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Age and growth of the American plaice, *Hippoglossoides pl. platessoides*, in ICNAF Subdivision 4Vn

by

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

I. Introduction

The American plaice, *Hippoglossoides pl. platessoides*, is a northern Arctic subspecies of the Northwest Atlantic where its geographic distribution is very extensive. In fact, we find it from the tip of Cape Cod (USA) to south of the latitude of Egedesminde in West Greenland (68°50'N). However, the most important concentrations are found on the banks surrounding Newfoundland (especially on the eastern Grand Bank), in the Gulf of St. Lawrence, and on the offshore banks of Nova Scotia. There has been an intensive fishing effort in these areas and it has continued to increase during recent years since landings almost tripled between 1960 and 1969.

The fishing effort in ICNAF Subdiv. 4Vn [2,308 tons of American plaice landed in 1969 which is one quarter of the catches on Nova Scotia banks (ICNAF Div. 4V, 4W, and 4X)] is relatively small compared to the total.

For these reasons, research on age and growth of the American plaice was conducted in the Gulf of St. Lawrence area (ICNAF Div. 4T) by Powles (1965), and on the Newfoundland and Labrador banks (ICNAF Subareas 2 and 3) by Pitt (1967). The work by Lux (1969) on growth of American plaice in the Gulf of Maine (ICNAF Subarea 5) should also be noted.

II. Material and methods

The material necessary for this study was collected during cruises by two ISTPM research vessels, the R/V *Thalassa* in April-May 1970 and the R/V *Cryos* in May 1971. The two vessels, stern trawlers, used the same type bottom trawl whose specifications are as follows: 31.20 m headline mounted on 30.80 m; groundrope of 17.70 m; 140-mm mesh in the wings and body and 50 mm in the codend. Positions of trawl hauls of 30-min duration are shown in Fig. 1.

A sample catch at each station was sexed and measured (total length to the cm below) to establish length frequencies by sex; 3,612 individuals were sexed and measured in 1970, and 2,734 in 1971.

In addition to the above, at certain stations, American plaice otoliths were taken and weighed individually for length/age, length/weight, and weight/age studies; 550 pairs of otoliths were taken from 782 individuals and weighed individually in 1970, and 445 pairs from 442 individuals in 1971.

Since data used for this study in Subdiv. 4Vn were collected during the same season (spring) in 1970 and 1971, it seemed preferable to attempt to compare rather than to cumulate them.

1. Method of age determination

With the research by Powles (1965, 1966) and Pitt (1967), it is now well established that age determination of the American plaice by otolith readings is valid. Ages were, therefore, determined by examination of otoliths sampled from fish specimens and preserved dry in envelopes. Most of the readings were done with a X20-powered binocular, under reflected light, by counting the hyaline rings on the whole otolith as described by Powles (1965). In order to reduce errors for older individuals whose rings are very close, the readings were made on otoliths cut in half, mounted on modelling clay and kept wet with ethyl alcohol, with the binocular under reflected light, as described by Pitt (1967).

As the spawning period in this area is March-May for the American plaice, and the sampling of otoliths was done in April-May, the number of rings were considered to be the exact age of the fish and it was not necessary to adjust the results of the readings.

2. Method of calculating growth curves

To describe the growth which is a prime factor of population dynamics, Beverton and Holt (1957) give a mathematical presentation. To form an equation of the length/age data (linear growth), the von Bertalanffy mathematical model was used:

$$L_t = L\infty\ [1 - e^{-K(t-to)}] \qquad (1)$$

where

L_t = length at age t (in years),
$L\infty$ = maximum theoretical length,
K = constant expressing variation of length increases,
to = theoretical age where length is invalid.

The parameters of this equation were obtained using the Walford method by calculating regressions by the method of least squares.

The representation of the growth in weight (weight/age relationship) is also interesting to consider in this study of the stock. Again using the mathematical model proposed by von Bertalanffy, it is sufficient to change L to W in equation (1):

$$W_t = W\infty\ [1 - e^{-K(t-to)}]\ n \qquad (2)$$

where

W_t = weight at age t (in years),
$W\infty$ = maximum theoretical weight,
K and to = same as in (1),
n = coefficient (approx. 3) joining length and weight in the equation:

$$W_t = q \cdot L_t^{\,n} \qquad (3)$$

To calculate equation (2), it is, therefore, necessary to resolve firstly equation (3). For that purpose, we express it logarithmically:

$$\log W_t = \log q + n \cdot \log L_t$$

and $$\log W_{t+1} = \log q + n \cdot \log L_{t+1}$$

from which one derives:

$$n = \frac{\log W_{t+1} - \log W_t}{\log L_{t+1} - \log L_t} \qquad \text{and the constant } q.$$

The values of L_t and of the corresponding W_t, taken two by two, allow the finding of $\overline{n}$ and $\overline{q}$. Therefore, $W\infty$ is easily found:

$$W\infty = q \cdot L\infty^{n}$$

and equation (2) is resolved.

III. Results

1. Distribution of length and year-class

Length and year-class frequencies were established separately for males and females in 1970 and 1971 (Fig. 2).

For males, we estimate that the length distribution varies very little from year to year, ranging from 12 to 52-54 cm with very close modal lengths of 26 and 28 cm. The distribution of year-classes for males during the course of two years illustrates the predominance of recruits of 1964 and of 1966, those of 1959 remaining relatively abundant.

The length range for females is much wider than that for males: from 10 to 72 cm in the course of two years. There again, their modal length varied very little from 1970 to 1971: between 24 and 26 cm, which is slightly less than that of the males. The distribution of year-classes again shows the predominance of recruits from 1964 and 1966. However, the female recruits from 1959 which seemed abundant in 1970 are very scarce the following year. On the other hand, those of 1968 (3 years) seemed to take on importance.

In addition, it must be noted that the distribution of year-classes for females is much greater than that of the males; few males reach more than 20 years, while 27-year-old females were encountered.

2. Linear growth

Equations representing the 1970 linear growth of the American plaice in ICNAF Subdiv. 4Vn are:

$$L_t = 54.8\ [1 - e^{-0.10\ (t+0.95)}] \qquad \text{for males;}$$

$$\text{and } L_t = 76.1\ [1 - e^{-0.06\ (t+1.86)}] \qquad \text{for females;}$$

and in 1971:

$$L_t = 54.8\ [1 - e^{-0.09\ (t+1.29)}] \qquad \text{for males;}$$

$$\text{and } L_t = 77.5\ [1 - e^{-0.06\ (t+1.36)}] \qquad \text{for females.}$$

Growth curves resulting from these equations are shown in Figs. 3-A and 3-B. As noted by Powles (1965), Pitt (1967), and Lux (1969) for their areas of study, the American plaice shows a different growth rate according to sex. In fact, although males and females have almost the same growth rate up to ages 4-5 years, the females grow more rapidly thereafter. Thus, the males of this region reach commercial size (L_t = 32 cm) at age 9 and the females at age 7. With this difference in length at the same age in favour of females, it is justifiable to add that the latter live much longer.

In addition to the difference in growth according to sex, it is worth noting those differences which can exist among individuals of the same sex from year to year. The linear growth curves for males in 1970 and 1971, fairly different at first (to = -0.95 years in 1970 and -1.29 in 1971) because of various increases in length (K constants), reach a common asymptote (L_∞ = 54.768 cm in 1970 and 54.836 cm in 1971). The linear growth curves for feamles vary more widely. In fact, the theoretical ages at initial growth are fairly different while the constant K does not vary. This leads to maxima theoretical lengths which are quite far apart: 76.148 cm in 1970, and 77.490 cm in 1971.

3. Length/weight relationship

The equations representing the length/weight relationship in 1970 are:

$$W = 4119 \cdot 10^{-6} \cdot L^{3.18401} \qquad \text{for males,}$$

$$\text{and } W = 1942 \cdot 10^{-6} \cdot L^{3.39498} \qquad \text{for females;}$$

and in 1971:

$$W = 4094 \cdot 10^{-6} \cdot L^{3.20234} \qquad \text{for males,}$$

$$\text{and } W = 1837 \cdot 10^{-6} \cdot L^{3.44608} \qquad \text{for females.}$$

Curves resulting from the length/weight data are shown in Figs. 4-A and 4-B. We estimate that up to lengths of approximately 20 cm, males and females are always of similar weights.

Thereafter, females of the same length as males always weigh more, which is shown in the equation by an exponent n approximately 3.2 for males and approximately 3.4 for females. Among the main reasons for this difference, the growth of the female genital glands must be noted.

In addition, the increase of the exponent n between 1970 and 1971 must be clearly noted: +0.01833 for males and +0.05110 for females.

4. Growth in weight

To bring the linear growth equations and the length/weight relationship closer together, equations for growth in weight were established for males and females.

For 1970:

$$W_t = 1413 \; [1 - e^{-0.10(t+0.95)}] \; 3.18401 \qquad \text{for males,}$$

and $$W_t = 4747 \; [1 - e^{-0.06(t+1.86)}] \; 3.39498 \qquad \text{for females;}$$

and for 1971:

$$W_t = 1518 \; [1 - e^{-0.09(t+1.29)}] \; 3.20234 \qquad \text{for males,}$$

and $$W_t = 5951 \; [1 - e^{-0.06(t+1.36)}] \; 3.44608 \qquad \text{for females.}$$

The curves for growth in weight are shown in Figs. 5-A and 5-B. Since these equations result from the two previous equations, they show the same phenomena, but under a form which takes into account the variations of weight as related to time.

However, the great variation in $W\infty$ from year to year must be noted, for males as well as for females. For males, it is 1,413 g to 1,518 g, while $L\infty$ had not varied (54.8 cm). This is due to the increase of the exponent n between 1970 and 1971 which occurs in the relationship: $W\infty = q \cdot L\infty^n$. This is more important for females who, having a higher $L\infty$ in 1971 and a greater increase of the exponent n, show a difference of 1,204 g between the $W\infty$ of 1970 and that of 1971.

IV. Discussion

Like the above-mentioned authors who studied the growth of the American plaice, *Hippoglossoides pl. platessoides*, we have tried to show the differences in growth between male and female individuals. One of the main explanations which we can give is rather simple. In fact, we have seen that up to about 4-5 years of age, the growth rate for males and females is practically identical. It is from this age upwards that growth rates are clearly different. Also, it is at this age when sexual maturity for most males occurs (length of 22-23 cm), while sexual maturity for females occurs much later. The lower growth rate for males for the following years is, therefore, due to the utilization of a greater proportion of the food for development of sexual products at the expense of growth. To be certain of this explanation, regular observations of the relationship between growth rate and sexual maturity would have to be made.

On the other hand, it is more difficult to explain the year-to-year differences in growth of individuals of the same sex in the same area and in the same time of year, which have been shown in this report. Firstly, one must not rule out the hypothesis of a bias in the equations due to insufficient sampling, even though particular effort was made to sample all sizes. One must also not neglect the amplification of differences shown by the application of length/weight data to growth in weight. The relationship $W = q \cdot L^n$ is, in fact, difficult to integrate in a theoretical model (Beverton and Holt, 1957, p.279-281). But the use of the simple cubic relationship $W = q \cdot L^3$ would not allow one to distinguish the specific gravity variations from the volumetric ones; in addition, it would not so clearly show the differences existing between males and females (variation of exponent n according to sex). But we can also believe, as do Beverton and Holt (1957), that all variations in food play an important role in the growth phenomenon, as do quantity of food available and variations in the metabolism of the fish. For these two factors, one must envisage modifications in population density (number of individuals and biomass, subject to natural or fishing mortality), and in hydrological conditions.

The influence of hydrological factors (especially temperature) has been illustrated by several authors (May, et al., 1965; Pitt, 1967) but for different populations and not for the same population from time to time.

The comparison of different ICNAF areas shows clearly that the growth of the American plaice is slower in ICNAF Subdiv. 4Vn than that described by Lux (1969) for the Gulf of Maine, and is much more rapid than that described by Pitt (1967) for the Labrador shelf, which is quite normal, considering the hydrological conditions. It would be better to have results closer to those found for the southwest region of the Grand Banks, that is, a growth slightly faster than that shown by Powles (1965) for the Gulf of St. Lawrence, but a little slower than that described for the southwest region of the Grand Banks (Pitt, 1967).

References

Beverton, R.J.H., and S.J. Holt. 1957. On the dynamics of exploited fish populations. *Fish. Invest., Lond. (2)*, Vol. 19, 533 p.

Lux, F.E. 1969. Growth of American plaice, *Hippoglossoides platessoides* (Fabricius), in ICNAF Subarea 5. *Annu. Meet. int. Comm. Northw. Atlant. Fish.*, Res.Doc. 69/55.

May, A.W., A.T. Pinhorn, R. wells, and A.M. Fleming. 1965. Cod growth and temperature in the Newfoundland area. *Spec. Publ. int. Comm. North. Atlant. Fish.*, No. 6, p. 545-555.

Pitt, T.K. 1967. Age and growth of American plaice (*Hippoglossoides platessoides*) in the Newfoundland area of the Northwest Atlantic. *J. Fish. Res. Bd. Canada*, 24 (5), p. 1077-1099.

Powles, P.M. 1965. Life history and ecology of American plaice (*Hippoglossoides platessoides* F.) in the Magdalen Shallows. *J. Fish. Res. Bd. Canada*, 22 (2), p. 565-598.

1966. Validity of ageing young American plaice from otoliths. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, No. 3, p. 103-105.

Ricker, W.E. 1958. Handbook of computations for biological statistics of fish populations. *Bull. Fish. Res. Bd. Canada*, No. 119, 300 p.

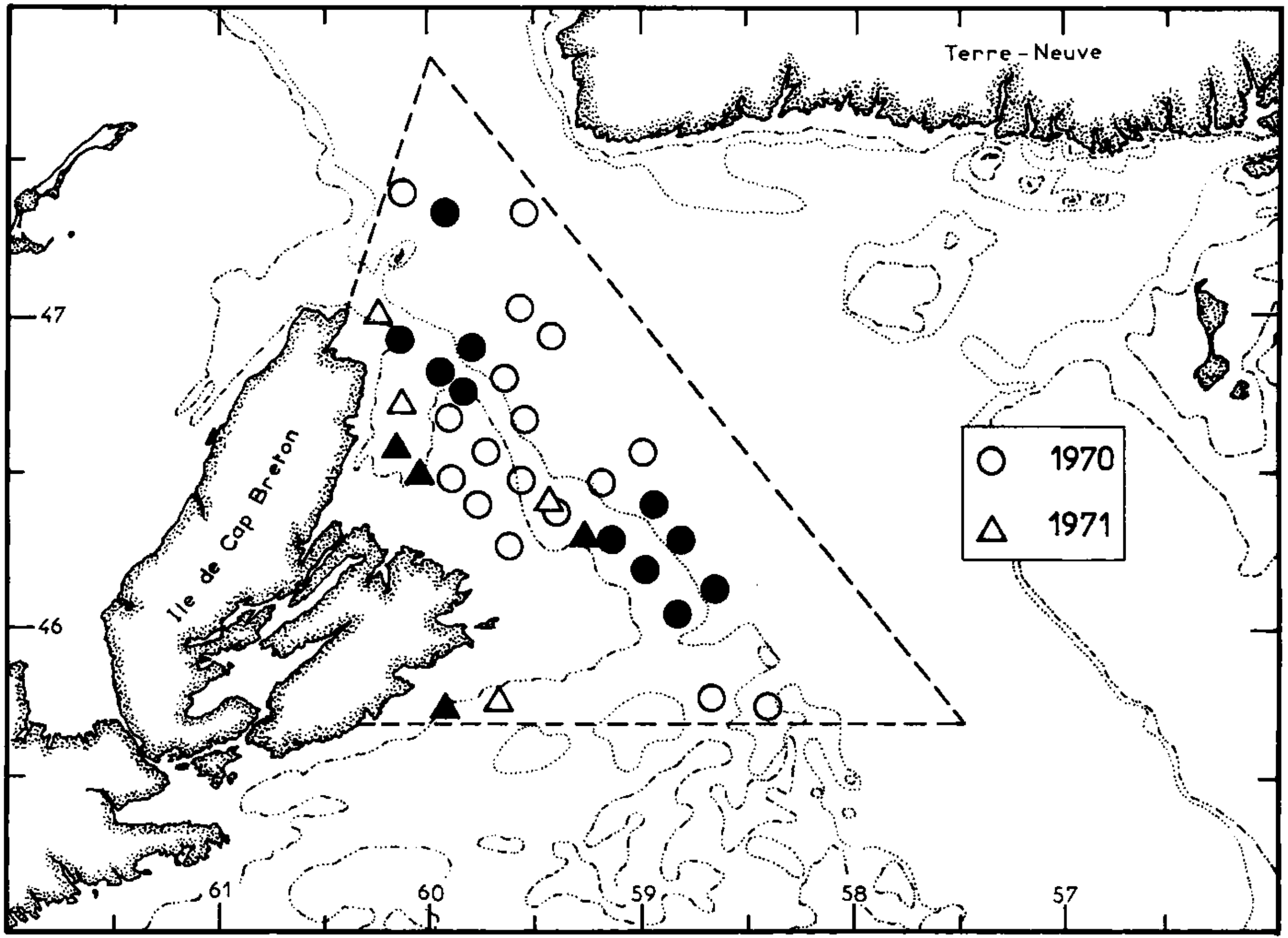

Fig. 1. Positions of stations occupied in ICNAF Subdiv. 4Vn.
Blank circles and triangles: determination of sex and length, 1970 and 1971 respectively.
Solid black circles and triangles: determination of sex and length from otolith samples, weighed individually, 1970 and 1971 respectively.

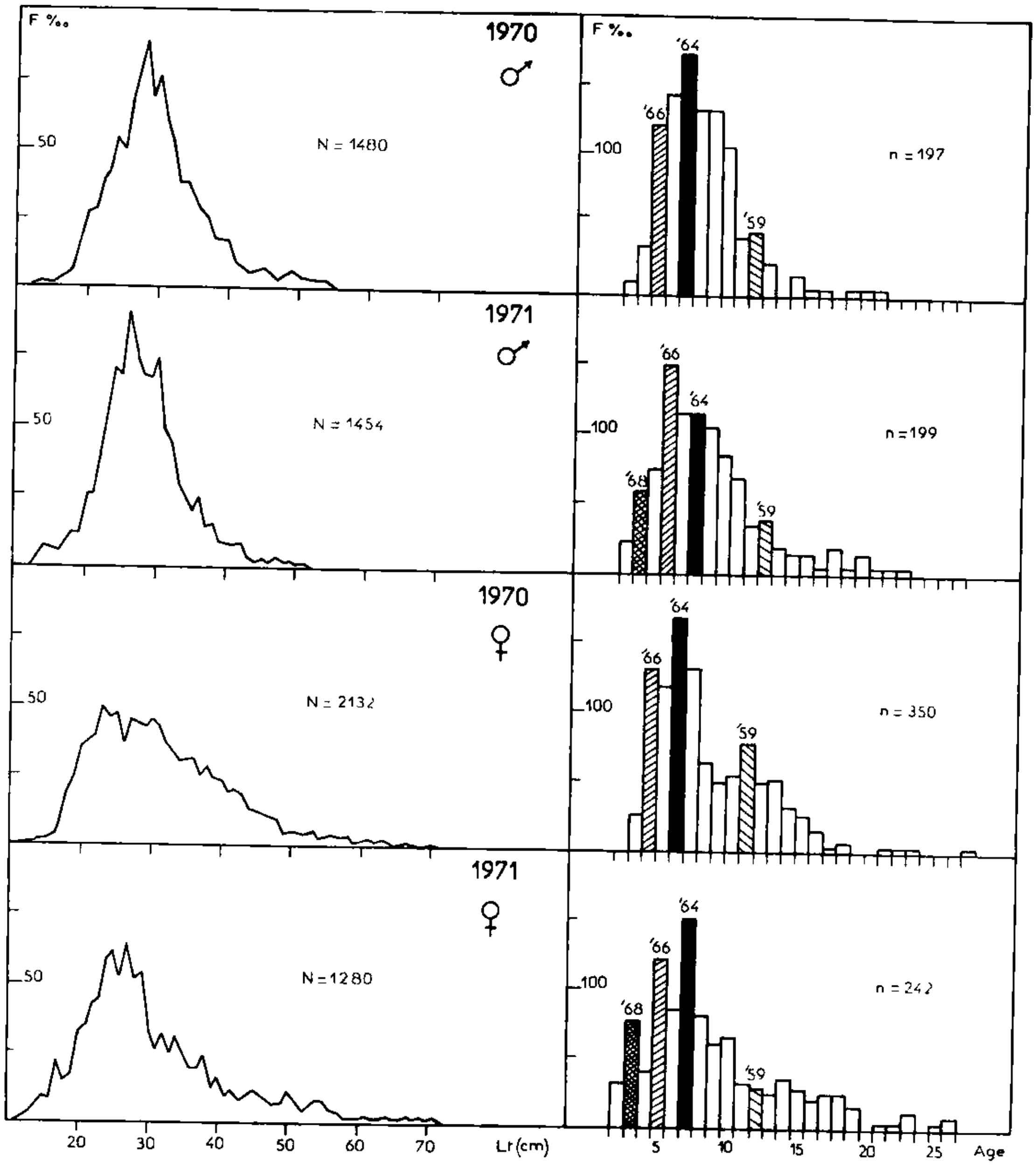

Fig. 2. Length and year-class distribution of the American plaice in relation to sex and year. N = number of fish measured; n = number of otoliths read.

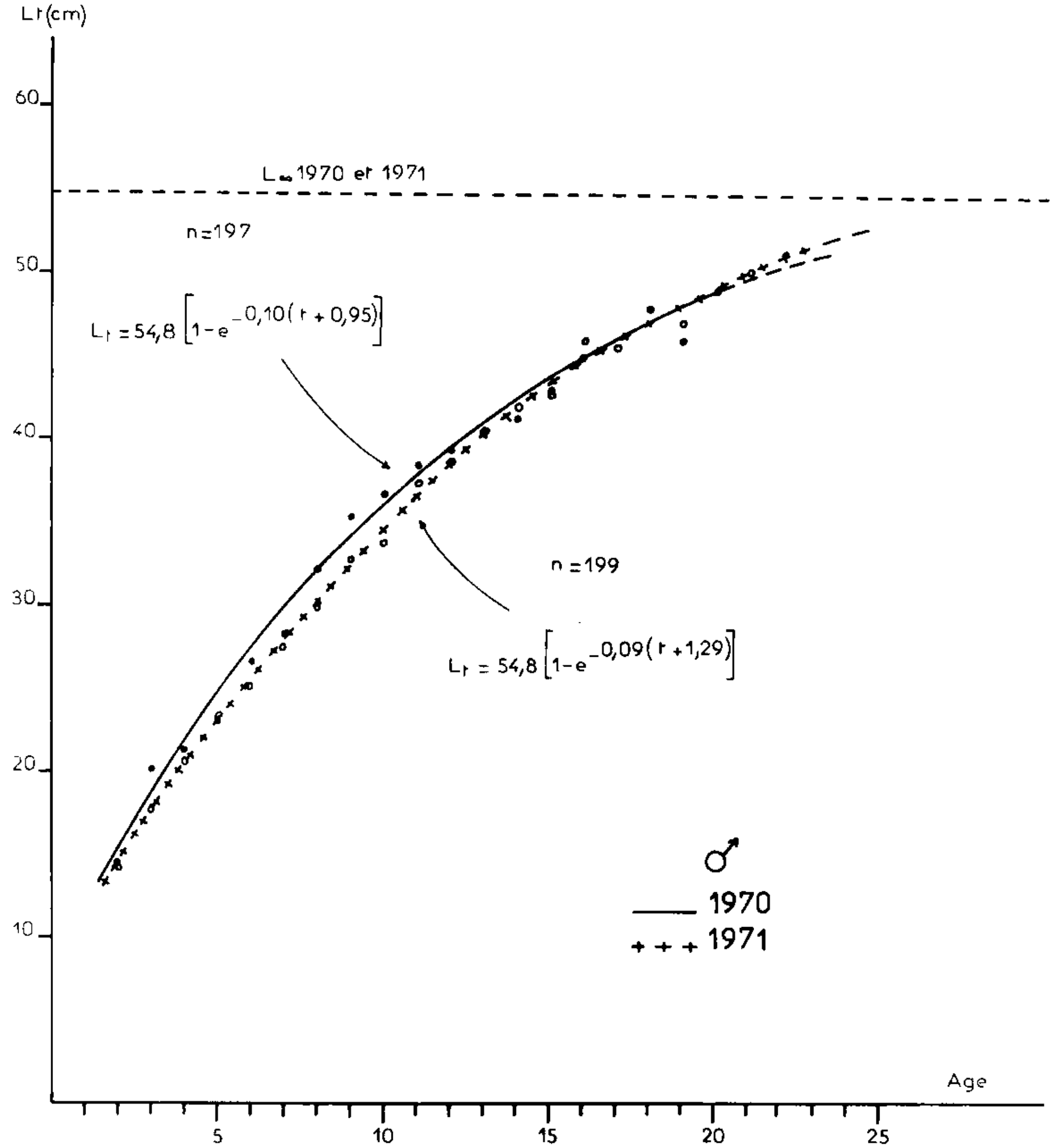

Fig. 3-A. Linear growth curves for males in 1970 and 1971.

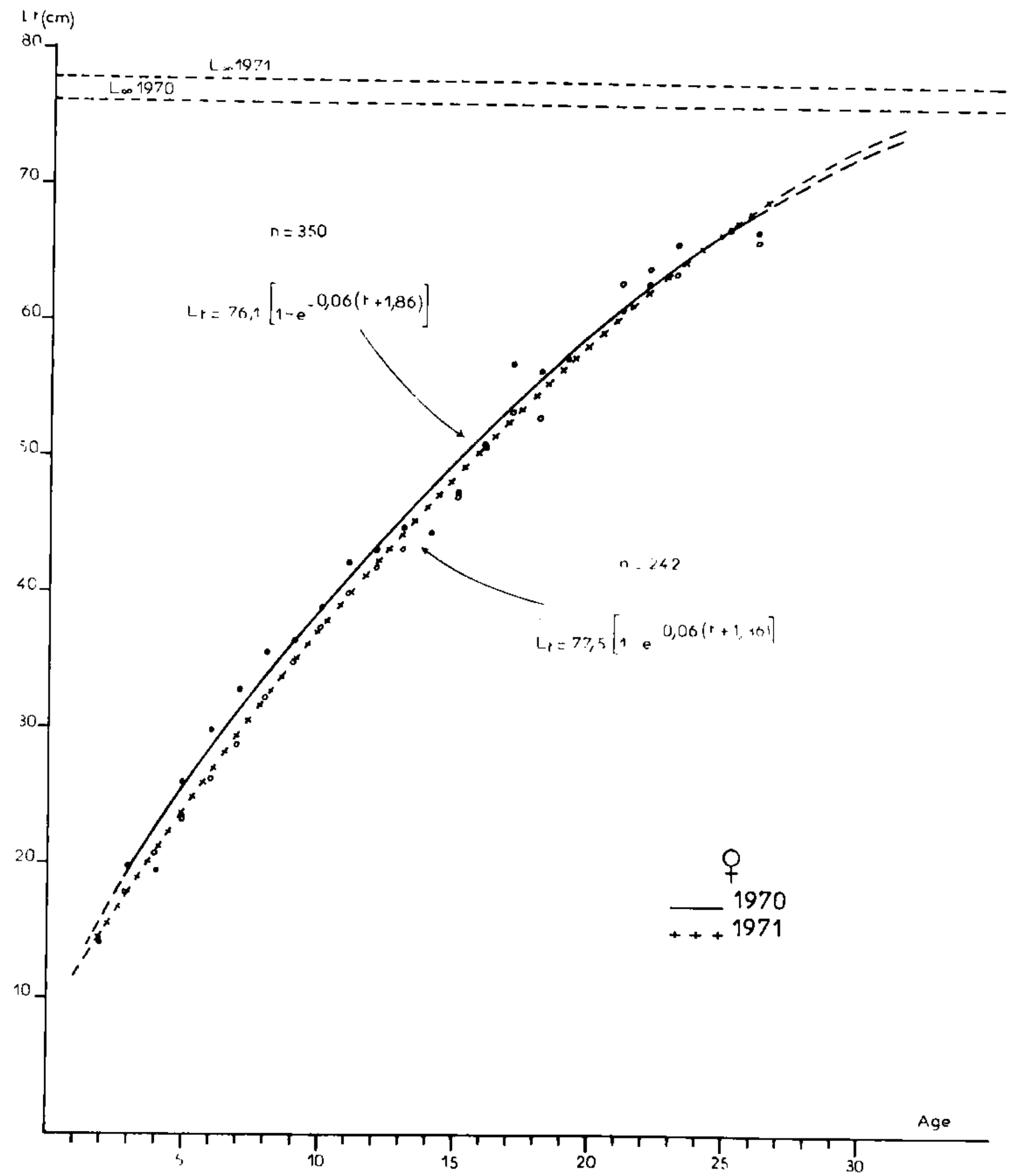

Fig. 3-B. Linear growth curves for females in 1970 and 1971.

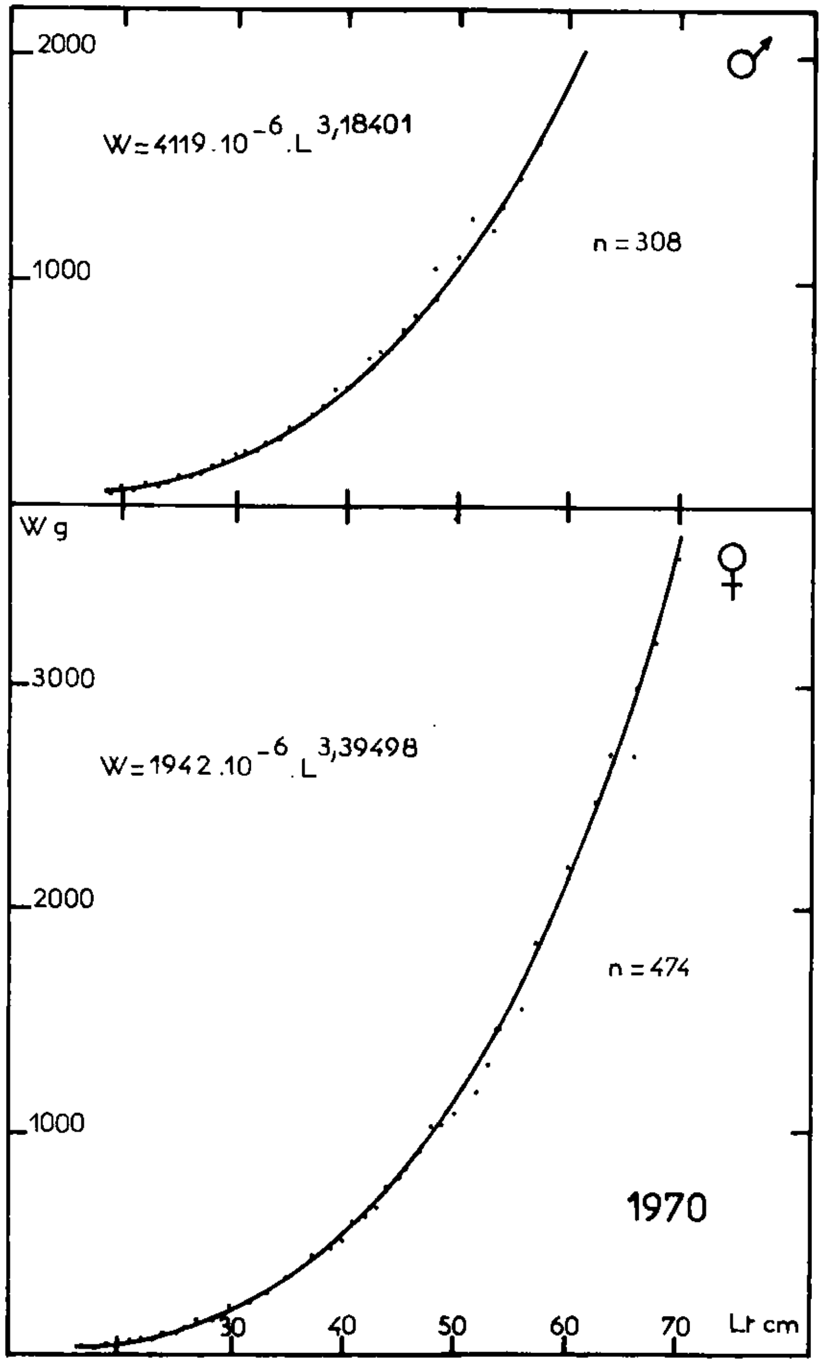

Fig. 4-A. Length/weight curves for males and females in 1970.
n = number of individuals measured and weighed.

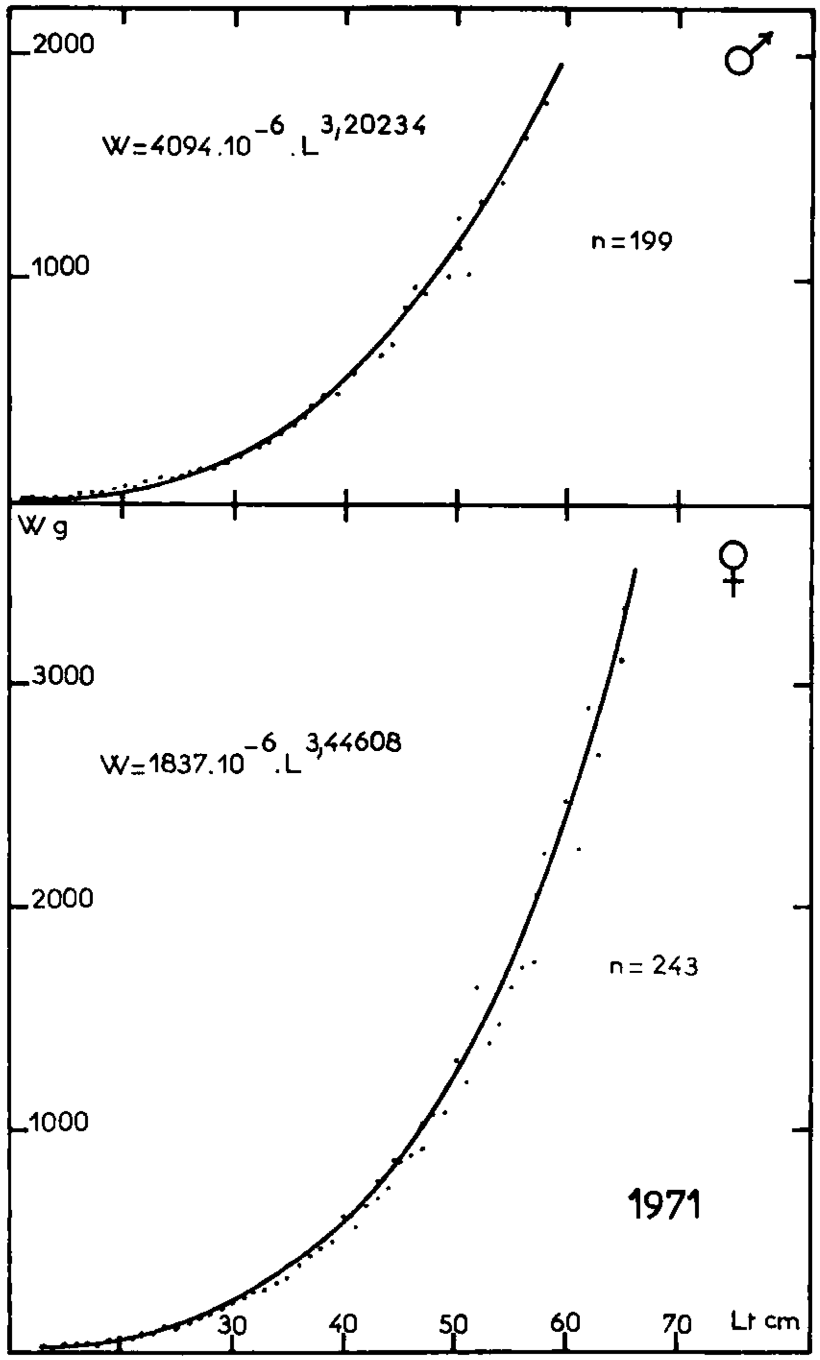

Fig. 4-B. Length/weight curves for males and females in 1971. n = number of individuals measured and weighed.

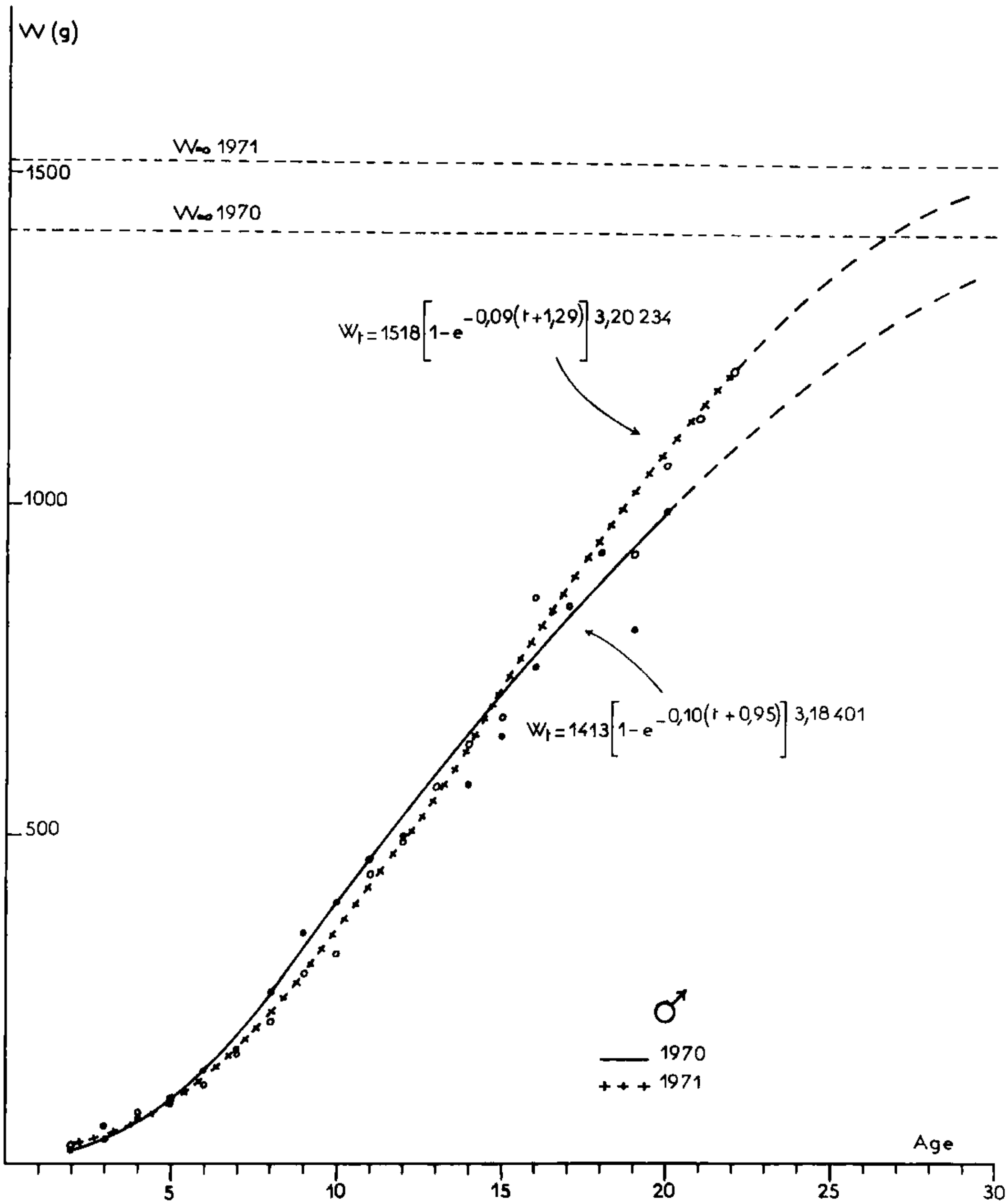

Fig. 5-A. Curves of growth in weight for males in 1970 and 1971.

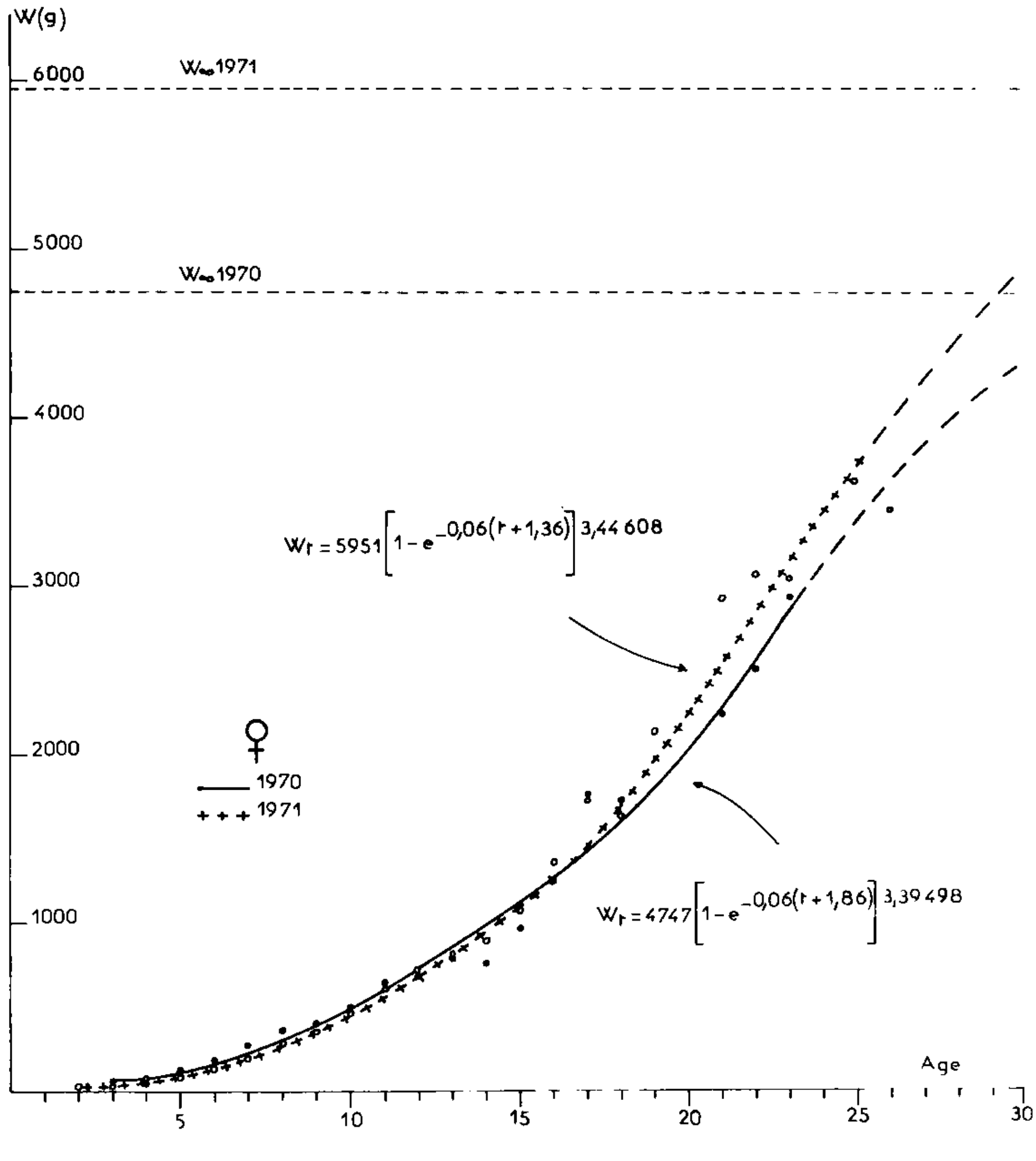

Fig. 5-B. Curves of growth in weight for females in 1970 and 1971.

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1. Under Section I. "Introduction", please replace the first three lines of the first paragraph with the following:

   "The American plaice, *Hippoglossoides pl. platessoides*, is an Arctic-boreal subspecies of the Northwest Atlantic where its geographic distribution is very extensive. In fact, we find it from the tip of Cape Cod (USA) in the south, to the latitude of Egedesminde"

2. Under Section II. "Material and methods", please replace the third paragraph with the following:

   "In addition to the above, at certain stations, American plaice otoliths were taken and individual weighings were made for length/age, length/weight, and weight/age studies; 550 pairs of otoliths were taken in 1971, and 445 pairs in 1970; 782 individual weighings were made in 1970, and 442 in 1971."

3. Under Section II.1. "Method of age determination", second last line on page 1, please change the word "reflected" to "transmitted".

4. Under Section II.2. "Method of calculating growth curves", first line of first paragraph, page 2, please change the word "prime" to "primary".

5. Under same section, second line of second paragraph, page 2, please change "regressions" to "regression lines".

6. Under same section, equation (2), page 2 should read:

   $$W_t = W_\infty \, [1 - e^{-K(t-t_o)}]^n \qquad (2)$$

7. Under Section III.3. "Length/weight relationship", second last line from bottom of page 3, please change the word "estimate" to "ascertain".

8. Under Section III.4. "Growth in weight", page 4, equations for growth in weight should read:

   $$W_t = 1413 \, [1 - e^{-0.10(t+0.95)}]^{3.18401} \qquad \text{for males,}$$

   and

   $$W_t = 4747 \, [1 - e^{-0.06(t+1.86)}]^{3.39498} \qquad \text{for females;}$$

   and for 1971:

   $$W_t = 1518 \, [1 - e^{-0.09(t+1.29)}]^{3.20234} \qquad \text{for males,}$$

   and

   $$W_t = 5951 \, [1 - e^{-0.06(t+1.36)}]^{3.44608} \qquad \text{for females.}$$

9. Under Section IV. "Discussion", fifth line of second paragraph on page 4, please change "was made to sample all sizes" to "was made to sample also extreme sizes".

(over)

10. On page 6, Fig. 1 caption should read:

"Fig. 1. Positions of stations occupied in ICNAF Subdiv. 4Vn.
Blank circles and triangles: determination of sex and length, 1970 and 1971 respectively.
Solid black circles and triangles: determination of sex and length, otolith samplings and individual weighings, 1970 and 1971 respectively."