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Technical Series 115

Oceanographic and biological features in the Canary Current Large Marine Ecosystem

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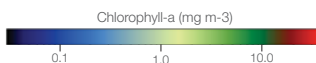
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Cover photo: Phytoplanktonic blooms along the coast of Northwest Africa and Iberian Peninsula, as seen from the concentration of chlorophyll-a, in March 2013, deduced from the data of the MODIS sensor. Numerous mesoscale features such as fronts and filaments can be observed. Image by Hervé Demarcq, IRD



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Editors:
Luis Valdés
Itahisa Déniz-González



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With the support of the Spanish Agency for
International Development Cooperation (AECID)



UNESCO 2015

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For bibliographic purposes, this document should be cited as: Valdés, L.¹ and Déniz-González, I.¹ (eds). 2015. *Oceanographic and biological features in the Canary Current Large Marine Ecosystem*. IOC-UNESCO, Paris. IOC Technical Series, No. 115: 383 pp.

¹ Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), Paris, France

The publication *Oceanographic and biological features in the Canary Current Large Marine Ecosystem* is also available online at:

<http://www.unesco.org/new/en/ioc/ts115>

(IOC/2015/TS/115)

5.5. BIODIVERSITY AND BIOGEOGRAPHY OF DECAPOD CRUSTACEANS IN THE CANARY CURRENT LARGE MARINE ECOSYSTEM

Eva GARCÍA-ISARCH¹ and Isabel MUÑOZ²

¹ Centro Oceanográfico de Cádiz, Instituto Español de Oceanografía. Spain

² Centro Oceanográfico de Santander, Instituto Español de Oceanografía. Spain

5.5.1. INTRODUCTION

Crustaceans constitute one of the most morphologically diverse taxonomic groups on the planet (Martin and Davis, 2001). Among them, decapods are the most studied taxon, mainly on account of the commercial interest of some species and their great diversity. Decapods are mainly composed of marine species that live in waters depths ranging from shallow to deeper than 5000 m. The importance of this group lies in several factors such as the great biomass they represent, their significant role in marine food webs and the commercial interest of many decapod species.

The main morphologic types of Decapoda (the word means “ten legs”) include: (i) shrimps and prawns (Dendrobranchiata -Penaeidae- and families Caridea, Stenopodidea and Axiidea), (ii) crabs (Brachyura), (iii) lobsters (infraorders Astacidea and Achelata) and (iv) squat lobsters and hermit crabs (Anomura).

A number of expeditions have been carried out in West African waters since the 19th century with the aim of studying their marine environment and fauna, which involved the first studies on crustaceans including part of the entire Canary Current Large Marine Ecosystem (CCLME) region. This is the case of the *Travailleur* and *Talisman* expeditions in the 19th century (Milne-Edwards and Bouvier, 1892, 1900), and the worldwide voyage of the HMS *Challenger* (Bate, 1888). In the 20th century, the expeditions *Mercator* (1935-1936 and 1938), *Atlantide* (1945 and 1946) and *Calypso* (1956) contributed to a better knowledge of different decapod groups in West Africa (Capart, 1951; Holthuis, 1951; Crosnier and Forest, 1965, 1966; Miyake and Baba, 1970; Saint Laurent and Le Loeuff, 1979). Some crustacean species from Moroccan Atlantic waters, Western Sahara and Mauritania were collected during the cruises on board the R/V *Meteor* in 1967, 1970, 1971 and 1975 (Türkay, 1975, 1976), the R/V *Thalassa* in 1962 (Maurin, 1963), 1968 and 1971 and the R/V *Atlor VII* in 1975 (Anadón, 1981). A significant number of organisms were collected during the CAPCAN expeditions to the Canarian-Caboverdian region (1976-1986) and the MAURITANIA expedition to the Bank d’Arguin (1988) (Fransen, 1991). The material collected in all these expeditions and surveys provided faunal inventories and species descriptions in the CCLME area.

More recently, the surveys carried out by the Instituto Español de Oceanografía (IEO) from 2002 to 2010, on board the R/V *Vizconde de Eza* in several Exclusive Economic Zones (EEZs) of the CCLME region provided excellent material for studying the taxonomy and ecology of decapods in the area. In addition, the analysis of the material collected in the last CCLME Ecosystem surveys conducted on board the R/V *Dr. Fridtjof Nansen* in 2011 and 2012, which is currently under study, will undoubtedly be a valuable tool in furthering knowledge of the crustacean biodiversity in the whole area.

There are certain studies concerning fisheries and biological aspects of some crustacean species (i.e. Maurin and Bonnet, 1969; Crosnier and De Bondy, 1967; Lhomme, 1978, 1979a, b; Bast et al., 1984; Lhomme and Garcia, 1984; Cervantes and Goñi, 1985; García, 1988; Cervantes et al., 1992; Sobrino and

García, 1991, 1992a, 1992b, 1994; Caveriviere and Rabarison Andriamirado, 1997; Laë et al., 2004; Thiaw et al., 2009). Only a few recent works have analysed ecological aspects of the decapod community structure in certain CCLME areas (Muñoz et al., 2012; García-Isarch et al., submitted). Aside from these studies, the literature about decapod crustaceans in the CCLME is rather dispersed and mainly focused on faunal lists and taxonomic aspects of certain species. There is a large number of studies concerning single species or genera. More generally, it is worth mentioning the excellent works carried out in the region by Crosnier and Forest (1973) on deep shrimps (*Caridea* and *Penaidea*) and Capart (1951), Monod (1956) and Manning and Holthuis (1981) on *Brachyuran* crabs. In addition, some excellent taxonomic reviews include West African records such as Zariquiey (1968) for decapods in general; Macpherson (1988) for *Lithodidae*; Pérez-Farfante and Kensley (1997) for penaeoid shrimps; Holthuis (1991) for lobsters; Galil (2000) for *Polychelid* lobsters; and McLaughlin (2003) for hermit crabs, among others.

In the CCLME, decapod species have been targeted by both artisanal (local) and industrial fisheries. Foreign industrial shrimper fleets have been established in the area since the decade of the 60s, first freely and, since the implementation of the Convention on the Law of the Sea (UNCLOS, 1982), through agreements between the different administrations involved. Later, most CCLME countries developed their own industrial fisheries. The exploitation of these resources has provided significant economic incomes to the coastal States.

The purpose of this article is to present a global overview of the biodiversity of crustaceans in the CCLME region considering the latest information available, supported by an extensive literature review.

5.5.2. METHODS

The main data sources considered for the study of decapod diversity in the CCLME region were:

- IEO surveys. These were carried out in waters off Morocco (2004 and 2005) and Western Sahara (2006), Mauritania (2007, 2008 and 2009) and Guinea-Bissau (2008) on board the R/V *Vizconde de Eza*. Samples were taken by means of bottom trawls, at depths ranging from 229 m to 1861 m (Morocco-Western Sahara), 81 to 1825 m (Mauritania) and 20 to 1000 m (Guinea-Bissau). Decapods taken in each haul were sorted and keyed as specifically as possible to the lowest taxonomic level, counted and weighed. In order to check and complete the species identification, specimens of all the species caught were preserved and transported to the laboratory, where they have already been exhaustively reviewed in the case of Mauritania (García-Isarch et al., submitted) and Guinea-Bissau (Muñoz et al., 2012).
- Decapod specimens deposited in the Collection of Decapod and Stomatopod Crustaceans of the Cádiz Oceanographic Centre (Colección de Crustáceos Decápodos y Estomatópodos del Centro Oceanográfico de Cádiz, CCDE-IEOCD) from the IEO. This collection contains a great number of specimens from West Africa, mainly provided by the IEO and CCLME surveys, together with the IEO programmes of scientific observations on board the shrimper fleet in Mauritania and Guinea Bissau.
- Other sources: IEO databases of commercial fisheries developed in the region.

These data were used to produce a faunal list of the decapods in the area. The island fauna of the CCLME (the Canary Islands and Cape Verde Islands) remained beyond the scope of this study, on account of the lack of data. Considering the different type of sources, only a qualitative analysis was performed, based on

the presence/absence of each species in the CCLME countries. Given the geographical situation of Senegal and The Gambia, both countries were considered the same area.

The sampling coverage level was not the same for all the countries. The areas better sampled and studied were Mauritania and Guinea-Bissau (Muñoz et al., 2012; García-Isarch et al., submitted). The information from Morocco and Western Sahara was quite comprehensive (Ramos et al., 2005; Hernández-González et al., 2006; Hernández-González, 2007), although an in-depth analysis is still needed for a better knowledge of the biodiversity in these waters. However, the data from Senegal, The Gambia and Guinea came only from the material deposited in the CCDE-IEOCD collection, meaning that it does not represent the real diversity in the area. Because of the small number of specimens listed from Guinea, we analysed the decapod fauna of this country together with that of Guinea-Bissau, considering that species occurring in both EEZs were unlikely to be very different, because of the vicinity and similar characteristics of the two areas. Estimations of the species richness by area and by taxonomic group were made using this information.

Taking into account the limitations of our data (not all the areas and depths are similarly represented), the literature available was reviewed to confirm the geographical range of certain species.

5.5.3. RESULTS AND DISCUSSION

5.5.3.1. Species composition and diversity

A total number of 228 decapod species belonging to 54 families are reported in this work for the CCLME. Table 5.5.1 shows the taxonomic list by area (Morocco-Western Sahara, Mauritania, Senegal-The Gambia, Guinea-Bissau-Guinea), indicating the origin of the record (IEO survey, CCDE-IEOCD collection or other sources). Geographical positions of the specimens deposited in the CCDE-IEOCD collection are shown in Figure 5.5.1.

Brachyura, with 87 different species, was the most diversified taxa, followed by Caridea and Anomura with 61 and 33 species, respectively. The most important families in terms of species richness were the Inachidae spider crabs (20 species), followed by the Macropipidae crabs (17 species), the Ophlophoridae deep sea shrimps (16), the Pandalidae shrimps (15) and the Penaeidae shrimps (10). Other diverse families were Crangonidae and Pasiphaeidae (8 species each) and the Diogenidae and Paguridae hermit crabs (7 species each). The remaining 45 families were represented by fewer than 6 species each (Figure 5.5.2).

Quantitative data have only been analysed in Mauritania and Guinea-Bissau so far. These analyses revealed quite similar decapod diversities in both areas ($H' = 3.22$ in Mauritania and $H' = 3.30$ in Guinea-Bissau; H' = Shannon diversity index) (Muñoz et al., 2012; García-Isarch et al., submitted), although samples were obtained at different depth ranges. When comparing the number of species registered in the current study, Morocco-Western Sahara and Mauritania showed the greatest species richness (137 and 134 species, respectively), followed by Guinea-Bissau-Guinea (119 species).

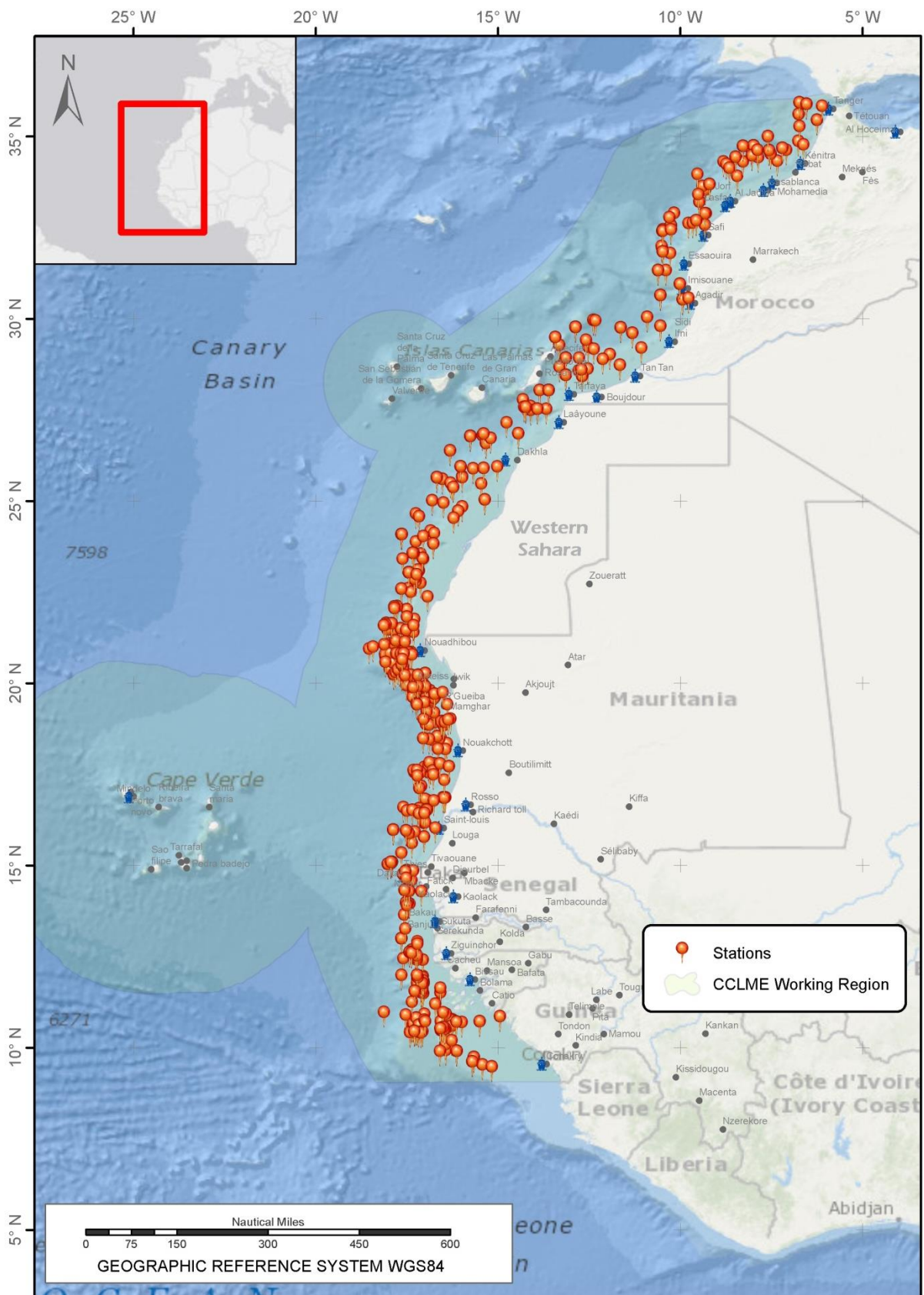


Figure 5.5.1. Geographical situation of the decapod specimens records from the CCLME deposited in the Collection of Decapod and Stomatopod Crustaceans of the Cádiz Oceanographic Centre - in Spanish *Colección de Crustáceos Decápodos y Estomatópodos del Centro Oceanográfico de Cádiz (CCDE-IOCD)*.

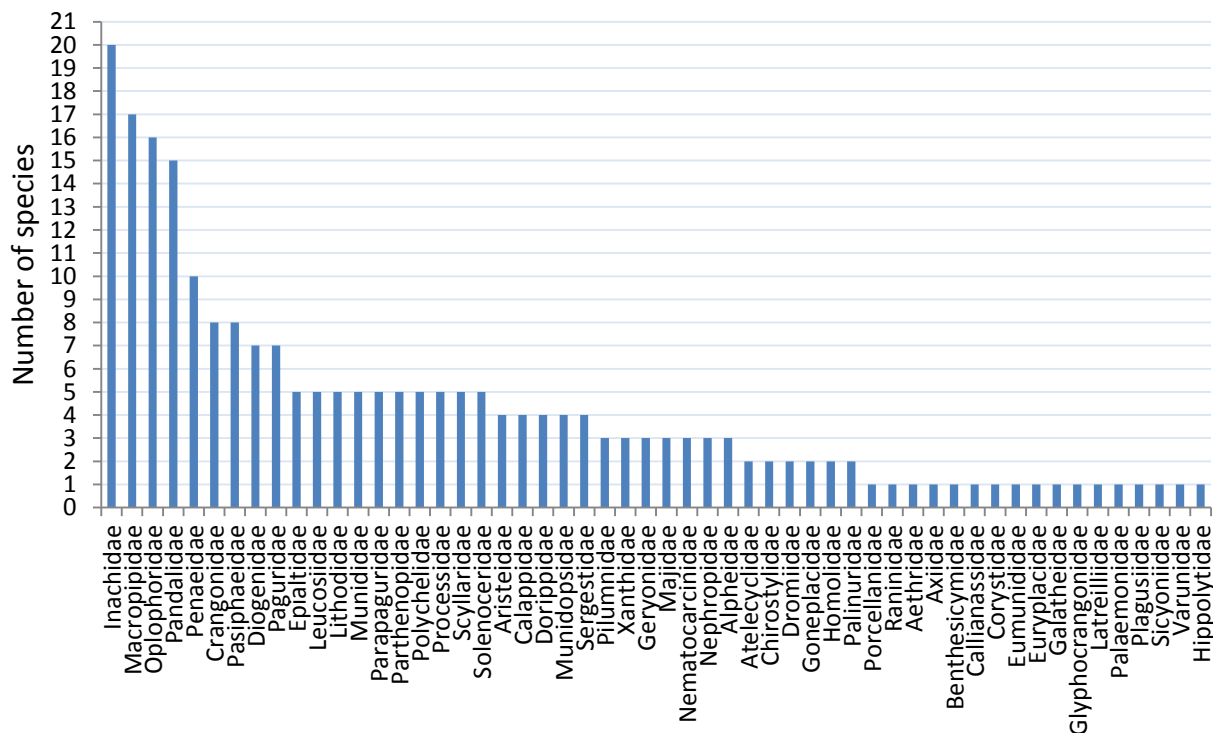


Figure 5.5.2. Species richness by decapod family in the CCLME.

As mentioned before, data from Senegal-The Gambia are not comparable to those of the former countries, because they do not represent the decapods' real diversity. Despite the fact that species richness is supposed to be higher in tropical and subtropical regions as compared to temperate and cold regions (Abele, 1982), the decapod diversity in the most temperate and northern areas of the region (Morocco-Western Sahara and Mauritania) was higher than in the most tropical and southern areas (Guinea-Bissau-Guinea). However, it should be borne in mind that deeper waters were prospected in Morocco-Western Sahara and Mauritania, a fact that may have increased the number of species recorded. In any case, the great diversity of decapods in the temperate area of the CCLME is evident. García-Isarch et al. (submitted) showed the exceptionally high decapod diversity in Mauritania, compared with other temperate areas. This fact gives an idea of the special character of the CCLME, where there is great diversity not only in the tropical southern areas (as typically occurs), but also in more temperate northern waters, in relation to the special hydrographical conditions under the influence of the Canary Current.

It is worth mentioning that our list contains two species that are new to science: *Munidopsis anamosae* (de Matos-Pita and Ramil, 2014) (Plate 5.5.1(6)) and *Paguristes candela* (de Matos-Pita and Ramil, 2015) and that some of the observations increased the bathymetric and/or geographic range of certain species in Atlantic waters (Muñoz and García-Isarch, 2013; de Matos-Pita and Ramil, 2014, 2015, submitted; de Matos-Pita et al., submitted, García-Isarch et al., submitted).

5.5.3.2. Biogeographical considerations

In spite of the sampling limitations due to different coverage levels, depth ranges and gears used in different surveys, certain biogeographical considerations are concluded from the available data.

There are some species that are cited only in the northern area of the CCLME region in our work and that have not been reported in southern Morocco-Western Sahara waters or in the literature. This is the case of

the solenocetid shrimp *Hymenopenaeus debilis*; the crangonid *Crangon crangon*, the Processidae *Processa canaliculata*, *Processa edulis edulis*, *Processa elegantula*, and *Processa nouveli nouveli*; the Nephropidae *Homarus gammarus* and *Nephrops norvegicus*; the Anomura *Munida curvimana*, *Pagurus excavatus* and *Strobopagurus gracilipes*; and the Brachyura *Corystes cassivelaunus*, *Dromia personata*, *Macropodia tenuirostris*, *Geryon trispinosus*, *Liocarcinus depurator*, *Liocarcinus pusillus*, *Liocarcinus zariquieyi* and *Polybius henslowii*. Accordingly, Morocco-Western Sahara represents the southern distribution limit for these north-east Atlantic species, which can be considered typically temperate. Other species such as *Notostomus gibbosus* and *Capartiella longipes* found their northern geographical distribution in this area. Waters off the Western Sahara constitute a boundary of zoogeographic regions in West Africa, where species composition changed abruptly (Burukovski, 1998). This may be the transition zone of species belonging to the same genus, as is the case of Solenocera (*S. membranacea* in the North and *S. africana* in the South) and Aristeus (*A. antennatus* in the North and *A. varidens* in the South).

Some other species were recorded only in the waters from Morocco to Mauritania, being considered subtropical-temperate species. This is the case of the solenocetid *Hadropenaeus affinis*; the caridean shrimps *Sabinea hystrix* and *Nematocarcinus ensifer*; the lobster *Palinurus mauritanicus*; and the crabs *Inachus communissimus* and *Macropipus tuberculatus*. The reviewed literature does not report them south of Dakar in Senegal (15°N) or off Cape Verde. More specifically, some of the species in our study only recorded in Mauritania found their southern limit in these waters (i.e. *Ephyrina figueirai figueirai*, *Munidopsis curvirostra* or *Anapagurus laevis*). Conversely, Mauritania also constitutes the northern known distribution area of other reported species such as *Plesionika holthuisi*, *Neolithodes asperrimus*, *Inachus nanus*, *Macropodia hesperiae* and *Macropodia macrocheles*. As mentioned above, two new species were described in Mauritanian waters (*Munidopsis anaramosae* and *Paguristes candelae*) from specimens collected in the IEO surveys. Others, like *Neolithodes grimaldii*, *Paragiopagurus macroceros* and *Diogenes pugilator* are newly recorded in Mauritanian waters (Muñoz and García-Isarch, 2013; de Matos-Pita and Ramil, 2015). The literature review confirmed that the hippolytid *Lebbeus africanus* has been found only in Mauritanian waters, being a possible endemism. On the open shelf, the boundary between temperate and tropical species occurs around 21°N (Cape Blanc), where a frontal zone is located, due to a coastal upwelling occurrence that changes the characteristics of the water masses. In the case of species living on the shelf edge and continental slope, the northern boundary is situated in the northern part, around 26°N (Burukovski, 1998).

Among the species registered only in Senegal and/or Guinea-Bissau-Guinea, some of them can be considered typically tropical; these include *Penaeus monodon*, *AcanthePHYRA kingsleyi*, *Psathyrocaris infirma*, *Polycheles perarmatus*, *Ciliopagurus caparti*, *Diogenes ovatus*, *Petrochirus pustulatus* and *Ranilia constricta*. In the absence of a representative number of records from Senegal, the northern limit of these species in Senegalese or southern waters was confirmed with the literature review.

Some 50 species were considered to be distributed in the entire area of the CCLME studied (see Table 5.5.1 and Plate 5.5.2). However, this number may be much higher as the origin of the records reported in this work is limited to certain bathymetric ranges, areas and gear samplers. Most of these widely distributed species inhabit deep waters. At greater depths, physical-geographical characteristics of the water masses are much more homogeneous, which explains the presence of numerous species that are common to the tropical zone and the temperate northern area. In addition, the system of currents in the CCLME contributes to the distribution of many species from the edge of the shelf up to the equatorial zone (Crosnier and Forest, 1973).

Among the species cited, 55 are known only in West African waters, with greater or lesser geographical distribution. They can be considered to be endemisms in the area (see Table 5.5.1.).

It is worth mentioning the presence of the Asian tiger shrimp *Penaeus monodon*, which is an invader species in West Africa. It has been widely farmed outside of its native range in the Indo-West Pacific. Introductions in the late 1980s to West Africa have resulted in the rapid establishment of the species in the wild along the coasts from Senegal to northern Angola, as a result of escapes from aquaculture (Fuller et al., 2014). In our study, it has been registered in Guinea-Bissau.

5.5.3.3. Commercial species

Coastal penaeids such as *Penaeus notialis* and *Penaeus kerathurus* have traditionally been exploited by the local artisanal fleets. The industrial fleets target both coastal shrimps and other species inhabiting deeper waters such as the penaeids *Parapenaeus longirostris* and the aristeids *Aristeus antennatus*, *Aristeus varidens*, *Aristaeopsis edwardsiana* or *Aristeomorpha foliacea* (Sobrino and García, 1991, 1992a, 1992b, 1994; FAO, 2012 b, c) (see Plate 5.5.2). Some crabs and lobsters also have great commercial interest (i.e: *Chaceon maritae*, *Palinurus mauritanicus*). The deep-water rose shrimp *P. longirostris* is the most important commercial species, being fished by industrial fleets in the whole of the region, with average annual catches of around 16,000 t during the period 1990-2012 (FAO b, c, in press). More than 60% of these catches occur in the Moroccan EEZ. The Southern rose shrimp *P. notialis*, with an average annual catch of around 5,000 t in the last 20 years (FAO b, c, in press), constitutes the second most important commercial species, being fished from Mauritania to Guinea. Most catches occur in Senegal-The Gambia (57%), where the species is mainly fished by the industrial fleet. These shrimp stocks are exploited by the coastal countries as well as by foreign fleets, which makes joint action necessary to assess their situation within a scientific framework, provided by the Fishery Committee for the Eastern Central Atlantic (CECAF), a regional fishery body dependent on the Food and Agriculture Organization of the United Nations (FAO). The latest assessments of the FAO/CECAF Working Groups on the Assessment of Demersal Resources were carried out in 2013 (Subgroup North, from Morocco to Senegal-Gambia), and in 2011 (Subgroup South, including Guinea-Bissau and Guinea). These assessments indicated a situation of overexploitation of the Moroccan stock of *P. longirostris* and the Senegal-The Gambia stock of *P. notialis*, while the remaining stocks assessed (*P. longirostris* and *P. notialis* stocks of Mauritania and *P. longirostris* of Guinea-Bissau) were considered not fully exploited. However, it should be kept in mind that abundances of these stocks suffer the typical cyclical fluctuations of short-living species, greatly depending on their annual recruitment and therefore on the environmental conditions.

The magnitude of the impact of trawl fishery on the marine ecosystems in the CCLME area is still unknown.

5.5.4. CONCLUSIONS AND RECOMMENDATIONS

This work constitutes a first contribution to the knowledge of decapod crustaceans in the CCLME region as a whole. The richness of this group in the area is fostered by the special hydrographical conditions of these waters where tropical and temperate species coexist. The detailed analysis of the samples obtained from the most recent surveys conducted in the area, still under study, will provide a better overview of the ecological communities in the region.

One of the main factors adversely affecting the crustacean populations in the CCLME region is the fishing pressure. Some of the species are directly targeted by specific fisheries, or they are captured as by-catch,

thus causing the overexploitation of some stocks, as is the case of the Moroccan stock of *Parapenaeus longirostris* and the Senegal-The Gambia stock of *Penaeus notialis* (FAO b, in press). In addition, there is an indirect impact produced by those fishing activities using certain gears (such as bottom trawls) that affect the benthic communities by disturbing the physical structures and habitats. Other anthropogenic factors such as pollution and eutrophication may affect crustacean populations, especially in shallow areas.

Crustaceans have a significant role in the marine ecosystem, especially in marine food webs, where they link high and low trophic levels (Cartes, 1998). It is therefore recommended first to follow the status and trends of these communities through faunal monitoring programmes in the area. Those especially vulnerable benthic habitats should be protected by specific conservation measures. Thus, protecting benthic habitats as a whole would involve the conservation of their decapod communities.

Another significant conservation measure to be adopted by the coastal countries should be the protection of overexploited stocks, following the recommendations established by the regional fishery organization in charge (FAO/CECAF).

Acknowledgements

We are very grateful to all the participants in the IEO and CCLME surveys, especially to Susana Soto, Fran Ramil, Paqui Salmerón and Caleli Burgos, who contributed to the decapods identifications onboard. We thank Tania Vera and Oscar Valle for their useful and enthusiastic assistance in the general activities of the Collection of Decapod and Stomatopod Crustaceans of the Cádiz Oceanographic Centre (Colección de Crustáceos Decápodos y Estomatópodos del Centro Oceanográfico de Cádiz, CCDE-IEOCD)-IEO. We thank Ana Ramos, Cheikh-Baye Braham and Samir Martins for reviewing the manuscript and Luis Miguel Agudo for providing the map. This work was undertaken within the framework of the ECOAFRIK project, under ECOAFRIK publication number 25.

Table 5.5.1. Decapod taxonomic list by area of the CCLME region: Morocco EEZ (MOR), Mauritania EEZ (MAU), Senegal-The Gambia (SEGAM) and Guinea Bissau-Guinea (GUI), indicating the origin of the record (S=IEO survey, C=collection CCDE-IEOCD, OS=other sources), and endemisms (E). Species highlighted in grey are considered to be distributed along the entire CCLME region.

	Species	MWS	MAU	SEGAM	GUI
Suborder Dendrobranchiata					
Superfamily Penaeoidea					
Family ARISTEIDAE					
	<i>Aristaeopsis edwardsiana</i> (Johnson, 1868)	C-S	S	C	C-S
	<i>Aristaeomorpha foliacea</i> (Risso, 1827)	C-S	C-S		
	<i>Aristeus antennatus</i> (Risso, 1816)	S	C-S		S
	<i>Aristeus varidens</i> Holthius, 1952	S	C-S		C-S
Family BENTHESICYMIDAE					
	<i>Benthescycymus bartletti</i> Smith, 1882	S	C-S		S
Family PENAEEIDAE					
	<i>Funchalia danae</i> Burkenroad, 1940	S	S	C	
	<i>Funchalia villosa</i> (Bouvier, 1905)	C-S			
	<i>Holthuispenaeopsis atlantica</i> (Balss, 1914)	E	C	C	C-S
	<i>Penaeus kerathurus</i> (Forskål, 1775)	C	C	OS	OS
	<i>Penaeus monodon</i> Fabricius, 1798				OS
	<i>Penaeus notialis</i> Pérez Farfante, 1967	E	C-S	C	C-S
	<i>Metapenaeopsis miersi</i> (Holthuis, 1952)	E	C-S		
	<i>Parapenaeus longirostris</i> (Lucas, 1846)	C-S	C-S	C	C-S
	<i>Pelagopenaeus balboae</i> (Faxon, 1893)		S	C	
	<i>Penaeopsis serrata</i> Spence Bate, 1881	C-S			
Family SICYONIIDAE					
	<i>Sicyonia galeata</i> Holthuis, 1952	E	C-S	C	C
Family SOLENOCERIDAE					
	<i>Hadropenaeus affinis</i> (Bouvier, 1906)	C	C		
	<i>Hymenopenaeus chacei</i> Crosnier & Forest, 1969	E	C-S	C	C
	<i>Hymenopenaeus debilis</i> Smith, 1882	C			
	<i>Solenocera africana</i> Stebbing, 1917	E	C-S	C	C
	<i>Solenocera membranacea</i> (Risso, 1816)	C-S	C		
Superfamily Sergestoidea					
Family SERGESTIDAE					
	<i>Eusergestes arcticus</i> (Krøyer, 1855)		S		
	<i>Sergia grandis</i> (Sund, 1920)		C-S		S
	<i>Sergia robusta</i> (Smith, 1882)	S	C-S		S
	<i>Sergia talismani</i> (Barnard, 1947)		C-S		C-S
Suborder Pleocyemata					
Infraorder Caridea					
Superfamily Alpheoidea					
Family ALPHEIDAE					
	<i>Alpheus talismani</i>		C		
	<i>Alpheus</i> sp.1				S
	<i>Alpheus</i> sp.2				S
Family HIPPOLYTIDAE					
	<i>Lebbeus africanus</i> Fransen, 1997		S		
Superfamily Crangonoidea					
Family CRANGONIDAE					
	<i>Aegaeon cataphractus</i> (Olivi, 1792)	C-S	C-S	C	C
	<i>Aegaeon lacazei</i> (Gouret, 1887)	C	C-S		C-S
	<i>Crangon crangon</i> (Linnaeus, 1758)	C			
	<i>Metacrangon bellmarleyi</i> (Stebbing, 1914)	E	S	C-S	S
	<i>Parapontophilus gracilis gracilis</i> (Smith, 1882)	E	C-S	C	
	<i>Philocheras echinulatus</i> (M. Sars, 1862)	C-S			
	<i>Philocheras sculptus</i> (Bell, 1847 [in Bell, 1844-1853])	C			
	<i>Sabinea hystrix</i> (A. Milne-Edwards, 1881)	S	S		
Family GLYPHOCRANGONIDAE					
	<i>Glyphocrangon longirostris</i> (Smith, 1882)	S	C-S		
Superfamily Nematocarcinoidea					
Family NEMATOCARCINIDAE					
	<i>Nematocarcinus africanus</i> Crosnier & Forest, 1973	E	S	C-S	C
	<i>Nematocarcinus ensifer</i> (Smith, 1882)	S	S		
	<i>Nematocarcinus gracilipes</i> Filhol, 1884	S	C		
Superfamily Oplophoroidea					
Family OPLOPHORIDAE					
	<i>Acanthephyra acanthitelsonis</i> Bate, 1888	S	S	C	S
	<i>Acanthephyra acutifrons</i> (Bate, 1888)	S			S
	<i>Acanthephyra curtirostris</i> Wood-Mason & Alcock, 1891	S	C-S		
	<i>Acanthephyra eximia</i> Smith, 1884	S	C-S		C-S
	<i>Acanthephyra kingsleyi</i> (Bate, 1888)	E			S

	Species	MWS	MAU	SEGAM	GUI
	<i>Acanthephyra pelagica</i> (Risso, 1816)	S	C-S	C	C-S
	<i>Acanthephyra purpurea</i> (A. Milne-Edwards, 1881)	C-S			S
	<i>Ephyrina figueirai figueirai</i> Crosnier & Forest, 1973		C-S		
	<i>Ephyrina ombango</i> (Crosnier & Forest, 1973)				C-S
	<i>Notostomus crosnieri</i> Macpherson, 1984		S		C-S
	<i>Notostomus gibbosus</i> A. Milne-Edwards, 1881	S	S		
	<i>Oplophorus spinosus</i> (Brullé, 1839)	C-S	C-S		
	<i>Systellaspis cristata</i> (Faxon, 1893)	S	C-S		C
	<i>Systellaspis debilis</i> (A. Milne-Edwards, 1881)	C-S	C-S	C	C-S
	<i>Systellaspis pellucida</i> (Filhol, 1885)	C-S	S		C
Superfamily Palaemonoidea					
Family PALAEMONIDAE	<i>Palaemon serratus</i> (Pennant, 1777)	C			
Superfamily Pasiphaeidea					
Family PASIPHAEIDAE	<i>Glyphus marsupialis</i> Filhol, 1884	S	C-S	C	C-S
	<i>Parapasiphae sulcatifrons</i> Smith, 1884	S	C-S		
	<i>Pasiphaea multidentata</i> Esmark, 1866	C-S	C-S		C-S
	<i>Pasiphaea semispinosa</i> Holthius, 1951	E	C-S	C	C-S
	<i>Pasiphaea sivado</i> (Risso, 1816)	S			S
	<i>Pasiphaea tarda</i> Krøyer, 1845	S	C-S		C-S
	<i>Psathyrocaris fragilis</i> Wood-Mason & Alcock, 1893	S	C-S	C	
	<i>Psathyrocaris infirma</i> (Alcock & Anderson, 1894)			C	C-S
Superfamily Pandaloidea					
Family PANDALIDAE	<i>Chlorotocus crassicornis</i> (A. Costa, 1871)	C			
	<i>Heterocarpus ensifer</i> A. Milne-Edwards, 1881	C-S	C-S	C	C-S
	<i>Heterocarpus grimaldii</i> A. Milne-Edwards & Bouvier, 1900	S	C-S		C-S
	<i>Heterocarpus laevigatus</i> (Bate, 1888)				S
	<i>Plesionika acanthonotus</i> (Smith, 1882)	C-S	C-S	C	C-S
	<i>Plesionika antigai</i> Zariquiey Alvarez, 1955	C			
	<i>Plesionika brevipes</i> (Crosnier & Forest, 1968)		C-S	C	
	<i>Plesionika carinata</i> Holthius, 1951	E	C-S	C	C-S
	<i>Plesionika edwardsii</i> (Brandt, 1851)	C-S	C-S		C-S
	<i>Plesionika ensis</i> (A. Milne-Edwards, 1881)	C-S	S	C	C-S
	<i>Plesionika giglioli</i> (Senna, 1903)	C			C-S
	<i>Plesionika heterocarpus</i> (A. Costa, 1871)	C-S	C-S	C	C-S
	<i>Plesionika holthuisi</i> (Crosnier & Forest, 1971)		C	C	S
	<i>Plesionika martia</i> (A. Milne-Edwards, 1883)	C-S	C-S	C	C-S
	<i>Plesionika narval</i> (Fabricius, 1787)	C	C-S	C	C-S
	<i>Plesionika williamsi</i> (Forest, 1963)	C-S		C	C-S
Superfamily Processoidea					
Family PROCESSIDAE	<i>Processa canaliculata</i> Leach, 1815 [in Leach, 1815-1875]	C			
	<i>Processa edulis edulis</i> (Risso, 1816)	C			
	<i>Processa elegantula</i> Nouvel & Holthuis, 1957	C			
	<i>Processa intermedia</i> Holthuis, 1951	C			
	<i>Processa noveli noveli</i> Al-Adhub & Williamson, 1975	C			
Infraorder Polychelida					
Superfamily Erynoidea					
Family POLYCHELIDAE	<i>Polycheles perarmatus</i> Holthuis, 1952				C
	<i>Polycheles typhlops</i> Heller, 1862	C-S	S		C-S
	<i>Stereomastis nana</i> (Smith, 1884)	S	C-S		
	<i>Stereomastis sculpta</i> (Smith, 1880)	S	C-S		C-S
	<i>Stereomastis talismani</i> (Bouvier, 1917)	E	C-S	C	
Infraorder Achelata					
Superfamily Palinuroidea					
Family PALINURIDAE	<i>Palinurus mauritanicus</i> Gruvel, 1911	C-S	C-S		
	<i>Panulirus regius</i> De Brito Capello, 1864	E		C	C
Family SCYLLARIDAE	<i>Acantharctus posteli</i> (Forest, 1963)		C	C	C-S
	<i>Scyllarides latus</i> (Latreille, 1803)				C-S
	<i>Scyllarus arctus</i> (Linnaeus, 1758)	C		C	C-S
	<i>Scyllarus caparti</i> Holthuis, 1952	C	C-S	C	C-S
	<i>Scyllarus subarctus</i> Crosnier, 1970	E	C	C	C-S

	Species	MWS	MAU	SEGAM	GUI
Infraorder Astacidea					
Superfamily Nephropoidea					
Family NEPHROPIDAE	<i>Homarus gammarus</i> (Linnaeus, 1758)	OS			
	<i>Nephrops norvegicus</i> (Linnaeus, 1758)	C-S			
	<i>Nephropsis atlantica</i> Norman, 1882	S	C-S		C-S
Infraorder Axiidea					
Superfamily Axioidea					
Family AXIIDAE	<i>Calocarides</i> sp		S		
Superfamily Callianassoidea					
Family CALLIANASSIDAE	<i>Cheramus oblonga</i> (Le Loeuff & Intes, 1974)		S		
Infraorder Anomura					
Superfamily Chirostyloidea					
Family CHIROSTYLIDAE	<i>Gastroptychus formosus</i> (Filhol, 1884)				C
	<i>Uroptychus concolor</i> (A. Milne Edwards & Bouvier, 1894)				C-S
Family EUMUNIDIDAE	<i>Eumunida bella</i> de Saint Laurent & Macpherson, 1990	E	S		
Superfamily Galatheoidea					
Family GALATHEIDAE	<i>Galathea intermedia</i> Liljeborg, 1851		C		
Family MUNIDIDAE	<i>Munida curvimana</i> A. Milne Edwards & Bouvier, 1894		C		
	<i>Munida guineae</i> Miyake & Baba, 1970	E	S	C	C-S
	<i>Munida intermedia</i> A. Milne Edwards & Bouvier, 1899		C-S		
	<i>Munida rutlanti</i> Zariquiey Álvarez, 1952		C-S	C	C
	<i>Munida speciosa</i> von Martens, 1878			C-S	C
Family MUNIDOPSISIDAE	<i>Munidopsis anaramosae</i> de Matos-Pita & Ramil, 2014			S	
	<i>Munidopsis chunii</i> Balss, 1913	E		S	
	<i>Munidopsis curvirostra</i> Whiteaves, 1874			S	
	<i>Munidopsis serricornis</i> (Lovén, 1852)			S	
Family PORCELLANIDAE	<i>Pisidia</i> sp.				S
Superfamily Paguroidea					
Family DIOGENIDAE	<i>Areopaguristes mauritanicus</i> (Bouvier, 1906)	E		S	
	<i>Ciliopagurus caparti</i> (Forest, 1952)	E			C
	<i>Dardanus arrosor</i> (Herbst, 1796)		C	S	C
	<i>Diogenes ovatus</i> Miers, 1881	E			C-S
	<i>Diogenes pugilator</i> (Roux, 1829)		C	S	
	<i>Paguristes candela</i> de Matos-Pita & Ramil, 2015			S	
	<i>Petrochirus pustulatus</i> (H. Milne Edwards, 1848)	E			C-S
Family PAGURIDAE	<i>Anapagurus laevis</i> (Bell, 1846)			S	
	<i>Pagurus alatus</i> Fabricius, 1775		S	S	
	<i>Pagurus cuanensis</i> Bell, 1845			S	
	<i>Pagurus excavatus</i> (Herbst, 1791)		C		
	<i>Pagurus forbesii</i> Bell, 1846		C	C	C
	<i>Pagurus prideaux</i> Leach, 1815			S	
	<i>Spiropagurus elegans</i> (Miers, 1881)		C		C-S
Family PARAPAGURIDAE	<i>Parapagurus macrocerus</i> (Forest, 1955)			S	
	<i>Parapagurus nudus</i> (A. Milne-Edwards, 1891)			S	
	<i>Parapagurus pilosimanus</i> Smith, 1879		S	S	C-S
	Parapaguridae indet.				S
	<i>Strobopagurus gracilipes</i> (A. Milne-Edwards, 1891)		C		
Superfamily Lithodoidea					
Family LITHODIDAE	<i>Lithodes ferox</i> Filhol, 1885		S	C-S	C-S
	<i>Neolithodes asperrimus</i> Barnard, 1947	E		S	
	<i>Neolithodes grimaldii</i> (A. Milne-Edwards & Bouvier, 1894)			S	
	<i>Paralomis cristulata</i> Macpherson, 1988			S	C-S
	<i>Paralomis erinacea</i> Macpherson, 1988	E		C-S	S
Infraorder Brachyura					
Superfamily Aethroidea					
Family AETHRIDAE	<i>Sakaila africana</i> (Manning & Holthuis, 1981)	E			C
Superfamily Cancroidea					
Family ATELECYCLIDAE	<i>Atelecyclus rotundatus</i> (Olivi, 1792)		C		S
	<i>Atelecyclus undecimdentatus</i> (Herbst, 1783)		C	C	

	Species	MWS	MAU	SEGAM	GUI
Superfamily Calappoidea					
Family CALAPPIDAE	<i>Acanthocarpus brevispinis</i> Monod, 1946	E	C-S	C	C-S
	<i>Calappa granulata</i> (Linnaeus, 1758)		C-S		
	<i>Calappa pelii</i> Herklots, 1851	E	C	C-S	C-S
	<i>Calappa rubroguttata</i> (Herklots, 1851)	E		C	C-S
Superfamily Corystoidea					
Family CORYSTIDAE	<i>Corystes cassivelaunus</i> (Pennant, 1777)		C		
Superfamily Dorippoidea					
Family DORIPPIDAE	<i>Ethusa mascarone</i> (Herbst, 1785)		C-S		
	<i>Ethusa</i> sp.				S
	<i>Medorippe lanata</i> (Linnaeus, 1767)		C	C-S	C-S
	<i>Phyllodorippe armata</i> (Miers, 1881)	E		C	
Superfamily Dromioidea					
Family DROMIIDAE	<i>Dromia personata</i> (Linnaeus, 1758)		C		
	<i>Sternodromia spinirostris</i> (Miers, 1881)	E	C	C	C-S
Superfamily Goneplacoidea					
Family EURYPLACIDAE	<i>Machaerus oxyacantha</i> (Monod, 1956)	E		C	C
Family GONEPLACIDAE	<i>Goneplax barnardi</i> (Capart, 1951)	E		S	C-S
	<i>Goneplax rhomboides</i> (Linnaeus, 1758)		C	S	
Superfamily Grapsoidea					
Family PLAGUSIIDAE	<i>Euchirograpsus liguricus</i> H. Milne Edwards, 1853		C	S	
Family VARUNIDAE	<i>Asthenognathus atlanticus</i> Monod, 1933		C		
Superfamily Homoloidea					
Family HOMOLIDAE	<i>Homola barbata</i> (Fabricius, 1793)		C	C-S	C
	<i>Paramola cuvieri</i> (Risso, 1816)		C-S	C-S	S
Family LATREILLIDAE	<i>Latreillia elegans</i> Roux, 1830		C-S		
Superfamily Majoidea					
Family EPIALTIDAE	<i>Apiomithrax bocagei</i> (Ozorio, 1887)	E			C
	<i>Pisa armata</i> (Latreille, 1803)		C	S	C-S
	<i>Pisa calva</i> (Forest & Guinot, 1966)	E			C-S
	<i>Pisa carinimana</i> Miers, 1879		C	C	
	<i>Rochinia carpenteri</i> (Wyville Thomson, 1873)		C-S		C-S
Family INACHIDAE	<i>Capartiella longipes</i> (Capart, 1951)	E	C		
	<i>Dorhynchus thomsoni</i> Thomson, 1873		C		
	<i>Inachus aguiarii</i> de Brito Capello, 1876		C	S	
	<i>Inachus angolensis</i> Capart, 1951	E		C-S	C
	<i>Inachus communissimus</i> Rizza, 1840		C	C	
	<i>Inachus dorsettensis</i> (Pennant, 1777)		C		
	<i>Inachus leptochirus</i> Leach, 1817		C	C-S	
	<i>Inachus nanus</i> Manning & Holthuis, 1981			S	
	<i>Inachus thoracicus</i> Roux, 1830		C		
	<i>Inachus</i> sp.				S
	<i>Macropodia doracis</i> (Manning & Holthuis, 1981)	E			C-S
	<i>Macropodia gilsoni</i> (Capart, 1951)	E		C-S	C
	<i>Macropodia hesperiae</i> Manning & Holthuis, 1981	E		S	
	<i>Macropodia linaresi</i> Forest & Zariquiey Alvarez, 1964		C		
	<i>Macropodia longipes</i> (A. Milne Edwards & Bouvier, 1899)		C	C-S	
	<i>Macropodia macrocheles</i> (A. Milne Edwards & Bouvier, 1898)	E		S	
	<i>Macropodia rostrata</i> (Linnaeus, 1761)		C	C	S
	<i>Macropodia spinulosa</i> (Miers, 1881)	E			C-S
	<i>Macropodia tenuirostris</i> (Leach, 1814)		C		
	<i>Stenorhynchus lanceolatus</i> (Brullé, 1837)		C	C	C-S
Family MAJIDAE	<i>Eurynome aspera</i> (Pennant, 1777)			S	
	<i>Maja crispata</i> Risso, 1827		C		
	<i>Maja squinado</i> (Herbst, 1788)		C		
Superfamily Leucosioidea					
Family LEUCOSIIDAE	<i>Atlantophila cristata</i> (Miers, 1881)	E		C	C-S
	<i>Ebalia nux</i> A. Milne Edwards, 1883			S	
	<i>Ilia spinosa</i> (Miers, 1881)	E			C-S
	<i>Merocryptus obsoletus</i> (A. Milne-Edwards & Bouvier, 1898)	E			C-S
	<i>Pseudomyra mbizi</i> Capart, 1951	E		C-S	C

	Species	MWS	MAU	SEGAM	GUI
Superfamily Parthenopoidea					
Family PARTHENOPIDAE	<i>Distolambrus maltzami</i> (Miers, 1881)		C		
	<i>Parthenopoides massena</i> (Roux, 1830)				C-S
	<i>Solenolambrus noordendei</i> (Capart, 1951)	E	C	S	C
	<i>Spinolambrus macrochelos</i> (Herbst, 1790)		C		
	<i>Spinolambrus notialis</i> (Manning & Holthuis, 1981)	E		S	C-S
Superfamily Portunoidea					
Family GERYONIDAE	<i>Chaceon affinis</i> (A. Milne-Edwards & Bouvier, 1894)		S		C
	<i>Chaceon maritae</i> (Manning & Holthuis, 1981)	E	S	C-S	OS
	<i>Geryon trispinosus</i>		C		
Family MACROPIPIDAE	<i>Bathynectes maravigna</i> (Prestandrea, 1839)		C		C-S
	<i>Bathynectes piperitus</i> Manning & Holthuis, 1981	E		C-S	C
	<i>Callinectes amnicola</i> (Rochebrune, 1883)	E			C
	<i>Callinectes marginatus</i> (A. Milne-Edwards, 1861)	E		C	C-S
	<i>Charybdis (Charybdis) hellerii</i> (A. Milne-Edwards, 1867)				C
	<i>Cronius ruber</i> (Lamarck, 1818)				C-S
	<i>Liocarcinus corrugatus</i> (Pennant, 1777)		C	C	S
	<i>Liocarcinus depurator</i> (Linnaeus, 1758)		C		
	<i>Liocarcinus marmoreus</i> (Leach, 1814)		C		S
	<i>Liocarcinus pusillus</i> (Leach, 1816)		C		
	<i>Liocarcinus vernalis</i> (Risso, 1816)		C		
	<i>Liocarcinus zariquieyi</i> Gordon, 1968		C		
	<i>Macropipus rugosus</i> (Doflein, 1904)	E	C-S	C-S	C
	<i>Macropipus tuberculatus</i> (Roux, 1830)		C	C	
	<i>Portunus (Portunus) hastatus</i> (Linnaeus, 1767)		C		
	<i>Polybius henslowii</i> Leach, 1820		C-S		
	<i>Sanquerus validus</i> (Herklots, 1851)	E			C
Superfamily Raninoidea					
Family RANINIDAE	<i>Ranilia constricta</i> (A. Milne-Edwards, 1880)				C-S
Superfamily Xanthoidea					
Family PILUMNIDAE	<i>Pilumnus inermis</i> A. Milne-Edwards & Bouvier, 1894		C-S		
	<i>Pilumnus spinifer</i> H. Milne Edwards, 1834		C		
	<i>Pilumnus stebbingi</i> (Capart, 1951)	E			C-S
Family XANTHIDAE	<i>Monodaeus couchii</i> (Couch, 1851)		C	C	
	<i>Monodaeus cristulatus</i> Guinot & Macpherson, 1988			S	
	<i>Paraxanthias eriphioides</i> (A. Milne Edwards, 1867)				C-S
Number of species	232	54	137	134	59
				119	

Plate 5.5.1. Five decapod species widely distributed throughout the CCLME: 1. *Nematocarcunus africanus* (© José Francisco González Jiménez, IEO); 2. *Plesionika edwardsii* (© José Francisco González Jiménez, IEO); 3. *Dardanus arrosor* (© Lourdes Fernández Peralta, IEO); 4. *Stenorhynchus lanceolatus* (© Pablo Expósito Martínez, IEO); 5. *Scyllarus subarctus* (© Alberto García García, IEO). Species new to science reported in Mauritanian waters: 6. *Munidopsis anaramosae* (© Ana Ramos Martos, IEO).



Plate 5.5.2. Six decapod commercial species of the CCLME. 1. *Parapenaeus longirostris* (© Alberto García García, IEO); 2. *Penaeus notialis* (© Lourdes Fernández Peralta, IEO); 3. *Penaeus kerathurus* (© Lourdes Fernández Peralta, IEO); 4. *Aristaeopsis edwardsiana* (© Alberto García García, IEO); 5. *Aristeus varidens* (© José Francisco González Jiménez, IEO); 6. *Chaceon maritae* (© José Francisco González Jiménez, IEO).



5.6. SEA TURTLES OFF NORTHWEST AFRICA

Adolfo MARCO^{1,2} and Samir MARTINS²

¹ Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas. Spain

² BIOS.CV. Cabo Verde

5.6.1. INTRODUCTION

Sea turtles are highly migratory mega vertebrates that have extremely important roles in the functioning of marine ecosystems since they first appeared in the Oceans over 100 million years ago. They have been relentlessly exploited for centuries and are currently facing a variety of global changes that are gravely threatening their continued survival. Their status in the Northwestern African waters are of special concern.

The earliest known accounts of sea turtles in the area of the Canary Current Large Marine Ecosystem (CCLME) go as far back as the second half of the XV century. Cadamosto in 1456 and Columbus in 1498 both described how sea turtles were captured for meat consumption in Madeira and the Azores. However, there are no records of reproduction taking place in these archipelagos. There are also accounts on the presence and abundance of sea turtles in the archipelagos of the Canaries and Cape Verde in ancient books that date from the XV to the XIX century (see reviews in Lazar and Holcer, 1998; López-Jurado, 2007; Loureiro and Torrão, 2008). These old texts describe the abundance of sea turtles on several islands as well as the capture of many individuals for meat consumption and for supposed medical remedies. However, it has predominantly been during the past three decades that the feeding grounds and nesting aggregations have become widely known in the scientific community (Brongersma, 1982; Barbosa et al., 1998; Fretey, 2001; López-Jurado, 1992, 2007; Catry et al., 2009).

5.6.2. SPECIES DESCRIPTION

Of the seven existing sea turtle species, six inhabit the waters of the Canary Current (Plate 5.6.1). The loggerhead turtle (*Caretta caretta*) and the green turtle (*Chelonia mydas*) are probably the most common in the CCLME and the only two species that nest regularly on its beaches. The Kemp's ridley sea turtle (*Lepidochelys kempii*), the most restricted and endangered sea turtle in the world, is very rare in the area although migrant juveniles can be found along the northwestern coast of Morocco.

Turtles belonging to the remaining three species (leatherbacks – *Dermochelys coriacea*; hawksbills – *Eretmochelys imbricata*; and olive ridleys – *Lepidochelys olivacea*) can be found in the waters of the Canary Current but are generally tropical nesters. Nevertheless, some nests can sometimes be found in the southern part of the region. Their distribution could change in the next decades if global warming predictions force certain species of sea turtle to select colder beaches in order to guarantee enough male production.

Two very different morphological forms of sea turtle are represented in the region. On one hand, those belonging to the chelonids present a typical turtle form with keratinized scutes covering a hard bony carapace. The other group, dermochelids, also present a bony carapace but in their case it is covered by oily flesh and leather skin.

The loggerhead turtle (*C. caretta*) is a medium-sized sea turtle that can reach up to 125 cm in Straight Carapace Length (SCL) and weigh up to 200 kg (LeBuff, 1990). It has an overly large head with a very thick neck and a strong jaw. Color patterns on its back are brown with reddish or orange shades at the edges, which are more visible on the front. Its plastron is whitish with cream and pale yellow shades. Large juveniles and adults usually have a variety of living organisms, such as seaweeds, tubeworms, barnacles or other crustaceans, attached to their dorsal carapaces. These turtles, in effect, are small moving reefs which act as dispersing agents for a wide range of marine species.

The green turtle (*C. mydas*) is the largest of the hard-shelled sea turtles. Although its external morphology is not geographically uniform, this species usually possesses a dorso-ventrally flat oval carapace, with 5 vertebral scutes, 4 pairs of costal scutes and 4 pairs of inframarginal scutes. The SCL of adults is around 120 cm (71-153 cm). This species is short-necked, has one pair of prefrontal scales and four pairs of postorbital scales. Its upper jaw has a slightly dentate edge, while its lower jaw has a clearer denticulation. Each flipper has a claw, although sometimes they have two. The hatchlings' carapace is predominantly black or dark grey, but will gradually change to dark brown or olive green as it grows up, whereas its plastron is whitish. Coloration is quite variable among adults, and they can have a spotted or striped carapace in brown, grey, black or green tones. The common name of this species is derived from its green body fat. During the subadult and adult stages they feed primarily on marine plants.

The hawksbill turtle (*E. imbricata*) is a medium-sized species with an elongated carapace, overlapping or imbricated scutes and serrated edges. The carapace presents 5 vertebral scutes, 4 pairs of lateral scutes, a variable number of marginal scutes (>10 pairs) and 2 supracaudal scutes, which have a high degree of hardness that is characteristic of the species. Ventrally, the plastron is made up of 4 pairs of inframarginal scutes. The nuchal scute is not in contact with the lateral scutes. The colour of their carapace varies with age; hatchlings are dark brown both dorsal and ventrally. As they grow up, their carapaces develop a characteristic colour pattern on the scutes, with yellow, brown and black spots; this colour remains when they reach maturity. Ventrally, the tone varies from pale yellow to white, sometimes with black spots. They feed on corals and sponges. Their carapace has long been highly valued, and has been traded for decorative purposes.

The two species belonging to the *Lepidochelys* genus are small sea turtles which can grow up to 72 cm in SCL and to 50 kg in weight. They are characterized by having a number of small pores located near the rear margin of every one of the four inframarginal scutes, two claws on each limb (although sometimes adults can lose one of them) and two prefrontal scales on the head. The main difference between the two species of *Lepidochelys* is that the Kemp's ridley has five pairs of costal scutes and the olive ridley has 6 or 7 pairs. Both species have a light olive-green dorsal and a yellow ventral coloration in adults, whereas coloration for immature individuals is grey for the dorsal and white for the ventral area. They can aggregate by the thousands in selected small sections of beaches for diurnal nesting, thus forming the *arribadas*.

The leatherback turtle is the largest species of sea turtle, reaching 200 cm in SCL and weighing up to 900 kg. Their main characteristic is a bony carapace which is completely covered with a leather-like soft tissue, no large scales, with seven longitudinal ridges on its back and five more ridges on its plastron. They are also characterized by their long front flippers and their lack of claws. Their dorsal surface is dark, mottled with pink or white, with a similar color on their ridges and large areas of their heads, necks and limbs. The abdomen color varies but is usually pinkish, white and black. Its head has no scales and its keratinized beak is strong, with smooth edges and a characteristic end adapted to catching slippery prey. The upper side of

their beak's tip is W-shaped. They eat jellyfish, other gelatinous marine invertebrates and, in some cases, they associate themselves with large shoals of jellyfish.

5.6.3. NESTING

Along the oriental coast of the Atlantic Ocean, it is only possible to find a stable loggerhead turtle nesting population in the archipelago of Cape Verde (Marco et al., 2012). This nesting population probably coexisted for centuries with a low human population in the archipelago, unlike on the continental African coast where loggerhead nesting is nowadays considered sporadic. At present, Cape Verde constitutes the third most abundant nesting site of loggerhead turtles in the world, but sadly this does not prevent it from also being considered one of the three most endangered loggerhead turtle populations in the world due to increases in the current extinction risk (Wallace et al., 2011). An average of 15,000 nests are laid annually in Cape Verde varying from 5000 to 30,000 (Fig. 5.6.1). Between 80% and 85% of all nests are laid on just 40 km of the beaches on the eastern half of Boa Vista (Marco et al., 2012). Boa Vista possibly contains the highest nesting density of this species in the world, with more than 2 nests per year for every linear meter of beach in stretches of over 800 m long (Martins, 2012) (Fig. 5.6.2). The islands of Maio, Sal and São Nicolau support a much lower number of nests, with an annual mean of around 1000 nests on each island (Cozens et al., 2011, 2012; Lino et al., 2010; own data). On the remaining islands of the archipelago, nesting is much lower with an estimate of less than 150 nests laid annually per island (Loureiro, 2008, Marco and collaborators, personal observations).

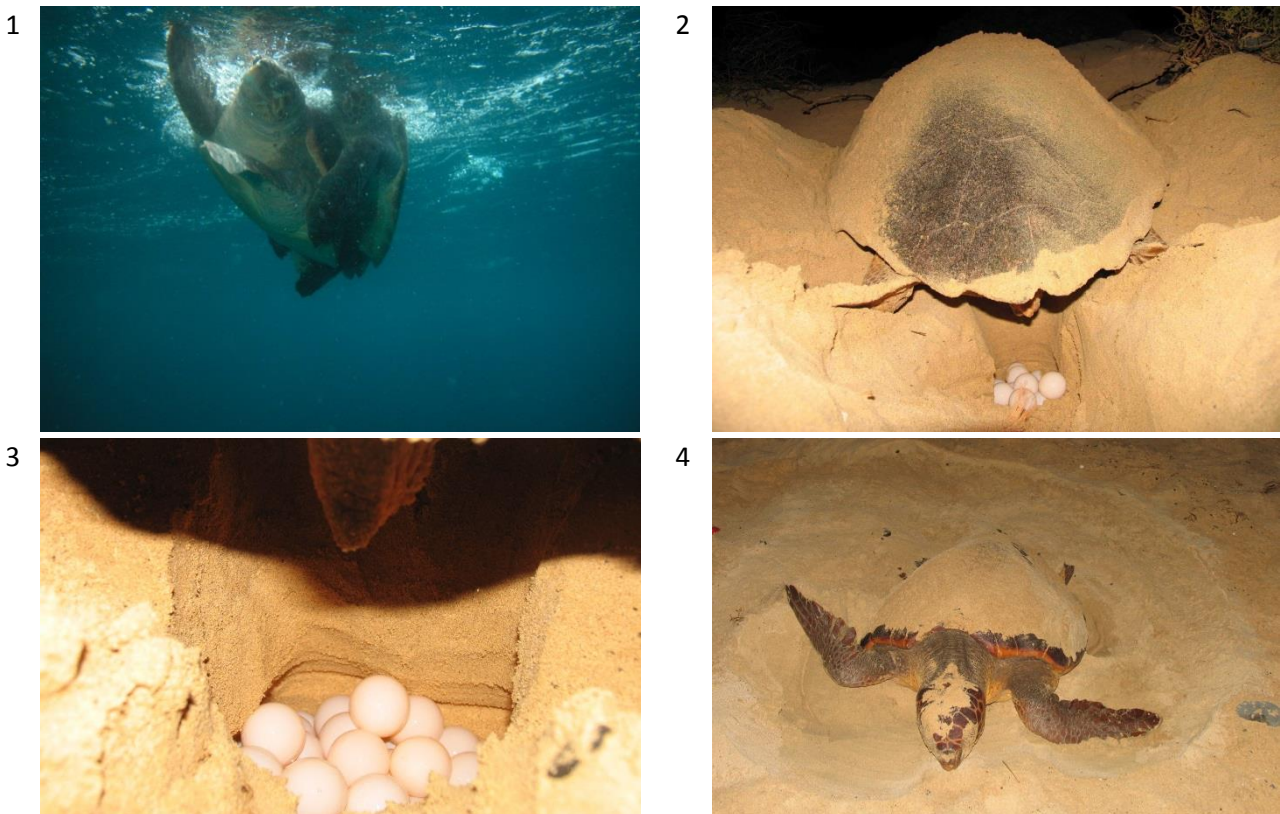


Figure 5.6.1. Loggerhead (1, © Pedro López) mating, (2, © Adolfo Marco) nesting, (3, © Adolfo Marco) egg-laying and (4, © Adolfo Marco) camouflaging of a nest in Cape Verde.

The island of Poilão in the Bijagós Archipelago, Guinea-Bissau, is known to be an important nesting site for the green turtle, but until recently there were no quantitative estimates of the number of clutches deposited annually. In 2000 a survey was carried out to assess the magnitude of nesting, and an estimated 7400 green turtle clutches were deposited. This study confirmed that Poilão is one of the most important nesting sites for green turtles in the Atlantic, and the largest known nesting colony on the west coast of Africa. Traditionally Poilão has been regarded as a sacred site by the Bijagós people, and this has contributed to the conservation of these turtles. However, the development of fisheries in this region is an emerging threat. To conserve this site a National Marine Park was designated in August 2000 (Fortes et al., 1998, Catry et al., 2009). A significant nesting rookery of olive ridleys turtles also been detected on the same beaches although with a much lower number of nests. The sporadic nesting of olive ridleys, as well as hawksbill, green and loggerhead turtles, has been documented along the continental coast from Mauritania to Guinea-Bissau (Fretey, 2001). Leatherback turtles are much more tropical and nests are very rare on the coast along the CCLME.

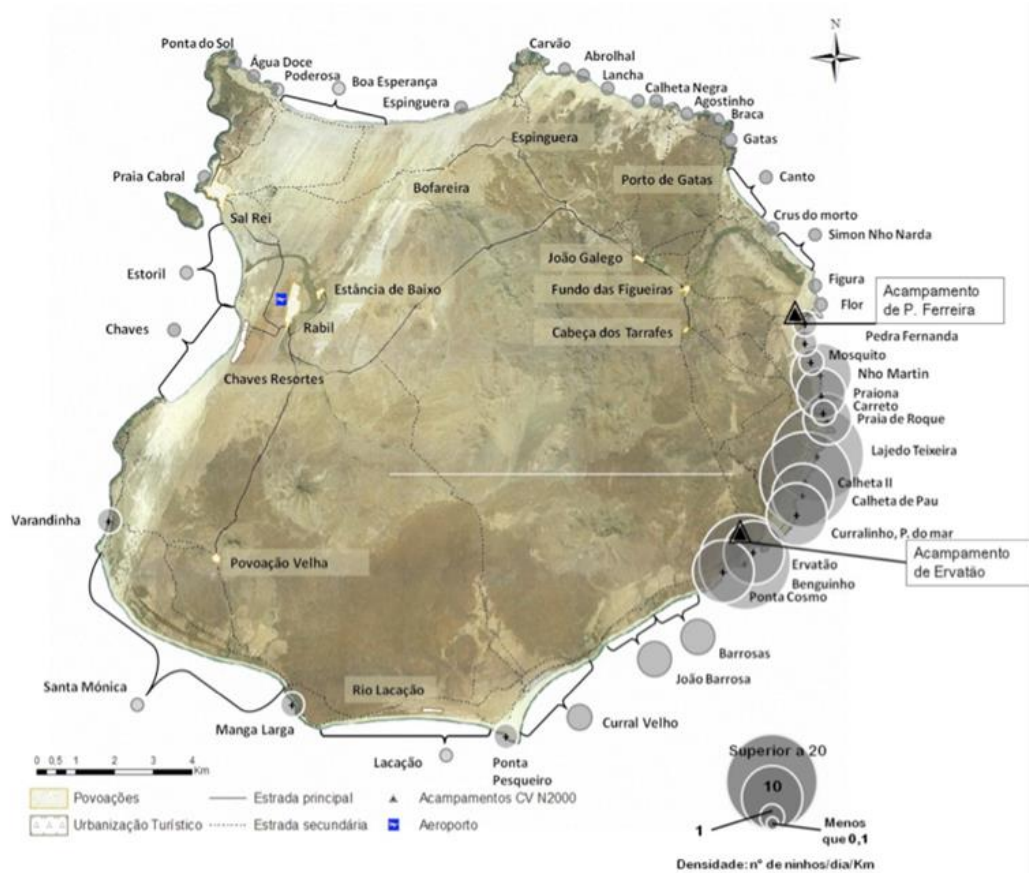


Figure 5.6.2. Annual nest density on the beaches of Boa Vista Island. The highest nest density for the species is found in the Reserva Natural da Tartaruga (southeast), which hosts 60% of the total nestings in Cabo Verde.

5.6.4. THE DISTRIBUTION AND MIGRATION OF ADULTS

Female sea turtles rarely breed annually due to the high energetic costs that are entailed by reproduction and migration. During the remigration interval, loggerheads that nest in Cape Verde move to the continental African coast to feed (Hawkes et al., 2006). The most frequent remigration interval is of 2 years (60%), followed by a 3-year interval (25%) (Gaona et al., in press). Whilst some individuals from the

population make a direct migration eastwards from Cape Verde towards shallow foraging grounds off the coasts of Guinea-Bissau and Senegal, the majority of the population migrates eastwards from the Cape Verde islands but then remains in the oceanic zone, traversing over half a million square kilometers of pelagic foraging habitat (Hawkes et al., 2006; Varo-Cruz et al., 2013). Interestingly, this behavior seems to be linked to body size; only the largest turtles forage in shallow coastal waters, whereas smaller individuals remain in the oceanic zone. In contrast with the females, males from Cape Verde may breed annually (Varo-Cruz et al., 2013). Some males may migrate to the African coast although it appears that others may remain near the nesting area for several months following the nesting season (Varo-Cruz et al., 2013). Oceanic adult loggerheads show a preference for the highly productive upwelling region between Cape Verde and mainland Africa, an area of intense frontal activity. Within the upwelling region, turtles appear to forage epipelagically around mesoscale thermal fronts, exploiting profitable foraging opportunities resulting from physical aggregation of prey (Scales et al., 2015).

Female green turtles from Bissagos lay multiple clutches in any given season and remain close to the islands within the boundaries of the João Vieira and Poilão National Marine Parks during internesting periods which last around 15 days (Fig. 5.6.3b) (Godley et al., 2010). After nesting season some females have short-range movements to locations within the Bissagos archipelago suggesting local residence. However, other females migrate from Poilão to the Park National du Banc D'Arguin, Mauritania (Fig. 5.6.3a), where they remain during long periods to feed (Godley et al., 2010). This post-nesting migration is of over 1000 km along the coastal and near-coastal waters of Gambia, Senegal and Mauritania. For this area, females show a degree of fidelity to shallow water foraging areas.

There seems to be quite an important feeding area along the Mauritanian coast for leatherback turtles coming from the American Atlantic coast (Eckert et al., 2006). Leatherbacks originally from the western African coast (Gabon) may also visit this upwelling area in the Canary Current.

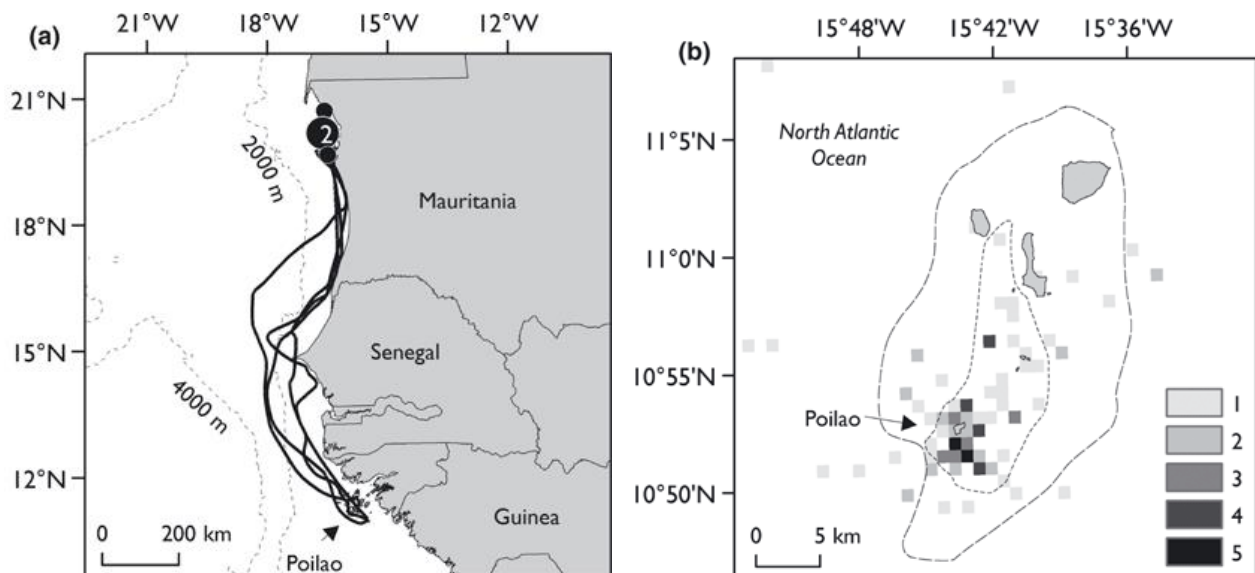


Figure 5.6.3. Satellite tracking offers insights into green turtle distribution and migrational pattern. (a) Post-nesting movements of four females tracked to their foraging sites in the Banc d'Arguin National Park (black dot 2). (b) Habitat utilization during the internesting interval. Colors indicate density of occupation (days per km²). Marks are the limits of the inner and outer zone of the JoãoViera e Poilão National Marine Park. (Figure published in Godley et al., 2010). © 2010 The Authors. Journal compilation © 2010 British Ecological Society.

5.6.5. THE DISTRIBUTION AND MIGRATION OF JUVENILES

Small juvenile turtles are known to disperse extensively on a transatlantic scale (Bolten et al., 1998) and are commonly associated with convergence zones, upwellings, major gyre systems, and eddies (Carr, 1987, Musick and Limpus, 1997) that provide productive foraging grounds by concentrating a variety of planktonic and neustonic organisms.

Juvenile loggerhead turtles from the Cape Verde Islands (Fig. 5.6.4) have been identified in feeding grounds off the Canary Islands, Madeira, the Azores, the Gulf of Cadiz and the southwestern area of the Mediterranean Sea (Monzón-Argüello et al., 2009; Carreras et al., 2011; Clusa et al., 2013). These juvenile turtles share feeding grounds with juveniles of the same species belonging to other Atlantic and/or Mediterranean populations (Monzón-Argüello et al., 2009; Carreras et al., 2011). Genetic studies (Monzón-Argüello et al., 2010a) suggest that less than half of the expected hatchling and juvenile turtles from Cape Verde are subsequently encountered in foraging grounds north of the Cape Verde islands. A significant proportion of juveniles may also disperse to American waters and/or southwards, to waters near the Gulf of Guinea (Monzón-Argüello et al., 2010a). However, due to a relative lack of research effort and funding, the western Atlantic coast of Africa could have other loggerhead feeding grounds yet to be discovered. Future research effort may help in gathering information to fill this important gap in our knowledge on the species. Loggerheads originally from the eastern American coast are frequently observed in the Atlantic archipelagos of Azores, Madeira and the Canaries (Brongersma, 1982; López-Jurado, 1992), as well as the Atlantic coast of Morocco (Aksissou et al., 2006; Benhardouze et al., 2012) where they spend their pelagic juvenile life stage. In these areas loggerhead juveniles and subadults are considered to be abundant.

Data from marine currents and genetic analysis suggest that most green turtle juveniles from Guinea-Bissau disperse to the southwest (Brazil) and the eastern Atlantic, which includes the Canary Current and waters off Senegal, Mauritania and Cape Verde (Godley et al., 2010; Monzón-Argüello et al., 2010b). Green turtle juveniles in the Cape Verde feeding grounds have been found to have come from the Caribbean Sea (Monzón-Argüello et al., 2010b), and hawksbill juveniles have been found to have come from the endangered population of the archipelagos in the Gulf of Guinea (Monzón-Argüello et al., 2011).

Occasionally, juvenile turtles may be displaced from their expected passive dispersal routes (Monzón-Argüello et al., 2012) by oceanic eddies, storm events and/or weather fronts. This appears to have been the case for small numbers of juvenile turtles from Cape Verde that were found stranded along the French coast (Monzón-Argüello et al., 2012).

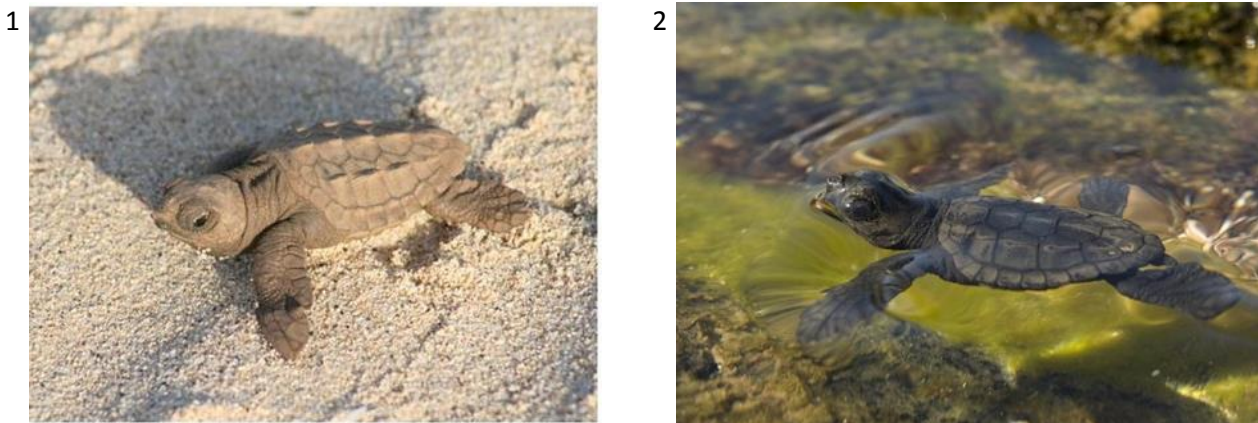


Figure 5.6.4. Loggerhead hatchlings on a (1, © Adolfo Marco) beach and at first contact with the (2, © Héctor Garrido) sea.

5.6.6. FEEDING

Juvenile sea turtles are known for their opportunistic feeding behaviour (Bjorndal, 1997; Frick et al., 2009), eating and digesting almost anything they can find. Early on their development they eat small prey which includes micro-algae, marine invertebrates and their eggs (decapods, barnacles, amphipods, hidrozoe, etc.), fish, land insects (diptera, formicidae, aphids, coleoptera, etc.) and fiber, feathers, or any kind of floating inert materials whatsoever (Richardson and McGillivray, 2001). For example, in waters around Madeira, Selvagens Islands, and the Azores, loggerhead turtle diet is rich in siphonophores and but less so in scyphomedusae and hydromedusae (van Nierop and den Hartog, 1984). During their development it is possible for them to undergo several habitat shifts that affect their feeding behaviours.

When turtles get to a large body size they usually specialize their diets and select habitats where they can find appropriate prey (Bjorndal, 1997). Leatherbacks consume jellyfish during their subadult and adult stages (Houghton et al., 2006). Green turtles prefer seagrasses and algae, thus selecting shallow waters that are rich in these species (Cardona et al., 2009). Hawksbills associate with coral reefs and rocky areas to feed on sponges, corals or anemones (Meylan, 1988). Kemp's and olive ridleys prefer muddy and sandy bottoms where they feed on hard prey such as crabs, shrimps, clams and other molluscs (Witherington, 2002). Loggerheads maintain an opportunistic feeding behaviour throughout adulthood (Tomás et al., 2001). In Cape Verde, females show a clear feeding dichotomy (Eder et al., 2012). Most of the individuals feed in pelagic habitats between Cape Verde and the African continental shelf and their diet is very rich in jellyfish. But less than 20% of females, in correspondence with the largest individuals, travel to neritic habitats closer to the Gulf of Guinea where they have a more diverse and nutritive diet (Eder et al., 2012).

A mix of natural and artificial debris is usually found with an alarmingly high frequency in the digestive tract of sea turtles, from plastics to wood, feathers, tar, nylon lines, coal, etc. This fact indicates that debris ingestion may be an important threat to loggerhead sea turtle juveniles in this area, consequence of the loggerhead's opportunistic feeding behavior, their low prey selectivity unluckily coinciding with a high level of marine pollution (Carr, 1987; Tomás et al., 2002; Hamann et al., 2010).

5.6.7. THREATS AND CONSERVATION

All sea turtle species present in the CCLME are globally considered as Endangered (EN) (IUCN, 2014). The loggerhead and green turtles of the CCLME constitute regional management units (Wallace et al., 2010). The loggerhead turtles in the region are genetically different from the other loggerhead populations in the Atlantic Ocean and in the Mediterranean Sea (Monzón-Argüello et al., 2010a; Godley et al., 2010; Shamblin et al., 2014). This genetic distinctiveness indicates a significant reproductive isolation, with little or no gene flow with other populations (Monzón-Argüello et al., 2010a).

Furthermore, the waters of the Canary Current hold a remarkable diversity of sea turtles of different origin, including those from the above mentioned rookeries, as well as turtles from the southeast of the United States of America (Bolten et al., 1998), the Caribbean or the Gulf of Guinea (Monzón-Argüello et al., 2010b, 2010c). These feeding aggregations host individuals from distant populations and that conform different management units, thus any management program involving these management units needs to have a multinational scope in order to include these Eastern Atlantic feeding aggregations. Even complete protection in one region may not be sufficient to save a population if excessive exploitation or mortality occurs in other geographic areas (Bolten et al., 1998).

Additionally, the long lives of sea turtles make them especially vulnerable to depletion and their vast oceanic ranges make them especially difficult to manage. This is why the only time unit by which sea turtle recovery can be measured is in decades (Bowen and Karl, 2007). Only such baseline data on population parameters will allow and enhance our ability to make informed management decisions. Otherwise, in these current times of rapidly changing environments we will not have the necessary information to assess possible impacts on sea turtle populations and apply early and appropriate management practices (Hamann et al., 2003).

Increasing fishing efforts worldwide put all sea turtle species at risk. Pelagic long line fisheries account for a yearly bycatch that is very difficult to quantify accurately. For example, only in Madeira, an estimated 500 turtles are caught every year in black scabbard fisheries using deep drifting longlines (Dellinger and Encarnação, 2000). In fact, for Madeira, several reports indicate that a few hundred loggerhead turtles may be captured every year, especially during the summer months (Serpa, 2000). Swordfish longliners based in the Azores, in the central north Atlantic, capture from 0.04 to 0.75 sea turtles per 1000 hooks (Prieto et al., 2000). In the region of Tangier, on the Atlantic coast of Morocco, the estimated bycatch of the entire fleet using drift nets is 719 (Standard Deviation = 543) captures of loggerheads yr^{-1} . For the longline fleet, the average estimated turtle capture in a year is 142 turtles (range = 20–357 turtles; SD = 31) (Benhardouze et al., 2012). There are no detailed studies regarding the impact of bycatch on loggerheads for the adult's feeding grounds in the waters off Cape Verde, Mauritania and Senegal. However, the intense fishing activities in these areas suggest that the capture of adult loggerheads could be very significant for the population. Similarly, emerging industrial fishing in capeverdean waters may also constitute a severe threat to the loggerhead rookery in the eastern Atlantic.

An additional menace for sea turtles in the pelagic environment is marine debris. Necropsies performed on turtles accidentally caught in fisheries indicate the dimension of the marine litter problem in the open ocean with over 90% of the turtles having marine debris in their stomachs. Although this cannot be ascertained as the ultimate cause of death, it surely has a debilitating effect on the turtles, hence reducing individual fitness.

The high concentration of turtle nesting on small beach stretches of Cape Verde and Guinea-Bissau makes the population extremely vulnerable to any kind of environmental disaster (oil spills, tropical storms, etc.) or artificial impact (urbanization, linear infrastructures, artificial lighting, massive tourism, etc.), putting the survival of the population, and a significant portion of the species' genetic variability, at risk (Catry et al., 2009; Marco et al., 2012). Reports from locals suggest that turtle nesting has significantly declined during the last decades. Many islands where turtles were once common now show virtually no signs of nesting (Catry, 2000; Marco et al., 2011). Similarly, many continental areas where nests of different species were often recorded in the past, now have a much scarcer number of nestings, or they are inexistent altogether (Fretey, 2001).

Turtle-watching activities are known as an alternative source of income for local communities that have historically exploited sea turtles for consumption. When natural resources have been employed for generations in an extractive way to sustain local populations, the transition to a non-extractive and sustainable use takes time. Nonetheless, when natural resources include sea turtles and other threatened species, and there are solid social and cultural changes, triggered by forces like tourist development, ecotourism and turtle-watching may rise as a community-based conservation tool, provided that communities are integrated and actively partake in the development of management plans for these species and their critical habitats.