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PRELIMINARY ESTIMATES OF DISTRIBUTION, ABUNDANCE, AND MORTALITY OF LARVAE AND THE SIZE OF THE *Nephrops norvegicus* (L) SPAWNING STOCK FROM LARVAL SURVEYS MADE OFF THE NORTH-EAST COAST OF ENGLAND IN 1976

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ABSTRACT

Planktonic larvae of the Norway lobster (*Nephrops norvegicus* (L.)) were collected on a series of twelve cruises in the sea area off the north-east coast of England in 1976. The larval distribution was restricted to known locations of adult abundance over muddy bottoms in deep water between the Farn Deeps and Baymans Hole and in the Outer Silver Pit. Production of Stage 1 larvae was measured at 57.6×10^9 in 1976 and peak hatching occurred in mid May. Mortality through the larval stages was estimated at 87% equivalent to a daily rate (Z) of 0.076 and was similar to that observed in laboratory experiments. The size of the spawning stock was estimated at 5,300 tonnes based on the seasonal production of Stage 1 larvae (corrected for a 10% per month mortality during development through the egg stages) and fecundity estimates from nearby Scottish stocks.

INTRODUCTION

Twelve plankton surveys were undertaken in the sea area off the north-east coast of England between January and November 1976 to study the distribution, abundance, mortality and drift of the eggs and larval stages of fish. The area surveyed was from latitude 53°N to 56°N and between the east coast of England and longitude 2°E. (Harding *et al.*, 1978).

Adult *Nephrops norvegicus* (L) occur within this area and there is a long established commercial fishery off the Northumberland coast which catches about 1000 tonnes annually. The larvae are known to be planktonic (Sars, 1884, 1890; Jorgensen, 1925; Santucci, 1926a, 1926b, 1926c, 1927) and to occur in this area (Jorgensen, 1925). While stock estimates of fish species based on their planktonic eggs are common (Cushing, 1957; Southward, 1963; Lockwood *et al.*, 1978) this method has not been applied to crustaceans although Scarratt (1973) used Stage I larval number as an index of abundance for the spawning stock of the American lobster, *Homarus americanus*. The present paper attempts to test this method of stock assessment for *Nephrops norvegicus* (L) and provides an estimate

of mortality through the larval stages.

MATERIALS AND METHODS

Nephrops norvegicus (L) occurred on six cruises between May and October, their distribution being generally restricted to the northwest quarter of the survey area. The sampling grid was the same for all cruises, except 10 and 11 when the international grid for herring larval surveys was combined with the standard plankton grid. Samples were taken at intervals of 9 or 18 nautical miles along lines of latitude which were 15 nautical miles apart on the standard plankton grid and at 10 nautical mile intervals along lines of latitude which were 10 nautical miles apart on the International herring larval grid. The whole water column was sampled using the Lowestoft high speed plankton sampler (Beverton and Tungate, 1967), which was fitted with a filtering net of 270 microns square aperture and had a 42 cm diameter mouth opening. A flowmeter mounted in the mouth opening of the nose cone was used to calculate the volume of water filtered. The catch at each station was fixed in 4% buffered formalin and subsequently transferred to an observation and preserving fluid for examination and storage (Nichols and Wood, 1978).

Because of their relatively large size *Nephrops* larvae were easily sorted from the plankton samples by eye and later separated microscopically into three larval development stages (Santucci, 1926a). Numbers per haul were converted to numbers under one square metre of sea surface and plotted on charts at the sampling positions. The distribution of each stage on each cruise was then contoured at selected intervals of density and the areas between contours found by planimetry. The product of the area between two contour levels and their mean density gave numbers within contours, and these were then summed over all contour levels to give total numbers of each Stage occurring on each cruise. The total numbers were converted to numbers produced per day by dividing by the Stage duration (Farmer, 1975) using the mean sea temperature at stations within the distribution. Numbers produced per day of all Stages were plotted against the mid-date of each sampling period to form a set of curves representing the production of each stage throughout the season (Figure 1). The area under each curve was determined by planimetry to give the total numbers of each Stage produced in the year. The mortality between each Stage and the instantaneous daily mortality rate ('Z') were then calculated from these data (Table 1).

The average size of the male and female *Nephrops* was recalculated from Table 6 in Symonds (1972) and the numbers of adult females determined using the estimate of Stage I larvae produced, which was adjusted for egg losses during the incubation period (Farmer, 1975), and fecundity data from Thomas (1962). Total spawning stock weight was raised from the number of females using a 1:1 ratio of male to female and length/weight regressions from Symonds (1972) (Table 2).

RESULTS

The distributions of Stage I larvae on four cruises covering the maximum period of hatching between May and July and illustrating the rapid decline in numbers hatching in August are shown in Figure 2. The southern edge of the distribution of larvae from a spawning area in the Firth of Forth can be clearly seen on RV CORELLA cruise 7. The production from this patch was not included in the north-east coast spawning stock estimate.

Figure 3 shows the distribution of Stage II larvae in mid-August. The Firth of Forth patch is still clearly defined and a new patch in the area of the Silver Pits demonstrates that another sub-population of *Nephrops* had released larvae between the July and August cruises. The loss of larvae between Stages I and II was 34.1% and between Stages II and III was 80.2%; the overall mortality through the larval stages was 87.0%. The total spawning stock was estimated at 5,300 tonnes.

DISCUSSION

Larvae of *Nephrops* began hatching in May and appeared for the first time in collections made on RV CORELLA Cruise 7 in mid-May, which proved to be near the peak hatching period in 1976. Numbers of *Nephrops* larvae were low compared with fish larvae taken in the same collections for which the sampling grid was designed; only 116 Stage I larvae were caught during the season. This fact is undoubtedly due to the restricted distribution of adults, which are confined to muddy bottoms in deep water between the Farn Deeps and Baymans Hole and in the Silver Pits, and to the widely dispersed grid of sampling stations. Nevertheless, the distribution of larvae reflects the adult distribution, and numbers were sufficiently high during the peak release period to allow accurate charts to be drawn (Figures 2 & 3) and to allow seasonal abundance and mortality estimates to be made (Table 1, Figure 1). The 87% mortality in the larval phase is of the same order as that measured at 72% in laboratory experiments under optimal conditions of temperature for a sub population of *Nephrops* from Portuguese waters (Figueiredo, 1971). These measurements of production and mortality depend upon adequate sampling of the distributions of larvae in space and time and accurate ageing of larvae. The high speed plankton net undoubtedly collects larvae in proportion to their abundance and vertical distribution and despite widely spaced stations adequate spatial resolution was attained. On the other hand information on the development rate of larvae is rather poor though sufficiently accurate for a preliminary exercise of this type. The stock estimate of 5,300 tonnes is also subject to similar errors and depends upon an estimated mortality of 70 per cent during incubation of the eggs; unknown pre-zoea mortality; a fecundity estimate based on a population of *Nephrops* from Scottish waters; an assumed ratio of 1:1 males to females in the Northumberland spawning stock and a calculated average weight derived from mean lengths of males

and females from the Northumberland stock in a previous year.

Despite all these possible errors the spawning stock estimate of 5,300 tonnes is of the right order of magnitude to sustain a fishery of 1,000 tonnes per annum. A more accurate estimate could only be obtained with a directed series of research cruises to obtain information on larval abundance on a fine grid of stations and to collect adult *Nephrops* for fecundity estimates, sizes of spawning males and females and the sex ratio. In addition more accurate estimates of development rates of eggs and larvae and of mortality rates for eggs and pre-zoea stages are required.

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TABLE 1 Estimates of abundance and mortality in *Nephrops norvegicus* (L.) larvae off the NE coast of England in 1976

Stage	Nos. produced x 10^9 (N)	% loss	Age in days	$\log_e$ No/Nt	Stage duration (t)	Z
I	57.556		14.0			
		34.1		0.41698	13.25	0.0315
II	37.931		27.25			
		80.2		1.6202	13.50	0.1200
III	7.505		40.75			
I to III		87.0		2.0372	26.75	0.0762

Z is the instantaneous mortality rate per day calculated from $Z = (\log_e No/Nt).1/t$

where t = stage duration in days, No=the numbers produced at time 0 and Nt=the numbers produced at time t

TABLE 2 A stock estimate of *Nephrops norvegicus* (L.) from larval surveys off the NE coast of England in 1976

Numbers of Stage I larvae produced in the 1976 spawning season	57.5559×10^9
Equivalent numbers of eggs laid	16.4445×10^{10}
Mean fecundity of females	2236
Number of mature females	73.544×10^6
Total weight of females	2061.4 tonnes
Total weight of males	3229.3 "
Total	5290.7 tonnes

Assuming the average weight of spawning females to be 28.03 g and that of males 43.91 g and the sex ratio in the spawning population 1:1.

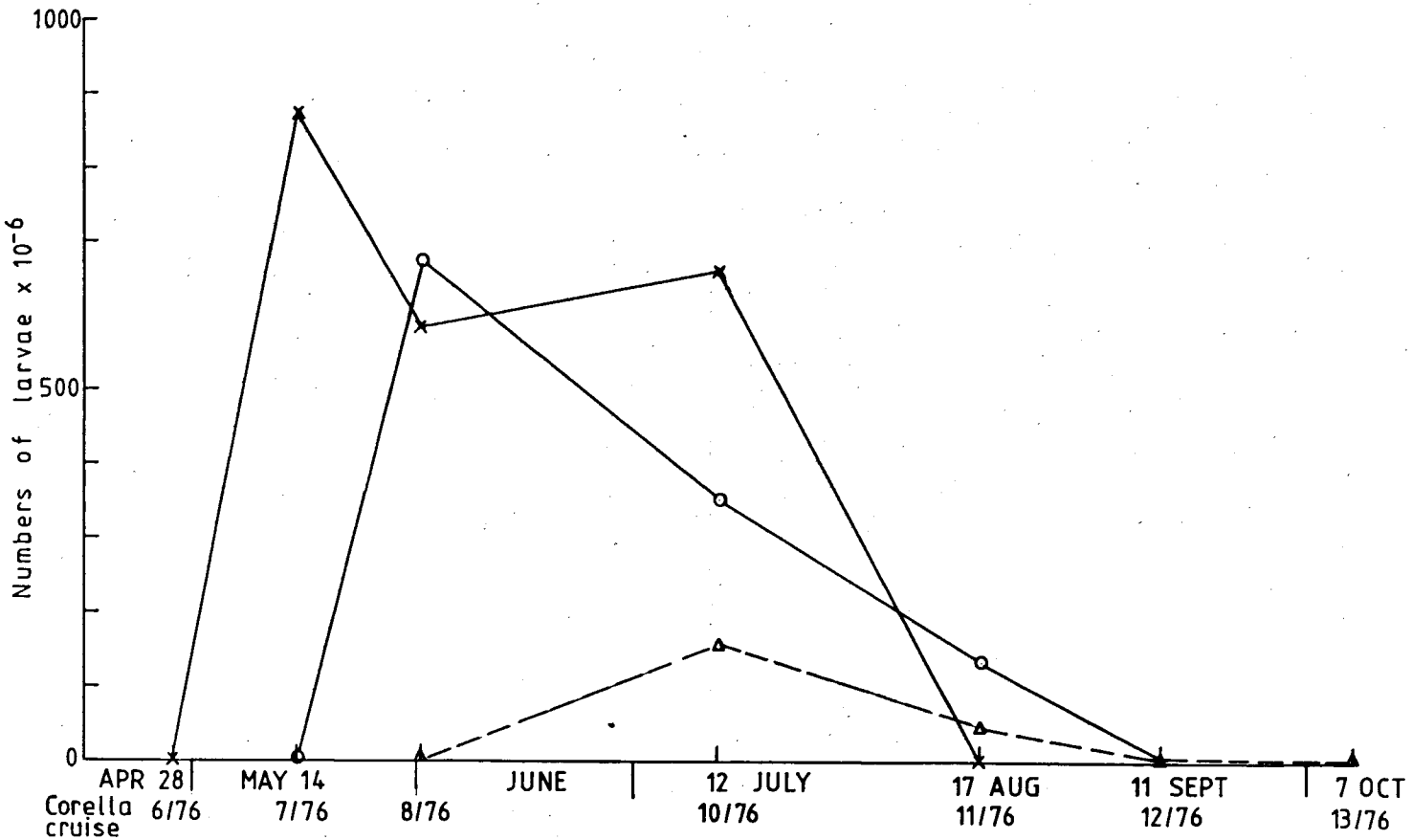

Figure 1 Seasonal production of Nephrops norvegicus (L.) larvae off the north-east coast of England in 1976. Production estimates are plotted against mid-cruise dates for CORELLA Cruise 6/76 to 13/76 as indicated on the x axis, for larval development Stages I(X), II(O) and III(Δ).

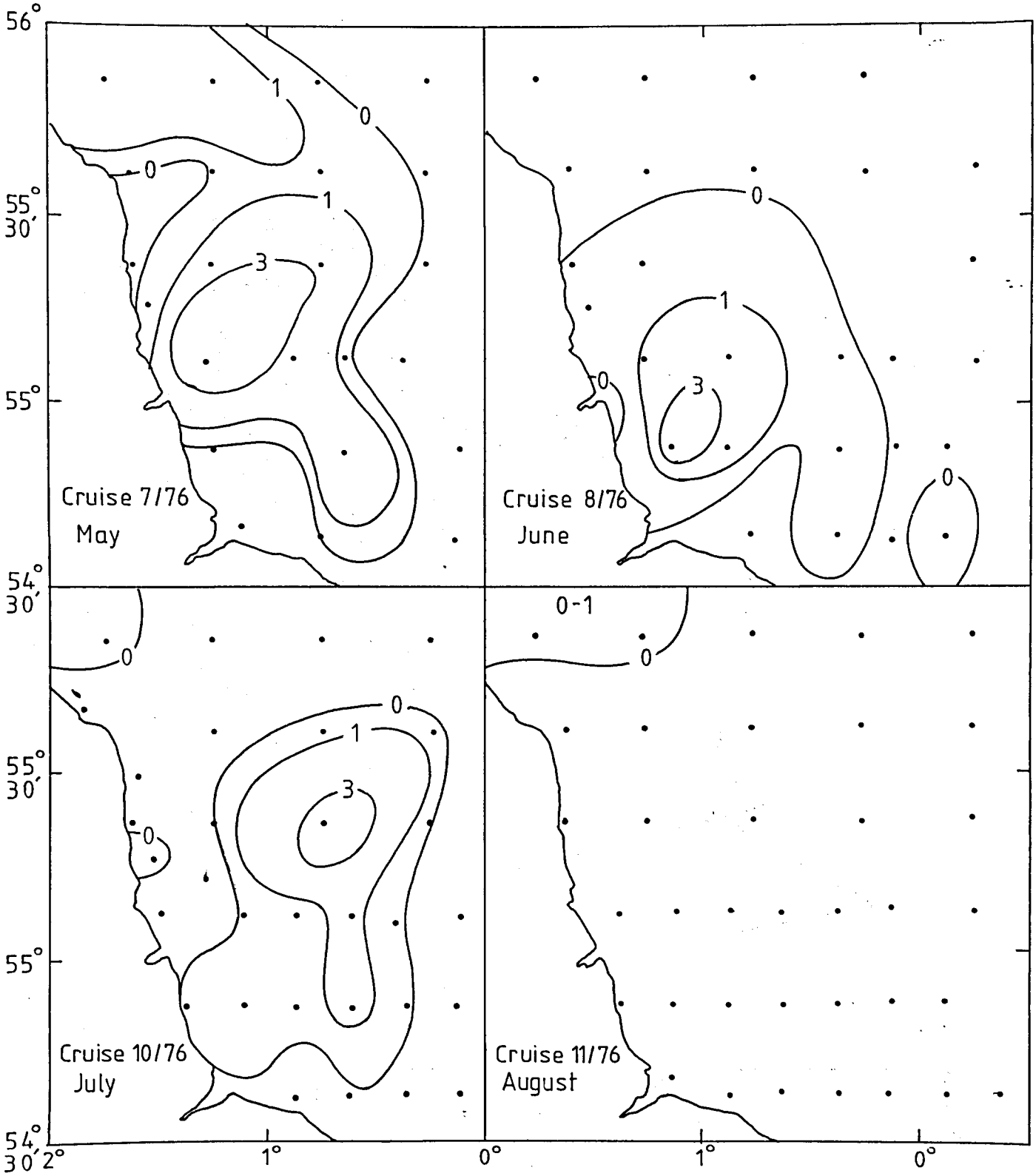

Figure 2 Distribution of Stage I larvae on four cruises covering the main release period of larval Nephrops.

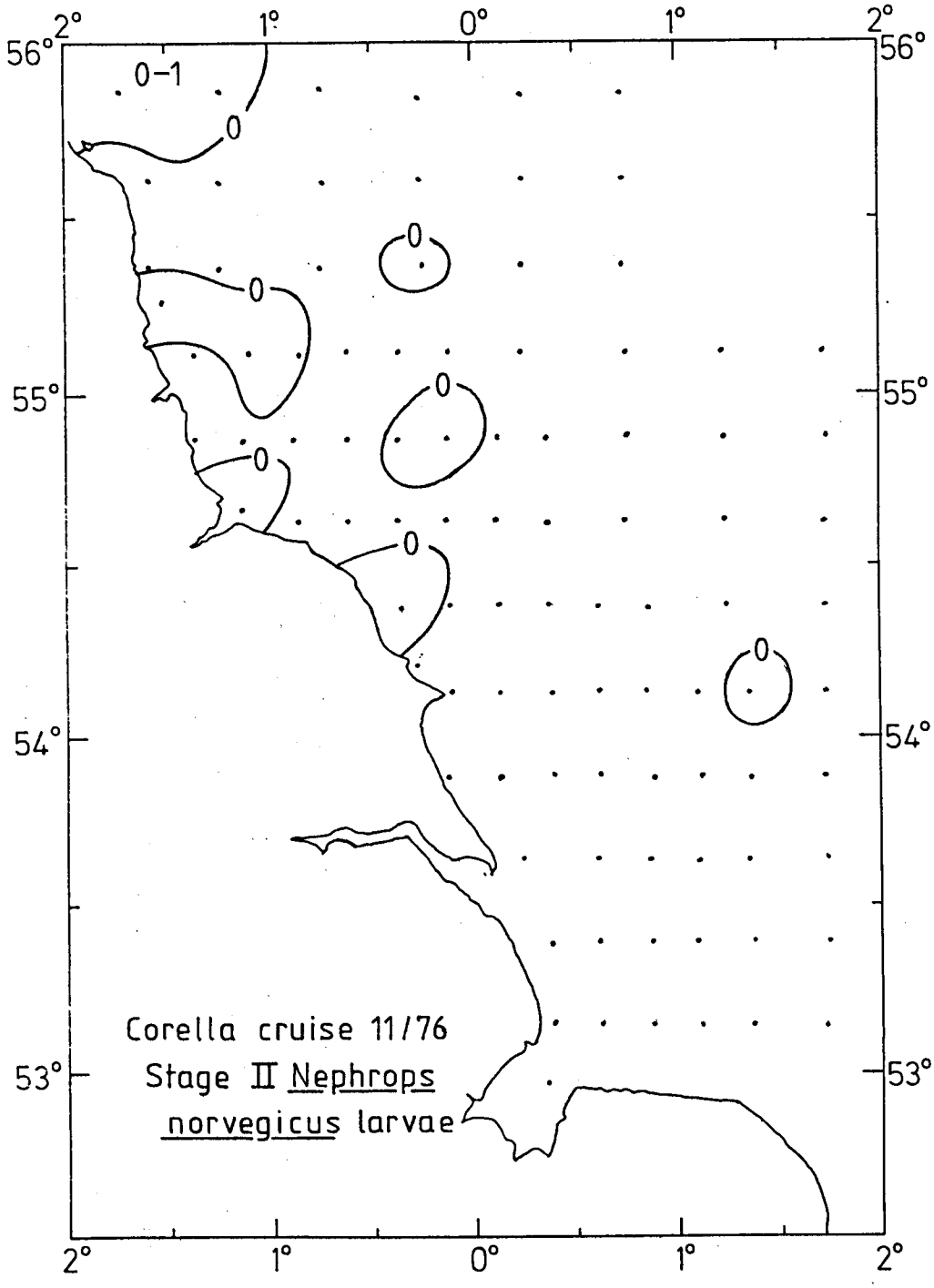

Figure 3 Distribution of Stage II Nephrops larvae in August 1976.