MARINE FAUNA (INCLUDING BRACKISH WATERS)

STATE OF KNOWLEDGE

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The concept of biodiversity as linked to the health of the environment and the functioning of ecosystems has finally been recognised. In any case, great attention seems to be paid to the biodiversity of terrestrial habitats, while marine biodiversity receives much less consideration.

It has been said that terrestrial biodiversity is much greater than that in the sea, but three quarters of terrestrial species are insects, above all coleopterans. All things considered, terrestrial fauna is represented by only a few types of animals. Apart from arthropods and vertebrates there are anelids, molluscs and a series of parasites (placed into the general category of 'worms') that includes platelminths, nematodes, nematomorphs, and acanthocephalans. With very rare exceptions, all of these animals are also present in the sea, where many other types of animals reside: placozoans, mesozoans, ctenophores, nemertines, loriciferans, gastrotriches, kinorhynchs, rotifers, gnathostomulids, chetognaths, phoronids, brachiopods, priapulids, sipunculids, echiurids, and hemichordates. Unknown animals are still discovered at sea, the latest being a few years ago: the cicliophorans. Hence, the diversity of marine animals is enormous at the structural level (types or *phyla*). On the other hand, species are very abundant on land. However, as advancement is made to knowledge, we are becoming conscious of the fact that marine biological diversity is perhaps as elevated as terrestrial, because up to now, only a few species have been described in the context of lesser known *phyla* or in poorly accessible habitats. Numeric estimates of unknown species, the inhabitants of the abysses (the most common habitat type of the planet), indicate that marine biodiversity could have a species richness that is far superior to what we currently know.

Life in the sea is expressed in a different manner to that on the land. On land, few animals have monopolised all the habitats, but the real dominators are plants. Instead, water limits the penetration of light and, beyond a certain depth, there is total darkness. If there is insufficient light, photosynthesis does not occur. For this reason, the area of the sea utilised by vegetation attached to the sea bed is limited to a few dozen metres. The greatest part of the marine habitat extends down to much greater depths. More than seventy percent of the Earth is covered by oceans, and of this area, microscopic marine organisms (phytoplankton, made up of bacteria and protists) are responsible for most of the photosynthetic activity that takes place in the first few dozen metres of depth. The role of phytoplankton as a primary producer (transformation of non-living matter to living matter) is superior to that of the famous Amazon forests, and it sustains the entire living marine system. Therefore, marine ecosystem functioning is also based on primary production, though the producers are often minuscule unicellular organisms and not plants with roots, trunk and leaves. Their presence in not conspicuous as their functioning is based of the fast rate of renewal that does not require the constant presence of large-sized organisms. The real structural dominators of the marine habitat are the animals.

One of their peculiarities is that of having a great quantity of food readily available made up of fragments of organic matter in decomposition and of small plankton organisms that are captured by filtering the water. This type of feeding does not exist on dry land and is only made possible by the presence of water, which always maintains some suspension even when it is very clear.

Another important difference between marine and terrestrial animals is colony propagation in the sea. There is nothing similar to colonies of sponges, cnidarians, kamptozoans, bryozoans, pterobranchs and tunicates on land.

In the marine habitat, thanks to the density of the water, life is carried out in three dimensions. A distinction should be made between *pelagos* (all the organisms that live in the water column) and *benthos* (all the organisms that live in or associated with the seafloor). Pelagic organisms always lead a free-floating existence, without ever resting on the seafloor and only approaching it occasionally. They are divided into two categories:

- some are powerful swimmers, like many fish, marine mammals and also squid: they are part of the so-called *nekton*.
- while those belonging to *plankton* are pelagic organisms that have no or little swimming ability and are transported through the water by the currents.

Most marine species however, belong to *benthos* or rather the domain of all the organisms that live on or at the seafloor or else in very strict proximity to it.

The recent *Checklist of Italian Fauna* includes 8,342 marine species. Owing to the geographical position of Italy, it is likely that Italian fauna represents the vast majority of living species in the Mediterranean. In comparing world estimates, the Mediterranean hosts between 4%

and 18% of all marine species in the world, while it represents only 0.82% in terms of surface area and 0.32% of the volume of the Earth's oceans. There are numerous endemic species to Italy, averaging more than a quarter of the entire Mediterranean biota. Why are there so many species in the Mediterranean? One reason is the variety of climatic and hydrological situations, along with the coexistence of temperate as well as tropical biota. Another reason is the tormented geological history that has led to a complex series of environmental changes. In an attempt to briefly summarise them, we can say:

- during the Triassic period, in the place of the Mediterranean Sea there was the Tetide basin, a wedge-shaped eastward-open equatorial body of water that indented Pangaea;
- during the Cretaceous period, that saw the lengthening and widening of Atlantic Ocean, the Tetide connected the recently formed ocean to the older gigantic ocean known as Panthalassa. At the time, the Tetide hosted a highly diversified hot water fauna, roughly comparable to that of the tropical Indopacific area today;
- during the Miocene period (about 10 millions of years ago), the Mediterranean separated from the Indo-Pacific. Towards the end of the Miocene (about 6 millions of years ago), the marine gateways between the Atlantic Ocean and the Mediterranean Sea were closed off and this led to the so-called Messinian Salinity Crisis. The negative hydrologic balance (evaporation in the Mediterranean exceeds both direct rainfall and the freshwater input by rivers) set off a desiccation process of the Mediterranean which was probably transformed into a series of large evaporating lakes. The great biodiversity of that period was thus drastically reduced;
- with the reopening of the Strait of Gibraltar, at the beginning of the Pliocene period (5 million years ago), the Mediterranean was repopulated with species of Atlantic origin, thus becoming an Atlantic biogeographical province. The alteration of the ice ages and warm interglacial periods during the Quaternary resulted in different immigration waves of Atlantic fauna of boreal or subtropical origin.

The great richness of species in the Mediterranean, therefore, is due to its long evolutionary history during the Tertiary as well as to the introduction of post-Pliocene species from the Atlantic. The present biota of the Mediterranean Sea is made up of species belonging to several biogeographic categories:

a) a temperate Atlantic-Mediterranean base;
b) pan-oceanic species;
c) endemic elements, including both paleoendemic species (probably of Tetide origin), as well as neoendemic species (above all of Pliocene origin);
d) subtropical Atlantic species (remnants of the interglacial periods, especially of the Tirrenian);
e) boreal Atlantic species (remnants of the glacial periods, especially of the Würm);
f) migrants from the Red Sea (above all in the Levant Sea);
g) migrants from the eastern Atlantic (especially in Alboran Sea).

These categories generally occur abundantly in different parts of the basin, currently subdivided into ten biogeographical sectors:

1) Alboran Sea;
2) Algeria and southern Spain;
3) From the Balearic Sea to the Tyrrhenian Sea;
4) Gulf of Lyon and Ligurian Sea;
5) Northern Adriatic;
6) Central Adriatic;
7) Southern Adriatic;
8) Northern Aegean;
9) Ionian and southern Aegean;
10) From the Gulf of Gabès to the Levant Sea.

Italian seas are representative of 6 biogeographical sectors out of 10; Spain then follows with 3 sectors, while all the other Mediterranean countries are representative of either 1 or 2 sectors. No other nation equals the importance of Italy in terms of richness of marine biodiversity of the Mediterranean. On the one hand, Italy has a great responsibility in defining biodiversity protection and management policies for the Mediterranean, while on the one hand, it has the possibility of impoverishing it like no other nation, simply within its own territorial waters.

The most typical fauna of the Mediterranean is found in the Tyrrhenian Sea, while fauna is impoverished and diversified in the Ligurian Sea, and even more so in the Adriatic Sea. The Alboran Sea, immediately east of Gibraltar, shows an evident affinity with the Atlantic, given the continual penetration of Atlantic species that reach the south-western coasts of Sicilia. The Levante Basin (and consequently the Ionian Sea) has gathered species from the Red Sea after the opening of the Suez Canal. Many Lessepsian species, now acclimatised in the Mediterranean, have reached the coasts of southern Italy.

PLANKTON

Plankton is the group of organisms that live suspended in water and which are transported through it by currents and tides. Plankton are very small organisms (bacteria and viruses), small organisms (unicellular organisms and microscopic animals such as rotifers and copepods), large organisms (shellfish, some jellyfish and molluscs) and very large organisms (jellyfish and thaliaceans even two metres long or more, excluding the tentacles). Therefore size is not a typical characteristic of plankton. Photosynthetic plankton, the phytoplankton, is made up of diatomeans, flagellates and other unicellular organisms. Animal plankton is called zooplankton, while the bacterioplancton are made up of bacteria, with the task of primary production and decomposition.

Plankton are not very abundant in Italian seas in winter, though storms help create the necessary conditions for their return by stirring up the seafloor, as does rainfall that washes down the land, thus increasing the quantity of nutrients (nourishment for plankton) in the water column. In spring, together with the nutrients made available from the winter, there are also more hours of sunlight, and so by utilising nutrients and sunlight, phytoplankton reproduces in a very rapid and considerable manner. This peak of primary production sustains the entire marine system for a year. As phytoplankton is a food source for herbivorous zooplankton, they, in turn, begin to increase. The activity of herbivores diminishes the phytoplankton which at the height to summer is scarce also because of the scarcity of nutrients. Herbivorous zooplankton reach their peak of abundance at the end of spring-early summer which in turn sets off the process of reproduction and growth of many other organisms, from carnivorous zooplankton to fish, the inhabitants of the seafloor and their larvae. Towards the end of summer this swarm of life is placated, many organisms die and their remains fall to the seafloor, often together with spores and eggs that will commence life in the following season. In autumn, with the remixing of the waters associated to degrees of temperature and sunlight that are similar to those of spring, they can be fluctuations of primary and secondary production, even though of minor entity with respect to spring. In winter, the process of decomposition takes place and the plankton cycle begins once more.

In the Mediterranean, free-living copepods will be found only by towing very fine nets. These small-sized crustaceans, usually around one millimetre in size, are cousins to shrimp. Copepods are among the most important animals of the entire planet. In fact, they are the principal consumers of phytoplankton (and therefore herbivores) and it is thanks to copepods that living material is synthesised by primary producers and thus transferred to higher trophic levels of the food chain, up to fish and then to man. As most of the Earth's surface is made up of water and a large part of primary production occurs in the sea, then it is possible to deduce that most vegetation is consumed by copepods. Hundreds of copepod species of live in the Mediterranean, subdivided into dozens and dozens of genera. They have a fusiform body, only a few millimetres in size, with long antennas and many legs rich with bristles which gather phytoplankton.

Fig. 5.32 - The Bogue (*Boops boops*) is sold all year round on the market and its taste is appreciated. It is very common in coastal waters (Photo by C.N. Bianchi).

Many other crustaceans adopt the same feeding system of copepods. The most well known are the euphausiids that is the *krill*: the main food source of whales. Other plankton crustaceans belong to decapods (larvae and shrimp), ostracods (enclosed in a bivalve shell), and amphipods (for example, *Hyperia*).

Rotifers are other plankton endowed with an external skeleton, usually smaller than copepods. Even in this case, a rotifer filters phytoplankton but instead of using bristles, it utilises a crown of hair-like cilia, the wheel, also used as a locomotion tool, that draws a vortex of water into the mouth which, the rotifer sifts for food. Rotifers are generally smaller than copepods.

An 'anomalous' group of planktonic crustaceans are chaetognaths, with a body divided into three sections, the body cover and muscular structure are similar to that of nematodes. These arrow-shaped animals, have strong jaws used to seize copepods.

Many copepods and rotifers are present in coastal waters in limited periods of the year, and then disappear for long periods. In recent times, the question has been raised as to where these animals go in the periods they are absent

from the water column. The answer was first provided for a group of crustaceans with few marine species: cladocerans. Marine cladocerans, as also copepods and rotifers, have a very complicated reproductive cycle due to the alternation of diploid parthenogenesis and sexual reproduction. 'Resting' eggs are released from the female and usually sink to the seafloor as do terrestrial plants with their seeds to the soil. Thus, marine sediment contains a reservoir of animal biodiversity that is ready to 'turn into' into new organisms when environmental conditions become favourable. The same occurs for many phytoplankton. Therefore, the study of the biological cycles of plankton provides a new interpretation of the functioning of marine ecosystems. The study of the relationship between biodiversity found in sediment and biodiversity expressed in the water column is one of the new frontiers of modern ecology. The Mediterranean is the most studied sea from this point of view, and it is a natural laboratory that is providing new interpretations of the functioning of marine ecosystems.

Jellyfish are the most common representatives of gelatinous plankton. As with plankton with a covering, they are not capable of swimming against the current, but unlike other representatives of plankton, they are large in size. *Pelagia noctiluca* is a scyphomedusa which, in the early 1980s invaded the entire Mediterranean basin with populations that were so abundant that they created problems over several tourist seasons and disrupted many fishing activities. In recent years, *Carybdea marsupialis*, a jellyfish belonging to the cubozoans is also abundant along the Italian coastline. The tentacles of jellyfish (and of all the cnidarians) are armed with thousands of small stingers (cnidocysts) that inject poison into those that they come into contact with.

The proliferation of gelatinous plankton, especially of large jellyfish, is very common in aquatic habitats. Gelatinous plankton does not only include scyphomedusa and cubomedusa: there are also siphonophores and other floating hydrozoans, hydromedusa, ctenophores, pteropods, heteropods, thaliaceans and larvaceans. All these animals have their gelatinous consistency in common. They usually pass unobserved, even though the *Velella*, a floating colony in the shape of a sailing boat, can at times become so abundant and arrive in mass on Italian beaches, where the colonies form long blue stripes. With very rare exceptions, all jellyfish have benthic (polyp) stages that are often colonial. Jellyfish are either male or female and reproduce sexually. The fertilised eggs are transformed into larvae called planula, sausage-shaped and often with cilia that swim for a few hours and then settle on the seafloor, where they are transformed into a polyp: tubular in shape shaped animal with the mouth, often lined with tentacles, facing upwards. The polyp usually divides itself asexually, producing many other polyps which, however, remain attached one to the other to form a colony. The colonies can be either male or female and, at a certain point of their life, start to produce male or female jellyfish. The small jellyfish and siphonophores are invisible to the eye, but their ecological role as crustacean and fish larvae predators is of vital importance.

Ctenophores, also known as comb jellies, are large animals that are propelled by the of beating their cilia. Some species, such as the Venus's girdle (*Cestum veneris*) reach a metre in length. In water they resemble a jellyfish, though in this case, they are completely inoffensive animals. They only have two tentacles which, in place of the deadly nematocysts typical of cnidarians, have colloblasts that are harmless for man. Nematocysts penetrate the prey with their poison, while colloblasts adhere to the prey with adhesive substances. Ctenophores are deadly plankton predators. There are no ctenophores specialists in Italy nor in the Mediterranean area so knowledge regarding these animals goes back to last century. In recent years, ctenophores have received a little more attention as an exotic species (*Mnemiopsis leidyi*) suddenly appeared in the Black Sea, perhaps transported there by the ballast waters of a ship, and for unknown causes, has given life to extremely abundant populations. These

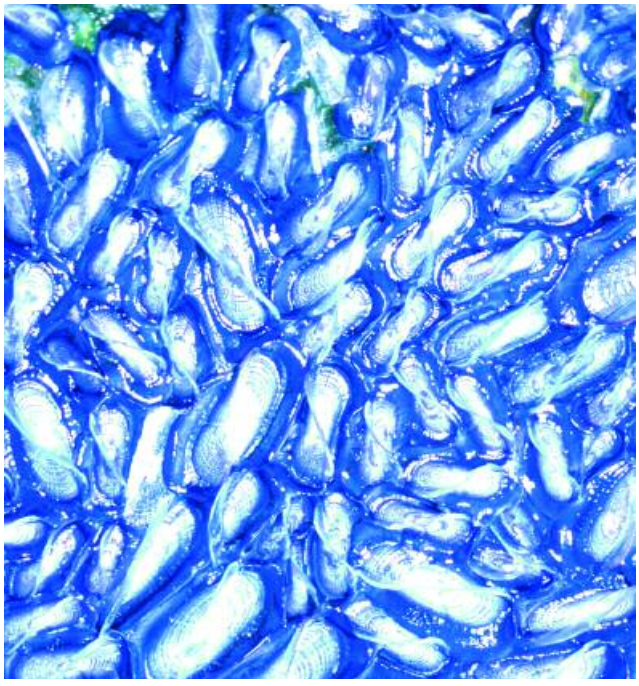

Fig. 5.33 - *Velella velella*, northern coast of Nurra (Sardegna) (Photo by L. Rosati).

ctenophores have practically decimated the fish populations of the Black Sea, by preying on fish larvae.

Therefore, it is clear that the gelatinous predators, cnidarians and ctenophores greatly affect fish populations. Almost all fish species produce millions of eggs and, if all were to develop into larvae and then reach the adult stage, fish populations would be enormous. Preying on eggs and larvae is the main cause of mortality for fish, and the success of a fishing season is strictly connected to the success of predation of these gelatinous plankton which clearly profoundly influences extremely important anthropic activity.

Others members of gelatinous plankton are heteropod and pteropod molluscs, rarely present in sufficient quantities to be identified without the use of special instruments and microscopes. They have a snail-like shape, though with a much thinner shell and transparent, gelatinous body. However, pteropods are found in large quantities in marine sediment under the form of shells. Pteropod oozes are quite common in the Mediterranean, which testifies to the fact that these organisms can constitute vast populations which then characterise the seafloor with their remains.

Last of all, thaliaceans and larvaceans are often mistaken for jellyfish, even though they are very distant from these in the classification of animals. In fact, cnidarians are primitive animals, while thaliaceans and larvaceans are classified in the *phylum* of chordates, our own *phylum*. Thaliaceans are barrel-shaped and possess a very effective filtering apparatus. Their similarity with jellyfish is connected to the jelly-like consistency of the body. The anatomy and ecology are clearly different. The larvae of Thaliaceans display definitive chordate-specific characters, such as a notochord, dorsal hollow nerve cord, that characterises the evolution of vertebrates, which is then substituted by the spinal cord. Appendicularians or larvaceans have a notacord even as adults and secrete and inhabit a complicated mucous filtering house. Both groups feed on phytoplankton and compete with copepods in grazing on this food source. A massive proliferation of thaliaceans (for example, *Thalia democratica*, *Doliolum denticulatum*, *Pyrosoma atlanticum*, *Salpa maxima*) or of appendicularians (for example, *Oikopleura fusiformis*) can remove the phytoplankton from the water column in a short time, without constituting a source of food for other organisms. The bodies of gelatinous zooplankton are not very sought-after as a source of food and so there are no important predators for these animals. While crustaceans are the foundation on which the trophic chain in the sea rest, gelatinous zooplankton represent a funnel into which primary production (eaten by the phytoplankton filter feeders), or secondary production (eaten by jellyfish and ctenophore predators of crustaceans and fish larvae) is poured.

Meroplankton (literally: in part plankton) includes the organisms that spend part of their life as part of plankton, which is usually the larval stage, and once reaching the adult stage, they become part of benthos or nekton. Sea urchins and star fish, for example, are typical organisms of the seafloor, while tuna and sword fish are among the most powerful swimmers. Before becoming adults, however, these animals are minuscule larvae, slightly larger than copepods and most hydromedusa, that are transported passively by the currents. Larvae are produced in the millions, but few develop to the adult stage. The continuity of the species and the physiognomy of habitats are linked to the possibility of substituting individuals that progressively die. In the sea, plankton larvae represent the future and it is unthinkable to manage the environment without considering the availability of larvae and their probability of success.

For example, Protected Marine Areas are sites of great landscape importance inserted into an environmental context made up of long areas of coastline subjected to elevated anthropic pressure. A Protected Marine Area far from other protected sites will becomes a source of larvae that will be taken away by the currents, perhaps without the possibility of finding suitable habitats in which to develop. In turn, a Protected Marine Area will not be refurnished with larvae if at least a part of the surrounding habitats is not protected.

Thus, it is better to set up many small Protected Marine Areas, distributed along the coast rather than only a few, though bigger Protected Marine Areas that are more isolated.

The same can be said for fishing. Fish populations depend upon the success of larval recruitment: an event such as the abnormal growth of plankton predators like jellyfish and ctenophores can place such pressure on anchovy and tuna larvae that it can compromise a fishing season.

Larvae are microscopic and completely different from adult forms. Therefore, it is not easy to recognise that a small being covered in cilia will one day become a gorgonian or a coral, or that a rounded jelly-like mass with two large eyes will become a tuna.

Unfortunately, those who study animals that live on the seafloor rarely study their larvae. The same occurs for those who study fish: the biological cycle remains unknown for most marine organisms!

Meroplancton is a very important though almost completely unknown part of plankton and its study will lead to a better understanding of the functioning of the marine animal community.

BENTHOS

The variety of zoological groups present in benthos is superior to that in the pelagic habitat. This is due to greater environmental heterogeneity and to the vast variety of habitats that characterise the bottom of the sea compared to the water column.

Benthos lends itself to the characterisation of ecosystems, providing information on the quality of the marine habitat. In fact, while pelagic organisms encompass very rapid dynamics (plankton) or extremely elevated mobility (nekton), the organisms of benthos are often long-lived not very mobile. They are subjected to and register changes in environmental quality, thus becoming a 'biological memory' of marine ecosystems.

Many resources that we extract from the sea derive from the benthos: there are species that produce pharmaceutical substances and others of industrial interest, and many invertebrates and benthic fish directly are part of man's diet. Seafood are comprised in the benthos, just as the most part of the edible crustaceans and molluscs, and much noble fish, such as the soles, the mullets, the hakes.

Fauna of the coastal seafloor

The coast is the frontier between land and sea. The changes that are found as one enters the marine habitat are so clear-cut that it is possible to differentiate different 'zones' inhabited by different fauna.

In supralittoral habitats, immediately adjacent to the littoral zone, the biological population is scarce and macroscopic life is principally composed of all animal forms. The mesolittoral (intertidal) zone then follows, with the never-ending alternation of high and low tide. Populations are more numerous at this plane and are made up of species that have more affinity with the sea. With the infralittoral one really enters into the water and populations are found that are composed exclusively by marine organisms. But the more superficial portion of the infralittoral, known as 'infralittoral fringe', may experience occasional emersions and still presents many transition characters.

On the rocky shores, the supralittoral level corresponds to the emerged area reached by sea spray or splash. The host fauna comprises elements exhibiting affinity for both environments. A typical supralittoral organism with terrestrial affinity is *Fucellia maritima*, a dipteran akin to flies. The isopod *Ligia italica* also has terrestrial affinity. The first truly 'marine' animal of the supralittoral zone is the gastropod *Littorina* (*Melaraphe*) *neritoides*.

'Rock pools' are a peculiar supralittoral environment not in direct connection with the sea and are only filled during a heavy sea or with rainfall, that can even dry up completely in the summer. The elements found in these habitats may have more affinity with either terrestrial fauna (the coleopteran *Ochthebius*) or marine affinity (the harpacticoid copepod *Tigriopus*). The larvae of the culicid dipteran *Aedes mariae* live in pools located on the upper shore which experience high temperatures, high water evaporation and hence high salinity, and, at the beginning of summer, before the pools dry up completely, they turn into the annoying mosquitos.

'Tidal pools' are small, permanent pools of water of the mesolittoral zone. They are small permanent water receptacles in which the organisms are not influenced by the alternation of the tides. They are subjected to variations in temperature and salinity in periods when they are isolated from the sea, being subjected to rain or strong insolation. Their fauna has infralittoral affinity though it tolerates environmental variations well, being particularly euriecious.

The upper mesolittoral zone, situated above the average level of the sea, is dominated by acorn barnacles, small volcano-shaped crustaceans cemented to rocks. The first show up at the inferior limit of the supralittoral level, with the species *Euraphia depressa*. In the mesolittoral, where they are present with two species, *Chthamalus stellatus* and *C. montagui*, they can be so abundant as to form wide bands due to the phenomenon of gregarism. Among the animals that inhabit the inferior mesolittoral zone, dominated by the algae, are prevalent the freely moving species. The gastropods of the genus *Patella* are important, grazing the algal film that covers the rocks; their pasture on the plantulas keeps in check the first stages of the algal communities, thus determining their dynamics. Different species of *Patella* exist, each one with preferences for a particular level. Two characteristic crabs also inhabit the mesolittoral zone: *Pachygrapsus marmoratus* and *Eriphia verrucosa*. In the lowest level of the mesolittoral zone, among the conspicuous calcareous encrustations of the red coral algae *Lithophyllum lichenoides*, a very rich and minute cryptic fauna dwells. Among the sessil invertebrates that can be found toward the inferior limit of the mesolittoral zone *Paracoryne huvei* deserves to be mentioned, a colonial hydroid forming catchy pink patches on the rocks and the mussels. It is a distinctly seasonal species, spending the summer as a cyst, which can probably live up to many years in a quiescent state;

this explains the fluctuating presence of this species. The Beadlet anemone (*Actinia equina)* is another well known animal that lives between the lower mesolittoral zone and the infralittoral fringe.

In the infralittoral fringe, a sort of transition strip that precedes the true infralittoral zone, the mussel *Mytilus galloprovincialis* may give rise to wide belts of rich associate mollusc faunula. The cyrriped *Balanus perforatus* (Figure 5.34) also can form very dense populations in the infralittoral fringe and in the first few meters. The shells of the dead specimens remain attached to the rock, and form large strips of concretions. Very few fish species can live in this area, where the risk is always present of ending up out of the water for good. Among others, several blennies can be mentioned (family Blennids and Clinids).

Fig. 5.34 - The cyrriped *Balanus perforatus*, better known as 'dog's tooth', can be commonly found along the rocky coasts of the Mediterranean, particularly in the first few meters of the infralittoral fringe (Photo by C. Morri).

Soft-bottom fauna

Solitary fauna is principally found in the sandy or muddy seafloors, generally called 'soft bottom'. This comes out of the necessity to possess a certain mobility (not akin to colonial habits) also for sedentary species, in order to escape more deep down in the sediment in case of danger, or, to rise up when the sedimentation rate is high. This is why soft bottoms are essentially populated by endofauna (fauna that live in the marine substrate), while epifauna (fauna that live on the surface of the seafloor) is almost always scarce.

The distribution of solitary endofauna is connected to the granulometry of the substrate: the sands have relative large grains, while the mud is fine. Typical sandy bottoms are present close to the shoreline, especially within the first 25 m deep, whereas the muddy bottoms are farther out. The latter occupy almost all of the continental platform, presenting their most typical aspect around the 50 m deep mark. The transition form the sands to the muds is rarely abrupt; it comes about through a transition belt more or less expanded. The fauna distribution reflects these situations.

Sandy seafloors are populated above all by filter feeders, and are found at relatively shallow depths along coastlines, where the movement of the water transports nutriment for filter feeders (plankton and other organic substances suspended in sea water) and does not foster its deposition on the bottom, where it would become available for the detrivores. The contrary is true of muddy seafloors: due to the minor movement of the water and the fine sediment, organic particles that detrivores feed on are deposited on the seafloor. This general picture is complicated by the fact that several species are both filter feeders and detrivores, according to the environmental conditions: thus they are privileged in transition situations, in both space and time.

The main animal groups that inhabit the soft-bottom seafloors are molluscs and annelids, followed by crustaceans and echinoderms, generally less abundant. One can also find representatives of numerous other animal types, though they are usually scarce and sporadic, or proliferate only in particular conditions. The typical molluscs of soft-bottom seafloors are bivalves. They are abundant on sandy beds and are almost all filter feeders. In muddy beds, there is a dominance of polychaetes over bivalves. Polychaetes (the most important marine worms) include many deposivore and limivore species. Echinoderms are represented above all by holothurians, starfish,

brittlestars and sea urchins. Many holothurians are limivore and are important in the transformation processes of marine sediments, ending up by processing tons of sand per year. Crustaceans also make their appearance with numerous species, above all, peracarids, among which the amphipods are very important, generally less than 1 cm long and usually very abundant. Among the larger-sized crustaceans there are stomatopods (eg. *Squilla mantis*) and decapods (lobsters, shrimps, thalassineids, the larger part of hermit crabs, and many crabs). Sipunculids, enteropneusts and cephalochordates (the Lancelet *Branchiostoma lanceolatum*) are also worthy of mention. The most typical fish of soft-bottom seafloors are pleuronettiforms and rayformes, both extremely flattened.

The general scarceness of epifauna is not seen in the detritus bottoms, especially biodetritus ones, where little sand and terrigenous muds are deposited while most of the sediment is made up of animal shells and skeletons, thallus of calcareous algae or coarse sand and gravel. The hard substrates create suitable habitats for the dispersion of epifauna. The ecological importance of these small hard substrates is paramount. The rocky bottoms, in fact, only make up a thin frame running around the islands and along the high coasts, whereas the large portion of the coastal platform is occupied by soft bottoms. The small hard substrates therefore work as bridges allowing for the dispersion of epifauna. It is not illogical to believe that this has also been the evolutive path leading to the appearance of the few epifauna species that are typical of soft bottoms. Which are the strategies that the sessile invertebrates adopt to colonize the soft bottoms? The simplest one is undoubtedly to 'jump' from an island of hard substrate to the next, avoiding the direct facing of the hostile sedimentary environment. Small size species are particularly apt to colonizing the small hard substrates, thanks to their rapid settlement and growth. Their competitors for space, more heavily built organisms which usually substitute them as secondary colonials on the hard bottoms, are partially hampered by the reduced expansion of the substrate. It may be figured that forms defined as rooting (eg. a few large cnidarians) may derive from species that had initially adopted this way of life: first they settle on a small hard substrate, which, as the colony grows, tends to sink in the sediment. More specialized strategies are observed in those species that directly confront themselves with the sedimentary environment. The pivoting species (eg. the pennatulaceans) avoid sinking in the sediment thanks to their solid stalk, which also works as a pivot around which the animal turns in order to better intercept the food particles in suspension in the bottom currents. The fossorial species live partially buried in the sediment: this strategy is adopted especially by a few actiniarians, which develop a sort of bulb instead of the typical basal disc of hard bottoms dwellers. The pivoting and fossorial species are undoubtedly the lsst product of evolution leading original epifauna forms to adapt to sof bottom life. Back to the small islands of hard substrate, several hydroids, sea anemones and bryozoans live as epibionts on the shells of bivalves or gastropods, occupied by the mollusc or by the hermit crab. The advantages of settling on a living

Fig. 5.35 - The soft-bottom populations are only apparently monotonous: only the sea star *Echinaster sepositus* and the anemone *Condylactis aurantiaca* are visible in this image, but deep in the sediment live fossorial and interstitial organisms capable of forming very dense populations (Photo by G. Affinito).

Fig. 5.36 - Hermit crabs are crustaceans which protect their own abdomen in the shell of a gastropod or sometimes in a sponge, as in the case of *Paguristes eremita* represented here. The animal moves dragging the shell behind, and hides inside it at the approach of danger; when it grows too large for the shell it chose, it either finds a new one or it tries to take one away from another Hermit crab (Photo by C. Morri).

substrate are not only those of finding an available space, but also the mobility, and, especially in the case of the lamellibranchs, the turnover of the filtering microcurrents. This way of life can lead to speciation out of ecological isolation brought about by habitat specialization. A high degree of specialization is found in the well known symbiosis between hermit crabs and sea anemones.

The large number of epifauna species found together with infauna species in the sandy or muddy matrix ensures that the faunistic richness of biodetritus seafloors is normally high, greater than that of the nearby seafloor bottoms that are only sandy or muddy. There are also numerous species that have a preferred connection with biodetritus bottoms, probably drawn by the size of the sediments with diverse grain dimensions, which make this habitat more varied, and more favourable for biological diversity. Bivalve molluscs of the family Pectenidae are characteristic of the biodetritus seafloors. Crustaceans and echinoderms are also numerous. The presence of very bright colours, often dominated by yellow and red, is a dominant trait of many invertebrates of detritus bottoms and is in contrast with the pale colours, and waning tones, usually exhibited by muddy bottoms' endofauna.

Interstitial fauna

The common dwellers of sandy bottoms, such as the clam shells, are buried in the sediment. To become so, they dig, move the sediment, and cover themselves with it. This is the fossorial habit of life. Many animals, instead, live between the grains of sediment, such as the grains of sand on a beach. Interstitial fauna, less than a millimetre in size, partially represent the miniaturisation of large forms living in other habitats. In interstitial fauna, there is almost always a numeric prevalence

of nematodes, a group of non-segmented worms made up of many species. To the non-specialist these may appear monotonously similar, but, to a closer look, species diversity is very high. Among the dominant groups of interstitial fauna, harpacticoid copepods are next in line to nematodes. In addition to the miniaturisation of animals also present in other environments, insterstitial fauna has in store incredible surprises for the willing explorers. Loriciferans, which were described for the first time in the 1980s are only present in interstitial habitats. Once discovered, the loriciferans have been found just about everywhere, from the North Sea to the Antarctics, to the Mediterranean. If they are so common and so special, so that they have been classified in a *phylum* of their own, how come they have not been discovered earlier? The answer is simple: the exploration of biodiversity is still far from being accomplished and there are many environments (especially marine ones) about which we know very little. Interstitial environments are undoubtedly the most original of the biosphere. There are no others, in fact, that are host to such exclusive animal types. Apart from loriciferans, there are also two other types of animals that are not found elsewhere: kinorhynchs and gnathostomulids. In interstitial habitats, moreover, groups that are common elsewhere acquire particular organisations. Cnidarians, for example, are represented by medusoid shapes, without the characteristic umbrella, and wormlike, with long tentacles (*Halammohydra*). Their medusoid nature is inferred from the presence of statocysts (organs of balance, typical of jelly fish). The bryozoans are represented by *Monobryozoon*, original in its non colonial habit. *Psammostyela* is a genus of insterstitial tunicates, less than three millimetres long, with a body architecture almost identical to that of the ascidiaceans of 'normal' dimensions. The list of the representatives of interstitial fauna continues with the tardigrades, isopods, amphipods, mistacocarids, gastropods, and, at this point, one could ask what could be the relevance of such insignificant minute animals. A possible answer is provided by a recent ecological hypothesis. Many members of the plankton, from copepods to dinoflagellates, to diatoms, have life cycles that include latent periods, spent as cysts. The cysts drop into the sediments, where they give rise to banks of possible biodiverstiy. The dimensions of such cysts are similar to those of interstitial fauna (fractions of a millimetre): interstitial fauna and cysts do coexist in the interstitial spaces. The specialists in interstitial fauna are not interested in the cysts, and viceversa; but a recent study, conducted in Italian waters, showed that the number of cysts in the sediment is enormous. Most members of the interstitial fauna could feed upon the cysts, especially those with piercing and sucking buccal organs. The cysts are chitinous cases of compact life matter, with large energy reserve in store, not unlike seeds, which, instead of germinating and giving rise to plants, hatch and give rise to animals and protists. Cysts and interstitial fauna live together since millions of years and it would sound odd if no trophic relationships had evolved between these organisms. Hence interstitial fauna could maintain a high plankton diversity, removing the most abundant cysts, possibly deposited after a monospecific *bloom* such as the well known red tides. The plankton cycle is one of the most important events throughout the biosphere and these little animals could contribute to its high diversity maintenance, preventing few species from becoming dominant, which would impair even our own life conditions. Interstitial fauna has to be investigated not only in order to increase our knowledge – which already is in itself a valid reason – but also as a means of unravelling strategically important processes for our own survival.

Rocky-bottom fauna

The animal populations of rocky bottoms are of great importance in that they are characterised by high production and biodiversity levels. They are dominated by sessile organisms which, fixed to the substrate, spend the rest of the post-larval life at a precise site. This makes them excellent environmental indicators: the presence of adult specimens of long-lived species indicates that environmental conditions have not varied significantly in the recent past. Moreover, practically, all sessile animals are filter feeders, and therefore, indicators of water quality, while soft bottom dwellers rather reflect the quality of the sediments. Finally, the rocky bottom habitats found down to a depth of forty metres are the most interesting for deep-sea diving, an eco-compatible activity, as long as it is well managed, and of great social and economic importance for marine parks.

The animals that live on the rocky bottoms are solitary or colonial: the last mentioned, also known as 'modular', since they are formed by a set of 'modules' – the single individuals or zooids- are in general dominant and eye-catching. The most important groups are porifers, cnidarians, bryozoans and ascidiaceans.

The infralittoral rocky bottoms, just below the sur-

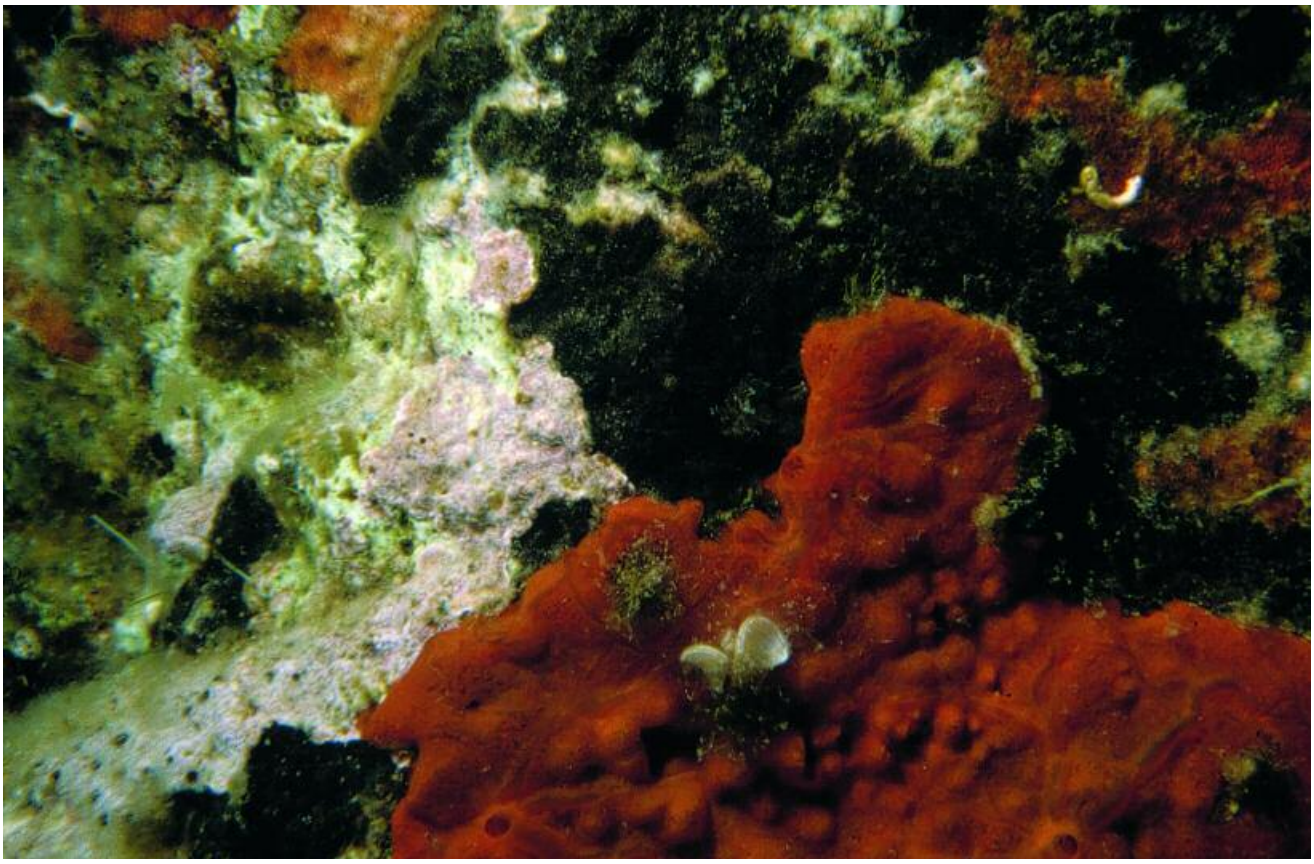

Fig. 5.37 - On hard substrates it is easy to observe organisms competing for space. In this image, the red-coloured sponge is growing on the encrusting species that surround it, thus proving itself to be competitively dominant (Photo by F. Boero).

face of the sea, are characterized by the dominance of algae often giving rise to rich populations, even down to a depth of forty metres. There are numerous but not very conspicuous animals among the algae: generally epiphyte life forms, such as many hydroids on algae, or those cave species that live hidden in the basal anfractuosities of algal vegetation. The algal populations also create suitable habitats for vagile species hiding among the fronds of the algae themselves, such as labrids that are the most characteristic fish, as well as several sparid species, including seabreams that are very common. Salemas, belonging to the same family, are among the few herbivorous fish in the Mediterranean and hence their elective habitats are the photophyle algal communities and the Posidonia prairies. Not all the conspicuous animals of the algal populations are vagile; a few sessile animals manage to contend with the algae for the substrate. It is interesting to note that they are mostly porifers and cnidarians provided with photosynthesizing endosymbiotic micro-organisms, thus functionally akin to primary producers. In the case of porifers (such as *Petrosia ficiformis* and *Chondrilla nucula*) such symbiotic microrganisms are cyanobacteria, called zoocyanells. The symbiotic microrganisms of many cnidarians (such as *Anemonia viridis*, *Cladocora caespitosa* and *Balanophyllia europaea*) are unicellular algae instead, called zooxanthells. Animals that can play a very important role in conditioning the development of photophyle algae are the sea urchins, such as *Arbacia lixula* and *Paracentrotus lividus*, which can greatly stunt the development of algal populations through grazing.

Coralligenous biocoenosis is typical of rocky bottoms in the circalittoral zone. Its main characteristic is the implementation of relevant bioconstructions by calcareous red algae (corallinacean). Animal organisms participate in bioconcretion, as builders (bryozoans, serpulids, madrepores, etc.) or 'disintegrators or excavators' (clionids, bivalves and perforating sipunculids) thus controlling the equilibrium. Coralligenous bottoms get their name from corallinacean algae, and not from coral. In any case, animals dominate the physiognomy of coralligenous biocoenosis, giving shape to the underwater land-

scape: one of the most typical features is the great gorgonian forests (*Paramuricea clavata*).

The gorgonians and many other animals of the coralligenous bottom are sessile and filter the organic particles suspended in the water, thus playing an important ecological role: they exploit primary production (phytoplankton) and paraprimary (detritus) and import energy from the column of water, connecting the benthonic dominion to the pelagic one. In the basal layer of the coralligenous bottom the porifers are common, as are the scleractinians, bryozoans, serpulids, and many other groups. There is also a very rich vagile fauna which includes some characteristic sea urchins, such as *Centrostephanus longispinus* and *Echinus melo*. Among the numerous fish species found along coralligenous bottoms, there is the Swallowtail sea perch (*Anthias anthias)*. The Dusky perch (*Epinephelus marginatus*) has become quite rare in the Italian rocky bottoms habitats and large specimens can practically only be observed in some marine parks.

Bioconstructor organisms

Many marine animals possess mineral skeletons capable of persisting after the death of the organism and thus of building large masses, even though it is true that in our seas they do not reach the dimensions of the tropical coral reefs. The phenomenon of bioconstruction, that is, the capacity on behalf of certain organisms to construct permanent structures capable of positively developing topography, increases the physical heterogeneity of habitats and the creation of landscapes, which in turn gradually influences biodiversity. Bioconstruction in the Mediterranean area are monospecific or, at the very most, oligospecific as far as 'constructor' species are concerned. In this respect the Mediterranean conforms to the empirical rule that the diversity of bioconstructors decreases from the intertropical belt to the higher latitudes.

Among the bioconstructing animals in the Mediterranean the scleractinians, vermetid molluscs, polychaetes and bryozoans may be mentioned. The scleractinians are represented by three littoral and five bottom species: the former, with facultative or compulsory presence of zooxanthelles, are *Cladocora caespitosa*, *Madracis pharensis* and *Oculina patagonica*. *C. caespitosa*, the only species that has been studied in some detail, has calcification rates comparable to those of many constructor corals of tropical seas. The five bottom species, without zooxanthelles, comprise the yellow corals *Dendrophyllia ramea* and *D. cornigera*, living toward the deep limit of the circalittoral zone, especially in the south western areas of the Mediterranean, and the white corals *Madrepora oculata*, *Desmophyllum cristagalli* and *Lophelia pertusa*, living in the bathyal zone. The vermetid *Dendropoma petraeum* can give rise to expanded calcareous platforms in the infralittoral fringe, especially along the more southern coasts of our seas. Among the bristleworms the serpulids build organogenic reefs especially in confined environments, such as harbours and lagoons: the most important species are *Ficopomatus enig-*

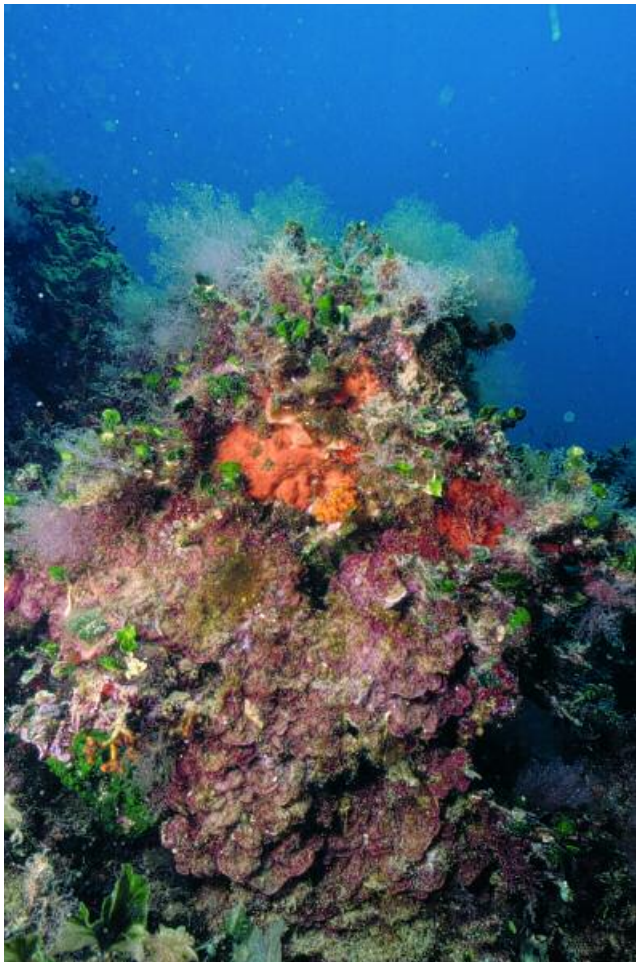

Fig. 5.38 - This image shows an example of a hard substrate community commonly called 'coralligen'. Typical of the coralligen is its high biological covering capacity, with bioconstructing encrusting organisms densely covering the rock, and overlapping until they hide completely the substrate on which they had settled. The organic concretion thereby produced is chiefly formed by red coral algae. Among them detritus piles up, but other encrusting organisms also settle in, such as sponges, bryozoans, madrepores and tubiculous polychaetes (Photo by F. Boero).

maticus and *Hydroides dianthus*; *Sabellaria alveolata* is another characteristic one, whose elongated cases of agglutinated sand look like huge petrified beehives. Among the bryozoans, *Schizoporella errata* can form masses in eutrophic environments, *Turbicellepora avicularis* (in cooperation with the vermetid *Serpulorbis arenaria*) on biodetritus bottoms.

Other animals are biodestructors instead: they perform a mechanical action, and sometimes also a chemical one (acid emission), upon biogenetic or sedimentary carbonates. The most relevant ones dig inside the carbonatic mass and are said to be piercing. Among them the most important ones are porifers (clionids, in particular), polychaetes (spionids and others) and molluscs (especially bivalves of the genera *Lithophaga*, *Gastrochaena*, etc.). For the sake of completeness a few animals capable of wood boring may be mentioned: they are mostly isopods, such as *Chelura terebrans*, and bivalves, such as *Teredo navalis*.

Fauna of underwater prairies

Posidonia oceanica is an endemic plant of the Mediterranean that forms underwater prairies (from the water surface down to a depth of 40 m) of enormous ecological importance: they produce oxygen, reinforce the bottom and are a source of nourishment and of shelter for many animals. Their rhizomes form the so said 'matte', which lifts the sea bottom even a few metres up. A very rich fauna lives among there, with numerous annelid and amphipod crustacean species. The sessile fauna of the leaves include many hydroid (such as *Sertularia perpusilla*) and bryozoan species (such as *Electra posidoniae*). Apart from sessile forms, Posidonia leaves offer shelter and nutriment to crustaceans and gastropod molluscs (especially Rissoidae). Many fish species reproduce and develop in Posidonia prairies. Other marine phanerogams, other than posidonia, can give rise, if not to prairies proper, to rather expanded meadows. *Cymodocea nodosa* is second only to Posidonia as for distribution and abundance; *Zostera marina*, *Nanozostera noltii* and *Halophyla stipulacea* are locally important. The first two develop in brackish waters too, where also species of the genus *Ruppia* are found; the latter is a lessepsian species, whose distribution in Italian waters is limited for the time being (North East coasts of Sicilia). Generally speaking, the fauna associated to these phanerogamic meadows is less specific and characteristic than that tied to *Posidonia oceanica*.

Fauna of marine caves

Cavernicolous biocoenoses are characteristic and rich in a particular fauna. The study of this fauna has only begun in rather recent times and is still leading to the discovery of rare or new species to science, among which truly relict species stand out (mainly of tetidean origin). Algae only dominate the first few metres of underground caves, after which life is only in the animal form. The food chain of cavernicolous biocoenosis is essentially based on sessile filter feeders that are passive (that do not stir up sources of food in the water, like cnidarians), but principally active ones (that stir up sources of food with their filtering apparatus, such as porifers, bryozoans and serpulids). Mysidaceans carry out an important role in the transfer of matter and energy within the caves with their daily migrations, but are becoming much more scarce in the last few years. In marine caves one also finds characteristic vagile fauna of decapods, such as *Herbstia condyliata* and *Stenopus spinosus*, and fishes, such as *Thorogobius ephippiatus*, *Oligopus ater* and the cardinal fish *Apogon imberbis*. The Monk seal *Monachus monachus*, nowadays virtually extinct in Italian seas, used to be a habitual dweller of our marine caves, as long as they were provided with a pebble beach in their inner portion.

Fauna of submarine hydrothermal vents

Hydrothermal vents are made up of fluids full of substances that originate from the deepest parts in the earth's crust: hot and unsalted waters, less dense than sea water, that rise towards the surface, propagating in the surrounding environment, and modifying its chemical and physical characteristics. In the vicinity of these hydrothermal vents, one finds a source of primary production that is not photosynthetic but rather due to the populations of sulphur bacteria – oxidating sulphurs to solphates, from which oxidation reaction they derive energy for their metabolism, which is thus defined as chemio-litho-autotrophic - that provide food and energy for the consumers and form the basis of the food chain of ecosystems that are independent from solar energy. Inside these ecosystems new species, new classes and even new animal types have been found. There are shallow hydrothermal vents in the Aeolian Archipelago, at Cape Palinuro and in the Bay of Pozzuoli. Close to the vents a few characteristic adaptations can be found in the fauna. Populations of certain nematode and polychaete species in

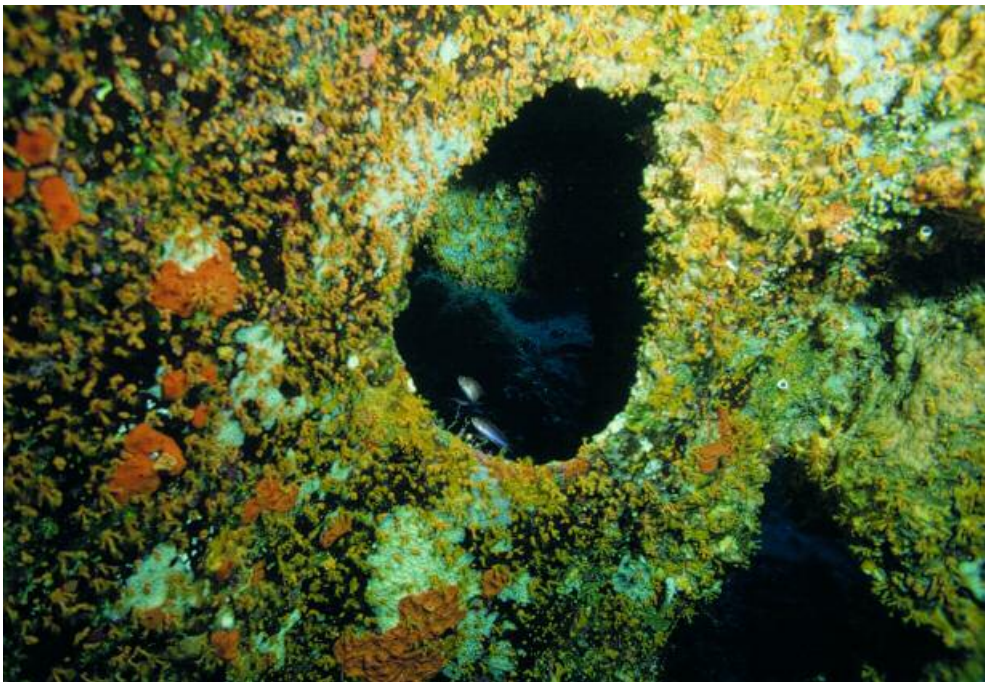

Fig. 5.39 - Marine caves are biodiversity-rich environments. Despite their relevance from an ecological point of view, as of today they are still relatively little studied since they are accessible only through scuba diving. The cave walls are lined up with stunning layers made of hard substrate sessile organisms, such as sponges, hydroids and bryozoans (Photo by F. Boero).

these areas have sufficiently differentiated characteristics with respect to typical populations, which lead one to consider the possibility of twin species. Other species, such as the tubiculous polychaete *Phyllochaetopterus socialis* and the decapod crustacean *Callianassa truncata* display peculiar arrangements ecological and ethological in character. Eventually, other species show a distinct preference for the areas surrounding the vents, appearing there more abundantly.

Deep-sea fauna

The greater part of the sea bottom reaches out to great depths: the marine abysses are the most common environment on earth. Italian seas are the deepest of all in the Mediterranean though their deep fauna has been explored only to a minor extent.

The transition from littoral fauna to deep-sea fauna is usually observed in correspondence to the edge of the continental shelf. Here animals exclusive to this area can be found. Two of the most characteristic species are the large brachiopod *Gryphus vitreus* and the crinoid *Leptometra phalangium*. A few species (for example *Plesionika narval*, *Paragalene longicrura*, *Vermiliopsis monodiscus* and many other invertebrates) are common both to this environment and to the sea caves. In the Messina strait the endemic hydrocoral *Errina aspera* is found.

The slopes and the foot of the continental escarpment constitute the so said bathyal level, hosting a typical and rich fauna that is subject to intense commercial fishing (for example, the red shrimps *Aristeus antennatus* and *Aristeomorpha foliacea*). The fish fauna of this level is rather well known.

It is not clear whether, below the bathyal level, an abyssal level exists in the Mediterranean. It is held that the deep isothermic property of the Mediterranean (13 °C as against the 4 °C typical of the other seas) prevents the development of a truly abyssal fauna in our sea. However, below 2,000 m in depth, there is a certain renewal of fauna especially as regards to of polychaetes, bivalves and crustaceans, but our knowledge in this regard is still too scarce: faunistic collections carried out below the 500 m mark in depth in Italian seas can be counted on the fingers of one hand.

Estuary, lagoon and coastal pool fauna

Estuaries, lagoons and coastal pools have a fundamental importance in our country, both for their frequency and distribution, and for the complex requirements impinging on them. From the ecological and faunistic point of view these environments are rather similar. In the 1980s the tendency emerged to put them together under the common name of paralic environments, characterised by some degree of confinement with respect to the sea habitat, confinement meaning a function of the

Fig. 5.40 - The species *Stylocidaris affinis* is a sea urchin that can be found down to a depth of 1,000 m. Its big spines can be covered by serpulids and cirripeds (Photo by C. Morri).

renewal time of the marine oligoelements and of other vital substances of marine origin.

An expression used since a much longer time is that of brackish waters. One of the principal features of these habitats is that the salinity level is different from that of the sea and characteristically much more variable both in time and space. Brackish waters can therefore be qualified on the basis of their salinity: 'euhaline' are those whose salinity is not too different from the sea, around 3.5%; 'hyperhaline' those that have a higher salinity than the sea; 'polyhaline' those less salty than the sea but more than 1.8%; 'mesohaline' those whose salinity is comprised between 1.8% and 0.5%; 'oligohaline' with a salinity between 0.5% and 0.05% (below this concentration the waters are considered to be 'fresh').

Salinity is not the only factor of variability of the paralic habitats. They are typically laminar in flow, shallow and either heated or cooled much more than the nearby tracts of open sea, therefore, even the temperature is more variable.

Oddly enough, though, environments that are so variable have a much more stable biological populating than could be expected. Anoxic (lack of oxygen) and dystrophic crises (overabundance of nutrients) drastically reduce animal populations of brackish waters, as do flood and dry seasons. After these events, fauna more or less returns to its typical state, while marine habitats requires much longer recovery periods. The population remains substantially the same in areas where the level of salinity in the water is either constantly lower or constantly greater than sea water, and in the case of great variations in salinity throughout the year.

This surprising ecological stability derives from the extraordinary ecophysiological capacity of the fauna and from the plasticity and variety of survival strategies adopted by various species. Among the most notable examples the following may be mentioned: the loss of specificity for the substrate, so that the animals are able to live practically anywhere, and the effectiveness of dispersal mechanisms, resulting in rapid repopulation.

Moreover, almost all of the species are very 'generalistic' from the nutritional point of view, as they are able to feed with equal ease on dissolved materials and on large food fragments.

Not many species are there that can adapt to such variable habitats. It goes without saying that those which can find very few competitors and thus can thrive abundantly. Among the most typical paralic invertebrates the hydroid *Cordylophora caspia* (Figure 5.41) should be mentioned, as well as the gastropods *Hydrobia ventrosa* and *Theodoxus fluviatilis* (the latter in almost 'fresh' waters), the bivalves *Abra ovata* and *Cerastoderma edule*, the serpulid *Ficopomatus enigmaticus*, the bryozoan *Conopeum seurati*, the amphipod *Gammarus aequicauda*, the isopod *Sphaeroma hookeri*, the crab *Carcinus aestuari*: the latter being subjected to fishing in the Venetian lagoon. As far as fishes are concerned, in addition to the resident species of paralic environments, such as *Aphianus fasciatus*, catadromic species may be mentioned, such as the Eel *Anguilla anguilla* as well as anadromic ones, such as the twaite shad *Alosa fallax*.

Fig. 5.41 - *Cordylophora caspia* is a colonial ramified hydroid, living in the brackish waters (Photo by C. Morri).

Other groups

Protozoa

Protozoans make up a vast and heterogeneous grouping of Protists traditionally considered unicellular animals. About one thousand of these numerous microscopic species are known for Italian seas. Foraminiferans, with their characteristic small chalky shell, live in plankton as well as in benthos and can play an important role in in the marine environments, in that they participate in the control of microbial demolition cycles of organic substance. Among the benthic foraminifers a few have dimensions that make them visible to the naked eye. They live in the sand, on rocks, or on other organisms. A common benthic foraminifer in the Italian seas is the *Miniacina miniacea*. Its colonies, irregularly ramified and bright pink in colour, are several millimetres in size and may be mistaken, at first sight, for small bryozoans or coral fragments. They are commonly found on Posidonia rhizomes, in coral reefs and underwater caves. The calcareous skeletons of dead colonies can sometimes pile up in large quantities on the beaches – especially on those facing large Posidonia meadows – giving rise to catchy pink stripes on the shoreline. The plankton is often strongly characterised by the presence of ciliates (especially tintinnids), but it is the heterotrophic flagellate *Noctiluca* that can become visible, giving rise to demographic explosions determining the phenomenon known as 'luminescent sea' during the night.

Porifera

Porifers or exclusively aquatic sponges, above all marine, are typically sessile and almost all filter- feeders: flagellate cells that cover the internal walls of the animal withold the organic substances from the water circulating through the sponge. The quantity of water that can be filtered by a sponge may add up to tens of litres per day, according to the animal's dimensions. When abundant, the Sponges carry out an important role in purifying marine water. They vary in size (from a few millimetres to a metre or more) and shape (crustose, globose, arborescent, cylindrical, dish-shaped, etc.). They live from the tidal zone to the abyssal plain and, above all, they are an important and spectacular component of the rocky coastal seafloors and underwater caves. Sea beds dominated by sponges are found especially in the southern areas of the Mediterranean. There are about 500 species in Italian seas, out of the 600 of the entire Mediterranean. The number of the species is under constant evolution as luckily research is active in less well known environments, as the deep areas and certain marine caves. Current research, however, essentially revolve around the class Demospongiae, by far the largest one; the classes Calcarea and Hexactinellida are less studied. The species that are found exclusively in the Mediterranean make up 45% of the total. Fifteen Mediterranean species, 14 of which are also reported in Italian seas (*Aplysina aerophoba* – Figure 5.42, *A. cavernicola*, *Axinella cannabina, A. polypoides, Geodia cydonium, Hippospongia communis, Ircinia foetida, I. pipetta, Petrobiona massiliana, Spongia agaricina, S. officinalis, S. zimocca, Tethya aurantium,* and *T. citrina*), have been inserted among those species worthy of protection (Annexes II and III of the Protocol SPAMI/ASPIM – Convention of Barcelona 1995 and Appendices 2 and 3 of the Bern Convention 1979). Bath sponges (Spongiidae family) are distributed almost exclusively in the Caribbeans and in the Mediterranean. The Mediterranean species, economically more valuable, are *Spongia officinalis* (with the two varieties *adriatica* and *mollissima*), *S. agaricina*, *S. zimocca*, and the common sponge *Hippospongia communis*. They are currently rare, following excessive fishing pressure and large-scale mortality not yet perfectly understood. Cultivation experiences are currently under way in Greece and in Italy.

Fig. 5.42 - *Aplysina aerophoba* is a sponge forming fleshy mats with 3 to 4 cm tall digitations. The surface is smooth and polished with a vivid yellow colouring. It is common within the first 10 m depth range, on rocky bottoms and among tufts of *Posidonia oceanica* (Photo by C. Morri).

Cnidaria

They are a vast *phylum* whose primary characteristic – apart from the presence of urticant organs – is the existence of two basic fundamental shapes: polypoid and medusoid, which can alternate within the metagenetic cycle. The two forms coexist within the *subphylum* Medusozoans, comprising three classes: Hydrozoans (with polyps originating medusas through budding), Sciphozoans (with polyps originating medusas through strobilation) and Cubozoans (with polyps turning into medusas). The other *subphylum*, the Anthozoans, comprises only polypoidic forms. Polyps, though with few exceptions, are typically benthic, while medusas are planktonic. Some medusa also sting man and periodic numeric explosions of these species create serious problems for bathing and fishing. Another important characteristic of Cnidarians is their tendency to form colonies, quite widespread among Hydrozoans and Anthozoans; in the former the colonies are frequently polymorphic, and highly specialised.

Several species, be they solitary or colonial, develop a chitinous, corneous or calcareous exoskeleton. Pelagic cnidarians are predators, while benthic ones are typically either passive filter feeders or sessile carnivores; many species host zooxanthelles, at times in such large quantities as to render irrelevant any further food supply from the outside. Out of the 10,000 world wide known species of cnidarians the large majority are marine, few live in brackish waters, very few in freshwaters. Their dimensions range from less than a millimetre to several metres. There 458 known species in Italian seas, some of which are confined to the southern sectors (*Halocordyle disticha*, *Astroides calycularis*, *Dendrophyllia ramea*, etc.). The hydrocoral *Errina aspera* is endemic to the Messina strait. The Hydrozoans are the only group with a satisfying level of knowledge for which a small group of Italian experts exists, well known at the international level, out of whose research a continuous update of Italian fauna derives, with new species reportings and descriptions. A hydroid species, recently popular in Italy, is *Turritopsis nutricula*, whose medusas are able to reorganize their cells and revert to the polyp's state; *Turritopsis* is therefore capable of inverting the aging processes, and this makes it particularly interesting for the study of senescence-related mechanisms. The case of this insignificant hydroid,

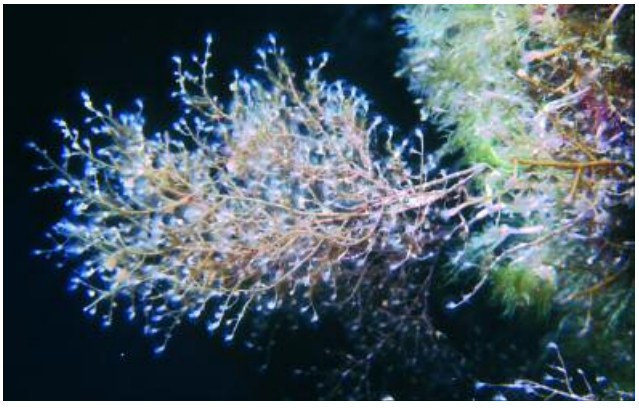

Fig. 5.43 - Hydroids often look like delicate vegetal structures. *Eudendrium racemosum* can give rise to large treelike colonies. The orange-coloured polyps are provided with stinging tentacles with which they capture their prey. The medusoid phase is absent and the reproductive organs are found beneath the crown of tentacles (Photo by C. Morri).

Fig. 5.44 - *Caryophyllia inornata* is a small solitary madriporian coral widespread on the rocky bottoms of the Mediterranean. The polyps are sometimes drawn together in groups, but never form colonies (Photo by F. Boero).

Fig. 5.45 - *Corynactis viridis* is the only Mediterranean representative of the family Corallimorphidae, a small group of anthozoans characterized by the absence of the skeleton and by the presence of tentacles each terminating in a small swelling (Photo by C. Morri).

which only a few specialists know about, demonstrates that further exploring the diversity of the organisms can open new perspectives of scientific research, possibly having relevant consequences.

Seven Mediterranean cnidarian species (*Antipathes dichotoma*, *A. fragilis*, *A. subpinnata*, *Astroides calycularis*, *Corallium rubrum*, *Errina aspera* and *Gerardia savaglia*) have been listed as species worthy of protection (Annexes II and III of the Protocol SPAMI/ASPIM – Barcelona Convention, 1995, appendixes 2 and 3 of the Bern Convention, appendix 5 of the Habitat Directive and Annex B of the CITES agreement), but in theory all the scleractinians should be protected following CITES. Of the 37 scleratinia species present in Italian seas, 8 are bioconstructors. The zooxanthelate species *Cladocora caespitosa* can form aggregations in the coastal environments, and is important as a paleoclimatic indicator. A few colonial sleractinians of the deep seas, such as *Lophelia pertusa* and *Madrepora oculata*, give rise to large expanses of biogenic reefs, that are under current study and protection measures in the North Sea and in the Atlantic, but no similar initiative has been undertaken in Italy nor in the Mediterranean. The large species borne on the soft bottoms of the continental platform (*Funiculina quadrangulata*, *Isidella elongata*, a few species of pennatulaceans and of hydroids, etc.) are experiencing rarefaction due to trawling. Red coral (Corallium rubrum) is abundant in several areas along the Italian coasts, though there are no longer large-sized specimens owing to excessive commercial taking. The red coral, the zooxanthellate scleractinians and the principal species of *Gorgonia* have turned out to be extremely vulnerable to climatic change, undergoing phenomena of large-scale deaths, as a consequence of the anomalous positive thermal coefficient recorded during the last few summer seasons.

Ctenophora

These carnivores, exclusively marine and prevalently planktonic (only a quarter of the species are benthonic, typically dwelling on other organisms). Their dimensions range from one centimetre up to one metre and are therefore part of the gelatinous macroplankton. All the species are carnivorous and during episodes of great numeric proliferation, they can seriously affect the juvenile fish stocks utilised for commercial purposes. Thirty-two species have been reported in the Italian seas out of the 110 that are known world-wide; no benthic species has so far been reported in the Italian seas.

Platyhelminthes

Once considered as a single *phylum*, Platyhelminthes or flat worms, are a vast and heterogeneous paraphyletic grouping of species, adding up to the amount of 15,000 species world-wide. In addition to the terrestrial and freshwater species, there are numerous marine species, both parasitic and free living. There are 187 digenean, 71 cestode and 88 monogenean parasite species in Italian seas. The free-living species are mainly turbellarians which are also probably paraphyletic: 314 known species in Italian seas. Many species are microscopic (less than a mm) and live in interstitial habitats where they are highly diversified. By means of an example, a few data may be reported relative to the proseriates group (Figure 5.46), which are studied by an Italian specialist: in fact, from 59 species reported in 1995, there are now 140 species, 78 of which have been described formally. Among the polyclads, large size animals are described (few centimetres) nad brightly coloured, too: they are for the most part carnivorous predators, and some species (eg. belonging to the genus *Stylochus*) infest oyster banks.

Fig. 5.46 - *Prostheceraeus roseus* belongs to the proseriates, vividly coloured platyhelminthes inhabiting the hard bottoms. Their showy colours make them look like nudibranchs, from which they may be easily distinguished by the extreme thinness of their bodies (Photo by C. Morri).

Gnathostomulida

They are microscopic (0.31 mm) interstitial marine worms, present with only 6 species in Italian seas, out of the 80 known species world-wide.

Orthonectida

Once ascribed together with the Dicyemida to the phylum Mesozoa, they are microscopic parasites of various marine invertebrates: turbellarians, nemertines, polychaetes, gastropods and bivalves molluscs, ophiurans and ascidians. In the Italian seas there are only 2 out of the 18 known species world-wide. *Rhopalura intoshi*, a parasite of the nemertine worm *Lineus lacteus*, has been reported in Italy, only around Messina, so it is to be considered endemic for the present time.

Dicyemida

Once ascribed together with the Orthonectida to the phylum Mesozoa, they are exclusively marine microscopic parasites in the renal sac of benthic cephalopods. In Italian seas, 13 out of the 14 known species for the Mediterranean have been reported.

Nemertea

Predator marine worms, common in various benthic habitats but not well studied. They have an extremely elongated ribbon-like body (a few Mediterranean species of the genus *Lineus* may reach 40 cm in length). There are 95 known species in Italian seas.

Gastrotricha

Aquatic microinvertebrates, 0.05 to 4 mm in length, they are phylogenetically akin to nematodes and rotifers. Worldwide there are around 690 species, out of which around 390 are marine. These last ones are typically interstitial, and, with densities up to 30 individuals per square centimetre, are second only in terms of numeric abundance to nematodes and harpacticoid copepods; their ecological role is carried out within the benthonic microphage-detritivorous community. The Italian fauna is the most well-known in the world (more than 130 years of continual studies, with samplings in more than 200 sites). In 1995 there were 142 known species which increased to 189 by 2002; it is probable that further studies may report new species. 70 species (37.6 %) are currently reported to be endemic to Italy.

Rotifera

Microscopic metazoans (802,000 mm) comprising around 1,800 species world-wide, grouped in three main *taxa*: Monogononta (around 1,450 species), Bdelloidea (around 350 species) and Seisonidea (2 species). Only this last group is exclusively marine, whereas the vast majority of the other species live in freshwater habitats. The distribution of rotifers throughout the sea is not well known, despite the fact that 105 species have been reported as being marine, to which another 90 freshwater dwellers must be added which have been reported also in brackish and marine waters. Many species are planktonic, others are interstitial, and seisonids are epizoic on the crustacean *Nebalia.* In the Mediterranean both species of seisonids have been reported, together with the single existing species of marine bdelloid and 17 species of monogononts, in addition to about 20 freshwater euhaline species. The Italian marine areas that have been considered are limited to the Adriatic Sea and the Gulf of Naples; 7 species have been reported.

Nematoda

They make up a vast *phylum* that is very rich in marine species. Many live in sediment (even in the abysses) while others are parasitic (above all of vertebrates). The sizes of the former are around 0.3-8 mm, while the latter can grow to a far larger size. They are the most important group of meiobenthos, where they can reach the density of 100 individuals per square cm, and carry out an essential role in the detritus cycle and in the control of the microbial compartment. The abundance of nematods to harpacticoid copepods ratio in the meiofauna is used as a measure of the quality of the marine sediments. The number of marine nematode species is probably comparable to that of insects in terrestrial habitats, but the difficulty in the study of their systematics explains why the major part of their species has yet to be described. There are 374 known species in Italian seas, which is certainly underestimated.

Nematomorpha

Group that has vermiform, long and thread-like individuals; the species of the class Nectonematoida are marine and measure 1 to 90 cm. During the juvenile stage they parasite decapod crustaceans. Very little is known of this group for Italy. Only one species has been reported in Italian seas: *Nectonema agile*.

Acanthocephala

Twelve species have been reported in Italian seas, out of the world-wide known 1,000 species. They have a par-

asitic larval stage on invertebrates, the adult stage on vertebrates: in Italy, the majority occurs in the intestine of definitive host fish. Their size range is between 1 mm and 1 m, but in most cases revolves around a couple of cm.

Kinorhyncha

Exclusively marine, typical of meiobenthos, little is known of their presence and distribution in Italian seas, where 22 species have, in any case, been reported. Their size range is between 0.2 mm and 1 mm, and they dwell in the most diverse sediments, from coastal sands to deep sea muds.

Loricifera

This *phylum* has only been created 20 years ago. These microscopic animals (50-500 mm) live in the sediment, from the tidal zone to deep-sea habitats. So far, only 10 species have been described world-wide. In the Mediterranean, four species have been captured in the French part of the Ligurian Sea, and it is likely that they are also present in Italian waters.

Priapulida

Small, benthic and carnivorous, ranging from 0.5 mm to 20 cm in length, two species out of the three known Mediterranean ones have been reported in Italian waters.

Kamptozoa

Also known as entoprocts, they are small, almost all marine and colonial. The colonies can give rise to expanded mats on the algae and on hard littoral substrates. Traditionally they are studied together with the bryozoans, to which they superficially resemble in their external appearance and living habits. About 5,000 species are known world-wide, 16 of which have been reported in Italian seas: their distribution range not being fully explored, for the time being 5 of these (*Loxocalyx cochlear*, *L. neapolitanus*, *L. pes*, *L. raja* and *Loxosomella globosa*) must be considered endemic to the Italian fauna.

Annelida

Vermiform, they have a cylindrical body divided into numerous ring-shaped segments (from which their name derives) and range from 0.5 m to 3 m in length. They are divided into two large groups to which the class status is generally assigned: clitellates and polychaetes. The former are typically terrestrial or freshwater dwellers, and are traditionally subdivided in oligochaetes and hirudineans. The presence of a rich oligochaete fauna in the world's seas and oceans is a recent discovery; 31 species are present in Italian seas, above all in littoral sediment, but their distribution has not been particularly investigated. Current state of knowledge enlists 13 species (*Akteledrilus magnus*, *A. mediterraneus*, *A. sardus*, *Gianus densespectinis*, *Thalassodrilus messanensis*, *Pectinodrilus rectisetosus*, *Heterodrilus arenicolus*, *H. subtilis*, *Limnodriloides agnes*, *L. pectinatus*, *L. roseus*, *Tectidrilus pranzoi* and *Tubificoides vestibulatus*) as endemic to Italian seas. Hirudineans include leeches, among which a few marine species are present, which are parasite of fishes. In Italian seas they are present with 7 species, which have not been seriously studied. Polychaetes instead are mainly marine, and can be carnivorous, omnivorous, limivore, detritivorous, filter feeders; over 800 species occur in Italian seas, many of which only described in recent times; 26 species (*Schroederella laubieri*, *Aricidea mariannae*, *A. pseudannae*, *Paraonides myriamae*, *Pseudophelia translucens*, *Clavodorum adriaticum*, *Sphaerodopsis longiparapodium*, *Gyptis arenicola*, *Microphthalmus tyrrhenicus*, *Otopsis chardyi*, *Synelmis dineti*, *Exogone cognettii*, *Autolytus neapolitanus*, *Rulliernereis anoculata*, *Micronereis siciliensis*, *Platynereis nadiae*, *Onuphis falesia*, *Lysibranchia paucibranchiata*, *Euniphysa italica*, *Lumbrineris longipodiata*, *Fabriciola tonerella*, *Pseudofabricia aberrans*, *Pseudofabriciola analis*, *Bispira mariae*, *Chone longiseta* and *Demonax tommasi*) are endemic to Italian seas. Some are part of plankton, but most conduct a benthic life on both sedimentary and rocky bottoms; there are also interstitial, endobiontic and parasite species. There are free-living species, and others that live in tube-like shelters that they themselves secrete and fixed to the substrate. The organogenic 'reefs' formed by lagoon serpulids (above all by *Ficopomatus enigmaticus*) are an important habitat for many associated fauna. On shallow sandy marine bottoms, remarkable organogenic 'reefs' are formed by *Sabellaria alveolata*, which offer some shelter to many juvenile stages of fishes and represent a relevant natural defense against beach erosion; excessive alteration of the littoral zone as well as manual depletion of the accumulated tubes to capture the worms to be used as baits are both causes of the rarefaction of such formations. Many other polychaetes are used as baits, and are captured, bred, or imported. A few large species of tubiculous polychaetes are interesting as aquarium species, in

particular the famous spyrograph *Sabella spallanzanii*. Overall, polychaetes are a group of primary importance in benthos communities and are rich in indicator species as well in those characteristic of biocoenosis. Some species are known to thrive in polluted environments. As for other groups, Italian polychaete fauna is richer in the southern seas, where thermophilic species are common that are rare or even absent in more northern seas; a very well-known case is the vermicane *Hermodice caruncolata*, a large and coloured species stingy to the touch. The large-sized species that live on trawlable seafloors of the continental platform are rare because of the excessive disturbance created by fish trawling: two examples are the Bobbit worm (*Eunice aphroditois*), that reaches 1 m in length, and the Sea mouse (*Aphrodita aculeata*) with an oval body up to 15cm long, with its distinctive covering of chaeta and bristles.

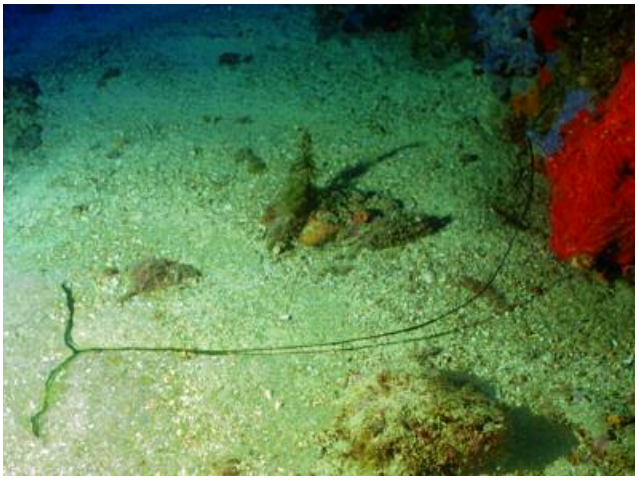

Fig. 5.47 - The long fourcate trunk on the sand belongs to *Bonellia viridis* an echiurid living embedded in the warp. The male is 1-3 mm long, does not feed and lives in tight association with the female, whose body can be (not considering the trunk), 10-12 cm long (Photo by C.N. Bianchi)

Pogonophora

They are sessile and tube sea worms that are part of the deep benthos. Only one species is known in the Mediterranean, *Siboglinum carpinei*, observed in 1970 off the coast of Corsica. To the best of current knowledge it must be considered as an endemic species.

Echiura

Benthic marine worms, similar to annelids, they are detritivores and essentially associated to sedimentary habitats. This group has not been deeply investigated as far as its presence in Italian seas goes; however 5 out of the 6 species reported in the Mediterranean have been sighted in Italian seas; 2 species (*Maxmuelleria gigas* and *Protobonellia brevirhyncus*) are apparently endemic. The best-known species is *Bonellia viridis* (Figure 5.47), studied in depth for its mechanisms of phenotypic sex determination.

Sipuncula

Cylindrical or globose marine worms, ranging in length from a few centimetres to less than a metre; they live in benthos of sedimentary or rocky seafloors, from the tidal zone to the depths of the abysses. The knowledge of the sipunculids present in the Italian seas is rather scarce; 18 species have been reported, out of the 33 present in the Mediterranean and out of the 162 existing world-wide. The best known is *Sipunculus nudus*, which can become very abundant in the sandy bottoms, and is used as bait. A few species are of ecological importance as they function as indicators or are characteristic of biocenoses. Other species on hard bottoms have a bioerosive action.

Tardigrada

Microscopic (between 50 mm and 1,2 mm), they are linked to water or to wetland habitats. They feed by ingesting other organisms' fluids. The marine species are present at all depths and on any type of sediment, from sandy coasts to the muddy abysses. The tardigrades of the Mediterranean are rather well known and comprise around 60 species, out of a little more than 150 world-wide. The species known for Italian seas are 52, but the recent growing interest for these animals, characterised by extreme resistance to adverse ecophysiological conditions, makes for an easily predictable increase in their numbers: in our countries internationally reknown specialists are present.

Phoronida

Exclusively marine wormlike invertebrates that live in chitinous tubes out of which a spiraling tuft of tentacles peeks, with which they capture plankton and organic detritus. They are 1 mm to 50 cm long and are mainly found in coastal benthos on several types of marine sediment. In Italian seas there are three species, out of the ten reported world-wide.

Bryozoa

They comprise more than 4,000 species world-wide, all aquatic and for the most part marine; quite a few live in brackish waters. They are filter-feeders colonial animals, with a well developed tendency to polymorphism. The colonies are typically sessile, on various substrates of the littoral zone, reaching down to great depths; many species are part of the *fouling* of harbours and ships. Colonies can be rather large and are 20-30 cm, occasionally up to 1 m long. They can take various shapes, linear, laminar, net-shaped, more or less compact, encrusting and erect, or even resemble algae or corals. A few large species with calcareous colonies can work as bioconstructors on detritus and rocky coastal bottoms (eg. *Schizoporella errata*, *Calpensia nobilis* and others). Italian bryozoan fauna is sufficiently well-known, thanks to the existence of recent monographical works and identification keys at the Mediterranean level and to the research work conducted by several Italian specialists. In the Mediterranean currently 453 species and 16 subspecies have been reported, 71 of which have been sighted or described in the last ten years. In Italian seas 294 species have been reported, but this number is most surely going to increase, as a consequence of the above mentioned issues. According to the current state of knowledge, 7 species are considered as endemic to Italian waters (*Benedipora catenata*, *B. delicatula*, *Tricellaria inopinata*, *Bugula aperta*, *Characodoma bifurcatum*, *Sertella harmeri* and *Turbicellepora torquata*). *Hornera lichenoides* is the only species considered worthy of protection (annex II of SPAMI/ASPIM Protocol, Barcelona Convention, 1995), though many other large species that form calcareous colonies (*Pentapora fascialis*, *Myriapora truncata*, *Sertella* or *Reteporella* spp.) are both vulnerable and sensitive.

Brachiopoda

Marine organisms akin to bryozoans and to phoronideans, but superficially similar to lamellibranchiate molluscs due to the presence of a bivalve shell. They comprise around 335 species world-wide, ranging from few mm to a few cm in length. Following recent estimates, 14 species live in the Mediterranean, out of which 12 species live in Italian waters. They appear essentially in marine caves and on deep coastal seafloors; *Gryphus vitreus*, the largest species of the Mediterranean, is characteristic of detritus bottoms on the fringe of the continental platform.

Chaetognatha

They comprise around 150 species of marine organisms, with an elongated body (0.5 to 15 cm long). For the most part planktonic, only some species live in benthos, where they are part of the interstitial fauna.. They are carnivores and can prey on juvenile forms of fish that are of commercial interest, as the anchovies. In the Atlantic, the species of the genus *Sagitta* (planktonic) are important water bioindicators. In the Mediterranean, benthic forms are yet to be further investigated; new species have been described in recent years from the deep abysses and from marine caves. Eighteen species have been reported for Italian seas.

Echinodermata

They are one of the most characteristic animal *phyla*: even though they are exclusively marine, they are in fact extremely familiar to the public at large, and to those who are not aquainted with marine fauna.

They include crinoids (sea lilies), holothuroids (sea cucumbers), asteroids (starfish), ophiuroids (brittle stars) and echinoids (sea urchins). Their size varies from less than 1 cm to quite a few dm. Most species conduct a free life in benthos (but there are however a few pelagic holothurioids), colonising various seafloors from shallow waters of the sea shore to the deep abysses. They comprise species that are characteristic of various biocenoses, and others which, through their abundance or activity, condition the structure of benthonic communi-

Fig. 5.48 - *Asterina gibbosa*, present on hard substrates, is a characteristic pentagonal sea star with very short arms (Photo by C. Morri).

Fig. 5.49 - Sea stars are echinoderms even known to those who are not familiar with marine organisms. As in the case of the species here reproduced, *Hacelia attenuata*, sea stars often present vivid colours. Their body consists of a central disc with five relatively rigid arms radiating from it. They are carnivores and the mouth is located on the underside of the body (Photo by C.N. Bianchi).

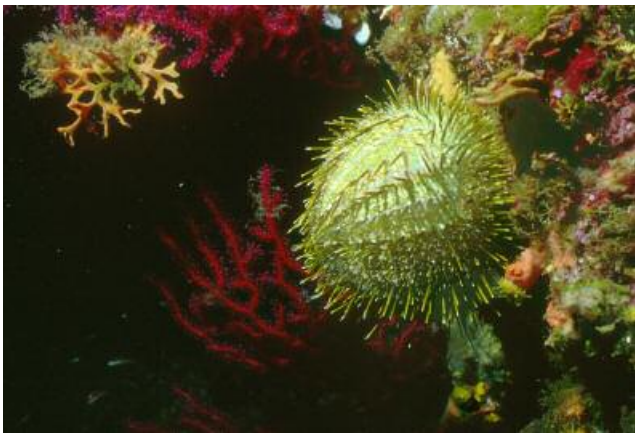

Fig. 5.50 - Sea urchins possess an external skeleton with plates closely pressing onto each other, covered with spines and pedicellarias. They are mainly grazers. *Echinus melo* is a sea urchin typical of coralligen formations (Photo by C.N. Bianchi).

ties: for example, the excessive proliferation of *Arbacia lixula* (often deemed as deriving from excessive coastal fishing practice, which cuts back the abundance and the size of its potential predator fishes) leads to massive grazing of the algal mats extended on the littoral rocky bottoms, and to their subsequent desertification. As far as nutrition is concerned, echinoderms comprise both microphagous (filter feeders, detritivore, limivore) and macrophagous species (predator or grazing).

Several sea urchin species and some holothurians (genera *Stichopus* and *Holothuria*) can be eaten by man. It may come as a surprise that a common Mediterranean species, *Holothuria tubulosa*, is exported to Japan; and that another Mediterranean species, *Stichopus regalis*, known as 'sea pizza', has come to be appreciated in other countries. As for the sea urchins, the gonads of the sea urchin *Paracentrotus lividus* are eaten. In recent years, epidemics, not fully understood as yet, have locally depleted populations of this sea urchin. Around 6,250 Echinodermata species are known world-wide (650 crinoids, 1,150 holothuroids, 1,500 asteroids, 2,000 ophiuroids and 950 echinoids). In the Mediterranean, there are 143 known species, of which 118 (2 crinoids, 35 holothuroids, 27 asteroids, 28 ophiuroids and 26 echinoids) have also been reported in Italian seas. Several species, especially among the sea urchins and the starfishes, are confined to the southern coasts and are thus considered to be thermophile. Four species (two starfish, *Asterina pancerii* and *Ophidiaster ophidianus* and two sea urchins, *Centrostephanus longispinus* and *Paracentrotus lividus*) are considered worthy of protection (annexes II and III of the SPAMI/ASPIM Protocol – Barcelona Convention, 1995, appendix 2 of the Bern Convention and appendix 4 of the Community Habitat Directive).

Hemichordata

Vermiform similar to chordates, around 90 species are reported throughout the world. There are five species in all in the Mediterranean: one pterobranch and four enteropneusts. The former are a badly known group of organisms not larger than 7 mm, mainly colonial and living in the benthos between 5 and 5,000 m deep. The only Mediterranean pterobranch, *Rhabdopleura normani*, has been found in France and it is likely that it also occurs in Italian waters. Three enteropneust species have been reported in Italian seas: they are limivore organisms, 2.5 to 250 cm in length, digging deep galleries in the sediment.

Tunicata

Also known as urochordates as they possess a dorsal cord in the caudal portion of the body, they are usually classified as a *subphylum* of chordates. The distinct characteristic of the group is that the body of an adult tunicate is essentially covered by a protecting sack, called

Fig. 5.51 - Solitary ascidian *Halocynthia papillosa* is a filter-feeding organism capable of maintaining a stable flow of current across its body (Photo by F. Boero).

'tunica', made of a substance akin to cellulose. They are exclusively marine animals feeding on microplankton and suspended detritus, filtering large quantities of water, and divided into three classes very different from each other: appendicularians, thaliaceans and ascidians. Appendicularians, also known as larvaceans, since the adults keep on looking and even behaving like larvae, are small (3 mm long) planktonic organisms, with 30 species in Italian seas. Thaliaceans are also planktonic, but generally have macroscopic size (they average a few centimetres in length), and are part of the so said jelly macro-plankton. The chains of salp, with a metagenetic cycle in which solitary organisms alternate with colonial organisms originating through stolonization, can even be several metres long. Thaliaceans constitute a rather heterogeneous group, home to three very different orders: salps, dolioles and pyrosomes. Such orders recur in Italian seas respectively with 14, 7, and 1 species, adding up to 22 thaliacean species. The class of ascidians, contrary to the two previous ones, includes species with sessile adults, from less than 1 cm to 12 dm in length, that principally live on the hard coastal sea beds, though also on detritus beds and at great depth. Various species live in the harbours, where they can become part of the *fouling* (eg. *Ciona intestinalis*, *Styela plicata* and others); a few penetrate brackish waters (eg. *Botryllus schlosseri*) as long as not too much deprived of salt. The ascidians can either be solitary (Figure 5.51) or colonial; the latter are divided into social, joined by a basal stolon, and composite, enveloped by a common tunica and resembling sponges. The large solitay ascidians of the genus *Microcosmus* are edible and are known on the market by the name of sea lemon or sea egg; excessive upteke has led to local rarefaction. A typical ascidian characteristic, with not a single other occurrence in any other animal group, is their heavy metal accumulation ability – vanadium and iron, for instance, are concentrated up to a million times more than their sea water occurrence, and this makes ascidians effective biological indicators of certain types of pollution. Worldwide around 1,250 ascidian species have been reported, 113 of which are present in Italian seas.

Cephalochordata

Considered a *subphylum* of chordates. They comprise few species, but are important to the researchers since they represent in many ways the transition point from invertebrates to vertebrates. They look like small fish no more than a few centimetres long. The only Mediterranean species, the Common lancelet (*Branchiostoma lanceolatum*) occurs on coarse sandy sea beds in Italian seas.

MOLLUSCS

[Marco Oliverio]

They are an extremely diversified phylum, with about 100,000 species world-wide, mostly marine, and classified into about 500 families. There are eight living classes (*Caudofoveata*, *Solenogastres*, *Polyplacophora*, *Monoplacophora*, *Gastropoda*, *Cephalopoda*, *Bivalvia* and *Scaphopoda*) each with profoundly different characteristics and length that goes from less than 0.5 mm of some microgastropods, also in the Mediterranean, to a metre or more of the *Tridacna gigas* in the Pacific, to several metres of the gigantic oceanic squid; though most species are minuscule in size (<5 mm). They include well known animals of commercial and food interest, such as the octopus and cuttlefish among cephalopods, the oyster and the clam among bivalves, the mussel and the sea snail among gastropods. Some classes, such as, chitons (polyplacophors) or scaphopods are not well known, while others, the neopilina (monoplacophors) and the aplacophors (caudofoveats and solenogasters) are almost unknown to the general public.

Italian marine malacofauna should be considered in the context of Mediterranean malacofauna, unanimously considered as the best known in the world. On the basic of the *Checklist of Italian Fauna* and considering the new sightings and descriptions of species along Italian coasts, there are currently 1,528 marine mollusc species attributed to Italian fauna (about 75% of the 2,000 or so species of Mediterranean malacofauna). About 255 families of Italian species represent more than 90% of the Mediterranean marine mollusc families, which corresponds to about 50% of the families known world-wide. All the mollusc classes are present, although the monoplacophor, *Veleropilina reticulata*, is only known on the basis of shell exhibits. The rate of new species discovered in the Mediterranean is high: almost 15-20 new species a year (with peaks of 40-50); about 30% of these are present in Italian seas.

Among the Italian marine malacofauna species, very few are strictly endemic due to geographical reasons because Italian coasts are more faunistic cross-roads than areas of endemisation: about twenty species, less than 1.4% of the total.

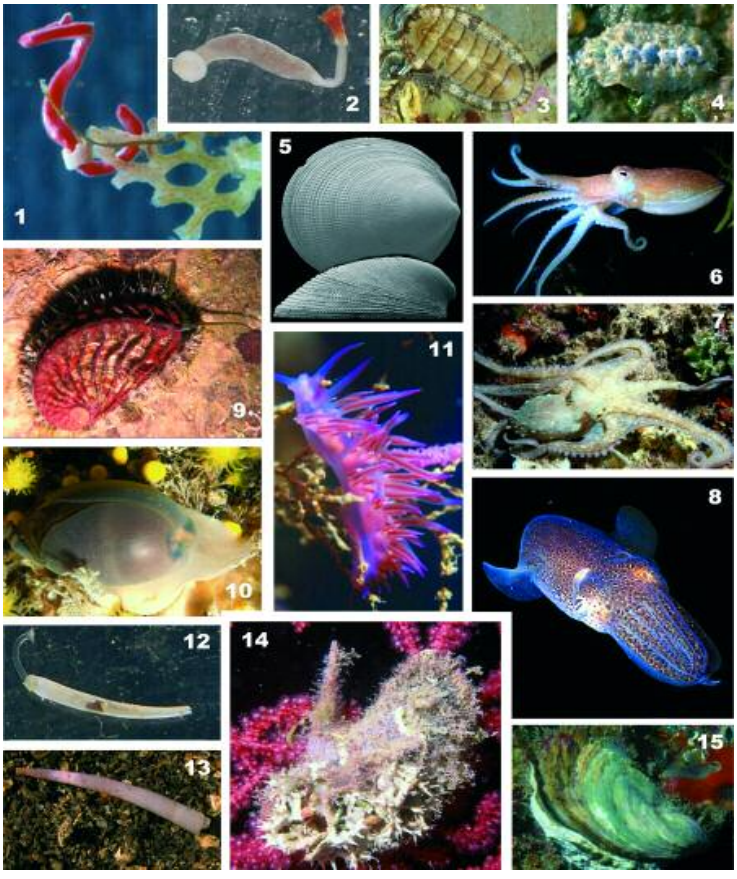

Plate 5.1 - Members of various mollusks classes. 1. Aplacophor (class *Solenogastres*). 2. *Falcidens gutturosus* (Kowalewsky, 1901) Malta (class *Caudofoveata*). 3. *Chiton olivaceus* Spengler, 1797, Capo Palinuro (class *Polyplacophora*). 5. *Acanthochitona fascicularis* (Linné, 1767), Liguria (class *Polyplacophora*). 5. *Veleropilina reticulata* (Seguenza G., 1876), Tyrrhenian Sea (classe *Monoplacophora*). 6. *Eledone cirrhosa* (Lamarck, 1798), Puglia (class *Cephalopoda*). 7. *Octopus vulgaris* Cuvier, 1797, Capo Palinuro (class *Cephalopoda*). 8. *Sepiola rondeleti* Leach, 1817, Puglia (class *Cephalopoda*). 9. *Haliotis tuberculata* Linné, 1758, Capo Palinuro (class *Gastropoda*). 10. *Luria lurida* (Linné, 1758), Capo Palinuro (classe *Gastropoda*). 11. *Flabellina affinis* (Gmelin, 1791), Capo Palinuro (class *Gastropoda*). 12. *Pulsellum lofotense* (Sars M., 1865), Malta (class *Scaphopoda*). 13. *Dentalium vulgare* da Costa, 1778, Salina (class *Scaphopoda*). 15. *Pteria hirundo* (Linné, 1758), Liguria (class *Bivalvia*). 15. *Ostrea edulis*, Capo Palinuro (class *Bivalvia*). Photo 1, B. Sabelli; 2, 12, C. Mifsud; 3, 7, 9-11, 14, 15, F. Barbieri; 4, S. Schiaparelli.

No Italian species is considered critically endangered out of man-made causes, with the sole exception of Maltese *Gibbula nevosa* followed by *Patella ferruginea,* the most endangered molluscs in the Mediterranean. Numerous species are in decline because of natural evolution, such as the community of white corals, or those endangered by man, such as the prairies of *Posidonia oceanica*. Notwithstanding this, no Mediterranean marine mollusc species has been included in the CITES appendices, while little more than a dozen are listed in Appendix II of the Bern Convention, and only three have been considered for the Habitats Directive (Table 5.40). Other species that are most certainly worthy of protection should be inserted in these lists, at least the few endemic species or those with very limited ranges, as well as several species considered 'rare' owing to particular aspects of their biological cycle which make them particularly vulnerable.

Present-day knowledge regarding the 2,000 Mediterranean species and the more than 1,500 of the Italian seas is quite outstanding, and at present, new opportunities are opening up thanks to this solid foundation. Mediterranean marine malacofauna (and hence the Italian one) is still the best known in the world. However, this is the result of a past European tradition for taxonomic research, while the present situation and future prospects on a continental and national scale are not encouraging, contrary to what occurs in other countries (for example, Japan, Australia and New Zealand, the United States and Spain) that have recently invested in many research projects on faunistic biodiversity. An important part of taxonomic work for most groups still remains to be carried out. The small quantity of taxonomical and systematics studies published up to now on Mediterranean molluscs has made use of modern methods (including molecular techniques or the scanning electron microscope). The level of knowledge on the biology of molluscs is still low for the vast majority of the species, above all, those small in size. For example, significant data on the biological cycle, autoecology, and detailed distribution are available for 2-3% of the malacofauna. Moreover, a systematic collection of distribution data does not exist.

Class	Family	Species	Endemism
Caudofoveata (3)	3	4	
Solenogastres (22)	9	12	
Polyplacophora (9)	6	29	
Monoplacophora (5)	1	1	1
Gastropoda (260)	149	1,096	15
Cephalopoda (45)	21	58	
Bivalvia (117)	64	315	5
Scaphopoda (9)	2	13	
total (470)	**255**	**1,528**	**21**

Table 5.39 - Known families and species of marine molluscs along Italian coasts, divided into their respective classes, and Italian endemisms: data obtained from the Checklist of species of the Italian fauna (BEDULLI *et al.*, 1995a, b, c; BELLO, 1995; BODON *et al.*, 1995), and subsequent updates. The number of families assigned to each class on a worldwide basis is between parentheses (VAUGTH, 1989).

Species	IUCN status	Document
Patella ferruginea Gmelin, 1721	CP	II, IV
Dendropoma petraeum (Monterosato, 1884)	VU	II
Zonaria pyrum (Gmelin, 1791)	PR	II
Schilderia achatidea (J.E. Gray in G.B. Sowerby II, 1837)	PR	II
Luria lurida (Lamarck, 1810)	PR	II
Erosaria spurca (Linnaeus, 1758)	PR	II
Charonia lampas lampas (Linnaeus, 1758)	PR	II
Charonia tritonis variegata (Lamarck, 1816)	PR	II
Bursa scrobilator Linnaeus, 1758	PM	-
Cymatium parthenopeum (Salis Marschlin, 1793)	PM	-
Ranella olearia (Linnaeus, 1758)	VU	-
Tonna galea (Linnaeus, 1758)	VU	II
Mitra zonata Marryat, 1818	PM	-
Lithophaga lithophaga (Linnaeus, 1758)	VU	II, IV
Pholas dactylus Linnaeus, 1758	VU	II
Pinna nobilis Linnaeus, 1758	VU	IV
Pinna rudis Linnaeus, 1758	VU	II
Atrina pectinata (Linnaeus, 1767)	PM	-
Solemya togata (Poli, 1795)	PM	-

Table 5.40 - List of endangered or threatened species in Italian waters, their current condition (IUCN categories – CP, critically endengered; PR, endangered; VU, vulnerable: SEDDON, 1998) and, where it applies, official document on the need for protection (II: appendix II of the Bern Convention; IV: annex IV to the EU's Species and Habitats Directive) (SCOTTI and CHEMELLO, 2000, modified).

ARTHROPODS

[Genuario Belmonte]

The *phylum* Arthropoda is the largest and most advanced group of invertebrate animals, rivalling and often exceeding the evolutionary success of vertebrates. The *phylum*, in fact, contains about 80% of known animal species and this percentage is also confirmed in the fauna present in the Italian territory.

Arthropods in the sea are present in plankton and benthos, both sessile and vagile, with various types of feeling habits and even complex life cycles that include parasitism. They display all types of evolutionary adaptations and colonise from marginal habitats (e.g. the coastal brackish lagoons) with a wide variability of abiotic conditions, to abiotically stable habitats (e.g. hypogean anchialine or batial zone) or those that are biologically complex (e.g. benthic coralligenous habitats) that requires elevated specialisation.

Fig. 5.52 - *Inachus phalangium* is part of a group of decapod crustaceans with a characteristic morphology: their carapace extends toward the front with a beak-shaped rostrum (Photo by C.N. Bianchi).

Fig. 5.53 - The Wool crab (*Dromia personata*) uses sponges or other organisms, which it carries atop its carapace, to more effectively camouflage itself (Photo by C.N. Bianchi).

The extent of Italian territorial waters is much greater than that of land (about 583,000 sq. km compared to 30,000 sq. km of land; Figure 5.54) and presents all the habitat types found in the rest of the Mediterranean.

The 2,222 arthropod species that occur in Italian seas, makes up about 24% of all known marine species (9,179 also including the 1,046 'protozoans') and constitute the highest number of species gathered in a taxon at the *phylum* or *subphylum* level (Table 5.41), in the sea. Another consideration made from consulting Tables 5.41 and 5.42 is that more than 95% of Italian marine *Arthropoda* are *Crustacea*, which supports the affirmation that, in terms of richness of forms, they are comparable to insects on

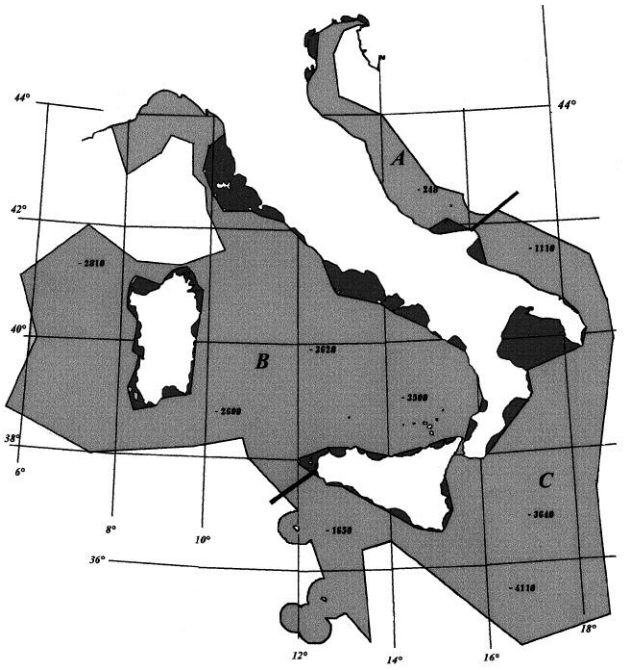

Fig. 5.54 - Italian territorial marine waters. The darker areas, near the coastline, are sea areas within the baseline- 'territorial waters' are those within 12 nautical miles measured from the baseline. A = central-northern Adriatic sector; B = western sector; C = south-eastern sector. Maximum depths are indicated for each sector in metres. (Lambert Azimuthal Equal-Area Projection, centred on 12° meridian east of Greenwich; graphics, G. Belmonte).

emerged land. The adaptive capacity of *Crustacea* at an anatomic level is even superior to that of *Insecta* since, judging by the numbers, there are more than 1,000 Italian species (30% of the total) that are terrestrial, while none of the thousands of insects present in Italian fauna have been reported in the sea.

The Italian marine *Arthropoda* are attributable to two classes *Pycnogonida* (44 species) and *Acarina* (58 species) and the *subphylum Crustacea* (2,120 species).

Their size which is generally small, greatly depends on the phylogenetic constraint of the arthropodan exoskeleton, but can reach elevated linear and ponderal growth rates, above all, in *Decapoda Reptantia*, thanks to the hydrostatic thrust. Though structurally extremely complicated, owing to the numerous body segments and the many articulations of the appendages, their minimum size, as adults, can be less than 0.20 mm (such as the copepods of the genus *Oncaea*). On the other hand, life in water allows lobsters (gen. *Palinurus*), crayfish (gen. *Astacus*) and spider crabs (gen. *Maja*) to reach exceptional dimensions (50 cm or more in length), unthinkable for terrestrial arthropods (Figure 5.55).

Phylum	total no. of species	%	no. of marine species	%
'PROTOZOA'	1,810	3.15	1,046	11.40
PORIFERA	479	0.83	472	5.14
CNIDARIA	463	0.81	458	4.99
CTENOFORA	32	0.06	32	0.35
PLATYHELMINTHES	1,318	2.30	676	7.37
GNATHOSTOMULIDA	6	0.01	6	0.07
NEMERTEA	96	0.17	95	1.04
GASTROTRICHA	232	0.40	142	1.55
ROTIFERA	265	0.46	7	0.08
CICLIOPHORA	*	*	*	*
NEMATODA	1,358	2.37	376	4.10
NEMATOMORPHA	23	0.04	1	0.01
ACANTOCEPHALA	27	0.05	0	0.00
KINORHYNCHA	22	0.04	22	0.24
LORICIFERA	4	0.01	4	0.04
PRIAPULIDA	3	0.01	3	0.03
KAMPTOZOA	16	0.03	16	0.17
MOLLUSCA	2,127	3.70	1,543	16.82
ANNELIDA	930	1.62	840	9.16
POGONOPHORA	1	0.00	1	0.01
ECHIURA	5	0.01	5	0.05
SIPUNCULA	18	0.03	18	0.20
ARTHROPODA	46,053	80.22	2,222	24.22
TARDIGRADA	244	0.43	52	0.57
ONICOPHORA	*	*	*	*
BRYOZOA	304	0.53	294	3.20
PHORONIDA	3	0.01	3	0.03
BRACHIOPODA	12	0.02	12	0.13
ECHINODERMATA	118	0.21	118	1.29
CHAETOGNATHA	18	0.03	18	0.20
EMICORDATA	5	0.01	5	0.05
CHORDATA	1,418	2.47	688	7.50
Total	**57,410**		**9,175**	

Table 5.41 - Animals of Italian fauna: number of species per *phylum.*

The *phyla* with at least 96% of species present in the sea. are indicated in boldface.
* Phyla not present in Italy.
Source: Minelli *et al.*. 1995

Fig. 5.55 - A large crab (Family Maididae), photographed at - 95 m in the Gulf of Taranto (Photo by A. Costantini).

At least 58 species (all *Crustacea*) reported in Italian seas are of commercial interest (FISHER *et al.*, 1987), thus the group is well known (Table 5.43). Of the 58 species, 56 are *Decapoda*, which leads the general public to automatically associate the name 'crustacean' to this particular *taxon*. In reality, the *Decapoda* (269 species) are only 11.2% of the marine *Arthropoda* and 12.7% of Italian marine *Crustacea*. The crustacean model, or the marine arthropod model, could best be represented by the anatomic model that characterises the class *Copepoda* (614 marine species), that of the *Ostracoda* (341 marine species), or the order of *Amphipoda* (445 marine species), less common and known by the general public, though with an adaptive radiation that is greater than that of the extremely well-known *Decapoda*.

Of the 136 endemic species of Italian marine arthropods, 73 are *Ostracoda* and 39 are *Amphipoda* (Table 5.42). This figure could be due to the great knowledge that Italy has of these groups with respect to the rest of the Mediterranean. Moreover, much more faunistic research (including deep water habitats) has been carried out on *Ostracoda* compared to what has been done for the most other groups. In fact, about 70% of the seafloors are more than 1,000 metres in depth (either peaks of more than 4,000 m) in Italian seas, and with rare exceptions, they are poorly known in terms of fauna. The waters of the bathypelagic zone and the deep sea bottoms have been defined as 'the planet of the crustaceans' given the undisputed dominion of *Copepoda* and *Amphipoda* (principally) there.

Class	Total no. of species	No. of marine species	No. of endemic species	No. of endemic marine species
Acari	2,863	58	24	0
Pycnogonida	44	44	4	4
Branchiopoda	132	5	5	0
Ostracoda	478	341	99	73
Copepoda	1,026	614	107	18
Mystacocarida	1	1	0	0
Branchiura	4	0	0	0
Cirripedia	49	49	0	0
Pentastomida	2	0	0	0
Malacostraca	1,598	1,110	334	41
Leptostraca	3	3	0	0
Stomatopoda	8	8	0	0
Bathynellacea	5	0	1	0
Thermosbenacea	4	0	3	0
Mysidacea	70	66	3	1
Cumacea	71	71	0	0
Tanaidacea	47	47	0	0
Isopoda	572	188	235	0
Amphipoda	522	445	89	39
Euphausiacea	13	13	0	0
Decapoda	280	269	1	1
Total	**6,197**	**2,222**	**573**	**136**

La classe *Malacostraca* è scomposta negli ordini che la costituiscono.
Fonte: MINELLI *et al.*, 1995

Table 5.42 - Marine *Arthropoda* of Italian fauna: number of species.

taxon	n. of species
Porifera	6
Cnidaria	6
Arthropoda	58
Mollusca	234
Echinodermata	6
Chordata	404

Table 5.43 - Species of Italian marine fauna of commercial interest. Source: FISHER *et al.*. 1987.

The great geographical distribution of the *Copepoda*, the most numerous group of marine arthropods, does not allow us to enumerate many endemic species (only 18 in Italy). Even in this case, the study of the deep-sea habitats is still somewhat lacking, thus studies carried out of these habits would most likely lead to new discoveries. Marine *Copepoda* can equally distributed as planktonic, benthic and parasite species, which highlights the structural versatility of these small crustaceans.

The scarce knowledge of crustacean fauna and of Italian marine habitats in general (only the coastal habitat is known at an acceptable level) is evident by the continual updating of the faunistic lists. Among the Italian species of marine *Arthropoda*, the *Crustacea* were 1,400 according to Ruffo, and only 3 years after providing this figure, the same author brought them up to 2,120. Up to now, little progress has been made to knowledge of deep sea habitats and even coastal ones, while exploration of particular habitats (e.g. underwater caves or the interface areas between the seafloor and the water column), or entire sectors of the Italian coastline (the entire Ionian arc, neglected up to recent times) has led to the discovery of new fauna.

In addition, the group has not been untouched by the faunistic changes that are occurring on a general scale: new species have arrived from the Red Sea through Lessepsian migration (*sensu* POR) since the end of the 19th century, a period in which *Portunnus pelagicus*, a crab of the northern coast of Atlantic America was reported in Sicily. Faunistic variations also occur as a result of deliberate (e.g. in the case of *Penaeus japonicus*) or accidental introduction (e.g. with ballast water discharged from ships, as in the case of copepods with resistant eggs) by man.

The varied distribution of species in the three Italian marine sectors (western, central-northern Adriatic, south-eastern, see Figure 5.54) is perhaps due to the poor amount of knowledge mentioned previously, rather than to the decline of species of the entire Mediterranean from west to east. In fact, in Table 5.44 one can see how the south-eastern sector of Italian seas, though being much more wide-ranging geographically, with a bathymetric range four times that of the Adriatic sector, is populated by fewer arthropod species (this fact can also be extended to other animal *phyla*).

	No. of species per geographic sector
1 Western sector	1,970
2 South-eastern sector	1,098
3 Northern Adriatic sector	1,249

Table 5.44 - *Arthropoda* of Italian Marine fauna.

At several research institutes that carry out studies in the coastal waters of the south-eastern sector, numerous species have been identified that are not present in the official Checklist published in 1995, which also include representatives of high ranking taxa (e.g. the order *Misophrioida* among copepods or the class *Facetotecta*, among crustaceans) never reported for Italian seas (Figure 5.56).

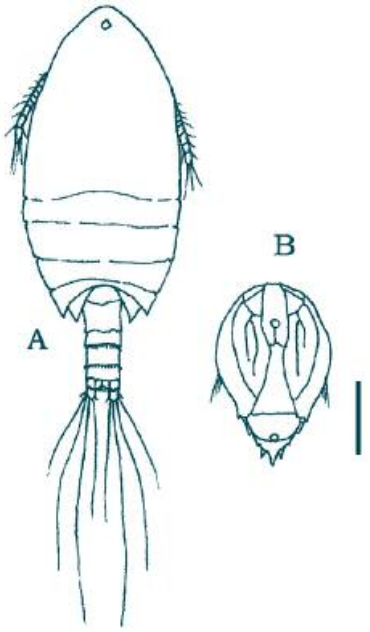

Fig. 5.56 - Recently identified arthropods species of Italian seas (not included in the recent Checklist by Minelli et al., 1995).
A = genus *Pseudocyclops* (Crustacea, Copepoda, Calanoida) typical of hyperbenthos.
B = class Facetotecta (nauplius). Dorsal view for both.
Bar = 100 µm (drawings, G. Belmonte).

The presence of *Facetotecta* is quite singular. The group was recognised on the basis of the anatomic uniqueness of the nauplius and cypris larvae, though an adult stage has never been described. The frequent findings of these larvae in coastal plankton (also common in the plankton of underwater caves) remind us of marine zoology more than a century when the nauplius, the typical larva of crustaceans, was not identified as such, and had been given a generic name (*Nauplius*) independently of the features that the adult forms corresponded to.

Therefore, it is clear from a simple analysis of data at our disposal that knowledge on the arthropod fauna of Italian seas is far from satisfactory. These faunistic lists are updated at a greater rate than other groups (e.g. the *phyla Mollusca* and *Vertebrata*). Entire sectors of Italian seas (e.g. the south-eastern ones) have yet to be adequately investigated and studied. The domains of the deep-sea (the benthonic as well as the planktonic one) are also still far from being explored and known by the scientific community.

Like all marine fauna, arthropods are perhaps not affected by anthropic presence that causes great environmental changes. The impending threat on arthropods as well as the rest of the entire marine fauna, probably derives from the scarce knowledge that we have of natural marine habitats in Italy (the only country in the world to have published a complete checklist of its fauna) and in the Mediterranean (one of the most studied seas in the world) (Plate 5.2).

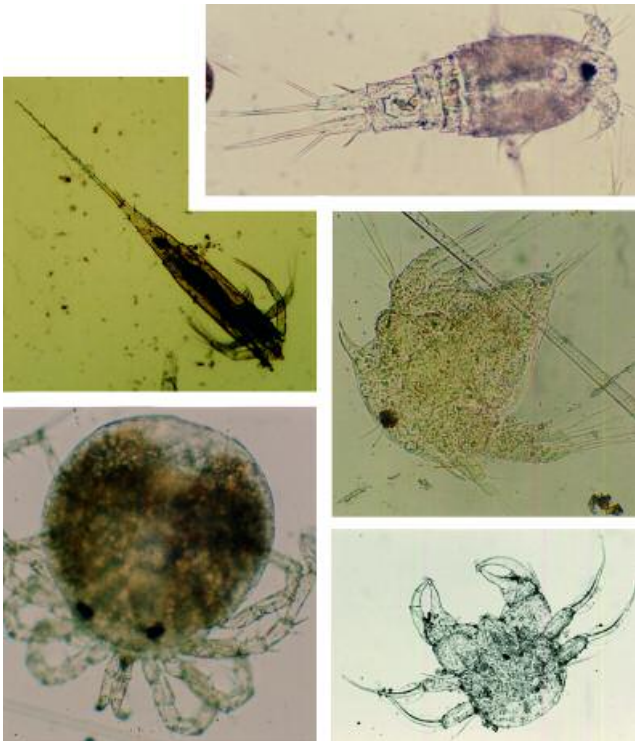

Plate 5.2 - Marine arthropods of Italian fauna. **a:** 'protonymphon' larva (class Pycnogonida); **b:** marine acaro (family Pontarachnidae); **c:** 'nauplius' larva, planktonic, benthic balanus (class Cyrripedia); **d:** 'nauplius' larva of holoplanktonic copepod (ord. Calanoida, fam. Pontellidae); **e:** copepodite stage of benthic copepod (order Harpacticoida; family Canuellidae).
Bar = 100 µm (Photos from of the Zoogeographical and Faunistic Laboratory of the DiSTeBA, University of Lecce).

FISHES

[Simona Bussotti, Paolo Guidetti, Marino Vacchi]

The present disribution of fish species in the Mediterranean is the result of the interaction of biogeographical, geomorphological, chemical-physical, trophic, climatic and antropic factors. Time, climatic conditions, the typical dispersive capacity of each species can explain the degree of 'penetration' into the Mediterranean with to respect to the gateways (Strait of Gibraltar and the Suez Canal). The species of Atlantic-oreal origin have grater affinity for colder waters and tend to occur mainly in the north-western sectors of the Mediterranean, displaying a limited capacity of penetration into the basin. Instead, the Indo-Pacific and Atlantic-tropical (thermophile) species, occur principally along the southern and eastern coasts of the Mediterranean: some have become so abundant and frequent that their findings are no longer worthy of note. The Ponto-Caspian species, finally, are found more commonly in the northern Egean and in the Adriatic.

Within the Mediterranean basin an expansion of thermophilic species from the South to the North is taking place. Along the Italian coasts this phenomenon has addressed a few species such as *Sparisoma cretense* (Figure 5.57), sighted at the island of Giglio and common by now in southern Tyrrhenian and Adriatic waters, *Thalassoma pavo* (Figure 5.58), and the blennid *Scartella cristata* both a frequent sight in recent years in the northern areas of the western basin (eg. Ligurian sea).

Fig. 5.57 - Specimens of *Sparisoma cretense* exhibiting different liveries (Photo by F. Costa).

Fig. 5.58 - Specimen of *Thalassoma pavo* (to the right) (Photo by S. Bava).

It is by all means quite difficult to establish whether or not an introduced species has become established by constituting populations capable of self-maintenance and reproduction, unless very high macroscopical abundances are observed, or reproduction and recruitment events (as in the case of *Thalassoma pavo* in North West Mediterranean). For instance, a few species may be hard to capture, just because they live too deep down or in hardly accessible sites.

The establishment of new species in new ranges is nevertheless associated to the risk of possible competition for resources (food, space, 'nursery' areas) with autochthonous species. A pertinent example is represented by the mentioned *Thalassoma pavo*. Mainly found in shallow rocky sea bed habitats, it was present to a large extent along Italian southern coasts, and considered rare along the northern ones (eg. in the Ligurian sea). In the past few years, it has rapidly become more abundant, and more frequent also in the Ligurian sea. *T. pavo*, in the recently colonised geographical areas or anywhere it has become more abundant, has been observed to take the place of *Coris julis* (Figure 5.59) in the more shallow rocky bottoms. *Coris julis* may be found again farther down, often below the summer thermocline (when present), where *T. pavo* is numerically esiguous. This suggests that *T. pavo* is competitively dominant in the more superficial water layers with respect to *C. julis*, and that its expansion has led to a change in the ichthyofauna of shallow rocky sea beds, where *C. julis* used to represent one of the most successful species.

Fig. 5.59 - Specimen of *Coris julis* (Photo by S. Schiaparelli).

In addition to the ensuing competition with the pre-exsisting species, the arrival of new species in a geographical area may determine infestations by pathogens and parasites that use the allochthonous species as vectors, with potentially relevant economic and ecological consequences.

In general, it is commonly accepted that the biodiversity of Mediterranean fish species tends to decrease in two directions: 1) west to east, 2) from the surface of the water downwards. The west-east gradient is substantially linked to the presence of gateways (such as the Canal of Sicily) and to the general and progressive oligotrophication of the waters eastward. Instead, the distribution in relation to depth is partly related to the homothermia of Mediterranean waters (about 12 °C) from 350-400 m down to more than 5,000 m in depth. This could make the establishment of extra-Mediterranean species of the bathyal zone somewhat difficult owing to the diverse envitronmental conditions.

The Mediterranean, apart from still being the receptacle today of many fish species from other geographical areas, also has an endemic component, above all, of bony fishes. In cartilaginous fish (sharks, rays and ratfishes) it is probable that the origin of new species requires much longer periods of time compared to bony fishes because of the biological and ecological characteristics of these marine vertebrates (e.g. strategy K that entails a slower renewal of populations). Many of these species (particularly sharks) have excellent swimmining capacities and usually migrate great distances, and so the exchange among mediterranean populations and those of the nearby oceanc can occur frequently.

The number of fish species present in the Mediterranean is estimated at 664: 575 Osteichthyes (Bony fishes), 86 Chondrichthyes and 3 Cyclostomes. Of the 156 families (132 Bony fishes, 22 Chondrichthyes, 2 Ciclostomes), almost half are reprsented by a single species. The endemic species of the basin are about 9% (10% of Bony fishes, 5% of Chondrichthyes) of the species reported for the Mediterranean.

About 80% of these, that is, little more than 500, are present in the Italian seas and brackish habitats. In fact, the recent *Checklist of Italian Fauna* lists a total number of 506 fish species: 429 Bony fishes, 74 Chondrichthyes and 3 Agnaths. The greatest number of Mediterranean endemisms are found in the Adriatic (about 15% of the total number of species), which include the Adriatic sturgeon (*Acipenser naccarii*) and several gobids (*Pomatoschistus canestrinii*, *Speleogobius trigloides*) that occur exclusively in this basin.

The family Gobidae represents 46% of the total number of endemic Meditterranean fish species which include *Pomatoschistus tortonesei, P. canestrinii* and *Knipowitschia panizzai*. This family includes endemic troglophyle and cryptobenthic species whose preferential habitats are underwater caves, such as *Speleogobius trigloides* or *Corcyrogobius lichtensteini*, that have been sighted in various sectors of the basin.

There are also deep-sea fish species that are endemic to the Italian Seas. Some have been studied owing to the presence of peculiar geographic areas to which these organisms have been transported to shallower depths than usual because of the conformation of the seafloors and the presence of strong currents. An example is the Strait of Messina where the impetuous movement of deep waters transports fish forms to the surface and beaches them, such as the epigonids *Microichthys coccoi* (Figure 5.60) and *M. sanzoi*. Another precious source in studying species is the analysis of the stomach contents of deep-sea predators. These predators have been found to be efficient sampling instruments that are much more incisive and selective than those devised by man.

Fish fauna does not contain insular endemic species in Italian seas nor in the reamaining area of the Mediter-

Fig. 5.60 - Specimen of *Microichthys coccoi* (Photo by F. Costa).

ranean basin. This fact can be attributed to the lack of real biogeographical 'island' separated by elements that isolate poulations and set off the speciation process.

The *Checklist of Italian Fauna* provides general indications on the distribution of each species in the various seas. In Table 5.45, the number of fish species belonging to Agnatha, Chondrichthyes and Osteichthyes, are provided for each of the three key sectors of Italian seas: 1) Ligurian Sea, Sardinian Sea and the Thyrrenian Sea, 2) Central and northern Adriatic Sea , 3) Ionian Sea and the southern Adriatic Sea.

	Agnatha		*Chondrichthyes*		*Osteichthyes*	
Sectors	No. of species	?	No. of species	?	No. of species	?
1	2	-	72	7	407	5
2	3	2	61	7	293	17
3	2	-	71	5	336	8

Table 5.45 - Number of fish species belonging to *Agnatha*. *Chondrichthyes* and *Osteichthyes* present in the three key sectors of the seas of continental and insular Italy (see text). ?: dubious presence.

The northern Adriactic sector seems to have the fewest number of species, and the greatest number of cases of dubious presence of species (principally for Bony Fishes). The number of species that can undoubtedly be considered ubiquitous, at least as far as the Italian seas are concerned, are 2 for Agnaths, 53 cartilaginous fishes and 247 bony fishes.

The appearance of new species in Italian seas is essentially due to new findings of allochthonous species for the Mediterranean or the extended distribution range of some species already reported for the Mediterranean, though previously absent along Italian coasts. Many fish species resident in Italian seas have only been reported in recent years thanks to the intensification of studies and research on fish fauna, as in the case of the gobid *Thorogobius macrolepis* (Figure 5.61), recentemently observed in the Ionian Sea and in the Lower Adriatic.

The fish fauna of Italian coasts are subjected to a wide range of negative influences such as generalised habitat deterioration, owing to the growing antropic pressure along the coasts and the excessive fishing (also illegal).

As far as fish fauna is concerned, the amount of organic matter (for example, sewerage discharge) or chemical pollantants (e.g. heavy metals, pesticides) introduced into the sea can produce high mortality rates in juvenile fish that are particularly sensitive to environmental conditions, apart from altering the structure of the communities (such as modifying the trophic organisation, the

Fig. 5.61 - Specimen of *Thorogobius macrolepis* (Photo by A. Terlizzi).

composition of species or the relative quantities). For example, in situations of increased organic load, *Mugilids* (mullets) tend to increase in numbers in that they are omnivores and capable of feeding on suspended organic matter. When massive quantities of nutrients are available, the fish that feed on plancton (for example *Ateriniidi*, *Pomacentridi*) increase numerically to such a degree that they harm other trophic categories. The abundance of nutrients, in fact, activates the trophic network 'from below', that is, an increase in phytoplancton, then that of zooplancton, and finally even of planctonofagous fish which feed on the last mentioned. Instead, in the case of chemical pollution caused by the introduction heavty metals or pesticides, the accumulation of these substances in fish populations can also damage human health when these species are eaten by man.

The disappearance of marine phanerogam prairies (the principal barricade of beaches against the movement of the waves) owing to increased torbidity of the waters can have negative effects of the reclument of several fish species. Many fish species, in fact, reclute exclusively of preferentially (e.g.. *Diplodus annularis*, *Spondyliosoma cantharus*) in submerged marine praries in which the juveniles stages find food and refuge from predators. The increased mud cover of seafloors can modify the characteristics of the substrate to such an extent that some species are forced

into restricted or unhabitual areas, for example to the Pleuronectiformes (flat fishes). Some authors also believe that micronektonic fishes (e.g.. Clupeiformes, Myctophiformes) are affected by the torbidity of the waters, tending to find refuge in coastal waters.

Many fish species are subject to intense and often irresponsible fishing acivity. There are specific laws that discpline fishing activity as well as norms that regulate the use of fishing equipment and establishes the minimum size to fish each species. Illegal practices such as trawling off the coast and with finer nets with respect to what is permitted is a great threat for the important coastal biocoenoses, as well as for the juvenile stages of several species.

Apart from illegal practices, the environmental and economic damage done by trawling, in the absence of precise fishing management, includes the capture of a large number of reproducers (with possible consequences to subsequent recruitments), the destruction of nesting sites and benthic eggs and the capture of sexually immature specimens. The excessive taking of fish can lead to the progressive rarefaction of species and a change in the demographic structure of the population, which could consequently lead to the collapse of the fish stock. In some species (as in the case of the Hake *Merluccius merluccius*, Figure 5.62), the excessive exploitation of these populations principally through the capture of juvenile specimens, has led to earlier sexual maturity in this species compared to other populationsthat are subjected to minor fishing pressure. In chondrichthyes, that have particular biological characteristics (reduced reproductive capacity, slow growth rate, very long life cycles), the consequences of excessive fishing activity can be even more distrastrous and the stock can be wiped out within in a few years. The Angelshark (*Squatina squatina*, Figure 5.63*)*, which in the past was common along all the Italian coasts, is currently only sporadically reported in the waters of Sardinia and the Canal of Sicily. The Guitarfish (*Rhinobatos* spp.), a coastal seafloor species, once a very common Sicilian fish product, is now considered locally extinct.

The main threats pelagic species such as the Sword fish, (*Xiphias gladius*) and the Tunnids (e.g. *Thunnus thynnus*) are diftnets, entrapment fish nets (for example, the 'flying' tunny-fishing nets), the fixed tunny-fishing nets and pelagic trawls. The impact of these fishing practices on the target fish, the bycatch, as well as on other species caught, including cetaceans, the marine turtle (e.g. *Caretta caretta*) and the cartilaginous fish (e.g. *Prionace glauca*), have progressively led to stricter measures in the use of some of these methods.

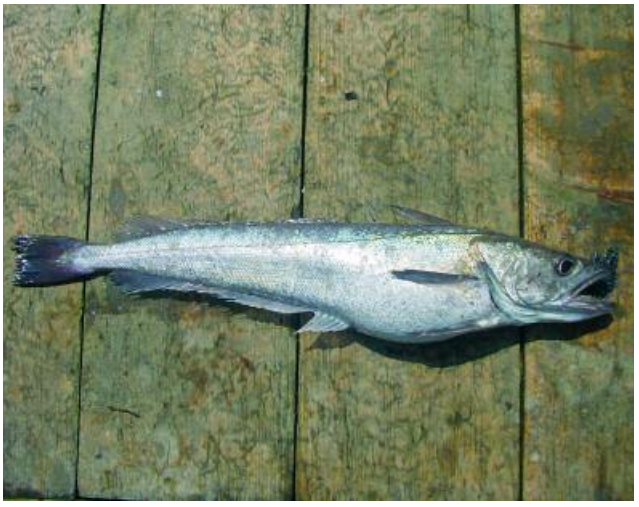

Fig. 5.62 - Specimen of *Merluccius merluccius* (Photo by M. Vacchi).

Fig. 5.63 - Specimen of *Squatina squatina* (Photo by C. Hernández González).

Other forms of fishing methods and sports fishing (underwater fishing and the use fishing rods) also have a great impact on both adults and juvenile sparids, such as the seabream of the genus *Diplodus* (*D. sargus,* Figure 5.64 *D. vulgaris*, *D. puntazzo*), on several serranids such as the Dusky grouper (*Epinephelus marginatus*, Figure 5.65), the Brown meagre (*Sciaena umbra*, Figure 5.66), on many labrids as well as on young individuals of large pelagic species such as the Greater amberjack (*Seriola dumerili*, Figure 5.67) and the Swordfish (*Xiphias gladius*).

Apart from species that are the object of fishing, the recent use of non-selective catch techniques has led to the catch of many 'additional' species which have little or no economic value (the so-called bycatch). This 'side effect' of some fishing methods can lead to great changes in fish communities, apart from causing negative effects on the populations of some species in particular. Seahorses (Hi*ppocampus hippocampuss* and *H. ramolosus*), for example, have recieved particular attention owing to their vulnerability (apart from their curious appearance). These fish, in fact, are closely associated to algal substrates and fanerogame pararies along the coast, they display complex social behaviour and relatively low fertility. Although their commerceial importance is almost nil, they are often accidentally fished, with the consequence means that seahorses are becoming much rarer in Italian waters.

In some regions, fishing with the use of poisons and explosives is stll practiced, with the subsequent serious impact on fish fauna and the rest of the marine community.

Fish species do not always react in a similar way to fishing activity; a rapid impoverishment is the conseuence for some species, while others remain substantially stable in terms of production. Others apparently to draw some sort of advantage from fishing activity with a local increase in populations, probably due to the ellimination of competitors or predators. The different impact of fishing on fish fauna was described in the north Adriatic at the beginning of last century: the predatory species (cartilaginous fishes and some bony fishs) resulted as being more sensitive to the catch than other fish species.The forced halt to fishing activity during WWI encouraged the expansion of predator fish populations to the detriment of those preyed upon.

Some fishing equipment and practices (illegal in some cases) additionally harm fish polulations through changes made to their habitats. For example, the continual movement of dragnets over unsuitable seafloors and the abra-

Fig. 5.64 - Specimen of *Diplodus sargus* (Photo by S. Bava).

Fig. 5.65 - Specimen of *Epinephelus marginatus* (Photo by F. Costa).

Fig. 5.66 - Specimen of *Sciaena umbra* (Photo by M. Ventin).

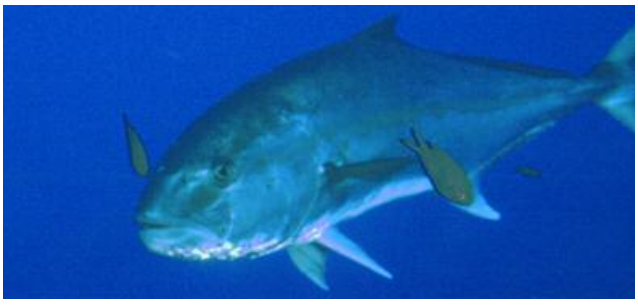

Fig. 5.67 - Specimen of *Seriola dumerili* (Photo by S. Bava).

sion caused by driftnets (including those that are lost or abandoned, the so-called 'ghost nets') on hard bottom seafloors, as well as the dissappearance of the the Date mussel from rocky beds caused by fisherman, are capable of greatly altering the ecosystems in terms of structure and functions, and of affecting the associated fish fauna either directly or indirectly. To understand the repercussions on fish fauna one must consider that some species commonly utilise the substrates with algal coverage, during both the adult and the delicate juvenile stages (e.g. recruitment) to seek refuge from predators and find nutriment. For these reasons, the eradication of benthic organisms can produce serious repercussions on a great number of fish species.

The protection and/or management of fish populations must firstly be linked to the implementation of more appropriate legislation especially as far as illegal activities are concerned. Secondly, as regards to 'ghost nets' (fish become trapped in these nets abandoned in the sea), experience from other geographical areas indicates that measure should be taken to remove these nets. Then, the catch must necessarily be proportional to the density of fish stock. The difficuty in understanding the dynamics of natural systems (e.g. assessment of populations density of species subjected to catch, their fertility, mortality, etc) calls for greater caution in the management of resources than before. The instruments used to manage this natural patrimony such as no-fishing seasons or investments in alternative activities such as aquaculture could contribute to the numeric recovery of those species populations that are subjected to intensive fishing activity, and to mitigate the impact on natural pooulations.

The negative effects of the excessive exploitation of fish resources and the general inefficiency of management programmes is a world-wide problem. This has also led Italy to consider the need to preserve (tempoaraily or permanently) some fish species or areas of the sea from fishing exploitation. An example is the 'Cetacean Santuary' in the international waters of the Ligurian Sea, which, in reality, originated as a biological protection area for the swordfish and cetaceans. The Protected Marine Areas found along the Italian coasts and the islands, as well as the Transfrontier Parks (e.g. Bocche di Bonifacio International Marine Park) are marine areas in which many of man's harmful activities, such as fishing, have been banned in order to mitigate the effects of excess catch. This was particularly evident in assessmemts of the recovery capacity of intensely exploited fish species populations was carried out elsewhere. An example which clearly illustrates this point regards the Dusky grouper (*E. marginatus*), subjected to intensive fishing, which has biological characteristics (e.g. rather slow growth rate, proterogynic hermaphroditism) which makes the effective recovery of this species from intense exploitation difficult. Fishing tends to remove the larger individuals (that is, the males), which creates a disbalance in the male/female ratio with negative effects on the recovery capacity of populations subjected to catch. Studies conducted on this species both within and outside protected marine areas, have revealed that if the Dusky grouper is protected, it establishes more numerous populations that are made up of individuals that are generally larger than those in unprotected coastal tracts.

As regards to protected marine and brackish water fish species, it is not possible to refer to only one protocol (e.g. 1979 Bern Convention, EEC 92/43 Habitats Directive, 1995 Barcellona Convention). Those species that currently receive some sort of protection in Italy are listed at the end of this section. They include critically threatened species that require strict protection measures (e.g. the White shark *Carcharodon carcharias*, Figure 5.68, the Basking shark *Cetorhinus maximus*, Figure 5.69, the Devil ray *Mobula mobular*, the Adriatic sturgeon *Acipenser naccari*, the Short-snouted seahorse *H. hippocampus*), as well as species whose exploitation require precise regulations (e.g. the Blue shark *Prionace glauca*, the Guinea Bottlenosed skate *Rostroraja alba*, the Brown meagre *Sciaena umbra*, the Dusky grouper *E. marginatus*, the Tunafish *T. thynnus* and the Swordfish, X. *gladius*).

There are a certain number of fish spcies that occur in Italian seas that are included in the IUCN (*World Conservation Union*) of Threatened Species. The Adriatic stock of the Great sturgeon (*Huso huso*) is classified as extinct and the European sea sturgeon (*Acipenser sturio*) a critically endangered. In IUCN Red List also includes several teleosts such as the Seahorses (*H. hippocampus and H. ramolosus*), the Dusky grouper (*E. marginatus*), the Mottled grouper (*Mycteroperca rubra*) and the Common seabream (*Pagrus pagrus*). Moreover, there are 16 shark species and 4 batoid that occur in Italian waters. The White shark, the Basking shark, the Grey nurse shark (*Carcharias taurus*), the Tope shark (*Galeorhinus galeus*), the Angel shark (*S. squatina*), the Devil ray and the Gulper shark (*Centrophorus granulosus*) are considered particularly vulnerable, while the re-

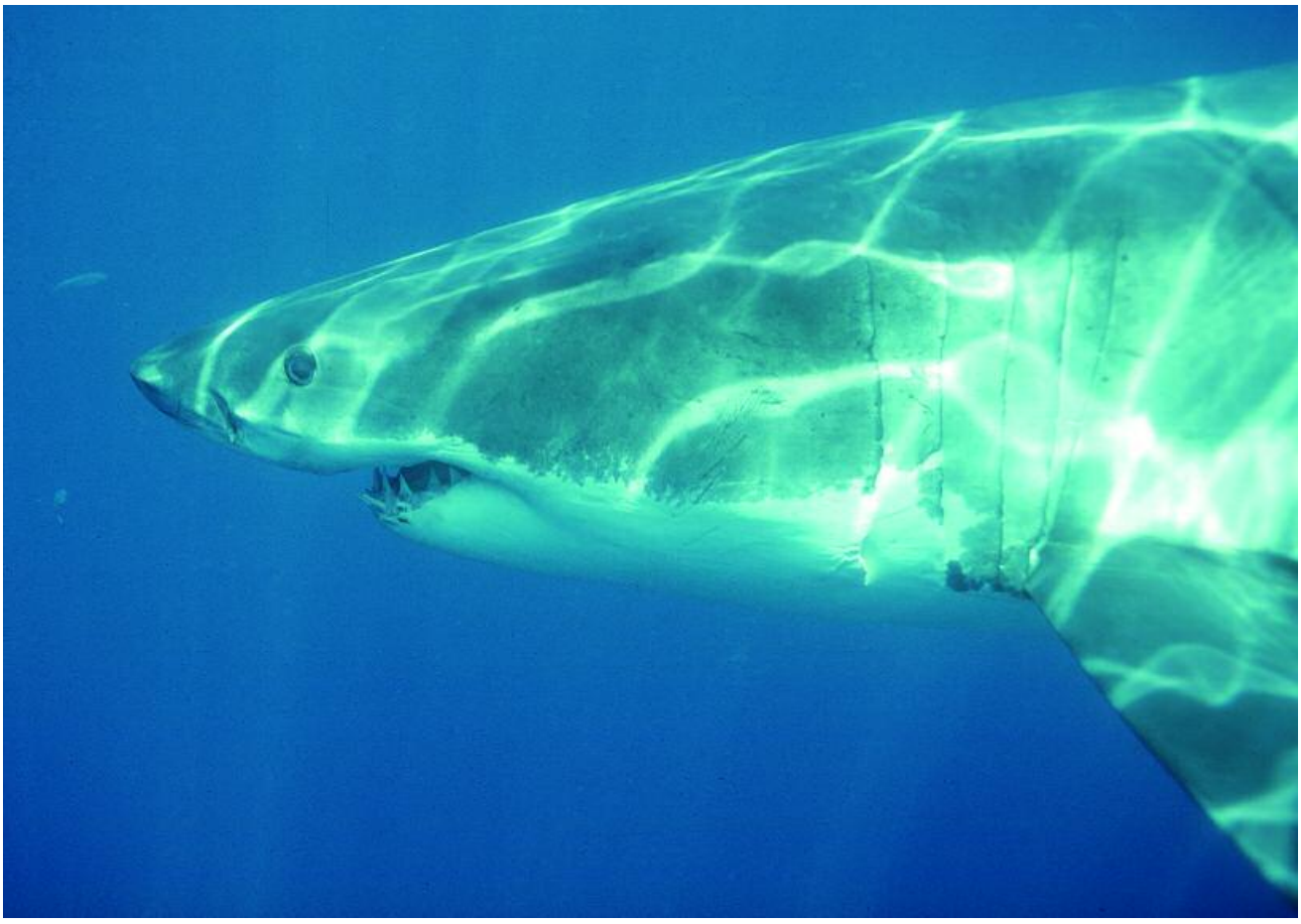

Fig. 5.68 - Specimen of *Carcharodon carcharias* (Photo by J. Stafford).

maining species are considered at minor risk. Two species belonging to the so-called 'sawfish' group (*Pristis sp.*) are classified as critically endangered on the IUCN Red List. However, it is important to say that the presence of these fish in the Mediterranean basin has recently been questioned as no reliable findings, recent or past, have been made in the area.

Even among the endangered species classified in the CITES appendices (Convention on International Trade in Endangered Species of Wild fauna and Flora) there are species that occur in Italian seas: the Elephant shark and the entire group of Sturgeons (*Acipenseriformes*), with the exception of the European sea sturgeon (*A. sturio*) that has been inserted into Appendix II greater protection.

Fig. 5.69 - Specimen of *Cetorhinus maximus* (Photo by J. Stafford).

REPTILES

[Giulia Mo]

There are five marine turtle species in the Mediterranean Sea, though there it is the likelihood of observing only three. The most common species is the Loggerhead sea turtle (*Caretta caretta*), followed by the Green sea turtle (*Chelonia mydas*) and the Leatherback turtle (*Dermochelys coriacea*). The other two species (*Eretmochelys imbricata* and *Lepidochelys kempi*) have been reported in the Mediterranean, though their presence is accidental and probably due to passive transportation into the basin.

Marine turtles utilise terrestrial habitats only to deposit their eggs and for embryo development. They are vulnerable to man-made disturbance and to the presence of predators during this phase. Turtles display two ecological phases in the sea: a pelagic one that concerns juveniles and a demersal one that concerns medium to large sized specimens. Adults carry out migration from the feeding sites (demersals) to the reproduction sites (coastal demersals). During both phases, the turtles are exposed to risks that can cause death, such as the diverse types of fishing equipment (the deep-sea boulters, trawl-nets, drift nets), the accidental ingestion of solid detritus and collision with boats. Last century, a series of threats to marine turtles together with their biological characteristics such as late sexual maturity, and the multi-annual reproductive cycle of females contributed to a considerable decline in populations. Today, all the marine turtle species found in the Mediterranean are classified as threatened and are the object of urgent conservation measures.

The Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758) is the most abundant in Italy. The subadults are found in shallow waters, where they feed on demersal invertebrates such as crustaceans and molluscs. In Italy, data regarding 'marked' specimens indicate the Adriatic sea as a possible feeding area. Mitochondrial DNA analyses of Mediterranean specimens confirm the low genetic exchange among Atlantic populations and those of the Mediterranean.

The Green sea turtle, *Chelonia mydas* (Linnaeus, 1758), is present in the eastern Mediterranean area where it nests. The young and the immature turtles prefer pelagic habitats of the south-eastern basin. The sporadic capture reported in the north-eastern Mediterranean is chiefly of sexually immature specimens. The finding of species in Italy varies from 1-2 a year and usually regards small-sized individuals. Mitochondrial DNA analyses on Cypriot specimens indicate the isolation of the Mediterranean populations from those of the Atlantic.

The Leatherback turtle, *Dermochelys coriacea* (Vandelli, 1761) is exclusively pelagic. The species has a wide circumglobal distribution and is capable of tolerating lower temperatures compared to marine turtles belonging to the family Cheloniidae. The nesting sites are mainly situated along the African and Caribbean Atlantic coastlines and the Pacific coastlines of Mexico, Asia and Australia. They do not nest in the Mediterranean, though specimens of Atlantic origin are sporadically present, entering the basin to use the pelagic habitats for feeding purposes.

BIRDS

[Nicola Baccetti]

The Mediterranean hosts nine nesting bird species with trophic habitats that are either exclusively or almost exclusively marine: four procellariforms, a cormorant, two seagulls and two terns. A tenth species, the common Caspian gull, which up to last century had mainly marine habitats, has partly modified its ecological niche because of the increased availability of food sources supplied by man on land.

During the wintering and migratory seasons, the Mediterranean population is supplemented with other species, often from the north or the Atlantic. Two Alcid populations, (*Alca torda* and *Fratercula arctica*), two seabirds of the Stercorariid family (*Stercorarius parasiticus* and *Stercorarius pomarinus*), the Northern gannet (*Morus bassanus*) and some Larids (*Rissa tridactyla*, *Larus melanocephalus* and *Larus minutus*) also reach the Italian territory. The distribution and the population density of these birds at sea are still unknown. Species often follow the Gibraltar or the Bosphorus route when crossing the Mediterranean, though typically marine migratory species are also capable of reaching Italy directly from the north by flying over hinterland Europe, following the route drawn out by of the main rivers.

To a certain extent, all marine birds depend on terrestrial habitats at least during the most important phase of reproduction: when the eggs are laid, incubation period and the early stages of rearing their offspring (Figure 5.70). The link with dry land is usually the interfacing sea-land zone, and for many species it is much more than simply a site where suitable solid substrate can be found to host a nest. There are marine birds that habitually feed along the coast or in brackish water lagoons. Some, characterised by greater ecological plasticity, regularly compute inland to exploit typically terrestrial trophic resources. Other birds, are totally marine for a certain period of the year (wintering and/or migration) and either terrestrial (the Stercorariids, that nest in the artic tundra) or freshwater (e.g. *Larus minutus*) during reproduction.

The scarce richness of marine bird populations in the Mediterranean, at least compared to many oceanic areas, can be explained by some geographical characteristics of this basin, such as the mainly longitudinal development, its peripheral position compared to the principal Atlantic migratory route which runs in a latitudinal sense, and the geological history of the area. In fact, the origins of the entire assortment of nesting species are subsequent to the opening of the Gibraltar gateway, and no surviving marine birds exist of the preceding populations that had became extinct following the almost total evaporation of the basin during the Messinian. Even the wave of Pleistocene recolonisation was followed by many extinctions, partly due to the climatic variations but also to the presence of man in this part of the world: and thus three quarters of the species that had originally inhabited this area have disappeared (e.g. three Alcids and the Gannet).

Fig. 5.70 - *Calonectris diomedea* incubating its single egg in its underground den in the Tuscan archipelago. Largest among the pelagic species nesting in the Mediterranean, its presence on land is only a consequence of reproduction exigencies.

The minor primary productivity of an isolated pelagic environment and the particular seasonal fluctuations that this productivity is subjected to have proven to be highly selective for populations of predatory species, such as marine birds. For these reasons, there is a progressive decrease in species richness, diversity and abundance of marine birds starting from the Strait of Gibraltar – the gateway to of the Atlantic – and moving eastwards. Moreover, very particular migratory routes allow some of the species present to avoid the most critical seasons.

The elevated temperature of surface waters in summer months leads to the impoverishment of plankton biomass in the layer most exposed to solar radiation. Even schools of small epipelagic fish are less accessible in areas of prey. This fact forces thousands Manx shearwaters to rapidly leave their own Tyrrhenian colonies at the end of July and head for the Black Sea. An annual exodus that is just as sudden forces almost all the shearwaters of the Balearic Islands to fly towards the Atlantic waters of the Gulf of

Biscaglia, the Audouin's gulls on the African coast fly from Gibraltar to Senegal, and a great part of the Caspian gull population to freshwater habitats in central Europe, to the Baltic coasts and to the North Sea. Their return does not come about before late autumn. Instead, the European shag population remains near its own colonies, thanks to its capacity to exploit the benthic prey of the first coastal zone.

Despite the high vagility that birds have developed thanks to their capacity of flight and notwithstanding even the relatively recent origin of the present Mediterranean bird fauna, in almost all cases, the nesting populations are endemic at the level of species or subspecies. The Audouin's gull, with a strictly Mediterranean reproductive range, is perhaps the most emblematic case because of the absence of similar species, if one excludes the very distant relationship with a northern European species (the Common gull, *Larus canus*).

Even the genus *Puffinus* is worthy of note due to the presence of two allopathic entities in the Mediterranean, recently both raised to the rank of species, characterised by migration in the opposite direction and by a clear morphological differentiation. Of the ten marine bird species that reproduce in the Mediterranean, only two, one coastal, and the other marginally present (respectively the Sandwich tern and the Leach's storm-petrel) do not have endemic forms. The rate of endemism is generally higher than that of the Red Sea, where more species nest (13) but only 6 are either endemic species or subspecies.

The ten marine species that nest in the Mediterranean are reduced to eight if one only considers the Italian seas: in fact, no confirmation has ever been made of dubious historical data concerning the nesting of the Leach's storm-petrel east of Catalonia and the Cory's shearwater that does not settle in areas outside the island from which it takes its name. The case of the Lesser crested tern is very particular, in that it has its own colonies only on the small islands of Libya, though at times it has joined large colonies of the Sandwich tern in the Comacchio Valleys, the Lagoon of Venezia, Camargue, and in the Ebro Delta. This presence of single pairs or even individual specimens heterospecific pairs, probably originated from the phenomenon of attraction that colonies of a similar species exerts on individuals that have gone astray by chance. Nesting is consolidated over time owing to the longevity of these birds and to individual fidelity to their own chosen nesting site. However, this has not given rise to large numeric populations. On average, the seven nesting species have an overall population of about 80,000 pairs and a distribution that covers the islands surrounding Sardinia and Sicily as well as the Tuscan Archipelago.

Fig. 5.71 - *Larus audouinii.* Arcipelago della Maddalena (Photo by L. Rosati).

Fig. 5.72 - *Puffinus yelkouan* and *Callonectris diomedea.* Arcipelago della Maddalena (Photo by L. Rosati).

		No. of pairs	Estimate accuracy	Nesting sites in Italy
Cory's Shearwater	*Calonectris d. diomedea*	15,000-18,000	low	**Pelagian islands** (more than 50 percent of the national total). Pantelleria. Egadi islands. **Islands around Sardegna**. Coasts of Sardegna. Tremiti islands. Pontino Archipelago. Archipelago of Toscana.
Yelkouan Shearwater	*Puffinus yelkouan*	11,000-18,000	low	Pelagian islands. Pantelleria. Egadi islands. Eolie islands. **Islands around Sardegna** (Archipelago of Tavolara: more then 25 percent of the national total). Coasts of Sardegna. Tremiti islands. Pontino Archipelago. **Archipelago of Toscana**.
Balearic Shearwater	*Puffinus mauretanicus*			Not present in Italy
Storm Petrel	*Hydrobates pelagicus melitensis*	1,500-2,000	average	Pelagian islands. Pantelleria. Egadi islands. Eolie islands. **Islands around Sardegna** (more then 25 percent of the national total). Coasts of Sardegna. Tremiti islands. Pontino Archipelago. **Archipelago of Toscana**.
Mediterranean Shag	*Phalacrocorax aristotelis desmaresti*	1,600-2,000	average	Pantelleria. **Islands around Sardegna** (more then 50 percent of the national total). Coasts of Sardegna. **Archipelago of Toscana**.
Audoin's Gull	*Larus audouinii*	510-950	High	Sant'Andrea di Gallipoli island. Palinuro's Cape. **Islands around Sardegna** (more then 50 percent of the national total). Coasts of Sardegna. **Archipelago of Toscana**.
Lesser Black-backed Gull	*Larus fuscus graellsii*			Not present in Italy
Yellow-legged Gull	*Larus m. michahellis*	30,000-60,000	average	All minor islands from the Pelagian to the Ligurian. Coastal stretches along the major islands and the peninsula. Coastal lagoons especially in the high Adriatic. Urban centres (Roma. Livorno. Trieste. etc.). Islands of large inland lakes.
Sandwich Tern	*Sterna s. sandvicensis*	500-900	high	Salt-pans of Margherita di Savoia (irreg.). **Comacchio lagoons**. **Venezia lagoon.**
Lesser Crested Tern	*Sterna bengalensis emigrata*	1-2	high	Comacchio lagoons. Venezia lagoon.

Table 5.46 - List of Mediterranean marine bird species and population density of those nesting in Italy (data referring to the 1991-2000 decade). The estimate accuracy attests whether the effective counts over which the estimate value intervals have been calculated involve more than 90 percent of the sites (high), 30-90 percent (average), or less than 30 percent (low). The last column reports the reproductive distribution (the sites are ordered from south to north, in bold the more relevant ones).

Mammals

Cetaceans

[Giuseppe Notarbartolo di Sciara]

Cetaceans are mammals adapted to an entirely aquatic life that have colonised a great variety of habitats in the course of their evolution, from equatorial seas to polar ones, from oceanic waters to freshwaters. There are, in any case, mostly marine: of the 83 known species only three (all tropical) are strictly freshwater. The order Cetacea is currently subdivided into two suborders: Mysticetes (5 families, 12 species mostly of colossal size), devoid of teeth and endowed with baleen plates, and Odontocetes (10 families, 71 species of average size, from 1.2 to 20 m), which are toothed.

In the table below, there is a list of 21 marine cetacean species that have all been observed in the Mediterranean (15 species sighted in Italian seas). Only 8 of these, including a Mysticete (the Fin whale) and seven Odontocetes (the Sperm whale, the Cuvier's beaked whale, the Long-finned pilot whale, the Risso's dolphin, the Bottlenosed dolphin, the Striped dolphin and the Short beaked common dolphin), occur in the Mediterranean and in Italian seas with populations that are regularly present, and carry out their entire life cycle in this region.

The remaining species appear in the Mediterranean sporadically, some only on rare occasions, others simply with a very low frequency (usually < 10 specimens reported in a decade for the entire basin). There have been cases of Lessepsian immigration (e.g. sightings along the Israeli coast of *Sousa plumbea*, present in the Red Sea though to be absent in the Atlantic), which makes one presume that the occasional presence of rare tropical species in the eastern Mediterranean area (e.g. *Pseudorca crassidens, Steno bredanensis*) bears witness to an Indo-Pacific origin. The possible influx of cetaceans from the Black Sea also exists, as demonstrated by the sporadic presence of *Phocoena phocoena* in the north Aegean. However, in the majority of cases, the occasional visitors are from the Atlantic Ocean through the Strait of Gibraltar, and with all probability, it is from this gateway that all the present 'regular' species of the Mediterranean entered to colonise the basin following the Messinian desiccation.

The distribution in the Mediterranean of the eight regular species faithfully reflects their habitat preference. Only the Tursiope is typically neritic; the Sperm whale, the Cuvier's Beaked Whale and the Risso's Dolphin are most common in submarine trenches at the edge of the continental shelf. Instead, the Fin whale, the Striped dolphin and the long-finned pilot whale prefer pelagic waters. The Common dolphin is the exception, as it can be found in coastal waters, as well as in the open sea. However, it is important to remember the great ecological plasticity of all these species, characterised by a elevated capacity of movement, and perhaps much more influenced by the ecology and the distributive fluctuations of their principal prey that do not have rigid, well defined habitat preferences. Moreover, it is not so unusual to come across typically pelagic species on the continental platform, and vice versa.

The few genetic comparisons carried out so far between Mediterranean and Atlantic specimens (the Fin whale, the Striped dolphin) or between Mediterranean specimens and those of the Black Sea (the Bottlenosed dolphin, the Short-beaked common dolphin) seem to indicate the existence of an extremely low genetic flow in Mediterranean populations. Within the Mediterranean, the scarce knowledge available today seems to indicate significant movements of the large-sized species (the Fin whale, Sperm whale), and the localised permanence of small coastal populations (the Bottlenosed dolphin and the Short-beaked common dolphin). Preliminary genetic analyses indicate the existence of polymorphisms in the Striped dolphin between the different geographical zones. The epicentre of Long-finned pilot whale's distribution is the far western area of the Mediterranean, gradually decreasing in frequency towards the east until it disappears completely in the eastern part of the Ionian Sea. No confirmation has yet been made as regards to the movements of the Cuvier's Beaked Whale and the Risso's Dolphin within the Mediterranean.

All cetacean species that regularly inhabit the Mediterranean could be threatened by human activity which is quite intense in this semi-enclosed sea. These activities are partly the cause of direct mortality (e.g. deliberate capture, accidental capture during a catch, collisions with boats, military sonar) and partly the cause of habitat deterioration (pollution from toxic substances, hydrocarbon, noise, presence of macro-pollutants, disturbance, impoverishment of food sources, climatic changes). A well known episode of morbillivirus infection, which occurred in the Mediterranean in 1990-91, and which mainly struck the Striped dolphin, show how natural causes of mortality can be significantly invigorated by the presence in the marine ecosystems of xenobiotic agents of anthropic origin, capable of compromising the correct functioning of the immune system.

Numerous international agreements and many national regulations countries protect cetaceans. The first worthy of mention is the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), which entered into force in 2001. ACCOBAMS identifies three cetacean species which considered priority species in the Mediterranean in virtue of their critical conservation status: the Sperm whale, the Short beaked common dolphin and the Bottlenosed dolphin. Moreover, the Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention classifies all the cetacean species in the Mediterranean as protected. Last of all, a sanctuary has been created solely to protect cetaceans, in the north-eastern Mediterranean area that France, Italy and Monaco have set up. It is a vast protected site (more than 80,000 sq km), comprising both territorial areas of the three countries and of the open sea, and important habitats for all regular Mediterranean cetaceans. The most abundant species there are the Fin whale and the Striped dolphin.

The species that occur regularly in the Italian seas are:

Fin whale, *Balaenoptera physalus* (L., 1758)

Cosmopolitan, occurs in temperate-cold and sub-polar waters, carries out extended oceanic migrations. It is the common most Mysticete in the Mediterranean, the only one with a resident population that is genetically distinct from the Atlantic population. It is more abundant in the western Mediterranean, where a 1991 census estimated a presence of 3,500 specimens. They may feed exclusively on the Northern Krill (*Meganyctiphanes norvegica*) in the Mediterranean which are found in abundance in deep waters of the western Ligurian Sea, the Corsican Sea and perhaps in the Ionian Sea. In the Italian seas it is present above all in the Ligurian sea, seasonally in the Sicilian channel, to a lesser extent in the Tyrrhenian and in the Ionian.

Sperm whale, *Physeter macrocephalus* (L., 1758)

Cosmopolitan, highly migratory, present throughout the Mediterranean, above all, in correspondence to the continental escarpment and submarine trenches. Prevalently teutophagous. It could be in drastic decline in the last decades, above all, due to mortality caused by entrapment in the 'spadare' pelagic nets. ACCOBAMS priority species. In the Italian seas it is present in the Ligurian sea, in the Tyrrhenian, in the Sardininan Sea and Channel and in the Ionian.

Cuvier's Beaked Whale, *Ziphius cavirostris* (G. Cuvier, 1823)

Cosmopolitan, present throughout the Mediterranean, above all, in correspondence to the continental escarpment and submarine trenches. Prevalently teutophagous. Particularly vulnerable to low-frequency sonar emissions utilised by the military marines. In the Italian seas it is present in the Ligurian sea, in the Tyrrhenian, in the Sardininan Sea and Channel and in the Ionian.

Long-finned pilot whale, *Globicephala melas* (Traill, 1809)

Widespread in temperate and cold waters of the north Atlantic and Austral hemisphere, common in the western portion of the Mediterranean, less frequent eastwards and does not occur beyond the Ionian Sea. It is pelagic, very gregarious, and prevalently teutophagous. In the Italian seas it is present in the Ligurian sea and in the Tyrrhenian.

Risso's Dolphin, *Grampus griseus* (G. Cuvier, 1812)

Cosmopolitan, occurring in temperate and tropical waters, generally found between Lat. 60° N and 60° S. Not infrequent in the Mediterranean from Gibraltar to the Aegean and perhaps even in the Levante Basin, teutophagous, above all, in waters above the steepest areas of the continental slope, even near the coast. In the Italian seas it is present everywhere, to the exception of the northern Adriatic.

Bottlenosed dolphin, *Tursiops truncatus* (Montagu, 1821)

Cosmopolitan, common along the continual shelf of all oceans in tropical and temperate waters, a pelagic form is also present. One of the most common cetaceans in the Mediterranean, where only the coastal form is known. It is often grouped into small population (about a hundred individuals), resident in inshore regions. It feeds on a large variety of marine organisms, with a particular preference for fish and demersal cephalopods. ACCOBAMS priority species. In the Italian seas it is present along the entire continental platform, including the Adriatic sea.

Striped dolphin, *Stenella coeruleoalba* (Meyen, 1833)

Cosmopolitan, widespread in tropical temperate-warm waters of all oceans; in the Mediterranean it is the most common cetacean in pelagic environments. Morphologically and genetically distinct from other conspecifics of the Atlantic; it feeds on a wide variety of species, with a great preference for fish, cephalopods and mesopelagic crustaceans. A census carried out in 1991 in a large area of the western Mediterranean area, from Gibraltar to the northern Tyrrhenian, estimated the presence of 118,000 specimens. In the Italian seas it is present in the Ligurian sea, in the Tyrrhenian, in the Sardininan Sea and Channel, in the Ionian and in the southern Adriatic sea.

Short -beaked common dolphin, *Delphinus delphis* L., 1758

Cosmopolitan (Figure 5.73), present in temperate-warm and tropical waters of the Atlantic, Pacific and perhaps even the Indian Ocean. Once common in the Mediterranean, today it only inhabits the Alboran Sea with a large population. A reduced and very localised presence in parts of the northern Tyrrhenian, Canal of Sicily, eastern Ionian and northern Aegean. It occurs in both neritic and pelagic habitats, with possible isolated populations. It feeds on a great variety of species, with a preference for small, gregarious, epipelagic fish such as anchovies and sardines. It was in rapid decline throughout most of the Mediterranean, probably in the early 1950s for unknown reasons. ACCOBAMS priority species. The Mediterranean population is listed as Endangered in the IUCN's Red List. In the Italian seas it is present with very reduced populations in the Sardinian sea, southern Tyrrhenian, and in the Sicilian channel.

Fig. 5.73 - Short-beaked common dolphin (*Delphinus delphis*).

The species that appear sporadically in Italian seas are:

Minke whale, *Balaenoptera acutorostrata* Lacépède, 1804

Cosmopolitan, present in the Atlantic and northern Pacific, most common in temperate-cold, sub-polar and polar waters. Individuals from Atlantic populations occasionally penetrate the Mediterranean (Ligurian sea, Tyrrhenian and Sicilian Channel).

Humpback whale, *Megaptera novaeangliae* (Borowski, 1781)

Cosmopolitan, a great oceanic migratory species, like the Minke whale, it occasionally carries out raids in the Mediterranean from the Atlantic. Specimens, generally juveniles, have been observed in Spain, France, Tunisia, Italy (Adriatic) and Greece.

Southern right whale, *Balaena glacialis* Müller, 1776

Cosmopolitan, present in the north Atlantic, north Pacific and Austral hemisphere with geographically separate populations. The north Atlantic population occurs along the coasts of the United States with about 300 specimens, while it has probably disappeared from the north-eastern side. The only two certain sightings in the Mediterranean refer to one in Algeria at the end of the 19th century and a beached specimen in Taranto in 1877.

Dwarf sperm whale, *Kogia sima* (Owen, 1866)

Cosmopolitan, found all along the continental shelf and slopes of all oceans, in the Mediterranean it has appeared twice, both times in Italian waters, a beached specimen in Tuscany in 1988 and one in Sicily in 2002.

Killer whale, *Orcinus orca* (L., 1768)

Cosmopolitan, though with a particular preference for cold waters. It sporadically appears in the Mediterranean, with greater frequency in the western sector (Morocco, Spain, France, Malta; in Italy in the Ligurian sea, Tyrrhenian and Ionian).

False killer whale, *Pseudorca crassidens* (Owen, 1846)

Cosmopolitan, extremely common in tropical and temperate-warm waters of three oceans. It rarely appears in

the Mediterranean, inhabits the warm waters of the Atlantic though also perhaps those the Red Sea, where it is not infrequent. In Italy it has shown up in Sicily.

Rough-toothed dolphin, *Steno bredanensis* (G. Cuvier, 1828)

Cosmopolitan in tropical and temperate-warm waters, preferably where the surface temperate is above 25°C, it rarely appears in the Mediterranean, inhabits the warm waters of the Atlantic also perhaps also those of the Red Sea, where it is not rare. Beachings and sightings of the Rough-toothed dolphin have been reported in France, Italy (Sicilian Channel) and Israel.

The Mediterranean monk seal

[Giulia Mo]

The Mediterranean monk seal, *Monachus monachus* (Hermann, 1799) was historically present along the coasts of all the Mediterranean countries. The human causes for its decline include direct killing by man, disturbance created by human activity and by deterioration of marine habitats. The species is currently present along the coasts of the Atlantic Sahara and the Desertas Islands. The largest colonies in the Mediterranean are found in Greece and Turkey (125-250 specimens). It is believed than small populations also survive along the African coasts of the Mediterranean, the western Adriatic and the Black Sea. The species is classified as critically endangered by the IUCN and is considered a protected species in most Mediterranean countries.

The Mediterranean monk seal utilises coastal terrestrial habitats to give birth, to nurse the pups, to rest and to moult. Differently from other Focids of colder seas, the female monk seal has a very long pregnancy, the interval between one birth and the next is almost 375 days, while the nursing period lasts a maximum of four months, during which time the pup is more vulnerable. In the last 50 years, the species seems to seek refuge along inaccessible cliff-bound coasts and in caves (often with underwater entrances). Their manner of utilising these coastal habitats is not completely understood due to the logistic difficulties of gaining access to these sea caves and to the potential disturbance that the study would create for the specimens present in the cave itself.

Even the use of the marine habitats is poorly known. Some studies have demonstrated that adult specimens move up to 30 km from the coast in one day, swimming at a maximum depth of 70 metres. Other data from Greece indicate that the adults are capable of moving up to 90 km over a period of a few days and more than 280km in the space of three months. This fact has implications for a country like Italy, whose coasts are easily reached by specimens from bordering sites such as Ionian Greece, Tunisia, Albania Montenegro and also Croatia, however, which do not provide updated information on the conservation status of the species. The last certain reproductive activity of this species goes back to 1986. At present, about 1-2 sightings along the south-eastern coast of the peninsular, south-eastern Sicily and Sardinia are reported annually which indicate the sporadic presence of monk seal specimens. Considering the sightings reported in Italy in recent years, one cannot exclude that these specimens remain along the Italian coasts for periods greater than a few weeks.

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