Northwest Atlantic Fisheries Organization

Serial No. N526

NAFO SCR Doc. 82/VI/37

SCIENTIFIC COUNCIL MEETING - JUNE 1982

Distribution, abundance and growth of cod (Gadus morhua) and redfish (Sebastes spp.) larvae on Flemish Cap, 1981

by

J. T. Anderson
Research and Resource Services
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

ABSTRACT

Cod larvae (Gadus morhua) appeared on Flemish Cap in 1981 in significant numbers for the first time since the beginning of the Flemish Cap Project four years ago. Larval abundances decreased from 3.5×10^{10} larvae in early May to 4.8×10^{8} larvae twelve weeks later, values being <1% of those estimated for redfish larvae. There is no immediate explanation for their occurrence in 1981 as compared to previous years. Abundances of larval redfish (Sebastes spp.) during April-May were similar to previous years although by July they were the lowest yet observed. Distribution on Flemish Cap and the estimated date of peak hatching in cod and extrusion in redfish, about 23 April 1981, were very similar for both species. However, trends in both growth and mortality rates, differed. Growth rates for larval cod ranged from 0.20-0.42 mm SL d^{-1}, increasing throughout the period as surface waters heated. Redfish growth rates, on the other hand, decreased initially from 0.08-0.04 mm SL d^{-1}, then increased to a maximum of 0.26 mm SL d^{-1} by July. There appeared to be no direct relationship between growth rates and mortality in either cod or redfish. Mortality rates for cod larvae peaked at 0.079 during early June while those of redfish increased from 0.043-0.093 throughout the sampling period.

INTRODUCTION

Ichthyoplankton surveys were carried out on Flemish Cap four times in 1981 as part of the Flemish Cap Project. This is a continuation of work carried out during the preceeding three years, with samples being taken during June for the first time in an attempt to sample the onset of a second peak in redfish spawning. The distribution, abundances and population growth rates of redfish (Sebastes spp.) and cod (Gadus morhua) larvae are reported.

MATERIALS AND METHODS

The 42-station grid on Flemish Cap was sampled three times in 1981, 2-9 May, 22-27 May and 26-30 June. During 1-4 August, 20 stations of the grid were sampled. In all cases double oblique Bongo tows were made to 200 m, or within 5 m of the bottom, following the basic procedures outlined by Smith and Richardson (1977). In most cases 61 cm Bongos were fitted with paired nets of 0.333 µm mesh sizes, although some stations during 2-9 May were sampled using 505 µm mesh net sizes. All eggs and larvae were counted and measured to the nearest millimeter standard length from both nets. Processing of samples and calculations of abundances followed procedures previously outlined (Anderson and Akenhead 1981).

RESULTS

Redfish

Redfish were the most abundant larvae sampled on Flemish Cap during 1981. Abundances during 2-9 May 1981, our first cruise to Flemish Cap in 1981, ranged from 0.2-559.6 larvae m^{-2}. There was an extensive area of values greater than 100 larvae m^{-2} over much of Flemish Cap (Fig. 1a) with total abundance estimated to be 2.44×10^{14} larvae. Approximately three weeks later, during 22-27 May 1981, abundance had approximately halved to 1.13×10^{14} larvae, ranging from 0.0-220.1 larvae m^{-2}. Distribution

of the most abundant larvae were now in a large band north of central Flemish Cap between ~200-400 m depth (Fig. 1b). One month later, during 26-30 June 1981, abundance had dropped by an order of magnitude, to 1.46×10^{13}. Larvae now ranged from 0.0-23.4 larvae m^{-2} being distributed in a broad irregular area over Flemish Cap (Fig. 1c). Finally, five weeks later during 1-4 August, 1981 abundance had dropped to approximately 2.5×10^{11} larvae. Values ranged from 0.0-2.1 larvae m^{-2}, highest values being observed in waters just west of central Flemish Cap >200 m depth (Fig. 1d).

During our first cruise to Flemish Cap, 2-9 May, 1981, the mean size of redfish larvae was 8.34 mm SL (Fig. 2a). This increased to 9.83 mm SL by the end of May and to 18.87 mm SL by the end of June. The re-appearance of 6 mm SL larvae during 26-30 June 1981 indicates the beginning of a second redfish spawning at this time (Fig. 2b and c). By 1-4 August, 1981 larvae ≥15 mm SL and ≥18 mm SL averaged 20.44 mm SL and 21.37 mm SL, respectively (Fig. 2d). Values were model around 20 mm SL, with a second peak at 16 mm SL. Larvae relatively abundant at 6 mm SL indicated extrusion was still taking place during this time.

Redfish abundances decreased from a maximum of 6.11×10^{12} larvae estimated for the 42-station grid area during 2-9 May, 1981 to approximately 1.24×10^{10} larvae during the first week of August (Fig. 3) (Table 1). During this time there was apparently 99.8% mortality in redfish larvae on Flemish Cap. Mortality rates ($\bar{z}$) increased from 0.04 to 0.093 d^{-1} throughout this period, with highest mortality occurring between the June and August surveys (Table 3). Abundances observed around the end of April through May were virtually identical with those observed during the preceeding three years. By July, however, values had decreased below that of preceeding years, including 1979 when only larvae <11 mm SL were observed (Fig. 3). July abundances, standardized to Julian day 200, indicated 1981 redfish larvae were only 1/3 of 1979 abundances and an order of magnitude less than estimates for 1978 and 1980 on this date.

Offsetting increasing rates of mortality were increasing growth rates in redfish larvae. Initially values were low, decreasing from 0.08 mm SL d^{-1} at day 136 to 0.04 mm SL d^{-1} at day 162. After this point growth rates increased for the remainder of the sampling period to a maximum of 0.26 mm SL d^{-1} between the June and August sampling dates (Fig. 4). Paralleling this increase in growth rates was increasing surface water temperature. Average water temperatures in the upper 30 m over central Flemish Cap, at 47°N 45°W, increased from 5.87°C in early May to 11.80°C in early August (Fig. 4). The greatest rates of increase occurred up to day 162 (12 June 1981) (0.11 °C d^{-1}) with values falling off after this date.

Cod

Cod larvae were present in significant numbers during 1981 for the first time in four years of survey work on Flemish Cap. During 2-9 May, 1981 values ranged from 0.0-4.1 larvae m^{-2} with highest values being observed in the area north of central Flemish Cap between 200-400 m depth (Fig. 5a). Three weeks later, during 22-27 May, 1981, larvae were again most abundant in the area just north of central Flemish Cap (Fig. 5b). In both cases abundances >1.0 m^{-2} were also observed just south of the central area. By the 26-30 June, 1981 cod larvae had disappeared from all but a small area in the central region (Fig. 5c) and 1-4 August, 1981 were only observed in small numbers at two stations on Flemish Cap (Fig. 5d).

Abundances of cod larvae decreased from an estimated 3.49×10^{10} in early May to $<5.0 \times 10^{8}$ larvae in early August 1981 (Table 1). While present during our surveys in significant numbers for the first time in four years abundances were still low, usually being <1% of redfish larvae. By the June survey the actual number of cod sampled at four stations on the grid was only 7 cod larvae.

As with redfish larvae estimates of mortality were higher, ranging to over 98%. Mortality rates ($\bar{z}$) ranged from 0.023 to 0.079 with the highest value occurring between Julian days 145 and 179 (Table 3). Unlike redfish larvae mortality rates did not increase throughout the sampling period. However, due to the extremely low numbers of cod larvae sampled, especially during the last two sampling dates 26-30 June and 1-4 August, 1981, these values should be viewed with caution.

Average size of cod larvae were 6.00, 9.83, 18.87 and 34.06 mm SL, respectively, during the four sampling periods. These values represent average growth rates ranging from 0.20 to 0.42 mm SL d^{-1}. Unlike redfish growth rates in cod larvae increased throughout the sampling period (Fig. 4). Although numbers are low the rate of growth increased in a linear fashion and the values appear to reasonably represent growth rate for these larvae. The increase in the rate of growth closely parrallels increasing water temperatures, at least to day 180 (24 June, 1981).

DISCUSSION

The most notable observation in ichthyoplankton samples form Flemish Cap during 1981 was the appearance of cod eggs and larvae in our samples. For the first time in four years of survey work cod larvae were observed throughout the Flemish Cap area. Reasons for their appearance remains a cause for speculation. Redfish larval abundance was very similar to previous years during the

April-May period, and lower during July. Redfish growth rates, although low initially, were approximately 0.152 mm SL d^{-1} from late May to July. This was very similar to an estimate of 0.146 mm SL d^{-1} during this same period in 1980 (Anderson MS 1981). Finally, water temperatures over central Flemish Cap were not substantially different in 1981 for the previous two years, being within ±1.0°C of each other at any one time from April to July (unpubl. data). In general, there did not appear to be any substantial differences in the overall Flemish Cap regime.

Abundance at age from Canadian research trawl surveys indicated 4-yr-old cod recruits decreased from 10.0 x 10^6 in 1978 to 2.7 x 10^6 in 1979 and 0.6 x 10^6 in 1980 but increased again in 1981 to 3.0 x 10^6 fish (Gavaris MS 1981). This increase in 4-yr-old fish can be attributed to incoming recruits from the 1977 year-class. Total abundance, however, has decreased steadly from 51.1 x 10^6 to 5.2 x 10^6 during this same period (Ibid.). Whether or not the appearance of cod larvae in our samples can be attributed to incoming recruits from the 1977 year-class is not known. Increased survival of cod eggs and larvae would account for the presence of cod larvae in 1981, redfish data did not indicate significant increases in abundance or mortality in 1981. Whether there was a response resulting in greater numbers of eggs being released in 1981 is not known.

The progression of redfish distributions in 1981 was very similar to previous years. Larvae were distributed throughout the area at earlier dates when abundant, but were confined to shallower waters later on. As in 1979 larvae were most often found in highest numbers in waters north and west of central Flemish Cap, numbers being low over the central area. A very similar distribution was observed for cod larvae. The extent to which water transport governs these distirbutions or whether there is higher survival in these areas associated with better feeding and growth has not yet been examined. Growth and condition studies carried out in 1980 indicated these factors were largely controlled by surface water temperatures specific to small water masses scattered on Flemish Cap (Anderson MS 1982). The question of the importance of variable larval survival in different areas versus physical retention mechanisms as determinants of growth and survial remains as one of the important outstanding questions for the Flemish Cap Project.

Redfish growth rates from 22-27 May to 1-4 August averaged 0.152 mm SL d^{-1}. This was very similar to that of 0.146 mm SL d^{-1} estimated for this same period in 1980. However, growth rates for redfish larvae ranged from 0.04 to 0.26 mm SL d^{-1} throughout the May-July sampling period. The initial decrease in growth rates was unexpected. Abundances were similar to previous years and water temperatures appeared to be seasonal. In addition, cod experienced increases in growth rates during this same time. A similar decrease was observed in instantaneous growth rates calculated from larval redfish otoliths (Penney MS 1982). This decrease occurred about 18 days post hatch. If peak extrusion of larvae was around the beginning of May than these low growth rates would have been expected during May, as was observed. Growth rates calculated from length-frequency data, however, indicated the minimum growth rate occurred between 25 May (day 126) and 28 June (day 145), much later than would have been expected from the otolith instantaneous growth estimates if peak extrusion occurred around in late April-early May.

Increased growth rates following the initial decrease in redfish larvae reached a maximum of 0.25 mm SL d^{-1} from the June through July. At this time larvae averaged 34 mm SL. If this rate of growth was maintained then 180 days later, corresponding to 1 Feburary, 1982, these fish would be ~80 mm SL. This corresponds very closely to the smallest size of juvenile redfish observed in cod stomachs at that time, around 70 to 80 mm total length (Lilly MS 1982). Incidence of feeding by cod on juvenile redfish, presumed to be 1-yr-old, would be a useful index of year-class strength corresponding to larval survival.

Cod larvae growth rate estimates increased from 0.20 to 0.42 mm SL d^{-1} throughout this same period. Unlike redfish cod larvae did not demonstrate any initial decrease in growth rate. If cod maintained a growth rate of 0.42 mm SL d^{-1} then 180 days later, corresponding to 1 February, 1982, cod would be ~110 mm SL. This correspond very closely to a model value of 100 cm observed in 0-group cod during February 1982. The increasing growth rate closely parallel increasing surface water temperatures which warmed from 5.5-5.9°C during 2-9 May to 10.7-11.8°C during 1-4 August, 1981. Similarly, increasing growth rates in redfish, following in initial decline, parallel this temperature increase. Obviously temperature is an important deterimant affecting growth rates. Significant changes from year to year in temperature and the rate of heating would be epxected to affect growth and survival in fish larvae on Flemish Cap.

Estimated date of peak extrusion in 1981 for redfish on Flemish Cap varies depending on the growth rate used. Calculating from the survey 22-27 May 1981 and using a growth rate of 0.08 mm SL d^{-1} calculated from 6-25 May indicates peak redfish extrusion occurred about 23 April 1981 (Day 113). Using data from 1-4 August 1981 with a mean value of 20.44 mm SL and an average growth rate of 0.15 mm SL d^{-1}, calculated for the June-July period indicates peak extrusion occurred 5 May 1981 (Day 125). However, given the lower growth rates observed during May, it is likely peak extrusion occurred prior to 5 May. Similarly for cod larvae, using a mean hatching length of 3.5 mm SL, cod larvae averaging 9.83 mm SL during 22-27 May 1981 and growing at 0.27 mm SL d^{-1} indicates peak hatching of cod larvae on Flemish Cap in 1981 occurred about 23 April (Day 113). The close agreement in estimated dates of peak hatching and extrusion in cod and redfish larvae is interesting. It indicates a close syncrony in their life histories no doubt related to their environment.

Data collected 26-30 June 1981 indicated a second spawning of redfish had recently begun and continued through July into at least the first week of August. This second spawning has been attributed to Sebastes fasciatus and possibly S. marinus as well (Templeman 1976). In overall abundance it is possibley two to three orders of magnitude less than the April-May spawning peak. However, the period of extrusion appears to extend over a longer time as larvae at 5 mm SL were still the most abundant of the small size group by the first week of August.

Mortality estimates for redfish larvae increased from 0.043 to 0.093 throughout the sampling period. These rates increased in a linear fashion indicating increased mortality as these larvae grew. Mortality rates also indicated there was no 'critical' period through the sampling period associated with the initial period of decreasing growth rates. Cod larvae, on the other hand, indicated maximum mortality occurred during the early part of June, decreasing from 0.079 to 0.031 by July, with no reduction in growth rates during this time. Thus, while cod larvae experienced maximum mortalities during June, redfish larvae had increasing rates of mortality throughout the sampling period. These data indicate there was no direct relationships between growth and mortality rates from May to early August 1981.

REFERENCES

Anderson, J. T. MS 1981. Larval fish surveys on Flemish Cap, 1980. NAFO SCR Doc. 81/IX/116.

MS 1982. Size and condition of larval Sebastes spp. on Flemish Cap during spring 1980. NAFO SCR Doc. 82/VI/38

Anderson, J. T., and S. A. Akenhead. 1980. Distribution and abundance of larval cod and redfish on Flemish Cap in 1978 and 1979. NAFO SCR Doc. 80/IX/150.

Gavaris, S. MS 1981. Assessment of the cod stock in Division 3M. NAFO SCR Doc. 81/II/12.

Lilly, G. R., and C. A. Gavaris. MS 1982. Distribution and abundance of juvenile redfish (Sebastes sp.) on Flemish Cap in winter 1982: evidence of strong recruitment. NAFO SCR Doc. 82/VI/35.

Penney, R. W. MS 1982. Otolith analysis of age and growth of larval redfish (Sebastes spp.) on Flemish Cap, 1981. NAFO SCR Doc. 82/VI/40.

Smith, P. E., and S. L. Richardson. 1977. Standard techniques for pelagic fish egg and larval surveys. FAO Fish. Tech. Paper No. 175.

Templeman, W. 1976. Biological and oceanographic background of Flemish Cap as an area for research on the reasons for year-class success and failure in cod and redfish. ICNAF Res. Bull. No. 12.

Table 1. Abundance estimates for cod (Gadus morhua) and redfish (Sebastes spp.) larvae on Flemish Cap, 1981

Period (Julian days)	n	Area (m^2)	Cod		Redfish	
			Abundance	In abundance	Abundance	In abundance
122-129	40	5.50×10^{10}	3.49×10^{10}	24.28	6.11×10^{12}	29.44
142-147	42	5.77×10^{10}	2.27×10^{10}	23.84	2.70×10^{12}	28.62
177-181	41	5.63×10^{10}	1.51×10^{9}	21.14	3.55×10^{11}	26.60
213-216	20	2.75×10^{10}	4.80×10^{8}*	19.99*	1.24×10^{10}*	23.24*

*Estimate based on 20 stations sampling 86% of the larvae present

Table 2. Larval Sebastes spp. abundance estimated for Flemish Cap during July during the period 1978-81. Values were standardized to Julian day 200.

Year	Abundance	In abundance
1978	2.78×10^{11}	26.35
1979	7.57×10^{10}	25.05
1980	1.52×10^{11}	25.75
1981	2.78×10^{10}	24.05

Table 3. Estimates of mortality in cod (Gadus morhua) and redfish (Sebastes spp.) larvae on Flemish Cap, 1981

Period (Julian days)	Mid-Date (Julian Day)	Cod		Redfish	
		% Mortality	Mortality Rate(Z)	% Mortality	Mortality Rate(Z)
126-145	136	34.9	0.023	55.8	0.043
126-179	153	95.6	0.059	94.2	0.054
145-179	162	93.3	0.079	86.9	0.059
126-215	171	98.6	0.048	99.8	0.070
145-215	180	97.8	0.055	99.5	0.077
179-215	197	68.2	0.031	96.5	0.093

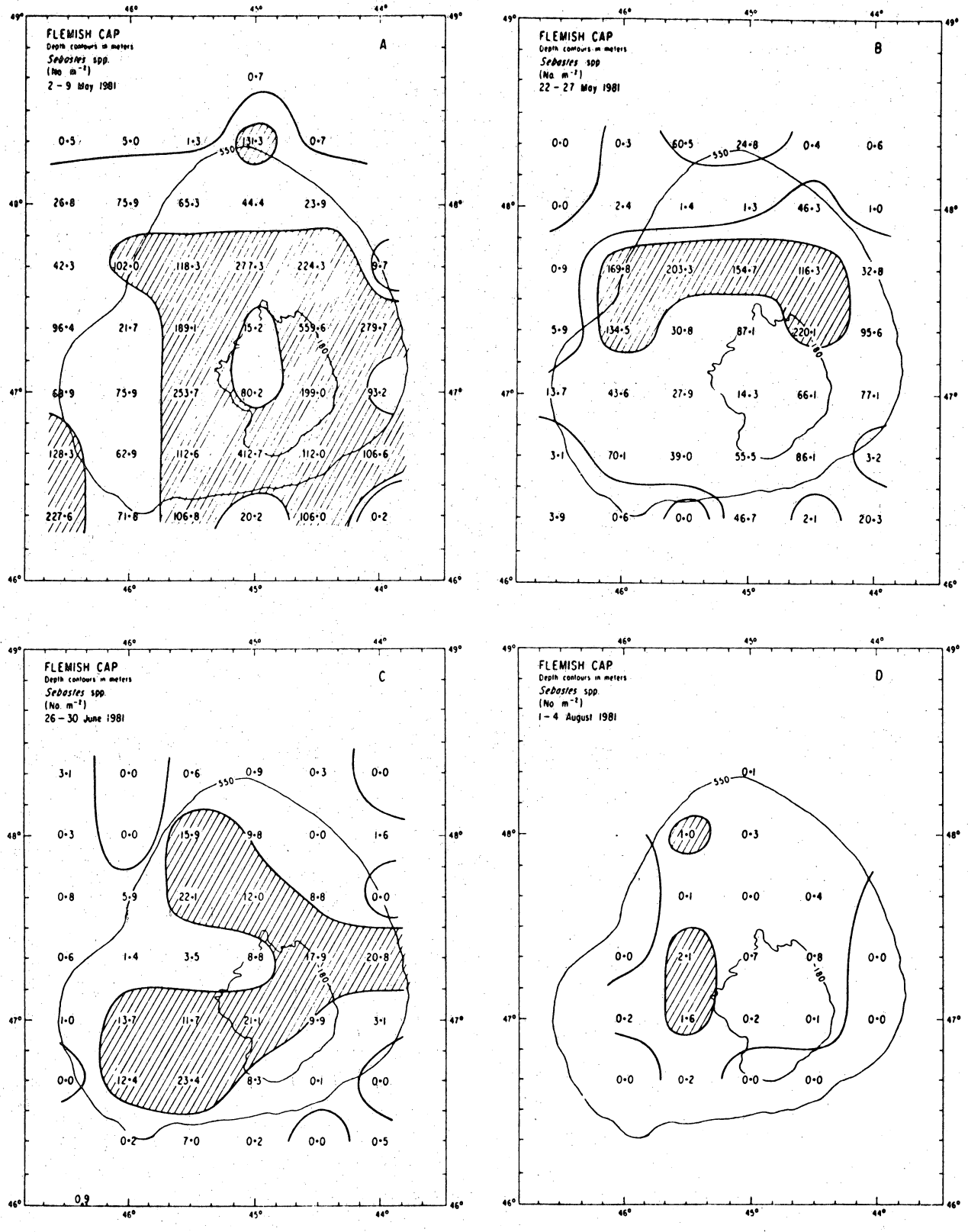

Figure 1. Distributions of Sebastes spp larvae (no. m^{-2}) on Flemish Cap in 1981: a) 2-9 May; b) 22-27 May; c) 26-30 June; d) 1-4 August.

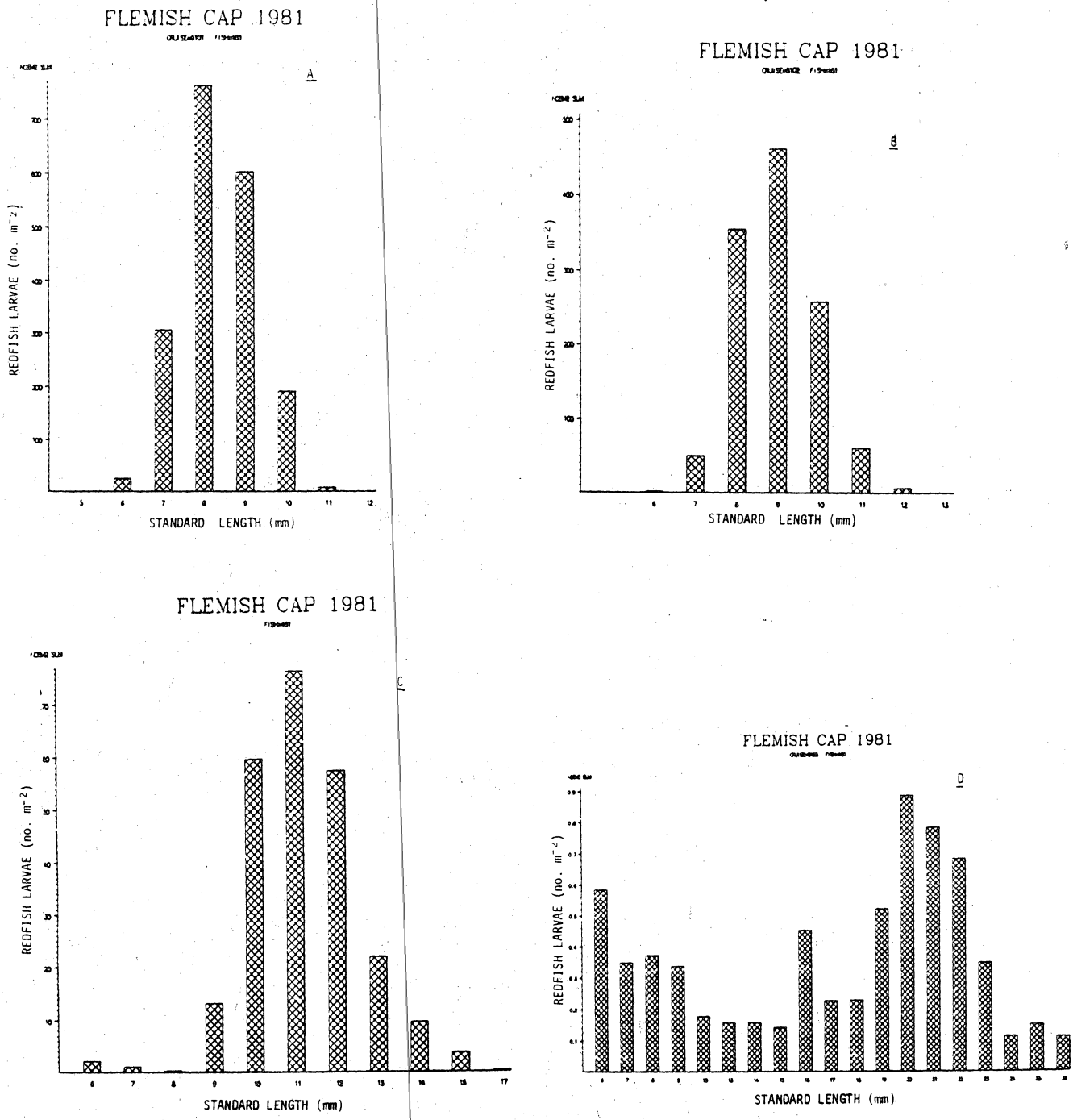

Figure 2. Length-frequency distributions of Sebastes spp. larvae on Flemish Cap in 1981: a) 2-9 May; b) 22-27 May; c) 26-30 June; d) 1-4 August.

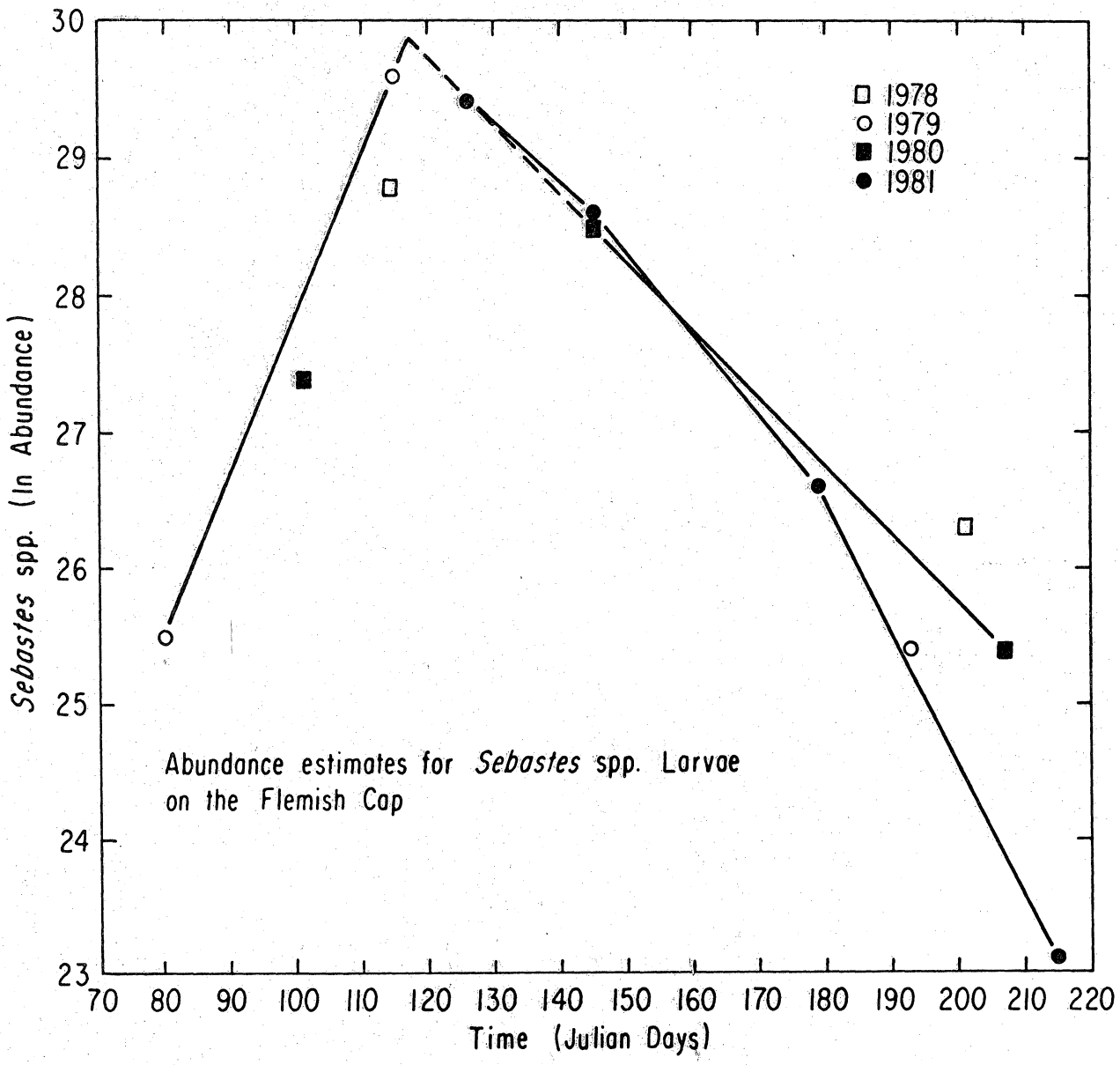

Figure 3. Abundance estimated for Sebastes spp larvae on Flemish Cap, 1978-1981.

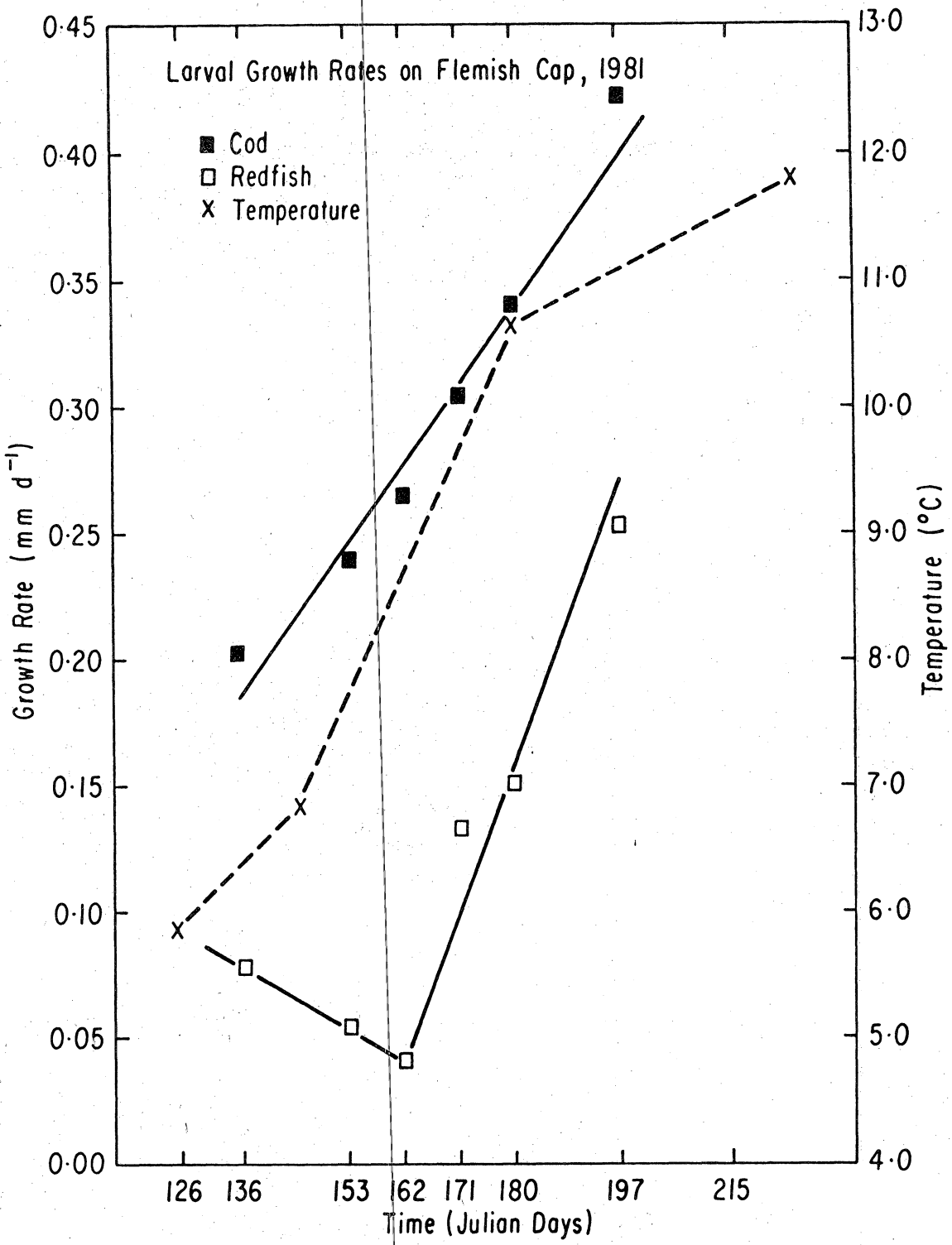

Figure 4. Growth rates (mm cl^{-1}) for cod (Gadus morhua) and redfish (Sebastes spp.) larvae on Flemish Cap in 1981. Temperatures are mean values calculated for the upper 30 m over central Flemish Cap (4700M 4500W).

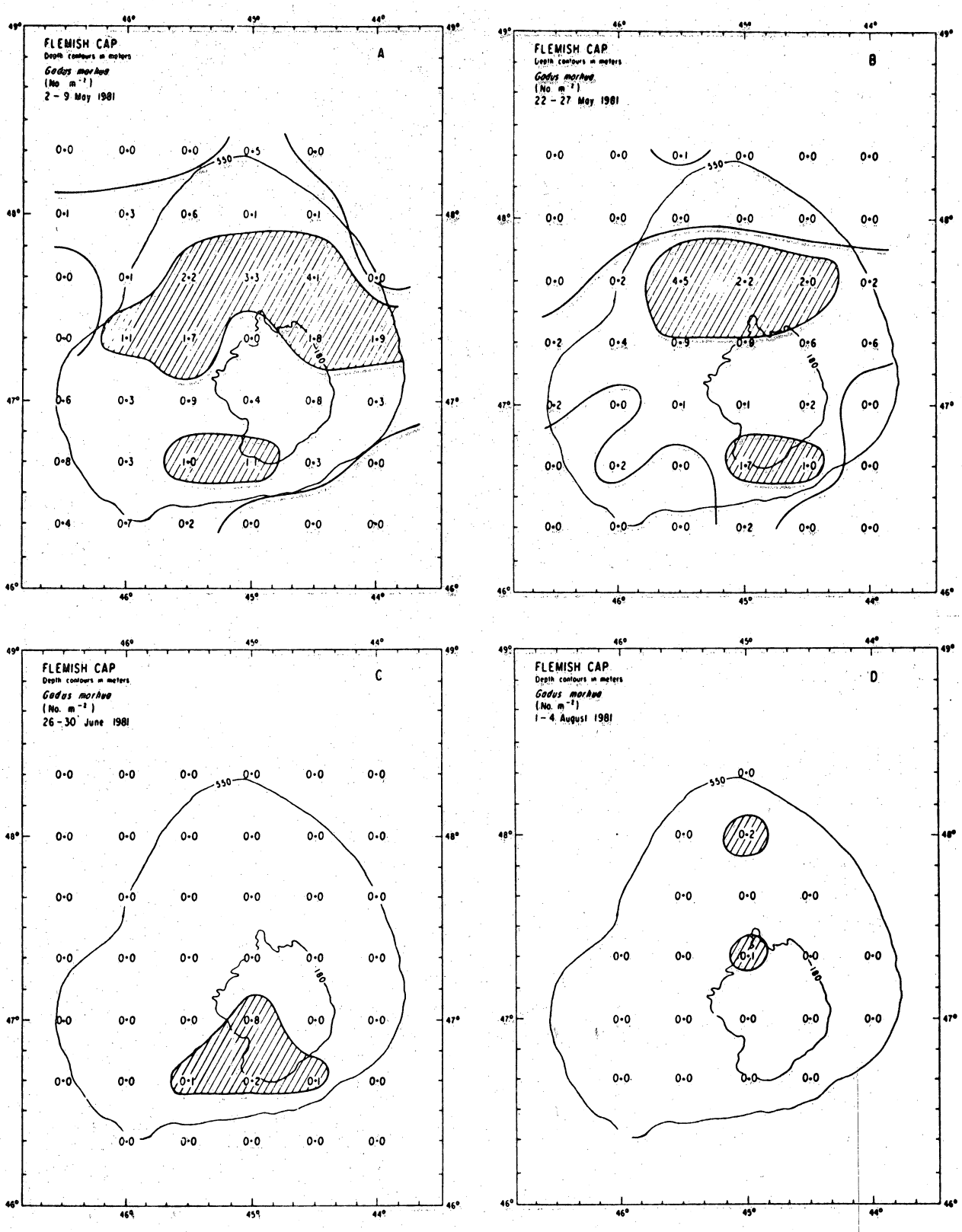

Figure 5. Distributions of Gadus morhua larvae (no. m^{-2}) on Flemish Cap in 1981: a) 2-9 May; b) 22-27 May; c) 26-30 June; d) 1-4 August.

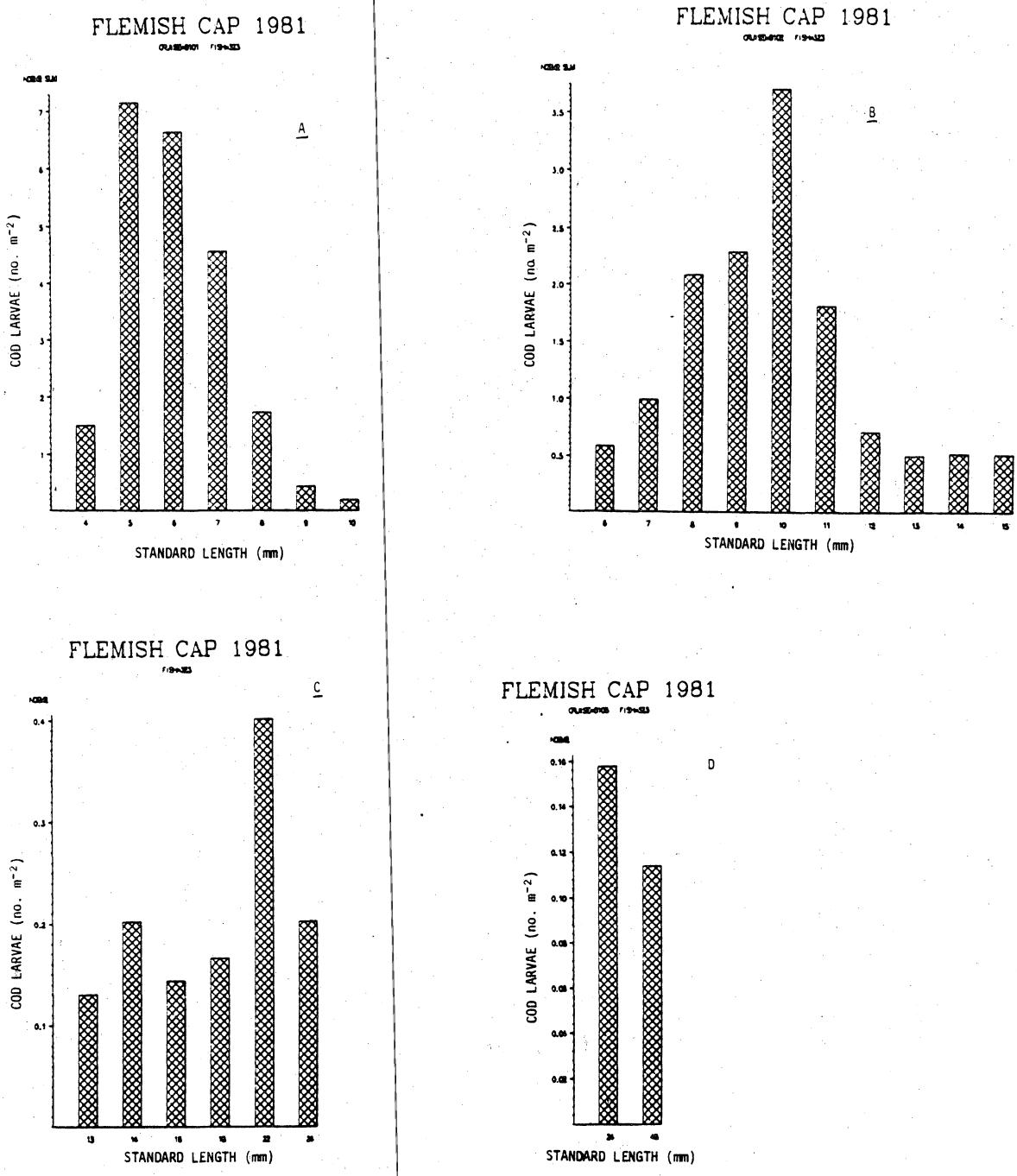

Figure 6. Length-frequency distributions of Gadus morhua larvae on Flemish Cap in 1981: a) 2-9 May; b) 22-27 May; c) 26-30 June; d) 1-4 August.