INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

RESTRICTED

Serial No. 1876
(D.c.2)

ICNAF Res. Doc. 67/80

ANNUAL MEETING - JUNE 1967

Changes in the Growth Rate of Cod from the Northeastern Gulf of St. Lawrence (ICNAF Divisions 4R and 4S) during 1947-66.

by M. Wiles
FISHERIES RESEARCH BOARD OF CANADA
Biological Station, St. John's, Newfoundland.

Introduction

Variations in cod growth can arise from changes in hydrographic conditions (Hermann and Hansen, 1965) or changes in stock abundance. In the first case the variations are regulated by external (physical) factors and in the second case by biotic factors involving population stability. When considering the biology of a commercially exploited fish species it is therefore useful to know the trends in the fishery which the species supports, as well as temporal changes in the hydrography of the area in which the stock lives. Knowing these an assessment of any changes in growth rate can usually be made.

For the Northeastern Gulf of St. Lawrence, a detailed study of the commercial cod fishery was made by Wiles, (MS, 1967). Generally increasing otter trawl effort in Divisions 4R and 4S has apparently resulted in a reduction in the abundance of larger and older fish in trawler and inshore catches. In the present study growth is examined to determine whether this reduction was accompanied by increased growth rates in the cod stock complex of 4RS.

Materials and Methods

Table I gives details of the samples used in this study.

Offshore material comprised otolith collections of fish caught by research vessels using small mesh otter trawl during the period 1947-66. Before 1962 random samples of the catches were measured and random sub-samples of these taken for otoliths. A similar sampling procedure was used from 1953 to 1964 for inshore data, which consisted of otoliths collected from fish caught by line gears. Since 1962 offshore otolith samples were random up to a certain size above which all fish measured were sampled for otoliths ("category" sizes). For inshore collections in 1966, "stratified" sub-samples were taken from the random measurements. For random plus category and stratified sub-samples, age distributions were adjusted to numbers measured by means of age-length keys. Mean lengths at age so derived were used together with values from random samples alone in a further analysis of growth rates.

Age readings were determined from otoliths according to the method given in the summary by Keir (MS, 1960). Since data were taken at different times of the year, annual collections were not strictly comparable because of seasonal growth differences. In preparing figures, the convention of adding 1/4 to the otolith age for each quarter of the year beyond January - March was adopted. Thus a fish of t years collected in April - June was called t+1/4, one collected in July - September, t+1/2 and one from October - December, t+3/4. Growth was expressed as average fork length at age. Data were analyzed according to the von Bertalanffy (1938) growth curve equation, $l_t = l_\infty [1-e^{-k(t-t^o)}]$ where l_t is mean length at age t years, l_∞ is average "maximum" or asymptotic length, k is a constant determining rate of change in length increment and t^o is the theoretical age at which the fish would be of zero length. Growth curves were fitted using the "trial l_∞" method of Ricker (1958)

RESULTS

A detailed preliminary analysis of growth data for all samples showed that there were usually no differences in growth rate between fish from Divisions 4R and 4S. Since samples were mostly small and scattered in time, data for Divisions 4R and 4S were combined by years up to 1961 but kept separate after 1961. Offshore otter trawl and inshore line gear collections were treated separately because of differences in gear selectivity. For plots of mean length at age the data were treated as yearly samples. However, examination of the composite yearly collections showed that it was necessary to combine data from different years for purposes of growth rate calculations. For offshore material, data were combined in three five year periods; 1947-51, 1957-61 and 1962-66. Material from 4R and 4S were treated separately in the most recent period. Inshore material was less extensive than offshore and was combined as follows; 1953-55, 1963-64, June - July 1966 and September 1966.

Average sizes at age of otter trawl fish show no discernible trends from 1947 to 1961 (Fig. 1). During the period 1962-66 in Division 4R an upward trend was observed for ages 10-14. A more marked increase was evident in Division 4S but for ages 11-14 (Fig. 1). For the sake of clarity, the plots of mean length of fish older than 12 years have been omitted fromFig. 1 Plots of average sizes at age for inshore line gear samples indicate a decline in all ages between 1953-55 and 1963-64 followed by an upward tendency during 1964-66 which is evident for all ages but is particularly noticeable in ages 10 and above (Fig. 2).

Growth curves fitted to offshore data indicate that no consistent trends occurred in growth rate of all ages sampled during 1947-64. Consequently, offshore data for the whole period were combined as shown in Fig. 3. A single Bertalanffy curve does not fit these data adequately, two different curves being obtained for ages 2-7 and 2-15 as follows:

$$\text{Ages 2-7} \quad l_t = 73.1\ [1-e^{-0.37\ (t-1.8)}]$$

$$\text{Ages 2-15} \quad l_t = 118.7\ [1-e^{-0.09\ (t+0.5)}]$$

Thus average growth of ages 8 and above was relatively greater than that of younger fish during 1947-66.

Inshore growth curves for 1953-55 and 1963-64 are shown in Fig. 4. These indicate that in the latter period growth decreased slightly for ages 4-9 but increased for ages 10 and above. Also included in Fig. 4 are growth curves for June - July and September 1966 which signify a higher growth rate in 1966 of most ages sampled. Data for 1953-64 were therefore combined and compared with the 1966 material as shown in Fig. 5, which indicates that growth of all ages was greater in 1966 than it had been previously, the fitted curves being as follows:

$$1953\text{-}64 \quad l_t = 90.9\ [1-e^{-0.14(t+0.3)}].$$

$$1966 \quad l_t = 143.1\ [1-e^{-0.05(t+3.5)}].$$

The differences in the values of l_∞ and K above are considerable. However, it was found that small changes in the observed data, or differences in the ranges of ages used to determine the growth equations could result in large changes in the growth parameters. This was also noted by Jones (1962) and May et al (1965). Thus the observed differences between l_∞ and K for 1953-64 and 1966 may be artificially large and are of empirical value only.

Despite these qualifications it appears that increases in growth of fish aged 10 or 11 and above was initiated in Divisions 4R and 4S during 1961 or 1962 and became more noticeable in recent years. The change probably occurred first in that portion of the stock complex in Division 4S. Increased growth of ages 8 and above occurred sometime during 1963-66 followed (at least according to inshore samples) by increased growth by 1966 of all ages sampled (ages 4-18). The general increase in average lengths at age in 1966 was also particularly noticeable for ages 10 and above in offshore samples.

DISCUSSION

The data used in this study have certain limitations. Firstly, a long series of collections was not available there being years when data were lacking or so limited that they were of little use. Secondly, although a correction was applied to ages when combining material from different seasons, this may not completely compensate for seasonal growth differences. Thirdly, since small numbers of fish were sampled at the oldest ages, values of mean length derived for these may not be accurate. Interpretations of trends in mean length of the oldest fish are therefore provisional. Fourthly, since temperature may well have had a significant influence on growth, the lack of hydrographic data limits the extent to which the effects of fishing on growth rates may be assessed.

Temperature and the growth rate of cod have been shown to be related in certain areas of the Northwest Atlantic (May et al, 1965; Hermann and

Hansen, 1965), and this relation is probably an indirect one working through effects on distribution of prey, feeding and food assimilation (Kohler, 1964). Under relatively stable hydrographic conditions, growth rate changes may be at least partially due to reduced densities of fish on bottom caused by increased fishing (Kohler, 1964 ; Williamson, MS, 1965; May, MS, 1966). This reduces competition for prey and allows some fish to take in more food and grow more rapidly. Temperature variations in the Northeastern Gulf of St. Lawrence are not well documented, so the degree to which these are responsible for the growth rate changes observed in this study is unknown. In the absence of hydrographic data for the area, changes in fishing effort were examined to see whether increased fishing coincided with increased growth rate. Since 1960, increased otter trawler effort in Divisions 4R and 4S appears to have reduced the number of older and larger fish in offshore and inshore catches, particularly in Division 4S (Wiles, MS, 1967).

The fact that in the present study increases in growth rate first appeared for some ages during 1961-62, (which is only one or two years after the peak of trawler fishing in 4RS), suggests that the increase in average size at age may be related to increased fishing. The marked increase in growth rate in Division 4S supports this idea since, as mentioned above, it is consistent with the more distinctive effects on age and length frequencies of commercial catches observed in that division.

The changes are not as marked as those which have occurred in other parts of the Northwest Atlantic (see Beverton and Hodder, editors, 1962) possibly because an intense offshore fishery has not yet developed to the same extent as in these other areas. The most definite increase in growth ocurred in 1966, which may indicate that the full effect of increased fishing is only now beginning to be felt.

SUMMARY

Age determinations and resultant average length at age values in Divisions 4R and 4S for 1947-66 suggest that,commencing in 1961 Or 1962, increased growth occurred in cod aged 10 and 11 years, to be followed by increased growth at all ages in 1966. Hydrographic data were not available but it is thought to be significant that the earliest manifestation of

increased growth occurred soon after the peak trawler landings in Divisions 4R and 4S in 1960. More marked growth changes in Division 4S coincide with well defined reductions in larger and older fish as observed by Wiles (MS, 1967) for commercial landings in this division.

REFERENCES

VON BERTALANFFY, L. 1938. A quantitative theory of organic growth. Human Biology, 10 (2) : 181-213.

BEVERTON, R.J.H. & V.M. HODDER. eds. 1962. Report of working group of scientists on fishery assessment in relation to regulation problems. Supplement to Annu. Proc. int. Comm. Northw. Atlant. Fish., 11 : 1-81.

HERMAN, F. and P.M. HANSEN, 1965. Possible influence of water temperature on the growth of West Greenland cod. Spec. Publ. int. Comm. Northw. Atlant. Fish., No. 6 : 557-564.

KEIR, R.S. MS, 1960. Techniques for reading otoliths. Annu. Meet. int. Comm. Northw. Atlant. Fish., 1960. Document No. 4 (mimeographed).

KOHLER, A.C. 1964. Variations in the growth of Atlantic cod. J. Fish. Res. Bd. Canada, 21 (1) : 57-100.

MAY, A.W., A.T. PINHORN, R. WELLS and A.M. FLEMING. MS, 1965. Cod growth and temperature in the Newfoundland area. Spec. Publ. int. Comm. Northw. Atlant. Fish., Contribution No. 6 : 545-556.

MAY, A.W. MS, 1966. Biology and Fishery of Atlantic Cod (Gadus morhua morhua L.) from Labrador. McGill University, Ph.D. thesis, 225 pp.

RICKER, W.E. 1958. Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Bd. Canada, No. 119 : 300 pp.

WILES, M. MS, 1967. Trends in the cod fishery in the Northeastern Gulf of St. Lawrence during 1953-65 (ICNAF Divisions 4R and 4S). Int. Comm. Northw. Atlantic Fish., Res. Doc. 67/79

WILLIAMSON, G.R. MS, 1965. Age, growth, sexual maturity and mortality of cod on the Grand Bank of Newfoundland and St. Pierre Bank during 1946-62. London University, Ph.D thesis : 140 pp.

Year	Month	ICNAF Divisions	Gear	No. of Random	Otoliths Categories	Total
Random Samples						
1947	Nov.	4R	Otter trawl[a]	159	--	159
1948	Aug.	4S	Otter trawl[a]	48	--	48
1950	Oct-Dec.	4R	Otter trawl[a]	457	--	457
1953	July-Sept.	4R	Longline	473	--	473
1955	Sept-Oct.	4R	Longline	225	--	225
1957	Dec.	4R	Otter trawl[c]	58	--	58
1961	Nov.	4R	Otter trawl[c]	62	--	62
	Nov.	4S	Otter trawl[c]	141	--	141
1962	Jan.	4R	Otter trawl[c]	537	128	665
	Oct.	4S	Otter trawl[b]	122	--	122
	Sept-Oct.	4R	Otter trawl[c]	183	32	215
1963	Sept.	4S	Longline	372	--	372
1964	Sept.	4R	Longline	123	--	123
	Nov.	4R	"	121	--	121
	Oct.	4S	"	205	--	205
1965	Nov.	4R	Otter trawl[c]	519	13	532
	Nov.	4S	Otter trawl[c]	70	8	78
1966	Oct.	4R	Otter trawl[c]	306	21	327
	Oct.	4S	Otter trawl[c]	449	9	458
Stratified Samples						
1966	June-July	4R,4S	Linetrawl	--	--	418
	Sept.	4R	Linetrawl	--	--	225

Symbols
a; non-lined, no cover
b; non-lined
c; lined

Table 1. Otolith collections of cod caught by inshore line gears and offshore research vessels using small mesh otter trawl during 1947-66 in Divisions 4R and 4S.

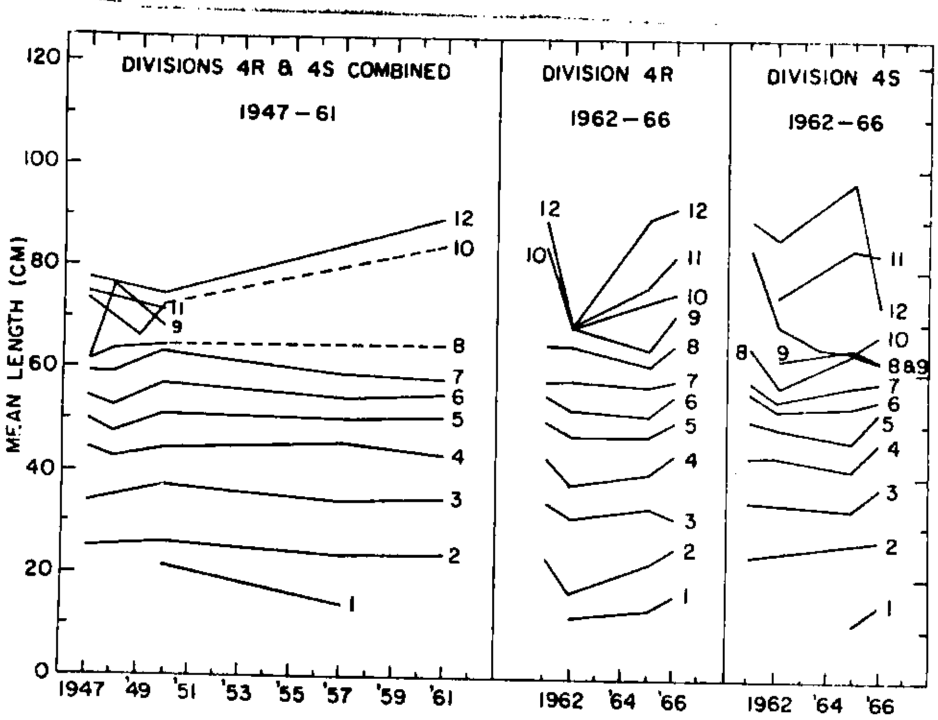

Fig. 1. Trends in mean length at age of offshore cod caught by small mesh otter trawl during 1947-66, Divisions 4R and 4S.

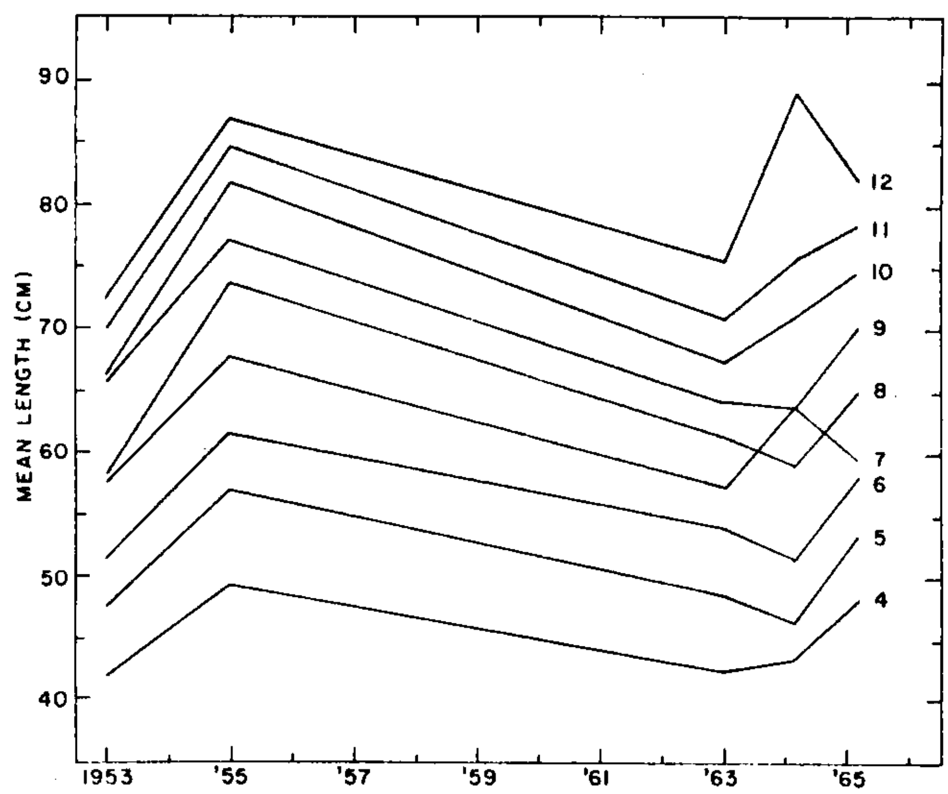

Fig. 2. Trends in mean length at age of inshore cod caught by line gears during 1953-65, Divisions 4R and 4S.

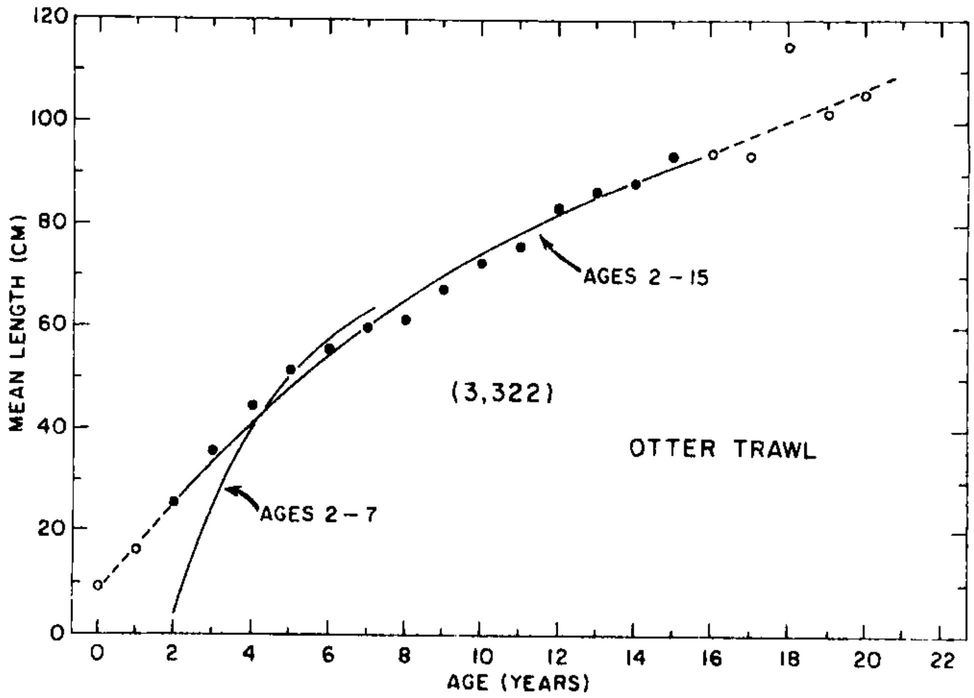

Fig. 3. Growth curves of offshore cod, Divisions 4R and 4S, 1947-66. Two curves are fitted to the data as calculated for ages 2-7 and 2-15 Shaded circles indicate ages used in growth calculations and open circles those not so used. Number of fish is in parentheses.

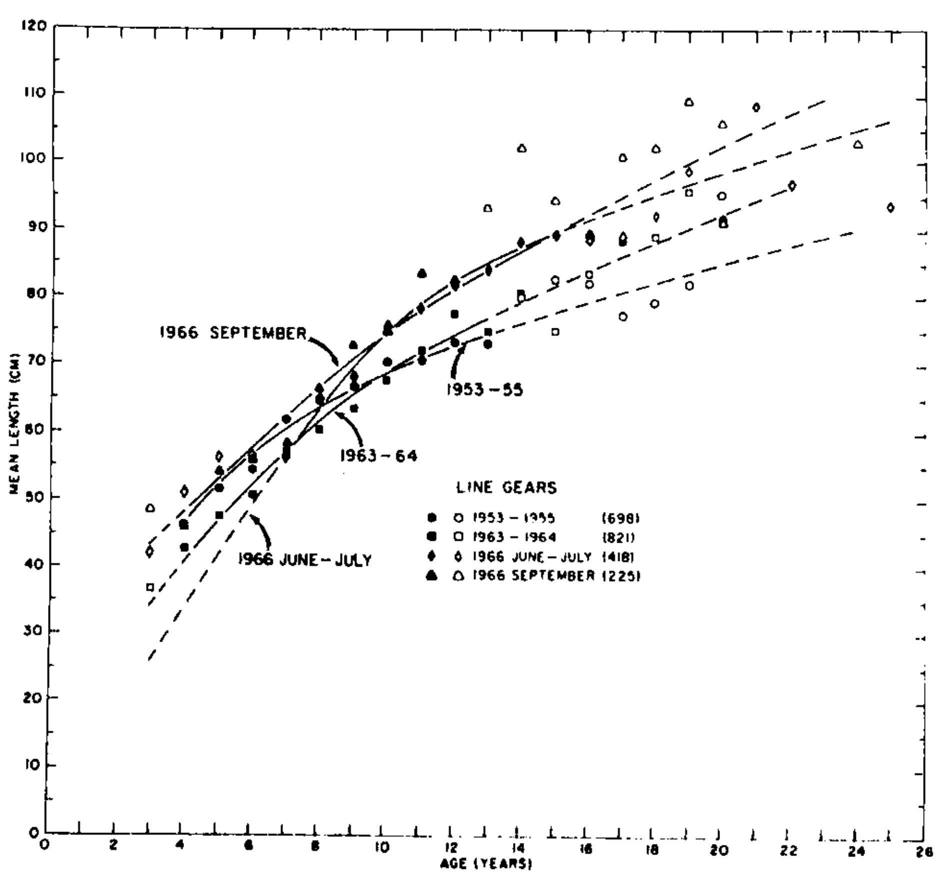

Fig. 4. Growth curves of inshore cod, Divisions 4R and 4S. Shaded symbols indicate ages used in growth calculations and open symbols those not so used. Numbers of fish are in parentheses.

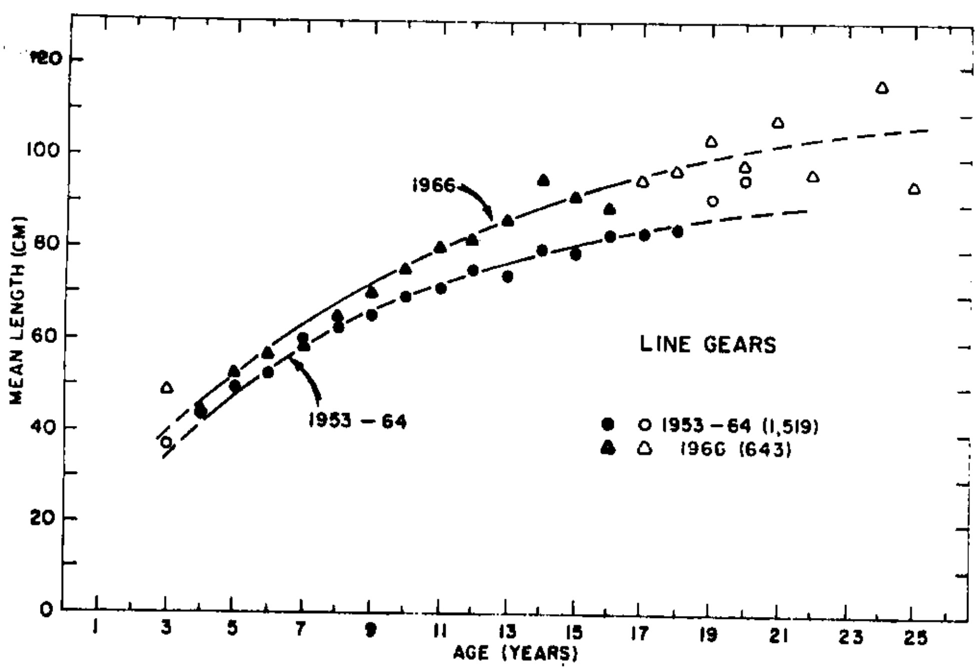

Fig. 5. Growth curves of inshore cod, Divisions 4R and 4S, 1953-64 and 1966. Shaded symbols indicate ages used in growth calculations and open symbols those not so used. Numbers of fish are in parentheses.