Cephalopods from the Canary Islands: a hotspot of species richness in the Atlantic Ocean

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Abstract

Cephalopods are a diverse group of high ecological and economic relevance, underlying the importance of identifying hotspots of cephalopod diversity as keys areas to prioritize them for conservation purposes and management. In this work, the current state of knowledge and diversity of cephalopods fauna of the Canary Islands (NE Atlantic Ocean) is updated. A systematic review of the scientific literature on historic and recent research cruises, from 1834 to 2019, species records and stomachs content analysis of marine top-predators were carried out. The current species richness in different habitats from coastal to deep-sea zones was determined according to records and previous information about the ecology of each species. A total of 37 publications and four references in museums collections of cephalopods records around the Canary Islands were identified. This small archipelago harbors *ca*. 10% of the total known cephalopod diversity, with 85 species belonging to 31 families. In addition, 19 doubtful species records are discussed. The cephalopod community are dominated by oceanic cephalopods (65 species) followed by shelf-slope (11) and coastal (9) cephalopods species. Most of the species showed a wide geographic distribution including 33

circumglobally species, 19 Atlantic-Mediterranean, 7 recorded in more than one ocean and 26 exclusively Atlantic. This richness is comparable with other hotspots of cephalopods diversity in the Indian Ocean or the Caribbean region. Despite this richness, significant knowledge gaps have been detected in inhabitants on midwater and deep benthic zones, such as cirrate octopuses. This work provides a baseline to measure future changes in cephalopods community of the region in a sea warming scenario under the current climate change perspective, evaluating effects such as tropicalization and meridionalization of the teuthofauna.

Keywords: Cephalopods, Biodiversity, Mesopelagic, Deep sea, Canary Islands.

1. Introduction

Cephalopods comprise approximately 845 living species and the order Teuthida, commonly known as squids, are the most diverse group of cephalopods. This group contains *ca.* 300 species belonging to 2 subclasses, 4 orders and 29 families (Hoving et al. 2014). It is well-known that oceanic cephalopods, particularly squids, are an important component in marine ecosystems and play a central role in marine food webs, being voracious predators and/or competitors for fishes, crustaceans and zooplankton, moving between tertiary to quaternary trophic level throughout their life cycle (Navarro et al. 2013). Oceanic squids are valuable prey items for marine top-predators such as, large finfishes, sharks, marine mammals and seabirds (e.g. Clarke 1996; Croxall and Prince 1996; Klages 1996; Smale 1996; Santos et al. 2001; Cherel and Duhamel 2004; Staudinger et al. 2013). Due to their high food consumption, generalist diet and fast growth, squids transfer a large amount of energy from lower to high trophic levels and also can have a top-down control effect on preys populations (Rodhouse and Nigmatullin 1996; Hunsicker and Essington 2008; Coll et al. 2013). In addition, squids are an important human food resource with over four million tons of annual worldwide landings (FAO 2014). Despite this ecological and economical importance, many aspects of the systematics, ecology and biogeography of cephalopods, especially regarding offshore communities and deep-sea habitats, are decades behind studies on other marine taxa (Hoving et al. 2014). The scarcity of information is due to the rarity of cephalopods collected in nets or other traditional sampling methods. Large and gelatinous squids inhabiting offshore, and deep-sea regions are generally difficult to capture by pelagic fishing gears, as they avoid both commercial and scientific trawl nets, and thus contribute a small proportion of the total catch (Clarke and Pascoe 1985; Wormuth and Roper 1983; Clarke 2003).

To fill this gap of information on cephalopods is pivotal to combine data from the fishing industry, research cruises and stomach contents analysis of marine top-predators. The latter is the most widely technique used to sample elusive or deep-water cephalopod species. This is because teutophagus predators consume a greater variety of sizes and cephalopod species than traditional sampling gears are able to capture. Further, knowledge about the distribution and foraging behavior of the predator provides also information on the horizontal and vertical distribution of their preys (Clarke 1977, 2006). Cephalopod beaks found in the digestive track of their predators can be identified to species level and, if there is morphometric data about the species, can base estimates of prey size and the biomass consumed by the predator (Clarke 1962, 1986; Lu and Ickeringil 2002; Xavier and Cherel 2009). All this contributes information on cephalopod diversity, distribution, and importance in regional ecosystems (Cherel et al. 2004; Lansdell and Young 2007; Romeo et al. 2011; Staudinger et al. 2013).

Knowledge about the mesopelagic fauna of the Canary Islands is based mainly on a discrete number of scientific cruises. In 1965 the SOND cruise carried out 76 mesopelagic trawls SW Fuerteventura, using a combination of small-framed scientific trawling nets (Foxton 1969; Clarke 1969). Later, Clarke (2006) reported unpublished data from two more mesopelagic surveys performed at the archipelago in 1961 and 1976. Finally, Bordes et al. (2009) carried out 119 trawls during six pelagic surveys around the Canary Islands between 1997 and 2002. Data from other sources, such as stomach content analysis of teuthophagus deep-diving toothed whales, are also scarce in the archipelago (Table 2) despite the high cetacean diversity in the Canary Islands. Here, at least 29 cetacean species (Carrillo 2007) have been described and several of these are deep diving whales that inhabit the archipelago all over the year, i.e. sperm whales *Physeter macrocephalus* Linnaeus, 1758 (André 2000), beaked whales (Ziphiidae) (Aguilar 2006), and short-fin pilot whales *Globicephala macrorhynchus* Gray, 1846 (Heimlich-Boran 1993).

The aim of this study is to provide the first comprehensive report of the cephalopod richness and distribution within the waters of the Canary Islands. We herein integrate information from a literature review on historic research cruises, species records and stomachs content analysis of marine top-predators, as well as, current mesopelagic surveys carried out in the Canary Islands.

2. Material and methods

2.1. Search and literature review

A comprehensive literature review was made on previously cephalopods records, including scientific surveys, fishing data reports and stomachs contents reports from diverse marine species caught or stranded in the region, to perform an updated list of cephalopods for the Canary Islands. Scientific literature review was carried out performing a basic search on databases (e.g. Web of Science, Scopus, Scielo), also in Google Scholar, ResearchGate among other webs. In addition, the revision of cephalopods list published previously by Guerra et al. (2003) and the online database Canary Island Biodiversity Data Bank (BDBC, 2017) of the Canary Government were revised.

Data obtained from stomach contents were extracted from published data on 35 cetaceans and 372 individuals of two bony fishes in Hernández-García and Martín (1994), Hernández-García 2002, Santos et al. (2007), Fernández et al. (2009) and Dürr and González (2002). In addition, four scientific surveys carried out around the Canary Islands since 1969 to 2002 were reviewed, since a total catch of 6.569 cephalopods was reported (Clarke 1969, Clarke 2006, Bordes et al. 2009). Also, data from 30 pelagic trawls (49-900 meters depth) in a survey carried out during 2012 on the island-slopes of El Hierro, La Palma and Tenerife were included. A total of 3.317 cephalopods captured in this survey, were included. In addition, literature on new records, technical reports of fishing surveys carried out by regional research organizations, such as, Instituto Canario de Ciencias Marinas (ICCM), Universidad de La Laguna (ULL) and Centro Oceanográfico de Canarias (COC-IEO) were reviewed (Table 1).

<Insert Table 1>

3. Results

3.1. Taxonomic composition and species richness in the Canary Islands

The current cephalopod list of the Canary Islands comprises 104 species and 33 families (Table 2). Nineteen of these listed species are considered dubious. Of these, 13 species have never been catched in Canarian waters. These species were included in previous cephalopods lists (Guerra et al. 2003; BDBC 2017) because they have a wide distribution in the Atlantic Ocean and their hypothetical geographical distributions included the Canary Islands. These species are the octopodid *Bathypolypus sponsalis* (Fischer & Fischer, 1892), the sepiid *Sepia elegans* Blainville, 1827, the sepiolids *Neorossia caroli* (Joubin, 1902), *Rondeletiola minor* (Naef, 1912), *Sepietta oweniana* (d'Orbigny, 1841) and *Sepiola rondeletii* Leach, 1817 and the squids *Bathyteuthis abyssicola* Hoyle, 1885, *Planctoteuthis exopthalmica* (Chun, 1908), *Egea inermis* Joubin, 1933, *Liguriella podophthalma* Issel, 1908, *Megalocranchia abyssicola* (Goodrich, 1896), *Alloteuthis media* (Linnaeus, 1758) and *Todaropsis eblanae* (Ball, 1841).

In addition, other three species are considered dubious because they were only found in the stomach content of cetaceans and it is possible that whales consumed these species outside the Canary Islands, or they were misidentified. These species are *Discoteuthis* spp., *Gonatus* spp., *Pholidoteuthis massyae* (Pfeffer, 1912) and *Stoloteuthis* spp. The genus *Discoteuthis* Young & Roper, 1969 with two recognized species, *D. laciniosa* Young & Roper, 1969 and *D. discus* Young & Roper, 1969, has broad distribution in tropical and subtropical waters (Young and Roper 1999). The presence of both *Discoteuthis* species in the Canary Islands is probable, but not captured so far. The distribution of the genus *Gonatus* in the Atlantic Ocean is typical of cold waters, as occurs with the species *G. fabricii* (Lichtenstein, 1818) though other species of the genus have a cold-temperate distribution, e.g. *G. steentrupi* Kristensen, 1981. Also, this genus comprises polar species, e.g. *G. antarticus* Lönnberg, 1898, that inhabits the Antarctic Ocean. Hence, the presence of this genus is doubtful in the Canary Islands. In the case of *P. massyae*, this species has a circumglobal subtropical-temperate distribution and thus its occurrence in the Canary Islands is plausible. This is also the case of *Stoloteuthis* spp. due to its broad distribution range, e.g. *S. leucoptera* (Verrill,

1878) is reported from eastern United States to the eastern Atlantic including the Mediterranean Sea.

Three *Leachia* species has been previously identified in the region: *L. atlantica* (Degner, 1925), *L. cyclura* Lesueur, 1821 and *L. pacifica* (Issel, 1908). However, currently the geographic distribution of *L. cyclura* is restricted to the Indian Ocean (37ºS; 33ºE) whilst *L. pacifica* is known only in the south Pacific (15°S. 168°W) (Young et al. 2016). The only species that seems to be present in the Canary Islands is *L. atlantica*.

Excluding these 19 doubtful species, 85 confirmed species of cephalopods are reported in the Canary archipelago, belonging to 31 families (Table 2). Among them, oceanic cephalopods were by far the most important group with 65 species, followed by 11 and 9 species inhabiting the shelf-slope and coastal waters, respectively (Fig. 2). All species identified in the study area have wide geographic distributions, including 33 world-wide distributed species, 19 Atlantic-Mediterranean, 7 recorded in more than one ocean and 26 exclusively Atlantic.

<Insert Table 2>

4. Discussion

4.1. Current state of knowledge of cephalopods fauna of the Canary Islands

The Canary Islands holds important year-round populations of teuthophagus cetaceans such as, pilot whales and sperm whales that partially feed on large cephalopods (Aguilar et al. 2008; Fernández et al. 2009). This suggests that large cephalopods are well represented in the archipelago, despite their scarcity in scientific fishing sampling. This is probably due to methodological bias because a single sampling device based in nets, catches only a fraction of the cephalopod community (Hoving et al. 2014). A combination of multiple types of gears would help enhance the spectrum of species sampled in a community (Judkins et al. 2016). In this regard, multiple types of fishing gears have been used in the Canary Islands: small gears as ring nets or Isaaks-Kid midwater trawls (IKMT) with mouth areas ranging 1 to 9 m^2 were employed in 76 and 16 hauls in Fuerteventura and Tenerife, respectively (Clarke 1969, 2006). While, large commercial nets with 80 and 300 m^2 of mouth area were employed during eight research cruises, performing a total of 119 and 30 hauls around the islands (Bordes et al. 2009, Ariza et al. 2016, Escánez 2019). As a result, the contribution of small size species families (10-40 mm Dorsal Mantle Length), such as Enoploteuthidae and Pyroteuthidae, to the cephalopod community have been probably overestimated. This type of species dominated the catches in Bordes et al. (2009) and CETOBAPH cruise (Escánez 2019), who employed large commercial nets. While, species with small and slow movements, such as cranchiids, spirulids and sepiolids, dominated the catches in Clarke (1969, 2006) who used small nets. In contrast, species with high movement capabilities and large sizes have been possibly underestimated in Clarke (1969, 2006), because they could be only represented by juvenile stages, or a few adults entangled in the large meshes of the nets.

Moreover, recent studies on the distribution of large cephalopods shown high-density spots for these species in the Canary Islands. The giant squid *Architeuthis dux* Steenstrup, 1857, the deep-sea hooked squid *Taningia danae* Joubin, 1931 and the giant deep-sea octopus *Haliphron atlanticus* Steenstrup, 1861 have been often found in overlap with areas where resident populations of short-finned pilot whales inhabit (Escánez and Perales-Raya, 2017). In addition, a multispecies small-scale fishery carried out along the islands is seasonally focused to some medium-large species, being the main exploited species the orangeback flying squid *Sthenoteuthis pteropus* (Steenstrup, 1855) that can reach 65 cm of ML and its catches are seasonally constricted to summer and early autumn. This pattern also occurs to the veined squid *Loligo forbesii* Steenstrup, 1856 that can reach 97 cm of ML and it is fished during autumn and early winter. The latter is restricted to certain localities of Tenerife, La Gomera and Fuerteventura (Escánez *per. obs*.). Nevertheless, other large-sized species of fishing interest are also recorded in the archipelago but are currently underexploited (e.g. *Thysanoteuthis rhombus* Troschel, 1857, *Ommastrephes bartramii* (Lesueur, 1821), *Todaropsis eblanae* (Ball, 4841) and *T. sagittatus* (Lamarck, 1798)) (Escánez et al. 2012; González-Lorenzo et al. 2018).

The knowledge about cephalopod diversity is generally scarce worldwide though some studies have identified exceptional cephalopod biodiversity areas. Laptikhovsky et al.

(2015) highlighted the SW Indian Ocean Ridge as a hotspot of cephalopods diversity with 68 species belonging to 26 families. In the SE Pacific Ocean, Ibañez et al. (2009) recorded 86 species from 18ºS to 56ºS of latitude, along the Chilean coast. In the Atlantic Ocean, Rocha et al. (2017) shows that Mauritanian waters have also a high cephalopod diversity, with 132 species belonging to 39 families.

Rosa et al. (2008) have previously studied large-scale diversity patterns of cephalopods in the Atlantic Ocean. This study identified several zoogeographic areas of high species richness: The Benguela Current Coastal Province, with 84 species, followed closely by the Southern Atlantic Convergence province, with 80 species. In the northern hemisphere the richest area is the province of the North Atlantic Temperate Region (Cape Hateras–Nova Scotia), with 74 species. Also, Arkhipkin and Laptikhovsky (2006) and Rocha et al. (2017) showed that Mauritanian waters represent a transitional faunistic region, an ecotone where tropical, subtropical and boreal species can be found. This cephalopod fauna is characterized by two main assemblages related to their horizontal speciation and stratifications patterns (Rocha et al. 2017).

In the past decade, some studies increased our knowledge about cephalopod diversity in several Atlantic regions. Vecchione and Pohle (2002) recorded 66 species in the continental slope of Nova Scotia. Judkins et al. (2010) reported 108 species for the Caribbean region. Brazilian waters are considered well-studied, with 86 species recorded (Haimovici et al. 2009). In the central eastern Atlantic, the extensively compilation of Guerra et al. (2014) recorded 141 known cephalopods species from 36°N to 23°S latitudes and westward from 30°W longitude off FAO fishing area 34 and westward to 20°W longitude off FAO fishing area 47. Rocha et al. (2017) reported a total of 132 species in Mauritanian waters and Rocha and Cheikh (2015) listed a total of 139 species in the Canary Current Large Marine Ecosystem, that comprise an extension of 1,120,439 km^2 along the NW African coast from Gibraltar to Guinea, including Cape Verde and the Canary Islands.

Atlantic archipelagos, such as Azores and Madeira, have historically attracted research effort of naturalists and teuthologists (Férrusac and d'Orbigny (1835-1848); White and Johnson 1860; Girard 1882). The combination of scientific research expeditions and whaling industry supplied valuable information that allowed an early and almost complete knowledge of the teuthofauna of these archipelagos (Rees and Maul 1956; Clarke and Maul 1962; Clarke et al. 1993; Clarke 1960, 1962, 2006). A recent update cephalopod list from Azores reported 83 species (Gomes-Pereira et al. 2016), whilst Madeira reported 77 species (Clarke and Lu 1995). The Canary Islands, with 85 reported cephalopods species constitutes the highest cephalopods richness per area documented for the Atlantic Ocean. This richness is only comparable with the other Macaronesian archipelagos: Azores and Madeira. This species richness represents approximately 10% of the total richness known worldwide (845 species) (Hoving et al. 2014) and *ca.* 60% of the known cephalopod species for the central eastern Atlantic (Guerra et al. 2014). Most of the cephalopod reports from the Canary Islands came from historical research expeditions, and to a lesser extent from the stomach content of cetaceans, including 13 toothed whales examined (14 cephalopod species). This leads us to conclude that the teuthological research effort has been considerable in the Canary Islands.

The high cephalopod species diversity reported in the Canary Islands could be explained by different factors, one of them is the geographical location and oceanography of the archipelago, an ecotone among several zoogeographic zones. The Canary Islands are part of the Mauritanian zoogeographic province, occupying the transitional zone between the Low-Boreal subzone, the North Subtropical zone and North Central zone, and this contributes to the presence of species with temperate-subtropical and tropical affinities (Nesis 2003). Also, the topography of oceanic islands increases turbulence and meso-scale structures like eddies and islands-wakes, which can increase the local productivity with respect to oligotrophic adjacent oceanic waters. These oceanographic processes, together with up-welling filaments interact with enhancing plankton productivity and respiratory activity by increasing vertical mixing and nutrient availability in surface waters (Barton et al. 1998; Arístegui et al. 2006; Sangrà 2015). All above-mentioned features have been proposed as responsible of the high diversity of pelagic species around oceanic islands, specially concentrated in leeward sides (Worm et al. 2003). In addition, the topographic features within the archipelagos, like submarine canyons, concentrate fishes and invertebrates (Vetter et al. 2010).

The high cephalopods diversity of the Canary Islands could be a key factor explaining the presence of large predators such as marine mammals, particularly deep-diving odontocetes throughout the year, as well as the abundance of temporal visitors like tuna species, which consume cephalopods in large extent (Battaglia et al. 2013; Ménard et al. 2013).

4.2. Prospects and further research.

The richness of cephalopods species in the region could be increase in the future, as result of a further research effort at bathyal depths, currently almost unexplored. This would explain the lack of deep-sea cirrate octopods (suborder: Cirrina) for the Canaries (Escánez et al. 2019). This information gap is partially explained by the trawl-fishing ban in the Canary Islands, together with the scarce research effort at these depths. Consequently, latest contributions to cephalopods list for the Canary Islands have been predominantly deep-sea species (Figure 2). In this manner, two oegopsids squids *L. grimaldii*, *T. danae* and one octopod, *H. atlanticus* have been reported during the last years (Escánez and Perales-Raya, 2017; Escánez et al. 2017). Also, coastal species such as the brown-striped octopus, *Amphioctopus burryi* (Voss, 1950), the lilliput longarm octopus, *Macrotritopus defilippi* (Vérany, 1851) and the fourhorn octopus, *Pteroctopus tetracirrhus* (delle Chiaje, 1830) (Figure 3) have been recently recorded by Guerra et al. (2013) and Escánez et al. (2019), these species might have come from neighbouring African coast in recent times. Finally, two octopod species were videotaped for the first time in 2009 around the Canaries, at 200–600 m depth range and tentatively classified as *Eledone moschata* (Lamarck, 1798) and *Eledone cirrhosa* (Lamarck, 1798) (see Aguilar et al. 2010). These two records have not yet verified and further investigations are needed to examine specimens and resolve its presence in Canarian waters.

In addition, molecular genetic techniques such as DNA-barcoding analysis or allozyme electrophoresis, applying to taxonomically difficult genus could increase the species discovery and clarify species complex where cryptic speciation has not yet resolved (e.g. Allcock et al. 2010; Undheim et al. 2010). In this manner, the presence of the dark comb-fin squid, *Chtenopteryx canariensis* Salcedo-Vargas and Guerrero-Kommritz, 2000, a doubtful species, has been recently confirmed in the Canary Islands using these techniques (Escánez et al. 2018). Another species complex such as, the neon flying squid (*Ommastrephes bartramii*) considered as monotypic cosmopolitan species, has been separated in various species (Fernández-Álvarez et al. 2020). In the Canary Islands, two *Ommastrephes* species have been reported, *O. bartramii* and its synonymy

O. caroli (Lönnberg 1896, Lozano-Soldevilla & Franquet 1986). The last one was synonymized to *O. bartramii* in Dunning (1998) and recently resurrected in Fernández-Álvarez et al. (2020) using molecular tools. In future studies, *Ommastrephes* species from the Canary Islands should be checked using these molecular techniques in addition to detailed morphological descriptions. In the same way, Bolstad (2010) has considered the hooked squid (*O. banksii*) a species complex. For this reason, the presence of one or several species in the Canary archipelago should be verified.

The ecological role of cephalopods in the Canary Islands is central, as they are important to support a rich community of odontocetes and other marine predators, as well as, mobilize nutrients between surface and deep-sea. Also, generate indirect economic activity linked to whale watching sector that provide benefits valued at 24 million euros annually in 2018 (Turismo de Tenerife, 2019). The list of 85 species considered in this work are a knowledge base providing a tool to monitor future changes in cephalopods community of the region in a current climate change perspective.

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TABLES AND FIGURES

TABLE 1: List of literature and additional sources of information on cephalopods records realized in the Canary Islands reviewed. USNM: specimens deposited in collections of the National Museum of Natural Sciences (USA).

Authors	Source	Nº of cephalopods species
Hernández-García and Martín 1994	Stomach content	5
Santos et al. 2007	Stomach content	15
Fernández et al. 2009	Stomach content	15
Dürr and González 2002	Stomach content	3
Clarke 1969	Scientific survey	18
Clarke 2006	Scientific survey	22
Bordes et al. 2009	Scientific survey	32
CETOBAPH survey (Herein)	Scientific survey	39
Browne 1834	List report	3
Gray 1854	List report	8
Aguilar et al. 2010	Record	13
Escánez et al. 2019	Record	2
Escánez et al. 2018	Record	2
Roper and Sweeney 1976	Record	1
Lozano-Soldevilla 1991	Record	1
López et al. 1993	Scientific survey	6
BDBC 2017	List report	
Guerra et al. 2003	List report	44
Guerra et al. 2007	Record	1
Salcedo-Vargas and Guerrero-Kommritz 2000	Record	1

Joubin 1905	Record	1
Nesis 1974	Record	2
USNM 817197 1	Record	3
Brito and Pascual 2002	Fishing report	1
USNM 817190	Record	1
Vecchione and Young 2014	Record	1
Young and Vecchione 2005	Record	1
Guerra et al. 2013	Record	2
Escánez et al. 2017	Record	1
Escánez et al. 2012	Record	1
Hernández-García et al. 1998	Fishing report	1
Ariza et al. 2016	Scientific survey	3
Lozano-Bilbao et al. 2018	List report	2
Hernández-García 2002	Stomach content	2
Baker-Webb and Berthelot 1959	Record	1
Guerra et al. 2006	List report	7
Lönnberg 1896	List report	6

TABLE 2: Cephalopods list of the Canary Islands. *: Species never catched in the region but with distribution ranges including the Canary Islands. †: Species with dubious presence. ‡: Species only video recorded.

Family	Species	Citation/reference	Distribution	Habitat	Stomach contents
Argonautidae	*Argonauta argo* Linnaeus, 1758	Browne 1834, Bordes et al. 2009	Worldwide	Oceanic	+
	Argonauta hians Lightfoot, 1786	Gray 1854, Clarke 1969	Worldwide	Oceanic	
Bolitaenidae	*Japetella diaphana* Hoyle, 1885	Clarke 1969, 2006	Worldwide	Oceanic	
	Bolitaena sp. Steenstrup, 1859	USNM 817181	Worldwide	Oceanic	
Octopodidae	*Amphioctopus burryi* (Voss, 1950)	Guerra et al. 2013	Atlantic	Coastal	
	Bathypolypus sponsalis (Fischer & Fischer, 1892)*	Guerra et al. 2003	Northeastern Atlantic-Mediterranean	Oceanic	
	Callistoctopus macropus (Risso, 1826)	Gray 1854, Lönnberg 1896	Northeastern Atlantic-Mediterranean	Coastal	
	Eledone cirrhosa (Lamarck, 1798)‡	Aguilar et al. 2010	Northeastern Atlantic-Mediterranean	Slope- Shelf	
	Eledone moschata (Lamarck, 1798)‡	Aguilar et al. 2010	Northeastern Atlantic-Mediterranean	Slope- Shelf	
	Macrotritopus defilippi (Vérany, 1815)	Guerra et al. 2013	Northeastern Atlantic-Mediterranean	Coastal	
	Octopus vulgaris Cuvier, 1797	Gray 1854, Lönnberg 1896	Worldwide	Coastal	
	Pteroctopus tetracirrhus (Delle Chiaje, 1830)	Escánez et al. 2019	Eastern Atlantic-Mediterranean	Slope- Shelf	
	Scaeurgus unicirrhus (Delle Chiaje, 1840)	Clarke 1969	Atlantic- Mediterranean	Slope- Shelf	
Ocythoidae	*Ocythoe tuberculata* Rafinesque, 1814	Roper and Sweeney 1976	Worldwide	Oceanic	
Tremoctopodidae	*Tremoctopus v. violaceus* Delle Chiaje, 1830	Lozano-Soldevilla 1991, Bordes et al. 2009	Atlantic- Mediterranean	Oceanic	
	Tremoctopus gelatus Thomas, 1977	López et al. 1993	Western Atlantic- Indian-Eastern Pacific	Oceanic	
Allopsidae	*Haliphron atlanticus* Steenstrup, 1861	Escánez et al. 2019	Worldwide	Oceanic	
Vitreledonellidae	*Vitreledonella richardi* Joubin, 1918	Clarke 2006	Worldwide	Oceanic	

Vampyroteuthidae	*Vampyroteuthis infernalis* Chun, 1903	Clarke 2006, Bordes et al. 2009	Worldwide	Oceanic	+
Sepiidae	*Sepia bertheloti* d'Orbigny,1835	Férusac and d'Orbigny, 1835, Gray 1854; López et al. 1993	Eastern Atlantic	Coastal	
	Sepia elegans Blainville, 1827*	BDBC 2017	Eastern Atlantic-Mediterranean	Coastal	
	Sepia hierredda Rang, 1835	Gray 1854, Lönnberg 1896	Eastern Atlantic	Coastal	
	Sepia officinalis Linnaeus, 1758	Browne 1834, Gray 1854	Eastern North Atlantic-Mediterranean	Coastal	
	Sepia orbignyana Férussac, 1826	López et al, 1993	Eastern Atlantic-Mediterranean	Coastal	
Sepiolidae	*Heteroteuthis dispar* (Rüppell, 1844)	Clarke 1969	Atlantic	Oceanic	
	Neorossia caroli (Joubin, 1902)*	Guerra et al. 2003	Atlantic- Mediterranean	Slope- Shelf	
	Rondeletiola minor (Naef, 1912)*	Guerra et al. 2003	Eastern Atlantic-Mediterranean	Shelf	
	Rossia macrosoma (Delle Chiaje, 1830)	López et al. 1993	North Eastern Atlantic-Meditteranean	Shelf	
	Sepietta oweniana (d'Orbigny, 1839-1841)*	Guerra et al. 2003	North Eastern Atlantic-Meditteranean	Shelf	
	Sepiola atlantica d'Orbigny, 1839–1842	Moro et al. 2011	North Eastern Atlantic	Shelf	
	Stoloteuthis spp. Verrill, 1881*	Fernández et al. 2009	-	Shelf	+
	Sepiola rondeletii Leach, 1817*	Guerra et al. 2003	Eastern Atlantic-Mediterranean	Shelf	
Spirulidae	*Spirula spirula* (Linnaeus, 1758)	Browne 1834, Gray 1854	Worldwide	Oceanic	+
Ancistrocheiridae	*Ancistrocheirus lesueurii* (d'Orbigny, 1842)	Clarke 2006	Worldwide	Slope	+
Architeuthidae	*Architeuthis dux* Steenstrup, 1857	Guerra et al. 2006	Worldwide	Oceanic	
Bathyteuthidae	*Bathyteuthis abyssicola* Hoyle, 1885*	Guerra et al. 2003	Worldwide	Oceanic	
Brachioteuthidae	*Brachioteuthis picta* Chun, 1910	Bordes et al. 2009	Worldwide	Oceanic	
	Brachioteuthis riisei (Steenstrup, 1882)	Clarke 2006, Bordes et al. 2009	Worldwide	Oceanic	
Chiroteuthidae	*Chiroteuthis mega* (Joubin, 1932)	Bordes et al. 2009	Atlantic	Oceanic	
	Chiroteuthis veranyi veranyi (Férussac, 1834)	Guerra et al. 2007	Worldwide	Oceanic	+

	Planctoteuthis exopthalmica (Chun, 1908)	Guerra et al. 2003	Eastern Atlantic -Indian Ocean	Oceanic	
Chtenopterygidae	*Chtenopteryx canariensis* Salcedo-Vargas & Guerrero-Kommritz, 2000	Salcedo-Vargas and Guerrero-Kommritz 2000, Escánez et al. 2018	Atlantic	Oceanic	
	Chtenopteryx sicula (Vérany, 1851)	Clarke 1969	Worldwide	Oceanic	+
Cranchiidae	*Bathothauma lyromma* Chun, 1906	Clarke 2006, Bordes et al. 2009	Worldwide	Oceanic	
	Cranchia scabra Leach, 1817	Clarke 2006	Worldwide	Oceanic	
	Egea inermis Joubin, 1933*	Guerra et al. 2003	Worldwide	Oceanic	
	Galiteuthis armata Joubin, 1898	Clarke 1969	Atlantic- Mediterranean	Oceanic	+
	Helicocranchia pfefferi Massy, 1907	Clarke 2006	Worldwide	Oceanic	
	Leachia pacifica (Issel, 1908) †	Clarke 1969	South Pacific	Oceanic	
	Leachia atlantica (Degner, 1925)	Bordes et al. 2009	Eastern North Atlantic	Oceanic	
	Leachia cyclura Lesueur, 1821 †	Joubin 1905, Clarke 2006	Worldwide	Oceanic	
	Liguriella podophthalma Issel, 1908*	Guerra et al. 2003	South Atlantic, Worldwide	Oceanic	
	Liocranchia reinhardtii (Steenstrup, 1856)	Clarke 1969, 2006	Worldwide	Oceanic	
	Megalocranchia oceanica (Voss, 1960)	Clarke 1969, Nesis 1974	Atlantic	Oceanic	+
	Megalocranchia abyssicola (Goodrich, 1896)*	Guerra et al. 2003	Atlantic	Oceanic	
	Sandalops melancholicus Chun, 1906	Clarke 1969, Nesis 1974	Worldwide	Oceanic	
	Taonius pavo (Lesueur, 1821)	Clarke 2006, Bordes et al. 2009	Atlantic	Oceanic	+
	Teuthowenia megalops (Prosch, 1849)	Nesis 1974	North Atlantic	Oceanic	+
Cycloteuthidae	*Cycloteuthis sirventi* Joubin, 1919	Clarke 2006	Eastern North Atlantic	Oceanic	+
	Discoteuthis spp. Young & Roper, 1969*	Fernández et al. 2009	Worldwide	Oceanic	+
Enoploteuthidae	*Abralia veranyi* (Rüppell, 1844)	Bordes et al. 2009	Atlantic- Mediterranean	Oceanic	
	Abraliopsis morisii (Vérany, 1839)	Bordes et al. 2009	Atlantic	Oceanic	
	Enoploteuthis anapsis Roper, 1964	Bordes et al. 2009	Atlantic	Oceanic	
	Enoploteuthis leptura (Leach, 1817)	Clarke 2006	Atlantic-Indian-West Pacific	Oceanic	

Histioteuthidae	*Histioteuthis celetaria* (Voss, 1960)	USNM 817197	Atlantic	Oceanic	
	Histioteuthis corona corona (Voss & Voss, 1962)	Bordes et al. 2009	Atlantic	Oceanic	
	Histioteuthis bonnellii (Férussac, 1834)	Fernández et al. 2009; Escánez 2019	Eastern Atlantic- Mediterranean- Southern Indian- Southwestern Pacific	Oceanic	+
	Stigmatoteuthis arcturi Robson, 1948	López et al. 1993	Tropical-Subtropical Atlantic	Oceanic	
	Histioteuthis meleagroteuthis (Chun, 1910)	Clarke 1969; Bordes et al. 2009	Worldwide	Oceanic	+
	Histioteuthis reversa (Verrill, 1880)	Bordes et al. 2009	Atlantic- Mediterranean	Oceanic	+
Joubiniteuthidae	*Joubiniteuthis portieri* (Joubin, 1912)	Bordes et al. 2009	Worldwide	Oceanic	
Lepidoteuthidae	*Lepidoteuthis grimaldi* Joubin, 1895	Clarke 1963; Escánez et al. 2017	Worldwide	Oceanic	+
Pholidoteuthidae	*Pholidoteuthis massyae* (Pfeffer, 1912)*	Fernández et al. 2009	Sub-Antartic	Oceanic	+
Loliginidae	*Alloteuthis africana* Adam, 1950	Bordes et al., 2009	Eastern Atlantic	Shelf	
	Alloteuthis media (Linnaeus, 1758)*	Guerra et al. 2003	Eastern Atlantic- Mediterranean	Shelf	
	Alloteuthis subulata (Lamarck, 1798)	López et al. 1993	Eastern Atlantic- Mediterranean	Shelf	
	Loligo forbesii Steenstrup, 1856	Brito and Pascual 2002	Northeastern Atlantic- Mediterranean	Shelf	
	Loligo vulgaris Lamarck, 1798	Gray 1854, Lönnberg 1896	Eastern Atlantic- Mediterranean	Coastal	
Lycoteuthidae	*Lampadioteuthis megaleia* Berry, 1916	USNM 817190	North Atlantic- Souhtwestern Pacific	Oceanic	
	Selenoteuthis scintillans Voss, 1959	Clarke 2006; Bordes et al. 2009	North Atlantic	Oceanic	
Mastigoteuthidae	*Mastigoteuthis agassizii* Verrill, 1881	Clarke 1969	Central North Atlantic	Oceanic	
	Echinoteuthis danae Joubin, 1933	Joubin 1933, Vecchione and Young 2014	North Atlantic	Oceanic	
	Mastigoteuthis grimaldii (Joubin, 1895)	Bordes et al. 2009	Tropical-Subtropical Atlantic	Oceanic	+
	Mastigopsis hjorti (Chun, 1913)	Clarke 2006, Bordes et al. 2009	North Atlantic- Central Pacific- Indian Ocean	Oceanic	

Neoteuthidae	*Neoteuthis thielei* Naef, 1921	Clarke 2006	Atlantic- North Pacific	Oceanic	
	Narrowteuthis nesisi Young & Vecchione, 2005	Young and Vecchione 2005	Eastern North Atlantic	Oceanic	
Octopoteuthidae	*Octopoteuthis sicula* Rüppell, 1844	Clarke 2006, Bordes et al. 2009	Worldwide	Oceanic	+
	Octopoteuthis sp. A Young, 1972	Escánez 2019	North Atlantic	Oceanic	
	Taningia danae Joubin, 1931	Bordes et al. 2009	Worldwide	Oceanic	+
Ommastrephidae	*Hyaloteuthis pelagica* (Bosc, 1802)	Clarke 2006	Atlantic- Pacific	Oceanic	
	Illex coindetii (Vérany, 1839)	Bordes et al. 2009	Atlantic	Shelf	
	Ommastrephes caroli (Furtado, 1887)	Lönnberg 1896	Worldwide	Oceanic	+
	Sthenoteuthis pteropus (Steenstrup, 1855)	Clarke 2006	Atlantic	Oceanic	
	Todarodes sagittatus (Lamarck, 1798)	Clarke 2006, Bordes et al. 2009	Eastern Atlantic-Mediterranean	Oceanic	+
	Todaropsis eblanae (Ball, 1841)*	Guerra et al. 2003	Easter Atlantcic-Indian-Western Pacific	Shelf	
Gonatidae	*Gonatus sp.* Gray, 1849*	Fernández et al. 2009	-	Oceanic	+
Onychoteuthidae	*Ancistroteuthis lichtensteinii* (Férussac, 1835)	Clarke 2006	Atlantic- Mediterranean	Oceanic	
	Onykia carriboea Lesueur, 1821	Bordes et al. 2009	Worldwide	Oceanic	
	Onychoteuthis banksii (Leach, 1817)	Clarke 2006, Bordes et al. 2009	Worldwide	Oceanic	
	Walvisteuthis rancureli (Okutani, 1981)	USNM 814625	Worldwide	Oceanic	
Pyroteuthidae	*Pterygioteuthis gemmata* Chun, 1908	Bordes et al. 2009	Atlantic-Indian-Pacific	Oceanic	
	Pterygioteuthis giardi Fischer, 1896	Clarke 1969, Bordes et al. 2009	Worldwide	Oceanic	
	Pyroteuthis margaritifera (Rüppell, 1844)	Clarke 1969, Bordes et al. 2009	Worldwide	Oceanic	
Thysanoteuthidae	*Thysanoteuthis rhombus* Troschel, 1857	Clarke 1969	Worldwide	Oceanic	+
Total: 34	**104**				**23**

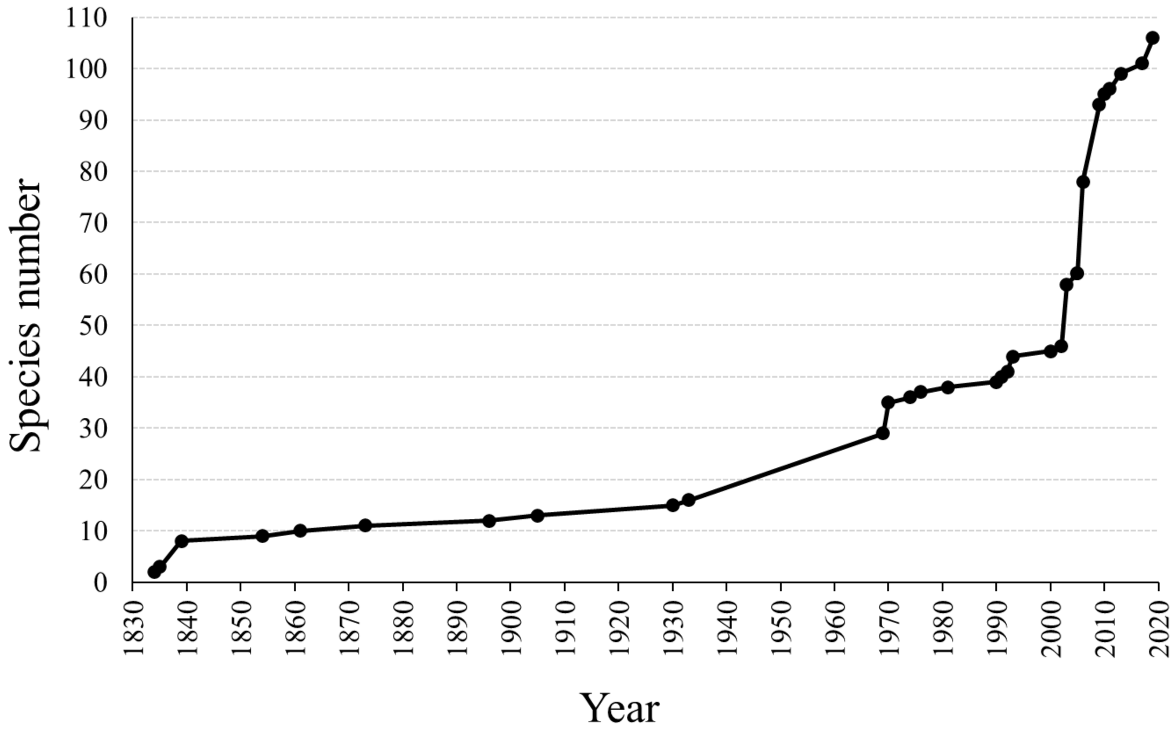
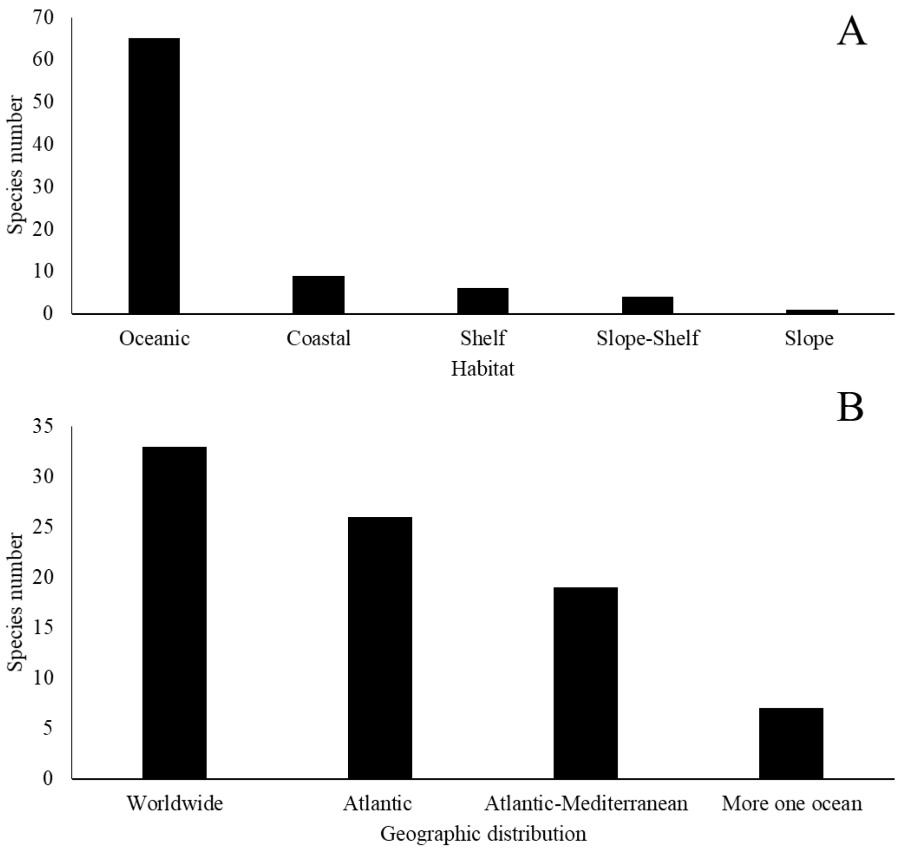


FIGURE 1. Cephalopods species discovery curve. This figure shows the accumulated number of species of cephalopods known to the Canary Islands over time, since 1834 until 2019.



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707 **FIGURE 2:** Pattern of distribution of cephalopods species richness for A) the marine
708 habitats explored in the Canary Islands and B) by its geographical distribution.

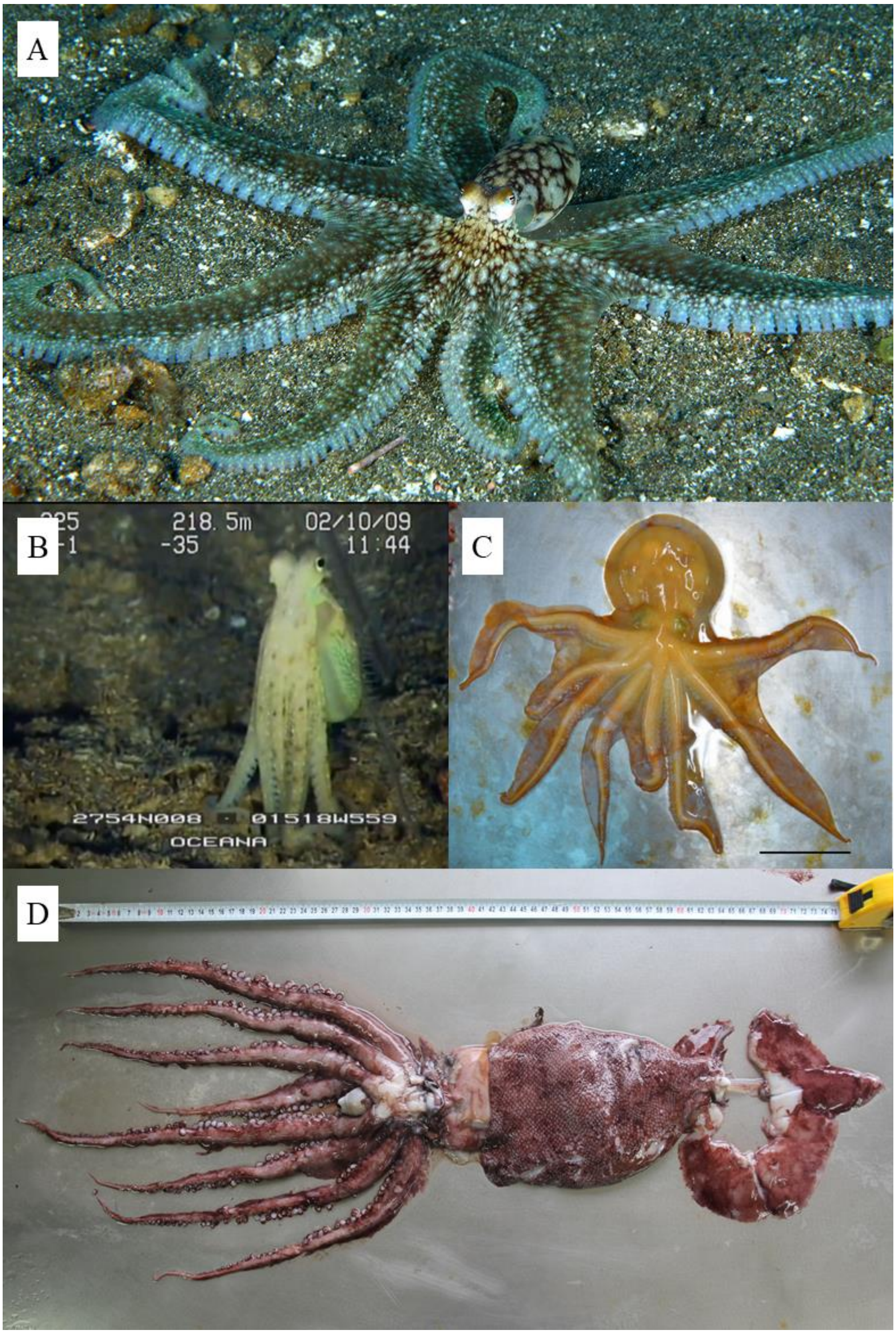

FIGURE 3. Some examples of cephalopods recently reported in the Canary Islands. A) Lilliput longarm octopus (*Macrotritopus defilippi*) described in 2013, photographed in Tenerife. Autor: Francis Pérez. B) The musky octopus (*Eledone cf. moschata*) filmed by a ROV on Oceana boat Ranger, Gran Canaria, 2009. C) Four horn octopus (*Pteroctopus tetracirrhus*) captured in Tenerife and described in 2018. D)

Scaled squid (*Lepidoteuthis grimaldii*) and described in 2017. Photo of a female caught in El Hierro (2017).

Revised species records reveal the Canary Islands as a cephalopod biodiversity hotspot

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: