DENSITY VARIATIONS AND POPULATION STRUCTURE OF *EURYDICE INERMIS* AND E *TRUNCATA (ISOPODA : CIROLANIDAE)* IN THE NEUSTON OF GALWAY BAY (IRELAND)

by

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Résumé

Le neuston nocturne de mai à septembre a permis de recenser trois espèces de *Eurydice, E. inermis* Hansen, *E. truncata* Norman et *E. spinigera* Hansen. Les *E. spinigera* étaient rares. Les deux autres espèces étaient abondantes et bien que réparties de façon très dispersée, on a pu mettre en évidence dans les deux espèces une considérable variation mensuelle de densité. Celle des *E. inermis* était indéniablement liée à la température de l'eau en surface, mais les *E. truncata* atteignaient de plus fortes densités à basse température.

Les *E. truncata* se sont reproduits plus tôt que les *E. inermis;* la vitesse de croissance a été rapide chez les deux espèces et on a pu remarquer une seconde génération chez les *E. inermis,* qui ont eu une population juvénile pendant l'hiver et au-delà.

L'existence d'*Eurydice* dans le neuston est contrôlée par un rythme endogène, l'éclairement et la température comme synchroniseurs primordiaux.

Introduction

Although the distribution and biology of the littoral species of *Eurydice, E. pulchra* Leach and *E. affinis* Hansen are known in Britain (Jones 1970, Fish 1970), little quantitative information on the ecology and biology of the 3 continental shelf species, *E. spinigera* Hansen, *E. inermis* Hansen and *E. truncata* Norman, seems to be available. Jones and Naylor (1967) reported that the distribution of each of the sublittoral species was related to water depth. Generally, *E. spinigera* inhabits the shallow sublittoral and gives way to *E. inermis* in deeper inshore waters, while *E. truncata* extends from 50m depth to the edge of the continental shelf. Both *E. grimaldi* Dollfus and *E. caeca* Hansen are oceanic species.

All 3 continental shelf species have been recorded from benthic sand/gravel communities (Crawford 1937, Jones 1951). In contrast Hansen (1905) suggested that *E. truncata* is entirely pelagic and Soika (1955) proposed a new subgenus for the offshore species since they lack mobile spines on the telson and are, according to him, always pelagic. More quantitative information on the ecology and

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behaviour of these 3 species has been given by Champalbert and Maquart-Moulin (1970) and Maquart-Moulin (1969) from the hyponeuston of the Gulf of Marseille. *Eurydice* spp., although inbenthic during daylight hours, emerge at dusk and migrate rapidly to the neuston (Champalbert and Maquart-Moulin 1970). Hempel and Weikert (1972) also recorded large numbers of *E. truncata* and *E. grimaldi* at night in the neuston of the subtropical north-east Atlantic. The deep burrowing behaviour and rapid migration at dusk to the neuston, which is not sampled adequately by conventional plankton gear, by *Eurydice* spp. has probably contributed to the lack of information on their biology. Sublittoral *Eurydice* may be regarded as facultatively neustonic (Hempel and Weikert 1972) or more precisely benthohyponeustonic species (Zaitsev 1970).

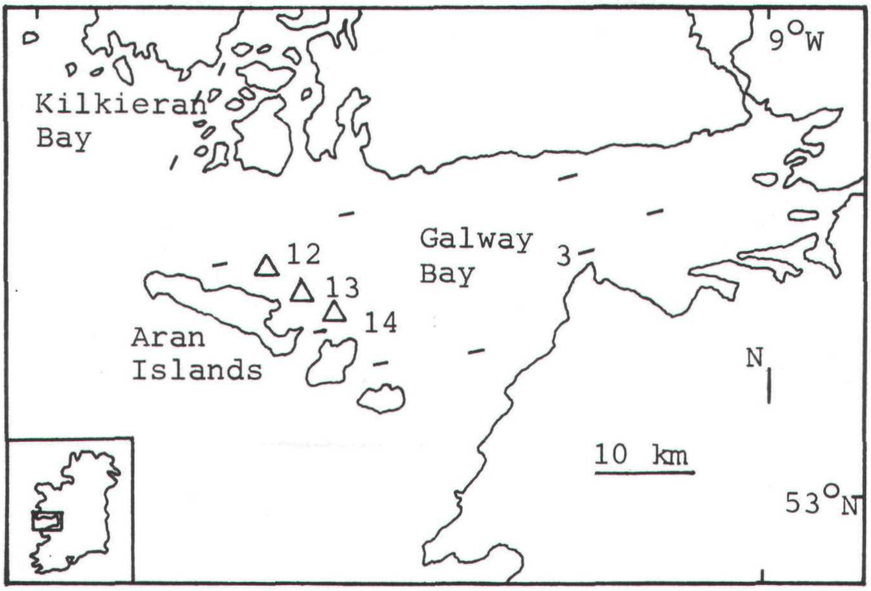

FIG. 1.
Day (—) and night (A) station positions in Galway and Kilkieran Bays.

During a general survey of the neuston of Galway Bay 3 species of *Eurydice* were recorded, mainly in night samples taken from May to September 1984. Variations in density and the population structure of *E. inermis* and *E. truncata* are discussed in this paper. The third species, *E. spinigera,* was rarely recorded.

The sampling area and methods

Galway Bay, which lies on the mid-west coast of Ireland, is an extensive inlet under direct oceanic influence. Neuston samples were taken during daylight hours throughout the year at stations 1-11 and 2-3 hours after sunset from May to September 1984 at stations 12-14 (Fig. 1). Water depth at night stations was approximately 40m. The substrates at stations 12-14 are complex, comprising of patches of rock giving way to narrow strips of mixed substrates of gravel, stone, shell fragment and coarse sand (O'Connor and McGrath 1981). Various banks and shoal patches, which influence water distribution and currents, also occur in this area (Berthois *et al.* 1978).

Samples were taken with a 2-stage neuston net with a flowmeter attached. Each net measured 1m in length by 0.36m depth and had a 500Mμ mesh net attached. The top net sampled the neuston proper (0-10 cm) while the bottom net fished the plankton community immediately beneath (12-48cm) (see Tully and O'Ceidigh 1986). The nets were towed for 15 minutes at 2 knots except during May when night hauls were reduced to 5 minutes due to the density of *Calanus* at the surface.

A total of 1224 specimens of *E. truncata,* 721 of *E. inermis* and 18 of *E. spinigera* were identified, using the descriptions of Hansen (1905) and Naylor

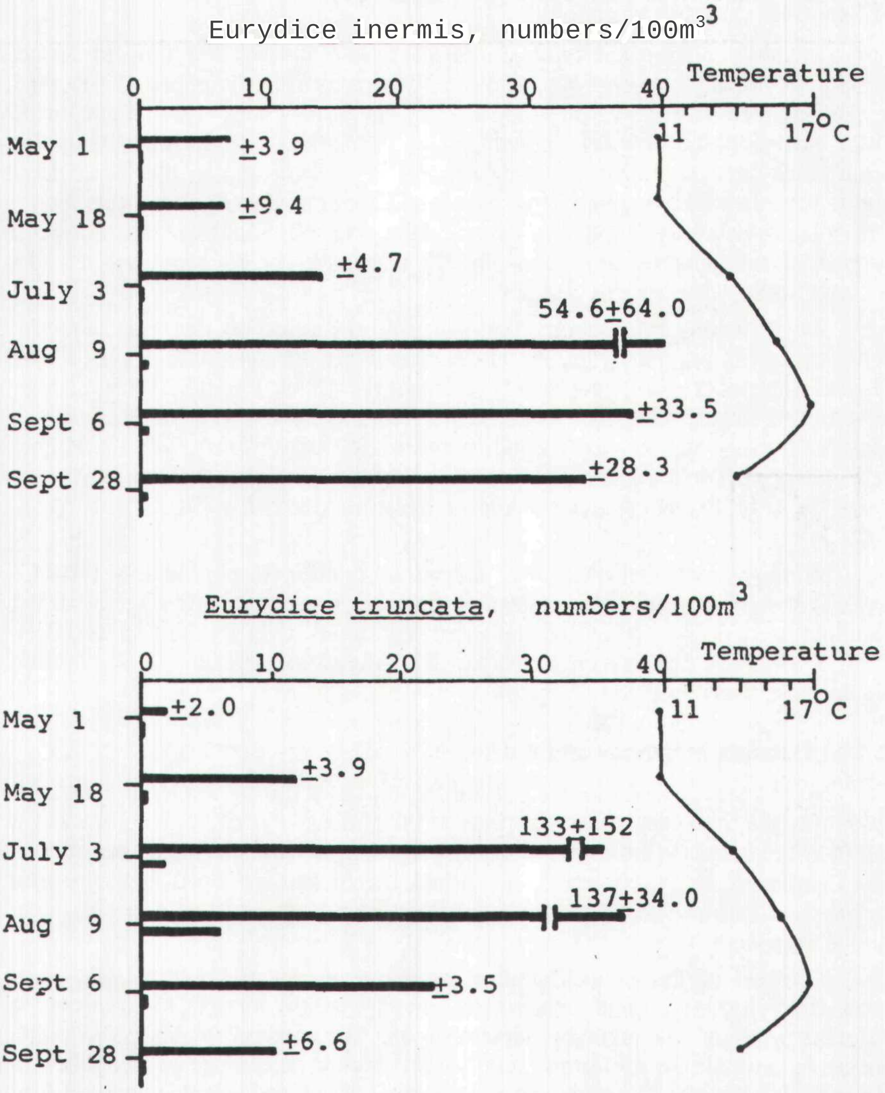

FIG. 2.

Mean density estimates ± s.d. of *E. inermis* and *E. truncata* from May to Sept. '84, in relation to sea surface temperatures. Top columns of each pair represents numbers in the upper neuston net and the bottom columns, those of the lower net.

(1957). Length measurements were taken on the dorsal mid-line, from the front of the cephalon to the posterior end of the telson, to the nearest 0.1mm. Sexes were distinguished at a length of 4.00mm by the presence or absence of penes. All statistical tests are non parametric and follow Siegel (1956).

RESULTS

1) Seasonal variation in density

Generally, all 3 species were confined to night samples and to the upper net. Eight individuals (3 males, 5 females) of *E. truncata,* all in the upper net, occurred in day samples at station 3 in August. Fifty-eight specimens were caught in the lower net at night. Fourteen individuals of *E. inermis* (11 juveniles, 3 males) occurred in day samples in the upper net and 35 were caught by the lower net at night. Juveniles in day samples occurred in Kilkieran Bay during December (3 individuals), February (2 individuals) and August (1 individual) and at station 3 in August (5 individuals). Sixteen of the 18 specimens of *E. spinigera* recorded occurred in September night samples.

Sample counts were overdispersed for most months so that mean monthly densities are not accurate (Fig. 2). However, monthly densities of *E. truncata* from May to September were significantly different (H=15.39, P=0.02). These changes were not correlated with sea surface temperatures. Numbers were generally low in May but by July had increased significantly to 133/100m^3 (U=0, P=0.05). Highest densities occurred in August (144/100m^3), which was higher than in July (U=0, P=0.05). After the beginning of August densities decreased significantly (U=0, P=0.05).

Monthly mean densities of *E. inermis* also differed significantly (H=12.4, p=0.03) and were positively correlated with surface temperatures (r_s=0.88, P=0.05). Numbers were low in May but had increased significantly by July to 14/100m^3 (U=0, P=0.05). A further increase occurred in August to 54/100m^3 (U=0, P=0.05). No decrease was observed in September.

2) Diel variation in density and feeding

Night stations were sampled at 4 different times during September 28/29 to determine the time each species appears at the surface in relation to sunset and to estimate the length of time they remain at the surface. No specimens occurred in day samples. *E. inermis* reached the surface earlier and remained in the neuston longer than *E. truncata* (Fig. 3). Champalbert and Maquart-Moulin (1970) noted similar behaviour.

Members of the genus *Eurydice* are active predators (Holme 1949, Jones 1968, Holdich 1981). Table 1 shows the condition of the hindgut of *E. inermis* at different times of the night of September 28. The hindgut dilates considerably during feeding (Jones 1968) and there was a higher percentage of animals with distented hindguts at 2100 hrs. and at 0640 hrs., which was approximately 1 hour after sunset and before sunrise respectively. The number of empty hindguts was highest at sunset and during the night. The antennae of calanoid copepods were present in some guts. These observations suggest that the function of the nocturnal migration in *Eurydice* is a feeding one and that feeding occurs primarily at dusk and dawn. *Eurydice* may be eaten by nocturnal feeding storm petrels *(Hydrobates pelagicus).* Two specimens of *E. truncata* were recorded in the stomachs of 2 birds caught in June.

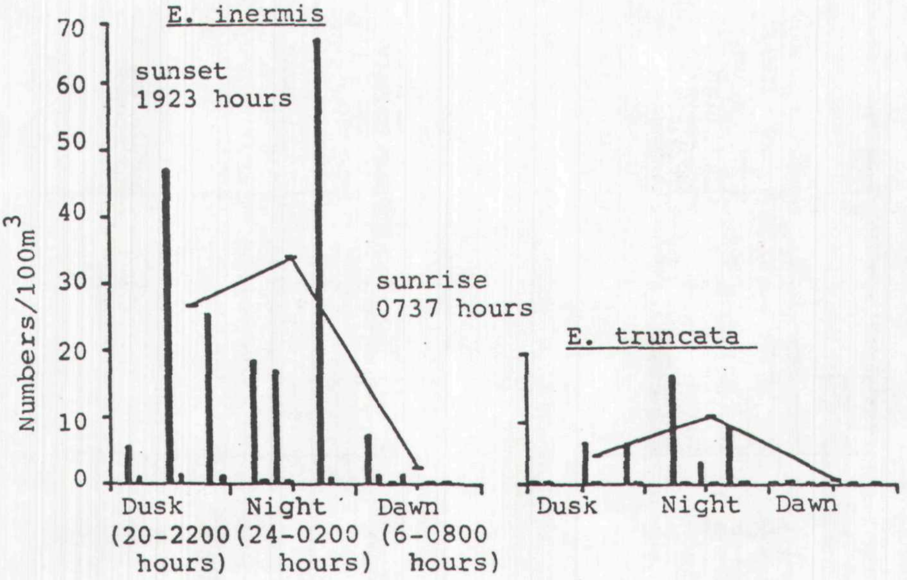

FIG. 3.

Densities of *E. inermis* and *E. truncata* in 9 samples, 3 each at dusk, night and dawn on Sept. 28th.. The left hand column of each pair represents numbers recorded in the upper neuston net and the right hand column those in the lower net. The mean estimates for each time is also shown.

TABLE 1.

The condition of the hindgut of *E. inermis* at different limes during the night of September 28th.. N = number examined.

	Condition of Hindgut			
Time (Hrs.)	% Swollen	% Food present	% Empty	N
1957	11	45	44	9
2100	70	20	10	44
0050	60	33	7	15
0120	45	30	25	20
0641	83	17	0	6

3) Monthly changes in population structure

All samples from Galway Bay were taken 2-3 hours after sunset. A representative crossection of the population, excepting ovigerous females which were never collected, should be present in the neuston at this time (Champalbert and Maquart-Moulin 1970 and Maquart-Moulin 1972). Ovigerous females are less active and remain buried in the sediment, living off food reserves (Maquart-Moulin 1969). The lack of expansive capacity of the hindgut due to pressure exerted by the developing embryos may be the reason for reduced predatory activity (Salvat 1966).

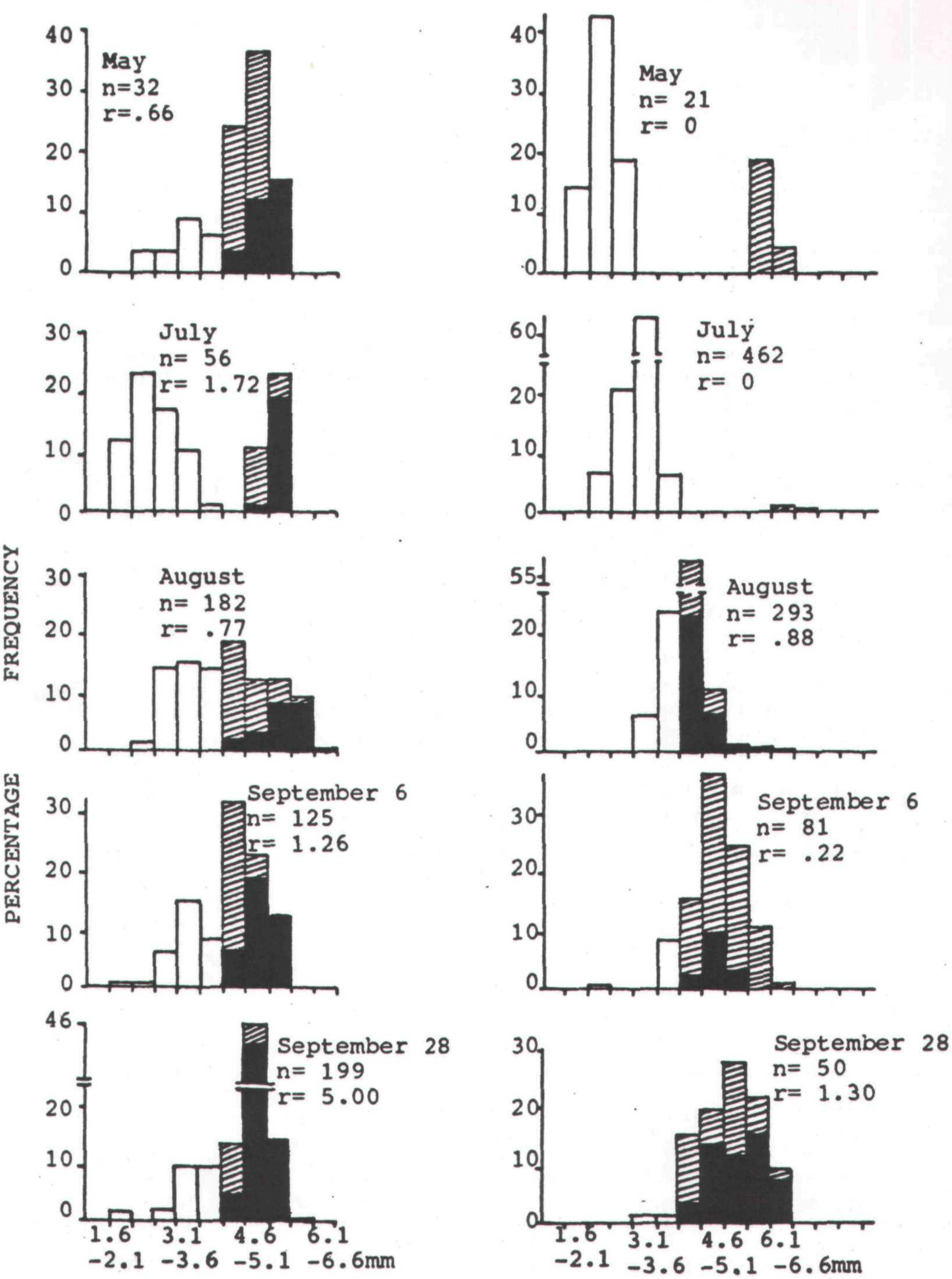

FIG. 4.

Changes in length frequency distribution of *E. inermis* and *E. truncata* from May to Sept. 84. ■ = males. ▨ = females. ☐ = juveniles, r = male : female sex ratio.

Changes in the population structure of *E. inermis* in the neuston from May and July to September is shown in Figure 4. Sixty percent of the population were juveniles in July and the population was bimodal, indicating that all the overwintering juveniles in the May samples had matured by then and had released the summer generation. Continued growth of both generations resulted in a unimodal population by August. The older generation are represented by the largest size classes. These largest individuals were eliminated from the population by early September. The origin of the small number of newly recruited juveniles present in late September and the overwintering juvenile population is uncertain. They may have been released by late maturing females of the previous overwintering stock, but the evident lack of such females, as indicated by the clearly bimodal population in July and the elimination of large females by early September seems to contradict this. Alternatively, they represent the start of a new generation that will supply the overwintering juveniles and were produced by precocious development of the early summer generation. Growth rates indicate that this was at least possible. A small proportion of females produced in early summer had reached 5.0mm by the end of September. The average length of females in July, that had already reproduced was 4.9mm. Also, the increase in the male/female ratio from 1.26 in early September to 5.0 by September 28 may indicate the presence of a large percentage of non-migrating ovigerous females at that time.

E. truncata bred earlier than *E. inermis* (Fig. 4). The population in May was bimodal, consisting of juveniles and large females. These females continued to grow and attained lengths of 7.1-7.6mm by July. This was larger than the maximum length attained by *E. inermis* (5.6-6.1mm). These females disappeared from the neuston in August and the population remained unimodal from the beginning of August to the end of September. There was no recruitment after May and there was no evidence of an autumn brood or a second generation by September 28. However, as in *E. inermis* the male/female ratio increased during September from 0.22 to 1.3. Individual females produced in May attained a length of 6.6mm by September.

DISCUSSION

The benthohyponeustonic behaviour of *Eurydice* is controlled by an endogenous rhythm with light intensity and temperature acting as primary external *Zeitgebers* (Maquart-Moulin 1973, 1980). *Eurydice* are photonegative to strong light but are capable of orientated photopositive activity in weak light (Maquart-Moulin 1973). This orientated swimming is responsible for concentrating the population in the neuston as the surface acts essentially as a barrier to upward movement

The time of arrival at the sea surface is presumably a function of the depth at which each species occurs (40m in Galway Bay), how rapidly the individuals can swim upwards and the light intensity at which the phototactic response changes from negative to positive. This may occur at a lower light intensity in *E, truncata* since that species reached the surface later than *E. inermis.* The former species also leaves the neuston before *E. inermis* indicating a shorter period of activity at the surface. This may be an inherent adaptation in *E. truncata,* which is a deeper water species, to allow adequate time for a longer descent and reburrowing before daylight.

Variation in temperature is the primary factor responsible for the observed seasonal variation in density at the surface. Temperature changes between 10 and 25°C was shown by Maquart-Moulin (1980) to greatly influence the expression of the endogenous rhythm. A critical threshold between 10 and 13°C imposed extensive variation in the numbers emerging and the rhythm may completely disappear at or below these temperatures. Between 13 and 25°C emergences increased linearly with temperature. Changes in density of *E. inermis* in Galway Bay indicates a similar temperature response. Temperatures of 10.7°C and 10.9°C recorded in May are within the critical threshold range and were probably responsible for the low densities recorded at that time. The first significant increase in density occurred in July at which time the temperature had risen to 13.8°C, which is within the range which augments the rate of emergence. Similarly, the significant variation in densities found in Galway Bay are in contrast to results of Maquart-Moulin (1969, 1973) from the Gulf of Marseille where no seasonal variation was evident in *E. inermis.* Water temperatures rarely descend below 12°C in Marseille (Maquart-Moulin 1969).

It is likely that the seasonal emergence rhythm of *E. truncata* is under a similar temperature control. The main increase in density occurred in July, a month earlier than in *E. inermis.* This may indicate a lower critical threshold temperature above which emergence is more consistent and in general an adaptation to slightly lower temperatures than *E. inermis.* In this regard, densities of *E. truncata* were not positively correlated with temperatures and breeding began at lower temperatures than in *E. inermis* in Galway Bay. In the Mediterranean it is more abundant in the neuston during colder months and no juveniles occur daring the warmest periods which suggests an arrest in development at higher temperatures (Maquart-Moulin 1969). *E. truncata* also extends to deeper water than *E. inermis* (Jones and Naylor 1967).

The high variation in sample counts for any given month could be due to a number of factors. If substrates are heterogenous then *Eurydice* spp. will be patchily distributed in the benthos. This may be reflected in the neuston since possible dispersion time is limited, in the present case, to 2-3 hours. Also, differential tidal currents caused by bottom topography may cause sediment agitation only in specific areas. Substrate agitation may affect the emergence of *Eurydice* spp. (Maquart-Moulin 1982).

E. inermis reproduces continuously in the Gulf of Marseille, although it is not clear if *E. truncata* does so during warmer months (Maquart-Moulin 1969). In Galway Bay reproduction seems to be confined to summer in both species although there was some evidence that *E. inermis* produces a second generation in autumn which overwinters as juveniles.

Summary

Three species of *Eurydice, E. inermis, E. truncata* and *E. spinigera* were recorded from the neuston at night from May to September . *E. spinigera* was rare. The other 2 species were abundant and although they showed an overdispersed distribution, significant monthly variation in density was detected in both species. The abundance of *E. inermis* was positively correlated with surface water temperatures, but *E. truncata* attained highest densities at lower temperatures.

E. truncata released young earlier than *E. inermis,* growth rates were rapid in both species and there was some evidence of a second generation in *E. inermis,* which had an overwintering juvenile population.

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