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Interannual Variations in Feeding Intensity and Structure of Trophic Links of Prespawning Cod on the Newfoundland Shelf (Div. 3L)

by

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Abstract

Results from Russian bottom trawl surveys in 1978-1991 indicated that mature cod on the Newfoundland Shelf fed rather actively before spawning, and intensity of their feeding showed little or no reduction with gonad maturation.

The most intensive feeding of prespawning cod was observed in 1982-1986; cod fed on capelin actively. In the beginning and in the end of the study period, intensity of cod feeding was average but coming from 1989 it has been observed to be comparatively low. In this period, cod fed on capelin less actively but more actively on shrimp and crabs. Sand lance were of marked importance in the feeding of prespawning cod until 1985.

The highest fatness was registered in 1981-1982 and in 1985, the lowest - in 1989-1991. No distinct relation between fatness and intensity of feeding of cod moving to Newfoundland shores to spawn was found.

Introduction

One of the characteristics of interannual dynamics of cod feeding being highlighted by researchers for both the Barents Sea and Newfoundland banks is weak feeding before spawning and during spawning. However, if in the early papers a possibility of cod "additional feeding" during their spawning migration is mentioned (Zatsepin, Petrova, 1939), in later papers, a thesis on discontinuation of cod feeding during spawning often do not exposed to any doubt (Postolakiy, 1963; Turuk, 1968; Fishery biological resources..., 1977).

However, in the recent years it was shown that spawning grounds of cod on the Newfoundland Shelf coincided with areas of their spring feeding on prespawning capelin (Hutchings et al., 1993; Gerasimova and Kiseleva, 1995; Gerasimova and Kuzmin, 1993). In regard with this we decided to analyze in details peculiarities of feeding of prespawning cod on the Newfoundland Shelf, its changes with gonad maturation and interannual dynamics.

Materials and Methods

The paper uses data from age samples and field analysis of cod feeding collected during Russian bottom surveys in May-June 1978-1991. Period of works in Div. 3L and body of the material included to the analysis are given in Table 1.

When carrying out analysis of cod stomachs in the sea, twenty five cod from a catch were examined for length, sex, maturity stage, stomach fullness and main prey species. Maturity stage was detrmined according to a 6-point scale (Sorokin, 1957,

1960) while stomach fullness according to a 5-point scale. When taking age samples, beside the aforementioned parameters, total cod weight was determined, and in first hundred individuals - weight of liver.

During the studies, the whole analyzed cod were separated by size intervals with 9 cm step. Analysis involved fish of five size intervals which were combined in three groups by similarity in maturation rates. They are: 36-53 cm, 54-62 cm, 63-80 cm groups (Fig. 1).

For each size group, separately for males and females, analysis of changes in feeding intensity and structure of trophic links with maturation was carried out. Intensity of feeding was estimated by the mean degree of stomach fullness, whilst structure of trophic links by frequency of the main prey ocurrence, such as capelin, sand lance, shrimp and crabs.

Physiological status of fish moving to spawn was estimated from their fatness which was determined as the ratio of liver weight to the cubed cod length expressed in per decimille. Traditionally, to estimate this parameter weight of fish is used (Postolakiy, 1963), however, we prefered to use length, because total weight of fish can vary in dependence on gonad weight and stomach fullness (Pravdin, 1966) but weight of fish without viscera during bottom surveys was far from regular estimation.

Indices of fatness of males and females from the same size group in some years were characterized by statistically certain distinctions at 95% significance level. In unisexual cod from different size groups statistically certain distinctions in fatness were not found. Therefore, comparative analysis of fatness was carried out with separation by sex but without classification under size groups.

Results

Throughout the study period, prespawning cod in Div. 3L fed rather intensively. The mean degree of stomach fullness in cod at different maturity stages were measured to be not lower than 1 on the 5-point scale. No clear evidence of decrease in intensity of feeding of males at maturity stage V-VI was found (Fig. 2). Unfortunately, information on feeding of females at maturity stage VI is hardly available. It is quite probable that such females occur mainly within the coastal zone which is not covered by Russian surveys.

Interannual differencies in intensity of cod feeding were more prominent. Thus, the highest values of stomach fullness were registered in all the size groups from 1983 to 1986. Since 1987, a decrease in feeding intensity has been observed, particularly in cod 36-53 cm long.

From year to year intensity of cod feeding on capelin varied markedly (Fig. 3). Until 1981, frequency of capelin occurrence in cod stomachs was relatively low, i.e. less than 25%. Later it increased and reached maximum values of more than 75% in 1985-1986. It should be noted that in those years the highest frequency of capelin occurrence was found in cod at maturity stage IV-VI.

Intensity of cod feeding on sand lance in the study period was somewhat below than on capelin (Fig. 4). Since 1985, significance of sand lance in cod food has reduced much and did not exceed 10% in the recent years.

Feeding on crustaceans, shrimp and crabs, was relatively intensive in the beginning and in the end of the study period, i.e. until 1982 and after 1988. Crabs were more intensively consumed by large cod (63-80 cm) but shrimp were eaten by small-sized cod (36-53 cm) (Fig. 5-6).

Analysis of interannual variations in the structure of cod feeding in Div. 3L suggests that crustaceans, shrimp and crabs, are standby food, because cod switch to feed on them in case of shortage of fish food. Similar conclusions were made when estimating peculiarities of the Barents Sea cod (Orlova, Matishov, 1993). It may be added that those crustaceans did not appear to be a valuable substitution for fish food because stomach fullness of cod when feeding on shrimp and crabs is lower than during their feeding on capelin.

An interesting problem is a relation between conditions of cod feeding in summer and autumn of the previous year and intensity of their spring feeding. One of the indices of a

successful feeding of cod in the previous year is their fatness before the beginning of spring feeding. Fatness of cod at maturity stage II varied markedly from year to year. The highest value of this index were registered in 1981-1982 and in 1985, but the lowest in 1990 and 1991 (Table 2, Fig. 7). A certain relation between values of fatness obtained and the level of capelin consumption by cod in autumn can be followed. According to Canadian data, intensity of capelin consumption in autumn 1978 was at a low level, in 1981 it sharply increased, in 1982-1983 reduced and then again reached the higher level in 1985-1986 (Lilly, 1991). As for the latest years of observations, since 1989 in Divs. 2J3K southeastern redistribution of autumn concentrations of capelin has been observed which entailed a change in migration routes of the feeding cod (Lilly and Davis, 1993). Judging from the low values of fatness in 1990-1991, the similar changes affected adversily the conditions of their summer and autumn feeding.

No clear dependence between cod fatness migrating to spawn to the Newfoundland shores and intensity of their spring feeding was found. In 1981-1982, cod having high fatness fed relatively weakly, while in 1983-1988 average indicies of fatness was followed by high intensity of feeding and since 1989 we have observed a combination of low fatness and weak feeding. It may be suggested that intensity of cod feeding before spawning on the Newfoundland Shelf is largely depend not on their physiological status but on quantity and availability of their prey speies in this period.

Discussion

As evident from the analysis, mature cod migrating to spawn to the Newfoundland shores fed rather actively. As it was already noted we have no information on feeding of females at maturity stage VI, but males at the same maturity stage did not reduce the activity of their feeding. This brings up another point, whether the decrease of cod feeding activity observed earlier in the prespawning period may be cited as an indispensable feature of the interannual dynamics of their feeding.

Comprehensive studies of cod feeding in the Barents Sea carried out in 1930's showed that the low activity of cod feeding before the spawning has an external reason, i.e. a wealth of fish forming prespawning concentrations on the small area eat prey species away quickly. If schools migrating to spawn meet on their way large concentrations of prey species, then prespawning "additional feeding" of cod is observed (Zatsepin, Petrova, 1939). This explanation may be applied to the Newfoundland conditions as by 1978 cod stock here reduced sharply and, obviously, cod are no longer form dense prespawning concentrations and have a possibility to feed as far as the beginning of spawning.

On the other hand, some of the researchers highlight the fundamental differencies in the character of interannual dynamics of American and European cod. Atlantic cod in the coastal North America fall into local groups associated with narrow areas in the limits of which both spawning and feeding take place. Unlike American cod, European cod execute extensive migrations from spawning grounds to feeding areas.

As regards Newfoundland cod, in 1960's it was concluded that they are better supplied with food throughout the year than European cod (Popova, 1962).

Studies of inshore cod in the Nova Scotia area showed that troughout the year frequency of empty stomachs occurrence did not exceed 20% which indirectly indicate a relatively even intensity of feeding. Nevertheless, biochemical composition of cod tissue in the spawning period were varying markedly, i.e. proportions of protein and fat were reducing and filling with water were increasing (Dambers, 1964). Probably, the variations observed in the biochemical composition are caused not by discontinuance of cod feeding before the spawning but by the fact that in this period consumption of energy for reproduction far exeed the energy supply.

Therefore, it may be suggested that the active prespawning feeding of the Newfoundland cod is not something non-specific for this species. Distribution within the narrow area,

a lack of extensive migrations and relatively good food supply throughout the year lead to the situation when not only areas but period of spawning and feeding are overlapping largerly and it is difficult to draw a clear border between them.

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Table 1. Dates of Russian surveys in NAFO Div. 3L and quantity of samples included into analysis

Years	Dates of surveys	Quantity of samples	
		stomachs, ind.	fatness, ind.
1978	8.05 - 10.06	602	48
1979	30.04 - 12.05	1043	49
1980	5.05 - 8.05	1129	56
	2.06 - 13.06		
1981	8.06 - 10.06	921	77
	27.06 - 11.07		
1982	25.05 - 11.06	788	57
1983	26.05 - 01.06	1233	100
	01.07 - 12.07		
1984	06.06 - 22.06	1071	25
1985	22.04 - 24.04	940	39
	17.05 - 19.05		
	04.06 - 17.06		
1986	16.04 - 19.04	1184	34
	10.05 - 22.05		
1987	26.04 - 11.05	947	72
1988	07.04 - 23.04	867	64
1989	27.04 - 21.05	1540	60
1990	26.04 - 23.05	958	35
1991	09.05 - 06.06	249	59

Table 2. Fatness of cod at maturity stage II in NAFO Div. 3L in spring 1978-1991

Years	Males			Females		
	X,o/ooo	St.err.	N	X,o/ooo	St.err.	N
1978	3.17	0.89	23	2.98	1.29	25
1979	2.39	0.77	20	2.67	1.01	29
1980	3.72	1.43	26	2.91	0.92	30
1981	4.61	1.08	30	4.81	1.00	47
1982	4.25	1.43	24	3.98	1.11	33
1983	3.09	0.74	51	3.46	0.85	49
1984	2.71	0.96	12	2.74	0.62	13
1985	4.68	1.44	22	3.89	1.04	17
1986	3.10	1.30	15	2.80	1.14	19
1987	3.62	1.60	31	3.89	1.48	41
1988	3.14	1.05	21	3.48	0.93	33
1989	2.55	0.97	28	2.96	1.18	32
1990	2.24	0.95	19	2.26	0.81	16
1991	2.15	1.05	23	2.18	0.80	26

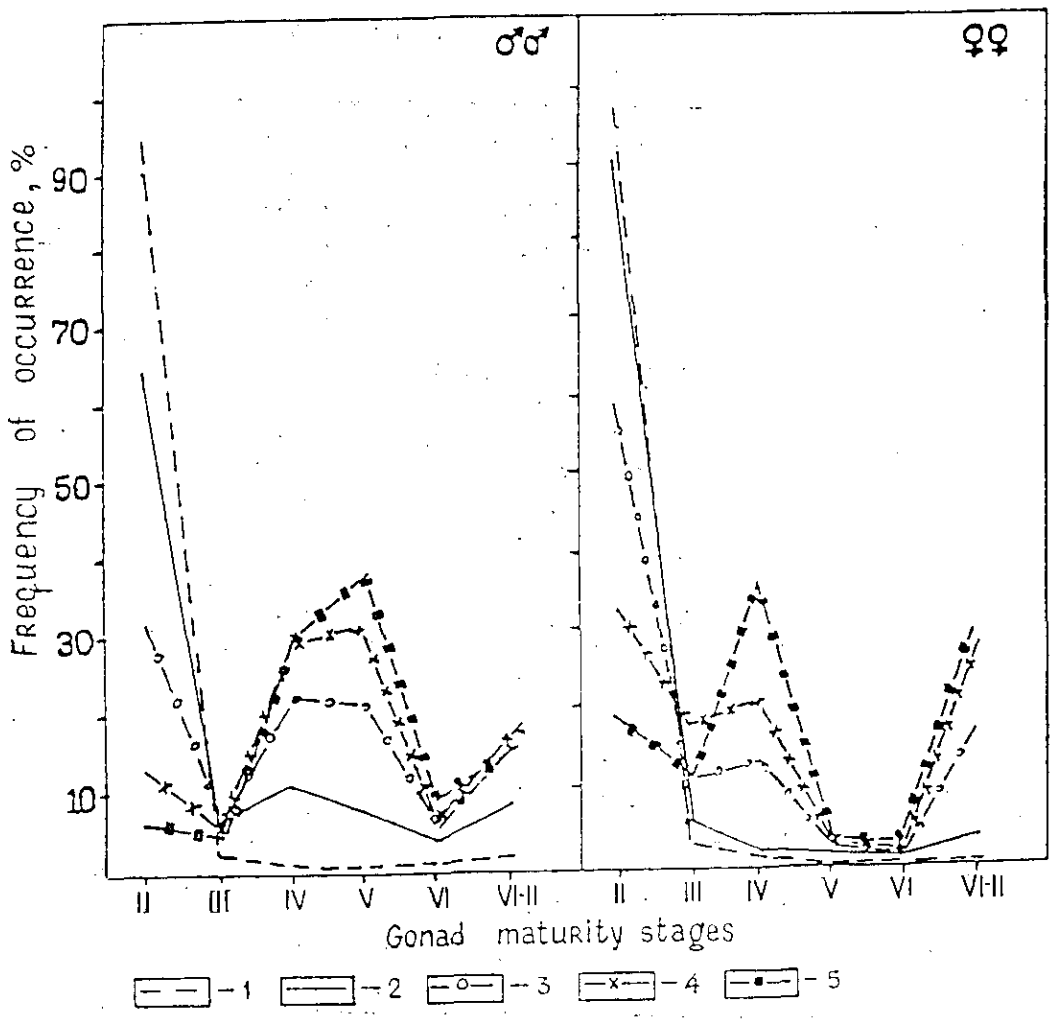

Fig.1. Mean long-term frequency of occurrence of cod with gonads at different stages of maturation in the NAFO Div. 3L during the Russian spring surveys.
1- cod of 36-44 cm; 2- 45-53 cm; 3- 54-62 cm; 4- 63-71 cm; 5- 72-80 cm.

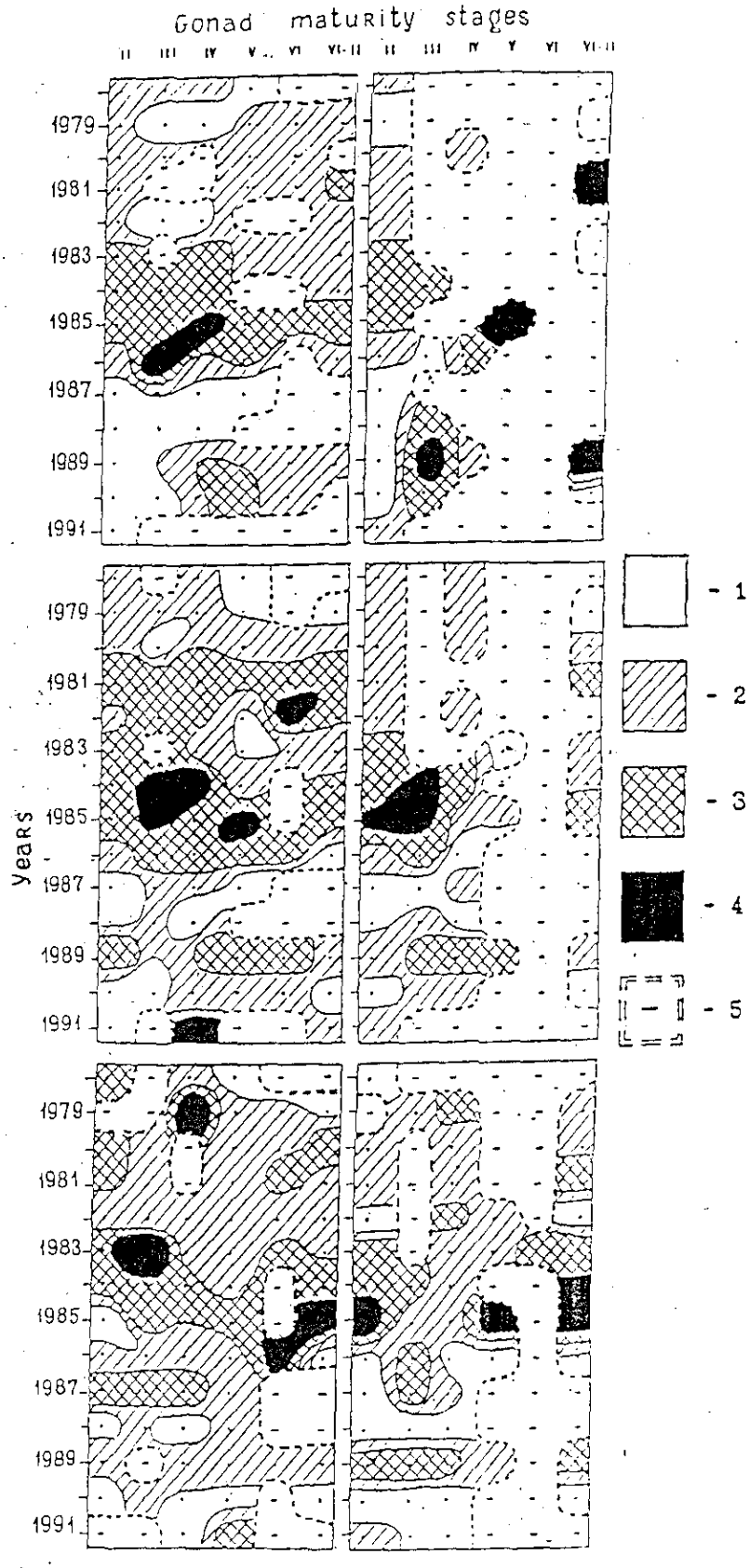

Fig.2. Intensity of spring feeding of cod in the NAFO Div. 3L. Left -males; right -females; top -cod of 36-53 cm; middle -54-62 cm; bottom 63-80 cm. 1 -stomach fullness lower than 2; 2 - 2.0-2.5; 3 - 2.6-3.0; 4 - hingher than 3; 5 - no data.

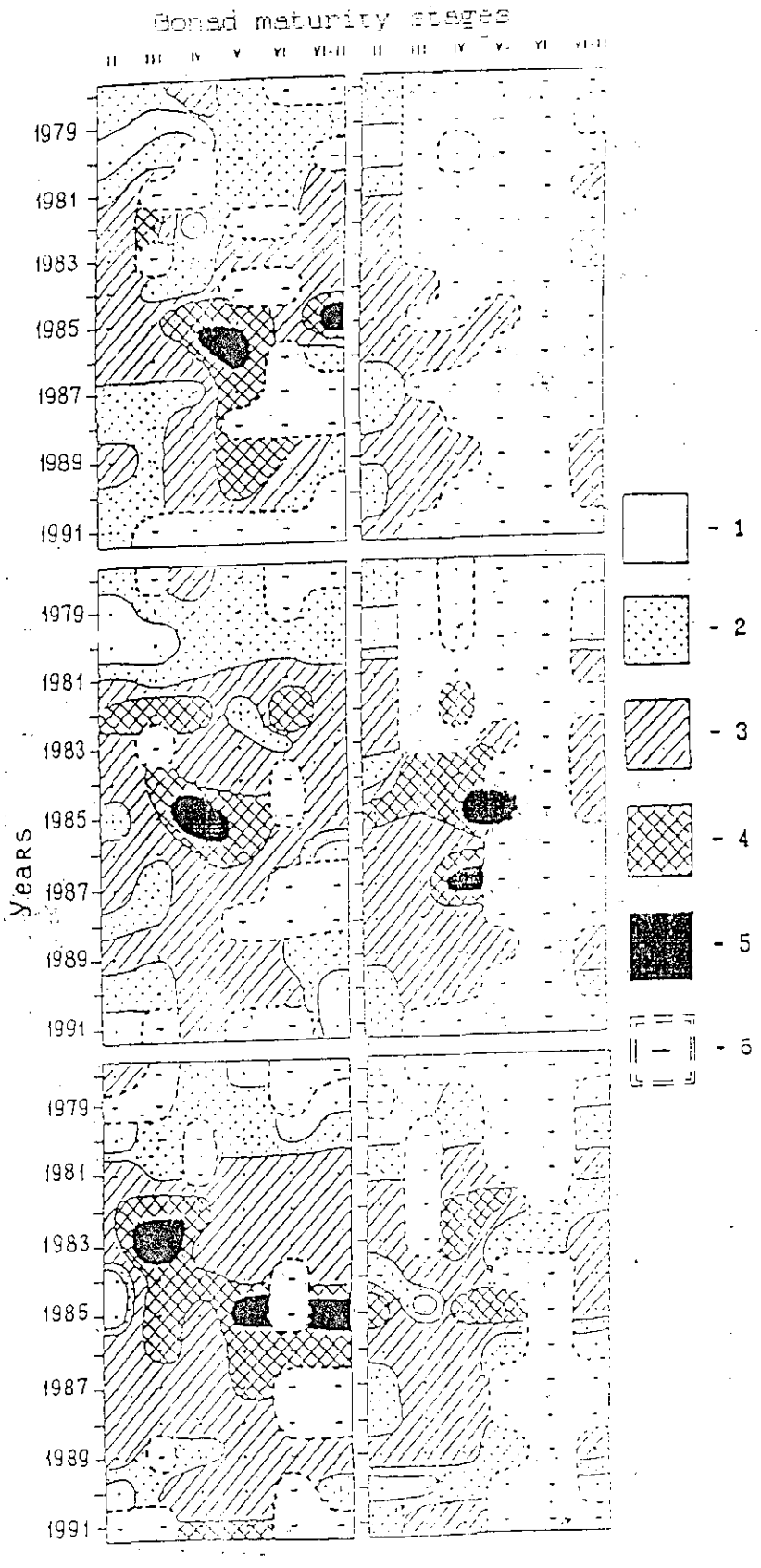

Fig.8. Frequency of occurence of capelin in cod stomachs during the spring feeding. Left - males; right - females; top - cod of 36-53; middle- 54-62 cm; bottom 63-80 cm.
1 - frequency of occurrence less than 10%; 2 - 11-25%; 3 -26-50%; 4 -51-75%; 5 -more than 75%; 6 - no data.

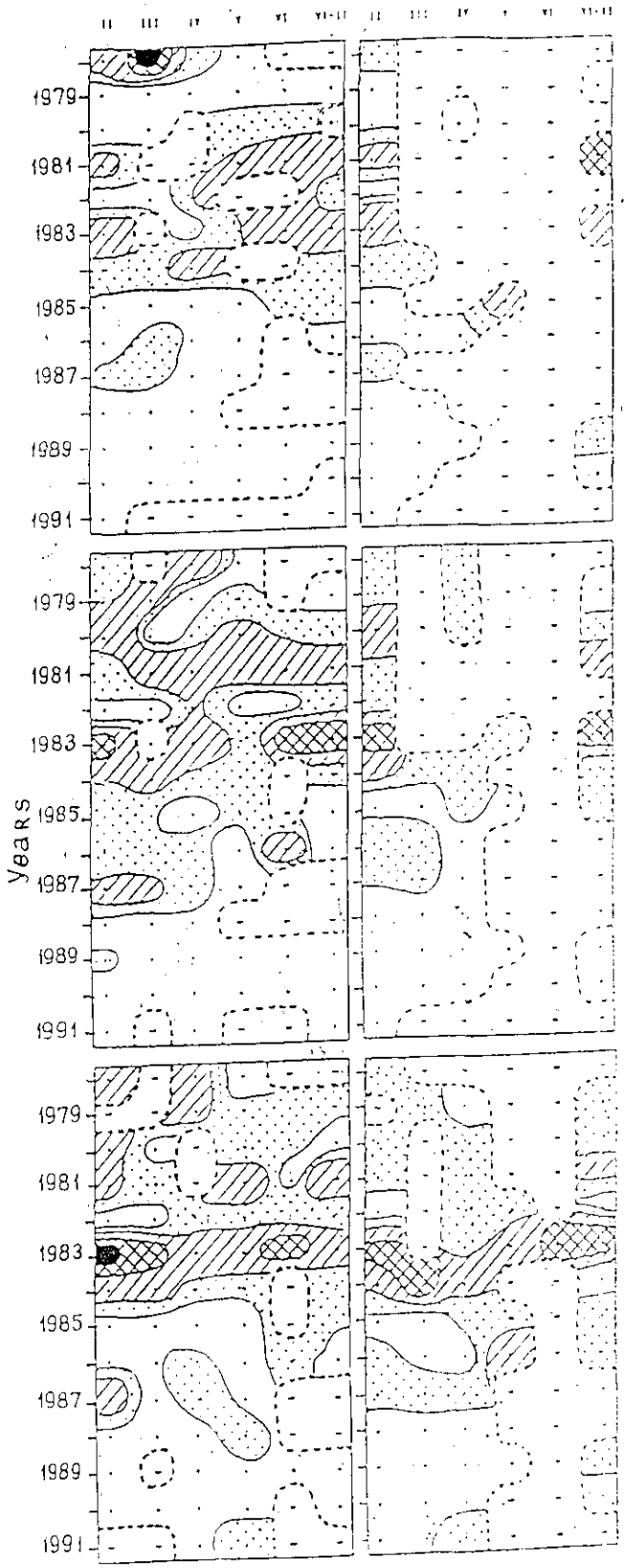

Fig.4. Frequency of occurence of sand lance in stomachs of cod during the spring feeding. See Fig.8. legend.

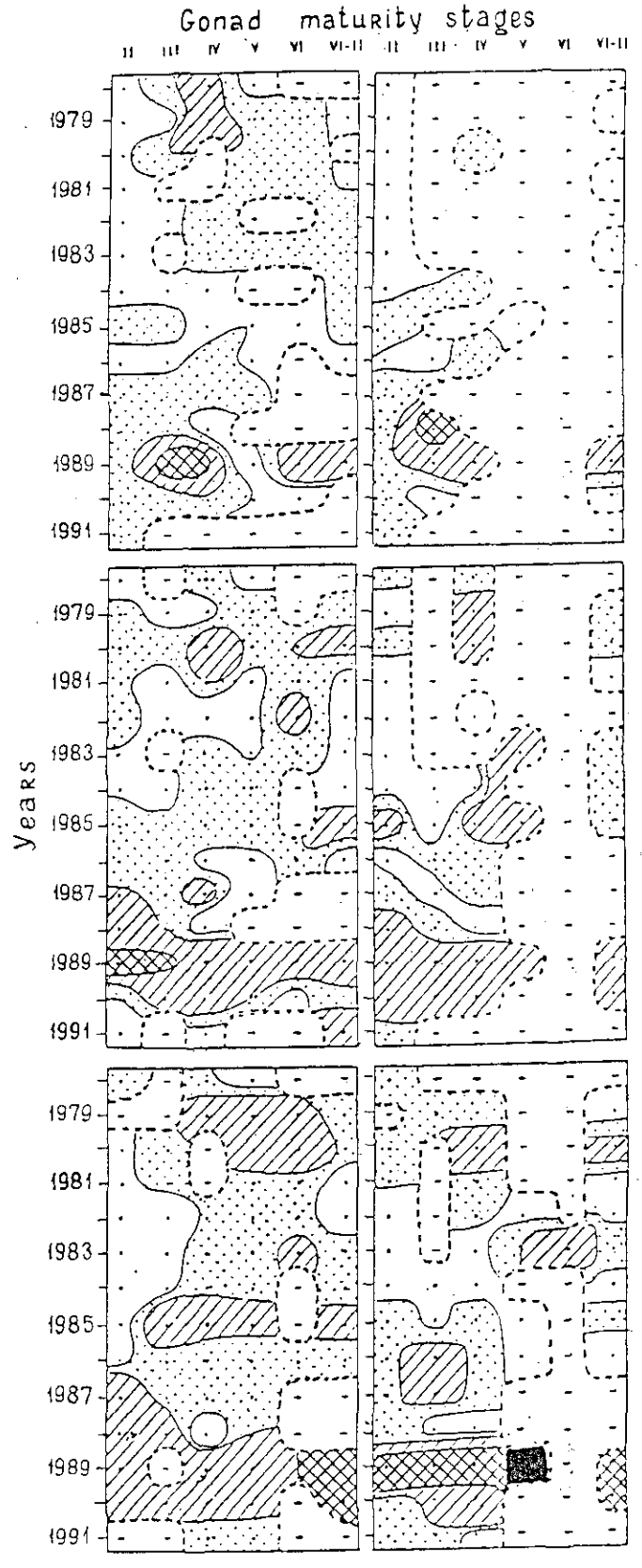

Fig.5. Frequency of occurence of crabs in stomachs of cod during the spring feeding.
See Fig.3. legend.

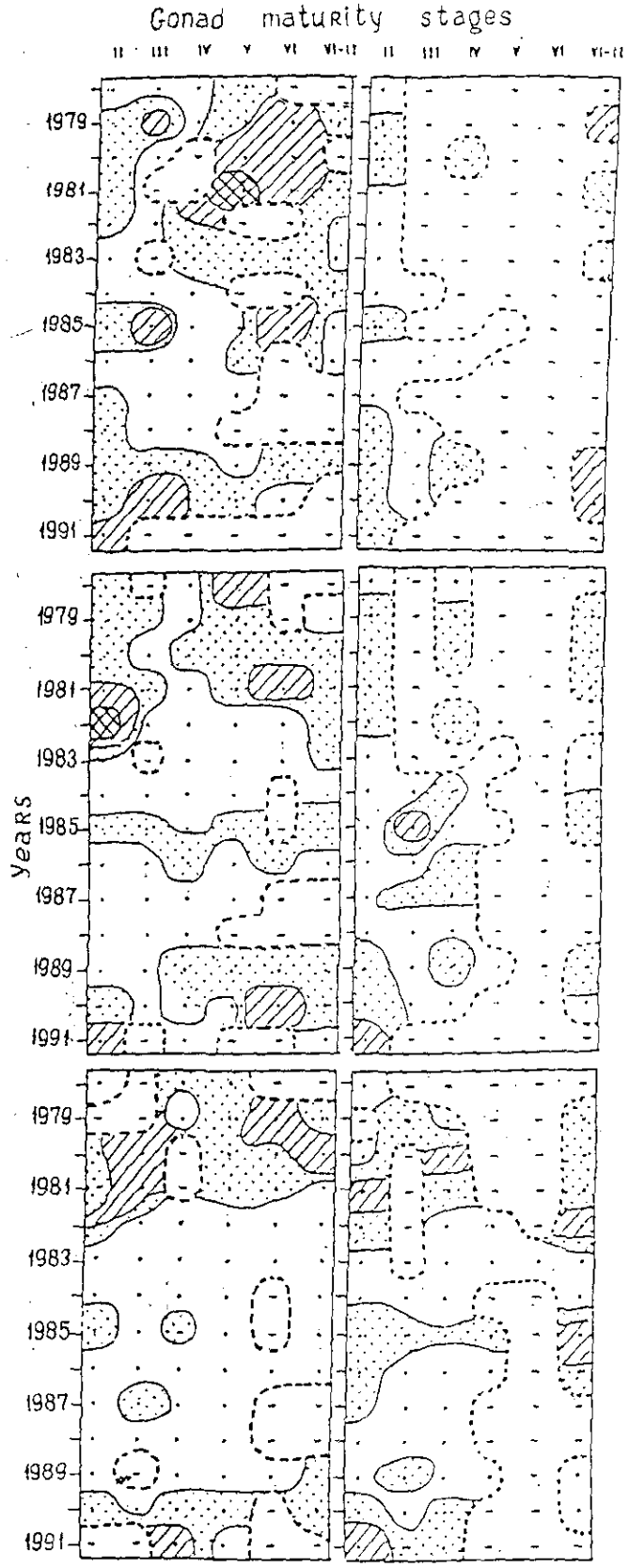

Fig.6. Frequency of occurence of shrimp stomachs of cod during the spring feeding. See Fig.3. legend.

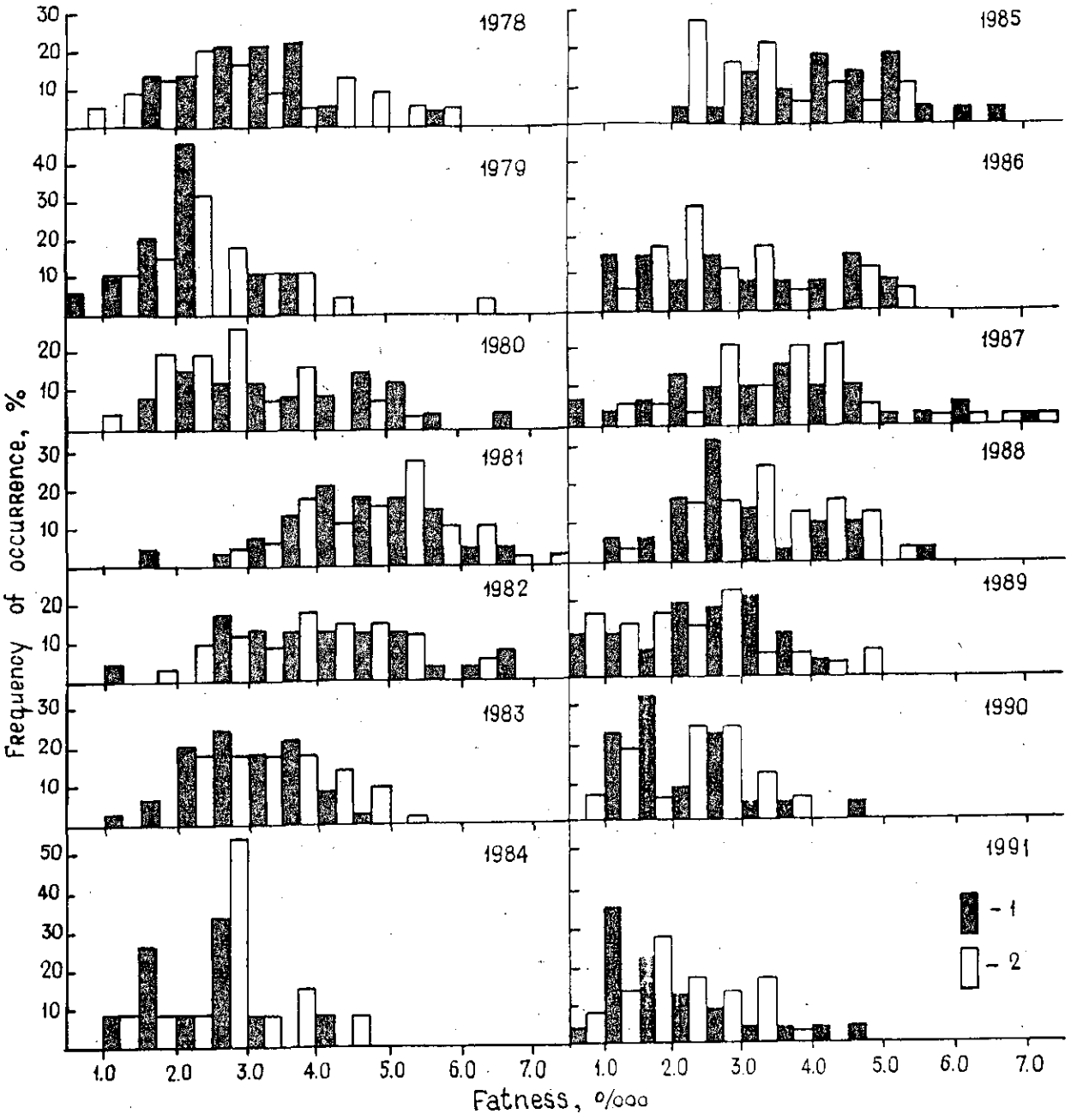

Fig.7. Variation of fatness of cod at maturity stage II in spring 1978-1991.
1 - males; 2 - females.