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Spatial and Temporal Variations in Greenland Halibut Females Ratio At Age in NAFO Divisions 0B, 2GH, 3K and 3LM

by

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INTRODUCTION

Since 1960's Greenland halibut has been an object of directed fishery in the Northwest Atlantic. In spite of this species has a wide area extended from the Davis Strait to Georges Bank an intensive fishery took place, as a rule, in the same areas. With a decrease in catches taken in traditional fishing grounds the fishery shifted to large depths and to new areas. Since 90's the main portion of halibut catch has been taken in the NAFO Regulatory Area, mainly off the Flemish Pass (Bowering et al., 1994) at the depth to 1800m.

Fish adaptation to impact of fishery and to environmental conditions over a whole area can accept different forms. Along with other factors, difference between males and females by M and F, selectivity of different fishing gears withdrawing certain length-age groupings of fish, as well as season, can influence the estimate for stock biological structute. In this case, biological peculiarities of Greenland halibut, such as variation in length composition of fish in aggregations by depth, sex separation on spawning grounds, etc.,should be considered.

Aim of the paper is to estimate differences in sex ratio of Greenland halibut (according to relative number of females) during the period 1984-1992 in Divs.0B, 2GH, 3K and from 1993 to 1996 - in Divs. 3LM.

MATERIALS AND METHODS

Data from directed trawl surveys on the Greenland halibut stock in Divs. 0B, 2GH, 3K for 1984-1992 were taken for the basis of analysis. The surveys were annually conducted during autumn-winter at the depth to 1500m, except Div.3K where in 1984-1985 and in 1987 the data were collected during groundfish surveys in spring-summer. Besides, data from trawl surveys on groundfish in Divs.3LM (Flemish Pass) to 730m depth for 1993-1994 were analysed, as well as those from halibut surveys conducted to 1100m depth in May 1995 and to 1460m - in February 1996. Total length of fish was measured. Fish were aged by scale and in 1996 - by otoliths. 15 specimens from each sex were aged from each 2cm length group. Age composition of catches measured and mean length of males and females at age were determined by length-age keys collected annually for each Subarea. A portion of females was determined by their amount divided into total number of fish in catch. Values for females ratio at age were made smoother through the use of a three point moving average.

RESULTS

By results from the surveys on Greenland halibut during 1984-1992 the total proportion of females increased from the northern Subareas to the southern ones (Table 1). Reduction in proportion of females in Divs. 0B, 2GH was pronounced from 1985 to 1988, during subsequent years this index remained to be higher or at the long-term mean level. Successive reduction in females proportion was observed in Div.3K from 1984 to 1992.

During surveys on the Greenland halibut stock in Divs.0B, 2GH in autumn-winter, males were predominant in catches. Proportion of females in Div.0B varied from 0.29 to 0.37 and from 0.37 to 0.50 in Divs. 2GH.

Prior to 1990, females were preponderant in catches taken in Div.3K and their proportion successively decreased from 0.70 in 1984 to 0.48 in 1992.

In Flemish Pass males were predominant during spring-summer period (1993-1994 surveys); females predominated at large depth during winter-spring (1995-1996).

Proportion of females in catches gradually increased with age (Table 1). This increase was observed in proportion of males to age 8 in Div.0B. Relative amount of females sharply increased above age 9, in 1992 - above age 7. Greenland halibut catches consisted only of females at age 14-15, in 1992 - at age 12.

In Divs.2GH, increase in proportion of females above age 8-9 takes place and in 1992 - above age 7 catches consisted only of females at age 13-14, in 1992 - at age 11.

In Div.3K, a notable increase in females proportion took place, as a rule, above age 6-8. 100% of females at age 11-12 (1984, 1988, 1990) and at age 14 (1986, 1992) were in catches.

In Divs.3LM, decrease in proportion of males in catches by the data from summer surveys conducted at depth to 730m began at earlier age - above age 4; catches of Greenland halibut at age 11 and above consisted only of females. At larger depths, by the data from winter-spring surveys, the amount of males started to reduce at age 9-10 and no males at age above 13 were registered in catches.

Variation in mean length of males and females at age is very similar to those at age to 9 in all areas when males in catches begin to disappear (Figs. 2-5). Growth rate during this interval is close to linear. Decrease in yearly increment of males mean length, compared to females, is observed at age 9-10. No males above 13 and females above 20 were found in our samples.

DISCUSSION

Male and female ratio genetically conditioned when borning as 1:1 can essentially vary to that or another side during individual development of fish, being one of the most important factors characterizing the stock structure, peculiarities of behaviour, migration, and in some cases, impact of fishery upon the stock status.

Sex separation in Greenland halibut is known to occur when forming prespawning and spawning aggregations. Males appear earlier on spawning grounds and leave them later than females (Nizovtsev, 1989; Zilanov et al., 1976). Predominance of males in catches was regular as far as Russian surveys on Greenland halibut was carried out in the northern Subareas during prespawning period.

With an increase in depth the halibut mean length grows, a proportion of females increases and the largest specimes are represented only by females (Gorchinsky, Vaskov, 1992; Gorchinsky, 1993; Junquera, Zamarro, 1992; Gorchinsky, 1996). Difference in depth, at which the survey was performed off Flemish Pass in 1993-1994 and in 1995-1996, is probably the main reason of the variations observed in total proportion of females and at age at which males disappeared from catches during those years (Table 1 and Fig.1).

Assumption of E.de Cardenas (1996) on exsisting relationship between geographical latitude and sex proportion seems to be reliable. As a rule, males are predominant in the northern areas whereas females are preponderant in the southern ones. By the data from Nizovtsev and Troyanovsky (1970) a proportion of females in catches from Iceland area varied from 0.44-0.48 on the northern and northwestern slopes to 0.79-0.81 - on the eastern

and northeastern slopes. In the area from the Rockall- Hatton seamounts to the Faroe-Icelandic Rapid western slope there were more males, approximately by 4 times, than females (Nizovtsev, 1989). Along the eastern coast of Canada a proportion of females increases from 38.9% off the Davis Strait to 51.5% on the Northern Newfoundlend Bank (Zilanov et al., 1976) and it constituted 51-58% in Flemish Pass (E.de Cardenas, 1996). By our data this index made up 34, 55 and 52%, respectively (56.5% - at large depths).

Trend of proportion of females at age for the same size fish was observed in spatial and temporal variations. Age, at which catches consist only of females, decreases from north to south from 13-15 in Div.0B to 11-14 in Divs.3K and 3LM (i.e. upgoing part of curves in Fig.1 shifts in general to the left). These data agree with the observations performed by Chumakov et al. (1978) that in Subareas 0+1 males at age 14 disappear from catches and with those by E.de Cardenas (1996) that proportion of females at age 12 grows to 100% off Flemish Pass. Increase of proportion of females in catches occurs as a rule at age 7-9, i.e. at age corresponding to mass maturation of males and their 100% recruitment to fishery (Serebryakov et al., 1992; E.de Cardenas, 1996).

No clear regularities of increase in proportion of females were found during the period investigated from 1984 to 1992 (Fig.1). However, proportion of females at age 7-9 had rather an upward trend in the northern areas and trend towards decrease in the southern.

Age, at which males begin to mature, as well as age M_{50} and M_{100}, increase from Subareas 0+1 in the north to Div.2J (Serebryakov et al., 1992). Increase of age M_{50} was observed from Div.3K to 3L by Morgan and Bowering (1995). Comparing these peculiarities with the mentioned above phenomenon of shifting to the left of proportion of females at age from north to south (Fig.1) one can suggest that the earlier the age at maturity of males commences the longer they remain in the stock.

Northern (0B, 2GH) and southern (3K, 3LM) Divs. differ between themselves by general sex ratio and pattern of variation in proportion of females at age. The reason for that was probably a shifting of mature males from south to northern spawning grounds taken place during the surveys. In this case, the spawning is probably non-intermitted and occurs during winter. One should recognize that a single population inhabits the areas mentioned (Templeman, 1973; Zilanov et al., 1976; Bowering, 1982).

It is also possible that separate population of Greenland halibut inhabits the southern divisions. Its main difference is that terms of spawning are prolonged during the year or have several peaks (Junquera, Zamarro, 1992). Both sex representatives inhabit these areas together without separating, they do not migrate far, with their ratio being around 1:1.

No essential difference in growth rate was observed between males and females when analyzing mean length at age (Figs.2-5). Reduction of proportion of males in trawl catches probably results from a sharp decline in their growth rate compared to females and in this connection, from a reduction of trawl efficiency regarding males. However, that was not observed in any area investigated. In this case, males and females would be fished off approximately in equal ratio by other fishing gears, such as long line and gill net. In fact, by the data from Chumakov and Soshin (1991) and K.Nedreaas et al. (1993) catches taken by long line and gill net consisted of large specimens compared to those from trawl catches, the proportion of males varied from 1/3 to 1/10.

At the same time, long impact of specific fishing gears upon the Greenland halibut stock can essentially influence sex ratio and its status. As far as a trawl fishery in the northern areas is based on prespawning aggregations consisting mainly of males and long-line and gill net fisheries - on females, long impact of any of these fishing gears may result in disturbance in sex natural balance.

On the other hand, in connection with that individual fecundity of Greenland halibut females is dependent on age, length and weight (Serebryakov et al., 1992), fishing of large females, contributing to the populational fecundity, can notably attenuate the stock reproductive capacity and finally result in its reduction.

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Table 1. Variation of the females ratio by years and areas (number of specimens analysed are in brackets).

Years	Divisions							
	0B		2GH		3K		3LM	
1984	0.29	(8550)	0.37	(9412)	0.70	(8044)		
1985	0.37	(13453)	0.50	(4126)	0.66	(3960)		
1986	0.31	(13323)	0.44	(3068)	0.54	(15141)		
1987	0.29	(5224)	0.44	(6109)	0.55	(7341)		
1988	0.30	(6788)	0.40	(4651)	0.53	(9407)		
1989	0.39	(5269)	0.41	(7505)	0.53	(5455)		
1990	0.36	(4215)	0.47	(2520)	0.50	(7104)		
1991	0.37	(2763)	0.45	(9368)	0.49	(2535)		
1992	0.34	(2192)	0.43	(6060)	0.48	(951)		
1993							0.49	(2441)
1994							0.47	(3555)
1995							0.58	(2152)
1996							0.55	(10969)
average	0.34		0.43		0.55		0.52	

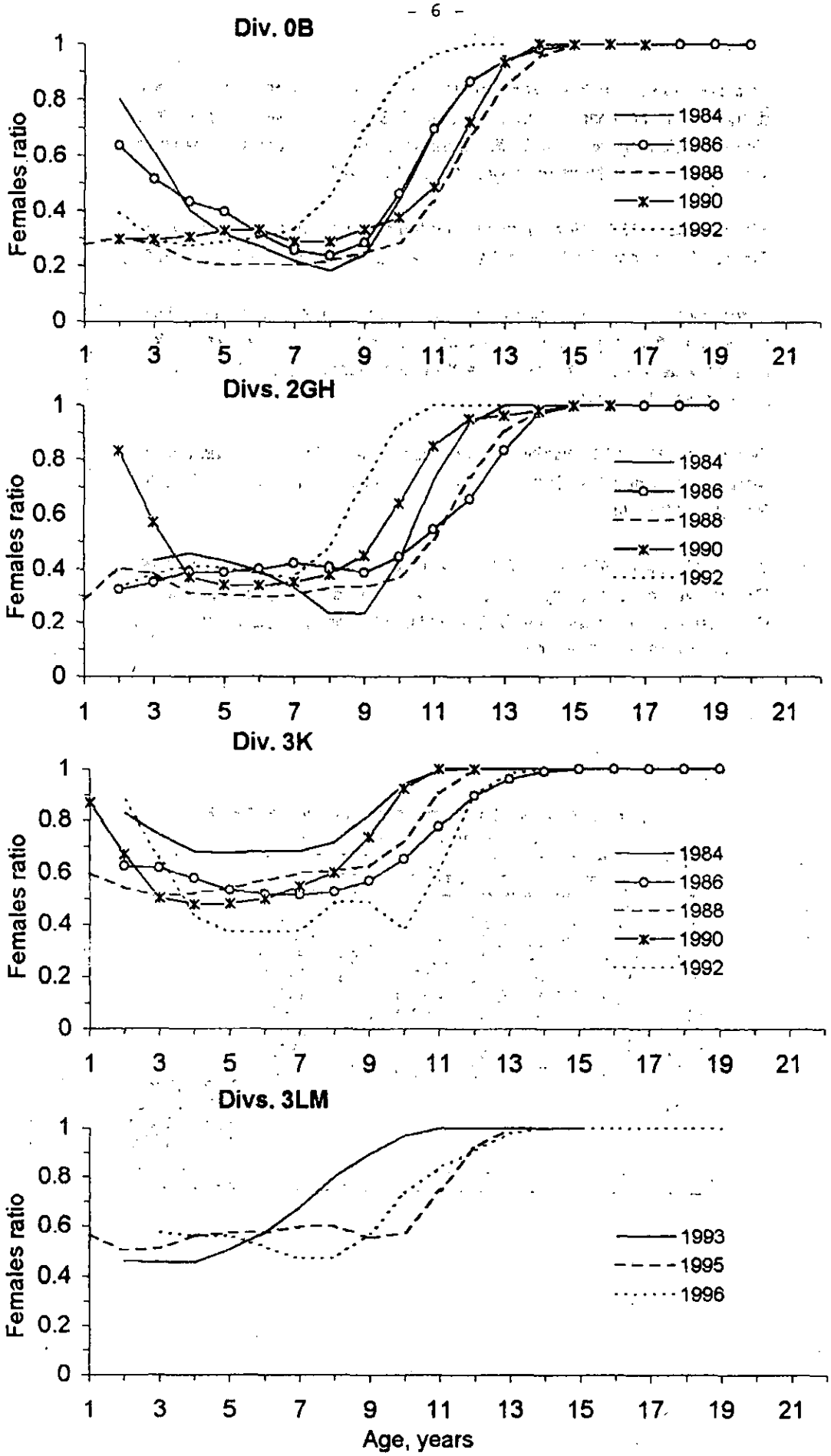

Fig. 1. Females ratio by age in 1984-1996

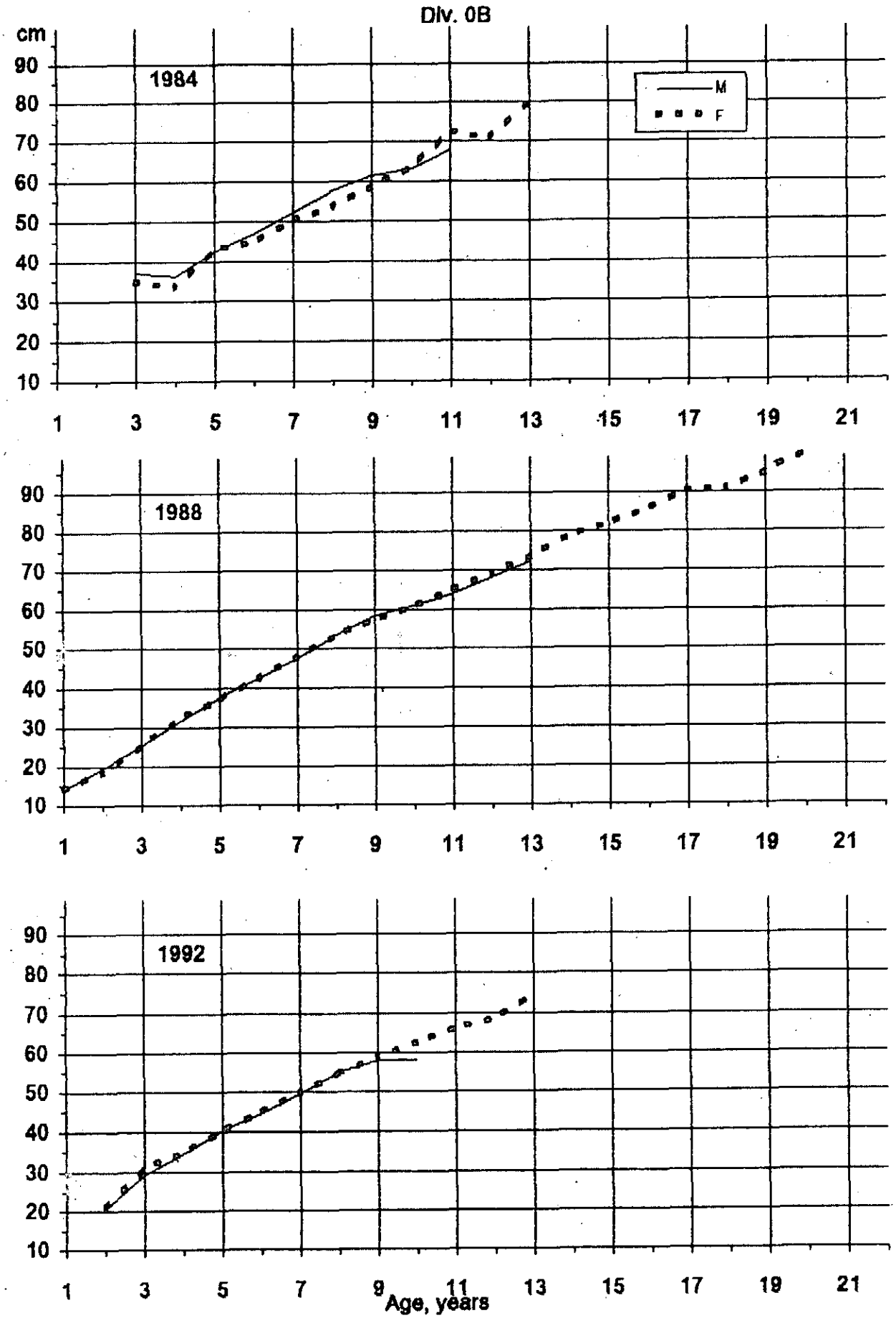

Fig. 2. Mean length at age in Div. 0B for 1984-1992.

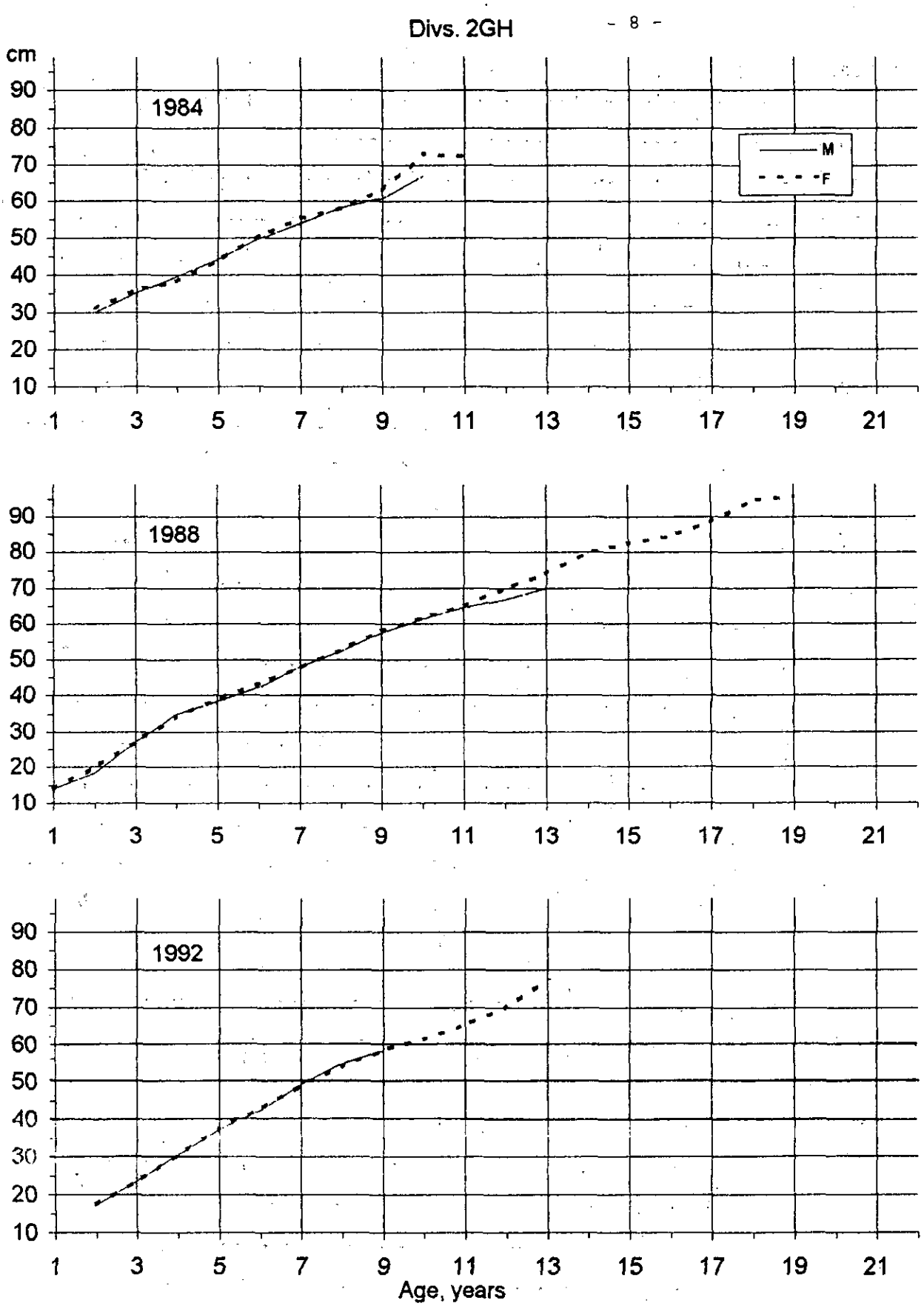

Fig. 3. Mean length at age in Divs. 2GH for 1984-1992.

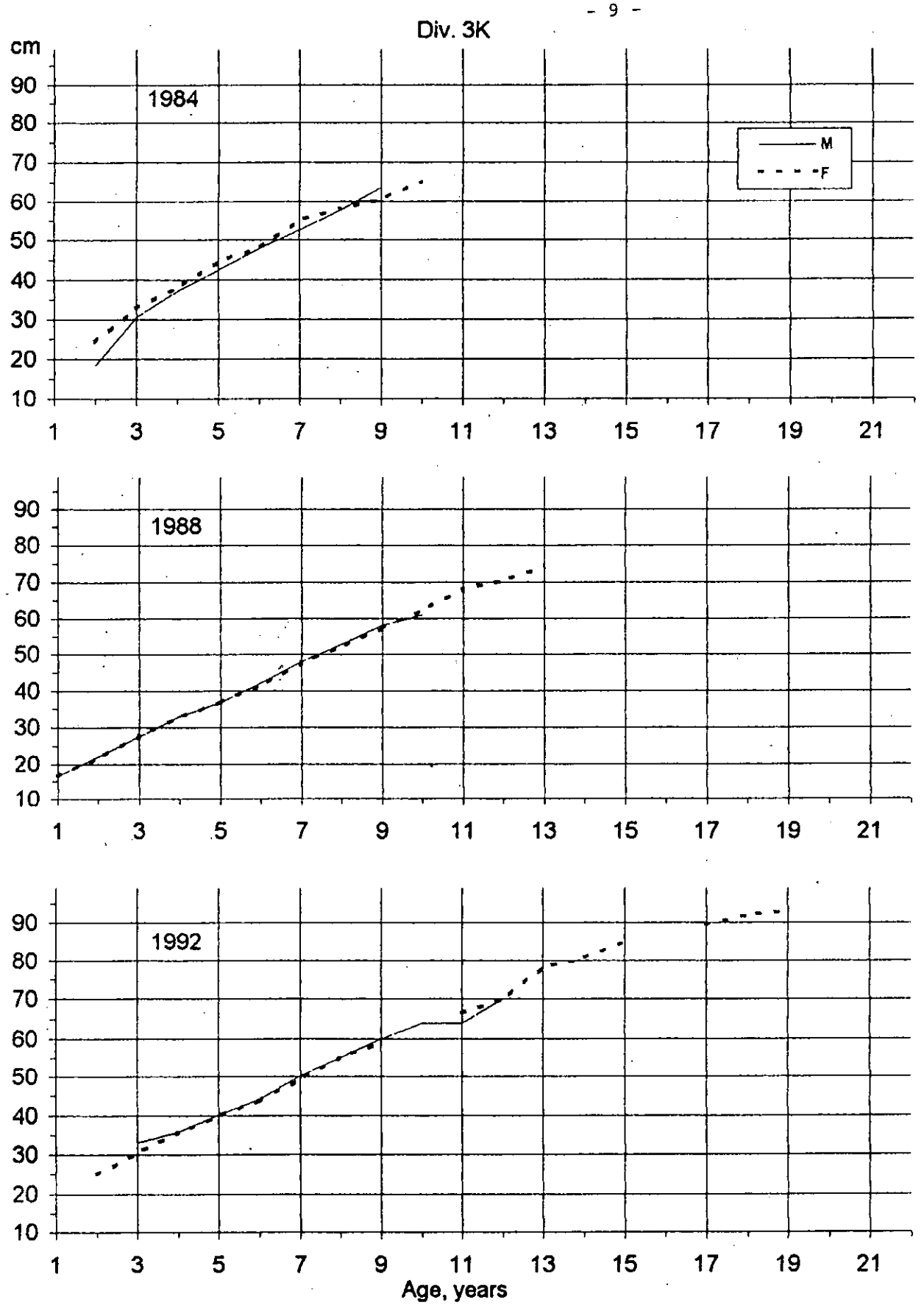

Fig. 4. Mean length at age in Div. 3K for 1984-1992.

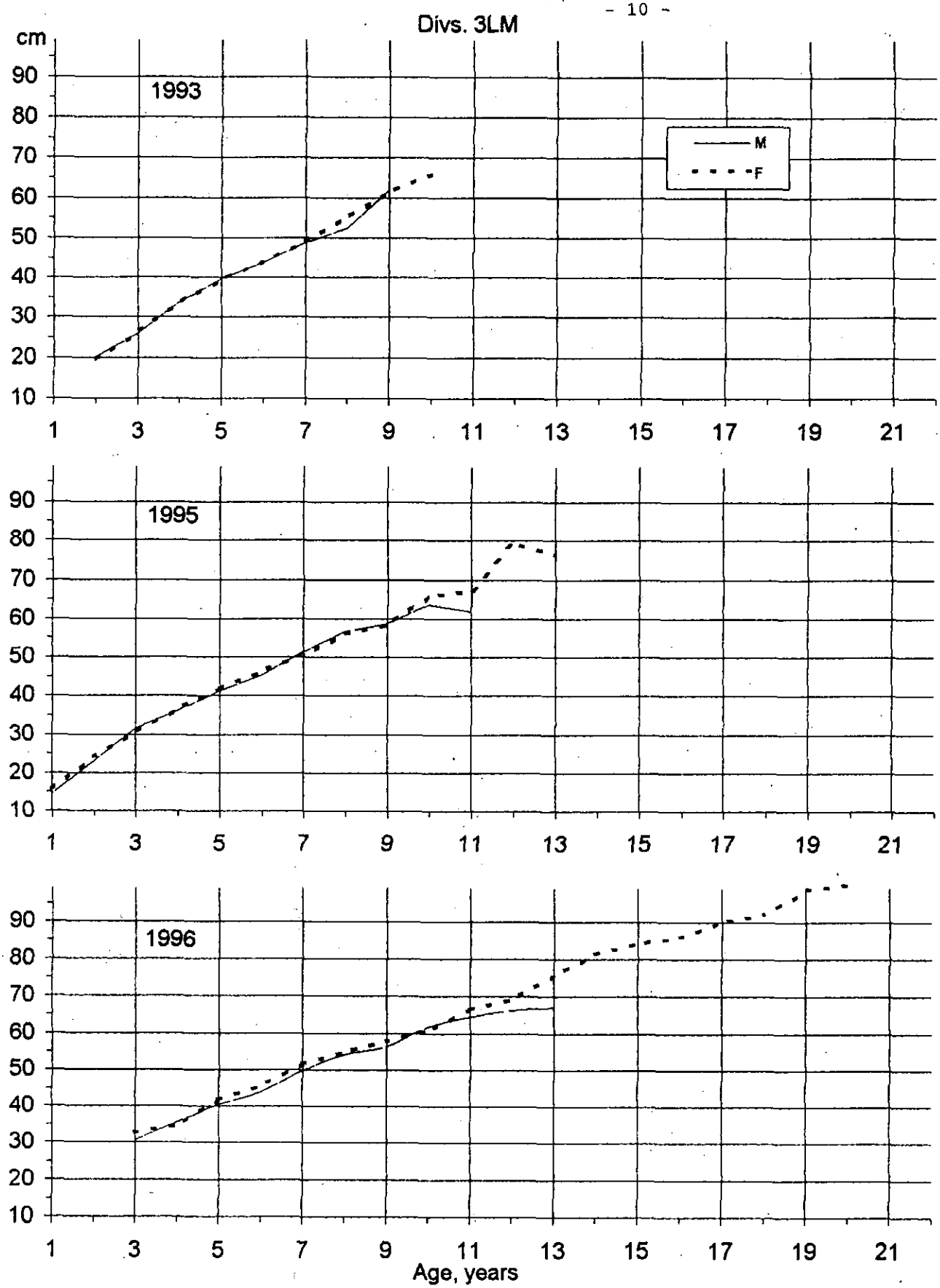

Fig. 5. Mean length at age in Divs. 3LM for 1993-1996.