slower than the stocks on the offshore banks. The otoliths have narrow zones and(especially in F_4) have many secondary rings. F_3 (Godthaab Fjord), the best known stock, has a composition of year-classes different from the offshore stock. Apart from having its own special population a fjord may receive even more numerous visitors from the outside. In Ikertok Fjord, for example, there is a local population (F_1) characterized by slow growth and relative lack of migration of the young cod and the highest (on 1 average) vertebral average in West Greenland, spawning in the fjord in spring at which time it is caught by Greenlanders through holes in the ice. There is, however, a great cod fishery in the fjord later in the year, based on cod from the outside which have migrated into the fjord. Cod also spawn in Kangia Fjord (F_2) and in Godthaab Fjord (F_3).

The cod of West Greenland (N and S) spawn from March to May, with a maximum in April or in some localities March-April, and mainly south of Lat. 65°N at depths of 200-550 metres.

Greenland and Labrador stocks

The difference of approximately 2 vertebrae, the Labrador stock having the higher number, between the cod populations of West Greenland and Labrador and the passage of only occasional strays in both directions across the Labrador Sea from the great numbers of cod tagged in West Greenland and in the Labrador and Newfoundland regions indicate no movement of adult cod between these regions large enough to affect significantly the characteristics of the great cod populations of these 2 areas. Hence the cod stocks of West Greenland can be considered to be well separated from those of the Labrador and Newfoundland regions.

Hansen (1958) showed that in 1957 there was probably a greater-than-usual transfer of West Greenland water toward the American coast with a resultant drift of cod larvae farther west than usual. Templeman (1961) also produced evidence that the young redfish found off Baffin Island came by way of West Greenland. There is no evidence from the Labrador vertebral numbers of the introduction in recent or earlier years of large numbers of individuals with the low-vertebral-count characteristic of cod of West Greenland origin. All cod vertebral averages taken by the St. John's Station along the coast and offshore on the Labrador Shelf in 1959-60 were 53.7 and over and most, including all 15 samples from the offshore shelf area, were over 54.

Ogac Lake stock

This is a small relict stock in Ogac Lake in Frobisher Bay, eastern Baffin Island, not in the ICNAF area. It is characterized by vertebral averages about 2 lower than the nearest cod of the outside waters.

The production in West Greenland of year-classes of cod very significantly more numerous than those of other year-classes whereas in Labrador the dominance of individual year-classes is not very noticeable or common, and the considerably lower growth rate of the Labrador cod, are additional evidences of the essential separation between the West Greenland and the Labrador stocks.

Labrador-Newfoundland stocks

Labrador-Newfoundland stock. The cod populations of the east coasts of Labrador and of Newfoundland and to the north of the Grand Bank have been shown in Fig. 5 as 1 large stock, the boundaries of which can also be extended to include the cod population of Ungava Bay and northward to the limit of the cod stock off Frobisher Bay along the east coast of Baffin Island. The basis of including this whole group in 1 major stock division is the presence of similar high-vertebral-count characteristics and the lack of migratory divisions in the area. The whole area is characterized by the presence of cold water, usually below -1°C from

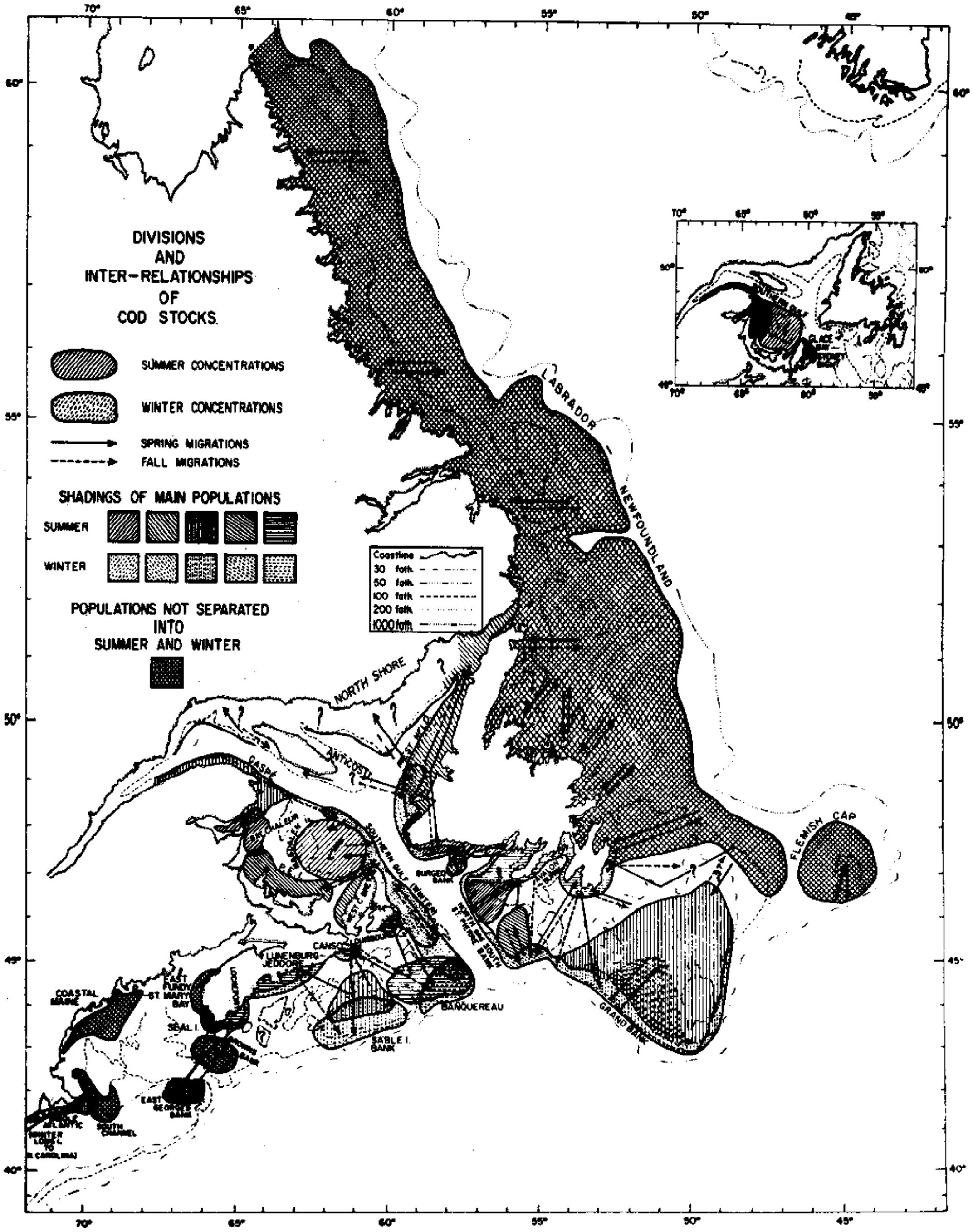

Fig. 5. Cod stocks of Subareas 2-5 and southward of Subarea 5. [Inset shows (from Yves Jean) outlines and concentrations of the southern Gulf of St. Lawrence population in summer when considered as a separate stock. Inset also shows the Glace Bay-Sydney Bight stock in summer.]

surface to 100 fathoms (185 m) or deeper during winter and early spring, ice cover during the winter and deep warmer water with temperatures above 0°C at depths of usually 100-140 fathoms (185-260 m) close to the shallow coastal water where great numbers of the smaller cod spend the summer. Thus there is a general offshore winter, onshore summer movement of cod in the whole area, but the onshore movement is earlier in the south than in the north. Although detailed information during the actual spawning season is relatively poor spawning is probably chiefly from April to early June throughout most of the area occupied by the Labrador-Newfoundland stock, at least from southern Labrador and Hamilton Inlet Bank southward. The onshore movement producing the inshore fishery is mainly from the latter half of June on the southern part of the east coast of Newfoundland to the first week of July in southern Labrador and to the first week of August farther north at Nutak. This is a feeding migration with mostly spent and immature fish following the spawning capelin to shore.

In the coastal waters during the summer there are no barriers to migration, apart from the break at the Strait of Belle Isle which interferes with near-bottom migration when the bottom water is cold in 40-50 fathoms (75-90 m) in June-September and the distances and interference involved by the deep bays and projecting headlands. Even these do not interfere much when the cod in June and early July are in the pelagic phase following the pelagic capelin. The deep water throughout the whole north-south range of the area is approximately of the same temperature at the same depth and thus apart from inherent restrictions of the fish there are few barriers to movement in the deep water except the great projections of the coastal shelves, bottom contours and occasional deep channels.

From lack of more detailed evidence on other characteristics than those we have mentioned above we have not for the present attempted to define closely the partially separated populations within this large Labrador-Newfoundland stock. However, growth differences exist. For inshore cod the slowest growth of this stock is off Labrador and in the Labrador population there is a slight increase in growth rate from north to south, approximately 3 cm difference at each size between inshore or coastal cod of the northern ICNAF Divisions 2G and 2H and of the more southern Division 2J (May, MS, 1961). There is also a gradual increase in growth rate southward from Labrador along the east coast of Newfoundland (Fleming, 1960). There is considerably difference in the condition of the cod when they arrive in the inshore waters. The cod of the Labrador-Newfoundland stock at the southern end of the range are in excellent condition with fat creamy-white livers when they arrive in June and this condition declines northward until off Labrador the cod arrive on the coast as thin fish with thin, brown livers, so depleted of fat that most of the livers sink in sea water. Usually feeding heavily on capelin, they recover rapidly after arrival on the coast and soon are in good condition. The cod remaining in deep water in summer were, in the virgin condition of the offshore fishery, large toward the south off Bonavista to Fogo and gradually smaller toward the north to

St. Anthony and Labrador (Templeman and Fleming, 1956; Templeman and Fleming, MS.,1962). The retention of a large proportion of the cod close to the tagging areas for many years after tagging and the lack of recovery in the Bonavista area, where over-fishing has produced continued low catches in spite of relatively good catches from the Baccalieu region to the south and the Fogo Shelf region to the north (Templeman, 1959, 1960; Fleming, MS, 1959,) make it likely that each large shelf region, such as the Bonavista Shelf, the Fogo Shelf and the St. Anthony Shelf, projecting seaward with deep water on each side has a basic stock of its own, some of which it loses temporarily in the summer by coastal or pelagic feeding migrations and in the winter by movements in the deep water, while receiving some migrants from other areas. There is generally little or no greater maximum migration of tagged fish of this area beyond that in the year after the tagging year. Consequently most of the cod are probably retained within the boundaries of their particular sub-stock and return to wintering and spawning areas and to feeding areas each year within the same general pattern.

Up to the present most of the tagging of these fish has been done in the summer feeding areas when they are dispersed from their spawning areas. When the over-winter pre-spawning and spawning concentrations have been tagged it may be possible to separate the sub-stocks of this area as for West Greenland into groups which intermingle far more among themselves than between adjacent areas. One such division inshore could be at the Strait of Belle Isle and the offshore topography indicates that Hawke Channel, south of Hamilton Inlet Bank, might offer a north-south impediment to the movements of offshore cod. However, the water in the bottom of this Channel is almost 2 degrees colder than the over 5°C water at the bottom of the Laurentian Channel and consequently may not be so great an impediment to cod movement. Meanwhile the present ICNAF divisions of the main area covered by the Labrador-Newfoundland stock are reasonably adequate for comparing biological differences between different parts of this large stock .

Very likely in the future enough differences will be found to indicate a number of north-south and inshore-offshore sub-stocks of this Labrador-Newfoundland stock which either do not intermingle greatly or separate out at certain seasons.

Flemish Cap stock. The slightly but significantly lower vertebral averages in summer of the Flemish Cap stock than those of deep-water cod on the slopes of the neighbouring northeastern Grand Bank, and the spawning of the Flemish Cap cod mainly in March (Travin, 1959; Templeman, MS, 1962), whereas the neighbouring cod of the northeastern and northern Grand Bank have a spawning season chiefly in May-June, make it certain that this Flemish Cap stock is a separate stock. Although from lack of tagging in the area the amount of westward pelagic feeding movement in summer to the Grand Bank area is unknown, the movement to the south of the Cap for spawning (Templeman, MS, 1962) together with Flemish Channel to the westward (600 fathoms (1,100 m) or more) very likely retain most of the cod on this bank through the year.

The lack of Lernaeocera branchialis in the Flemish Cap cod, while small but significant rates of infection with this parasite are found in cod of the neighbouring northeastern slope of the Grand Bank (Templeman and Fleming, MS, 1961), is another evidence of the isolation of the Flemish Cap stock from that of the Grand Bank.

Grand Bank stock. This stock has a low vertebral number, over 1 vertebra lower than the Labrador-Newfoundland stock. Summer migrations from the southern part of this stock are northward over the surface of the bank. Many of these cod (and until recently we had believed almost all belonging to this stock) spend the winter on the southwestern and southeastern slopes and partly on the southern part of the Grand Bank itself. In March, 1961, however, in a set of the A. T. Cameron just east of the North Cape of the Grand Bank at 100 fathoms (183 m) we found a great accumulation of adult cod, with a low vertebral average (53.03) within the range of vertebral averages of this southern Grand Bank stock, whereas at 122 fathoms (223 m) the vertebral average was 53.8 and at 199-244 fathoms (364-446 m), 54.4. It seems possible, therefore, that low-vertebral-average populations of the Grand Bank stock may also spend the winter and spawn on the northern slope of the bank. If this is a usual situation it immediately raises the question of whether there is not more than 1 low-vertebral-count stock on this bank, 1 spending the winter and spawning southward and 1 spending the winter and spawning northward and each with at least part of its population passing over the surface of the Grand Bank in summer.

This stock in the southern part of its area, at least, has the fastest growth rate and the greatest size and age at sexual maturity (Fleming, 1960) of all the cod stocks of the Newfoundland-Labrador area, ICNAF Subareas 2 and 3. Spawning is in April-June with spawning at its peak during the last half of May.

The cod of the southern Grand Bank and of the general plateau areas of the Grand Bank (not including those on the northern, northeastern and northwestern slopes) have a very low rate of infection by Lernaeocera branchialis (Templeman and Fleming, MS, 1961) compared with the much higher rates of infection of the nearest coastal areas. On the southern part of the bank the rate of infection decreases with distance from the coast. This is evidence that there is no very great relation between the coastal Avalon Peninsula stocks and the Grand Bank stock (surface and southern Grand Bank) but that, as might be expected, the cod of this stock closest to the coast have a little more intermingling with coastal stocks than those farther away toward the tail of the bank.

Spring and early summer tagging has shown that the Grand Bank stock has some late spring to summer migrants from the northern part of the southwestern slope of the Grand Bank to southeastern Newfoundland. Although it is better, where possible, to consider the spawning stock as the concentrated unit of the stock which spreads out to feed, and these western migrants probably spawn on the Grand Bank, it is more convenient and may be more suitable here to consider that these western migrants to the coast of the Avalon Peninsula belong to the coastal Avalon-Burin stock which, because of the coastal cold water and the lack of neighbouring warm deep water such as occurs to the northward and westward, pass the winter offshore on the slopes of the neighbouring banks.

St. Pierre Bank stocks. On St. Pierre Bank the winter-early spring concentrations of cod are on the western and southern slopes of the bank with a large concentration at the southern entrance to the Halibut Channel and there are late spring, summer and autumn feeding concentrations on the shallower parts of the bank. Many of the cod over-wintering on St. Pierre Bank migrate to the inshore waters of the eastern half of the south coast of Newfoundland in late spring to early summer but as on the Grand Bank there is apparently a bank stock also which tends to remain throughout the year on St. Pierre Bank.

Spawning is in April to early July with peak spawning in the last half of May and early June. The fish are slower growing than those on the Grand Bank (Fleming, 1960).

Studies of the incidence of cod nematodes (Templeman, Squires and Fleming, 1957) and of *Lernaeocera branchialis* (Templeman and Fleming, MS, 1961) for both of which infection apparently occurs mainly in the inshore waters, show that, as would be expected, the cod of the northern part of St. Pierre Bank are much more related to those of the neighbouring inshore area than are those of the southern part of the bank. The cod very closely related to the inshore area are those of the northern quarter of St. Pierre Bank, and the remainder of the cod are less closely related, with those of the southern part of the bank showing the least indication of having been in inshore waters previously.

Avalon-Burin stock. The Avalon-Burin stock is an inshore stock, with intermediate vertebral averages, extending from the outer coast of the Avalon Peninsula into Fortune Bay. Migration is considerable within the stock but occurs only to a small extent outside the main limits of the stock. This stock overlaps with the Burgeo Bank stock and during the winter usually to a limited extent with the West Newfoundland stock. During the winter some of its members are intermingled with the St. Pierre Bank and the western Grand Bank stocks with a relationship to the northern St. Pierre Bank stock which may be close enough so that it may be inaccurate to separate the stocks. The tagging reported for this Avalon-Burin stock thus far has been all from the western and eastern coasts of the Burin Peninsula. Thus not so much is known of the amount of mixing of the part of this stock on the southern half of the Avalon Peninsula with neighbouring stocks including the part of the Avalon-Burin stock to the westward.

In the general neighbourhood of St. John's, which we have shown in Fig. 5 as the southern boundary of the high-vertebral-average Labrador-Newfoundland stock, the vertebral averages of the fish at the time of the large inshore trap fishery in June-August are over 54 whereas for the larger inshore fish caught by linetrawl within several miles of the shore, but deeper, in the autumn the vertebral average declines until it is 53.5 or lower, generally similar to the vertebral numbers of the Avalon-Burin stock. When cod are tagged at St. John's some migrate in summer southward and westward as far as the Burin Peninsula, others northward as far as the Strait of Belle Isle and many are caught in winter in the deep water to the north of the western Grand Bank. Also some cod tagged south of St. John's as far west as Burin and Fortune move east and north to the east coast but mainly not beyond the Avalon Peninsula. Thus the St. John's area is at the boundary of the Labrador-Newfoundland and the Avalon-Burin stocks, receiving its greatest abundance of northern high-vertebral-count Labrador-Newfoundland stock fish in summer and smaller quantities of fish from the intermediate-vertebral-number Avalon-Burin stock in late autumn. North of the St. John's area the contributions of low-vertebral-count fish from the southern stocks are not usually sufficient to lower the vertebral average below 54 and south of this area the contributions of northern stock fish are not usually great enough to raise the vertebral average to as high as 54. The limiting factors are the supply of high-vertebral-average cod fry which are restricted to the northern stock and very likely the habit of this northern stock to retreat each year to the deep waters to the north of the Grand Bank for wintering and spawning. This would limit their southward feeding dispersal.

Populations not divided between stocks in Fig. 5, occupying the area between the Labrador-Newfoundland, Grand Bank, Avalon-Burin and St. Pierre Bank stocks. These areas are often supplied with abundant cod at various times of the year, often, near the coast, with cod migrating from the inshore stock to the bank slopes and channels in winter. The vertebral-average characteristics are in summer intermediate between those of adjacent stocks showing admixture of stocks with the characteristics of each stock in turn predominating near its own main borders. Sometimes, however, what appear from vertebral characteristics to be almost pure schools of each type may be found close together, but in some cases at different depths, in the intermediate area between the main borders of these adjacent stocks. These remarks presumably apply to other blank spaces in the Nova Scotian and Gulf of Maine areas and presumably there are a number of spawning and other stocks not yet delimited on these stock division charts but for which future research will reveal division at least at certain seasons.

Burgeo Bank stock. Tagging results have shown that this cod stock occupying Burgeo Bank in the winter to early spring spends the summer in the inshore waters of the western half of the south coast of Newfoundland, intermingling to a modest extent with the cod of the West Newfoundland stock and the Avalon-Burin stock and to a more limited extent with stocks adjacent to these. (Note remarks, however, under West Newfoundland stock.) This Burgeo Bank stock has a low vertebral average of the West Newfoundland type and spawns in April-June with the spawning peak in late April to early May.

West Newfoundland stock. Tagging returns and the location of great concentrations of cod in winter and spring, but not in summer and autumn, mainly between 60-130 fathoms (110-240 m) off the southwest coast of Newfoundland immediately outside and inside the Gulf of St. Lawrence near the northern entrance of Cabot Strait, show that there is a West Newfoundland stock of cod. This stock, except for strays, does not pass eastward in winter-spring beyond the western quarter of the south coast of Newfoundland, but occasionally reaches Burgeo Bank and the western part of the Avalon-Burin stock. In the winter-early spring of 1962, however, unusual numbers of cod, partly, at least, from the West Newfoundland stock since some cod tagged in January 1962 off the west coast of Newfoundland were included, were caught as far east as Hermitage Bay. Hence it is possible that returns from new tagging experiments will show that the Burgeo Bank stock is only the most southward extension of the West Newfoundland stock and that it intermingles with the southern part of this stock too much to be readily separated. Fish tagged as far south as Bay of Islands in autumn rarely pass northward through the Strait of Belle Isle. Cod of the northern Quebec Coast (North Shore) of the Gulf of St. Lawrence also join the West Newfoundland stock in winter.

On the southern or Newfoundland side of the Strait of Belle Isle vertebral numbers and tagging indicate significant passage of Newfoundland east coast cod inward to the southern end of the Strait with no great quantities passing farther inward although some pass inward through the Strait on the southern side. In this connection Fleming (1960) for cod collected at Eddies Cove at the southern entrance to the Strait of Belle Isle on the Newfoundland side found that the small and mainly immature cod up to about 6 years of age were similar in growth rate to those of the west coast of Newfoundland whereas the cod of 10-14 years of age had the same growth rate as cod from the northern part of the east coast of Newfoundland. The growth rate of 7-, 8- and 9-year-old cod was intermediate, with that of the 7-year-olds very close to the west coast type whereas the growth of 9-year-olds was close to that of cod of the northern part of the east coast. Thus it is indicated that the younger cod of the area were mainly resident Gulf fish while the larger and older fish were mainly inward-migrating east coast fish. Spawning in the cod of the West Newfoundland stock probably begins in April and continues to October but with most individuals spawning before the end of June.

North Shore Gulf of St. Lawrence and Anticosti stocks?

It is likely that the cod populations of these 2 areas are enough separate from the West Newfoundland and other Gulf stocks in summer to be described as 1, 2 or more separate stocks, but essential migratory and other information is at present lacking.

On the northern or Labrador side of the Strait of Belle Isle vertebral numbers in summer and early autumn are very low and do not in any way indicate the passage of significant quantities of high-vertebral-number Labrador cod into the Gulf, nor of low-vertebral-number Gulf cod outward. Recoveries from tagging in southern Labrador and northern East Newfoundland (unpublished data, St. John's Station) indicate only a small amount of passage into the Strait on its northern side.

Vertebral averages of the North Shore cod are apparently a little higher than for the purely west coast of Newfoundland stock but there is a wide shallow bank area south of the Strait of Belle Isle where the West Newfoundland stock must mix with the cod population of the North Shore. The cod from the North Shore and Anticosti populations join the West Newfoundland stock in their winter migration southward. Recent information from Yves Jean (April 13, 1962) reveals that cod tagged in the Seven Islands area in the western part of 4S in 1961 were caught in the winter of 1961-62 in 4R and 3P-N among the West Newfoundland stock. This would indicate an eastward winter migration track across the moderately shallow 140 to 150-fathom (255 to 275-m) Esquiman Channel to the west coast of Newfoundland and from there southward along the West Newfoundland Coastal Shelf.

Alexandre Marcotte of the Station de Biologie Marine, Grande-Rivière, Gaspé, Quebec has sent information (April 17, 1962) on his tagging near the end of June 1954 along the Quebec North Shore at Natashquan, La Tabatiere, River St. Paul, Blanc Sablon and Red Bay, Labrador. Out of more than 360 returns 19.9% were recovered in February-March from the southern part of the west coast of Newfoundland and an additional 9.7% also February-March, from the western part of the south coast of Newfoundland, while only 0.7% were captured south of the Laurentian Channel at Gaspé. It is thus apparent that the summer stock of the Quebec North Shore is strongly intermingled in winter with the West Newfoundland stock but not enough information is available at present to indicate the degree of summer intermingling or separation of the Quebec North Shore and the west coast of Newfoundland populations.

Greater depths of about 180-200 fathoms (330-365 m) with accompanying warmer water exist in the Laurentian Channel southward of the area of tagging off Seven Islands and south of Anticosti Island, apparently forming a greater barrier to southward movements to join southern Gulf stocks than does the shallower Esquiman Channel to eastward movements to join the West Newfoundland stock.

Although shown as definite trans-Esquiman Channel migration tracks in Fig. 5 the places where these trans-Channel movements are made, or whether a more circuitous northward and then southward route in shallower water is taken rather than a direct line, are at present unknown.

Stocks in the Canadian region south of the Laurentian Channel

Although strays pass in both directions over the Laurentian Channel, especially from tagging carried out on the stocks bordering the Channel, there do not appear to be any migration tracks or any considerable intermingling across this Channel and stocks on each side of the Channel are thus separate. The temperatures of over 5°C in the deep water of the Channel and the depth of the Channel also tend to prevent bottom movement across the Channel and limit the intermingling to pelagic crossings of the Channel.

For this region the author has had the great benefit of a stock division chart provided by Yves Jean of the St. Andrews Station. The author has, however, modified the chart somewhat, combining in certain areas and dividing in others so that only the Louisbourg, Canso, Lockeport, Banquereau, Sable I. and winter habitat of the Gulf stocks are basically unchanged from the original chart presented to ICNAF in 1961. Our changes have been the splitting of the southern Gulf stocks during the summer, the introduction of the Glace Bay-Sydney Bight stock and the Halifax sub-stock, the combining of the Lunenburg-Halifax-Jeddore stocks into one Lunenburg-Jeddore stock, and the dividing of the East Fundy-Seal Island stock into 2 stocks. The winter abode of the Sable Island Bank stock has been extended to take in the Emerald Bank area. Much of this changing has been a matter of personal choice from the arguments for and against combining or dividing, and moderately good arguments could often be developed for leaving the original stock outlines unchanged.

Southern Gulf of St. Lawrence stocks. On the basis of the information given under vertebral numbers and migrations there is evidence for the separation in summer of a Gaspé stock mainly extending from the northern entrance to Bay Chaleur and the mouth of Bay Chaleur to the Laurentian Channel and northward for some distance around the Gaspé Peninsula. This stock evidently mixes especially on the north side and off the mouth of Bay Chaleur with the Bay Chaleur stock. There is evidence for a Bay Chaleur stock which is well intermingled with Gaspé stock in the north and may be considerably intermingled with the western part of the Prince Edward Island stock, a doubtful Magdalen Islands stock possibly including Bradelle Bank, a Prince Edward Island stock which is different from the northern part of the Bay Chaleur stock in having none of the high-vertebral-average characteristics of the Gaspé stock, and a West Cape Breton stock. All these stocks while intermingling to some degree with other stocks have either vertebral or migratory characteristics or both which show that a great part of the population returns each summer to the location of its parent stock. The Magdalen Island stock is the most difficult to delimit or indeed to show that it is essentially a separate stock, because part of all the other stocks except the West Cape Breton stock may intermingle with this stock during the autumn-early winter outward and the spring-early summer inward migration. There is also an area of doubt regarding whether the western part of the Prince Edward Island stock is not much more closely related to the Bay Chaleur stock than we have shown in Fig. 5. The tagging at Alberton in July 1939 (McKenzie, 1956, fig. 42) indicates this relationship whereas tagging at nearby Ellerslie (McKenzie's fig. 41) indicates a more separated Prince Edward Island stock. The vertebral averages of the Prince Edward Island stock, however, in McKenzie's original records are definitely lower than those of the Bay Chaleur stock even if the samples with Gaspé-type high vertebral averages are eliminated when considering the Bay Chaleur stock. It is also impossible for reasons of geography, the stocks meeting in and off Bay Chaleur, to use a single line to separate the Bay Chaleur and Gaspé stocks, so that the Bay Chaleur stock is at present only poorly defined.

This division of the Gulf stocks is very similar to that made by McKenzie and Smith (1955) who on the basis of vertebral averages concluded that there were 4 cod stocks in the southwestern Gulf of St. Lawrence: Gaspé, Bay Chaleur, Prince Edward Island and Cape Breton stocks.

A caution must be expressed regarding our use of vertebral numbers to help separate these southern Gulf stocks. Overall averages are used and because of different size and age there is a possibility that the stock and locality differences are due in some cases to year-class differences. Only new vertebral averages, preferably taking into account year-class differences, will completely resolve this problem. However, some more recent vertebral counts than McKenzie's taken by the St. John's Station in the years 1950-51, also show low vertebral averages in the Bay Chaleur and Magdalen Islands shallow water area and higher averages in the Gaspé region.

In winter, although many of the youngest immature fish remain closer to the summer abode of the stock, most of the larger or mature fish of all the Gulf stocks move along the southern slope of the Laurentian Channel to occupy the region mainly between 60 and 130 fathoms (110 and 240 m), and according to Martin (MS, 1961) especially 100-125 fathoms (185-230 m), from just west of the Bird Rocks, Magdalen Islands region of the Gulf to the Misaine Bank region with strays as far as Banquereau. With migration along the southern border of the Laurentian Channel unrestricted by deep-water intercepts the vanguard of the southern Gulf stocks moves out of the Gulf farther toward the offshore banks than the West Newfoundland stock which tends to follow along the coastal shelf at the western end of the south coast of Newfoundland, and whose movements in the direction of St. Pierre Bank are intercepted by the deep Hermitage Channel. Very likely these outward movements are earlier, farther and return migration is later in very cold winters with severe ice conditions than in warmer winters. Because of the inward current, also, on the north side of Cabot Strait there is unusually less ice here than on the Cape Breton side.

During the winter and early spring these various southern Gulf stocks doubtless mix considerably with local resident stocks in their extension over the northern fringe of the Scotian Shelf. According to Powles (1958) and information presented to the ICNAF Environmental Subcommittee by the St. Andrews Station, the southern Gulf stocks spawn not in their winter abode off Cape Breton but in the Gulf of St. Lawrence between May and September with peak spawning at the end of June and in July. (In the remainder of the discussion for Subarea 4, unless authorities are mentioned it should be understood that the spawning-time information is that presented by Yves Jean for the St. Andrews Station in 1961 to the ICNAF Environmental Subcommittee.)

Although on present published knowledge it is not possible to separate the southern Gulf stocks in their winter abode at the southern edge of the Laurentian Channel off Cape Breton it is possible that tagging the southern Gulf stocks in July or August in the same year may in the following winter show differences between the stocks in depth distribution during winter and in the distance which each stock moves out of the Gulf. These stocks also should have different migration tracks which are to some degree concealed by relatively small amounts of fishing in the central part of the southern Gulf. Recent Gulf of St. Lawrence tagging has been in the neighbourhood of Bay Chaleur and the Magdalen Islands and McKenzie's tagging which covered a wider area was in an earlier period before the establishment of a European trawler fishery at the entrance to the Gulf of St. Lawrence.

In practice it is not possible because of their winter intermingling and spring and fall intermingling movements to treat these southern Gulf stocks for management purposes other than as a large southern Gulf super-stock (Fig. 5 - inset) of which the other stocks mentioned will form sub-stocks for which partial separation at least is possible in summer-early autumn.

Banquereau stock. This stock is located on the eastern plateau and slope of the bank during the winter and passes westward and shallower to occupy the whole surface of Banquereau and impinges also on neighbouring banks and to some extent mixes with the coastal stocks of northern Nova Scotia in summer. Or it may be that coastal stock migrants wintering on this Bank return to the coastal area in summer. Very likely both possibilities occur. In winter it is intermingled with the most distant migrants of the southern Gulf stocks and to some degree with neighbouring Nova Scotian coastal stocks. Spawning occurs in April-June with peak spawning in May (McKenzie, 1956 and St. John's Station observations by the author in mid-May, 1950).

Sable Island Bank stock. Similarly, as for the Banquereau stock, the Sable Island Bank stock is located more seaward and extends deeper on the seaward slope in winter whereas in summer it is distributed more shoreward on the northerly parts of Sable Island and over its northern projection, Middle Ground. In winter also there are some fish on this bank from the neighbouring Nova Scotian coastal stocks and a few strays from the Gulf of St. Lawrence and as for Banquereau and with the same qualifying remarks, there are some migrants from Sable Island Bank to the neighbouring Nova Scotia coast in summer. Tagging on Emerald Bank (McKenzie, 1956, fig. 27) and also McKenzie's original vertebral averages, chiefly 52.8-53.4 in both areas, indicate that the Emerald Bank stock is enough related to and intermingled with that of southwestern Sable Island to be considered as part of the Sable Island stock. Spawning at the southwestern part of the bank and Emerald Bank is in March-April, chiefly in April, while on the western part on Middle Ground it occurs a little later, in April-May (McKenzie, 1956).

Nova Scotian coastal stocks. These 7 Nova Scotian coastal stocks shown in Fig. 5 are local stocks, generally with their distribution a little more concentrated and coastward in summer and a little more dispersed and seaward in winter. They have been named chiefly from the locations of the tagging from which so much of the information on the limits of the stocks has been derived. From southward to northeast they may be called the East Fundy-St. Mary Bay, Seal Island, Lockeport, Lunenburg-Jeddore, Canso, Louisbourg and Glace Bay-Sydney Bight stocks. However, if tagging had been carried out in areas between some of these locations, other inshore stocks with restricted migration could presumably be named. These stocks have some but not much movement along the coast and mixing with neighbouring stocks and some but except in the more northern stocks not much movement offshore in winter to mix with the offshore bank stocks.

Additionally there is the Halifax fall-spawning stock with a significantly lower vertebral average than the spring-spawning stock of that area.

The limits of the East Fundy-St. Mary Bay and the Seal Island stocks are based on tagging at St. Mary Bay and Seal Island (McKenzie, 1956) and the Lockeport stock on the results of taggings off Shelburne (McKenzie, 1956) and off Lockeport (McCracken, 1957).

The small St. Mary Bay tagging (16 recoveries from 83 tagged) shows an area of admixture on the western fringe of the area and further tagging is needed in this area to show to what degree this stock is separate from the Seal Island stock. In many recoveries from tagging at Seal Island, however, only an occasional stray reached the East Fundy-St. Mary Bay area. Thus there is apparently very little mixing between the western half of the East Fundy-St. Mary Bay stock and the eastern half of the Seal Island stock. On the east there is some movement of the Seal Island stock both summer and winter into the western part of the area occupied by the Lockeport stock. The Seal Island stock is, however, enough separate from the Lockeport stock that, from southeast of Cape Sable west to off Port Maitland at Lat. 44°N which includes almost all the Seal Island stock migrants and the eastward extension of the St. Mary Bay migrants, in McKenzie's original vertebral averages 21 of 22 averages were from 52.2 to 52.6, whereas in the approximate area to the eastward of Cape Sable occupied by the Lockeport stock, 22 or 25 vertebral averages were between 52.8 and 53.1. Two of the remaining 3 averages were 52.5-52.6 on the eastern fringe of the Lockeport stock and presumably belong to the Lunenburg-Jeddore group which has low-vertebral-average fall spawners from the Halifax area included in it; and only 1 average below 52.8 occurred in 23 averages in the main area occupied by the Lockeport stock. In spite, therefore, of some intermingling in the vicinity of Cape Sable, the Lockeport stock is essentially distinct from the Seal Island stock.

While in the Seal Island stock the vertebral averages in McKenzie's original records were between 52.2 and 52.6, in the western sector north of Lat. 44°N (the East Fundy-St. Mary Bay stock) 10 of 18 vertebral averages were between 52.3 and 52.6 and 8 were 52.7-52.8. Thus there is not a strong separation on the basis of vertebral averages between the Seal Island and East Fundy-St. Mary Bay stocks.

The delimiting of the Lunenburg-Jeddore stock is based on taggings off Lunenburg, Halifax and Jeddore (McKenzie, 1956). Each of these taggings gave in ensuing years strong localization of returns to the tagging area in summer, but more spreading in winter between the 3 tagging areas and in lesser degree to the offshore banks. In McKenzie's original vertebral averages the area of the Lunenburg-Jeddore stock has vertebral averages, omitting the obvious low-vertebral-average fall-spawning group, almost entirely between 52.8 and 53.2 with occasional averages very slightly higher than those of the Lockeport stock. There is also intermingled in the Lunenburg-Jeddore stock a small fall spawning group with vertebral averages from 51.6-52.0. Each of the 3 sub-stocks included in the Lunenburg-Jeddore stock has some of the migratory characteristics of a separate stock. However, the areas are close together, there are no vertebral average differences and there is a moderate amount of mixing in summer and considerable in winter. Presumably taggings between the Lunenburg, Halifax and Jeddore locations would give other partly localized, partly mixing populations. Thus these 3 sub-stocks have been included in this paper as 1 stock.

Migratory information on the Canso stock has been obtained from taggings off Canso (McKenzie, 1956; McCracken, 1957). Recoveries are strongly localized both winter and summer in the tagging area with very little intermingling either in winter or summer with the Lunenburg-Jeddore stock to the west or the Louisbourg stock to the east and only a little winter movement to the offshore banks mainly to the southwestern end of Sable Island Bank.

Tagging at Louisbourg (McCracken, 1957) outlined a Louisbourg stock with almost all recoveries, in the summer after tagging, coming from the vicinity of the tagging and with little intermingling with the Glace Bay-Sydney Bight stock to the northward and little if any with the Canso stock to the westward. In the winter following tagging most of the returns were from near the tagging area but in the following winter only about 1/4 of the returns were from near the tagging area. Winter recaptures, apart from those in the tagging area, were mainly from Sable Island Bank with some offshore from northeast Cape Breton, from along the outer Nova Scotian coast on Banquereau and from the Newfoundland area.

The boundaries of the Glace Bay-Sydney Bight stock are indicated from tagging at Glace Bay in July-August 1927 (McKenzie, 1956). There has been no tagging reported from Sydney Bight itself. However, the Glace Bay tagging showed little movement into the neighbouring area to the southwest occupied by the Louisbourg stock although there must be some mixing in the intermediate fringes of the 2 stocks. There was a strong summer movement of the Glace Bay fish into the Sydney Bight area, possibly enough to include the cod population of this area with that off Glace Bay. There were few summer migrants into the Gulf of St. Lawrence. In winter coastal fishing off northeast Cape Breton is considerably interfered with or prevented by ice, so most of the winter recaptures were on the banks of the northern half of the Scotian Shelf.

Spawning in the Louisbourg area off eastern Cape Breton is from May to June with a peak in May and for the Canso stock from April to May with maximum spawning in April. In the Lunenburg-Jeddore area the peak spring spawning is in April, but the fall-spawning stock of this area spawns from October to December with peak spawning in November. In southwestern Nova Scotia from Lockeport southwards to beyond Cape Sable spawning is from April-May with a maximum in April, whereas farther westward in the East Fundy-St. Mary Bay area spawning extends from January to April with a peak in April (McKenzie, 1934, 1956). These spawning dates are often not yet well enough defined but the St. Mary Bay spawning beginning in January may be additional evidence for the separation of the East Fundy-St. Mary Bay cod as a separate stock from that of the Seal Island stock.

Gulf of Maine stocks.

The part of Fig. 5 showing the cod stocks of the Gulf of Maine was obtained from the U. S. Dept. of the Interior, Fish and Wildlife Service, Biological Laboratory at Woods Hole, Mass., through Mr. Albert Jensen. It represents the unpublished results of cod tagging in this area by the Woods Hole Laboratory. There are Browns Bank and eastern Georges Bank stocks, probably essentially separate as spawning stocks but with some inter-migration in both directions across the Fundian Channel and some intermingling of both these stocks with those of southwestern Nova Scotia. The coastal Maine stock is a local stock of limited movement, similar in the restricted nature of its migrations to the Nova Scotian coastal stocks. The South Channel stock spends the summer in South Channel, especially on the western side of this Channel, and for most of the remainder of the year migrates southward and inshore to the Nantucket Shoals-Chatham region.

The Browns Bank stock (from information supplied by the U. S. Fish and Wildlife Service Biological Station at Woods Hole) spawns from March to May with peak spawning in late March. The eastern Georges Bank stock spawns in February-April with a peak in late February.

Middle Atlantic stock

This southernmost stock of cod (only partially shown in Fig. 5) spends the winter and spawns (Wise, 1958) southward outside the ICNAF area, mainly from Long Island to North Carolina, and in feeding migration moves northward to summer at Nantucket Shoals (near Cape Cod) with strays passing to Georges Bank and the Gulf of Maine. In parts of this stock spawning cod are to be found from November to April (Schroeder, 1930).

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9. HADDOCK STOCKS IN THE ICNAF CONVENTION AREA

by Marvin D. Grosslein

Introduction

The distribution of haddock in the ICNAF Convention Area was described earlier in a general review of the stocks of important commercial species (Wise and Jensen, 1960). More up-to-date summaries of the knowledge of haddock stocks in Subareas 3, 4, and 5 were presented at the 1961 Annual ICNAF Meeting (Ann. Meeting, Standing Comm. on Res. and Stat., 1961). The purpose of the present report is to document those summaries, particularly the map of haddock stock divisions.

Subarea 1

Haddock were recorded off West Greenland only once or twice in the last century (Tåning, 1958). They were taken for the first time at Sydpröven, at the southern tip of Greenland, in 1929, and since then several other captures have been reported (Hansen, 1949). The northernmost catch of haddock was made in Disko Fjord in 1944. More recently small landings of haddock have been recorded annually from West Greenland (see ICNAF Statistical Bulletins).

Subarea 2

Haddock are taken in negligible quantities off Labrador. Nothing is known about the stocks in this subarea (Wise and Jensen, 1960).

Subarea 3[1]

There appear to be at least three haddock stocks in the Newfoundland area as shown in figure 1: the western Newfoundland stock (4R and northern part of 3P), the St. Pierre Bank stock (3P), and the Grand Bank stock (3O-3N). Occasionally a few haddock are to be found on Flemish Cap, but these may have drifted as larvae from the Grand Bank stock.

The western Newfoundland stock is small, and it is taken incidentally by the cod fishery in that area. Little is known about the life history of haddock off western Newfoundland.

1/ Much of material presented by W. Templeman in ICNAF document 33, Third Annual Meeting, 1953. Changes and additions were included in material provided by Templeman in personal communication, March 1961.

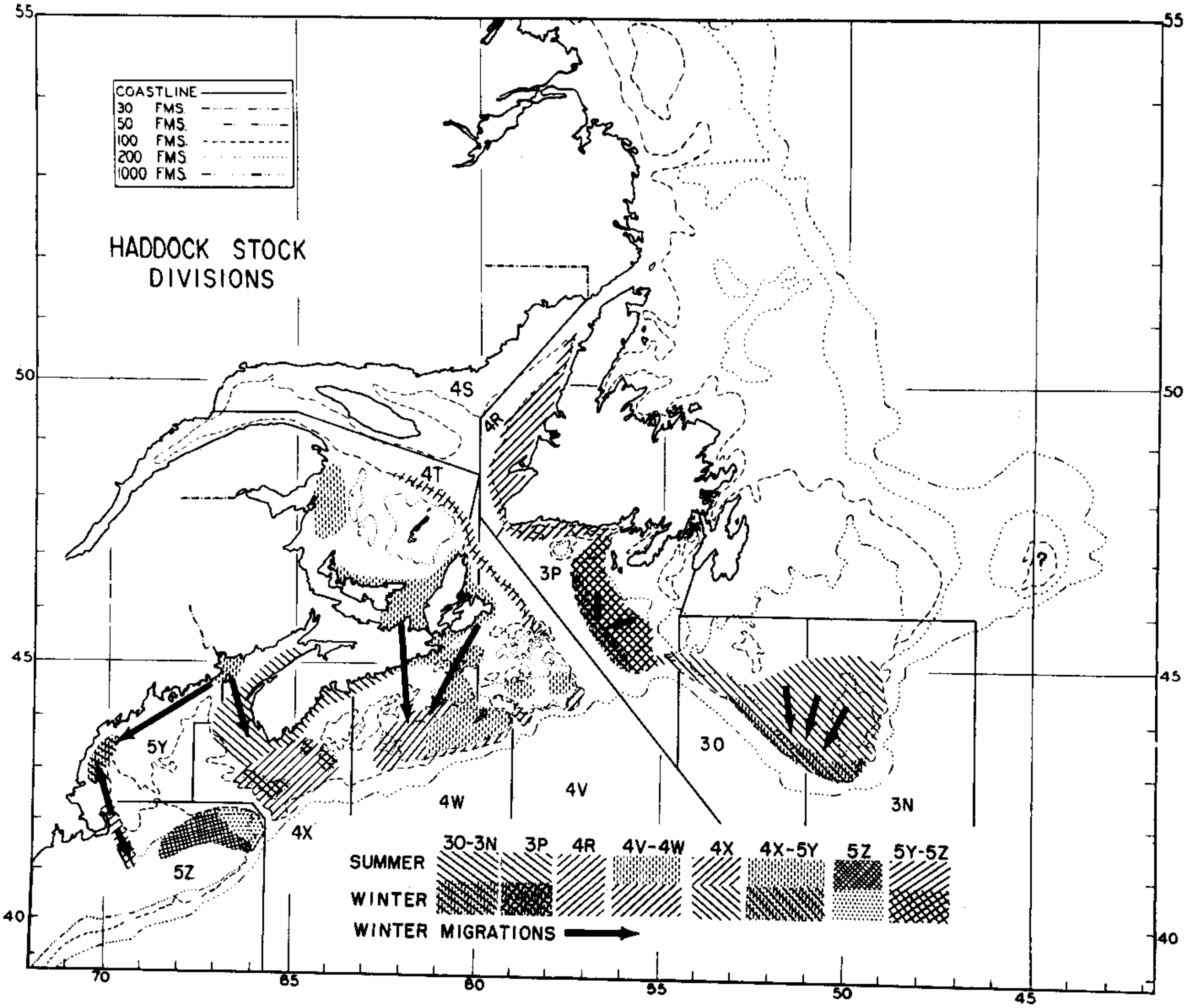

Fig. 1. Haddock stock division in the ICNAF Convention Area.

The main commercial fishery occurs on the Grand Bank stock which apparently does not mingle extensively with the smaller St. Pierre Bank stock as indicated by year-class differences. For example, the strong 1952 and 1955 year-classes supported a large Grand Bank fishery, but these same year-classes did not appear on St. Pierre Bank in numbers sufficient to support a commercial fishery. Tagging of about 1000 haddock caught by otter trawls has yielded no returns.

In summer the St. Pierre Bank haddock stock is found chiefly in shallow areas of that Bank, but some fish move to the Burin peninsula. The greatest summer concentration of the Grand Bank stock is found on the southeast shoal of the Grand Bank. However, there is a general northward movement during the summer, and in some years concentrations appear on the east coast of Newfoundland. In winter the haddock stocks of St. Pierre Bank and Grand Bank move to the southwestern slopes of these banks (fig. 1).

On St. Pierre Bank and Grand Bank haddock spawning begins in May, reaches a peak in June, and may extend into the first part of July.

The average size of haddock on St. Pierre Bank is greater than on Grand Bank, and it is believed that this may be partly due to a more rapid growth rate on St. Pierre Bank. Growth of the 1949 year-class from subdivisions 3N and 3O is shown in figure 2. Haddock growth in Subarea 3 is substantially slower than in Subareas 4 and 5.

The average vertebral number of Newfoundland haddock is less than 53 which is significantly lower than that of neighbouring Nova Scotian stocks with an average of about 54 (fig. 3). This difference lends confirmation to the separation of Newfoundland and Nova Scotian stocks based on other evidence. Stock differentiation between Subareas 3, 4, and 5 also has been based on differences in vertebral counts (Clark and Vladykov, 1960).

Subarea 4 [2]

Haddock occur along the entire Nova Scotian coast both inshore and offshore, but landings are very small from division 4R, 4S, and 4T (Martin, 1953). Subarea 4 stocks are separated from those of Subarea 3 (and the west coast of Newfoundland, 4R) by the Laurentian Channel. To the west, Subarea 4 stocks are largely separated from those in Subarea 5 by the Fundian Channel, and the deep water of the Gulf of Maine except for haddock in the Bay of Fundy region. Significant differences in vertebral counts have been found among these major groups; and the existence of sub-groups off Nova Scotia has been suggested on the basis of slight differences in vertebral counts (Clark and Vladykov, 1960).

2/ Except for publications cited, material supplied by F. D. McCracken in personal communication, April, 1961.

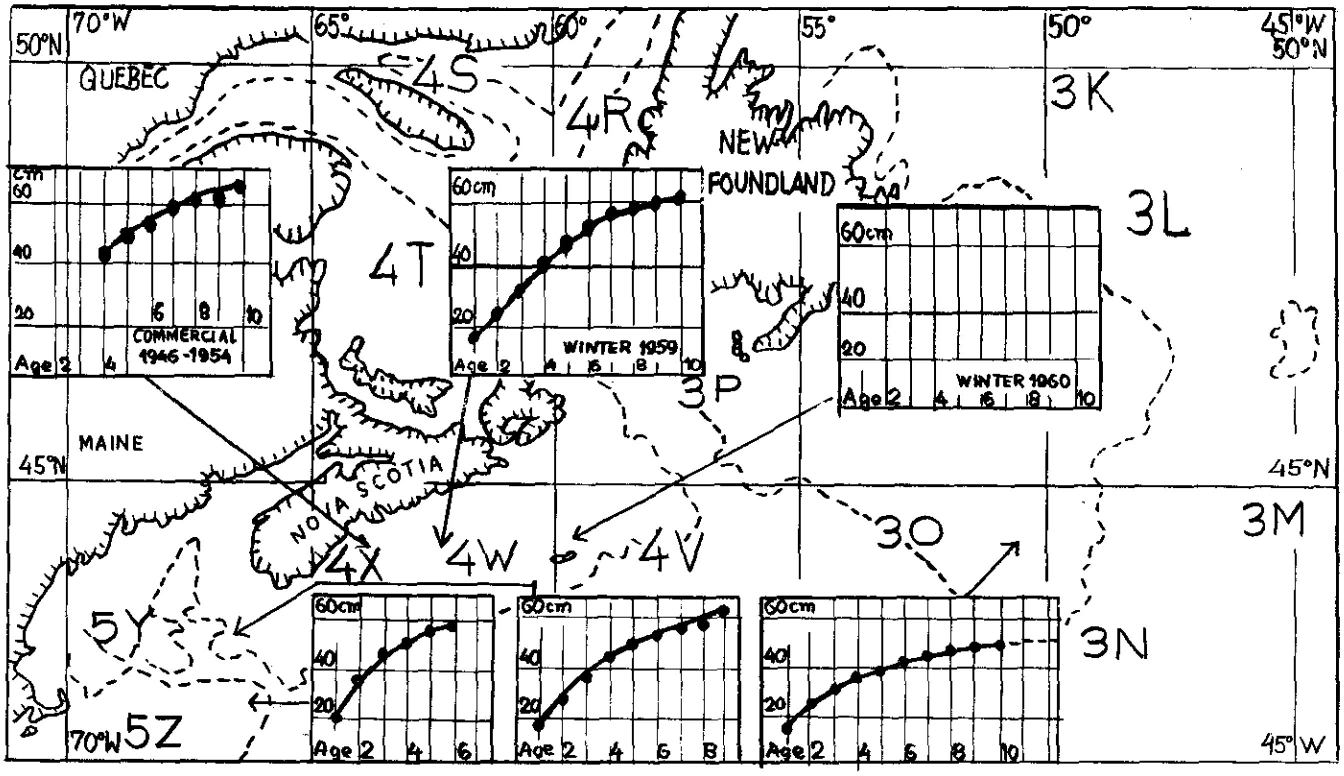

Fig. 2. Haddock growth curves in the ICNAF Convention Area.

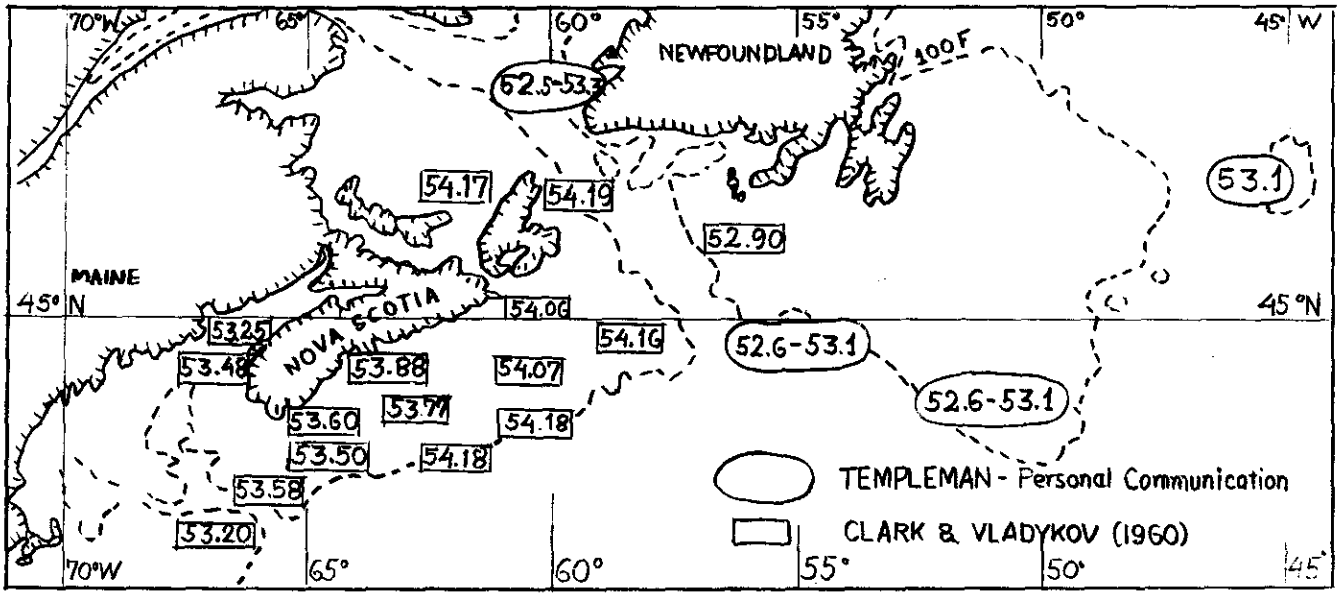

Fig. 3. Haddock vertebral counts in the ICNAF Convention Area.

In addition to Division 4R described above, two major stock divisions are recognized within Subarea 4: those east (4V-W) and west (4X) of the Scotian Gulf. There appears to be limited mixing between the 4X and 4V-W stocks, occurring chiefly along the Nova Scotian coast as 4X haddock spread eastward in summer and as 4V-W haddock move southwest in winter (McCracken, 1956). The separation of the 4X and 4V-W stocks is also confirmed by unpublished records of U. S. tagging on Browns Bank which show rare returns east of Subarea 4X.

Offshore winter movements have been demonstrated by tagging east of the Scotian Gulf, but the reverse movement has not been demonstrated because of poor returns from offshore tagging. Winter surveys in 1959 and 1961 found low numbers of small haddock in 4V, and these were found chiefly along the deep water edges of the shelf. The major winter concentration is in 4W and this is substantiated by statistics of landings. In summer the 4V-W stock spreads northward into the Gulf of St. Lawrence, and haddock are found in shallower water both inshore and offshore.

The 4X stock occupies inshore areas along western and southwestern coasts of Nova Scotia in summer, and moves southward to the vicinity of Browns and La Have Banks in winter. Segments of the 4X stock appear to be year-round residents of these offshore banks. Most returns of haddock tagged on these banks by Canada have come from the western Nova Scotia region. Similarly, about 80 percent of returns from haddock tagged by the U. S. on Browns Bank have come from the western Nova Scotia area; the remaining 20 percent came from Subarea 5[3]. On the other hand, less than 2 percent of returns of haddock tagged in Subarea 5 have come from 4X. Part of this difference probably is due to greater exploitation in Division 5Z.

Mixing is much more extensive between haddock found in Passamaquoddy Bay and Subarea 5. About half of the first-year tag returns from the 1957 fall tagging in Passamaquoddy came from Subarea 5, chiefly on Jeffrey's ledge between Portland and Gloucester (McCracken, 1960). These haddock belong to a stock (4X-5Y) which during winter moves south concentrating on Jeffrey's Ledge (fig. 1). Some of these fish go further down to the South Channel and northwest Georges Bank in 5Z (McCracken, 1960). Only 35 percent of the first-year returns came from Passamaquoddy Bay itself, and less than 15 percent came from western Nova Scotia and Browns Bank areas. In summer these fish returned to the Bay of Fundy region as indicated by the fact that most returns again came from Passamaquoddy (McCracken, 1960). In the fall of 1957, the U. S. tagged haddock on Lurcher Shoal and on Grand Manan Banks, south and west of Digby

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3/ Unpublished U. S. tagging records.

Neck respectively. Results were similar to those from Browns Bank tagging, i.e., 75 percent of the returns came from western Nova Scotia, and 25 percent from Subarea 5 (unpublished U. S. tagging records). However, all the Subarea 5 returns were from 5Z (South Channel and Georges), and none from 5Y (including Jeffrey's Ledge) or Passamaquoddy. These data further substantiate the separation of the 4X and 4X-5Y stocks.

Peak spawning of the 4X and 4V-W stocks occurs in April. Growth of 4V-W haddock taken near Emerald and Banquereau Banks is faster than that of Grand Bank haddock, but slower than that of the 4X stock taken off Lockeport and on Browns Bank (fig. 2).

Subarea 5[4]

There appear to be three somewhat distinct stocks in Subarea 5: the 4X-5Y stock noted above, a stock on Georges Bank (5Z) which is east of the south channel (about 69°W), and one inshore (5Y-Z) extending at least from Nantucket Shoals just south of Cape Cod in 5Z to Jeffrey's Ledge in 5Y (fig. 1). These tentative divisions are based chiefly on a geographic distribution of tag returns without reference to time. Further clarification of the relationships between haddock in the above areas will require analysis of tag returns in relation to time and comparisons of vital statistics such as growth, mortality, etc. Since there is some mixing between the above divisions, clearly, they cannot be regarded as separate stocks in the strict sense. It should be noted, however, that U. S. surveys found haddock egg concentrations in five locations in the Gulf of Maine, thus tending to confirm the existence of at least as many spawning groups as presumed stocks (fig. 4).

The 5Z stock on Georges Bank appears to be a resident population since 95 percent of returns from haddock tagged on Georges Bank come from "Georges Bank "(the area east of 69° and south of 42°20' chosen arbitrarily for tag return summaries). Extensive tagging indicates that movement of 5Y-Z haddock is limited chiefly to the inshore grounds between Nantucket Shoals and Jeffrey's Ledge. Some fish move out to Georges Bank, particularly the northwestern part, but such movement is not extensive. Of haddock tagged just off Cape Cod about 80 percent of returns were reported west of 69°, although only about 35 percent of Subarea 5 haddock landings come from grounds west of 69°. Only about 5 percent of these returns were reported on Georges Bank east of 68°.

Inshore haddock tagging between Cape Cod and Cashes Ledge (due east of Jeffrey's Ledge) has yielded practically no returns north of 43° 30'. Further analysis of tag returns in relation to landings in 5Y may clarify the relation

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4/ Information on Subarea 5 haddock stocks based chiefly on unpublished tagging records of the Woods Hole Laboratory.

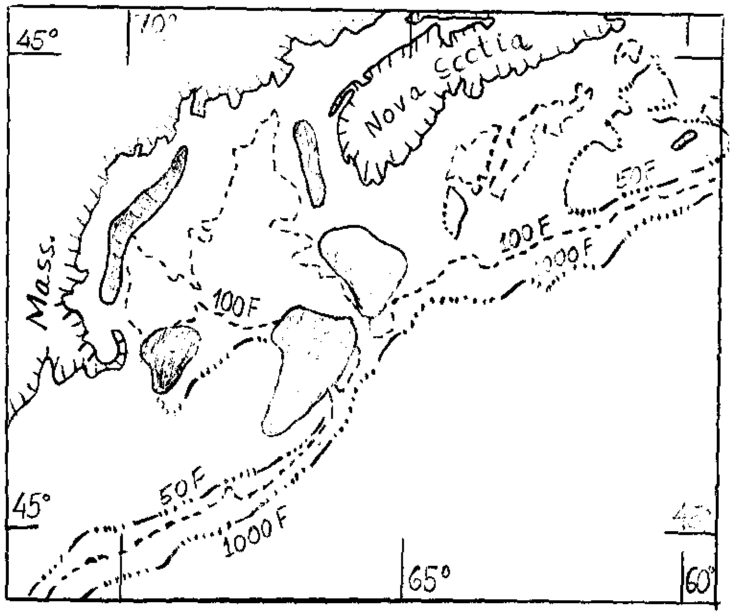

Fig. 4. General areas of haddock egg concentration from Hardy Plankton Recorder surveys in the Gulf of Maine.

between 5Y-Z and 4X-5Y stocks.

Seasonal movements of haddock making up the 5Y-Z and 5Z groups are not well known. However, maximum seasonal abundance of mature haddock does occur during spring spawning concentrations which are found in the south channel, where 5Y Z and 5Z overlap, and on the northeastern part of Georges Bank (figs 1 and 4).

Growth of 5Z haddock appears to be more rapid than any other haddock stock studies so far (fig. 2).

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10. FEEDING HABITS OF "BEAKED" REDFISH (Sebastes mentella Travin) IN THE NEWFOUNDLAND-LABRADOR AREA.

by K. P. Yanulov

Studies of feeding habits of "beaked" redfish from the Newfoundland-Labrador area aboard research and scouting vessels have been under way since 1956.

The present report is based on the material collected from August 1956 to December 1960. A total of 41421 specimens of "beaked" redfish captured in the Labrador, Newfoundland and Nova Scotia regions, have been examined for stomach contents using the field analysis method, determining the degree of stomach filling by a five-point scale and food composition. Food was only found in the stomachs of 12542 specimens, or a little more than 30% of the total number.

The data were treated to produce figures of the frequency of occurrence of various food components as related to the number of stomachs containing food.

Studies of feeding habits of "beaked" redfish indicate that they should be classed with plankton-eaters. Their diet includes about 40 plankton and bathypelagic species (see table 1). The most frequent species are: Calanus finmarchicus, Themisto libellulla, Th. abyssorum, Meganyctiphanes norvegica, Thysanoessa inermis, Th. raschii, Pandalus borealis, and some others. The most frequent species of fish are lantern anchovy (Benthosema glaciale, Myctophum punctatum, Ceratoscopelus maderensis) and Paralepis coregonoides.

With increasing length of "beaked" redfish, plankton organisms are getting gradually replaced by fish (see table 2). Individuals up to 30 cm long feed primarily on euphausiidae, copepoda and gammarus, individuals from 41 to 45 cm long on fishes (more than 40% of the total diet). At the same time a certain increase in the frequency of occurrence of various plankton animals is observed, possibly, to be explained by the fact that adult individuals are not so well provided with basic food. There is no difference in the composition of food of male and female "beaked" redfish (see Table 2).

The composition of food remains more or less constant all the year round, with no regular (cyclic) changes. The intensity of feeding of mature individuals, however, changes with season. It decreases abruptly in April and May in connection with extrusion of larvae. The intensity of feeding of males also decreases at the same time, since by that season they have already got fattened to the highest possible degree as a physiological preparation for mating.

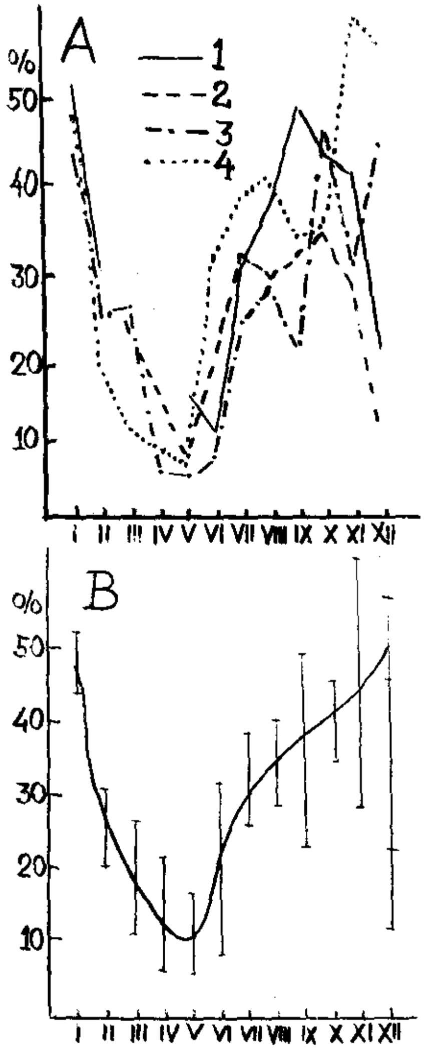


Fig. 1.Monthly changes in the number of feeding "beaked" redfish(%%).1956-60. A-Actual course;B-Supposed course. 1. S.Labrador(2J). 2.Flemish Cap (3M) 3.N.Nfld.Shelf(3K) 4.NW Slope of Grand Bank (3L)

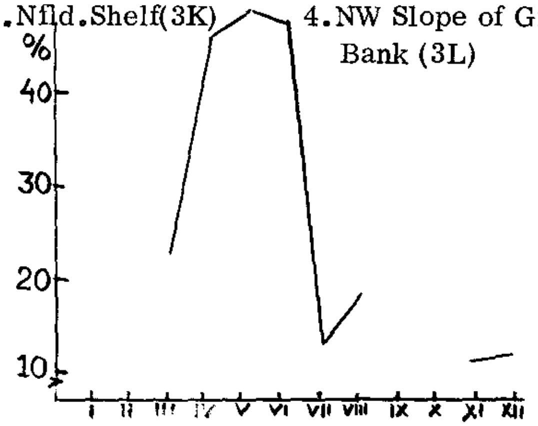


Fig. 3. Monthly changes in the number of feeding "beaked" redfish on the S. Slope of the Grand Banks (%%).

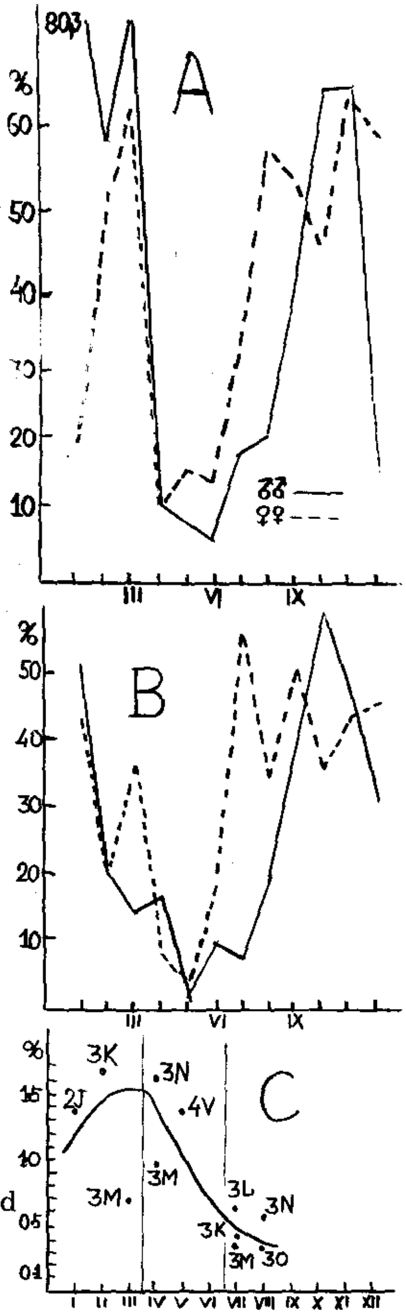


Fig. 2.Monthly changes in the number of feeding males and females of "beaked" redfish and in the ration of maturity of males. Data from 1959-60. A-S. Labrador(2J) and N.Nfld. Shelf (3K).
B. NW Slope of the Grand Bank (3L)
C. Changes in the ration of maturity of males (each point represents an average value for 25 spec.).

After the end of the period of spawning, the intensity of feeding of females increases, reaching its peak in autumn and winter. Males regain their normal intensity of feeding, after the seasonal spring-summer recession, somewhat later than the females apparently due to their sexual activity during the period of mating in May-July. (see figs. 1 and 2). The intensity of feeding of immature individuals remains high in spring and summer, but may decrease in winter. On the southern slope of the Great Bank, for instance, where immature fish up to 30 cm long usually account for 80%, the highest intensity of feeding is observed in May-July (see fig. 3).

Data collected by the research vessel "Sevastopol" (March-August) show that "beaked" redfish feed most actively at night, when they rise above the ground to chase their food. This is illustrated by the relation between the numbers of specimens with filled and empty stomachs caught at night and in the day time, and by the lower degree of digestion of the organisms in stomachs of redfish caught at night (see fig. 4). It is therefore evident that the reduction in catches during night is directly connected with feeding migrations.

Although discussion of qualitative compositions of food of "beaked" redfish from individual subareas is beyond the scope of this paper, it can be pointed out that the major components of their food are extremely uniform. In all the areas investigated two groups of organisms, - euphausiidae and bathypelagic fish, - are the main items of redfish diet. There are, of course, some variations, for instance, more frequent presence of capelin in the food of redfish from the southern (3O) and north-eastern (3L) slopes of the Grand Bank, or complete absence of this species in the diet of redfish from Flemish Cap.

The results of observations made in all areas and all seasons, have shown definitely that the qualitative composition of food of "beaked" redfish does not depend upon the depth of their concentration. An increase in the occurrence of fish, mostly of lantern anchovy, in the food composition at greater depths was only rarely observed (see fig. 5).

The main result of the investigation is that the greatest concentrations of "beaked" redfish are at the depths where their favourite food, - euphausiidae and bathypelagic fish, - is most abundant in the given period of time. It can be assumed that concentrations of "beaked" redfish are more constant when the main food is euphausiidae instead of fish. A positive correlation exists between the amount of feeding fish (the intensity of the feeding of a population) and the size of catches (see fig. 6).

The food relation of Sebastes mentella, Sebastes marinus, and cod is considered by following the method of calculating the coefficient of food similarity (CFS), in order to compare food compositions of various fish on the basis of frequency of occurence of food components:

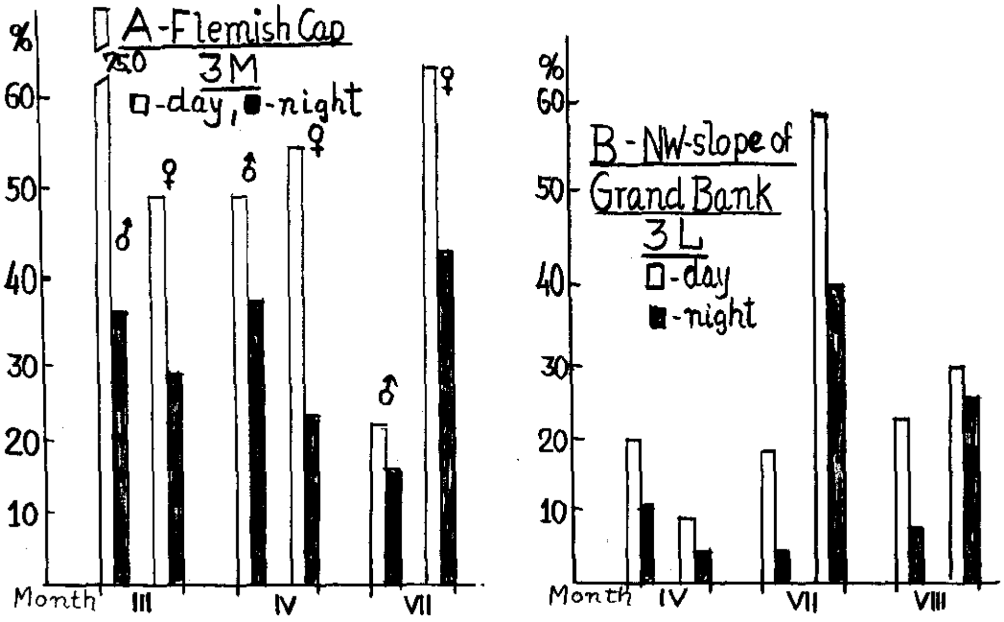


Fig. 4. Number of "beaked" redfish with food in their stomachs captured by day and by night.

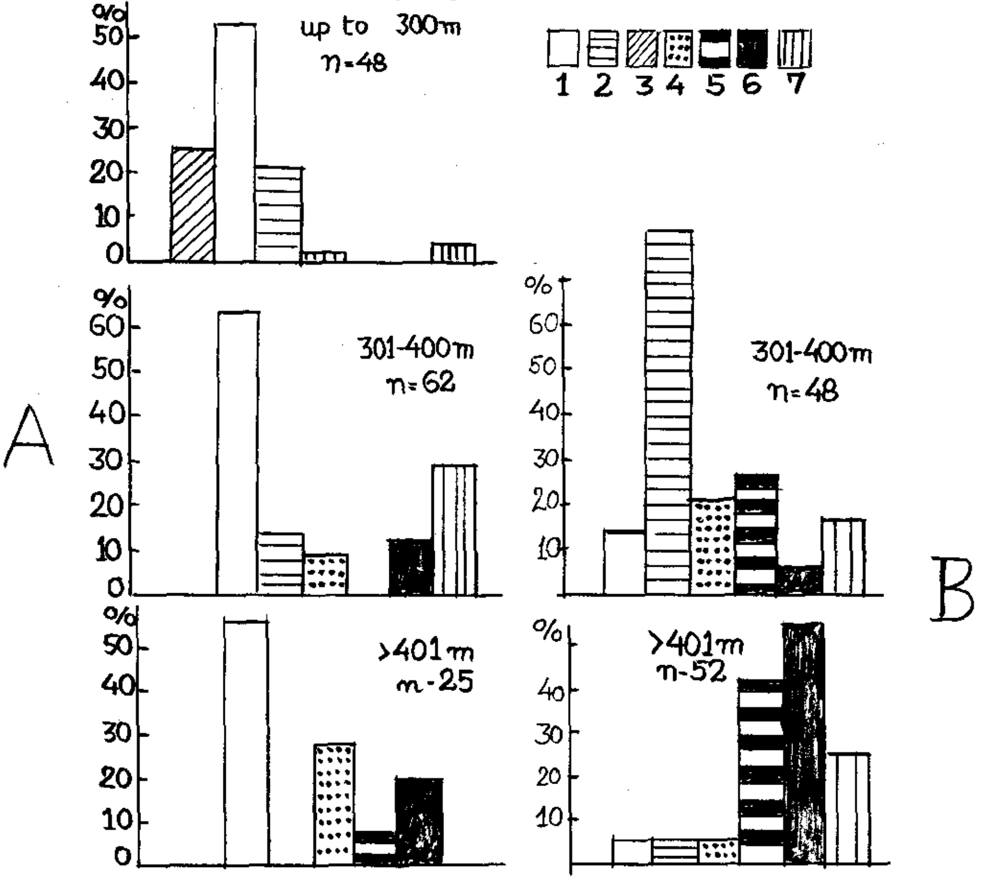


Fig. 5. Food of "beaked" redfish at various depths (frequency of occurence,%). A-S. Slope of the Grand Bank (3N), August; B-S. Labrador (2J), November.
1 - Euphausiidae; 2 - Amphipoda; 3 - Copepoda; 4 - Other plankton organisms; 5 - Shrimps; 6 - Lantern anchovy; 7 - Other fish.

$$CFS = \frac{n.100}{N}$$

where N - the total of higher per cents of frequencies of occurence of food organisms found in the species being compared;

n - the total of lower per cents of frequencies of occurence of food components common for fish being compared.

According to this formula, in case of complete difference in the compositions of food of the two species the CFS will be 0, whereas in case of complete identity it will be 100. The coefficient of food similarity determined for *Sebastes marinus* and *Sebastes mentella* from Flemish Cap (3M), is 65.0, from the Northern Newfoundland Shelf (3K) - 52.1, and from Southern Labrador (2J) - 61.5. Figure 7 is a graphical presentation of the similarity of spectra of food. The spectra of food of *Sebastes marinus* and *S. mentella* overlap to a considerable extent, *S. marinus* showing, however, a greater tendency toward fish-eating. The same regularity was revealed by comparisons of the compositions of food of these two species captured at the same station (see fig. 8). Coefficients of food similarity were then determined to be 22.3 (3M) and 26.5 (2J). The spectra of food of "beaked" redfish and cod overlap inconsiderably, so the possibility of their competition in most areas is only slight. The coefficient of food similarity for the spectra of food of redfish and cod from the North-Eastern Slope of the Grand Bank is 18.3 (see fig. 9). A similar picture is gained by a comparison of the spectra of food of redfish and cod caught simultaneously (see fig. 10).

TABLE I

Organisms found in the food of "beaked" redfish (+ very rare; ++ rare; +++ frequent; ++++ very frequent)

HYDROIDEA	
1. Aglantha digitale (Müller)	+++
CTENOPHORA	
2. Pleurobrachia pileus Müller	++
3. Beroe cucumis Fabricius	++
POLYCHAETA	
4. Nereis pelagica Linne	+
COPEPODA	
5. Calanus finmarchicus (Gunner)	++++
6. Calanus hyperboreus Kröyer	+++
7. Pareuchaeta norvegica (Boeck)	+++
MYSIDACEA	
8. Amblyops abbreviata (M. Sars)	++
AMPHIPODA	
9. Hyperia galba Montagu	+++

10. Themisto libellula Maudt	++++
11. Themisto abyssorum (Boeck)	++++
12. Pseudolibrotus glacialis Sars	++
EUPHAUSIACEA	
13. Meganyctiphanes norvegica (M. Sars)	++++
14. Thysanöessa inermis (Kröyer)	++++
15. Thysanöessa raschi (M. Sars)	++++
16. Thysanöessa longicaudata (Kröyer)	++
DECAPODA	
17. Pandalus borealis Kröyer	++
18. Sergestes sp.	+
PTEROPODA	
19. Clione limacina Phipps	++
20. Limacina retroversa Flemming	++
CEPHALOPODA	
21. Genus indet.	++
CHAETOGNATHA	
22. Sagitta elegans Verrill	++
23. Sagitta maxima conant	+++
APPENDICULARIA	
24. Oikopleura sp.	+
PISCES	
25. Alepocephalus bairdi Goode and Bean	+
26. Mallotus villosus (Müller)	++
27. Bathylagus euriops Goode and Bean	++
28. Maurolicus mülleri Gmelin	+
29. Cyclothone signata Garman	++
30. Stomias ferox Rheinhardt	+
31. Chauliodus sloanei Bloch and Schneider	+
32. Paralepis coregonoides Reinhardt	+++
33. Hygophum benoiti (Cocco)	+
34. Benthosema glaciale (Reinhardt)	++++
35. Myctophum punctatum Rafinesque	+++
36. Lampanictus cuprarius Tåning	+
37. Ceratoscopelus maderensis (Lowe)	+++
38. Notoscopelus elongatus (Costa)	++
39. Nemichtys scolopaceus Richardson	+
40. Ammodytes americanus DeKay	++

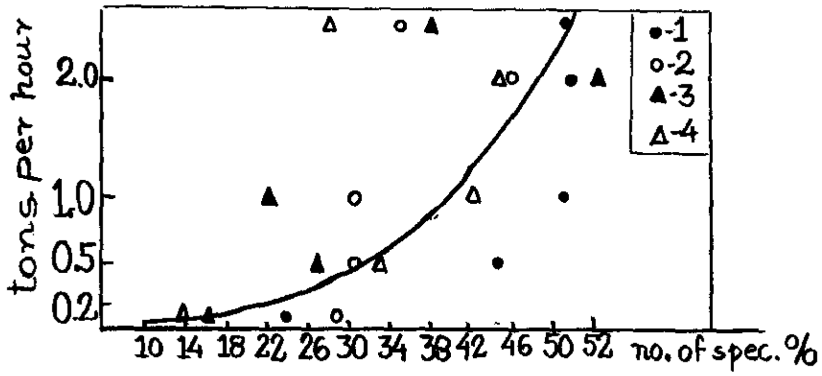


Fig. 6. Relationship between captures of "beaked" redfish (tons per hour) and the number of feeding individuals (intensity of feeding). Based on the results of field analyses.

1. Material collected during cruise No. 3 of the RT-99 "Novorossiisk", in November-December 1958 (m-1200);
2. Material collected during cruise No. 14 of the r/v "Sevastopol", in June-August 1959 (m-2425);
3. Material collected during cruise No. 16 of the r/v "Sevastopol" in February-April 1960 (m - 1300)
4. Material collected during cruise No. 17 of the r/v "Sevastopol" in June-September 1960 (m-3400).

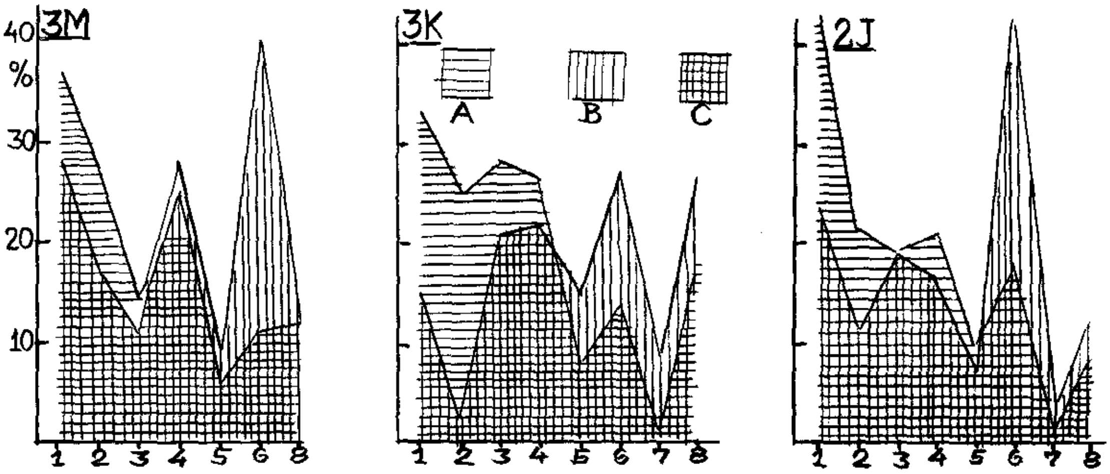
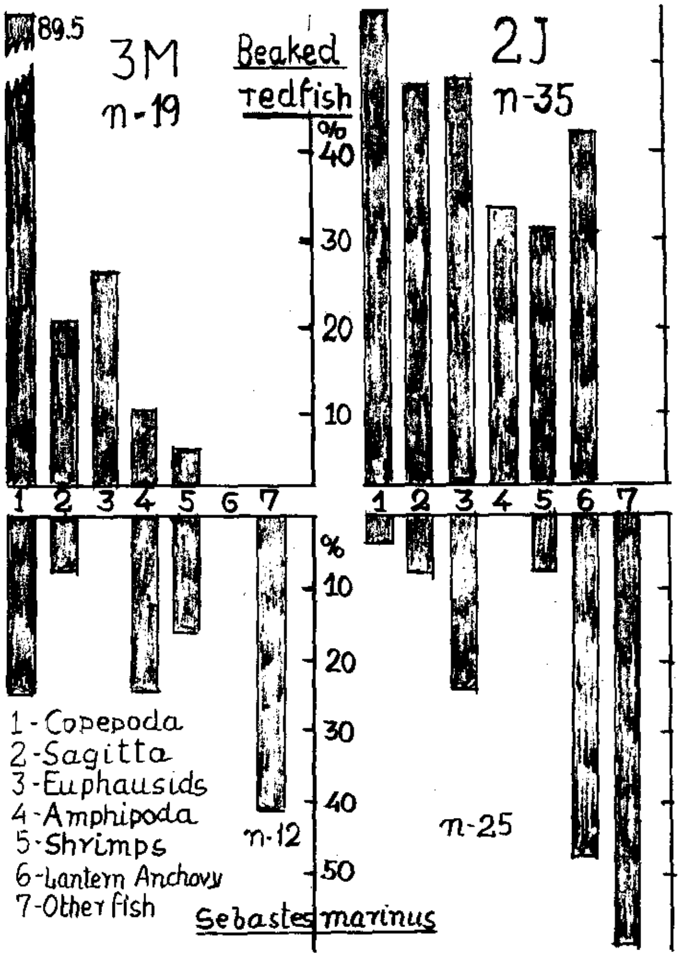


Fig. 7. Comparison of compositions of food of "beaked" redfish and Sebastes marinus from areas 3M, 3K, and 2J (frequency of occurrence, %). Based on the data collected in 1956-1960.

A - Food of "beaked" redfish; B- Food of Sebastes marinus;
C - Common food.

1 - Euphausiidae; 2 - Copepodes; 3 - Amphipodes; 4-Other Plankton organisms; 5 - Shrimps; 6 - Lantern anchovy; 7 - Capelin; 8 - Other fish.



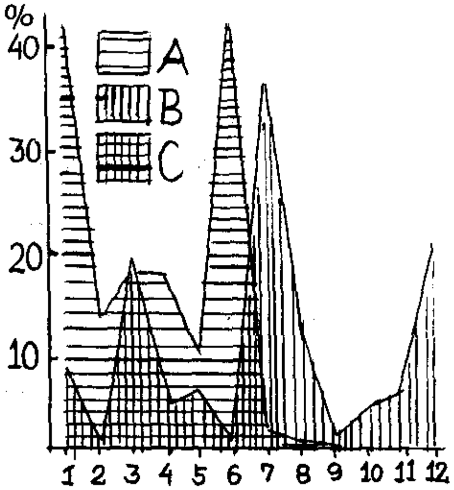


Fig. 9. Compositions of food of "beaked" redfish and cod from the North-Eastern Slope of the Great Banks (3L). A-Food of "beaked redfish (from the data collected in /57-60. B-Food of cod(from the data collected in 1959); C-Common food. 1. Euphausiids; 2-Copepoda; 3-Amphipoda; 4-Other plankton organisms; 5-Shrimps; 6-Bathypelagic fish; 7-Capelin; 8-Sand-eel; 9-Redfish; 10-Cadoid fish; 11-Other demersal fish; 12-Benthos.

Fig. 8. Compositions of food of "beaked" redfish and Sebastes marinus fished at the same time and the same stations in 3M(March)and2J(Aug.)

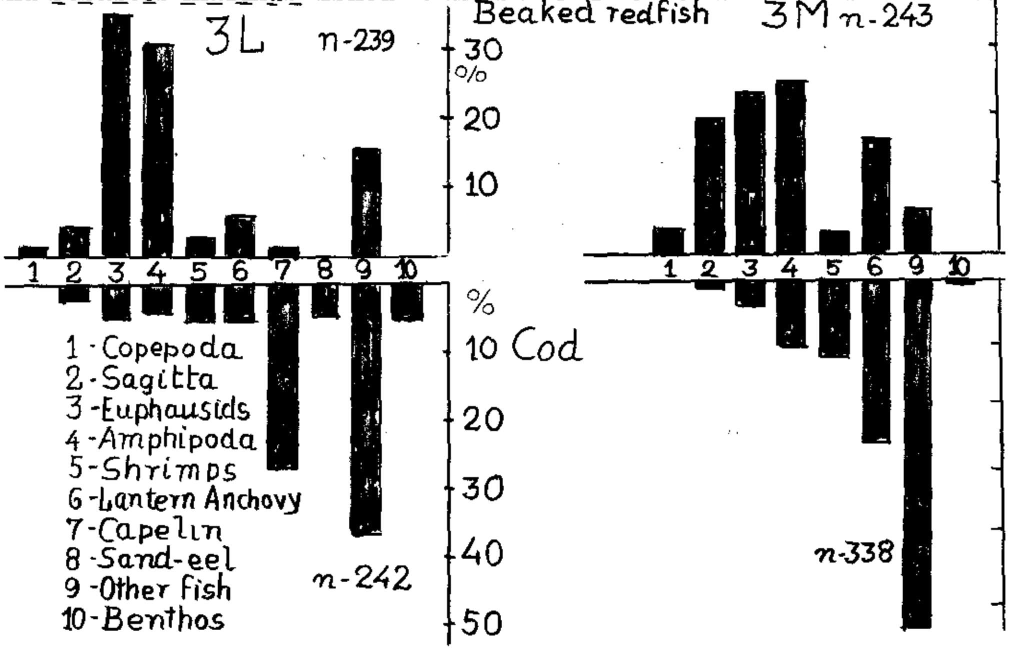


Fig. 10. Compositions of food of "beaked" redfish and cod fished at the same time and same stations in 3M and 3L.

TABLE II

Feeding habits of various size groups of "beaked" redfish
(frequency of occurence of components, %).

Food components	Length, cm											
	26		26-30		31-35		36-40		41-45		45	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Copepoda	18.0	23.3	31.1	24.2	22.8	20.7	13.1	18.8	9.1	15.0	-	8.7
Euphausids	52.5	46.6	50.0	54.1	41.9	45.4	35.4	38.5	29.9	29.5	14.3	30.6
Gammarus	19.7	16.7	24.3	21.0	30.5	21.9	26.6	22.6	13.0	20.1	-	16.4
Other Plankton Organisms	3.3	20.0	13.2	9.7	22.2	17.8	23.1	24.0	19.5	20.4	14.3	28.4
Shrimps	1.6	10.0	8.0	6.9	8.8	6.3	9.6	9.6	10.4	11.8	-	15.3
Lantern anchovy	11.5	3.3	8.6	8.1	13.1	11.0	17.2	19.9	20.8	28.3	28.6	20.8
Capelin	-	-	0.3	0.8	0.3	0.1	0.8	0.9	-	2.3	-	2.7
Other fish	9.8	10.0	3.1	3.6	6.2	7.5	11.4	10.1	18.2	13.9	57.2	21.4
Total % of fish	21.3	13.3	12.0	12.5	19.6	18.6	29.4	30.9	39.0	44.5	85.8	44.9
Other food	1.6	-	0.3	1.2	1.1	0.5	1.4	0.8	1.3	0.7	-	-
No. of stomachs containing food	61	30	325	248	1483	966	731	2453	77	1586	7	183

11. COMPARISONS OF ICNAF AND WESTHOFF GAUGES UNDER FIELD CONDITIONS.

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Abstract

The ICNAF and 1959 model Westhoff gauges have been used in the field to measure meshes of manila netting of various twine and mesh sizes. Differences between mean mesh sizes as obtained by eight different operators using the two gauges were extremely variable and almost always highly significant. This is considered to be due largely to between-operator variability with the ICNAF gauge. The 1959 model Westhoff gauge is considered to be far superior to the ICNAF gauge in producing consistent results under field conditions.

Introduction

The difficulty of obtaining comparable mesh size measurements with wedge-type and direct-pull mesh gauges has been recognized for a number of years. The two types are inherently different in that the load on the mesh is applied indirectly (at right-angles to the direction of measurements) by means of a downward vertical thrust with a wedge-type gauge, and directly by means of a longitudinal pull on the mesh with a direct-pull gauge. Bedford and Beverton (MS, 1956) have shown that with a wedge-type gauge there is no constant relation between applied pressure and resultant longitudinal load on the mesh because of high and variable friction between the mesh and the gauge. On the other hand it should be possible with a direct-pull gauge to apply a fairly constant direct longitudinal load to the mesh being measured, particularly if the gauge is fitted with a pressure limiting device which locks it when a desired pressure is reached.

In recent years a number of controlled mesh measuring experiments have been performed in order to compare results with various models of the two basic types of mesh gauges. It is of interest here to summarize briefly the results for manila twine with the two gauges employed in this study, i.e. the ICNAF (wedge-type) and 1959 model Westhoff (direct-pull) gauges, as well as the Scottish gauge, of which the 1959 model Westhoff is a modification. Basic descriptions of the ICNAF and Scottish gauges may be found in Parrish, Jones and Pope (1956) and von Brandt and Bohl (MS, 1959). The Westhoff gauge is described by Westhoff and Parrish (MS, 1959).

In general, for measurements on manila meshes, it has been found that the ICNAF gauge gives consistently higher readings than either of the other two, as well as a greater bias between operators. Higher measurements with the ICNAF gauge as compared with the Scottish gauge have been reported by Parrish, Jones and Pope (1956), McCracken (MS, 1957), Templeman (MS, 1957), von Brandt and Bohl (MS, 1959), and Sandeman and May(1961). The ICNAF gauge has also been found to measure consistently higher than the 1959 model Westhoff gauge by Sandeman and May (1961) and Bohl and Nomura (MS, 1961). Roessingh (MS, 1961), on the other hand, finds the 1959 model Westhoff to measure consistently higher than the ICNAF, but results with the former were not consistent and are attributed to the fact that the gauge used was the heavy prototype of the 1959 model and was difficult to handle.

Several authors have presented a statistical treatment of their data to illustrate the greater operator variability of the ICNAF gauge as compared with the direct-pull gauges. Their results are summarized in Table 1. Bohl and Nomura (MS, 1961) also conclude that results with the ICNAF gauge are more variable than those with the 1959 model Westhoff because of the greater standard deviation of measurements with the former gauge.

Table 1. Summary of "between-operator" comparisons by various authors using the ICNAF, Scottish, and 1959 model Westhoff gauges.

			Significant Differences	
Source	Mesh Gauge	No. of Comparisons	P = .05	P = .01
Parrish et al (1956)	ICNAF	3	3	
	Scottish	3	0	
McCracken (MS, 1957)	ICNAF	3	2	
	Scottish	3	2	
von Brandt and Bohl (MS, 1959)	ICNAF	6	5	4
	Scottish	6	2	0
Sandeman and May (1961)	ICNAF	45	40	39
	Scottish	45	23	17
	Westhoff	45	14	10

This laboratory has been aware for some time that considerable operator variability existed in mesh measurements made at sea using the ICNAF gauge, and this variability was also found to occur in controlled laboratory experiments (Sandeman and May, 1961). Of three gauges tested in the latter experiments, operator variability was found to be minimal with the 1959 model Westhoff gauge. In most of our mesh selection experiments during 1961, both ICNAF and Westhoff

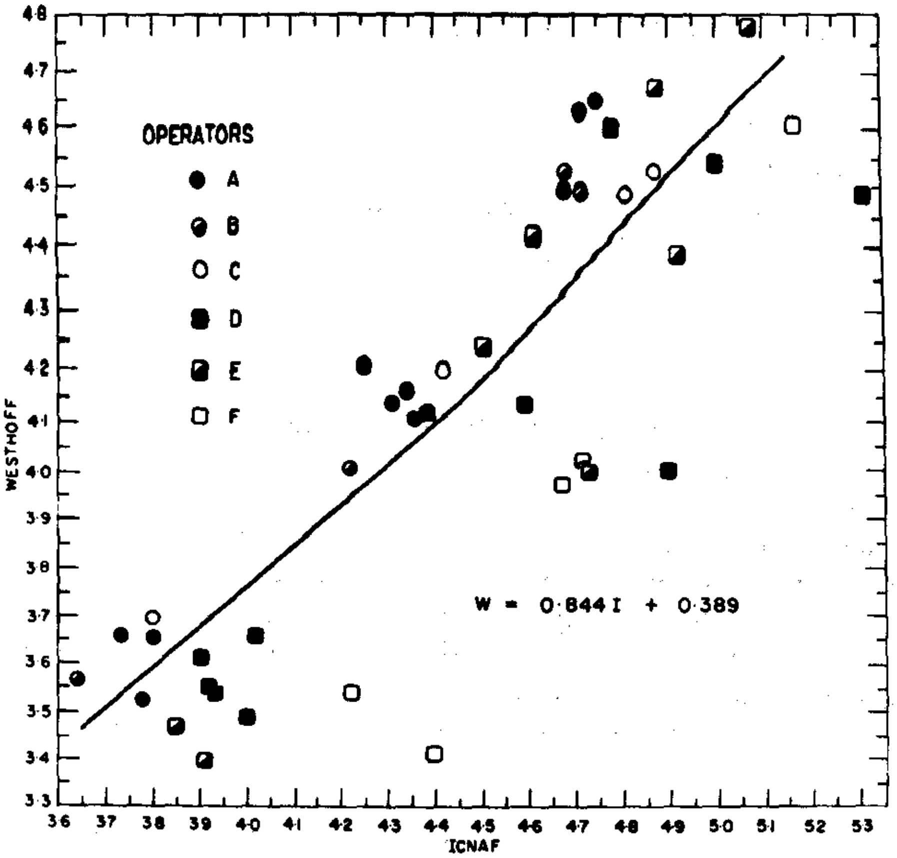

Fig. 1. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 50/4 single manila twine.

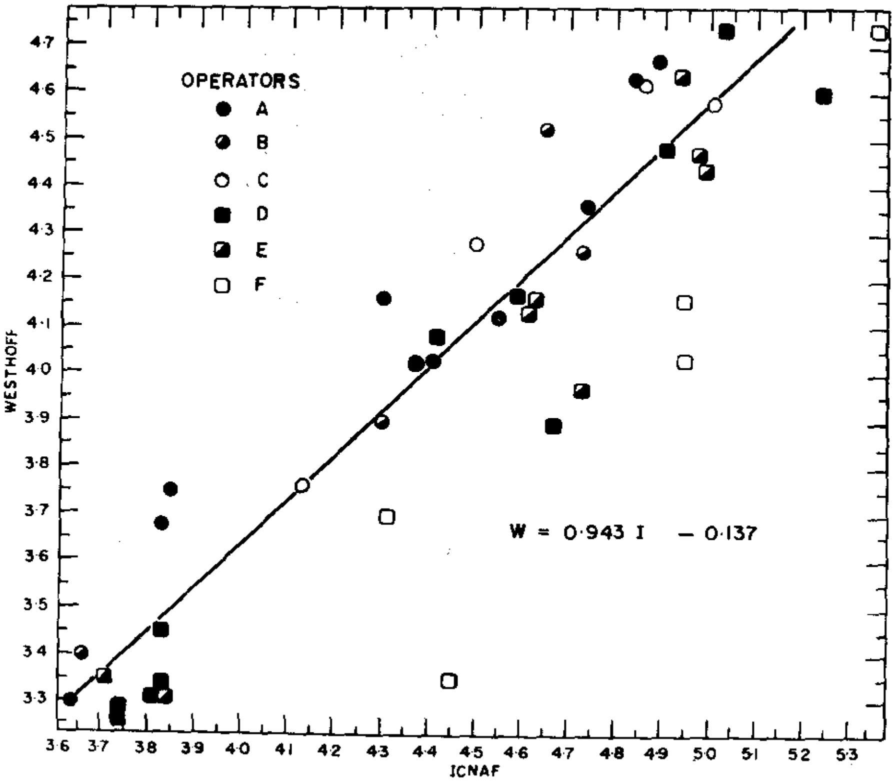

Fig. 2. Straight line regression fitted to plots of Westhoff versus

gauges were used at sea to measure the net meshes in order to

(1) test the Westhoff gauge in the field,
(2) compare results with each gauge on a variety of twine and mesh sizes, and
(3) obtain some method of converting measurements made at sea with the ICNAF gauge to those that might be obtained if the Westhoff gauge were used.

Materials and Methods

All measurements were made on manila netting, and all were made as soon as possible after completion of a drag so that the nets were always well soaked in sea water. In order to compare results for a variety of twine and mesh sizes, we have examined measurements made on codends, lengthening (extension) pieces and squares of nets of three of our research vessels: the 177-foot A. T. Cameron, the 82-foot Investigator II and the 62-foot Marinus. The variety of gear on which results are based is listed in Table 2. Dry mesh size is the size of stretched dry meshes between knot centres, as ordered from the manufacturer. In the notation for twine size, or runnage, the first number denotes yards per pound of twine, while the second refers to the twine ply.

Table 2. List of twine and mesh sizes of a variety of manila net sections measured at sea.

Twine size (Runnage)	Dry Mesh Size			
	Double Knit		Single Knit	
	inches	mm	inches	mm
50/4	5 1/8	(130)	4 5/8	(117)
	5 3/4	(146)	5 1/8	(130)
	6 1/4	(159)	5 5/8	(143)
75/4	3 1/4	(83)	3 1/4	(83)
	5	(127)	4 1/2	(114)
	6	(152)	5 1/2	(140)
100/3	--		5	(127)
	--		5 1/2	(140)
125/3	3	(76)	3	(76)
	3 1/4	(83)	3 1/2	(89)
	3 1/2	(89)	4 1/2	(114)
	--		5	(127)
	--		5 3/8	(137)
	--		6	(152)

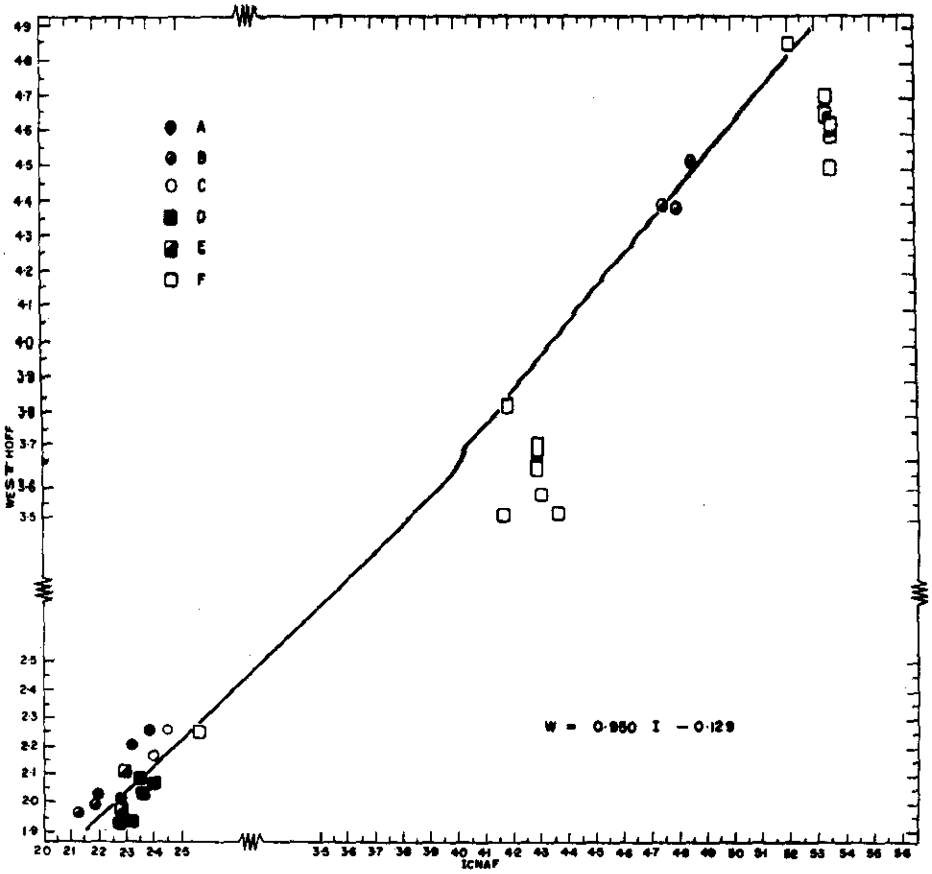

Fig. 3. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 75/4 single manila twine.

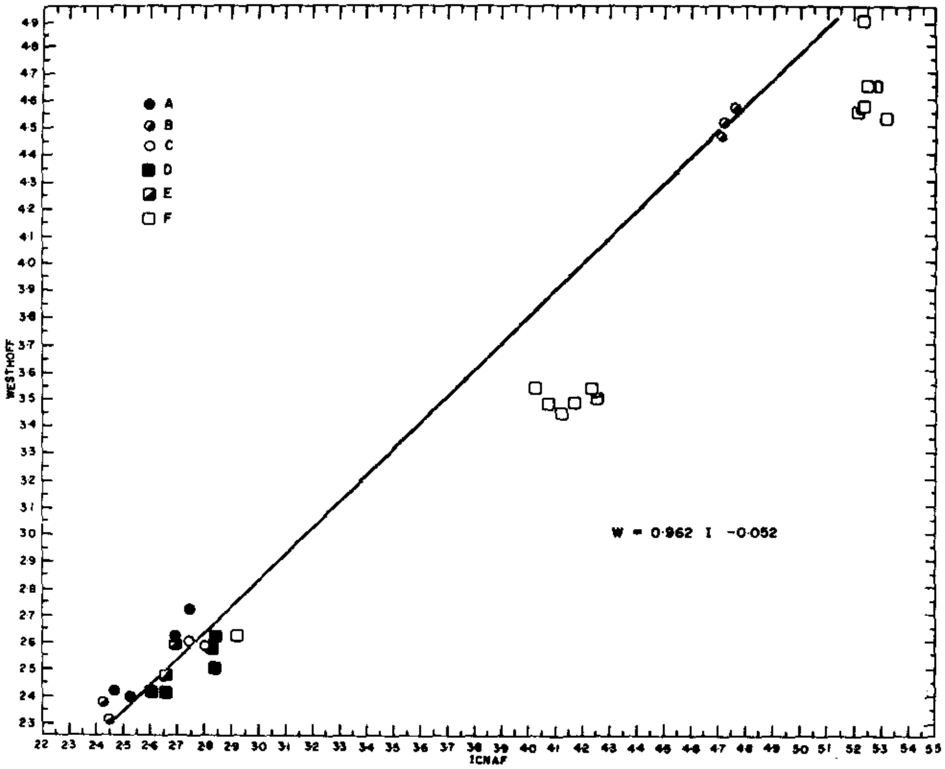

Fig. 4. Straight line regression fitted to plots of Westhoff

Measurements by eight operators are included in the results. Six operators had a number of years' experience in the use of the ICNAF gauge, whereas none had used the Westhoff gauge prior to 1961.

The operators were instructed to use the ICNAF gauges at a pressure of 12 lbs (5.4 kg), and the Westhoff gauges were adjusted to lock at the same pressure. Initially, some difficulty was experienced in attaining this pressure with the Westhoff gauges as originally supplied. New (heavier) springs were eventually inserted to make an adjustment to 12 lbs pressure more easily attainable. The gauges were periodically oiled and checked at sea to ensure that they were registering correct pressure.

The various nets used in any particular selection experiment were generally measured after the first, second and fifth drags with each net, and every fifth drag thereafter. All measurements after any particular drag were made by one operator, using each of the gauges on a different row of meshes. The sequence of measurement began at the fourth mesh of the codend, anywhere from 8 to 15 meshes away from the lateral lacings (selvage), and continued forward in the same row to the headrope. Every consecutive mesh was measured in the codend, and every third mesh in the lengthening piece and square. The measurer was assisted by a second person who straightened out the net as the measuring proceeded and held it at waist level above the deck.

Since the data for this study have been collected entirely at sea, analysis of gauge and operator variation is complicated by the introduction of several factors which would not be present in controlled laboratory experiments. These may be enumerated as follows:

(1) Since some of the data were collected during 24-hour selection experiments with operators on one schedule and use of nets on another, and since measurements were made on a number of cruises of three different vessels, it was impossible to have each operator measure any one net section an equal number of times, or even to obtain measurements by any one operator for the whole variety of gear.

(2) Due to the loss and wearing-out of gear, particular net sections or entire nets were often replaced during and between cruises, thus making direct comparisons of a number of measurements invalid.

(3) Variable changes in mesh size associated with size of catch probably occurred over the experiments, especially if a cruise was begun with new gear.

(4) The same row of meshes was seldom measured by any two operators. This probably would not affect the analysis since it can be reasonably assumed that any particular row is a normal sample of the net section, i.e. that no significant

differences occur between rows of the same piece of netting, at least in the central part from which the measurements were obtained.

Because of the foregoing, direct comparisons of average mesh size measurements for the examination of operator and gauge variation are not possible. In fact there is no meaningful way of comparing operator variation for any particular gauge, since, for the same or different operators, variations in mesh size measurement may be due either to operator variability or to actual differences in mesh size caused by fishing or by insertion of new twine. However, it should be possible to obtain meaningful comparisons between gauges for each operator by examining the order of difference obtained between measurements with each gauge. For any particular net section it is necessary only to assume that any actual changes in mesh size due to fishing or insertion of new twine will be recorded by both gauges, and, since such mesh size changes would undoubtedly be small, the order of difference obtained should be similar. Also, of course, it must be assumed that an operator's method of using the gauge remains constant, i.e. that the within operator variability with each gauge is negligible.

Results

Differences in mesh size as measured with the ICNAF and Westhoff gauges have been average for each operator and are listed in Table 3 separately for each twine size, knit and dry mesh size. The average difference obtained by all operators for each type of netting is also shown. Numbers in parentheses refer to the number of times the particular type of netting was measured. Differences between the two gauges as used by all the operators have been analysed by means of paired comparisons tests, and t-values are shown. Several points are apparent:

(1) Measurements made with the ICNAF gauge are consistently higher than those with the Westhoff gauge, and the differences found are almost invariably highly significant.

(2) A good deal of variability exists between operators with regard to the order of differences obtained. It is apparent that these are not always random differences for any particular type of netting, as, in general, particular operators tend to obtain a consistent relative order of differences as compared with those of the other operators. In particular the differences obtained by operators A and B are almost always smaller than those obtained by any of the other operators, while the differences obtained by operator F are almost always greater.

(3) The differences obtained by each operator when measuring double knit twine are generally greater than those for single knit twine of similar mesh size.

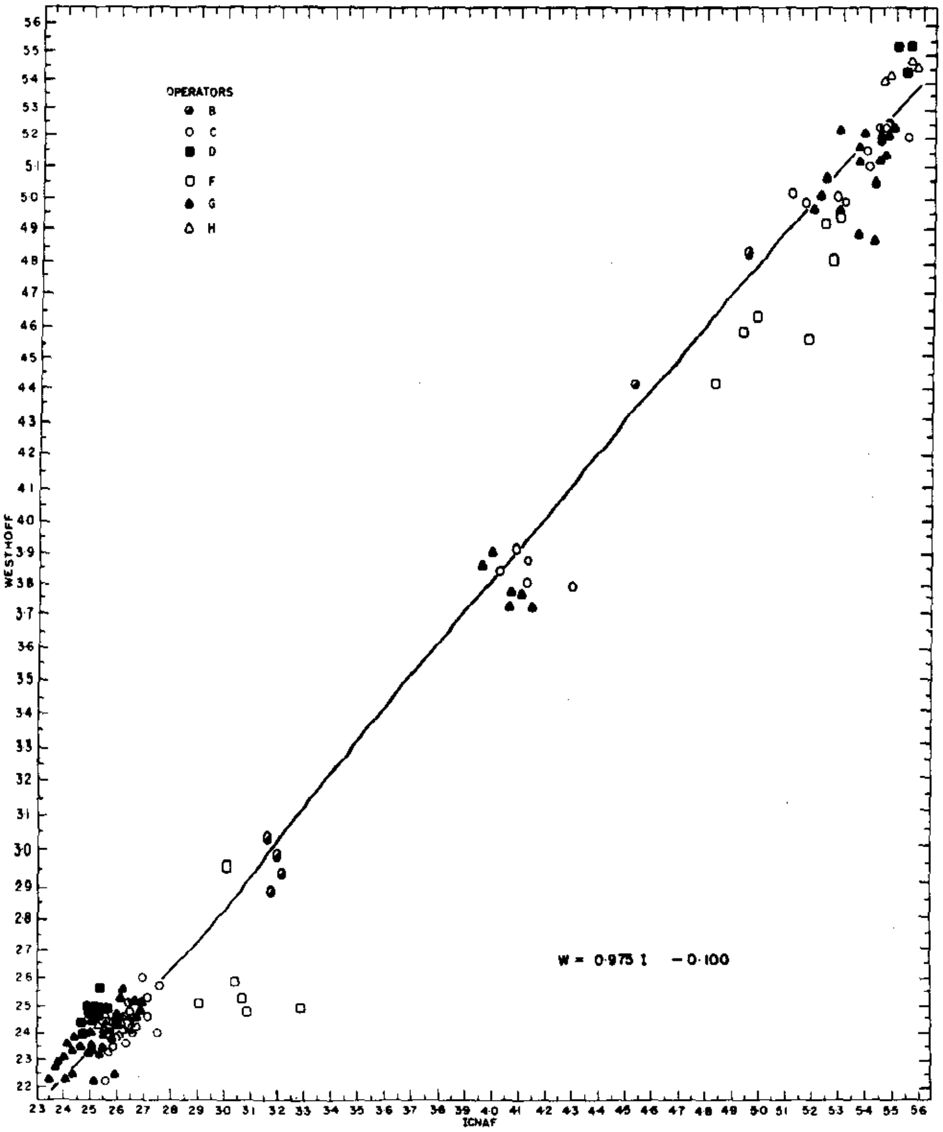

Fig. 5. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 125/3 single manila twine.

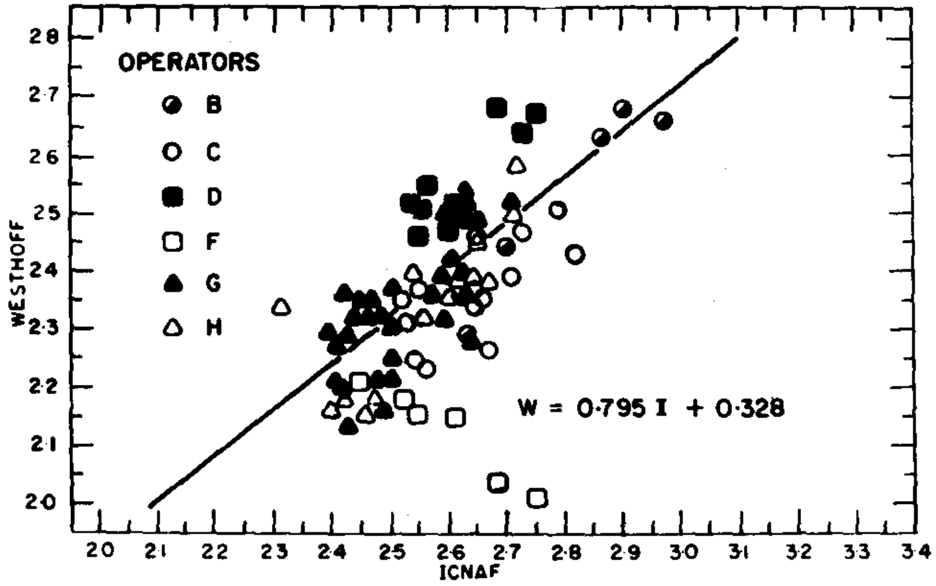

Fig. 6. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 125/3 double manila twine.

Average mesh sizes obtained by each operator in measurements with each gauge on the various types of netting cannot be directly compared because of the nature of the data. However, some indication of variability between operators for each gauge may be obtained by plotting results with one gauge against those for the other, as in Figures 1 to 7. The resultant plots generally consist of several groups of points since each kind of twine is usually represented by net sections of different mesh sizes. A straight line trend is evident in each of the plots, indicating that changes in mesh size as recorded by one of the gauges tend to be proportional to the changes recorded by the other. The scatter of the points within each group gives an indication of the variability of results with each gauge as handled by the different operators. The horizontal scatter of points within each group generally tends to be greater than the vertical scatter, indicating greater variability between operators using the ICNAF gauge for measurements of any particular net section. It may be noted that the plots of results for operator F never appear to be distributed randomly within any group, but tend to be on the extreme right of the horizontal axis of any group. This is caused by the fact that this operator's measurements with the ICNAF gauge were consistently very high, and as a result, relatively large differences between his ICNAF and Westhoff averages were obtained. It must be concluded that pressures applied by this operator using the ICNAF gauge were appreciably higher than the intended 12 lbs (5.4 kg).

It is useful to be able to convert measurements made in the field by a particular gauge to measurements that would likely result had another gauge been used. In order to accomplish this, straight lines have been fitted by the method of least squares to the data of Figures 1 to 7 (excluding the results of operator F). Such lines could be fitted to the plots for each operator separately, if adequate data were available, to provide a more exact means of converting measurements. The regressions given here are those of Westhoff gauge means on ICNAF gauge means, and provide a method of converting ICNAF gauge results in terms of the Westhoff gauge. Since the correlation coefficient is obviously not unity for any of the plots of Figures 1 to 7, these regression equations theoretically should not be used to convert Westhoff gauge measurements to those that might be obtained with the ICNAF gauge. For this purpose it would be necessary to compute another regression, using Westhoff gauge values as the independent variable, though the value of this procedure would depend on the nature of the data and the practical use of such conversions. Errors would certainly be small near the regression means.

Discussions and Conclusions

The differences found between mean mesh sizes of any particular piece of netting as measured with each of the gauges can largely be explained in terms of the pressures at which the gauges were used. Notwithstanding the fact that both gauges were intended to be used at pressures of approximately 12 lbs(5.4 kg), it was found to be very difficult to obtain this pressure with the Westhoff gauges ble 3. Average amounts in inches by which ICNAF gauge measurements exceeded Westhoff gauge measurements each operator separately, and for all operators combined for each type of netting measured. t-values from ired comparisons tests are also shown. Two asterisks (**) indicate significance at the 1% level; a single asterisk licates significance at the 5% level.

ine ize unnage)	Knit	Dry Mesh Size (inches)	A	B	C	D	E	F	G	H	Mean	t
0/4	Single	4 5/8	.151(3)	.075(1)	.099(1)	.387(5)	.444(2)	.830(2)			.365(14)	5.39**
		5 1/8	.161(4)	.145(1)	.225(1)	.528(3)	.399(3)	.714(2)			.371(14)	5.17**
		5 5/8	.118(3)	.197(2)	.328(2)	.487(3)	.341(3)	.553(1)			.318(14)	5.77**
	Double	5 1/8	.197(3)	.255(1)	.371(1)	.462(5)	.437(2)	.853(2)			.435(14)	6.92**
		5 3/4	.320(4)	.401(1)	.224(1)	.513(3)	.568(3)	.854(2)			.490(14)	7.94**
		6 1/4	.275(3)	.303(2)	.335(2)	.454(3)	.451(3)	.615(1)			.391(14)	9.14**
75/4	Single	3 1/4	.075(4)	.095(2)	.183(2)	.247(5)	.135(2)	.290(1)			.166(16)	7.10**
		4 1/2	--	--	--	--	--	.649(6)			.649(6)	16.85**
		5 1/2	--	.218(3)	--	--	--	.608(6)			.478(9)	6.32**
	Double	3 1/4	.174(4)	.184(2)	.213(12)	.333(5)	.244(2)	.304(1)			.248(16)	11.97**
		5	--	--	--	--	--	.618(6)			.618(6)	9.30**
		6	--	.364(3)	--	--	--	.659(6)			.561(9)	8.47**
00/3	Single	5	.120(6)	.146(1)	.255(4)	.356(3)	.259(3)	.654(4)			.299(21)	6.36**
		5 1/2	.044(2)	.058(1)	.229(3)	--	.230(1)	.703(1)			.216(8)	2.85*
25/3	Single	3	--	--	.220(15)	.045(9)	--	.484(6)	.150(32)	.187(12)	.185(74)	11.82**
		3 1/2	--	.231(4)	--	--	--	--	--	--	.231(4)	6.66**
		4 1/2	--	--	.294(5)	--	--	--	.270(6)	--	.278(11)	7.22**
		5	--	.124(1)	--	--	--	.453(4)	--	--	.390(5)	4.68**
		5 3/8	--	.134(1)	--	--	--	.377(3)	--	--	.316(4)	4.75*
		6	--	--	.245(11)	.031(3)	--	--	.276(16)	.080(4)	.211(34)	10.31**
	Double	3	--	--	--	--	--	.465(6)	--	--	.465(6)	6.00**
		3 1/4	--	--	.287(15)	.062(9)	--	--	.190(32)	.209(14)	.198(7)	17.13**
		3 1/2	--	.254(4)	--	--	--	--	--	--	.254(4)	12.83**

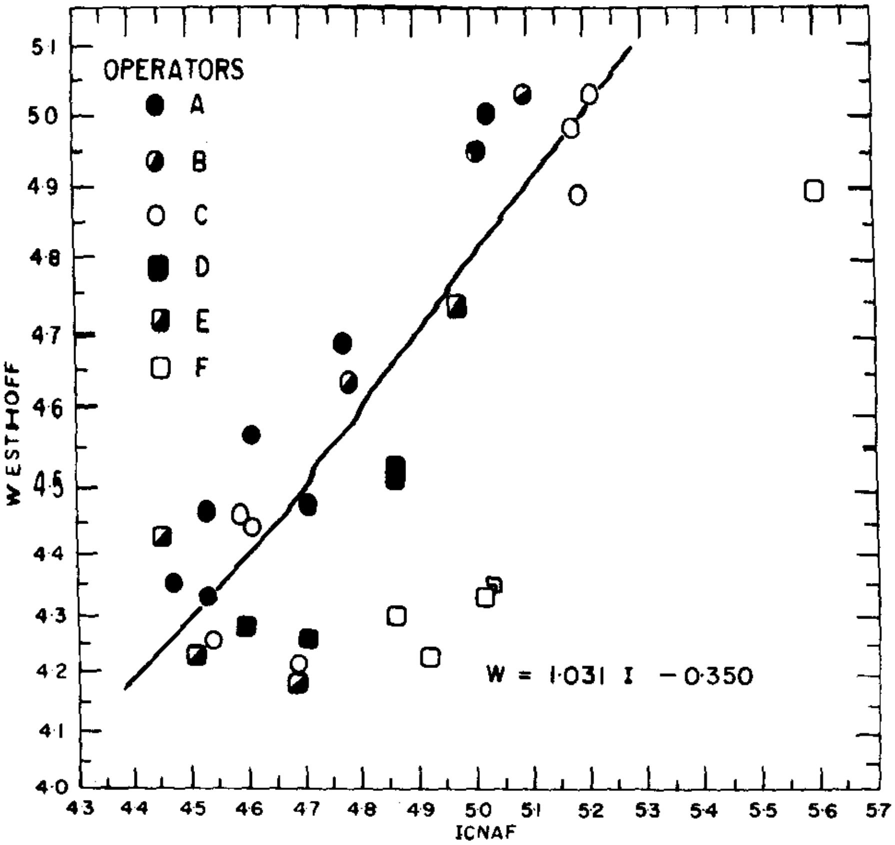

Fig. 7. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 100/3 single manila twine.

as originally supplied. and new springs had to be inserted in order to accomplish this. Thus, for much of the data for the Westhoff gauge, 12 lbs pressure was probably the maximum, and a range of 9 to 11 lbs (4.1 to 5.0 kg) is more likely. On the other hand it is thought that the ICNAF gauge was often used at pressures considerably in excess of 12 lbs, and that 12 lbs is a minimum value for this gauge, probably being consistently approached only by operators A and B. These apparent differences in pressures applied with the two gauges may possibly explain why greater differences in mesh size measurement were obtained for double than for single knit twine. Differential stretching of double and single knit meshes might not have been as great at the pressures applied with the ICNAF gauge as they were at the lower Westhoff gauge pressures. Thus, for single twine, the Westhoff gauge might tend to stretch the meshes in relatively high proportion to the stretch by the ICNAF gauge, but in relatively lower proportion for double twine. The wide variation in applied pressures with the ICNAF gauge must be due largely to careless use of the gauge by at least some of the operators, but may also be a reflection of a criticism put forth by von Brandt and Bohl (MS,1959) in that when measuring quickly, a too high initial pressure as the gauge is being inserted in the mesh often cannot be avoided.

It is considered that the wide variations in differences in mesh measurement as found in the present study between ICNAF and Westhoff gauges were due largely to variable results with the ICNAF gauge. The extreme variability of this gauge as compared with the Westhoff has previously been demonstrated by Sandeman and May (1961) in controlled laboratory experiments in which most of the operators involved in this study took part. The ICNAF gauge can be very easily misused, especially under the relatively uncomfortable conditions often prevailing at sea. Inherent faults in the gauge which contribute to its misuse have been described by Bedford and Beverton (MS, 1956) and von Brandt and Bohl (MS, 1959) and are briefly summarized here:

(1) Insertion of the wedge into the mesh until a desired pressure is reached does not take place smoothly or continuously. The high and variable friction between mesh and wedge results in a variable relation between downward thrust and resultant longitudinal load.

(2) It is difficult to watch the pressure scale on the handle and the measuring scale on the wedge at the same time. Thus the wedge may not enter the mesh perpendicularly, but rather at some other angle to the direction of measurement. Attempting to straighten the gauge may result in the application to the mesh of greater loads than intended.

(3) When working quickly, the initial pressure as the gauge is being inserted into the mesh may be too high.

(4) Results vary according to the time during which the thrust is applied.

Another fault may be added. Friction between the fixed and movable parts of the gauge handle, especially if this area is not well lubricated and if the operator does not apply a force exactly perpendicular to the mesh, may cause higher loads than intended to be applied to attain a pressure reading of 12 lbs.

Most of these faults are not present in the 1959 model Westhoff gauge, and although this gauge has a few inherent faults of its own, the authors consider it to be far superior to the ICNAF gauge as regards its capability of producing consistent results when used by different operators in the field. The 1961 model of the same gauge as described by Westhoff (MS, 1961) may be even better in this respect. In spite of the faults of the ICNAF gauge as described, and the variable results produced by it, Sandeman and May (MS, 1962) have found that if the ICNAF and 1959 model Westhoff gauges are carefully calibrated and carefully used, no significant differences between mesh measurements by each gauge are found over a range of pressures and with a variety of manila netting. However, it does seem impractical to attempt to use the ICNAF gauge with such precision under field conditions. Not only is great care in handling required, but the measurements when such care is exercised take considerably longer to obtain.

Operator variability in measurement of meshes presents a very serious problem in comparison of selection factors (since average mesh size is one of the variables on which selection factor depends) and must be minimized if meaningful comparisons are to be made.

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12. COMPARATIVE EFFECTS OF GAUGE PRESSURE ON MESH SIZE MEASUREMENTS OF MANILA NETS.

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Abstract

Mesh measuring experiments have been carried out to determine the effects of various gauge pressures (6-13 lb, 2.7-5.9 kg) with the ICNAF and Westhoff (1959) gauges on mesh size measurements of single and double braided manila netting of different twine and mesh sizes. The gauges were carefully calibrated at each pressure used in the experiments, and mesh measuring was performed with very great care.

The relation between applied pressure and resultant mesh elongation was found, for both types of gauge, to follow a straight line trend over the range of pressures applied. Analyses of fitted regressions of mesh size on applied pressure have been used to effect gauge comparisons. These indicate that with careful use, and over the range of pressures tested, significant differences between average mesh measurement with each gauge are unlikely, in spite of the inherent difference in method of applying pressure in the two types of gauge. However, the Westhoff (1959) gauge was found to be superior to the ICNAF in its ability to produce a constant relationship between gauge pressure and resulting mesh elongation for a variety of different twine sizes (runnage, ply and braiding) of manila netting.

Introduction

At the 1961 annual meeting of the ICNAF Standing Committee on Research and Statistics, the Working Group on Gear Research and Selectivity recommended that experimental studies with the Westhoff gauge (1959 model) be extended to include an alalysis of the comparative effects of pressures between 7 and 12 pounds (3.2-5.4 kg) on mesh size measurements for various materials (ICNAF Redbook 1961). As it was the intention of the Working Group to examine the possibility of standardisation of ICNAF and ICES gauge pressures, it seemed desirable to include the ICNAF gauge in the comparison. Furthermore, as our previous experiments (Sandeman and May, 1961) had shown that when the ICNAF gauge was used by different operators at our laboratory a great deal of the variation found was due to incorrect use of the gauge, it was decided that an attempt should be made to use the ICNAF gauge precisely and with the utmost care during this experiment in an attempt to provide a comparison between the ICNAF gauge (used correctly) and the Westhoff (1959 model) gauge.

The experiment was thus designed with the hope that it would provide some useful data toward a better understanding of the following points:

(a) The effects of different pressures (6-13 lbs, 2.7-5.9 kg) with the Westhoff gauge on mesh measurement of manila nets of different runnage and mesh size,

(b) the effects of similar pressures in the same netting measured with the ICNAF gauge, and

(c) a comparison of the ICNAF gauge (used precisely) with the Westhoff gauge.

It is unfortunate that we were not able to include the Westhoff 1961 gauge (Westhoff, MS, 1961), which has been recommended by the Comparative Fishing Committee of ICES for adoption as the standard for scientific work in the ICES area.

The Experiment

General Considerations

Data have been presented by several authors (von Brandt, MS, 1955; Boerema, 1956; Bedford and Beverton, MS, 1956; Strzyzewski and Zaucha, MS, 1957 a and b) which show that, in general, when meshes are measured under different tensions, provided a minimum tension is applied and a maximum tension is not exceeded, mesh size is proportional to the tension applied. This proportionality was found to apply, within the general limits above, not only to tensions which were directly applied longitudinally to the mesh either by direct loading of a mesh by weights (Bedford and Beverton, MS, 1956) or by longitudinal tension applied by a caliper-type mesh gauge (Strzyzewski and Zaucha, MS, 1957b), but also to loads applied normally to the direction of measurement and translated to longitudinal tensions by means of a wedge (Boerema, 1956; von Brandt, MS, 1955). Thus for both the Westhoff and ICNAF gauges it might be expected, at least over a particular span of tensions, that straight line relationships between mesh size and pressure applied would be obtained, and that a regression analysis might well provide a satisfactory means of comparison of these two gauges at a series of different gauge pressures.

As the relationship between pressure applied and the resulting mesh measurement was likely to be different for different net materials, as well as the dimensions, twist, and braiding of twine used, it seemed advisable to limit the experiment to a single type of netting, e.g. manila. In an effort to obtain a high degree of precision from the gauges, all measurements with the one gauge, as well as the associated calibration operations, were made by the same operator who, in addition to taking the greatest care in obtaining as precise measurements as possible, also applied the same careful technique to all the meshes measured.

The general plan

A series of eight rows of thirty meshes each was chosen in the central portion of each section of netting to be tested. These rows were labelled and any broken or mended meshes were tied off and consequently not used in the measurements. In two of the sections of netting, where it was not possible to obtain 30 consecutive meshes in the one longitudinal row (the two sections of netting from the square of the otter trawl - see below) 16 rows of 15 meshes were labelled, and two adjacent rows used to provide the 30 meshes desired. A single person held the netting as the measurer preferred throughout the complete experiment and the recording of the mesh sizes was performed by the operator not measuring at the time.

The mesh measurements were carried out in two phases and the general plan of the experiment is described diagrammatically below. Phase I was completed on all sections of netting before the gauges were recalibrated for the start of phase II some days later.

Mesh measuring gauge experiment - General Plan

Row of mesh		a	b	c	d	e	f	g	h	
1st measurement	Gauge	W	W	W	W	W	W	W	W	
	Pressure	8	8	8	8	8	8	8	8	Phase I
2nd measurement	Gauge	W	I	W	I	W	I	W	I	
	Pressure	6	6	7	7	8*	8	9	9	
3rd measurement	Gauge	W	I	W	I	W	I	W	I	
	Pressure	13	13	12	12	11	11	10	10	Phase II

* See text.
W=Westhoff gauge I=ICNAF gauge Pressure=mean pressure applied in pounds.

It can be seen from this plan that each of the 8 rows of 30 meshes chosen in each net would be measured three times in all. The first measurement was made with the Westhoff gauge at the same pressure over all the rows in each net. This was done to provide a means of eliminating, in the analysis of the results, abnormally large between-row variation. In the second and third measurements similar pressures were applied with the two types of gauge to two adjacent rows, the pressure applied being increased by approximately one pound in each further pair of rows measured.

This plan allows that each mesh would be measured only three times and furthermore the total of the pressures applied during these three measurements (von Brandt and Bohl, MS, 1959; Sandeman and May, 1961) that, provided only a few measurements are made on each mesh and these under relatively low tensions, very little irreversible stretching of the twine or tightening of the knots occurs; consequently with only three measurements being made on each mesh it should be reasonable to assume that this effect was negligible during the experiment.

In actual fact the above condition of only three measurements being made on each mesh was not wholly attained, as in the course of measuring the 50/4 double braided netting the ICNAF gauge was dropped and broken. This necessitated repair and recalibration, as well as the repetition of some rows of measurements, and caused the rows in question to be measured four times. Also at the conclusion of the experiment an extra series of 4 rows of measurements at about 16 lbs (7.3 kg) pressure with the ICNAF gauge were made on each of the 50/4 single braided sections of netting.

During the second measurement, when the Westhoff gauge was used with a locking pressure of about 8 lbs (3.6 kg), the normal experimental procedure was not followed (marked * in the diagram of the general plan). In this row of measurements, the net was not held at waist height by another person, but the measurements were made with each section of netting spread out on the floor. This constituted a small experiment within the large experiment to provide a test of possible differences in measurements depending on whether the net was held or not held. The results of this test are reported below.

In making the measurements with both gauges care was taken to insert the gauges into the meshes at the open sides of the assymetrical knots, following the recommendation of Beverton and Bedford (MS, 1958). The time taken to measure each row of 30 meshes was recorded.

The netting used

The experimental procedure was carried out on each of the nine pieces of netting listed below. These net sections were portions of several No. 41 otter trawl nets which had been used for a varying number of tows in selectivity experiments on redfish and haddock. For the experiment here described they were all thoroughly wetted in fresh water for periods of 12 hours or greater before being measured.

Net Section	Twine Runnage (yds/lb)	Ply	Braiding	Nominal Mesh Size (inches)	Hours in use fishing (hours)
Top Lengthening piece	50	4	Single	4	16
	50	4	Single	4 1/2	17
	50	4	Single	5	16
Top Codend	50	4	Double	4	20 1/2
"	50	4	Double	4 1/2	20 1/2
"	50	4	Double	5	16
Square	100	3	Single	5	27
"	100	3	Single	5 1/2	16
Top Codend	75	4	Double	3	20

The mesh measuring gauges

Four Westhoff gauges were available for the experiment. These were all of the 1959 variety (Westhoff and Parrish, MS, 1959) with the locking mechanism operating in one direction only. These gauges were all cleaned and oiled carefully before being adjusted to the required pressures. When each of these gauges were used at the higher pressures (11-13 lbs) (5.0-5.9 kg) it was necessary to replace the tension spring with a heavier one.

A single ICNAF gauge of the standard pattern was used throughout the complete experiment. Three alternative blades (2"-4", 3" - 5" and 4"-6") were available and the most suitable blade was chosen for each size of mesh to be measured.

Calibration of the gauges

Westhoff gauge. The Westhoff gauges were first adjusted to lock at pressures approaching the whole numbers of lbs as determined by the experimental plan. Having done this, the mean pressure at which locking occurred was calculated from a series of 50 operations in a jig similar to that described by Parrish and Pope (MS, 1961), using a spring balance which could be read to the nearest 0.25 lbs (0.1 kg). Care was taken during this calibration procedure to simulate the actual measurement of meshes. This was not completely possible as the distance travelled by the jaws of the gauge to attain the locking pressure was considerably greater in the jig than it was in the measurement of meshes of a relatively non-elastic material. At the completion of a phase of the experiment the gauges were checked to see whether any major changes had taken place, the mean locking pressure being calculated from a further 50 operations in the jig.

ICNAF gauge. The ICNAF gauge was calibrated by a mark on the dynamometer being chosen such that when the handle was pressed to this mark the pressure normal to the direction of measurement would be similar to the longitudinal pressure exerted by the Westhoff gauge. The mean pressure of the ICNAF gauge was then determined by simulating the measurement of meshes in a fixed wooden mesh, attached below a pan-type spring balance, in such a manner that the operator could stand over the gauge as he would over a section of netting. A vertical force was applied to the handle of the gauge until the mark on the dynamometer was reached, and the maximum pressure applied to the dummy mesh was recorded. This was repeated 50 times to obtain the mean pressure applied.

In establishing the calibration procedure for the ICNAF gauge, several points were raised which indicate some of the cautions which must be observed in using this gauge in a manner likely to provide a high degree of precision.

(a) Because the vertical pressure applied is equal to the sum of the spring tension and the weight of the gauge, it was necessary to calibrate the gauge for each of the blades used. The difference in weights between the blades was of the order of 1/3 lb., and thus if calibrated with the small blade (2"-4"), the load applied by the gauge if the large blade (4"-6") were used without recalibrating would be about 0.65 lbs (0.29 kg) higher.

(b) It is important to keep the gauge perpendicular to the mesh and to apply pressure without grasping the handle of the gauge. If the handle of the gauge is grasped, it becomes very difficult to apply pressure without initiating a turning moment on the sliding cylinders of the dynamometer, causing an increase in friction between the moving and the fixed parts of this device. It was found best to rest the gauge in the mesh and apply pressure with the rounded end of the handle resting in the palm of the hand and the fingers not gripping the handle at all.

(c) It is necessary to oil the dynamometer frequently. It was apparent that differences in pressure applied of the order of about one pound (.5 kg) could easily arise through the dynamometer being not quite as well oiled on one occasion as on another. During the experiment the dynamometer was oiled before almost all the measurements of 30 meshes.

(d) To avoid the application of too much pressure it is necessary to push the blade into the mesh with a slow, even motion. It is difficult to maintain this when large numbers of meshes are to be measured, as it largely precludes the formation of a rhythm, and conversely, if a rhythm does become established, it is unlikely that a controlled pressure is being applied to all sizes of meshes. When a slow, even pressure is applied, the velocity of the gauge approaches a constant value; but usually when rapid measurements are made, the gauge no longer penetrates the mesh with constant velocity, but with acceleration, and greater velocities will be generated when the gauge travels further. This could result in the large meshes being measured with much greater pressures relative to the true mean mesh size, whereas the reduction in pressures due to small gauge movements and consequent small velocities while measuring small meshes, would not be likely to produce proportionately smaller mesh measurements. This would result in a bias towards obtaining larger mean mesh sizes.

The pressures used in the Experiment

In Table 1 are shown the intended pressures, as required by the experimental plan, and the actual mean pressures used with each gauge (the mean pressures obtained from 50 measurements of a dummy mesh) as well as the standard errors of these means. Two points are particularly worthy of comment concerning this table. It is quite striking how much lower are the standard errors of the ICNAF gauge relative to those of the Westhoff gauge. The standard errors may be regarded as representative of the relative accuracies of the pressure devices of the gauges. In the case of the Westhoff gauges they refer to the precision inherent in the tension barrel and locking device, whereas in the ICNAF gauge the reference is to the barrel of the dynamometer and the human error involved in applying pressure to a particular mark on the dynamometer. Thus it would seem that, provided human error is minimized and the pressure devices of these gauges are used under controlled conditions, the pressure device on the ICNAF gauge is capable of a greater degree of precision than was obtained with the 1959 model Westhoff gauges that were used.

The other point of note concerns the change in the locking pressure that apparently occurred in the Westhoff gauges during the measurements made throughout phase II of the experiment (with intended pressures of 10, 11, 12 and 13 lbs). Mean locking pressures of the Westhoff gauge were determined before and after the completion of each phase of the experiment. The ICNAF gauge, on the other hand, was recalibrated twice during each phase when measurements had been completed with one blade and a new blade was substituted. The changes in locking pressure over phase I of the experiment are not significant, the greatest change being recorded in gauge No. 16 which had measured over 2,400 meshes as opposed to the 270 measured by the other three gauges. In phase II, however, significant differences may be noted between the "before" and "after" mean locking pressures with three of the four gauges in spite of each having been used to measure only 270 meshes. It seems unlikely that the calibration technique is at fault as such excellent agreement was forthcoming from the "before" and "after" measurements of phase I. However, the changes in locking pressure that occurred may well have been due to the fact that the gauges were being used at pressures greater than that for which they were designed, as well as to the substitution, in order to obtain these pressures, of less compressible springs than the ones initially supplied with the gauges.

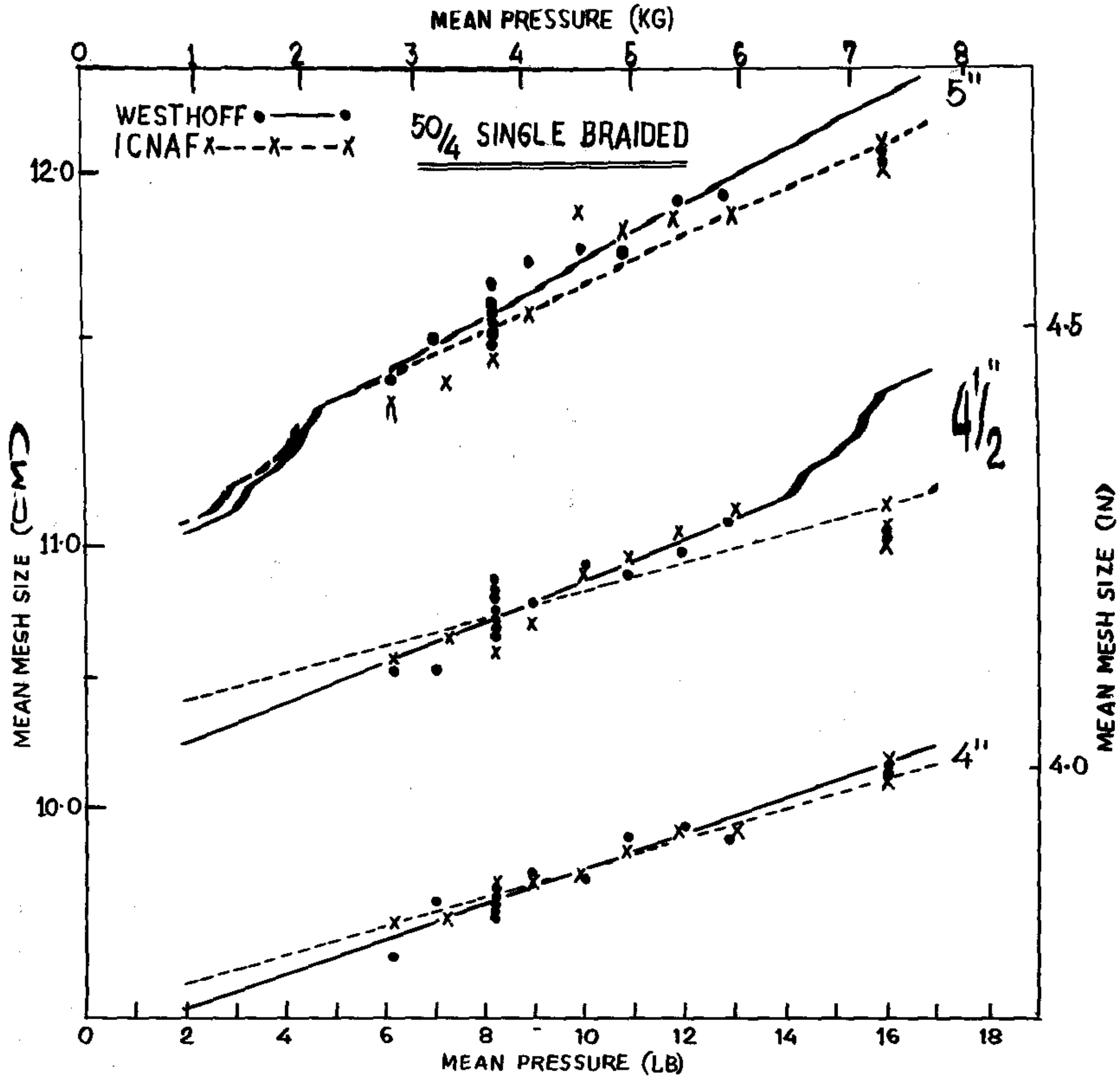

Fig. 1. Regressions of mean mesh size on mean pressure applied for the ICNAF and Westhoff (1959 model) gauges as used on sections of 50/4 single braided manila netting having nominal mesh sizes of 4", 4 1/2" and 5".

Results and Discussion

For each row of meshes measured, the mean mesh size has been calculated. For the rows measured by the Westhoff gauge these mean mesh sizes are in cm, but for the rows measured by the ICNAF gauge they were obtained in inches and have been converted to cm. The average mesh sizes have been plotted against the gauge pressures used in obtaining them in Figures 1 and 2 for the netting of 50/4 single and 50/4 double twine respectively, and in Figure 3 for the netting of 100/3 single and 75/4 double twine. With the lack of further knowledge on which of the two pressures obtained in calibrating the Westhoff gauges before and after the phase II measurements was correct, if either, the pressures obtained

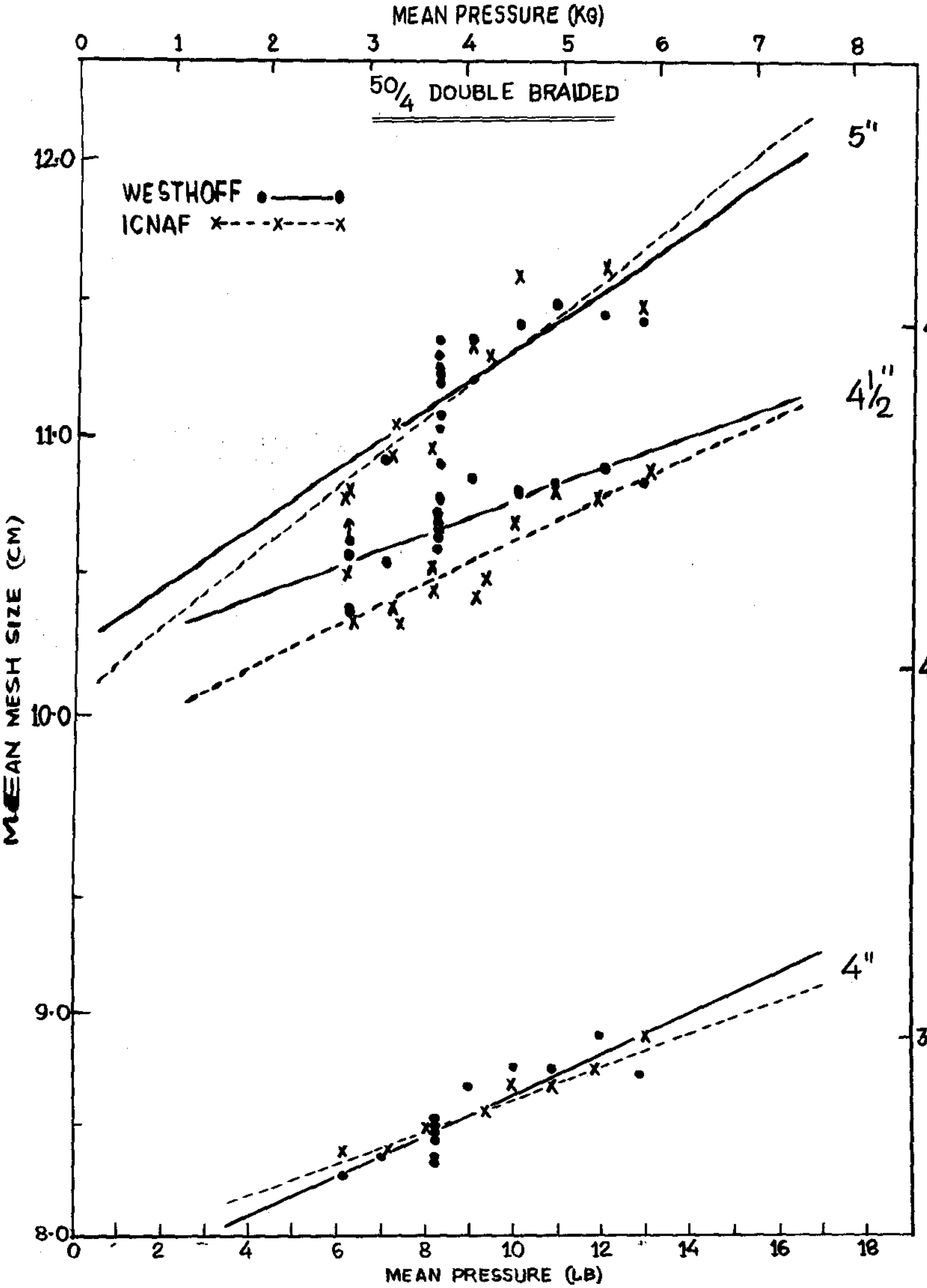

Fig. 2. Regressions of mean mesh size on mean pressure applied for the ICNAF and Westhoff (1959 model) gauges as used on sections of 50/4 double braided manila netting having nominal mesh sizes of 4", 4 1/2", and 5".

Regression lines have been calculated for average mesh size on average pressure applied for each type of gauge as used on the sections of netting, and these are shown in the figures. These regression lines provide estimates of the change in mesh size that resulted from given changes in pressure. Furthermore the comparison of the regression lines making up each pair provides a comparison between the two types of gauges as used on the same net. It is apparent from the overlap and scatter of the points, that in most of these comparisons and within the range of pressures studied, the differences between the mesh measurements obtained by the Westhoff and ICNAF gauges are rather small. A question already posed is whether or not the ICNAF gauge (used precisely) with the pressure applied perpendicular to the direction of measurement, provides different mesh measurements from those obtained by the Westhoff (1959) gauge used with the same pressure applied longitudinally and in the direction of measurement. If the regression lines for the two gauges are parallel, then a test of significance between the two regression means would provide a test as to whether or not differences were present between the gauges. However, if the regressions are not parallel, such a test becomes meaningless as the regression for each gauge will yield equal mesh size measurements at the position where they cross and greater and greater differences at pressures remote from the pressure at this position. Thus it is necessary to first test whether or not the slopes of the regression lines are different.

The regression constants together with analyses of covariance are summarized for each piece of netting in Table II. In computing these regressions all data have been used, including the first measurement during which all rows of the net were measured at a pressure of 8.18 lbs by the Westhoff gauge, and the extra measurements made by the ICNAF gauge at a pressure of 16.01 lbs on the three pieces of netting of 50/4 single braided twine.

It is apparent from Table II that a significant difference between the regression coefficients occurred in only one of the net sections examined, i.e. 75/4 double braided netting. With all the other pieces of netting the rate of change in mesh size with change in pressure can be considered the same with each gauge. Significant differences in elevation between the parallel pairs of regression lines, the slopes of which have already been shown not to be significantly different, occurred in only 3 of the 8 net sections. In one of these the difference could be regarded as slight (50/4 single 5" netting), whereas in the other two, where the differences could be regarded as very significant, the ICNAF gauge gave greater mesh measurements on the average than the Westhoff gauge for one (100/3 single 5 1/2" netting), and smaller measurements for the other (50/4 double 4 1/2" netting). With respect to the 50/4 single 5" netting, it may be noted that for the netting where a significant difference was found between the regression coefficients (75/4 double 3" netting) the regression lines lie very close together over the range of pressures at which it is customary to use the Westhoff gauge, indicating that at this range of pressures very little difference is likely to exist between the two types of gauges when used on this type of netting.

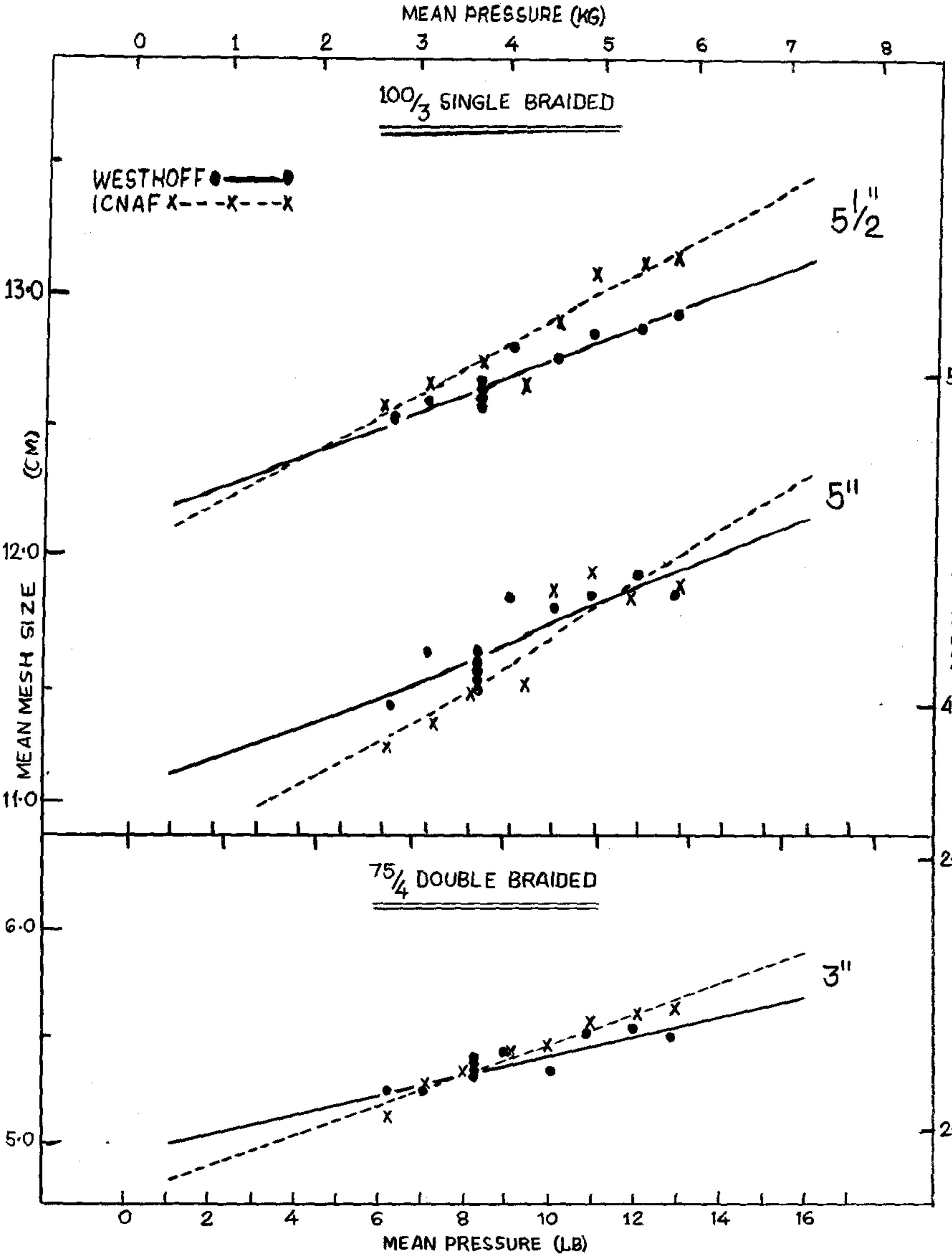

Fig. 3. Regressions of mean mesh size on mean pressure applied for the ICNAF and Westhoff (1959 model) gauges as used on sections of manila netting - 100/3 single braided with nominal mesh size of 5" ,and 5 1/2" and 75/4 double braided with nominal mesh size of 3".

As was mentioned earlier in the text, provision was made in the experiment to allow a test to be made between the Westhoff gauge operated at a given pressure (8.18 lbs) when the net was held by an assistant at about waist height, and the mesh measurement obtained when the same row of meshes was measured by the same gauge at the same pressure without holding and with the net lying flat on the floor. The results are summarized in Table III together with the appropriate "t" values. Although only one of the tests showed the means to be significantly different, the fact that the average mesh size was found to be lower when the netting was not held than when held in every comparison made but one, together with the fact that the differences were greatest (to 3.4 mm) in measurements of the heaviest double braided netting, indicates that some consideration should be given to this point when measuring heavy manila otter-trawl nets.

A conclusion derived from the results discussed so far is that, within the range of pressures of 6 to 13 lbs (2.7 to 5.9 kg), differences in mesh size obtained between the ICNAF gauge with the pressure applied normal to the direction of measurement and the Westhoff (1959) gauge where the pressure is directly applied longitudinally and in the direction of measurement are negligible. This is difficult to understand in the light of our previous experience with these gauges. Not only do our field measurements with the ICNAF gauge consistently yield average mesh sizes considerably greater than those obtained from the same section of netting measured with the Westhoff gauge (May and Hodder, MS, this meeting), but also the results of previous experiments have shown the same (Sandeman and May, 1961). This difference has been noted by many other workers and a discussion of this may be found in the document by May and Hodder (MS, this meeting).

With regard to our own experience, there is little doubt that this anomalous result is due, in large part, to the fact that at no time before have we really attempted to use the ICNAF gauge with precision. Very little attention has been normally paid by our technicians to proper calibration and, even if correctly calibrated, very little attention to attempting to apply the correct pressure. Some idea of the relative precision obtained (assuming that precision is related to the time taken to perform the measurements under standard laboratory conditions) can be derived from the mean time taken to measure a mesh with the ICNAF gauge by several operators. These mean times, as obtained by different operators when instructed to measure the meshes in the manner to which they were accustomed (from Experiment I, Sandeman and May, 1961), are shown in Table IV together with the mean time taken by the junior author using the Westhoff gauge and the senior author using the ICNAF gauge in the present experiment. Although some of these different operators measured the nets on different occasions, the measurements all took place in the same room of the laboratory and over sections of netting of 50/4 double braided manila twine having a nominal mesh size of 5". The fact that the operator of the ICNAF gauge in this experiment took well over twice as long to measure a mesh must indicate considerably greater care in measurement and presumably also a greater degree of precision. As the method of operation of the ICNAF gauge is such that increase in speed of measurement must always result in an increase in pressure, the net result is a bias toward higher mesh measurements under any but extremely carefully controlled conditions.

Concerning the relationship between the elongation and load, the experiment has shown that the ICNAF gauge (used carefully) and the Westhoff (1959) gauge are rather similar and that not only is the mesh size proportional to the pressure applied within the range of pressures 6 to 13 lbs, but also the change in mesh size resulting from an equal increase in pressure is similar in most cases.

The question may now be raised whether or not there is any difference between slopes of the regression lines obtained by the one gauge measuring all the different sections of netting. The results of this comparison are shown for each gauge in Table V. It is apparent that the slopes of the regression lines of both gauges show some differences, but the difference obtained for the Westhoff gauge is considerably less than that obtained for the ICNAF gauge.

The end results of the above tests and those to follow are summarized in the table below, in the hope that this brief summary of the results will clarify the line of argument.

Significance tests between regression coefficients

Test	Westhoff Gauge	ICNAF Gauge	
All netting	*	**	From Table V
50/4 single braided netting	None	None	
50/4 double braided netting	None	*	From Table VI
100/3 single braided netting	None	None	
All single braided netting	None	*	From Table VII
All double braided netting	*	*	
All netting except 75/4 double braided netting	None		From Table VIII

None = No significant difference detected between regression coefficients examined in test (slopes of regression lines may be considered parallel).

* = Significant difference noted (5% to 1% level).

** = Very significant difference (1% or less).

The analysis has been extended in Tables VI and VII in an attempt to determine in which netting materials the cause of these differences might be found. In Table VI the regression coefficients are compared for each net material (twine size and braiding) and in Table VII the comparison is made between the double and single braided materials irrespective of twine size. It is evident from Table VI that within any one type of netting the Westhoff gauge has provided statistically parallel regressions, and mesh measurements obtained by this gauge may be considered proportional to the pressure applied, irrespective of the mesh size of each of the three types of netting material which this experiment allowed. (Strictly, this applies only over the range of mesh measurements obtained for each material in the experiment). This cannot wholly be said, however, for the ICNAF gauge, since with this gauge a significant difference appeared in the results from the 50/4 double braided netting.

Considering the braiding, irrespective of twine size, i.e. when the regression coefficients obtained with the Westhoff gauge are compared for single and double braided twine separately and the same done for the ICNAF gauge (Table VII), no significant difference is detected between the regression coefficients obtained by the Westhoff gauge in measuring the single braided netting of two different twine sizes (50/4 and 100/3), but a difference is detectable in the regression coefficients obtained by this gauge in measuring the double braided twines (50/4 and 75/4). In view of the fact that no significant differences were detectable in the Westhoff gauge regressions from the 50/4 double braided twine, it would appear that the difference in Westhoff gauge regression coefficients noted in the overall comparisons of all nets (Table V) was due to the inclusion of the results from the 75/4 double braided twine, and indeed when this one section of twine is excluded from the overall comparison no significant difference is detectable between the regression coefficients obtained by this gauge on the three dissimilar pieces of manila netting - 50/4 single, 50/4 double and 100/3 single.

It would appear from these results that, from the point of view of constancy of the relationship between load applied to the meshes and the resulting mesh elongation, the Westhoff gauge is far superior to the ICNAF. This is in accordance with the results of experiments performed by Bedford and Beverton (MS, 1956) who examined the load-elongation characteristics of a wedge-type gauge as compared with elongation due to a direct longitudinal stress. von Brandt (1955) found that with a wedge-type gauge the mesh size per unit increase in pressure could change according to the size of twine used, and our results indicate a similar situation.

As a caution, perhaps attention should be drawn to the fact that in a simple statistical comparison of the type we have used, the significance of any difference is related to the spread in the data, and in saying that no significant difference can be detected between two or more estimates we are merely implying that the spread in the data is such that the estimates can be considered as having been drawn from the same population. In the case of these results we could have a particular gauge with a very high degree of precision, and showing an almost perfect relationship between mesh size and elongation, appearing as statistically different in such tests, while a grossly inaccurate gauge with a high degree of variation might provide non-significant differences because of the large spread in the basic data. It can be seen in Table II that the correlation coefficients of the ICNAF and Westhoff gauges are rather similar although, in general, less variation is apparent in the basic data provided by the ICNAF gauge. The weighted mean of the slopes of all the regressions obtained in this experiment by the Westhoff gauge is .0740±.0044 cm/lb and this may be regarded as a best estimate of the elongation per lb pressure applied for this gauge.

If mesh measurements are to be made with a particular gauge by different operators, at different pressures, it is obviously advantageous to employ a gauge which will provide a relatively constant relationship between applied pressure and resultant elongation of meshes, at least within nets made of the same material, irrespective of the size of twine and braiding used. However, if all operators used the gauge at the one pressure, and if all mesh measurements were to be made using one type of gauge with an accurate pressure controlling device, a constant relationship between pressure and elongation would not be necessary (for straight mesh measuring purposes). This seems to us to be the proper solution to the problem of obtaining consistent results when measuring meshes. With the advent of the Westhoff (1961) gauge and the apparent low between-operator differences that are obtained by it (Roessingh, MS, 1961; Parrish and Pope, MS, 1961; Bohl and Nomura, MS, 1961), together with the acceptance of it as the standard for scientific work in the ICES area, this seems the proper gauge to use as the standard for scientific work in the ICNAF area also. We do, however, consider that in the interest of obtaining the best and most consistent results in the hands of different persons, in addition to specifying the pressure at which the gauge should be used, a satisfactory procedure should also be standardized by which the mean locking pressure of the gauge may be checked and adjusted to within rather narrow limits.

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Table I. Mean gauge pressures and standard errors of these pressures as determined from the measurement of fifty dummy meshes.

Intended Pressure (lbs)	(Kg)	Westhoff gauge reference numbers	Westhoff Before Phase (lbs)	Westhoff After Phase (lbs)	ICNAF Small Blade (lbs)	ICNAF Medium Blade (lbs)	ICNAF Large Blade (lbs)
6	2.7	5	6.15 ± .05	6.17±.06	6.14±.02	6.09±.03	5.96±.03
7	3.2	7	6.98 ±.09	6.91±.10	7.05±.03	7.15±.04	6.93±.04
8	3.6	16	8.18 ±.07	8.00±.08	7.96±.03	8.03±.05	8.25±.04
9	4.1	3	8.94 ±.06	8.95±.05	8.95±.03	9.32±.05	9.25±.04
10	4.5	16	10.02± .06	10.79±.10	9.92±.02	9.95±.02	10.02±.02
11	5.0	3*	10.83±.06	11.00±.09	10.91±.03	10.86±.02	10.84±.02
12	5.4	5*	11.96 ±.05	12.29±.06	12.06±.02	11.83±.02	12.01±.02
13	5.9	7*	12.82 ±.09	12.36±.06	12.91±.03	12.99±.02	12.80±.02
16	7.3					16.01±.02	

* Gauges fitted with a special spring to allow these pressures to be attained.

Table III. Summary of data and significance tests between mean mesh sizes obtained by the Westhoff gauge operated on the same row of meshes and at the same pressure with the net being held at waist level and not being held at all.

Net		Mean (holding) (cm)	Mean (not holding) (cm)	Diff. (cm)	t
50/4 Single	4"	9.617	9.587	-.030	.337
	4 1/2"	10.710	10.653	-.057	.679
	5"	11.557	11.533	-.024	.242
50/4 Double	4"	8.500	8.160	-.340	2.656
	4 1/2"	10.633	10.483	-.150	1.071
	5"	11.353	11.143	-.210	1.040
100/3 Single	5"	11.637	11.630	-.007	.099
	5 1/2"	12.620	12.653	+.033	.347
75/4 Double	3"	5.403	5.343	-.060	.522

at df = 60

P = .50	.10	.05	.02	.01	
t = .679	1.671	2.000	2.390	2.660	
		←*→	←**→	←***→	

Table II - See next page.

Table II. Summary of Regression Constants and Analysis of Covariance

Net	Source of Variation	Corr. coeff.	Regress. coeff.	Inter-cept	Degree of freedom	Sum of Squares	Mean Square	F	F at 5%	F at 1%	Significance of difference
50/4 single 4"	Westhoff	.9216	.0686	9.075	13	.0375					
	ICNAF	.9947	.0585	9.180	10	.0055					
	Total				25	.0470					
	Common				24	.0466	.00194				
	Combined within gauge				23	.0430	.00187				
	Between regress. coeff.				1	.0036	.0036	1.93	4.28	7.88	None
	Between means				1	.0004	.0004	0.21	-	-	None
50/4 single 4 1/2"	Westhoff	.8896	.0784	10.088	13	.0731					
	ICNAF	.8850	.0512	10.303	10	.1092					
	Total				25	.2184					
	Common				24	.2079	.00866				
	Combined within gauge				23	.1823	.00793				
	Between regress. coeff.				1	.0256	.0256	3.23	4.28	7.88	None
	Between means				1	.0105	.0105	1.21	4.26	7.82	None

Table II. Cont'd. Summary of Regression Constants and Analysis of Covariance

Net	Source of Variation	Corr. coeff.	Regress. coeff.	Inter-cept	Degree of freedom	Sum of Squares	Mean Square	F	F at 5%	F at 1%	Significance of difference
50/4 single 5"	Westhoff	.9458	.0838	10.881	13	.0373					
	ICNAF	.9425	.0712	10.931	10	.0960					
	Total				25	.1657					
	Common				24	.1388	.00578				
	Combined within gauge				23	.1333	.00580				
	Between regress. coeff.				1	.0055	.0055	0.95	-	-	None
	Between means				1	.0269	.0269	4.65	4.26	7.82	*
50/4 double 4"	Westhoff	.8762	.0895	7.740	13	.1091					
	ICNAF	.9810	.0740	7.893	6	.0082					
	Total				21	.1229					
	Common				20	.1223	.00612				
	Combined within gauge				19	.1173	.00617				
	Between regress. coeff.				1	.0050	.0050	0.81	--	--	None
	Between means				1	.0006	.0006	0.09	-	-	None

Table II. Continued. Summary of Regression Constants and Analysis of Covariance

Net	Source of Variation	Corr. coeff.	Regress. coeff.	Inter-cept	Degree of Freedom	Sum of Squares	Mean Square	F	F at 5%	F at 1%	Significance of difference
50/4 double 4 1/2"	Westhoff	.8032	.0594	10.162	13	.0877					
	ICNAF	.8781	.0764	9.850	10	.0905					
	Total				25	.3579					
	Common				24	.1852	.00772				
	Combined within gauge				23	.1782	.00775				
	Between regress. coeff.				1	.0070	.0070	0.90	-	-	None
	Between means				1	.1727	.1727	22.37	4.26	7.82	*
50/4 double 5"	Westhoff	.7664	.1078	10.237	13	.3680					
	ICNAF	.9148	.1287	10.046	10	.1701					
	Total				25	.5489					
	Common				24	.5487	.02286				
	Combined within gauge				23	.5381	.02340				
	Between regress. coeff.				1	.0106	.0106	0.45	-	--	None
	Between means				1	.0002	.0002	0.009	-	--	None

Table II. Cont'd. Summary of Regression Constants and Analysis of Covariance

Net	Source of Variation	Corr. coeff.	Regress. coeff.	Inter-cept	Degree of freedom	Sum of Squares	Mean Square	F	F at 5%	F at 1%	Significance of difference
100/3 single 5"	Westhoff	.8515	.0696	11.024	13	.0805					
	ICNAF	.9105	.1023	10.656	6	.0835					
	Total				21	.2208					
	Common				20	.1877	.00939				
	Combined within gauge				19	.1640	.00863				
	Between regress. coeff.				1	.0237	.0237	2.75	4.38	8.18	None
	Between means				1	.0331	.0331	3.53	4.35	8.10	None
100/3 single 5 1/2"	Westhoff	.9136	.0631	12.113	13	.0356					
	ICNAF	.9332	.0910	11.982	6	.0491					
	Total				21	.1825					
	Common				20	.1012	.00506				
	Combined within gauge				19	.0847	.00446				
	Between regress. coeff.				1	.0165	.0165	3.70	4.38	8.18	None
	Between means				1	.0813	.0813	16.07	4.35	8.10	**

Table II. Cont'd. Summary of Regression Constants and Analysis of Covariance

Net	Source of Variation	Corr. coeff.	Regress. coeff.	Inter-cept	Degree of freedom	Sum of Squares	Mean Square	F	F at 5%	F at 1%	Significance of difference
75/4 double 3"	Westhoff	.8800	.0465	4.962	13	.0283					
	ICNAF	.9753	.0721	4.754	6	.0107					
	Total				21	.0571					
	Common				20	.0530	.00265				
	Combined within gauge				19	.0390	.00205				
	Between regress. coeff.				1	.0140	.0140	6.83	4.38	8.18	*
	Between means				1	.0041	.0041	1.53	4.35	8.10	None

The regression coefficients are expressed as cm/lb

Intercept values are in cm

Calculated "F" values less than 1.0 show obvious non-significance and no F values from tables are shown (See Snedecor, 1956, p. 398).

Table IV. Mean time taken by different operators, under laboratory conditions, to measure a single mesh of a 50/4 double braided manila net with a nominal mesh size of 5".

Operator	Gauge	Mean time per mesh (secs)	No. of meshes on which mean is based
A	ICNAF	3.10	600
B	ICNAF	3.59	400
C	ICNAF	3.03	550
D	ICNAF	3.53	450
E	ICNAF	2.91	550
F	ICNAF	8.71	360
G	Westhoff	5.06	480

Operator F. Sandeman - this experiment taking extreme care. ICNAF gauge.
G. May - this experiment taking normal care. Westhoff gauge.

Significance tests between regression coefficients. All netting irrespective of mesh size, twine size and braiding.

Westhoff gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Squares
Common regression	125	.9763	
Combined within nets	117	.8571	.00733
Between regression coefficients	8	.1192	.01490

F = 2.03 (F ≃ 2.01, at 5%, 2.65 at 1%) *

ICNAF gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Squares
Common regression	82	.9363	
Combined within nets	74	.6228	.00842
Between regression coefficients	8	.3135	.03919

F = 4.65 (F ≃ 2.07, at 5%, 2.77 at 1%) **

Table VI. Significance tests between regression coefficients. Each type of netting separate.

50/4 Single braided — Westhoff gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	41	.1533	
Combined within nets	39	.1479	.00379
Between regression coefficients	2	.0054	.0027

F < 1.0. No significant difference.

50/4 Single braided — ICNAF gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	32	.2415	
Combined within nets	30	.2107	.00702
Between regression coefficients	2	.0308	.0154

F = 2.19 (F = 3.32 at 5%, 5.39 at 1%). No significant difference

50/4 Double braided — Westhoff gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	41	.6185	
Combined within nets	39	.5648	.01448
Between regression coefficients	2	.0537	.02685

F = 1.85 (F = 3.23 at 5%, 5.18 at 1%). No significant difference.

Table VI. cont'd. Significance tests between regression coefficients. Each type of netting separate.

50/4 Double braided (continued) ICNAF gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	28	.3638	
Combined within nets	26	.2688	.01034
Between regression coefficients	2	.0950	.04750

F = 4.59 (F = 3.37 at 5%, 5.53 at 1%) *

199/3 Single braided Westhoff gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	27	.1167	
Combined within nets	26	.1161	.00447
Between regression coefficients	1	.0006	.0006

F < 1.0. No significant difference

100/3 Single braided ICNAF gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	13	.1351	
Combined within nets	12	.1326	.01105
Between regression coefficients	1	.0025	.0025

F < 1.0. No significant difference

Table VII. Significance tests between regression coefficients

All single braided netting

Westhoff gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	69	.2767	
Combined within nets	65	.2640	.00406
Between regression coefficients	4	.0127	.00318

$F < 1.0$. No significant difference.

ICNAF gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	46	.4651	
Combined within nets	42	.3433	.00817
Between regression coefficients	4	.1218	.03045

F = 3.73 (F = 2.59 at 5%, 3.80 at 1%). *

All double braided netting

Westhoff gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	55	.6985	
Combined within nets	52	.5931	.01141
Between regression coefficients	3	.1054	.03513

F = 3.08 ($F \simeq 2.79$ at 5%, 4.20 at 1%). *

ICNAF gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	35	.3909	
Combined within nets	32	.2795	.00873
Between regression coefficients	3	.1114	.03713

F = 4.25 (F = 2.90 at 5%, 4.46 at 1%) *

Table VIII. Significance tests between regression coefficients. All netting irrespective of mesh size, twine size and braiding, but with the 75/4 double braided netting excluded.

Westhoff gauge

Source of Variation	Errors of Estimate		
	Degrees of freedom	Sum of Squares	Mean Square
Common regression	111	.9096	
Combined within nets	104	.8288	.00797
Between regression coefficients	7	.0808	.01154

F = 1.45 (F≃2.10 at 5%, 2.82 at 1%). No significant difference.

13. COLLABORATION BETWEEN FAO AND ICNAF 1960/61

FAO FISHERIES DIVISION:

The following notes report action by FAO Fisheries Division in response to recommendations made in the Report of the 11th Meeting of ICNAF and other aspects of the current work of the Division of interest to the Commission.

1. Follow-up of Joint Scientific Meeting of ICNAF, ICES and FAO Lisbon, 1957.

The Chairman of the Standing Committee on Research and Statistics has been informed by letter of the situation regarding the publication of contributed papers.

2. Methodological Manuals

- Sampling Manual. Mr. G. Gulland expects to finish the draft in July this year. The Manual will be published in time for use at the Training Course on Dynamics of Populations to be held in Lowestoft (February 1963);

- Manual on Gear Selectivity. Mr. Pope (Aberdeen) has completed a draft based on the report of the ICES Selectivity Working Group, now in press. This draft has been revised by Mr. E. Cadima, who has been working for two months as FAO Consultant. Mr. Cadima has also tabulated the selectivity data for areas other than the North Atlantic, using the ICES standard pattern.
  FAO has taken steps to bring to the attention of countries outside the North Atlantic area, the decisions of ICES concerning a standard mesh gauge, and to encourage adoption of the ICES standard gauge elsewhere.

- Manual on Fish Tagging. This will be based on the proceedings of the ICNAF Meeting on this subject held in Woods Hole last year. FAO is also beginning, in co-operation with IAEA, experiments on the tagging of Mediterranean species, including hake, underwater.

- Manual of Methods in Fisheries Biology. Second edition (revised) English version is being printed; French and Spanish translations are nearly finished and will be printed in 1963.

3. Other Publications

The Proceedings of the World Scientific Meeting on the Biology of Sardines and Related Species. Volume I-Report; Volume II Species Synopses, Subject Synopses; Volume II Stock and Area Papers, have just been published. The Synopsis of Biological Data on Cod (Gadus morhua L.), published as FAO Fisheries Biology Synopsis No. 21 has been issued and circulated to interested organizations and specialists. A document on the Preparation of Synopses of the Biology of Species of Living Aquatic Organisms, prepared by Mr. H. Rosa, Jr. has also been published. It is an introduction to the series and discusses its purpose, scope, pattern and future development. FAO would welcome further comments from ICNAF on the eventual revision of the cod synopsis, and suggestions as to the desirability of preparing synopses for other species of particular interest to ICNAF.

4. Co-ordination of Fisheries Statistics

Two documents (Documents Relating to the Design and Use of Form STANA IE and Form STANA 2 for Reporting Fishery Statistics covering the ICES Statistical Area; Simplification of National Reporting of Fishery Statistics in the North Atlantic Region to ICNAF, ICES and FAO) have been prepared by Mr. Gertenbach as the basis for work of the ICNAF Standing Committee on Research and Statistics, at 1962 Meeting on this subject. Paragraphs 1.8, 1.9, 1.10, 1.11, 1.12, and 1.13 contain information on the recent developments of these matters.

5. Preparations for the World Scientific Meeting on the Biology of Tunas and Related Species being held at La Jolla, California, from 2 to 14 July, 1962, are well advanced and about 70 working papers have been received. A first pre-meeting distribution of 20 papers took place at the beginning of the month. Participation from about 30 countries is expected as well as large attendance from the host country. FAO is now considering the subject of a further world meeting on a commercially important species group, which might be held in 1964. Groups which have been suggested for priority are crustaceans (especially shrimps and prawns), hakes and also anchovies. ICNAF R and S Committee might wish to express a view on this matter.

6. Mesh Assessments

The Fisheries Division has again been pleased to co-operate by participation on one of its staff in the ICNAF Working Group. In addition arrangements were made for Mr. Cadima, a member of the group, to continue work on some of its problems, as FAO Consultant.

7. Bibliographies and Documentation

The Current Bibliography for Aquatic Sciences and Fisheries continues to be compiled with the collaboration and assistance of ICES and several national laboratories. Volumes 3 and 4 and the first four parts of volume 5 of the printed version have now been published and copies supplied to ICNAF Secretariat for use in making the ICNAF list. Arrangements have now been made to supply ICNAF with manuscript cards so that its list will not be affected by delays in publication.

The "World List of Periodicals for Aquatic Sciences and Fisheries" is now being printed. A list of names of marine and freshwater genera encountered in the taxonomic indexing of the Current Bibliography has now been published. Preparations are being made for publishing a news service on fisheries research programs and activities etc. as a supplement to the Current Bibliography during this year.

8. Biogeography of Marine Organisms and World Fisheries Atlas

The first fascicule of this Atlas is now published, and it relates to the ICNAF area. FAO has asked the publishers to supply the Research and Statistics Committee with copies of this document. The first revised parts of the North Sea Synopsis, (which is now the joint responsibility of a FAO and an ICES Working Group), has been completed and submitted for publication. It was prepared by a WMO Consultant and describes the Climatology and Meteorological characteristics of the area.

9. Vessel Characteristics Related to Fishing Power

A progress report has been prepared by Mr. Traung, of FAO Fishing Boat Section, and submitted as a document to this meeting.

10.

In recent years oceanographic and fisheries researches have shown an important expansion at national and international levels. In relation to this development, efforts have been made to adapt the existing international organisations to meet the increasing need for co-ordination and co-operation in this field and to set up new bodies where necessary. At the 10th ICNAF Meeting these matters were analyzed and a recommendation approved (see Redbook, 1961, p. 15). Some years ago, FAO recognized that it would be necessary to deal more effectively with these matters as they concerned its program by constitution of an advisory body. Bearing in mind this need, and also considering the ICNAF recommendation an Advisory Committee on Marine Resources Research has been established by the Director-

General on the authorization of the Eleventh FAO Conference. ICNAF was informed of these decisions early in 1962. The first session of the Committee is expected to take place during the autumn of 1962. ACOMRR is to be composed of not more than fifteen fisheries scientists and experts who will be appointed for a one-year period and be eligible for reappointment. Regional and subject representation will be taken into consideration, but members are being selected on the basis of their expert knowledge and not as representatives of Governments. Its purpose is to study and report to the Director-General on the formulation and execution of the programs of FAO concerned with research on marine fisheries resources, and the dissemination, interpretation and application of the results of such research, special attention being paid to the fisheries aspects of oceanographic research. Candidates for membership are presently under consideration, and ICNAF has been consulted in this connection.

The Intergovernmental Oceanographic Commission under UNESCO has been informed of these actions, of the 1961 ICNAF resolution that such a committee might serve a useful function in advising IOG of matters pertaining to fisheries aspects of oceanography, and of the FAO Conference concurrence with this view. Co-ordination of the activities of the UN Agencies concerned with marine sciences at the Secretariat level is being achieved through the Sub-committee on Oceanography under the Economic and Social Council of the U.N.

14. LIST OF PAPERS PERTINENT TO ICNAF

compiled in the Secretariat. 1)

I. HYDROGRAPHY

Bumpus, D. F. 1961. Drift bottle records for the Gulf of Maine, Georges Bank and Bay of Fundy, 1956-58. U. S. Fish and Wildlife Serv., Bur. Comm. Fish., Spec. Sci. Rept. Fish. No. 378, 127 pp.

Hachey, H. B. 1961. Oceanography in Canada 1957-60. Fish. Res. Bd. Canada, Studies 1960, No. 590, 19 pp.

Nutt, D. C., L. K. Coachman and P. F. Scholander, 1961. Dissolved nitrogen in West Greenland waters. Jour. Mar. Res. New Haven,.Conn. 19(1): 6-11.

Rodewald, M. Die Windigkeit des Nordatlantik hat zugenommen (Stronger winds in the North Atlantic). - Der Wetterlotse, 13, No. 174/75: 149-152, 1961.

Unsteinn Stefansson, Baldur Lindal, Johann Jakobsson and Isleifur Jónsson: The Salinity at the Shores of Southwest Iceland, Rit. Fiskid. II, no. 9, 1961.

II. PLANKTON

Miller, D. 1961. A modification of the small Hardy Plankton Sampler for simultaneous high-speed plankton hauls. Bull. Mar. Ecol. 5(45): 165-172.

III. FISHES

A. Cod-Group

Clark, J. R. and F. A. Dryer. 1961. New England haddock fishery biostatistics -1956 U. S. Fish and Wildlife Ser., Bur. Comm. Fish. Spec. Sci. Rept. - Fish. No. 375, 89 pp.

Conover, J. T., R. L. Fritz, and M. Vieira. 1961. A morphometric study of silver hake. U. S. Fish and Wildlife Ser., Bur Comm. Fish., Spec. Sci. Rept. - Fish. No. 368, 13 pp.

Fritz, R. L. 1961. Size distribution by depth of the longfin hake, *Phycis chesteri*. Copeia 1961 (2): 229-230.

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Meyer, A. Erste Ergebnisse der deutschen Kabeljau-Markierungen bei Grönland (First Results of the German Cod-Tagging off Greenland). - Hansa, 98 (20): 2170-2172, 1961.

Sherman, K., and J. P. Wise. 1961. Incidence of the cod parasite *Lernaeocera branchialis* (L.) in the New England Area, and its possible use as an indicator of cod populations. Limnology and Oceanography 6(1): 61-67.

B. Flat Fishes

Colton, J. B., Jr. 1961. The distribution of eyed flounder and lantern-fish larvae in the Georges Bank area. Copeia 1961 (3): 274-279.

Jensen, A. C., and J. P. Wise. 1961. Movement of tagged halibut off New England. - II. Trans. Am. Fish. Soc. 90 (4): 489-490.

Saila, Saul B. 1961. A study of winter flounder movements. Limnology and Oceanography 6 (3): 292-298.

C. Redfish

Sindermann, C. J. 1961. Serological studies of Atlantic redfish. U. S. Fish and Wild. Ser., Bur. Comm. Fish., Fish. Bull. 191, Vol. 61: 347-354.

D. Others

Boyar, H. C. 1961. Swimming speed of immature Atlantic herring with reference to the Passamaquoddy tidal project. Trans. Am. Fish. Soc. 90(1): 21-26.

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Jensen, A. C. 1961. Recaptures of tagged spiny dogfish, *Squalus acanthias*. Copeia 1961 (2): 228-229.

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McKenzie R. A. and S. N. Tibbo. 1961. Herring movements in the Bay of Fundy and Gulf of Maine, 1957 and 1958. J. Fish. Res. Bd. Canada, 18 (2): 221-252.

Olsen, Steinar. Contribution to the biology of the herring (*Clupea harengus* L.) in Newfoundland waters. Journal of the Fish. Res. Bd. of Can., 18, No. 1, pp. 31-46, 1961.

Sindermann, Carl J., and D. F. Mairs. 1961. A blood group system for spiny dogfish *Squalus acanthias* L. Biol. Bull. 120 (3): 401-410.

Smith, K. A. 1961. Air-Curtain fishing for Maine sardines. U. S. Fish and Wildl. Ser., Bur. Comm. Fish., Comm. Fish. Review 23 (3): 1-14.

IV. SHELLFISH

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Merrill, A. S. 1961. Shell morphology in the larval and postlarval stages of the sea scallop. *Placopecten magellanicus* (Gmelin). Bull. Mus. Comparative Zool. 125 (1): 20 pp.

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Squires, H. J. Shrimp survey in the Newfoundland fishing area, 1957 and 1958. Fish. Res. Bd. of Can., Bull. No. 129, pp 1-29, 1961.

V. OTHER MARINE ORGANISMS

Krefft, G. Erhaltung der Klappmützen - und Sattelrobben-Bestande im Nordwestatlantik (Conservation of the hood and harp seal stocks in the Northwest-Atlantic). Inform. f.d. Fischwirtsch. 8 (4): 95, 1961.

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VI. FISHERIES AND FISHING INDUSTRY

Boulanger, J. M. 1961. La Pêche à la palangre. Act. Mar., 5, No. 1, pp.9-13.

Lundbeck, J. Biologisch-statistischer Bericht über die deutsche Hochseefischerei im Jahre 1960 (Biological-Statistical Report on the German Deep-Sea Fishery in 1960).-Jahresb. über die Deutsche Fischwirtschaft 1960/61: 116-144, Berlin, 1961.

Meyer, A. Die deutsche Salzfischproduktion 1960 (The German Production of Salt Fish in 1960). - Jahresh. d. deutshcen Fischwirtschaft 1961.

VII. GEAR

Krefft, G. Regulierung der Maschenweiten fur Schlepp-und Zugnetze im ICNAF-Gebiet (Mesh-regulations for trawl and seine nets inside the ICNAF Area).-Inform f.d. Fischwirtsch. 8 (4): 101-102, 1961.

VIII. MISCELLANEOUS

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