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An Attempt to Estimate Dynamics of Capelin Stock on the Grand Bank Using Trawlable Biomass Data from Canadian Bottom Trawl Surveys, Spring 1990-2001

by

V. N. Shibanov, K. V. Gorchinsky and V. S. Mamylov

Polar Research Institute of Marine Fisheries and Oceanography
(PINRO), 6 Knipovich Str., 193763, Murmansk, Russia, e-mail: inter@pinro.murmansk.ru

Abstract

Data from Canadian spring trawl surveys of demersal fish, as well as Canadian and Russian acoustic surveys of capelin, were used to calculate biomass of capelin on the Grand Bank in 1977-2001. Data for different trawl types were correlated with a conversion factor of 49. The biomass of capelin on the Grand Bank in the recent years has remained at a steadily low level.

Introduction

Trawl acoustic surveys of capelin on the Grand Bank previously conducted by Russia and Canada on a regular basis have not been undertaken since 1995. The only indicator of stock dynamics presently available may be capelin biomass indices obtained during Canadian stratified-random bottom trawl surveys. In the course of spring surveys in 1990-2001 two-trawl types were used and the data were not directly compatible. In autumn 1995, a new research trawl Campelen 1800 was introduced, which led to an increase in absolute values of capelin by-catch by several tens of times. The reasons for that had to be investigated.

We attempted to estimate stock dynamics of the Grand Bank capelin on the basis of the results from Russian and Canadian acoustic surveys of capelin conducted in 1977-1994, as well as Canadian bottom trawl surveys of 1977-2001.

Materials and Methods

We used capelin by-catch data (trawl positions, depths, catch in numbers and by weight) available by courtesy of our Canadian colleagues. These data were obtained during Canadian spring surveys with bottom trawls Engel 145 (1990-1995) and Campelen 1800 (1996-2001).

Distribution of capelin by-catch (indiv./haul and kg/km^2) in the near-bottom layer of Div. 3NO in 1990-2001 was mapped by the isoline method. To remove certain differences in survey techniques (regarding speed, tow duration and wing spread), capelin by-catches were standardized as per 1 km^2. For calculation of fish aggregation areas only those with distribution density exceeding 1 kg/km^2 were taken into account. This permitted to reduce spatial approximation errors. The maps were plotted in Alber's equal-area conic projection with kilometers as units. In all cases approximation was done by kriging, the number of grid knots being 200 x 140. If several hauls were made at the same position, by-catches were averaged.

Trawlable biomass of capelin in Div. 3LNO and 3NO for 1977-2001 was converted into absolute values on the basis of the relationship between trawl (Lilly and Simpson, 2000) and acoustic (Bakanev and Sergeeva, 1994) estimates of capelin stock in Div. 3LNO in spring 1977-1994.

Regression analysis of trawl and acoustic estimates for Div. 3NO indicated a very weak relationship (R = 0.3) and its results were not further used for biomass calculations.

Based on the *apriori* assumption about similar catch rates for same sized cod and capelin of 14 cm length (mean length of capelin by Russian acoustic survey data) caught by the Campelen trawl, data on capelin by-catch in 1996-2001 were made compatible with the Engel trawl data. Transformation coefficient **K** for cod of 14 cm length was calculated as follows:

$$Ln(K) = 10{,}857058 + 0{,}0030710*L - 2{,}654115*Ln(L) \text{ (Warren, 1996),}$$

which corresponds to **K** = 49.

Considering the absence of statistical relationship between trawl (X) and acoustic (Y) biomass estimates, geometric mean regression was used (Ricker, 1973).

To maximize the correlation between trawl and acoustic data, we attempted to apply combined Russian-Canadian and only Canadian estimates of capelin biomass in Div. 3LNO. Total biomass ($Y = W_{regr}$) was calculated by 4 different regressions, using data from trawl surveys in Div. 3LNO ($X = W_{tr}$) for 1977-2001 converted into the Engel trawl data.

By the combined Russian-Canadian acoustic data:

$$Y = 125.0 * X^{1.212} \ (R^2 = 20.1\%) \text{ and}$$
$$Y = 188.8 * X - 14.9 \ (R^2 = 10.5\%);$$

By the Canadian acoustic data:

$$Y = 542.3 * X^{0.773} \ (R^2 = 36.0\%) \text{ and}$$
$$Y = 231.1 * X + 754.6 \ (R^2 = 17.1\%).$$

Results and Discussion

Divisions 3LNO

In 1987-1992, capelin TAC in Div. 3NO increased from 10 000 to 30 000 tons. In succeeding years the direct fishery was closed as stock collapsed. As far as we know, no reliable data on the status of capelin stock after 1994 are presently available. One of the few available sources of information on capelin stock can be the data from Canadian trawl surveys of demersal fish on the Grand Bank.

Data on by-catches of capelin in bottom trawls reflect the availability (seasonal, diurnal, etc.) of its aggregations in the 5 m near-bottom layer for research trawls rather than actual capelin biomass in all layers. Besides, catch size variations indicate that capelin aggregations can migrate from year to year within the Grand Bank. Capelin stock is subject to considerable distribution variations. During the survey (April-June), the stock was mainly distributed both in Div. 3L and Div. 3NO (Lilly and Simpson, 2000). The suitability of trawl data for capelin biomass assessment is still unclear.

The correlation between biomass estimates derived by the acoustic and the trawl methods was relatively weak. R^2-statistics describes only to 36% of data variability. Biomass estimates for 1977-2001 derived on the basis of the above regressions and the acoustic survey data for 1977-1994 are presented in Table 1 and in Fig.1.

Assuming the existence of a certain relationship, we can conclude that in 1990-1995, both the calculated and the trawlable biomass of capelin in Div. 3LNO fluctuated within a wide range, tending to decrease. The stock fluctuation cycle is about 2-3 years. Since 1995 capelin biomass has remained at a steadily low level (Fig. 1, 2).

Divisions 3NO

By-catches of capelin in bottom trawls indicate that in 1990-1995, major capelin aggregations in Div. 3NO were mainly distributed in the margins of the Grand Bank at the ca. 200 m depth (Fig. 3). In 1996, 1998 and 2000 the largest catches were taken in the central area of the bank (Fig. 4). The widest distribution of capelin was observed in 1998 and the smallest one – in 1991.

In our opinion, the isoline method gives more correct estimates of pelagic fish biomass as compared to random stratification. Calculations by both methods showed similar trends. However, in certain years, deviations of biomass estimates calculated by the isoline method ranged from +22 to -45% (Table 2). Trawl biomass of capelin for the entire period was the highest in 1993 and the lowest in 1999 (Table 2, Fig. 5).

Conclusions

The data obtained show that the biomass of capelin on the Grand Bank is subject to considerable fluctuations. Since 1995 it has remained at a steadily low level. It should also be noted that the assessment of capelin stock in Div. 3NO separately from Div. 3L can lead to incorrect results due to overlapping distribution of these two stocks.

For obtaining reliable data on the status of capelin stock in Div. 3NO, it can be recommended to resume trawl acoustic surveys and to conduct a restricted trial fishery by 1-2 vessels.

Acknowledgements

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TABLE 1. Calculated capelin biomass (W * 10^3 t) in Div. 3LNO by the data from trawl and acoustic surveys conducted in spring 1977-2001 (1996-2001 for the Engel trawl).

YEAR	$W_{tr.}$	$W_{ac.}$	$W_{(lin.\ reg.)}$	$W_{(pow.\ reg.)}$	$W_{(lin.\ reg.)}$	$W_{(pow.\ reg.)}$
	Can. data	Rus/Can. data	Rus/Can. data		Can. data	
1977	20.84	8369*	3920	4959	5571	5672
1978	0.54	310	87	59	879	337
1979	17.48	483	3285	4007	4794	4951
1980	0.54	2*	87	59	879	337
1981	12.24	655	2296	2602	3583	3759
1982	7.60	885	1420	1460	2511	2601
1983	-	330	-	-	-	-
1984	0.13	1453	10	11	785	112
1985	3.90	2920	721	651	1656	1553
1986	34.02	2842	6408	8982	8617	8285
1987	19.50	2493	3667	4575	5261	5388
1988	4.24	4350	786	720	1734	1657
1989	7.26	3156	1356	1382	2432	2510
1990	16.67	5850	3132	3784	4607	4773
1991	3.23	160	595	518	1501	1342
1992	1.01	-	176	127	988	546
1993	12.64	315	2372	2705	3676	3854
1994	0.67	278*	112	77	909	398
1995	1.88	-	340	269	1189	883
1996	2.51	-	459	381	1335	1105
1997	0.74	-	125	87	926	430
1998	2.60	-	476	398	1355	1135
1999	1.79	-	323	253	1168	851
2000	1.84	-	332	262	1180	869
2001	2.34	-	427	350	1295	1046

* - very approximate data, excluded from the analysis

TABLE 2. Calculation of trawlable biomass by the isoline and stratified-random methods (thousand tons) and the area of capelin aggregations (thousand km^2) in Div. 3NO in 1990-2001.

Method	Year											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Random stratification	0.87	1.88	0.67	9.08	0.20	0.54	0.57	0.34	1.18	0.15	0.83	0.22
Isolines	1.06	1.03	0.39	6.82	0.20	0.51	0.51	0.39	1.29	0.15	0.79	0.22
Deviation, %	17.9	-45.2	-41.8	-24.9	0.0	-5.6	-10.5	12.8	8.5	0.0	-4.8	-0.7
Area	26.23	18.60	30.88	46.37	23.47	19.46	41.42	54.50	62.79	28.18	38.93	26.35

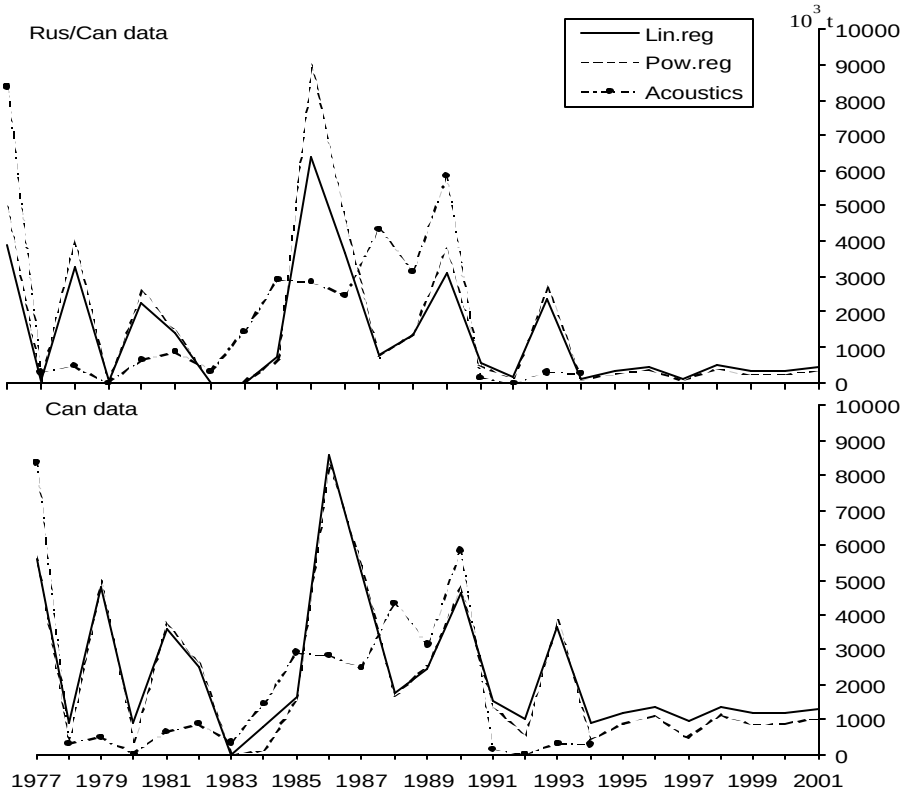


Fig.1. Dynamics of capelin stock in Div. 3LNO in 1977-2001 by calculated biomass.

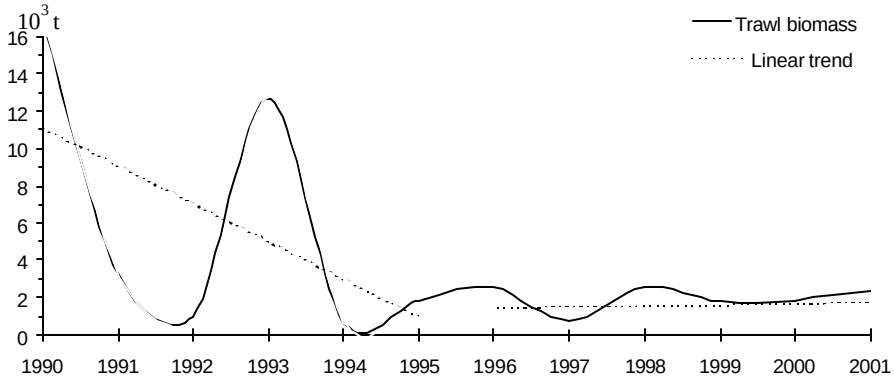


Fig. 2. Capelin trawlable biomass and linear trend in 1990-1995 (Engel) and 1996-2001 (Campelen) in Div. 3LNO.

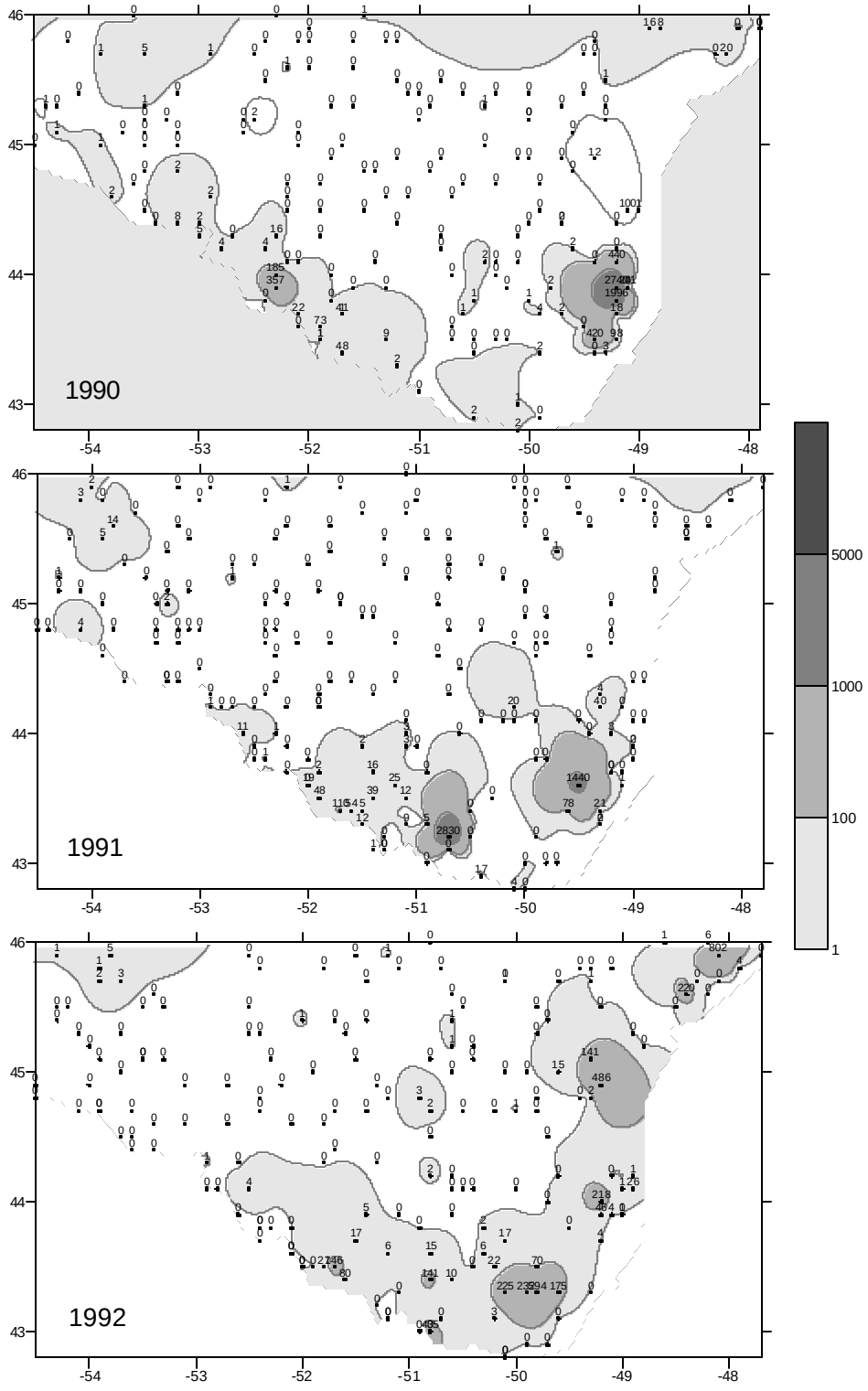


Fig. 3. Distribution of capelin catches (specimens/tow) in Div. 3NO. 1990-1995.

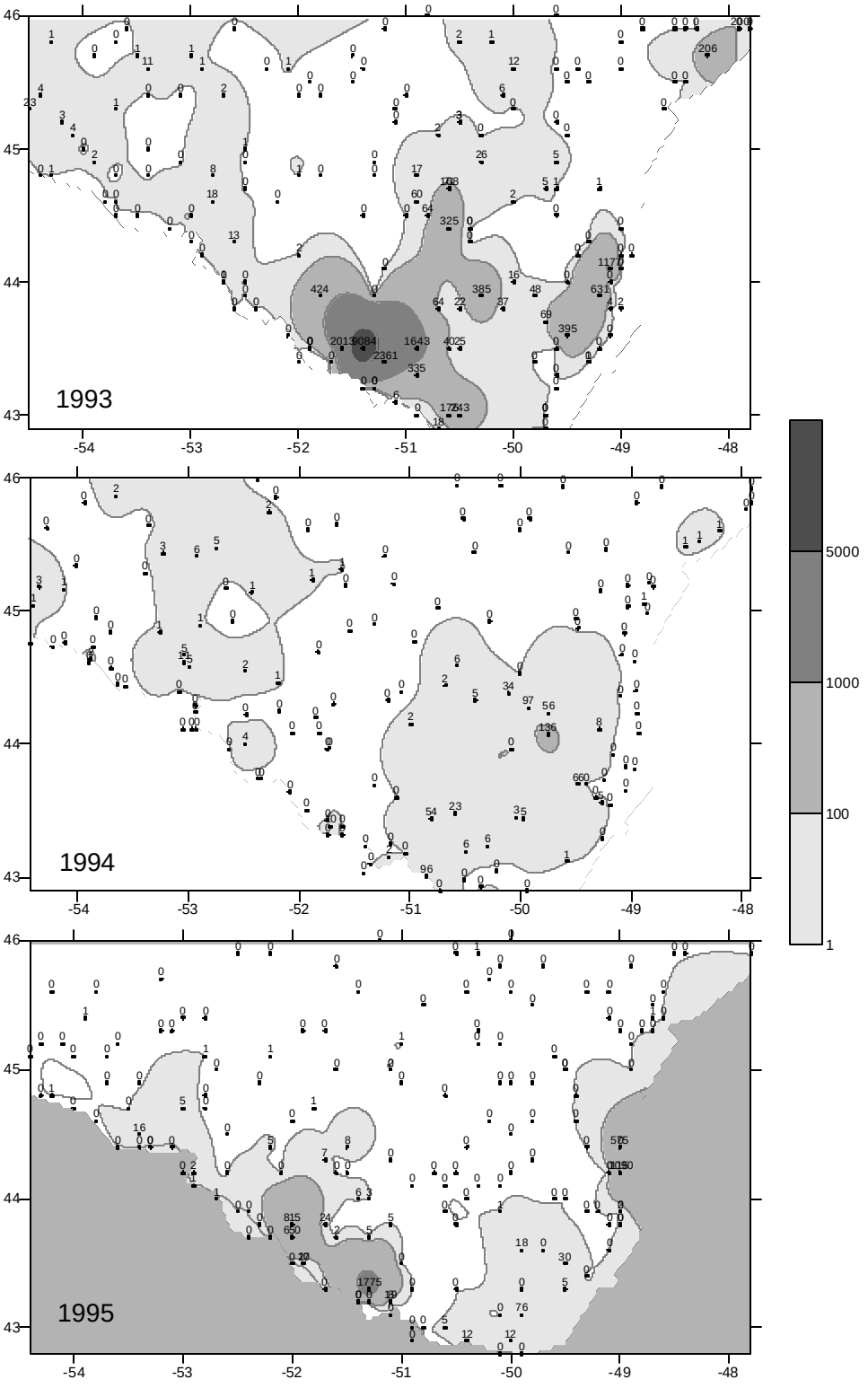


Fig. 3. (Continued).

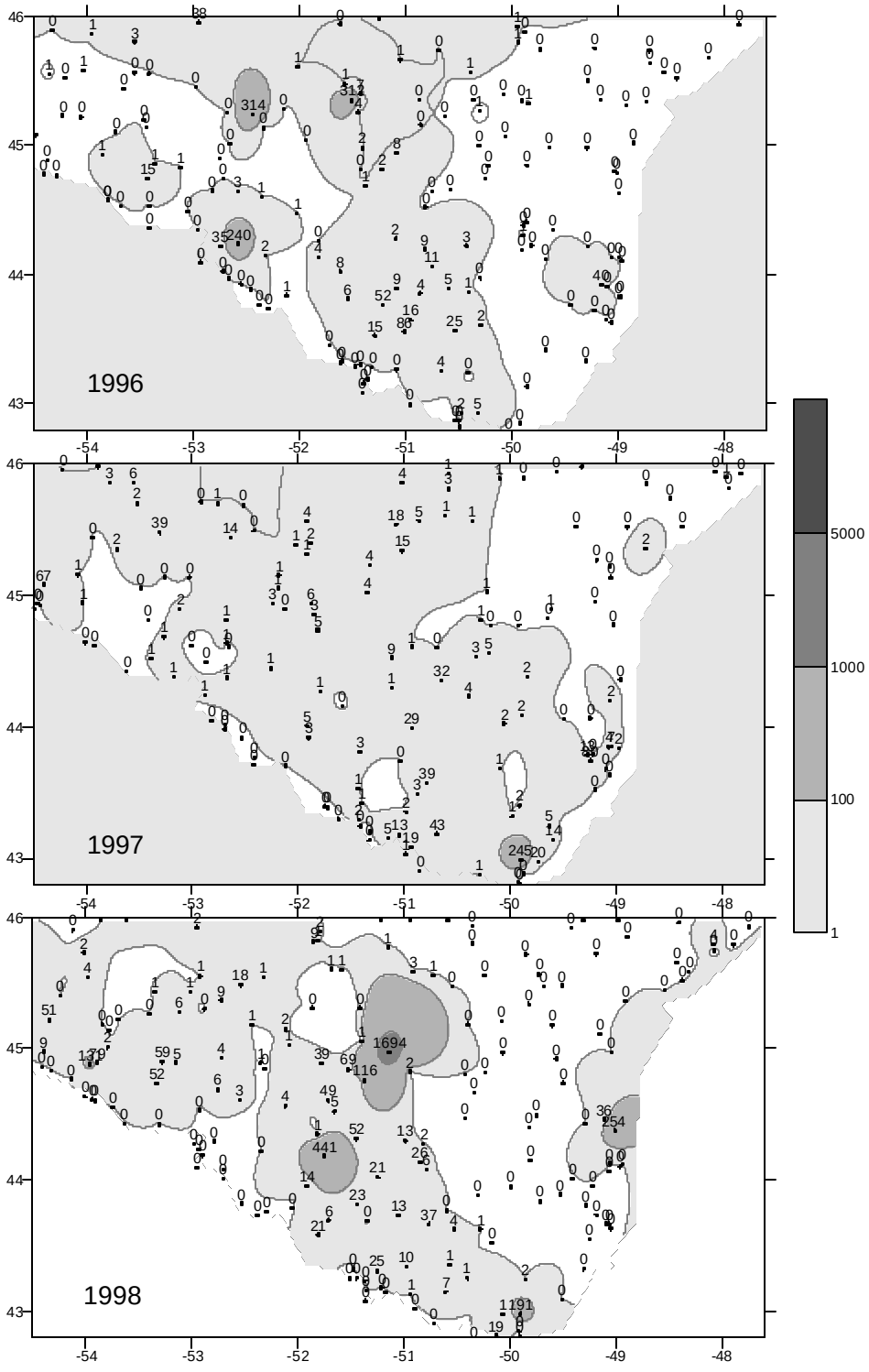
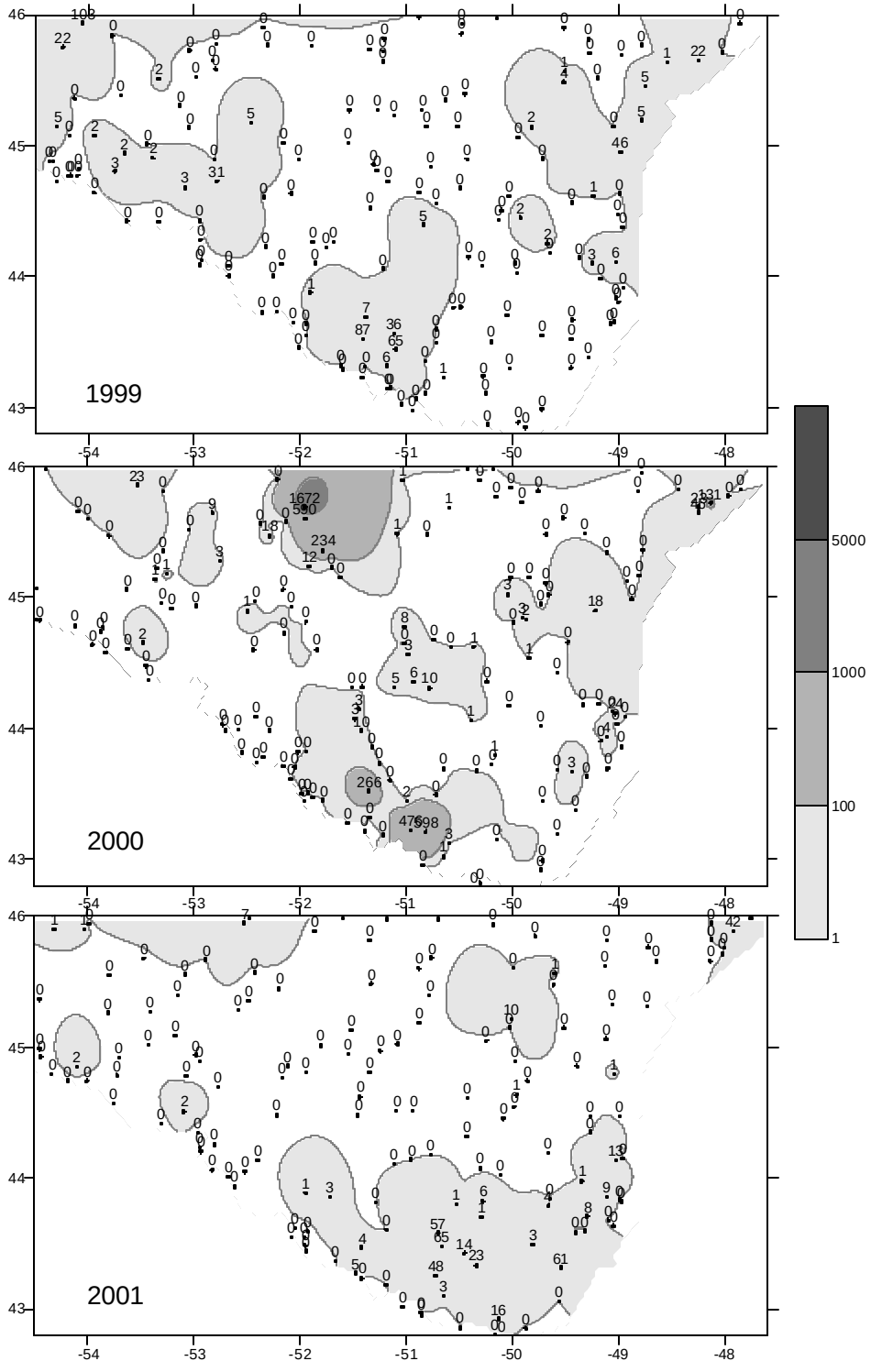


Fig. 4. Distribution of capelin catches (specimens/tow) in Div. 3NO. 1996-2001.



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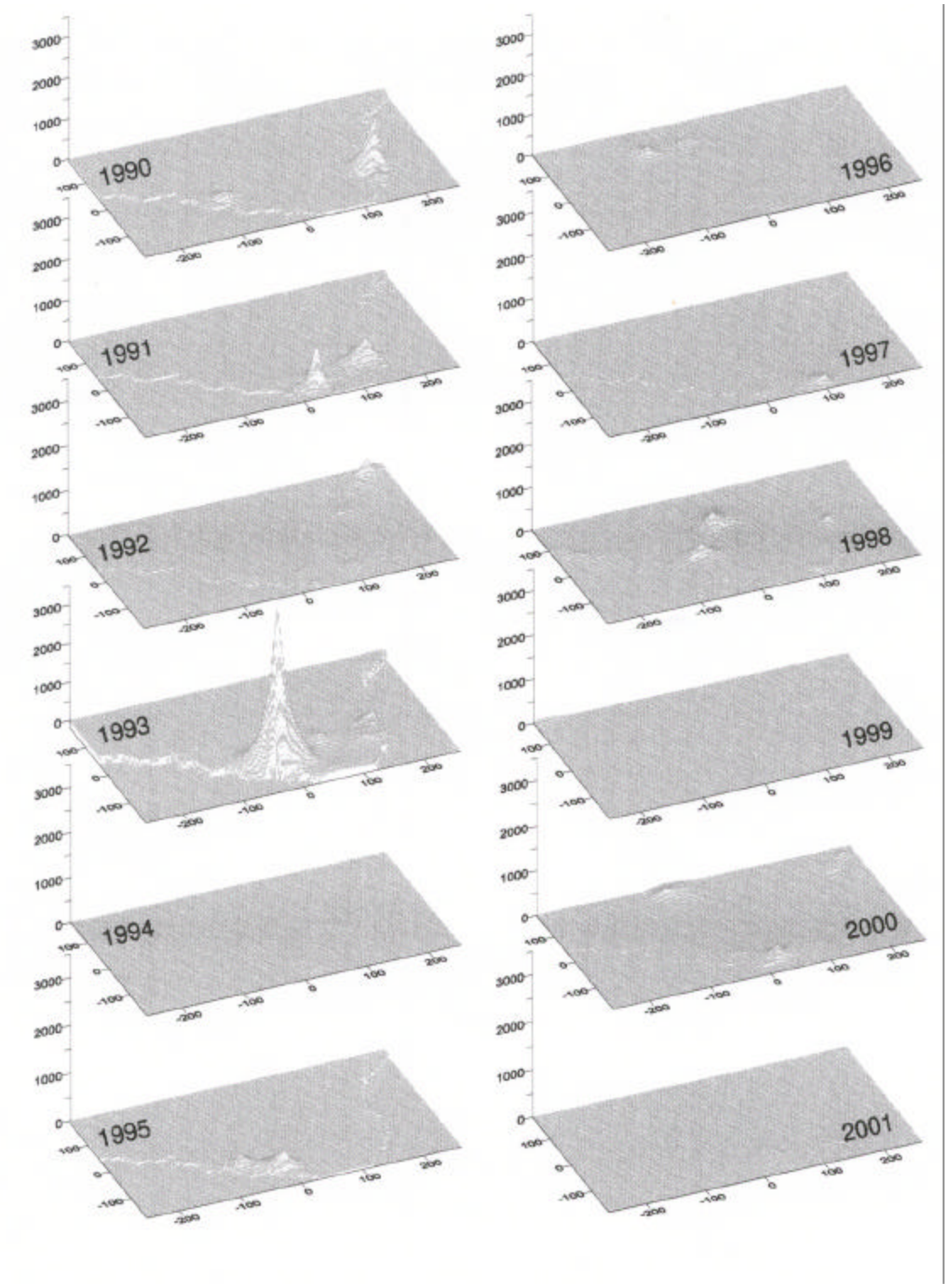

Fig. 5. Distribution of capelin biomass (kg/km^2) in Div. 3NO, 1991-2001.