

10 *Sepiola atlantica* d'Orbigny, 1842

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Common names

Sépiole grandes oreilles (France), chopo-anão (Portugal), sepiola atlántica (Spain), Atlantic bobtail squid (UK) (Figure 10.1).

Synonyms

None.

10.1 Geographic distribution

The Atlantic bobtail squid, *Sepiola atlantica* d'Orbigny, 1842, is found in the Northeast Atlantic from ca. 65 to 35°N (Reid and Jereb, 2005) (Figure 10.2). Its distribution extends from Iceland (Degner, 1925; Adam, 1939; Bruun, 1945) and the Faroe Islands (Nielsen, 1930) to the Norwegian Sea and the west coast of Norway (Grimpe, 1925; Grieg, 1933; Jaeckel, 1958). Old records from the Skagerrak and Kattegat (Grimpe, 1925) are confirmed by recent information (Hornborg, 2005), and incursions into the western Baltic Sea have been reported (Grimpe, 1925). Widely distributed and very common in the North Sea (Russell, 1922; Grimpe, 1925; Adam, 1933; Gittenberger and Schrieken, 2004; De Heij and Baayen, 2005; Oesterwind *et al.*, 2010), it extends along the north and west coasts of Scotland (Russell, 1922; Stephen, 1944), through Irish and British waters (Massy, 1928; Lordan *et al.*, 2001a), the Porcupine Seabight (southwestern Ireland; Collins *et al.*, 2001), and the Celtic Sea (Lordan *et al.*, 2001a). From the English Channel (Pfeffer, 1908; Grimpe, 1925), it extends south along the west coasts of France and Spain (Guerra, 1992) to Northwest Africa off the Moroccan coast (as far as due west of Casablanca; Robson, 1926). A single record from the Mediterranean Sea has never been confirmed (Würtz *et al.*, 1995).

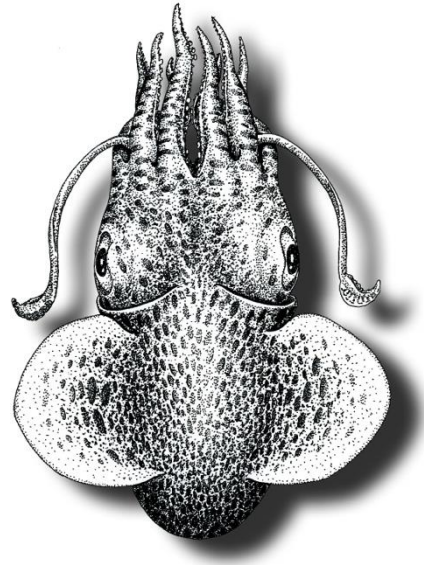


Figure 10.1. *Sepiola atlantica*. Dorsal view. From Guerra (1992).

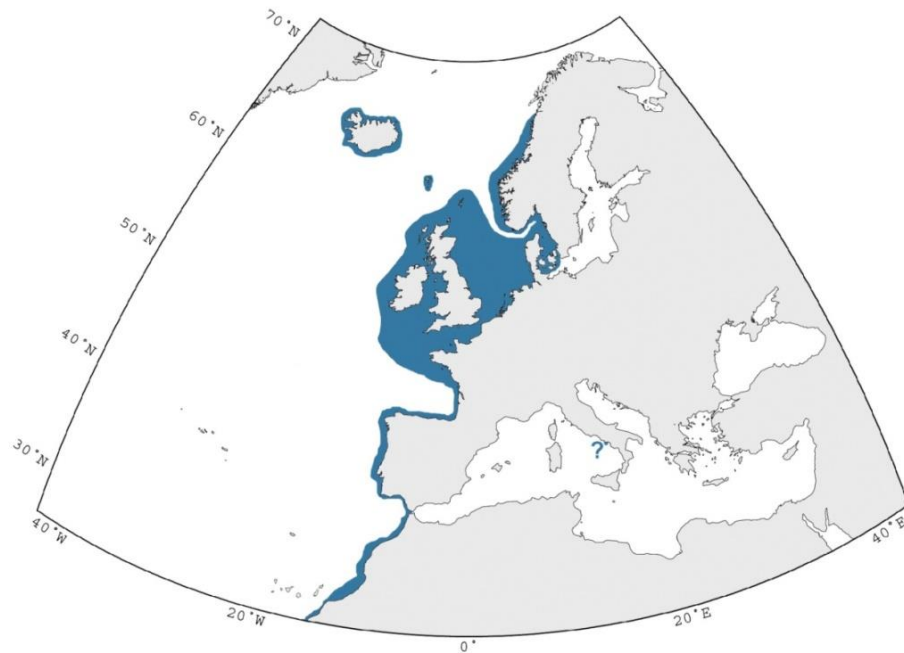


Figure 10.2. *Sepioloidea atlantica*. Geographic distribution in the Northeast Atlantic.

10.2 Taxonomy

10.2.1 Systematic

Coleoidea – Decapodiformes — Sepiolidae – Sepiolinae – *Sepioloidea*.

10.2.2 Type locality

Bay of Biscay, France.

10.2.3 Type repository

Muséum National d'Histoire Naturelle, Laboratoire Biologie Invertébrés Marins et Malacologie, 55, rue de Buffon, 75005 Paris 05, France; syntype 2-1-1209 [fide Lu *et al.* (1995)].

10.3 Diagnosis

10.3.1 Paralarvae

The size of individual hatchlings obtained in the laboratory ranges between 1.1 and 1.7 mm (Rodrigues *et al.*, 2011a). In Galician waters (northwestern Spain), they range from 1.5 to 2.0 mm ML and have been collected in midwater both night and day. Paralarvae are similar to adults except for their shorter arms and tentacles in relation to mantle length (Á. Guerra, pers. comm.).

10.3.2 Juveniles and adults

Recent observations on populations around Anglesey (north Wales; Jones and Richardson, 2012) and from the Ría de Vigo (Galicia, northwestern Spain; Rodrigues *et al.*, 2011b) recorded maximum mantle length as 24 mm for females, larger than previously reported for the species (i.e. 21 mm; Yau and Boyle, 1996; Reid and Jereb 2005). Adult males and females are of similar size. Fins are short and do not exceed mantle length anteriorly or posteriorly. Arms IV bear biserial suckers proximally, and 4–8 rows of

minute suckers at the distal tips; the remaining arms bear two series of suckers throughout.



The dorsal left arm is modified (hectocotylized) in mature males (Figure 10.3) and strongly bent in its distal half; it is characterized by the presence of a fleshy pad formed from enlarged and fused sucker pedicels, and a copulatory apparatus formed by a large swollen horn, with secondary lobes, basally. In the dorsal series of suckers, distal to the copulatory apparatus, there are 3–4 slightly enlarged suckers with swollen pedicels, followed by 3–4 greatly reduced suckers, then by 3–5 greatly enlarged suckers, ca. halfway along the arm. Tentacular clubs bear 8 longitudinal series of suckers, arranged in transverse rows; suckers in the dorsal series are larger than those in the ventral ones.

Figure 10.3. *Sepioloidea atlantica*. Hectocotylized arm. From Guerra (1992). Mature females do not have a “muscle constrictor” and have a small bursa copulatrix. Paired, kidney-shaped light organs (photophores) are present inside the mantle cavity on each side of the ink sac (Guerra, 1992; Bello, 1995b; Reid and Jereb, 2005). There is a dimorphism in the brachial crown in mature individuals, with males having a muscular nodule at the base of the ventral arms (Rodrigues *et al.*, 2012).

10.4 Remarks

A single record of *S. atlantica* in the Mediterranean Sea exists (Würtz *et al.*, 1995). However, the presence of this species has not otherwise been reported there, either before or since (e.g. Bello 1986, 1992a, 2004; Mangold and Boletzky, 1987; Salman, 2009); therefore, that record is likely a misidentification.

The subfamily Sepiolinae, to which *Sepioloidea* belongs, can be distinguished from other subfamilies in the Sepiolidae by several features: the anterior edge of the mantle does not cover the funnel ventrally and is fused with the head dorsally by a cutaneous occipital band that occupies from 33 to 50% of the head width. Unlike other genera within the subfamily Sepiolinae, *Sepioloidea* species have a pair of kidney-shaped light organs (photophores) inside the mantle cavity, over the ink sac. *Sepietta* species do not have photophores, and in *Rondeletiola*, the light organ is large and round, being formed by the fusion of the two organs (Guerra, 1992; Bello, 1995b; Reid and Jereb, 2005).

Recent molecular data (Groenenberg *et al.*, 2009) highlighted the presence of an additional species of sepiolid in the North Sea, now described as *Sepioloidea tridens* De Heij and Goud, 2010, which is closely related to *S. atlantica*. In their study, Groenenberg *et al.* (2009) found that some one-third of samples they originally identified as *S. atlantica* formed a separate well-supported clade in a phylogenetic tree constructed from Bayesian inference analysis of the mitochondrial gene cytochrome oxidase subunit I (COI: the “barcode of life” gene). The molecular data suggested that members of this clade, now described as *S. tridens*, were more closely related to *S. atlantica* than to any of the other *Sepioloidea* species in the North Sea, a fact supported by their morphological similarity. However, despite the similarity, De Heij and Goud (2010) identified differences in the tentacular club (length <7 mm in adult *S. tridens* vs. >7 mm in adult *S. atlantica*; 6 club sucker rows in *S. tridens* vs. 8 club sucker rows in *S. atlantica*), in the hectocotylus (5–8 large suckers on the crest before the tip in *S. tridens* vs. 3–4 in *S. atlantica*) and in

body patterning (light pink base colour with a strong honeycomb pattern of chromatophores on the dorsum of *S. tridens* vs. a whitish base colour with a less strong pattern on dorsum in *S. atlantica*). The *S. tridens* used in the molecular study were captured in slightly deeper water (*S. tridens* 43–94 m, *S. atlantica* 19–68 m; Groenenberg *et al.*, 2009). A preliminary analysis of additional trawl data confirmed the difference; the average capture depth for *S. tridens* was 81.8 m vs. 37.4 m in *S. atlantica* (De Heij and Goud, 2010). Subsequent data (De Heij and Goud, 2010) show that *S. tridens* is also present in much deeper water 250 km west of Ireland. De Heij and Goud (2010) report *S. tridens* from the North Sea, the Skaggerak, the English Channel, the Celtic Sea, southwestern Ireland, deep water west of Ireland, and off northwestern Spain. It is possible that some records of *S. atlantica* actually pertain to *S. tridens*, although De Heij and Goud (2010) confirm that the populations in Firemore Bay (Yau and Boyle, 1996) and Ría de Vigo (various authors) likely do pertain to *S. atlantica*. *Sepioida tridens* has been identified genetically in samples collected off the Portuguese shelf at night at bottom depths of 100–148 m. Its presence off the Portuguese coast increases its southern geographic limit to 41°23'N (Roura, 2013).

10.5 Life history

An intermittent terminal spawner, *S. atlantica* spawns year-round with peaks in summer and autumn. Hatchlings resemble adults, but have a brief pelagic phase. Lifespan probably varies between 7 and 10 months.

10.5.1 Egg and juvenile development

Eggs are laid singly, but attached close together in clusters to hard structures on the seabed, including hydroids and bryozoans (e.g. *Cellaria* spp.) (Rees, 1957; Rodrigues *et al.*, 2011c). Eggs are spherical, with a slightly pointed apical tip, resulting in a typically droplet-like shape. In an aquarium-based study, the major axis of egg capsules ranged in length between 1.75 and 4.92 mm (mean 2.75 ± 0.44 mm; Rodrigues *et al.*, 2011c). The duration of embryonic development determined in aquaria is strictly dependent on water temperature, varying from 61.8 (± 3.8) d at 13°C, to 40.1 (± 4.8) d at 16.4°C, and 22.6 (± 1.7) d at 18°C (Rodrigues *et al.*, 2011a). The percentage of eggs that successfully hatch varies from 98.5 to 100%. Newly hatched paralarvae measure 1.1–1.7 mm (1.5 ± 0.3 mm) ML. Total length ranges between 2.6 and 3.6 mm (3.2 ± 0.5 mm), and body weight between 0.077 and 0.098 g (0.081 ± 0.02 g). There are no relationships between hatchling body size and the duration of the embryonic phase, or between hatchling length and weight (Rodrigues *et al.*, 2011a). Similar results were obtained by Jones and Richardson (2010), who recorded embryonic development duration of 33 d at 14.4°C. Newly hatched individuals measured 1.91 mm ML and entered a pelagic paralarval phase lasting 6 d. Some 10–20 days after hatching, the internal yolk sac was exhausted (Jones and Richardson, 2010).

Recruitment occurs year-round, but peaks in spring, early summer, and autumn have been observed in Scottish and Galician waters (Yau, 1994; Yau and Boyle, 1996; Rodrigues *et al.*, 2012).

10.5.2 Growth and lifespan

Little information is available on *S. atlantica* growth. Measured as the increase in dorsal mantle length, growth recorded in aquaria consisted of two distinct phases: relatively slow during the first 120 d (ca. 0.05 mm d⁻¹; 0.043 mm d⁻¹ in males and 0.055 mm d⁻¹ in females) and increasing slightly thereafter until day 210, when it levelled off (Jones and

Richardson, 2010). Limited data are available on length–weight relationships (Table 10.1).

Table 10.1. *Sepiola atlantica*. Length–weight relationships in different geographic areas for females (F), males (M), and sexes combined (All). Original equations converted to $W = aML^b$, where W is body mass (g) and ML is dorsal mantle length (cm). Only records from the ICES Area are included.

Region	a	b	Sex	Reference
West coast of Scotland	0.581	2.46	F	Yau and Boyle (1996)
	0.572	2.75	M	
North Sea	0.557	2.30	All	Robinson <i>et al.</i> (2010)

Rodrigues *et al.* (2013) reported regression equations to predict body weight and mantle length from measurements on the beaks of individuals sampled in the Ría de Vigo (both sexes combined):

$$\ln(\text{BW}) = 1.486 + 2.174 \times \ln(\text{LRL}) \text{ and } \ln(\text{ML}) = 3.173 + 0.974 \times \ln(\text{LRL})$$

$$\ln(\text{BW}) = 1.590 + 2.734 \times \ln(\text{URL}) \text{ and } \ln(\text{ML}) = 1.223 + 3.206 \times \ln(\text{URL})$$

where LRL is the lower rostral length (mm) and URL the upper rostral length (mm).

The lifespan of *S. atlantica* likely varies between 7 and 10 months, depending on the duration of embryonic development, which, as noted above, is related to water temperature (Jones and Richardson, 2010).

10.5.3 Maturation and reproduction

Yau and Boyle (1996) reported a sex ratio in animals of >10 mm ML (the sex of smaller animals could not be determined accurately) of ca. 1:1 in Scotland (ratio of males to females 1.4:1.0, $n = 138$). Rodrigues *et al.* (2011b) also reported that the sex ratio did not differ significantly from 1:1 in Galicia.

Observations on the population in Loch Ewe (northwest coast of Scotland; Yau and Boyle, 1996) showed that $ML_{m50\%}$ was ca. 13 mm in males and 16 mm in females. However, the mean body size of mature animals was similar in both sexes (ca. 15 mm). Mature animals were present from March to August, suggesting an extended spawning season, but with a peak in June for both sexes. The number of mature ova in females ranged between 42 and 126. Juvenile occurrence peaked in May, and no juveniles were recorded in March (Yau and Boyle, 1996). Similar results were obtained from studies of the population around Anglesey (north Wales; Jones and Richardson, 2012), where $ML_{m50\%}$ was 13–14 mm in males and 16–17 mm in females. In the Ría de Vigo (northwestern Spain), however, *S. atlantica* matures smaller; the smallest mature males measured 8.05 mm ML, the smallest mature females 6.47 mm (Rodrigues *et al.*, 2012), and $ML_{m50\%}$ was 8.9 and 9.8 mm for males and females, respectively.

Sepiola atlantica is an intermittent terminal spawner, with group-synchronous ovary maturation; it lays multiple eggs and deposits egg clutches in multiple locations (Rodrigues *et al.*, 2011c).

Examination of the ovaries has revealed that immature oocyte size varies between 0.03 and 3.75 mm (maximum diameter; Rodrigues *et al.*, 2011c). Mature oocytes range in size between 1.57 and 5.42 mm (Rodrigues *et al.*, 2012). The largest oocytes have been found in the largest females. The total number of eggs laid by a single female ranges between 31 and 115, and potential fecundity (i.e. the sum of the number of oocytes in

the ovary and the oviducts plus the number of eggs already spawned) from 119 to 304 (Rodrigues *et al.*, 2011c).

The maximum number of spermatophores recorded in males is 1243 (Rodrigues *et al.*, 2012), with a mean value of 369. Spermatophore length ranges from 3.31 to 9.23 mm. No significant relationship was observed between number of spermatophores and mantle length (Rodrigues *et al.*, 2012).

Mating behaviour has been studied in the laboratory (Rodrigues *et al.*, 2009). There was no courtship in any of the mating events observed. The male moved quickly towards the female, holding her around the middle of the ventral mantle region with his arms. Positioned underneath the female, the male then introduced his pair of dorsal arms into the female's mantle cavity (the left dorsal arm is hectocotylized and transfers spermatophores), while grasping her ventral body with the laterodorsal pair of arms, and neck with the lateroventral pair, sometimes introducing these arms into the female's mantle cavity. Male colour remained constant throughout mating, whereas females slowly and continuously changed their chromatic patterns. Mating duration varied between 68 and 80 min (Rodrigues *et al.*, 2009).

10.6 Biological distribution

10.6.1 Habitat

Sepiola atlantica inhabits the continental shelf, its distribution extending to the edge of the slope. It can be considered a neritic species, occurring from the sublittoral zone to depths of 150 m. In Scottish waters, it is most common between 50 and 120 m (Yau, 1994; Yau and Boyle, 1996). In Iberian waters, it is commonly found from 6 to 50 m, as well as inside the Galician Rías (sheltered tectonic valleys), and it prefers clean sandy bottoms. It is epibenthic, but has been collected in midwater during both night and day (Collins *et al.*, 2001). Bruun (1945) commented that most specimens recorded around Iceland were caught pelagically. The species is stenohaline and not found in areas with high salinity variation (Guerra, 1992; Rodrigues *et al.*, 2011d). Collins *et al.* (2002), in their study on the distribution of cephalopods from plankton surveys around the British Isles, found that *S. atlantica* was the most abundant cephalopod in samples from the North Sea.

10.6.2 Migrations

Seasonal migrations have been observed in the waters around Anglesey (north Wales; Jones and Richardson, 2012), where *S. atlantica* migrates inshore in July, reaching peak abundance between July and August, declining in numbers between September and October, and migrating offshore in late October. These movements are probably related to feeding strategies, because of the abundance of prey such as shrimps in shallow water in summer, and, more generally, to take advantage of environmental conditions favourable for enhanced growth and maturation. In addition, congregation in shallow waters may favour encounters with mates.

Seasonal differences in abundance were also recorded in the Areamilla area (Galician waters, northwestern Spain; Rodrigues *et al.*, 2011b), where, however, lowest abundance was recorded in summer. It was proposed that this seasonal pattern of abundance was due to migration of individuals from shallow to deeper waters, related to changes in bottom temperature.

10.7 Trophic Ecology

10.7.1 Prey

The main prey species of *S. atlantica* are mysids and decapod shrimps. Foraging primarily takes place at dawn and dusk, and prey are taken above the seabed (Yau, 1994).

10.7.2 Predators

Sepiolo atlantica is the most frequently recorded cephalopod in the diet of harbour porpoise in Scottish waters. The sepiolids are probably detected by porpoises directing their sonar into the substratum, detecting the acoustic signal given by the hole in which the animal lies (Santos and Pierce, 2003; Santos *et al.*, 2004b). In Galician waters, the species has been recorded in the stomach contents of hake and gurnards (Á. Guerra, pers. comm.). Known predators of this species are listed in Table 10.2.

Table 10.2. Known predators of *Sepiolo atlantica* in the Northeast Atlantic.

Taxon	Species	References
Myxini	Hagfish (<i>Myxine glutinosa</i>)	Shelton (1978)
Chondrichthyes	Lesser spotted dogfish (<i>Scyliorhinus canicula</i>)	Ellis <i>et al.</i> (1996)
	Greater spotted dogfish (<i>Scyliorhinus stellaris</i>)	Ellis <i>et al.</i> (1996)
	Spotted ray (<i>Raja montagui</i>)	Ellis <i>et al.</i> (1996)
	Spurdog (<i>Squalus acanthias</i>)	Ellis <i>et al.</i> (1996)
	Thornback ray (<i>Raja clavata</i>)	Ellis <i>et al.</i> (1996)
Osteichthyes	Tope shark (<i>Galeorhinus galeus</i>)	Ellis <i>et al.</i> (1996)
	European hake (<i>Merluccius merluccius</i>)	P. Torres, pers. comm.
Cetacea	Gurnards: family Triglidae	Á Guerra, pers. comm.
	Common dolphin (<i>Delphinus delphis</i>)	González <i>et al.</i> (1994a), Silva (1999a), De Pierrepont <i>et al.</i> (2005)
	Harbour porpoise (<i>Phocoena phocoena</i>)	Santos and Pierce (2003), Víkingsson <i>et al.</i> (2003), Santos <i>et al.</i> (2004b), Jansen <i>et al.</i> (2013)

10.8 Other ecological aspects

10.8.1 Behaviour

Sepiolo atlantica may bury itself in the sand by day to hide from predators and as a technique for hunting. The burying behaviour in natural substrata in the aquarium was described by Rodrigues *et al.* (2010a). After a short period in an alert position, the animal starts burying itself, and on average the whole process taking 21.9 (\pm 4.93) s. Burial time does not appear to be related to size. Burying behaviour is accompanied by a display of colour changes peculiar to the species.

In the laboratory, the entire body of newly hatched individuals is yellow and covered with expanded dark brown chromatophores. Individuals often assume a "flamboyant" arm display (as shown and described in Mauris, 1989, for *Sepiolo affinis*). This posture consists of stretching the dorsal and latero-dorsal arms upwards perpendicular to the body axis, while the latero-ventral and ventral arms together are stretched downwards on each side of the body; all arm tips are rolled inwards.

Hatchlings are generally less active during daylight and attempt to bury themselves in the sand immediately after hatching (see Rodrigues *et al.*, 2011a). Although equipped with yolk reserves, they are ready to hunt mysid shrimp of equal size soon after hatching, and display a characteristic pattern of expanded dark brown chromatophores when focusing on prey. Prior to attacking prey, all chromatophores are contracted and, consequently, the animal turns virtually transparent. Arms are spread to form a circular crown, enabling the tentacles to be shot out rapidly (generally to the dorsal side, towards the middle of the mysid shrimp). If the attack is successful, tentacles are quickly retracted with the prey. When the tentacles are retracted (with or without prey), animals regain the dark brown colour (Rodrigues *et al.*, 2011a).

10.9 Fisheries

Bobtail squids *Sepiola* spp. are not usually identified in fishery landings (ICES, 2010). However, they are known to be landed and sold in fish markets in southern Europe (Reid and Jereb, 2005).

10.10 Aquaculture

Although of no commercial value, *S. atlantica* is a potential species for experimental work under controlled conditions. For that reason, the University of Vigo and the Instituto de Investigaciones Marinas-CSIC are developing sepiolid culture techniques (Rodrigues *et al.*, 2011d).

10.11 Future research, needs, and outlook

Despite *S. atlantica* being a relatively common nearshore species, information on its biology, ecology, and life history was, until very recently, limited to waters around Scotland (e.g. Yau, 1994; Yau and Boyle, 1996). More recently, there has been research on the species in Wales (Jones and Richardson, 2010, 2012) and Galicia (Rodrigues *et al.*, 2009, 2010a, b, c, 2011a, b, c, d, 2012). However, life cycle biology and ecology remain poorly known through most of its range, and more research is needed.