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Distribution, Abundance, and Mortality Estimates of Larval Butterfish, *Peprilus triacanthus*, from MARMAP Surveys, 1977 and 1978

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ABSTRACT

Butterfish, *Peprilus triacanthus*, occur on the US Atlantic coast from South Carolina to Cape Breton, Nova Scotia. Spawning begins in late May and continues through June and July in Chesapeake Bay. Further north on Georges Bank and the Gulf of Maine, spawning begins in June, peaks in July and ends in August.

Bimonthly Marine Resources Monitoring, Assessment and Prediction (MARMAP) surveys by the Northeast Fisheries Center cover the area from Nova Scotia to Cape Hatteras. Distribution and abundance of butterfish larvae were examined for the 1977 and 1978 surveys, with the focus on the two summer season cruises each year. Larvae were mainly found in the Middle Atlantic and Southern New England areas. The largest concentration was found east of Long Island in late June 1977 ($1140/10m^2$). Butterfish larvae were found only on one occasion in the Gulf of Maine (August 1978) and only a few larvae were found on Georges Bank (August 1977). Generally, distribution and abundance followed the expected trend of first occurrence in the Middle Atlantic region off Cape Hatteras, moving northward as the summer and spawning season progressed. Mortality coefficients were calculated using length frequency distributions for both years. In June-July, the mortality coefficients were 0.522 and 0.579 (1977 and 1978, respectively). Coefficients for August-September were 0.439 and 0.425 (1977 and 1978, respectively).

INTRODUCTION

Butterfish, *Peprilus triacanthus* (Peck), occur on the US Atlantic coast from South Carolina to Nova Scotia (Bigelow and Schroeder, 1953). North of Cape Hatteras their migratory patterns apparently are influenced by water temperatures, summer movements being both inshore and northward (Horn, 1970; Murawski et al., 1978). According to Bigelow and Schroeder (1953) butterfish prefer sandy bottoms.

Butterfish spawn once a year. In Chesapeake Bay spawning begins in late May and continues through June and July in waters with temperatures ranging from 16.3° to 22.5°C (Hildebrand and Schroeder, 1928; Colton, et al., 1979). Gulf of Maine spawning begins in June, peaks in July, and ends in August (Bigelow and Schroeder, 1953). Newly hatched larvae average 1.72 mm in length (Colton and Honey, 1963). Kawahara (1977) determined the von Bertalanffy growth function for males and females combined:

$$L_t = 210.2 \{1 - \exp [-0.8618 (t + 0.0699)]\}$$

Length at maturation is 140-180 mm, and butterfish are probably fully recruited at two years, 180 mm standard length (Murawski et al., 1978). Life expectancy, which appears to be related to fishing intensity, has been reported to be one to two years, with a maximum of three years (DuPaul and McEachran, 1973; Waring, 1975; Kawahara, 1977).

In late 1976, the Northeast Fisheries Center of the National Marine Fisheries Service (NMFS) initiated bimonthly Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton surveys. MARMAP is a comprehensive program of interrelated investigations which use the multispecies approach to provide information on seasonal and annual changes in the composition, biomass and production of living marine resources from Nova Scotia to Cape Hatteras. This report describes the distribution and abundance of larval butterfish during these surveys in 1977 and 1978 (Table 1) and provides an estimate of larval mortality using length frequency data.

METHODS

The continental shelf from Cape Hatteras to Nova Scotia was surveyed for ichthyoplankton six times during each year 1977 and 1978. Stations were selected from a stratified-random design used for the NMFS trawl surveys (Grosslein, 1969), and are evenly spaced at 25 to 35 km intervals. Stations are also situated along transects (Figure 1).

MARMAP surveys use paired 61 cm Bongo frames fitted with 0.505 and 0.333 mm mesh nets. They are lowered at 50 m/min to within 5 m of the bottom or to a maximum depth of 200 m, and are retrieved at 20 m/minute. Vessel speed varies between 1 and 2 knots to maintain a 45° wire angle during the double oblique tows. At shallow water stations, payout and retrieval rates are adjusted to obtain a 5 minute tow, with one minute for wire release and 4 minutes for retrieval. By doing so, the volume of water filtered per amount of depth fished is increased at shallow stations versus deeper stations, but this type of tow is considered more desirable than filtering very small volumes of water (Houde, 1977). A time-depth recorder traces the tow profile and flowmeters in the mouth of the net record amount of water strained.

Plankton Samples

Plankton samples were preserved in 5% buffered formalin. The 1977 samples (0.505 mm) were sorted, identified and measured at the NMFS laboratory in Sandy

Hook, N. J. The 1978 samples were sorted, identified and measured at the Morski Instytut Rybacki (MIR), Szczecin, Poland; with which NMFS has a cooperative research agreement.

ANALYSIS

Catches of larval butterfish at each station were standardized to give abundance in numbers under 10 m^2 of sea surface:

$$N_j = \frac{C_j Z_j}{V_j} \cdot 10$$

where

N_j = the number of larvae at station j under 10 m^2 of sea surface
C_j = the catch of larvae at station j
Z_j = the depth of tow (in meters) at station j
V_j = the volume filtered by the net (in m^3) at station j

Larval lengths to the nearest 0.1 mm were grouped into 1 mm increments. These frequencies were plotted for each cruise against length (Figure 2). Mean lengths were determined along with standard deviation and variance (Table 2).

Mortality with respect to length was estimated in the exponential regression of frequency on length as described by Houde (1977):

$$N_L = N_A e^{-ZL}$$

where

Z = the instantaneous coefficient of rate of decline in catch. It is the instantaneous mortality coefficient per millimeter of standard length if factors such as gear avoidance are not significant contributors to decline in catch as larvae grow older.
N_L = number of larvae at length L
N_A = y axis intercept
L = standard length of larvae (mm)

Only fully vulnerable length classes (3.0 to 15.0 mm) were used in calculating the regressions.

Length frequencies were transformed to log (x + 1). Linear regressions were run on the six cruises where five or more stations contained butterfish larvae. Linear regressions were then tested to determine which cruise data could be fitted with one regression line using the method described in Ostle and Mensing (1975):

$$F_e = \frac{(S_T - S_1)/2(K-1)}{S_1/(n-2K)} \sim F_{2(K-1),\ n-2K, 0.05}$$

where

S_T = SS Deviation from combined data regression d.f. = n-2
S_1 = individual SS Deviation from regression d.f. = n-2K

RESULTS

Distribution and Abundance

Larvae of butterfish were collected in surveys from May to October (Table 1) and did not occur in surveys from November to mid-April. The focus of all analyses is on June through August cruises when larvae were most abundant. Larvae only occurred once in the Gulf of Maine (in August 1978) and only a few larvae were found on (Southeast) Georges Bank (in August 1977). The largest concentration (1140/10 m^2) was found east of Long Island in late June 1977. On this survey (Delaware II 77-07), there was also a high concentration of butterfish larvae off Chesapeake Bay. Contours of abundance for the peak spawning surveys are shown in Figure 3, suggesting two major areas of spawning: the continental shelf off Chesapeake Bay and the New York Bight. These contours illustrate the northward migration of spawning adults during the summer. The larvae sampled in later summer cruises are distributed over most of the shelf between the Chesapeake Bay and the New York Bight. No data were available on the sequence of spawning of individuals in a population, nor information on variation and causes of variation of spawning grounds (Murawski et al., 1978). Horn (1970) and Caldwell (1961) have postulated the existence of depth isolated populations of butterfish along the Atlantic coast. Caldwell proposed that one population group is distributed south of Cape Hatteras in waters shallower than 12 fm, and that another group is distributed north of Cape Hatteras and in all Atlantic waters deeper than 12 fm. Horn's examinations showed some genetic exchange between the populations but not enough to group them as a single stock (Murawski et al., 1978). Therefore, we are dealing with a single migrating stock north of Cape Hatteras.

Correlations of larval abundance with salinity, depth, bottom and surface temperature showed no significance. However, these correlations ignore spatial relationships between butterfish larvae and their environment. In general, the distribution of larvae when compared with distributions of surface temperatures (unpublished data, NEFC) shows that the warmer (> 18°C) areas of the shelf are the areas of major concentration. The question of environmental relations to the larval butterfish is being further explored as part of ongoing research at the NEFC. Another aspect, examined by Houde (1977), was that of day-night differences in larval catch. Apparently, adult butterfish migrate to the surface at night and stay near the bottom during the day. Waring (1975) noted that in joint US-USSR surveys catches with an otter trawl during the day were much larger than those at night. In these data, however, there was no significant difference in numbers of larvae caught during the day versus number caught at night.

Mortality

Numbers of larvae decreased exponentially as lengths increased during each of the four surveys examined. Estimates of the instantaneous mortality coefficient per millimeter increase in length were $Z = 0.220$ and 0.439 for June-July and August-September in 1977, and $Z = 0.579$ and 0.425 for the same months in 1978. This corresponds to a 41% and 36% loss per millimeter growth for the 1977 larvae, 44% and 35% for the 1978 larvae. Corresponding survival rates were 59% and 64% for 1977, 56% and 65% for 1978. The null hypotheses of no difference in mortality coefficients between early and late summer in each year and between years were accepted at the $\alpha = 0.05$ probability level. The larvae sampled in June-July had higher mortality rates both years than the larvae from August-September cruises, although this difference was not significant. The difference may be a function of sampling occurring closer to hatching time (in the case of the higher rate).

A reasonable estimate of growth rate could not be calculated from the data, since spawning is continuous over a large area and the time lapse between surveys is great (31 and 23 days for 1977 and 1978, respectively). Finer scale sampling, both areally and temporally, would be necessary to determine a reliable estimate of growth for this species.

SUMMARY

Butterfish larvae were taken in significant numbers beginning in early May off Cape Hatteras. As the spawning season progresses and adults migrate northward, larvae occur further northward, onto southern Georges Bank. Two major spawning areas are suggested by distribution of larvae, the continental shelf off the Chesapeake Bay area and the continental shelf in the New York Bight region. Abundance over the entire sampling area is greatest during the summer months. Instantaneous mortality coefficients calculated for the June-July larvae were higher than those of August-September although this difference was not significant. By September, spawning season has ended and by late October butterfish larvae have disappeared from the plankton.

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Table 1. MARMAP cruises, 1977 and 1978, examined for butterfish larvae.

Data Set	Vessel	Cruise	Dates	N	+N	Cruise Area
I	*Goerlitz*	77-01	3/3-4/7	109	0	GM,GB,SNE
	Delaware II	77-03	3/19-4/8	69	0	MA
II	*Albatross IV*	77-02	4/13-5/20	133	0	GM,GB,SNE
	Delaware II	77-05I	5/3-5/13	91	11	MA
III	*Delaware II*	77-05II	5/17-5/27	89	1	MA
	Nogliki	77-02	5/22-6/6	95	1	GM,GB,SNE
	Delaware II	77-07	6/9-6/30	133	25	GM,GB,SNE,MA
IV	*Yubileiniy*	77-02	7/30-9/3	154	50	GM,GB,SNE,MA
V	*Argus*	77-01	10/12-11/12	142	2	GM,GB,SNE,MA
VI	*Mt. Mitchell Kelez*	77-11	11/12-12/13	90	0	GM,GB,SNE
VII	*Delaware II*	78-02	2/14-3/17	133	1	GM,GB,SNE,MA
VIII	*Argus*	78-04	4/13-4/28	149	5	GM,GB,SNE,MA
	Albatross IV	78-04	4/17-5/8	38	0	GM,GB
IX	*Albatross IV*	78-07	6/22-7/17	149	32	GM,GB,SNE,MA
X	*Belogorsk*	78-01	8/9-9/5	155	47	GM,GB,SNE,MA
XI	*Belogorsk*	78-03	10/6-11/1	130	0	GM,GB,SNE,MA
XII	*Belogorsk*	78-04	11/16-11/29	73	0	GM,GB,SNE,MA

N = total number of stations sampled
+N = number of stations with larval butterfish occurring
GM = Gulf of Maine
GB = Georges Bank
SNE = Southern New England
MA = Middle Atlantic

Table 2. Larval butterfish, *Peprilus triacanthus*, length frequency data for peak spawning season cruises, 1977-1978, and instantaneous mortality coefficient estimate based on the exponential regression: $N_L = N_A \exp(-Z_L)$ where N_L = number of length L, N_A = y-axis intercept, and L is the standard length.

	Cruise Number and Date			
Larval Length Class	DL 77-07 6/20-6/30	YU 77-02 7/31-8/1	AL 78-07 6/22-7/17	BE 78-01 8/9-9/5
2.0	38	66	41	30
3.0	111	157	111	118
4.0	78	60	33	115
5.0	26	36	29	40
6.0		22	17	27
7.0		18	15	15
8.0		7	7	13
9.0		10	3	7
10.0		4	1	3
11.0		6	1	1
12.0	1	2		2
13.0		1		3
14.0				1
15.0				1
$\overline{L}$	3.40	4.05	3.89	4.34
s^2	1.03	2.97	3.02	4.45
s	1.02	1.73	1.74	2.11
r^2	0.804	0.949	0.961	0.918
N_A	335.83	383.48	541.49	355.81
Z	0.522	0.439	0.579	0.425
S	0.59	0.64	0.56	0.65
% Loss/mm	40.67	35.53	43.95	34.62

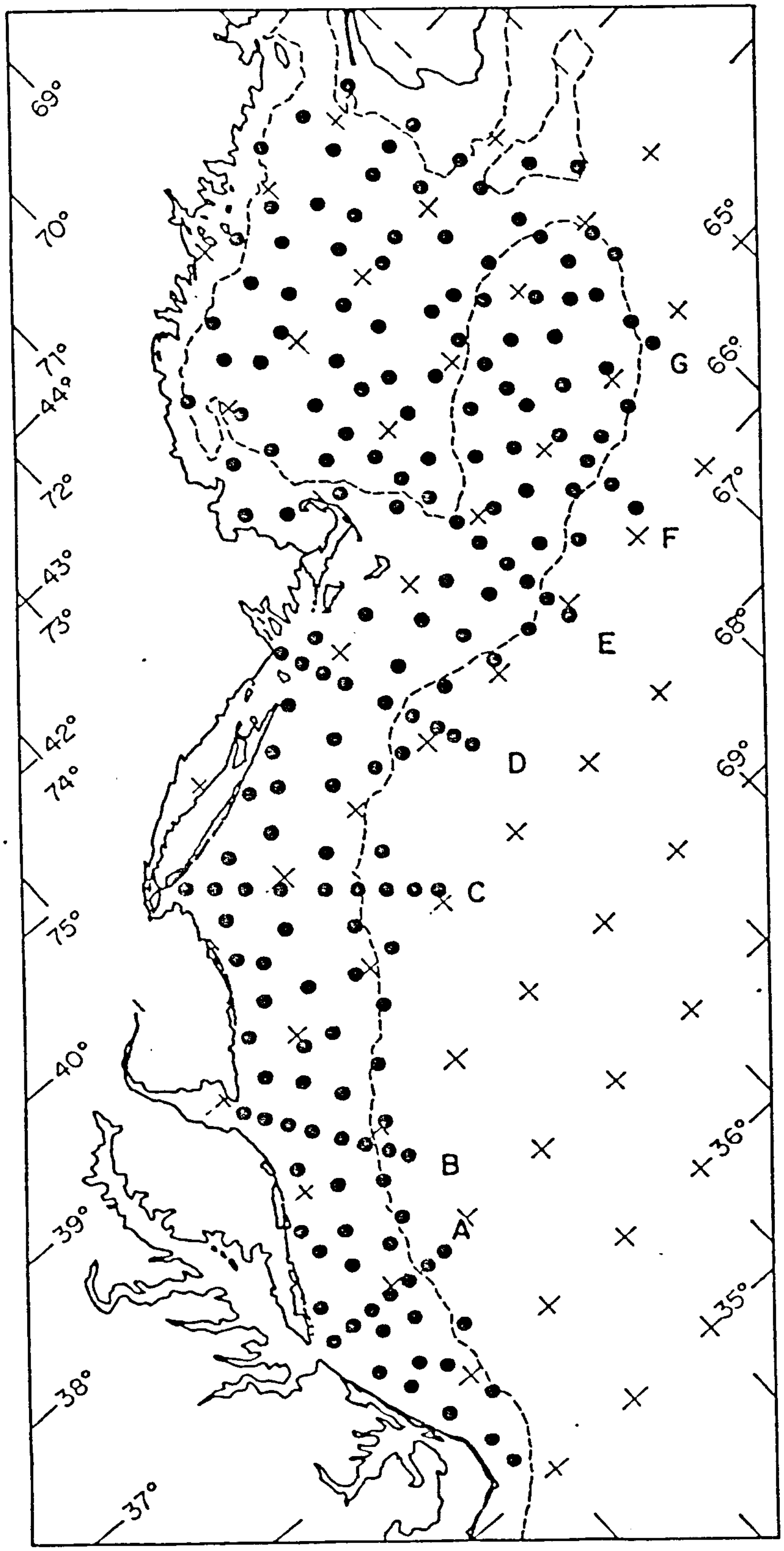

Figure 1. Station plan for MARMAP surveys.

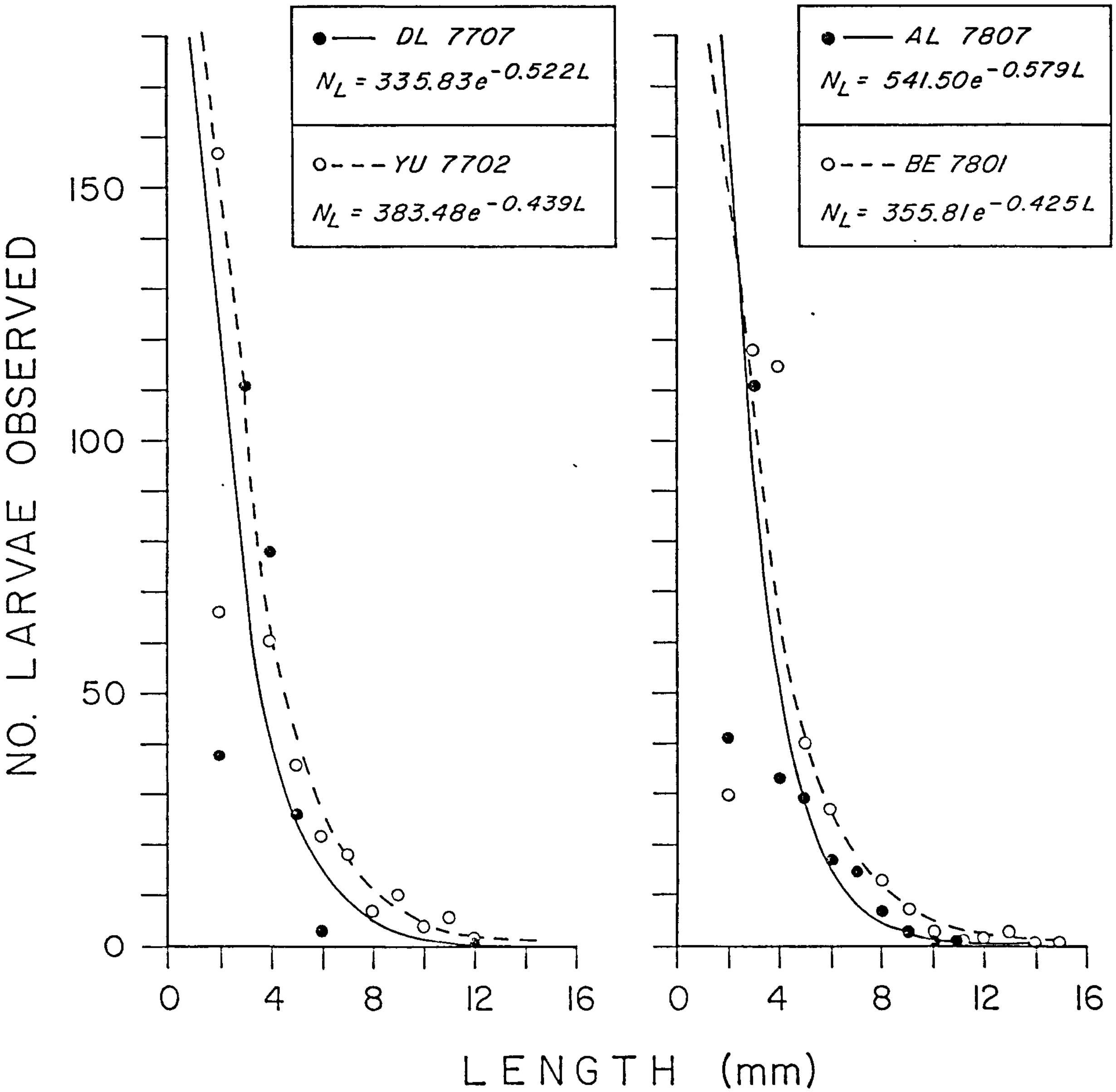

Figure 2. Fitted exponential functions giving estimates of the instantaneous rates of decline in numbers for butterfish larvae using length-frequency data.

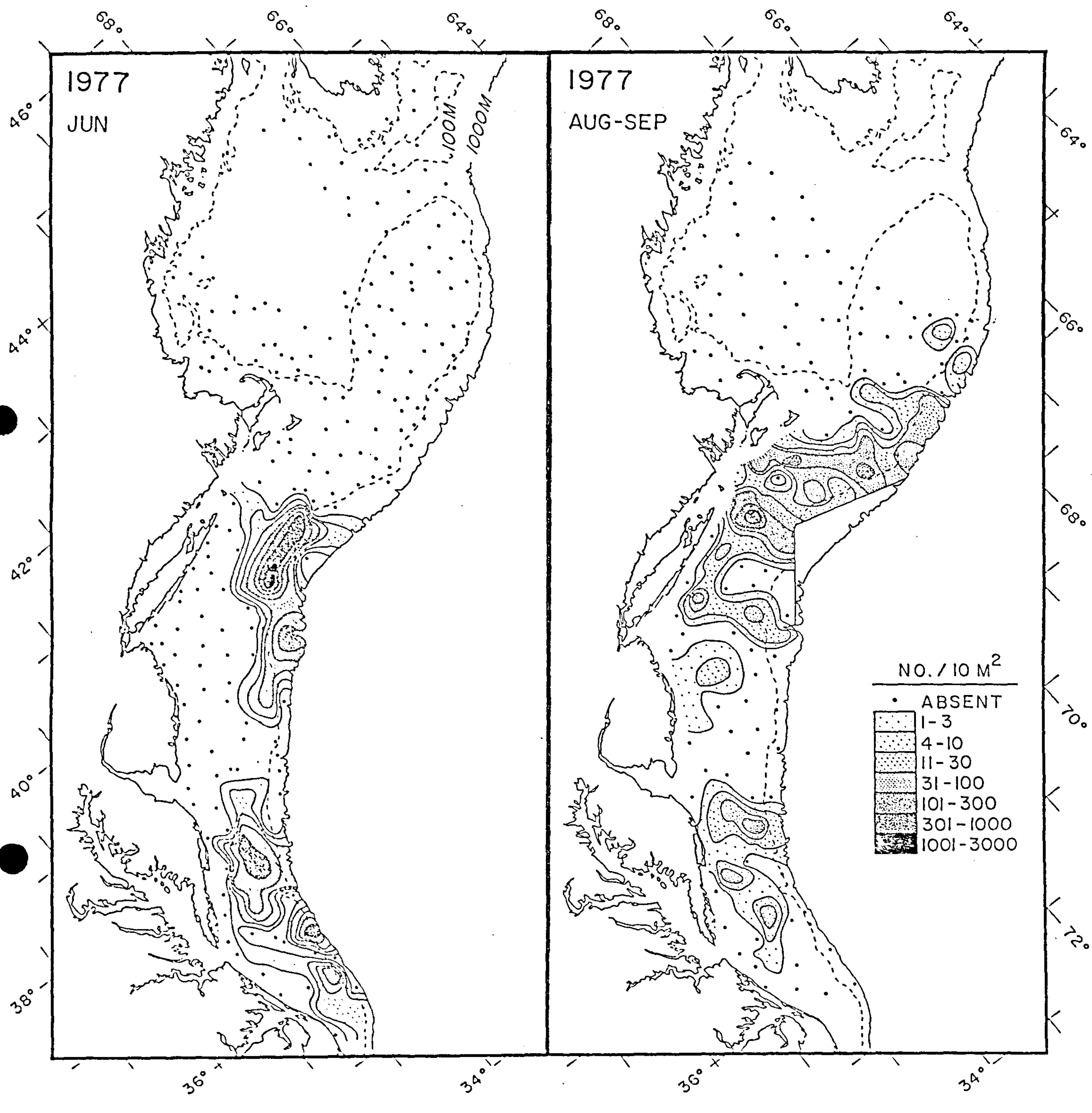

Figure 3. Distribution and abundance of larval butterfish on the continental shelf, 1977 and 1978. (Continued next page)

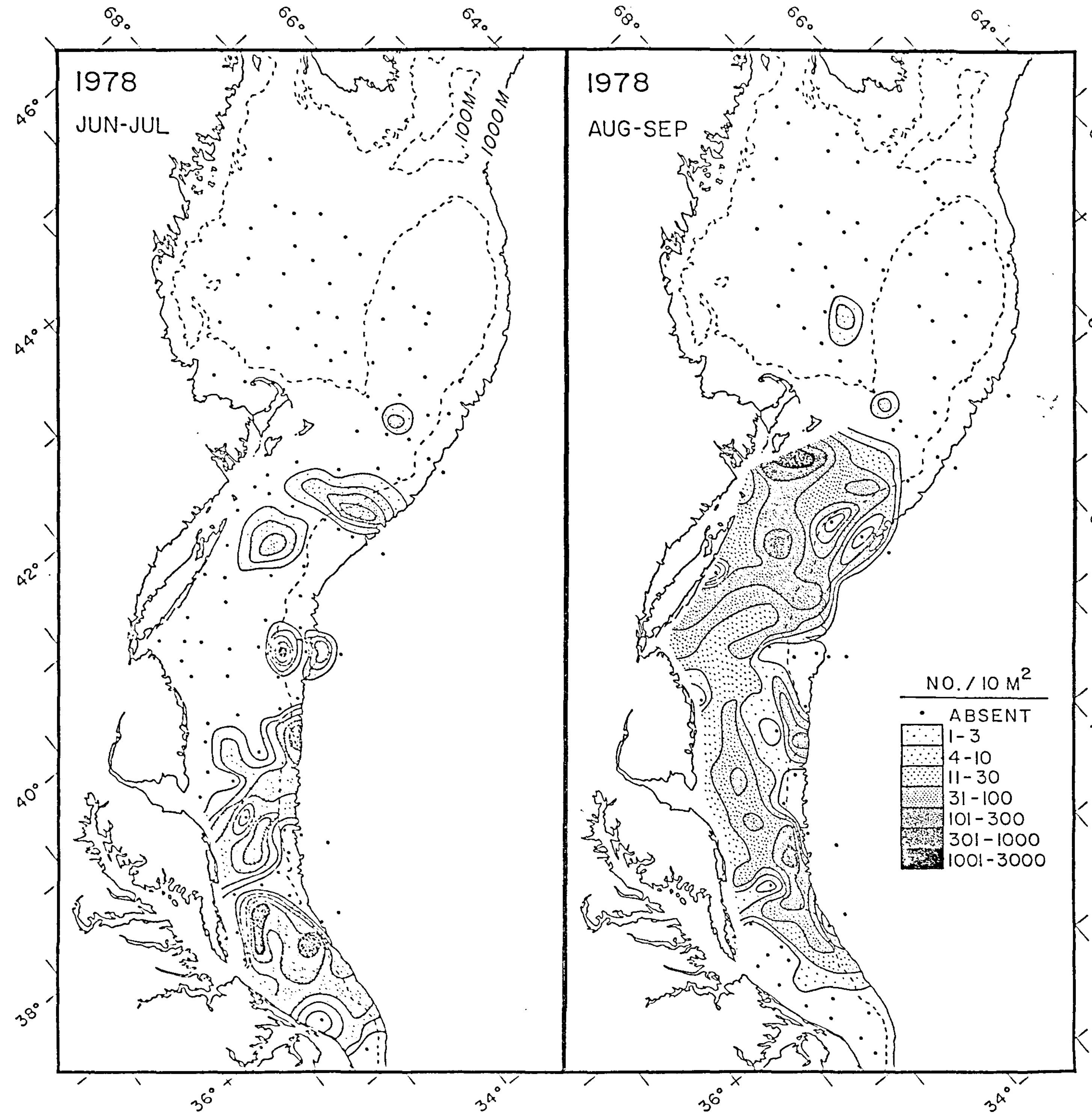

Figure 3 Continued.