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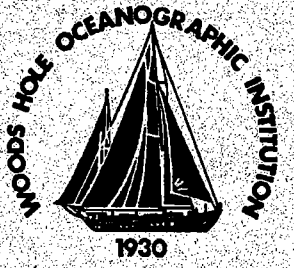

Distribution and Taxonomy of Zooplankton in the Alboran Sea and Adjacent Western Mediterranean

A Literature Survey and Field Guide.

by

Laurence P. Madin

September, 1991

Technical Report

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Abstract.

This is a survey of literature records for occurrence and taxonomy of zooplankton in the Western Mediterranean, with particular emphasis on the Alboran Sea. It is intended to give a general background on the fauna, and facilitate identification of specimens collected or observed. A description of the hydrography of the Alboran Sea is followed by a general account of zooplankton biomass distribution, and more detailed lists of the occurrence of 361 species of medusae, siphonophores, ctenophores, worms, tunicates and crustaceans in 7 regions of the Western Mediterranean. Bioluminescent properties of the organisms are indicated where known. An illustrated taxonomic guide provides capsule descriptions and illustrations of 254 of the listed species.

Key Words. zooplankton, Alboran Sea, bioluminescence

Table of Contents

Introduction.

This document is a literature-based survey of the occurrence and taxonomy of zooplankton in the Alboran Sea and adjacent regions of the western Mediterranean. It's purpose is to provide background on the kinds of plankton that one would expect to encounter in this area, and a convenient reference for shipboard identification of collected or photographed specimens. Because it is intended to support *in-situ* investigations, by submersible and SCUBA diving, of luminescent organisms, the taxonomic guide focusses on the gelatinous macrozooplankton and the more common crustaceans. It emphasizes characteristics of intact, live animals, and indicates whether they are known or suspected to be luminescent.

The western Mediterranean Basin is divided into several regional seas, as illustrated in Figure 1. The present survey includes distributional records for zooplankton in the:

a. Alboran Sea - extending from Gibraltar eastward to approximately 0° longitude;

b. Strait of Gibraltar;

c. Catalan (Balearic) Sea - between the southeast coast of Spain and the Balearic Islands;

d. Gulf of Lyon - extending southeast into the central basin west of Corsica and Sardinia;

e. Ligurian Sea - between the French Riviera and Corsica;

f. Tyrrhenian Sea - bounded by Corsica and Sardinia on the west, Italy on the east and Sicily at the south;

g. Adriatic Sea - between Italy and the Dalmatian coast.

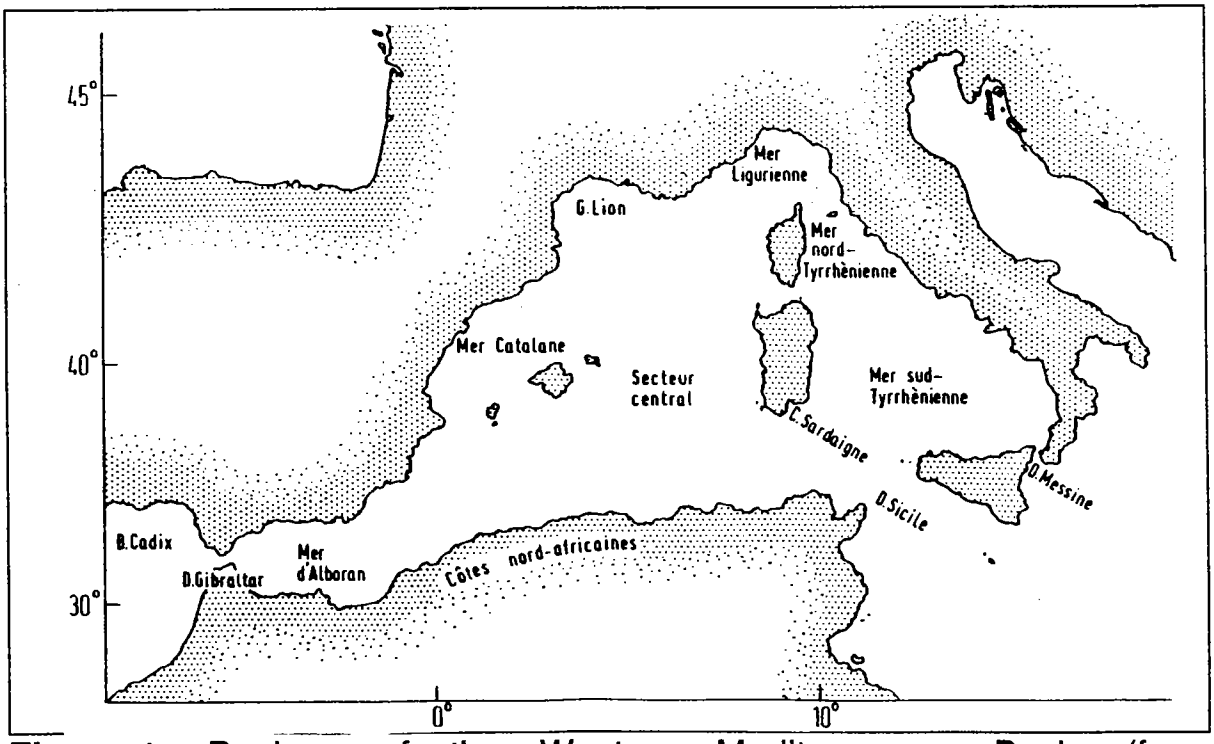

Figure 1. Regions of the Western Mediterranean Basin (from Furnestin, 1968)

The extent to which the planktonic fauna of these regions has been studied depends partly on the geographic distribution of marine laboratories on the coasts of these seas. Upwelling regions near Messina, Naples and Nice in the Tyrrhenian and Ligurian Seas have been known since antiquity. Laboratories have been established in these regions for over a hundred years, and the fauna is quite well known. Other laboratories in France and Italy have supported surveys in the Gulf of Lyon, the Catalan Sea and the North African coast. In addition, several oceanographic cruises have been undertaken in the western Mediterranean, adding coverage of the regions further offshore.

There is a fairly considerable classical literature on the planktonic fauna of the Mediterranean, based on work done in the mid to late 19th century at Messina, Naples, Villefranche, Trieste and a few other locations by pioneers like Brandt, Chun, Haeckel, Lohmann and others. A valuable and comprehensive systematic treatment of phytoplankton and zooplankton in the Mediterranean, the "Manuel du Planctonologie Mediterraneenne" was published by Gregoire Tregouboff and Maurice Rose in 1957. It is a quite inclusive work, summarizing the basic biology of each group and providing keys and illustrations for identification. It is somewhat cumbersome to use in the field however, because of the complex structure of the keys and the separation of the illustrations from accompanying text (including captions) in a separate volume. This work, and some of the old literature, has been used here as a source.

For the most part, however, the present survey is based on more recent investigations that used modern techniques for sampling zooplankton from larger areas and depth ranges. These studies also have the advantage of using a taxonomic nomenclature fairly well settled by major revisions published in the last several decades. Another relevant source of information for this survey are the reports of observations made from other submersibles and bathyscaphes. French scientists made numerous dives in the Gulf of Lyon and Ligurian Sea during the 1950's and 1960's (Bernard, 1955, 1958; Tregouboff, 1956, 1957) and more recently (Laval and Carré, 1988; Laval et al. 1989, Mills and Goy, 1988; Biggs et al., 1987). Although these reports provide mainly qualitative visual observations, the sightings have been included in the distributional lists and discussions where possible.

This survey is organized into three main sections. The first considers general patterns of zooplankton distribution. This is intended as an overview of hydrography, zooplankton biomass distribution, seasonal abundances and vertical zonation in the Alboran sea specifically, and in the adjoining regions.

The second section considers the occurrence and abundance in the western Mediterranean of the major groups of zooplankton with emphasis on gelatinous forms and bioluminescent species: colonial radiolaria, hydromedusae, scyphomedusae, siphonophores, ctenophores, some polychaetes, some molluscs, pelagic tunicates and some crustaceans. Groups with no known bioluminescent species, notably the pteropods, heteropods, and chaetognaths, are not included in

this survey; neither are adult or larval fishes. Cephalopods, although luminescent have not been included for lack of time and space, and because they are thought unlikely to contribute significantly to luminescence observed from the submersible (E. Widder, pers. comm.). Occurrence in the western Mediterranean of a total of 361 species is summarized in 7 tables. Species are listed alphabetically within Class, Order or Suborder, as appropriate. Abundance and vertical distribution of the most common species are discussed in more detail.

The tables also indicate whether the species is bioluminescent. The letter "a" in the "Lum" column means the genus is considered "definite" in the list of Herring (1987). The letter "b" indicates a genus is considered "uncertain" and the letter "c" indicates that the particular genus is not known to be luminescent, but one or more other genera in the same family is. A blank in the "Lum" column indicates no mention in Herring (1987).

The third section is a taxonomic guide designed to facilitate rapid field identification of animals collected by divers or a submersible, or photographed or videotaped *in situ*. Instead of keys, brief descriptions accompanied by line drawings are arranged in the same order as they appear in the tables of distribution. The illustrated guide includes 254 (70%) of the species listed in the tables. For each species, two higher taxa (Family, Suborder, Order, Subclass or Class) are listed to place species in context of their classification. It is hoped that acccurate identifications can be made fairly quickly by flipping through the pictures. Because the majority of Mediterranean species also occur in the Atlantic and elsewhere, this part of the survey should prove useful in other oceans as well.

General distribution patterns

1. General hydrography

The Alboran basin is relatively shallow, exceeding 1000 m only at the east and northeast. On the south it is bounded by a plateau stretching between Oran (Algeria) and Cabo Tres Forcas (Morocco). On the north, banks exist southeast of Malaga and southwest of Almeria (Spain). As the entry point for Atlantic waters into the Mediterranean, the Alboran Sea is strongly influenced by incurrent water masses. Circulation in the Alboran and western Mediterranean is discussed by Furnestin (1960) and Allain (1960); this brief outline is taken largely from the latter source.

The principal Atlantic surface current entering through the strait of Gibraltar bears east-northeast, but soon curves to the right, taking a more easterly direction (see Fig. 2). Water in the lower edge of this current comes completely around, forming an anticyclonic eddy to the west of Cabo Tres Forcas. Currents in this gyre attain about 1.2 knots on the westerly side. The main current accelerates in passing over the ridge beneath the Isla Alboran, changes direction toward the north. A second anticyclonal eddy is spun off in the bight east of Cabo Tres Forcas; it circulates more slowly, at about 0.2 knots. Turning southerly again, the main

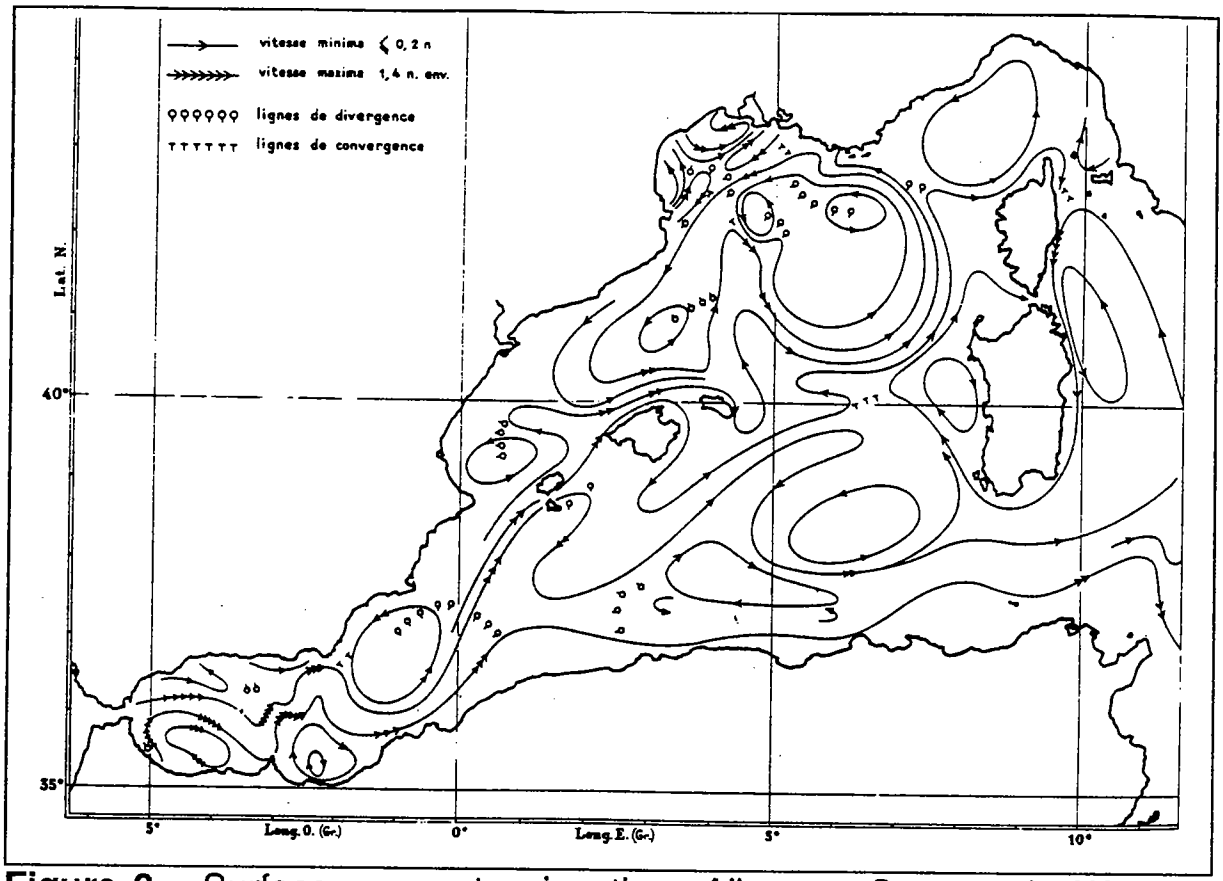

Figure 2. Surface currents in the Alboran Sea and Western Mediterranean (from Allain, 1960).

current passes close to the coast at Oran, then bears northeast, over deeper water, toward the Balearic Islands. A branch of the current continues to follow the north African coastpast Tunisia, and a large cyclonic eddy is produced on the north side of the main stream, within the bight bounded by Cabo de Gata and Cabo Palos in Spain.

The general pattern of surface circulation remains the same to a depth of about 200 m, though velocities are lower. Below 200 m, the water is mainly of Mediterranean origin, and a westerly current carrying Mediterranean water towards the strait of Gibraltar becomes established in the northeast part of the Alboran Sea. Below about 400 m, the circulation is reduced to almost nothing, with only the large cyclonic gyre east of Cabo de Gata and Cabo Palos still moving slowly.

2. Distribution of zooplankton biomass

Biomass and diversity of zooplankton are generally higher than in the eastern parts, due largely to the influence of Atlantic waters. The surface waters (to about

200 m) of the Alboran Sea therefore have the greatest abundances and the most similarity in species composition to the Atlantic. Species composition is in most respects identical to that found outside the strait of Gibraltar. Both abundance and Atlantic character of the fauna are diluted as the surface currents move east and northeast, so that the Ligurian and northern Tyrrhenian seas are poorer, and of a more Mediterranean character (Furnestin, 1968).

Within the Alboran Sea, a divergence zone south of the Spanish coast was found by Rodriguez et al. (1982) to have a zooplankton community distinct from that of neritic waters to the north of it. They did not provide any data, however, on biomass distribution within these communities. Bracconot et al. (1983) provide some rather sketchy data from October and November, 1981, on total zooplankton biomass in the 0-200 m layer from stations both within the Sea and in the strait of Gibraltar. Lowest values, around 150 mg d.w. per m^2, were found in the axis of the strait. Values of 500 mg/m^2 for the 200 m water column were found in the northwest part of the Alboran. In the divergence zone south of the Spanish coast and in the southeast part of the basin biomass ranged from 200 to 500 mg/m^2. Much of the zooplankton biomass in the east and southeast parts of the Sea was due to numerous *Salpa maxima*.

Sampling by Greze et al. (1983) on the Alboran (270 m deep) and Tofinio (90 m deep) banks in the southern part of the Alboran Sea indicated that zooplankton abundance (mainly copepods) was similar to that found in adjacent areas of open water. Numbers of individuals ranged from about 500 to 4600 per m^3, and biomass from 22 to 100 mg (d.w.) m^3 over the two banks.

Zooplankton distribution along the Catalan coast near Barcelona was investigated by Sabates et al. (1989) between April and July, and September through October, 1983. They found greatest abundances in April and May, when biomass values were as high as 60 mg/m^3 in the top 200 m that were sampled. Biomass decreased to about 12 mg/m^3 by June and July, and reached a seasonal minimum of 4.5 mg/m^3 in September, increasing slightly in October. Values were higher further from shore. Gelatinous forms were a major part of this biomass in the spring. Salps peaked in April and May, and doliolids in July. Medusae and siphonophores were present throughout the sampling period at about the same abundance. Euphausiids were most abundant in April and June, but copepods dominated the abundances in April, June and July.

Occurrence and distribution of zooplankton groups in the Alboran Sea and adjacent areas.

1. Colonial Radiolaria and Acantharia

Radiolaria, both solitary and colonial forms, are widely distributed in all the world oceans. Colonial forms consist of hundreds of cells in a gelatinous matrix and can attain sizes of several cm. The *Collozoum, Thalassicolla, Raphidozoum, Sphaerozoum, Acrosphaera, Collosphaera, Siphonosphaera* and *Cytocladus* are bioluminescent (Herring, 1987). These organisms are readily recognized as radiolarians by their gelatinous or "fluffy" appearance, and some species have quite consistent appearances.

The species listed in Table 1 are those reported from submersible observations. Bernard (1958) ranked the radiolarians, mainly colonial forms, third in abundance after copepods and other crustaceans in his visual census of the water column. They were found throughout the water column, to 900 m.

TABLE 1. RADIOLARIANS AND ACANTHARIANS. Geographic Occurrence

Species	Figure	Lum	Alboran	Gibralter	Catalan	Lyon	Ligurian	Tyrrhenian	Adriatic
acantharians							X		
Acanthometra sp.						X			
Arachnosphaera sp.							X		
Aulacantha scolymantha						X	X		
Aulosphaera spp.		a					X		
Collozoum spp.		a				X	X		
Myxosphaera coerulea		b					X		
Sphaerozoum spp.		a					X		
Spongosphaera streptacantha							X		

References

Lyon: Bernard '58, Franqueville '70
Ligurian: Tregouboff '56, '58

2. Hydromedusae and Scyphomedusae.

There appears to be relatively little data on the distribution of hydromedusae or scyphomedusae within the Alboran Sea itself (Goy, 1983; Rodriguez, 1983), but there are several studies that consider seasonal and sometimes vertical occurrence of medusae from the Catalan Sea (Gili et al., 1987, 1988), Gulf of Lyon (Casanova, 1970) Ligurian Sea (Goy, 1972; Goy et al., 1989), Gulf of Naples (Vannucci, 1966; Brinckmann, 1970, 1987) and the Adriatic (Benovic, 1973a, 1973b, 1976, 1977; Vucetic, 1982). Probably many of these species are widely distributed throughout the Mediterranean, but simply haven't been as well sampled in the Alboran Sea as they have at Naples, Messina or Villefranche. Although Goy (1983) refers to the strait of Gibraltar as a "planktonic desert" and considers it a zoogeographic barrier for hydromedusae, most species known from the Mediterranean also occur in the Atlantic and elsewhere.

Table 2 lists 104 species of hydromedusae and 9 species of scyphomedusae reported from the Western Mediterranean; of these 92 are described and illustrated in Section D. The species are listed alphabetically within orders. The medusan species which appear to be most abundant in the Alboran Sea and adjacent regions are discussed here, with seasonal and vertical distributions, where known.

Some hydromedusae noted as common in the Alboran area include *Lizzia blondina*, and *Obelia* spp., both abundant in March and April (Rodriguez, 1983). Goy (1983) reported 11 species in the Alboran Sea in autumn, of which *Eucheilota paradoxica* was most abundant, especially in the southwest part of the Sea. Numerous specimens of *Pandea conica* were collected in 1986 by divers in the Alboran (Harbison, pers. comm.). *Persa incolorata* was the only species found in any abundance in the strait of Gibraltar by Goy (1983). Along the Catalan coast, the commonest species collected in the upper 200 m during May and June were *Podocoryne carnea, P. minuta, Lizzia blondina, Obelia spp. Eirene viridula, Aglaura hemistoma* and *Persa incolorata* (Gili et al., 1988). Spring and early summer appeared to be the times of peak abundance for the medusae in this area, with *Lizzia* and *Aglaura* occurring at densities of 10's m^{-3}.

Deeper collections were reported by Casanova (1970), who found a few species of trachymedusae and narcomedusae in tows as deep as 2000 m. Commonest was *Solmissus albescens*, a large, widely distributed and luminescent narcomedusa. This species occurs throughout the Mediterranean, and is a vertical migrator. In the Adriatic, populations of *S. albescens* migrate between about 600 m and the surface (Benovic, 1973). Mills and Goy (1988) characterize *S. albescens* as "the most numerous medusa in the mesopelagic western Mediterranean", and describe its vertical migration and swimming behavior as observed from a submersible diving near Villefranche. There the medusa moved from daytime depths between 400-700 m to the upper 100 m at night, swimming at about 100 m h^{-1}. *Solmissus* has also been reported by other observers in submersibles as one of the commonest medusae seen (Tregouboff, 1956, 1957; Bernard, 1958). Laval et al. (1989) estimated densities of 15 to 208 *Solmissus* per 1000 m^3. The abundance,

fairly large size (to 5 cm) and bright luminescence of this species make it likely to be an important source of midwater bioluminescence. Sketches of its appearance *in-situ*, as reported by Mills and Goy (1989) are reproduced in Fig. 3.

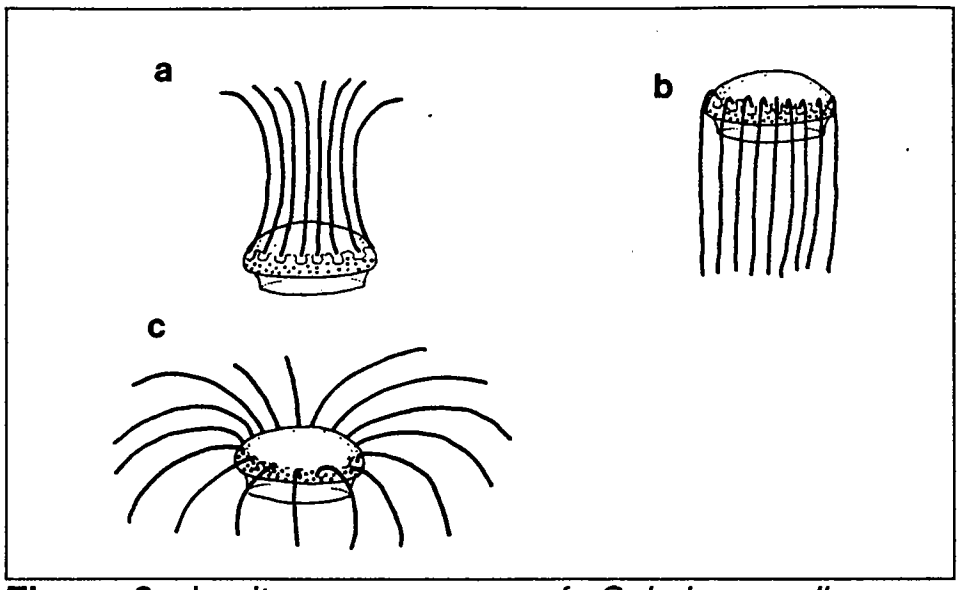

Figure 3. In-situ appearance of *Solmissus albescens* (from Mills and Goy, 1989).

The most abundant scyphomedusa from this area appears to be the ubiquitous and troublesome *Pelagia noctiluca*, a medium-size but strongly bioluminescent semaeostome. In recent years, populations of *Pelagia* have reached nuisance proportions in several parts of the Mediterranean. Gili et al. (1987) report maximium densities in the Catalan area of 30 m^{-3} in June. In the Gulf of Lyon and waters off Toulon, Franqueville (1971) found *Pelagia* migrated vertically between about 500 m and the surface. Individuals collected in April had bell diameters between 10 and 50 mm. Evidently, populations of *Pelagia* fluctuate on a cycle of approximately 12 years, going from almost none to very high densities (Goy et al., 1989). Other scyphomedusae that appear fairly common in the western Mediterranean are *Atolla wyvillei,* and *Periphylla periphylla*, which do not migrate (Franqueville, 1971), but are found below about 500 m.

TABLE 1. HYDRO- AND SCYPHOMEDUSAE. Geographic Occurrence

Species	Fig	Lum	Alboran	Gibralter	Catalan	Lyon	Ligurian	Tyrrhenian	Adriatic
HYDROMEDUSAE									
Anthomedusae									
Amphinema dinema	M-1	c			X			X	X
Amphinema rubrum	M-2	c					X		
Amphinema rugosum	M-3	c						X	
Amphinema turrida	M-4	c					X		
Bougainvillia ramosa	M-5	c				X	X	X	X
Bythotiara murrayi	M-6					X			X
Calycopsis simplex	M-7						X		
Calycopsis sp.								X	
Cirrholovenia tetranema							X	X	
Cladonema radiatum	M-8						X	X	
Cytaeis tetrastyla	M-9		X					X	
Dipurena halterata	M-10						X	X	
Dipurena ophiogaster	M-11						X	X	
Ectopleura dumortieri	M-12						X	X	X
Ectopleura larynx								X	
Ectopleura sacculifera								X	
Eleutheria dichotoma							X	X	
Eucodonium brownei	M-13				X			X	
Euphysa aurata	M-14	a			X	X		X	X
Halitiara formosa	M-15						X	X	
Hybocodon prolifer	M-16				X				
Koellikerina fasciculata	M-17				X			X	
Leuckartiara nobilis	M-18	a					X	X	
Leuckartiara octona	M-19	a			X	X		X	X
Lizzia blondina	M-20	b	X		X	X	X		
Lizzia fulgurans	M-21	b						X	
Merga tergestina	M-22	c						X	
Merga tregoubovii		c					X		

Species	Fig	Lum	Alboran	Gibralter	Catalan	Lyon	Ligurian	Tyrrhenian	Adriatic
Merga violacea	M-23	c					X		
Neoturris pileata	M-24	c			X	X			X
Niobia dendrotentaculata	M-25							X	
Oceania armata	M-26							X	X
Octotiara violacea							X		
Pandea conica	M-27	c	X			X	X	X	
Paragotoea bathybia	M-28						X	X	
Podocoryne areolata							X		X
Podocoryne carnea	M-29				X	X		X	
Podocoryne hartlaubi	M-30					X		X	
Podocoryne minima	M-31				X			X	X
Podocoryne minuta	M-32				X				X
Rathkea octopunctata	M-33	b				X	X		
Sarsia eximia	M-34						X		
Sarsia gemmifera	M-35		X			X		X	X
Sarsia prolifera	M-36						X		
Sarsia tubulosa	M-37				X				
Staurocladia portmanni								X	
Steenstrupia nutans	M-38				X		X	X	X
Thamnostoma sp.							X		
Tiaranna rotunda	M-39					X			
Tregoubovia atentaculata							X		
Turritopsis nutricula	M-40							X	
Zanclea costata	M-41		X		X		X	X	X
Leptomedusae									
Aequorea aequorea	M-42	a				X	X	X	
Eirene viridula	M-43					X	X		X
Eucheilota paradoxica	M-44		X						

Species	Fig	Lum	Alboran	Gibralter	Catalan	Lyon	Ligurian	Tyrrhenian	Adriatic
Eugymnanthea inquilina					X			X	
Eutima gegenbauri	M-45				X	X			X
Eutima gracilis	M-46								X
Eutima sp.								X	
Eutonina scintillans							X		
Helgicirrha schulzei	M-47				X	X		X	X
Krampella dubia	M-48						X		X
Laodicea neptuna	M-49	b						X	
Laodicea ocellata	M-50	b				X			X
Laodicea undulata	M-51	b			X	X		X	X
Lovenella cirrata	M-52	a						X	
Mitrocoma annae	M-53	c						X	
Mitrocomella brownei	M-54	c			X				
Obelia spp.	M-55	a	X		X	X	X	X	X
Octophialucium funerarium	M-56	a			X	X	X		X
Orchistomella graeffei							X		X
Phialidium hemisphaericum	M-57	a			X	X	X		X
Phialidium mccradyi	M-58	a						X	
Phialidium sp.		a					X		
Tima lucullana	M-59	a			X			X	
Limnomedusae									
Gonionemus vertens	M-60						X		
Odessia maeotica	M-61					X	X	X	
Olindias phosphorica	M-62						X	X	
Proboscidactyla ornata	M-63						X	X	
Scolionema suvaensis	M-64						X	X	