The corals of the Mediterranean

The corals of the Mediterranean

Index

Berried anemone (*Alicia mirabilis)* © OCEANA/ Juan Cuetos

01.

Introduction

There are corals which live as solitary animals or in colonies, composed of rigid, semi-rigid or soft structures, and which protect themselves under rock formations or grow erect like trees; there are those which prefer exposure to the sun or which live in zones of darkness; those which generate light or which have medicinal properties, existing in shallow waters or at depths of more than 5,000 meters; those with polyps that grow anew each year, or in colonies as old as 50 to 1,000 years on reefs which have taken more than 8,000 years to develop. Although the number of coral species found in the Mediterranean represents less than 5% of those extant throughout the world today, the diversity of the types and forms of life serve as an example to us, demonstrating the full importance of these animals in relation to the global marine ecosystem.

Corals are simple animals and as such, are capable of forming very complex and diverse communities. Contrary to popular belief, simple organisms show the highest capacity for adaptation and mutation, since complex organisms are more specialized and therefore less likely to undergo genetic and physical modifications over a short period of time.

Fire coral (*Millepora planata*) © OCEANA/ Houssine Kaddachi

False coral (*Myriapora truncata)* © OCEANA/ Juan Cuetos

Many people believe that corals are plants. This is because the great majority of these creatures are species which live fixed to the substrate, and with a quick glimpse they do not seem to be very active. Because we are terrestrial animals, we are used to drawing a distinction between plants and animals according to their respective ability to move. Yet, what is an obvious observation as far as land creatures are concerned, does not apply to the sea. Appearances to the contrary, there are other animals which also spend all or part of their life anchored to rocks or other substrates, or even to other organisms. This is seen in porifers (sponges), bryozoans, hydrozoans and a great number of worms, mollusks and crustaceans. The fact that some species look like tree branches only serves to increase the confusion.

Corals are animals whose cells are organized in tissues. They have a nervous system, grow and reproduce, form colonies and can feed directly from the organisms which surround them in the water.

All of them are uniquely marine species which exist in all of the ocean habitats known to us, from shallow water and tide pools to the greatest depths known to support marine life.

Corals belong to one of the oldest extant classes of animals in the world. Their fossil remains can be traced back to the pre-Cambrian era,[1] when there was a great surge in oceanic life over 500 million years ago.

Occupying 1.1% of the surface of the world's oceans and 0.3% of all salt water, the Mediterranean no longer shelters the great coral reefs that thrived 60 million years ago. This is due to millennia of climactic and oceanographic changes. However, even today this sea harbors a spectacular array of corals, including some which are not found anywhere else.

Brief explanation of the taxonomy of anthozoans and the terminology used in this document

The very term "coral" is ambiguous in itself, since it can be a common term for a few species with rigid skeletons or, specific anthozoan groups. Sometimes, it is used to describe species which belong to other classes of marine life, such as hydrozoans and bryozoans. This occurs with fire, or stinging, coral (*Millepora* sp.) and with false coral (*Myriapora truncata*).

We have selected to use "corals" as the name to group together all anthozoans species, including true corals, black coral, sea fans (or, gorgonians), sea feathers, and anemones. We do not include here the other species commonly referred to as corals, such as fire coral. These are hydrozoans, a class of animals with distinct differences.

The anthozoans, or "flower animals" from the original Greek translation, are a class within the Cnidaria phylum. They are a group of of animals which spend their whole life in the polyp phase.

The cnidarians, or coelenterates, derive their name from their cnidocytes or stinging cells - cnidocyte means stinging or itching needle, derived from the Greek word knidé (nettle). The other older name they are known by, coelenterates means vacuous intestine - from the Greek koilos (vacuous) and enteron (intestine).

The Cnidarian phylum is divided into four classes of species: hydrozoans, cubozoans, scyphozoans and anthozoans.

The hydrozoans and cubozoans spend part of their life as medusas and part as polyps. The scyphozoans only exist as medusas and never enter the polyp stage. Anthozoans only exist as polyps and do not go through a medusoid phase. The cnidarians once included a fifth class, conulata, which went extinct in the Triassic period.

As for the anthozoans, which we have decided to treat as corals and to which this writing is dedicated, they have traditionally been subdivided into two subclasses: Octocorallia and Hexacorallia.

The Octocorallia (or Alcyonacea) derive their name from the 8-fold tentacular symmetry of their polyps, and an equal number of septa or complete, but unpaired, mesentery (the layers of the gastrovascular cavity which reaches from the mouth to the anus). They divide into five orders: Stolonifera (organ-pipe coral; tree fern coral), Alcyonacea (soft corals), Gorgonacea (gorgonians, or sea fans; sea feathers), Helioporacea or Coenothecalia (Indo-Pacific blue coral) and Pennatulacea (sea pens).

Hexacorallia (or Zoantharia) is not only the name for the species with six tentacles, but also signifies the species with more than eight tentacles (many times they are found in multiples of six), with six complete and paired

mesenteries. They divide into seven orders: Actinaria (sea anemones), Scleractinia or Madreporaria (stony corals), Ceriantharia (tube-dwelling anemones), Antipatharia (black corals), Corallimorpharia (coral anemones), Zoanthidea or Zoantharia (colonial anemone) and Ptychodactiaria. Other orders that used to belong to this class are now extinct, such as the Rugosa, Tabulata, Heterocorallia, etc. Two-thirds of all anthozoans in the world belong to this subclass.

Various colourations of the *Leptogorgia sarmentosa*
© OCEANA/ Juan Cuetos

In the second half of the 20th century, some authors proposed a third subclass to unite Ceriantharia and Antipatharia under a common order, Ceriantipatharis, given their similarities during the larval stage as well as their unpaired mesenteries, among other common traits. This in turn was a subclass that could be divided into two very distinct orders: the Ceriantharia, or tube-dwelling anemones, which can retract entirely into their tubes, and the Antipatharians, or black corals, which have retractable tentacles. In contrast to all other anthozoans, the latter do not form a ring around their mouths.

There is no scientific consensus as to the classification of these animals. Anthozoa is an animal phylum which has yet to be adequately defined. This can be expected, as the taxonomic classifications and the subsequent identification of their related species can be very divergent.

The taxonomic classification which we have decided to use in this report is the one used in Sistema Naturae 2000[2] (excluding the Scleractinia, which follow the definition of Vaughan T.W. & J.W. Wells, 1943[3], updating certain types and species based on the MARBEF,[4] ITIS[5] and Hexacorallia of the World[6] databases). On the other hand, we have kept the names Octocorallia and Hexacorallia instead of Alcyonacea and Zoantharia to avoid confusing, respectively, the two subclasses and two orders.

02.

Physical characteristics of corals

White gorgonia (*Eunicella singularis*) © OCEANA/ Juan Cuetos

A coral is a polyp which can live alone or in colonies and cover itself with a hard or soft exoskeleton, but its overall constitution is rather simple.

The polyps are sac-like with radial symmetry and two layers of tissue: an external one called the ectoderm or epidermis, and an internal one known as the grastrodermis. There is also a third gelatinous layer in between called the mesoglea.

The polyp produces calcium carbonate from within the ectoderm for the purpose of building the firm skeleton of many corals.

On their bottom side they have an anchoring or basal disk which is used to anchor the polyp to the substrate or other structure securing a large colony, while the disk-shaped tentacular mouth is found on the upper side, facing away from the substrate.

Corals only have one orifice serving as both mouth and anus, leading to the pharynx, a short tube connecting the mouth with the gastrovascular cavity. This is separated by the wall of the septa or mesentery, forming the chambers in which the digestive cells are located.

One particularly characteristic trait of anthozoan and other cnidarians are the "cnidos" (*greek)*, stinging needles known as cnidocytes. There are three different types:
1) nematocysts, shaped like small harpoons, which can shoot out and penetrate the tissue of prey, inoculating it with the toxin they contain. They are found in the tentacles and gastrovascular cavity of all anthozoans;
2) spirocysts, only found among hexacorallias, which use adhesion with their victims instead of needles; and
3) ptychocysts, also adhesive, and used by ceriantharias (tube-dwelling anemones) to construct their tubes.

Configuration

Corals can be found living in isolation or in immense colonies; they may display only their soft bodies live inside a tube or create erect structures that are rigid, semi-rigid or soft and on which they anchor their polyps. They may rise into branch formations, with many or few dendrites, or carpet vertical walls on the sea-floor, making it look like a carpet of grass; they may take on the aspect of cushions, balls, feathers, whips, globules, etc. There are also those which have taken over the external housing of sponges or other corals.

The great variety these colonies present has created an endless naming process and attempt to categorize them. Some have little branching and are whip-like (such as *Elissela paraplexauroides* or *Viminella flagellum*), cable-like (such as *Eunicella filiformis*), or feather-like (such as *Virgularia mirabilis* or those of the *Pennatula* type).

Often, these forms reflect a specialized adaptation for survival in different marine environments, conditioned by hydrodynamics, temperature, etc.

In some cases, the coral colonies form tree-like structures, like most gorgonians or some scleractinias such as *Dendrophyllia ramea* or *Pourtalosmilia anthophyllites*. For these types of colonies, the structure is usually rigid or

White gorgonia (*Eunicella singularis*) with protruding calyces
© OCEANA/ Thierry Lanoy

semi-rigid, but there are also soft body colonies, such as dead man's fingers (*Alcyonum* spp.) or the sea feathers (Pennatulacea), among others.

One of the structures most characteristic of coral formation is the reef. In the Mediterranean, coral reefs are scarce and there are only a few species of colonial anthozoans that have the capacity to create them.

However, there are other cnidarians which form complex and sizeable colonies, even though these may not always be considered reefs. Some examples of these are the anemone colonies of the type *Epizoanthus, Parazoanthus* and *Corynactis*, or some corals living in colonies such as the *Madracis pharensis, Astroides calycularis, Polycyathus muellerae, Phyllangia mouchezii* and *Hoplangia durotrix*.

Clavularia sp. © OCEANA/ Juan Cuetos

One must not forget that although the small size of some of the stoloniferas and alcyonaceas colonies makes them less visible, the abundance of individual specimens may be considerable, enough to create micro habitats. This is the case of the *Clavularia* sp.*, Cornularia* sp., or *Maasella edwardsi*.

Although the general perception of corals is usually one of large colonies, there are a number of species which either live in isolation or in small groups.

White gorgonia (*Eunicella singularis*) with bulging calyces
© OCEANA/ Juan Cuetos

Solitary anthozoans may be found living in the habitats created by other corals. Some deep-water species are often found existing in cold water coral reefs. In the Mediterranean, this is seen with species such as *Desmophyllum cristagalli* or *Stenocyathus vermiformis*.[7]

All anemones live in isolated units or in small colonies, although they can sometimes form habitats when there are enough of them in a given area. This also occurs with many true corals of the Balanophyllidae and Caryophyllidae families.

An alternative favored by some corals is to occupy structures made by other anthozoans. The soft coral *Parerythropodium coralloides* and the false black coral (*Gerardia savaglia*) form such habitats. While they are capable of creating branch-like colonies on their own, they sometimes invade gorgonian colonies and partly or entirely cover them over.

Some species of corals may also appear different according to the environmental conditions in which they have grown.

Although *Cladocora caespitosa* takes its name from its typical presentation in sweeping "grass" carpets or as small cushions, they may rise into shrub-like formations when the hydrodynamics are low and permit it. The white (*Eunicella singularis*) or yellow (*Eunicella cavolini*) gorgonia, may also look differ-

Maasella edwardsii © OCEANA/ Juan Cuetos

ent depending on the ambient hydrodynamics;[8] while some hardly branch at all, and the branching appears flat, they may also have a fuller, bushy appearance. Even their exoskeletons can me modified.[9]

Exoskeletons for all tastes

The exoskeleton of hard corals (scleractinias) is composed of a crystallized form of calcium carbonate ($CaCO_3$), known as aragonite,[10] which also composes the shells of many mollusks. In rare cases or with varying marine chemicals, aragonite has been found to be a substitute of calcite.[11]

The high mineralization rate of the soluble calcium carbonate found in corals is maximized in certain symbiotic algae (zooxanthelae) living in their tissue.[12]

Tube anemone (*Cerianthus membranaceus*) © OCEANA/ Juan Cuetos

There are other corals which use composites of proteins, carbohydrates and allogeneic composites such as gorgonian to form a horn-like skeleton[13], sometimes dotted with calcareous spicules, common among octocorallias. It is softer than scleractinias, making for greater flexibility. Some octocorallias have opted for an intermediate system, substituting gorgonian for calcium carbonate. This is the case of scleractinias. Thanks to these alterations, their structure is more rigid. This can be seen with red coral (*Corallium rubrum*).

There are also examples of soft skeletons, as with anemones and zoantharias. Or those that have opted for a tube instead of a skeleton, using stinging cells (ptychocysts) and mucus to insulate the polyp, and to fix sand and other particles[14] in the manner of some polychaete worms.

In touch

When polyps live in colonies, they must find ways to coordinate themselves. For gorgonians and other octocorallias living in branching colonies, the polyps are in contact internally via living tissues such as the coenenchyme. In addition, the gastrovascular cavities are also intercommunicated via canals and tubes.

But if there can be only one particularly striking technique to stay in touch with one another, it is that exhibited by the stoloniferas corals. These are simple polyps that are united by means of offshoots containing internal canals which maintain continuous contact. When a single polyp or its offshoots is touched, all of the animals retract simultaneously into their calyx.

03.

Coral species of the Mediterranean

Mediterranean madreporaria (*Cladocora caespitosa*) © OCEANA/ Juan Cuetos

More than 200 species of coral (from a total of 5,600 species which have been described world-wide, 500 of which are in Europe) live in the Mediterranean. Some of the species living there are endemic, while others have a subtropical origin from the warmer waters of the Atlantic. Still others are more common in arctic zones, while some are found everywhere.

Anthozoan species found in the Mediterranean:

OCTOCORALLIA

Alcyionacea

· **Alcyionidae**
Dead man's fingers *Alcyonium acaule*
Dead man's fingers *Alcyonium palmatum*
False red coral *Parerythropodium coralloides*

· **Paralcyionidae**
Maasella edwardsi
Paralcyonium spinulosum

Gorgonacea

· **Acanthogorgiidae**
Acanthogorgia armata
Acanthogorgia hirsuta

· **Elliselliidae**
Elisella paraplexauroides
Viminella flagellum

· **Gorgoniidae**
Yellow sea fan/gorgonia *Eunicella cavolini*
Cable gorgonia *Eunicella filiformis*
Eunicella gazella
Senegalese gorgonia *Eunicella labiata*
White gorgonia *Eunicella singularis*
Pink gorgonia *Eunicella verrucosa*
Guinea gorgonia *Leptogorgia guineensis*
Portuguese gorgonia *Leptogorgia lusitanica*
Leptogorgia sarmentosa
Leptogorgia viminalis

· **Isididae**
Isidella elongata

· **Plexauridae**
Bebryce mollis
Echinomuricea klavereni
Muriceides lepida
Red gorgonia *Paramuricea clavata*
Spiny gorgonia *Paramuricea macrospina*
Crown gorgonia *Placogorgia coronata*
Placogorgia massiliensis
Spinimuricea atlantica
Spinimuricea klavereni
North Sea gorgonia *Swiftia pallida*
Villogorgia bebrycoides

· **Primnoidea**
Callogorgia verticillata

· **Coralliidae**
Red Coral *Corallium rubrum*

Pennattulacea

· **Funiculinidae**
Tall sea pen *Funiculina quadrangularis*

· **Kophobelemnidae**
Koster sea pen *Kophobelemnon stelliferum*
Leuckart sea pen *Kophobelemnon leucharti*

· **Veretillidae**
Cavernularia pusilla
Pluma de mar redonda o Veretilo *Veretillum cynomorium*

· **Pennatulidae**
Sea Feather *Pennatula aculeata*
Phosphorescent Sea Feather *Pennatula phosphorea*
Red Sea Feather *Pennatula rubra*
Grey Sea Feather *Pteroeides griseum*

· **Virgularidae**
Sea Pen *VIrgularia mirabilis*

Stolonifera

· **Cornularidae**
Cornucopia *Cornularia cornucopiae*
Cervera *Cervera atlantica*

· **Clavulariidae**
Common clavularia *Clavularia crassa*
Dwarf clavularia *Clavularia carpediem*
Clavularia marioni
Clavularia ochracea
Rolandia coralloides
Sarcodyction catenata
Scleranthelia microsclera
Scleranthelia rugos

HEXACORALLIA

Actiniaria

· **Andresiidae**
Andresia parthenopea
· **Edwardsiidae**
Edwardsia beautempsi
Edwardsia claparedii
Edwardsia grubii
Edwardsia timida
Edwardsiella janthina
Edwardsiella carnea
Scolanthus callimorphus
· **Halcampoididae**
Synhalcampella oustromovi
Halcampella endromitata
Halcampoides purpurea
· **Haloclavidae**
Anemonactis mazeli
Mesacmaea mitchelli
Mesacmaea stellata
Peachia cylindrica
Peachia hastata
· **Boloceroididae**
Bunodeopsis strumosa
· **Actiniidae**
Actinia atrimaculata
Actinia cari
Actinia cleopatrae
Actinia crystallina
Actinia depressa
Beadlet anemone *Actinia equina*
Strawberry anemone *Actinia fragacea*
Actinia glandulosa
Actinia judaica
Actinia mesembryanthemum
Actinia phaeochira
Actinia rondeletti
Actinia rubra
Actinia rubripuncatata
Actinia striata
Actinia zebra
Anemonia cereus
Mediterranean snakelocks anemone *Anemonia sulcata*
Anthopleura ballii
Bunodactis rubripunctata
Gem Anemone *Bunodactis verrucosa*
Deep-water Anemone *Condylactis aurantiaca*
Thick tentacle anemone *Cribrinopsis crassa*
Paranemonia cinerea
Paranemonia vouliagmeniensis
Pseudactinia melanaster
· **Actinostolidae**
Paranthus chromatoderus
Paranthus rugosus

· **Aiptasiidae**
Aiptasia carnea
Aiptasia diaphana
Aiptasia saxicola
Trumpet anemone *Aiptasia mutabilis*
Aiptasiogeton pellucidus
· **Aliciidae**
Alicia costae
Alica *Alicia mirabilis*
· **Aurelianiidae**
Imperial anemone *Aureliana heterocera*
· **Condylanthidae**
Segonzactis hartogi
Segonzactis platypus
· **Diadumenidae**
Orange anemone *Diadumene cincta*
Orange striped anemone *Haliplanella lineata*
· **Hormathiidae**
Actinauge richardi
Cloak anemone *Adamsia carciniopados*
Amphianthus crassus
Sea fan anemone *Amphianthus dohrnii*
Parasitic anemone *Calliactis parasitica*
Hormathia alba
Hormathia digitata
Hormathia coronata
Hormathia nodosa
Paracalliactis lacazei
Paracalliactis robusta
· **Isophellidae**
Club tipped anemone *Telmatactis cricoides*
Swimming anemone *Telmatactis forskalii*
Telmatactis solidago
· **Metridiidae**
Plumose or Frilled anemone *Metridium senile*
· **Phymanthidae**
Phymanthus pulcher
· **Sagartiidae**
Actinothoe clavata
Actinothoe sphyrodeta
Daisy anemone *Cereus pedunculatus*
Kadophellia bathyalis
Octophellia timida
Sagartia elegans
Sagartia troglodytes
Sagartiogeton entellae
Sagartiogeton undatus
· **Gonactiniidae**
Gonactinia prolifera
Protanthea simplex

HEXACORALLIA (continued)

Corallimorpharia

- **Corallimorphidae**
  Corynactis mediterranea
  Jewel anemone *Corynactis viridis*
- **Sideractiidae**
  Sideractis glacialis

Scleractinia

· **Caryophyllidae**
  Cup coral *Caryophyllia calveri*
  Cup coral *Caryophyllia cyathus*
  Southerm cup coral *Caryophyllia inornata*
  Devonshire cup coral *Caryophyllia smithii*
  Ceratotrochus magnaghii
  Coenocyathus anthophyllites
  Coenocyathus cylindricus
  Desmophyllum cristagalli
  Hoplangia durotrix
  Tuft coral *Lophelia pertusa*
  Paracyathus pulchellus
  Sphenotrochus andrewianus
  Polycyathus muellerae
  Pourtalosmilia anthophyllites
  Phyllangia mouchezii
  Thalamophyllia gasti

· **Faviidae**
  Thin tube coral *Cladocora caespitosa*
  Cladocora debilis

· **Flabellidae**
  Javania cailleti
  Monomyces pygmaea

· **Guyniidae**
  Guynia annulata
  Stenocyathus vermiformis

· **Dendrophylliidae**
  Orange coral *Astroides calycularis*
  Cup coral *Balanophyllia cellulosa*
  Cup coral *Balanophyllia europaea*
  Scarlet and gold star coral *Balanophyllia regia*
  Cladopsammia rolandi
  Yellow tree coral *Dendrophyllia cornigera*
  Yellow coral *Dendrophyllia ramea*
  Sunset cup coral *Leptopsammia pruvoti*

· **Oculinidae**
  White Madrepora *Madrepora oculata*
  Oculina patagonica

· **Pocilloporiidae**
  Star coral *Madracis pharensis*

Zoanthidea

· **Epizoanthidae**
  Brown epizoanthidae *Epizoanthus arenaceus*
  Epizoanthis frenzeli
  Epizoanthus incrustans
  Epizoanthus mediterraneus
  Epizoanthus paguricola
  Epizoanthus paxi
  Epizoanthus steueri
  Epizoanthus tergestinus
  Epizoanthus univittatus
  Epizoanthus vagus
  Epizoanthus vatovai

· **Parazoanthidae**
  Gerardia lamarcki
  False black coral *Gerardia savaglia*
  Yellow cluster anemone *Parazoanthus axinellae*

· **Zoanthidae**
  Palythoa axinellae
  Palythoa marioni
  Zoanthus lobatus

Antipatharia

  Antipathes dichotoma mediterranea
  Antipathes gracilis fragilis
  Antipathes subpinnata
  Bathypathes patula
  Leiopathes glaberrima
  Parantipathes larix

Ceriantharia

  Mediterranean tube anemone *Cerianthula mediterranea*
  Tube anemone *Cerianthus lloydii*
  Colored tube anemone *Cerianthus membranaceus*
  Dohm tube anemone *Pachycerianthus dohrni*
  Pachycerianthus solitarius
  Arachnantus nocturnus
  Dwarf tube anemone *Arachnantus oligopodus*

Mediterranean madreporaria (*Cladocora caespitosa*)
© OCEANA/ Juan Cuetos

The evolution of corals in the Mediterranean

Six million years ago, towards the end of the Miocene (Messinian) period, there were still some remains of coral reefs from the following genuses in the Mediterranean:[15] *Porites*, *Tarbellastrea*, *Siderastrea*, *Plesiastraea*, *Favites*, *Stylophora* o *Acanthastrea*. Some of them remain as submerged fossils (like at Alborán), others are currently above sea level, and still others straddle both environments, such as those found in Cap Blanc (Mallorca)[16] or the gulf of Antalya and the Taurus Mountains of southwest Turkey.[17] These are examples of fossils from both sides of the Mediterranean.

During the Messinian salinity crisis, the Mediterranean Sea underwent one of its most drastic changes, causing the extinction of many species and the coral reefs.[18] Later, when the straits of Gibraltar opened again, the water rushed in and filling the Mediterranean Sea once again, but the reefs did not reform. Insead, other coral forms were generated representing a great diversity.

The actual origins of corals and reefs in the Mediterranean go far back into geological time. There were coral formations during the Paleocene and Eocene[19] epochs, and much older coral formations have even been discovered that date back to the Triassic, when the Mediterranean was part of the immense, ancient sea of Tethys, more than 200 million years ago. Some of these sites have been excavated at the Italian location of Zorzino.[20]

The oldest coral reef discovered to date is located in the state of Vermont in the United States. It is 450 million years old.[21] However, this reef does not really fall into the category of a "coral reef" as per the current definitions, because, although some corals contributed to its formation, it is not principally the product

of corals. Neither does it present a pervasive ecosystem, made up of complexly interrelating habitats and the multitude of organisms which depends on and interacts with it. In fact, as per the "modern" definition of a coral reef, the oldest known example is located in the Monte Bolca region of Italy[22], belonging to the Eocene epoch. Here were whole communities of fish, including the first known presence of herbivorous ones, and other organisms living in a coral-built reef. For some observers, a shift occurred in the ecological structure of

	Eon	Era	Period		Epoch	Stage	Age (millions of years ago)
	Phanerozoic	Cenozoic	Quaternary	Neogene	Holocene		
					Pleistocene	Upper	0.0115
						Middle	0.126
						Lower	0.781
					Pliocene	Gelasian	1.806
			Tertiary			Piacenzian	2.588
						Zanclian	3.600
					Miocene	Messinian	5.332
						Tortonian	7.246
						Serravallian	11.608
						Langhian	13.650
						Burdigalian	15.970
						Aquitanian	20.430
				Paleogene	Oligocene	Chattian	23.030
						Rupelian	28.4
					Eocene	Priabonian	33.9
						Bartonian	37.2
						Lutetian	40.4
						Ypresian	48.6
					Paleocene	Thanetian	55.8
						Selandian	58.7
						Danian	61.7
		Mesozoic	Cretaceous		Upper	Maastrichtian	65.5
						Campanian	70.6
						Santonian	83.5
						Coniacian	89.3
						Turonian	93.5
						Cenomanian	99.6
					Lower	Albian	112.0
						Aptian	125.0
						Barremian	130.0
						Hauterivian	136.4
						Valanginian	140.2
						Berriasian	145.5
			Jurassic		Upper	Tithonian	150.8
						Kimmeridgian	155.0
						Oxfordian	161.2
					Middle	Callovian	164.7
						Bathonian	167.7
						Bajocian	171.6
						Aalenian	175.6
					Lower	Toarcian	183.0
						Pliensbachian	189.6
						Sinemurian	196.5
						Hettangian	199.6
			Triassic		Upper	Rhaetian	203.6
						Norian	216.5
						Carnian	228.0
					Middle	Ladinian	237.0
						Anisian	245.0
					Lower	Olenekian	249.7
						Induan	251.0

coral reefs some time between the Mesozoic and Cenozoic[23], 65 million years ago, when the Mediterranean was about to be cut off from the Indo-Pacific zone by the formation of the Arabian Peninsula.

The Mediterranean coral reefs from the Eocene and the marine life which they sheltered show a strong similarity with those that have been found in the Indo-Pacific zone, with an even closer resemblance between some of their fish species than with the fish populations in the tropical Atlantic zone.[24]

Just as the Mediterranean seems to be one of the areas from which modern tropical coral reefs have originated, some deep-sea or cold water reefs may also come from this sea.

The deep-sea coral reef fossils formed by species such as *Lophelia pertusa*, *Madrepora oculata* and *Desmophyllum dianthus* found in the Mediterranean date back to the end of the Pliocene and the early Pleistocene[25] (1.8 million years ago), which makes them the oldest ones found to date.[26]

Coinciding with the early Miocene, it appears that many of these reefs suffered a serious regression and today, only a few zones in this sea have been shown to bear live specimens, such as those found in the Ionian Sea[27], while their distribution in the Atlantic covers both margins of the northern hemisphere[28].

Many scientists have mentioned the possibility that the in outflow waters from the Mediterranean (known by the acronym MOW -Mediterranean Outflow Water-), larvae of these species then invaded the Atlantic waters, thus propagating through the whole Ocean[29]. As already indicated by Oceana[30] and other authors, some of the principal coral reefs in the deep waters of the Eastern Atlantic are in the flow path of Mediterranean water as it passes through the straits of Gibraltar.

Furthermore, the madreporaria coral that is endemic to the Mediterranean, *Cladocora caespitosa*, has also lived in this sea for a long period of time. It is known that some reefs date back to the Pliocene and have lasted through the Pleistocene and Holocene up to today[31]. However, today's reefs are only a small portion of their original range. The Mediterranean madreporaria is in a progressive state of regression.

Exclusive corals and imported corals

Oculina patagonica © OCEANA/ Juan Cuetos

However, the Mediterranean appears not only to have "exported" species and reefs. In the last decades, some species of non-native corals have settled in the Mediterranean. This is the case of the orange striped anemone *(Haliplanella lineate)*, and possibly the colonial coral *Oculina patagonica*.

The colonial coral *Oculina patagonica* is traditionally considered to be a species that was imported into the Mediterranean[32].

The first specimens of *Oculina patagonica* were found in 1966 in Savona (Gulf of Genoa, Italy).[33] They are today well represented

throughout the Mediterranean, especially in areas between Italy, France and Spain,[34] and there is also a second pocket in the Eastern Mediterranean, between Egypt, Israel, Lebanon[35] and Turkey[36].

At present there is a dispute among scientists as to whether this species is foreign or not. At the very least, doubt exists as to whether it should be excluded from the list of Mediterranean species. The only data on extra-Mediterranean samples of this species come from sub-fossil excavations in the south of Argentina[37] (hence its name) of Tertiary strata. But, there is neither a record of any live specimens of this scleractinia nor of any testimony from the annals of past centuries.

There are many questions to be made regarding this species. When and how was it introduced into the Mediterranean? Is it a relic from the Tertiary? Is *Oculina patagonica* really the specimen found in the Mediterranean? Are there living colonies of *Oculina patagonica* to be found in South America but which have yet to be discovered? Many of these questions still go unanswered.

The orange striped anemone *(Haliplanella lineate)* is originally from the Pacific and is thought to have been introduced in the 19th[38] century into European Atlantic waters on the hulls of ships[39]. It was discovered for the first time in Mediterranean waters off Corsica in 1971[40].

The Mediterranean also shelters some endemic species of corals. Some of them are typical of this sea, yet may be found in surrounding zones. This is the case of the red gorgonia (*Paramuricea clavata*) which may have traveled as far as the Berlengas Islands of Portugal. As documented by Oceana, they are to be found in the submarine mountains of Gorringe[41].

Other species that are endemic to the Mediterranean but which may also be found in surrounding areas are *Leptogorgia sarmentosa, Maasella edwardsi, Actinia striata, Astroydes calycularis, Balanophylla europaea, Cribrinopsis crassa, Cladocora caespitosa, Phymanthus pulcher* and *Corallium rubrum*.

Golden cup coral (*Astroides calycularis*) © OCEANA/ Juan Cuetos

04.

Coral habitats and corals as habitats

Bunodeopsis strumosa on *Cymodocea nodosa*
© OCEANA/ Juan Cuetos

The forms in which corals congregate give rise to the creation of different types of marine habitats, or else, participate in existing ones. Among the most significant in the Mediterranean are the following:

Coral reefs

As mentioned above, the Mediterranean lacks large-scale reefs. Only the biotopes formed by some species may reasonably be classified as such.

In the Mediterranean, only a few species belong to the scleractinians or madreporarians, which is the type of coral that forms the great reefs of the tropics. But the great majority of these specimens are only represented by small colonies or in isolation (or as part of reefs created by other species). Among these, and in the infralittoral and circumlittoral waters, the Mediterranean madreporaria (*Cladocora caespitosa*) stands out as a species extant only in the Mediterranean and adjacent Atlantic waters. It can create large colonies up to four meters in diameter, although it is usually found in smaller colonies of a few hundred polyps. In some areas of the Mediterranean, they can occupy significant zones. This can be seen with the species found in the different reefs of the western Mediterranean, such as in the costal lagoon of Veliko jezero in Croatia, which measure approximately 650 square meters and between four and 18 meters deep.[42] *Oculina patagonica* can also form dense colonies and occupy significant areas of the sea bed with abundant sunlight.

Reefs formed by cold water or deep water corals is another type of coral habitat existing in the Mediterranean, mainly formed by tuft coral (*Lophelia pertusa*) and madreporaria (*Madrepora oculata*). This type of reef is also found in extensive areas of the North Atlantic and can generate an ecosystem capable of clustering more than 800 different species, including corals and deep-sea gorgonia. In the Atlantic, reefs have been found extending over several dozen kilometers and reaching up to 30 meters in height[43], with an ample range of depths from 40 to over 3,000 meters[44].

Mediterranean madreporaria (*Cladocora caespitosa*)
© OCEANA/ Thierry Lanoy

Today these deep-sea reefs are rare in the Mediterranean. Most of the findings are of fossil or sub-fossil corals, although some live polyps have been found in different areas. The most important of these is in Santa Maria di Leuca (Italy) in the Ionian Sea, where both species appeared together with other deep-sea corals, such as *Desmophyllum dianthus* and *Stenocyathus vermiformis,* in waters from 300 to 1,200 meters deep, occupying areas as large as 400 square kilometers[45]. Other concentrations of deep-sea corals were found in the Palamós and Cap de Creus canyons of Spain.

In both types of reefs, the temperature and availability of nutrition seem to be the limiting factors in distribution. Salinity, topography, the substrate of the sea floor and light intensity seem to be the variables for the species zooxanthelae[46], not to mention the impact of

human activities such as bottom trawling. In some areas, it has pushed back these formations to less accessible regions such as canyons and ravines.
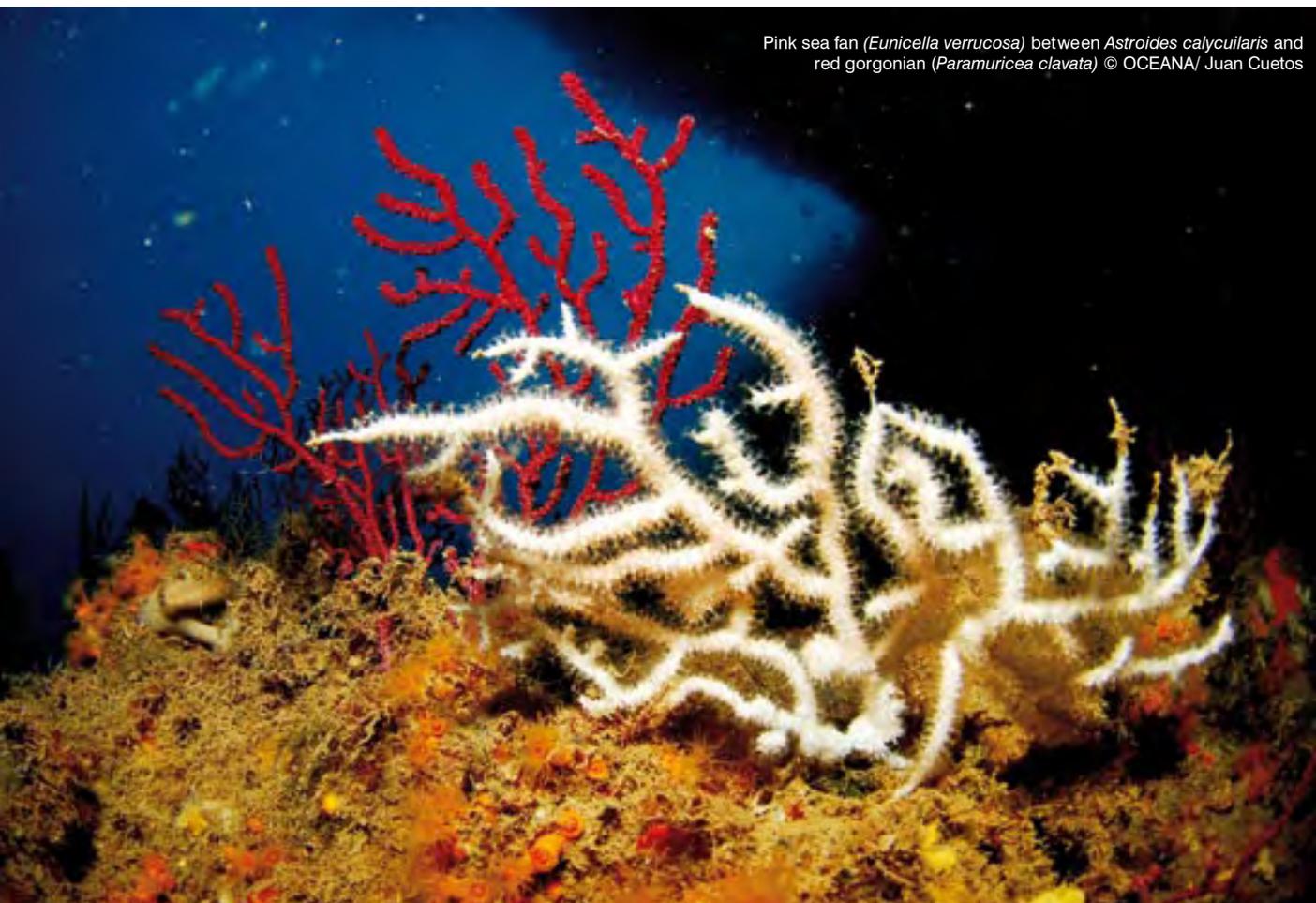
For deep-sea corals, the hypothesis for measuring the settlement and growth of a reef or colony is influenced by oceanographic and paleo-environmental factors. It is thought that the microbial role in hydrocarbon seepage during carbonate formation facilitates their growth[47].

Coralline algae

The predominant species which form this vital ecosystem are not corals at all, but as the name indicates, a type of algae. However, one of the most characteristic representatives of these formations are gorgonias, which serve

(the environmental function) as "large trees". This ecosystem is typical in the Mediterranean[48], although similar formations may be found in other areas, including the Atlantic.

Some researchers have managed to differentiate up to five types of coralline algae.[49] All of them have corals present. Up to 44 species have been counted in this ecosystem[50]. Among the most representative are the gorgonia (*Paramuricea clavata, Eunicella cavolinii, E. singularis, E. verrucosa*, etc.), other octocorallians like red coral (*Corallium rubrum*), dead man's fingers (*Alcyonium* sp.), zoantharia such as the orange colonial anemone (*Parazoanthus axinellae*) and hexacorallia such as the yellow coral (*Leptosamnia pruvotii*), the orange coral (*Astroides calycularis*), etc.

Pink sea fan *(Eunicella verrucosa)* between *Astroides calycuilaris* and red gorgonian *(Paramuricea clavata)* © OCEANA/ Juan Cuetos

The contribution of gorgonians and corals to coralline algae is significant. They fix nutrients and sift sediments[51], producing calcium carbonate[52] and generating a large biomass[53], or can also procure substrate for the settlement of epibionts[54].

In this respect, the larger gorgonians are often colonized by a multitude of organisms such as bryozoans (*Pentapora fascialis* or *Turbicellepora avicularis*), hydrozoans (*Eundendrinum* sp.*, Sertularella* sp.*)* or sponges (*Dysidea* sp., *Hemimycale columella*)*.* They are also useful as an egg depository for various species including the Cat shark (*Scyliorhinus canicula*), as Oceana and other researchers[55] have been able to verify. Eggs are deposited in species such as *Paramuricea clavata* and *Eunicella cavolinii* in Portofino (Italy) and in other areas of the Mediterranean.

Trumpet anemone colony *(Aiptasia mutabilis)* amongst sponges *(Ircinia variabilis)* © OCEANA/ Juan Cuetos

Large concentrations of anemones

There are some anthozoans which are usually found in large colonies, like the jewel anemone (*Corynactis viridis*) and the yellow cluster anemone (*Parazoanthus axinellae*), but there are also true anemones which although normally found in small groups or in isolation, can occasionally form large colonies, giving rise to unique habitats. This is the case of *Anemonia sulcata* and *Aiptasia mutabilis* found on Mediterranean facies.

In the case of *Anemonia sulcata*, Oceana has documented large concentrations of this species frequently in association with brown algae forests, such as the kelps *Saccorhiza polyschides* and *Laminaria ochroeleuca*.

Mediterranean snakelocks anemone *(Anemonia sulcata)* © OCEANA/ Juan Cuetos

Concentrations of anemones with these characteristics have already been documented by other researchers on the sea floors of some marine reserves, such as Columbretes[56] or Alborán[57].

Although *Aiptasia mutabilis* is often found alone or in small groups, it has also been detected in large concentrations in the company of poriferaria such as *Ircinia variabilis*, or in rocky areas between prairies of marine seagrasses.

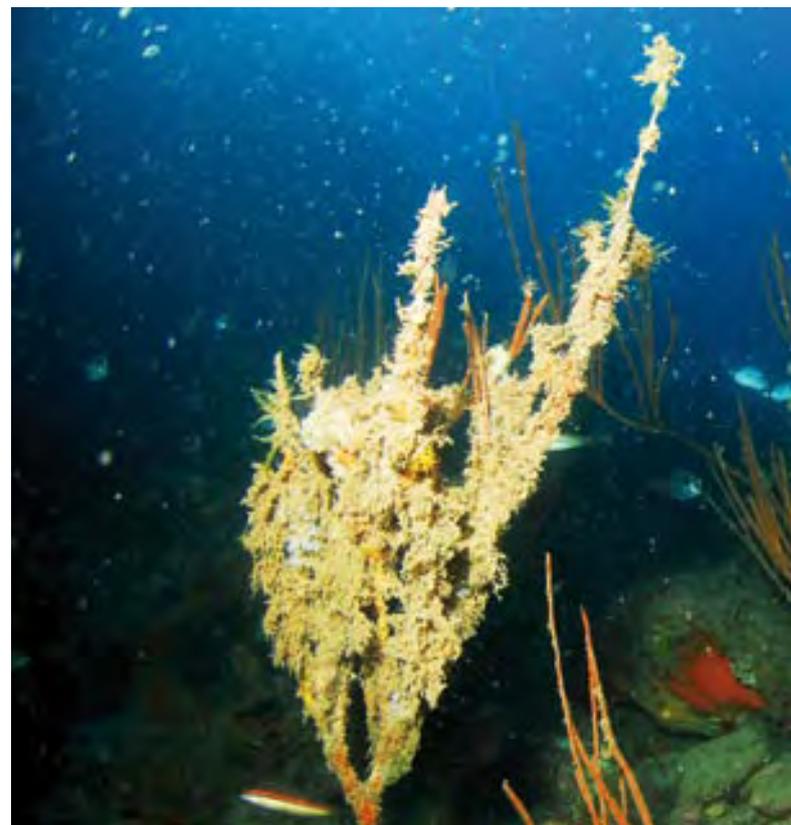*Phyllangia mouchezii* © OCEANA/ Juan Cuetos

On rocks, walls and hard substrates

The capacity to adhere to different substrates makes corals efficient colonizers, even on very steep rocks and walls. Walls, the costal shelf and high rocks are favorite places for many corals species. These privileged outcrops are ideal for filtering plankton-filled water which usually gets swept upward in these zones, or else are brought here by the currents.

Some species are authentic specialists when it comes to forming a dense cover of colonies on vertical substrates. The jewel anemone (*Corynactis* sp.) or yellow cluster anemone (*Parazoanthus axinellae*) can occupy widespread zones of submarine walls. But some hexacorallias also occupy this strategic high ground. Some of them form large colonies such as the orange coral (*Astroides calycularis*) and star coral (*Madracis pharensis*), while others form isolated colonies yet become quite numerous, such as the yellow coral (*Leptosamnia pruvotii*) and different dendrophylliidas and caryophylliidas. Some coral species such as *Polycyathus muelerae* or *Phyllangia mouchezii* can mantle entire rocks.

Other hard substrates like gravel floors, small rocks and stones, can also serve as settlement locations. This is the choice of many anemones such as *Diadumene cincta*, *Anemonia melanaster*, and *Metridium senile*[58].

Some species have taken maximum advantage of the hard structures which exist on the sea floor, whether it occurs naturally or artificially. Small zoanthidas (*Epizoantus* sp.)

Eunicella cavolini, red gorgonian (*Paramuricea clavata*) and *Leptosamnia pruvoti* in a cave© OCEANA/ Carlos Suárez

can colonize almost any substrate which they find: stones, shells, coral skeletons, bottles, fishing lines, cables, etc.

In caves and fissures

Not all corals like sunlight. Some of them look for caves or hollows in which to grow. Some species have become specialized in shady habitats while others have added them to an already ample habitat range, and others still have retreated to them for lack of choice, forced by over-exploitation of more exposed or accessible zones.

Overgrowth on *Elisella paraplexauroides* © OCEANA/ Juan Cuetos

As far as we know today, there are no anthozoans that live exclusively in caves, although some have become more specialized in that type of habitat. Among these are many species of dendrophylliidas, given that the majority of species belonging to this genus does not coexist with any symbiotic algae and therefore they do not need light. One of the dark-water corals is the Southern cup coral (*Caryophyllia infornata*) which is frequently found in caves and under low lying overhangs[59]. Other species often associated with walls and rocks, such as *Polycyathus muellerae, Parazoanthus axinellae* or *Leptosamnia pruvoti,* are also quite common in this type of habitat[60].

Polycyathus muellerae © OCEANA/ Juan Cuetos

However, many corrals can simultaneously exist in dark zones such as caves and fissures as well as in open zones. The *Halcampoides purpurea*[61] anemone lives in caves, as well as on sandy floors and on gravel. Many daisy anemones, such as *Sagartia elegans* or *S. troglodytes* are not exclusive tube-dwellers of such habitats, but it is common to find them in holes as well. One species which used to be found in wider ranging areas has been found limited to caves, fissures and low lying overhangs in many areas where it is commonly found. This is the red coral (*Corallium rubrum*), which has been intensively harvested in more exposed areas that are easily accessible to fishermen, divers and robots.

Golden anemone (*Condylactis aurantiaca*) © OCEANA/ Juan Cuetos

On muddy and sandy floors

Desert sea floors, or floors composed of fine sediment such as sand and mud, are usually more challenging places for anthozoans to settle on. However, a few species have colonized this terrain in which the colonization strategy must take into account the softness of the substrate. It often shifts, requiring adaptive anchoring systems or complete alternatives altogether.

Some species found on such floors are highly specialized for this habitat. This is the case of the sea feathers, *Funiculina quadrangularis*, *Virgularia mirabilis*, *Pennatula* spp., *Kophobelemnon stelliferum*, etc. They are commonly found in marine deserts and sometimes may

even form dense colonies. In some Atlantic European waters, *Virgularia mirabilis* densities[62] of up to 10 individuals per square meter have been found, making these areas virtual sea feather *forests*.

Many species bury part of their skeleton in the soft substrate in order to anchor themselves, and might even retract their bodies entirely inside the sand or mud. This can be seen with some sea feathers and the anemone *Anemonactis mazeli*. *Cerianthus membranaceus* can submerge its tube one meter into the substrate with only the tentacles of its superior end showing through[63]. Oceana was able to verify the presence of this species in mixed communities of crinoideas (*Leptometra phallangium*) and sea urchin (*Stylocidaris affinis*) in sandy floors below 80 meters.

Another species which is characteristic of these floors, but only at depths of 200-300 meters, is *Isidella elongata*, which is an ideal habitat for crustaceans.

The deep-water anemone (*Condylactis aurantiaca*) only appears on sandy bottoms[64], but it does not delve very far into them, preferring to stay close to sandy areas abutting rock zones. Other anemones which have similar preferences are *Cereus pedunculatus*, *Peachia cylindrica*, and *Andresia partenopea*.

There are also corrals which simply sit on the surface of the substrate without anchoring at all, as with *Sphenotrochus andrewianus*, an infralittoral and circalittoral species.

Hermit crab (*Dardanus* sp.) with *Calliactis parasitica*
© OCEANA/ Juan Cuetos

Dead man's fingers (*Alcyonium palmatum*) © OCEANA/ Juan Cuetos

In shallow waters and at great depths

Very restricted luminosity or even with absolute lack of luminosity is sought after by some species. Excluding those species which live in symbiosis with zooxanthellas, corals are sciaphilic animals: that is, they prefer shady areas and even those with absence of light. Even though the most well-known species are found in surface waters, most of the world's corals grow below the photic zone or optimal light filtration zone. In fact, two-thirds of all known coral species live in dark and cold zones[65]. Deep-sea corals can live at depths of up to 6,000 meters, although the majority live between 500 and 2,000 meters[66].

The Mediterranean is a good example of this "phobia" to light. The oligotrophia of Mediterranean waters shows that species populating shallow areas with greater turbidity do not start to grow until depths of over 30 or 40 meters, where light has been sufficiently filtered by the water column. Even in the Mediterranean, the distribution of species such as the red gorgonian (*Paramuricea clavata*) is strongly influenced by the water's clarity[67]. The Bal-

earic Islands is an example of this: It is one of the zones poorest in nutrients, and therefore the least turbid. Red gorgonian are not seen above 30 meters[68], while in the Gulf of Lion and the Ligurian Sea it is not uncommon to observe them above 15 meters deep.

We know that some species can even spend part of their day out of the water in inter-tidal zones or in tide pools.[69] This is the case of the beadlet anemone (*Actinia equina*). To avoid desiccation and the effects of high salinity, they retract their tentacles to reduce exposure to the air, while simultaneously storing water reserves.

For species composed of 80%-90% water, and as such with a low gast content[70], the challenge to resist pressure at great ocean depths is minor. This allows them to colonize sea abysses at depths greater than 3,000 meters.

However, there are species that seek light, in many cases so that their resident zooxanthellae can photosynthesize it. *Cladocora caespitosa* is mostly found in light-filled or slightly shaded areas, although some colonies have also been found in deep water. The effects of higher temperatures have also been noted. It increases their calcification, so that they usually seek water at temperatures between 11°C and 25°C, but if they are in temperatures above 28 degrees they lose their zooxanthela and turn white[71]. But not all corals prefer warm waters. Temperature, as we shall see in greater detail, is also a limiting factor for certain species of corals. Deep-sea species such as *Lophelia pertusa*, prefer water below 13°C[72], which means Mediterranean depths of 250-300 meters or more.

Dirty water

Dirty water is not a problem for some species of corals. While pollution and turbidity can be fatal for many species of anemones, corals and gorgonians, some anthozoans have become specialists in adapting to damaged ecosystems, such as those found in marine ports or other places with unclean water. This is the case of some anemones such as *Diadumene cincta* and *Aiptasia diaphana*.

Scleractinian corals are often the most demanding regarding environmental conditions. However, there are some that have occupied niche habitats in polluted areas, such as *Oculina patagonica*, frequently seen in commercial ports.

Some corals cluster near locations of anthropogenic spills or runoffs, such as the dead man's fingers (*Alcyonium* sp.). Species which are not too picky can find an important source of nutrition from the outflow of residual waters, which have a high density of suspended matter.

The ease with which they adapt to polluted water has made it possible for the orange striped anemone *(Haliplanella lineate)* to occupy many coastal areas of the Mediterranean. Their arrival in the waters of many European countries has been propagated by ports[73].

Living on the backs of others

The inherent plasticity of anthozoans has not limited their distribution to particular physical habitats, such as rocks, sands, mud or biological debris (shells, coral skeletons or bryozoans) or non-organic substrates. Many species have preferred to live on live organisms such as seagrass, algae or animals. In some instances, the relation between anthozoan and host is an opportunistic and limited

Bunodeopsis strumosa on *Cymodocea nodosa*
© OCEANA/ Juan Cuetos

to being table companions. However, some have managed a more specialized and symbiotic relationships.

On algae and seagrasses

Different anemones, usually smaller ones, have adapted to the substrate afforded them by marine plants and algae in order to settle. Species such as *Bunodeopsis strumosa* are often found on the leaves of marine seagrasses such as *Posidonia oceanica* or *Cymodocea nodosa*. *Paranemonia cinerea* and *Paractinia striata* have similar tastes. *Actinia striata* is more common on seagrasses of the *Zostera* genus.

Others often settle on algae, such as *Gonactinia prolifera*. Some can grow to a large size, like *Anemonia sulcata,* which manages to anchor on large kelp.

Mediterranean snakelocks anemone *(Anemonia sulcata)* on Furbellows kelp *Saccorhiza polyschides* © OCEANA/ Juan Cuetos

Gobius xantocephalus under a colony of *Epizoanthus arenaceus* © OCEANA/ Juan Cuetos

On living creatures ■

Some look for means of transportation to carry them to new sources of food and in exchange lend their irritating tentacles as a form of defense for their host. The most common anemones in this type of trade are the parasitic anemone (*Calliactis parasitica*), the cloak anemone (*Adamsia carciniopados*) and *Hormathia alba,* which are all common on snail shells inhabited by hermit crabs (genus *Pagurus* and *Dardanus*)[74].

When it comes to giving a ride to species such as *A. carcinopados* and *H. alba*, there is usually one on the back of each hermit crab, although some species, such as *C. parasitica*, are limited by the surface area of the hermit crab's shell and the capacity of the crab to drag this weight across the sea floor. Thus, it is not rare to see two, three, or even more anemones on the shells of these animals.

There are also many examples of anthozoans looking for an anchor point from which to optimize access to food sources suspended in

Oculina patagonica © OCEANA/ Juan Cuetos

Orange cluster anemone *(Parazoanthus axinellae)* growing on a sponge from the *Axinella* genus © OCEANA/ Juan Cuetos

the water, without having to go from one to place to another; the entire better if the perch is high up. This is the vantage point of the yellow colonial anemone (*Parazoanthus axinellae*) which often seeks the structures offered by branching sponges of the *Axinella*[75] genus. Other anemones have chosen the familiarity of cnidarians, like *Amphiantus dohrni,* which prefers the knoll offered by the large hydrozoan, or some gorgonians such as *Eunicella verrucosa* or *Isidella elongate*[76]*. Protanthea simplex* seeks its fortune on reefs of *Lophelia pertusa*[77].

In company: corals and symbiotic/commensal animals

The anthozoans have created wide variety of relationships between species. Some of the more well-knows ones, mentioned above, are those maintained with hermit crabs, or the close sharing between various corals and zooxanthellae algae, a type of dinoflagellate which depends on the light intensity and water temperature. Zooxanthellas can be found on the Mediterranean madreporaria (*Cladocora caespitosa*)[78], the snakelocks anemone (*Anemonia viridis*)[79], the *Paranemonia cinerea*[80], in star coral (*Madracis pharensis*)[81], and the Mediterranean cup coral (*Balanophyllia europaea*)[82]. Some symbiotic algae have also been found on *Oculina patagonica*, including some endoliths of the *Ostreobium* genus in the coral's skeleton[83]. These microalgae fulfill other vital functions such as protecting the corals from bleaching and ultraviolet radiation[84].

There are different species of small crustaceans that often live in association with anemones, like *Telmatactis cricoides*. In studies carried out on specimens from the Atlantic Madeira and Canary Islands -which are often larger than Mediterranean specimens- it was found that 86% lived symbiotically with an average of 2-3 shrimps, usually of the *Thor amboinensis*[85] species.

Phyllangia mouchezii catching a mauve stinger jellyfish (*Pelagia noctiluca*) © OCEANA/ Juan Cuetos

In the Mediterranean, the shrimp that most often live in symbiosis with anemones are those of the *Periclimenes* genus, such as *P. sagittifer* or *P. amethysteus*. They often live this way on large specimens of *Anemonia sulcata, Aiptasia mutabilis*, *Cribrinopsis crassa* and *Condylactis aurantiaca*. It is not strange either to see some mysidaceas, such as *Leptomysis lingvura* nestled between the tentacles of these anemones.

Other crustaceans often live in association with corals, such as the cirripedes balanomorphas. *Megatrema anglicum* is often found on club coral (*Caryophyllia smithii*),[86] yellow coral (*Leptopsammia pruvoti*),[87] *Hoplangia durotrix* or corals of the *Dendrophyllia* and *Balanophyllia* genus.

Anemonia sulcata is the queen of specific inter-species relationships. In addition to the species mentioned above, this one can shelter other crustaceans between its tentacles, such as the hairy crab (*Pilumnus hirtellus*), the lesser spider crab (*Maja crispata*), or the spider crab (*Inachus phalangium*).[88] In the latter case, it prefers the more stationary females.[89] It is also the species associated with the only anemone fish of the Mediterranean: the anemone clown fish (*Gobius bucchichii*).[90] *This Mediterranean native makes it different from all other clown fish in the world that belong to the Pomacentridae family, not present in the Mediterranean.*

However, in some cases roles get reversed and it is the anthozoan which is parisitic on other species or even on other anthozoans, as indicated previously with *Parazoanthus axinellae* on sponges (*Axinella* sp.), *Epizoanthus arenaceus, Calliactis parasitica, Adamsia palliata* and *Hormathia alba* on hermit crabs, and *Parerythropodium coralloides* and *Gerardia savaglia* on gorgonians.

Ascidian (*Pycnoclavella taureanensis*) on *Elisella paraplexauroides* © OCEANA/ Juan Cuetos

05.

Coral reproduction

Gerardia savaglia on red gorgonian (*Paramuricea clavata*)
© OCEANA/ Carlos Suárez

The various ways in which anthozoans reproduce has long been used as a method for classifying them, but recent studies[91] show that thee systems which some species use to reproduce depend to a large extent on the characteristics of the colonies and the environmental conditions to which they are subjected.

As such, the same species may use different methods of reproduction, although there may be a single way that is more characteristic for some speices, or at least one observed as such in laboratories or the natural environment. This is a topic which has generated much debate and controversy as well as numerous scientific studies.

Using the current knowledge we have on this matter, we can make the following observations:

Sexual and asexual reproduction

Sexual reproduction, that is, reproduction which requires the participation of males and females for the production of eggs (oocytes) and sperm, has always been considered the most normal way for anthozoans. In addition to oviparous fertility, viviparous has also been noted, whereby the female coral becomes "pregnant" through internal fertilization of the ovocyte resulting in polyps which are then expulsed or delivered into the environment.

Asexual or vegetative reproduction, on the other hand, is carried out by an isolated polyp and new individuals are created without the participation of the other gender. In this way, colonies (or species) arise with only one sex present. Furthermore, asexual reproduction can take various forms. There are descriptions of budding, transversal and longitudinal fission, basal laceration, fragmentation, en-

cystment, and some more typical methods of sexual reproduction, whether oviparous or viviparous, through parthenogenesis.

Some species which appear to primarily use sexual reproduction can also select the vegetative mode under conditions of stress or as an opportunistic preference, or due to the isolation of the colonies or polyps.

Synchronized reproduction

One of the most spectacular methods of sexual reproduction among corals is synchronized reproduction. This is characterized by the synchronization of various colonies of corals (sometimes, from different species), expulsing their sperm and eggs at the same time. This strategy is very common among scleractinians in coral reefs[92], and has also been seen among zoanthias[93] and even octocorallias[94].

With mass production of male and female gametes over a short period of time, the chances that conception will be successful increases and along with the possibility that at least a certain percentage will escape predators.

Red gorgonian (Paramuricea clavata) and yellow cluster anemone (*Parazoanthus axinellae*) © OCEANA/ Carlos Suárez

Moreover, as researchers have observed, some species have demonstrated strategies that increase the chances that their gametes will fuse, by means of a chemical substance which attracts semen.[95]

In the Mediterranean this type of reproduction exists among certain gorgonians, like *Paramuricea clavata*[96], and among madreporarian coral colonies such as *Oculina patagonica*.

In the case of the red gorgonian (*P. clavata*), the synchronization sessions are not unique or concentrated (that is, not all colonies participate in reproduction at the same time), but rather they repeat themselves over several months in spring and summer, three to six days after the full or new moon[97].

It is believed that these time periods may give rise to hybrids.[98] In tropical reefs, some cases have been observed among the *Acropora*[99] and *Montanstraea*[100] genus. In the Mediterranean, no such occurrence has yet to be documented.

Oviparous, viviparous

Depending on the way in which corals reproduce, they can create complete new polyps or intermediary phases. Both oviparous and viviparous reproduction, be it sexual or asexual, has been widely documented in various anthozoans.

In sexual reproduction, the generation of a new lineage may occur by means of eggs and their subsequent fertilization, or else, by fertilization of a female ovocyte in the interior of the female polyp of a coral.

In the case of oviparous reproduction, the eggs are fertilized outside the coral. In some species, they are expulsed outward, while in others they remain stuck to the colony by means of mucus produced by the polyps. They then mature there until the larvae emerge and settle in their surroundings[101].

In most cases, oviparous and viviparous reproduction are the result of sexual reproduction, but they have also been found to occur

Daisy anemone (*Cereus pedunculatus*) © OCEANA/ Juan Cuetos

asexually through parthenogenesis[102]. This sometimes occurs with the red anemone or Beadlet anemone (*Actinia equina*), which is found in the Mediterranean and the Atlantic[103].

Budding, fission and laceration

As we have mentioned above, asexual reproduction can give rise to different means of generation of new polyps. One method which has been widely studied is budding. This consists in the production of a bud or yolk by the female polyp, which grows until another polyp sprouts which either takes its place in the coral that produced it or is expulsed at such a distance that it finds a new location to settle. Although this type of reproduction is more common among cnidarians, such as hydrozoans or scyphozoans, it has also been reported for various anthozoans.[104]

Fission occurs when a polyp gives rise to a new polyp. This may occur by transversal or longitudinal fission, depending on whether the polyp buds laterally or on top of the other one. Transversal fission is more common in other cnidarians, although it may occur in anthozoans as well, but this is thought to be exceptional and nearly always provoked under conditions of stress.[105] Lateral fission is more common among corals and in fact has been found in both octocorallians[106] and hexacorallians[107], such as the orange striped anemone (*Haliplanella lineate*)[108] which has invaded the Mediterranean.

There is another of asexual reproduction which has been found to exist, at least for some anemones[109] and black corals.[110] This is fragmentation- the generation of new polyps from a piece of coral, usually a tentacle.

Egg, larva/planula and polyp phases

Although asexual reproduction may give rise to new polyps, the normal process for many anthozoans is to pass through different phases until reaching the adult state.

Solitary coral (*Balanophyllia europaea*) © OCEANA/ Carlos Suárez

When those which reproduce with eggs hatch, a ciliated larva appears. This is a planula, and for a short period of time (normally a few days) it lives like plankton until it once again anchors to the substrate and gives rise to a new polyp or initiates a colony. What makes it different from all other cnidarians is that it never exists in the medusa phase.

Planulas may be found in the water after newly expulsed eggs that were fertilized by sperm are hatched. They may also come directly from a polyp which was fertilized internally and which instead of liberating an egg, waits until it turns into a planula. In other words, the incubation of the eggs may differ from one species to another. While for red coral it is internal,[111] for red gorgonian it is external.[112]

White gorgonian can produce an average of four eggs per polyp, which means that a colony usually disperses an average of around 6000 planulas[113] into the water. Red coral has a very low reproduction rate of one planula per polyp, on average.[114]

In some species the larva have negative floatability to avoid being swept away by currents and to allow them to settle in the vicinity of the polyp or mother colony, as for example the Mediterranean cup coral (*Balanophylla europaea*).[115]

This negative floatability has also been found in the eggs of zoantharia (*Epizoanthus* sp.), found in the South Pacific at depths between 80 and 200 meters.
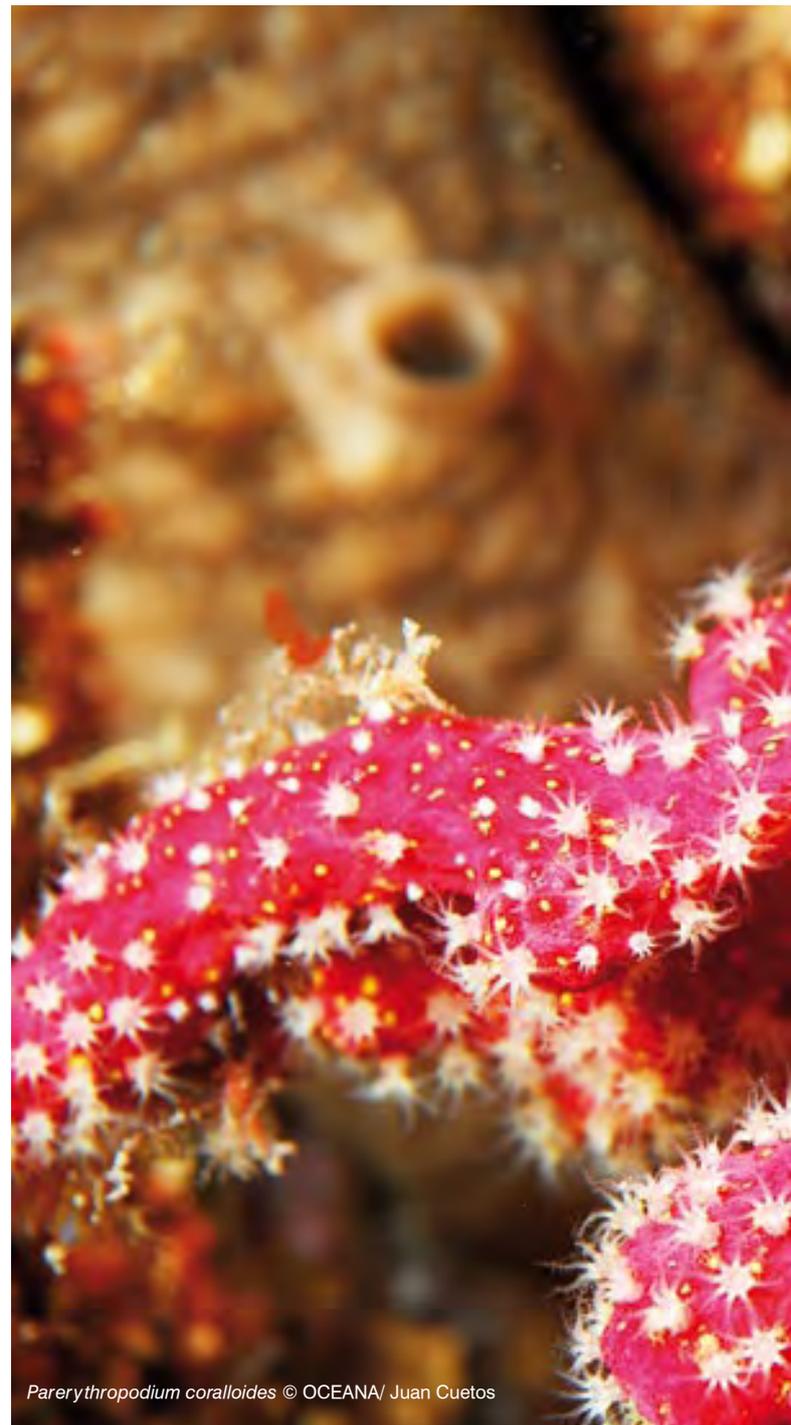
Separate sexes and hermaphrodites

The separation of sexes, that is, the existence of both males and females (gonochorism), is common among corals, not only among individual polyps but also between whole colonies.

In many species in the Mediterranean, the sexes are usually separate. Thus, while a colony is usually composed of exclusively male polyps, another will be exclusively female. This characteristic has been documented in many octocorallian gorgonaceas, such as *Eunicella verrucosa*[116], *Eunicella singularis*[117], *Paramuricea clavata*[118], and *Corallium rubrum*[119], and also in hexacorallians and deep-water species (*Enallopsammia rostrata*, *Madrepora oculata* or *Lophelia pertusa*)[120].

Hermaphroditism is another reproductive strategy of some anthozoans. It is mainly seen in tropical corals of the Pocilloporidae[121] family, although it is not an exclusive trait.

Hermaphroditism can define an entire colony when polyps of both sexes are present, as in the case of the orange coral (*Astroides calycularis*)[122], endemic to the Mediterranean. It can also be individual, when a polyp has both the male and female gamete, as with the colonial coral *Madracis phaerensis*[123] and another endemic coral of the Mediterranean, the solitary

Parerythropodium coralloides © OCEANA/ Juan Cuetos

cup coral *Balanophyllia europaea*[124] (this is a rare trait among dendrophyllidas and unique to this genus).

And of course, in the great diversity of corals morphology, there are species which may have both gonochoric and hermaphrodite characteristics. Hermaphroditism is less common among octocorallians. However, some hermaphrodite colonies have been found among coral colonies of *Carijoa riisei* studied in the Pacific[125] and among the Indo-Pacific gorgonias *Heteroxenia* sp.[126], as well as some Mediterranean colonies of *Pareritropodium coralloides*[127], among others.

06.

The fight for survival

Cerianthus sp. © OCEANA/ Juan Cuetos

Of great importance for the development of corals is the energy expended on reproduction, as it can provoke a decrease in growth rates[128]. In addition, the fight for space with other anthozoans can consume much energy. As such, bigger colonies can better distribute tasks and compete for survival and expansion[129].

Trouble with the neighbours: space

Corals and sponges competing for space © OCEANA/ Juan Cuetos

In the zone where different species of anthozoans, or even colonies of the same species, are found, there is usually a battleground where polyps that are on the "front line" modify their morphology to better fight the competitor. For example, they may develop specialized tentacles[130]. In fact, corals and anemones have different types of tentacles[131]: feeder tentacles; tentacles for capturing plankton and suspended particles; feeler tentacles to find out whether there are enemies lurking nearby. The latter may be up to 10 times longer than the feeder tentacles. Hunting tentacles are those which are deployed for combat.

These tentacles are present in Mediterranean species, such as the plumose anemone (*Metridium senile*)[132] or in the invading orange striped anemone (*Haliplanella lineate*)[133].

In the fight for survival, mortality rate and regeneration can play an important role. The capacity of anthozoans to recover after sustaining wounds varies widely. While some species need centuries to rebuild a reef or colony that has been damaged, others regenerate much more quickly. However, the general trend reflects the long-living and slow-growing nature of the species, and damage, be it natural or anthropogenic, is usually a significant challenge.

Competition for space is also found among other marine organisms. When this happens, different species of hydrozoans, bryozoans, etc. colonize the coral structures and thereby provoke their death by covering it. For species such as *Paramuricea clavata*, death caused by process represents half of the natural mortality rate of the species[134]. For *Eunicella cavolini,* it is the main cause of mortality, along with uprooting[135].

Growth

Corals must deal with various conditions in order to grow and survive in a marine environment,

One of the determining factors on coral growth is the availability of food. This may be favorable in zones with strong currents or where different water masses mix together.

Low levels of sedimentation and turbidity also play an important role.

Most colonies barely grow a few millimeters a year. Such a slow growth rate is especially common in those species which need to grow a calcareous skeleton or create large, branching masses. The longevity of anemones can be quite significant as well.

Unfortunately, little is known about the life of anthozoans, and their growth rate and longevity remains a mystery for a great number of species. However, present data seems to corroborate the estimates regarding longevity. For example, the yellow coral (*Leptosamnia pruvoti*), a colonial scleractinian with a calcium carbonate skeleton, and gorgonian anemone (*Amphianthus dohrni*), a solitary hexacorallia without a skeleton, have estimated life spans of between 20 and 100 years[136].

Examples of growth and longevity studied in some anthozoans[137]

Species	Basal growth (mm/year)	Vertical growth (mm/year)	Longevity (years)
Cladocora caespitosa	0.7 - 1.6	3.28 - 6.06 2.9 - 5.2 2.79 - 6.07 1.36 - 4.42	300
Corallium rubrum	0.24 - 0.64		98
Desmophyllum cristagali	0.5 - 2 0.1 - 3.1	0.5 - 1	70 - 160
Enallopsammia rostrata	0.07	5	210
Primnoa raesediformis		1.6 - 2.32 1.5 - 2.5	+ 200
Lophelia pertusa		5.5	
Balanophyllia europaea	0.23 - 2.49	1.1 - 2.4	20
Eunicella verrucosa		6 - 10	50 - 100
Paramuricea clavata		18	+ 30
Leptosamnia pruvotii			100 ?
Amphianthus dohrni			20 - 100

Leptosamnia pruvoti and *Hoplangia durothrix*
© OCEANA/ Juan Cuetos

The false black coral (*Gerardia savaglia*) might possibly be the longest living colonies in the Mediterranean. It is the only zoantharia that can produce a skeleton. In the Pacific, colonies of other species of the genus *Gerardia* might reach 2,700 years of age.[138] In the Mediterranean, it is believed that some *G. savaglia* formations might be more than one thousand years old.

There are specific techniques used to measure the growth of corals. In older colonies, dating can be done with carbon (Ca^{14}) or other representative isotopes[139], such as lead (Pb^{210}), radium (Ra^{226}), thorium (Th^{230}) or uranium (U^{234}). For younger animals, the rate of the increase in the thickness and vertical expansion of a polyp or colony can be monitored. Some of the most efficient methods for some species are similar to those used for trees: the rings that form in the skeleton of anthozoans are counted. This has been carried out successfully with sea feathers[140], gorgonians[141] and scleractinian corals[142].

Size matters

There is a correlation between size and the age of anthozoans, as well as the nature and extent of damages they may suffer[143]. Larger specimens are more vulnerable to incurring serious damage, although they also show better resiliency in regenerating, while younger specimens have a limited or absent response, although damage may be lesser. This is why the size of colonies is an important factor in the survival of species.

Damage suffered by the colony also brings to light one of the main causes of mortality among anthozoans: excessive growth of epibionts[144].

Size is not only important for corals or a colony, but it is also a significant factor for a population as a whole. With species such as *P. clavata,* which depend on synchronized reproduction involving numerous colonies, the larger the population, the larger the chances that new colonies will be generated and that the species will survive. The mass mortality suffered by this species in recent years might endanger the survival of this characteristic Mediterranean species.

Overgrowth of algae, hydrozoans and sponges on red gorgonian (*Paramuricea clavata*) © OCEANA/ Carlos Suárez

A seat at the table: coral nutrition

Most anthozoans are suspension feeders. They extend their tentacles and wait for small organisms and particles floating in the water to touch them. Their cnidos then shoot out to catch the nutrients which are brought into their oral disc and subsequently introduced into their gastrovascular sac. The other common form of coral feeding is the use of a mucus layer which particles in suspension adhere to, and are then brought to the digestive tract with the help of cilia.[145]

For some corals, a large part of their nutrition comes via their symbiotic relationship with small algae living in their gastrodermis. In most cases, these algae are dinoflagellates (zooxanthellas), although green algae have sometimes been found (zoochlorellas).[146]

Another method is to absorb the cells of organic matter dissolved in the water directly through the ectoderm[147].

In the case of soft corals, such as dead man's fingers, plankton is caught through absorbing water and filtering it like sponges.

Most corals are carnivorous. They feed on zooplankton, although they can also combine this nutrient with small algae or even bacteria. Polyps can also catch prey of even greater size, such as jelly fish. Anemones may even try to catch crustaceans and fish.

Crustaceans are often an important part of the diet of many anthozoans, although what is actually ingested can vary greatly according to the species. Tuft coral (*Lophelia pertusa*) has been observed catching cumaceans and copepods[148], while Mediterranean snakelocks

Dead man's fingers (*Alcyonium acaule*)
© OCEANA/ Thierry Lanoy

Red coral (*Corallium rubrum*) © OCEANA/ Carlos Suárez

anemones (*Anemonia sulcata*) and *Cereus pedunculatus* feed on amphipods and decapods. In the case of *Actinia equina*, their preferred food tends to be detritus[149], while the red gorgonian (*Paramuricea clavata*) ingests eggs and larva[150].

Guess who's coming to dinner: natural predators of corals

The cycle of nature some eat and others are eaten. Corals also form part of the diet of certain animals. While the presence of stinging cells and toxic substances in their bodies has

reduced the number of predators preying on them, some species have become immune to their venom and have specialized in consuming them.

In the Mediterranean, there are not any fish which consume corals, unlike in coral reef where it is quite common. Here, the main consumers of corals are mollusks, although there are also some arthropods and worms that choose to feed on polyps.

The most common coral-eating mollusks are snails, especially ovulidas and coralliophilas.

As with Caribbean ovulidae such as the flamingo tongue cowrie (*Cyphoma gibbossum*), they feed on gorgonians. Mediterranean mollusks have become specialists of this type of octocorallian. One of the more common species is *Neosimnia spelta* which devours polyps and live tissue of gorgonians[151] such as *Eunicella verrucosa*, *Eunicella singularis* and *Leptogorgia sarmentosa*. Other species of ovulidae in the Mediterranean are *Pseudosimnia carnea*, *Simnia nicaeensis*, *Simnia purpurea*, *Aperiovula adriatica*, *Aperiovula bellocqae*, *Globovula cavanaghi* and *Pedicularia sicula*.

Spinimuricea atlantica
© OCEANA/ Juan Cuetos

Regarding the coralliophilae snails, most are Indo-Pacific species, but there are at least a dozen in the Mediterranean as well[152], including *Coralliophila meyendorffi* and *Babelomurex cariniferus*[153]*,* which often feed on the *Cladócora caespitosa* polyp. Other Mediterranean species are *Babelomurex babelis, Coralliophila brevis, Coralliophila sofiae,* and *Coralliophila squamosa*.

Other mollusks which have also been observed feeding on corals are the epitoniidae snails, such as *Epitonium dendrophyllidae,* which consumes orange corals (*Astroides calycularis*)[154], and some nudibranches, such as *Okenia elegans,* which can feed on *Paramuricea clavata*[155].

The bearded fireworm (*Hermodice carunculata*) is a polychaete which is found in wide ranging areas of warm and temperate Atlantic waters[156], and can reach lengths of up to 40 cm. Although their diet consists mostly of carrion and decomposed matter (saprophagous), it also devours coral polyps. In the Caribbean, it usually feeds on different species of gorgonians[157] and hydrozoans[158]. In the Mediterranean, its source of nutrition is usually *Oculina patagonica*[159].

Pycnogonids (*Pycnogonum littorale)*, or sea spiders*,* feed on diverse actinias[160], including the plumose anemone *(Metridium senile)*[161]. Red coral may suffer attacks from mollusks and crustaceans, such as *Pseudosmnia carnea* and *Balssia gasti,* respectively[162].

Finallly, in more recent times, human beings have also added anthozoans to their diet. In some areas of the Mediterranean, some species of anemone are sold under the generic name "sea urchin" or "urchin" for certain gastronomic dishes.

Corals with light

One of the adaptive advantages of some marine species is the possibility of successfully surviving in certain habitats by carrying their own lantern. The luminescence they create may be used to attract prey, avoid predators, communicate, and search for a mate, as well as other functions that are still being researched.

Although for many animals bioluminescence is due to the presence of bacteria such as *Vibrio fischeri* or the existence of specialized cells, corals owe this feat to the presence of luciferin and the enzyme luciferase, which catalyzes its own oxidation and produces light.[163] Although, like in other cnidarians, it is possible that some species do not need luciferase for their bioluminescence and instead produce a photoprotein (coelenterazine), which reacts in the presence of Ca^{2+} to produce the chemical reaction.[164]

The pennatulaceas are the octocorallians that have been shown to demonstrate bioluminescence most often. In the Mediterranean, this has been found in *Cavernularia pusilla*, *Veretillun cynomorium*, *Funiculina quadrangularis*, *Virgularia mirabilis*, *Pennatula rubra*, *Pennatula phosphorea* and *Pteroides spinosum.*[165]

Outside of sea feathers, bioluminescence is quite rare among octocorallians. It has only been observed in a single genus of Pacific alcyonidae (*Eleutherobia* sp.[166]) and in a few species of gorgonians of the Isididae family,[167] such as *Lepidisis olapa, Keratoisis* sp., *Primnoisis* sp., o *Isidella elongata.* The latter may also be found in the Mediterranean.

The only species of anemone which has been found to have bioluminescent properties is the *Hormathia alba*[168], a common species in the Mediterranean and in some areas of the Atlantic. This species which can also live on the shells of hermit crabs.

In other species, bioluminescence is exchanged for phosphorescence[169], as with Mediterranean snakelocks anemone (*Anemonia sulcata*).

Corals that move

Most anthozoans are anchored to the substrate on which they live and stay in the same spot for their entire lifespan. Only during the larval stage do the ciliated planula of some coral and gorgonian species move freely in the sea.

However, some species of anemones or sea feathers can change their location in search of a better one. Or, with the help of a symbiont, they may travel great distances, as with the anemone that lives on the shells of the hermit crab.

Some of them can slowly move away from areas that have become hazardous to their survival, as with *Actinia equina, Anemonia Sulcata, Anthopleura ballii* and *Sagartia* sp., which can move a few centimeters with the help of their basal disk to avoid exposure following low tide, to flee an enemy or to avoid a light source[170].

Others, such as the *Paranemonia cinerea*[171], can migrate by moving vertically to new locations according to the season or to hibernate on the sea floor among plant detritus, awaiting a rise in the temperature for them to climb onto the leaves of marine seagrasses.

Others, such as *Telmatactis forskali*[172], can swim short distances using their tentacles as fins. This behavior has also been observed in *Bunodeopsis strumosa*, especially when they fall from a seagrass blade. This behaviour has also been observed in anemones of the genus *Boloceroides* and *Gonactinia*[173].
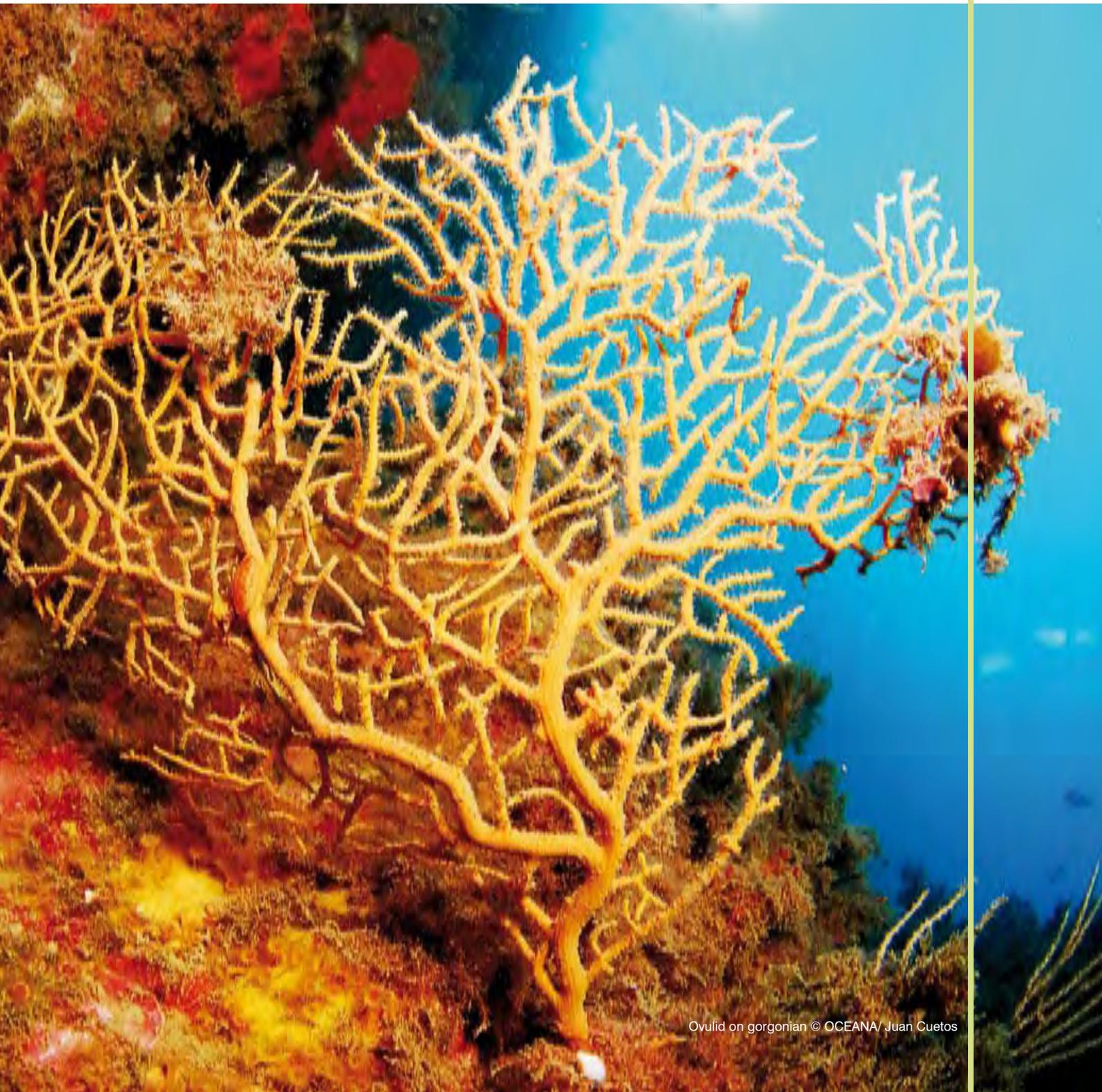
Still others are crawlers that use their tentacles to creep along the sea floor, covering several meters in search of a new place to perch themselves. Some studies[174] have shown that tube anemones of the genus *Cerianthus y Pachycerianthus* can move across the sediment. This behavior has also been observed in sea feathers after they have been torn from their original anchorage point, dragging themselves across the sea bed until they borrow in once again, or swelling up and letting the current carry their bodies to a new location[174].

Cerianthus sp. © OCEANA/ Juan Cuetos

07.

Threats to corals

Ovulid on gorgonian © OCEANA/ Juan Cuetos

Coral diseases

At least 18 diseases have been identified around the that can have a massive effect on corals.[176]

Diseases detected in corals

ASP = Aspergillosis
DSD = Dark Spots Disease
PLS = Pink Line Syndrome
SEB = Skeletal Eroding Band
VCB = *Vibrio corallilyticus* Bleaching
WBD I = White Band type 1
WPD = White Pox Disease
WPL II = White Plague type 2
YBD = Yellow Band
BBD = Black Band Disease
FPS = Fungi-protozoo Syndrome
SDR = Shut Down Reaction
SKA = Skeletal Anomalies
VSB = Vibro shiloi Bleaching
WBD II = White Band type 2
WPL I = White Plague type 1
WPL III = White Plague type 3

In many cases, mortality is caused by an increase in water temperature or abnormally long periods of high temperatures. In some cases, the pathogen responsible for mortality has not been identified, but in at least 10 of the infections, marine and land fungi, cyanobacteria, bacteria, protozoa, nematodes, algae and crustaceans have been the cause of some of the documented symptoms.

In aspergiliosis (ASP), the infectious agent is the land fungus *Aspergillus sidowyi*[177], which mainly affects gorgonians of the genus *Gorgonia*. In black band disease (BBD), a multitude of microorganisms such as cyanobacteria[178] *Phormidium corallyticum* and *Trichodesmium* spp., *Cyanobacterium* sp., bacteria[179] (*Desulvovibrio* spp., *Beggiatoa* spp.) and marine fungi[180] have been detected. In the Fungo-protozoico Syndrome (FPS), it

Black Band Disease (BBD) in a tropical coral (*Siderastrea* sp.) © OCEANA/ Houssine Kaddachi

is fungi (*Trichoderma* spp., *Clodosporium* spp., *Penicillum* spp. and *Humicola* spp.) and protozoa[181]. Pink Link Line Syndrome (PLS) has been linked to cyanobacteria[182] (*Phormidium valderianum).* Skeletal Eroding Band (SEB) is attributed to a protozoan[183] (*Halofolliculina corallasia*). For Skeletal Anomaly Syndrome (SKA), land fungi[184] such as (*Aspergillus sydowii*) and *endolíticos*[185] have been shown to play a part, in addition to algae[186] (*Entocladia endozoica* and the Syphonals), nematodes[187] (*Podocotyloides stenometra)* and crustaceans[188] (*Petrarca madreporae).* Coral bleaching by bacteria (VCB and VSB) is caused by the bacteria *Vibrio coralliilyticus* and *V. shiloi*[189] respectively. A bacterium[190] (*Vibrio charcharia*) has been identified in cases of White Band Disease. White Pox Disease (WPD) also appears to be provoked by bacterium[191] (*Serratia marcescens*). And in White Plague (WPL), another bacterium, *Aurantimonas coralicida*[192]*,* seems to be the origin of the disease.

Sea fan *(Gorgonia ventalina)* suffering from Aspergillosis (ASP) © OCEANA/ Houssine Kaddachi

More than 50 species have been affected by high mortality rates or degradation processes which have been traced to the diseases mentioned above. Although the majority of these cases occur in tropical reefs, two of them have been detected in the Mediterranean (VSB and FPS).

In the summer of 1999, a massive die-off of anthozoans and other animals (mollusks, bryozoans, tunicates, and sponges) took place during high waters temperatures down to more than 40 meters deep in the sea of Liguria and the French coasts of Provence[193]. The corals that were affected were red gorgonian (*Paramuricea clavata*), white gorgonian (*Eunicella singularis*), yellow gorgonian (*Eunicella cavolini*), pink gorgonian (*Eunicella verrucosa*), red corrals (*Corallium rubrum*), (*Leptogorgia sarmentosa*), Mediterranean madreporaria (*Cladocora caespitosa*) and yellow colonial anemone (*Parazoanthus axinellae*). In some areas, between 60% and 100% of the existing colonies were killed, resulting in the deaths of millions of gorgonians and other anthozoans[194].

For reasons still unknown, the female polyps of the *P. clavata* population had an especially high mortality rate.[195]

Studies have shown that gorgonians suffered a high degree of stress due to the high temperatures and were susceptible to a while range of microorganisms, including fungi and protozoans. As a result, this disease was named as the Fungio-protozoo Syndrome (SFP).

These occurrences have not been isolated cases. In colonies of *Parazoanthus axinellae*, the mortality rate was repeated over various years, considerably reducing the presence of this species in Portofino and other zones of the Ligurian Sea. Recently, these mortalities have been blamed on high temperatures and the proliferation of a number of pathogenic agents such as cyanobacteria of the *Porphyrosiphon*[196] genus.

In 2003, new mortalities were registered in anthozoan populations of the Mediterranean, which this time extended beyond the French and Italian coast to Spanish waters. During

Bearded fireworm (*Hermodice carunculata*)
© OCEANA/ Juan Cuetos

that year, a high mortality rate among red gorgonians (*Paramuricea clavata*) was detected and traced to the overgrowth of mucilage[197] and madreporaria (*Cladocora caespitosa*) with necrosis[198] in the Columbretes Islands Marine Reserve, which affected more than 60% of the colonies of both species. Similar mortality rates were detected in other coralline algae colonies from Cabo de Creus to Cabo de Palos[199]. All cases pointed to abnormally high water temperatures.

The high mortality rates of red gorgonians in the straits of Messina were also attributed to high water temperatures and the concurring increase in mucilaginous algae (*Tribonema marinum* and *Acinetospora crinita*)[200]. The same causes were traced to episodes of bleaching observed in Mediterranian madreporaria corals, (*Cladocora caespitosa*), Mediterranean cup coral (*Balanophyllia europaea*) or Argentinean coral (*Oculina patagonica*) in different zones of the western and eastern Mediterranean over the last few decades[201].

Bleaching is usually attributed to the bacteria *Vibrio shiloi*, which can cause extensive damage in large swathes of *Oculina patagonica* colonies*;* however, the bacteria appears to be sensitive to ultraviolet radiation, which has therefore spared the more shallow coral colonies[202].

Recently, the bearded fireworm (*Hermodice carunculata)* has been proven to be a disease vector for corals. This polychaete can act as a winter reservoir for pathogens[203], preventing the bacteria from dying in cold water months and allowing them to spread outside once ambient temperatures rise again.

Climate change

As we have already seen, climate change has been behind the mass die-offs of anthozoans that have occurred in recent years in the Med-

iterranean Sea. But aside from diseases and bleaching, higher water temperatures have other pernicious effects on anthozoans.

Due to the release of carbon dioxide emissions into the atmosphere, it is predicted that the oceans will increase their absorption of CO_2, thereby provoking changes in the chemical composition of the water. A larger quantity of CO2 leads to a lower pH of water, increasing the acidity of the oceans and reducing the availability of carbonate ions. The consequence of this is a reduced calcification rate[204], which will affect many marine organisms that need calcite or aragonite to form their skeletons, like corals.

If we take into account that calculations forecasting conditions over this millennium say that the oceans will absorb 90% of anthropogenic CO_2[205], we can understand the changes this will have on the marine ecosystem. Studies indicate decreases in calcification around 40% over the next 50 years, and can even decrease as much as 80% before the end of the century.
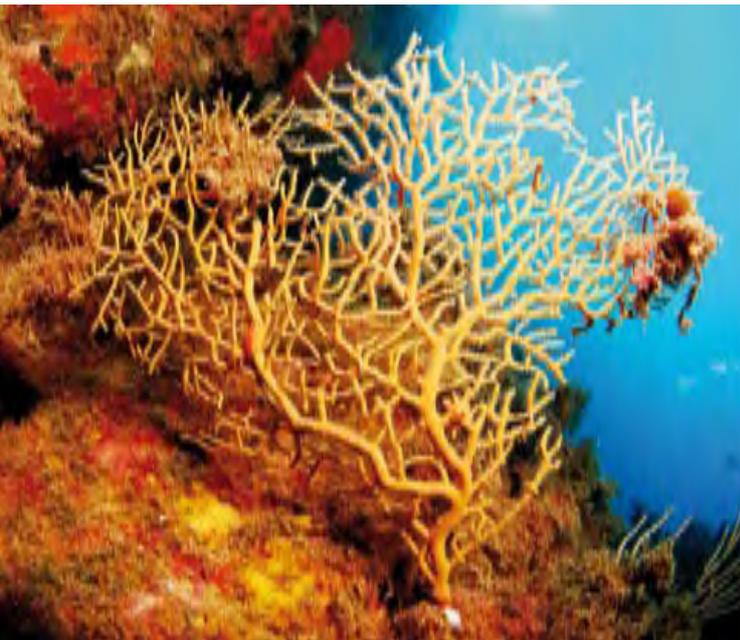
In the Mediterranean, climate change is bringing with it other threats to coral life: changes in the abundance of species that are sensitive to changes in water temperature and the introduction and spread of non-native species which may compete with the Mediterranean ones[206].

Other anthropogenic effects on corals

Ripping out colonies
In areas that are popular with divers, the natural mortality rate of gorgonians is increased three-fold by damages and uprooting that occur there[207]. Significant amounts of death are caused by divers ripping out gorgonians and other large anthozoans through bad diving practices and by damage inflicted through the anchoring of boats in areas where these

colonies are present. Some protected areas in the Mediterranean, such as Medas Islands in Spain or Port Cros in France have suffered damage caused by excessive diving and anchoring in vulnerable zones[208].

Ovulid on gorgonian © OCEANA/ Juan Cuetos

Chemical pollution

There is very little data on the effect of chemical pollution on corals. However, some episodes of gorgonian and red coral mortality have been traced to it. For example, in deep waters of the Mediterranean (80-160 meters) in 1987, mortality trends were linked to high rates of organochlorides such as PCB at the mouth of the Rodan Estuary[209].

Burial and colmatation

For many species of corals, sedimentation levels are a natural limiting factor. This is why it is not common to see gorgonians or corals close to the mouths of rivers or in horizontal seabeds where the colmatation (high level of sedimentation) occurs at a great rate. Conversely, they are more common on rocks and vertical walls where sedimentation is less likely[210].

Dredging, beach regeneration, and the construction of coastal infrastructure may move large amounts of sediments or create a change in the location of deposition, thereby affecting corals. It is known that the mechanisms which corals use to avoid burial by an excess of sediment have a high energetic cost associated with them[211]. Furthermore, in some seas such as the Caribbean, the high rate of sedimentation has been traced to diseases that affect gorgonians[212].

Fishing and corals

One of the greatest threats to corals are the various fishing techniques and fishing gears which damage colonies or rip them from the substrate they are anchored too. Bottom trawling and other such methods requiring dragging nets across the sea floor have the gravest impact on these animals.

Oceana has also been able to verify the impact of other fishing gear in contact with the seabed (fixed nets, longlines, and traps). While setting or removing the gear, or while they are dragged by marine currents, they can snag on corals, rip them from their substrate or lacerate them. Nevertheless, dredging and trawling are the techniques which cause the most damage and mortality to populations of coral, gorgonians, sea feathers and anemones. Each day more studies verify the damage these types of gear cause to corals and other benthic sea life[213].

It is well known that trawling is the principal cause of the deterioration of these ecosystems in many parts of the world.[214] Scientists have recognized that "in general, wherever trawlers drag over coral reefs there is a chance that serious damage will be caused".[215] The Secretary General of ICES, David Griffith, considers that "*dragging a heavy net over a deep-sea reef is similar to driving a bulldozer through a natural reserve. The only way to*

protect those reefs is to find out where they are located and to prevent the trawlers from dragging their nets over them".

Various studies have revealed the damage inflicted on coral reefs by different fishing techniques in zones of Atlantic of depths between 200 and 1,200 meters.[216] Trawlers can destroy up to 33 km² of habitat on the continental shelf in less than 15 days.[217] The United States National Marine Fisheries Service (NMFS) has estimated that in Alaska alone a single trawler can rip out 700 kilos of deep-sea coral in a single cast.[218]

In the Mediterranean, it has been shown that fishing for crustaceans over bottoms with fine sediments that shelter the *Isidella elongata* gorgonian and sea feathers (*Funiculina quadrangularis*) provokes a significant loss of biodiversity.[219] Furthermore, the surfaces harboring these two species in the western Mediterranean have almost disappeared completely due to this type of fishing.[220]

Different conclusions derived from observing gorgonians damaged by fishing gear show how extremely vulnerable their colonies are, as well as the long recovery time they need, sometimes exceeding a century.[221]

But corals do not only suffer damage from direct impacts. Some colonies can be buried or suffer severely reduced feeding capacity due to water turbidity from resuspended sediments after bottom trawling events. The sediment stirred up by trawlers can be redeposited hundreds of meters deeper than its original location, leading to sessile organisms very far away being buried.[222]

When a colony is damaged by fishing gear or anchors, it can lead to the opportunistic settlement of epibionts (hydrozoans and bryozoans) which can then finish them off- by either a coverage that prevents the polyps

from feeding, or by creating a greater surface area that is resistant to wave action and currents. They can also be colonized by nematodes and polychaetes which can weaken the colony.[223]

Some fisheries management measures in the Mediterranean could avoid causing damage to some populations of anthozoa.

One regulatory proposal for fishing in the Mediterranean presented by the European Commission[224] seeks to prohibit trawling in waters less than 50 meters deep and to thus protect some of the most vital ecosystems of this sea, such as coralline algae. These measures have been accepted by countries such as Spain and are now part of their national legislation[225] (although there is a lack of a consistent characterization of Mediterranean seabeds, which prevents more efficient protection of these areas). Unfortunately the proposal has not yet been applied in all territorial EU waters because it has been repeatedly blocked by some Mediterranean countries, provoking a legal loophole which only bnefits destructive fishing techniques and accentuates the destruction of benthic habitat.

On the other hand, recent decisions rendered by the General Fisheries Council for the Mediterranean (GFCM) prohibit trawling below a depth of 1000 meters[226] and in some marine seamounts and coral reefs[227] could help conserve some reefs and gorgonian gardens in this sea.

Unfortunately, illegal fishing in prohibited areas is a common practice in the Mediterranean, which means that no species of coral is safe from menace.

08.

Coral uses

Tree coral (*Dendrophyllia ramea*) © OCEANA/ Juan Cuetos

Commercial exploitation of corals

Some species of coral have been sought and collected since antiquity because of their attractive appearance. They have been used as elements of jewelry and costume accessories, and more recently, souvenirs.

The jewelery industry has focused on the exploitation of so-called "precious corals". Among these are the various species of the *Corallium* genus. The most sought-after are those that may be found throughout the Mediterranean and adjacent Atlantic waters, such as the red Mediterranean coral (*Corallium rubrum*). Also highly prized are those of the Pacific, like the red Pacific coral (*Corallium regale*), pink corals (*Corallium secundum* y *C. laauense*) and others (*C. japonicum, C. nobile, C. elatius*). Black corals, blue coral (*Heliopora coerulea*), and recently, bamboo corals (*Keratosis, Isidella,* and *Lepidis* genuses) are also used. 'Golden' corals (*Gerardia, Narella, Calyptrophora* or *Callogorgia* genuses) are also used, although they are less valuable as jewels due to their porosity, small size, fragility and other qualities which make them unsuitable, and they generally wind up on the *souvenir* market. The large colonies of false black coral (*Gerardia savaglia*) extracted from the Sea of Marmara are also used to make costume jewelry[228].

In the Mediterranean, red coral has been the most prized species and has given rise to an industry specialized in extracting it, which has had a large impact on the species and on the seabed itself.

The intensive exploitation of this octocorallians has caused a nearly 70% reduction in the last decades[229]. Extraction has gone from around 100 tons caught per year at the end of the 1970s, to catches of barely 30 tons per year barely 20 years later[230].

Today is it a rare species despite the fact that it once had a density of more than 1,000 colonies per square meter. That density is only extant today in marine protected areas or in places where access is difficult. Furthermore, many of the colonies existing today are small. In Spanish areas where red coral exploitation is still permitted, 91% of the colonies measure less than five centimeters tall[231]. In Italy, 66% of the colonies that were studied are not reproductive[232].

Red coral (*Corallium rubrum*) © OCEANA/ Juan Cuetos

The extraction of these corals has traditionally involved very destructive methods, such as the 'San Andrés Cross' or the 'Italian Bar'. The latter instrument consists of a metal bar weighing over a ton with chains and crests made of nets attached to it. This was dragged over the seabed and broke apart the coral. Only a small portion of the uprooted coral was actually captured in the nets and recuperated, while the rest lay lost and dead on the seabed. Sometimes there were up to 2,000 boats dedicated to capturing red coral[233].

In 1994, the EU[234] prohibited the use of the 'San Andrés Cross' and similar systems for capturing red coral, but this method has yet to be included among those prohibited by the Bern Convention.

Tree coral (*Dendrophyllia ramea*) © OCEANA/ Juan Cuetos

Today, extraction of red coral is mainly performed by divers[235] who collect it at depths of up to 120 meters, although in some areas they use remotely operated robots with mechanical arms.

Torre del Greco (Italy) is the main market for precious Mediterranean coral. The lack of red Mediterranean coral has obliged the industry to seek imports mainly from other areas, especially in the Pacific. Today the town operates a coral industry which is valued at more than 30,000 million dollars per year[236].

Given the small sizes of most colonies that still exist today in the Mediterranean, in the last few years a new system to exploit and sell the smaller colonies has come into existance. It consists of melting down the specimens which bear little market value due to their small size, and generating a soft paste used to make various articles of costume jewelry.

Although there organized market, other species of anthozoa may also join the ranks of the souvenir items, like *Cladocora caespitosa* or *Dendrophyllidae* spp. and other scleractinians.
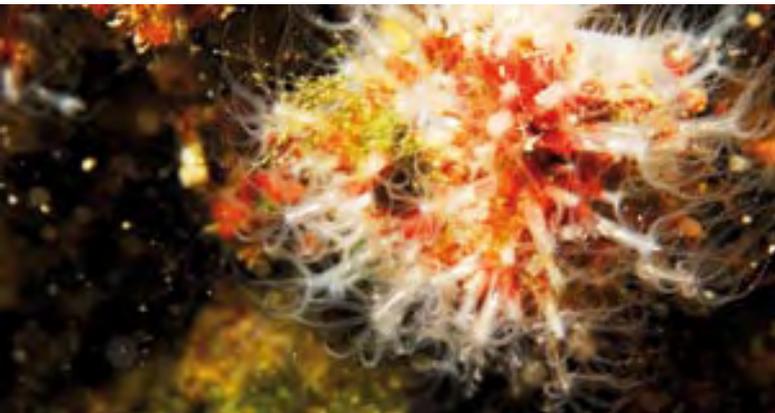
Corals and medicine

Over the last decades, biomedical research has looked to the sea as a source of new medicine. Sponges and actinia have been among the animals in which new composites for pharmaceutical use have most frequently been found, along with the cnidarians. Gorgonians, corals and anemones are supplying raw materials and useful information to fight diseases. The Mediterranean is seen as an excellent place to seek these species.

Antivirals have been found in the yellow gorgonian (*Eunicella cavolini*).[237] The synthetic composite 9-β-D-arabinosiladenina (ara-A) has been found to be analogous to espongotimidina, a metabolite which is naturally produced by this species along with its close 'cousin' spongouridine, analogous to 1-β-D-arabinofuranosiluracil, (ara-U).

Gorgonias are also important as sources of diterpenes: the eunicellin present in the white gorgonian (*Eunicella singularis*)[238] or palmonine found in the pink gorgonian (*Eunicella verrucosa*)[239] are other examples. Other anthozoa have also contributed their share, with

Eunicella cavolini © OCEANA/ Juan Cuetos

Sarcodyction catenatum © OCEANA/ Juan Cuetos

cembranolides being found in false red gorgonians (*Parerythropodium coralloides*)[240] and sarcodictine in Stolonifer coral (*Sarcodyction catenatum*).[241]

One must not forget the sesterterpene cladocoranes found in Mediterranean madreporaria (*Cladocora cespitosa*)[242], which has pharmaceutical value in the treatment of various diseases, including cancer, as it has potential antitubercular and antibacterial properties that inhibit the growth of Gram-positive bacteria.

Equally important is the false black coral (*Gerardia savaglia*), which has been found to contain lectin which could potentially be used in the treatment of the Human Immunodeficiency Virus (HIV)[243].

New applications for phosphorescent proteins found in some anthozoa are also being sought for their use in detecting and visualizing cancerous cells[244].

Anthozoans have great pharmaceutical potential and one of the most singular characteristics of these animals, is their stinging cells and the toxins they contain. As is well known, venoms are very useful compounds in medicine. There are very varied compounds found in corals, including peptides, proteins, phospholipids, phospholipase, glycoproteins, sterols, bioactive amines and carbohy-
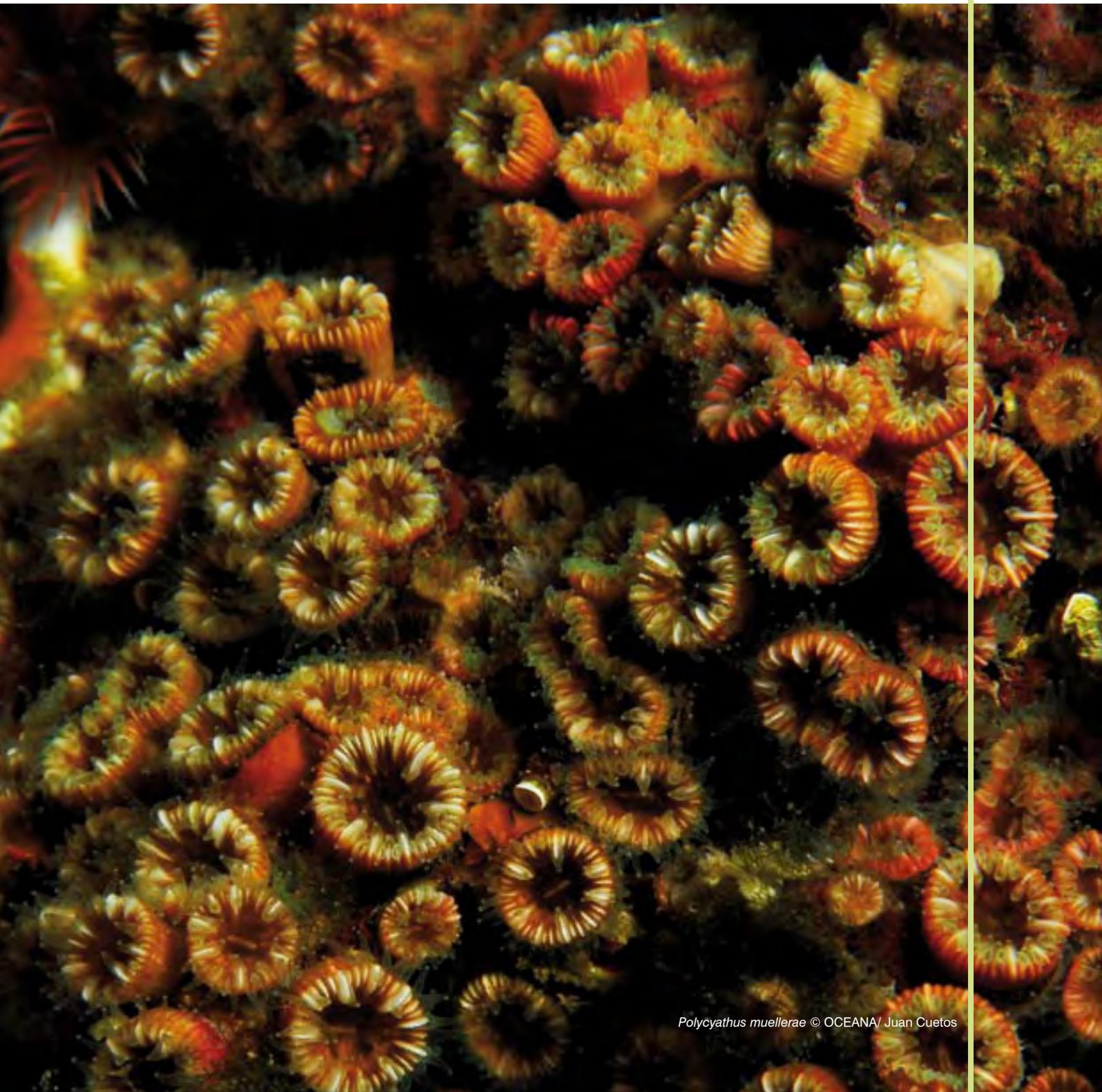
drates[245]. For example, the paralyzing toxins born by certain anemones, such as those in the *Anthopleura* and *Anemonia* genus, could be useful as local anesthetics[246]. The equinatoxin found in the beadlet anemone (*Actinia equina*) may be useful for controlling cholesterol levels[247].

Gerardia savaglia © OCEANA/ Juan Cuetos

09.
Protected corals

Polycyathus muellerae © OCEANA/ Juan Cuetos

Invertebrates are the forgotten 'souls' of national, international and EC legislation. It is even worse if they happen to live in the oceans. This is why corals are hardly present in conservation proposals and laws despite their great importance to oceanic ecosystems.

Of the nearly one and a half thousand species listed in the annexes of the EU Habitats Directive, less than 200 are invertebrates. Of these, eight are from the sea, and only one is an anthozoan. Furthermore, of the nearly 200 habitats listed therein, only nine are marine habitats and only one is directly related to corals: the reefs.

In the Bern Convention, the annexes list around 2000 species, of which 130 are invertebrates, some 40 are of marine origin, and five are anthozoans. Moreover, the list prohibiting capture techniques and gear does not include a single vertebrate except in the section regarding the use of explosives and venom for harvesting decapods (crustaceans).

In the Washington Convention (CITES) for controlling the international commerce of endangered species of plants and animals, the three appendices list nearly 35,000 taxons, but only 2,100 of these are invertebrates. In Annex II, however, there are a number of anthozoans, including all of the species belonging to the orders Sclaractinia and Antipatharia, as well as the helioporidae and tubiporidae families, which brings the total to more than 1,200 species.

In Europe, there are also some conventions which refer exclusively or particularly to the sea. These are the Barcelona Convention for the protection of the Mediterranean Region and the OSPAR Convention for the protection of the marine environment of the North-East Atlantic.

The Barcelona Convention comprises several different protocols. The Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean is the one focused on marine animals and plants. Together they list some 120 species among the different annexes: 48 are invertebrates, but only five of them are anthozoans.

OSPAR Convention does not include a single anthozoan and only two of the 14 priority habitats have some type of relation to corals: *Lophelia pertusa* reefs and the sea feather clusters and other species which are able to burrow.

Furthermore, the the World Conservation Union (IUCN), which has evaluated over 40,000 species,[248] only includes three anthozoans among the nearly 4,000 invertebrates that were analyzed: The Ivell anemone (*Edwardsia ivelli*), the starlet anemone (*Nematostella vectensis*) and the pink gorgonian (*Eunicella verrucosa*). These last two are classified as vulnerable.

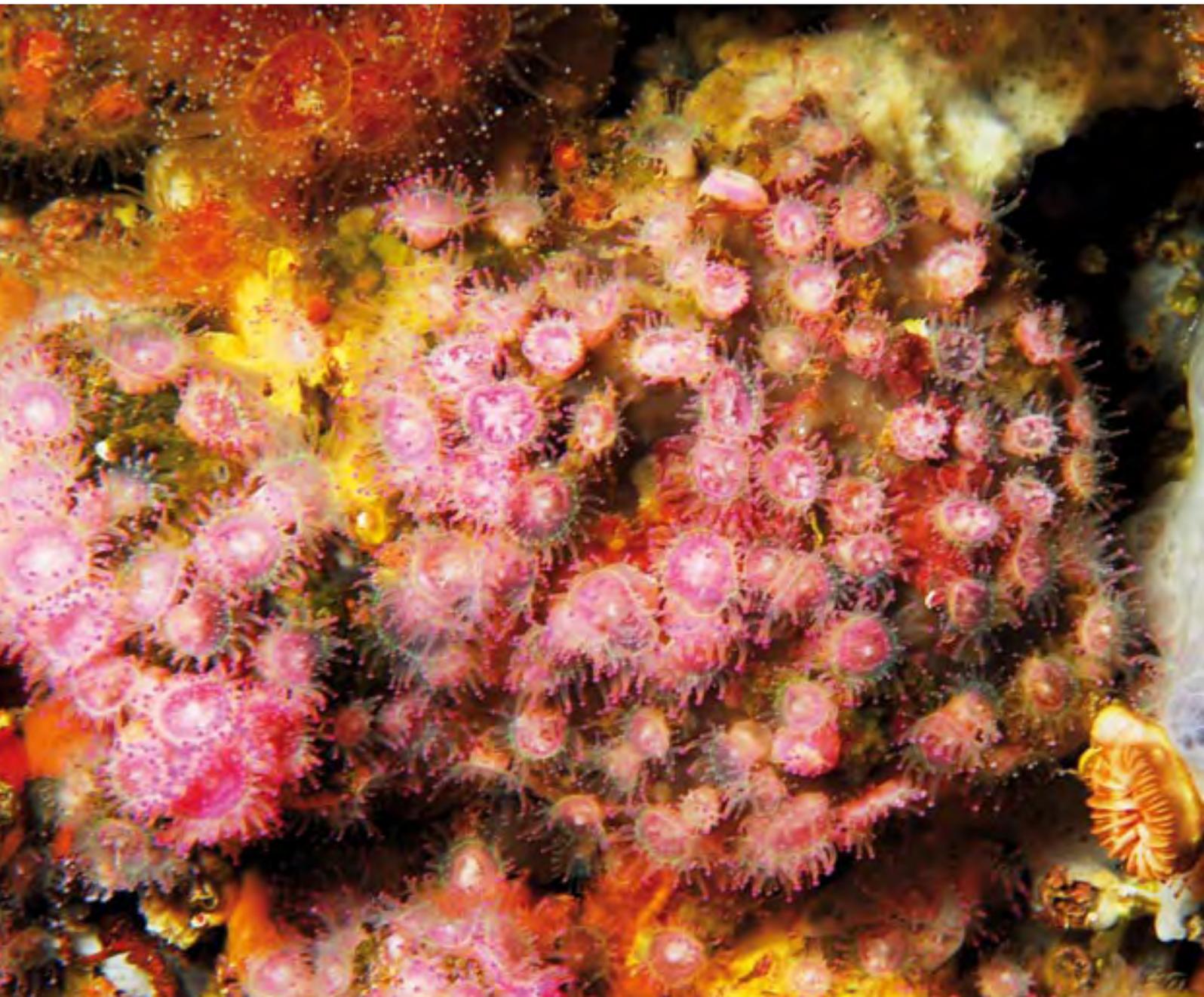Red gorgonian (*Paramuricea clavata*) © OCEANA/ Juan Cuetos

Corals that are included in international agreements and European regulations

OCTOCORALLIA	HABITATS	BERN	BARCON	CITES
Alcyionacea				
Coralliidae				
Corallium rubrum	V	III	III	
HEXACORALLIA				
Scleractinia				
Caryophyllidae				
Caryophyllia calveri				II
Caryophyllia cyathus				II
Caryophyllia inornata				II
Caryophyllia smithii				II
Ceratotrochus magnaghii				II
Coenocyathus anthophyllites				II
Coenocyathus cylindricus				II
Desmophyllum cristagalli				II
Hoplangia durotrix				II
Lophelia pertusa				II
Paracyathus pulchellus				II
Sphenotrochus andrewianus				II
Polycyathus muellerae				II
Pourtalosmilia anthophyllites				II
Phyllangia mouchezii				II
Thalamophyllia gasti				II
Faviidae				
Cladocora caespitosa				II
Cladocora debilis				II
Flabellidae				
Javania cailleti				II
Monomyces pygmaea				II
Guyniidae				
Guynia annulata				II
Stenocyathus vermiformis				II
Dendrophylliidae				
Astroides calycularis		II	II	II
Balanophyllia cellulosa				II
Balanophyllia europaea				II
Balanophyllia regia				II
Cladopsammia rolandi				II
Dendrophyllia cornigera				II
Dendrophyllia ramea				II
Leptopsammia pruvoti				II
Oculinidae				
Madrepora oculata				II
Oculina patagonica				II
Pocilloporiidae				
Madracis pharensis				II
Zoanthidea				
Parazoanthidae				
Gerardia savaglia		II	II	
Antipatharia				
Antipathes dichotoma mediterranea		III	III	II
Antipathes gracilis fragilis		III	III	II
Antipathes subpinnata		III	III	II
Bathypathes patula				II
Leiopathes glaberrima				II
Parantipathes larix				II

Less than 20% of the corals living in the Mediterranean have been included under the annexes of the conventions for the protection of animal life. Of these, most of them (85%) are only protected under Annex II of CITES, which does not extend full protection but rather regulates their commercial trade. Furthermore, this control does not cover the fossils of these species, despite their importance for the marine ecosystem, vital both for reef formation as well as for serving as an optimal substrate for the settlement of new colonies.

This means that, excluding CITES, there are six species of anthozoans which are protected under EC legislation or international conventions for the protection of wildlife which have been signed and ratified by the EU. However, only two are included in the lists with maximum protection (Annex II of the Bern Convention and Annex II of the Barcelona Convention). The other species have been included on the list of species for which management plans should be established. Moreover, these species of coral are not protected in their full range of habitat, but only in the Mediterranean.

Jewel anemone (*Corynactis viridis*) © OCEANA/ Juan Cuetos

10.

Oceana and corals

Elisella paraplexauroides © OCEANA/ Juan Cuetos

Given the importance of corals, gorgonians and anemones to the marine ecosystem and the uncertain future of many species given the various dangers and degree of vulnerability, Oceana proposes the development of a Management Plan for Mediterranean Anthozoa which includes the following measures:

**Prohibiting the use
of destructive fishing gear
over coral seabeds**

A first necessary measure for conserving corals is prohibiting the use of trawling, dredging and other similar techniques in places with vulnerable ecosystems, such as those formed by the corals mentioned hereafter for inclusion in the Habitats Directive. This prohibition must also be part of a definitive and approved list used to regulate fishing in the Mediterranean.

Equally important is the execution of resolutions that have already been approved by the GFCM, among which are the protection of the Eratosthenes seamount, the protection of the *Lophelia Pertusa* reef at Santa Maria di Leuca, the cold infiltration of hydrocarbons from the Nile Delta, and the protection from bottom trawling at depths greater than 1,000 meters. All of these should be present in EC legislation.

Regulating the capture of corals

To avoid non-selective and high-impact techniques for capturing coral, the definitive prohibition of trawling gear and other apparatus for capturing coral, including robots with mechanical arms, must be passed into law. These methods must be included both within Annex IV of the Bern Convention, as well as Annex VI of the Habitats Directive.

There must also be quotas, closed areas and minimum sizes for red coral or any other commercialized anthozoan. The manufacture of paste derived from small coral specimens must be prohibited.

In the case of red coral, there must be specific limits to oversee the reduction of quotas by 50%, together with recovery plan and a five year monitoring plan to evaluate the evolution of the species so that a moratorium on all captures can immediately be established should their number keep diminishing.

**Updating and improving
European legislation and
international conventions for
the protection of flora and fauna**

Habitats that are generated or inhabited by anthozoans must urgently be included in Annex I of the Habitats Directive. It should include the different types of corral reefs, gorgonian gardens, coralline algae and anthozoan clusters (sea feathers or gorgonians) in soft sediment bottoms, among other habitats.

Furthermore, many species of corals should become part of the annexes of the Habitat Directive and the Bern Conventions, BARCON and CITES.

For example, Annex I of the Habitats Directive should be included the following species: *Cladocora caespitosa* reefs, deep-sea coral reefs, gorgonian gardens, clusters of *Isidella elongata* and pennatulaceas in fine sediment beds, gorgonian facies and other anthozoa in coralline algae, carbonate mounds, submarine elevations (including seamountains, hills and mounds), cliffs and walls, and fossil and sub-fossil reefs.

Annex II of the Habitats Directive should be listed all the anthozoan species that are vulnerable or threatened, starting with the species mentioned hereafter.

Annex IV of the Habitats Directive, Annex II of BARCON and Annex II of the Bern Convention should add the following species to their lists at the very least: *Astroides calycularis, Gerardia savaglia, Isidella elongata* and *Funiculina quadrangularis.*

In Annex III of BARCON and in Annex III of the Bern Convention, the following species must be included: *Paramuricea clavata, Eunicella singularis, Cladocora caespitosa, Dendrophyllia* sp. In addition, all species of antipatharians should be included as well.

In Annex V of the Habitats Directive, all species of scleractinias and antipatharians should be included as a preventive measure to avoid overexploitation and abusive commercialization.

As mentioned above, Annex VI of the Habitats Directive and Annex IV of the Bern Convention should include a description of prohibited anthozoan capture techniques, such as the 'Italian Bar', the 'San Andrés Cross', and any other trawling gear or mechanic device created for that purpose.

Finally, CITES should include *Gerardia savaglia* in Appendix I for maximum protection, and *Corallium rubrum* in Appendix II.

Evaluation and recovery plans for threatened species

Given the great unknown that currently exists regarding most Mediterranean anthozoans and their conservation status, a 10-year evaluation plan must be provided for within the Barcelona Convention in order to assess the state of coral populations, gorgonias, and anemones in the Mediterranean.

Once this assessment period is finished, the species of anthozoans which are found to be in danger or vulnerable must then be extended to international conventions and European legislation aimed at preventing the degradation of these populations. Furthermore, a management and recovery plan for the species to be protected should be prepared for inclusion in the annexes of these agreements and laws.

As a matter of urgency, the first studies must focus on those species which are in gravest danger (such as the scleractinians), those which are commercially exploited (such as red coral, false black coral, anemones, etc.), those which face the greatest mortality rates (*Paramuricea clavata*, *Eunicella singularis*, *Cladocora caespitosa*, etc.), those which form and maintain habitats and those of which little is yet known (such as the species of the inferior circumlittoral and the deep-sea species, such as *Viminella flagellum*, *Elisella paraplexauroides*, *Paramuricea macrospina*, *Spinimuricea klavereni*, and *Callogorgia verticillata*).

In addition, it is very possible that in the next few years new corals will appear or be discovered in this sea that will be in need of management plans. In fact, Oceana has recently found a new species in the Mediterranean whose known distribution in the Atlantic Ocean was limited to areas like the Bay of Biscay and the Canary islands.[249] This new species is the whip gorgonian, *Spinimuricea atlantica*.

Reducing the impact of human activities on corals

The Mediterranean countries, especially the European ones, should be more scrupulous in executing their international agreements for reducing CO_2 emissions into the atmosphere in order to avoid the harmful effects that climate change and subsequent acidification of the sea has on coral life. Moreover, they must lead international efforts to achieve more drastic reductions of contaminating gases, since the Mediterranean will be one of the zones most affected by climatic change.

Also, all necessary measures to avoid spilling pollutants into the sea must be enacted, and the International Convention for the Control and Management of Ships Ballast and Sediments, under the International Maritime Or-

Leptogorgia lusitanica © OCEANA/ Thierry Lanoy

ganization (IMO) charter for preventing spills and the introduction of non-native species, must be ratified, applied, and improved.

The development of activities which can adversely affect corals, gorgonians, and anemones must not be permitted. These include coastal construction, dredging, quarrying, etc., carried out without first performing due and proper environmental impact studies and sustainability plans.

Marine protected areas

All Mediterranean countries must keep anthozoans in mind as one of the most important values when it comes to creating marine reserves and protected areas.

Control and regulations systems must also be developed for recreational diving and the anchoring of watercraft in areas with vulnerable seabeds, including the development of educational materials.

11.

Bibliography

01. Introduction

1 | Scrutton C.T. (1979). Early Fossil Cnidarians. In M. R. House (ed.). The Origin of Major Invertebrate Groups. Academic Press, London. Pp. 161-207.

2 | Brands, S. J. (comp.) 1989-2005. Systema Naturae 2000. Amsterdam, The Netherlands. [http://sn2000.taxono-my.nl/]

3 | Vaughan T. W. & J. W. Wells (1943). Revision of the suborders, families, and genera of the Scleractinia. Geological Society of America, Special Papers, 44:363 pp.,

4 | Marine Biodiversity and Ecosystem Functioning. EU Network of Excellence. http://www.marbef.org/

5 | Integrated Taxonomic Information System http://www.itis.usda.gov/index.html

6 | Hexacorallians of the World. http://hercules.kgs.ku.edu/hexacoral/anemone2/index.cfm

02. Physical characteristics of corals

7 | Tursi A., Mastrototaro F., Matarrese A., Maiorano P. & G. D'onghia (2004) Biodiversity of the white coral reefs in the Ionian Sea (Central Mediterranean). Chemistry and Ecology. Volume 20, Supplement 1: 107-116 pp. June 2004.

8 | Velimirov B. (1976) Variations in growth forms of Eunicella cavolinii Koch (Octocorallia) related to intensity of water movement. J exp mar Biol Ecol 21:109-117.

9 | Skoufas G. 2006). Comparative biometry of Eunicella singularis (Gorgonian) sclerites at East Mediterranean Sea (North Aegean Sea, Greece). Marine Biology. Volume 149, Number 6:1365-1370. September, 2006.

10 | Cohen A.L. & T.A. McConnaughey (2003). A geochemical perspective on coral mineralization, in Dove, P. M., et al., eds., Biomineralization: Reviews in Mineralogy and Geochemistry Volume 54, p. 151-187.

11 | Ries J. B., Stanley S. M. & L. A. Hardie (2006). Scleractinian corals produce calcite, and grow more slowly, in artificial Cretaceous seawater. Geology 34 (7):525-528.

12 | Stanley G. D. (2003). The evolution of modern corals and their early history. Earth-Science Reviews, Volume 60, Number 3, February 2003, pp. 195-225 (31).

13 | Goldberg W. M. (1978). Chemical changes accompanying maturation of the connective tissue skeletons of gorgonian and antipatharian corals. Mar. Biol., 49:203-210.

14 | Mariscal R. N., Conklin E. J. & C. H. Bigger (1977). The ptychocyst, a major new category of cnida used in tube construction by a cerianthid anemone. Biol Bull 1977 152:392-405.

03. Coral species of the Mediterranean

15 | Martin J., Braga J & R. Riding. (1997). Late Miocene Halimeda alga-microbial segment reefs in the marginal Mediterranean Sorbas Basin, Spain. Sedimentology. Volume 44 Issue 3 44 Page 441 - June 1997; Martín J. M, J. C. Braga & I. Sánchez-Almazo (1999). The Messinian Record of the Outcropping Marginal Alboran Basin Deposits: Significance and Implications. Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 161. Zahn R., Comas M. C. & A. Klaus (Eds.), 1999; Karabiyikoglu M., Çiner A. & S. Tuzcu (2003). Miocene reefs evolution within the shelf carbonates and fan delta complexes of the Antalya basin, Southern Turkey. Geophysical Research Abstracts, Vol. 5, 09201, 2003. European Geophysical Society 2003; Brachert T., Reuter M., Kroeger K.F., Felis T., Lohmann G. & A. Micheels (2005). Growth Band Analysis in Porites Corals: A fully unexplored Tool in Palaeoclimatology. Late Miocene, Island of Crete (Greece). Geophysical Research Abstracts, Vol. 7, 09730, 2005.

16 | Pomar L. & W. C. Ward (1999). Reservoir-Scale Heterogeneity in Depositional Packages and Diagenetic Patterns on a Reef-Rimmed Platform, Upper Miocene, Mallorca, Spain. The American Association of Petroleum Geologists (AAPG) Bulletin, V. 83, No. 11 (November 1999), P. 1759-1773.

17 | Hayward A. B. (1982). Coral reefs in a clastic sedimentary environment: Fossil (Miocene, S. W. Turkey) and modern (Recent, Red Sea) analogues. In Coral Reefs. Publisher: Springer Berlin / Heidelberg. Issue: Volume 1, Number 2. October 1982: Pp. 109-114.

18 | CHAVALIER J. J. P. (1977), Aperçu sur la fame corallienne recifale du Naogene. Second Symposium international sur les coraux, et refeifs coralliens fossiles, Memiires du B. R. G. M.. N. 89, s. 359-366.

19 | Budd, A. F., Bosellini F. R. & T.A. Stemann (1996). Systematics of the Oligocene to Miocene reef coral Tarbellastraea in the northern Mediterranean. Palaeontology, 39 (3), 515-560.

20 | Tintori A. (1995). Biomechanical fragmentation in shell-beds from the Late Triassic of the Lombardian Basin (Northern Italy). Preliminary Report.

21 | Raymond, P. E. (1924), The oldest coral reef: Vermont State Geologist Report, 14th, p. 72-76.

22 | Bellwood, D. R. (1996). The Eocene fishes of Monte Bolca: the earliest coral reef fish assemblage. Coral Reefs, 15:11-19.

23 | Bellwood D. R. (2003). Origins and escalation of herbivory in fishes: a functional perspectiva. Paleobiology, 29(1), 2003, pp. 71-83.

24 | Sorbini L. (1983), L'ittiofauna fossile di Bolca e le sue relazioni biogeografiche con i pesci attuali: vicarianza o dispersione? Bollettino della Società Paleontologica Italiana, 22 (1-2), 109-118.

25 | Taviani M. & the CORTI & COBAS Shipboard Teams (2004). Coral mounds of the Mediterranean Sea: results of EUROMARGINS Cruises CORTI and COBAS. EUROMARGINS Conference, 11-13 November 2004. Palau de les Heures, Barcelona, Spain.

26 | Expedition Scientists (2005). Modern carbonate mounds: Porcupine drilling. IODP Prel. Rept., 307. doi:10.2204/iodp.pr.307.2005.

27 | Taviani M., Corselli C., Freiwald A., Malinverno E., Mastrototaro F, Remia A., Savini A., Tursi A. & the CORAL Shipboard Staff (2003). Pleistocene to recent deep-coral growth on peri-ionian escarpments, Mediterranean basin. Geophysical Research Abstracts, Vol. 5, 10916, 2003.

28 | Oceana (2003). Out of sight but no longer out of mind.

29 | Henry L. A. & J. M. Roberts (2005). First record of Bedotella armata (Cnidaria: Hydrozoa) from the Porcupine Seabight: do north-east Atlantic carbonate mound fauna have Mediterranean ancestors? JMBA2 - Biodiversity Records. Published online. November 2005. De Mol, B., Henriet, J.- P. & Canals, M., 2005. Development of coral banks in Porcupine Seabight: do they have Mediterranean ancestors? In Cold-water corals and ecosystems (ed. A. Freiwald and J. M. Roberts), pp. 515-533. Berlin, Heidelberg: Springer-Verlag. [Erlangen Earth Conference Series, no. 1.]; Henriet, J.- P., De Mol, B., Pillen, S., Vanneste, M., Van Rooij, D., Versteeg, W., Croker, P. F., Shannon, P., Unnithan, V., Bouriak, S., Chachkine, P., and the Porcupine-Belgica 97 Shipboard Party (1998). Gas hydrate crystals may help build reefs. Nature (London, U. K.), 391:648-649.

30 | Oceana (2005). The Seamounts of the Gorringe Bank.

31 | Aguirre J. & A. P. Jiménez (1998). Fossil analogues of present-day Cladocora caespitosa coral banks: Sedimentary setting, dwelling community, and taphonomy (Late Pliocene, W Mediterranean). Coral Reefs 17, 203-213: Dornbos S. Q. & M. A. Wilson (1999). Paleoecology of a Pliocene coral reef in Cyprus: recovery of a marine comunity from the Messinian Salinity Crisis. Neues Jarhrb. Geol. Palaontoll. Abh. 213/1, 103-118; Bernasconi M. P., Corselli C. & L. Carobene (1997). A bank of the scleractinian coral Cladocora caespitosa in the Pleistocene of the Crati valley (Calabria, Southern Italy): growth versus environmental conditions. Boll. Soc. Paleontol. Ital. 36 (1-2), 53-61; Peirano, A., Morri, C., Mastronuzzi, G. & C. N. Bianchi (1998). The coral Cladocora caespitosa (Anthozoa, Scleractinia) as a bioherm builder in the Mediterranean Sea. Mem. Descr. Carta Geol. Ital. 52 (1994), 59-74.

32 | Zibrowius H. (1974). Oculina patagonica sclératiniaire hermatypique introduit en Méditerranée, Helgol, Meeresunters 26 (1974) 153.

33 | Zibrowius H. (1974). Oculina patagonica, Scléractiniaire hermatypique introduit en Méditerranée. Biomedical and Life Sciences and Earth and Enviromental Science. Volume 26, Number 2 / September, 1974.

34 | Zibrowius H. & A. A. Ramos (1983). Oculina patagonica, Scléractiniaire exotique en Méditerranée, nouvelles observations dans le Sud-Est de l'Espagne. Rapp. Comm. int. Mer. Médit., 28 (3):297-301.

35 | Bitar G, & H. Zibrowius (1997) Scleractinian corals from Lebanon, Eastern Mediterranean, including a non-lessepsian invading species (Cnidaria: Scleractinia). Scientia Marina 61:227-231.

36 | Çinar M.E., Bilecenoglu M., Öztürk B. & A. Can (2006). New records of alien species on the Levantine coast of Turkey. Aquatic Invasions (2006) Volume 1, Issue 2:84-90.

37 | De Angelis D'Ossat G. (1908). Altri Zoantari del Terziario Della Patagonia. Anales del Museo Nacional de Buenos Aires 3.:93-102.

38 | Manuel R. L. (1988). British Anthozoa (Coelenterata: Octocorallia and Hexacorallia): keys and notes for the identification of the species. 2nd ed. Leiden, Linnean Society of London, Estuarine and Coastal Sciences Association. (Synopses of the British fauna (New series), No. 18).

39 | Stephenson T. A. (1935). The British sea anemones, Vol. 2. London, The Ray Society.; Gollasch S. & K. Riemann-Zürneck (1996). Transoceanic dispersal of benthic macrofauna: Haliplanella lineata (Verrill, 1898) (Anthozoa, Actinaria) found on a ship's hull in a ship yard dock in Hamburg Harbour, Germany. Helgoländer Meeresuntersuchungen, 50:253-258.

40 | Kiener A. (1971) Contribution a l'ecologie, la physiologie et l'ethologie de l'actinia Diadumene luciae (Verril). Bulletin de la Societ e Zoologique de France 96, 581±603

41 | Oceana (2005). Las montañas submarinas de Gorrringe.

04. Corals habitats and corals as habitats

42 | Kruzic P. & A. Pozar-Domac (2002). Skeleton growth rates of coral bank of Cladocora caespitosa (Anthozoa, Scleractinia) in lake Veliko jezero (Mljet National Park). Periodicum Biologorum 57:61. Vol. 104, No 2, 123-129, 2002

43 | Freiwald A. (2002). Reef-forming cold-water corals. In: Wefer, G., Billett, D., Hebbeln, D., Jørgensen, B. B., Schlüter, M., van Weering, T. (Eds.), Ocean Margin Systems. Springer-Verlag, Berlin, Heidelberg.

44 | Thiem Ø., Ravagnan E., Fosså J. H. & J. Berntsen (2006). Food supply mechanisms for cold-water corals along a continental shelf edge. Journal of Marine Systems 60 (2006) 207-219.

45 | Corselli C., Favali P., Rosso M. A., Spezie G., Taviani M., Etiope G., Tursi A., Remia A. & F. Mastrototaro (2006). The 'Santa Maria di Leuca' Lophelia reefs of Mediterranan Sea: State-of-the-art and on-going research. Geophysical Research Abstracts, Vol. 8, 05714, 2006.

46 | Mortensen, P. B., Hovland, M., Fosså, J. H. & D. M. Furevik (2001). Distribution, abundance and size of Lophelia pertusa coral reefs in mid-Norway in relation to seabed characteristics. Journal of the Marine Biological Association of the United Kingdom 81, 581-597; Rogers, A. D., 1999. The biology of Lophelia pertusa (Linnaeus, 1758) and other deep-water reef-forming corals and impacts from human activities. International Revue of Hydrobiology 84, 315–406; Kruzic P. & A.. Pozar-Domac (2002). Skeleton growth rates of coral bank of Cladocora caespitosa (Anthozoa, Scleractinia) in lake Veliko jezero (Mljet National Park). Periodicum Biologorum 57:61. Vol. 104, No 2, 123-129, 2002.

47 | Hovland M., Mortensen P. B., Brattegard T., Strass P. & K. Rokengen (1998). Ahermatypic coral banks off mid-Norway: evidence for a link with seepage of light hydrocarbons. Palaios, 13:189–200; Henriet J. - P., De Mol B., Vanneste M., Huvenne V., Van Rooij D., & the Porcupine-Belgica 97, 98, and 99 Shipboard Parties (2001). Carbonate mounds and slope failures in the Porcupine Basin: a development model involving fluid venting. In Shannon, P. M., Haughton, P., and Corcoran, D. (Eds.), Petroleum Exploration of Ireland's Offshore Basins. Geol. Soc. Spec. Publ., 188:375–383.

48 | Laborel J. (1987). Marine biogenic constructions in the Mediterranean. Scientific Reports of Port-Cros National Park, 13:97-126.

49 | Laborel J. (1960). Contribution à l'étude directe des peuplements benthiques sciaphiles sur substrat rocheux en Méditerranée. Recueil Travaux Station Marine Endoume, 33 (20):117-174; Laborel J. (1961). Le concretionnement algal "coralligène" et son importance géomorphologique en Méditerranée. Recueil Travaux Station Marine d'Endoume, 23:37-60.

50 | Ballesteros E. (2003). The coralligenous in the Mediterranean Sea. Definition of the coralligenous assemblage in the Mediterranean, its main builders, its richness and key role in benthic ecology as well as its threats. Project for the preparation of a Strategic Action Plan for the Conservation of the Biodiversity in the Mediterranean Region (SAP BIO). RAC/SPA- Regional Activity Centre for Specially Protected Areas 2003.

51 | Laubier L. (1966). Le coralligène des Albères: monographie biocénotique. Annales Institut Océanographique de Monaco, 43:139-316.

52 | Cebrian E., Ballesteros E. & M. Canals (2000). Shallow rocky bottom benthic assemblages as calcium carbonate producers in the Alboran Sea (Southwestern Mediterranean). Oceanologica Acta, 23 (3):311-322.

53 | True M. A. (1970). Étude quantitative de quatre peuplements sciaphiles sur substrat rocheux dans la région marsellaise. Bulletin Institut Océanographique Monaco, 69 (1401):1-48.

54 | Gili, J. M. 1986. Estudio sistemático y faunístico de los cnidarios de la costa catalana. Tesis Doctoral. Universidad Autónoma de Barcelona. 565 pp.

55 | Zabala M. (1986). Fauna dels briozous dels Països Catalans. Arxius Secció Ciències I.E.C., 84:1-833.

56 | Templado J., Calvo M., García Carrascosa A. M., Boisset F. & J Jiménez (2002). Flora y Fauna de la Reserva Marina de las Islas Columbretes. Secretaría General de Pesca Marítima (SGPM) - Museo Nacional de Ciencia Naturales - Consejo Superior de Investigaciones Científicas (CSIC). Madrid 2002.

57 | Templado J. Calvo M., Moreno D., Flores A., Conde F., Abad R., Rubio J., López-Fé C. M. & M. Ortiz (2006). Flora y Fauna de la Reserva Marina y Reserva de Pesca de la Isla de Alborán (J. Templado t M. Clavo, editores). Secretaría General de Pesca Marítima y Museo Nacional de Ciencias Naturales, CSIC. Madrid, 2006.

58 | Hofricther R. (2005). El Mar Mediterráneo. Fauna, Flora, Ecología. II/1 Guía Sistemática y de identificación. Ediciones Omega. Barcelona. 849 pp.

59 | Micael J., Azevedo J. M. N. & A. C. Costa (2006). Biological characterisation of a subtidal tunnel in São Miguel island (Azores). Biodiversity and Conservation. Volume 15, Number 11: 3675-3684. October, 2006; Martí R., Uriz M. J., Ballesteros E. & X. Turon (2004). Benthic assemblages in two Mediterranean caves: species diversity and coverage as a function of abiotic parameters and geographic distance. Journal of the Marine Biological Association of the UK (2004) 84: 557-572 Cambridge University Press; Peckett F. (2003). Caryophyllia inornata. Southern cup coral. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 11/01/2007]. Available from: <http://www.marlin.ac.uk/species/Caryophylliainornata.htm>

60 | Marti R., Uriz M. J. & X. Turon (2004). Seasonal and spatial variation of species toxicity in mediterranean seaweed communities: Correlation to biotic and abiotic factors. Marine ecology progress series [Mar. Ecol. Prog. Ser.]. Vol. 282, pp. 73-85. 2004; Martí R., Uriz M. J., Ballesteros E. & X. Turon (2004). Benthic assemblages in two Mediterranean caves: species diversity and coverage as a function of abiotic parameters and geographic distance. Journal of the Marine Biological Association of the UK (2004), 84: 557-572 Cambridge University Press.

61 | Boero F., Cicogna F., Pessani D. & R. Pronzato (1991). In situ observations on contraction behaviour and diel activity of Halcampoides purpurea var. mediterranea (Cnidaria, Anthozoa) in a marine cave. Marine Ecology. 1991, vol. 12, no3, pp. 185-192.

62 | Hughes D. J. & R. J. A. Atkinson (1997). A towed video survey of megafaunal bioturbation in the north-eastern Irish Sea. Journal of the Marine Biological Association of the United Kingdom, 77:635-653.

63 | Hofricther R. (2005). El Mar Mediterráneo. Fauna, Flora, Ecología. II/1 Guía Sistemática y de identificación. Ediciones Omega. Barcelona.

64 | Moreno D. (2004). Tesoros sumergidos: La flora y fauna marinas. En Paracuellos, M.; Nevado, J. C. y Mota, J. F. (dir.) (2006). Entre África y Europa. Historia Natural de la Isla de Alborán. RENPA, Consejería de Medio Ambiente (Junta de Andalucía). Sevilla.

Hermit crab (*Dardanus* sp.) with *Calliactis parasitica*
© OCEANA/ Juan Cuetos

65 | Cairns mentioned in Roberts S. & M. Hirshfield (2003). Deep sea corals: Out of sight, but no longer out of mind. Oceana. Washington, USA.

66 | Cairns S. D. & G. D. Stanley Jr. (1982). Ahermatypic coral banks: Living and fossil counterparts Proc. Fourth Int. Coral Reef Symp. Manila 1, 611 (1981).

67 | Cocito S., Bedulli D. & S. Sgorbini (2002).Distribution patterns of the sublittoral epibenthic assemblages on a rocky shoal in the Ligurian Sea (NW Mediterranean). Sci. Mar., 66(2): 175-181.

68 | Ballesteros E. & M. Zabala (1993). El bentos: el marc físic. In: Història Natural de l'arxipèlag de Cabrera (eds. J. A. Alcover, E. Ballesteros & J. J. Fornós). Mon. Soc. Hist. Nat. Balears, 2: 663-685. CSIC-Ed. Moll. Palma de Mallorca.

69 | Fish J. D. & S. Fish (1989) A student's guide to the seashore. Unwin Hyman Ltd., London.

70 | SHICK, J. M., BROWN, W. I., DOLLIVER, E. G. JCKAYAR, S. R. (1979). Oxygen uptake in sea anemones: effects of expansion, contraction, and exposure to air and the limitations of diffusion. Physiol. Zool. 52, 50-62; Brafield A. E.& G. Chapman (1983). Diffusion of oxygen through the mesogloea of the sea anemone Calliactis parasitica. J. exp. Biol. 107, 181-187 (1983).

71 | Kruzic P. & A.. Pozar-Domac (2002). Skeleton growth rates of coral bank of Cladocora caespitosa (Anthozoa, Scleractinia) in lake Veliko jezero (Mljet National Park). Periodicum Biologorum 57:61. Vol. 104, No 2, 123-129, 2002

72 | Tunesi L., Diviacco G. & G. Mo (2001). Observations by submersible on the biocoenosis of the deep-sea corals off Portofino Promontory (Northwestern Mediterranean Sea) In: Proceedings of the First International Symposium on Deep-sea Corals (eds JHM Willison, J Hall, S Gass, ELR Kenchington, M Butler, P Doherty), pp. 76-87, Ecology Action Centre and Nova Scotia Museum, Halifax, Nova Scotia.

73 | Gollasch S. & K. Riemann-Zürneck (1996). Transoceanic dispersal of benthic macrofauna: Haliplanella luciae (Verrill, 1898) (Anthozoa, Actinaria) found on a ships hull in a shipyard dock in Hamburg harbour, Germany. Helgoländer Meeresunters., 50 (2), 253-258.

74 | Ross D. M. (1959). The Sea Anemone (Calliactis parasitica) and the Hermit Crab (Eupagurus bernhardus). Nature 184, 1161-1162; 10 October 1959; Ross D. M. & L. Sutton (1961). The Association between the Hermit Crab Dardanus arrosor (Herbst) and the Sea Anemone Calliactis parasitica (Couch). Proceedings of the Royal Society of London. Series B, Biological Sciences, Vol. 155, No. 959 (Nov. 21, 1961), pp. 282-291; J. M. Tur (1993). Redescription and biological aspects of Hormathia alba (Andres, 1881), a luminescent sea anemone (Anthozoa, Actiniaria). Helgoland marine Research. Volume 47, Number 2. June, 1993; Ates R.M.L. (1995) Pagurus prideaux and Adamsia palliata are not obligate symbionts. Crustaceana (Leiden) 68:522-524.

75 | Gili, J. M. 1986. Estudio sistemático y faunístico de los cnidarios de la costa catalana. Tesis Doctoral. Universidad Autónoma de Barcelona. 565 pp.

76 | Bellan-Santini D., Bellan G., Bitar G. Harmelin J. - G. & G. Pergent (2002). Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest (G. Pergent, Coord). United Nations Environment Programme Action Plan for the Mediterranean. Regional Activity Centre for Specially Protected Areas. December 2002.

77 | Zibrowius H. & M. Taviani (2005). Remarkable sessile fauna associated with deep coral and other calcareous substrates in the Strait of Sicily, Mediterranean Sea. Erlangen Earth Conference Series. Cold-Water Corals and Ecosystems Part VI. André Freiwald and J. Murray Roberts (Coords).

78 | Schiller C. (1993). Ecology of the symbiotic coral Cladocora caespitosa (L.) (Faviidae, Scleractinia) in the Bay of Piran (Adriatic Sea): II. Energy budget. P.S.Z.N.l.: Mar Ecol 14 (3):221–238

79 | Stambler N. & Z. Dubinsky (1987). Energy relationships between Anemonia sulcata and its endosymbiotic zooxanthallae. Symbiosis (Symbiosis) 1987, vol. 3, no3, pp. 233-248.

80 | Hofricther R. (2005). El Mar Mediterráneo. Fauna, Flora, Ecología. II/1 Guía Sistemática y de identificación. Ediciones Omega. Barcelona. 849 pp.

81 | Banin E., Israely T., Fine M., Loya Y. & E. Rosenberg (2001). Role of endosymbiotic zooxanthellae and coral mucus in the adhesion of the coral-bleaching pathogen Vibrio shiloi to its host. FEMS Microbiology Letters 199 (1), 33-37.

82 | Goffredo S. (2004) Growth and population dynamics model of the Mediterranean solitary coral Balanophyllia europaea (Scleractinia, Dendrophylliidae). Coral Reefs 23 (3)

83 | Fine M., Steindler L. & Y. Loya (2004). Endolithic algae photoacclimate to increased irradiance during coral bleaching. Marine and Freshwater Research 55 (1) 115-121.

84 | Fine M. & Y. Loya (2002) Endolithic algae: an alternative source of photoassimilates during coral bleaching. Proceedings of the Royal Society of London 269, 1205-1210.

85 | Wirtz P. (1997). Crustacean symbionts of the sea anemone Telmatactis cricoides at Madeira and the Canary Islands. Journal of Zoology, 242, 799-811.

86 | Moyse J. (1971). Settlement and growth pattern of the parasitic barnacle Pyrgoma anglicum, En Proc. IV Eur, Mar. Biol. Symp., ed. D. J. Crisp (1971) 125-141, Cambridge University Press.

87 | Ballesteros E. (2003). The coralligenous in the Mediterranean Sea. Definition of the coralligenous assemblage in the Mediterranean, its main builders, its richness and key role in benthic ecology as well as its threats. Project for the preparation of a Strategic Action Plan for the Conservation of the Biodiversity in the Mediterranean Region (SAP BIO). RAC/SPA- Regional Activity Centre for Specially Protected Areas 2003.

88 | Diesel R. (1986). Population dynamics of the commensal spider crab Inachus phalangium (Decapoda: Maiidae). Marine Biology. Volume 91, Number 4:481-489. June, 1986

89 | Wirtz P. (1997). Crustacean symbionts of the sea anemone Telmatactis cricoides at Madeira and the Canary Islands. Journal Zoology London, 242, pp 799-811.

90 | Pölzer W. (1994). Der Anemonenfisch im Mittelmeer. Gobius bucchichi i. - DATZ 49:233-234; Abel E. F. (1960). Liaison facultative d'un poisson (Gobius bucchichii Steindachner) d'une anemone (Anemonia sulcata Penn.) en Mediterranee. Vie et Milieu 11:517-531.

05. Coral reproduction

91 | Fautin D. G. (2002). Reproduction of Cnidaria. Canadian Journal of Zology, 80: 1735-1754.

92 | Harrison P. L., Babcock R. C., Bull G. D., Oliver J. K., Wallace C. C. & B. L. Willis (1984). Mass spawning in tropical reef corals. Science (Washington, D.C.), 223: 1186–1189; Babcock R. C., Bull G. D., Harrison P. L., Heyward A. J., Oliver J. K., Wallace C. C. & B. L. Willis (1986). Synchronous spawning of 105 scleractinian coral species on the Great Barrier Reef. Mar. Biol. (Berl.), 90:379-394.

93 | Ryland J. S. & R. C. Babcock (1991). Annual cycle of gametogenesis and spawning in a tropical zoanthid, Protopalythoa sp. Hydrobiologia, 216/217:117-123. [Published also in Coelenterate biology: recent research on Cnidaria and Ctenophora. 1991. Edited by R. B. Williams, P. F. S. Cornelius, R. G. Hughes, and E. A. Robson. Kluwer Academic Publishers, Dordrecht, the Netherlands. pp. 117-123.]

94 | Alino P. M. & J. C. Coll (1989). Observations of the synchronized mass spawning and postsettlement activity of octocorals on the Great Barrier Reef, Australia: biological aspects. Bull. Mar. Sci. 45: 697-707.

95 | Coll, J. C., Bowden B. F., Meehan G. V., König G. M., Carroll A. R., Tapiolas D. M., Aliño P. M., Heaton A., De Nys R., Leone P. A., Maida M., Aceret T. L., Willis R. H., Babcock R. C., Willis B. L., Florian Z., Clayton M. N. & R. L. Miller (1994). Chemical aspects of mass spawning in corals. I. Sperm-attractant molecules in the eggs of the scleractinian coral Montipora digitata. Mar. Biol. 118:177-182.; Coll J. C., Leone P. A., Bowden B-F., Carroll A. R., König G. M., Heaton A., de Nys R., Maida M., Aliño P. M., Willis R. H., Babcock R. C., Florian Z., Clayton M. N., Miller R. L. & P. N. Alderslade (1995). Chemical aspects of mass spawning in corals. II. (-)-Epi-thunbergol, the sperm attractant in the eggs of the soft coral Lobophytum crassum (Cnidaria: Octocorallia). Mar. Biol. 123:137-143.

96 | Coma R., Zabala M. & J.- M. Pili (1995). Sexual reproductive effort in the Mediterranean gorgonian Paramuricea clavata. Mar. Ecol. Prog. Ser. 117:185-192.

97 | Coma R., Ribes M., Zabala M. & J.- M. Gili (1995). Reproduction and cycle of gonadial development in the Mediterranean gorgonian Paramuricea clavata. Marine Ecology Progress Series, 117, 173-183.

98 | Babcock R. (1995). Synchronous multispecific spawning on coral reefs: potential for hybridization and roles of gamete recognition. Reprod. Fertil. Dev. 7: 943-950.

99 | Kenyon J. C. (1993). Chromosome number in ten species of the coral genus Acropora. In Proceedings of the 7th International Coral Reef Symposium, Guam, Micronesia, 22–27 June 1992. Vol. 1. Edited by R. H. Richmond. University of Guam Marine Laboratory, Mangilao. pp. 471-475.

100 | Szmant A. M., Weil E., Miller M. W. & D. E. Colón (1997). Hybridization within the species complex of the scleractinan [sic] coral Montastraea annularis. Mar. Biol. (Berl.), 129:561–572.

101 | Coma R., Zabala M. & J. M. Gili (1995). Sexual reproductive effort in the Mediterranean gorgonian Paramuricea clavata. Marine Ecology Progress Series, 117; 185-192

102 | Shaw P. W. (1989). Seasonal patterns and possible long-term effectiveness of sexual reproduction in three species of sagartiid sea anemones. In Reproduction, genetics and distributions of marine organisms. Edited by J. S. Ryland and P. A. Tyler. Olsen and Olsen, Fredensborg, Denmark. pp. 189-199

103 | Gashout S. E. & G. F. Ormond (1979). Evidence for parthenogenetic reproduction in the sea anemone Actinia equina L. J. Mar. Biol. Assoc. U. K. 59:975-987.

104 | Chadwick-Furman, N. E. & M. Spiegel (2000). Abundance and clonal replication in the tropical corallimorpharian Rhodactis rhodostoma. Invertebr. Biol. 119: 351-360: Ryland J. S. (1997). Budding in Acrozoanthus Saville-Kent, 1893 (Anthozoa: Zoanthidea). In Coelenterate Biology: Proceedings of the 6th International Congress of Coelenterate Biology, The Leeuwenhorst, Nordwijkerhout, the Netherlands, 16–21 July 1995. Edited by J. C. den Hartog. Nationaal Natuurhistorisch Museum, Leiden, the Netherlands. pp. 423-428.

105 | Schmidt H. (1970). Anthopleura stellula (Actiniaria, Actiniidae) and its reproduction by transverse fission. Mar. Biol. (Berl.), 5:245-255.

106 | Fabricius K. & A. Alderslade (2001). Soft corals and sea fans. Australian Institute of Marine Science, Townsville, Queensland.

107 | Cairns S. D. (1988). Asexual reproduction in solitary Scleractinia. In Proceedings of the 6th International Coral Reef Symposium, Townsville, Queensland, Australia, 8-12 August 1988. Vol. 2. Edited by J. H. Choat, D. Barnes, M. A. Borowitzka, J. C. Coll, P. J. Davies et al. Sixth International Coral Reef Symposium Executive Committee. pp. 641-646.

108 | Mire P. & S. Venable (1999). Programmed cell death during longitudinal fission in a sea anemone. Invertebr. Biol. 118:319-331.

109 | Pearse V.B. (2002). Prodigies of propagation: the many modes of clonal replication in boloceroidid sea anemones (Cnidaria, Anthozoa, Actiniaria). Invertebr. Reprod. Dev. 41:201-213.

110 | Miller K. & K. Grange (1997). Population genetic studies of antipatharian black corals from Doubtful and Nancy Sounds, Fiordland, New Zealand. In Coelenterate Biology: Proceedings of the 6th International Congress of Coelenterate Biology, The Leeuwenhorst, Nordwijkerhout, the Netherlands, 16-21 July 1995. Edited by J. C. den Hartog. Nationaal Natuurhistorisch Museum, Leiden, the Netherlands. pp. 353-363

111 | Vighi M. (1970) Ricerche sul ciclo reproduction del corallo rosso [Corallium rubrum (L)] del Promon torio di Por®no. Atti accad Lincei Roma (Ser 8) 10:1-26.

112 | Coma R., Ribes M., Zabala M. & J.- M. Gili (1995) Reproduction and cycle of gonadal development in the Mediterranean gorgonian Paramuricea clavata. Mar. Ecol. Prog. Ser. 117:173-183

113 | Weinberg S. & F. Weinberg (1979) The life cycle of a gorgonian: Eunicella singularis (Esper 1794). Bijdr Dierkd 48:127-140

114 | Santangelo G., Maggi E., Bramanti L. & L. Bongiorni (2004). Demography of the over-exploited Mediterranean red coral (Corallium rubrum L. 1758). Scientia Marina, 2004, suplemento 1 (68):199-204

115 | Goffredo S., Mezzomonaco L. & F. Zaccanti (2004). Genetic differentiation among populations of the Mediterranean hermaphroditic brooding coral Balanophyllia europaea (Scleractinia: Dendrophylliidae). Marine Biology. Volume 145, Number 6: 1075-1083. November, 2004

116 | Munro L. (2004). Determining the reproductive cycle of Eunicella verrucosa. Reef Research: ETR 11. July 2004.

117 | Weinberg S. & F. Weinberg (1979). The life cycle of a gorgonian: Eunicella singularis (Esper, 1794). Bijdragen tot de dierkunde, 48, 127-140.

118 | Coma R., Ribes M., Zabala M. & J.- M. Gili (1995). Reproduction and cycle of gonadal development in the Mediterranean gorgonian Paramuricea clavata, Marine Ecology Progress Series 117, 173-183.

119 | Santangelo G., Carletti E., Maggi E. & L. Bramanti (2003b) Reproduction and population sexual structure of the overexploited Mediterranean red coral Corallium rubrum. Mar Ecol Prog Ser 248:99-108.

120 | Burgess S. N. & R. C. Babcock (2003). Ecological Aspects of Deep-Sea Scleractinians in the New Zealand Region 2nd International Symposium on Deep-Sea Corals September 8th-13th 2003. Erlangen, Germany.

121 | Kinzie R. A., III (1996). Modes of speciation and reproduction in archaeocoeniid corals. Galaxea, 13:47-64.

122 | Fadlallah Y. H. (1983). Sexual reproduction, development and larval biology in scleractinian corals. A review. Coral Reefs 2:129-150.

123 | Vermeij M. J. A., Sampayo E., Bröker K. & R. P. M. Bak (2004). The reproductive biology of closely related coral species: gametogenesis in Madracis from the southern Caribbean. Coral Reefs. Volume 23, Number 2:206-214. July, 2004.

124 | Goffredo S., Telò T. & F. Scanabissi (2000). Ultrastructural observations of the spermatogenesis of the hermaphroditic solitary coral Balanophyllia europaea (Anthozoa, Scleractinia). Zoomorphology, 119:231-240.

125 | Kahng S. E., Toonen R., Benayahu Y., Wagner D. & G. Concepcion (2006). Reprodution and developmental characteristics of the alien octocoral Carijoa riisei in Hawai'i. 2004-2005 HCRI-RP Final Report. January 31, 2006.

126 | Ben-David-Zaslow R., Henning G., Hofmann D. K. & Y. Benayahu (1999). Reproduction in the Red Sea soft coral Heteroxenia fuscescens: seasonality and long-term record (1991 to 1997). Marine Biology 133:553-59.

127 | MacFadden C. (2001). A molecular phylogeneticanalysis of reproductive trait evolution in the soft coral genus Alcyonium. Evolution 55 (1):54-67.

06. The fight for survival

128 | Anthony K. R. N., Connolly S. R. & B. L. Willis (2002). Comparative Analysis of Energy Allocation to Tissue and Skeletal Growth in Corals. Limnology and Oceanography, Vol. 47, No. 5 (Sep., 2002), pp. 1417-1429; Jokiel P. L. (1998). Energetic cost of reproduction in the coral Pocillopora damicornis: a synthesis of published data. Reproduction in Reef Corals. Results of the 1997 Edwin W. Pauley Summer Program in Marine Biology. Cox E. F., Krupp D. A. & P. L. Jokiel (Ed). University of Hawai'i. Hawai'i Institute of Marine Biology. Technical Report No. 42. September 1998.

129 | Zilberberg C. & P. J. Edmunds (2001). Competition among small colonies of Agaricia: the importance of size asymmetry in determining competitive outcome. Marine Eoclogy. Progress Series. Vol. 221:125-133, 2001.

130 | Sheppard C. R. C. (1982). Coral populations on reef slopes and their major controls. Marine Ecology. Progress Series 7: 83-115; Chornesky A. (1984). The Consequences of Direct Competition between Scleractinian Reef Corals: Development and Use of Sweeper Tentacles. Dissertation presented to the Faculty of the Graduate School of The University of Texas at Austin in Partial Fufillment of the Requirementsfor the Degree of Doctor of Philosophy. The University of Texas, 1984.

131 | Kass-Simon G. & A. A. Scappaticci Jr. (2002). The behavioral and developmental physiology of Nematocysts. Can. J. Zool. 80:1772-1794 (2002)

132 | Purcell J. E. (1977). Aggressive function and induced development of catch tentacles in the sea anemone Metridium senile (Coelenterata, Actiniaria). Biol. Bull. (Woods Hole, Mass.), 153:356-368.

133 | Watson G.M. & R.N. Mariscal (1983). The development of a sea anemone tentacle specialized for aggression: morphogenesis and regression of the catch tentacle of Haliplanella luciae (Cnidaria, Anthozoa). Biol. Bull. (Woods Hole, Mass.), 164:506-517.

134 | Coma R., Pola E., Ribes M. & M. Zabala (2003). Long-Term Assessment of Temperate Octocoral Mortality Patterns, Protected vs. Unprotected Areas. Ecological Applications. Vol. 14, No. 5, pp. 1466-1478.

135 | Weinbauer M. G. & B. Velimirov (1996). Population Dynamics and Overgrowth of the Sea Fan Eunicella cavolini (Coelenterata: Octocorallia) Estuarine, Coastal and Shelf Science, Volume 42, Number 5, 1996, pp. 583-595 (13).

136 | Irving, R. A. 2004. Leptopsammia pruvoti at Lundy – teetering on the brink? Porcupine Marine Natural History Society Newsletter, 15:29-34; Jackson A. (2000). Sea fan anemone, Amphianthus dhornii. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [On-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 29 July 2002]. Available from:htpp://www.marlin.ac.uk

137 | Peirano A., Morri C., Bianchi C. N., Aguirre J., Antonioli F., Calzetta G., Carobene L. Mastronuzzi G., & P. Orru (2004). The Mediterranean coral Cladocora caespitosa: a proxy for past climate fluctuations? Global and Planetary Change 40 (2004) 195-200; Tsounis G. (2005) Demography, Reproductive Biology and Trophic Ecology of Red Coral (Corallium rubrum L.) at the Costa Brava (NW Mediterranean): Ecological Data as a Tool for Management. Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Natural Sciences. University of Bremen Fachbereich 2January 2005; Adkins J. F., Henderson G. M., Wang S.- L., O'Shea S. & F. Mokadem (2004). Growth rates of the deep-sea scleractinia Desmophyllum cristagalli and Enallopsammia rostrata. Earth and Planetary Science Letters 227 (2004) 481-490; Risk M. J., Heikoop J. M, Snow M. G. & R. Beukens (2002). Lifespans and growth patterns of two deep-sea corals: Primnoa resedaeformis and Desmophyllum cristagalli. International Deep-Sea Coral Symposium No1, Halifax , CANADA (31/07/2000) Hydrobiologia 2002, vol. 471, pp. 125-131; Andrews A. H., Cordes E. E., Mahoney M. M., Munk K., Coale K. H., Cailliet G. M. & J. Heifetz (: Age, growth and radiometric age validation of a deep-sea, habitat-forming gorgonian (Primnoa resedaeformis) from the Gulf of Alaska, International Deep-Sea Coral Symposium No1, Halifax, CANADA (31/07/2000). Hydrobiologia, 2002, vol. 471 (1 p.1/4), pp. 101-110. pp. 101–110; Mortensen P. B. & H. T. Rapp (1998). Oxygen and carbon isotope rations related to growth line patterns in skeletons of Lophelia pertusa (L) (Anthozoa, Scleractinia): Implications for determination of linear extension rates. Sarsia 83: 433-446; Goffredo S., Mattioli G. & F. Zaccanti (2004). Growth and population dynamics model of the Mediterranean solitary coral Balanophyllia europaea (Scleractinia, Dendrophylliidae). Coral

Reefs (2004) 23: 433-443; Cheng H., Adkins J., Lawrence Edwards R. & E. A. Boyle (2000). U-Th dating of deep-sea corals Geochimica et Cosmochimica Acta, Vol. 64, No. 14, pp. 2401-2416, 2000; Adkins J. F. & E. A. Boyle (1997) Changing atmospheric D14C and the record of paleo-ventilation ages. Paleoceanography 12, 337–344; Kruzic P. & A. Pozar-Domac (2002). Skeleton growth rates of coral bank of Cladocora caespitosa (Anthozoa, Scleractinia) in lake Veliko jezero (Mljet National Park). Periodicum Biologorum 57:61. Vol. 104, No 2, 123-129, 2002; Bullimore B. (1987). Skomer Marine Reserve subtidal monitoring project. Photographic monitoring of subtidal epibenthic communities 1986. Nature Conservancy Council CSD Report, No. 744; Fowler S. L. & G. M. Pilley (1992). Report on the Lundy and Isles of Scilly marine monitoring programmes 1984 to 1991. Report to English Nature fron The Nature Conservation Bureau Ltd.; Garrabou J. & J. G. Harmelin (2002). A 20-year study on life-history traits of a harvested long-lived temperate coral in the NW Mediterranean: insights into conservation and management needs. Journal of Animal Ecology 71 (6), 966–978; Coma R., Ribes M., Zabala M. & M.- J. Gili (1998). Growth in a modular colonial marine invertebrate. Estuarine, coastal and shelf science. 1998, vol. 47, no4, pp. 459-470.

138 | Roark E. B., Guilderson T. P., Dunbar R. B. & B. L. Ingram (2006). Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. Marine Ecology. Progress Series. Vol. 327:1-14, 2006.

139 | Hillaire-Marcel C., Pons-Branchu E., Ghaleb B., Williams B. & D. Sinclair (2205). U-Series Systematics in Deep Corals (238u-234u-230th-226ra-210pb): Implications for their Trace-Element Study and Dating. ASLO Summer meeting. Santiago de Compostela, Spain. 19-24 June 2005.

140 | Wilson M. T., Andrews A. H., Brown A. L. & E. E. Cordes (2002), Axial rod growth and age estimation of the sea pen, Halipteris willemoesi Kolliker, Hydrobiologia, 471, 133-142.

141 | Mitchell N. D., Dardeau M. R. & W. W. Schroeder (1993). Colony morphology, age structure, and relative growth of two gorgonian corals, Leptogorgia hebes (Verrill) and Leptogorgia virgulata (Lamarck), from the northerm Gulf of Mexico. Coral reefs. Volume 12, Number 2: 65-70. July, 1993.

142 | Goffredo S. (2004) Growth and population dynamics model of the Mediterranean solitary coral Balanophyllia europaea (Scleractinia, Dendrophylliidae). Coral Reefs 23 (3).

143 | Kramarsky-Winter E. & Y. Loya (2000). Tissue regeneration in the coral Fungia granulosa: the effect of extrinsic and intrinsic factors. Mar. Biol. 137: 867-873; Bak R. P. M. & M. S. Engel (1979). Distribution, abundance and survival of juvenile hermatypic corals (Scleractinia) and the importance of life history strategies in the parent coral community. Mar. Biol. 54: 341-352; Jackson J. B. C. (1979). Morphological strategies of sessile animals. In: Rosen, B. R. & G. Larwood (Eds.) Biology and Systematics of Colonial Animals. Academic Press, New York, pp 499-555.

144 | Bavestrello G., Cerrano C., Zanzi D. & R. Cattaneo-Vietti (1997). Damage by fishing activities to the Gorgonian coral (Paramuricea clavata) in the Ligurian Sea. Aquatic Conservation: Marine and Freshwater Ecosystems, Vol 7, No. 3: 253-262. 1997

145 | Sebens K. P. & A. S. Johnson (1991). Effects of water movement on prey capture and distribution of reef corals. Hydrobiologia. 226:91-102.

146 | O'Brien T. L. (2005). The symbiotic association between intracellular zoochlorellae (chlorophyceae) and the coelenterate Anthopleura xanthogrammica. Journal of Experimental Zoology. Volume 211, Issue 3, Pages 343-355.

147 | Schlichter D. (1982). Nutritional Strategies of Cnidarians: The Absorption, Translocation and Utilization of Dissolved Nutrients by Heteroxenia fuscescens. American Zoologist 1982 22 (3): 659-669.

148 | Freiwald A. (2002). Reef-forming cold-water corals. In: Wefer, G., Billett, D., Hebbeln, D., Jørgensen, B. B., Schlüter, M., van Weering, T. (Eds.), Ocean Margin Systems. Springer-Verlag, Berlin, Heidelberg.

149 | Chintiroglou Ch. & A. Koukouras (1992). The feeding habits of three Mediterranean sea anemone species, Anemonia viridis (Forskål), Actinia equina (Linnaeus) and Cereus pedunculatus (Pennant). Helgoland Marine Research. Volume 46, Number 1: 53-68. March, 1992.

150 | Coma R., Gili J.- M., Zabala M. & T. Riera (1994) Feeding and prey. capture cycles in the aposymbiotic gorgonian Paramuricea. clavata. Marine Ecology Progress Series 115:257-270.

151 | López González P. Megina C. & J.- M. Gili (2002). El bosque animado. De cerca. Investigación y Ciencia. Julio 2000.

152 | Sabelli B., Giannuzzi-Savelli R. & D. Bedulli (1990): Catalogo annotato dei molluschi marini del Mediterraneo - Annotated check-list of Mediterranean marine mollusks, 1: XIV + 348 pp. Libreria Naturalistica Bolognese, Bologna.

153 | Richter, A. y Luque, Á, A., 2004. Intracapsular development and nutrition of two Mediterranean coralliophilids, Coralliophila meyendorffii and Babelomurex cariniferus (Neogsastropoda). World Congress of Malacology. Perth, Western Australia, 2004.

154 | Richter, A. & Luque, A. A., 2004. Epitonium dendrophylliae (Gastropoda: Epitoniidae) feeding on Astroides calycularis. (Journal of Molluscan Studies, 70 (1):119-121.

155 | Cattaneo-Vietti R., Chemello R. & R. Giannuzzi-Savelli (1990) Eds. Atlas of Mediterranean nudibranchs [Atlante dei nudibranchi del Mediterraneo]. Roma: Editrice La Conchiglia, 1990. 264 pp.

156 | Salazar-Vallejo S. I. (997). Anfinómidos y eufrosínidos (Polychaeta) del Caribe Mexicano con claves par alas especies reconocidas del Gran Caribe. Rev. Biol. Trop. 44 (3) / 45 (1):379-390.

157 | Vreeland H. V. & H. R. Lasker (1989). Selective feeding of the polychaete Hermodice carunculata Pallas on Caribbean gorgonians. Journal of Experimental Marine Biology and Ecology. Vol. 129, no. 3, pp. 265-277. 1989.

158 | Witman J. D. (1988). Effects of predation by the fireworm Hermodice carunculata on milleporid hydrocorals. Bulletin of Marine Science. Vol. 42, no. 3, pp. 446-458. 1988.

159 | Sussman M., Loya Y., Fine M. & E. Rosenberg (2003). The marine fireworm Hermodice carunculata is a winter reservoir and spring-summer vector for the coral-bleaching pathogen Vibrio shiloi. Environmental Microbiology. Volume 5, Number 4, April 2003, pp. 250-255 (6).

160 | Jarvis J. H. & P. E. King (1972). Reproduction and development in the pycnogonid Pycnogonum littorale. Marine Biology Volume 13, Number 2: 146-154. March, 1972.

161 | Behrens W. (1984). Larvenentwicklung und Metamorphose von Pycnogonum litorale (Chelicerata, Pantopoda). Zoomorphology. Volume 104, Number 5: 266-279. October, 1984.

162 | Abbiati M., Buffoni G., Dicola G. & G. Santagelo (1991) Red coral population dynamics: stabiltiy analysis and numerical simulation of time evolution of perturbed states. In: Ravera O. (ed) Terrestrial and aquatic ecosystems: perturbation and recovery. Hellis Horwood, New York, p 219–228.

163 | M. J. Cormier, K. Hori, Y. D. Karkhanis, J. M. Anderson, J. E. Wampler, J. G. Morin and J. W. Hastings. "Evidence for Similar Biochemical Requirements for Bioluminescence Among the Coelenterates", J. Cell. Physiol., 81, 291-298 (1973).

164 | Shimomura O. & F. H. Johnson (1979). Comparison of the amounts of key components in the bioluminescence system of various coelenterates. Comp. Biochem. Physiol. 1979, 64B, 105–107.

165 | Herring P. J. (1991). Observations on bioluminescence in some deep-water anthozoans. Hydrobiologia 216/217: 573-579; Titschack H. (1965). Untersuchungen über das Leuchten der Seefeder Veretillum cynomorium (Pallas). Vie et Milieu 15: 547-563; Titschack H. (1966). Über die Lumineszenz und ihre Lokalisation bei Seefedern. Zoologischer Anzeiger, Supplementband 29, 1965(1966):120-131; Nicol J. A. C. (1958). Observations on the luminescence of Pennatula phosphorea, with a note on the luminescence of Virgularia mirabilis. Journal of the marine biological Association of the United Kingdom 37: 551-563; Panceri P. (1872). Études sur la Phosphorescence des Animaux Marins. II. Du siège du mouvement lumineux dans les Méduses; III. Organes lumineux et lumière des Pennatules; VI. Sur un Pennatulaire phosphoresenct encore inconnu dans les environs de Naples (Cavernularia pusilla); IX. Des organes lumineux et de la lumière des Béroidiens. Annales des Sciences Naturelles, sér. 5 (Zoologie)16 (8):1-66.

166 | Williams G. C. (2000). First record of a bioluminescent soft coral: Description of a disjunct population of Eleutherobia grayi (Thomson and Dean, 1921) from the Solomon Islands, with a review of bioluminescence in the Octocorallia. Proceedings of the California Academy of Sciences 52 (17):209-255.

167 | Muzik K. (1978). A bioluminescent gorgonian, Lepidisis olapa, new species (Coelenterata: Octocorallia), from Hawaii. Bulletin of Marine Science 28(4): 735-741; Harvey E. N. (1952). Bioluminescence. Academic, New York.

168 | Tur J. M. (1993). Redescription and biological aspects ofHormathia alba (Andres, 1881), a luminescent sea anemone (Anthozoa, Actiniaria). Helgoland marine Research. Volume 47, Number 2. June, 1993

169 | Matz M. V., Fradkov A. F., Labas Y. A., Savitsky A. P., Zaraisky A. G., Markelov M. L., and S. A. Lukyanov (1999). Fluorescent proteins from nonbioluminescent Anthozoa species. Nature biotechnol. 17, 969-973; Wiedenmann J., Röcker C. & W. Funke (1999). The morphs of Anemonia aff. Sulcata (Cnidaria, Anthozoa) in particular consideration of the ectodermal pigments. In Verhandlungen der Gesellschaft für Ökologie, Band 29, J. Pfadenhauer, ed. (Heidelberg, Berlin: Spektrum Akademischer Verlag), 497-503.

170 | McFarlane I. D. & I. D. Lawn (1991). The senses of sea anemones: responses of the SS1 nerve net to chemical and mechanical stimuli. Hydrobiologia. Volume 216-217, Number 1: 599-604. June, 1991; Parker G.H. (1916). Locomotion of Sea-Anemones. Proceedings of the National Academy of Sciences of the United States of America, Vol. 2, No. 8 (Aug. 15, 1916), pp. 449-450

171 | Hofrichter R. (2005). El Mar Mediterráneo. Fauna, Flora, Ecología. II/1 Guía Sistemática y de identificación. Ediciones Omega. Barcelona. 849 pp.

172 | Shoukr F. A. (2004). Ecology of some benthic cnidarians inhabiting marine environment in Egypt. Electronic internet document available at http://www.marine.tanta.8m.net/ Published by the author, web page established December, 2004.

173 | Josephson R. K. & S. C. March (1966). The Swimming Performance Of The Sea-Anemone Boloceroides. J. Exp Bwl. (1966), 44, 493-506.

174 | Ross D. M. & G. A. Horridge (1957). Responses of Cerianthu (Coelenterata). Nature 180:1386–1370; Collins A. G., Lipps J. H. & J. W. Valentine (2000). Modern mucociliary creeping trails and the bodyplans of Neoproterozoic trace-makers. Paleobiology, 26 (1), 2000, pp. 47-55

175 | Shimek R. L. (23005). The Life and Death of Sea Pens. Reefkeeping. August 2005.

07. Threats to corals

176 | Sutherland K. P., Porter J. W. & C. (2004). Disease and immunity in Caribbean and Indo-Pacific zooxanthellate corals. Marine Ecology Progress Series. Vol. 266: 273-302, 2004.

177 | Smith G. W., Harvell C. D. & K. Kim (1998). Response of sea fans to infection with Aspergillus sp. (Fungi). Rev Biol Trop 46:205–208; Geiser D. M., Taylor J. W., Ritchie K. B. & G. W. Smith (1998). Cause of sea fan death in the West Indies. Nature 394:137-138.

178 | Frias-Lopez J., Bonheyo G. T., Jin Q. & B. W. Fouke (2003). Cyanobacteria associated with coral black band disease in Caribbean and Indo-Pacific reefs. Appl Environ Microbiol 69: 2409-2413; Rützler K. & D. Santavy (1983). The black band disease of Atlantic reef corals. I. Description of a cyanophyte pathogen. PSZN I: Mar Ecol 4:301-319; Cooney R. P., Pantos O., Le Tissier M. D. A., Barer M. R., O'Donnell A. G. & J. C. Bythell (2002). Characterization of the bacterial consortium associated with black band disease in coral using molecular microbiological techniques. Environ Microbiol 47:401-413.

179 | Schnell S., Assmus B. & L. L. Richardson (1996). Role of sulfate-reducing bacteria in the black band disease of corals. Annual Meeting of the VAAM (Vereinigung fuer Allgemeine und Angewandte Mikrobiologie) and GBCH (Gesellschaft fuer Biologische Chemie). Biospektrum, p 116; Garrett P. & H. Ducklow (1975). Coral diseases in Bermuda. Nature 253:349-350; Cooney R. P., Pantos O., Le Tissier M. D. A., Barer M. R., O'Donnell A. G. & J. C. Bythell (2002). Characterization of the bacterial consortium associated with black band disease in coral using molecular microbiological techniques. Environ Microbiol 47: 401-413; Ducklow H. & R. Mitchell (1979) Observations on naturally and artificially diseased tropical corals: a scanning electron microscope study. Microbiol Ecol 5: 215-223; Frias-Lopez J., Zerkle A. L., Bonheyo G. T. B. W. Fouke (2002). Partitioning of bacterial communities between seawater and healthy black band diseased and dead coral surfaces. Appl Environ Microbiol 68:2214-2228.

180 | Ramos-Flores T. (1983). Lower marine fungus associated with black line disease in star corals (Montastraea annularis E & S). Biol Bull 165:429–435.

181 | Cerrano C., Bavestrello G., Bianchi C. N., Cattaneo-vietti R. Bava S.., Morganti C., Morri C., Picco C. P., Sara G. & S. Schiaparelli (2000) A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (Northwestern Mediterranean) summer 1999. Ecol Lett 3:284-293.

182 | Ravindran J. C. & C. Raghukumar (2002) Pink line syndrome (PLS) in the scleractinian coral Porites lutea. Coral Reefs 21:252.

183 | Antonius A. A. & D. Lipscomb (2000). First protozoan coral-killer identified in the Indo-Pacific. Atoll Res Bull 481:1-21.

184 | Dube D., Kim K., Alker A. P. & C. D. Harvell (2002). Size structure and geographic variation in chemical resistance of sea fan corals Gorgonia ventalina to a fungal pathogen. Mar Ecol Prog Ser 231:139-150; Smith G. W., Harvell C. D. & K. Kim (1998). Response of sea fans to infection with Aspergillus sp. (Fungi). Rev Biol Trop 46:205-208.

185 | Le Champion-Alsumard T., Golubic S. & K. Priess (1995) Fungi in corals: symbiosis or disease? Interaction between polyps and fungi causes pearl-like skeleton biomineralization. Mar Ecol Prog Ser 117:137-147; Ravindran J., Raghukumar C. & S. Raghukumar (2001). Fungi in Porites lutea: association with healthy and diseased corals. Dis Aquat Org 47:219-228.

186 | Goldberg W. M., Makemson J. C. & S. B. Colley (1984). Entocladia endozoica sp nov a pathogenic chlorophyte: structure life history physiology and effect on its coral host. Biol Bull 166:368–383; Morse D. E., Morse A. N. C. & H. Duncan (1977). Algal 'tumors' in the Caribbean sea-fan Gorgonia ventalina. Proc 3rd Int Coral Reef Symp Miami 1:623-629; Morse D. E., Morse A., Duncan H. & RK. Trench (1981). Algal tumors in the Caribbean octocorallian Gorgonia ventalina:II. Biochemical characterization of the algae and first epidemiological observations. Bull Mar Sci 31:399-409.

187 | Cheng T. C. & A. K. L. Wong (1974). Chemical, histochemical, and histopathological studies on corals, Porites spp., parasitized by trematode metacercariae. J Invertebr Pathol 23:303–317; Aeby G. S. (1998). A digenean metacercaria from the reef coral, Porites compressa, experimentally identified as Podocotyloides stenometra. J Parasitol 84:1259-1261.

188 | Grygier M. J. & S. D. Cairns (1996). Suspected neoplasms in deepsea corals (Scleractinia: Oculinidae: Madrepora spp.) reinterpreted as galls caused by Petrarca madreporae n. sp. (Crustacea: Ascothoracida: Petrarcidae). Dis Aquat Org 24:61-69.

189 | Ben-Haim Y. & E. Rosenberg (2002). A novel Vibrio sp pathogen of the coral Pocillopora damicornis. Mar Biol 141:47–55; Ben-Haim Y., Thompson F. L., Thompson C. C., Cnockaert M. C., Hoste B., Swings J. & E. Rosenberg (2003) Vibrio coralliilyticus sp nov, a temperature-dependent pathogen of the coral Pocillopora damicornis. Int J Syst Evol Microbiol 53:309-315; Ben-Haim Y., Zicherman-Keren M. & E. Rosenberg (2003). Temperature-regulated bleaching and lysis of the coral Pocillopora damicornis by the novel pathogen Vibrio coralliilyticus. Appl Environ Microbiol 69:4236-4242; Kushmaro A., Rosenberg E., Fine M. & Y. Loya (1997). Bleaching of the coral Oculina patagonica by Vibrio AK-1. Mar Ecol Prog Ser 147:159-165; Kushmaro A., Rosenberg E., Fine M., Ben-Haim Y. & Y Loya (1998). Effect of temperature on bleaching of the coral Oculina patagonica by Vibrio shiloi AK-1. Mar Ecol Prog Ser 171:131–137; Kushmaro A., Banin E., Loya Y., Stackebrandt E. & E. Rosenberg (2001). Vibrio shiloi sp nov the causative agent of bleaching of the coral Oculina patagonica. Int J Syst Evol Microbiol 51:1383–1388; Rosen-

berg E., Ben-Haim Y., Toren A., Banin E., Kushmaro A., Fine M. & Y. Loya (1998). Effect of temperature on bacterial bleaching of corals. In: Rosenberg E (ed) Current perspectives in microbial ecology. ASM Press, Washington, DC, p 242–254.

190 | Ritchie K. B., Smith G. W. (1995) Carbon-source utilization patterns of coral associated marine heterotrophs. J Mar Biotechnol 3:105-107.

191 | Patterson K. L., Porter J. W., Ritchie K. B., Polson S. W., Mueller E., Peters E. C., Santavy D. L. & G. W. Smith (2002). The etiology of white pox a lethal disease of the Caribbean elkhorn coral Acropora palmata. Proc Natl Acad Sci USA 99:8725-8730.

192 | Richardson L. L., Goldberg W. M., Carlton R. G. & J. C. Halas (1998). Coral disease outbreak in the Florida Keys: plague type II. Rev Biol Trop 46:187–198; Richardson L. L., Goldberg W. M., Kuta K. G., Aronson R. B. & Smith G. W., Ritchie K. B., Halas J. C., Feingold J. S. and S. M. Miller. (1998) Florida's mystery coral killer identified. Nature 392:557–558; Denner E. B. M., Smith G., Busse H. J., Schumann P., Narzt T., Polson S. W., Lubitz W. & L. L. Richardson (2003) Aurantimonas coralicida gen. nov., sp. nov., the causative agent of white plague type II on Caribbean scleractinian corals. Int J Syst Evol Microbiol 53:1115-1122.

193 | Perez T., Garrabou J., Sartoretto S., Harmelin J.- G., Francour P. & J. Vacelet (2000). Mortalité massive d'invertébrés marins: un événement sans précédent en Méditerranée nord-occidentale. C. R. Acad. Sci. Paris, Sciences de la vie / Life Sciences 323 (2000) 853-865

194 | Cerrano D., Bavestrello G., Bianchi C. N, Cattaneo-vietti R., Bava S., Morganti C., Morri C., Picco P., Sara G., Schiaparelli S., Siccardi A. & F. Sponga (2000). A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. Ecology Letters 3 (4), 284-293.

195 | Cerrano C., Arillo A., Azzini F., Calcinai B., Castellano L., Muti C., Valisano L., Zega G. & G. Bavestrello (2004). Gorgonian population recovery after a mass mortality event. Aquatic Conservation: Marine and Freshwater Ecosystems. Volume 15, Issue 2 , Pages 147-157.

196 | Cerrano C., Totti C., Sponga F. & G. Bavestrello (2006). Summer disease in Parazoanthus axinellae (Schmidt, 1862) (Cnidaria, Zoanthidea). Italian Journal of Zoology. Volume 73, Number 4: 355-361. December 2006.

197 | Kersting D. K. & C. Linares (2006). Mortandad de Paramuricea clavata asociada a un evento de macroagregados mucilaginosos ("llepó") tras el verano de 2004 en Islas Columbretes. XIV Simposio Ibérico de Estudios de Biología Marina. CosmoCaixa Barcelona, Museo de la Ciencia de la Obra Social "la Caixa" 12-15 septiembre 2006.

198 | Kersting D. K. & J. Templado (2006). Evento de Mortandad masiva del Coral Cladocora caespitosa (Scleractinia) en las Islas Columbretes tras el calentamiento anormal del agua en el verano de 2003. XIV Simposio Ibérico de Estudios de Biología Marina. CosmoCaixa Barcelona, Museo de la Ciencia de la Obra Social "la Caixa" 12-15 septiembre 2006.

199 | Coma R., Linares C., Ribes M. & M. Zabala (2006). A large scale disturbance espisode affecting Paramuricea clavata populations along the Mediterranean peninsular coast of Spain in 2003. XIV Simposio Ibérico de Estudios de Biología Marina. CosmoCaixa Barcelona, Museo de la Ciencia de la Obra Social "la Caixa" 12-15 septiembre 2006.

200 | Sartoni G. & C. Sonni (1992)., Tribonema marinum J. Feldmann e Acinetospora crinita (Carmichael) Sauvageau nelle formazioni mucillaginose bentoniche osservate sulle coste toscane nell'estate La crisi del Mediterraneo in seguito alla fioritura di masse algali, Accad. Intern. Sci. Tecn. Sub. Ustica 9 (1992) (1991) 37-46; Mistri M. & V. U. Ceccherelli (1995). Damage and partial mortality in the gorgonian Paramuricea clavata in the strait of Messina (Tyrrenian Sea), Mar. Life 5 (1) (1995) 43-49.

201 | Metalpa R. R., Bianchi C. N. & A. Peirano A. (2000). Coral mortality in NW Mediterranean, Coral Reefs 19 (2000) 24.–24; Kushmaro A., Rosenberg E., Fine M. & Y. Loya (1997). Bleaching of the coral Oculina patagonica by Vibrio AK-1, Mar. Ecol. Prog. Ser. 147 (1997) 159–165; Kushmaro A., Rosenberg E., Fine M., Haim Y. B. & Y. Loya (1998). Effect of temperature on bleaching of the coral Oculina patagonica by Vibrio AK-1, Mar. Ecol. Prog. Ser. 171 (1998) 131-137.

202 | Fine M., Banin E., Israely T., Rosenberg E. & Y. Loya (2002). Ultraviolet radiation prevents bleaching in the Mediterranean coral Oculina patagonica. Marine Ecology Progress Series Vol 226. p249-254, January 2002.

203 | Sussman M., Loya Y., Fine M. & E. Rosenberg (2003). The marine fireworm Hermodice carunculata is a winter reservoir and spring-summer vector for the coral-bleaching pathogen Vibrio shiloi. Environmental Microbiology. Volume 5, Number 4, April 2003, pp. 250-255(6); Rosenberg E. & L. Falkovitz (2004). The Vibrio shiloi/Oculina patagonica Model System of Coral Bleaching. Annual Review of Microbiology, Vol. 58: 143-159.

204 | Kleypas J. A., Feely R. A., Fabry V. J., Langdon C., Sabine C. L. & L. L. Robbins (2006). Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers: A Guide for Future Research, report of a workshop held 18-20 April 2005, St. Petersburg, FL, sponsored by NSF, NOAA, and the U.S. Geological Survey, 88 pp.

205 | Archer D., Kheshgi H. & E. Maier-Reimer (1998). Dynamics of fossil fuel CO_2 neutralization by marine $CaCO_3$. Global Biogeochem. Cy., 12, 259-276.

206 | Zibrowius H. (1991). Ongoing modification of the Mediterranean marine fauna and flora by the establishment of exotic species. Mésogée, 51: 83-107.

207 | Coma R., Pola E., Ribes M. & M. Zabala (2003). Long-Term Assessment of Temperate Octocoral Mortality Patterns, Protected vs. Unprotected Areas. Ecological Applications. Vol. 14, No. 5, pp. 1466–1478; Harmelin J.-G. & J. Marinopoulos (1994). Population structure and partial mortality of the gorgonian Paramuricea clavata (Risso) in the North-Western Mediterranean (France, Port-Cros Island) (Structure de la population et mortalité partielle de la gorgone Paramuricea clavata (Risso) en Méditerranée nord-occidentale (France, île de Port-Cros)). Marine life 1994, vol. 4, no1, pp. 5-13.

208 | Sala E., Garrabou J. & M. Zabala (1996). Effects of divers frequentation on Mediterranean sublittoral populations of the bryozoan Pentapora fascialis. Marine Biology, 126(3): 451-459; Harmelin J.G. & J. Marinopoulos J. (1994). Population structure and partial mortality of the gorgonian Paramuricea clavata (Risso) in the north-western Mediterranean (France, Port-Cros Island). Marine Life, 4(1): 5-13; Garrabou J., Sala E., Arcas A. & M. Zabala (1998). The impact of diving on rocky sublittoral communities: a case study of a bryozoan population. Conservation Biology, 12(2): 302-312.

209 | Rivoire G. (1991). Mortalité de corail et de gorgones en profondeur au large des côtes provençales, in : Boudouresque C. F., Avon M., Gravez V. (éd.), Les espèces marines à protéger en Méditerranée, GIS Posidonies publ., France, 1991, pp. 53-59; Arnoux A., Harmelin J. G., Monod J. L., Romaña L. A. & H. Zibrowius (1992). Altérations des peuplements benthiques de roches profondes en Méditerranée nord-occidentale : quelques aspects biologiques et molysmologiques, C. R. Acad. Sci. Paris 314 (1992) 219-225.

210 | Antoniadou C., Voultsiadou E. & C. Chintiroglou (2006). Sublittoral megabenthos along cliffs of different profile (Aegean Sea, Eastern Mediterranean). Belg. J. Zool., 136 (1): 69-79. January, 2006; Bell J., Barnes D., Shaw C., Heally A. & A. Farrell (2003). Seasonal "fall out" of sessile macro-fauna from submarine cliffs : quantification, causes and implications. J. Mar. Biol. Ass. U.K., 83 : 1199-1208.

211 | Rogers C.S. (1990). Responses of coral reefs and reef organisms to sedimentation. Mar. Ecol. Prog. Ser. 62: 185-202.

212 | Kim K., Harvell C.D., Kim P. D., Smith G. W. & S. M. Merkel (2000). Fungal disease resistance of Caribbean sea fan corals (Gorgonia spp.). Marine Biology, 136, 259-267.

213 | Oceana (2003): European trawlers are destroying the oceans. Oceana; Jennings S., Dinmore T. A., Duplisea D.E., Warr K. J. & J. E. Lancaster (2001). Trawling disturbance can modify benthic production processes. J. Anim. Ecol., 70; 459-475; Watling L. & E. A. Norse (1998). Disturbance of the seabed by mobile fishing gear: A comparison with forest clear-cutting. Conservation Biology, 12: 1180-1197.

214 | Fossa, J. H., P. B. Mortensen, & D. M. Furevik (2000). Lophelia-korallrev langs norskekysten forekomst og tilstand. Fisken Havet 2, 1–94; Koslow, J. A., K. Gowlett-Holmes, J. K. Lowry, T. O'Hara, G. C. B. Poore & A. Williams (2001). Seamount benthic 450 macrofauna off southern Tasmania: community structure and impacts of trawling. Mar. Ecol. Prog. Ser. 213, 111-125.

215 | Fossa J.H. …Op. cit. nota 222.

216 | Roberts J. M., Harvey S. M., Lamont P. A. & J. A. Gage (2000). Seabed photography, environmental assessment and evidence for deep-water trawling on the continental margin west of the Hebrides. Hydrobiologia, 44: 173-183; Rogers A. D. (1999). The biology of Lophelia pertusa (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. International Review of Hydrobiology, 84: 315-406; Bett B. J., Billett D. S. M., Masson D. G. & P. A. Tyler (2001). RRS Discovery cruise 244, 07 Jul–10 Aug 2000. A multidisciplinary study of the environment and ecology of deep-water coral ecosystems and associated seabed facies and features (The Darwin Mounds, Porcupine Bank and Porcupine Seabight). Southampton Oceanography Centre, Cruise Report No. 36. 108 pp; Fossa J. H., Mortensen P. B. & D. M. Furevik (2000). Lophelia-korallrev langs norskekysten forekomst og tilstand. Fisken Havet 2, 1–94.

217 | Hall-Spencer J., Allain V. & J. H. Fossa (2001). Trawling damage to Northeast Atlantic ancient coral reefs. Proceedings of the Royal Society of London.2001.1910. The Royal Society 2002.

218 | Mentioned in: Anon. (2002). Deep-Sea, Cold Water Corals. Fact-sheet. Marine Conservation Biology Institute/American Oceans Campaign 2-22-02. http://www.americanoceans.org/fish/ohpa-coral.pdf

219 | Maynou F. & J. Cartes (2006). Fish And Invertebrate Assemblages From Isidella elongata Facies In The Western Mediterranean. Report of the Working Group of Sgmed 06-01 (of the Scientific, Technical and Economic Committee for Fisheries-STECF) on Sensitive and Essential Fish Habitats in the Mediterranean Sea. Rome 6-10 March 2006. Pages 289-307.

220 | SGMED (2006). Report of the Working Group of Sgmed 06-01 (of the Scientific, Technical and Economic Committee for Fisheries-STECF) on Sensitive and Essential Fish Habitats in the Mediterranean Sea. Rome 6-10 March 2006. .

221 | Kaiser M., Rogers S. & J. Ellis (1999). Importance of benthic habitat complexity for demersal fish assemblages. In Fish Habitat; Essential Fish Habitat and Rehabilitation, American Fisheries Society Symposium 22.

222 | Palanques A., Martín J., Puig P., Guillén J., Company J. B. & F. Sardà (2004). Sediment gravity flows induced by trawling in the Palamós (Fonera) canyon. Rapp. Comm. int. Mer Médit., 37: 63.

223 | Bavestrello G., Cerrano C., Zanzi D. & R. Cattaneo-Vietti (1997). Damage by fishing activities to the Gorgonian coral Paramuricea clavata in the Ligurian Sea Aquatic Conservation: Marine and Freshwater Ecosystems. Volume 7, Issue 3 , Pages 253-262.

224 | CE (2003). Proposal for a Council Regulation concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea and amending Regulations (EC) No. 2847/93 and (EC) No. 973/2001 (COM(2003) 589 final -2003/0229 (CNS)).

225 | BOE (2006). ORDEN APA/79/2006, de 19 de enero, por la que se establece un plan integral de gestión para la conservación de los recursos pesqueros en el Mediterráneo. BOE Nº 22; 3367-3368. Jueves 26 enero 2006.

226 | GFCM (2005). Recommendation GFCM2005/1 on the Management of Certain Fisheries Exploiting Demersal and Deepwater Species. FAO General Fisheries Commission for the Mediterranean. Report of the twenty-ninth session. Rome, 21-25 February 2005. GFCM Report. No. 29. Rome, FAO. 2005. 50p.

08. Coral uses

227 | GFCM (2006). Recommendation GFCM/2006/3 Establishment of Fisheries Restricted Areas in Order to Protect the Deep Sea Sensitive Habitats. FAO General Fisheries Commission for the Mediterranean. Report of the thirtieth session. Istanbul, Turkey, 24–27 January 2006. GFCM Report. No. 30. Rome, FAO. 2006. 56p.

228 | İlham Artüz M., Levent Artüz M. & O Bülent Artüz (1990). Mercan Türlerine Getirilen Yasaklar İle İlgili Görüşler. T.C. Çevre Bakanlığı Raporu K. K. G. M. Su Ürünleri Sirküleri Düzenlemeleri 1990.

229 | Bramanti L., Iannelli M. & G. Santangelo (2006). Population dynamics and global change-induced mortality in the precious red coral Corallium rubrum (L.1758). 7th International Temperate Reef Symposium (ITRS), June 26-July 1, 2006. Santa Barbara, CA.

230 | FAO-FIGIS (2008). A world overview of species of interest to fisheries. Corallium rubrum SIDP -Species Identification and Data Programme 2001 FIGIS Species Fact Sheets FAO – FIGIS.

231 | Tsounis G, Rossi S., Gili J.- M. & W. Arntz (2006). Population structure of an exploited benthic cnidarian: the case study of red coral (Corallium rubrum L.). Mar. Biol. 149:1059-1070.

232 | Santangelo G., Carlietti E., Maggi E. & L. Bramanti (2003). Reproduction and population sexual structure of the overexploited Mediterranean red coral Corallium rubrum. Marine Ecology Progress Series 248:99-108.

233 | Tescione G. (1973). The Italians and Their Coral Fishing. Fausto Fiorentino, Naples.

234 | EC (1994). COUNCIL REGULATION (EC) No 1626/94 of 27 June 1994 laying down certain technical measures for the conservation of fishery resources in the Mediterranean. OJ L 171, 6.7.1994, p. 1.

235 | Tsounis G. (2005). Demography, reproductive biology and trophic ecology of red coral (Corallium rubrum L.) at the Costa Brava (NW Mediterranean): ecological data as a tool for management. Reports of Polar and Marine Science. 512. Alfred Wegener Institute for Polar and Marine Research, Bremerhaven.

236 | Torntore S.J. (2002). Italian Coral Beads: Characterizing their Value and Role in Global Trade and Cross-Cultural Exchange, PhD dissertation, St. Paul: University of Minnesota. 259 pp.

237 | Cimino G., De Rosa S., & S. De Stefano (1984). Antiviral agents from a gorgonian, Eunicella cavolini. Experientia. 1984, vol. 40, no4, pp. 339-340.

238 | Kennard O., Riva de Sanserverine W. D. G. L., Tursch B. & R. Bosmans (1968). Chemical Studies of Marine Invertebrates. IV..sup.1a Terpenoids LXII..sup.1b Eunicellin, a Diterpenoid of the Gorgonian Eunicella Stricta. X-ray Diffraction Analysis of Eunicellin Dibromide. Tetrahedron Lett, No.24, pp. 2879-2884, 1968.

239 | Ortega M. J., Zubia E. & J. Salva (1994). Structure and absolute configuration of palmonine F, a new eunicellin-based diterpene from the Gorgonian Eunicella verrucosa. Journal of Natural Products (Lloydia) 57(11): 1584-1586.

240 | D'Ambrosio M., Guerriero A. & F. Pietra (2004). Coralloidolide F, the First Example of a 2,6-Cyclized Cembranolide: Isolation from the Mediterranean Alcyonacean Coral Alcyonium coralloides. Helvetica Chimica Acta, Volume 73, Issue 4, Pages 804-807.

241 | D'Ambrosio M., Guerriero A. & F. Pietra (1987). Sarcodictyin A and Sarcodictyin B, Novel Diterpenoidic Alcohols Esterified by (E)-N(1)-Methylurocanic Acid. Isolation from the Mediterranean Stolonifer Sarcodictyon roseum. Helvetica Chimica Acta-vol. 70, pp. 2019-2027 (1987).

242 | Fontana A., Ciavatta M. L. & G. Cimino (1998). Cladocoran A and B: Two Novel γ-Hydroxybutenolide sesterterpenes from the Mediterranean Coral Cladocora cespitosa J. Org. Chem., 63 (9), 2845 -2849, 1998.

243 | Müller W. E., Renneisen K., Kreuter M. H., Schröder H. C. & I. Winkler (1988). The D-mannose-specific lectin from Gerardia savaglia blocks binding of human immunodeficiency virus type I to H9 cells and human lymphocytes in vitro. J Acquir Immune Defic Syndr. 1988;1(5):453-458.

244 | Verkhusha V. & K. A. Lukyanov (2004). The molecular properties and applications of Anthozoa fluorescent proteins and chromoproteins. Nature Biotechnol. 22, 289-296 (2004); Katz M. H., Takimoto S., Spivack D., Moossa A. R., Hoffman R. M. & M. Bouvet (2003). A Novel Red Fluorescent Protein Orthotopic Pancreatic Cancer Model for the Preclinical Evaluation of Chemotherapeutics. Journal of Surgical Research: Vol. 113, No. 1, July 2003.

245 | Watters M. R. (2005). Tropical marine neurotoxins: venoms to drugs. Semin. Neurol. 2005, 25, 278-289.

246 | Arias H. R. (2006). Marine Toxins Targeting Ion Channels. Mar. Drugs 2006, 4, 37-69.

247 | Bonev B. B., Lam Y.- H., Anderluh G., Watts A., Norton R. S. & F. Separovic (2003). Effects of the Eukaryotic Pore-Forming Cytolysin Equinatoxin II on Lipid Membranes and the Role of Sphingomyelin. Biophys J. 2003 April; 84(4): 2382–2392; Caaveiro J. M. M., Echanbe I., Gutierres-Aguirre I., Nieva J. L., Arrondo J. L. R. & J. M. Gonzalez-Manas (2001). Differential interaction of Equinatoxin II with model membranes in response to lipid composition. Biophys. J. 80:1343-1353.

09. Protected corals

248 | IUCN (2006). 2006 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 27 January 2007.

10. Oceana and corals

249 | Altuna A. (2006). Listado de los cnidarios bentónicos del Golfo de Vizcaya y zonas próximas (42° N a 48° 30'N y 10° W). Fauna Ibérica Project, National Museum of Natural Sciences, Madrid. http://www.fauna-iberica.mncn. csic.es/faunaib/altuna4.pdf (Last revision: 01/12/2006); Brito A. & O. Ocaña (2004). Corals of the Canary Islands. Skeleton anthozoa of the littoral and deep bottoms. (F.Lemus, ed.). La Laguna, 2004

Caryophyllia inornata making room for itself within the *Spirastrella cunctatrix* sponge
© OCEANA/ Juan Cuetos

OCEANA

Plaza de España – Leganitos, 47
28013 Madrid (España)
Tel: + 34 911 440 880
Fax: + 34 911 440 890
E-mail: europe@oceana.org
www.oceana.org

Rue Montoyer, 39
1000 Brussels (Belgium)
Tel.: + 32 (0) 2 513 22 42
Fax: + 32 (0) 2 513 22 46
E-mail: europe@oceana.org

2501 M Street, NW, Suite 300
Washington, D.C, 20037-1311 USA
Tel.: + 1 (202) 833 3900
Fax: + 1 (202) 833 2070
E-mail: info@oceana.org

175 South Franklin Street -Suite 418
Juneau, Alaska 99801 USA
Tel: + 1 (907) 586 40 50
Fax: + 1(907) 586 49 44
E-mail: northpacific@oceana.org

Avenida General Bustamante, 24. Departamento 2C
750-0776 Providencia, Santiago
República de Chile
Tel.: +56 2 427 0970
Fax: +56 2 427 0955
E-mail: Info-AmericadelSur@oceana.org

E.C.F

PAPEL RECICLADO 100%