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PATTERNS IN REPRODUCTION AND RECRUITMENT OF *LOLIGO FORBESI* AROUND THE BRITISH ISLES

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Abstract

Interannual and geographic variation in the timing of reproduction and recruitment of *Loligo forbesi* in Scottish and Irish waters is compared by two methods: the proportions of maturity stages present in monthly samples and estimation from the landings data of the abundance of recruits and mature males and females present each month. In all areas and all years squid in spawning condition (maturity stages IV and V) were present during the winter months (November-April), with the highest proportions of mature animals occurring between January and March. Recruitment, as indicated by an increase in the proportion of immature animals principally occurred in the late summer in both Scottish and Irish waters, with an additional period of recruitment in April in Scottish waters. Estimating the abundance of mature animals showed the peaks in reproduction to be in December-January in Scottish waters and in November-December in Irish waters. The numbers of recruits (< 150 mm ML) in landings peaked in the autumn in Irish and Scottish waters, with an additional spring recruitment evident in Scottish waters.

Introduction

The squid *Loligo forbesi* Steenstrup is distributed in coastal waters throughout the north-east Atlantic, where it is caught, mostly as a by-catch, in commercial fisheries. The timing of reproduction and recruitment of *L. forbesi* has been the subject of a number of studies in recent years (Lum-Kong *et al.*, 1992; Boyle and Ngoile, 1993; Pierce *et al.*, 1994a; Guerra and Rocha, 1994; Moreno *et al.*, 1994; Collins *et al.*, 1995). The results of these studies support the theory of a one year life cycle for *L. forbesi* across the range, but some annual and geographic differences are apparent in the timing of life cycle events in different areas. In Scottish and Irish waters the main periods of breeding are reported during the winter months, (Lum-Kong *et al.*, 1992; Boyle & Ngoile, 1993; Pierce *et al.*, 1994a; Collins *et al.*, 1995), but differences are reported in the timing of recruitment to the fishery.

In *L. forbesi*, as in other squid species, the spawning season has usually been identified as the time of year at which the highest proportion of mature squid are present in samples from commercial catches, however since this could occur at a time when squid are relatively scarce it may not reflect the period of maximum spawn production. Likewise recruitment has been indicated by an increase in the proportion of immature animals or by the presence of squid below a certain size threshold (*e.g.* 150 mm, see Pierce *et al.*, 1994), but this may not reflect the absolute abundance of recruits.

This paper describes annual and geographic variation in the timing of recruitment and spawning of *L. forbesi* around the British Isles and takes a more quantitative approach to assessing the timing of recruitment and spawning by taking into account monthly landings of *L. forbesi*.

Methods

Monthly sampling of commercially caught *Loligo forbesi* has been undertaken during the last 5 years, with samples obtained from a number of Scottish ports, but primarily from Peterhead, Fraserburgh, Aberdeen and Kinlochbervie. The target sample size of 200 individuals was not always attained due to differences in the seasonal availability of *Loligo forbesi*. Additional samples were obtained from the southern Irish ports of Dunmore East, Dingle and Kilmore Quay during the years 1991-1995, again with a target of 200 animals per month.

Each animal sampled was measured to the nearest mm dorsal mantle length, weighed (g) and assigned a maturity stage in accordance with Ngoile's (1989) modification of

Lipinski's (1979) maturity scale. All measurements were conducted where possible on freshly caught animals.

Two approaches were made to assessing the timing of reproduction and recruitment in *L. forbesi*. In the first approach the proportion of each maturity stage in each monthly sample is examined to show the months in which the highest proportion of mature animals were present (indicating the spawning season) and the months in which immature animals appear (indicating recruitment).

The second approach combines the monthly landings of *L. forbesi* with the proportion of mature animals or recruits in the samples to produce an estimate of the number of mature animals or recruits each month, termed 'Population Maturity Index' or 'Population Recruitment Index'. Equation 1 illustrates how the Population Maturity Index is calculated for male *L. forbesi*. This approach was applied to Scottish squid landings data for the years 1990-1994, and to the Irish data for the years 1991-1993 using monthly landings in the port of Dunmore East as an indication of squid abundance. By applying the proportion of squid of size less than 150 mm ML to the monthly landings figures a 'Recruitment Index' was produced using a similar calculation.

Equation 1. Calculation of Population Maturity Index for male *Loligo forbesi*.

$$PMM \times L(Kg) = MML(Kg)$$

$$MML(Kg) + \text{MeanMMW}(Kg) = \text{NoMML}$$

PMM = Proportion of mature males (by weight) in monthly sample
 L = Monthly landings
 MML = Weight of mature males in monthly landings
 MeanMMW = Mean weight of mature males in monthly sample
 NoMML = Number of mature males landed that month (Male Population Maturity Index for that month)

Results

Timing of Maturation

Figure 1 shows the proportion of each maturity stage in monthly samples of *L. forbesi* from Scottish waters in the years 1990-1995. In all years mature females were present from November until May, with the highest proportions present between January and March. Mature males were usually present slightly earlier (October). Figure 2 shows comparative data for Irish waters (partly from Collins *et al.*, 1995). Mature females

were present from November until April with, as in Scottish waters, the highest proportion of mature squid occurring between January and March. As in Scottish waters mature males were found in samples in October. Irish samples could not be obtained from May or June in any year due to the absence of *L. forbesi* in commercial landings.

Figure 3 shows the population maturity index calculated for male and female *L. forbesi* in Scottish waters for the years 1990-1994. This analysis shows that the peak in numbers of spawning animals in the commercially exploited population occurs between December and January, slightly earlier than is indicated by looking at the proportion of mature squid in samples. These results also indicate that mature males are present before mature females. Figure 4 shows the population maturity index for *L. forbesi* in Irish waters, with peaks in November and December in both sexes.

Timing of recruitment

An increase in the proportion of immature animals gives an indication of recruitment. In Scottish waters recruitment occurred sporadically through the year, with the principal peaks in April-May. In Irish waters the main recruitment appears to be in July-August, with additional recruitment in December or January.

Figure 5 illustrates the recruitment index calculated for *L. forbesi* in Scottish waters for the years 1990-1994 and in Irish waters for the years 1991-1993. The analysis indicates scattered recruitment in Scottish waters, but with some evidence of two main peaks in spring (April-May) and in autumn (August-November). In Irish waters there appears to be only one recruitment season, in the autumn.

Discussion

The reliance on relatively small monthly samples to predict life-cycle events in *L. forbesi* means that results must be treated with a degree of caution, since a single sample of squid may not be truly representative of the exploited squid population. It is quite common to see different vessels landing different sized squid from apparently similar areas, although the proportion of maturity stages is usually more consistent (MAC, personnel observation). The two methods used here to identify the timing of spawning and recruitment produced slightly different results. The use of an index that accounts for squid abundance is clearly a better method of identifying the seasonality of life cycle events and in this study showed the peak of reproduction to occur earlier than would be predicted by relying solely on the proportion of mature animals. The difference between the results is mostly due to the higher abundance of squid in the late

autumn. The index used here did not take into account fishing effort, mainly because this was unavailable for the Irish data, however Pierce *et al* (1994b) has showed that since squid is predominantly a by-catch, landings and CPUE are closely coupled. The use of a population maturity or recruitment index, such as those employed here also allows interannual comparisons between the relative sizes of the spawning and recruiting stocks.

Although there are some interannual variations, repeated trends are clearly apparent in both the Irish and the Scottish data. In all years and in both regions the peak in spawning is in the winter months, with the highest numbers of mature animals occurring between November and December in Irish waters and between December and January in Scottish waters. In Spanish (Galician) waters spawning of *L. forbesi* is also reported to occur during the winter (Guerra and Rocha, 1994), whilst in Portuguese waters spawning is during autumn and winter (Moreno *et al.*, 1994). Holme (1974) identified a summer spawning group of *L. forbesi* in the English channel and two mature females were found in Irish waters in June 1992 (Collins *et al.*, 1995), but there is no evidence from commercial samples of a significant summer spawning group in Scottish or Irish waters. Egg masses of *L. forbesi* have been reported in Irish (Collins *et al.*, 1995) and Scottish (Collins, unpublished) waters in the summer months.

Recruitment of squid in Scottish waters is less predictable than the timing of spawning, but there appear to be two main periods of recruitment, one in spring and one in autumn, and it might be expected that these periods of recruitment would lead to two distinct spawning periods, but there is no evidence of this. If the autumn recruits produce the winter spawners, then what happens to the spring recruits? It is possible that these squid spawn on the Rockall Bank in the late summer and early autumn (Pierce *et al.*, 1994a), an area that is outside the normal sampling range of the present study. In Irish waters the only identified period of recruitment is in the autumn.

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References

- Boyle, P. R. and Ngoile, M. A. K. 1993a. Assessment of maturity state and seasonality of reproduction in *Loligo forbesi* (Cephalopoda: Loliginidae) from Scottish waters. In Recent advances in cephalopod fisheries biology, pp. 37-48. Ed. by T. Okutani, R. K. O'Dor and T. Kubodera. Tokai University Press, Tokyo. 752pp.
- Collins, M. A., Burnell, G. M. and Rodhouse, P. G. 1995a. Recruitment, maturation and spawning of *Loligo forbesi* Steenstrup (Cephalopoda: Loliginidae) in Irish waters. ICES Journal of Marine Science, 52: 127-137.
- Guerra, A. and Rocha, F. 1994. The life history of *Loligo vulgaris* and *Loligo forbesi* (Cephalopoda: Loliginidae) in Galician waters (NW Spain). Fisheries Research, 21: 43-70.
- Holme, N. A. 1974. The biology of the squid *Loligo forbesi* (Mollusca: Cephalopoda) in the Plymouth area. Journal of the Marine Biological Association of the United Kingdom, 54: 481-503.
- Lipinski, M. R. 1979. Universal maturity scale for the commercially important squids (Cephalopoda: Teuthoidea). The results of maturity classification of *Illex illecebrosus* (LeSueur, 1821) population for years 1973-1979. International Commission for Northwest Atlantic Fisheries (ICNAF), Research Document 79/II/38. Serial No. 5364, 40pp.
- Lum-Kong, A., Pierce, G. J. and Yau, C. 1992. Timing of spawning and recruitment in *Loligo forbesi* (Cephalopoda: Loliginidae) in Scottish waters. Journal of the Marine Biological Association of the United Kingdom, 72: 301-311.
- Moreno, A., Cunha, M. M. and Pereira, J. F. M. Population biology of veined squid (*Loligo forbesi*) and European squid (*Loligo vulgaris*) from the Portuguese coast. Fisheries Research, 21: 71-86.
- Ngoile, M. A. K. 1987. Fishery biology of the squid *Loligo forbesi* Steenstrup (Cephalopoda: Loliginidae) in Scottish waters. Ph.D. Thesis, University of Aberdeen.
- Pierce, G. J., Boyle, P. R., Hastie, L. C. and Key, L. 1994a. Life history of *Loligo forbesi* (Cephalopoda: Loliginidae) in Scottish waters. Fisheries Research, 21: 17-41.
- Pierce, G. J., Boyle, P. R., Hastie, L. C. and Shanks, A. M. 1994b. Distribution and abundance of the fished population of *Loligo forbesi* in UK waters: analysis of fishery data. Fisheries Research, 21: 193-216.

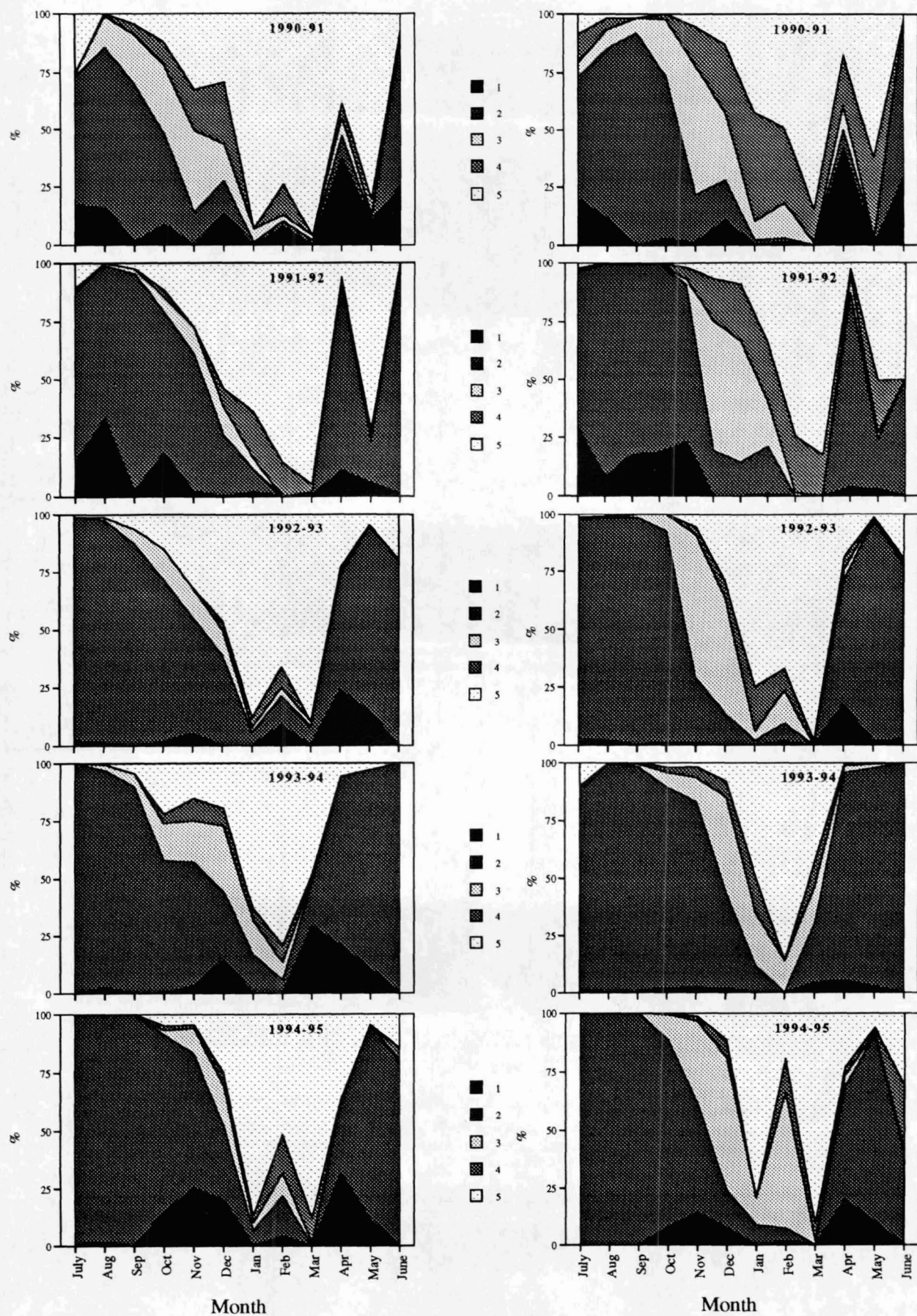


Figure 1. Percentage of each maturity stage in samples of male (left) and female (right) *Loligo forbesi* in Scottish waters for the years 1990-95. The scale used is Ngoile's (1987) modification of Lipinski's (1979) Universal maturity scale.

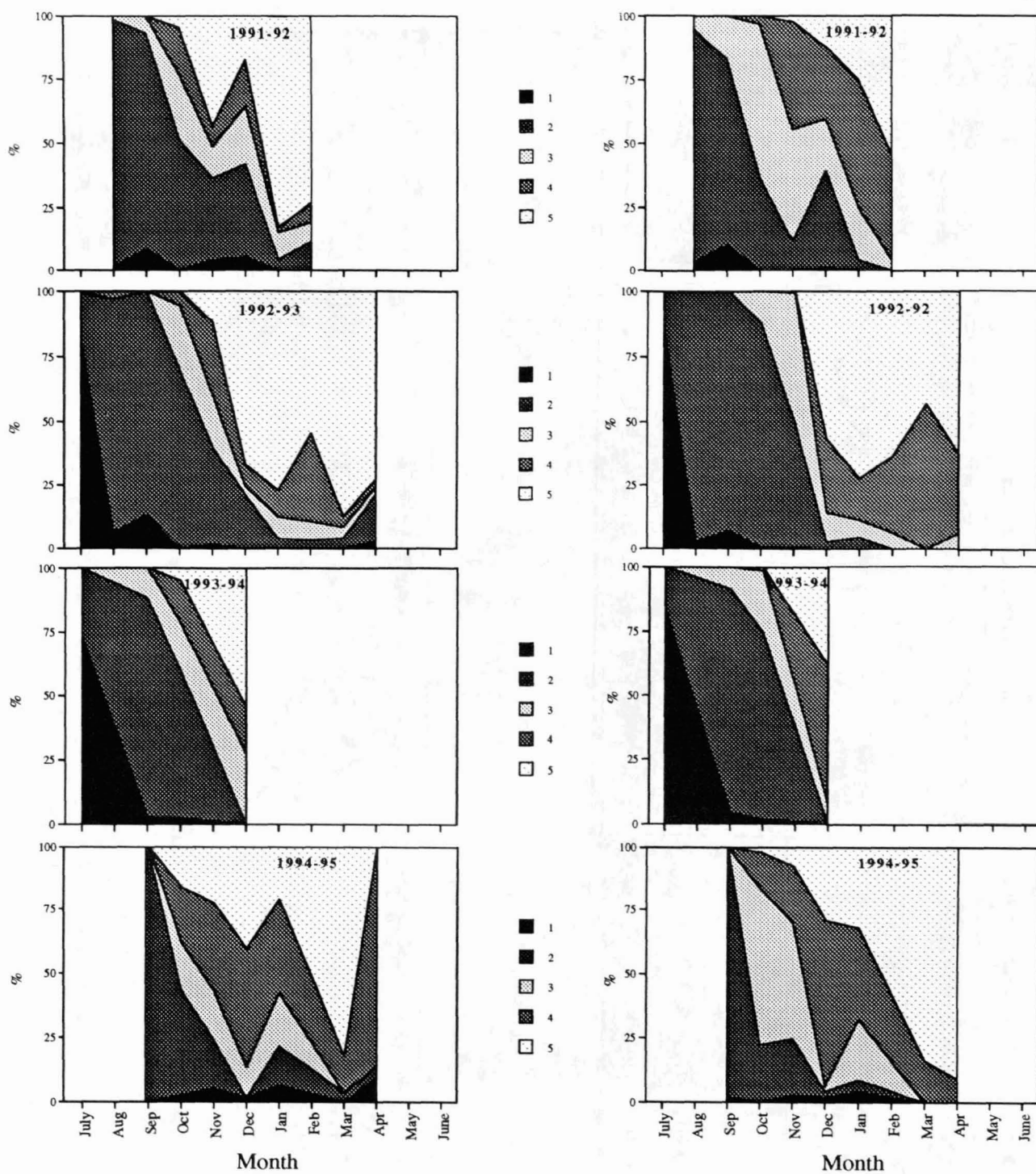


Figure 2. Percentage of each maturity stage in samples of male (left) and female (right) *Loligo forbesi* in Irish waters for the years 1991-95. The scale used is Ngoiles's (1987) modification of Lipinski's (1979) Universal maturity scale.

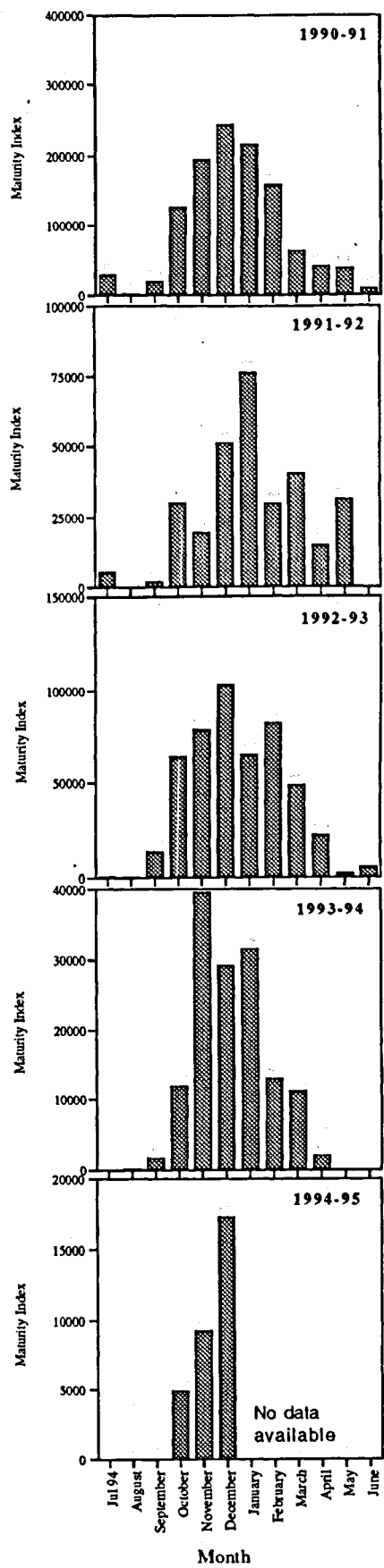
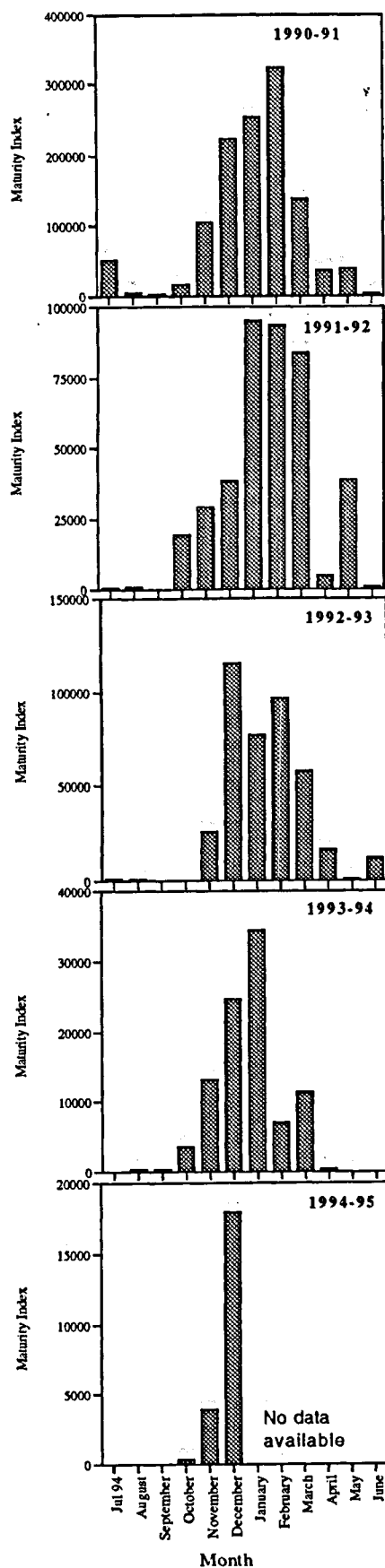


Figure 3. Population Maturity Index for female (left) and male (right) *Loligo forbesi* in Scottish waters for the years 1990-95. Index based on an estimation of the number of mature animals landed each month.

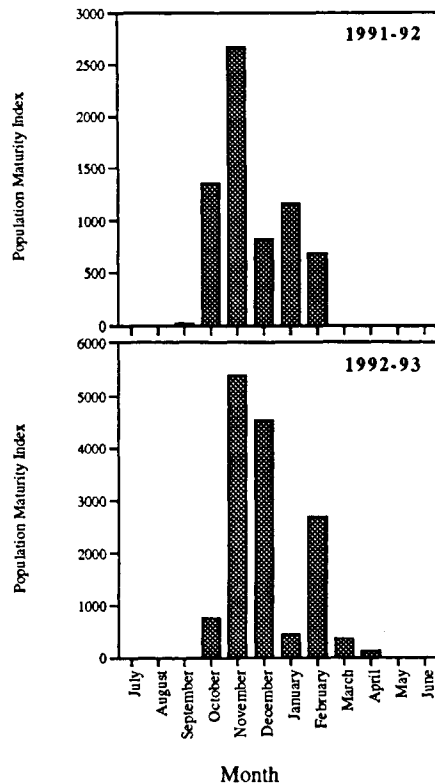
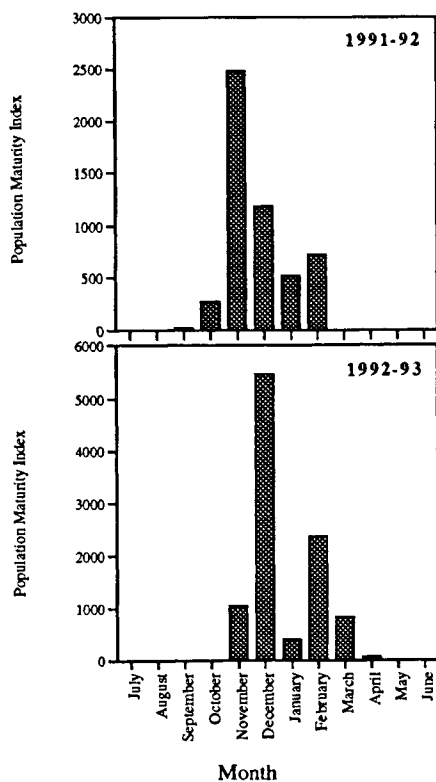


Figure 4. Population Maturity Index for female (left) and male (right) *Loligo forbesi* from the south-east of Ireland for the years 1991-93. Population index based on an estimation of numbers of mature squid landed at the port of Dunmore East.

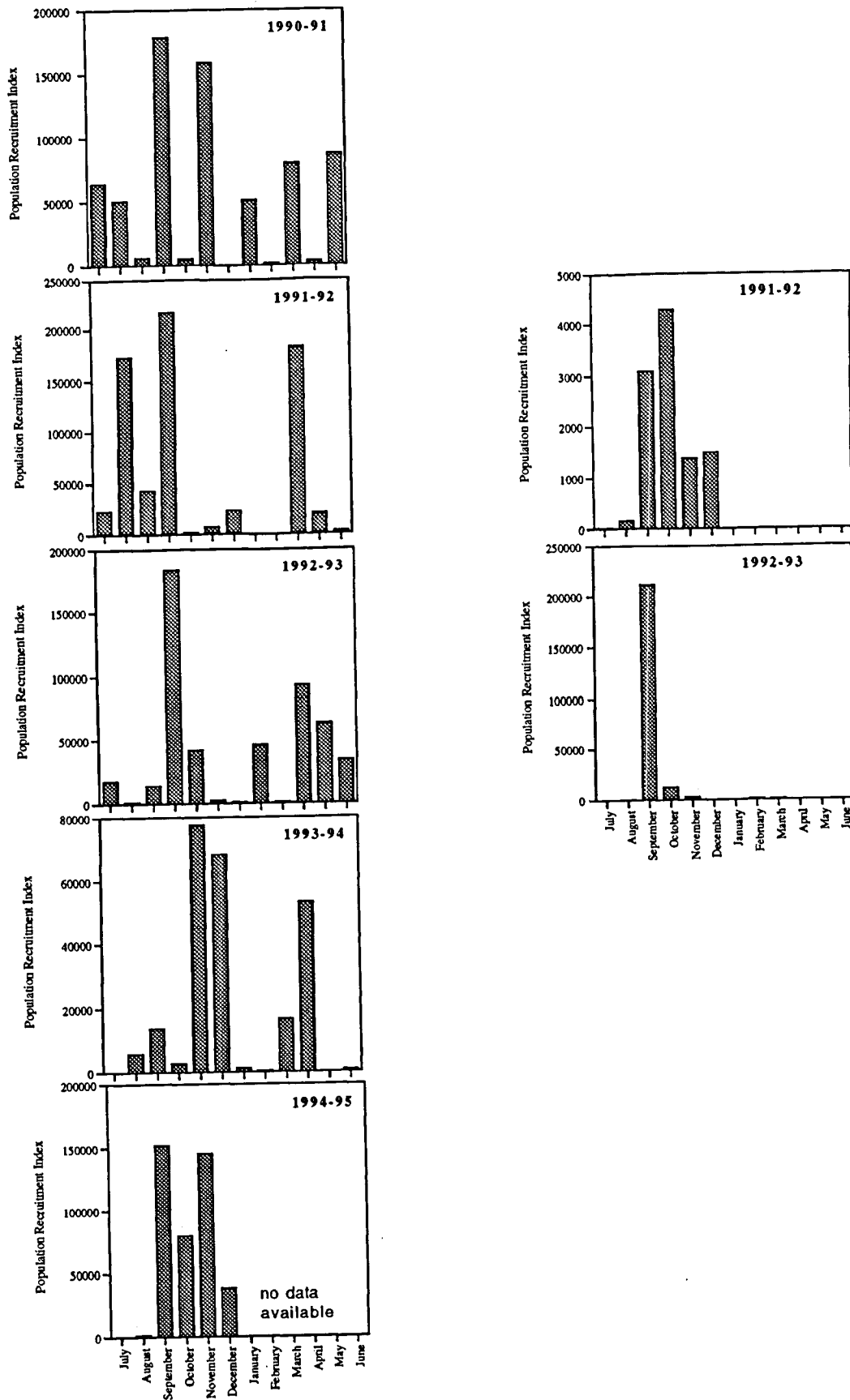


Figure 5. Population Recruitment Index for *Loligo forbesi* in Scottish waters (left) and the south-east of Ireland (right). Scottish index calculated by estimating the number of recruits (ML < 150mm) in each months landings. Irish index calculated by estimating the numbers of recruits landed each month in the port of Dunmore East.