RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 1874
(D. c. 5)

ICNAF Res. Doc. No. 67/78

ANNUAL MEETING - JUNE 1967

Biological data on cod from the summer fishery on the north shore Strait of Belle Isle

by A. W. May

CONTENTS

1. Introduction

(a) The stock

A regular census of the inshore Labrador cod fishery, to provide basic data for population studies and to assess the effects of offshore fishing, was begun in 1959. Various fishing centres on the north shore of the Strait of Belle Isle (Fig. 1) were first visited in 1962 and sampling continued through 1966.

Very little mixing of cod occurs between the north shore of the Strait of Belle Isle and the more northerly Labrador Coast (Templeman, 1962). The Straits cod form part of the "West Newfoundland" stock which ranges from southwestern Newfoundland, along the Newfoundland west coast, and possibly to the Quebec north shore, depending on season (Templeman, 1962). Summer distribution is mainly in the northern and northeastern Gulf of St. Lawrence (Divisions 4R and 4S), while in winter and early spring the cod are distributed around the southwest corner of Newfoundland (Divisions 4R and $3P_N$). It is possible that at least two "sub-stocks" are presented; both wintering in the same area while separating in summer between western Newfoundland and the north shore of the Gulf.

The data presented here cover only a small part of the area of summer distribution for a very brief period of sampling in each year, being a by-product of more intensive investigations along the coast of Labrador. They are summarized to provide a preliminary description of the biology of the stock and as background for more widespread studies begun in 1966 (Wiles, MS, 1967a).

(b) The fishery

The inshore cod fishery is relatively small, being carried out by less than 500 men fishing from small boats mainly from June to September. Cod are taken by trap, gillnet, jigger and longline, the trap probably being the single most productive gear, though no estimates of annual catch by each gear are available.

Annual catches exhibited large fluctuations since 1957 (Fig. 2) with an overall downward trend. Numbers of cod fishermen increased to 1964 but decreased slightly in 1965 and 1966. Catch per man was variable, but declined from an average 17 tons during 1957-60 to less than 10 tons during 1964-66 (Fig. 2). Trends in catch per man are comparable to those described for Labrador by May (1967b).

Over the past 10 years variations in annual catch have closely followed the annual variations in catch per man. These year to year variations are probably due to a combination of varying year-class survival and varying availability to the inshore gears. Downward trends in catch and catch per man may be due to competition from the offshore otter trawl fishery.

2. Collections

Details of collections are listed in Table 1, and location of areas sampled in Figure 1. Virtually all the material was taken from the summer trap fishery during a one or two day visit each year. Several communities were sampled in 1962 and 1963, but the material from each was so similar that one community only was visited from 1964 onwards. Two samples of small cod were obtained by hook and line from the shore in years when these were abundant. A single sample was obtained from the centre of the Strait (Centre Bank) in October, 1962 by the research vessel Investigator II, using an otter trawl with small-mesh codend.

Random samples of the commercial catches were taken for length measurements (fork length to the nearest cm). From 1962-64 random sub-samples of the measured fish were taken for otolith collections, determination of sex and maturity, and measurements of opercular girth and whole and gutted-gilled weights. Otolith collections were also made from "category" samples of the smallest and largest size categories of the measured fish (generally fish less than 35 cm and greater than 60 cm in length). During 1965 and 1966 "stratified" sub-samples of the measured fish were taken at the rate of 20-25 per 3-cm length group. These were examined for sex and maturity and otoliths collected.

3. Age Validation

(a) Otolith edge

Otoliths were used for age determination and appearance of the otolith edge (i.e. whether opaque or hyaline) was recorded for all fish aged. The data were analysed for each age group using random samples from 1962-64 and stratified samples adjusted to the random length distributions for 1965 and 1966.

Deposition of opaque material at the otolith edge was well advanced during the June-July period when most of the sampling was done (Table 2). As in Labrador, opaque material appears to be deposited first in the younger fish, but appears earlier in the year in the population as a whole than in the Labrador (Subarea 2) cod (May, 1967a). Thus for the period 1962-66, 71% of the present collections exhibited opaque material at the otolith edge in June-July, as opposed to 18% during the same months of 1958-64 in Subarea 2. This indicates that annual growth begins earlier each year in Division 4R.

By September-October all the fish had either opaque edges in the otoliths or had completed deposition of opaque material and begun to deposit the hyaline material of the next winter zone. Using the convention of January 1 as the fish's "birthday" the narrow hyaline zone at the edge is ignored for determining age. Should this zone not be recognized as the beginning of the next "winter" errors in age determination will occur. Cod from Subarea 2 also begin to form a hyaline zone in autumn (May, 1967a).

The data were not sufficiently distributed throughout the year to demonstrate conclusively the validity of the otolith method, but by analogy with the pattern in Subarea 2 (May, 1967a) and addition of the evidence immediately following the otolith method is considered reliable. It should be noted, however, that secondary or check zones do occur. Familiarity with the otolith pattern in the area provides the best means of recognizing these.

(b) Length distributions of small fish

In September, 1962 and July, 1964 small cod were sufficiently numerous near the shore at Red Bay (Fig. 1) to obtain samples with hook and line. Length distributions of these with assigned ages from otoliths are shown in Figure 3. In July of 1964 the smallest fish (9-15 cm) exhibited a single hyaline zone near the otolith edge, followed in most by a varying amount of opaque material. In September of 1962 41% of the sample (12-19 cm) exhibited a hyaline zone followed by a wide opaque zone, while the remainder had an additional very narrow hyaline zone at the otolith edge. The latter was considered to represent the beginning of the next "winter" (see above); thus both groups were regarded as age 1. In July of 1964 fish of length 17-23 cm were assigned an age of 2 from the otoliths; those greater than 23 cm in length an age of 3. From the progression of modes in the length distributions (Fig. 3), and the correspondence of age interpretations to these modes it is evident that otolith age interpretations are valid.

4. Age and Length Distributions

Length distributions of all fish measured (Table 1) were combined for each year (except the summer and autumn collections of 1962). Corresponding age distributions were adjusted to the number measured by use of age-length keys from combined random and category samples in 1962-64 and stratified samples in 1965-66.

Age and length distributions from the summer inshore commercial fishery and from a research vessel sample on Centre Bank in autumn of 1962 are compared in Figure 4. The distributions are very similar considering the small numbers involved and differences in gear selectivity. The research vessel sample is likely from the same population as that fished inshore in summer, the fish having moved deeper and farther from shore as the season progressed.

Age and length distributions from the inshore trap fishery (Fig. 5) are again similar from year to year, being made up largely of very young and small fish. In each year, except 1962, almost one-half the fish in the age distributions were age 4. In 1962 age 5 fish were dominant. This was an anomalous situation due to the relatively great survival of the 1957 year-class. In all years most of the fish were less than 50 cm in length. Virtually no fish older than age 10 or larger than 70 cm were taken. It is obvious that in this fishery, where catches are heavily dependent on the newly recruited age-groups, the relative success of the fishery will depend very greatly on fluctuations in year-class survival. Thus increased landings in 1962 and 1963 (Fig. 2) were at least partly due to better than average survival of the 1957 year-class.

5. Mortality

Estimates of total mortality were obtained from annual age distributions (Fig. 5). It is obvious from these that old fish were relatively less numerous in 1965-66 than in 1962-63. Catch curves for these two pairs of years (from combined percentage age distributions) are shown in Figure 6, along with the catch curve for the whole period of sampling. Values of total mortality (Z) were .46 for 1962-63, .68 for 1965-66 and .54 for the whole period. The increase in total mortality (which is also evident as a concavity between ages 5 and 11 on the combined curve) is likely due to increased fishing on the stock as a whole. However it must be pointed out that the values given here probably do not represent the true population values. Availability of cod to traps probably decreases with age since the older fish are distributed in depths beyond the range of the gear. Thus the catch curves contain a measure of availability as well as abundance. They remain of value in describing the direction and magnitude of changes in total mortality, though the absolute values of Z from the catch curves may not represent the population as a whole.

6. Growth

(a) Age-length

Average length at each age was determined on an annual basis from the adjusted age-length distributions. A plot of the combined data (weighted averages) for the 1962-66 period is shown in Figure 7. The von Bertalanffy growth curve shown in the figure gave a reasonable fit to the data, though the common "levelling-off" at the older ages followed by increased growth for the very oldest ages (May et al, 1965) was very much in evidence (Fig. 7). Average lengths for ages 1 and 3 were artificially high because of hook selection in the former group and trap mesh selection in the latter.

(b) Growth variations and possible causes

Attained sizes at each age were quite variable from year to year. Plots of average sizes of the most abundant age-groups (Fig. 8) reveal a general decline in average sizes from 1962 to 1964, followed by an increase to 1966. Wiles (MS, 1967b) has suggested that increased growth of the oldest age groups in the Newfoundland part of Division 4R is due to the reduction of old fish by otter trawlers since the mid-1950's. However, there is little possibility that variation in abundance is the causative factor for the changes described here.

Lacking synoptic hydrographic data in the area, air temperatures at selected meteorological stations were examined for trends from year to year. The population sampled is known to range at least from the north shore of the Strait of Belle Isle to southwestern Newfoundland. Meteorological stations at the northern, middle and southern parts of the range are located at Belle Isle, Daniels Harbour (Newfoundland west coast) and Port aux Basques (southwest coast) respectively.

Mean daily temperatures on a monthly basis were available from publications of the Meteorological Branch, Canada Department of Transport. These were the mid-points of average daily minimum and maximum temperatures for the month. Mean daily temperatures for each year were estimated by averaging the monthly values. Trends in the annual means corresponded roughly with the trends in average lengths.

Since cod in this area are known to be distributed at the southern extremity of their range in winter, and over the middle and northern parts of the range in summer, the air temperature data were reworked to give averages for those months in which cod might be expected to be under the influence of local conditions in each area. Mean daily temperatures for winter (December-April) at Port aux Basques, and summer (May-November) at Daniels Harbour and Belle Isle, exhibited trends very similar to those in average size over the 1962-66 period (Fig. 8).

Templeman (MS, 1967) has shown that mean annual sea temperatures exhibit variations parallel to those in the air, though of lesser amplitude. Thus air temperatures provide reliable indices of the direction, if not the magnitude, of temperature variations in the sea. The present comparison leaves much to be desired; in particular it should be noted that the mean summer temperatures in each year cover the period May to November, while the fish were collected in late June to late July. Also the data series is too short to rule out a coincidental pattern. Nevertheless the comparison does provide the working hypothesis that growth variations in this area, and for the range of ages considered, are largely environmentally induced.

(c) Length-weight and girth-length

Weights of whole cod, and with viscera and gills removed, were obtained for all fish sampled during 1962-64. All weights were made in the field and recorded to the nearest ounce (1 oz = 28 g). Weight-length curves of the form $W = kl^n$ were fitted to the data (about 1000 observations) and are shown in Figure 9. Plotted averages of both whole and gutted-gilled weights adhered closely to a logarithmic straight line though there was some tendency for the largest sizes to depart from the regression. Points above 60 cm were better fitted by regressions employing greater exponents. Thus values of $\underline{n}$ for fish greater than 60 cm in length were 3.43 for the whole weight curve (3.01 for all sizes) and 3.37 for the gutted-gilled weight curve (2.91 for all sizes). A similar phenomenon was described by May (MS, 1966).

Measurements of girth at the posterior edge of the operculum were obtained from 874 fish during the 1962-64 period. These measurements were originally made in mm using a flexible tape, and later combined into 1-cm groups. Preliminary analysis revealed no sex differences. Combined averages for the period are plotted in Figure 10. A weighted straight line fitted to the data gave the regression

$$G = 0.56L - 0.87$$

where G = opercular girth in cm and L = fork length to the nearest cm.

7. Maturity and Spawning

Observations on stage of maturity were made by gross examination in the field of gonads of all fish sampled. For present purposes various stages were combined as immature, pre-spawning, spawning and spent-recovering. Spawning was completed by virtually all fish during the period of sampling. In June-July 97% of the mature fish were spent-recovering, 2% spawning, and 1% pre-spawning. All mature fish had completed spawning by October 1.

The proportion of mature fish at each 3-cm length group and each age were determined for the June-July collections (Fig. 11). Males were first mature at 34 cm and age 4; females at 43 cm and age 5. All males were mature at 64 cm and age 8; all females at 64 cm and age 10. Sizes and ages at 25%, 50% and 75% maturity were estimated from straight lines fitted by eye to plots of the data on probability paper, and are tabulated below.

	Size at Maturity (cm)		
	25% mature	50% mature	75% mature
Male	42.9	45.7	48.4
Female	47.5	49.7	51.9
Combined	44.7	47.7	50.7

	Age at Maturity		
	25% mature	50% mature	75% mature
Male	4.7	5.3	5.9
Female	5.4	6.1	6.9
Combined	4.8	5.7	6.7

8. Summary

Data on cod from the north shore of the Strait of Belle Isle, collected from the trap fishery during 1962-66, are summarized. The cod belong to the West Newfoundland stock and are distributed in the northern and eastern Gulf of St. Lawrence in summer; around southwestern Newfoundland in winter. The trap fishery along the north shore of the Strait is a relatively minor one, and annual catches and catch per man, though variable, have declined over the past 10 years.

Size and age distributions show the fishery to be heavily dependent on newly recruited year-classes, with few fish older than age 10 present in the samples. Total mortality increased over the 1962-66 period. Growth was variable from year to year, apparently in response to varying hydrographic conditions. Length-weight and girth-length relationships are described. Spawning was virtually complete by June. Males matured at a smaller size and younger age than females.

9. References

May, A. W. MS, 1966. Length-weight relation in Labrador cod. Int. Comm. Northw. Atlant. Fish., Res. Doc. 66-25, 4 p.

1967a. Otolith age validation in Labrador cod. Int. Comm. Northw. Atlant. Fish., Res. Bull., No. 4 (in press).

1967b. Effect of offshore fishing on the Labrador inshore cod fishery. Int. Comm. Northw. Atlant. Fish., Res. Bull., No. 4 (in press).

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. Northw. Atlant. Fish., No. 6, p. 545-556.

Templeman, W. 1962. Divisions of cod stocks in the northwest Atlantic. Int. Comm. Northw. Atlant. Fish., Redbook, 1962, Part III, p. 79-123.

MS, 1967. Anomalies of sea temperature at Station 27 off Cape Spear and of air temperature at Torbay-St. John's. Annu. Meet. int. Comm. Northw. Atlantic Fish., Res. Doc. 67-26, 6 p.

Wiles, M. MS, 1967a. Trends in the cod fishery in the northeastern Gulf of St. Lawrence during 1953-65 (ICNAF Divisions 4R and 4S). Annu. Meet. int. Comm. Northw. Atlant. Fish., Res. Doc. 67/79

MS, 1967b. Changes in the growth rate of cod from the northeastern Gulf of St. Lawrence during 1947-66. Annu. Meet. int. Comm. Northw. Atlant. Fish., Res. Doc. 67/80.

Table 1. Collections for length and age.

Year	Locality	Date	Depth (metres)	Gear	Otolith collections: Random	Category	Stratified	Total	Length meas.
.962	L'Anse au Loup	July 14	13	Trap	101	34	-	[illegible]	[illegible]
	Red Bay	July 16	13-15	Trap	100	25	-	125	500
	Henley Harbour	July 17	11-17	Trap	99	33	-	132	500
	* Red Bay	Sept. 29	2	Hook	61	-	-	61	61
	Centre Bank	Oct. 1	51	O.T.	122	32	-	154	172
963	Red Bay	July 16	17	Trap	120	46	-	166	479
	L'Anse Amour	July 19	7	Trap	164	-	-	164	164
	Henley Harbour	July 22	15	Trap	125	30	-	155	500
964	Red Bay	July 21-22	18	Trap	130	-	-	130	130
	* Red Bay	July 22	7	Hook	25	-	-	25	25
'65	Red Bay	June 24-26	11-18	Trap	-	-	198	198	495
'66	Red Bay	June 28-29	17-18	Trap	-	-	211	211	603
		Totals			1,047	200	409	1,656	4,129

* Special Collections of Small Cod

Table 2. Proportions of fish exhibiting opaque material at the otolith edge in June-July, 1962-66, and either an opaque (O) or narrow hyaline (NH) zone on Sept. 29-Oct. 1, 1962. Values based on less than 5 fish are not included.

Age	% O	% O	% NH
1	100	54	46
2	73	-	-
3	92	-	-
4	80	24	76
5	68	20	80
6	63	23	77
7	49	50	50
8	38	70	30
9	17	75	25
10	24		
11	7		
12	25		
13	13		
All ages	71	41	59

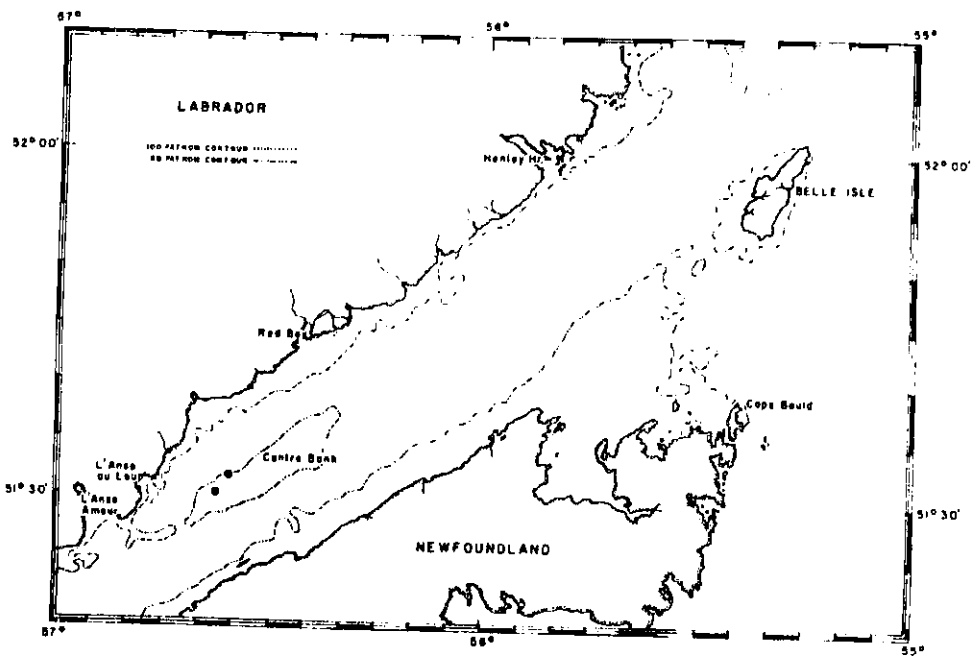

Fig. 1. Map of the Strait of Belle Isle showing areas where sampling was carried out.

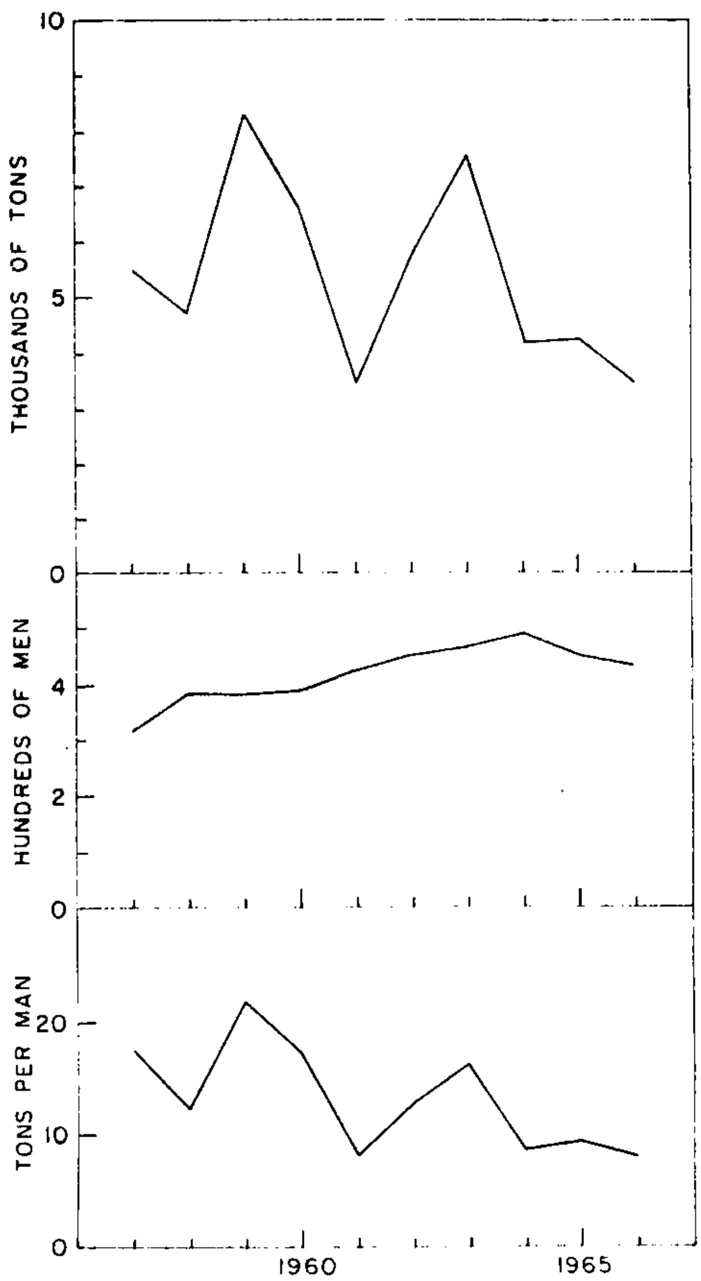

Fig. 2. Catch, effort and C/E in the inshore fishery on the north shore of the Strait of Belle Isle.

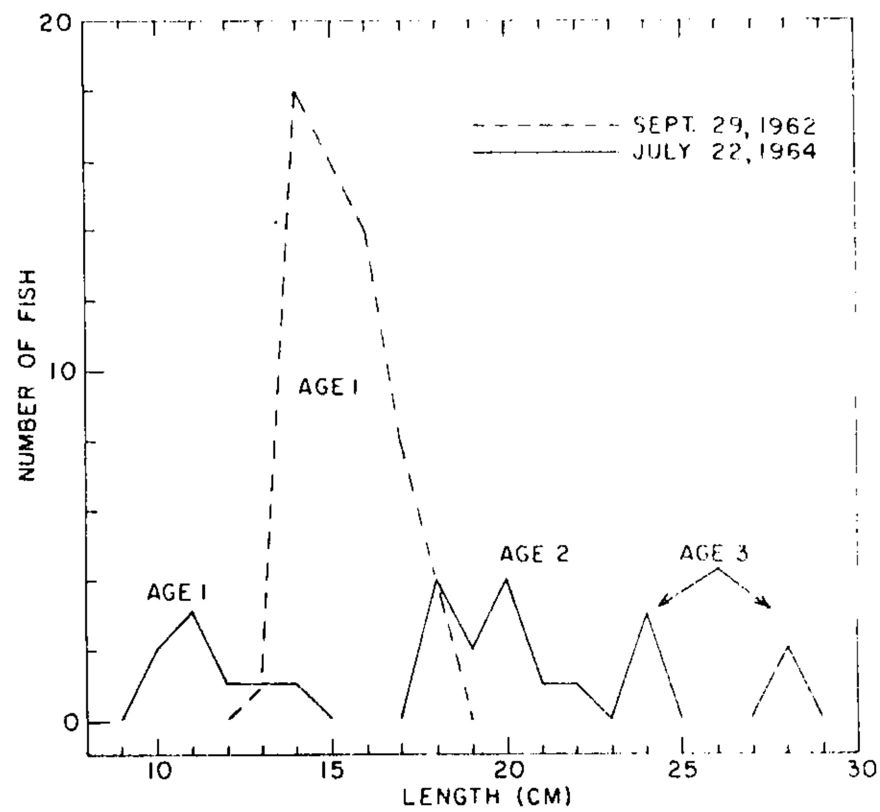

Fig. 3. Length distributions of small cod showing ages assigned from otoliths.

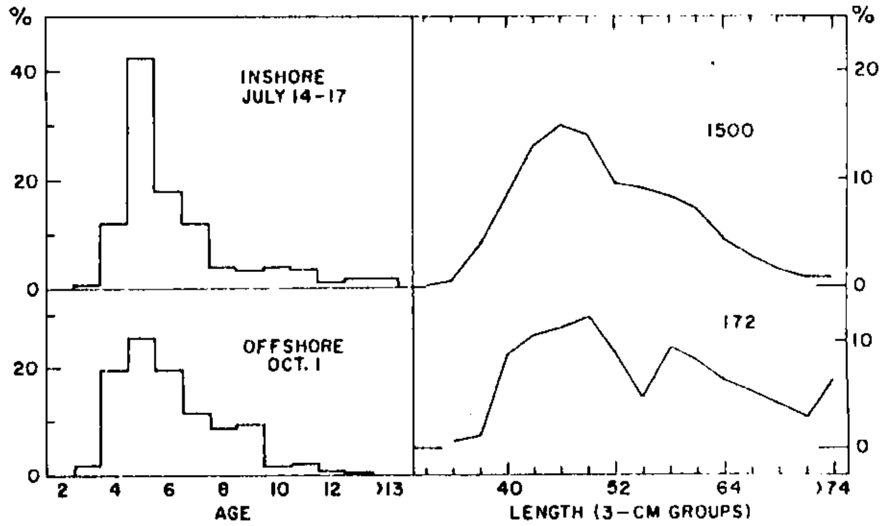

Fig. 4. Age and length distributions, 1962. Numbers refer to measured fish.

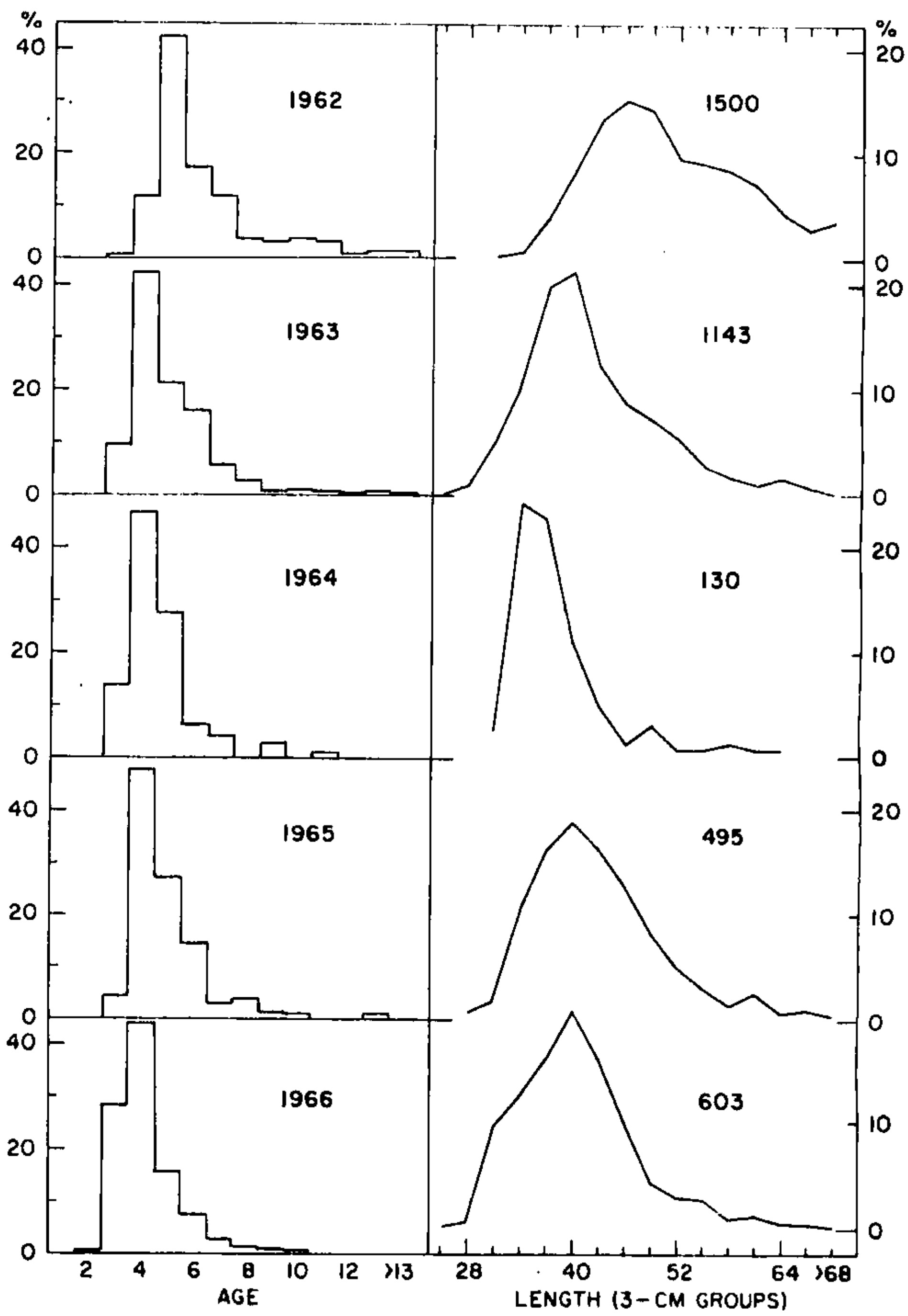

Fig. 5. Age and length distributions from the inshore trap fishery. Numbers refer to measured fish.

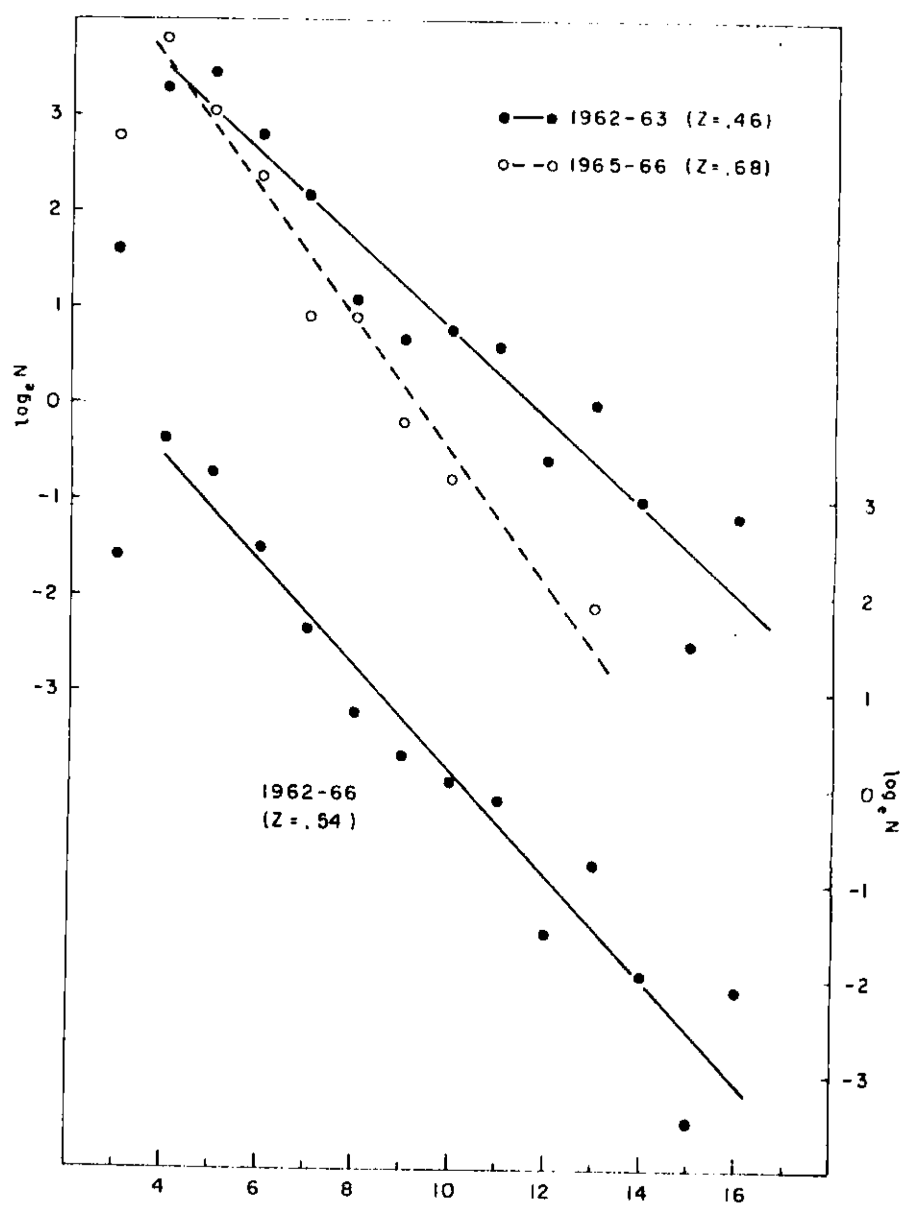

Fig. 6. Catch curves from the inshore trap fishery.

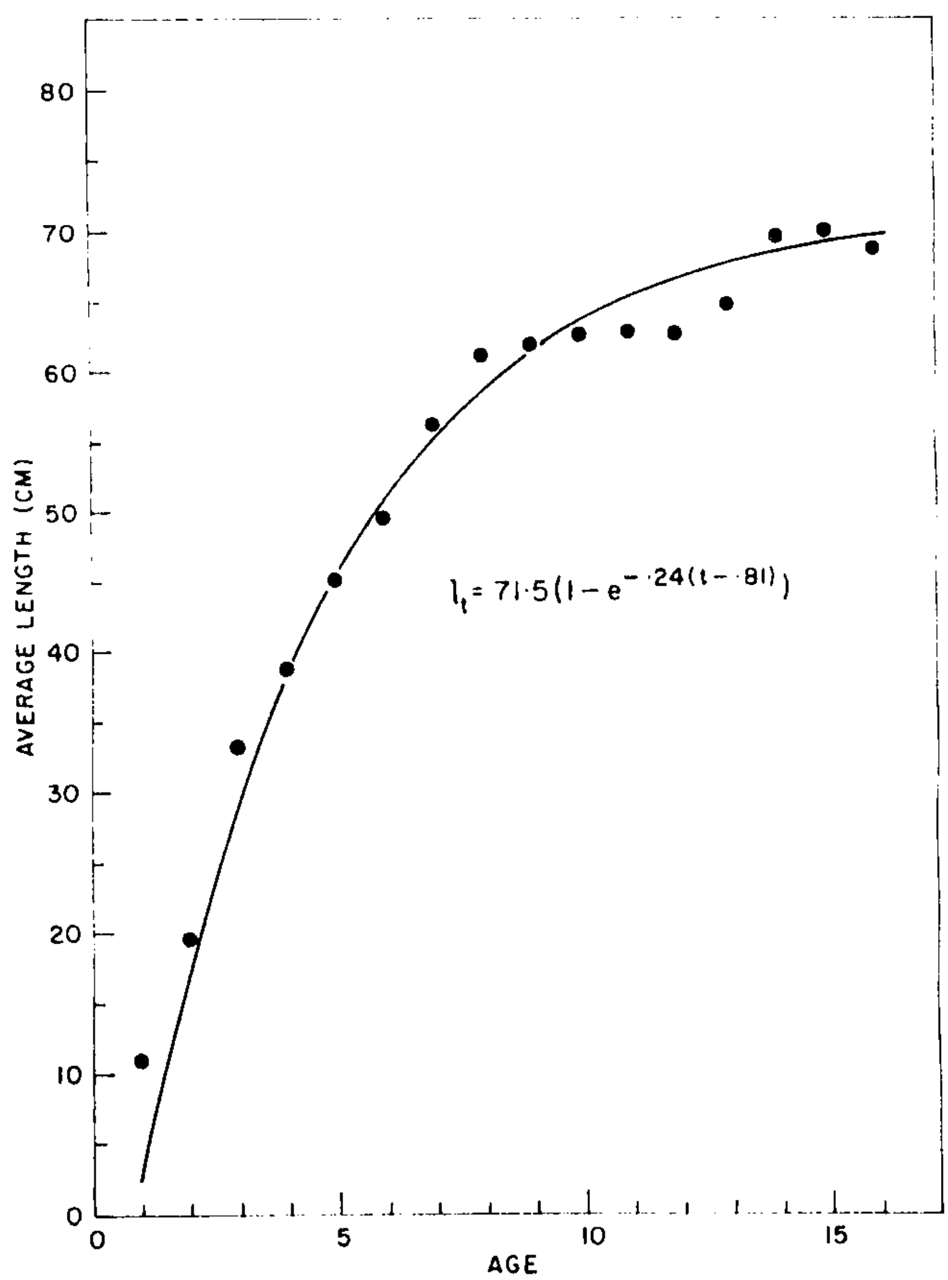

Fig. 7. Fitted growth curve for inshore data, June-July, 1962-66.

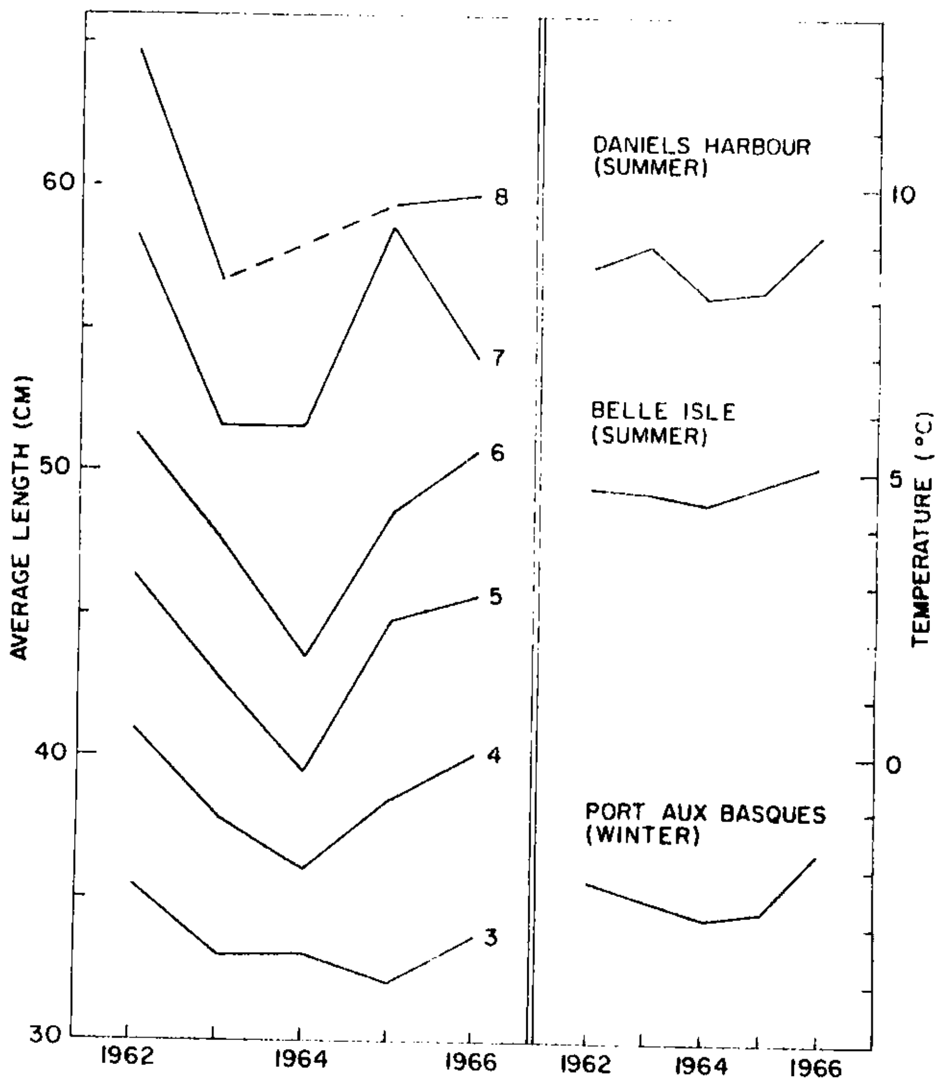

Fig. 8. Average lengths of cod of ages 3 to 8 from the period 1962-66, with mean daily air temperatures at selected stations over the same period.

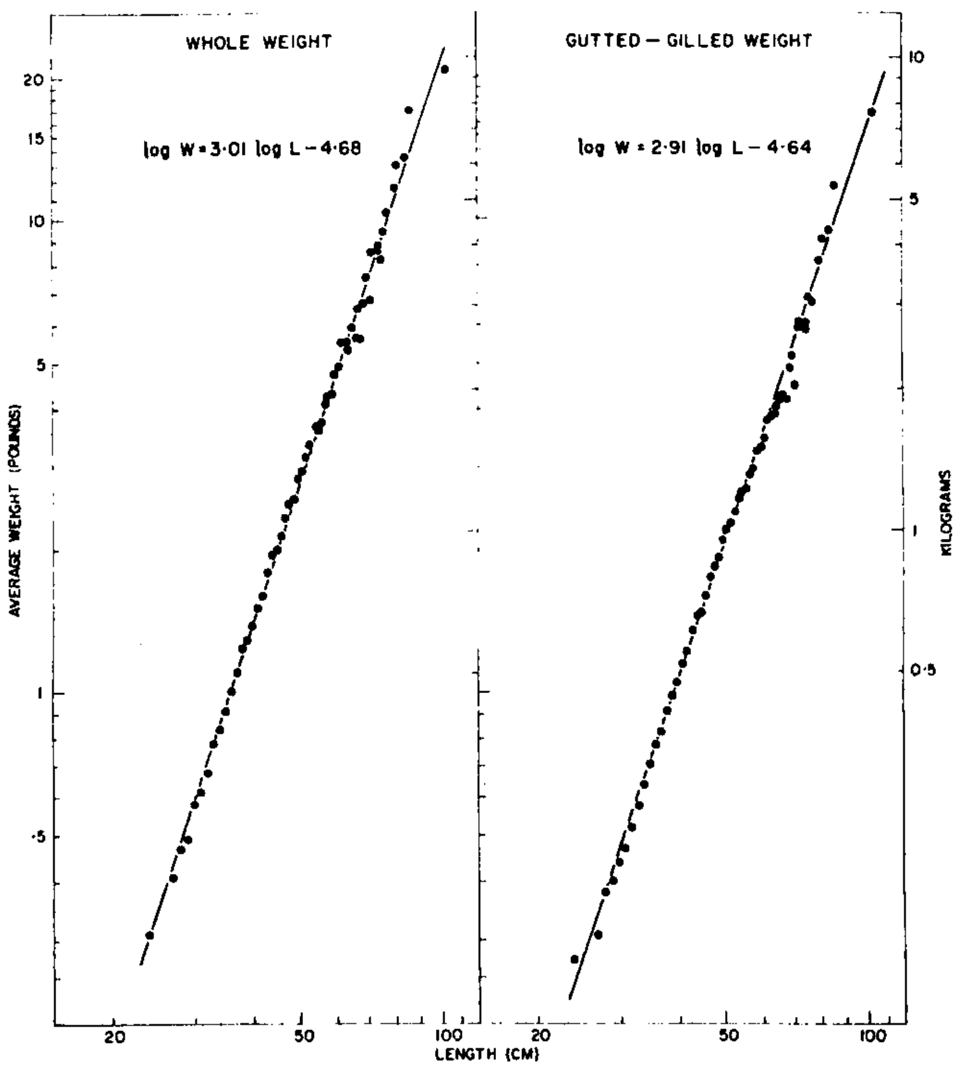

Fig. 9. Weight-length relationships for combined data, July, 1962-64.

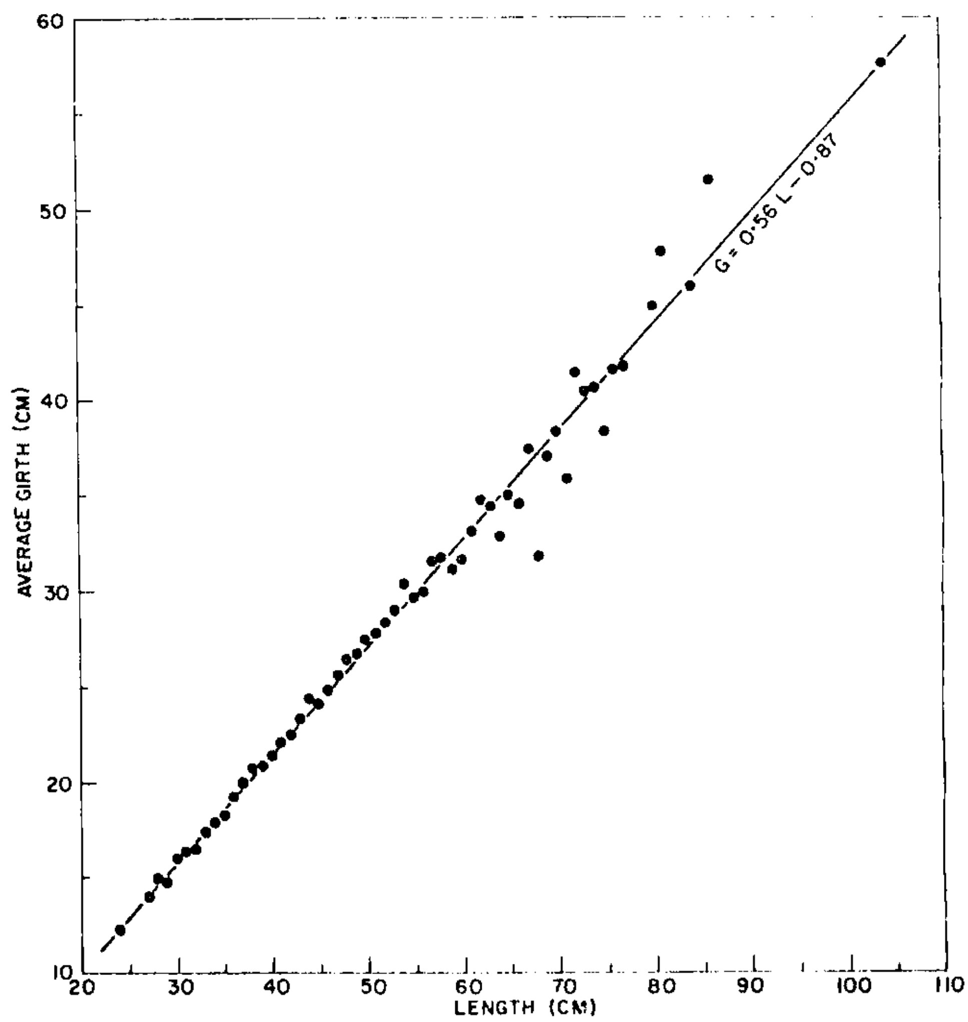

Fig. 10. Girth-length relationships for combined data, July, 1962-64.

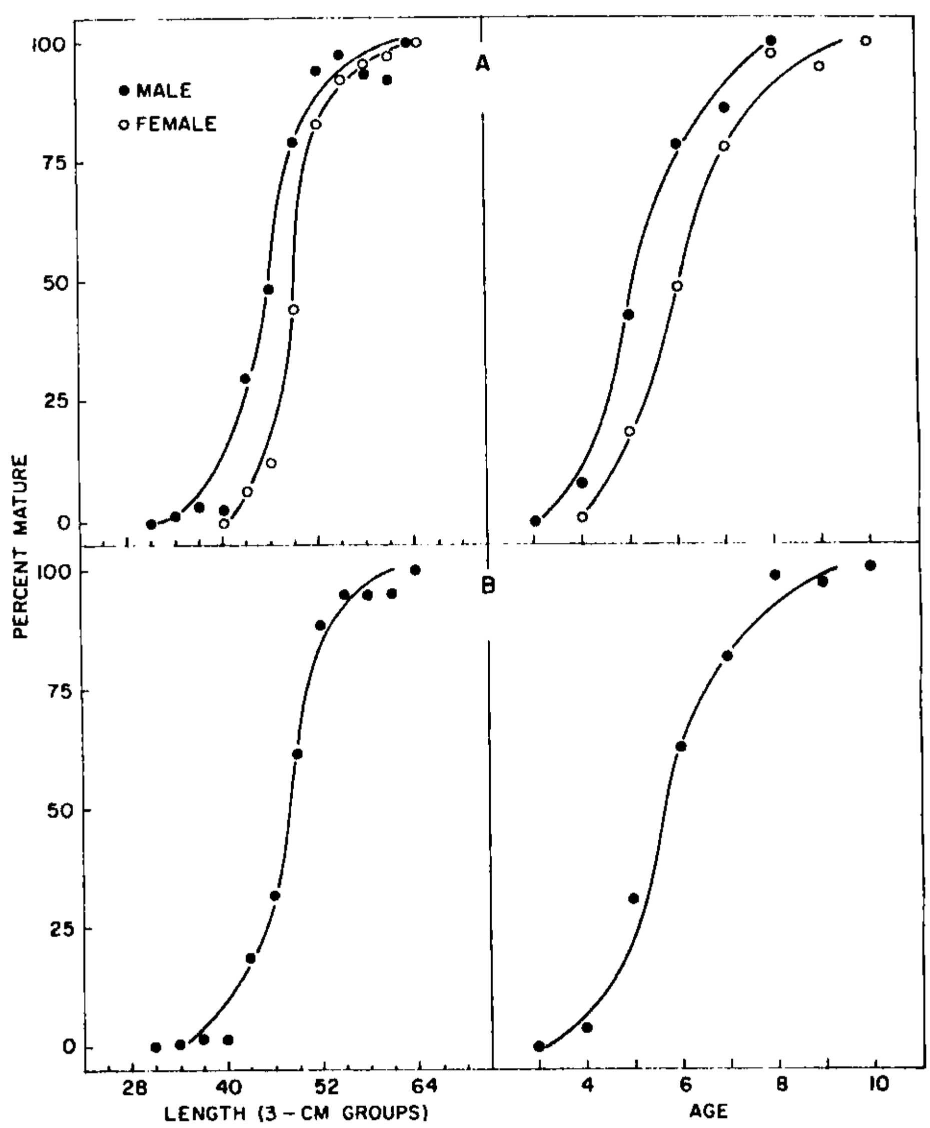

Fig. 11. Size and age at maturity, sexes separate (A) and combined (B).