Northwest Atlantic Fisheries Organization

Serial No. N5098 **NAFO SCR Doc. 05/17**

SCIENTIFIC COUNCIL MEETING – JUNE 2005

State of Capelin Stock in NAFO Divisions 3NO Based on Data from Trawl Surveys

by

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Abstract

Indices of capelin trawl biomass obtained in Canadian random stratification bottom trawl surveys are the only available at the present time indicators of capelin stock dynamics. In 2003-2004, trawl biomass of capelin in Divisions 3NO was 25.3 and 35.5 thousand tons correspondingly and the average since 1996 was 27.9 thousand tons. The average catch in these years per km^2 was 0.37 and 0.42 thousand accordingly and the average was 0.38 thousand tons. The estimate in 2004 corresponded to a low level of the stock, which was observed in 1996, 2002-2003. Fishery was conducted in the years when this value was equal or higher than 2-t/km^2. Capelin stock in Div. 3NO remains in depressive state.

Introduction

Estimation of capelin stock (*Mallotus villosus*) in Div. 3NO was based on the results of Russian and Canadian acoustic surveys conducted before 1996. In all subsequent years, data on capelin by-catch in Canadian trawl surveys of demersal fish has been the only source of data on state of capelin stock. Before 1995, Yahkee 41-5 trawl and Engel 145 Hi-Lift trawl were used. Since autumn 1995, Campelen 1800 shrimp trawl has been applied as standard sampling gear. After taking in use a new trawl by-catches of capelin increased greatly, which made it even more difficult to interpret the obtained results.

Since capelin is a pelagic fish species, a bottom trawl cannot be used as adequate sampling gear for quantitative estimation of the stock. Therefore, relationship between biomass indices from bottom trawl survey and stock size remains unclear. As analytical methods could not be applied, the purpose of this work was to estimate current state of capelin stock in the Div. 3NO according to the available indirect data.

Materials and Methods

The data used in this investigation was collected in Canadian trawl surveys of demersal species conducted in 1977-2004 in Div. 3NO and in Canadian acoustic surveys performed in 1981-1992 in Div. 3NO and in 1999-2004 in Div. 3L.

Trawl surveys were conducted according to standard stratification grid based on depth intervals and lines of latitude and longitude (Doubleday, 1981; Bishop, 1994). The number of hauls was in proportion to the area of strata but not less than two in each.

Before 1982, Yahkee 41-5 trawl was used and Engel 145 Hi-Lift trawl was applied in 1984-1995. In subsequent years, Campelen 1800 shrimp trawl with rockhopper was used. Campelen was hauled in 15 minutes at speed of 3 knots. In order to hold fish in the trawl a panel with mesh size of 29 mm was used in the trawl bag.

Capelin biomass in each stratum was calculated as:

$$W_h = \frac{A_h \sum_{i=1}^{n_h} W_{hi}}{a n_h}$$

where W_{hi} is weight (kg) of capelin in set i (i = 1, 2, ..., nh) in stratum h, and a is the area sampled by a standard haul. Biomass in each Division was calculated by adding the values of all strata (Lilly and Simpson, 2000).

Besides, a standardised catch per area unit (t/km^2) calculated as an average of all non-zero catches (B_s) was used in the analysis. Owing to small size of statistic sample (number of catches in each survey), bootstrap samples were used for calculation of confidence intervals. Nearest Neighbour method and Euclidean Distance Metric were used for clustering of B_s values.

Results and Discussion

Fishery and management

Fishery for capelin started in 1971 and total catch was maximal in mid-1970s with the highest catch of 132 000 tons in 1975. The fishing was closed in 1979-1986 and then opened in 1987-1992. Annual catches in this period did not exceed 25 000 tons. In subsequent years due to abrupt decline of the stock size, the target fishery for capelin was banned. Highest historical catches were taken by Russia (former USSR), Norway, Iceland and Japan (Table 1).

TAC of capelin was set for the first time in 1974 and in 1977-1978 it reached 200 000 tons, then TAC was reduced to 30 000 tons in 1990-1992. Considering that in the whole regulation period the catch did not exceed TAC, the decline of stock size observed since early 1990s could hardly be caused by overexploitation of the stock. A similar idea about capelin stock in NAFO Subareas 2 and Div. 3KL was expressed by J. Carscadden (DFO, 2000). Because of dramatic decline of the capelin stock size since 1993, the ban on target fishery for capelin was imposed as a regulation measure.

At first, capelin stock distributed in Div. 3NO+3Ps was considered as one stock (Winters, 1974). However, taking into account that capelin spawn at the same time in the coastal area of Newfoundland and in the South-eastern shallow waters (3N), it was assumed that there were two separate stocks in SA2+3KL and 3NO. Subsequent investigations of meristic and morphological features as well as collection of data on tagging and distribution proved these assumptions (Carscadden, 1986; Nakashima, 1991).

Research surveys

Stock assessment based on data of acoustic surveys

Acoustic surveys of capelin stock in Div. 3NO were conducted by the USSR/Russia in 1975-1994 and Canada in 1981-1992. Now, it is difficult to compare the results of these surveys since some Russian assessments were merged for Div. 3LNO. However, both surveys showed that maximum stock size was registered in 1988 and then an abrupt decline was observed after 1990 (Table 2). Despite the collapse of the stock registered in surveys conducted in Div. 3 LNO, TAC remained at the same level of 30 000 tons in 2 years (Fig. 1). Dynamics of annual catches in Div. 3NO corresponded better to the acoustic estimates of the stock in Div. 3L than that in Div. 3NO. This relationship was probably caused by the timing of acoustic survey and specific features of capelin behaviour, which means that aggregations of capelin from both stock before migration to the spawning areas concentrated in Div. 3L.

In recent years, STACFIS several times has advised to conduct investigations of capelin stock in Div. 3NO using methods of trawl-acoustic survey. However, this advice was not followed.

Indices of trawl biomass according to the data from Canadian spring surveys

Indices of capelin biomass obtained in Canadian random stratification bottom surveys are the only available at the present time indicators of capelin stock dynamics. When shifting the standard survey trawl from Engel 145 Hi-Lift to Campelen 1800 shrimp the catch rate for capelin of the latter turned out to be much higher (Lilly and Simpson, 2000). Absolute values of capelin by-catches increased by several tens of time and therefore were not comparable with the previous data (Fig. 2a).

Since capelin was not included in the comparison investigations of catch rates of Engel and Campelen trawls in 1995 and 1996, the conversion factor for capelin was not calculated (Lilly, 1999). Previously, in order to compare the results of surveys conducted with different trawls, it was assumed that catch rate for equal in size capelin and cod of 14 cm in length was the same. Based on this assumption, the calculations showed that effectiveness of capelin fishing by Campelen was approximately 49 times higher than that of Engel (Shibanov *et al*., 2002). When standardising the indices of biomass obtained in 1977-1995 by catch rate of Campelen trawl, the estimate of the current state of the stock will probably become more realistic (Fig. 2b).

The applicability of biomass indices obtained by Campelen trawl for assessment of capelin stock was investigated by identification of relationship between values of trawl and acoustic biomasses of capelin in Div. 3L obtained in 1999-2004 (Table 3, Fig. 3). Two years (2001 and 2004) when index of biomass of trawl survey exceeded or was close to that of acoustic survey were excluded from the available data set. Obtained linear regression was statistically significant ($R^2 = 0.90$, $F = 18.93$, $df = 2$), therefore, in case of no acoustic surveys the trawl indices could be used in estimation of the stock size.

In 1996-2004, when Campelen was used as sampling gear, trawl biomass of capelin in Div. 3NO varied from 7.2 to 58.1 thousand tons (Fig. 4). In 2003-2004, this parameter was 25.3 and 35.5 thousand tons correspondingly and the average for the period from 1996 was 27.9 thousand tons.

Since interpolation by density of bottom trawl catches to the area of strata for such pelagic fish species as capelin can lead to significant deviation of the total biomass, in our opinion the average catch per km^2 (B_s) can better describe the state of the stock. According to data from 1996-2004, B_s had a linear significant relationship ($R^2 = 0.93$, $F = 90.44$, $df = 7$) with indices of trawl biomass (Fig. 5) and varied between 0.13 and 0.76. The average in these years was 0.38. In 2003 and 2004, this parameter was 0.37 and 0.42 correspondingly (Fig. 6).

Classification of average catches by the degree of affinity in 1990-2004 allowed us to distinguish two clusters, which characterize two periods of stock condition: satisfactory (1990-1991) and poor in subsequent years (Fig. 7). The estimate of 2004 corresponds to a low level of stock size that was observed in 1996, 2002-2003. Fishing was conducted in the years when this parameter exceeded or was close to 2-t/km^2. In our opinion, this point can indicate the beginning of stock rebuilding.

The results of previous assessments show that capelin stock in Div. 3NO remains in depressive state (Shibanov *et al*., 2002; Gorchinsky, 2003, 2004). Comparing with previous years, trawl biomass of capelin in 2004 in Div. 3NO was at low level close to the average for 1996-2004, which gives us ground to prolong advice of the Scientific Council about the ban on target fishery for capelin in 2006-2007. A more precise estimation of the stock will be possible if trawl and acoustic surveys are resumed.

In today situation when the target fishing is banned and no acoustic surveys of capelin in Div. 3NO are conducted on a regular basis, it is impossible to calculate LRPs.

Distribution of capelin stock

In seven cases during last 9 years capelin stock distributed mostly in Div. 3N or approximately in even proportions between the Divisions (Fig. 4). In 2003, the most part of capelin distributed near the southern slopes of the Grand bank. In 2004, the distribution was to some extant different from that in previous year. The highest catches were registered in the central shallow part of the bank (Fig. 8).

Acknowledgment

We would like to express our gratitude to doctor G. R. Lilly и F. K. Mowbray from Department of Fisheries and Oceans, St. John's, Canada for data of Canadian scientists collected in trawl surveys and cooperation on this report.

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TABLE 1. Nominal catch and TAC of capelin in NAFO Div. 3NO (tons).

Year	BGR	CAN	CUB	DDR	ISL	IRL	JPN	NOR	POL	E/PRT	ROM	E/ESP	RUS	**Total**	TAC
1970														**0**	
1971													750	**750**	
1972	166												20598	**20764**	
1973		1658						41293	203				83721	**126875**	
1974		3698						43682		500		4016	48855	**100751**	148000
1975					15814		2734	37477	4306			3748	67704	**131783**	180000
1976	311	5233			8839	230	5007	23178	3778				63610	**110186**	180000
1977		36	700		2994		3746	21499	401				17322	**46698**	200000
1978				56	116		665	4237	7		7		119	**5207**	200000
1979														**0**	0
1980														**0**	0
1981														**0**	0
1982														**0**	0
1983														**0**	0
1984														**0**	0
1985			3											**3**	0
1986														**0**	0
1987							793						14	**807**	10000
1988							1395	1094					4738	**7227**	15000
1989							2222	4085					3189	**9496**	28000
1990			85				2054	8415					14076	**24630**	30000
1991			118											**118**	30000
1992			65											**65**	30000
1993			3											**3**	0
1994														**0**	0
1995														**0**	0
1996														**0**	0
1997														**0**	0
1998														**0**	0
1999														**0**	0
2000														**0**	0
2001														**0**	0
2002														**0**	0
2003														**0**	0
2004														**0**	0
Total	**477**	**10625**	**1059**	**56**	**27763**	**230**	**20670**	**193375**	**8695**	**500**	**7**	**7764**	**338772**	**609993**	

Note: TACs in 1974-1978 are merged for NAFO Div. 3LNO.

TABLE 2. Estimate of capelin stock according to the data of Russian and Canadian acoustic survey in 1975-1994 (thousand tons).

Year	USSR 3LNO	Canada 3NO	Year	USSR/Russia 3LNO	Canada 3NO
1975	1050*		1985	2200	212
1976	685*		1986	1491	494
1977	1000*		1987	2161	229
1978	310		1988	3900	561
1979	483		1989	2455	28
1980	0		1990	3752	
1981	109	223	1991	118	
1982		419	1992		4
1983	346	219	1993	315	
1984	2880	85	1994	83	

* biomass of mature capelin in Divisions 3NO.

TABLE 3. Trawl and acoustic survey estimates of capelin biomass in Div. 3L according to Canadian surveys in 1999-2004 (thousand tons)

Type of Survey	Year					
	1999	2000	2001*	2002	2003	2004*
Trawl	80.78	49.38	103.89	20.64	42.90	262.30
Acoustic	258.78	209.02	138.50	125.87	149.23	160.10

Note: * - near values of trawl and acoustic biomasses were not used in the analysis.

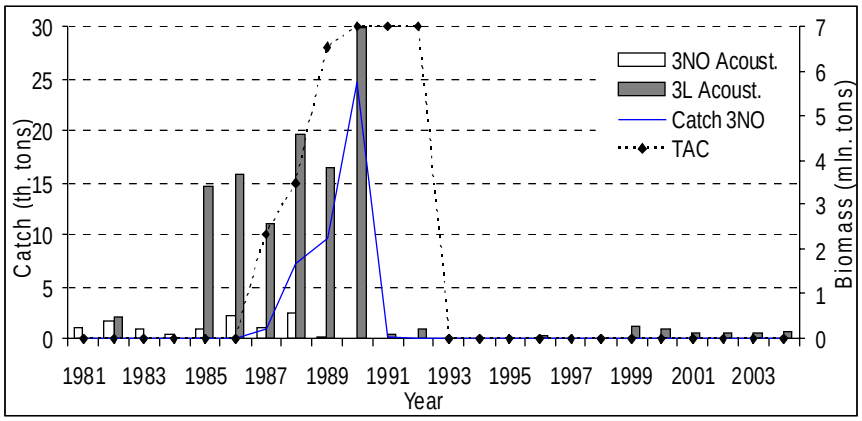


Fig. 1. Acoustic estimates of capelin biomass in Div. 3L and 3NO and catch of capelin in Div. 3NO in 1981-2004.

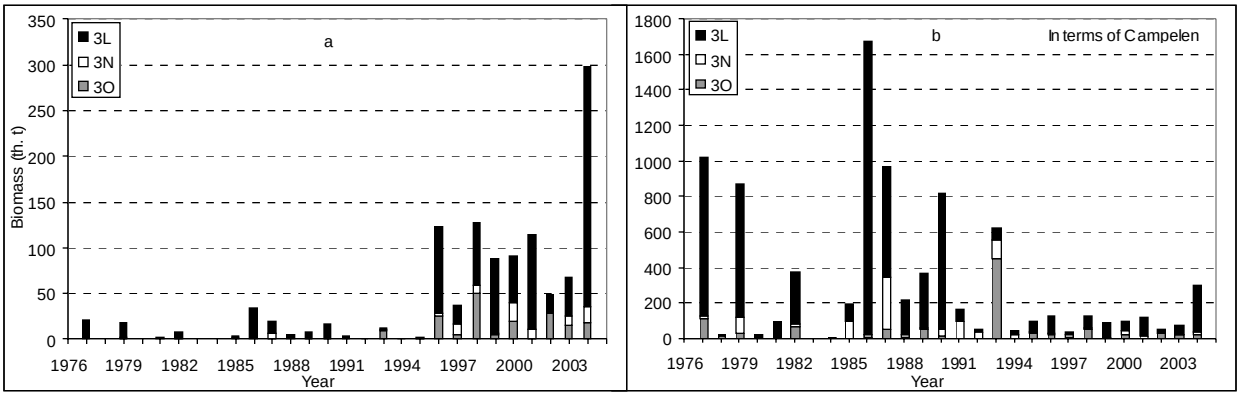


Fig. 2. Estimates of capelin biomass in Div. 3LNO according to the data of Canadian spring surveys conducted by different types of bottom trawls in 1977-2004.

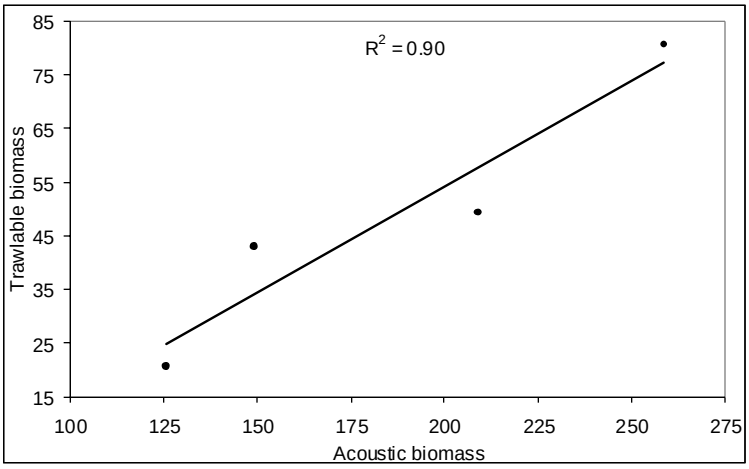


Fig. 3. Relationship between trawl (Campelen) and acoustic biomasses of capelin in Div. 3L according to the data of Canadian surveys conducted in 1999-2004.

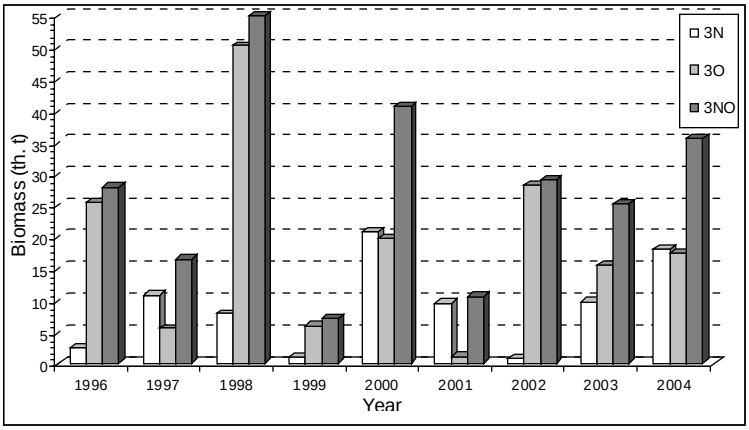


Fig. 4. Estimates of trawl biomass of capelin in Div. 3NO according to the data of Canadian spring surveys conducted in 1996-2004.

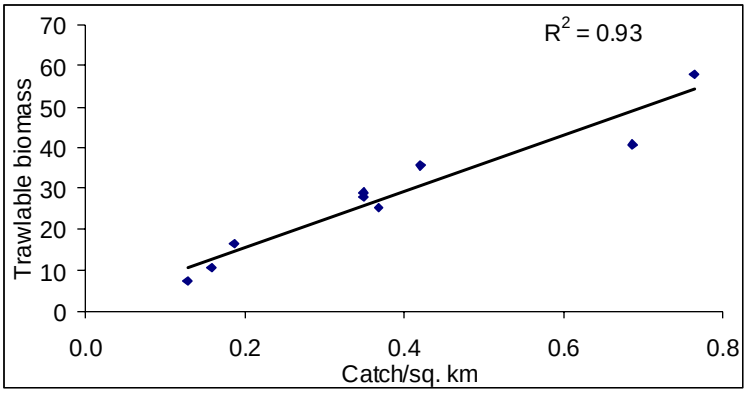


Fig. 5. Relationship between trawl (Campelen) and acoustic biomasses of capelin in Div. 3L according to the data of Canadian surveys conducted in 1999-2004.

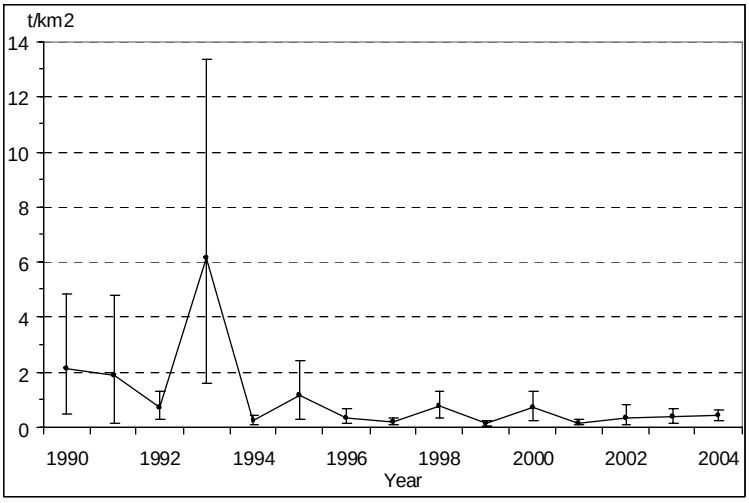
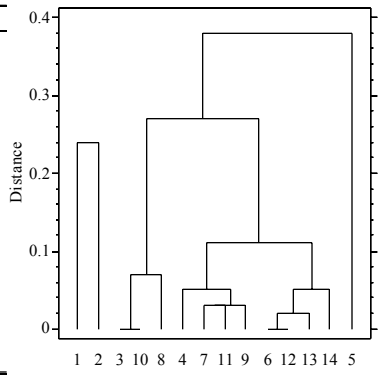


Fig. 6. Average catch (t/km^2) according to the data of Canadian spring surveys in Div. 3NO.

Membership Table

Row	Year	B_S	Cluster
1	1990	2.14	1
2	1991	1.9	1
3	1992	0.69	2
-	1993	*6.17**	-
4	1994	0.24	2
5	1995	1.14	2
6	1996	0.35	2
7	1997	0.19	2
8	1998	0.76	2
9	1999	0.13	2
10	2000	0.69	2
11	2001	0.16	2
12	2002	0.35	2
13	2003	0.37	2
14	2004	0.42	2

Dendrogram



Note: * - value considerably diverge from the neighbouring ones.
It was not used in the analysis.

Fig. 7. Classification of average catches (t/km^2, B_s) by the degree of affinity in 1999-2004 (data from 1990-1995 were standardised for Campelen).

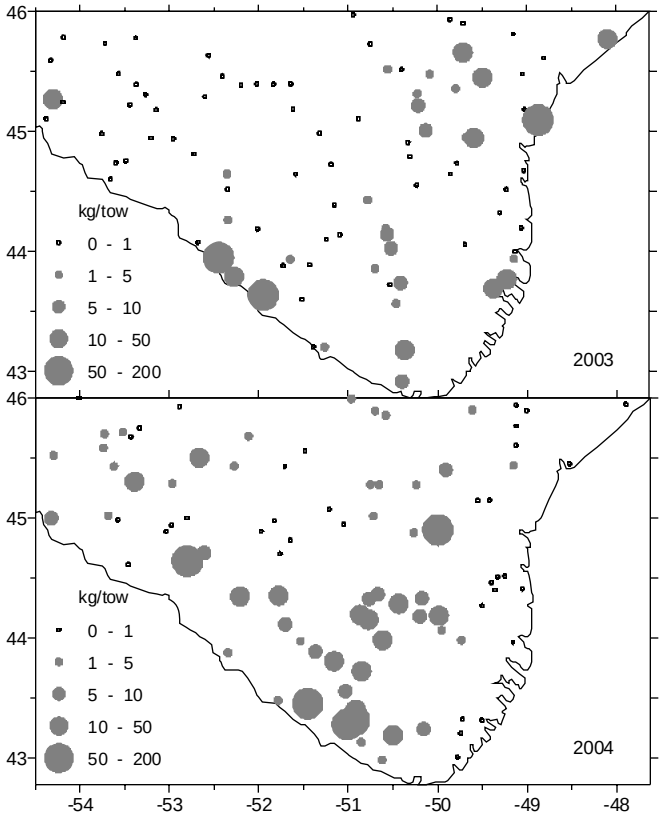


Fig. 8. Distribution of capelin by-catches in Div. 3NO according to the data of spring trawl surveys conducted in 2003-2004.