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Length composition and abundance of eel larvae, *Anguilla anguilla* (Anguilliformes: Anguillidae), in the Iberian Basin (northeastern Atlantic) during July–September 1984

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ABSTRACT: 376 leptocephali of *Anguilla anguilla* (L., 1758) from the Iberian Basin were analysed. The observed horizontal trends of abundance and particularly the mean sizes contradict the expectations based on the hypothesis of larvae distribution exclusively by drift with Gulf and North Atlantic Currents, and support the hypothesis of an active larval migration also south of the Azores.

INTRODUCTION

During the period July–September 1984, investigations of the epi- and mesopelagic fish resources of the Iberian basin (outside EEZs) were performed by R.V. "Prof. Siedlecki" (MIR, Gdynia). Thereby, a great number of leptocephali of anguilliform fish (mainly *Anguilla anguilla*) were caught, though the program was not especially designed for this purpose. Importance of the subadult eels as an extensively used valuable fishery resource, and the low extent of knowledge on the fate of larvae after leaving the hypothetical spawning area and before reaching the coastal shelves (cf. Tesch, 1980) induced us to analyse the collected material.

MATERIAL AND METHODS

At 109 stations (for complete list, see Bast & Klinkhardt, 1987), hauls were made in depths between 5–1260 m. The depth of the hauls was measured by an echo sounder attached to the net. As gear a modified krill trawl net (mesh size of cod end 4.5 mm; opening 15.7 m^2) was used. Assuming a theoretical filtration rate of 100 %, at a towing speed of 2.5 kn, a water volume of 72 691 m^3 is filtered per hour. Unfortunately, the gear lacks an opening-closing mechanism, and therefore conclusions on exact depth of capture are impossible. Eel larvae were captured at 55 stations. For calculations of mean abundance, 17 additional trawls which yielded no eel larvae but which were performed in the depth range typically inhabited by leptocephali (above 250 m at night and 250–650 m at daytime; Tesch, 1980) were included. After capture, the leptocephali were preserved in seawater formalin (4 %). Measurements (nearest 0.1 mm) and counts were

Table 1. Abundance of eel larvae in different subareas of the Iberian Basin in summer 1984 (eel larvae per 10^6 m^3 water)

Sub area	Coordinates latitude longitude	All hauls from typical depths included			Hauls without eel larvae excluded		
		Number of hauls	Mean abundance (±S.E.)	Confidence limits (P = 10 %)	Number of hauls	Mean abundance (±S.E.)	Confidence limits (P = 10 %)
NW	41°–47° N 20° 30'–30° W	28	44.1 (65.5)	21.1	22	56.2 (69.4)	25.5
NE	41°–47° N 12°–20° 30' W	27	85.4 (141.5)	46.4	20	115.3 (154.1)	59.6
C	39°–41° N 13°–22° W	8	23.2 (26.2)	17.6	6	31.0 (26.0)	21.4
S	36°–39° N 13°–21° W	9	176.9 (272.2)	168.8	7	227.4 (292.3)	214.6
Weighted mean		72	73.9 (45.1)	8.9	55	96.7 (59.1)	13.3

carried out in the laboratory, after 3 years storage, as part of the work for a diploma (Strehlow, 1988).

RESULTS AND DISCUSSION

The mean number of myomeres amounted to 114.82 ± 1.64 (N = 363). This agrees well with the results of Schoth (1982) (114.68 ± 1.80; N = 895) and Kleckner & McCleave (1985) (114.52 ± 0.047; N = 932) but less with the data of Tesch & Deelder (1978) (114.00 ± 1.89; N = 30) and Kracht (1982) (113.9). Our value also coincides very closely with the mean number of vertebrae of European eels calculated by Boëtius (1980) (114.62 ± 0.011; N = 15 854).

One specimen (68.7 mm total length; stn. 12: 37°53′ N/14°0.5′ W) showed only 107 myomeres and because, moreover, the number of myomeres to the third visible intestinal blood vessel amounted only to 44, it had to be placed to *Anguilla rostrata*. The hitherto easternmost record of a larval American eel was a specimen of 70 mm total length from 49°43′N/20°45′ W (Kleckner & McCleave, 1985). Schoth & Tesch (1981, 1982) found *A. rostrata* larvae eastward until 52 °W. According to the number of vertebrae, approximately 0.13 % of 15 854 analysed eels from European waters proved to belong to *A. rostrata* (Harding, 1980).

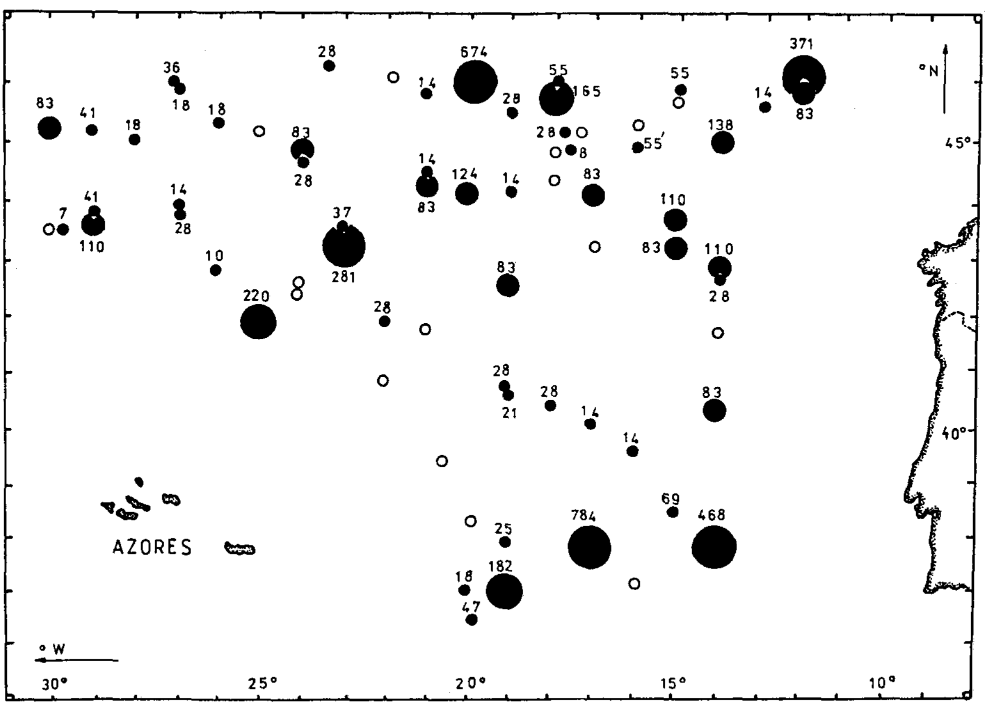

Fig. 1. Horizontal distribution of eel leptocephali from the Iberian Basin during summer 1984 (numbers = larvae per 10^6 m^3; open circles = stations without larvae)

For the investigated area, a mean abundance of 74 larvae/10^6 m^3 water was found (Table 1). If the unsuccessful hauls are disregarded, a mean of 97 specimens/10^6 m^3 results. The horizontal pattern of abundances shows a high degree of patchiness (Fig. 1). If the investigation area is subdivided (Table 1), highest values occur in the southern subarea which seems to be separated from the northern part by a zone of low abundance. The mean abundance of eel larvae in the northeastern part of our investigation area was found to be nearly twice the value for the northwestern subarea. These results are difficult to interpret, unless we assume a migration of larvae from the southern to the northeastern subarea that increases in amount from west to east. However, evidence for this idea is lacking so far.

Around 3 months later (Nov./Dec. 1984), R. V. "Friedrich Heincke" made 29 hauls in the area from Biscay to Gibraltar, and a mean abundance of 94 larvae/10^6 m^3 was found (Tesch et al., 1986). Our value for the northeastern subarea (85 larvae/10^6 m^3) agrees surprisingly well with this result. While our values may be underestimates due to the less appropriate fishing method, the mean abundance reported by Tesch et al. (1986) could,

Table 2. 3-year means of eel larvae abundance off the European continental shelf 1971–1985 (values compiled from data of Tesch (1980) and Tesch at al. (1985, 1986)

Period	Mean abundance (larvae/10^6 m^3)	Relative abundance (%)
1971–1973	1099	100
1974–1976	708	64
1977–1979	559	51
1980–1982	172	16
1983–1985	105	10

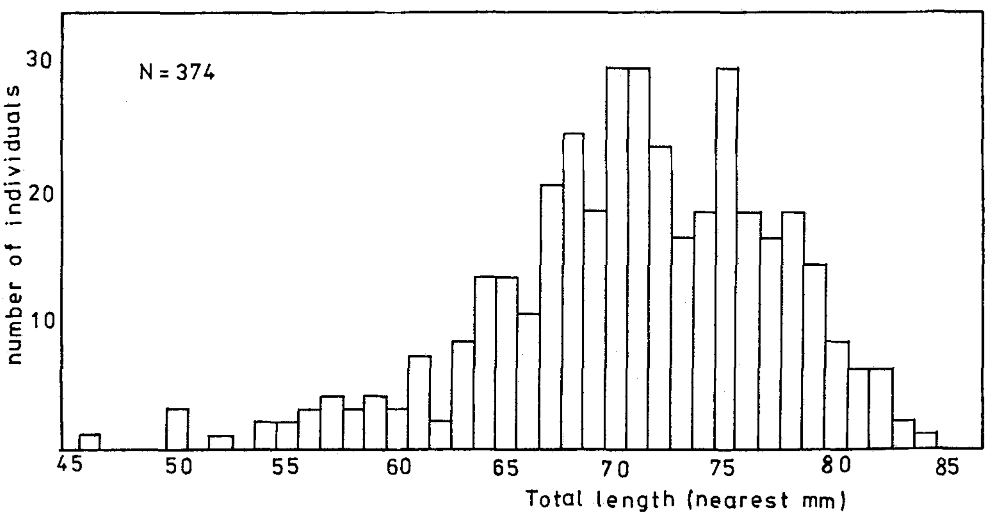

Fig. 2. Length frequency distribution of eel larvae

on the other hand, represent an overestimate because of a crowding effect at the continental shelf. In any case, the close correspondence of both values confirms the validity of making conclusions on the general trends of larval abundance west of the European continental shelf from samples in the Biscay and adjacent regions as was done by Tesch (1980) and Tesch et al. (1985, 1986). So it can be stated that the observed alarming decline of eel larvae abundance (Table 2) must be taken as valid for the whole European eel stock and should be reflected by further drastically decreasing commercial eel yields from European waters during coming years. Taking into account these perspectives, Tesch (1986) suggested placing the European eel on the "red lists" of endangered species and demanded measures to sustain and to promote natural eel reproduction. Our results also support this suggestion. Unfortunately, successful effort presupposes a joint action by several countries (e.g. restriction of catches especially of glass and silver eels; improvement of possibilities for unrestricted ana- and katadromous migration; restocking measures).

Measurement of total length of 374 larvae from 61 stations (including 5 stations from 1985) gave a mean of 70.74 ± 6.46 mm. The broad range of observed individual lengths (Fig. 2) must be interpreted as a representation of several age groups and/or of groups of larvae with differing life histories during migration. Utrecht & Holleboom (1985) found that eel larvae from the mid and eastern North Atlantic showed 3–5, and glass eels from the Netherlands and France even 1–6 otolith growth zones. Length composition of our

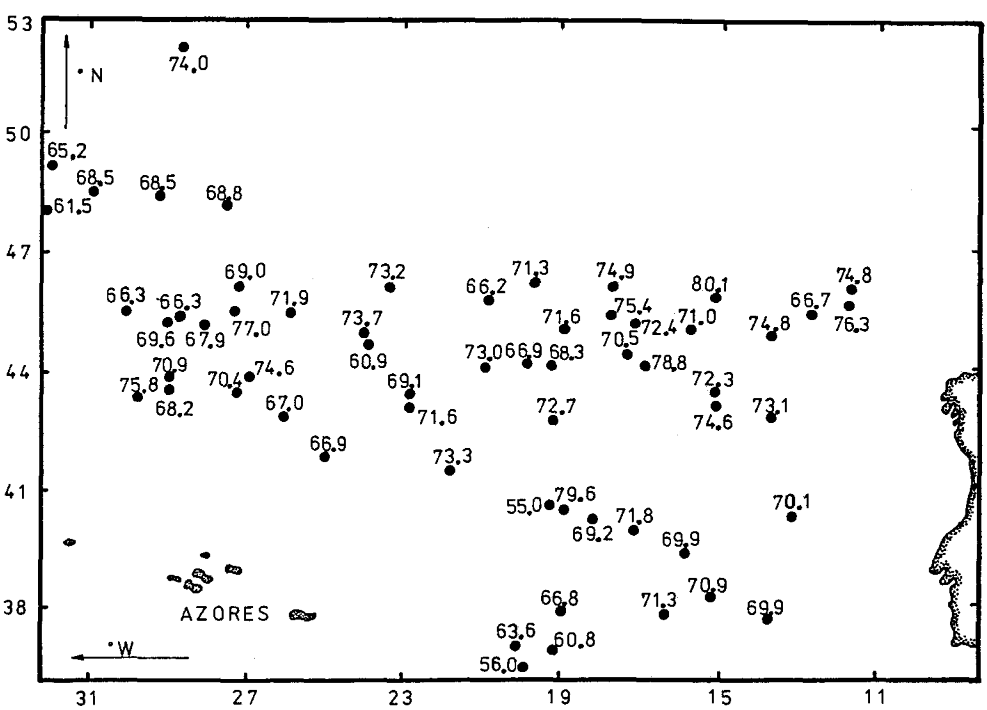

Fig. 3. Horizontal distribution of mean lengths of eel larvae from the Iberian Basin

material is similar to that found by Tesch (1980) off Great Britain and France (with total lengths between 62–80 mm) and by Tesch & Deelder (1978) at 11 stations between the Azores and northern Biscay (mean length = 68.3 ± 8.72 mm; N ≈ 23). Comparing the mean lengths of different stations, increasing values are recognizable from west to east

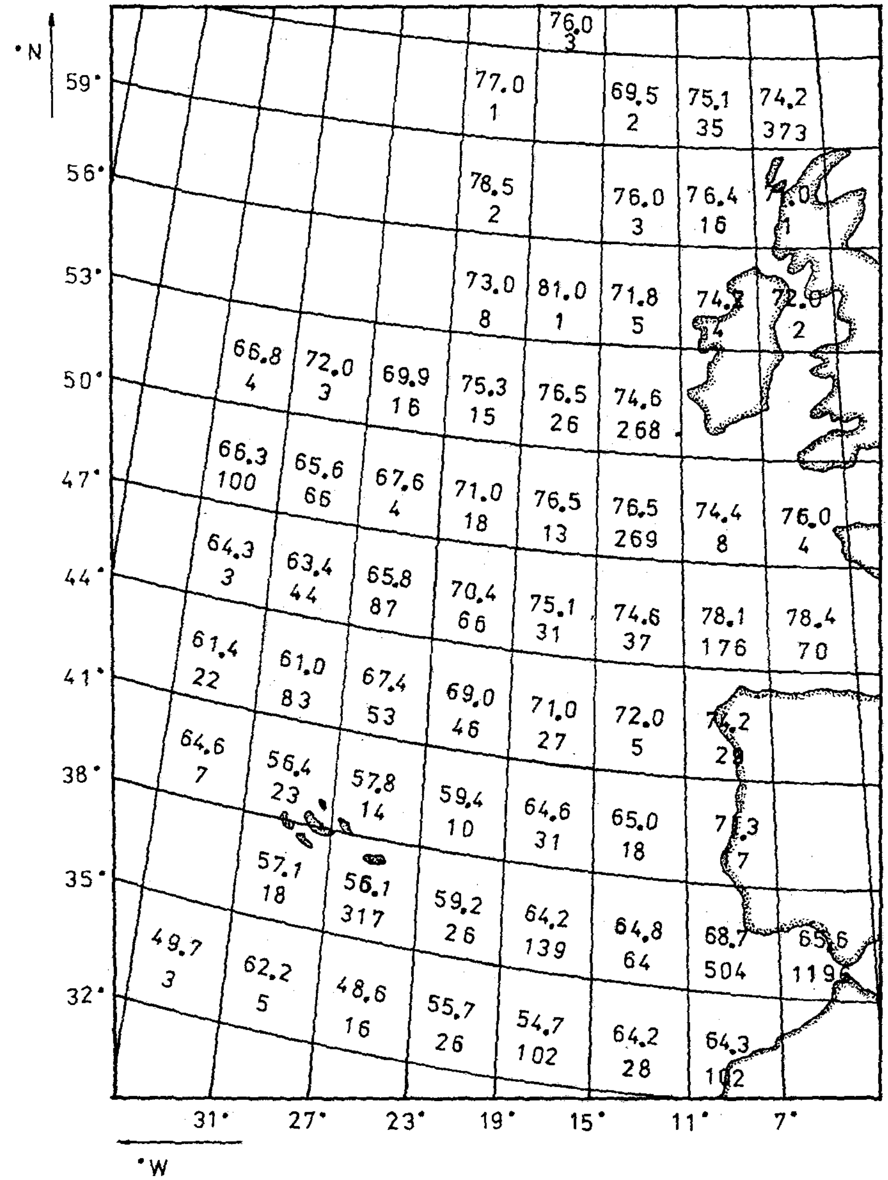

Fig. 4. Horizontal distribution of mean lengths of eel larvae from different areas of the Northeast Atlantic [data compiled from Boëtius & Harding (1985) together with our values] upper number = mean length; lower number = number of values included

and from south to north. It seems remarkable that, contrary to expectations (based on drift hypothesis), in the southern part of our investigation area significantly shorter (younger ?) specimens occur (Fig. 3). This phenomenon becomes even more evident when our data are combined with other published values from the Northeast Atlantic (Boëtius & Harding, 1985) (Fig. 4).

Until recent years, most authors assumed that the migration of leptocephali from the spawning areas to the continental shelves is a passive drift by means of the Gulf Stream and North Atlantic Current (Schmidt, 1922, 1925; Bruun, 1963; Sinha & Jones, 1967; Harden Jones, 1968; Tesch, 1973; Power & McCleave, 1983; Boëtius, 1985; Kleckner & McCleave, 1985; McCleave & Kleckner, 1985, 1987; McCleave et al., 1987; Helfman et al., 1987). Doubts concerning this assumption first arose when animals of lower lengths and earlier development stages were found south of Gibraltar compared to those from northern stations (Tesch et al., 1979; Kracht, 1982; Tesch, 1983; Tesch et al., 1985, 1986). Likewise not consistent with the hypothesis of continuous passive drift is the observation of a great range in the number of growth zones in the otoliths of leptocephali and glass eels (0+–10+) (Utrecht & Holleboom, 1985; Moriarty, 1986). Also the occurrence of numerous larvae southwest of the Azores (an area not directly influenced by North Atlantic Current), higher abundances of older larvae (above 30 mm) to the south of the Gulf Stream than within the Gulf Stream (Tesch et al., 1979; Kracht, 1982), and modern opinions on the circulation system of the North Atlantic (Köse et al., 1986; Krauss, 1986; Wenzel, 1986) support the hypothesis of an at least partly active migration of leptocephali towards the European shelf. The Azores Current may support this active migration and facilitate orientation. The 0+-larvae are distributed in a huge area (about 1.6 million km^2) between 70 °W and 50 °W (e.g. Tesch et al., 1979; Schoth & Tesch, 1981). If we continue to accept drift by Gulf Stream as the exclusive mechanism of larvae transport, we would have to explain how the larvae of the eastern part of the distributional range could cover the far distance (about 2500 km) to the point of entrance into the Gulf Stream north of the Bahamas (Kleckner & McCleave, 1982) or elsewhere without support of any suitable current. Beyond this, the larvae have also to overcome by some means the great gap between Gulf Stream and North Atlantic Current. The logical conclusion from all facts can only be the assumption of an active east-northeastward migration of a considerable portion of the larvae stock directly to the European shelf. The importance of the Gulf Stream as a transport medium has been greatly overrated up to this day.

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