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The Development and Distribution of *Calanus finmarchicus* on Flemish Cap in the Spring of 1979

by

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INTRODUCTION

Calanus finmarchicus is the dominant calanoid in the Northwest Atlantic, and specifically on Flemish Cap. The dynamics of this species are expected to reveal the main processes affecting the entire zooplankton community. In particular, the regions of highest standing stocks of C. finmarchicus indicate areas of high phytoplankton standing stock and productivity. These productive zones are to be subsequently explained by physical oceanographic mechanisms.

This zooplankton study is directed at determining the conditions for survival of Sebastes sp. ichthyoplankton, the dominant larval fish species on Flemish Cap in recent years. The regions where first released larval fish appear should be in areas most suitable for their survival, if natural selection controls spawning site selection on Sebastes sp. The timing and regions of C. finmarchicus small copepodite appearance in large numbers probably plays an important role in Sebastes sp. ichthyoplankton survival, since they are a dominant food item for early Sebastes sp.as eggs and nauplii.

MATERIALS AND METHODS

This information from 1979 comes from three Canadian research vessel cruises to Flemish Cap. These were Gadus Atlantica 19, 20A and 20B. The Julian dates were days 78-84, 113-118, 125-128. Each cruise occupied stations based on the 'Flemish Cap Plankton Grid' agreed to in the ICNAF Environmental Subcommittee. There were 51, 41 and 25 usable stations in these cruises. Other data exists from USSR cruises of that year.

Sampling in the field was by double oblique tows to 125 (Cruise 19) or 200 (Cruises 20A, 20B) meters, using BONGO nets with flowmeters, depthmeters and 333 micrometer mesh. Tow speed was approximately 3 nmi/h, and tows lasted about 20 minutes. Preservation was in 5% formalin stock and 2% concentrated sodium borate solution. No correction has been made for day-night variation, or for the possible loss of CVI that are in water beneath the plankton tows.

Counting each copepodite stage was done after using a Matoda splitter. Some stations had as many as 9 consecutive splits, most had approximately 6. Calculation of numbers/m^2 involved multiplying the numbers counted by a suitable power of 2 to account for splitting, dividing by the volume filtered by the BONGO net, and multiplying by the depth of tow. Usually between 2 and 3 meters squared were sampled.

Smallest copepodites, CI, CII, are not retained fully by 333 micrometer mesh (Cohen, this session). To some extent their presence is biased by other materials that might clog the mesh. However they do exhibit apparently meaningful patterns of 'relative abundance'. While the numbers observed can't be expressed as numbers/m^2, they are comparable within themselves, yielding valuable conclusions. Calanus finmarchicus is the largest common calanoid on the Cap, and samples from 333 micrometer mesh nets do not have the same useful information on the development of other calanoids.

Given all uncertainties, particularly in tow profile and splitting errors, the accuracy of each count is perhaps as low as ±30%. Since the numbers range over 3 orders of magnitude, this does not obscure the spatial pattern. Variability at a single station, but the mean abundance of CIII, CIV, CV, and CVI is felt to be well determined.

RESULTS

Table 1 presents the abundance of each of the 6 copepodite stages for each station of the 3 cruises. The values for CI and CII are relative abundance only, for CIII to CVI these are valid estimates of numbers/m^2. Table 2 summarizes these abundances and standard errors for each stage by cruise.

Figures 1 through 9 present the spatial patterns of early, late, and adult copepodites (CI-CIII, CIV-CV, CVI). Fig. 10 demonstrates changes in the population composition over the cruises.

GADUS 19

Early copepodites, (Fig. 1) are comparatively very rare in all stations, and no pattern of relative abundance is observable. Late copepodites (Fig. 4) show a clear pattern, with a mean abundance of 279 (±29)/m^2 CIV, 705 (±27)/m^2 CV. The centre of Flemish Cap is sparse, the deeper waters (>400 m) richer. A concentric ring of 1000 to 2000/m^2 is discernible, with a disruption in the west near 4730N 4600W. 3700 CIV + CV was the maximum observed, a 'patch' in the southeast. Adult C. finmarchicus also showed a concentric pattern. The northwest and north in particular demonstrate that there was a concentration of adults in a band, with the abundance over deep waters in the northwest tending to drop. High values, 25-89,000/m^2 were encountered at the shallowest part of the Flemish Cap. The southwest slopes over 300 meters were also very rich in adults. The mean abundance of adults over 50 stations was 11700 (±1830)/m^{-2}. Thus CVI was about 10 times more abundant than CIV and CV combined.

Gadus 20A

In the 35 days since Gadus 19, there was a great development of early copepodites which were sampled by Gadus 20A. In spite of unreliable net retention, the abundance increased at 10 to 200 fold. Abundance was high in the north over waters deeper than 400 m (greater than 10,000/m^2), and a high value of 26,000 was encountered in the southwest slopes in waters of 250 meters deep at 4700 N 4530W. Other abundant stations were immediately south of this station. Most of the Flemish Cap shallow water was relatively poor in early copepodites by comparison. In general, the shallower the water, the lower the abundance of early copepodites, except for the one patch of 26,000. Since no estimate of retention of CI and CII has been made, the true abundance is unknown.

Late copepodites abundance had not declined considerably from Gadus 19. The mean abundance over 41 stations was 540 (±65)/m^2 and 704 (±152)/m^2. The range of 300 to 3900/m^2 is not supportive of a concentric pattern. The greatest abundances are over 300-1000 meter water in the north and near the steep slopes of the south. Stations of >1000/m^2 are present in all regions making a claim of any particular pattern unjustified.

Adult C. finmarchicus had a mean abundance over 41 stations of 8598 (±1153)/m^2. This is lower than the mean of Gadus 19, but is not statistically significant. A concentric pattern is apparent, in the northeast, east and south. Adults are common over the shallowest (<250 m deep) part of the Flemish Cap. Comparing the distribution to Gadus 19 reveals that although the mean abundance has not changed significantly, there have been great changes. Values of 10,000 to 25,000/m^2 in the northwest have been reduced to 2000 to 7000. Some suggestion of remmants of the earlier highly abundant stations is found at 4740N 4530-4600W, in values of 10,000 and 17,900/m^2. Possible dispersal of the 89000/m^2 patch encountered in Gadus 19 in the shallows, resulted in stations to the west changing from 4000 to 10,000 and 27,000. These comparisons are only tentative, the scale of the spatial patterns is apparently at the limit of resolution of stations every 20 nmi, and smaller scale (between 2 and 10 miles) patchiness could be aliasing these interpretations.

Gadus 20B

In spite of the relatively few stations, the 3 transects of stations on the grid support a concentric pattern in the early copepodites. Very high numbers (> 50,000/m^2) were observed over deep waters in the northwest, northeast and southeast. Levels over the shallows were 50 times lower. Relatively high (> 20,000/m^2) numbers were over the southwest. Growth from nauplii to copepodites was still vigorously underway from Gadus 20A to Gadus 20B, an interval of only 10 to 12 days.

Late copepodites were abundant for the first time, with levels above 10,000/m^2 in 4 stations in the southwest. The means, not strictly comparable to Gadus 19 and Gadus 20A, were 2940 (±759)/m^2 and 2067 (±558)/m^2, indicating a 5 and 3 times increase for CIV and CV. This indicates that the leading edge of the cohort of copepodites began to move into CIV and CV in the 10 days between Gadus 20A and Gadus 20B.

Adult C. finmarchicus have a mean over the 25 stations of 7595/m^2, continuing down insignificantly from the abundance of Gadus 20A. However, high numbers were encountered in only 5 stations, 2 in the southwest, 2 over the shallowest part of the bank, and 1 in the northwest. A decline in the shallowest part of the bank is apparent, the mean over the 8 central stations in common dropping from 12290 (±3110)/m^2 to 4737 (±1576)/m^2, which is significant at $\alpha = .05$ ($t = 2.165$).

DISCUSSION

SPATIAL PATTERNS

The spatial patterns presented seem to show areas of consistently high abundance of copepodite of Calanus firmarchicus. These areas are 1) the deeper water in waters of 400 to 1000 m, 2) the southwest area in 300-800 m north of Beothuk Knoll, and 3) as evidenced by CVI early concentrations, the shallowest area, particularly toward the southern steep slopes.

In spite of the high levels of CVI observed in the area less than 250 m deep in Gadus 19 and 20A, relatively very few early copepodites were encountered later. These adult may be the contributions to the early copepodites of the southwestern area however, this would be expected if the presumed slow anticyclonic gyre carried the eggs and nauplii passively.

DEVELOPMENT TIMING

Fish (1936) reviewed rates of early development for Calanus. In the Clyde Sea, the period from egg to CI was 11 days, and each succesive adult took 3 days. Temperatures were approximately 7°C. Off Norway the life cycle was almost 90 days, and there were 49 days between the nauplii maximum and the maximum of CVI. In Georges Bank there were two major spring peaks of early copepodtes, March-April and June-July. He concluded that 75 days development was required. Further, this broke down as 30 days from NI to CI, 15 days from CI to CV, and another 30 days as adults.

Assuming that Flemish Cap has a spring ocean climate is slightly colder then Norway and Georges Bank, 90 days seems to be a good approximation. The temperatures of the northwest concentrations of C. finmarchicus CVI in Gadus 19 and CI, II, III in Gadus 20A and 20B were:

Gadus 19	3.2-3.6
Gadus 20A	2.0-2.3
Gadus 20B	5.5-6.0

Marshall and Orr (1955, p. 79) contains the following timetable for a copepod in the summer in the Clyde Sea:

Stage	Development duration
I-II	2
II-III	3
III-IV	3
IV-V	3½
V-VI	10½
Total	22

Applying this timetable to a 90 day lifespan in Flemish Cap, allowing 30 days for egg to CI development, suggest the following first estimates for Flemish Cap copepodites ages:

Stage	Age (Days)
CI	30-32
CII	32-35
CIII	35-38
CIV	38-42
CV	42-50 (Summer only)
CVI	50-90 (Summer only)

This agrees with the Norwegian Sea observation of 49 days from nauplii maxima to CVI maxima.

The ages of CV and CVI will be uncertain since these animals overwinter largely as CV and mature in spring to become CVI (adults). The presence of abundant CVI suggests spawning is imminent.

The survey data can be used to estimate when spawning began in 1979 for *C. finmarchicus* at Flemish Cap by using the following table:

	Stage first appearing	Stage peaking	Development time	Day os peak egg release
78-84 (81)	I	CVI	-	>78-84
113-118 (116)	I, II, III	-	30-38	>78-86
125-129 (127)	IV, V		38-50	>77-89
125-128	-	II	32-35	92-95

From this the conclusion is that *Calanus* mass spawning began some time around day 90 and may have been peaking around day 100. These dates are March 31 and April 10, 1979 respectively.

CALANUS FINMARCHICUS SPAWNING COMPARED TO *SEBASTES* SP. SPAWNING

Anderson and Akenhead (1980) identified *Sebastes* sp spawning starting in days 80 to 84. Peak *Sebastes* sp. spawning was apparently not until day 115 or so. The earliest spawning of *Sebastes* sp. observed in the southeast and northwest. At that time there were concentrations of *Calanus firmarchicus* CVI in those areas. The implication is that *Sebastes* sp. have maximal extrusion timed to coincide with maximum abundance of *Calanus finmarchicus* eggs and nauplii. Since the main food of early *Sebastes* sp. is copepod eggs and nauplii, these observations strengthen the hypothesis that there could be dependence of *Sebastes* sp. year-class success on vagarities of *Calanus finmarchicus* production. A mismatch of predatory ichthyoplankton extrusion to the appearance of prey eggs and nauplii could conceivably decrease survivorship signficantly. Further examinations of the zooplankton in years of good and poor *Sebastes* sp. ichthyoplankton survival are required to test this match-mismatch hypothesis. The conclusion at this point is that in 1979, the *Sebastes* sp. spawning was not too early. The other two cases, too late and matching, are not distinguished with this data.

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Table 1. Calanus finmarchius copepodite abundance, spring, 1979.

Set	Lat.	Long.	CI	CII	CIII	CIV	CV	CVI
Gadus 19, days 78-84, 1979								
22	48'20"	43'30"	0	100	70	100	400	8900
23	48'00"	43'30"	0	0	60	400	900	15000
24	47'40"	43'30"	0	140	140	200	600	5400
25	47'20"	43'30"	0	150	40	400	600	10700
26	47'00"	43'30"	0	0	30	30	250	1400
27	46'40"	43'30"	0	0	100	200	260	2800
28	46'20"	43'30"	0	0	0	300	500	9030
30	46'40"	44'00"	0	20	0	240	600	690
31	47'00"	44'00"	0	100	0	400	1200	14600
32	47'20"	44'00"	0	0	0	300	400	11700
33	47'40"	44'00"	50	100	800	600	1100	9700
34	48'00"	44'00"	50	0	50	300	150	6500
35	48'20"	44'00"	0	120	300	250	1700	11500
36	48'20"	44'30"	310	50	50	260	600	20900
37	48'00"	44'30"	0	30	90	90	300	8400
38	47'40"	44'30"	3	140	300	120	500	12800
39	47'20"	44'30"	0	70	60	40	40	1000
40	47'00"	44'30"	0	460	200	0	900	88800
41	46'40"	44'30"	0	0	30	50	300	7600
42	46'20"	44'30"	0	150	300	500	1000	15800
43	46'20"	45'00"	0	0	0	300	1200	7000
44	46'40"	45'00"	0	0	40	80	80	3700
45	47'00"	45'00"	0	120	60	60	60	3500
46	47'20"	45'00"	0	100	350	100	1200	25500
47	47'40"	45'00"	0	50	90	130	600	8100
48	48'00"	45'00"	10	30	90	50	60	1700
49	48'20"	45'00"	0	0	0	800	1000	22200
50	48'20"	45'30"	0	0	110	300	700	18400
51	48'00"	45'30"	0	270	200	200	1900	22100
52	47'40"	45'30"	0	30	410	70	100	7200
53	47'20"	45'30"	0	0	140	130	150	3700
54	47'00"	45'30"	0	100	130	0	260	8900
55	46'40"	45'30"	10	40	670	360	1200	8400
56	46'20"	45'30"	0	60	130	350	400	4600
57	46'00"	45'30"	0	220	190	430	700	7200
58	46'00"	46'00"	10	70	70	360	400	2100
59	46'20"	46'00"	0	0	60	350	400	5500
60	46'29"	45'53"	0	60	30	170	900	2800
61	46'40"	46'00"	0	0	130	500	1500	25500
62	47'00"	46'00"	0	0	210	800	2500	27900
63	47'20"	46'00"	0	30	130	800	300	9000
64	47'40"	46'00"	0	40	40	200	200	7700
65	48'00"	46'00"	0	110	110	200	700	10200
67	48'20"	46'30"	0	40	20	140	700	5200

Table 1 (Cont'd).

Set	Lat.	Long.	CI	CII	CIII	CIV	CV	CVI
68	48'00"	46'30"	40	60	310	500	2100	2600
69	47'40"	46'30"	0	150	70	400	1600	25200
70	47'20"	46'30"	0	40	120	200	350	4300
71	47'00"	46'30"	0	20	0	100	120	6800
72	46'40"	46'30"	0	0	140	610	1500	18200
73	46'20"	46'30"	0	0	470	470	300	19800
79	46'13"	45'45"	0	0	20	110	300	3200
Gadus 20A, days 13-118, 1979								
21	46'30"	44'00"	443	728	560	672	443	10310
22	46'37"	43'59"	0	256	415	525	354	4238
23	47'00"	44'00"	92	459	550	92	550	30820
24	47'20"	44'00"	43	129	237	215	194	3141
25	47'39"	44'01"	0	289	286	289	723	9498
26	48'00"	44'00"	374	2952	2541	860	1233	15470
27	48'20"	44'00"	1896	6005	1761	90	316	3567
28	48'21"	44'29"	11710	3650	1903	732	1317	20350
29	48'00"	44'30"	531	1111	1304	1063	435	21740
31	47'20"	44'30"	91	76	334	395	273	3979
32	47'00"	44'30"	1172	830	486	514	1029	10550
33	46'45"	44'30"	0	16	263	476	213	5366
34	46'20"	44'30"	0	82	736	429	307	5030
35	46'20"	45'01"	2413	3410	5508	1836	682	4249
36	46'39"	44'59"	1467	367	122	1345	2567	27010
37	47'00"	45'00"	0	154	231	308	366	9966
38	47'20"	45'00"	0	217	1959	142	1088	24160
39	47'40"	45'00"	0	275	452	178	178	1973
40	48'04"	45'01"	594	4846	2651	411	823	6949
41	48'20"	45'00"	13650	2793	233	621	1241	7215
42	48'20"	45'30"	16680	3107	690	230	1381	7250
43	48'00"	45'30"	2495	3381	831	594	653	6118
44	47'39"	45'28"	43	175	786	371	218	9960
45	47'20"	45'30"	2865	7537	3488	346	249	1433
46	47'00"	45'30"	11270	9778	4153	1494	697	13170
47	46'40"	45'30"	6592	6112	2272	384	224	4448
48	46'20"	45'30"	3279	6558	2018	1135	757	6432
49	46'20"	46'00"	399	599	1198	699	599	11380
50	46'40"	46'00"	149	568	987	209	239	3140
51	47'00"	46'00"	1680	2320	1280	760	280	6520
53	47'40"	46'00"	4772	985	1893	1060	3257	17870
54	48'00"	46'00"	163	1478	458	88	222	1041
55	48'20"	46'00"	61	10340	1885	304	304	1338
56	48'20"	46'30"	10700	2077	559	479	1877	7029
57	48'00"	46'32"	7209	1802	416	139	1294	6839
58	47'40"	46'30"	1113	712	267	178	134	2048
59	47'20"	46'30"	341	3781	1116	279	248	2882
60	47'00"	46'30"	340	227	340	340	340	2322
61	46'40"	46'30"	570	6956	2737	1254	1140	11400
62	46'20"	46'30"	66	355	377	266	199	2196
63	46'00"	46'30"	89	244	399	355	266	1553
Gadus 20B days 125-128								
113	46'40"	44'00"	1805	2467	1985	1324	1504	6137
114	47'00"	44'00"	324	1137	1353	595	487	7144
115	47'20"	44'00"	3749	7456	2500	431	775	3189
116	47'40"	44'00"	6347	26920	17940	2731	2341	9557
117	48'00"	44'00"	14010	39970	12360	1648	824	3709
119	48'19"	45'00"	887	13940	9251	1774	633	5830
120	48'00"	45'00"	63	317	222	633	1014	8491
121	47'40"	45'00"	370	296	715	197	370	3601

Table 1. (Cont'd.

Set	Lat.	Long.	CI	CII	CIII	CIV	CV	CVI
122	47'20"	45'00"	41	343	822	301	343	2562
123	47'00"	45'00"	1301	3036	2721	1341	592	3115
124	46'40"	45'00"	43	586	629	1475	736	3920
127	46'52"	44'37"	44	657	1140	2016	1841	15340
128	47'00"	44'30"	0	230	480	1358	877	4971
129	47'10"	44'45"	0	327	600	1800	3109	9982
130	47'20"	44'30"	170	800	1188	824	1018	3369
132	48'00"	46'00"	6053	47920	16900	2774	504	10340
133	48'00"	46'00"	860	18170	15410	859	737	2517
134	47'40"	46'00"	5102	37120	29220	1002	668	3951
135	47'20"	46'00"	3493	4223	1929	365	365	886
136	47'00"	46'00"	9779	9449	6592	7581	2417	6043
137	46'40"	46'00"	1969	13000	11220	8271	3545	53170
138	46'20"	46'00"	1006	10860	35810	15290	11060	13480
140	46'20"	35'40"	158	5452	9006	5610	2923	3872
141	46'40"	45'30"	2301	12430	14040	11280	10590	4027
142	47'00"	45'30"	3424	10580	5136	2023	1401	622

Table 2. Mean abundance of Calanus firmarchicus copepod in three surveys of Flemish Cap, 1979.

Days	Stations		CI	CII	CIII	CIV	CV	CVI
78-84	50	Mean	10	64	136	279	705	11712
		Std. Err.	6	12	23	29	27	1834
113-118	41	Mean	2545	2384	1251	540	704	8598
		Std. Err.	670	436	192	65	152	1153
125-128	25	Mean	2424	10707	9696	2940	2067	7597
		Std. Err.	678	2714	1886	759	558	2037

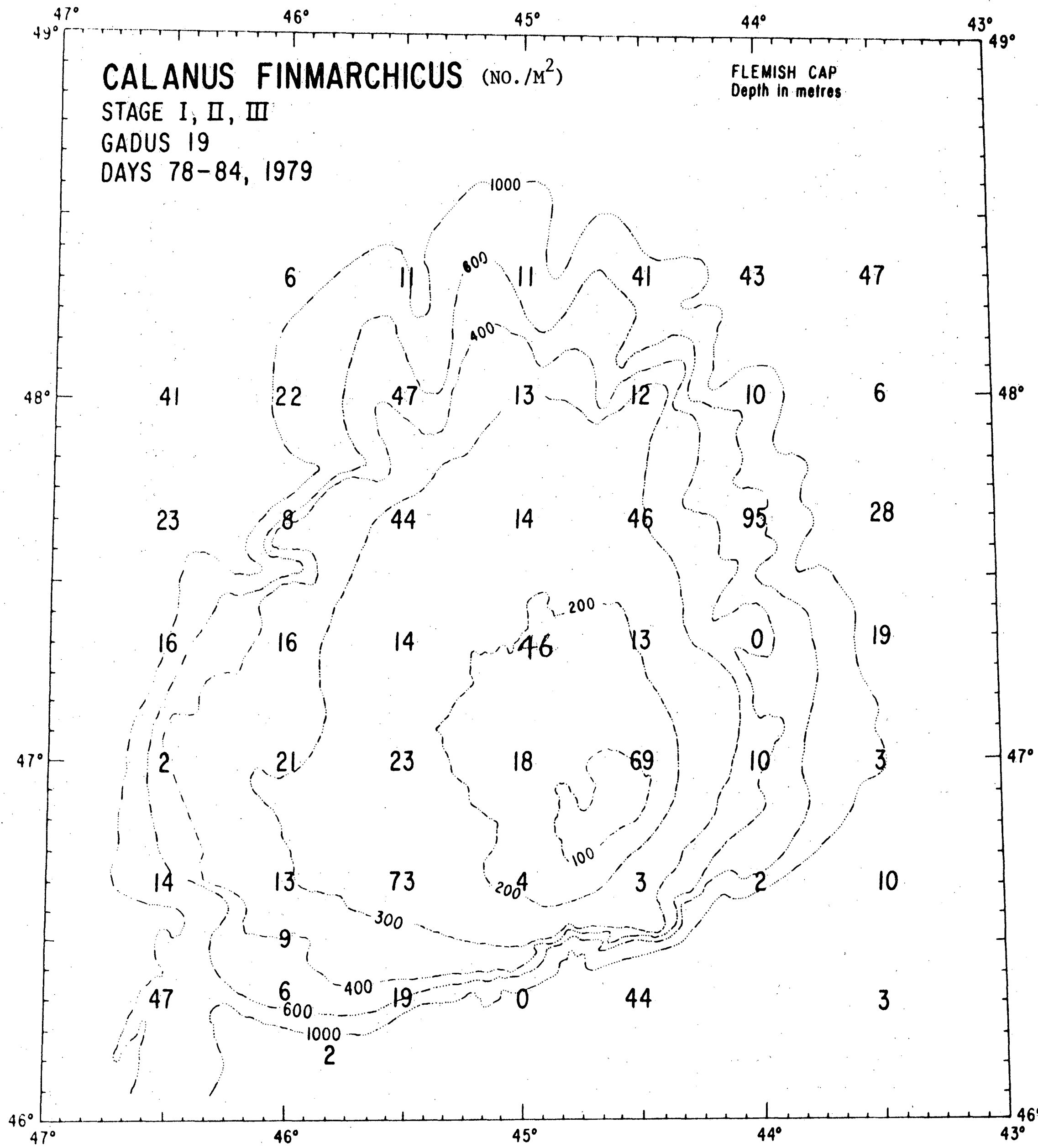
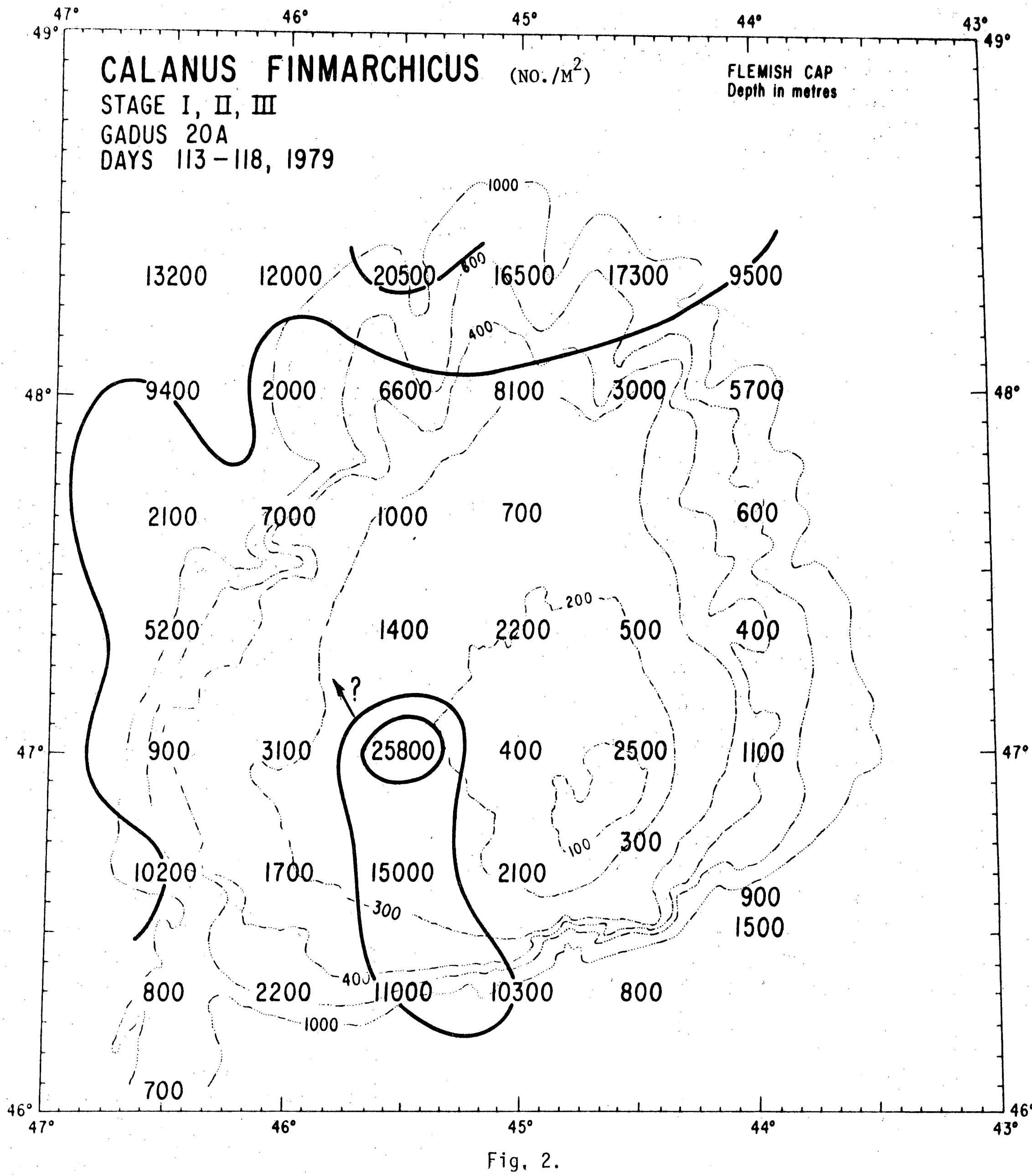

CALANUS FINMARCHICUS (NO./M²)
STAGE I, II, III
GADUS 19
DAYS 78-84, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
1000
600
400
300
200
100

Fig. 1.


CALANUS FINMARCHICUS (NO./M2)
STAGE I, II, III
GADUS 20A
DAYS 113-118, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
13200
12000
20500
16500
17300
9500
9400
2000
6600
8100
3000
5700
2100
7000
1000
700
600
5200
1400
2200
500
400
900
3100
25800
400
2500
1100
300
10200
1700
15000
2100
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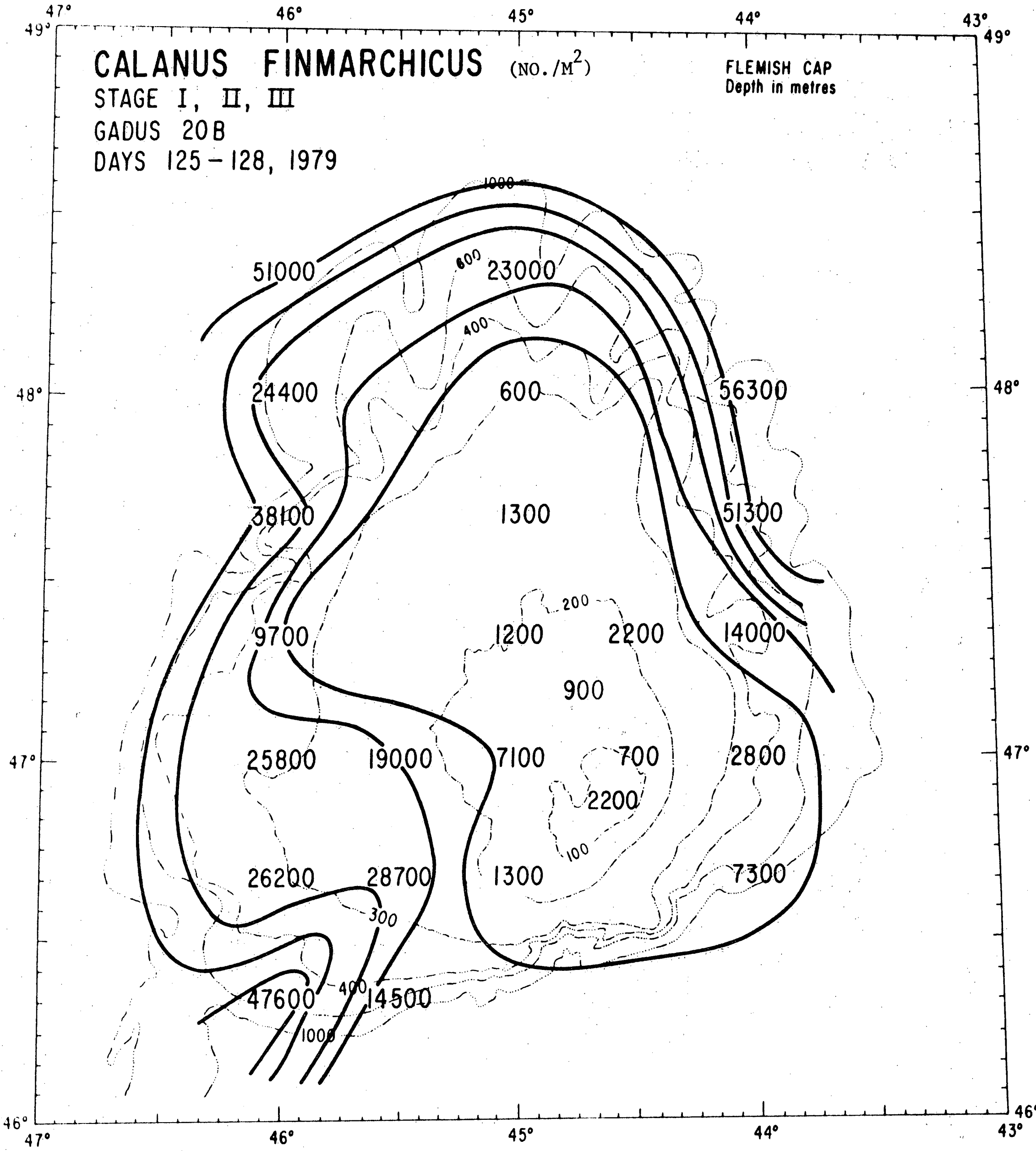
400
1000
?

Fig. 2.


CALANUS FINMARCHICUS (NO./M²)
STAGE I, II, III
GADUS 20B
DAYS 125 – 128, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
51000
23000
24400
600
56300
38100
1300
51300
9700
1200
2200
14000
900
25800
19000
7100
700
2800
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300
400
1000

Fig. 3.

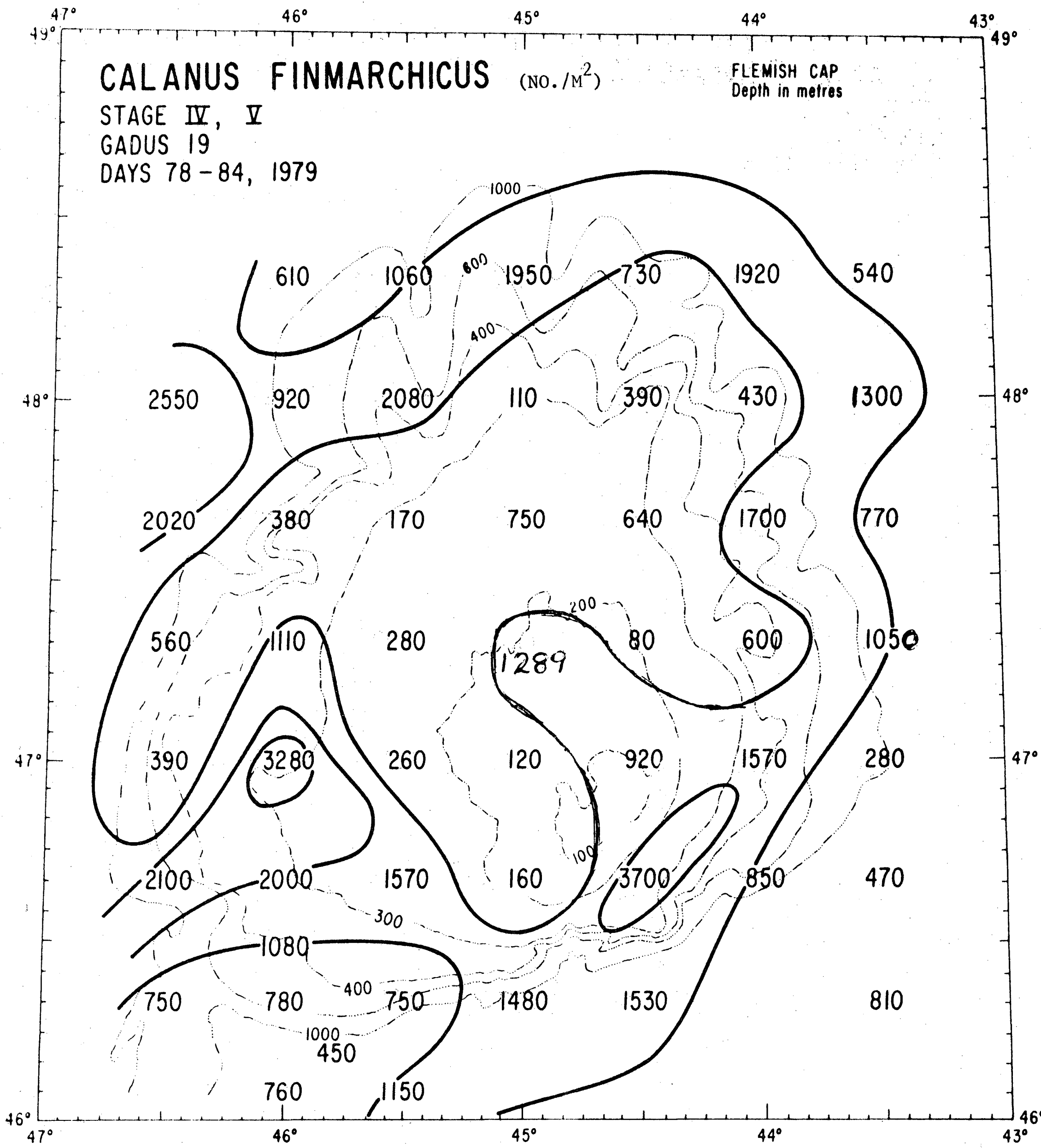
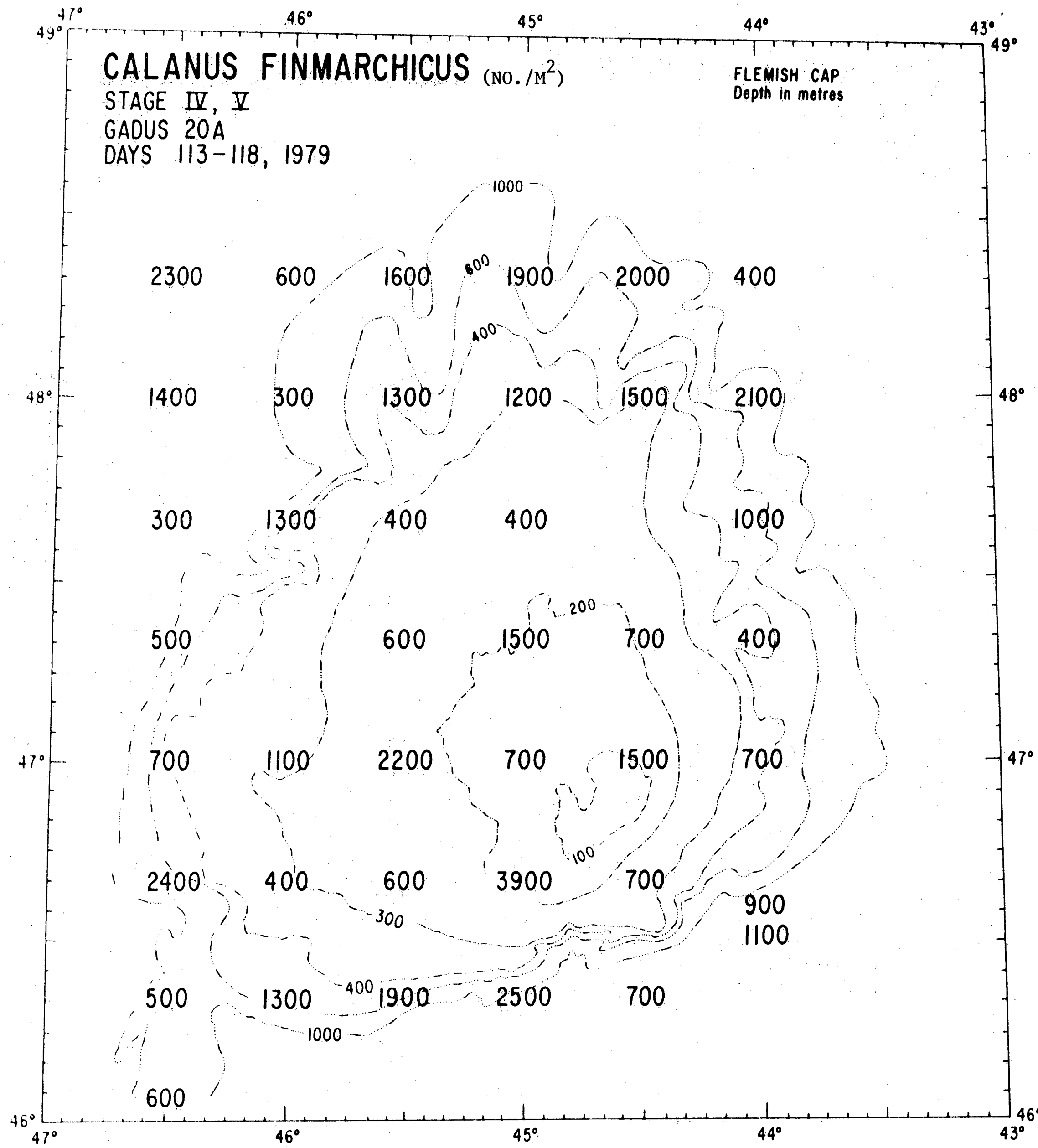
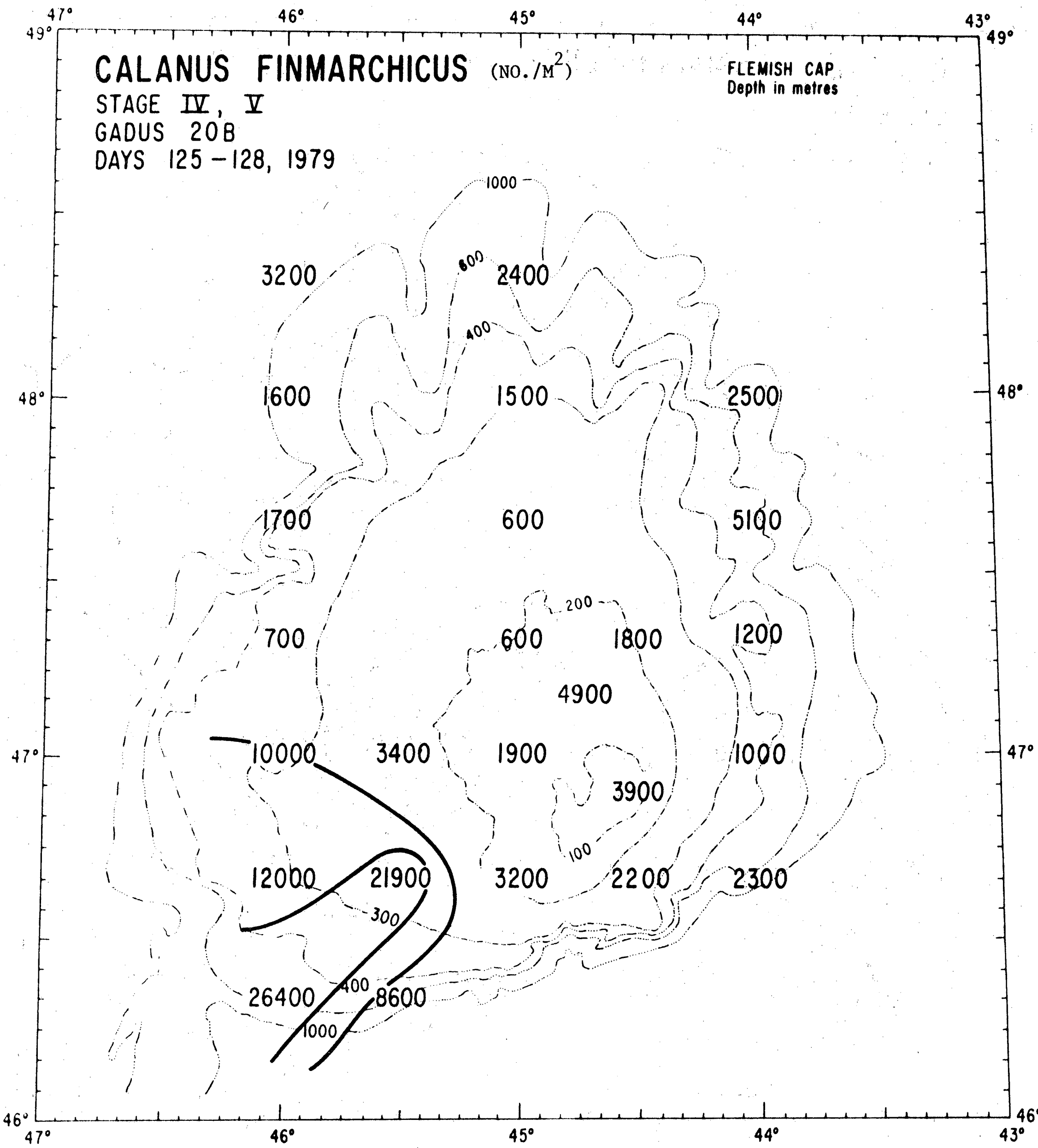

CALANUS FINMARCHICUS (NO./M2)
STAGE IV, V
GADUS 19
DAYS 78 - 84, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
610
1060
1950
730
1920
540
2550
920
2080
110
390
430
1300
2020
380
170
750
640
1700
770
560
1110
280
1289
80
600
1050
390
3280
260
120
920
1570
280
2100
2000
1570
160
3700
850
470
1080
750
780
750
1480
1530
810
450
760
1150
1000
600
400
200
100
300
400
1000

Fig. 4.



CALANUS FINMARCHICUS (NO./M²)
STAGE IV, V
GADUS 20A
DAYS 113-118, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
2300
600
1600
1900
2000
400
1400
300
1300
1200
1500
2100
300
1300
400
400
1000
500
600
1500
700
400
700
1100
2200
700
1500
700
2400
400
600
3900
700
900
1100
500
1300
1900
2500
700
600
1000
600
400
200
100
300
400
1000

Fig. 5.



CALANUS FINMARCHICUS (NO./M²)
STAGE IV, V
GADUS 20B
DAYS 125 – 128, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
3200
2400
1600
1500
2500
1700
600
5100
700
600
1800
1200
4900
10000
3400
1900
1000
3900
12000
21900
3200
2200
2300
26400
8600
1000
600
400
200
100
300
400
1000

Fig. 6.

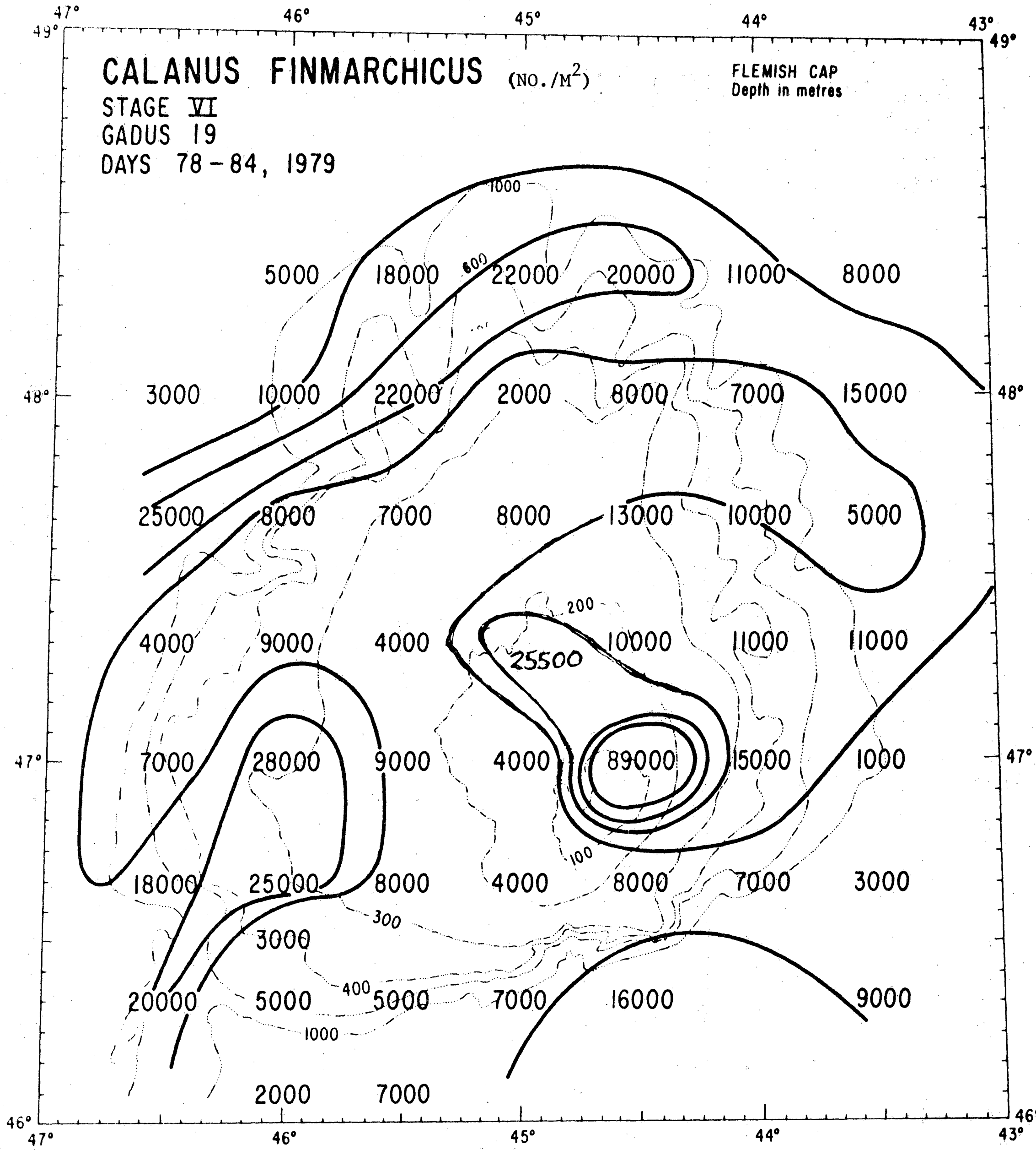

CALANUS FINMARCHICUS (NO./M²)
STAGE VI
GADUS 19
DAYS 78 - 84, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
5000
18000
22000
20000
11000
8000
3000
10000
22000
2000
8000
7000
15000
25000
8000
7000
8000
13000
10000
5000
4000
9000
4000
25500
10000
11000
11000
7000
28000
9000
4000
89000
15000
1000
18000
25000
8000
4000
8000
7000
3000
3000
20000
5000
5000
7000
16000
9000
2000
7000
1000
600
200
100
300
400
1000

Fig. 7.

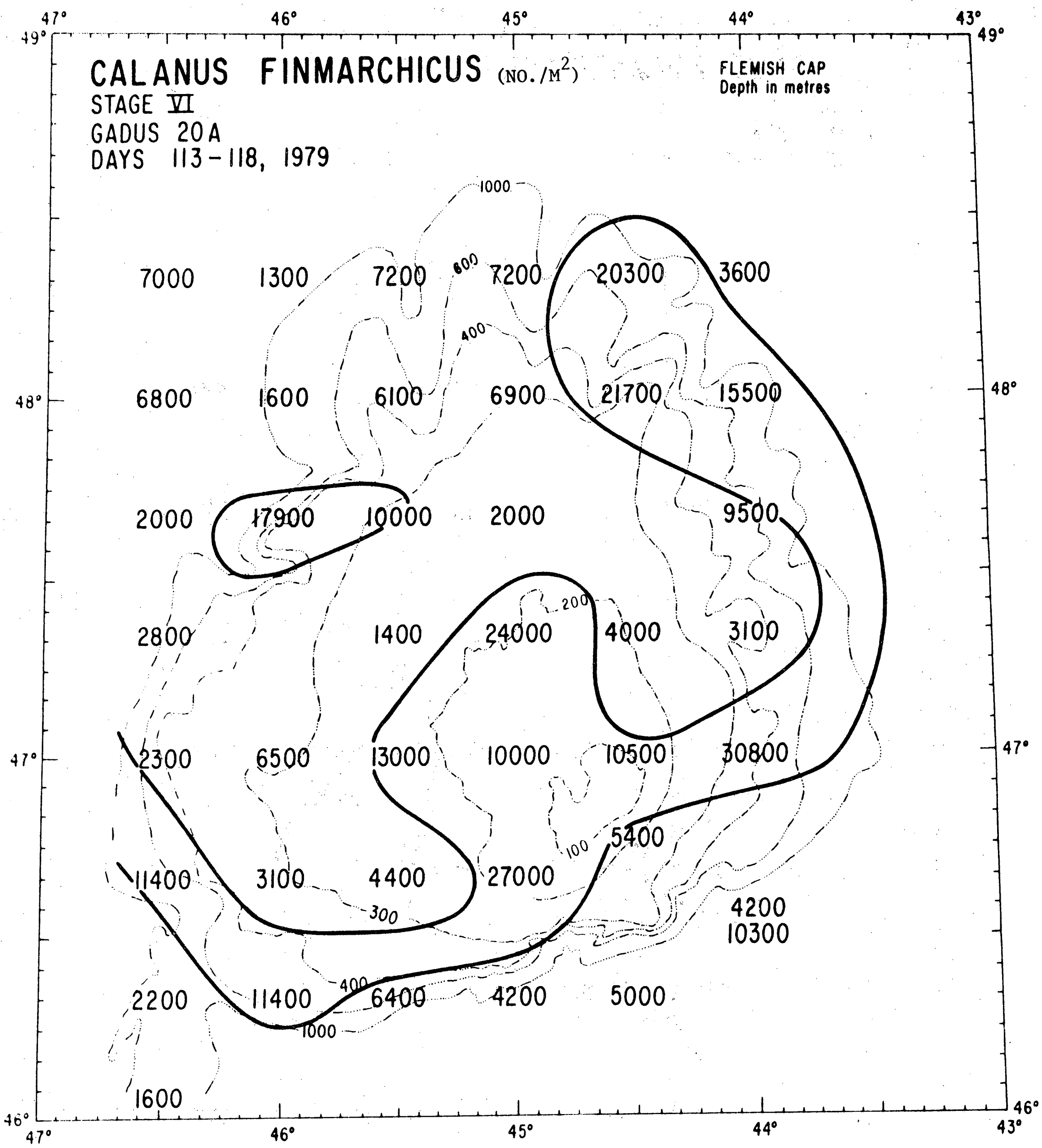

CALANUS FINMARCHICUS (NO./M^2)
STAGE VI
GADUS 20A
DAYS 113-118, 1979
FLEMISH CAP
Depth in metres
47° 46° 45° 44° 43°
49° 48° 47° 46°
1000 800 400 200 100 300
7000 1300 7200 7200 20300 3600
6800 1600 6100 6900 21700 15500
2000 17900 10000 2000 9500
2800 1400 24000 4000 3100
2300 6500 13000 10000 10500 30800
11400 3100 4400 27000 5400 4200 10300
2200 11400 6400 4200 5000
1600

Fig. 8.

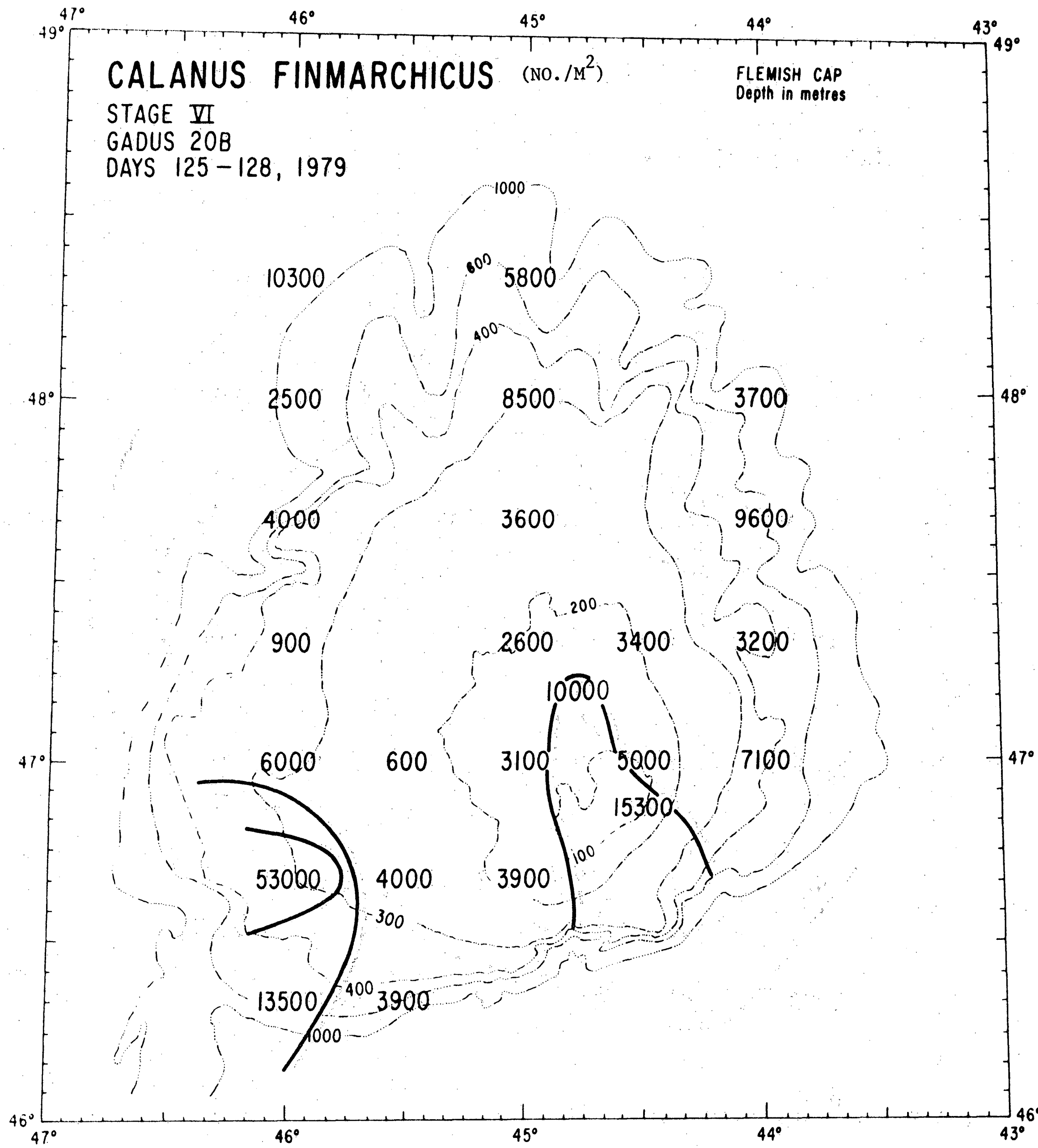

CALANUS FINMARCHICUS (NO./M^2)
STAGE VI
GADUS 20B
DAYS 125 – 128, 1979
FLEMISH CAP
Depth in metres
47°
46°
45°
44°
43°
49°
48°
47°
46°
1000
600
400
200
100
300
10300
5800
2500
8500
3700
4000
3600
9600
900
2600
3400
3200
10000
6000
600
3100
5000
7100
15300
53000
4000
3900
13500
3900

Fig. 9.

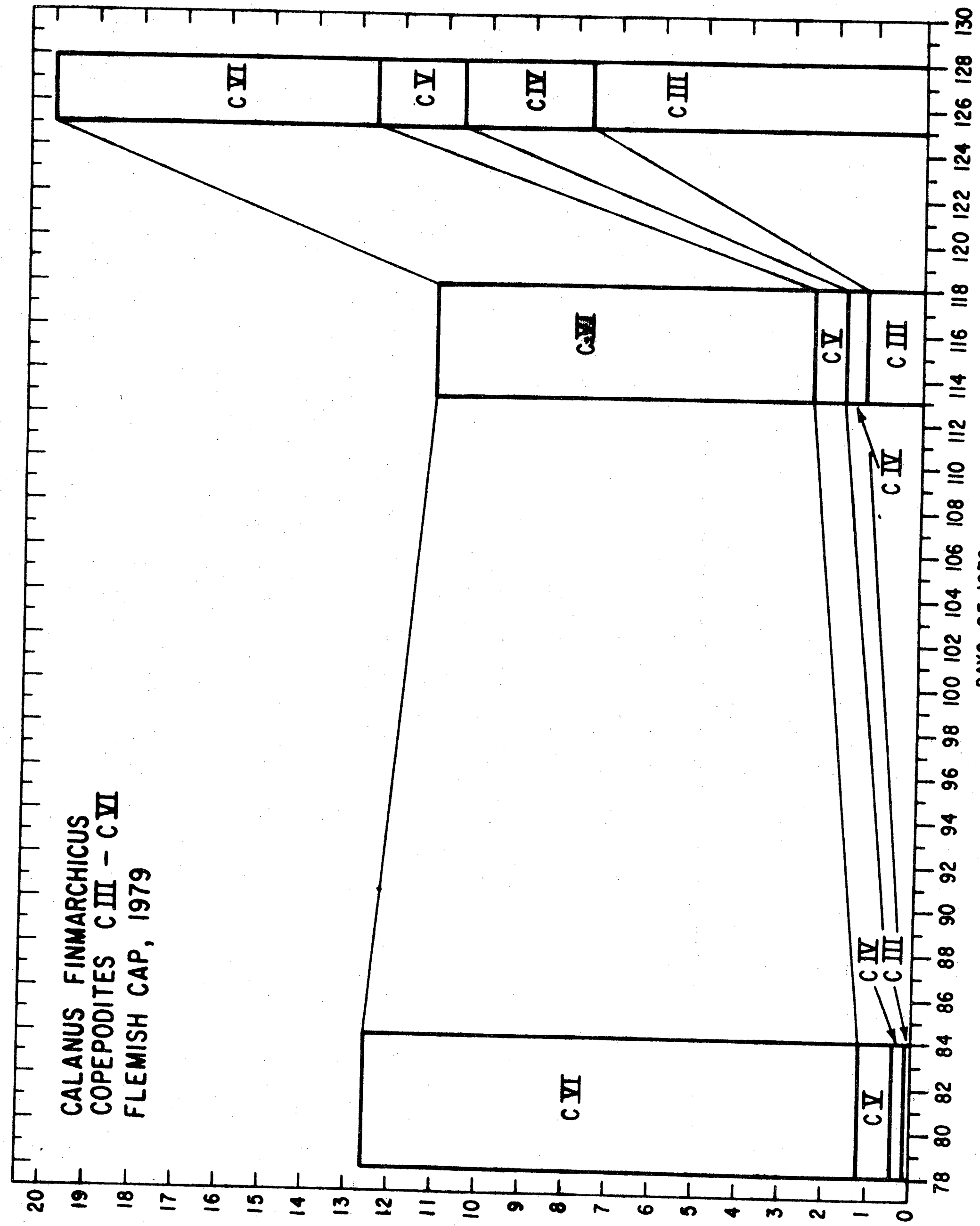

CALANUS FINMARCHICUS
COPEPODITES C III - C VI
FLEMISH CAP, 1979
NUMBER M^{-2} x 10^{-3}
DAYS OF 1979
C VI
C V
C IV
C III

Fig. 10