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SELECTED PAPERS
FROM THE
1972 ANNUAL MEETING

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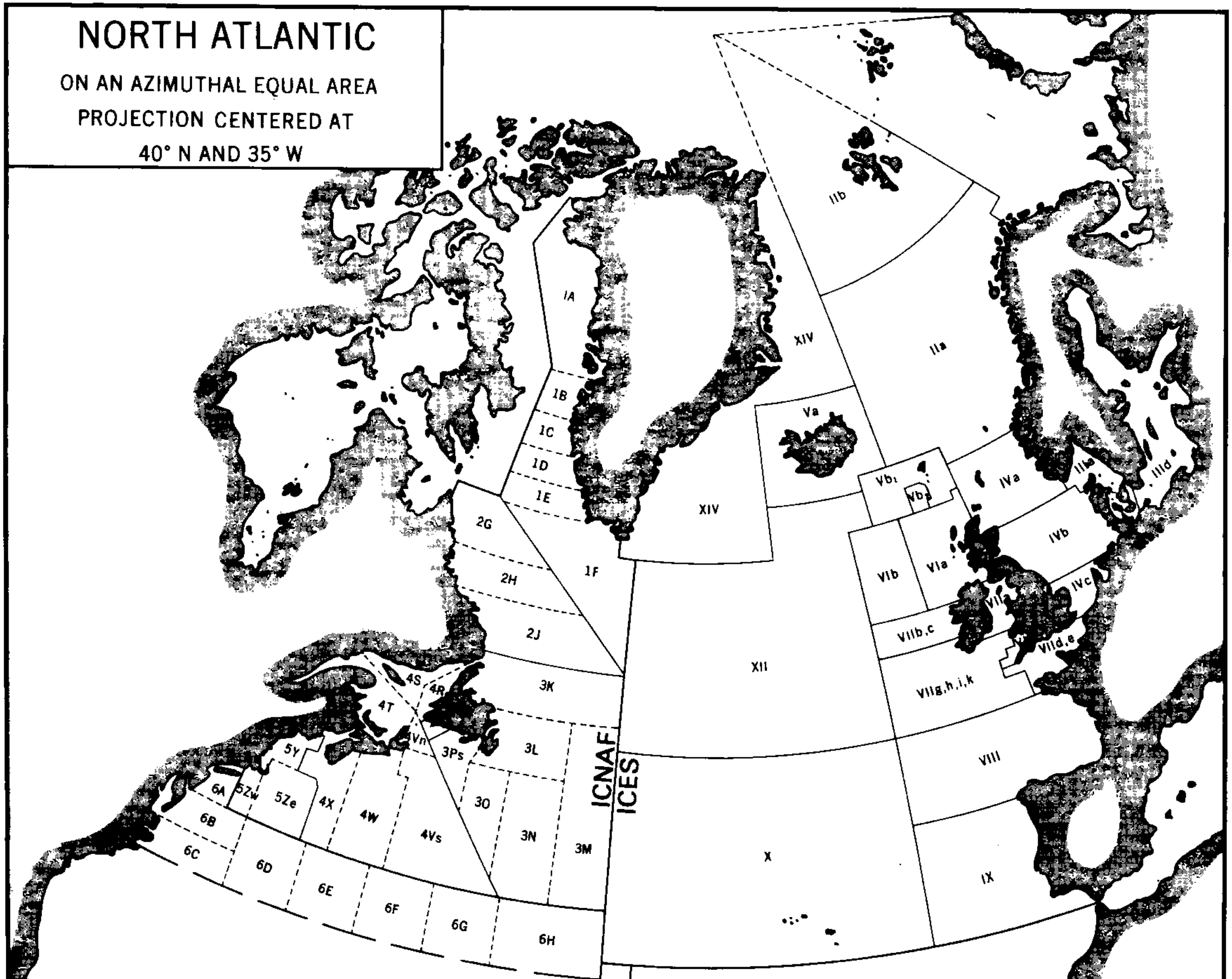
NOTE

REDBOOK 1972 is in three parts: PART I contains Proceedings of the Standing Committee on Research and Statistics; PART II contains Research Reports by Member Countries for the year 1971; and PART III (this volume) contains Selected Papers from the 1972 Annual Meeting.

This volume was produced in the Secretariat largely through the efforts of Mrs. Vivian C. Kerr who did the typing and to Messrs. R. Myers and G. Moulton who did the multigraphing.

PART III. SELECTED PAPERS FROM THE 1972 ANNUAL MEETING


NORTH ATLANTIC
ON AN AZIMUTHAL EQUAL AREA
PROJECTION CENTERED AT
40° N AND 35° W
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Vb₁
Vb₂
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IIId
VIIb,c
VIId,e
VIIg,h,i,k
VIII
IX

SECTION A
OCEANOGRAPHY

1. Hydrographic conditions off West Greenland during 1971[1]

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As in 1969 and 1970, ice conditions were rather severe off West Greenland in 1971. During its maximum extension in July the "storis" reached from Cape Farewell to the latitude of Godthåb (64°N). The westward extension was extremely great, more than 120 nautical miles from the coast at 62°N in July, but, in many periods, icefree land water was found along the coast.

Sections occupied by R/V's *Adolf Jensen* and *Dana* are shown in Fig. 1. *Dana* worked Sections II to IV in July and Section I in August. *Adolf Jensen* worked Section II in January, May and October, Section III in January and June and Section IV in November.

Temperature conditions in the sections are shown in Figs. 2 to 11. Very cold conditions were found until June in the upper 100 m as a result of strong winter cooling and inflow of cold polar water from the East Greenland Polar Current. As the temperature in June over the shallow part of Fylla Bank was below 1°C and earlier experience indicated that good cod year-classes only occur when the temperature here exceeds 1.8°C in June, it is hardly probable that the 1972 cod year-class will be great. In July water masses with sub-zero temperatures were still found west of Fylla Bank, but the core of the cold water was situated further westwards than usual.

Deviations of temperature and salinity from the mean values for the years 1950-66 (Hermann, 1967) for the station at 63°53'N-53°22'W west of the slope of Fylla Bank in July are shown below:

Depth Interval (m)	Mean Temperature 1950-66	Mean S ‰ 1950-66	T°C July 1972	S ‰ July 1972
0- 50	2.07	33.29	+0.46	-0.63
50-100	1.33	33.65	-0.99	-0.48
100-200	1.85	34.00	-1.55	-0.52
200-300	2.88	34.39	-1.18	-0.33
300-400	3.79	34.67	-0.49	-0.07
400-500	4.22	34.81	+0.14	+0.03
0-500	2.89	34.27	-0.67	-0.29

In the upper 300 m negative anomalies prevail both in the temperature and the salinity distribution, indicating great inflow of polar water. The temperature anomaly was highest in the layer between 100 m and 300 m. In the area north of Fylla Bank a strong summer heating of the upper 20 m had occurred in July causing relatively high surface temperatures over the northern banks.

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/38, Part II.

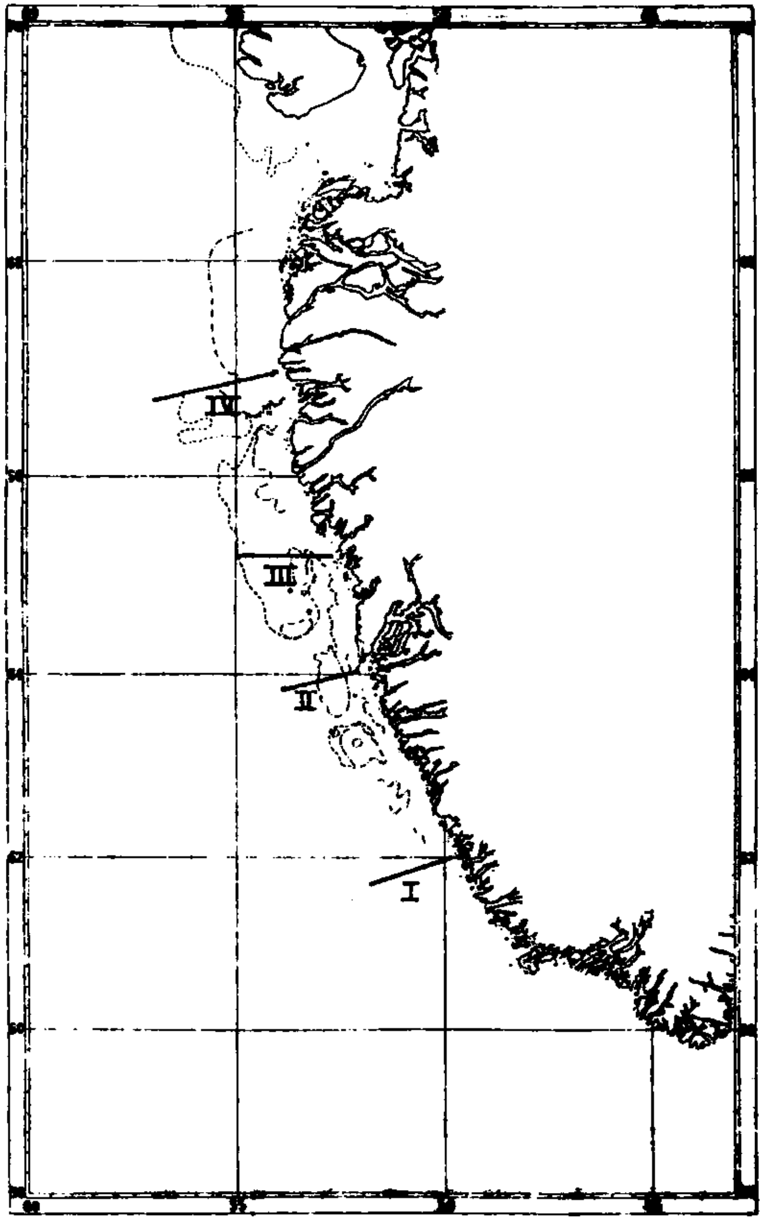


Fig. 1. Location of hydrographic sections off West Greenland.

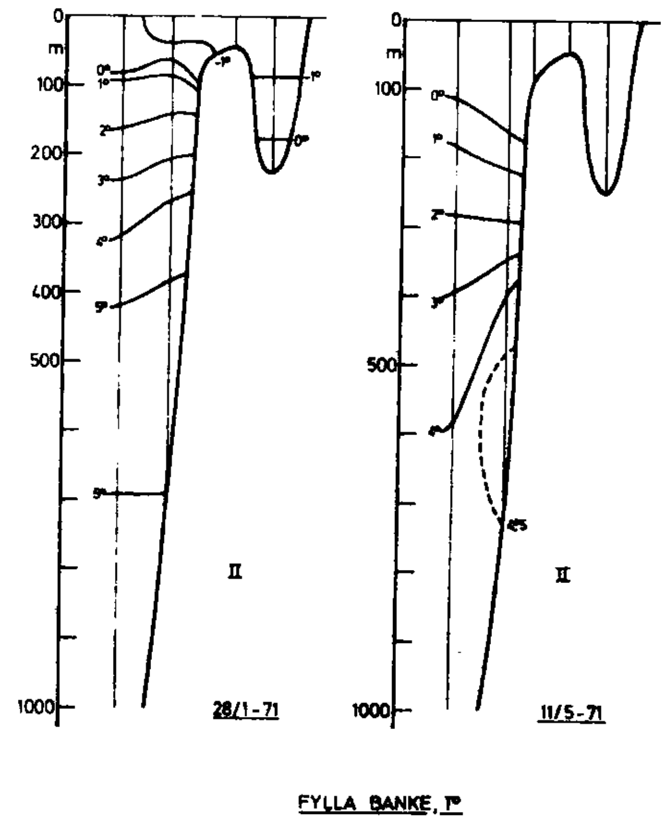


Fig. 2. Temperatures across Fylla Bank (Section II) in January and May.

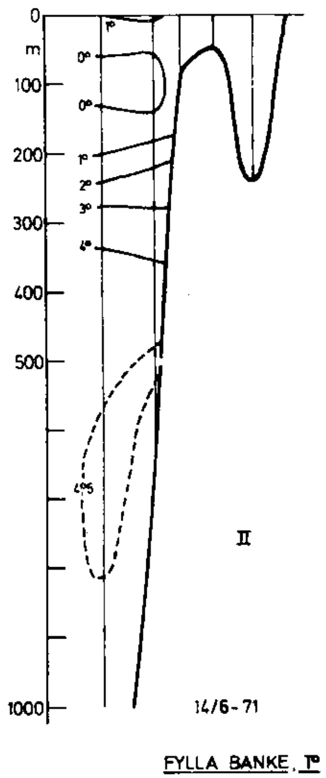


Fig. 3. Temperatures across Fylla Bank (Section II) in June.

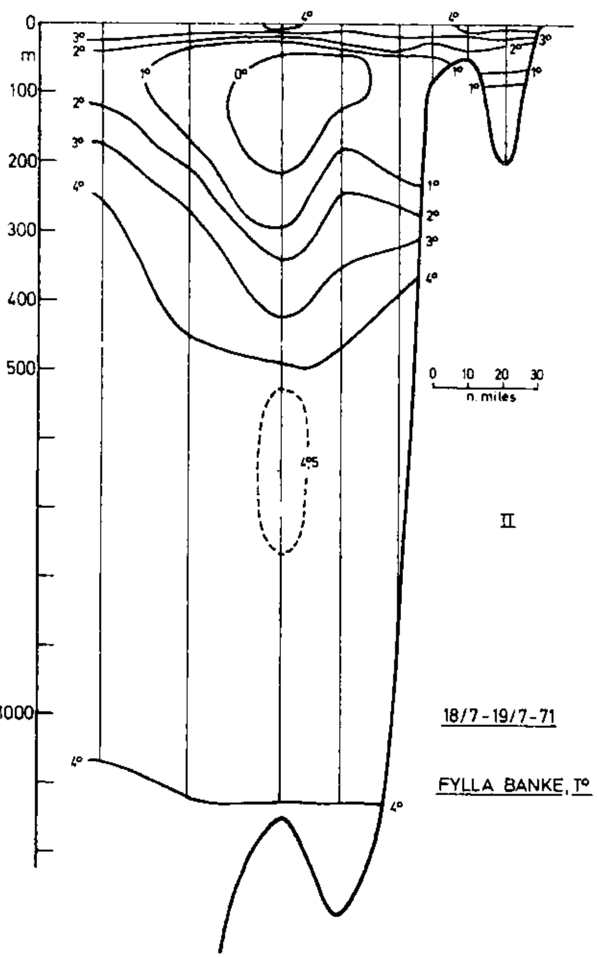


Fig. 4. Temperatures across Fylla Bank (Section II) in July.

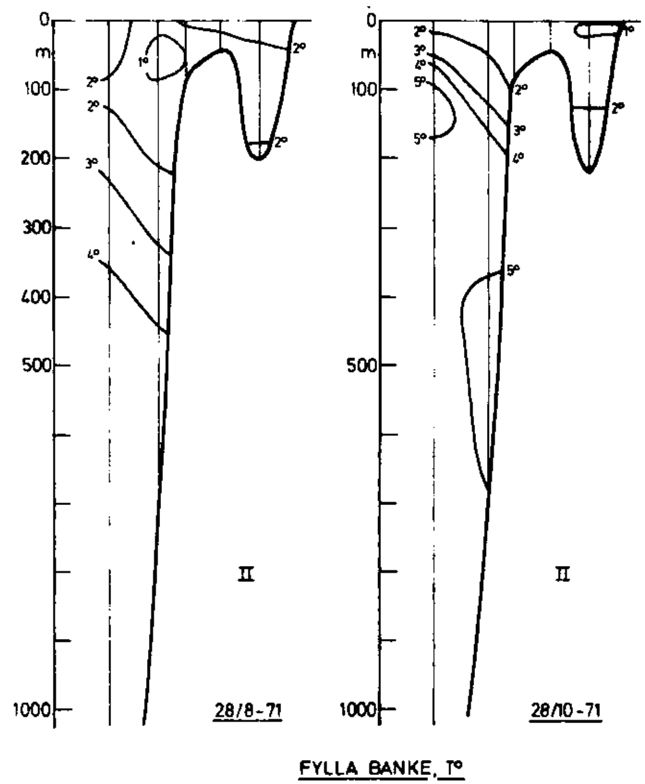


Fig. 5. Temperatures across Fylla Bank (Section II) in August and October.

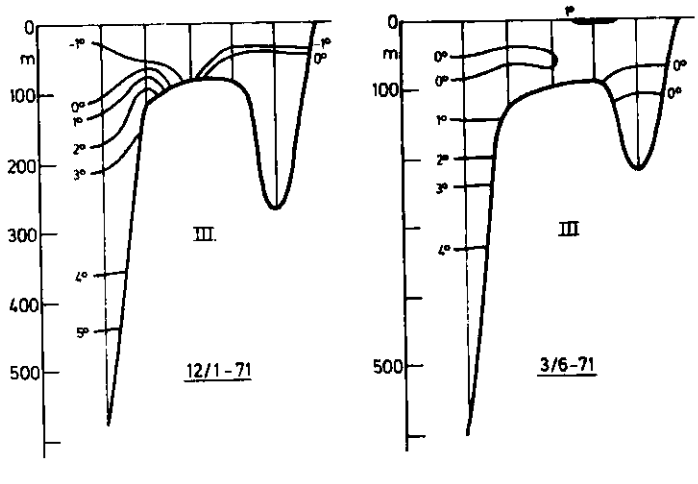


Fig. 6. Temperatures across Lille Hellefiske Bank (Section III) in January and June.

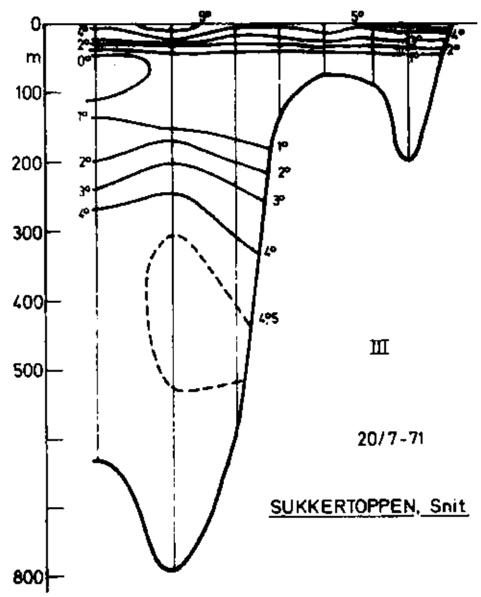
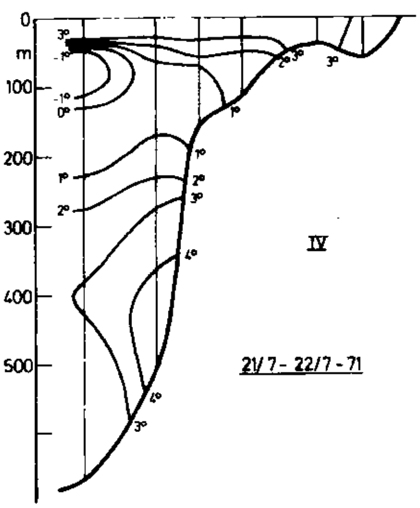
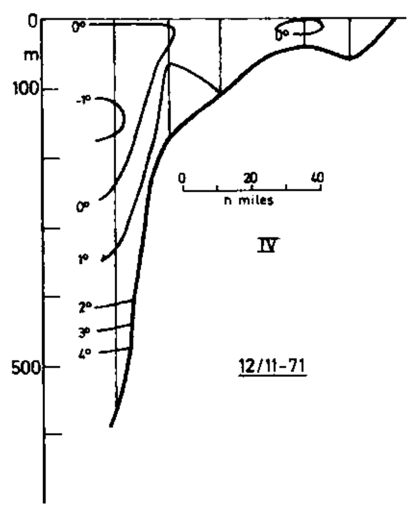


Fig. 7. Temperatures across Lille Hellefiske Bank (Section III) in July.





HOLSTINSBORG, I°

Fig. 8. Temperatures off Holsteinsborg (Section IV) in July.

Fig. 9. Temperatures off Egedesminde (Section V) in July.

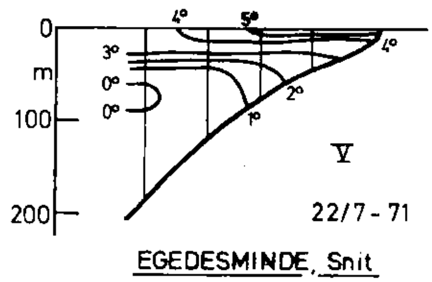


Fig. 10. Temperatures off Egedesminde (Section V) in July.

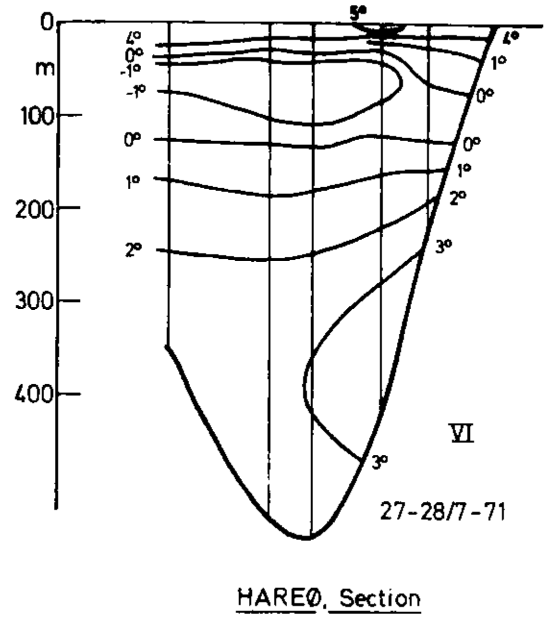


Fig. 11. Temperatures from Hare Island (North of Disko Island) towards NW.

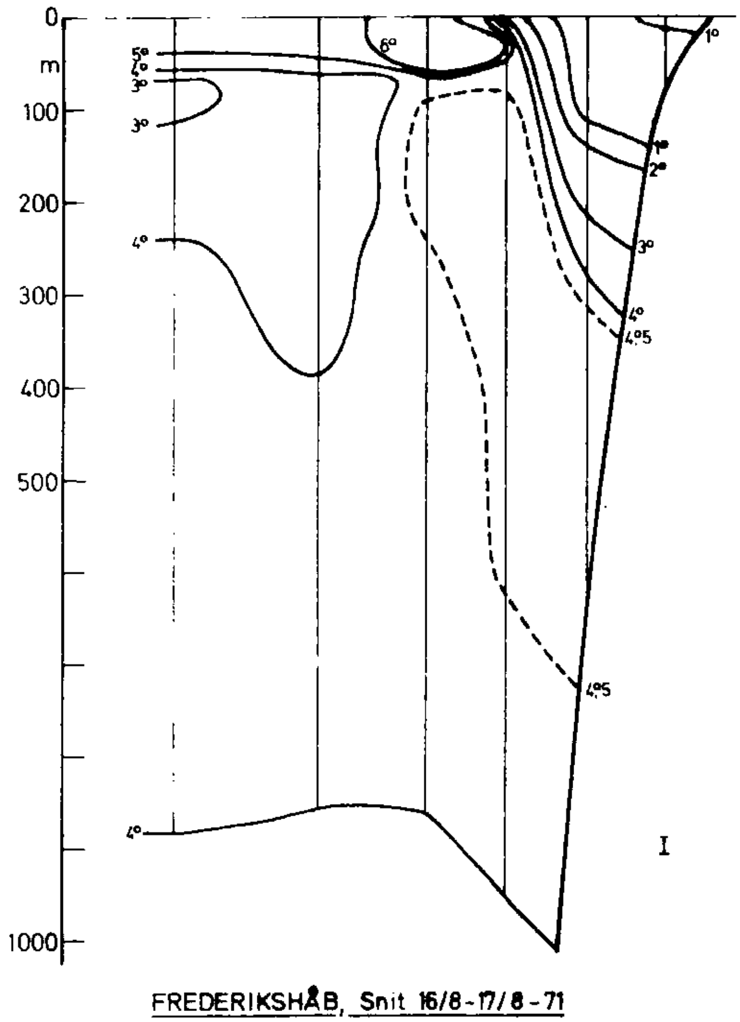


Fig. 12. Temperatures off Frederikshåb (Section I) in August.

2. Hydrological conditions in Labrador and Newfoundland areas in 1971[1]

by B.P. Kudlo and V.V. Burmakin
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Introduction

In 1971 USSR research vessels *Protsion*, *Perseus III* and *Akademik Knipovich* conducted hydrological observations in the Labrador and Newfoundland areas. The temperature and salinity were measured at 788 stations of the standard sections up to a depth of 2,000 m (Fig. 1). R/V *Protsion* carried out investigations in the March-May period, S/V *Perseus III* in the May-July period and in November, and R/V *Akademik Knipovich* in June-July. The comparison of temperature conditions was done as earlier (Burmakin, 1967-1971) on the basis of the average water temperature of various layers at standard sections within the boundaries according to Elizarov (1962) and Burmakin (1971). These boundaries are shown in Fig. 1 by square brackets.

Water temperature

Earlier, Burmàkin (1971) constructed the curves of the average yearly course of temperature in the 0-200-m layer for Sections 8-A, 7-A, 6-A, 4-A, 3-A, 2-A and 44-A. These curves were also used to determine the temperature anomalies from the observations in 1971.

Table 1 shows that the March-May period of 1971 is characterized by considerable negative anomalies (ranging from -0.7° to -1.4°) on sections crossing the main branch of the Labrador Current on the northeastern (Sections 7-A and 6-A) and southern (Section 2-A) slopes of the Grand Bank. In April and May Sections 3-A and 4-A (across the southeastern slope of the Grand Bank) exhibited temperature anomalies from -0.1° to +0.9°.

Table 1. Temperature anomalies in the 0-200-m layer (°C) from observations in 1971.

Sections and dates		Months					
		March	April	May	June	July	November
8-A (B)	29 July, 9 November	-	-	-	-	+0.7	-0.1
7-A	3 May, 28 May, 16 July	-	-	-0.8	-0.8	-1.2	-
6-A (G)	19 March, 30 April, 24 May	-1.4	-0.7	-1.4	-	-	-
4-A	25 April, 18 May, 3 July	-	+0.9	0.0	-	+0.6	-
3-A	20 April, 16 May, 26 June	-	0.0	-0.1	+0.8	-	-
2-A	3 April	-	-0.8	-	-	-	-
1-A	10 April, 19 June, 23 July	-	+0.4	-	+2.4	-0.5	-
44-A	28 March, 24 May, 16 July	+1.3	-	+1.2	-	-1.9	-

On Sections across the southwestern slope of the Grand Bank (Section 1-A) and Cabot Strait (Section 44-A), the temperature anomalies in spring were positive (+0.4° and +1.3°).

In the June-July period the temperature anomalies in the 0-200-m layer were positive on Section 8-A (+0.7°) in the southern Labrador area, on Sections 3-A and 4-A (+0.8° and +0.6°) across the southeastern slope and on Section 1-A (+2.4°) across the southwestern slope of the Grand Bank.

These anomalies remained negative both in spring and summer on the northeastern slope of the Grand Bank, Section 7-A (-1.2°), while on the southwestern slope of the Grand Bank and in Cabot Strait the anomalies became negative (-0.5° and -1.9°, Sections 1-A and 44-A) in summer.

In November off southern Labrador on Section 8-A, the temperature in the 0-200-m layer in the main branch of the Labrador Current (B) was below the norm by 0.1°.

Table 2 shows the average temperature in the 0-200-m layer and its anomalies adjusted to the dates. This method of estimating the temperature conditions was used in our previous works (Burmakin, 1967-1971).

We made an attempt to elucidate which layers were the coldest in the spring of 1971. To this end, we compared the average water temperature by layers: surface layer (0-50 m), active layer (0-200 m), the

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/105.

core of the Labrador Current (50-200 m), and Atlantic waters (200-500 m). The sections across the southern slopes of the Grand Bank and Cabot Strait had additional layers: Labrador waters (50-100 m) and mixed Labrador and Atlantic waters (100-200 m).

Table 2. Average temperature of the 0-200-m layer (°C) and its anomalies in 1971 adjusted to certain dates.

Sections	Dates of adjustment of average temperature					
	20 March	15 April	15 May	15 June	15 July	1 November
8-A (B)	-	-	-	-	0.55 (+0.29)	1.19 (-0.10)
8-A (AB)	-	-	-	-	0.00 (+0.10)	0.57 (-0.33)
7-A	-	-	0.26 (-0.58)	-	-	-
6-A	0.56 (-1.46)	-	-	-	-	-
4-A	-	2.33 (+1.50)	2.09 (+0.83)	2.91 (+0.42)	-	-
3-A	-	0.26 (-0.09)	0.65 (+0.17)	1.68 (+0.80)	-	-
2-A	-	0.89 (-0.16)'	-	-	-	-

The comparison of temperature in these layers in the spring-summer period 1957-1971 reveals that in 1971 on Sections triangle (northwestern side) 7-A and 6-A (H_1), the minimum temperature was observed in the 50-200-m layer, i.e., in the core of the Labrador Current, and amounted on these Sections to: 0.02°, 0.11° and -78°, respectively, and the temperatures given were lower than the minimum temperatures observed at the same period in 1963: 0.90°, 0.66° and -0.74°, respectively. On the same Sections above and below the core of Labrador waters, i.e., in the 0-50-m and 200-500-m layers, the temperature was about normal in spring 1971.

In the channel between the Grand Bank and Flemish Cap Bank (sector G of the 6-A Section), the lowest temperature was observed in 1971 for the whole period 1957-1971, not only in the 50-200-m layer but also in the 0-50-m layer (-0.69° against -0.09° in March 1963). But in this area relatively high temperatures were found in the 200-500-m layer (3.33° in March 1971 against 2.77° in March 1963).

Table 3 shows more detailed data on average temperature in different layers in spring and summer of the coldest years and in 1971.

Table 3. Average temperatures of different water layers (°C) on Sections "triangle" (northwestern side), 6-A and 7-A, in the spring-summer period of the coldest years and in 1971.

Section	Dates of observations	Water layers (in m)			
		0-50	0-200	50-200	200-500
"Triangle" (northwestern side)	4- 5 February 1962	0.79	1.18	1.30	2.48
	5- 6 May 1971	-0.10	0.07	0.09	2.67
	30-31 May 1963	1.85	1.16	0.90	2.49
	30 May 1971	1.52	0.32	0.02	2.65
	15 July 1963	3.72	2.02	1.35	2.78
	12 July 1971	2.14	0.58	0.05	2.33
7-A	15 May 1969	0.73	0.70	0.66	2.80
	15 May 1971	0.57	0.26	0.11	2.89
6-A (H_1)	25 March 1963	-1.03	-0.81	-0.74	-
	19 March 1971	-0.61	-0.69	-0.78	-
	19 April 1963	-1.07	-0.46	-0.21	-
	30 April 1971	0.89	0.32	-0.38	-
	25 May 1963	1.12	0.87	-0.06	-
	25 May 1971	2.74	1.30	-0.25	-

(continued)

Table 3. continued

Section	Dates of observations	Water layers (in m) 0-50	0-200	50-200	200-500
6-A (G)	25 March 1963	-0.09	1.09	1.45	2.77
	19 March 1971	-0.69	0.56	0.97	3.33
	19 April 1963	-0.52	0.66	1.07	2.90
	30 April 1971	0.25	0.65	0.74	3.29
	19 May 1959	-0.13	0.56	0.54	2.42
	25 May 1971	1.25	0.35	0.05	2.86
6-A (H_2)	17 March 1959	2.65	2.70	2.71	3.51
	19 March 1971	1.50	2.64	3.02	4.70
	19 April 1963	1.86	2.69	2.97	3.76
	30 April 1971	1.35	2.84	3.34	4.48
	19 May 1959	2.85	2.68	2.62	3.42
	25 May 1971	2.46	2.74	2.84	4.56

In the 0-50-m layer on Section 3-A across the southeastern slope of the Grand Bank, the following temperatures were observed in April, May and June: 0.62°, 1.37°, 4.87°, respectively, and on Section 2-A the temperature was +1.44° in April, this temperature was higher than normal. During the same months water temperatures in the 50-100-m layer on Section 3-A were: in April -0.41°, in May -0.36°, in June -0.47°, and in the 100-200-m layer: -0.34°, -0.22° and -0.57°, respectively, i.e., they were close to temperatures in cold years (Table 4).

Table 4. Average temperatures in the 50-100-m and 100-200-m layers (°C) on Section 3-A in April, May and June 1971 and in cold years.

Section	Date	Water layers (in m) 50-100	100-200
3-A	12 April 1959	-0.68	1.48
	20 April 1971	-0.41	-0.34
	20 May 1963	-0.08	0.84
	15 May 1971	-0.36	-0.22
	1 June 1959	-0.54	0.82
	26 June 1971	-0.47	-0.57

In April and May 1971, the water temperature in the 0-500-m layer on Section 4-A was higher than that in the warm 1958.

On the Sections across the southwestern slope of the Grand Bank (Section 1-A) and across the Cabot Strait (Section 44-A), the water temperature in March, May and June 1971 was higher than in 1964, 1966, 1968 and 1970 (Table 5).

As is evident from Table 5, especially warm waters were observed in March in near-bottom layers (200-500 m), in May warm waters were found in the 100-200-m and 50-200-m layers and in June an intensive solar heating was observed in the 0-50-m layer (8.11° was registered on 19 June 1971 compared to 4.84° on 16 June 1968). Waters in the 50-100-m layer were also warmer than in the warm year 1968, but colder in the deeper 100-200-m and 200-500-m layers.

An intensive influx of warm Gulf Stream waters was observed between St. Pierre, Green and Grand

Banks and especially in Haddock Channel. Near the bottom in the Channel at 45°20'N, temperatures higher than 4° were recorded, whereas in other years in this area temperatures were below 0°.

Table 5. Average temperatures of different water layers (°C) on Sections 1-A and 44-A in March, May-July 1971 and in 1964, 1966, 1968 and 1970.

Section	Date	Water layers (in m)					
		0-50	0-200	50-200	50-100	100-200	200-500
1-A	16 June 1968	4.84	4.87	4.38	3.21	7.62	6.89
	19 June 1971	8.11	6.86	4.96	4.98	7.09	5.29
	20 July 1970	8.35	6.00	4.00	3.34	6.71	6.11
	23 July 1971	8.09	5.75	2.22	1.74	4.69	5.34
44-A	14 March 1964	-0.59	0.33	0.64	0.53	1.23	3.58
	28 March 1971	0.16	1.50	1.95	0.41	2.72	5.16
	24 May 1966	2.43	1.87	1.64	1.06	1.95	4.30
	24 May 1971	3.18	3.28	3.59	2.07	3.78	5.18
	6 June 1968	4.38	4.53	4.58	2.67	5.54	5.48
	16 July 1971	2.15	2.99	3.18	1.59	3.98	5.16

Decrease in temperature on the southwestern slope of the Grand Bank and on the St. Pierre Bank in July 1971 (Table 5) was due to displacement of the Polar Front towards the ocean and to an inflow of the cold waters of the coastal stream of the Labrador Current.

In November, on Section 8-A (AB), the temperature in the 0-50-m layer of the Labrador Current was 0.88° and was below the normal by 0.67° (as in 1969). In the 50-200-m layer temperature was 0.20° below the normal and amounted to 0.43°. In the 200-500-m layer, the temperature was 0.39° higher than the normal and equalled 1.58° approximating that for 1962.

Salinity

Comparison of the horizontal distribution of salinity with the geostrophic circulation of waters over the same period (Kudlo and Burmakin, 1972) shows that isohalines are in good agreement with lines of flow. Thus, one can assume that the distribution of salinity in the southern Labrador and Newfoundland areas results from the interaction of the Labrador Current waters with the saltier waters of the Labrador Sea and Gulf Stream restricting the area at the side of great depths along the shelf contour. In this process the relief of the shelf and also the carrying-out of diluted waters from the Hudson Strait and St. Lawrence Bay are of great importance.

A main feature of the distribution of salinity in this area is its increase towards the ocean in the whole of the water column and from surface to bottom.

Demersal waters of the Labrador Sea and Gulf Stream penetrate further onto the shelf than surface layers; the frontal zone is sloping towards the ocean.

Vortices on the Great Newfoundland Bank cause the formation of areas with increased or lower salinity, which evidently are not stationary.

In order to obtain the numerical characteristic of the salinity regime of the Labrador Current, mean values of salinity in the 0-200-m layer were calculated on Sections 8-A, 6-A and 3-A (Fig. 1) and also on the corresponding Sections of South Wolf Islands-Cape Farewell, F, and U, worked by the International Ice Patrol for many years (Elizarov, 1962; U.S. Coast Guard Bulletin, 1956 -1964). Data on Sections, corresponding each other, were joined into one set and thus formed a basis for the construction of the mean many-years' curves of the yearly variations of salinity.

The value and sign of salinity anomalies in the 0-200-m layer on the date of observations were determined as a difference between the estimated value of salinity and many-years' mean salinity for this date.

Division 2J: The curve of the yearly variation of salinity, average for the sector B of Section 8-A

(Arctic waters of the Labrador Current) in the 0-200-m layer, is given in the contribution by Burmakin and Kudlo (1971). From 1970-1971 observations, salinity anomalies indicate that salinity of Arctic waters of the Labrador Current on Section 8-A in 1970 and in July 1971 somewhat exceeded the norm.

In July 1971 on Hamilton Bank, positive salinity anomaly corresponded to the negative transport anomaly (Kudlo and Burmakin, 1972). One can make a supposition, that a weakening in the intensity of the current caused a stronger inflow of Labrador Sea waters with a greater salinity onto the bank in the demersal layers.

Division 3L: On Section 6-A (F), crossing the Flemish Channel at 47°N, salinity means in the 0-200-m layer were calculated for sector G from 47°30' to 46°50'W. Based on these data, the "normal" curve of the yearly variation of mean salinity was obtained (Fig. 2A). Values of salinity in accordance with the observations in 1970 and 1971 are marked with corresponding indices. Values of salinity anomalies on Section 6-A are given in Table 6.

Table 6. Water salinity of the Labrador Current and its anomalies on some standard sections in the area of Labrador and Newfoundland in the 0-200-m layer, 1970-1971, ‰.

Section	Date	Salinity (‰)		
		Observed	Norm	Anomaly
8-A (B)	4- 5 May 1970	33.85	33.78	+0.07
	4- 5 September 1970	33.58	33.43	+0.15
	30 October 1970	33.59	33.55	+0.04
	29-30 July 1971	33.67	33.41	+0.26
6-A (G)	1- 2 January 1970	34.17	33.99	+0.18
	19-20 May 1970	33.63	33.76	-0.13
	8 August 1970	33.64	33.84	-0.20
	5- 6 October 1970	33.72	33.72	0.00
	19-20 March 1971	33.73	33.99	-0.26
	30 April-1 May 1971	33.45	33.83	-0.38
	24-25 May 1971	33.30	33.77	-0.47
3-A	10-11 January 1970	34.17	33.96	+0.21
	18 May 1970	33.25	33.70	-0.45
	10-11 October 1970	33.47	33.75	-0.28
	19-20 April 1971	33.41	33.87	-0.46
	15-16 May 1971	33.23	33.71	-0.48
	26 June 1971	33.30	33.87	-0.57

As opposed to Section 8-A, on Section 6-A in 1970, negative salinity anomalies were observed; in October, salinity reached the norm. In the first half of 1971, salinity again decreased below the norm, and in May negative anomaly was 0.47‰. On Section 6-A and on Hamilton Bank, in most cases, positive anomalies of Labrador Current water transport correspond to the negative salinity anomalies, i.e., salinity in the 0-200-m layer is evidently a function of intensity of current.

Division 3N: Mean salinity on Section 3-A (U) crossing the Labrador Current on the southwestern slope of the Grand Bank was calculated within 45°00'N, 49°10'W and 44°50'N, 48°30'W. The number of observations, based on which the curve of yearly variation of salinity on this section has been plotted, is less than on Section 6-A (Fig. 2B). The portions of the curves, plotted in accordance with single observations, are shown as a broken line.

In four out of five cases, the signs of salinity anomalies on Sections 6-A and 3-A coincide, i.e., the trend in change of salinity on both sections is equal (Table 6). During the second half of 1970 (May, October) and the first half of 1971, salinity on Section 3-A in the 0-200-m layer was considerably lower than the norm; in May and June 1971, it was at the minimum level, which is determined in agreement with the many years' data; negative anomalies reached 0.5-0.6‰ (Table 6).

Conclusions

1. In spring and in early summer 1971, water masses of the Labrador Current on the north Newfoundland Bank and on the northeastern slope of the Grand Bank were colder than in the coldest years during the period of 1957-1971. At the same time, on the southwestern slope of the Grand Bank and in the straits between St. Pierre-Green-Grand Banks, temperatures were above the norm.

2. In July 1971, as well as in spring, waters of the Labrador Current on the northeastern slope of the Grand Bank remained cold. However, to the north and south of this slope, temperatures rose above the norm. By summer, temperatures fell below the norm on the southwestern slope of the Grand Bank and on St. Pierre Bank.

3. In March-April 1971 on Sections "triangle", 7-A, and 6-A, minimum temperatures lower than in "cold" 1963 were registered in the 0-200-m layer. In the upper 50-m layer, it was also colder than in the "cold" years 1959 and 1963.

4. In March-May 1971, temperatures above 4° were registered in demersal layers in the channel between Green and Grand Banks, whereas in previous years it was usually below 0°.

5. Curves of the annual variation of salinity have been obtained for the Labrador Current on Sections 6-A and 3-A from many-years' data, which make it possible to determine anomalies of mean salinity on the sections.

6. In the 0-200-m layer of the Labrador Current, salinities were considerably below the norm on Sections 6-A and 3-A in the first half of 1971, and in June-July the anomalies reached -0.5 to -0.6‰. In July, salinity anomaly was positive on Hamilton Bank (Section 8-A).

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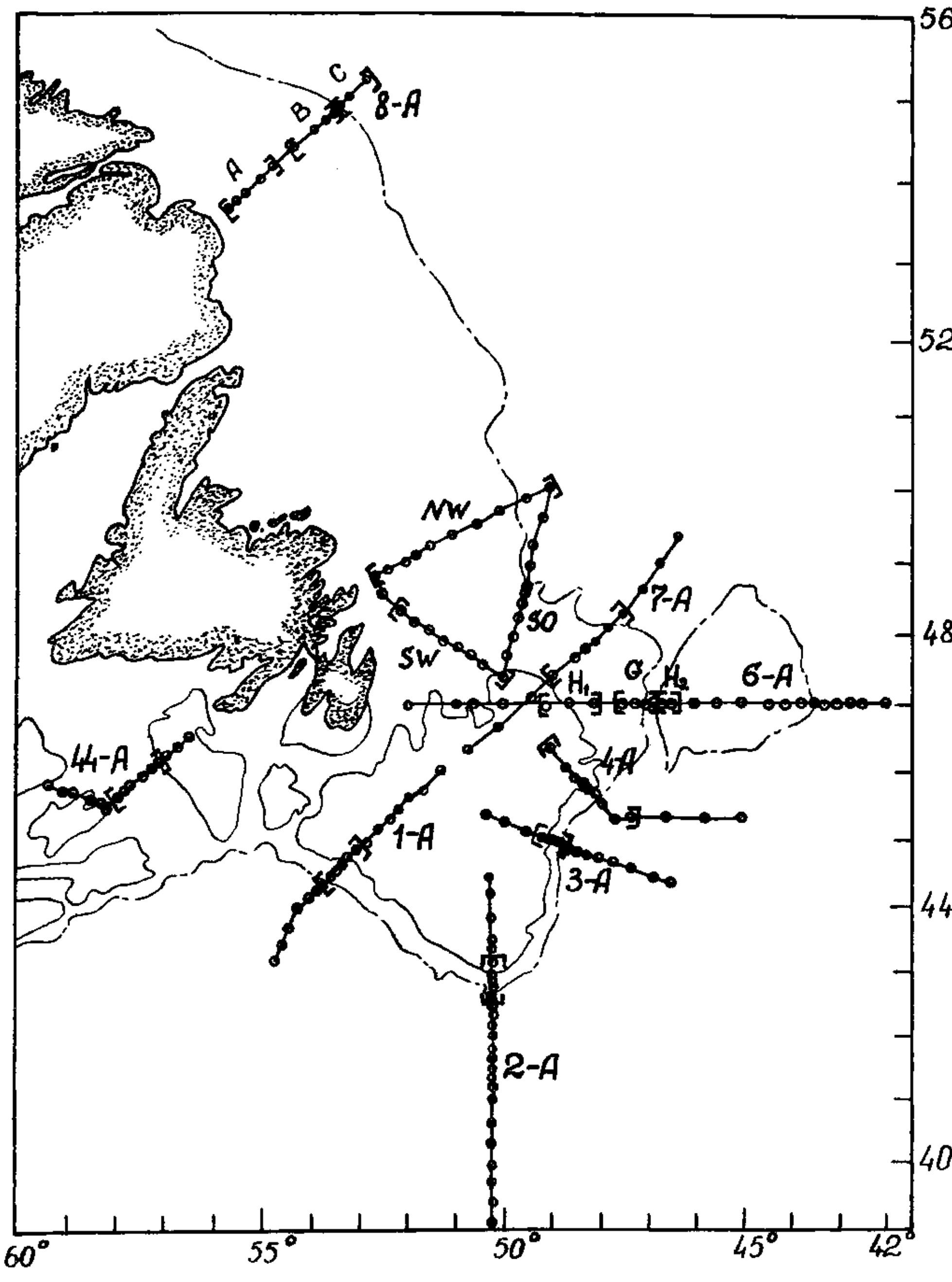

Fig. 1. Location of standard hydrological sections in the Labrador and Newfoundland areas. Square brackets denote the sectors of the sections for which average temperature and salinity were calculated.

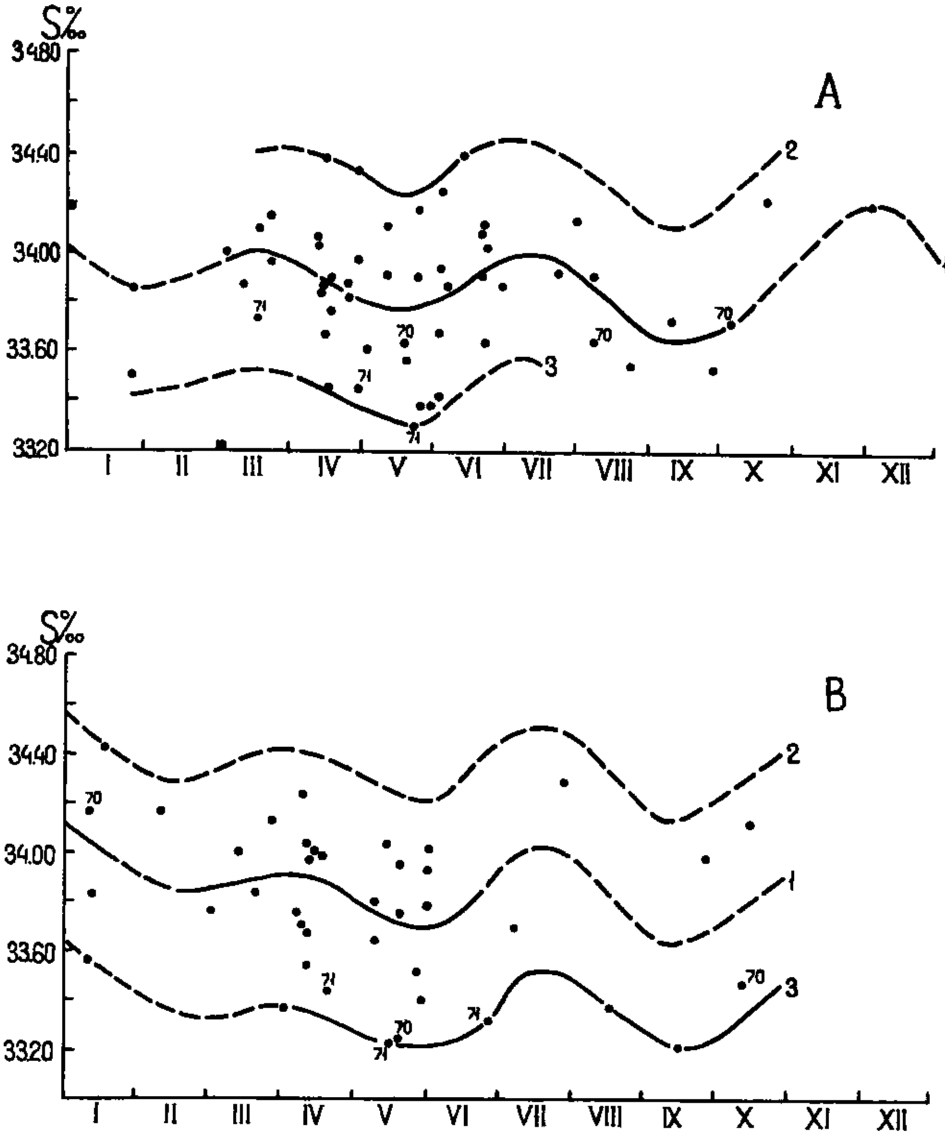

Fig. 2. The yearly course of average (1) and extreme (2, 3) values of salinity of the Labrador Current in the 0-200-m layer (A) in the core of the Current, Sector G of Section 6-A along 47°N, and (B) in Section 3-A across the southeast slope of the Grand Bank.

3. Temperatures and salinities in the eastern Newfoundland area in 1971[1]

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Introduction

In July-August 1971, the 6 standard monitoring sections taken across the Labrador Current east of Newfoundland at approximately the same time each year were occupied by the *Cape Freels*. Station 27, off Cape Spear, was occupied monthly or more often during the year. The 1971 section temperatures are compared with the lowest, average, and highest temperatures at each station and depth in 1951-65 at approximately the same dates (unpublished) and also with temperatures in 1969 and 1970 (Templeman, 1970, 1971).

In the sections, the surface temperatures and salinities are by necessity placed above and occasionally somewhat displaced from the stations which indicate the correct location, otherwise the position of the decimal point indicates the level and position of the temperature or salinity.

Sections across the Labrador Current in July-August

Temperatures

In Section A, Labrador, from off Seal Islands across Hamilton Inlet Bank (Fig. 1), apart from surface temperatures at the shoreward Stations No. 51-54 which were above average, the temperatures of the western, colder water part of the Labrador Current were below, and the volumes of water below -1°C and below 0°C greater than the 1951-65 average and conditions were closer to those of the years with the lowest observed temperatures than to the average of this period. Temperatures of the cold water section at or below 0°C were not as low as in 1969, but were not greatly different from those of 1970, except that the small coastward volume of water below -1.5°C present in 1970 was not present in 1971. In the offshore, warmer part of the Labrador Current of West Greenland origin, temperatures of the deeper water at the most seaward stations east of the continental slope were close to the 1951-65 average, having fallen considerably from those of 1970 which were similar to the highest and in some cases higher than any previously encountered, and for the deeper parts of all the deeper stations east of the continental slope were slightly lower than in 1969. Offshore surface temperatures were close to the average for 1951-65.

In Section B off Cape Bonavista (Fig. 2), surface temperatures, except at Station No. 47, were higher than any previously recorded. Temperatures in the western, colder mid-water portion of the Labrador Current were below the 1951-65 average and close to the lowest previously encountered but the volumes of below -1.5 and -1°C water were less than the maximum. Coastward in the deepest water and over the Northeast Newfoundland Shelf, temperatures were slightly higher than any of the 1951-65 and 1969 periods, and on the average were similar to those of 1970. In the offshore deeper water adjacent to the continental slope, temperatures were above the average of the 1951-65 period and higher than in 1969 but lower than in 1970.

In Section C from St. John's to Flemish Cap (Fig.3), surface temperatures were above the average but below the highest recorded for the 1951-65 period and were in all except Station 27 in 1970 above those of 1969 and 1970. In the western cold water part of the Labrador Current in the Avalon Channel and over the surface of the Grand Bank, temperatures were lower and low temperatures ran deeper than the average of 1951-65 and lower than in 1969 and 1970. Core temperatures in the eastern branch of the colder water of the Labrador Current were lower than the lowest of the 1951-65, 69-70 period. Lower temperatures also extended farther seaward than in any year of the above period. Temperatures in the offshore deeper water of the Flemish Channel and on the seaward slope of Flemish Cap were generally higher than the highest of the 1951-65, 69-70 period but were most similar to those of 1970 when temperatures near the bottom of the western side of Flemish Channel were a little higher, but for most of the remainder lower than in 1971.

In Section D from St. John's to the southeast slope of the Grand Bank (Fig. 4), surface temperatures at the 3 shoreward stations and Station 33D were close to the highest, at the intermediate stations No. 30 and 31 about halfway between the average and the highest, and at the remaining seaward stations close to the average of the 1951-65 period. Surface temperatures were considerably higher than in 1969, and slightly higher for the shoreward Stations No. 27 to 29, and lower in the remaining seaward stations (except 33D) than in 1970. Temperatures in the deeper water of the Avalon Channel were close to the average of the 1951-65 period but at intermediate levels higher than in 1970. Water below 0°C extended a little farther eastward on the Grand Bank than the average of 1951-65 or in 1969-70. The core temperatures in the eastern branch of the Labrador Current to the east of the Grand Bank were lower than the 1951-65 average and lower than in 1969 and 1970. Deep water temperatures below 200 m in the most easterly Station 33F were above the average of the 1951-65 period and at 600-800 m above or equal to the highest of this period, but as for the whole station, lower than 1969 when very high temperatures were recorded and at 200-300 m lower than in 1970.

In Section E extending along the southwestern edge of the Grand Bank at about 75 m (Fig. 5), surface temperatures were usually above the 1951-65 average, much higher than in 1969 and higher than in 1970 at the western Stations No. 20A-24 but generally lower at the eastern stations. Temperatures in the

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/31.

Haddock Channel were below the average of the 1951-65 period and below those of 1969 and 1970. Bottom temperatures over the surface of the Grand Bank were below the 1951-65 average on the central part of the bank and slightly above the 1951-65 level on the eastern part of the bank and were not greatly different from those of 1969 and 1970. The eastern branch of the Labrador Current had a greater than average volume of water below 0°C, temperatures below -1°C extended farther eastward and the lowest temperature of -1.42°C was lower than was previously recorded. Deep water temperatures below 400 m were well above average and close to the highest recorded.

In Section F at about 275 m along the southwestern slope of the Grand Bank to St. Pierre Bank (Fig. 6), surface temperatures were above the average but lower than the highest surface temperatures of the 1951-65 period. Most surface temperatures were considerably higher than those of 1969, and at most of the western stations they were higher, and at most of the eastern stations lower than in 1970. Temperatures in the colder part of the western branch of the Labrador Current at Stations 10 and 13 were lower than the average of the 1951-65 period and lower than in 1969 and 1970. The volume of cold water in the eastern branch of the Labrador Current passing westward around the tail of the Grand Bank was greater than the 1951-65 average and the lowest temperature of this branch, -1.41°C, was the lowest yet recorded in our observations. Temperatures in the warmer slope water impinging on the bank at Stations 15 and 16 between the west and east cold water masses were similar to the highest recorded in the August sections since 1951. Bottom temperatures at the level surface were above average but, except that at Station 18 (which was higher), not as high as the highest recorded in 1951-65, and were higher than in 1969 and higher at some and lower at other stations than in 1970. The eastern slope Stations shown (26D-H) were the same as those in Section E (Fig. 5).

Salinities

In the Seal Island Section A (Fig. 1), salinities near the bottom in Hawke Channel and at the crest of Hamilton Inlet Bank were lower than in 1970, resembling those of 1969. The deep water salinities seaward of Hamilton Inlet Bank were lower than in 1969 and still lower than in 1970.

In Section B off Cape Bonavista (Fig. 2), salinities of the deep water east of the continental slope were lower than in 1970 and fairly similar to those of 1969.

In Section C from St. John's to Flemish Cap (Fig. 3), near-bottom salinities in Avalon Channel and over the surface of the Grand Bank were lower than those of 1969 and 1970. Salinities in the deeper parts of Flemish Channel and seaward of Flemish Cap were lower than in 1970 and not greatly different from those of 1969.

In Section D from St. John's to the southeast slope of the Grand Bank (Fig. 4), near-bottom salinities in the Avalon Channel were fairly similar to those of 1970 and lower than in 1969. In the deep water east of the Grand Bank, salinities at the deepest levels ranged from slightly lower to slightly higher than in 1970 and 1969.

In Section E at about 75 m extending along the southwestern slope of the Grand Bank (Fig. 5), salinities in the Haddock Channel were lower than in 1969 and 1970, and near-bottom salinities over the surface of the Grand Bank were low as in 1970 and lower than in 1969. Salinities in the water on the eastern slope of the Grand Bank and continental slope were lower than in 1969 and 1970.

In Section F at 275 m along the southwestern slope of the Grand Bank to St. Pierre Bank (Fig. 6), near-bottom salinities at the level surface were lower than in 1970 but usually little different from those of 1969.

Station 27, 1971

In Station 27 off Cape Spear (Fig. 7), surface temperatures from May to September were above the 1950-62 average (Templeman, 1965); in other months they were lower than this average. Winter-spring surface temperatures were generally lower, June-August temperatures approximately similar and October-November temperatures lower than in 1970. At intermediate levels, in the coldest water of the Labrador Current, temperatures were below the 1950-62 average, below those of 1970 and well below that of 1969. Bottom temperatures were close to the 1950-62 average and generally lower than those of 1969, 1970.

The salinity picture in the deeper water and near bottom was generally similar to that of 1970.

Acknowledgements

I am grateful to Mr A.G. Kelland, hydrographic technician at the St. John's Station, and to Mr L. N. Cluett for their interest in gathering data for this paper; also to the scientists and technicians of the St. John's Station who have taken hydrographic observations at Station 27 and on the various sections.

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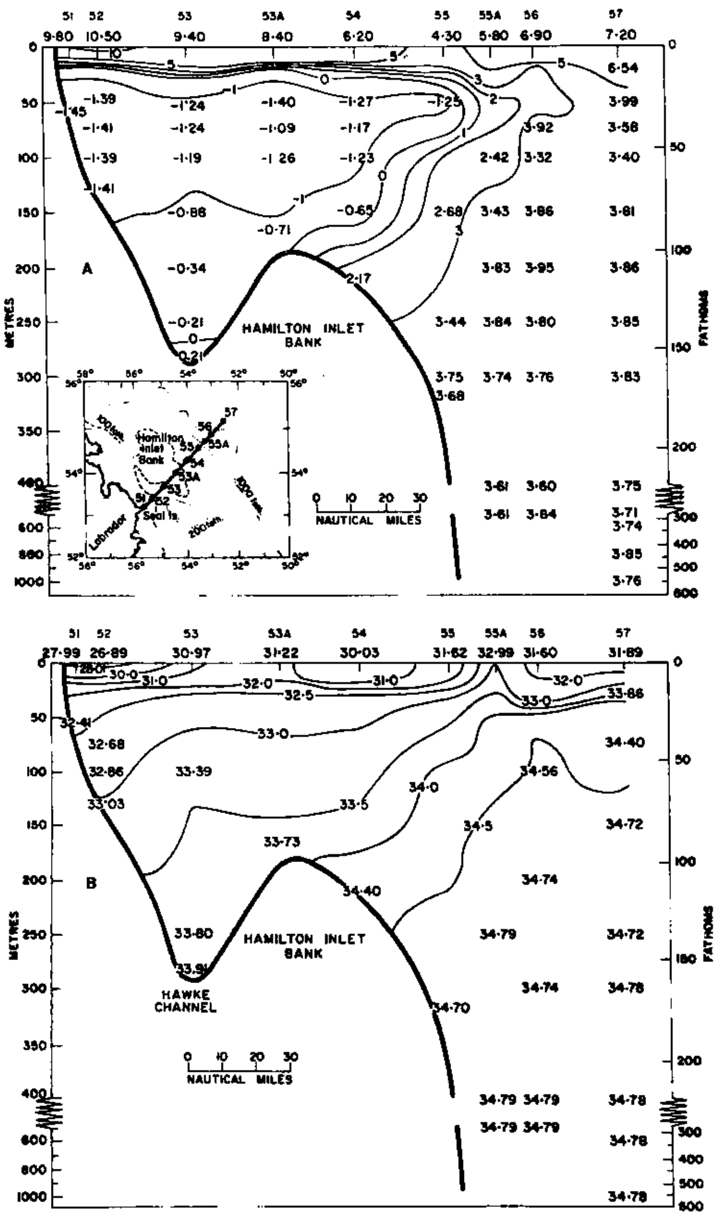

Fig. 1. Temperature (°C) above and salinity (‰) below, Section A, Seal Island-Hamilton Inlet Bank, 3-4 August 1971.

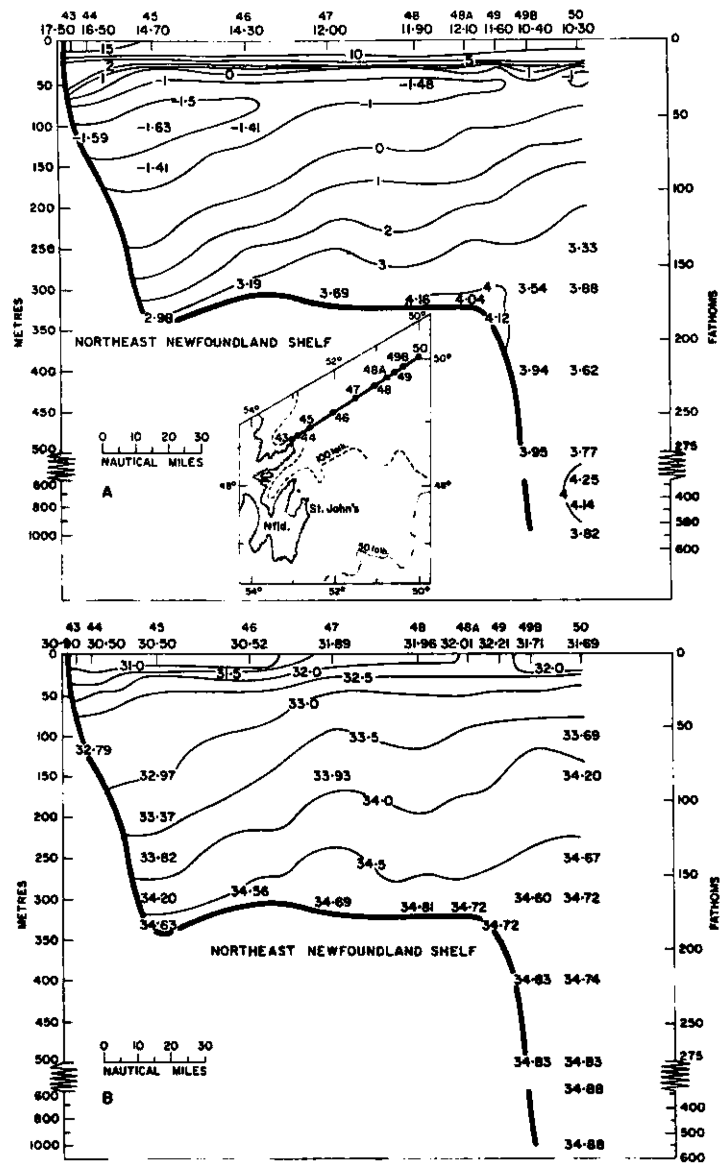

Fig. 2. Temperature (°C) above and salinity (‰) below, Section B, off Cape Bonavista, 1-2 August 1971.

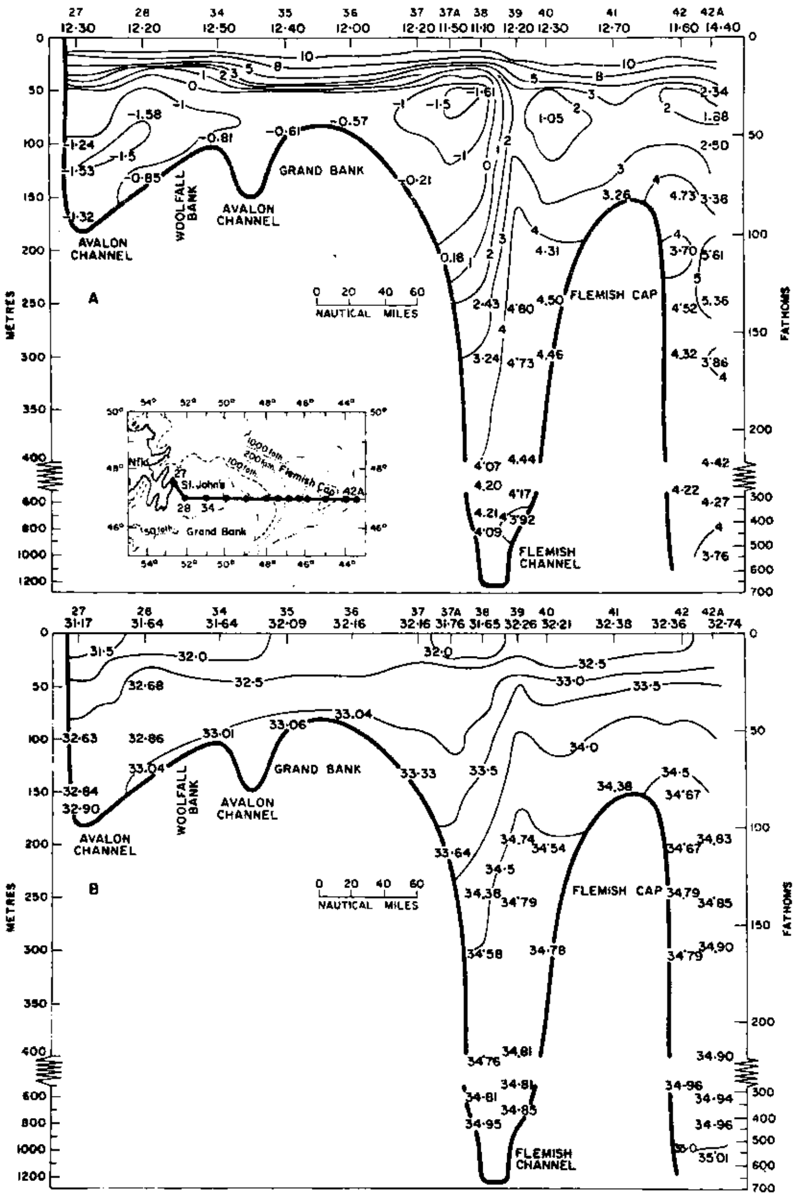

Fig. 3. Temperature (°C) above and salinity (‰) below, Section C, St. John's-Flemish Cap, 29-31 July 1971.

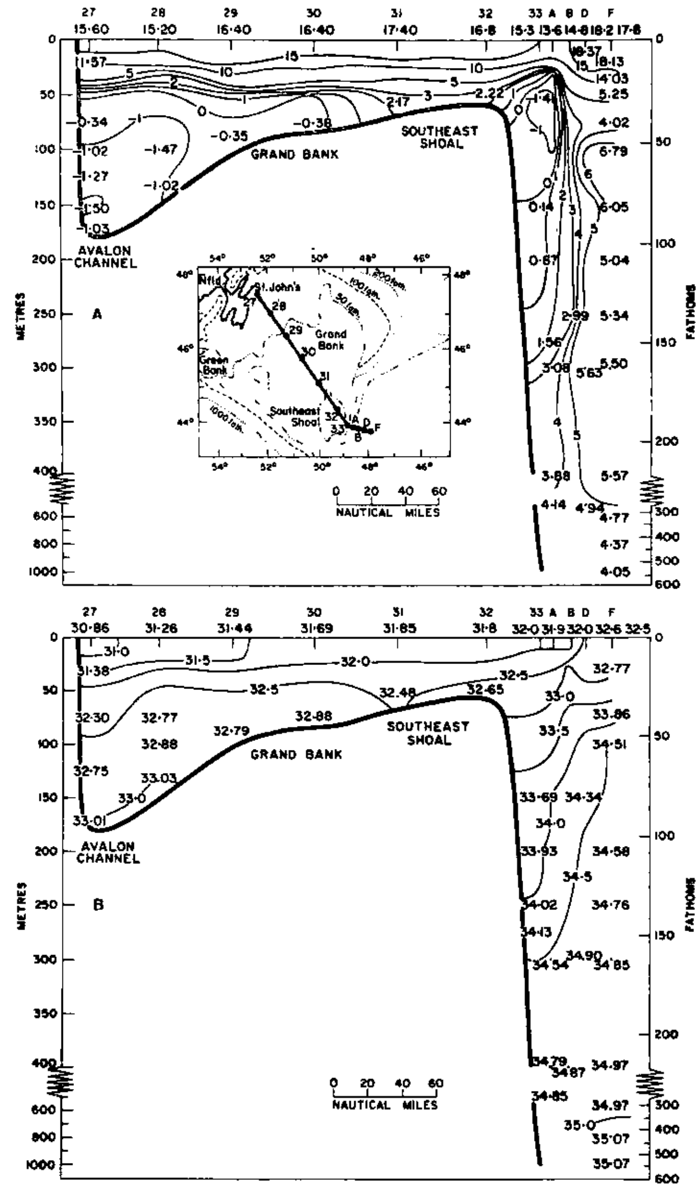

Fig. 4. Temperature (°C) above and salinity (‰) below, Section D, St. John's-SE slope Grand Bank, 18-19 August 1971.

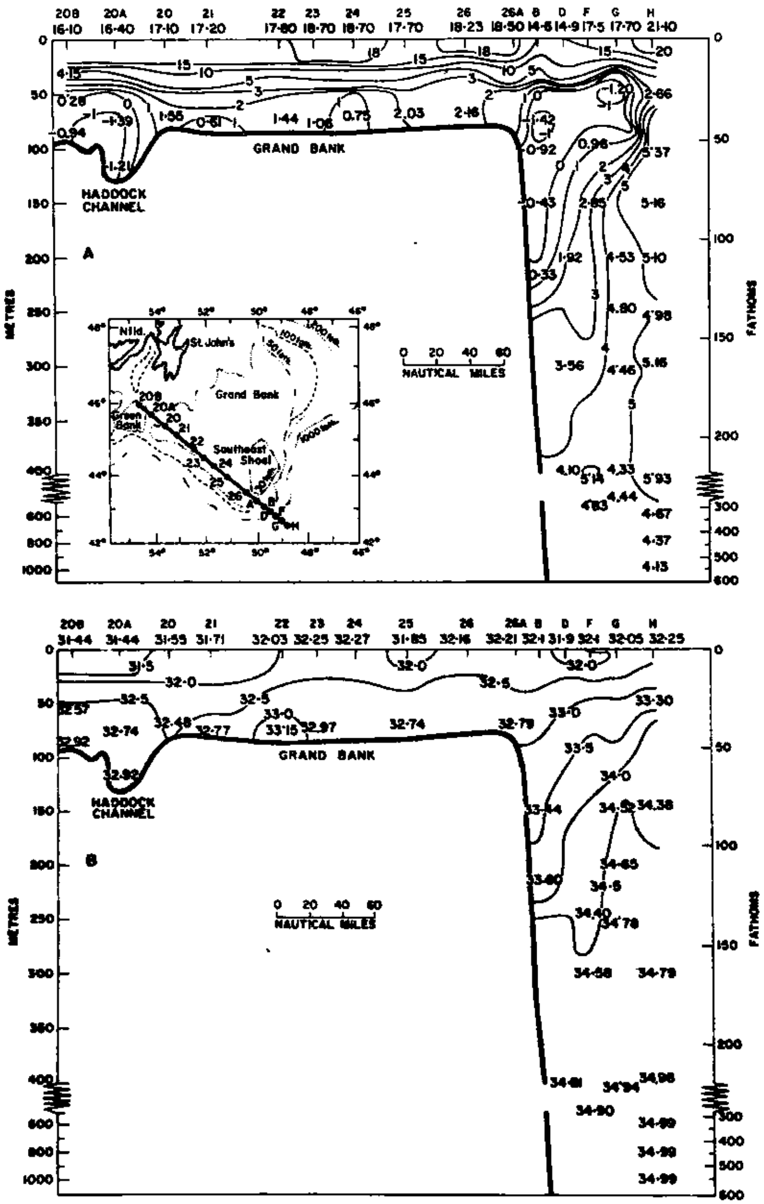

Fig. 5. Temperature (°C) above and salinity (‰) below, Section E, Green Bank-SE Grand Bank, 20-23 August 1971.

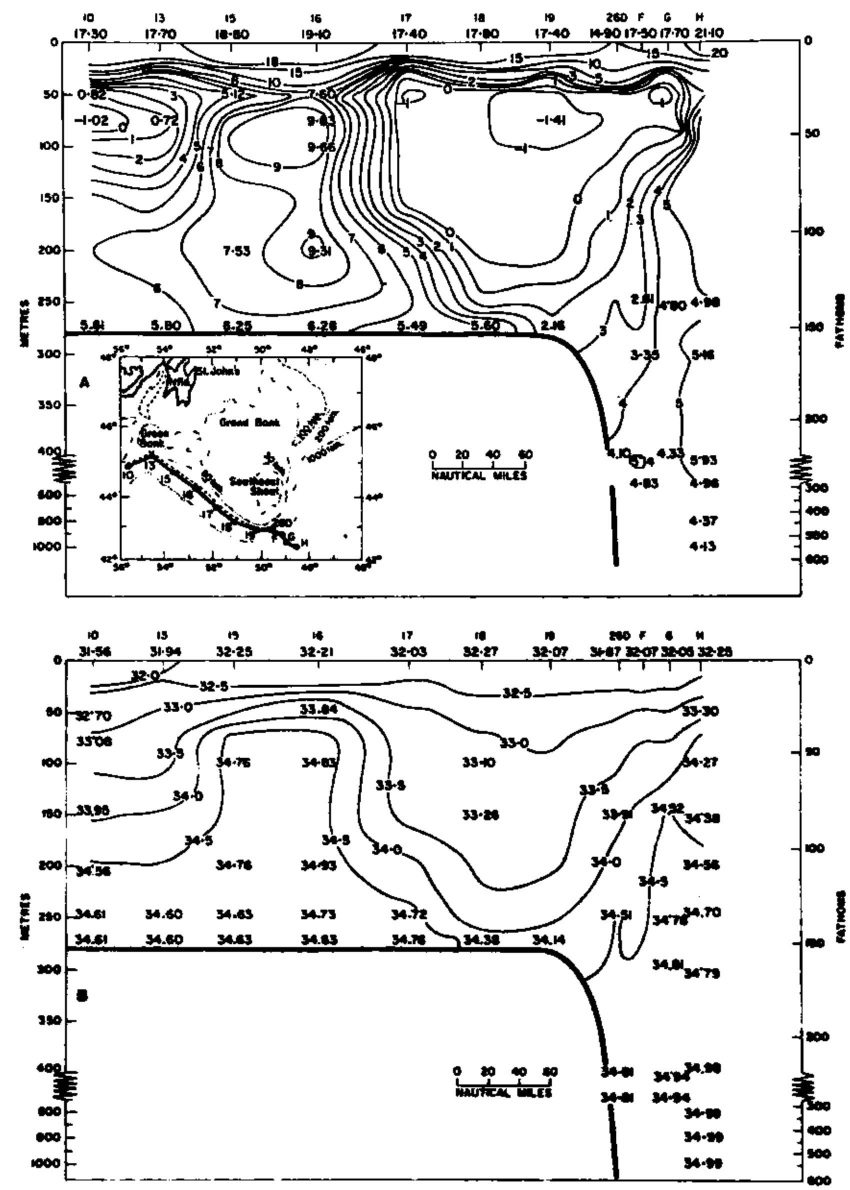

Fig. 6. Temperature (°C) above and salinity (‰) below, Section F, SW slope Grand Bank-St. Pierre Bank, 20-23 August 1971.

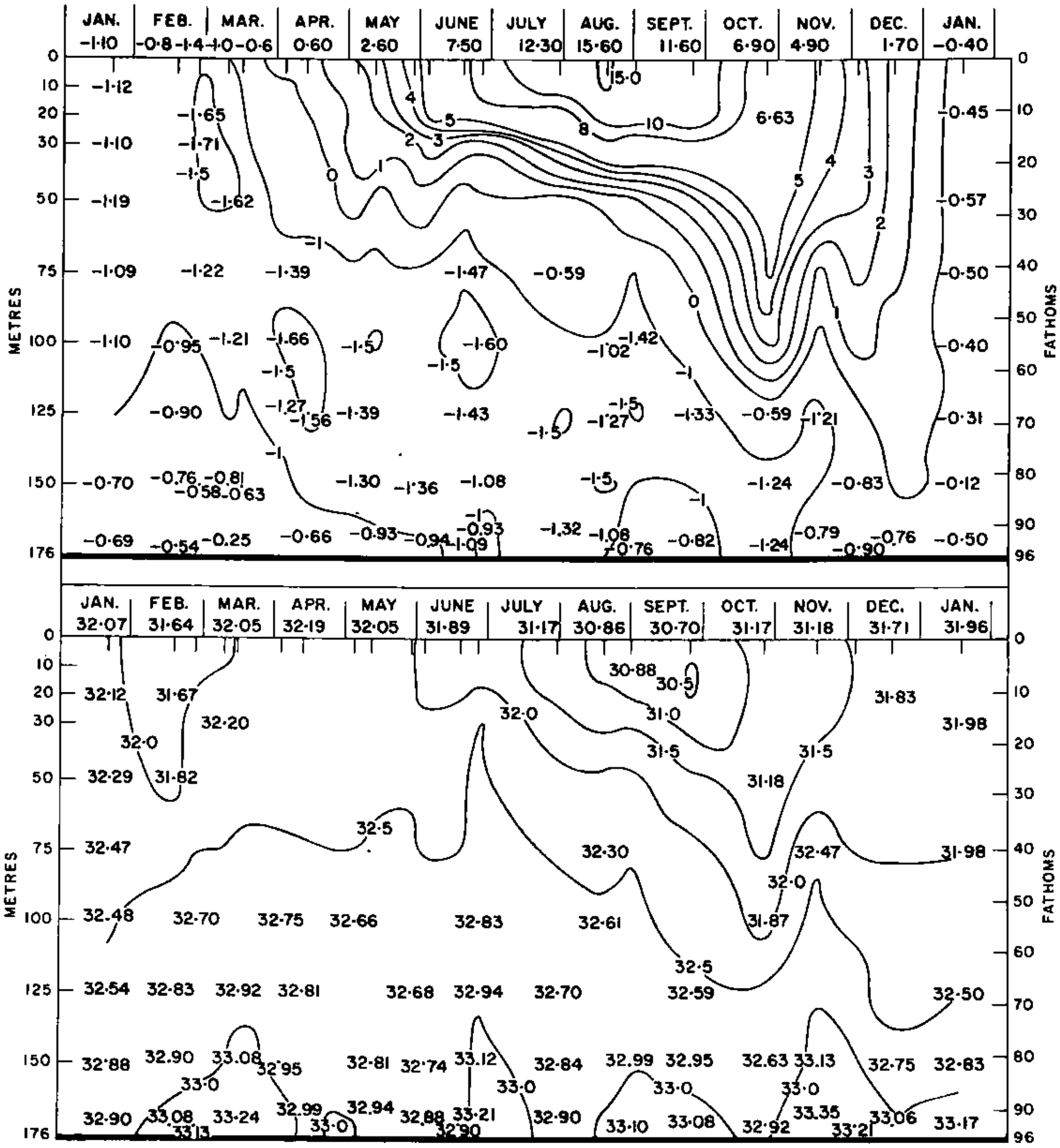

Fig. 7. Temperature (°C) above and salinity (‰) below, January 1971 to January 1972, from surface to bottom at Station 27 (see Fig. 3, 4, inset), 2 nautical miles off Cape Spear near St. John's.

4. Water circulation in the South Labrador and Newfoundland areas in 1970-1971[1]

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Introduction

In 1970-1971 research vessels of PINRO, *Protsion* and *Rossiya*, conducted several hydrological surveys in ICNAF Divs. 2J, 4V and Subarea 3. Treatment of the data obtained by the dynamic method (Zubov and Mamaev, 1956) made it possible to consider the peculiarities of water circulation in the regions mentioned for the last two years.

Variability of water circulation was studied by two methods:

a) by compiling and comparing the dynamic charts;
b) by analyzing the sequences of water transport values in some hydrological sections intersecting the main branches of the currents in the area.

The first method allows for analyzing the changes in circulation with space and time. The second gives quantitative values for the intensity of the currents and permits the evaluation of these relative to normal.

Spatial changes of circulation

A total of seven dynamic charts were compiled. They are presented in Figs. 1-3. In all cases, the level of 200 decibars was taken as the reference surface since the area investigated is rich in banks with depths shallower than 200 m.

Comparison of the dynamic charts themselves and charts by other authors (Smith, *et al.*, 1937; Buzdalin and Elizarov, 1962) shows that in 1970-1971 the main pattern of water circualtion in the area investigated did not differ, in principle, from the known pattern. So, the Labrador Current and its branch, moving clockwise around Flemish Cap Bank, anticyclonic movements of waters in the central part of the Grand Bank and Flemish Cap Bank and other peculiar features of circulation are clearly seen on all the charts.

The most comprehensive circulation chart was constructed on the basis of data from 355 hydrological stations worked out during the 13 cruises of R/V *Rossiya* (Fig. 2). On the standard stations observations were made at standard depths; at trawl stations they were carried out at depths of 0, 20, 50, 100, 200, 300 m and near the bottom. An increase in the velocity of the Labrador Current in the core of the stream and its strong eddying is clearly seen on the chart. Bottom relief is one of the reasons for the eddying, because the streams meanderings originate mainly in the area of submarine canyons located at right angles to the axis of the current.

On the southwestern slope of the Grand Bank, the velocity of the Labrador Current decreases, is deflected to the right and flows onto the shallow of the Grand Bank. At about 45°N, 53°W the main stream almost connects with the coastal branch of the Labrador Current. The latter flows farther in a westerly direction along the southern coast of Newfoundland.

Figures 1-3 point to a great stability of the system of water circulation in the area investigated and to the constancy of action of main factors forming this system. However, comparison of the charts shows that there are differences in some details of the system from one survey to another. The differences mentioned, i.e., peculiarities of water circulation apparently are responsible for the origin of anomalies of temperature and other hydrological elements in separate parts of the area.

The most distinctive features of water circulation in 1970-1971 that were revealed from the dynamic charts are:

1) In the Hamilton Inlet Bank area, the Labrador Current apparently weakened from winter to spring, then strengthened again by autumn. The main stream in the 0-200-m layer moved east of the Bank above the continental slope (Fig. 1).

2) In autumn, the velocity of the current was maximal on the Zundal Bank (Fig. 1).

3) In winter and spring of 1970, an enlargement of the area of action of the Labrador Current was observed to the south of the parallel of Belle Isle. In autumn this phenomenon was not observed (Fig. 1).

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[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/104.

4) In winter of 1970 on the northeastern slope of the Grand Bank of Newfoundland, waters moved in a clockwise direction (Fig. 1A). The subsequent surveys reveal there, both complete absence of vortices (Fig. 1B and C, Fig. 3A) and a slow movement of waters in an anticlockwise direction (Fig. 2B). Consequently, this area of the Grand Bank is characterized by weak currents of unstable directions. The main volume of the Labrador Current waters moves along the continental slope into the Flemish Channel passing around the Grand Bank of Newfoundland.

5) On the southern half of the Grand Bank, a vast vortex is usually located with its waters moving in a clockwise direction. Small secondary vortices, that are mostly developed in the frontal zone, are observed in the outlying areas of the vortex.

6) Eddying of the stream of the Labrador Current from time to time causes intensive influxes of cold waters onto the shallow on the northeastern and southwestern slopes of the Grand Bank (Fig. 2B).

7) Above the Green and St. Pierre Banks, the currents are weak and unstable in directions. Apparently, circular motion of waters is most often observed there (Fig. 2B).

On the Flemish Cap Bank waters mainly move in a clockwise direction, but on the southeastern part of the Bank secondary eddies with a movement of waters in an anticlockwise direction are observed (Figs. 2A, 3A).

Observations on the section along the isobath of 275 m on the southwestern slope of the Grand Bank (Divs. 3O and 3P) made during the six cruises of R/V *Protsion* are indicative of the existence of great influxes of the Gulf Stream waters onto the shallow of the Bank and into the deep water layers, from a depth of 100-200 m to the bottom of the Laurentian Channel (Fig. 4). A comparison between the diagrams of vertical distribution of temperature, salinity, density and isotach shows that on the southwestern slope of the Bank:

a) transformed waters of the Gulf Stream underlie the Labrador Current waters in the areas of canyons and trenches,

b) there exists an intensive exchange of water masses in the direction that is transversal to the axis of the Labrador Current. The latter circumstance promotes transformation of cold waters of the Labrador Current.

Variation of the circulation intensity

The value of transport across a selected section is an integral indicator of the circulation intensity. The main sections making up the existing pattern of standard sections cross the Labrador Current approximately at right angles. The transports were computed for Sections 8-A, 6-A and 3-A, i.e., for various parts of the Labrador Current. The average curves of the yearly course of transports based on many-years' data (*Bull. U.S. Cst. Guard*, 1956-64) were used as the basis to estimate the anomaly of transports. We partially corrected these curves, using the results of our observations and calculations.

Section 8-A coincides with the section South Wolf Islands-Cape Farewell. The transport across the section was calculated from 53°43'N to 55°12'N, i.e., within the limits of all three branches of the Labrador Current (ABC) (see Fig. 1 in Res.Doc. 72/105 by Kudlo and Burmakin, this book) right to the bottom (0-2,000 m). We can assume that the values of transports thereby calculated are similar to American data. From the data collected by R/V *Perseus III* during the sixth cruise, the transport of the Labrador Current on the Hamilton Inlet Bank in July 1971 (Table 1) was lower than the norm by 3.7 $10^6 m^3$/sec which is a minimum value from a series of observations for July.

The distance between Section 6-A along 47°N and the International Ice Patrol section F along 46°50'N being small makes it possible to assume that the values of transports of the Labrador Current across these sections do not differ essentially.

The transports from the PINRO materials across Section 6-A were calculated from 49°07' to 46°30'W (H_1G H_2) (Table 1) and combined with American data pertaining to section F. The average (normal) curve is satisfactorily substantiated with the data only for the April-July period. For the rest of the months, a preliminary curve of the seasonal course of transports based on single observations was constructed. In relation to this curve the intensity of the Labrador Current on Section 6-A from May to October 1970 varied from the norm to considerably exceeding it in August and then dropped by 0.5 $10^6 m^3$/sec below the norm in October (Table 1). In March 1971 the transport was higher than the norm but by the end of April decreased nearly to the norm, exceeding it by only 0.3 $10^6 m^3$/sec and at the end of May dropped below the norm by 1.5 $10^6 m^3$/sec.

Section 3-A was identified with section U of the International Ice Patrol.

The transport of the Labrador Current across Section 3-A from the PINRO observations in 1971 was calculated from 45°00'N, 49°10'W to 44°50'N, 48°30'W. The curve of the seasonal course of transport from

April to June 1971 appeared to be reverse to the long-term curve of the yearly course of transports of the Labrador Current across this Section (Table 1). Within a period of 3 months the anomaly of transports varied from -3.0 to +3.2 000 000 m^3/sec. A series of observations being short diminishes the reliability of the "normal" curve used to compute the anomaly of transports.

Table 1. Transports of the Labrador Current and their anomalies across some standard sections in the Labrador and Newfoundland area in mill.m^3/sec (1970-1971).

Sections and sectors		Date	Transport		
			Observed	Norm	Anomaly
8-A	ABC	29-30 July 1971	2.14	5.8	-3.7
6-A	H_1GH_2	19-20 May 1970	3.28	3.2	0.0
		8 August 1970	6.38	3.5	+2.9
		5- 6 October 1970	2.92	3.4	-0.5
		19-20 March 1971	4.03	2.9	+1.1
		30 April-1 May 1971	3.42	3.1	+0.3
		24-25 May 1971	1.67	3.2	-1.5
3-A		19-20 April 1971	1.98	5.0	-3.0
		15-16 May 1971	3.72	4.2	-0.5
		26 June 1971	6.20	3.0	+3.2

Though the data on the transport of water masses by the Labrador Current pertaining to its various parts are scarce, they indicate that its intensity varies greatly. The intensity of the Current in various parts varies with time having different signs: at one and the same period, one section can exhibit a high positive anomaly while another shows a high negative anomaly. What causes this phenomenon is not yet clear but there can be no doubt this process is a decisive one in the forming of water temperature anomalies in various parts of the Current.

Conclusions

1. The general circulation in the South Labrador-Newfoundland area is highly stable.

2. The intensity of the Labrador Current in its various parts varies having different signs. One of the reasons of it is the eddying of the Current and cold water influxes on the shallows of the Grand Bank.

3. On the southwest slope of the Grand Bank and in the trenches between the Green Bank and St. Pierre Bank, the penetration of warm waters in shallows is observed. This phenomenon as well as the lateral exchange accelerate the transformation of the cold Labrador waters.

4. The intensity of the Labrador Current on the Hamilton Inlet Bank in July 1971 was the lowest for a whole period of observations. In March 1971 the transport across Section 6-A was higher, then decreased to the norm by the end of April, and at the end of May dropped below the norm by 1.5 $10^6 m^3$/sec. On Section 3-A the anomalies of the transport from April to June 1971 varied from a high negative to a high positive value.

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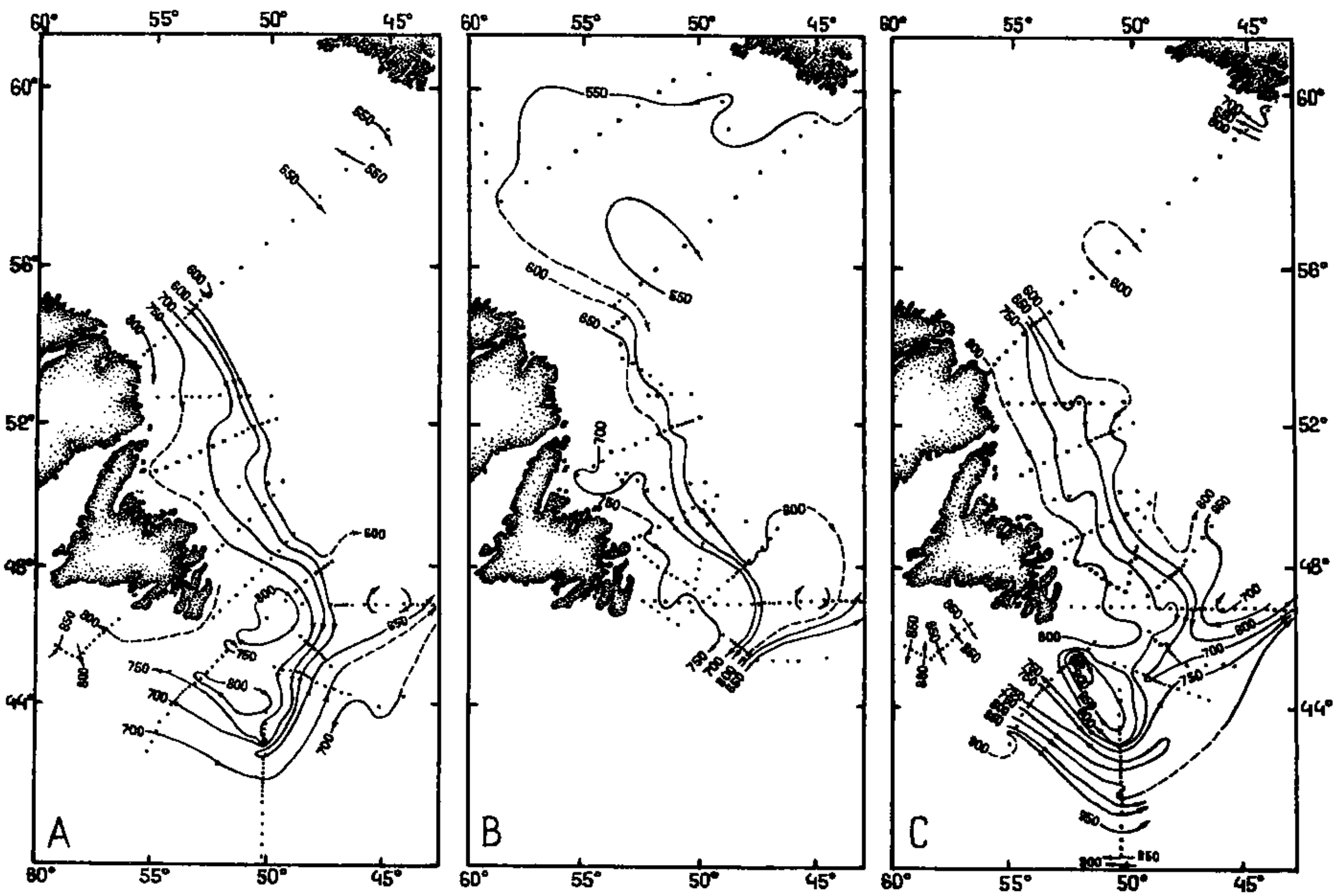

Fig. 1. Dynamic charts (0-200 decibars) from data of the second, third and fourth cruises of R/V *Protsion* in 1969-1970: 14 December 1969-14 February 1970 (A); 23 April-12 June 1970 (B); 1 September-30 October 1970 (C).

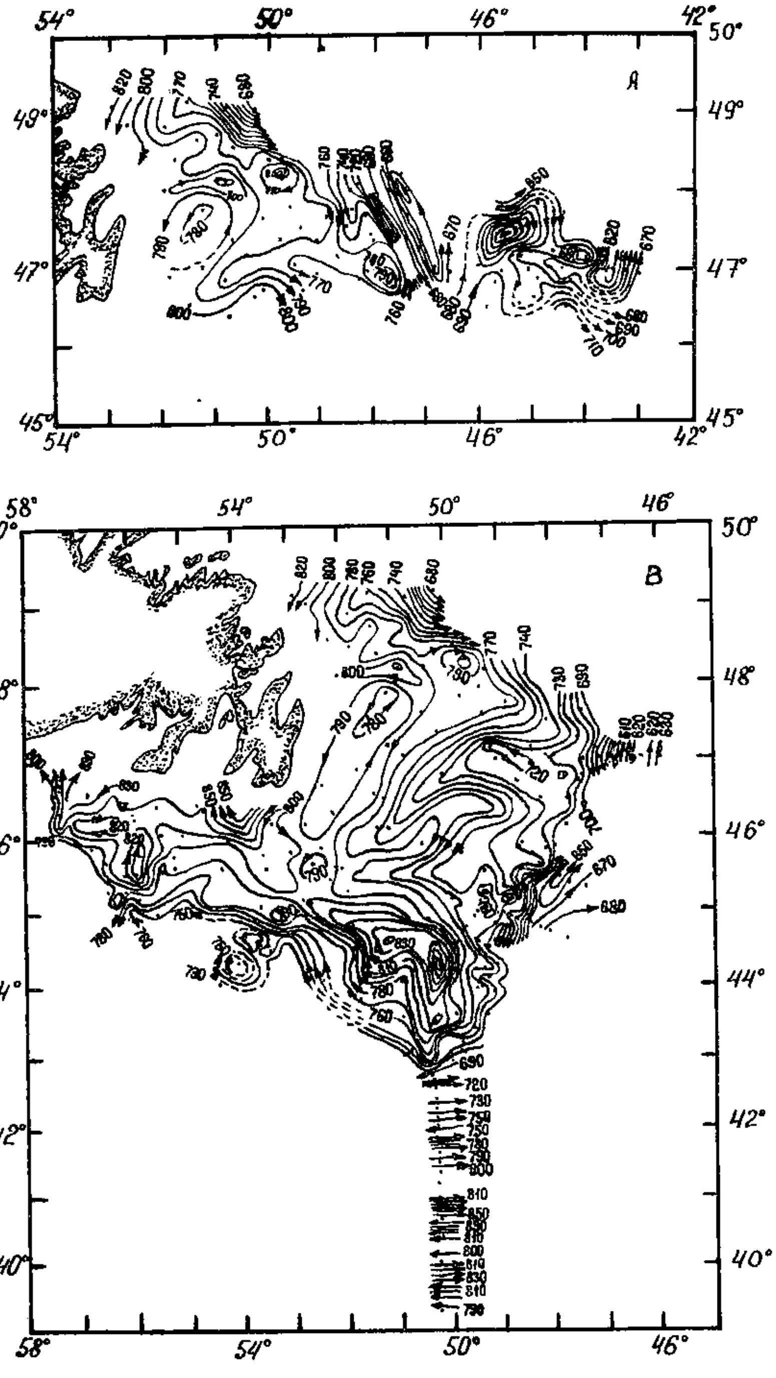

Fig. 2. Dynamic charts (0-200 decibars) from data of the thirteenth cruise of R/V *Rossiya* in 1970: 24 July-13 August (A); 15 May-31 July (B).

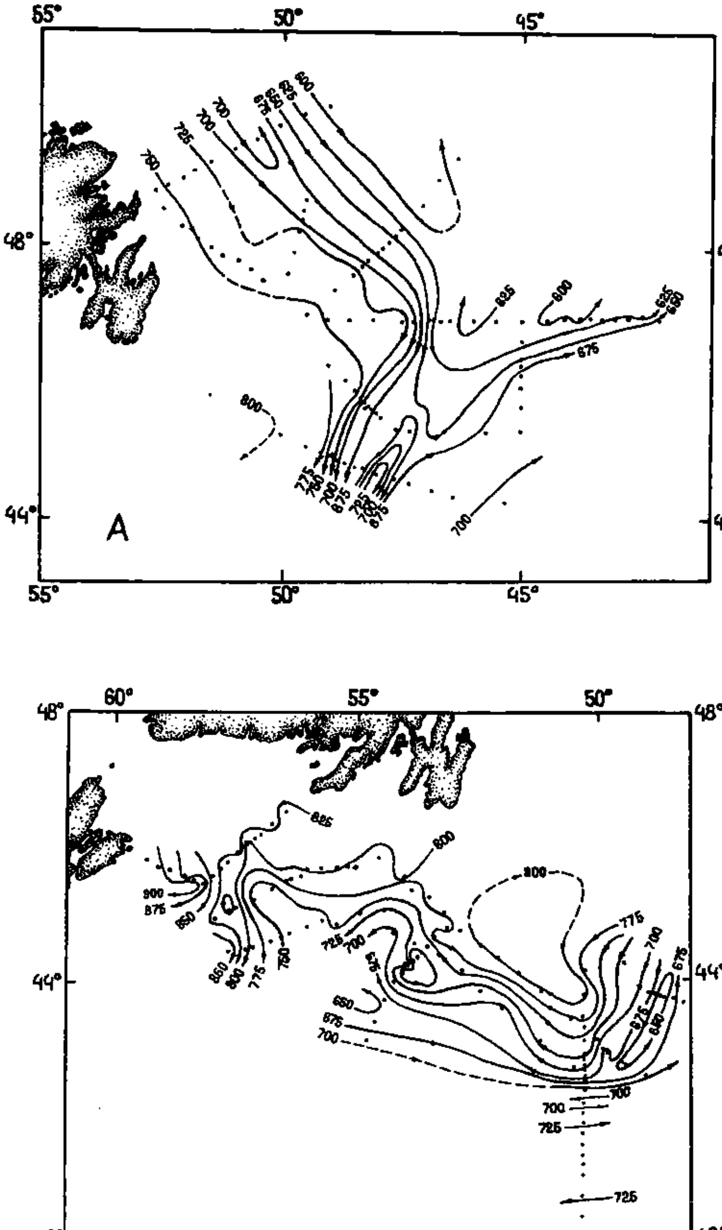

Fig. 3. Dynamic charts (0-200 decibars) from data of the sixth cruise of R/V *Protsion* in 1971: 19 April-8 May (A); 22 March-11 April (B).

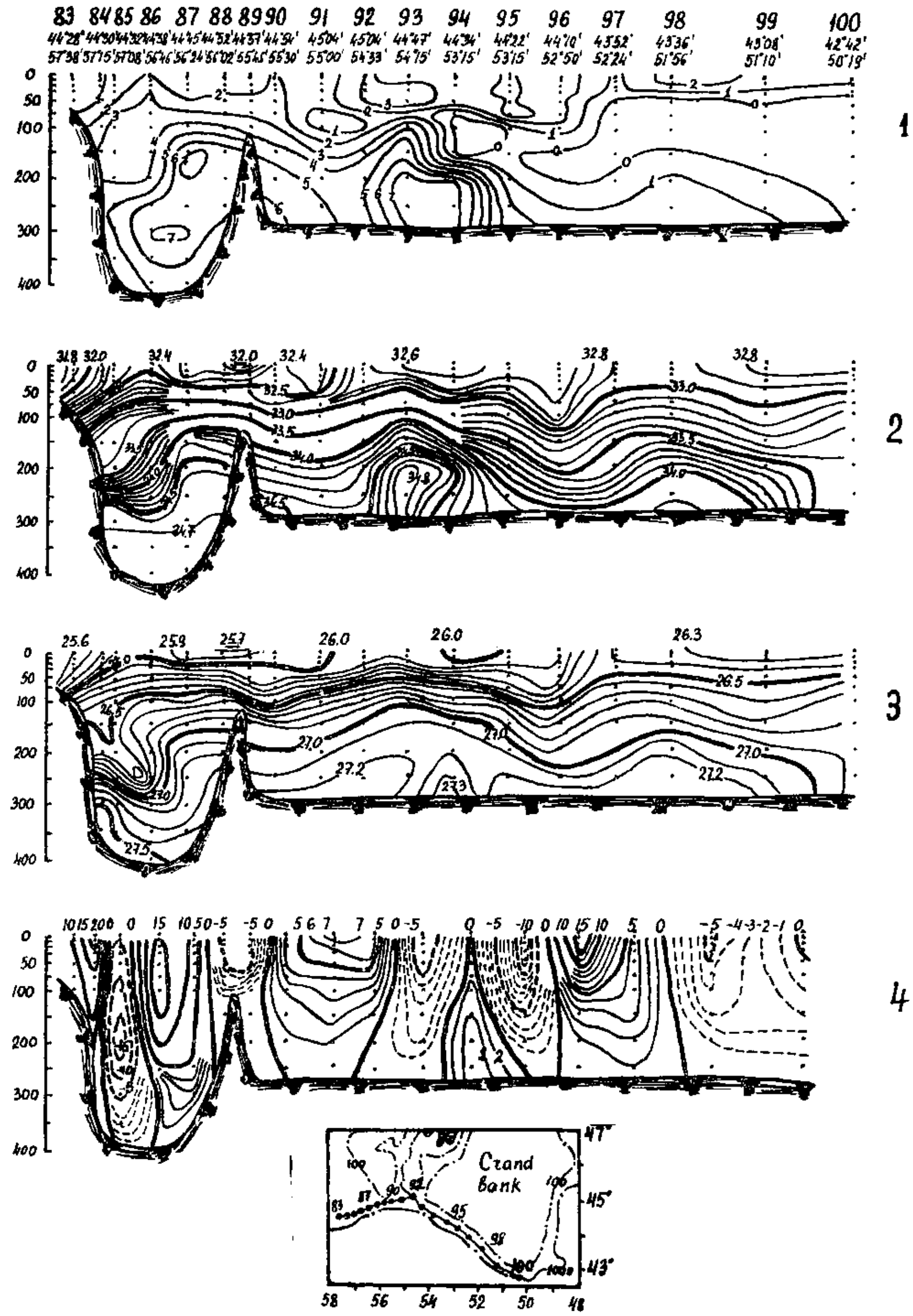

Fig. 4. The distribution of temperature (1), salinity (2), conventional density (σ_t) (3), and isotachs (4) on the section along the 275-m isobath on the southwest slope of the Grand Bank, 30 March-2 April 1971, the sixth cruise of R/V *Protsion*.

Solid isotachs represent southward flows.

SECTION B
COD

5. Combined virtual population assessment for ICNAF Divisions 2J, 3K and 3L cod[1]

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Introduction

A virtual population assessment of ICNAF Division 2J cod has been presented by Pinhorn (1971) and has been updated at the present meeting (Res.Doc. 72/3). In addition, a similar assessment for Divisions 3K and 3L cod is contained in a document to the 1972 Annual Meeting. The combined assessment for Divisions 2J-3L cod is presented here.

Materials and methods

The basic data used and the method of treatment of the data to produce the individual virtual population assessment for Divisions 2J, 3K and 3L cod are presented in the relevant documents. In deriving the assessment for Divisions 2J-3L combined, numbers of cod caught at each age (Table 1) were combined for the three divisions and a separate VPA was determined using the combined data. Natural mortality of 0.2 was again used and $E(1-e^{-Z}) = 0.506$ was assumed for the oldest age-groups. Average weight-at-age data were derived from growth curves and length-weight curves for the most recent period available for each division and these were weighted by the average numbers caught in each division for the same period to produce average weight-at-age values for Divisions 2J-3L.

Table 1. Number of cod caught per year and age-group, ICNAF Divisions 2J-3L, 1961-70 (x 10^{-3}).

	Year									
Age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
3	1,543	8,866	5,644	18,183	5,042	14,177	15,587	5,993	4,192	17,053
4	32,268	26,682	27,069	26,676	28,034	66,290	78,450	91,606	38,098	57,228
5	45,692	65,820	59,173	56,321	45,633	94,234	100,904	199,044	96,366	77,311
6	58,462	59,973	115,864	58,957	65,481	63,221	97,204	144,998	153,370	93,961
7	45,345	48,635	57,875	98,050	62,862	59,771	55,252	80,902	100,645	78,789
8	34,903	28,389	28,760	49,025	67,106	30,656	38,820	37,891	49,342	26,873
9	29,480	20,748	15,186	20,191	33,353	24,045	17,190	22,431	18,370	9,981
10	22,169	18,599	11,371	11,792	14,674	8,828	16,103	7,647	11,540	3,576
11	12,793	10,767	8,061	8,433	6,845	4,652	5,962	5,374	6,002	1,876
12	12,025	9,755	4,117	6,111	3,680	2,254	3,360	3,362	4,190	1,129
13	9,766	8,038	3,855	4,811	3,881	1,836	2,113	1,902	2,820	478
14	7,398	5,954	2,872	3,869	3,672	1,194	1,523	1,302	1,479	215
15	4,026	4,798	2,864	2,615	2,685	972	683	802	598	210
15+	4,941	11,321	5,060	5,407	4,012	2,331	1,094	1,010	852	349
Total	320,811	328,345	347,771	371,241	346,960	374,461	434,245	604,264	487,921	375,510

Results

Fishing mortality

Fishing mortality estimates (F) for ages 3-13 fluctuated around 0.3-0.4 during 1961-66, except for 1965 when F was 0.46 (Table 2). The F in 1968 was 0.56, the highest value during the period. F-values for fully recruited age-groups of 1.20 for 1969 and 0.68 for 1970 were estimated from stock sizes at the beginning of each year and the catch in that year as shown below. Cod from this stock complex are fully recruited at 7 years of age with very few 3-year-olds being taken, the 50% recruitment age being about 5.4 years.

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/109.

Age	1969	1970
4	0.05	?
5	0.16	0.13
6	0.42	0.24
6+	1.20	0.68

Table 2. Fishing mortality estimates for ICNAF Divisions 2J-3L cod, 1961-68.

Age	Year 1961	1962	1963	1964	1965	1966	1967	1968	$\bar{F}$ 1961-68	Change in F with age as % of fully recruited age-groups 1961-68
3	0.003	0.014	0.012	0.026	0.006	0.012	0.015	0.006	.01	2
4	0.042	0.059	0.055	0.070	0.050	0.10	0.08	0.11	.07	15
5	0.11	0.11	0.18	0.15	0.15	0.23	0.22	0.31	.18	38
6	0.24	0.20	0.30	0.27	0.27	0.31	0.39	0.56	.32	67
7	0.33	0.33	0.31	0.45	0.51	0.43	0.50	0.66	.44	100
8	0.35	0.35	0.33	0.48	0.64	0.50	0.56	0.78	.50	100
9	0.39	0.37	0.32	0.41	0.69	0.50	0.58	0.77	.50	100
10	0.44	0.46	0.35	0.44	0.59	0.39	0.75	0.56	.50	100
11	0.31	0.39	0.37	0.47	0.50	0.37	0.51	0.60	.44	100
12	0.42	0.41	0.25	0.53	0.39	0.30	0.49	0.61	.43	100
13	0.58	0.56	0.28	0.52	0.77	0.34	0.50	0.59	.52	100
Average ages 4-13	0.32	0.32	0.27	0.38	0.46	0.35	0.46	0.56		
Average ages 7-13	0.40	0.41	0.32	0.47	0.58	0.40	0.56	0.65		

Stock size

Numbers present in the stock at the beginning of the year (Table 3) indicated that the total stock size of fish 4 years old and older decreased from 2,200 million in 1961 to 1,800 million in 1964, but increased to 2,400-2,500 million in 1968-69, due to better recruitment from the year-classes of the early 1960's. The numbers of fully recruited fish (6+) decreased from 643 million in 1961 to 320 million in 1969.

Yield per recruit

Yield per recruit calculations incorporating the partial recruitment estimates shown in Table 2 produced an almost flat-topped curve with a point of maximum sustainable yield per recruit at an F-level of about 0.4 and an optimum fishing level according to the definition of the Mid-Term Assessment Subcommittee Meeting (1972) at a level of 0.28 (Fig. 1). The level of F in fully recruited age-groups during 1961-66 fluctuated around the level of maximum yield per recruit except for 1965 when it was beyond it, but the F during 1967-70 was estimated to be well beyond the maximum level. Considerable reduction in fishing effort below the recent levels is necessary to even return to the point of maximum sustainable yield and as indicated by the Assessment Subcommittee at its Mid-Term Meeting (1972), fishing at a point somewhat below the maximum level is more practicable in cases of flat-topped yield curves. Such a reduction would not impair the long-term yield but would result in increased catch per unit of effort.

Predicted yields in 1973

Probable yields in 1973 for any likely combination of F in 1971-73 are shown in Figs. 2 and 3. These are calculated in a similar manner to those calculated in recent years for Subarea 1 cod (*Redbook* 1971, Part I). Recruitment of the 1967 and 1968 year-classes in 1971 and 1972 was estimated from USSR survey data in Division 3K as presented in Konstantinov (1971) and in 1972 Mid-Term Assessment Subcommittee Report (ICNAF Res.Doc. 72/1). Recruitment from the 1969 year-class in 1973 was assumed to be at the same level as the 1968 year-class in 1972. Since the recruitment pattern (pattern of fishing) in 1969 and 1970, as is shown by the above text table, was different from the average recruitment pattern for 1961-68, probably

Table 3. Number of cod present in the stock at the beginning of the year (x 10^{-6}), ICNAF Divisions 2J-3L, 1961-68.

	Year								
Age	1961	1962	1963	1964	1965	1966	1967	1968	1969*
4	811	482	566	429	630	764	1,092	948	903
5	484	666	396	439	347	499	565	833	707
6	301	360	501	272	309	257	329	369	491
7	177	192	241	297	171	189	155	183	173
8	129	104	112	143	155	85	99	76	77
9	100	75	61	66	73	67	42	46	29
10	68	55	42	36	36	30	33	20	17
11	53	36	29	24	19	16	16	13	9
12	38	32	20	16	13	10	9	8	6
13	24	21	17	13	8	7	6	5	4
14	25	15	11	11	8	3	4	3	2
15	13	15	11	7	6	4	2	2	1
15+	16	26	20	15	11	8	4	2	2
Total ages 4-15+	2,239	2,079	2,027	1,768	1,786	1,939	2,356	2,508	2,421
Total ages 7-15+	643	571	564	628	500	419	370	358	320

* Estimated from stock at beginning of 1968 and F in 1968.

because of severe ice conditions in the north and since ice conditions were reported to be more severe than usual in this area in 1971 and 1972, two sets of calculations were performed; those shown in Fig. 2 using the average recruitment pattern for 1971-73 and those shown in Fig. 3 using the 1969-70 recruitment pattern for 1971 and 1972 and the average recruitment pattern for 1973.

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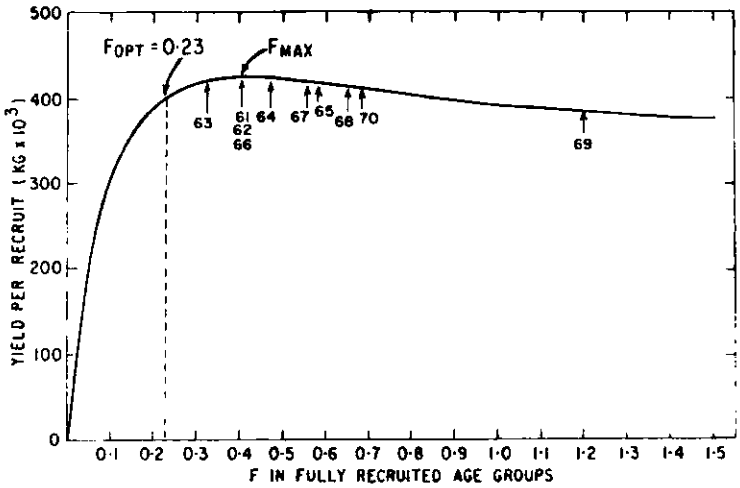

Fig. 1. Yield per recruit for Divisions 2J-3L cod.

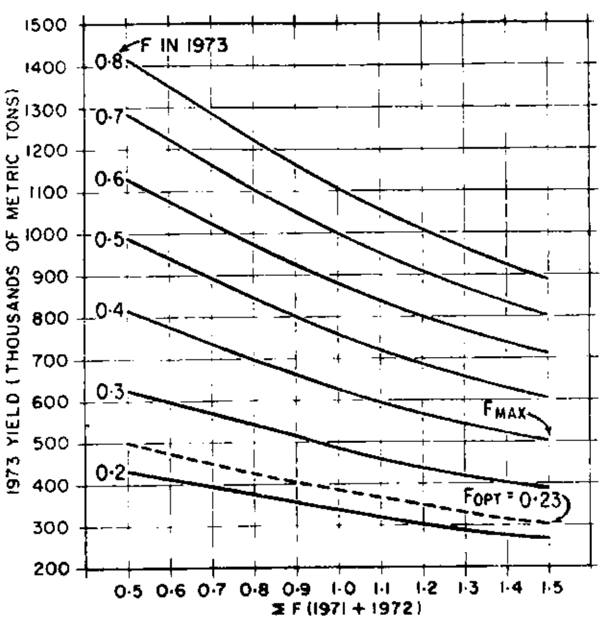

Fig. 2. Estimated yield in 1973 for likely combinations of F in 1971-73 assuming average recruitment pattern in 1971-73.

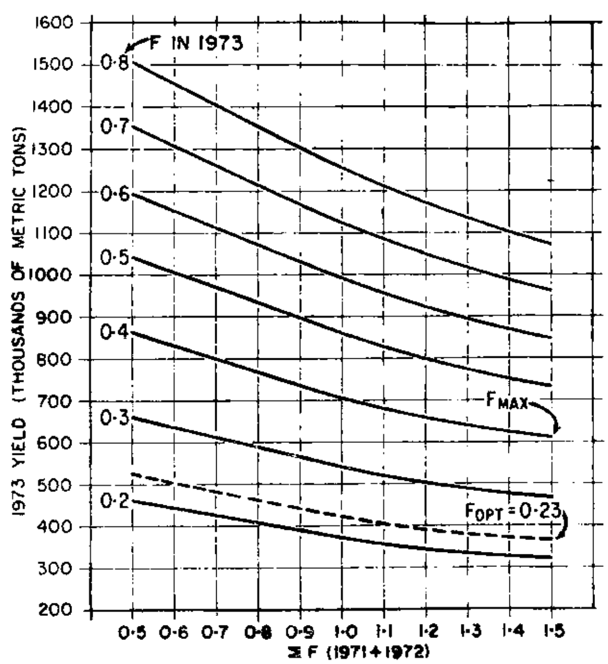

Fig. 3. Estimated yield in 1973 for likely combination of F in 1971-73 assuming recruitment pattern in 1971 and 1972 to be same as in 1969-70 and average recruitment pattern in 1973.

6. On two types of diurnal vertical migrations of sea fishes[1]

by K.G. Konstantinov and T.N. Turuk
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Staying close to the bottom in the daytime and scattering in upper water layers at night are very typical for cod and haddock behaviour. Consequently, catches of these fish species taken by a bottom trawl are, as a rule, larger in the daytime than at night. The biological importance of cod and haddock diurnal vertical migrations is related to the food supply. These fish move up and down in the water layers together with their travelling prey. In their turn, capelin, herring, Euphasiidae, etc., the main food objects of cod and haddock, repeat the diurnal vertical migrations of zooplankton, for instance, Calanoida. While surfacing at night, Calanoida get in the feeding area where phytoplankton occur. But, as the small plankton Crustacea sink in the daytime, they avoid plankton-eaters that search their prey mainly with their eyes. Therefore, by sinking into semi-lit deep layers by day, zooplankton find themselves relatively safe from predation.

Change in illumination is an orienting factor for all water animals performing diurnal vertical migrations (Konstantinov, 1958, 1964*a*). In the process of evolution there developed an adaptive reaction to illumination. Such a reaction enables the migrating animals to get into the feeding or safe layers at the proper time. Similarly, almost indefinable differences in the chemical composition of river water enable the diadromous salmon to find a way in "their" stream and insignificant fluctuations of sea water temperature pre-determine areas to which capelin will migrate to spawn (Konstantinov, 1964*b*, 1965, 1967; Prokhorov, 1965).

However, it is known that cod and haddock sometimes perform diurnal vertical migrations of another, quite opposite type: they migrate to deep water at night and to the upper water layers in the daytime. In such cases, catches taken by bottom trawl at night are greater than those obtained in the daytime (Kopytov, 1955; Jones, 1956). Both types of diurnal vertical migrations for cod are essentially described by Brunel (1963, 1965).

Regular expeditions were carried out by the authors in an attempt to reveal reasons why cod sometimes make diurnal vertical migrations of the first type and sometimes of the second type. In 1964-1968 diurnal stations were occupied in the Northwest Atlantic by USSR research vessels (*Sevastopol*, *Novorossiisk*, *Rossiya*). A number of trawlings of equal duration was carried out at each station along a constant course (near a moored buoy). All the cod caught were measured and stomachs of 10 small fish (less than 50 cm in length), of 10 average-size specimens (51-70 cm) and of 10 large fish (greater than 70 cm) taken from each catch were fixed in formalin solution. Later, the content of stomachs was analyzed in the laboratory on shore. A comparison of all results showed that diurnal vertical migrations of the second type (to the bottom at night and to upper water layers in the daytime) are performed by cod while feeding on *bottom animals*.

Data on the food composition of cod stomachs taken at one diurnal station occupied during 3-5 March 1967 near a buoy moored at 48°35'N, 50°32'W are given in Table 1. Figure 1 shows the fluctuation in cod catches taken by bottom trawl, the largest catches being obtained at night when the cod were close to the bottom.

To characterize a value of main food objects for cod, an index often used by the Soviet ichthyologists was applied: it is a *partial index of stomach fullness*. The weight of any food object found in the stomach of a fish analyzed is divided into the weight of the fish and the result expressed in per decimilles (‱). Using this index one can compare the food value of any object in different fish or in various samples (sets) even when the individual fish are different in weight. A partial index of stomach fullness was introduced into practice by Zenkevich and Brotskaya (1931).

In stomachs of cod caught at the diurnal station, both the bottom and actively swimming animals were found. To find out what animals affect the behaviour of feeding cod to a greater extent, it is necessary to take into account not only a partial index of stomach fullness but also the *frequency of occurrence* (i.e., the ratio of a number of stomachs containing a certain food object to the whole number of stomachs in a sample). As is evident from Table 1, actively swimming animals (for instance, capelin) were found in a smaller number of stomachs compared to bottom animals. When studying the feeding of fish, Komarova (1939) and Zatsepin (1939) used a further index called the *significance index*, which is the geometric mean of a *partial index of stomach fullness* and *frequency of occurrence*. (In other words, when "a" is an index of stomach fullness, "b" is frequency of occurrence; then $\sqrt{ab}$ is significance index.)

A comparison of the significance indices for bottom and actively swimming animals indicates that cod caught at the diurnal station were feeding more on bottom animals than on pelagic ones (Table 1).

The fact that cod feeding on such animals remain near the bottom at night is easily explained. Cod is a night and crepuscular predator; as shown in aquarium observations by Tarverdieva (1962) and Woodhead (1965), cod move and feed more actively at night than in the daytime. When they are feeding on animals which

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/99.

Table 1. Food composition of cod caught on a diurnal station.

Trawl haul No.	Date of trawling	Time and duration of trawling	Pelagic animals (Mallotus, Themisto)			Bottom animals (Polychaeta, Isopoda, Cumacea, Amphipoda, Decapoda, Mollusca, Ophiurae)		
			Partial index of stomach fullness (‰o)	Frequency of occurrence in stomachs (%)	Significance index	Partial index of stomach fullness (‰o)	Frequency of occurrence in stomachs (%)	Significance index
101	3 March	2110 - 2210	874.1	13.3	107.8	631.6	90.0	238.4
102	4 March	0010 - 0110	873.9	33.3	170.5	539.1	96.6	228.2
103		0455 - 0555	3321.2	60.0	446.3	728.6	83.2	246.2
104		1010 - 1110	239.9	43.3	101.9	629.2	96.6	246.5
105		1400 - 1500	851.9	30.0	159.9	436.5	86.6	194.6
106		1735 - 1835	446.4	10.0	66.8	968.1	100.0	311.1
107		2110 - 2210	720.1	43.3	176.6	339.4	86.6	171.4
108	5 March	0025 - 0125	73.5	20.0	38.3	668.3	93.2	249.6
109		0335 - 0435	489.5	26.6	114.1	775.3	90.0	264.1
110		0705 - 0805	4.6	30.0	11.7	700.0	100.0	264.6

move to the upper water layers, cod also swim to the surface together with these animals at night (changes in intensity of illumination serve as an orienting factor); i.e., when feeding on actively swimming animals, cod conduct diurnal vertical migrations of the first type. On the contrary, when they are feeding mainly on bottom animals, cod remain near the bottom at night and scatter in the water layers in the daytime; i.e., they carry out diurnal vertical migrations of the second type.

It is essential to note that bottom animals play a smaller role in a diet of the Barents Sea cod than in that of the Northwest Atlantic cod (Turuk, 1968). In connection with such a difference in feeding, the Barents Sea cod mostly conduct diurnal vertical migrations of the first type, whereas cod in the Northwest Atlantic mainly perform those of the second type. A knowledge of these features of cod behaviour is very essential in conducting a fishery using a bottom trawl.

Many fish species, such as redfish, herring, argentine, luminous anchovy, etc., feed only in upper water layers and seldom take food from the bottom. Diurnal vertical migrations of the first type (moving upwards at night and sinking to depths in the daytime) are common to all these fishes. For instance, bottom trawl catches of redfish are always greater in the daytime (Konstantinov and Scherbino, 1958; Templeman, 1959).

The biological importance of diurnal vertical migrations for fish is concerned with the food supply and periodical changes in illumination serve as an orienting factor. Other environmental conditions (e.g., temperature, salinity, etc.) are not motive forces for diurnal vertical migrations, although in some cases, they can be limiting, especially when a sharply pronounced thermocline is observed. However, as indicated in Table 2, the temperature and salinity both near the bottom and in the upper water layers were either almost unchanged or fluctuated without any certain periodicity.

Table 2. Water temperature (°C) and salinity (°/₀₀) at a diurnal station in the Northwest Atlantic.

Depth (m)	Date and time								
	3 March 2340	4 March 0425	4 March 0937	4 March 1330	4 March 1649	4 March 2040	5 March 0010	5 March 0310	5 March 0620
0	-1.67	-1.66	-1.67	-1.60	-1.60	-1.64	-1.66	-1.66	-1.66
20	-1.64	-1.66	-1.68	-1.64	-1.65	-1.64	-1.65	-1.65	-1.66
50	-1.70	-1.66	-1.64	-1.59	-1.64	-1.61	-1.64	-1.66	-1.69
75	-1.64	-1.64	-1.57	-1.58	-1.61	-1.60	-1.61	-1.62	-1.65
100	-1.51	-1.55	-1.58	-1.55	-1.56	-1.56	-1.57	-1.60	-1.64
150	-1.44	-1.55	-0.84	-0.55	-1.64	-1.02	-0.68	-1.36	-1.44
200	0.31	0.16	-0.12	-0.01	-0.24	-0.21	-0.20	-0.31	-0.40
0	32.72	32.72	32.70	32.72	32.73	32.73	32.73	32.71	32.74
20	32.73	32.71	32.71	32.90	32.73	32.73	32.73	32.71	32.73
50	32.79	32.69	-	32.79	32.76	32.78	32.75	32.73	32.75
100	32.89	32.86	32.83	32.85	32.82	32.84	32.83	32.80	32.76
200	33.38	33.35	33.25	33.32	33.24	-	33.26	-	33.21

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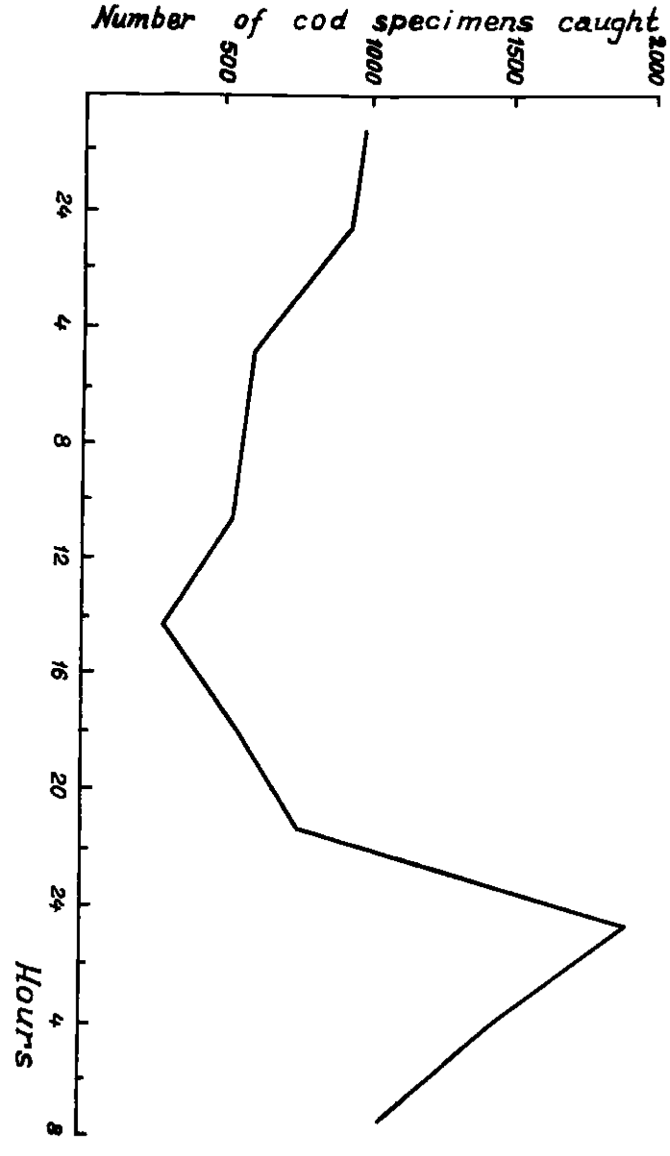

Fig. 1. Cod catches per 1 hour trawling taken by a bottom trawl on a diurnal station.

SECTION C
AMERICAN PLAICE

7. Note on length at sexual maturity of American plaice, *Hippoglossoides pl. platessoides*, on Saint Pierre Bank (ICNAF Subdivision 3Ps)[1]

by J.P. Minet
ISTPM, St. Pierre and Miquelon

I. Introduction

The American plaice (*Hippoglossoides pl. platessoides*) population on Saint Pierre Bank has been long exploited by Canadian fishermen (especially Newfoundlanders) and Saint Pierrers. ICNAF statistics show that this fishing was of little importance until 1969. Average catches between 1960 and 1969 were 2,459 tons a year.

The sexual maturity of American plaice has been the subject of several studies, notably that by Pitt (1966) part of which was on Saint Pierre Bank.

The samples for our study were collected during a cruise made by R/V *Cryos* on Saint Pierre Bank in February 1972. The trawling locations and stations where the sexual state of the fish was studied are shown in Fig. 1. Measurements (total length in centimeters below) and gonad examinations were made on 1,072 specimens. To determine precisely the maturity stages of the individuals collected, we used the descriptions of Pitt (1966, p. 653).

From these data, length frequency curves were established for immature individuals as well as for each sex. Further, these data permitted calculation of the length (Lt) at which 50% of the males and 50% of the females became ripe. For that, we used the method described by Fleming (1960).

II. Results

The results of gonad examination are shown in Table 1. This shows that 83.8% of the males were ripe and only 6.4% of the females. The average percent of ripe males and females combined was 39.5%.

Table 1. Results of gonad examination. (M% = percentage of ripe fish).

	No. Immature	No. Mature	No. Total	M%
No. males	74	384	458	83.8
No. females	575	39	614	6.4
No. total	649	423	1,072	39.5

The length frequency of immatures has been shown in relation to that for the males and females (Fig. 2). This shows very clearly the different proportions of immatures in each sex. We note, furthermore, that immature males are found to a length of 34 cm with a maximum number at 24 cm. For the females, the maximum length attained by the immatures is almost 50 cm, the modal length agreeing with that for all the females (30 cm).

The relationship between length and sexual maturity for males and females is shown in Fig. 3. The inflection points (where 50% of the individuals are mature) of the sigmoid curves show that half of the males are mature at 22.7-cm length, while half of the females are ripe at 44.3 cm. These lengths reported in the linear growth of American plaice on Saint Pierre Bank by Pitt (1967) correspond to about 6 years of age for the males and a little more than 14 years for the females. Our results are somewhat different from those of Pitt (1966) for Saint Pierre Bank; for this author, the length at 50% maturity is 27.8 cm (age 7.48 years) for males and 44.6 cm (age 14.21 years) for females. With the results for the females very close (lengths of 44.3 cm and 44.6 cm), the difference between the length at maturity of the males (22.7 cm and 27.8 cm) is difficult to explain.

III. Conclusions

Our results show that 16.2% of males and 93.6% of females taken on Saint Pierre Bank were immature; this gives an average of 60.5% of immatures for the whole population.

The average length at 50% ripeness obtained in the combined sexes is about 33.5 cm (Lt). Now we know that the minimum commercial length of American plaice is fixed on the different markets at 32 cm (Lt). The fishing effort seems then to fall on the mature stock of the population, thus saving the individuals

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/56.

which have still not spawned even once. Such a hasty conclusion would not take account of individuals captured of less than 32-cm length, largely immature, which are discarded at sea by the commercial vessels and so lost from the stock, as noted by Powles (1965, p. 573-574) for American plaice in the Gulf of St. Lawrence.

To better show the situation, we have calculated the percentage of males and females less than 32 cm taken by the R/V *Cryos* on Saint Pierre Bank in three other seasons (spring, summer and autumn). This vessel has made seasonal trawlings at the standard locations shown in Fig. 1. The length frequencies at different seasons (Fig. 4) allow us to assess the order of magnitude of the discards of young specimens by the commercial fishing boats on Saint Pierre Bank. We note that in the three seasons under consideration, the fish not of commercial size varied from 63 to 77%. Examining the length frequencies for February 1972 (Fig. 2), we note, on the other hand, that 71% males and 64% females are not commercial size. Taking account of the fact that all these percentages only take in immature females and a large proportion of males not yet sexually mature, the future of such a population appears very uncertain.

To these observations, it is necessary to add that fishing effort on American plaice on Saint Pierre Bank has very definitely intensified in 1970: 12,328 tons landed in 1970 against 4,295 tons only in 1969. Table 2 shows the development of the catches from Saint Pierre Bank from 1967 to 1970: catches by Saint Pierre relatively small and stable, catches by Canada increased x4 by the Maritimes and x3 by Newfoundland, a small Soviet fishery appearing in 1970.

Table 2. The development of the landings (in metric tons) from 1967 to 1970 for American plaice from Saint Pierre Bank as shown by ICNAF statistics.

Country	Year			
	1967	1968	1969	1970
Maritime Provinces	805	1,512	1,162	4,227
Newfoundland	2,199	4,007	2,888	7,368
St. Pierre & Miquelon	533	524	245	397
USSR	-	-	-	336
Total	3,537	6,043	4,295	12,328

It is very evident that all the factors just described:

- very important percentage of immature (60.5%) in the population,
- relatively great average length at maturity (33.5 cm),
- high capture or discard (average of 70% of the population) of young fish less than 32 cm in length,
- and considerable intensification of the fishery (total catch increases x3 from one year to the other),

can only, in this combination, seriously compromise the future of the American plaice fishery on Saint Pierre Bank.

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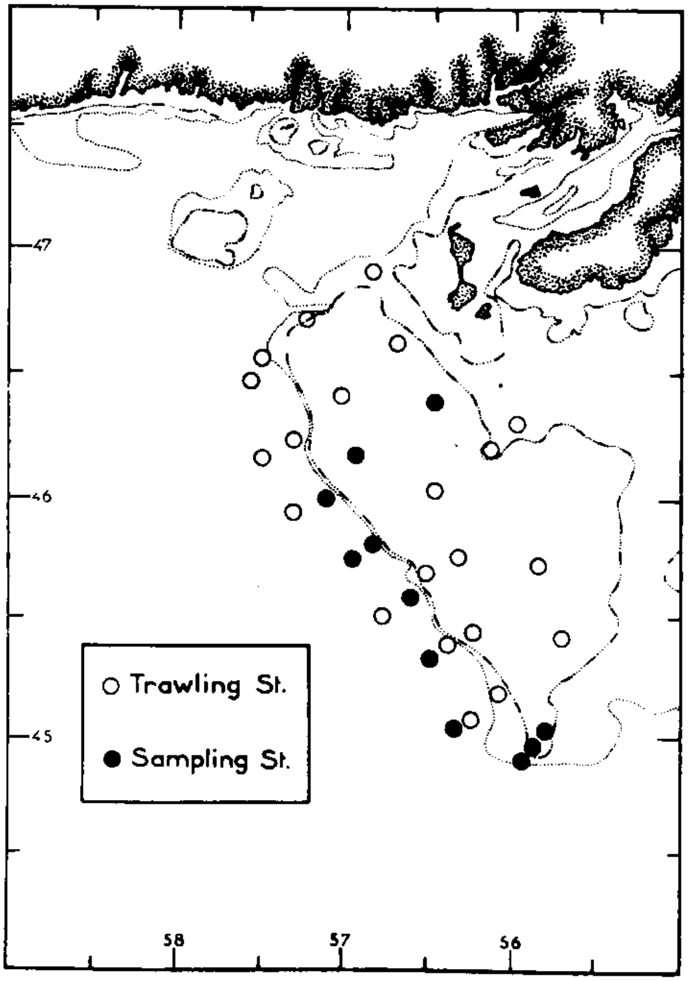

Fig. 1. Location of seasonal stations occupied by R/V *Cryos* on Saint Pierre Bank. Solid black circles: Gonad sampling stations during the February 1972 cruise.

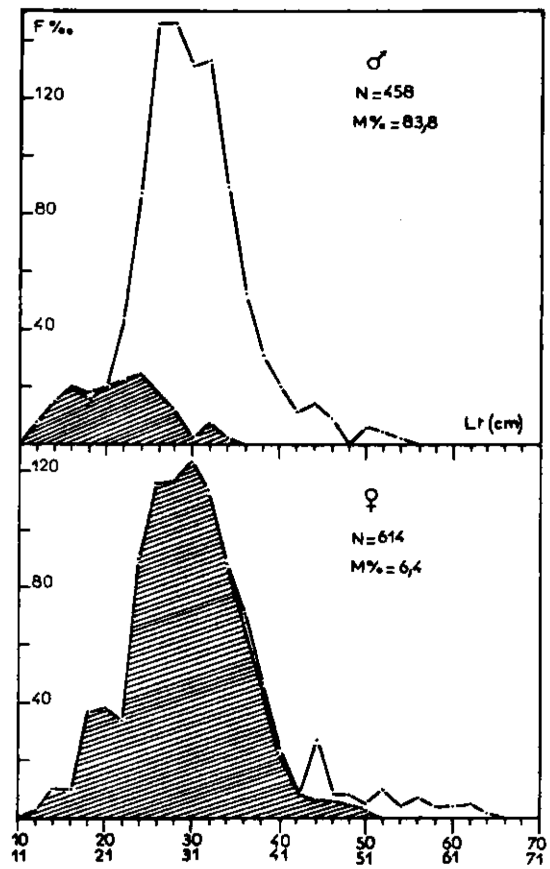

Fig. 2. Length frequency of males and females in February 1972. Hatched area: immatures.

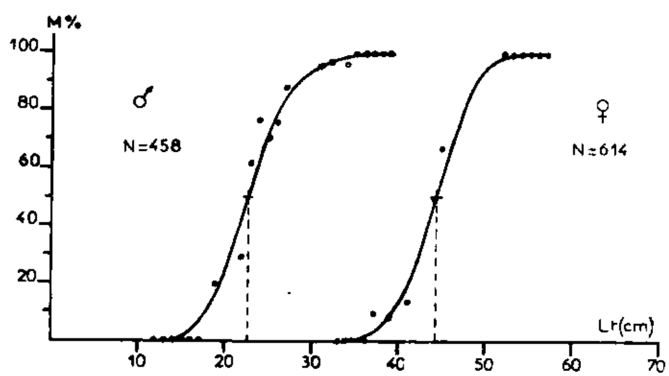

Fig. 3. Relation between length and sexual maturity of males and females.

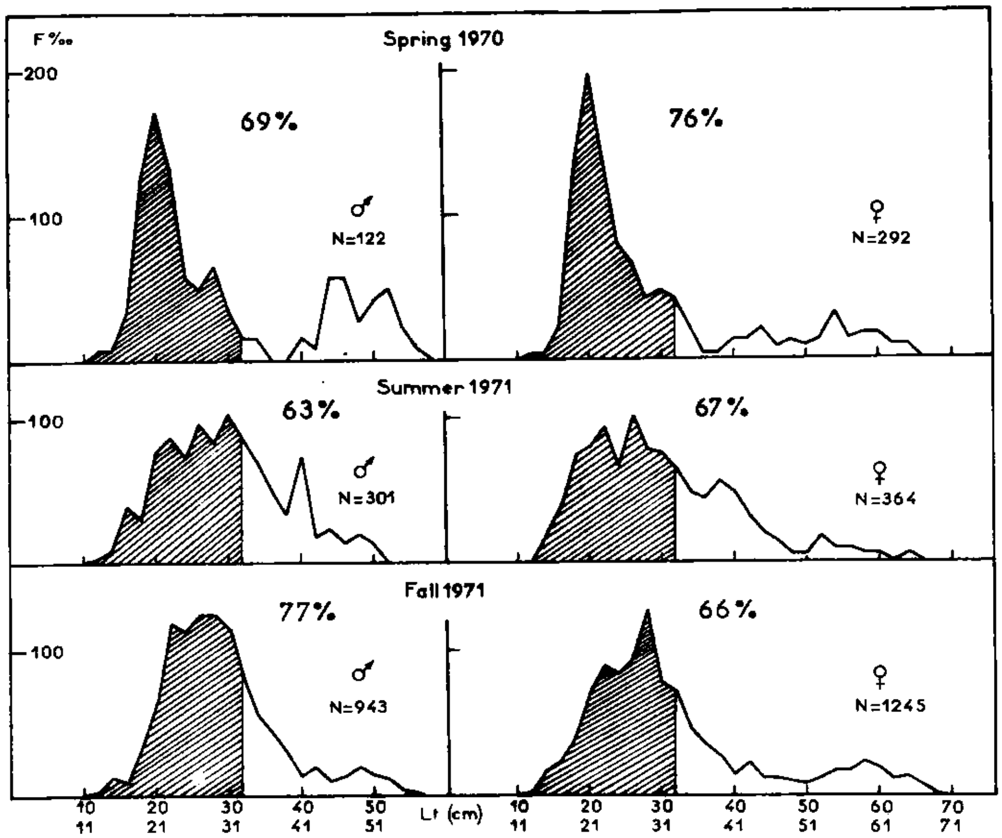

Fig. 4. Seasonal length frequencies of American plaice on Saint Pierre Bank. Hatched area: non-commercial specimens (length less than 32 cm). The percentage non-commercial is also shown.

SECTION D
RED HAKE

8. An estimate of the stock abundance of red hake (*Urophycis chuss*) in 1965-1972[1]

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Introduction

The year 1965 can be considered as a beginning of an intensive fishery for red hake. Not so much time has elapsed since then, but the events for the past period compel us to pay some attention to estimating and forecasting the stock abundance of this species. Maximum catches in 1965-1966 were followed by a sharp drop during the next two years. In 1969 the catches again increased abruptly. In 1970 the red hake fishery was closed during January, February and March for 3 years when the fish formed winter concentrations. There is no doubt that the catch fluctuations were caused by the state of the stock. Since the period of restrictions expired in 1972, the estimate of the red hake population, both in the year of intensive fishing and in the period of restrictions when the catches dropped to the pre-1965 level, is of great importance because we should decide whether it is advisable to re-impose restrictions for the winter period in the fishery for this species.

Material and methods

The material used in the present paper was taken from the fishery statistics for the period of 1965-1970, as well as from the joint surveys in 1967-1970. Mostly, the data on age-composition of the catches obtained by the 36 Yankee trawl during the joint surveys have been used. Age-composition of the commercial catches was an additional source of information. Estimates of absolute stock abundance were made using two methods. One method is the calculation of the mean stratified catches per haul for the group of strata in 13-25, 1-12 and 61-76 similar to the calculations made by Grosslein (1971). Then, using the catchability coefficient equal to 0.07 (Edwards, 1968) the stock for each group of strata was assessed. The following equation[2] was used:

$$P_w = \frac{\overline{Y}_s \, A}{q \, a}$$

where P_w = absolute stock
$\overline{Y}_s$ = mean stratified stock
A = area of the strata groups
a = area fished by the 36 Yankee trawl per haul
q = catchability coefficient

The other method of stock evaluation (with the exception of fish of age 1+ in the present case) was based on the equation:

$$C_i = N_i \frac{F}{F+M} (1-e^{-Z})$$

where C_i = catch in a given year i
N_i = stock abundance in the beginning of the year i
Z, F and M = coefficients of the total fishing and natural mortality, respectively.

Z was everywhere taken as equal to 1.1 (Rikhter, 1972). As the results of the author's investigations show, with M = 0.8-0.9 (Rikhter, *op. cit.*), the catch approximating the optimum level is attained when F = 0.7 (Rikhter, 1970). The latter value of F was accepted for the stock size evaluation in 1965-1969.

The age at which the main recruitment to the commercial stock takes place was determined by the method of Horsted and Garrod (1969), while the evaluation of the stock size in the beginning of 1972 was based on the scheme of calculations developed by Halliday (1970).

Estimates of the stock during 1965-1971

The estimates of the mean size of the stock in the beginning of each commercial fishery year by using the catchability coefficient suggested by Edwards (1968) are based on the mean stratified catches per haul which were obtained during joint surveys in 1967-1970 (Table 1). A doubled standard deviation (± 2 S.D.) served as a measure of precision.

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/27.
[2] In this case, the size of the stock in the beginning of each year following the survey was determined including the young fish (age 1+ at the time of survey) which had not yet entered the recruiting category.

Table 1. Mean stratified catches (lb) per haul and estimates of their precision.

Year of survey	First stock: Mean catch 13-25	First stock: ± 2 SD	Second stock: Mean catch 1-12	Second stock: ± 2 SD	Second stock: Mean catch 61-76
1967	-	-	7.0	3.6	0.2
1968	3.7	1.6	10.3	5.3	1.8
1969	3.0	1.2	13.5	6.1	1.0
1970	1.2	0.6	8.6	2.2	0.4

For the group of strata 13-15, the error in the estimates averaged 43%; for the strata 1-12, 44%, which are significant values. However, the nature of these errors is not quite clear. Thus, according to Grosslein (1971), the error in the mean stratified catches for yellowtail flounder and haddock appeared to be the same or even higher. Nevertheless, the coincidence of the abundance indices with the commercial catches for these species turned out to be rather good.

Since the surveys were carried out in the end of a year, the stocks evaluated by the first method were referred to the beginning of each year following the survey (Table 2).

Table 2. Stock abundance values ('000 tons) estimated by the catchability coefficient.

Year	First stock (13-25): Stock	First stock (13-25): Confidence intervals	Second stock (1-12) (61-76): Stock	Second stock (1-12) (61-76): Confidence intervals	Total
1968	10-15	-	43.8	21.1- 66.5	54-58
1969	13.7	7.8-19.6	71.7	35.2-108.2	85.4
1970	17.5	10.5-24.5	87.1	47.8-126.4	104.6
1971	9.6	4.8-14.4	53.8	39.8- 67.8	63.4

There was no survey made on Georges Bank in 1967. However, judging from the catches (slightly over 5,000 tons), the biomass of the first stock in the beginning of 1968 could hardly exceed 15,000 tons. Thus, the total size of both red hake stocks was about 55,000-60,000 tons.

It is necessary to consider the catchability coefficient used in the present paper.

Edwards (1968) gives similar coefficients for many other species. However, the absence of any calculation makes their validity doubtful, although they certainly have some biological foundation. It is also rather difficult to presume the invariability of these coefficients from year to year. The precision of the stock estimates obtained by this method seems to be judged only by comparing them with the commercial catches and the estimates obtained by other methods.

The catches of red hake during 1965-1970 are given in Table 3.

Comparing the catches with the stock estimates (Tables 2 and 3), it can be seen that in 1968 and 1969 the stock size was markedly above the lower limit of the confidence intervals and seemed to be about at the level of the mean values.

Particular attention should be paid to a sharp decrease in the catches in 1968. A decrease in the fishing effort in this case is nothing but the consequence of a significant reduction of the catch-per-unit effort (Rikhter, 1970) which increased again in the following year. One would think that the data on the joint surveys in 1967-1968 would also indicate a sharp decrease of the commercial stock in the beginning of 1968 and an increase in 1969. However, the analysis of the age-composition of the second red hake stock for 1968-1969 makes such an interpretation of events rather doubtful (Table 4).

Table 3. Total red hake catches ('000 tons) during 1965-1970.

Year	First stock	Second stock	Total
1965	54.8	29.6	84.4
1966	39.9	74.5	114.4
1967	27.3	31.0	58.3
1968	5.1	15.2	20.3
1969	4.6	50.4	55.0
1970	1.9	9.7	11.6

Table 4. Catch-per-unit effort (number of individuals) of different age-groups from the second red hake stock.

Year	Age						Total
	1	2	3	4	5	6	
1968	-	346	391	792	545	122	2196
1969	527	787	3240	2400	672	15	7641

Table 4 shows that the increase in catch in 1969 occurred due to the abundance of 3- to 5-year-old individuals (1964 to 1966 year-classes). Nevertheless, in 1968, the abundance of these year-classes at age 2-3 years, judging by the catches, was significantly lower, while 4-year fish were only slightly more numerous than fish at age 5 years in 1969, although the mortality rate of red hake at the fifth year of their life was very high (Rikhter, 1972). Such a paradox can only be explained by the behaviour pattern of red hake late in 1967 and in the first half of 1968 which made fishing for this species by bottom trawls rather difficult. It is rather doubtful, however, that during this period a significant proportion of the commercial stock was somewhere beyond the reach of research and commercial gears. Unfortunately, we are unable to find any certain explanation for the unusual behaviour of red hake late in 1967 and in the first half of 1968. However, judging from the above, we can suppose that the stock estimates for the first part of 1968 are underestimated.

For estimation of the commercial stock size by the second method for the period from 1965 to 1969, the F and Z values were assumed to be 0.7 and 1.1, respectively. For 1970, considering that the survey data showed stock abundance at least not lower than in the previous year, while the fishing effort and the catches decreased sharply, we assumed that the F value had decreased in proportion to the fishing intensity in 1970 and for the first and second stocks it was 0.28 and 0.15, respectively. The results of the calculations are given in Table 5.

Table 5. Stock abundance ('000 tons) estimated by the second method.

Stock	Year					
	1965	1966	1967	1968	1969	1970
1	125.3	91.2	62.1	12.2	10.9	11.3
2	69.1	173.5	72.4	35.6	117.2	104.0
Total	194.4	264.7	134.5	47.8	128.1	115.3

Comparing Tables 2 and 5 we can see that similarity in the stock abundances calculated by the two methods is generally rather close. We can suppose that the estimates given in both Tables are sufficiently real and valid for practical use.

To avoid the danger of over-estimation, we suggest that from the stock estimates obtained by different methods the lowest ones should be used. Thus, the size of the lowest stock in the beginning of 1968, 1969, and 1970 should be 47,800, 85,400 and 104,600 tons, respectively.

Estimate of abundance and biomass of the commercial stock at the beginning of 1972

Estimation of the abundance for the stock which will be exploited some years later, that is the forecast, requires a knowledge of the dynamics of the commercial stock.

Certainly, the ratio of individuals which enter every age-group of the commercial stock for the first time does not remain unchanged. The process is affected by such factors as growth rate and maturity rate which can vary within the limits acceptable for a given species. At present, however, we are unable to take into consideration the effect of these factors upon the recruitment dynamics separately for each year, and so we must use the ratios of recruit numbers averaged for several years. Nevertheless, these data reflect rather precisely the most characteristic features in the abundance dynamics of the species under study and can be used for a tentative forecast of the stock size.

Table 6 presents estimates of the so-called partial recruitment (ratio of the individuals fished from each age-group) calculated by the method suggested by Horsted and Garrod (1969).

Table 6. Estimates of recruitment to the commercial part of the stock.

	Age				
	2	3	4	5	6
Partial recruitment	0.084	0.811	0.881	0.990	1.000

The above data show that the 6-year-olds are represented exclusively by the remainder. At ages 5, 4 and 3 years, the recruitment accounts for 1%, 12%, and 19%, respectively. However, in the 2-year-old fish population the recruits account for 90%. Thus, the process of recruitment to the exploited stock is practically completed by the age of 3 years. Knowing the total abundance of the 3-year fish in the forecast stock and the abundance of the remainder of the previous years stock, we can readily obtain the unknown value.

Data from the joint surveys allow us to estimate the total number of age 1+ red hake. To estimate the abundance of that year-class after two years, it is necessary to have the corresponding survival coefficients which were calculated from the data on age structure for 1967-1970 (joint surveys). The results are given in Table 7.

These data seem to be rather strange. But all this is explained by the lower catchability of the first two age-groups as compared with the following ones (Rikhter, 1971).

Table 7. Survival of 1966-1968 year-classes at ages 1+ to 3+ (%).

Age	Year-classes			Mean value
	1966	1967	1968	
1+ - 2+	138	88	164	130
2+ - 3+	122	124	55	100

With the accumulation of data, the values in Table 7 will undoubtedly change. Yet, as long as the old gear (36 Yankee trawl) is employed, any significant change will hardly occur in the catchability as compared with the period of 1967-1970. Consequently, the mean survival coefficients will remain at about the same level and in the same correlation, and can be used for a tentative evaluation of the 3-year individuals.

According to the 1970 survey the total abundance of red hake in the second stock was about 420,000,000 individuals by the beginning of 1971. Among these, the commercial stock (fish at age 2+ and older) and 2-year-old fish (1+) made up 312,500,000 and 107,500,000 individuals, respectively. The remainder of the commercial stock with Z = 1.1 would be 104,000,000 individuals by the beginning of 1972. This figure is somewhat underestimated, since the fishing mortality in 1971 is likely to have remained at the low level of the preceding two years, and the actual total annual withdrawal from the stock was below that used in the present paper.

The abundance of 3-year-old fish at the beginning of 1972, according to the above survival coefficients, would be 107,600 x 1,300 = 140,000,000 individuals.

Thus, the total abundance of the commercial stock would be 104,000,000 + 140,000,000 = 244,000,000 individuals, or in terms of weight = 59,000 tons.

The abundance of the first stock according to the survey data will remain at a low level, and in 1972 is unlikely to exceed 10,000-11,000 tons. Thus, the total abundance of the commercial stock at the beginning of 1972 will be about 70,000 tons. This figure is entirely tentative and, as stated above, seems to be underestimated.

Discussion

The stock estimates obtained by the three methods were combined in Table 8 for easier analysis.

Table 8. Estimates of the stock biomass ('000 tons) in 1965-1972*.

Stock	Year							
	1965	1966	1967	1968	1969	1970	1971	1972
1	125.3	91.2	62.1	12.2	13.7	17.5	9.6	11.0
2	69.1	173.5	72.4	35.6	71.7	87.1	53.8	59.0
Total	194.4	264.7	134.5	47.8	85.4	104.6	63.4	70.0

*Estimates for 1965/1968 are obtained by the commercial fishing statistics and by the coefficients of the total and fishing mortality. The stocks for 1969-1971 were evaluated by catchability coefficients.

The above data indicate that the biomass dynamics of the two red hake stocks during the period under study differed significantly. The abundance of the first stock decreased until 1968, and then it stabilized at a new low level (1968-1971) indicating the entry into the fisheries of a number of poor year-classes. The abundance of the second stock was oscillating continuously, not showing any particular trend.

The abundance dynamics of the first stock was to a certain degree affected by intensive fishing in 1965-1967, although no special exploitation of red hake on Georges Bank was conducted since 1968. In contrast, the second stock, in spite of a rather active exploitation in 1965, increased significantly at the beginning of the following year. In 1970 stock abundance exceeded that of 1965 and 1969, although in 1969 the fishing intensity was significantly higher than in the pre-1965 period. In 1971 the stock abundance decreased again, although the fishing activity in the preceding year fell sharply. The above facts suggest that the fluctuations in the abundance of the second stock are caused mainly by natural factors, and not by the fishing activity. It may also be suggested that on Georges Bank, as well, fishing activity does not play a decisive role, especially as its effect here was shorter in time than in the habitat of the second stock.

In 1964-1968 the conditions for survival of the young fish at earlier stages (the year-classes subject to the fishery in 1968-1971) seemed to be unfavourable on Georges Bank, while in the western part of the area under study, though unstable, they were in general satisfactory. The differences in the abundance dynamics of the two red hake stocks during the period under study caused by the natural factors indicate a reproductive isolation of these stocks.

Summary

The data presented suggest that the restrictions placed on the fishery for red hake for the winter seasons, 1970-1972, did not produce the desired end. Despite the sharp decrease in fishing activity during the above period, fluctuations occurred in the abundance which are accounted for by the influence of the environmental factors, the size of the second stock in 1970 being higher than in 1965 when the intensive fishing had just begun. That and the other above-mentioned facts are readily explained if recruitment is assumed to play the decisive role in the formation of the commercial stock of red hake. This means that closed fishing seasons and areas will not yield the results sought for. The proportion of fish removed from the stock by fishing in earlier years would now be removed by a high rate of natural mortality.

A more expedient measure for regulation of the red hake fishery would seem to be the introduction of annual quotas based on data on stock size at the beginning of each year and on optimum removal by the commercial fishery.

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9. Estimates of total and natural mortality rates for red hake (*Urophycis chuss* Walbaum) from the Northwest Atlantic[1]

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Introduction

The first attempts to determine the mortality rate for red hake were made in 1968 and 1970 (Rikhter, 1968 and 1970). However, insufficient material and a rather short series of observations pointed to the obvious need for more reliable evaluations of the mortality rate. The present paper gives mean values of the total and natural mortality rates for red hake from the Georges Bank stock and the Cape Cod-Hudson Canyon stock.

Material and methods

Mortality rate was determined using the difference between the natural logarithms of abundance for the adjacent age-groups (Beverton and Holt, 1956). The main material was taken from the USSR-USA joint research surveys conducted from 1967 to 1970 inclusive.

Size composition for red hake was recalculated into age-composition by using length-age keys. At first, mortality rate (Z) was calculated separately for each year, and then, in order to diminish the effect of the fluctuations in the abundance of the year-classes, a mean value was determined for the whole period (Ricker, 1958). Negative values for some age-groups in particular years, which seem to be accounted for not only by the sharp fluctuations in abundance, but partially by the errors in the age reading as well, have been excluded from the calculations of the mean values.

In contrast to the age samples obtained from the commercial catches, the joint trawl surveys data permitted us to get some idea of the age structure of the whole population, beginning from yearlings. This provided additional opportunities for evaluation of the natural mortality rate. Such a method was used earlier by Halliday (1970) in his studies of dynamics of the Nova Scotia haddock populations.

An attempt was also made to calculate the mortality rate for the adjacent age-groups of one and the same year-class. However, this was successful for only the individuals aged 3 years and older, because the catchability of the gear used in the joint trawl surveys (36 Yankee trawl) appeared to be lower for the younger age-groups (Rikhter, 1971). It turned out that abundance indices (mean catch per haul) for the first two age-groups of red hake are not proportional to the actual abundance of the year-class in that age.

For comparative purposes, the data from commercial catches obtained in the period from 1965 to 1970 were also used. The catch per unit of effort was recalculated into age-composition.

Results

Table 1 shows the age-composition of red hake in the catches made by the research 36 Yankee trawl (joint surveys, 1967-1970).

Table 1. Age-composition (%) from research catches in the Georges Bank (1) and Cape Cod-Hudson Canyon (2) stocks, 1967-1970.

Age	1967	1968		1969		1970	
	2	1	2	1	2	1	2
1	33.5	15.6	35.7	11.2	31.4	3.2	25.6
2	28.3	22.8	29.7	16.3	23.3	15.3	49.9
3	22.5	36.4	22.3	37.1	27.2	25.9	12.4
4	9.8	15.6	7.8	20.7	11.0	33.1	8.4
5	3.7	6.2	3.1	7.8	4.7	16.9	3.1
6	1.1	1.7	0.7	3.4	1.2	3.2	0.3
7	0.7	1.1	0.5	2.6	0.8	1.6	0.3
8	0.4	0.6	0.2	0.9	0.4	0.8	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/28.

Table 1 shows that there is a significant difference in the age structure of the two stocks. First and rather notable is the small number of 2-year-old fish in the first stock and their dominance in the second one. Also notable, though not so significant, is the difference in the relative quantity of 3-year-old fish. Georges Bank seems to be inhabited by the older and mature fish and the age data from this area can be used for mortality estimate of only matured fish, starting from the 3-year-old individuals.

Table 2 shows the age-composition of red hake from the commercial catches.

Table 2. Age-composition (%) from the commercial catches of the Georges Bank (1) and Cape Cod-Hudson Canyon (2) stocks of red hake, 1965-1970.

Age	1965		1966		1967		1968		1969		1970	
	1	2	1	2	1	2	1	2	1	2	1	2
1	-	-	-	4.9	-	-	-	-	7.1	6.9	-	-
2	28.7	-	17.7	35.5	-	18.6	11.0	15.0	3.7	10.3	2.1	1.5
3	35.7	-	41.7	27.8	-	43.6	22.3	16.9	12.9	42.4	70.5	73.7
4	27.6	-	24.5	19.9	-	25.0	29.4	34.3	62.9	31.4	24.0	23.0
5	5.4	-	8.5	9.9	-	8.6	17.9	23.6	13.0	8.8	3.3	1.6
6	2.6	-	6.4	2.0	-	3.1	10.3	5.3	0.4	0.2	0.1	0.2
7	-	-	1.2	-	-	1.1	4.2	-	-	-	-	-
8	-	-	-	-	-	-	1.4	4.9	-	-	-	-
9	-	-	-	-	-	-	3.5	-	-	-	-	-
Total	100.0	-	100.0	100.0	-	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In comparison to the data from the research catches (Table 1), from Table 2 there is an almost total absence of fish of the first age-group, in a significantly lesser quantity of the 2-year-old individuals and in a notable predominance of the 3- to 4-year-old fish. Also, Table 2 shows that, in 1969-1970, there is a rather high portion of 5-year-old fish on Georges Bank and an almost complete absence of 6-year-olds which results in an extremely high mortality rate (see further in the text) at the sixth year of the life history. This is not confirmed by the trawl survey data (Table 1). This fact supposes that the age samples from the episodical catches do not give a true picture of the age structure of the commercial stock. Recently, there has been no commercial fishing for red hake on Georges Bank.

Table 3 presents mortality rates (Z) for red hake of the Georges Bank stock.

Table 3. Total mortality rates (Z) for red hake of the Georges Bank stock based on commercial (1) and research (2) catches.

Year of study	Age (years)						$\bar{Z}_1$	$\bar{Z}_2$
	3		4		5			
	1	2	1	2	1	2		
1965	0.26	-	1.62	-	0.73	-	0.87	-
1966	0.53	-	1.05	-	0.29	-	0.89	-
1967	-	-	-	-	-	-	-	-
1968	-0.27	0.84	0.49	0.93	0.55	1.30	0.52	1.02
1969	-1.59	0.58	1.58	0.97	3.48	0.81	2.53	0.79
1970	1.07	-0.25	1.98	0.57	3.50	1.76	2.18	1.16
$\bar{Z}_1$	0.62	-	1.34	-	1.71	-	1.40	-
$\bar{Z}_2$	-	0.71	-	0.82	-	1.29	-	0.99

Rather significant differences observed in the mortality rates seem to be explained by an insufficient representation of the samples from the commercial catches on the Georges Bank in 1968-1970. In the latest case, the obtained mortality rate seems to be above its actual value.

Table 4 gives mortality rates (Z) for red hake of the Cape Cod-Hudson Canyon stock.

Table 4. Mortality rates (Z*) based on the commercial (1) and research (2) catches for red hake of the Cape Cod-Hudson Canyon stock.

Year of study	1		2		3		4		5		$\overline{Z}_1$	$\overline{Z}_2$
	1	2	1	2	1	2	1	2	1	2		
1966	-	-	-	-	0.33	-	0.70	-	1.60	-	0.88	-
1967	-	0.17	-	0.33	0.56	0.82	1.07	0.97	1.02	1.20	0.88	1.00
1968	-	0.19	-	0.29	-0.12	1.05	0.37	0.92	1.50	1.47	0.93	1.14
1969	-	0.30	-	-0.15	0.30	0.90	1.27	0.86	3.80	1.40	1.79	1.05
1970	-	-0.67	-	1.40	1.16	0.38	2.66	1.00	2.08	2.20	1.96	1.19
$\overline{Z}_1$	-	-	-	-	0.59	-	1.21	-	2.00	-	1.27	-
$\overline{Z}_2$	-	0.22	-	0.64	-	0.79	-	0.94	-	1.57	-	1.09

* Z was calculated only for 3- to 5-year-old fish.

Table 4 shows that the similarity of the mean estimates for all years appears to be rather significant in this case, though the data from the commercial catches supposes that the mortality has increased markedly in the last two years (1969-1970). However, this increase is unlikely to be explained by the fishery effect, since in 1970 its intensity was extremely low.

Based on the joint trawl survey data, the mean value of the total mortality for hake can be considered as equal to 1.1.

The estimates of the mortality rates for the adjacent age-groups of the same year-class are given in Table 5.

As can be seen, the estimate for the 1964 year-class is very close to the mean values for all years. A very small number of 6-year-old fish in the commercial catches for 1969 resulted in an overestimation for the 1963 year-class.

Estimates of the mortality rate for the first two age-groups of red hake of the Cape Cod-Hudson Canyon stock (research catches) can evidently be taken as the value of the natural mortality, since, as can be seen from the data in Table 2, fishery effect upon these age-groups from 1967 was insignificant.

Table 5. Estimates of mortality for red hake of the Cape Cod-Hudson Canyon stock for 1963 (commercial catches) and 1964 (research catches) year-classes.

Year-class	Age-group			Z
	3	4	5	
1963	0.55	0.69	3.59	1.61
1964	0.66	0.20	2.58	1.14

Thus, the mean estimate of the natural mortality rate (M) for the first age-group is 0.22, while for the second one it is 0.54 (assuming that the fishing mortality for this age averages about 0.1).

Further, the discussion takes the following pattern. It can be assumed with a high degree of probability that the fishing mortality rate is equal for the degree groups on which the fishery is based (3- to 5-year-old fish). It means that the increase of Z (Table 4), as the fish becomes older, is explained exclusively by the increase of the natural mortality rate. This factor was used to obtain an approximation of the natural mortality rate for the unexploited stock of 3- to 5-year-old hake. Actually, it seems that, with intensive fishing, the natural mortality of the age-groups in the catch is overlapped by the fishing mortality and, consequently, is directly associated with the fishing intensity (Beverton and Holt, 1957).

Thus, we assume that the natural maturity rate of 2- and 3-year-olds is about equal. It cannot be lower because, if in the case of the 3-year-old fish the losses due to predation decrease, then its post-spawning mortality increases. Consequently, the 3-year-old fish have also $\overline{M}$ equal to 0.54. The same circumstance is preserved: the fishery is absent or it is insignificant.

Now, the calculations are simple with $\overline{M}_1 = 0.54$, then

$$\overline{M}_2 = (\overline{Z}_2 - \overline{Z}_1) + \overline{M}_1$$

$$\overline{M}_3 = (\overline{Z}_3 - \overline{Z}_2) + \overline{M}_2$$

where $\overline{M}_1$, $\overline{M}_2$ and $\overline{M}_3$ are mean estimates of the natural mortality rate for hake of age 3, 4 and 5 years, respectively; $\overline{Z}_1$, $\overline{Z}_2$ and $\overline{Z}_3$ are mean estimates of the total mortality rate of the same groups (Table 4). Mean estimate for the natural mortality rate for 3- to 5-year-old hake will be:

$$\frac{0.54 + 0.69 + 1.32}{3} = 0.85$$

Conclusion

The estimates given in the present paper are, certainly, approximate. Nevertheless, they are, in our opinion, within the range of the real values for the species. The high rate of the natural mortality under conditions of non-exploitation of the stock agrees rather well with the age structure of the population. As the amount of data increases, the quality of the estimates will improve. But even now, the results obtained seem to be valid for use in calculations of the abundance dynamics of the red hake population.

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SECTION E
SALMON

10. Exploitation of Miramichi Atlantic salmon based on smolts tagged in 1968, 1969 and 1970[1]

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1.0 Introduction

The Miramichi River system, New Brunswick (Fig. 1), draining over 5,500 square miles and emptying into the Gulf of St. Lawrence, is a major contributor to Canadian Atlantic coast sport and commercial fisheries for salmon. In 1968 a tagging program on wild smolts was initiated to provide data for comparison with hatchery smolt releases in this river. The program on wild smolt tagging has continued through 1969, and 1970 and returns to date have provided information on migration routes, timing of migration and areas of exploitation of this Miramichi wild stock.

Wild smolt, on their seaward migration, were trapped for tagging in the Miramichi estuary at Millbank (Fig. 1), and are considered to be representative of the total Miramichi stock. Smolt, anaesthetized with M.S. 222, were tagged with a modified Carlin tag attached with black, monofilament nylon in the dorsal fin region. Smolt were then released back to the estuary after a short recovery period. Between 1968 and 1970, inclusive, a total of 18,940 wild smolt were tagged and released. Yearly totals are shown in Table 1.

Table 1. Miramichi wild smolt tagging recaptures from 1968, 1969 and 1970 tagging. Percentages based on total smolt tagged and released. () - number of recaptures; * - number of tagged smolt released.

Recapture site	Sea year of recapture	Year tagged		
		1968 * 3,421 % return	1969 * 8,684 % return	1970 * 6,835 % return
Greenland	1	0.35 (12)	0.32 (28)	0.42 (29)
	2	- (0)	0.02 (2)	-
Newfoundland	1	0.24 (8)	0.35 (30)	0.35 (24)
	2	0.24 (8)	0.45 (34)	-
Miramichi System (home waters)	1	0.99 (34)	0.50 (43)	0.26 (18)
	2	1.34 (46)	0.28 (24)	-
	3	0.03 (1)	-	-
Miscellaneous (undetermined areas)	1	0.06 (2)	0.01 (1)	- (0)
	2	- (0)	0.02 (2)	-
Total of return		3.25 (111)	1.90 (164)	1.03 (71)

2.0 Results

Returns as percentage of yearly smolt releases from the three years of tagging are shown by major areas of recapture in Table 1. These include recaptures reported up to 31 December 1971. Past tagging studies have shown that one- and two-sea-year fish represent the majority of the returns so the 1968 figures can be considered final; minor additions can be expected to the 1969 group, and the 1970 group will have major changes when 1972 returns are reported. For the two years of comparable data, the 1968 tagged group shows the higher rate of returns.

Percentage return by area over the three-year period show an interesting pattern. In the three years that one-sea-year recaptures have been made, the returns to Greenland and Newfoundland show slight upward trends, while the returns to the Miramichi system show a steady decline in the same period. A similar pattern is noted in the two years of data available on two-sea-year recaptures. Newfoundland percentage returns from the 1969 tagged smolt are higher than the 1968 recaptures, while the Miramichi returns show a sharp drop.

Table 2 shows the total reported adult recaptures in percent by major areas of exploitation from the 1968 and 1969 tagged smolts. A considerable shift in proportion of returns to the various areas is

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/71.

noted between the two years. The 1968 releases show a very high return (almost 75%) to the Miramichi system, whereas the 1969 group change substantially, with Miramichi recaptures dropping to approximately 41% and Newfoundland recaptures increasing to 39%. When the 1968 and 1969 data were averaged, the distant fisheries (Greenland and Newfoundland) accounted for 41.2% of the total adult recaptures, while 57% were taken in home waters (Miramichi).

Table 2. Percent returns from Miramichi Atlantic salmon tagged as wild smolt in 1968 and 1969 on the Miramichi Estuary. () - number of recaptures.

Recapture site	Percent recaptures		
	1968 tagging	1969 tagging	Average 1968 & 1969
Greenland	10.8 (12)	18.3 (30)	14.5
Newfoundland	14.4 (16)	39.0 (64)	26.7
Miramichi System	73.0 (81)	40.9 (67)	57.0
Miscellaneous	1.8 (2)	1.8 (3)	1.8

A further analysis of the returns was made by considering only 2-sea-year or older fish and the Greenland recaptures which, if not caught, would return to home waters as 2-sea-year or older fish. These data are presented in Table 3. Once again, a great difference is found in home-water utilization between the wild stocks tagged in 1968 and 1969. When data for the two years were averaged, the distant water fisheries returned 53.5% and the home-water fisheries 45.4%.

Table 3. Percent returns of large salmon from 1968 and 1969 wild smolt tagging on Miramichi River estuary. () - number of recaptures.

Recapture site	Percent recaptures		
	1968 tagging	1969 tagging	Average 1968 & 1969
Greenland	21.0 (12)	33.7 (30)	27.4
Newfoundland	14.0 (8)	38.2 (34)	26.1
Miramichi - commercial angling	65.0 (37)	25.8 (23)	45.4
Miscellaneous	0 (0)	2.3 (2)	1.1
Total	100.0 (57)	100.0 (89)	100.0

Recaptures in the Miramichi System were taken mainly by commercial fishermen and anglers, with the commercial fishermen harvesting the largest proportion of these fish (Table 4). Returns to commercial fishermen on the Miramichi from 1968 and 1969 tagging accounted for 73.0% and 61.5% of total home-water recaptures, respectively.

Table 4. Miramichi System commercial and angling recaptures from wild smolt tagging on the Miramichi Estuary, 1968 to 1970, inclusive. Percentages based on recaptures in system. () - number of recaptures.

Tagging year	One-sea-year return (%)		Two-sea-year & older (%)	
	commercial	angling	commercial	angling
1968	21.4 (15)	24.2 (17)	51.6 (36)	2.8 (2)
1969	26.2 (17)	38.4 (25)	35.4 (23)	0 (0)
1970	36.8 (7)	63.2 (12)	-	-

Timing of recapture of one- and two-sea-year salmon from 1968, 1969 and 1970 tagging for West Greenland, the east and south coast of Newfoundland and the Miramichi areas is shown in Fig. 2. One-sea-year recaptures from Greenland were taken in August, September, October and November, with September and October yielding the highest returns. One-sea-year returns from Newfoundland were from June, July and to a lesser extent August, while on the Miramichi one-sea-year (grilse) returns to the trap net fishery (first home-water fishery to harvest them) were from June to early September, inclusive. June and July yielded the highest returns to the Miramichi; however, it should be noted that commercial trap net fishery normally closes before the major portion of the late-run enters the river.

Two-sea-year or older recaptures from Greenland are almost negligible from wild Miramichi salmon stocks tagged in 1968-69. Two-sea-year returns from Newfoundland were taken in May, June and July, with June returns the most numerous. It is probable that the majority of Miramichi two-sea-year salmon migrating towards home waters pass through the Newfoundland fisheries by the end of June. Miramichi drift net recaptures were taken from June to 15 August which covers the period this type of fishing is permitted in this area.

3.0 Relative exploitation

The above data considers only the reported tag returns in presenting the relative exploitation of Miramichi stock in the various salmon fishing areas of the western Atlantic. In order to arrive at a more realistic figure for large salmon of Miramichi origin, some other information must be considered. Elson (1971) estimates that only 50% of tags recovered in the Greenland fishery are reported. Recapture data on time and location of one-sea-year fish in waters off the northeast coast of Newfoundland would indicate that not all one-sea-year fish could return as grilse to the Miramichi, and if not captured in Newfoundland, could be available as two-sea-year fish.

Two assumptions are made then to cover these two points to adjust the figures on two-sea-year recaptures. First, Greenland reports only 50% of all recaptured tags, so the reported figure must be doubled to include all recaptures in Greenland. Second, one-third of the one-sea-year recaptures are considered to be potential two-sea-year fish if not captured as one-sea-year, so this amount must be added to the Newfoundland two-sea-year recaptures. These corrections were applied to the data and relative exploitation rates by area were calculated for large salmon and presented in Table 5.

Table 5. Relative exploitation of large salmon, based on "corrected" data, from 1968 and 1969 wild smolt tagging on the Miramichi Estuary. () - number of recaptures.

	"Corrected" percent recaptures		
Recapture site	1968 tagging	1969 tagging	Average (2 yrs)
Greenland	33.3 (24)	46.5 (60)	39.9
Newfoundland	15.3 (11)	34.1 (44)	24.7
Miramichi	51.4 (37)	17.8 (23)	34.6
Miscellaneous	(0)	1.6 (2)	0.8
Total	100.0 (72)	100.0 (129)	100.0

Thus, if these assumptions are valid, the relative exploitation of large salmon of Miramichi origin in Greenland was 33.3% for 1968 tagged salmon and 46.5% for 1969 tagged salmon, while Miramichi exploitation was 51.4% and 17.8% for the same tagging years. The two-year average shows Greenland and Newfoundland combined accounting for 64.6% of the recaptures. The percent return from Greenland (39.9) is higher than for the Miramichi System (34.6).

The data presented in the last column of Tables 2, 3 and 5 are shown in three pie graphs in Fig. 3. These illustrate the changes in the utilization of Miramichi stock during two years by various major fishing areas when different sea-year ages and methods of interpretation are considered.

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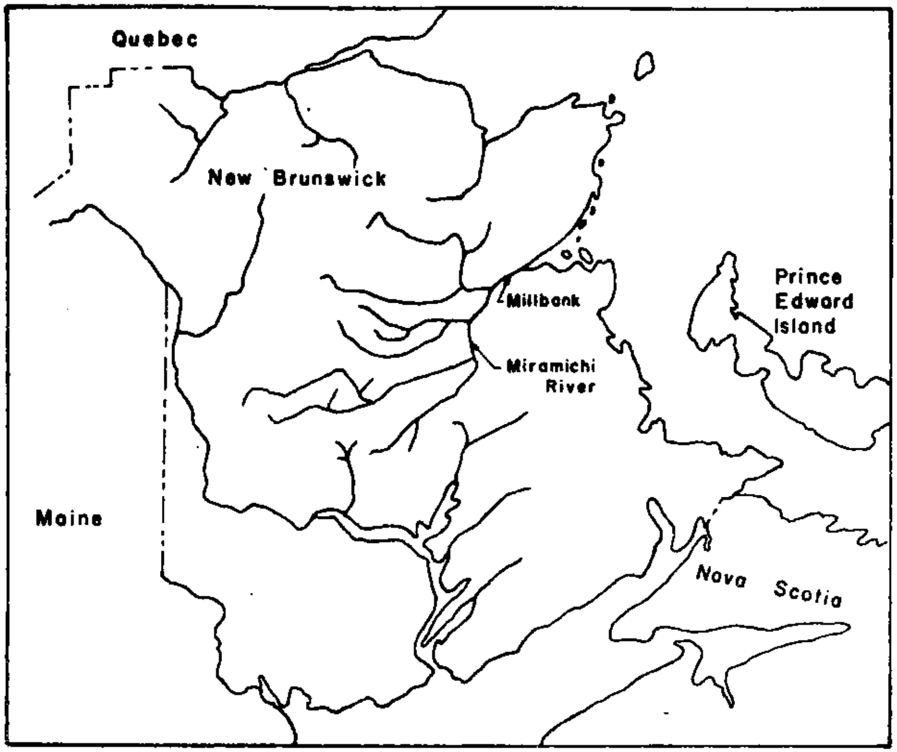

Fig. 1. New Brunswick showing location of Miramichi River System and Millbank smolt trapping and tagging site.

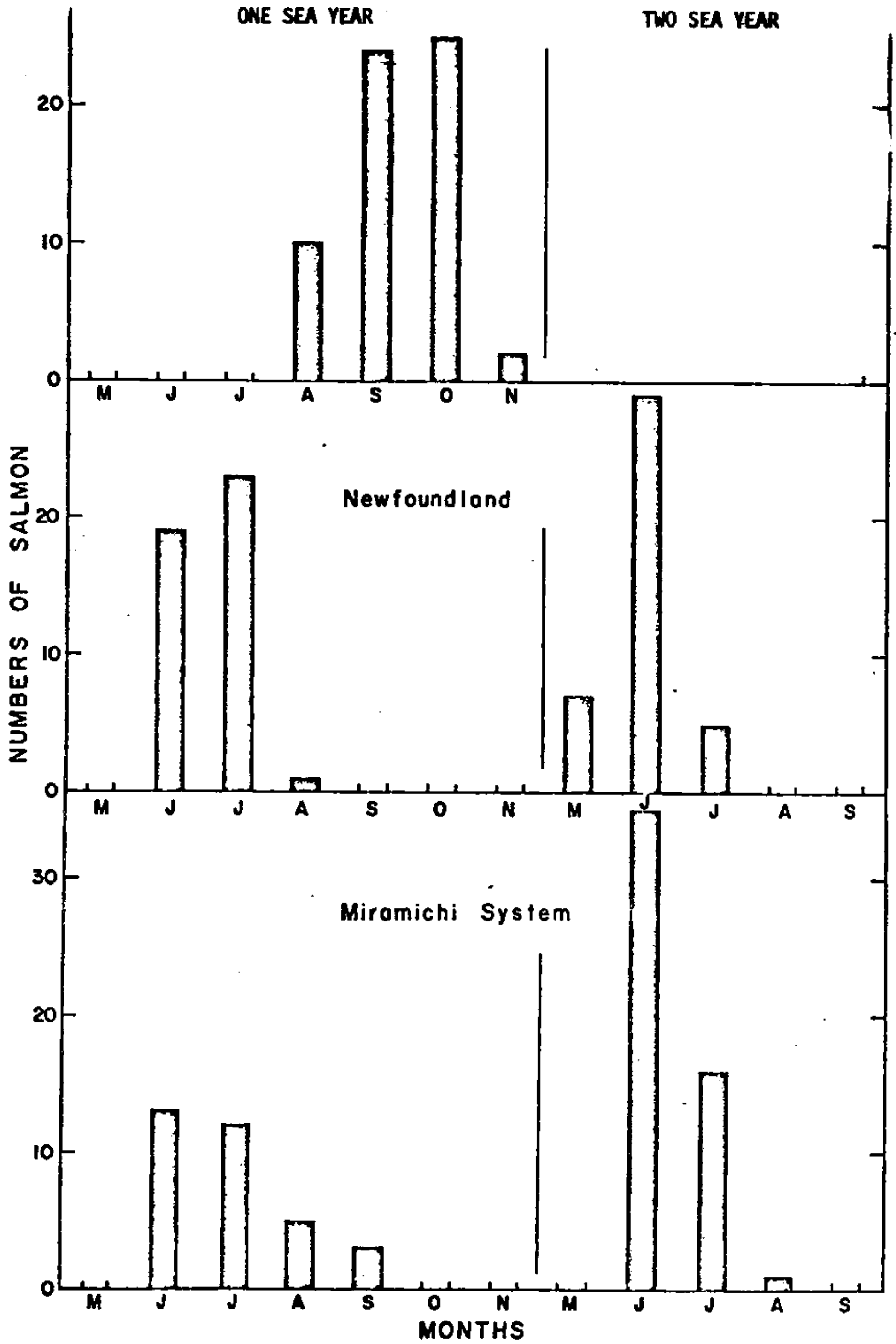

Fig. 2. Recapture by month, in western Atlantic fishing areas, of Atlantic salmon tagged as wild smolt in the Miramichi estuary in 1968 and 1969.

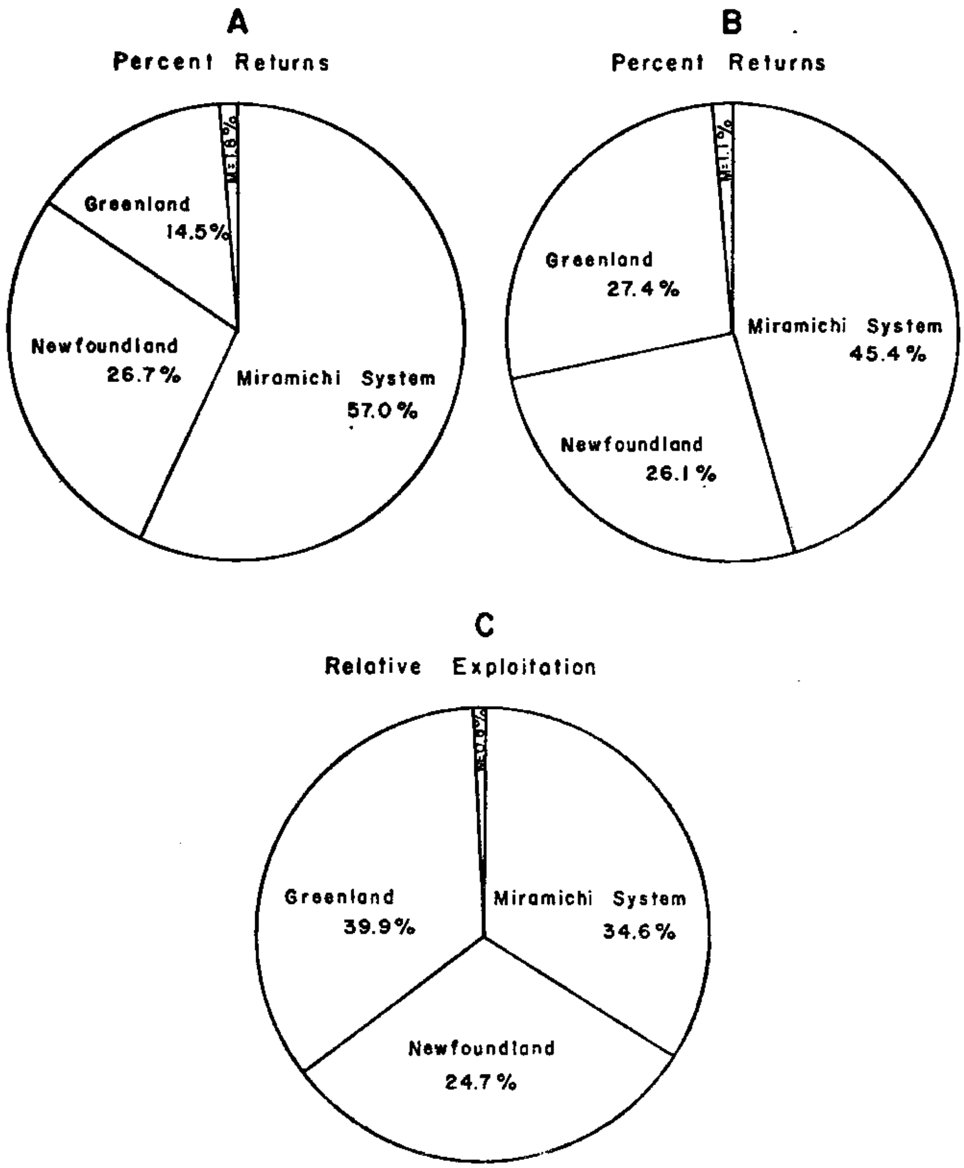

Fig. 3. Average percent returns to Greenland, Newfoundland and Miramichi fisheries from wild smolt tagged in the Miramichi estuary in 1968 and 1969.

A. One-, two- and three-sea-year salmon combined.
B. Two-sea-year salmon only.
C. Adjusted data on two-sea-year salmon.

11. Distant and local exploitation of a Labrador Atlantic salmon population by commercial fisheries[1]

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Introduction

Atlantic salmon smolts and adults have been tagged at Sandhill River located at lat. 53°35'N, long. 56°21'W in southeastern coastal Labrador (Fig. 1) since 1969. The river drainage area is approximately 623 square miles and almost the entire system is open to anadromous fish species.

The project is part of the Canadian investigation into the origin of salmon stocks being exploited by the large commercial fishery off West Greenland. Sandhill River was chosen as the site of operations after evaluation of reconnaissance surveys and population counts at selected rivers along the coasts of Labrador and northern Newfoundland during 1966 and 1967. Annual tagging began in 1969 and complete smolt and adult run counts have been obtained since 1970.

Comparison of samples of the Sandhill Atlantic salmon population in terms of size and age composition with samples from both small and large rivers along the Labrador coast showed that the Sandhill population was typical of most anadromous salmon populations produced by rivers in the northern area.

Materials and methods

Collections and counts of smolts and adults were achieved by use of a dual purpose counting fence. The river at the project site is 410 feet wide and the fence is 500 feet long running in the form of a "W" with the base upstream. The fence contains 3 adult and 3 smolt traps.

Anaesthetized smolts were tagged with a Carlin type wire-tied tag attached to the fish under the anterior portion of the dorsal fin. The anaesthetic used was tertiary amyl alcohol at a concentration of 96 ml per 2 gallons (Bell, 1967). Details of the tagging procedure and materials used are described by Saunders (1968). Adults were tagged without anaesthetic using a wire-tied Atkins type tag which was attached to the back through the proximal anterior pterygiophores of the dorsal fin.

Throughout the smolt and adult runs, fish were measured, weighed and scale sampled for size and age composition analysis.

Results and Discussion

a) Sampling

Table 1 summarizes the population assessments at Sandhill River since 1969. Since 1970 a complete adult and smolt count has been obtained.

Table 1. Summary of Atlantic salmon smolt production and adult spawning escapements. Sandhill River, 1969-1971.

	Smolt production			Adult escapement		
Year	No. tagged	Total run	No./100 yd^2	No. tagged	Total run	G:S ratio
1969	6,741	54,600[2]	1.8	399	942[1]	95:5
1970	8,014	55,000	1.8	516	3,759	95:5
1971	10,511	55,000	1.8	391	3,754	93:7

[1] Partial census only; no estimate possible.
[2] Mark-recapture estimate, based on partial count only.

Table 2 gives the results of length, weight and age sampling. Approximately 90% of the adult spawning escapement of Sandhill River is composed of grilse, while most of the remaining percentage is composed of 2-sea-year virgin salmon. About 1% are repeat spawners, most of which are alternate as opposed to successive year spawners that are undertaking a second spawning migration.

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/82.

Table 2. The results of sampling the Atlantic salmon population of Sandhill River for fork length, weight and age, 1967-71.

Stage	Sample size	Average length (cm)	Average weight (gm)	Years in F.W.					
				2	3	4	5	6	7
Smolt	25,433	16.1	36.5	0.2	5.4	60.0	29.3	4.9	0.2
Grilse	1,783	53.8	1,720	-	13.7	67.6	16.8	1.8	-
Virgin 2-sea-year	185	72.0	3,900	-	17.3	74.0	8.6	-	-
Successive spawner[1] (spawned once as a grilse)	6	63.4	2,690	16.7	16.7	50.0	16.7	-	-
Alternate spawner[2] (spawned once as a grilse)	12	76.5	4,810	-	25.0	66.7	8.3	-	-
Virgin 3-sea-year	3	79.2	5,550	-	66.7	-	33.3	-	-

1 A successive spawner is a fish which returns each year to respawn.
2 An alternate spawner is a fish which spends 1 full year in the sea before returning to respawn.

b) Tagging

Table 3 summarizes the tag-recapture data for Sandhill River. The survival of smolt to year-1 grilse in terms of tagged smolt released showed a substantial increase in 1970/71 over that of 1969/70 (i.e., 1.35% compared to 0.709%). This may be partly due to the fact that the fence facilities were not complete in 1969 and fyke nets were used for trapping and tagging. Almost all smolt which were collected by fyke nets were tagged. The remainder of the smolt run was estimated by a mark recovery method (Table 1). Use of nets probably resulted in a larger mortality of tagged smolt after release, although holding tests lasting up to 3 days duration showed no significant difference in immediate mortality between tagged and control fish in 1969. In 1970, permanent trap and fence facilities were used which greatly reduced the handling of fish and physical damage caused by traps. Examination of the survival of untagged smolt to year-1 grilse, in which fyke-net-caught smolts were deleted from consideration, also supports the hypothesis that fyke nets may have been the main causative factor in the poorer survival of fish tagged in 1969 compared to 1970. The annual survivals for untagged fish calculated in this way were almost identical between years (11.3% in 1969/70 and 11.1% in 1970/71).

Of special interest is the large return of both Carlin and Atkins tags from Greenland in 1971, a substantial increase over 1970. Whether this can be attributed specifically to better tag recovery by authorities, increased availability of tagged fish because of better survival, or to an increase in exploitation of northern Canadian fish stocks is difficult to determine. Most probably it is a combination of the latter two of these factors as preliminary reports of the poundage landed in Greenland for 1971 show an increase of approximately 500 metric tons compared to previous years, and it is probable that the permanent fence facility promotes better tagged smolt survival. It is not felt that there has been a greater effort on the part of Danish authorities to return Canadian tags in 1970 compared to 1969.

If better survival of smolt tagged in 1970 is the major factor involved in the increase in tag returns from Greenland in 1971 as compared to the return in 1970 from smolt tagged in 1969, then the increase in year-1 tag returns in 1971 from the local commercial fishery and spawning escapement compared to the number of year-1 tags returned in 1970 from the 1969 tagging should also be proportional. This is not the case as the increase in returns from Greenland in 1971 is approximately 7 times that of 1970, while returns from the local commercial fishery and the spawning escapement in 1971 were approximately twice those of 1970.

With the knowledge that the Danish catch increased by a significant amount in 1971 over 1970, it seems that the main factor contributing to the large return of tags from Greenland in 1971 over 1970 is an increase in exploitation of northern Canadian fish stocks off Greenland.

Estimates based on 2 years of returns from the 1969 smolt tagging show that the adult population of Sandhill River is composed of approximately 66% grilse and 33%, 2-sea-year or older fish. In compiling this percentage composition, the 1970 Greenland year-1 returns were grouped with 1971 year-2 returns, as these fish were destined to be 2-sea-year or older salmon. This is a much larger proportion of 2-sea-year fish than was determined by sampling the adult spawning run to the river (Table 1). River samples show that the run that survives to spawn is composed of an average of 93.8% grilse and 6.2% 2-sea-year or older fish. Estimates of exploitation of virgin fish by commercial fisheries based on smolt tag returns show that approximately 66% of the grilse return to the river to spawn, 2% are angled, while 32% are taken by commercial fisheries. Only 10% of the 2-sea-year or older fish return to the river, while 90% are taken by commercial fisheries.

Table 3. A summary of Atlantic salmon tagging operations, Sandhill River, 1969-1971. (Returns compiled to 29 February 1972.)

Year	Type tag & series	Stage and no. tagged	Returns Year of tagging		Returns Year 1				Other*	Returns Year 2			
			Home river angled	Home fishery	Home river angled/fence		Comm. fishery home/Greenland			Home river angled/fence		Comm. fishery home/Greenland	
1969	Green Carlin (L8000-14643) (L14700-14915)	Smolt (6741)	-	15	-	32	15	4	-	-	4	34	2**
	Blue Atkins (L500-902)	Adult (399)	-	-	-	2	12	3	-	-	1	2	-
1970	Green Carlin (L14644-14699) (L14916-22999)	Smolt (8014)	-	40	2	71	34	34	1	-	-	-	-
	Blue Atkins (L165-199) (L902-1399)	Adult (516)	-	-	-	-	17	15	-	-	-	-	-
1971	Green Carlin (L23000-33699)	Smolt (10511)	-	169	-	-	-	-	-	-	-	-	-
	Blue Atkins (L1400-1799)	Adult (391)	-	-	-	-	-	-	-	-	-	-	-

* Includes strays and place of recapture not known.

** 1 of these fish was counted through Sandhill fence in 1970.

In 1971, the majority (Table 3) of 2-sea-year fish tagged as smolt in 1969 were taken by the local commercial fishery while only 4, also destined to become 2-sea-year salmon in 1971, were taken the previous year (1970) in Greenland. It will be interesting to note the number of 2-sea-year fish taken in local waters in 1972 considering the large return in 1971 from West Greenland of 34 fish destined to be 2-sea-year or older salmon which were tagged as smolt in 1970. If the catch of these fish is small in comparison to 1971, then it is possible that there is an inverse relationship between exploitation in Greenland and subsequent exploitation in home waters. However, it has been noted in past years that whenever there has been an increase in the West Greenland catch, there has been a corresponding increase in the number of 2-sea-year salmon caught in home waters during the following year, and it is now known that the 1971 catch of salmon off West Greenland is the highest on record. This may mean that there will be a record return of tags from the 1970 smolt tagging in 1972. Whichever pattern emerges, one conclusion which may be drawn is that not many 2-sea-year fish will survive to return to the natal river for spawning.

The distribution of recoveries from 1969 and 1970 smolt tagging shows that northern fish are taken by commercial fisheries along the east coast of the Great Northern Peninsula of Newfoundland, mostly from Canada Bay North and along the Labrador coast as far as Sandhill Cove in Table Bay (Figs. 2 & 4). Figure 1 shows the commercial salmon collection centers along the coast and the percentage of the Labrador salmon catch that each accounts for, averaged over a 10-year period. Very few tags were returned from the large commercial fishery in the Packs Harbour area north of Sandhill River which accounts for an average of 35% of the total Labrador salmon catch.

The 1971 catch of tagged salmon was divided such that most of the 2-sea-year fish were taken from mid-June to early July, while the 1-sea-year fish (i.e., grilse) were taken from the second week in July to late July. While returns at present are not sufficient to accurately show the timing of the migration through the local commercial fisheries, the pattern of tag returns and the distribution of the Labrador commercial fishery suggests that the path of migration of returning tagged fish is generally northwards from the White Bay area along the Labrador coast to Sandhill River and agrees with the hypothesis of Lindsay and Thompson (1932) as to the probable migration routes of salmon from the northern population which are caught in the various commercial fisheries off the northern coasts of Newfoundland and Labrador.

Tag recaptures from smolt tagging in Greenland were distributed from Disko Bay in the north to Cape Farewell in the south and fish were taken from early August to late October. Most tagged fish (43%) were taken in September and the main area of concentration was south of Godthaab where 62% of the tags were taken in ICNAF Divisions 1D, 1E and 1F (Fig. 2).

The fishery is divided into two components, the offshore drift net fishery and the coastal gill net fishery. At present it is not possible to give an accurate breakdown of the return of tags by component as two-thirds of the returns did not list the method of recapture.

Results from adult tagging (Table 3) show that recovered spawners do not make a substantial contribution either to commercial fisheries or the spawning escapement of Sandhill River as they do in some rivers in insular Newfoundland. However, the pattern of returns (Figs.3 & 5) and the area of exploitation are similar to those of the grilse and 2-sea-year virgin fish which were tagged as smolt (Figs. 2 & 4). There was an increase in tag returns from Greenland between 1970 and 1971 as occurred with the returns from smolt tagging in these years (i.e., only 3 Atkins tags were taken in Greenland in 1970 as opposed to 12 in 1971). This corroborates that there might have been a greater degree of exploitation of northern stocks in 1971.

Tagging of smolt and adults further south in Newfoundland at Salmon River in Hare Bay and Indian River in Halls Bay within the northeastern section of the island indicates that these populations are composed mainly of grilse and do not make large contributions to distant fisheries as compared to Sandhill River. No recoveries of smolt tags from these rivers have been made in West Greenland but adults tagged at Salmon River have been recovered. Most of the respawners at Salmon River are alternate-year spawners, while at Indian River most respawners are successive-year spawners. Home-water exploitation of these populations is considerable. Sixty to eighty percent of the total annual recoveries from smolt tagging are taken by local commercial and sports fisheries, while 80% to 97% of the total annual recaptures from adult tagging are also taken by the local commercial fishery. The distributions of fish tagged as smolt and adults were similar within the commercial fishery with the majority being harvested along the coast at a distance less than 50 miles from their natal river. However, it is felt that the results from tagging at these two rivers cannot be taken as representative of the entire northeast coast of the island. Further smolt tagging is required in salmon-producing streams on the other coasts and in larger watersheds before it can be concluded that most of the streams of insular Newfoundland produce mainly grilse populations which are not harvested by distant commercial fisheries, in particular the Greenland commercial fishery.

Summary and conclusions

1. Smolt tagging studies have shown that a large component of the Sandhill River Atlantic salmon population is composed of 2-sea-year virgin fish.

2. Nine tenths of the 2-sea-year salmon produced by Sandhill River are taken by the Greenland and

home-water commercial fisheries, while very few return to the natal river for spawning.

3. One third of the grilse produced are taken by the home-water commercial fisheries, while two thirds return to the river to spawn.

4. Salmon tag returns in 1971 from West Greenland have increased 6 to 7 fold over the 1970 West Greenland recaptures per number of smolts tagged. Most of the increase in 1971 is attributed to a record harvest off Greenland which may cause a decline in the number of 2-sea-year salmon taken in home-water catches and in spawning escapements in 1972. Tag returns from 2-sea-year salmon within the home waters during 1972 will determine the validity of this assumption.

5. Smolt tag recaptures within the Greenland fishery were distributed from Disko Bay in the north to Cape Farewell in the south and fish were taken from early August to late October. There have been returns from both offshore drift nets and coastal set gill nets but the proportionate recovery by type of gear is not presently known.

6. Smolt tag recoveries within the home-water fishery were distributed from the east coast of the Great Northern Peninsula of Newfoundland north along the Labrador coast to Sandhill Cove in Table Bay. Two-sea-year fish are taken from mid-June to early July while grilse are harvested somewhat later from the second week in July to late July.

7. Kelt tagging studies show that recovered kelts also enter the West Greenland and local commercial fisheries but their contribution to the fisheries or spawning escapement is insignificant in comparison to the contribution of virgin fish. The distribution of tag returns from adult tagging follows the same pattern as the returns from smolt tagging.

8. Tagging of smolt and adult river populations further south in Newfoundland shows that they are predominantly grilse populations which do not make a large contribution to the West Greenland fishery but do make significant contributions to the home-water coastal fisheries. However, more widespread smolt tagging is required before the exact nature and utilization of insular populations can be determined.

Acknowledgements

The authors gratefully acknowledge the assistance of H.P.J. Murphy in operating the tagging-recovery facility at Sandhill River and in preparing data for presentation in this paper.

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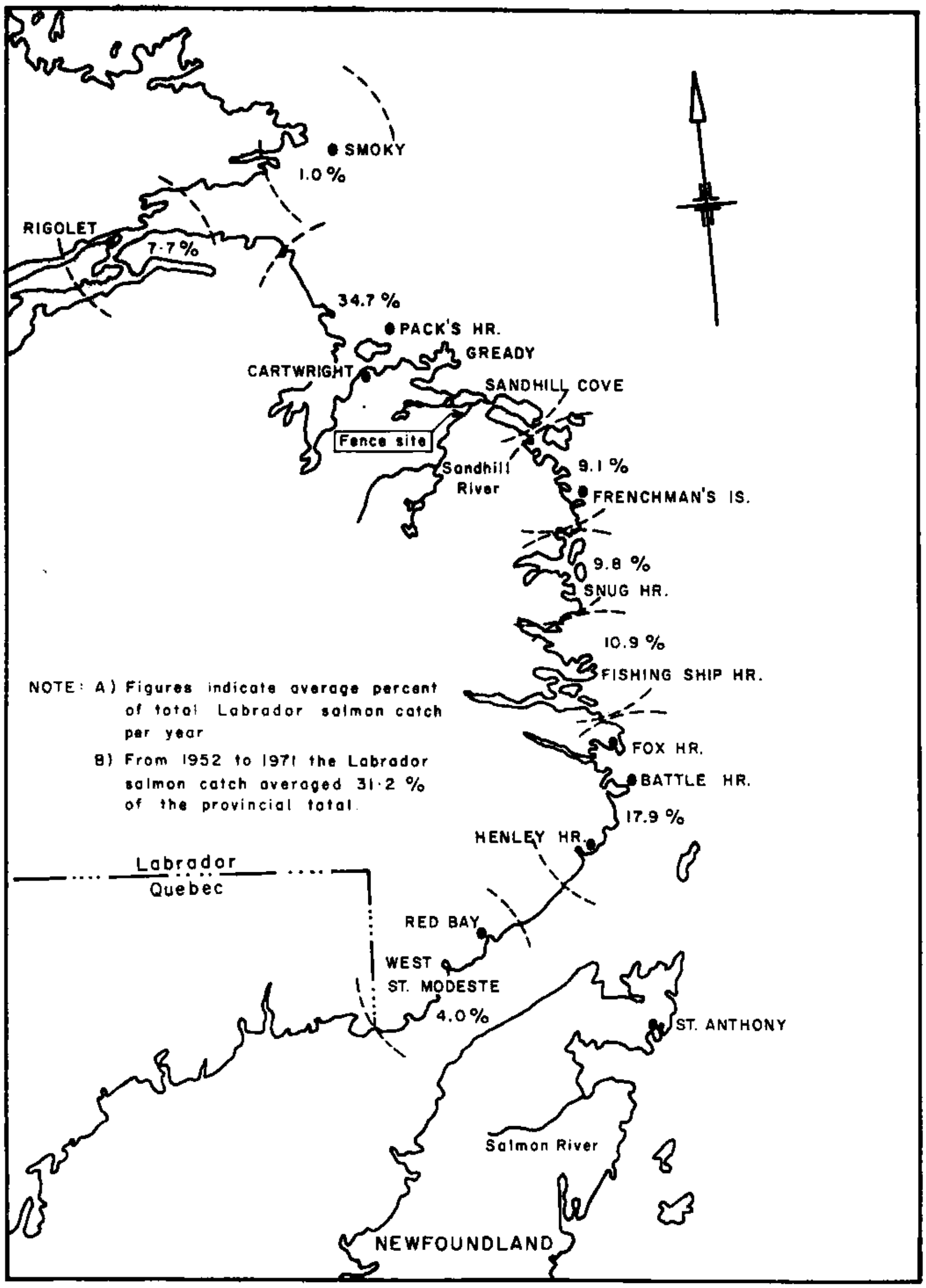

Fig. 1. Location map of Labrador area showing main commercial salmon fishing areas.

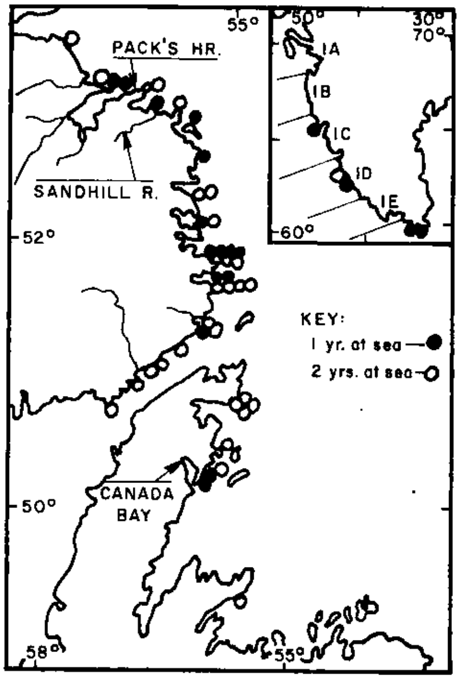

Fig. 2. Distribution of tag returns, 1969 smolt tagging (years 1 and 2). Inset shows ICNAF areas.

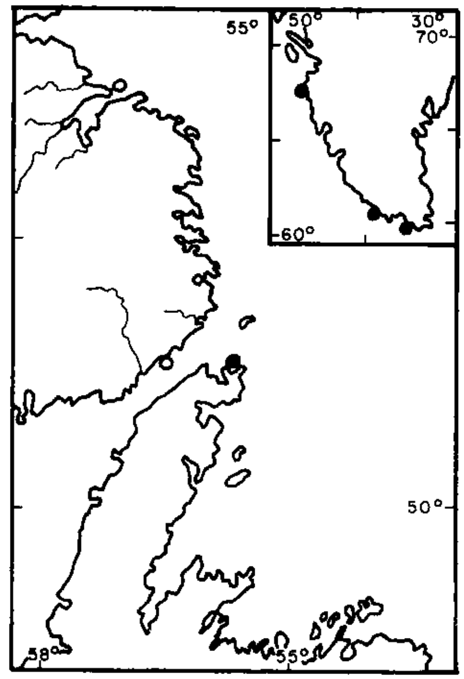

Fig. 3. Distribution of tag returns, 1969 adult tagging (years 1 and 2).

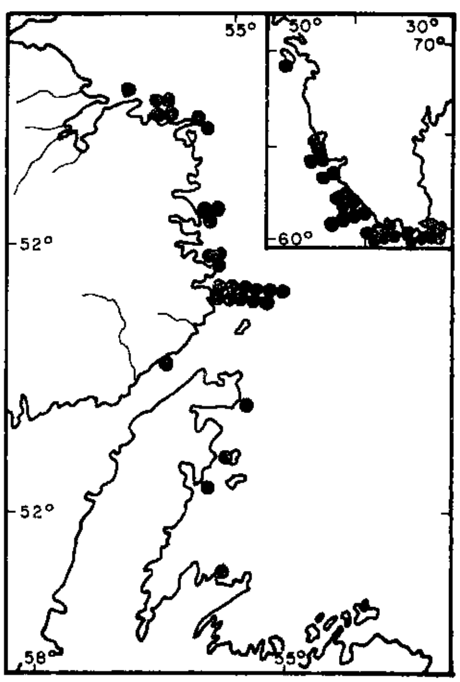

Fig. 4. Distribution of tag returns, 1970 smolt tagging (year 1).

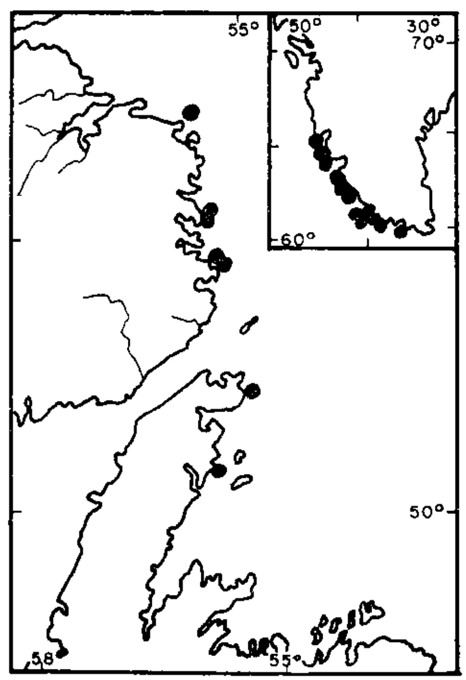

Fig. 5. Distribution of tag returns, 1970 adult tagging (year 1).

SECTION F
YELLOWTAIL FLOUNDER

12. Assessment of yellowtail flounder in ICNAF Divisions 3L and 3N[1]

by

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Introduction

The yellowtail flounder fishery on the Grand Bank has increased from practically nil in 1966 to nearly 26,000 tons in 1970. There is evidence that this species has increased in abundance in this area since 1962 (Pitt, 1970). Some estimates of the total mortality were presented at the 1971 ICNAF Annual Meeting. These were based on annual catch curves, but because the stock was probably increasing in abundance it was felt that the mortality rates were probably overestimated. With the inclusion of the 1970 data some mortality estimates from a limited number of year-classes are available. Thus, the best available information has been used to give an indication of the status of this stock.

Materials and methods

In calculating the total number landed (Table 2) the USSR 1970 breakdown of unspecified flounder (Res.Doc. 71/26) was used to determine the nominal catch of yellowtail flounder for countries other than Canada (Table 1). No adjustments for discards were made; however, judging from a comparison with research age frequencies, the 4-year-olds only would be affected to any great degree. Ageing of yellowtail flounder was by otoliths from random and stratified samples taken from landings at fish plants.

American plaice and yellowtail flounder are both fished on the shallow part of the Grand Bank (< 90 m) with the fishery for plaice extending beyond the 50-fm (90-m) contour, which for all practical purposes is the lower depth limit for yellowtail flounder. The calculation of fishing effort was based on the nominal catch per unit effort of yellowtail flounder by Canada (N) stern trawlers (501-900 tons). In calculating the catch per hour, all tows with recorded depths less than 50 fm (90 m) containing yellowtail flounder in sufficient numbers to be recorded on the log of the commercial vessel were used. In addition to this, the catch per hour where yellowtail accounted for more than 50% of the catch was also calculated (Fig. 1).

It seems highly likely that Grand Bank yellowtail flounder belong to one stock and nearly all of the landings were reported from Divisions 3L and 3N. In the case of American plaice, there are major differences in the size at age between 3L and 3N, however, for yellowtail flounder the growth curves are practically identical (Fig. 2). As yet no tagging data are available to indicate seasonal migrations, but spring and fall research vessel catches suggest a possible southern movement of yellowtail flounder from the area north of 46°N (Div. 3L) in the autumn. Thus, on the basis of present knowledge, it must be assumed that there is a single Grand Bank stock of yellowtail.

Although the males usually spawn about one year earlier and grow at a slightly lower rate than the females, the differences were not considered to be great enough to warrant treatment of the sexes separately.

Yield curves (Fig. 3) were calculated using FAO tables (Beverton and Holt, 1966). The parameters necessary to produce the curves were as follows:

$$l_c = 34.20 \text{ cm (50\% selection point)}$$
$$K = 0.241$$
$$L_\infty = 52.08 \text{ cm}$$

Curves for three values of M were plotted, M = 0.20, 0.30 and 0.40.

From an examination of catch data and the survival ratios (Tables 3-4) yellowtail flounder were considered to be fully recruited at age 7 (about 40 cm). This is about the same size as reported by Lux (1969) for New England yellowtail flounder but at a younger age (age 4).

Results and discussion

The estimation of total mortality from survival ratios based on the number of yellowtail flounder caught per unit effort (Table 3) gave high values for Z with mean values of Z for 1965 to 1970 at 1.52 and 1.77 (Table 4). Estimates of Z from the catch curves of 1958 to 1961 year-classes (Fig. 4) for ages 7 and over also gave high values of Z, ranging from 1.21 to 1.89 with a mean value for the four year-classes of 1.51.

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/86.

Table 1. Nominal catches of yellowtail flounder in ICNAF Divisions 3L and 3N (metric tons). "Other" landings based on USSR 1970 breakdown of unspecified flounder.

Year	Country	Division 3L	Division 3N	Total
1965	Canada (M)	115	951	1,066
	Canada (N)	-	2,001	2,001
	Other	-	19	19
	TOTAL	115	2,971	3,086
1966	Canada (M)	57	1,737	1,794
	Canada (N)	5	1,948	1,953
	Other	-	2,035	2,035
	TOTAL	62	5,720	5,782
1967	Canada (M)	118	429	547
	Canada (N)	334	1,081	1,415
	Other	-	3,451	3,451
	TOTAL	452	4,961	5,413
1968	Canada (M)	632	149	781
	Canada (N)	2,164	1,081	3,245
	France (S.P.)	3	5	8
	Other	60	5,138	5,198
	TOTAL	2,859	6,373	9,232
1969	Canada (M)	3,217	1,048	4,665
	Canada (N)	2,033	3,840	5,873
	Other	19	1,867	1,886
	TOTAL	5,269	6,755	12,424
1970	Canada (M)	718	2,069	2,787
	Canada (N)	6,657	13,003	19,660
	Other	16	3,426	3,442
	TOTAL	7,391	18,498	25,889
1971	Canada (N)	5,741	13,851	19,592

Table 2. Number of yellowtail flounder caught, ICNAF Divisions 3L and 3N (x 10^{-3}).

Age \ Year	1965	1966	1967	1968	1969	1970
4	172	559	385	351	300	105
5	524	3,341	3,097	3,854	789	2,537
6	1,006	2,711	3,041	7,755	7,252	17,850
7	1,201	3,128	1,662	5,670	8,949	18,817
8	1,064	922	769	873	2,708	4,221
9	766	110	227	30	126	398
10	247	116	85	-	37	67
11	60	-	28	-	-	-
12	24	-	-	-	-	-

Table 3. Number of yellowtail flounder caught per 100 hours' fishing with total fishing effort shown at the bottom.

Age \ Year	1965	1966	1967	1968	1969	1970
4	3,846	4,454	2,564	1,274	763	193
5	11,717	26,631	20,622	13,988	2,007	4,674
6	22,495	21,603	20,249	28,146	18,450	32,888
7	26,792	24,926	11,067	20,579	22,767	34,670
8	23,792	7,347	5,120	3,168	6,889	7,777
9	17,128	876	1,511	109	320	733
10	5,523	924	566	-	94	123
11	1,314	-	186	-	-	-
12	536	-	-	-	-	-
Total effort (hours)	4,472	12,549	15,018	27,553	39,307	54,275

Table 4. A. Survival ratios of yellowtail flounder based on catch per 100 hours (Table 3) for 1965-70.
B. Survival ratios for Σ 7-9/Σ 8-10.

	Years					
Age	1965-66	1966-67	1967-68	1968-69	1969-70	
"A"						
4-5	6.924	4.630	5.456	1.575	6.126	
5-6	1.844	0.760	1.365	1.319	16.387	
6-7	1.108	0.512	1.016	0.809	1.879	
7-8	0.273	0.205	0.286	0.335	0.342	
8-9	0.037	0.206	0.022	0.101	0.106	
9-10	0.054	0.646	-	0.862	0.384	
G.M.	0.082	0.301	0.079	0.307	0.240	
7/8 to 9/10						
Z	2.50	1.20	2.53	1.18	1.43	Mean = 1.77
"B"						
S =	0.135	0.217	0.185	0.306	0.288	
Z =	2.00	1.53	1.69	1.18	1.25	Mean = 1.52

Unfortunately, no estimates of natural mortality are available for Grand Bank yellowtail flounder. Lux (1969) suggested a natural mortality rate for New England yellowtail flounder of about 20% (M = 0.22). It was previously shown (Pitt, 1971) that research vessel catch curves from Div. 3N, 1951-52, gave a Z of 0.77. However, it was pointed out that the population of yellowtail flounder was apparently at a low level and the large haddock fishery probably removed quantities of yellowtail flounder that were not recorded; hence, a possible reason for the apparent high total mortality.

If a natural mortality rate of 0.20 is accepted, the apparent fishing mortality rate would in recent years be somewhat in the vicinity of 1.3 to 1.5. This would appear to be an extremely high fishing mortality rate. However, there has been a rapid increase in the total fishing effort for yellowtail flounder (Table 3) from 4,472 hours in 1965 to 54,275 in 1970. In addition to the recorded landings of plaice, quantities may have been removed and not reported by vessels fishing cod for salting.

With the uncertainty about the value of M, it seemed appropriate to present three yield curves (Fig. 3) using M = 0.20, 0.30 and 0.40.

a) M = 0.20 The optimal value of F occurs at about 0.30 which is approximately 90% of the maximum yield. The maximum sustainable yield occurs at F = 0.80, hence if the estimated value of F for recent years (1.30 to 1.50) is realistic, the fishing is well beyond the maximum.

b) M = 0.30 The optimal F = 0.45 (approximately) at about 85% of the maximum, and if F is 1.20 to 1.40, the fishing is very close to the maximum (99%).

c) M = 0.40 The optimal F = 0.65 and the present level of fishing (1.1 to 1.3) would be about 90% of the maximum.

The catch-per-unit effort (Fig. 1) indicates that with the total catch and effort of yellowtail flounder the catch per hour has remained relatively stable since 1967. The "main species" catch-per-unit effort, on the other hand, shows a gradual decline from 1965 to 1969 and a stabilization in the last three years.

Division 3N was the only area from which substantial landings were reported for 1965 to 1967, but for 1968 to the present year, Div. 3L has also been an important source (Table 1). Research data indicate that yellowtail flounder apparently only spread into Div. 3L during the 1966-68 period (Pitt, 1970). Whether the recent increase in abundance of the species will continue is not known at present. So far, research cruises have not been able to give good indications of recruitment with relatively small numbers of 3-year-olds and no 2-year-olds being recorded in the past 5 or 6 years at least. Both the research and commercial age-composition data have indicated a progression of year-classes of roughly equal strength.

It would appear that the yellowtail flounder stock is being exploited at too high a level, although the catch per hour has stabilized in the past year or two in spite of increased effort. This may be the result of expanding stock at least up to now. Some control of fishing effort on this stock is desirable and the data suggest that a reduction may be necessary. When the complete 1971 and 1972 landings are available, a better indication of the appropriate level might be forthcoming. However, even if the degree of reduction cannot be determined at present, it would appear prudent to at least hold to the 1970 level of 25,000 tons which could be split between Divs. 3L and 3N if necessary in the proportion of the landings from these divisions in the past three years.

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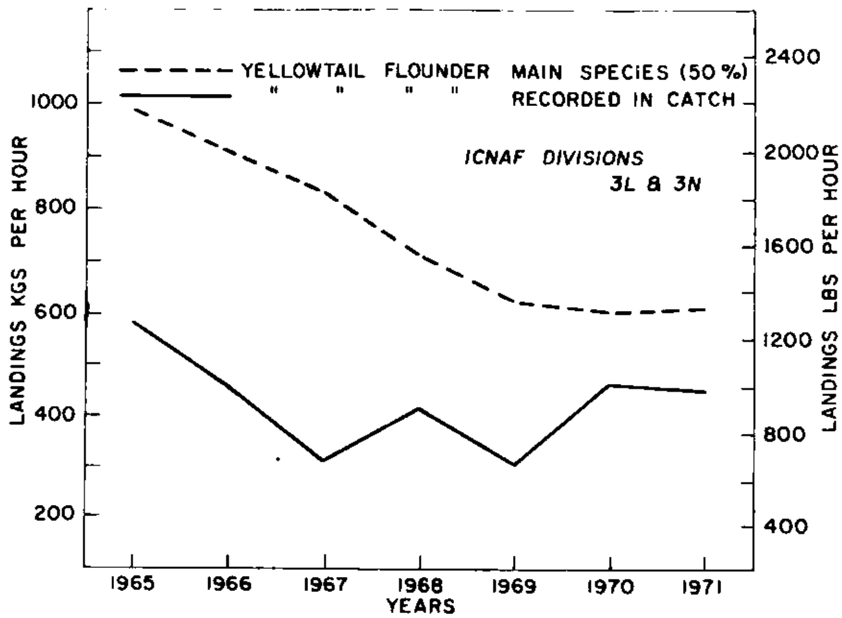

Fig. 1. Catch per hour of yellowtail flounder by Canada (N) stern trawlers. Broken lines: main species (50%); and solid line: some yellowtail flounder recorded in catch.

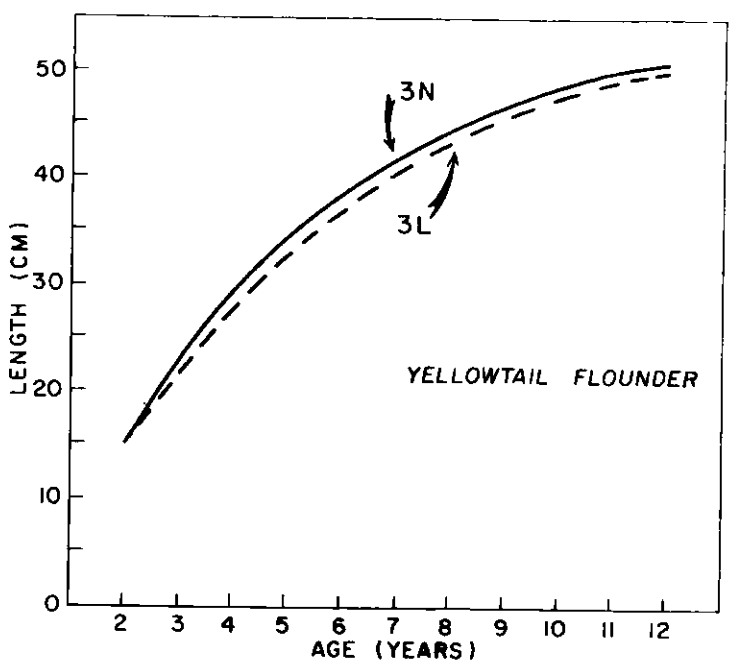

Fig. 2. Growth curves of yellowtail flounder from Divs. 3L and 3N.

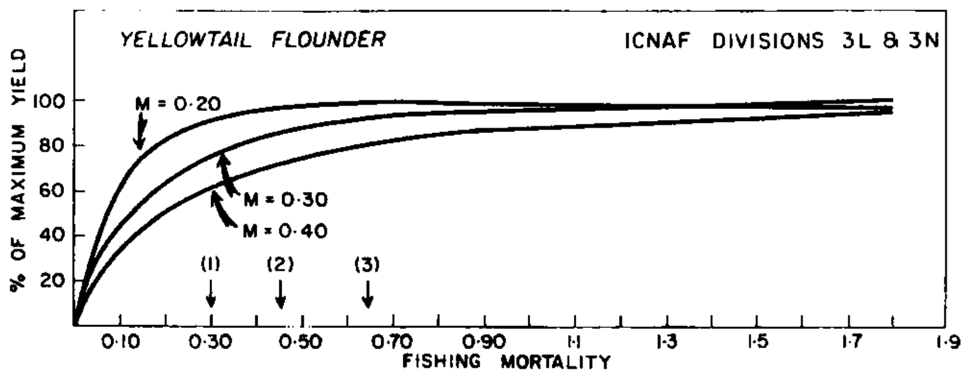

Fig. 3. Yield curves for yellowtail flounder for three levels of natural mortality. Arrows at base indicate "optimal fish level" for (1) M = 0.20, (2) M = 0.30 and (3) M = 0.40.

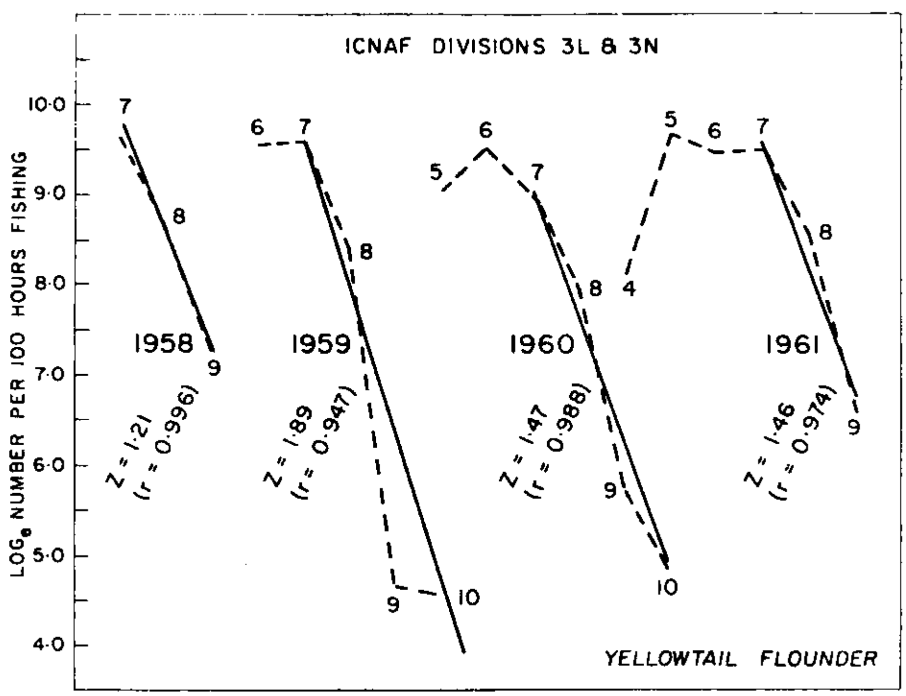

Fig. 4. Catch curves of 4 year-classes of yellowtail flounder with estimates of total mortality (Z).

SECTION G
SCALLOP

13. Size selectivity of the Georges Bank offshore dredge and mortality estimate for scallops from the northern edge of Georges in the period June 1970 to 1971[1]

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Introduction

A recent analysis of the statistics for the Georges Bank fishery (Caddy and Lord, 1971) showed that over the period 1961 to 1969, catch per hour dragged fell to one fifth of its value in 1961. Poor recruitment and continued intensive fishing are both responsible for this decline in abundance, and a threefold increase in average landed price per pound over the last five years has provided added incentive to fish the already depleted stocks.

In 1970 a dense localized area of young scallops, approximately 80 square miles in extent (274 sq. km), was located between 66°35' and 67°15'W long. on the northern edge of Georges Bank (Caddy, 1971*a*). This area was fished heavily in the period 1970 to 1971, and evidence was obtained (Caddy and Sreedharan, 1971) that cull size for some Canadian boats fishing this area had fallen to around 70 mm (cull size was 90-95 mm in the early 1960's).

Twenty-two stations within the area of recent recruits were refished in June 1971, one year after the first survey, and concurrently with both 1970 and 1971 surveys, cover experiments were carried out on the offshore dredge used in the comparative fishing to determine its selectivity. The selection curve for the gear obtained in this way was used, together with back data on the growth rate of Georges Bank scallops, to estimate a value for Z from the combined size frequencies of catches made on the same stations in the two years. This estimate is necessarily very approximate and does not apply to the whole Georges Bank stock, but only to the area of recent recruits which was subject to intensive fishing in 1970 and 1971.

Growth data

As noted by Merrill, Posgay and Nichy (1966), annual marks on Georges Bank scallops are usually weak, and when masked by strong shock marks resulting from fishing, are particularly difficult to read. This was the case for the shell samples taken during the 1970 and 1971 surveys, and for this reason it was considered impractical to attempt estimates of mortality from age reading of shells. The following analysis of the size frequency data for the two years is supplemented by data on back measurements of size at ring formation summarized for 20 readable shell samples of Georges Bank scallops (approximately 100 shells per sample), taken in the period 1961 to 1964 (Table 1). From these data, a plot of annual increment ($L_{t+1} - L_t$) against initial shell size (L_t) has been considered to represent the annual growth of scallops in the one-year period between the two surveys.

Table 1. Summary of back measurements of size at ring formation for 20 shell samples taken on Georges Bank in the period 1961 to 1964. (Standard deviation of sample means given.)

Ring number:	1	2	3	4	5	6	7	8	9	10
Mean size:	9.6	28.3	53.4	77.1	95.2	108.6	117.9	124.6	130.2	137.1
S.D. mean:	1.8	3.4	6.6	9.3	10.0	9.8	8.3	7.4	7.6	8.3

Gear experiments

The ICNAF Working Group on Sea Scallops in 1962 recommended that further attempts be made to determine a selection curve for the offshore dredge. Preliminary studies on the performance of an 8-ft offshore dredge were carried out in June of 1970 and 1971. In this work, a loose cover of 1-1/2" polypropylene mesh was stretched over the entire back of the dredge, terminating in a codend trailing 1 m behind the club stick. Tows were made over distances of 1 nautical mile (15-20 minutes duration). Scallops in both dredge and cover were measured and the following expression calculated for each 10-mm size-group.

$$\frac{100\ (\text{No. scallops in dredge})}{\text{No. scallops in dredge + cover}}$$

This expression was plotted against size for the combined 1970 and 1971 data, and a selection curve drawn through the points by eye (Fig. 2). This is considered to represent the increase in retention of scallops with size by the back of the dredge.

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/5.

It may be noted that the 50% selection point for the dredge back (83 mm) is greater than the inside diameter of the dredge rings (76.5 mm) which were linked 1:2 (back:belly) in the dredge used for survey work. This indicates (contrary to the findings of Bourne (1965)), that a major part of the selection occurs through the inter-ring spaces. The interquartile range of selection by the dredge back is 40 mm (65 to 105 mm) and the size at 100 % retention is 135 mm. (This is also the maximum size of scallop that can be forced through a single-linked inter-ring space.) The data for size-at-age given in Table 1 suggest that scallops remain within the selection range of the back of the dredge between ages 3 and 9. It can be seen, therefore, that some selection occurs over almost the whole range of sizes at which the scallop is susceptible to capture by the dredge. Presumably, the use of multiple links between adjacent rings (up to 6 links per ring are now used by the Canadian offshore fleet) will reduce the selection range of the gear by decreasing the size of the inter-ring spaces. Preliminary studies in which tagged scallops were released into the dredge during a tow (Caddy, 1971*b*) suggest that a considerable proportion of the selection occurs through the belly of the dredge. These experiments suggest that the lower limb of the true selection curve for the survey dredge is displaced about 10 mm to the right and is slightly steeper than that shown in Fig. 2. However, until more complete tagging data are available, the selection curve for the back of the dredge will be considered to apply to the dredge as a whole. Since a correction for the effects of selection is to be applied to both years' data, it seems unlikely that this error will have a major effect on the mortality estimate.

Comparison of the 1970 and 1971 surveys

Figure 3 gives the catches in 22 duplicate tows over the same area of the Northern Edge of the Bank in the two years. Catches are summarized in Table 2 as numbers of scallops in three size categories: <50 mm, 50-100 mm, and 100+ mm, to facilitate comparison with bottom photographs in which scallop sizes could not be estimated any more accurately. The bottom photographs taken in 1971 are not yet analyzed, but dredge catches in 1971 were much lower than in 1970 and contained few scallops smaller than 50 mm compared with 1970 when small scallops were abundant. Fifty-100-mm scallops were by far the most abundant size-class in both years. Grouping catches for the two years for 22 tows made over the same area (Table 2) indicates that there was a major decline in the numbers of scallops in all three size-classes in the 1-year interval. The decline was 89%, 70%, 42% and 69% for <50 mm, 50-100 mm, 100+ mm, and all sizes of scallops respectively.

Table 2. Numbers of scallops in 22 tows duplicated in 1970 and 1971.

Year	Scallop size (mm)			Total
	<50	50-100	100+	
1970	1,478	8,935	1,235	11,648
1971	166	2,719	715	3,600

Estimate of Z

Assuming that the decline in numbers is a result of mortality, a first estimate of the total mortality (Z), not allowing for any new recruitment between the two surveys, might be $\log_e \frac{11,648}{3,600} = 1.18$. This is higher than any previous estimate of mortality for the stock. (Estimates made in 1962 (Posgay, pers. comm.) suggested values of 0.71 to 0.99 for Z.)

Four main factors affect the validity of this estimate:

(1) Scallops at size L_t in 1970 with a probability of retention by the dredge of P_t will have a greater probability of retention P_{t+1}, one year later at size L_{t+1}. This factor is likely to lead to an underestimate of the value of Z.

(2) Individual cover results suggest that a higher proportion of small scallops may be retained in the dredge when catches are high than when they are low. Separate estimates from cover experiments of the 50% retention point in 1970 and 1971 suggest that L_{50} rose from 78.5 to 87.5 mm between the two years due to the reduced abundance of scallops in 1971. Therefore, the proportion of small scallops retained in the dredge was higher in 1970 than in 1971, leading to an overestimate of mortality.

(3) Some recruitment of new scallops to the fishable stock may have occurred in the interval. This would lead to an underestimate of the value of Z.

(4) The possibility must also be considered that dispersal of scallops took place from the dense population of scallops located in 1970. This would have led to an overestimate of Z. No estimate of the magnitude of this effect can be made until the bottom photographs taken in 1971 are analyzed, but evidence from tagging experiments and from laboratory and field studies

on young scallops, have shown that scallops less than 100 mm shell height spend much of their time attached to the bottom with a byssus on gravel substrates. Many scallops caught in the surveys were attached to pieces of gravel in the dredge. There was little evidence of locomotor activity during the 1970 survey: less than 1% of the 2,830 scallops in bottom photographs taken in front of the dredge were swimming. All of these considerations suggest that any dispersion which may have occurred was only local in extent.

Taking factors (1) to (3) into consideration (Appendix I) gives an estimate of Z for scallops 50 mm and larger of 1.06. This suggests that the change in dredge selectivity between the two years had a major influence on the magnitude of Z. Because of the many potential sources of error in the method used in the appendix, it is difficult to decide what significance should be given to values of Z for individual size-classes. Nonetheless, there is a fairly good correspondence between the predicted and actual size frequencies of scallops in 1971. Although the modal size predicted for 1971 is 10 mm greater than the actual modal size (probably accounting for the high value of Z for scallops reaching 80-90 mm shell height in 1971), there is fairly close correspondence between the predicted and actual size frequencies in 1971. This gives support to the main conclusion indicated from these data, namely that scallop mortality in the period June 1970 to June 1971 remained high throughout the whole size range captured by the dredge and not just for scallops within the size range exploited by the fleet (70 mm and larger).

Discussion

There is evidence that a high mortality of scallops occurred within a heavily fished area of the Northern Edge of Georges Bank in the period June 1970 to June 1971. Preliminary estimates reported here suggest that the annual mortality was approximately 65% for all sizes of scallops. Because there is evidence that indirect fishing mortality played a large part in this decline in numbers, especially for the smaller scallops, it is not possible to separate this mortality into components of direct fishing mortality (F) and natural mortality (M). Although the value for M of 0.10 for commercial-size scallops determined by Merrill and Posgay (1964) is probably an underestimate for scallops smaller than 90 mm, invertebrate predators were not common in the area, and it seems unlikely that natural mortality can account for more than a small fraction of the estimated value of Z. In view of the fact that the Canadian fleet concentrated in the area in 1970 (Caddy and Sreedharan, 1971), it is probable that a large part of this mortality results directly or indirectly from fishing. From landed meat sizes, it is estimated that scallops as small as 70-mm shell height were shucked by the fleet in 1970 and direct fishing mortality was undoubtedly high for scallops larger than 70 mm. However, from bottom photographs, it is estimated that at least half of the population present in 1970 was smaller than 70 mm, and yet the value of Z estimated for scallops in the size range 50-70 mm is still around 0.9. It seems likely that the indirect effects of fishing played a large part in this mortality.

Incidental effects of fishing on the stocks

The high incidence of shock marks on shells of Georges Bank scallops was mentioned earlier, and promises to provide a useful measure of fishing effort once the factors determining shell breakage and regeneration have been elucidated. Multiple shock marks are frequently seen on individual shells, and this is likely to be due to the wide range of sizes and ages over which selection occurs. The possibility of repeated destructive encounters with the gear before eventual retention makes this phenomenon an important one, and calls for further studies on the effect of repeated fishing on growth and survival of small scallops. It is probably significant in this respect that a large proportion of small scallops pass out through the belly of the dredge. This undoubtedly increases the probability of damage as the heavy dredge passes over them. The design of a 'savings gear' with sharper size selectivity and reduced incidental mortality is being given a high priority.

Direct confirmation of the important role of incidental mortality from dragging was provided recently by observations made from a research submarine in Chaleur Bay in ICNAF Div. 4T in the tracks left by an offshore dredge over gravel bottom. Of the 323 scallops seen in the dredge tracks, 11% were estimated to be damaged due to encounters with the gear, and a further 7% were either partly buried in the sediment, or wedged under rocks displaced by the dredge. Fish and invertebrate predators rapidly aggregated to feed in the tracks.

Significance of the mortality to the fishery

If incidental mortality due to dragging is a major cause of death for juvenile scallops, then the practice of fishing areas of recent recruitment in order to capture a few scallops of exploitable size has little to commend it, even if small scallops pass through the gear on bottom, or are discarded by fishermen after capture.

Full exploitation of each new year-class as soon as it enters the fishery will accentuate fluctuations in abundance already caused by irregularities in recruitment. This is likely to have a particularly damaging effect at the present time, when prospects for conversion to other fisheries are poor.

Without any information on the magnitude of the three mortality components discussed above, it is impossible to arrive at a precise estimate of the effect of postponing harvesting for 1 year on the productivity of the grounds. However, it was estimated from bottom photographs taken in 1970 (Caddy 1971*a*) that there were 270 million scallops with an estimated mean size of 73 mm within the 80 square miles of the concentration. Using data from Haynes (1966), this is equivalent to a standing stock of around 1.7 million kg of meats. Assuming a value for M of 0.2 (twice that estimated by Merrill and Posgay (1964)), there would have been 221 million scallops in the area in June 1971, with an estimated mean size (Fig. 1) of 92 mm, which would be approximately equivalent to 2.8 million kg meats, 65% more than was available in 1970. Undoubtedly, a higher proportion of the stock could have been landed in 1971 than in 1970 since retention by the dredge would have risen from 33 to 62% (Fig. 2). Using the same reasoning, it can be calculated that if harvesting had been postponed for one year, a value of M as high as 0.7 could have been tolerated and still resulted in the same standing stock of meats in the area in 1971 as in 1970. This value for M is undoubtedly too high, since it is close to the value for Z calculated in 1962 when landings from the Bank were close to a maximum. It must be concluded that postponing exploitation for one year would have resulted in a substantial increase in yield.

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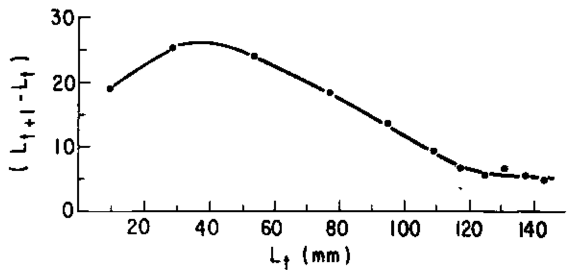

Fig. 1. Plot of initial shell length (L_t) against annual increment during the following year ($L_{t+1} - L_t$) based on back measurements of 20 samples of scallop shells taken in the period 1961-64.

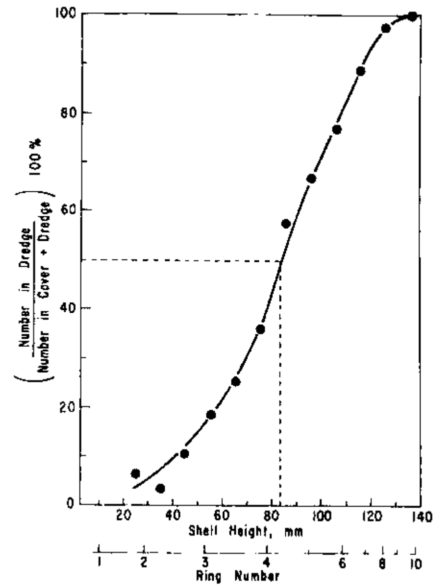

Fig. 2. Selection ogive for the back of the covered dredge, based on 37 tows made with an 8-ft offshore dredge on Georges Bank in 1970-71.

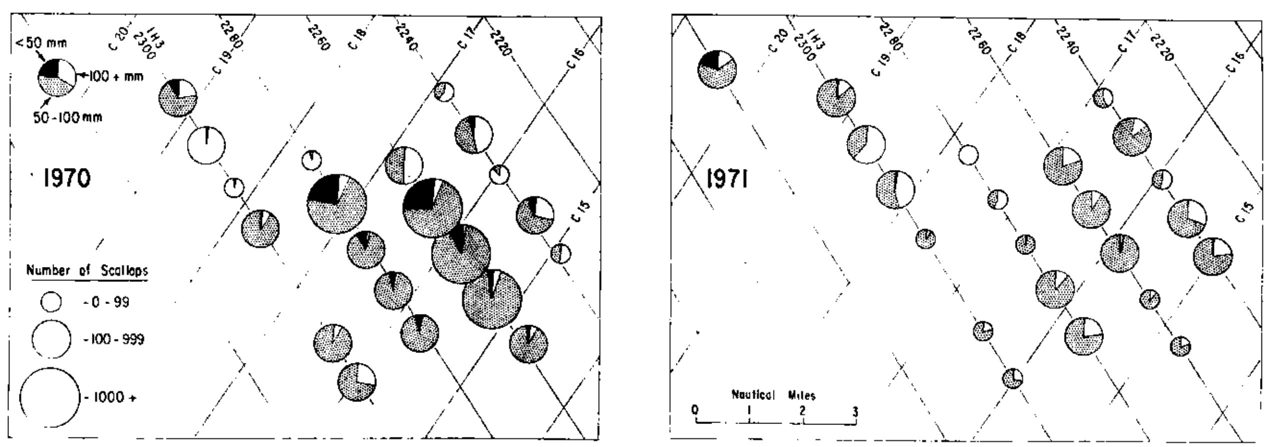

Fig. 3. Abundance and distribution of scallops in three size categories within a localized area of the Northern Edge of Georges Bank in 1970 and 1971. (Tows made along Loran 1H3 lines with red Decca cross bearings.)

Appendix I

The effect of gear selectivity and growth on the estimate of Z from size frequency of dredge catches in 1970 and 1971

It is assumed that the growth data in Fig. 1 represent the mean increase in shell height between the two surveys.

The 50% retention points for the survey dredge were estimated to be 78.5 and 87.5 mm respectively in 1970 and 1971. It is assumed that the separate selection curves passing through these points are parallel to each other, and the mean selection curve in Fig. 2.

The calculations in Appendix Table 1 are then as follows:

1) The number of scallops entering the dredge in 1970 is calculated from the length frequency and the 1970 selection data for each 10-mm size-group, using the relationship:

$$\text{Number entering dredge} = \frac{100 \text{ (Number caught in dredge)}}{\% \text{ retained in dredge}}$$

2) The mid-point of each 10-mm size-class L_t is considered to be a measure of the mean size of scallops within that size-class. The shell increment added by a scallop of initial size L_t during 1 year's growth is obtained from Fig. 1, and added to L_t giving an estimate of L_{t+1}. Unlike the values for L_t, which are the mid-points of 10-mm size-classes, values for L_{t+1} are likely to fall between the mid-points of two adjacent size-classes, L_x and L_y, where $L_x < L_{t+1} < L_y$, and the intervals $(L_{t+1} - L_x)$ and $(L_y - L_{t+1})$ are x and y respectively. The N scallops of estimated mean size L_{t+1} in 1971 were divided between L_x and L_y in inverse ratio to the intervals separating L_x and L_y from L_{t+1}, i.e., $\frac{y\,N}{10}$ scallops were allocated to size-class L_x and $\frac{x\,N}{10}$ scallops to size L_y. The numbers calculated from this procedure were summed for each 10-mm size-class and a size frequency obtained. For the purposes of this argument, this is considered to represent the size frequency of scallops available to the dredge after a year's growth with zero recruitment and mortality.

3) This size frequency was then compared with the size frequency of the 1971 catches, also adjusted for selectivity using the 1971 selection curve. This gave an estimate of the number of scallops in each size-group which entered the dredge in 1971. The two size frequencies were then compared to give estimates of Z for each 10-mm size-group using the relationship:

$$Z = -\log_e \frac{\text{Calculated number entering the dredge (1971 data)}}{\text{Calculated number entering dredge (1970 data)}}$$

It is evident that there are many potential sources of error in this procedure but it is likely to reveal any marked changes in Z with size. Obviously, the values for Z for the earlier size-groups are likely to be underestimates, since they do not take into account annual recruitment between the two surveys. As indicated earlier, recruitment was low in 1970-71 and its effects can be eliminated by ignoring the values of Z for scallops smaller than 50 mm, since from Fig. 1, it is unlikely that many scallops smaller than 20 mm in 1970 will have exceeded a size of 50 mm in 1971. A mean value of Z for scallops over 50 mm shell height is, therefore, 1.06.

Appendix Table 1. Estimation of Z for each 10-mm size-class for the period June 1970 to 1971.

	Mid-point of 10-mm size-class (L_t)													
	25	35	45	55	65	75	85	95	105	115	125	135	145+	Totals
Combined length frequency for 22 tows in 1970	7	88	526	173	927	2,079	549	252	240	397	215	65	10	5,528
% retention by dredge back in 1970	5.2	9.2	15.0	21.5	30.3	42.5	59.0	71.3	83.0	93.0	98.7	100.0	100.0	
Calculated number entering dredge in 1970	135	957	3,507	805	3,059	4,892	931	353	289	427	218	65	10	15,648
Predicted mean size (mm) after 1 year's growth (L_{t+1})	49	61	70	78	86	94	101	108	115	123	131	141	150+	
Predicted length frequency after 1 year's growth (N_{1970})	-	-	81	437	2,327	2,317	3,484	5,081	806	480	429	157	49	15,648
Combined length frequency for 22 tows over same ground in 1971	2	4	2	46	192	384	672	409	185	202	142	34	13	2,287
% retention by dredge back in 1971	-	5.7	10.2	15.2	22.3	31.0	45.0	60.0	75.0	84.0	94.0	99.0	100.0	
Calculated number entering dredge in 1971 (N_{1971})	-	70	20	303	861	1,239	1,493	682	247	240	151	34	13	5,353
$-\text{Log}_e\ (N_{1971}/N_{1970}) = Z$	-	-	1.40	0.36	0.99	0.63	0.85	2.01	1.18	0.69	1.04	1.53	1.33	$\overline{Z}_{>50} = 1.06$

SECTION H
TRAWL MATERIAL AND MESH SIZE SAMPLING

14. Summaries of trawl material and mesh size sampling data, 1969-1971

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Introduction

In accordance with the recommendations of the Gear and Selectivity Subcommittee of STACRES (Standing Committee on Research and Statistics), Member Countries are requested to report annually on trawl materials and mesh sizes in use, including data on the use of topside chafers (*Redbook 1964*, Part I, p. 44; *1965*, Part I, p. 62; *1966*, Part I, p. 64; *1967*, Part I, p. 65. Forms, entitled "Summary of Trawl Material and Mesh Size Sampling", are circulated to Member Countries in early January of each year with the request that they be completed and returned to the Secretariat by 31 March, so that the data can be collated and summarized as a meeting document for consideration at the Annual Meeting in June.

Usually, the meeting document was a year late in being prepared at the Secretariat, due to the tardiness of some Member Countries in submitting their returns, and, in any case, only about two-thirds of the Member Countries bothered to submit information. Data for 1969 were summarized as a meeting document for the 1971 Annual Meeting (Res.Doc. 71/29) as were also the data for 1970 (Res.Doc. 71/123), although the latter was very incomplete. Data for 1971 were not prepared as a 1972 meeting document due to the scarcity of returns up to the time of the Annual Meeting (only 6 countries had reported up to 31 May).

In accordance with a recommendation of the 1966 Annual Meeting (*Redbook* 1966, Part I, p. 20) that the data on trawl materials and mesh sizes be summarized and published in Redbook every third year, the 1964 and 1965 data were published in *Redbook* 1966, Part III, and the 1966-68 data in *Redbook* 1970, Part III. This report contains the summaries of data submitted for the years 1969-71 as Tables 1, 2 and 3 respectively.

For 1969 data were received from 8 Member Countries - Canada, Denmark (G), Poland, Portugal, Romania, Spain, USSR and USA, while Fed. Rep. Germany, Norway and UK submitted "nil" returns (Table 1).

For 1970 data were received from 6 Member Countries - Canada, France, Poland, Portugal, USSR and USA, while Japan and UK submitted "nil" returns (Table 2).

For 1971 data were received from 8 Member Countries - Canada, France, Japan, Norway, Poland, Portugal, USSR and USA, while Fed.Rep. Germany, Denmark and UK submitted "nil" returns (Table 3).

Abbreviations used

Species:
- Arg - Argentines
- Flo - Flounders
- Had - Haddock
- Hak - White hake
- Her - Herring
- Mac - Mackerel
- Mix - Mixed species
- Pol - Pollock
- Red - Redfish
- SH - Silver hake
- Shr - Shrimp
- Yel - Yellowtail

Gear:
- DS - Danish seine
- MT - Midwater trawl
- OT - Otter trawl
- OTSI - Otter trawl side
- OTST - Otter trawl stern
- PT - Pair trawl

Material:
- CO - Courlene
- PA - Polyamides and polyesters
- PE - Polyethylenes
- PP - Polypropylenes

NS - Not specified

Table 1. Summary of Trawl Material and Mesh Size Sampling, 1969.

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Material	Mesh Gauge Type	Number of codends measured by size group (mm) <80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Chafer Type	Chafer No.
Canada	3	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	2	1	-	-	-	-	-	-	ICNAF	14
				PE	"	-	-	-	-	-	1	2	-	3	-	1	-	-	-		
				PP	"	-	-	-	-	-	1	1	3	1	-	-	-	-	-		
			Red	PA	ICNAF	-	-	-	-	-	-	-	-	2	-	-	-	-	-	ICNAF	11
				PE	"	-	-	-	-	-	-	1	3	2	-	-	-	-	-		
				PP	"	-	-	-	-	-	2	-	1	1	-	-	-	-	-		
			Flo	PA	ICNAF	1	-	-	-	2	4	14	2	-	-	1	-	-	-	ICNAF	53
				PE	"	-	-	-	-	1	2	2	8	8	9	4	-	-	-		
				PP	"	-	-	-	-	-	2	5	5	2	1	2	-	-	-		
		OTST	Cod	PA	ICNAF	-	-	-	-	-	6	13	7	2	2	-	-	-	-	ICNAF	NS
				PE	"	-	-	-	-	1	-	-	-	-	-	-	-	-	-		
				PP	"	-	-	-	-	1	-	4	2	3	-	-	-	-	-		
			Had	PP	ICNAF	-	-	-	-	-	-	5	-	-	-	-	-	-	-	NS	
			Flo	PA	ICNAF	-	-	-	-	1	7	38	15	9	3	1	-	-	-	ICNAF	3
				PE	"	-	-	-	-	-	1	-	-	2	1	-	-	-	-		
				PP	"	-	-	-	-	1	9	39	16	114	31	-	-	-	-		
	4	OTSI	Cod	PA	ICNAF	3	-	-	-	-	1	8	14	29	4	-	-	-	-	ICNAF	26
				PE	"	-	-	-	1	1	1	7	8	3	4	-	-	-	-		
				PP	"	1	-	-	-	-	2	3	64	9	1	1	-	-	-		
			Had	PA	ICNAF	-	-	-	-	1	-	-	1	-	1	-	-	-	-	ICNAF	3
				PE	"	-	-	-	-	-	1	2	1	2	-	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	-	2	-	-	-	-		
			Red	PA	ICNAF	68	-	4	-	-	1	3	4	-	-	-	-	-	-	ICNAF	28
				PE	"	6	-	-	-	-	-	-	5	1	-	-	-	-	-		
				PP	"	59	1	1	2	6	2	3	2	-	-	1	-	-	-		
				CO	"	1	-	-	-	-	-	-	-	-	-	-	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	-	4	2	3	-	-	-	-	-	ICNAF	6
				PE	"	1	-	-	-	-	-	-	4	1	3	-	-	-	-		
				PP	"	-	-	-	-	-	-	2	3	-	-	-	-	-	-		
			Pol	PA	ICNAF	-	-	-	-	-	-	1	-	-	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	1	-	-	-	-	-	-	-	-		
			Hak	PA	ICNAF	-	-	-	-	-	-	1	1	1	-	-	-	-	-	NS	
		OTST	Cod	PA	ICNAF	-	-	-	-	-	-	4	5	2	-	-	-	-	-	ICNAF	2
			Had	PE	ICNAF	-	-	-	-	-	1	-	-	1	-	-	-	-	-	NS	
				PP	"	-	-	-	-	-	-	-	1	10	-	-	-	-	-		

Table 1. Continued

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	Number of codends measured by size group (mm)															Chafer	
						<80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up		Type	No.
Canada	4	OTST	Red	PA	ICNAF	1	-	-	-	-	-	-	-	1	-	-	-	-	-		ICNAF	3
				PP	"	-	-	-	-	-	-	-	-	1	-	1	-	-	-			
			Flo	PA	ICNAF	-	-	-	-	-	1	1	-	1	-	1	-	-	-		ICNAF	1
				PE	"	1	-	-	-	-	-	-	-	1	-	1	-	-	-			
			Pol	PP	ICNAF	-	-	-	-	-	-	1	-	-	-	-	-	-	-		NS	
	5	OTSI	Pol	PE	ICNAF	-	-	-	-	-	1	-	-	-	-	-	-	-	-		NS	
		OTST	Cod	PP	ICNAF	-	-	-	-	-	-	-	3	-	4	-	-	-	-		ICNAF	2
Denmark	1	OTST	Cod Red	PP	ICNAF	-	-	-	-	-	-	-	-	-	-	-	-	-	13		NS	
Germany (FR)						NIL RETURN																
Norway						NIL RETURN																
Poland	2	OTST	Mix	PA	ICNAF	-	-	-	-	-	-	-	39	-	-	-	-	-	-		POLISH	39
	5	OT	Her Mac	PA	ICNAF	113	-	-	-	-	-	-	-	-	-	-	-	-	-		POLISH	113
Portugal	1-4	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	-	18	21	6	-	-	-	-		ICNAF	34
				PE	"	-	-	-	-	-	-	-	42	60	3	-	-	-	-		POLISH	5
		OTST	Cod	PA	ICNAF	-	-	-	-	-	-	-	-	8	3	-	-	-	-		ICNAF	8
				PE	"	-	-	-	-	-	-	-	-	9	4	-	-	-	-		POLISH	6
Romania	5	OTST	Her	PA	ICNAF	-	-	-	-	-	-	-	20	-	-	-	-	-	-		POLISH	NS
Spain	1	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	-	-	-	10	-	-	-	-		ICNAF	6
				PE	"	-	-	-	-	-	-	-	-	-	4	-	-	-	-			
				PA	ICNAF	-	-	-	-	-	-	-	-	-	24	-	-	-	-		NS	
				PE	"	-	-	-	-	-	-	-	-	-	14	-	-	-	-			
	2	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	-	16	-	-	-	-	-	-		ICNAF	5
				PE	"	-	-	-	-	-	-	-	5	-	-	-	-	-	-			
				PA	ICNAF	-	-	-	-	-	-	-	6	-	-	-	-	-	-		NS	
				PE	"	-	-	-	-	-	-	-	2	-	-	-	-	-	-			

Table 1. Continued

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	Number of codends measured by size group (mm) <80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Chafer Type	Chafer No.
Spain	3	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	-	24	-	-	-	-	-	-	ICNAF	12
				PE	"	-	-	-	-	-	-	-	12	-	-	-	-	-	-		
				PA	ICNAF	-	-	-	-	-	-	-	48	-	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	-	-	16	-	-	-	-	-	-		
	4	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	-	8	-	-	-	-	-	-	ICNAF	4
				PE	"	-	-	-	-	-	-	-	3	-	-	-	-	-	-		
				PA	ICNAF	-	-	-	-	-	-	-	40	-	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	-	-	18	-	-	-	-	-	-		
	5	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	-	32	-	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	-	-	10	-	-	-	-	-	-		
USSR	3	OTSI	Cod	PA[1]	ICNAF	-	-	-	-	-	-	2	4	4	-	-	-	-	-	POLISH	10
		OTST	Cod	PA[1]	ICNAF	-	-	-	-	-	-	4	1	1	-	-	-	-	-	POLISH	6
			Red Arg	PA[1]	ICNAF	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
UK						NIL RETURN															
USA	4	OTSI	Cod Had	PA	ICES	-	-	-	-	-	37	29	-	-	-	-	-	-	-	ICNAF	6
				PE	"	-	-	-	-	-	2	-	-	-	-	-	-	-	-		
	3-5	OTSI	Red	PA	ICES	22	-	-	-	-	-	-	-	-	-	-	-	-	-	NS	
				PE	"	3	-	-	-	-	-	-	-	-	-	-	-	-	-		
	5	OTSI	Cod Had	PA	ICES	-	-	-	-	52	60	78	10	-	15	-	-	-	-	NS	
				PE	"	-	-	-	-	-	-	2	1	-	-	-	-	-	-		
			Cod Had	PA	ICNAF	-	-	-	-	-	6	114	22	2	-	-	-	-	-	ICNAF	2
				PE	"	-	-	-	-	-	-	3	-	-	-	-	-	-	-		
			Yel	PA	NS	-	25	15	-	-	32	28	-	-	-	-	-	-	-	NS	
			SH	PA	ICES	117	-	-	-	-	-	-	-	-	-	-	-	-	-	OTHER	7
			Ind[2]	PA	ICES	96	-	-	-	-	-	-	-	-	-	-	-	-	-	NS	
				PE	"	3	-	-	-	-	-	-	-	-	-	-	-	-	-		
				PP	"	3	-	-	-	-	-	-	-	-	-	-	-	-	-		

1 Nets measured wet (used).
2 Industrial fishery.

Table 2. Summary of Trawl Material and Mesh Size Sampling, 1970.

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	<80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Chafer Type	Chafer No.
Canada	3	OTSI	Cod	PE	ICNAF	-	-	-	-	-	-	-	-	1	-	-	-	-	-	ICNAF	3
				PP	"	-	-	-	-	-	-	-	4	-	2	-	-	-	-		
			Had	PA	ICNAF	-	-	-	-	-	-	2	6	-	-	-	-	-	-		
				PE	"	-	-	-	-	2	-	-	1	1	2	-	-	-	-	ICNAF	15
				PP	"	-	-	-	-	-	-	-	-	1	1	-	-	-	-		
			Red	PE	ICNAF	1	-	-	-	-	-	-	-	-	-	1	-	-	-	ICNAF	12
				PP	"	-	-	-	-	-	-	-	4	3	3	1	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	-	-	1	-	-	-	-	-	-		
				PE	"	-	-	-	-	-	-	-	5	2	-	-	-	-	-	ICNAF	NS
				PP	"	-	-	-	-	-	-	-	2	2	-	-	-	-	-		
		OTST	Cod	PP	ICNAF	-	-	-	-	-	-	-	-	26	22	-	-	-	-	ICNAF	4
			Had	PA	ICNAF	-	-	-	-	-	-	-	1	1	-	-	-	-	-	ICNAF	1
				PP	"	-	-	-	-	-	-	-	-	2	3	-	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	-	13	19	9	7	-	-	-	-		
				PE	"	-	-	-	-	-	-	-	-	-	1	-	-	-	-	ICNAF	9
				PP	"	-	-	-	-	2	-	-	16	132	112	1	-	-	-		
	4	OTSI	Cod	PA	ICNAF	3	-	-	-	-	1	2	10	3	1	-	-	-	-		
				PE	"	-	-	-	-	-	2	3	20	8	3	-	-	-	-	ICNAF	20
				PP	"	10	3	-	-	-	1	2	24	5	1	-	-	-	-		
			Had	PA	ICNAF	-	-	-	-	-	1	1	6	-	-	-	-	-	-		
				PE	"	-	-	-	-	1	2	-	5	1	-	-	-	-	-	ICNAF	6
				PP	"	-	-	-	-	1	-	-	5	-	-	-	-	-	-		
			Red	PA	ICNAF	31	12	-	-	-	1	-	9	-	-	1	-	-	-		
				PE	"	18	-	-	-	-	-	1	2	-	-	1	-	-	-	ICNAF	1
				PP	"	47	1	1	-	-	1	1	3	7	4	1	-	-	-		
			Flo	PA	ICNAF	2	-	-	-	1	4	6	5	2	1	-	-	-	-		
				PE	"	-	-	-	-	-	2	2	5	4	-	-	-	-	-	ICNAF	6
				PP	"	-	-	-	-	-	-	-	6	-	-	-	-	-	-		
			Pol	PA	ICNAF	-	-	-	-	-	-	1	-	-	-	-	-	-	-		
				PE	"	-	-	-	-	1	2	-	-	-	-	-	-	-	-	ICNAF	1
				PP	"	-	-	-	-	-	-	2	-	-	-	-	-	-	-		
			Hak	PE	ICNAF	1	-	1	-	-	-	-	-	-	-	-	-	-	-	NS	
		OTST	Cod	PA	ICNAF	-	-	-	-	-	1	-	1	-	-	-	-	-	-		
				PE	"	-	-	-	-	-	-	2	2	-	-	-	-	-	-	ICNAF	3
				PP	"	-	-	-	-	-	-	3	11	3	1	-	-	-	-		

Table 2. Continued

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	Number of codends measured by size group (mm)														Chafer	
						<80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Type	No.
Canada	4	OTST	Had	PA	ICNAF	-	-	-	-	1	-	2	1	-	-	-	-	-	-	POLISH	4
				PE	"	1	-	-	-	-	1	-	-	-	-	-	-	-	-		
				PP	"	1	-	-	-	1	-	-	5	-	-	-	-	-	-		
			Red	PA	ICNAF	2	-	-	-	-	-	-	-	-	-	1	-	-	-	NS	
				PE	"	8	-	-	-	-	-	-	2	1	-	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	3	-	-	-	-	-	-		
			Flo	PA	ICNAF	1	-	-	-	2	1	-	1	-	1	1	-	-	-	NS	
				PE	"	-	-	-	-	-	-	-	2	1	-	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	1	3	1	-	-	-	-		
			Pol	PA	ICNAF	-	-	-	-	-	-	1	1	-	-	-	-	-	-	NS	
				PP	"	-	-	-	-	-	-	-	1	1	-	-	-	-	-		
		DS	Cod	PA	ICNAF	-	-	-	-	-	-	2	1	-	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	1	1	-	-	-	-	-	-	-		
				PP	"	-	-	-	-	-	-	1	1	1	-	-	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	1	-	4	4	-	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	-	3	1	-	-	-	-	-	-		
				PP	"	-	-	-	-	-	2	1	1	3	3	3	-	-	-		
	5	OTST	Cod	PP	ICNAF	-	-	-	-	-	-	-	3	-	-	-	-	-	-	NS	
			Had	PP	ICNAF	-	-	-	-	-	-	-	1	-	-	-	-	-	-	NS	
			Red	PP	ICNAF	-	-	-	-	-	-	1	-	-	-	-	-	-	-	NS	
France	1-4	OTSI	Cod	PA	NEAFC	-	-	-	-	-	-	-	-	13	-	-	-	-	34	NONE USED	
		OTST	Cod	PA	NEAFC	-	-	-	-	-	-	-	-	-	-	10	-	-	20	NONE USED	
Japan	3-5	OTST	Mix	PE	-	NO MESH MEASUREMENTS														NONE USED	
Poland	2	OTST	Cod Red	PA	ICNAF	-	-	-	-	-	-	15	-	-	-	-	-	-	-	POLISH	NS
	3	OTST	Cod Red	PA	ICNAF	-	-	-	-	-	-	21	-	-	-	-	-	-	-	POLISH	NS
	4-5	OTST	Her Mac	PA	ICNAF	51	-	-	-	-	-	-	-	-	-	-	-	-	-	POLISH	51
	5	OTSI	Her Mac	PA	ICNAF	75	-	-	-	-	-	-	-	-	-	-	-	-	-	POLISH	75

Table 2. Continued

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	Number of codends measured by size group (mm)														Chafer	
						<80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Type	No.
Portugal	1-4	OTSI	Cod	PA	NEAFC	-	-	-	-	-	-	-	9	-	-	-	-	-	-	ICNAF	7
				PE	"	-	-	-	-	-	-	-	-	-	12	-	19	-	3		
		OTST	Cod	PA	NEAFC	-	-	-	-	-	-	-	-	-	-	-	4	-	-	POLISH	7
				PE	"	-	-	-	-	-	-	-	-	-	2	-	12	-	-		
USSR	2	OTST	Mix	PA[1]	ICNAF	-	-	-	-	-	-	-	-	-	3	-	-	-	-	POLISH	3
	3	OTST	Cod Red	PA[1]	ICNAF	-	-	-	-	-	-	6	2	-	-	-	-	-	-	POLISH	8
	4	OTST	Her Red	PA[1]	ICNAF	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
UK						NIL RETURN															
USA	4	OTSI	Cod Had	PA	ICNAF	-	-	-	-	-	-	6	11	-	-	-	-	-	-	ICNAF	2
			Red	PE	ICES	2	-	-	-	-	-	-	-	-	-	-	-	-	-	NS	
	5	OTSI	Cod Had	PA	ICNAF	-	-	-	-	-	-	7	11	-	-	-	-	-	-	ICNAF	3
			Red	PE	ICES	6	-	-	-	-	-	-	-	-	-	-	-	-	-	NS	
				PP	"	1	-	-	-	-	-	-	-	-	-	-	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-	0
			S H	PP	ICES	1	-	-	-	-	-	-	-	-	-	-	-	-	-	NS	
				PE	"	3	-	-	-	-	-	-	-	-	-	-	-	-	-		
			Cod Had Flo	PA	ICNAF	-	-	-	-	-	-	-	-	1	-	-	-	-	-		
			Shr	PE	ICES	11	-	-	-	-	-	-	-	-	-	-	-	-	-	NS	
				PP	"	1	-	-	-	-	-	-	-	-	-	-	-	-	-		
		OTST	Cod Had Flo	PA	ICNAF	-	-	-	-	-	-	-	-	-	-	1	-	-	-	NS	

[1] Measured when wet (used).

Table 3. Summary of Trawl Material and Mesh Size Sampling, 1971.

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	Number of codends measured by size group (mm) <80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Chafer Type	Chafer No.
Canada	3	OTSI	Cod	PE	ICNAF	-	-	-	-	-	-	-	1	-	1	-	-	-	-	ICNAF	5
				PP	"	-	-	-	-	-	-	-	-	-	3	-	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	-	1	2	1	-	-	-	-	-	ICNAF	14
				PE	"	-	-	-	-	-	-	-	1	1	3	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	2	9	-	-	-	-		
			Red	PA	ICNAF	-	-	-	-	-	-	-	1	-	1	-	-	-	-	ICNAF	17
				PE	"	-	-	-	-	-	-	1	1	4	2	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	5	2	1	-	-	-		
		OTST	Cod	PA	ICNAF	-	-	-	-	-	-	-	3	-	-	-	-	-	-	ICNAF	NS
				PE	"	-	-	-	-	-	-	-	-	2	2	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	13	21	-	2	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	-	6	24	1	1	1	2	-	-	ICNAF	NS
				PE	"	-	-	-	-	-	-	1	4	7	18	3	3	-	-		
				PP	"	-	-	-	-	-	-	1	10	63	167	7	97	-	-		
			Red	PP	ICNAF	-	-	-	-	-	-	-	-	-	1	-	-	-	-	ICNAF	NS
	4	OTSI	Cod	PA	ICNAF	-	-	1	-	-	-	2	7	2	1	-	-	-	-	ICNAF	24
				PE	"	4	-	-	-	-	1	3	15	5	5	1	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	3	9	-	-	-	-		
			Had	PA	ICNAF	-	-	-	-	-	-	-	1	3	1	-	-	-	-	ICNAF	3
				PE	"	-	-	-	-	-	-	-	-	3	3	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	3	-	-	-	-	-		
			Flo	PA	ICNAF	3	-	-	-	3	-	9	2	6	-	-	-	-	-	ICNAF	2
				PE	"	-	-	-	-	-	-	-	4	5	-	-	-	-	-		
				PP	"	1	-	-	-	-	-	-	-	-	-	-	-	-	-		
			Red	PA	ICNAF	48	11	15	1	-	-	-	2	-	1	-	-	-	-	ICNAF	37
				PE	"	45	1	1	-	-	-	-	7	3	3	-	-	-	-		
				PP	"	26	1	3	-	-	-	1	-	4	12	-	1	-	-		
			Hak	PA	ICNAF	-	-	-	-	-	-	-	1	-	-	-	-	-	-	NS	
				PE	"	2	-	-	-	-	-	-	-	-	-	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	1	-	-	-	-	-		
			Pol	PA	ICNAF	-	-	-	-	-	-	-	-	-	1	1	-	-	-	ICNAF	1
				PE	"	-	-	-	-	-	-	-	1	1	2	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	1	-	-	-	-	-	-		
		OTST	Cod	PA	ICNAF	1	-	-	-	-	-	-	1	2	1	-	-	-	-	POLISH	6
				PE	"	-	-	-	-	-	-	-	-	2	3	-	-	-	-		
				PP	"	-	-	-	1	-	-	-	3	8	6	1	-	-	-		

Table 3. Continued

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	Number of codends measured by size group (mm) <80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Chafer Type	Chafer No.
Canada	4	OTST	Had	PA	ICNAF	-	-	-	-	-	-	1	1	2	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	1	2	-	4	2	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	5	1	-	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	-	1	1	1	1	-	-	-	-	ICNAF	5
				PE	"	-	-	-	-	-	-	-	1	-	2	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	1	4	1	-	-	-		
			Red	PA	ICNAF	18	-	-	-	-	-	-	-	-	-	-	-	-	-	ICNAF	2
				PE	"	2	-	-	-	-	-	-	-	-	-	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	3	4	1	-	-	-		
			Pol	PA	ICNAF	-	-	-	-	-	-	1	1	-	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	-	-	-	2	1	-	-	-	-		
				PP	"	-	-	-	-	-	-	-	-	-	1	1	-	-	-		
		DS	Cod	PA	ICNAF	-	-	-	-	-	-	1	1	2	-	-	-	-	-	ICNAF	NS
				PE	"	-	-	-	-	-	-	3	1	1	-	-	-	-	-		
			Flo	PA	ICNAF	-	-	-	-	-	1	-	1	2	-	-	-	-	-	NS	
				PE	"	-	-	-	-	-	-	-	1	2	-	-	-	-	-		
				PP	"	-	-	-	-	-	1	1	2	1	2	3	-	-	-		
	5	OTST	Cod	PP	ICNAF	-	-	-	-	-	-	-	-	1	-	-	-	-	-	NS	
			Pol	PP	ICNAF	-	-	-	-	-	-	-	-	1	-	-	-	-	-	NS	
France	1-4	OTSI	Cod	PA	NEAFC	-	-	-	-	-	-	-	-	-	32	-	16	-	25	ICNAF & M. FLAP	NS
		OTST	Cod	PA	NEAFC	-	-	-	-	-	-	-	-	-	22	-	6	-	11	ICNAF & M. FLAP	NS
Germany (FR)						NIL RETURN															
Japan	6	OTST	Mix	PE	ICNAF	1	2	-	-	-	-	-	-	-	-	-	-	-	-	NS	
Norway	1-3	OTST	Cod	PA PE	-	NUMBER NOT SPECIFIED														POLISH	NS
Poland	2	OTST	Mix	PA	ICNAF	-	-	-	-	-	-	-	-	-	22	-	-	-	-	POLISH	22

Table 3. Continued

Country	Sub-area	Vessel & Gear Type	Main Spec.	Net Mat-erial	Mesh Gauge Type	Number of codends measured by size group (mm) <80	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-up	Chafer Type	Chafer No.
Poland	5	OTST	Her Mac	PA	NEAFC	30	-	-	-	-	-	-	-	-	-	-	-	-	-	POLISH	30
		OTSI	Her Mac	PA	NEAFC	40	-	-	-	-	-	-	-	-	-	-	-	-	-	POLISH	40
Portugal	1-4	OTSI	Cod	PA	ICNAF	-	-	-	-	-	-	-	12	-	-	-	-	-	-	ICNAF	9
				PE	"	-	-	-	-	-	-	-	-	-	17	-	24	-	-		
		OTST	Cod	PA	ICNAF	-	-	-	-	-	-	-	-	-	-	-	3	-	-	POLISH	12
				PE	"	-	-	-	-	-	-	-	-	-	5	-	15	-	-		
Spain	1-4	OT	Cod	PA	ICNAF	-	-	-	-	-	-	-	-	-	22	-	-	-	-	ICNAF	8
				PE	"	-	-	-	-	-	-	-	-	-	7	-	-	-	-		
	1-5	PT	Cod	PA	ICNAF	-	-	-	-	-	-	-	-	49	128	-	-	-	-	Nil	
				PE	"	-	-	-	-	-	-	-	-	11	31	-	-	-	-		
USSR	3	OTST	Cod Red	PA[1]	ICNAF	-	-	-	-	-	-	-	-	-	9	-	-	-	-	POLISH	9
	4	OTST	Her	PA[1]	ICNAF	9	-	-	-	-	-	-	-	-	-	-	-	-	-	Nil	
	5	OTST	Her	PA[1]	ICNAF	10	-	-	-	-	-	-	-	-	-	-	-	-	-	Nil	
UK						NIL RETURN															
USA	4-5	OTSI	Cod Had	PA	ICES	-	-	-	-	8	3	4	-	-	-	-	-	-	-	ICNAF	2
	5	OTSI	Yel	PA	ICNAF	-	-	-	-	-	8	10	9	8	40	13	2	-	1	Nil	
			Cod Had	PA	ICNAF	-	-	-	-	-	3	9	9	1	1	2	-	-	-	NS	
				PE	"	-	-	-	-	-	-	-	2	-	-	-	-	-	-		
			Red	PA	ICES	10	-	-	-	-	-	-	-	-	-	-	-	-	-	ICNAF	2
			NS	PA	ICES	44	2	1	2	3	5	2	5	1	-	-	-	-	-	ICNAF	8
				PP	"	7	-	-	-	-	-	-	-	-	-	-	-	-	-		

[1] Measured when wet (used)

SECTION I
DISCARDS

15. Summary of information on discards and industrial fish (ICNAF Statistics Form 4) for the year 1970[1]

by the Assistant Executive Secretary

Discards

Table 1 is a summary of information on quantities of fish discarded at sea by otter trawlers from data submitted by Canada (M), Canada (N), France (M), Germany (FR), Portugal, Spain and USA on Statistics Form 4 (UK and Denmark reported that no data were available), and these data are compared with nominal catch statistics of finfish for the particular "main species" and "gear and tonnage class" groupings of Table 5 in ICNAF Statistical Bulletin Vol. 20 for the year 1970. It is thus assumed that the discard data reported on Statistics Form 4 pertain to the nominal catch data reported on Statlant 21B.

Germany (FR) reported discards by principal species and a "mixed" category, France (M) reported discards for cod and redfish, Portugal for cod and "others", Spain for cod, haddock and "others", and Japan for mackerel. Canada, in reporting discard information for certain "main species" and "gear and tonnage class" groupings only, listed discards for some commercial species, and, while it is normal practice to discard all or nearly all of such species as silver hake, argentines, sculpins, lumpfish, sea robins, anglers, eelpouts, skates, etc., no indication of the quantities of these species discarded was given.

The available data for the ICNAF Statistical Area indicate that discards of cod, haddock and redfish were small (1-2%), whereas discards of flounders and "others" were 9% and 10% respectively, the former mostly yellowtails in Subarea 5 and the latter (species unknown) mostly in Subareas 1-3 by the cod-fishing fleets.

Industrial Fish

Table 2 is a summary of information on quantities of fish converted to fish meal at sea by otter trawlers from data submitted by Germany (FR), Portugal, Poland and USSR on Statistics Form 4, and these data are shown in relation to nominal catch statistics of finfish for 1970.

Germany (FR) reported industrial fish by principal species and a "mixed" category, Portugal for cod and "others", Poland for a "mixed" category with herring as the principal species used for fish meal, and USSR by species for all vessels combined. Nearly all of the USSR data of fish converted into fish meal consisted of species in the "Other Fish" and "Other Groundfish" groups and of unsorted fish.

For the ICNAF Statistical Area the available data indicate that negligible quantities of cod, haddock, redfish and flounders were converted to fish meal at sea, but that 16% of "other" fish, mostly in Subareas 4, 5 and 6, were classed as industrial.

From Table 2 it is noted that Germany (FR) and Portugal reported, under "Others", quantities of industrial fish which exceed the nominal catches, and these are indicated by the percentage "100+". Notes for the completion of Statlant 21A and 21B Forms indicate that quantities of fish converted to fish meal should be included in the nominal catch. Such does not appear to be the case in Subareas 1, 2 and 3, where industrial fish catches exceed nominal catches. The question then arises as to whether or not the quantities shown under "Industrial Fish" for cod and redfish are included in the Nominal Catches of those species.

Abbreviations and Symbols Used in the Tables

Country

Can (M)	= Canada (Maritimes and Quebec)
Can (N)	= Canada (Newfoundland)
Fr (M)	= France (Metropolitan)
Ger (FR)	= Germany, Federal Republic
Port	= Portugal
USSR	= Union of Socialist Soviet Republics
USA	= United States of America

Species

Red	= redfish
Flo	= flounders
Her	= herring
Mix	= mixed
Mac	= mackerel
SH	= silver hake
OF	= other fish

Tonnage Class

7	= over 1800
6	= 901-1800
5	= 501-900
4	= 151-500
3	= 51-150
2	= 0-50

Symbols

-	= magnitude indicated to be less than one-half the unit used
?	= quantities discarded or turned into fish meal might be included in quantities shown under "others"

Gear

OT	= otter trawl
OTSI	= otter trawl, side
OTST	= otter trawl, stern
PT	= pair trawl

Source of Information

Log	= logbook
Int	= port interview
Cap	= captains' reports

Note: The nominal catches given under "Others" in Tables 1 and 2 included all "finfish" species, except cod, haddock, redfish and flounders.

[1] Submitted to the 1972 Annual Meeting of ICNAF as ICNAF Res.Doc. 72/84.

Table 1. Summary of information on quantities of fish (metric tons) discarded at sea in relation to nominal catch for the year 1970.

Sub-area	Main Species	Country	Gear and Tonnage Class	COD Nominal Catch	COD Dis-cards	COD Rate (%)	HADDOCK Nominal Catch	HADDOCK Dis-cards	HADDOCK Rate (%)	REDFISH Nominal Catch	REDFISH Dis-cards	REDFISH Rate (%)	FLOUNDERS Nominal Catch	FLOUNDERS Dis-cards	FLOUNDERS Rate (%)	OTHERS Nominal Catch	OTHERS Dis-cards	OTHERS Rate (%)	OTHERS Prin. Species	Source of Infor-mation	Samp-ling Rate (%)
1	Cod	Fr(M)	OTSI 6	3238	31	1	-			-	13	100	-	?		10	?		Mix	Cap	100
	"	"	OTST 6	1502	-	-	-			-	1	100	-	?		-	?			Cap	100
	"	Ger(FR)	OTST 5-7	40667	30	1	-			3592	-	-	13	-	-	245	26	10	Mix	Cap	100
	"	Port	OTSI 6	801	-	-	-			-	?		-	?		-	-	-		Log	100
	"	"	OTST 7	2677	46	2	-			-	?		-	?		-	72	100	Mix	Log	100
	"	Spain	OT 6	1303	1	-	-			-	?		-	?		-	45	100	Mix	Log	86
	"	"	PT 4	17499	36	-	5	1	17	-	?		-	?		-	243	100	Mix	Log	80
	Total Reported			67687	144	-	5	1	17	3592	14	-	13	-	-	255	386	60			
	Total All Countries			111443			6			4101			1802			14898					
2	Cod	Fr(M)	OTSI 6	8726	264	3	-			-	36	100	-	?		6	?		Mix	Cap	100
	"	"	OTST 6	7084	21	-	-			-	13	100	-	?		6	?		Mix	Cap	100
	"	Ger(FR)	OTST 6-7	50007	634	1	-			408	83	17	13	-	-	92	223	71	Mix	Cap	100
	"	Port	OTSI 6	25024	930	4	-			-	?		-	?		-	729	100	Mix	Log	100
	"	"	OTST 7	16989	198	1	-			-	?		-	?		-	22	100	Mix	Log	100
	"	Spain	OT 6	10469	53	1	-			-	?		-	?		-	347	100	Mix	Log	86
	"	"	PT 4	214	-	-	-			-	?		-	?		-	2	100	Mix	Log	80
	Total Reported			118513	2100	2	-			408	132	24	13	-	-	104	1323	93			
	Total All Countries			216569			2			6960			11870			3481					
3	Cod	Can(N)	OTSI 4	1381	-	-	56	-	-	104	-	-	1154	-	-	28	-	-	Mix	Log	9
	"	"	OTST 5	8341	-	-	454	-	-	26	-	-	3480	200	6	170	-	-	Mix	Log	2
	"	Fr(M)	OTSI 6	9075	96	1	-	?		-	406	100	-	?		132	?		Mix	Cap	100
	"	"	OTST 7	2795	-	-	-	?		-	23	100	-	?		18	?		Mix	Cap	100
	"	Ger(FR)	OTST 6-7	11856	-	-	-	-	-	31	35	53	-	-	-	8	15	65	Mix	Cap	100
	"	Port	OTSI 6	57983	1934	3	-	?		-			-	?		-	2037	100	Mix	Log	100
	"	"	OTST 7	7554	67	1	-	?		-			-	?		-	56	100	Mix	Log	100
	"	Spain	OT 6	18091	43	-	18	-	-	-			-	?		387	1128	74	Mix	Log	86
	"	"	PT 4	146447	720	-	3093	103	3	-			-	?		497	3167	86	Mix	Log	80
	Red	Can(N)	OTSI 3	21	-	-	-	-	-	357	10	3	10	-	-	-	-	-	Mix	Log	100
	"	"	OTSI 4	571	-	-	16	-	-	8380	-	-	191	-	-	58	-	-	Mix	Log	14
	Flo	Can(M)	OT 4	870	?		87			115			7953	230	3	125	?		Mix	Log	2
	"	Can(N)	OTSI 4	986	-	-	16	-	-	46	-	-	7259	-	-	25	-	-	Mix	Log	17
	"	"	OTST 5	8542	-	-	284	-	-	157	-	-	61368	983	2	889	-	-	Mix	Log	2
	Mix	Japan	OT 7	50	-	-	6	-	-	2586	-	-	3	-	-	835	67	7	Mac	Cap	100
	Total Reported			274563	2860	1	4030	103	2	11802	474	4	81418	1413	2	3172	6528	67			
	Total All Countries			528457			7117			78201			162215			181011					

Table 1. Continued

Sub-area	Main Species	Country	Gear and Tonnage Class	COD Nominal Catch	COD Dis-cards	COD Rate (%)	HADDOCK Nominal Catch	HADDOCK Dis-cards	HADDOCK Rate (%)	REDFISH Nominal Catch	REDFISH Dis-cards	REDFISH Rate (%)	FLOUNDERS Nominal Catch	FLOUNDERS Dis-cards	FLOUNDERS Rate (%)	OTHERS Nominal Catch	OTHERS Dis-cards	OTHERS Rate (%)	OTHERS Prin. Species	Source of Infor-mation	Samp-ling Rate (%)
4	Cod	Can(M)	OT 2	9782	412	4	258	?		222	?		1417	1	-	362	?		Mix	Log	4
	"	"	OT 3	6980	473	6	333	?		599	?		1759	?		336	?		Mix	Log	8
	"	"	OT 4	13440	1192	8	1059	?		816	?		1835	?		923	?		Mix	Log	13
	"	Can(N)	OTSI 4	7448	-	-	126	-	-	693	-	-	657	-	-	81	-	-	Mix	Log	17
	"	"	OTSI 5	2636	-	-	23	-	-	62	-	-	120	1	1	9	-	-	Mix	Log	70
	"	Fr(M)	OTSI 6	30294	696	2	-	?		-	207	100	13	-	-	65	?		Mix	Cap	100
	"	"	OTST 6	3414	3	-	-	?		-	?		-	?		7	?		Mix	Cap	100
	"	Port	OTSI 6	18582	328	2	-	?		-	?		-	?		-	255	100	Mix	Log	100
	"	"	OTST 7	2274	-	-	-	?		-	?		-	?		-	-	-		Log	100
	"	Spain	OT 6	18477	47	-	9	-	-	-	?		-	?		41	322	89	Mix	Log	86
	"	"	PT 4	48154	155	-	2598	122	4	-	?		-	?		564	966	63	Mix	Log	80
	Red	Can(M)	OT 2	214	?		-	?		2419	71	3	174	?		20	?		Mix	Log	5
	"	"	OT 3	1340	43	3	15	?		21762	2380	10	949	13	1	282	?		Mix	Log	2
	"	Can(N)	OTSI 4	1322	-	-	7	-	-	25240	-	-	484	-	-	157	-	-	Mix	Log	16
	"	"	OTST 5	233	-	-	4	-	-	4650	-	-	202	3	1	15	-	-	Mix	Log	73
	Flo	Can(M)	OT 2	492	?		168	?		40	?		2911	239	8	758	?		Mix	Log	14
	"	"	OT 3	1558	?		21	?		80	?		2387	329	12	242	?		Mix	Log	16
	"	"	OT 4	1137	?		125	?		489	?		4963	621	11	138	?		Mix	Log	2
	"	Can(N)	OTSI 4	48	-	-	-	-	-	6	-	-	71	-	-	2	-	-	Mix	Log	100
	"	"	OTST 5	45	-	-	-	-	-	57	-	-	390	6	2	6	-	-	Mix	Log	50
	Her	Ger(FR)	OTST 6-7	1	-	-	-	-	-	-	-	-	-	-	-	5935	-	-	Mix	Cap	100
	Mix	Japan	OTST 6-7	153	?		13	?		968	?		9	?		3607	7	-	Mac	Cap	100
	Total Reported			168024	3349	2	4759	122	3	58103	2658	4	18341	1213	6	13650	1550	10			
	Total All Countries			262096			27992			119167			41454			661785					
5	Cod	Spain	OT 4	7249	1	-	845	61	7	-	?		-	?		69	109	61	Mix	Log	80
	Flo	USA	OT 2-4	4180	?		2026	?		4	?		32328	10129	24	2704	?		Mix	Int	18
	Her	Ger(FR)	OTST 6-7	14	-	-	-	-	-	2	-	-	-	-	-	91720	1577	2	Mix	Cap	100
	Mix	Japan	OT 6-7	15	?		1	?		19	?		119	1	1	5173	285	5	Mac	Cap	100
	Total Reported			11458	1	-	2872	61	2	25	?		32447	10130	24	99666	1971	2			
	Total All Countries			33368			12852			15958			54922			456181					
6	Flo	USA	OT 2-4	21	?		1	?		-	?		1460	60	4	433	?		Mix	Int	31
	Her	Ger(FR)	OTST 6-7	-	-	-	-	-	-	-	-	-	-	-	-	401	-	-	Mix	Cap	100
	Total Reported			21	-	-	1	-	-	-	-	-	1460	60	4	834	-	-			
	Total All Countries			508			2			-			9055			42719					
ALL	Totals Reported			640266	8454	1	11667	287	2	73930	3278	2	133692	12816	9	117681	11758	10			
	Totals All Countries			1152441			47971			224387			281318			1744550					

Table 2. Summary of information on quantities of fish converted to fish meal at sea in relation to nominal catch for the year 1970.

Sub-area	Main Species	Country	Gear and Tonnage Class	COD			HADDOCK			REDFISH			FLOUNDERS			OTHERS				Source of Infor-mation	Samp-ling Rate (%)
				Nominal Catch	Dis-cards	Rate (%)	Nominal Catch	Dis-cards	Rate (%)	Nominal Catch	Dis-cards	Rate (%)	Nominal Catch	Dis-cards	Rate (%)	Nominal Catch	Dis-cards	Rate (%)	Prin. Species		
1	Cod	Ger(FR)	OTST 5-7	40667	1560	4	-			3592	395	11	13	-	-	245	646	100+	Mix	Cap	100
	"	Port	OTSI 6	801	-	-	-			-	-	-	-	-	-	-	-	-		Log	100
	"	"	OTST 7	2677	63	2	-			-	-	-	-	-	-	-	3	100+	Mix	Log	100
	Mix	USSR	OTST 7	849	-	-	-			231	-	-	576	-	-	6155	665	11	Mix	NK	NK
2	Cod	Ger(FR)	OTST 6-7	50007	900	2	-			408	192	47	13	-	-	92	476	100+	Mix	Cap	100
	"	Port	OTSI 6	25024	69	-	-			-	-	-	-	-	-	-	3	100+	Mix	Log	100
	"	"	OTST 7	16989	605	4	-			-	-	-	-	-	-	-	97	100+	Mix	Log	100
	Mix	USSR	OTST 7	49829	-	-	-			4296	-	-	8765	-	-	2533	1557	61	Mix	NK	NK
3	Cod	Ger(FR)	OTST 6-7	11856	312	3	-	-	-	31	42	100+	-	-	-	8	72	100+	Mix	Cap	100
	"	Port	OTSI 6	57983	172	-	-	-	-	-	-	-	-	-	-	-	25	100+	Mix	Log	100
	"	"	OTST 7	7554	292	4	-	-	-	-	-	-	-	-	-	-	37	100+	Mix	Log	100
	Mix	USSR	OT 4-7	59997	-	-	157	-	-	58278	-	-	37116	-	-	30163	5946	20	Mix	NK	NK
4	Cod	Port	OTSI 6	18582	34	-	-	-	-	-	-	-	-	-	-	-	-	-		Log	100
	"	"	OTST 7	2274	32	1	-	-	-	-	-	-	-	-	-	-	-	-		Log	100
	Her	Ger(FR)	OTST 6-7	1	-	-	-	-	-	-	-	-	-	-	-	6055	375	6	Her	Cap	100
	Mix	Poland	OTST 7	344	?		-			20			6	?		1588	365	23	Her	Int	33
	"	USSR	OT 4-7	2531	-	-	672	-	-	13218	-	-	5705	-	-	260693	17843	7	SH	NK	NK
5	Her	Ger(FR)	OTST 6-7	14	-	-	-	-	-	2	-	-	-	-	-	91720	2812	3	Her	Cap	100
	Mix	Poland	OTST 7	339	?		15	?		30	?		8	?		64908	21570	33	Her	Int	33
	"	"	OTSI 5	302	?		-	-	-	-	-	-	-	-	-	36138	3130	9	Her	Int	33
	"	USSR	OT 4-7	364	-	-	103	-	-	-	-	-	4445	-	-	160224	13639	8	OF	NK	NK
6	Mix	Poland	OTST 7	61	?		-	-	-	-	-	-	-	-	-	24750	4990	20	Her	Int	33
	"	"	OTSI 5	82	?		-	-	-	-	-	-	-	-	-	20488	370	2	Her	Int	33
ALL	Totals Reported			349127	4129	1	947	-	-	80106	629	1	56647	-	-	705760	74621	16			
	Totals All Countries			1152441			47971			224387			281318			1744550					