

Stanisław KRZYKAWSKI

Fish Biology

A CHARACTERISTIC OF GROWTH OF GREENLAND HALIBUT,
Reinhardtius hippoglossoides (WALBAUM), FROM THE NORTH ATLANTIC
CHARAKTERYSTYKA WZROSTU HALIBUTA NIEBIESKIE GO
Reinhardtius hippoglossoides (WALBAUM) Z PÓŁNOCNEGO ATLANTYKU

Institute of Ichthyology

Results of studies on length distribution, length and weight growth rates, and length-weight relationship in Greenland halibut are presented. The populations concerned are those inhabiting the New Foundland ICNAF fishing grounds as well as those in the ICES areas of the Barents Sea and Icelandic waters.

INTRODUCTION

Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), is one of more important commercially *Pleuronectiformes* species occurring in the ICNAF and ICES regions. The hitherto-published literature dealing with the species' growth has not given the von Bertalanffy equation coefficients which would provide a basis for the abundance and biomass estimations and calculations of the halibut population dynamics. Therefore the goals of the present work were set as studies on the length distribution and age composition, determination of length and weight growth rates using mathematical models, fitting of optimal growth model, and establishing of a length-weight relationship.

MATERIAL AND METHODS

Materials

These were obtained from three North Atlantic regions: the Barents Sea (IIb, IIa), Iceland (Va), and New Foundland (3K, 3L) fishig grounds. The materials were collected within 1968–1972. Mass measurements were performed on total number of 13 752 Greenland halibut specimens, 1364 of which were retained for further detailed biological analyses. Table 1 contains the detailed data on the materials collected from the three regions.

Methods

The Greenland halibut individuals to be analysed in detail were measured to the nearest cm and weighed with an accuracy of 1 g, the sex determination ensuing.

In order to determine an age and growth rate, scales were collected from the caudal part on the ocular side of the fish body, above the lateral line, according to the recommendations given by Krzykawski (1976). Also the methodological remarks on the growth rate back calculations described in that paper were followed.

The rate of growth of the Greenland halibut has been expressed by three mathematic methods: Ford-Walford, Gompertz and v. Bertalanffy.

When statistically processing the back-calculated length growth rate, standard deviation and variation coefficient were given.

The length-weight relationship was ascertained from mean body weight calculated for each length class (the classes were set at 1 cm intervals). These studies are based on 1359 specimens measured. The relationship was presented following the generally accepted equation:

$$W = k \cdot l^n$$

The weights calculated from this relationship were used to characterise the Greenland halibut body weight growth by means of the v. Bertalanffy equation; as an exponent the value of "n" from the length-weight relationship was applied in place of an exponent equalling 3, which allowed the results to approach the empiric data. Minet (1973) took a similar way of presenting the American plaice weight growth rate by the v. Bertalanffy equation.

RESULTS

Length frequency distribution and age composition

Fig. 1 presents abundances in the respective length classes and the age composition of fish caught from the New Foundland, Barents Sea, and Iceland regions. The graph indicates the lengths of the New Foundland fishes to range within 13–83 cm, with a mean length of 42 cm. The length classes of 35 to 49 cm predominated. The age of fish examined ranged within 1–12 years with 3–6 years old fishes prevailing and the fourth age group being most numerous. The mean age was 4.69 years.

Date on the material collected within 1968–1972

Table 1

| No. | Region of capture | Date of capture | Geographic co-ordinates | Number of fish examined | | Fish length (l.t.) in cm | | Number of females | Number of females | Fish with readable scales | |
|-------------|-----------------------------------|-----------------|-------------------------|-------------------------|-------------------|--------------------------|-------------|-------------------|-------------------|---------------------------|------------|
| | | | | Mass measurement | Detailed analysis | Length range | Mean length | | | Number | Percentage |
| 1 | Grounds of New Foundland sub-area | 17.10.68 | 50°07'N–54°00'W | 107 | 107 | 25–83 | 49.1 | — | — | 93 | 86.9 |
| | | 19.04.71 | 46°08'N–51°00'W | 113 | 113 | 31–71 | 44.7 | 54 | 21 | 104 | 92.0 |
| | | 08.04.72 | 50°04'N–52°47'W | 109 | 98 | 29–59 | 42.5 | 64 | 34 | 97 | 99.0 |
| | | 17.09.72 | 51°35'N–54°00'W | 250 | 250 | 13–81 | 37.4 | 128 | 54 | 230 | 92.0 |
| | | Total | 1968–1972 | New Foundland | 579 | 568 | 13–83 | 42.0 | 246 | 109 | 524 |
| 1 | Barents Sea fishing grounds | 17.04.70 | 73°23'N–15°04'E | 154 | — | 34–89 | 57.4 | — | — | — | — |
| 2 | | 18.04.70 | 73°30'N–15°08'E | 339 | — | 34–92 | 58.8 | — | — | — | — |
| 3 | | 11.05.70 | 75°46'N–14°08'E | 680 | — | 33–84 | 46.7 | — | — | — | — |
| 4 | | 13.05.70 | 74°30'N–16°10'E | 1050 | — | 28–78 | 50.3 | — | — | — | — |
| 5 | | 14.05.70 | 74°32'N–16°18'E | 914 | — | 37–70 | 49.1 | — | — | — | — |
| 6 | | 11.06.71 | 75°00'N–15°45'E | 1317 | — | 36–92 | 54.9 | — | — | — | — |
| 7 | | 14.06.71 | 76°10'N–14°34'E | 657 | — | 37–92 | 53.4 | — | — | — | — |
| 8 | | 15.06.71 | 77°25'N–11°20'E | 1166 | — | 33–94 | 50.5 | — | — | — | — |
| 9 | | 18.06.71 | 75°51'N–14°05'E | 878 | — | 32–92 | 52.0 | — | — | — | — |
| 10 | | 02.11.71 | 73°08'N–15°01'E | 50 | 50 | 49–81 | 58.9 | 31 | 19 | 38 | 76.0 |
| 11 | | 04.11.71 | 72°50'N–15°15'E | 395 | — | 43–103 | 60.4 | — | — | — | — |
| 12 | | 05.11.71 | 72°55'N–15°12'E | 50 | 50 | 44–88 | 59.8 | 29 | 21 | 40 | 80.0 |
| 13 | | 10.11.71 | 73°20'N–15°24'E | 173 | — | 44–84 | 57.5 | — | — | — | — |
| 14 | | 18.11.71 | 72°55'N–15°12'E | 50 | 50 | 45–88 | 59.7 | 32 | 18 | 43 | 86.0 |
| 15 | | 19.11.71 | 72°48'N–15°17'E | 223 | 223 | 41–85 | 56.5 | 167 | 56 | 207 | 92.8 |
| 16 | | 23.11.71 | 72°53'N–15°27'E | 268 | — | 36–80 | 55.2 | — | — | — | — |
| Total | 1970–1971 | Barents Sea | 8364 | 373 | 28–103 | 52.6 | 259 | 114 | 328 | 87.9 | |
| 1 | Fishing grounds off Iceland | 23.05.71 | 67°17'N–20°46'W | 155 | — | 34–80 | 51.9 | — | — | — | — |
| 2 | | 02.06.71 | 67°25'N–21°50'W | 119 | — | 29–82 | 54.9 | — | — | — | — |
| 3 | | 18.06.71 | 67°29'N–20°46'W | 881 | — | 38–85 | 59.9 | — | — | — | — |
| 4 | | 20.06.71 | 67°39'N–20°30'W | 313 | — | 31–86 | 57.5 | — | — | — | — |
| 5 | | 23.06.71 | 67°27'N–21°05'W | 515 | 100 | 43–89 | 61.8 | 47 | 53 | 85 | 85.0 |
| 6 | | 24.06.71 | 67°42'N–20°11'W | 952 | — | 35–87 | 60.6 | — | — | — | — |
| 7 | | 05.07.71 | 67°35'N–20°57'W | 633 | 99 | 31–96 | 66.2 | 59 | 40 | 92 | 92.5 |
| 8 | | 07.07.71 | 67°23'N–22°44'W | 680 | 101 | 29–86 | 60.4 | 61 | 40 | 91 | 90.1 |
| 9 | | 08.07.71 | 67°21'N–22°13'W | 22 | 22 | 49–68 | 61.7 | 20 | 2 | 22 | 100.0 |
| 10 | | 09.07.71 | 67°27'N–21°08'W | 539 | 101 | 42–85 | 65.5 | 55 | 46 | 91 | 90.1 |
| Total | 1971 | Iceland | 4809 | 423 | 29–96 | 61.3 | 242 | 181 | 381 | 90.1 | |
| Grand total | New Foundland Barents Sea Iceland | 1968–1972 | | 13752 | 1364 | 13–103 | 55.2 | 747 | 404 | 1233 | 90.4 |

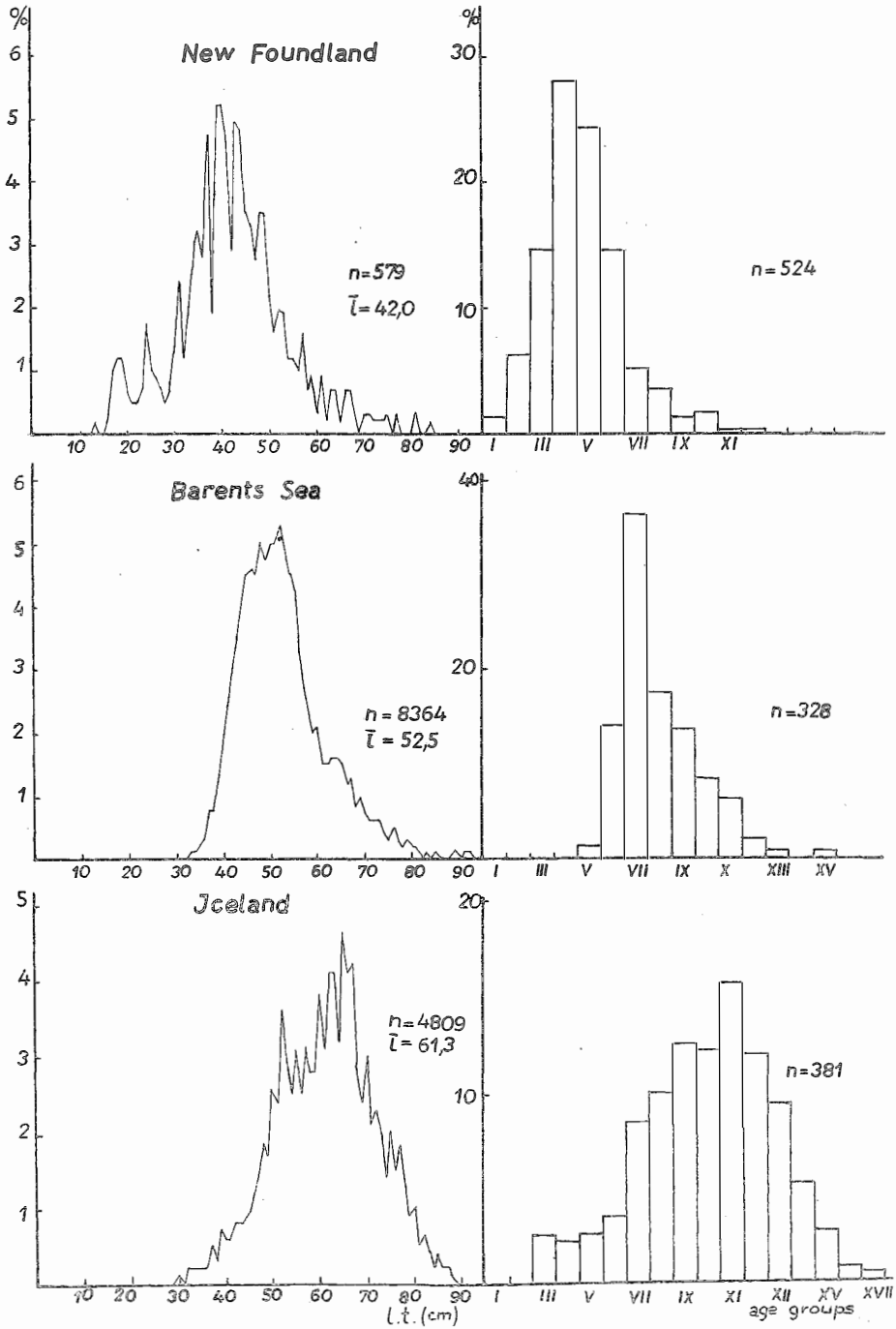


Fig. 1. Length frequency distribution and age composition of Greenland halibut from different regions

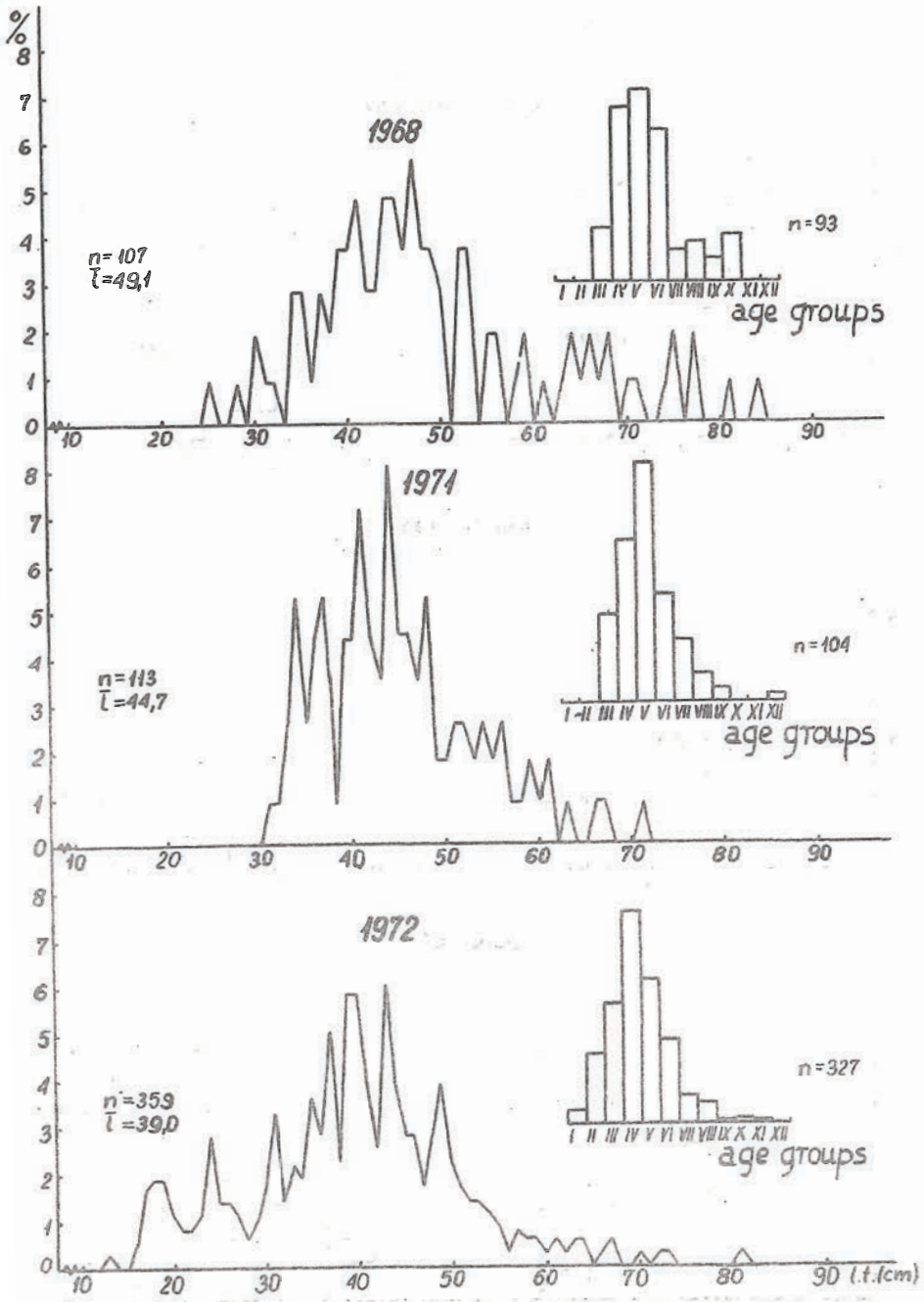


Fig. 2. Length frequency distribution and age composition of Greenland halibut from the New Found-land sub-area fishing grounds in different years

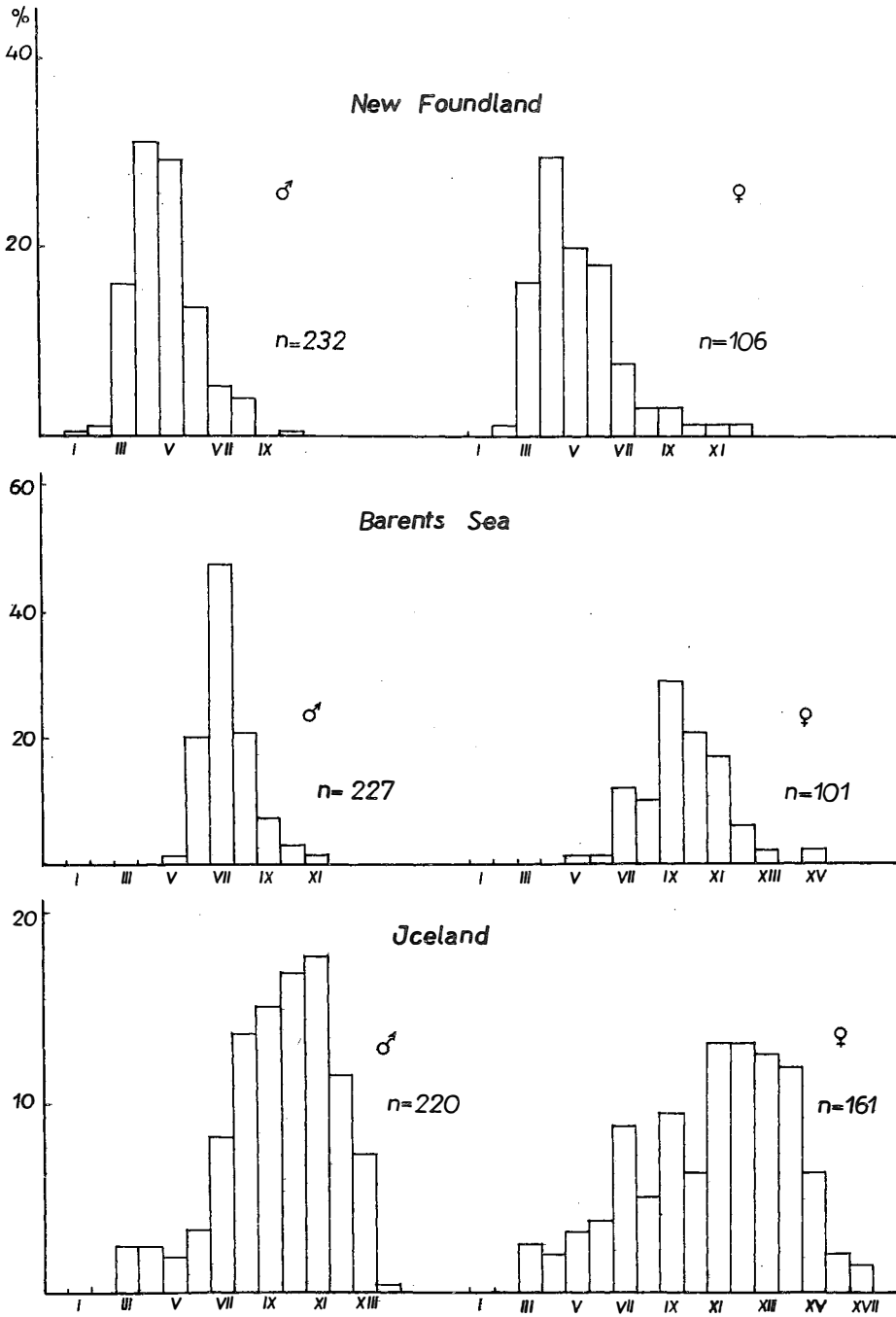


Fig. 3. Age composition of Greenland halibut males and females from different regions

The 28 to 103 cm long Greenland halibut (52.5 cm average length) occurred in the Barents Sea. The length classes of 45–55 cm predominated, one peak being noted on the length frequency curve. The age ranged within 5–15 years, the seventh age group being represented most abundantly. The mean age was 7.95 years.

Specimens of length ranging from 29 to 96 cm forming a multi-peak curve occurred off Iceland. The mean length was 61.3 cm. The age range of halibut in this region was 3 to 17 years, the 7–13 interval prevailing and the 11 years old fishes being most abundant. The mean age amounting to 9.98 years was higher than the previous two.

The size frequency and age composition curves for the New Foundland fishes in the years studied are shown on Fig. 2. The curves, as it can be seen, are the multi-peak ones. The most abundantly represented length classes varied from 47 cm in 1968 to 43 cm in 1972. A decrease in mean length calculated for each year should be paid an attention to. Also the age compositions differed from years to year. In 1968 the most abundant groups were the fourth, fifth and sixth ones. The 5 years old individuals prevailed in 1971, while the 4 years old ones in 1972. Accordingly the mean age of fish caught in those calendar years diminished from 5.52 years in 1968 to 4.32 in 1972.

The age composition of males and females from the three regions is shown on Fig. 3. The age ranges of the New Foundland males and females were 1–10 and 1–12 years, respectively, with females showing a slightly older mean age.

When comparing the age composition of the Barents Sea males to that of females one finds the respective ranges being 5–11 and 5–15 years. Furthermore, the males are definitely dominated by the seventh, while the females by the ninth age group. The females lived, on average, by more than 2 years longer than the males.

The Icelandic Greenland halibut males examined were at the age of 3 to 14 years, while the females of 3 to 17. The age groups prevailing in males and females were the 8th to 11th and 11th to 14th, respectively, the mean age of the latter exceeding that of the males by over 1 year.

Length growth rate

Examination of applicability of three mathematical models to characterise Greenland halibut length growth.

Mean lengths of each Greenland halibut age group, back-read, were used to describe the species' growth rate by means of the Ford-Walford, Gompertz, and v. Bertalanffy equations. The equation parameters were calculated, and the results compared in order to assess which of the three models deviated least from the back readings, that is to say, which one was the best-fitting to the species' growth.

The growth parameters of Greenland halibut, calculated for the three equations, are shown each region of study in Table 2.

In Table 3, the back-calculated growth rate is compared with that computed by the v. Bertalanffy, Gompertz and Ford-Walford equations. The differences are slight for the New Foundland region, values obtaining from the v. Bertalanffy equation (the least sum of absolute values of differences) being the least-deviating. On the other hand, the results

Table 2

Values of Greenland halibut growth parameters in different regions, calculated for v. Bertalanffy, Gompertz and Ford – Walford equations

| Region | Equation parameters | | |
|-------------------------------|---|--|---------------------------|
| | v. Bertalanffy | Gompertz | Ford – Walford |
| New Foundland fishing grounds | $L_{\infty} = 126,5$ $k = 0.080$ $t_0 = -0.02$ | $a = 83.9$ $b = 0.077$ $c = 0.770$ | $k = 0.92$ $l_1 = 9.9$ |
| Barents Sea fishing grounds | $L_{\infty} = 116.5$ $k = 0.080$ $t_0 = -0.031$ | $a = 88.1$ $b = 0.082$ $c = 0.813$ | $k = 0.91$ $l_1 = 9.4$ |
| Icelandic fishing grounds | $L_{\infty} = 144.0$ $k = 0.050$ $t_0 = -0.93$ | $a = 98.7$ $b = 0.099$ $c = 0.853$ | $k = 0.92$ $l_1 = 8.9$ |

calculated using the Ford-Walford equation show the least deviation for the Barents Sea Greenland halibut, the difference between them and those obtained from the v. Bertalanffy equation being very slight (only 0.7 cm). The v. Bertalanffy equation fits best to the data derived from the Icelandic fishes. In recapitulation, the v. Bertalanffy equation proved most useful to characterise the Greenland halibut's growth.

Length growth rate in three regions investigated

The data concerning the Greenland halibut's growth rate, backcalculated for the New Foundland, Barents Sea, and Icelandic fishes are contained in Table 3. The mean lengths in the respective age groups are given in Tables 4, 5 and 6.

Table 4 points out that during the first four years of life the mean length of the New Foundland fishes changes rather insignificantly, the differences increasing with age, as evidenced by the standard deviation and variation coefficient increasing with age (particularly from the sixth year on).

Table 5 contains the same kind of data for the Barents sea fish; mean lengths differ considerably during the first six years of life. As it is shown by the variation coefficient, these differences tend to diminish in older fishes (more than 6 years old) rather than to increase with age. The largest mean lengths during the first five years of life were found in the fifth and sixth age groups.

The individual age groups of the Icelandic fishes showed only slight variations in their mean lengths (Table 6), particularly so in older age (more than 7 years).

The length growth rates of Greenland halibut from the three regions investigated are similar resulting in similar shapes of growth rate curves. The fastest growth was found for

Table 3

Comparison of length growth rates derived from back calculations
and from v. Bertalanffy, Gompertz, and Ford – Walford equations (cm)

| Age | Back-calculated length | Length according to v. Bertalanffy | Length according to Gompertz | Length according to Ford–Walford | Difference between 2 and 3 | Difference between 2 and 4 | Difference between 2 and 5 |
|---------------------------------------|------------------------|------------------------------------|------------------------------|----------------------------------|----------------------------|----------------------------|----------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| New Foundland fishing grounds | | | | | | | |
| 1 | 11.6 | 9.9 | 11.6 | 9.9 | + 1.7 | 0.0 | + 1.7 |
| 2 | 18.9 | 18.9 | 18.3 | 19.0 | 0.0 | + 0.6 | - 0.1 |
| 3 | 26.4 | 27.2 | 26.0 | 27.4 | - 0.8 | + 0.4 | - 1.0 |
| 4 | 34.2 | 34.8 | 34.0 | 35.1 | - 0.6 | + 0.2 | - 0.9 |
| 5 | 41.8 | 41.9 | 41.9 | 42.2 | - 0.1 | - 0.1 | - 0.4 |
| 6 | 48.1 | 48.4 | 49.2 | 48.7 | - 0.3 | - 1.1 | - 0.6 |
| 7 | 54.2 | 54.4 | 55.7 | 54.7 | - 0.2 | - 1.5 | - 0.5 |
| 8 | 59.3 | 60.0 | 61.1 | 60.2 | - 0.7 | - 1.8 | - 0.9 |
| 9 | 65.7 | 65.1 | 65.8 | 65.3 | + 0.6 | - 0.1 | + 0.4 |
| 10 | 70.2 | 69.8 | 69.6 | 70.0 | + 0.4 | + 0.6 | + 0.2 |
| Sum of absolute values of differences | | | | | 5.4 | 6.4 | 6.7 |
| Barents Sea fishing grounds | | | | | | | |
| 1 | 11.5 | 9.3 | 11.5 | 9.4 | + 2.2 | 0.0 | + 2.1 |
| 2 | 18.2 | 17.5 | 16.8 | 18.0 | + 0.7 | + 1.4 | + 0.2 |
| 3 | 25.2 | 25.1 | 22.9 | 25.8 | + 0.1 | + 2.3 | - 0.6 |
| 4 | 32.2 | 32.1 | 29.5 | 32.9 | + 0.1 | + 2.7 | - 0.7 |
| 5 | 38.9 | 38.6 | 36.3 | 39.3 | + 0.3 | + 2.6 | - 0.4 |
| 6 | 45.1 | 44.6 | 42.8 | 45.2 | + 0.5 | + 2.3 | - 0.1 |
| 7 | 50.2 | 50.2 | 49.0 | 50.5 | 0.0 | + 1.2 | - 0.3 |
| 8 | 54.5 | 55.3 | 54.7 | 55.4 | - 0.8 | - 0.2 | - 0.9 |
| 9 | 59.6 | 60.0 | 59.8 | 59.8 | - 0.4 | - 0.2 | - 0.2 |
| 10 | 63.4 | 64.3 | 64.2 | 63.8 | - 0.9 | - 0.8 | - 0.4 |
| 11 | 68.3 | 68.3 | 68.2 | 67.5 | 0.0 | + 0.1 | + 0.8 |
| 12 | 72.2 | 72.1 | 71.6 | 70.8 | + 0.1 | + 0.6 | + 1.4 |
| 13 | 76.7 | 75.5 | 74.5 | 73.8 | + 1.2 | + 2.2 | + 2.9 |
| 14 | 76.4 | 78.6 | 76.8 | 76.6 | - 2.2 | - 0.4 | - 0.2 |
| 15 | 78.6 | 81.5 | 78.7 | 79.1 | - 2.9 | - 0.1 | - 0.5 |
| Sum of absolute values of differences | | | | | 12.4 | 17.1 | 11.7 |
| Icelandic fishing grounds | | | | | | | |
| 1 | 13.7 | 13.3 | 13.7 | 8.9 | + 0.4 | 0.0 | + 4.8 |
| 2 | 19.0 | 19.6 | 18.3 | 17.1 | - 0.6 | + 0.7 | + 1.9 |
| 3 | 24.6 | 25.7 | 23.5 | 24.6 | - 1.1 | + 1.1 | 0.0 |
| 4 | 30.3 | 31.5 | 29.0 | 31.5 | - 1.2 | + 1.3 | - 1.2 |
| 5 | 36.2 | 37.0 | 34.7 | 37.9 | - 0.8 | + 1.5 | - 1.7 |
| 6 | 42.0 | 42.2 | 40.4 | 43.8 | - 0.2 | + 1.6 | - 1.8 |
| 7 | 47.2 | 47.2 | 46.2 | 49.2 | 0.0 | + 1.0 | - 2.0 |
| 8 | 52.2 | 51.9 | 51.6 | 54.2 | + 0.3 | + 0.6 | - 2.0 |
| 9 | 56.8 | 56.4 | 56.7 | 58.8 | + 0.4 | + 0.1 | - 2.0 |
| 10 | 61.1 | 60.7 | 61.5 | 63.0 | + 0.4 | - 0.4 | - 1.9 |
| 11 | 65.0 | 64.8 | 65.9 | 66.9 | + 0.2 | - 0.9 | - 1.9 |
| 12 | 68.5 | 68.6 | 70.1 | 70.4 | - 0.1 | - 1.6 | - 1.9 |
| 13 | 72.7 | 72.3 | 73.7 | 73.7 | + 0.4 | - 1.0 | - 1.9 |
| 14 | 76.6 | 75.8 | 76.8 | 76.7 | + 0.8 | - 0.2 | - 0.1 |
| 15 | 80.7 | 79.1 | 79.7 | 79.5 | + 1.6 | + 1.0 | + 1.2 |
| 16 | 81.5 | 82.3 | 82.4 | 82.0 | - 0.8 | - 0.9 | - 0.5 |
| 17 | 84.5 | 85.3 | 84.5 | 84.3 | - 0.8 | 0.0 | + 0.2 |
| Sum of absolute values of differences | | | | | 10.1 | 13.9 | 26.1 |

Back – calculated length growth rate of Greenland halibut from New Foundland sub-area (cm)

| Age group | Subsequent years of life | | | | | | | | | | | | Number of fishes |
|-----------------------|--------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|------------------|
| | l ₁ | l ₂ | l ₃ | l ₄ | l ₅ | l ₆ | l ₇ | l ₈ | l ₉ | l ₁₀ | l ₁₁ | l ₁₂ | |
| I | 12.8 | | | | | | | | | | | | 7 |
| II | 11.0 | 18.0 | | | | | | | | | | | 32 |
| III | 11.6 | 19.7 | 28.0 | | | | | | | | | | 76 |
| IV | 11.4 | 18.7 | 25.9 | 34.3 | | | | | | | | | 146 |
| V | 11.7 | 19.1 | 26.5 | 34.7 | 42.0 | | | | | | | | 127 |
| VI | 11.4 | 18.4 | 25.6 | 33.2 | 40.8 | 47.6 | | | | | | | 76 |
| VII | 11.4 | 18.5 | 25.3 | 33.1 | 40.6 | 48.2 | 54.5 | | | | | | 26 |
| VIII | 11.4 | 18.4 | 26.3 | 33.5 | 41.3 | 47.8 | 53.4 | 58.4 | | | | | 18 |
| IX | 12.6 | 19.6 | 26.8 | 33.5 | 42.1 | 49.1 | 55.9 | 60.6 | 65.9 | | | | 6 |
| X | 12.3 | 19.1 | 25.9 | 34.6 | 42.0 | 48.4 | 54.6 | 60.5 | 66.3 | 71.0 | | | 8 |
| XI | 9.9 | 15.5 | 22.6 | 36.1 | 43.4 | 53.2 | 59.7 | 68.1 | 72.5 | 75.8 | 78.7 | | 1 |
| XII | 10.1 | 19.4 | 24.1 | 29.3 | 33.9 | 38.1 | 42.5 | 48.3 | 52.4 | 57.6 | 61.5 | 66.3 | 1 |
| Weighed mean | 11.6 | 18.9 | 26.4 | 34.2 | 41.8 | 48.1 | 54.2 | 59.3 | 65.7 | 70.2 | 70.1 | 66.3 | 524 |
| Standard deviation | ±0.88 | ±1.20 | ±1.66 | ±1.97 | ±3.11 | ±4.61 | ±5.85 | ±7.11 | ±8.63 | ±9.77 | ±12.16 | – | – |
| Variation coefficient | 7.59 | 6.35 | 6.29 | 5.76 | 7.44 | 9.58 | 10.79 | 11.99 | 13.14 | 13.92 | 17.35 | – | – |

Table 5

Back – calculated length growth rate of Greenland halibut from Barents Sea fishing grounds (cm)

| Age group | Subsequent years of life | | | | | | | | | | | | | | | Number of fish |
|-----------------------|--------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|
| | l ₁ | l ₂ | l ₃ | l ₄ | l ₅ | l ₆ | l ₇ | l ₈ | l ₉ | l ₁₀ | l ₁₁ | l ₁₂ | l ₁₃ | l ₁₄ | l ₁₅ | |
| V | 13.2 | 23.3 | 30.7 | 38.6 | 46.8 | | | | | | | | | | | 4 |
| VI | 12.3 | 19.4 | 27.2 | 34.7 | 42.6 | 49.6 | | | | | | | | | | 46 |
| VII | 11.3 | 18.1 | 25.0 | 32.2 | 39.2 | 46.0 | 51.9 | | | | | | | | | 119 |
| VIII | 11.2 | 17.1 | 23.8 | 30.5 | 36.6 | 42.9 | 48.9 | 54.5 | | | | | | | | 57 |
| IX | 11.6 | 18.3 | 25.6 | 32.4 | 38.4 | 44.2 | 50.1 | 55.6 | 60.8 | | | | | | | 45 |
| X | 11.5 | 17.7 | 24.7 | 31.4 | 37.4 | 42.9 | 48.6 | 53.8 | 58.8 | 63.7 | | | | | | 27 |
| XI | 11.6 | 18.0 | 24.8 | 30.9 | 36.7 | 41.9 | 47.9 | 53.3 | 58.9 | 63.2 | 68.6 | | | | | 20 |
| XII | 10.9 | 18.1 | 24.7 | 29.9 | 36.3 | 42.0 | 47.2 | 52.4 | 58.3 | 63.3 | 67.6 | 72.5 | | | | 6 |
| XIII | 10.0 | 16.8 | 24.2 | 30.9 | 35.9 | 45.5 | 50.4 | 56.3 | 61.9 | 67.3 | 72.0 | 75.8 | 80.7 | | | 2 |
| XV | 10.5 | 16.0 | 21.7 | 30.0 | 36.9 | 42.9 | 48.2 | 51.8 | 55.9 | 58.6 | 63.5 | 67.9 | 72.7 | 76.4 | 78.6 | 2 |
| Weighed mean | 11.5 | 18.2 | 25.2 | 32.2 | 38.9 | 45.1 | 50.2 | 54.5 | 59.6 | 63.4 | 68.3 | 72.2 | 76.7 | 76.4 | 78.6 | 328 |
| Standard deviation | ±0.90 | ±1.99 | ±2.36 | ±2.67 | ±3.48 | ±2.66 | ±1.95 | ±1.74 | ±2.16 | ±3.10 | ±3.53 | ±3.98 | ±5.65 | – | – | – |
| Variation coefficient | 7.32 | 10.93 | 9.37 | 8.29 | 8.95 | 5.90 | 3.88 | 3.19 | 3.62 | 4.89 | 5.17 | 5.51 | 7.37 | – | – | – |

Table 6

Back – calculates length growth rate of Greenland halibut from Icelandic fishing grounds (cm)

| Age group | Subsequent years of life | | | | | | | | | | | | | | | | | Number of fish |
|-----------------------|--------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|
| | l ₁ | l ₂ | l ₃ | l ₄ | l ₅ | l ₆ | l ₇ | l ₈ | l ₉ | l ₁₀ | l ₁₁ | l ₁₂ | l ₁₃ | l ₁₄ | l ₁₅ | l ₁₆ | l ₁₇ | |
| III | 15.2 | 21.3 | 27.7 | | | | | | | | | | | | | | | 9 |
| IV | 15.1 | 21.5 | 28.7 | 36.1 | | | | | | | | | | | | | | 8 |
| V | 13.9 | 20.6 | 27.9 | 35.1 | 41.8 | | | | | | | | | | | | | 9 |
| VI | 14.2 | 20.7 | 27.2 | 34.0 | 42.0 | 48.6 | | | | | | | | | | | | 13 |
| VII | 13.9 | 19.8 | 25.9 | 32.4 | 38.9 | 45.3 | 51.2 | | | | | | | | | | | 32 |
| VIII | 13.4 | 18.5 | 24.5 | 30.5 | 36.5 | 42.8 | 49.4 | 55.1 | | | | | | | | | | 38 |
| IX | 13.6 | 19.1 | 24.7 | 30.7 | 36.6 | 42.6 | 48.2 | 53.7 | 58.5 | | | | | | | | | 48 |
| X | 13.2 | 18.4 | 23.9 | 29.8 | 35.9 | 41.6 | 47.3 | 52.9 | 58.3 | 62.9 | | | | | | | | 47 |
| XI | 13.6 | 18.6 | 24.2 | 29.8 | 35.6 | 41.5 | 46.8 | 52.0 | 56.9 | 61.7 | 66.3 | | | | | | | 60 |
| XII | 13.4 | 18.3 | 23.3 | 28.8 | 34.2 | 39.7 | 44.8 | 50.0 | 54.9 | 59.6 | 64.2 | 68.3 | | | | | | 46 |
| XIII | 13.8 | 18.8 | 24.1 | 29.3 | 34.7 | 40.6 | 46.0 | 50.8 | 55.9 | 60.1 | 64.6 | 68.6 | 72.5 | | | | | 36 |
| XIV | 14.0 | 18.4 | 23.2 | 28.7 | 34.3 | 39.8 | 45.0 | 50.3 | 55.2 | 59.9 | 64.3 | 68.4 | 72.4 | 76.0 | | | | 20 |
| XV | 14.4 | 19.5 | 24.5 | 30.5 | 35.6 | 41.1 | 46.2 | 50.9 | 55.7 | 60.3 | 64.6 | 69.2 | 74.0 | 78.3 | 81.6 | | | 10 |
| XVI | 13.6 | 19.3 | 25.3 | 30.2 | 36.0 | 41.5 | 46.0 | 51.3 | 55.8 | 60.1 | 63.9 | 68.0 | 72.6 | 76.0 | 78.7 | 81.4 | | 3 |
| XVII | 13.5 | 19.0 | 22.9 | 27.9 | 33.7 | 39.6 | 46.1 | 52.3 | 57.6 | 61.2 | 65.1 | 68.3 | 72.6 | 76.7 | 79.1 | 81.7 | 84.5 | 2 |
| Weighed mean | 13.7 | 19.0 | 24.6 | 30.3 | 36.2 | 42.0 | 47.2 | 52.2 | 56.8 | 61.1 | 65.0 | 68.5 | 72.7 | 76.6 | 80.7 | 81.5 | 84.5 | 381 |
| Standard deviation | ±0.63 | ±1.18 | ±1.96 | ±2.54 | ±2.73 | ±2.51 | ±1.95 | ±1.64 | ±1.37 | ±1.19 | ±0.85 | ±0.41 | ±0.68 | ±1.21 | ±1.92 | ±0.1 | – | – |
| Variation coefficient | 4.60 | 6.21 | 7.97 | 8.38 | 7.54 | 5.98 | 4.13 | 3.14 | 2.41 | 1.95 | 1.31 | 0.60 | 0.94 | 1.58 | 2.38 | 0.12 | – | – |

the first year of life; it approaches uniformity from the second till fifth year and from then on a slight slow-down is seen in the growth rate. The von Bertalanffy growth rate curves for all the regions studied are presented on Fig. 4. As it can be seen, the highest growth rate is observed in Greenland halibut of the New Foundland fishing grounds, the fishes from the Barents Sea growing slower and those caught off Iceland showing the slowest growth, although they are found to have had the highest increments in their first year of life.

Variability in length growth of males and females

The back-calculated growth rate of Greenland halibut males and females from the three regions is presented on Fig. 5. The New Foundland + Barents Sea and Iceland fishes of both sexes exhibit a similar growth rate till the seventh and eighth year of their life, respectively. Later on females grow faster. The curves illustrating growth of the New Foundland males and females basically represent the two sexes only up to their 8 years of life since no 9 years old male and only one 10 years old one were found. As the number of females over 9 years of age was also low, the reliable data resulting from the comparison of both sexes' growth rates can concern solely the first 8 years of life. No male older than 11 years was found in the Barents sea. As it was mentioned above, differences between the male and female growth rates are marked starting from the 8th year of life, the differences increasing with age and reaching ca 7 cm in favour of females in the 11th year. On the other hand, the curves drawn for the Icelandic males and females represent the two sexes as long as till the 14th year of life. Starting from the 9th year, the curves diverge, as the variability of both sexes' growth increases with age, reaching ca 4.8 cm in favour of females in the 14th year.

Length-weight relationship

The length-weight relationship of Greenland halibut from the three regions under comparison is pictured on Fig. 6. The best condition is seen to be attributed to the Barents Sea fishes, those from the New Foundland fishing grounds having worse and the Icelandic ones the worst condition. However, it should be pointed out that the material from the last region mentioned was obtained in summer, while that from the New Foundland sub-area was collected in spring and autumn, the Barents Sea yielding fish in autumn. The equations representing the relationship are thus:

$$\text{New Foundland } W = 0.002415 \cdot l^{3.32}$$

$$\text{Barents Sea } W = 0.002233 \cdot l^{3.35}$$

$$\text{Iceland } W = 0.009556 \cdot l^{2.98}$$

where W is weight in g, and l is length in cm.

Growth of weight

In order to describe the growth of weight of fish in different regions more detaily, the theoretical growth rate till the 50th year of life, following v. Bertalanffy, is presented on Fig. 7. Weight, until the 15th year of life, grows fastest in halibut of New Foundland; the

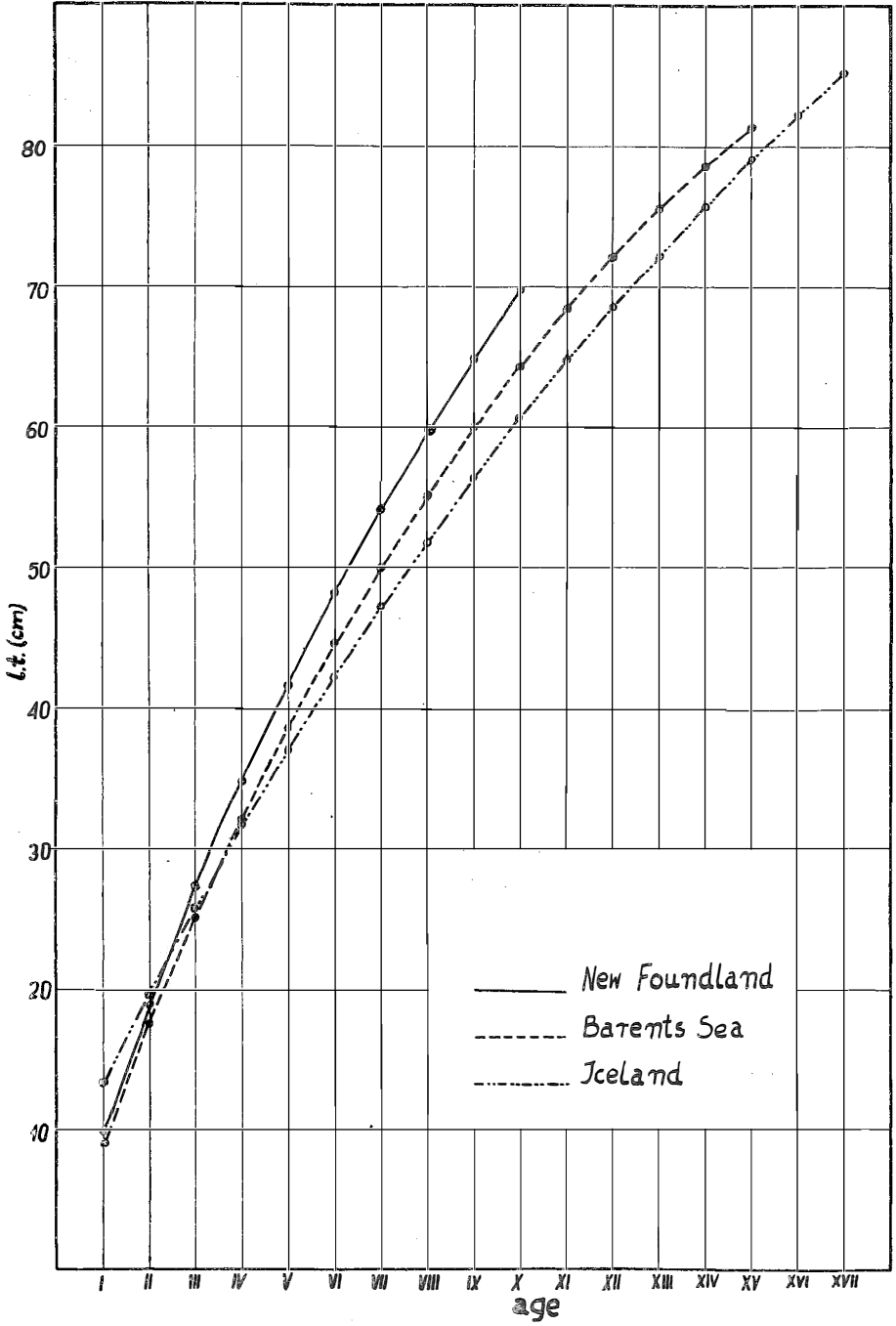


Fig. 4. Von Bertalanffy growth curves for Greenland halibut from different regions

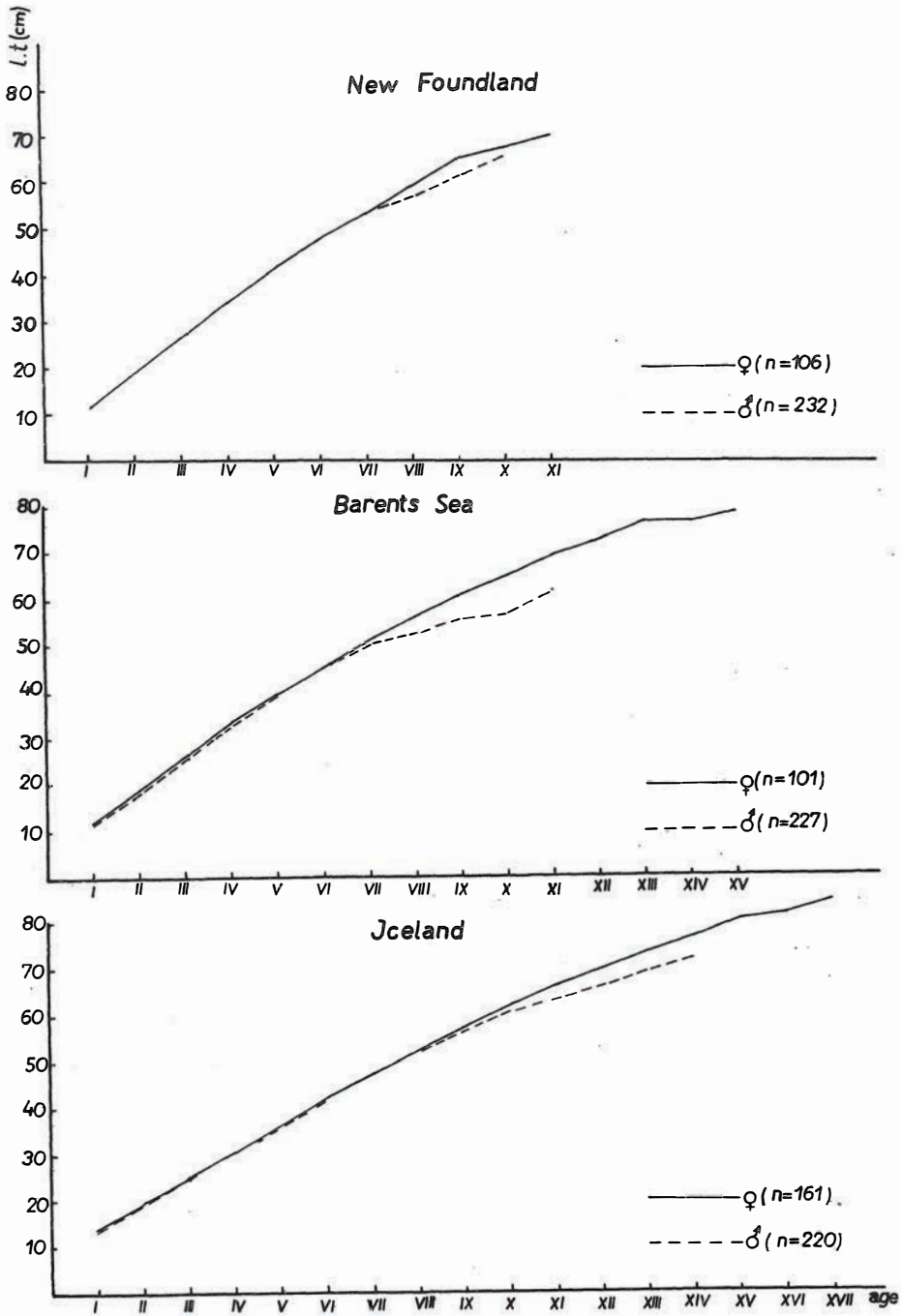


Fig. 5. Back calculation-based growth curves for Greenland halibut males and females from different regions

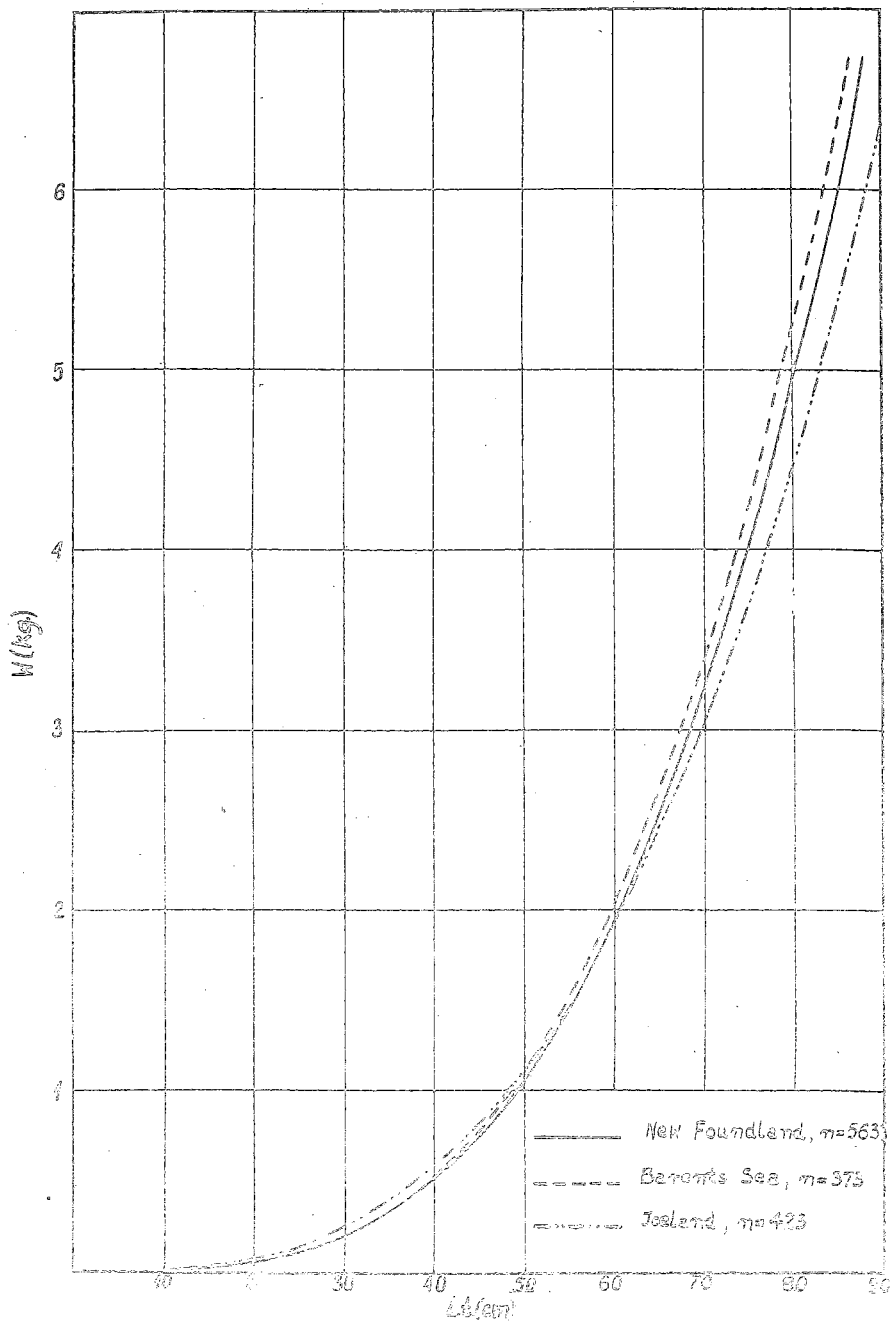


Fig. 5. Length-weight relationship for Greenland halibut in three regions studied

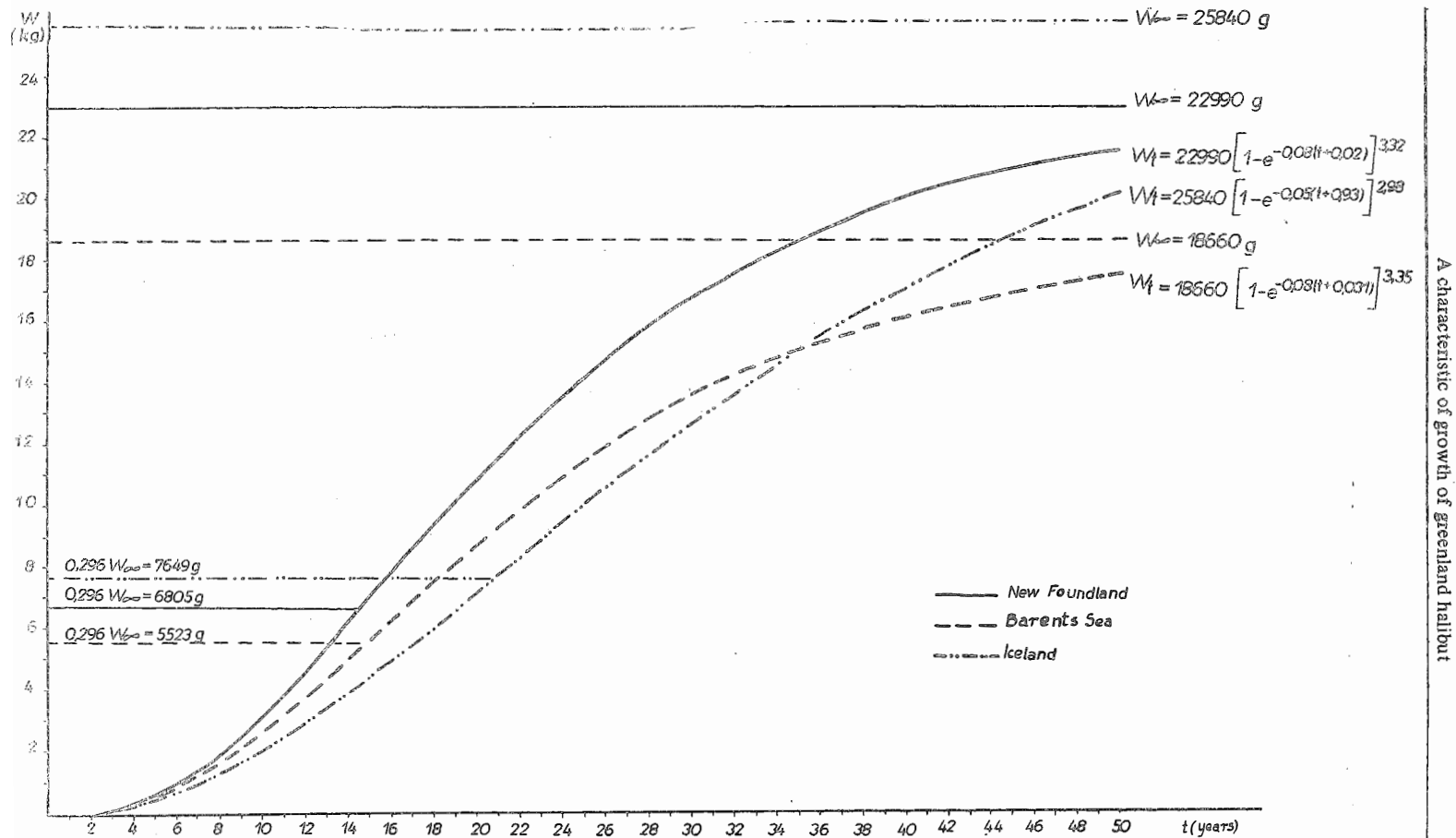


Fig. 7. Von Bertalanffy growth rate of Greenland halibut from different regions

growth is slower in the Barents Sea, and the slowest off Iceland. Later on the theoretical curves are of similar shape for New Foundland and Barents Sea, the weight growth being clearly faster off New Foundland, which results in a gradual increase of differences with age. On the other hand, the weight growth is different in Greenland halibut off Iceland. In the both regions discussed above, the annual weight increments increase until the fishes are 14–15 years old, which corresponds to lengths of 81.0 and 87.7 cm in the Barents Sea and New Foundland fishes, respectively. Starting from these points the annual increments keep decreasing. In the region off Iceland, a breakthrough in weight increments is observed as late as in the 21st year of life corresponding to 95.7 cm of length; the following years show a slower decrease in the increments than it is the case in the remaining regions, resulting in the largest asymptotic weight. The pattern of theoretical curves indicates a most uniform growth in the region off Iceland.

DISCUSSION

Analyses of length frequency distribution and age composition enable some conclusions, concerning a possible impact of fisheries on populations inhabiting each region, to be drawn. Alterations in the length distribution and age composition, presented on Fig. 2 and in Table 7, consisting in decreases in mean length and age in subsequent years of study, indicate a New Foundland Greenland halibut fisheries to be too intensive. An additional confirmation of a tendency presented above is found in data by Cieglewicz

Table 7

Greenland halibut mean age for both sexes in different regions

| Region | Year | Males (♂) | | Females (♀) | | Males + females (♂ + ♀) | |
|---------------|-----------|----------------|----------|----------------|----------|-------------------------|----------|
| | | Number of fish | Mean age | Number of fish | Mean age | Number of fish | Mean age |
| New Foundland | 1968 | — | — | — | — | 93 | 5.52 |
| | 1971 | 51 | 5.20 | 21 | 5.10 | 104 | 5.11 |
| | 1972 | 181 | 4.56 | 85 | 5.05 | 327 | 4.32 |
| Total | 1968–1972 | 232 | 4.70 | 106 | 5.06 | 524 | 4.69 |
| Barents Sea | 1971 | 227 | 7.26 | 101 | 9.51 | 328 | 7.95 |
| Iceland | 1971 | 220 | 9.46 | 161 | 10.70 | 381 | 9.98 |

and Kosior (1971) on mean length of Greenland halibut caught in 1966 from the 2J and 3K ICNAF sub-areas. The authors record the respective mean lengths of 60.7 and 55.2 cm, which are greater than those obtained in the course of the present study in 1968. However, it has to be stated that the mean length and age obtained can be slightly underestimated as no samples were collected within November – January, when, according to Pechenik and Troyanovskij (after Templeman, 1973), the densest concentrations of large Greenland halibut are observed on deep fishing grounds of the continental slope in this region.

Fig. 1 and Table 7 indicate that the mean length of Greenland halibut as well as the mean age were different in different samples and calendar years; moreover, they were dependent upon the region of capture. The attention is drawn to the fact that the lowest values were found off New Foundland, whereas higher in the Barents Sea fishing grounds, and the highest values were recorded from those off Iceland. Hence it could be assumed that the greatest overfishing presumably occurred in the New Foundland sub-area, while the relatively greatest possibilities of intensifying the exploitation of the species are provided by the Icelandic fishing grounds. The above assumptions, however, should be tested by means of observations, more detailed than it was possible to do in the course of the present study, on the fishing activities.

The maximum age reached by Greenland halibut (two specimens caught from the Icelandic fishing grounds) was 17 years (own data). Smidt (1969) determined the age of fish from off the western Greenland as 18 years, basing his calculations on a 99 cm long specimen, whereas the age of longer individuals (120 and 123 cm) was estimated by him as above twenty years. Milinskij (1944) gave as estimate of 14 years as the age of the oldest Barents Sea halibut, while the Paschen's (1968) estimation is 12 years for fish obtained from fishing grounds NW off Iceland.

The present author's studies on the age of males and females indicate to a shorter life-span of males, which is the case in most fish species. In the three regions studied the mean age of females was much longer than in males, the difference being relatively small off New Foundland only, since the mean age of both sexes was very low. Milinskij (op. cit.) determined the age of oldest Barents Sea males as 10 years, while his estimate was 14 years for females. In the present study, the oldest individuals from this region were found to be 11 and 15 years old, males and females respectively.

Table 8 summarises the back-calculated present author's results and the Greenland halibut growth rate and those obtained by the other workers from direct measurements. The comparison of data is difficult, since various skeletal elements were used in age readings, and different methods were applied to growth rate determinations. However, it can be concluded that the highest growth rate is an attribute of the fishes caught off the western Greenland. A comparison of own results with those obtained by Milinskij (1944) for the Barents Sea fishes is worth to pay an attention to. The results are very similar (scales being used to read the age in the both instances) with a slightly higher growth rate calculated by Milinskij. This small discrepancy emerges presumably from different

Table 8

Greenland halibut length growth in different regions (cm)

| Region | Age groups | | | | | | | | | | | | | | | | | Basis for age determination | Method | Author and year |
|-------------------|------------|-------|-------|-------|-------|------|------|------|------|------|--------|--------|------|--------|------|------|------|-----------------------------|---------------------|-----------------|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | | | |
| Western Greenland | 14-15 | 21-23 | 29-30 | 33-38 | 43-46 | | | | | | | | | | | | | - | Petersen | Smidt (1969) |
| | - | - | - | 39 | 46 | 51 | 58 | 61 | 67 | 71 | 75 | 79 | - | - | - | - | - | otoliths | Direct measurements | |
| Iceland | - | - | - | 39 | 46 | 52 | 56 | 60 | 64 | 66 | 70 | 72 | - | - | - | - | - | otoliths | Direct measurements | Paschen (1968) |
| Barents Sea | - | - | - | - | 43 | 46 | 54 | 57 | 62 | 64 | 69 | 73 | - | - | - | - | - | scales | Direct measurements | Miliński (1944) |
| New Foundland | 11.6 | 18.9 | 26.4 | 34.2 | 41.8 | 48.1 | 54.2 | 59.3 | 65.7 | 70.2 | (70.1) | (66.3) | - | - | - | - | - | scales | Back calculations | Own data (1976) |
| Barents Sea | 11.5 | 18.2 | 25.2 | 32.2 | 38.9 | 45.1 | 50.2 | 54.5 | 59.6 | 63.4 | 68.3 | 72.2 | 76.7 | (76.4) | 78.6 | - | - | scales | Back calculations | Own data (1976) |
| Iceland | 13.7 | 19.0 | 24.6 | 30.3 | 36.2 | 42.0 | 47.2 | 52.2 | 56.8 | 61.1 | 65.0 | 68.5 | 72.7 | 76.6 | 80.7 | 81.5 | 84.5 | scales | Back calculations | Own data (1976) |

methods used by the two authors: Milinskij used direct measurements which always give higher results than the back calculations as an increment since the last annulus is additionally included. On the other hand, when comparing own data with those obtained by Paschen (1968) for the Icelandic fishes, certain differences are noted, namely the higher growth rate calculated by Paschen. The discrepancy seems to have resulted, to some extent, from different anatomical elements and methods of study being used.

The present author's results show the rates of length and weight growth of Greenland halibut in each region to be different, which can be a proof of different biological features of fish inhabiting waters off New Foundland, the Barents Sea, and off Iceland, and belonging to separate stocks. The differences in rates of length and weight growth may be caused by different hydrological and climatic regimes prevailing in the areas studied. For example, the fastest growth in the first year of life was recorded in the Icelandic region, which could point out to favourable conditions for development of young fish. However, in the next years the growth slows down being presumably affected to a certain extent by a greater concentration of this population which, as it has been stated above, is probably less intensively exploited. Nizovcev (1974) states that the Icelandic and Barents Sea stocks of Greenland halibut diverge in a number of biological features, particularly in their growth rates and feeding habits.

In Table 5 presenting mean lengths of the Barents Sea Greenland halibut in subsequent years of life for each age group, the attention is focused upon the fact that the greatest mean lengths occur within the first five years of life for the fifth and sixth age groups, i.e., for the youngest fishes among the entire material studied. This can be explained by a selective action of fishing gear used, drawing the largest individuals out of these age groups.

A certain amount of caution should also be exercised when treating the results obtained for fishes older than 10, 12, and 15 years from the New Foundland (Table 4), Barents Sea (Table 5), and Icelandic (Table 6) fishing grounds, respectively, since their contribution to the material studied was very low.

The differentiation in length growth of Greenland halibut males and females from the different regions studied, presented in Fig. 5, indicates the retardation in the growth rate of males to take place after the seventh and eighth year of their age (New Foundland + Barents Sea, and Iceland, respectively), in both cases corresponding to the length exceeding 50 cm. According to Smidt (1969), both sexes of the western Greenland fish begin to differ in their growth rate in their ninth year of life. This phenomenon is suggested to be associated with an earlier sexual maturity of males as well as with their longer stay in the spawning grounds as compared to females, leading to their shorter feeding period. Smidt (1969) observes Greenland halibut males off the western Greenland to reach maturity earlier than females, at a younger age and smaller size; in consequence they also earlier migrate to the spawning grounds in the Davis Strait. The smallest mature male, 7 years old, was 55 cm long, while the length range of the smallest mature females was 60–70 cm, their age ranging within 8–10 years; the majority of males, however,

reach the sexual maturity when they are 60 cm long, while the corresponding length of females is 70–80 cm. Andriašev (1954) found, for the South-western part of the Barents Sea, 7–8 years old males and 10–11 years old females to reach sexual maturity. Cięglewicz and Kosior (1971) found maturing gonads (stages III and IV) in males and females of 48 and 66 cm, and more, lengths, respectively, their studies concerning Greenland halibut of regions 2J and 3K of the North-West Atlantic.

In his studies on condition of some more important stocks of Greenland halibut from the western Greenland region, Smidt (1969) found it to differ, which was explained as a result of diverse trophic conditions. The stocks in which 80 cm long individuals weigh in average more than or about 5 kg are considered by him well-nourished. According to the present author's data (Fig. 6), this prerequisite is fulfilled by the New Foundland and Barents Sea fishes, while those off Iceland are of a worse condition.

CONCLUSIONS

1. Of the three methods of a mathematical presentation of length growth rate, i.e., Ford-Walford, Gompertz, and von Bertalanffy, the latter has been found to fit best to the growth of Greenland halibut.
2. The region off New Foundland was inhabited by one to twelve years old Greenland halibut of a 13–83 cm length range. The mean length and age were 42.0 cm and 4.69 years, respectively. Three to six years old individuals predominated, the fourth age group being represented most abundantly.
3. In the Barents Sea, five to fifteen years old 28 to 103 cm long individuals were found to occur. The mean length and age were 52.5 cm and 7.95 years, respectively. The seventh age group was the predominant one.
4. In the region off Iceland, three to seventeen years old fishes of 29–96 cm length range were present. The mean length and age were 61.3 cm and 9.98 years, respectively. Seven to thirteen years old fishes prevailed, the eleventh age group being the most numerous one.
5. The Greenland halibut length growth rates showed similar patterns in the three regions investigated, resulting in similar shapes of growth curves. The fastest growth takes place in the first year of life; the growth approaches a uniform course from the second through fifth year, a slight decline in the growth rate being noted in later years.
6. The highest length growth rate is noted in Greenland halibut of the New Foundland fishing grounds, lower – in fishes of the Barents Sea, those caught off Iceland showing the lowest rate. Similar is the pattern of the weight growth rates in the three regions studied.
7. Greenland halibut males and females were observed to exhibit different growth rates. Beginning from eight years of life in females of the New Foundland and Barents Sea fishing grounds, and from the ninth year off Iceland, the females grow faster than males.

REFERENCES

- Andriašev A.N., 1954: Ryby severnych morej SSSR, Izd. Ak. Nauk SSSR, Moskva-Leningrad.
- Cięglewicz W., Kosior A., 1971: Charakterystyka eksploatacyjno-biologiczna połowów płastug w Północno-Zachodnim Atlantyku. [Biological and exploitative characteristic of flatfish catches in the Northwest Atlantic].— Prace Morsk. Inst. Ryb., Gdynia, 16/A: 7–48.
- Krzykawski S., 1976: A comparative analysis of some anatomical elements with regard to their relevance to the age and growth rate determination to Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), *Acta Ichthyol. Pisc.*, VI, 2: 63–78.
- Miliński G.I., 1944: Materiały po biologii i przemyśle żurnego paltusa *Barenceva moria.*, Tr. Polarn. naučno-issl. inst. morsk. ryb. choz. okeanogr., vyp. 8.
- Minet J.P., 1973: Age and Growth of the American Plaice, *Hippoglossoides platessoides*, off Cape Breton Island in ICNAF Subdivision 4 Vn., ICNAF, Res. Bull., Canada, 10: 99–105.
- Nizovcev G.P., 1974: Čornyj paltus *Reinhardtius hippoglossoides* (Walbaum), pomečennyj v vodach vostočnoj Islandii, vyloven v Barencevom morie., *Vop. Ichtiol.*, 14, vyp. 2(85): 328.
- Paschen U., 1968: Ergebnisse einiger Untersuchungen am Schwarzen Heilbutt (*Reinhardtius hippoglossoides*) im Jahre 1967 bei Island., *Fischerei-Forschung*, 6, 1: 29–36.
- Smidt E.L.B., 1969: The Greenland Halibut, *Reinhardtius hippoglossoides* (Walb.), Biology and Exploitation in Greenland Waters., *Meddelelser fra Danmarks Fiskeri- og Havundersøgelser*, København, N.S. 6, 4: 79–148.
- Templeman W., 1973: Distribution and Abundance of the Greenland Halibut, *Reinhardtius hippoglossoides* (Walbaum), in the Northwest Atlantic., ICNAF, Res. Bull., Canada, 10: 83–98.

Translated: mgr Teresa Radziejewska

CHARAKTERYSTYKA WZROSTU HALIBUTA NIEBIESKIEGO
REINHARDTIUS HIPPOGLOSSOIDES (WALBAUM)
 Z PÓŁNOCNEGO ATLANTYKU

Streszczenie

Celem pracy było zbadanie składu długościowego i wiekowego, określenie tempa wzrostu długości i ciężaru przy zastosowaniu modeli matematycznych, wybór optymalnego modelu wzrostu oraz ustalenie zależności pomiędzy długością a ciężarem ciała. Badania przeprowadzono na rybach pochodzących z łowisk Nowej Fundlandii (rejon ICNAF) oraz Morza Barentsa i Islandii (rejon ICES). Ogółem wykonano pomiar masowy 13752 sztuk halibuta niebieskiego, z czego do analiz biologicznych pobrano 1364 ryby.

Zaobserwowano, że średnia długość oraz średni wiek ryb z łowisk Nowej Fundlandii są wyraźnie niższe niż obserwowane u ryb z łowisk Islandii i Morza Barentsa.

Najszybszym tempem wzrostu długości charakteryzuje się halibut niebieski z łowisk Nowej Fundlandii, wolniejszym – z łowisk Morza Barentsa a najwolniejszym z łowisk Islandii. Równania wzrostu długości dla tych rejonów przedstawiają się następująco:

| | | |
|-----------------|---------------|----------------------------|
| Nowa Fundlandia | $l_t = 126,5$ | $[1 - e^{-0,08(t+0,02)}]$ |
| Morze Barentsa | $l_t = 116,5$ | $[1 - e^{-0,08(t+0,031)}]$ |
| Islandia | $l_t = 144,0$ | $[1 - e^{-0,05(t+0,93)}]$ |

Podobnie przedstawia się zróżnicowanie tempa wzrostu ciężaru w trzech wymienionych rejonach:

| | | |
|-----------------|---------------|----------------------------------|
| Nowa Fundlandia | $W_t = 22990$ | $[1 - e^{-0,08(t+0,02)}]^{3,32}$ |
|-----------------|---------------|----------------------------------|

$$\begin{aligned} \text{Morze Barentsa} & \quad W_t = 18660 [1 - e^{-0,08(t+0,031)}]^{3,35} \\ \text{Islandia} & \quad W_t = 25840 [1 - e^{-0,05(t+0,93)}]^{2,98} \end{aligned}$$

Zaobserwowano różnice w tempie wzrostu samców i samic. Od ósmego roku życia samice z łowisk Nowej Fundlandii oraz Morza Barentsa, a od dziewiątego – z łowisk Islandii, rosną szybciej niż samce.

ХАРАКТЕРИСТИКА РОСТА ЧЁРНОГО ПАЛТУСА *RWINHARDTIUS*
HIPPOGLOSSOIDES (WALBAUM) ИЗ СЕВЕРНОЙ АТЛАНТИКИ

Р е з ю м е

Целью работы явилось изучение размерного и возрастного состава, определение темпа роста длины и веса на основе математических моделей, выбор оптимальной модели роста и определение зависимости между длиной и весом тела.

Исследования проводились на рыбах, выловленных в районах Нью-Фаундленда (район ИКНАФ), Баренцева моря и Исландии (ИКЕС). Всего измерили 13 752 экз. чёрного палтуса, из которых 1364 взяли для биологических анализов.

Отмечено, что рыбы из нью-фаундлендских районов лова характеризуются меньшей средней длиной и меньшим средним возрастом, чем рыбы из районов лова Исландии и Баренцева моря.

Наибольшим темпом роста длины характеризуется чёрный палтус из районов лова Нью-Фаундленда, более медленным – из района Баренцева моря, а наименьшим – из районов лова Исландии. Уравнения роста длины для рыб из этих районов лова представлены следующим образом:

$$\begin{aligned} \text{Нью-Фаундленд} & \quad l_t = 126,5 [1 - e^{-0,08(t+0,02)}] \\ \text{Баренцево море} & \quad l_t = 116,5 [1 - e^{-0,08(t+0,031)}] \\ \text{Исландия} & \quad l_t = 144,0 [1 - e^{-0,05(t+0,93)}] \end{aligned}$$

Темп роста веса в трёх вышеназванных районах имеет сходный характер:

$$\begin{aligned} \text{Нью-Фаундленд} & \quad W_t = 22990 [1 - e^{-0,08(t+0,02)}]^{3,32} \\ \text{Баренцево море} & \quad W_t = 18660 [1 - e^{-0,08(t+0,031)}]^{3,35} \\ \text{Исландия} & \quad W_t = 25840 [1 - e^{-0,05(t+0,93)}]^{2,98} \end{aligned}$$

В ходе исследований отмечены различия в темпе роста самцов и самок. С восьмого года жизни самки из районов лова Нью-Фаундленда и с девятого года жизни – из районов лова Исландии растут быстрее, чем самцы.

Address:

Received: 10 V 1976 г.

Dr Stanisław Krzykowski
Instytut Ichtiologii AR
71-550 Szczecin, ul. Kazimierza Królewicza 4
Polska – Poland