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The first evidence of offshore spawning in the squid species *Loligo forbesi*

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Records of the squid (*Loligo forbesi*) egg masses which were incidentally caught in demersal trawls at three offshore sites are presented. These sites were at water depths of 135, 302 and 507 m. This represents the deepest ever record of spawning in a loliginid squid species. There has been speculation in the literature about offshore spawning in *L. forbesi* but it has not previously been recorded and may have important implications for the life cycle.

Loligo forbesi (Steenstrup, 1856) is a commercially important fisheries resource throughout its range. In recent years numerous studies on the fisheries biology of the species have been aimed at preparing the ground work for stock assessment and eventual management of the *L. forbesi* fishery in the north-east Atlantic (Collins et al., 1995b, 1997; Guerra & Rocha, 1994; Moreno et al., 1994; Pierce et al., 1996, 1994a,b). One of the fundamental prerequisites for successful management of any squid stock is a knowledge of spawning sites and factors affecting the early life stages (Pierce & Guerra, 1994).

Loligo forbesi egg masses are bunches of semi-translucent and gelatinous finger-like strings of eggs (Figure 1). Loliginid species are thought to mainly spawn in inshore areas (Roper et al., 1984). All *L. forbesi* spawning records come from inshore areas. Collins et al. (1995b) recovered egg masses from static fishing gear over rocky ground at 10–50 m off the south coast of Ireland. Holme (1974) reported that egg masses have been found attached to tree twigs, submerged fishing floats, rope moorings and crab pots in inshore areas off Plymouth. Lum-Kong et al. (1992) found egg masses attached to inshore creel lines in Scotland and Porteiro & Martins (1992) found egg masses on an octopus trap at 25–30 m in the Azores.

However, in the Mediterranean it is likely that spawning occurs offshore since *L. forbesi* is displaced in inshore areas (<150 m) by its conspecific *L. vulgaris* (Boletzky & Mangold, 1985). Holme (1974) and Lum-Kong et al. (1992) also suggest that it is likely that most *L. forbesi* spawning occurs offshore in waters around the UK but, as Collins et al. (1995b) notes, there is no direct evidence. This note represents the first direct evidence of natural offshore spawning of *L. forbesi* on the continental shelf edge and slope west of France, Ireland and in the Celtic Sea.

All the eggs collected offshore were caught incidentally in demersal trawls. Two of the records of egg masses come form the annual Celtic Sea groundfish surveys conducted by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) aboard RV 'Cirolana' in 1995 and 1997. The third record is of egg masses collected on a routine ommastrephid squid sampling trip on the Dingle based commercial trawler MFV 'Shannon'. The gear type employed on RV 'Cirolana' was a modified Portuguese

Figure 1. Examples of the *Loligo forbesi* egg masses caught at 'site A'. Scale bar: 10 cm.

Table 1. *Details of demersal trawl caught* Loligo forbesi *egg masses.*

Record	Date	Vessel	Coordinates	Water depth (m)	Bottom temperature (°C)	Salinity (psu)
A	31/3/95	'Cirolana'	47°31′N 05°13′W	135	10.99	35.58
B	10/4/96	'Shannon'	53°09′N 12°16′W	302	10.70	
C	12/3/97	'Cirolana'	51°19′N 11°32′W	507	10.79	

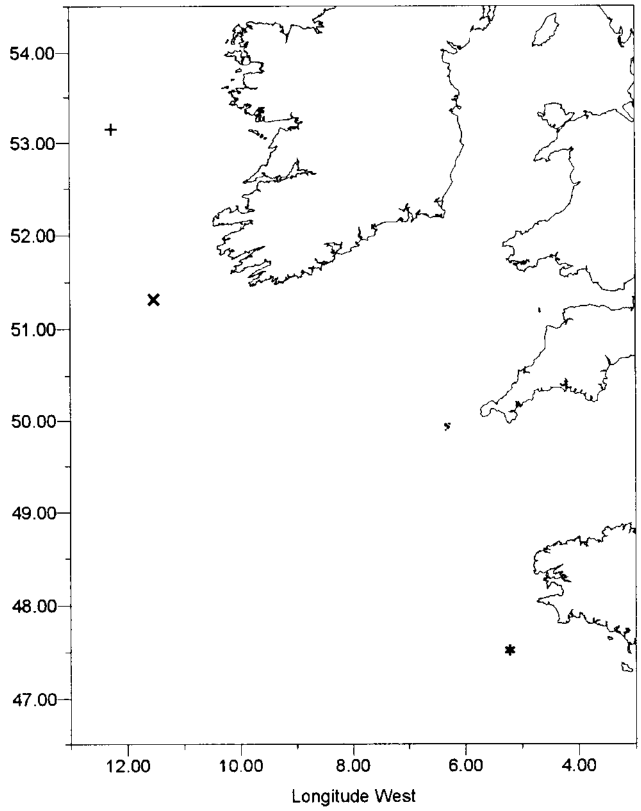

Figure 2. Locations where the naturally spawned eggs of *Loligo forbesi* were incidentally trawl caught: sites A (*), B (×), C (+).

bottom trawl fitted with 35 cm rubber bobbins on the ground rope, a bunt tickler chain and a small mesh liner fitted to the cod end (nominal diagonal stretched mesh size 20-mm). The net was towed for 1 h at approximately 3 kn. Motor fishing vessel 'Shannon' employed a modified Spanish type demersal trawl with a cod-end mesh size of 90-mm towed at 2.7 kn along a similar depth contour for approximately six hours. Temperature and salinity on the bottom were recorded using SCANMAR™ net sensors. Identification of the eggs and level of embryonic development were according to Segawa et al. (1988). Identification of the maturity of the squid caught was macroscopic according to Lipinski's universal maturity stage (in Juanico, 1983).

The dates, vessels, locations, depths, bottom temperatures and salinities for the sites where the eggs were incidentally caught are presented in Table 1. The geographical location of the sites is presented in Figure 2. Only 'site A' is regularly surveyed and egg masses have not been noted before or since 1996. At 'site A' the meshes on the belly of the net were covered in egg masses when it was hauled on deck, the eggs were identified as '*Loligo* type' eggs. Five mature female *L. forbesi* and several mature males were also caught in the trawl. The eggs were held in a tank with flow through seawater for several days before transportation to Aberdeen where they were identified as *L. forbesi* eggs (M.A. Collins, personal communication). At 'site B' what appeared to be the remains of a tree branch was found in the cod end of the net, this was covered with a total of 35 fingers of *L. forbesi*, no post recruit *L. forbesi* were caught at the same location. At 'site C' three fragments of egg fingers were found in the cod-end, these were identified as *L. forbesi* from the embryos which were well developed (stage 28+ after Segawa et al., 1988). One immature female *L. forbesi* was also caught at that site.

The eggs caught at two of the three offshore locations ('site B' and 'site C') could have been detached eggs that were not naturally laid in the area where they were caught. However, this must be considered as unlikely given the large distances the egg masses were found from inshore sites and the fact that the eggs were alive and appeared to be developing normally. Given the large amount of egg masses on the net at 'site A' this area is almost certainly a natural spawning area. Egg masses are not often taken in trawls possibly because they are in areas that are inaccessible to trawls (Holme, 1974). Collins et al. (1995b), found that most inshore spawning occurred away from trawling grounds in rocky areas, it seems plausible that offshore spawning would be on similar solid substrate type. Therefore these records ('sites A, B and C') of spawning on sandy/muddy trawling ground might be regarded as unusual and spawning on hard ground offshore may be common. It also seems likely that spawn trawled up offshore normally goes unreported so this note seeks to highlight the importance of keeping future records of offshore spawning in this species.

Loligo pealei (LeSueur, 1821) is known to spawn as deep as 250 m, *L. opalescens* (Berry, 1911) usually spawns in relatively shallow waters but in some cases spawns as deep as 180 m (Roper et al., 1984). Records 'B' and 'C' at 303 and 507 m respectively therefore represent the deepest ever records of loliginids spawning and greatly extend the known depth range of spawning in family Loliginidae. This may have implications for other loliginid species such as *L. gahi* and *L. sanpaulensis* which are thought to spawn inshore but can live down to 400–600 m (Hatfield et al., 1990; Andriguetto & Haimovici, 1996).

One of the most interesting implications of spawning at those depths is the effect of temperature and possibly pressure on embryonic development rates. Lower temperatures in particular retard embryonic development rates in cephalopods (Boletzky, 1994). At 12.5 °C *L. forbesi* hatch at 68–75 d (Segawa et al., 1988). Boyle et al. (1995) recovered an egg mass from an area where water temperature ranged between 8 and 10 °C and according to the fishermen it may have been in the water for as long as six months. Bottom temperatures at 'site B' and 'site C' remain approximately 10.5 ± 1 °C year round therefore it may take a long time for the eggs to develop and hatch. This has important implications for the life cycle of *L. forbesi*. Collins et al. (1995a) estimated *L. forbesi* in Irish waters have a 1-y lifespan by counting post-hatching increments on statoliths, however this method does not take account of the embryonic development

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period. If offshore spawners have retarded embryonic development rates then a 1-y life cycle may not always be possible in Irish waters. This supports the evidence from laboratory culture experiments which did not predict a 1-y life cycle in *L. forbesi* (Hanlon et al., 1989).

Inconsistencies in life cycle, marked interannual fluctuations in total landings and shifts in distribution have been described in some of the recent studies on the reproductive biology and life history of *L. forbesi* (Boyle et al., 1995; Pierce et al., 1994b). The location of spawning sites together with environmental factors affecting the eggs, developing embryos and hatchlings play a key role in explaining some of the stock fluctuations and apparent inconsistencies in the *L. forbesi* life cycle. The effects of these environmental factors will need to be addressed before management of *L. forbesi* is possible.

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