



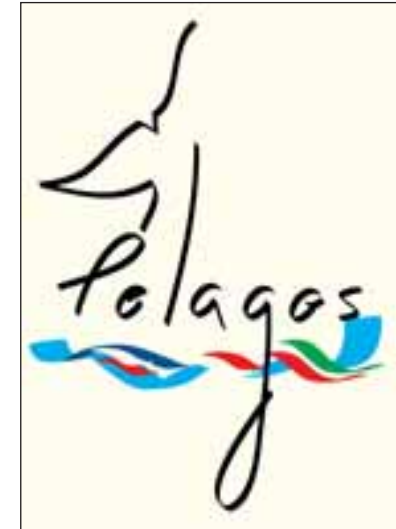
## Conservation and management

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103

In line with the declared main aims of conservation and the sustainable use of biodiversity, according to the Convention on Biodiversity, the establishment of a Marine Sanctuary extending beyond national boundaries promotes the conservation of the main components of our human and natural heritage.

These aims require an ecosystem approach with, in particular, integrated, active and flexible management, together with the involvement of public and private partners and associations. It is also necessary to consider the needs of the three countries directly involved - Principality of Monaco, Italy and France - and to balance and



Logo of the Sanctuary for Marine Mammals

coordinate operations in the national and international waters of each country. Obviously, there are difficulties and limitations in managing the Sanctuary, due to the differing marine jurisdictions of the three countries which signed the Agreement on the Pelagos Sanctuary and, above all, to the extreme mobility of the animals to be protected and the space-time variations occurring in their habitats. These problems fall into three general categories: administrative, juridical and ecological.

Administrative problems may arise from choices made by the contracting parties to establish a very small international structure and to refer mainly to national Pilot Committees. There are several administrations and their competences sometimes overlap, which means that decisions are not easy or do not allow competences for specific tasks to be identified in good time.

Juridical problems exist because national juridical authority applies to inland and territorial waters, whereas, when there is no exclusive economic zone,

international and maritime law in particular applies to offshore waters. Ecological difficulties are those due to the movements of species and to variations in the water mass and its productivity which, obviously, affect the distribution of those species. Another problem is our still scanty knowledge of the biological and ecological characteristics of marine mammals, which adds to difficulties in choosing the best measures for management and conservation. For all these reasons, it is difficult to create zoning with areas of different levels of protection, which is easier in protected coastal and land areas. The main purpose of the Sanctuary, according to Art. 4 of the Agreement, is to define the best state of conservation for marine mammals, in order to protect them and their habitats from the direct or indirect negative effects of human activities.

Other articles contain clearer indications such as the monitoring of animal populations, their mortality rates and threats to their habitat (Art. 5); controlling and combating pollution (with reference to the Barcellona Convention) (Art. 6); prohibition against capturing them (unless otherwise authorised); fishing regulations (Art. 7); regulation of tourist activities (Art. 8); regulation and/or prohibition of offshore high-speed motorboat races (Art. 9); promotion and coordination of scientific research for improved knowledge of cetaceans and their habitats, and activities for enhancing greater awareness in those who work with the sea and the public.



Greater amberjack (*Seriola dumeril*)

Among human activities affecting marine mammals, pollution and fishing are certainly the first and foremost, but we cannot ignore others such as shipping movements and also whale-watching, which are expanding rapidly.

This chapter focuses in particular on whales, but it should be stressed that other organisms such as turtles and fish also require protective measures. The numbers of pelagic elasmobranchs have fallen drastically in recent years, mainly because of fishing (see chapter on deep-sea fishing), although they are not normally target species. To safeguard the integrity of the offshore ecosystem, vigilance is essential, to reduce or ban fishing of offshore cephalopods and mesopelagic organisms (euphausiaceids in particular), since these animals are crucial components of food webs.

Prevention of fishing and control of pollution both by ships and land sources, rational and sustainable management of fishing, and regulation and control of shipping traffic are three of man's activities which assume priority in the Sanctuary's aims of conservation and protection.

#### ■ Professional pelagic fishing

Professional fishing for large pelagic fish in the Ligurian Sea and within the Sanctuary has as its main targets tuna and swordfish. This activity is extremely



A catch of swordfish

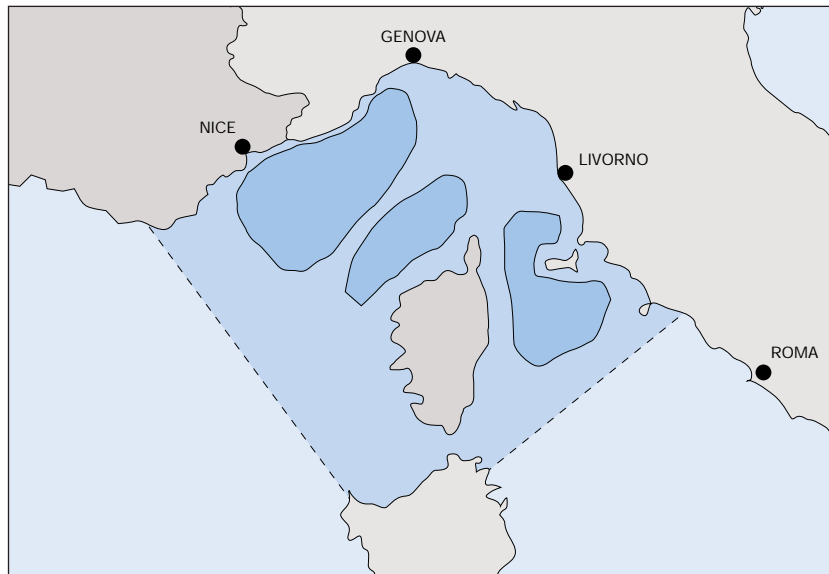
remunerative for fishermen who, in three or four months of work, are often able to earn enough to balance their low winter income. Fishing for swordfish and tuna are based on different gears which originated and developed in very different ways.

**Swordfish fishing.** The Italian fishing fleets operating within the Sanctuary use surface longlines as their main gear. Fishing with this type of equipment goes back to the 1960s.

Over the years, many changes have taken place, mainly thanks to technological developments as regards fishing gear and equipment and also on-board safety. However, this kind of fishing never took on that “industrial” character which is typical of southern Italian fleets, and thus fishing has remained more or less constant for decades.

The fishing season goes from May to October and, if weather and sea conditions are favourable, may extend to November and December. The start of the season changes according to port: in the ports of Tuscany and on the island of Elba, fishing begins in June and peaks from July to September. Towards the western Ligurian, fishing peaks from August to October.

Some fishing-boats belonging to the maritime compartments of Sicily and Calabria, which use surface longlines, occasionally travel to Sanctuary waters,



Main fishing areas for swordfish in the Sanctuary

mainly off western Corsica, where Ligurian and Tuscan boats also operate. Overall, there are 55-60 fishing-boats practising this type of fishing, with great variations not only from one year to the next but also within one fishing season, according to the area fished. The vessels in question are medium-sized, rarely exceeding 16 m in length and 10 tons displacement.

Another piece of equipment which was used in the past for swordfish by a small number of local fishermen was the driftnet, or *spadara* (the Italian for swordfish is *pesce spada*). Following the European ban on such nets and the plan for conversion promoted by the Italian Ministry for Agricultural and Forestry Policies, some fishing-boats were equipped with surface longlines, others received licences for a type of net called *ferrettara*, and yet others were demolished. At the present time, therefore, within the Sanctuary there are no *spadare*, understood as the type of driftnet mainly used until the end of the 1980s.

As well as the target species, swordfish fishing, with either longlines or nets, involves the capture of by-catch species which appear, as marketable catches, in quantities varying in relation to the type of gear used.

Overall, in longline fishing, by-catches form less than about 10% (by weight) of the total swordfish catch. For more detailed information about these species, see chapter 4 on macrofauna.



Swordfish (*Xiphias gladius*)

**Tuna fishing.** Tuna fishing has been carried out in the Sanctuary since ancient times, when many well documented tuna-traps were active. At present, several types of gear are used to catch tuna. Besides the by-catches obtained with swordfish longlines, in some seasons Ligurian fishermen use a specific surface longline with small hooks, with sardine as bait. Instead, French fishermen use a driftnet called *thonaille*, bluefin tuna being their main target species. However, most catches are made with purse seines, large circular nets which gradually close as large schools of tuna are surrounded.

The fishing area is very large and covers nearly all the Sanctuary waters, particularly in the north-western portion. The number of local fishing-boats using purse seines has fallen drastically in the last few years - from eight vessels in 1990 to three in 1995, and only one in 1999. In the last decade, therefore, tuna catches in the Sanctuary with purse seines have mainly been made by French vessels, and a few from southern Italy.

As far as we know, no cetaceans have been caught by *tonnare* anywhere in the north-western Mediterranean. To avoid or at least reduce the number of cetaceans caught with *spadare* or similar types of nets, acoustic devices to dissuade animals from approaching, and other types of signalling devices have been used to keep the nets at a certain distance from the surface, so that dolphins can leap over the obstacle. Results, however, have been conflicting.



Main fishing areas for bluefin tuna in the Sanctuary

**Pelagic fishing in the Sanctuary.** The events which led to the introduction of swordfish fishing with longlines in the Sanctuary differ according to source, but initial attempts were made during the 1950s and 1960s by a few fishermen in the western Ligurian Sea.

The boats were small and the first catches were made along the coast. Surface longlines were very different from those used now: the nets were still made of hemp which, being a natural fibre, had to be dried in the sun after use, and very few, much larger hooks were used, with squid as bait.

Considering the value of the catches and the possibility of landing large quantities of fish, this type of fishing gradually developed considerably, and the fishing season was extended for much of the year, some boats moving south in spring and then returning to the Ligurian Sea in summer.

The present surface longline is very different from that used 40 years ago. For a long time now, nylon fibre has replaced old natural fibres, and the size of hooks has been greatly reduced, although it is still considerable - they are usually 8 cm long - due to the reduction in average prey size. Frozen mackerel imported from Northern Europe is now used as bait.

The mainline is made of nylon ( $\varnothing$  1.4mm), 20 to 40 km long, with branchlines ( $\varnothing$  1.3mm) every 40 metres. One branchline in two has a small float, and every 30-50 floats, there is a buoy with a flagpole carrying a light and radar



A fishing-boat dropping a purse seine



*Caretta caretta*

equipment for location purposes. Other changes are made according to the personal experience of fishermen, but the system is the same. Only in recent times have fishermen been inclined to take a float off in order to allow the longline to go deeper, and also put a luminous bait near the deepest hook. Starting from the mid-1990s, hydraulic hauls were introduced on boats, and now all of them use such systems. Although working conditions have improved and fishing is less arduous than in the past, the fishing effort of every boat - calculated as the number of hooks used - has not risen.

The boats leave port in the afternoon, reach a distance of 7-20 miles off the coast, and drop their gear. After 2-3 hours, with the coming of darkness, the surface longline has been let out completely. After a wait of about two hours, the fishermen start hauling, an operation which lasts 5-6 hours, until dawn or even later. Landing takes place in the morning, from about 9 a.m. to noon, but autumn days are shorter and landing is anticipated to dawn. The number of hooks used in each operation is generally about 500 or 800, but may change greatly according to season and sea conditions.

Around the mid-1980s, following transformation plans promoted by Italian Ministries, many Italian fishermen turned to swordfish fishing with vessels equipped with driftnets, called *spadare*. This type of net, unlike the traditional longline, had many advantages, not least the greatly reduced purchase price



Bluefin tuna

of bait and, generally, greater ease of handling. In addition, as catches were abundant, this type of fishing became so successful that in a few years, all over Italy, more than 700 vessels were equipped with *spadare* nets. Made of multifibre nylon, the nets varied in length from a few dozen metres to more than 15 km (according to the size of the fishing-boat and the number of crew), and was sometimes 30 metres tall, with a very large mesh size, 35-45 centimetres.

In 1990, there were 17 fishing-boats equipped with *spadare* nets registered in the Ligurian maritime compartments (4 at Bordighera, 7 at Imperia, 1 at Andora, 3 at Chiavari, 1 at Lavagna, 1 at Monterosso). However, to this figure must be added the many vessels from southern Italian maritime compartments which, in August and September, sailed north to the Ligurian Sea to prolong their fishing season, which began in spring. In 1988 and 1989, this disproportionate number of boats, with consequent excessive catches of cetaceans and other protected or valuable species, gave rise to a series of public protests and initiatives for protection, which ultimately led to the creation of the Sanctuary.

The *thonaille* is a driftnet, used by French fishermen in the Sanctuary and on its most westerly borders, with a mesh size of 22-24 cm. In the Mediterranean, about 60 French fishing-vessels, all between 9 and 15 m long, use this type of



A pelagic ray of the mliobathyds family

net, mostly sailing from ports in the Gulf of Lions. As they carry out daily fishing sorties, they have a limited range of action, and many of them work in Sanctuary waters.

The influence of the *thonaille* on fish and above all cetaceans populations has been studied directly by researchers on board the fishing-boats themselves. Research, which is still in progress, reports a certain number of accidental catches of striped dolphin (*Stenella coeruleoalba*), mainly juveniles. Tests are in progress on trying to avoid this problem by using acoustic devices to dissuade cetaceans from approaching the nets, but with conflicting results until now.

For centuries, tuna-traps were built along the coasts of Tuscany, Liguria, Corsica, northern Sardinia and, above all, along the French coast towards Toulon and Marseilles, on the western boundary of the present-day Sanctuary. However, during the last century, the generalised, steady fall in catches has meant that fixed tuna-traps gradually became less profitable, and all of them, with two exceptions, were abandoned. The Saline trap at Stintino in north-west Sardinia, after a period of inactivity, has occasionally been used in recent times. The second trap is at Camogli, and is now the only active one, although at present bluefin tuna is not its main target species.

In the Sanctuary, purse seine tuna fishing started around the mid-1970s, when new and larger boats, usually fishing for anchovy, began to move from southern Italy at the end of the season, in order to exploit the possibility of fishing in the Ligurian Sea from August until October, like the French boats. Some local fishermen began equipping their anchovy boats with purse seines for tuna as well, although there were not many of them.

Ligurian fishing-vessels operating with purse seines are 20-30 m long, have a gross tonnage of between 40 and 90 tons, and engine power of about 600 hp. They are all equipped with purse seines 1000-1300 m long and 100-200 m high. The purse seines on fishing-boats from southern Italy are similar but larger, sometimes reaching 1500 m, with heights of 300 m. The number of boats which come every year from the south to exploit fishing areas in the



Purse seine fishing-boats in harbour



A school of dolphins put on a spectacular display

Sanctuary varies from 15 to 25, according to fishing trends. They are generally large vessels (more than 25 m long).

At present, tuna fishing with purse seines has undergone considerable technological development: the new vessels are faster, and are fitted with more powerful engines, security systems for offshore navigation, and improved onboard comfort, as fishing far from home may sometimes last several months.

Catches are stored in large holds with seawater at low temperature, for proper conservation.



Landing the catch from a purse seine

### ■ Shipping and whales

Many studies have been carried out worldwide to evaluate the influence of vessels on whales - with differing results depending on species of animal and type of craft examined, without considering the effects of collisions. The immediate and short-term reactions of animals to the passage of boats have been studied, e.g., changes in respiration, time spent on the surface and underwater, and swimming speed and direction.

"Shipping" means both cargo ships and passenger vessels, generally very large (more than 100 m), travelling at speeds between 14 and 40 knots, following well-defined routes without diversions from them; and pleasure craft, of smaller tonnage, engine power and speed, which do not follow definite routes and always change speed.

With regard to whales, we must distinguish among sizes, habitat and ethology. For better understanding of their long-term behaviour, they are identified photographically.

**Short-term reactions.** Cetacean species living along coastal areas, where vessels are frequent and animals are more accustomed to human activities than pelagic species, have been much more fully studied.

There are three kinds of short-term reactions: positive, negative, and neutral:



Jellyfish *Rhizostoma pulmo*

1. Positive reaction: the animal is attracted by the sound of the boat, and may find pleasure in playing in the areas of different water pressure caused by its passage.
2. Neutral reaction, or no disturbance, which is more frequent: the animal continues what it is doing without paying attention to boats, unless they cross its path.
3. Negative reaction: the animal moves away quickly, diving deep and trying to be as inconspicuous as possible; it is silent, does not jump out of the water, and prolongs immersion times, if necessary going even deeper.



Sperm whale (*Physeter macrocephalus*) in the first step of immersion: the position of the tail is characteristic of the species

The type of reaction depends on species, size, age and, consequently, the animal's experience and social habits, and also season.

- Cetaceans living in a group react more slowly than a single one, because the latter's reaction does not depend on the group and a single animal is generally on the alert.
- Young animals are more vulnerable, because they have less experience and swim more slowly.
- Females with young become frightened more easily.
- Animals occupied in eating or socialising are certainly less aware.
- Animals in the mating season, at the moment of giving birth, suckling their young or simply searching for food, are attending to these things and are consequently more vulnerable.

Contact with vessels depends on their tonnage, type of propulsion, route and speed, distance from animals, and number. Cetaceans seem to react calmly when a large vessel, following a constant route, passes, but are more wary of small pleasure boats, which are always changing direction.

**Long-term reactions.** These are divided into direct and indirect reactions.

Direct consequences are:

- Changes in behaviour;
- Leaving the area permanently or temporarily;
- Changes in physiology (reproduction rate, disturbances in growth, size at maturity);

- Distressed animals spend less time on essential activities such as searching for food, resting or suckling, with consequent deterioration in their health.

Indirect consequences are:

- Disorders in the food chain;
- Reduction and/or destruction of habitats.

Long-term consequences include habits and tolerance, since the animals may slowly become accustomed to the presence of boats and humans.

In the Mediterranean, there are few studies on the subject and the conclusions are not always the same: for instance, two different researches on fin whale, carried out around the island of Ischia and the Ligurian Sea, led to differing results. In the Ligurian Sea, whales seemed to be disturbed by the passage of vessels, whereas around Ischia they appeared to be indifferent.

Again, studies on striped dolphins around Gibraltar explain how these cetaceans became used to shipping. The same type of adaptation has been observed in dolphins in the Lagoon of Venice.

Many studies on the space-time distribution of cetaceans have highlighted numerous seasonal and annual changes: are they to be attributed to natural causes or to disturbance caused by humans? For instance, animals may be confined in less favourable areas, thus modifying their normal life-cycle, or



Cuvier's beaked whale (*Ziphius cavirostris*)

their habitat may be damaged or even destroyed. Vessels travelling fast leave wakes formed of millions of air-bubbles, which penetrate deeply into the water; and water is also used to cool ships' turbine engines, which means that it is heated, and warmer than the natural temperature of the sea when it is discharged.

Wakes last for many hours, so that, for example, a ship may sail the France-Corsica route and return in its own previous wake! What effect does this have on plankton and, in particular, on phytoplankton, an essential element in the food chain?

Researches in the Mediterranean have shown how animals try to react to disturbances caused by maritime traffic by changing their habits: a difference in the number of cetaceans during daytime hours has been observed, according to the frequency of passing vessels and seasonal changes. For instance, in summer, when there are many more vessels, animals move away from the coast. Thus, coastal areas, which are choked with traffic, are progressively abandoned.

**Collisions with cetaceans.** In areas with intense maritime traffic and high numbers of cetaceans, there is a considerable risk of collision, especially if the animals are large. Data on this kind of accident are generally collected in two



Group of pilot whales

## Proper behaviour for whale watching

Behaviour while whale-watching.

Rules to be followed when approaching any marine mammal:

- Reduce speed; the boat should not be moving faster than the animal itself.
- Reduce noise; some machinery must be turned off, but not the engine, so that the animal can locate the boat.
- Choose the right angle of approach: approach must be slow, and at an oblique angle to the direction in which the animal is moving.
- Respect the previously established route: routes should not be haphazard, but should follow a clearly-defined direction.

Rules regarding distances.

- Do not approach closer than 30 m to the animal, at least 50 m is better.
  - A boat is in the "sighting zone" when it is 300 m from the animal.
- Rules on number of boats allowed in the "sighting zone".
- Only one boat may stay in this zone for a short time (15-30 minutes), then it must move off, to allow other boats to approach.

Rules regarding the biology of the species approached:

- Do not approach a group in which very young animals are present;
- Do not chase, surround or separate animals from each other;
- Special care is required when animals are eating or socialising;
- Let the animals decide whether they want to approach the boat or move away from it;
- For the animals' health and safety, do not give them food, touch them, or swim with them.

The ship's crew should include an expert and qualified guide, in order to promote knowledge, to provide information on the conservation of these animals, and to ensure that the above rules are rigorously followed.

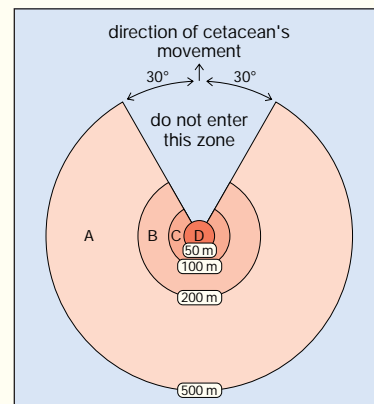
**To summarise:**

Zone A: reduce speed, avoid sudden changes of speed and/or direction.

Zone B: remain behind or to one side of the animals; never approach to within an angle of less than 30°. No more than three boats should be in this zone at any time.

Zone C: only one vessel at a time should approach, rigorously respecting the above guidelines.

Zone D: first, avoid moving too close to the animals. If necessary, put the engine in neutral gear and wait for the animals to move away. An exception may be made for dolphins, which sometimes like to play in the bow wave of a moving vessel.



ways: the animal dies and is found stranded on a beach, or a photographic identikit is composed, when the animal is only injured. Sometimes a dead whale arrives in port on the bow of a ship.

Data on stranding of whales are numerous, although it is not always easy to establish the cause of death, especially if the carcass has been in the sea for some time.

However, it should also be borne in mind that records always underestimate numbers - firstly, because not all dead animals are found, and secondly, because ships' crews, particularly if their vessels are large, often do not even notice that they have hit a large

animal. An illustration of this is the fact that, on five separate occasions between 1991 and March 2005, ships reaching the port of Genova only discovered that they had a dead whale attached to the hull during docking manoeuvres.

Photographic identikits can record injuries caused by boats and propellers to living animals.

All cetacean species may be involved in collisions, although some are more frequently involved than others. Smaller species are rarely injured, unless shipping is intense or the animals are inshore, but large animals quite often suffer too. In fact, for fin whales, collisions seem to be the first cause of death.

It is clear that the increasing numbers of vessels, especially fast motor-boats, in areas with high numbers of cetaceans like the Ligurian Sea, greatly increase the risk of impact, with probable injuries for passengers as well. Nor must we underestimate the effects of small boats sailing along the coast. There are accidents and injuries to whales even with motorised sailing-ships and, in particular, water-scooters which, being very fast and easy to steer, can injure species frequenting shallower waters.

In one study on beached animals in the Mediterranean, six out of 13 species showed evident signs of collision. 28% of the stranded specimens were minke whales (although there are only a few of them in the Mediterranean), 18.8% fin



Ctenophore

whales, 4.3% sperm whales, 1.1% pilot whales, 0.5% bottlenose dolphins, and 0.6% striped dolphins.

It is difficult to estimate the real ecologic damage due to collisions, because two issues must be taken into account:

- **individual:** we cannot know the long-term effects of impact, nor - in particular - its effects on the life-span of a more or less seriously injured animal;
- **population:** as preservation depends on the number, sex and age of injured animals, clearly, the more a population is reduced and limited in space, the greater the damage caused by collisions.

### ■ Whale- and dolphin-watching in the Sanctuary

The hobby of whale-watching is relatively recent, and aims at sighting these animals in their natural environment, approaching and watching them, while following a code of conduct aimed at causing minimal disturbance.

In the Mediterranean, watching marine mammals is a tourist business, and involves species whose biology and ecology are still not well-known. For this reason, whale- and dolphin-watching must be developed with caution: too much interest on the part of sailors in all kinds of boats, all trying to carry their



Watching on pilot whales

customers as close as possible to the animals, may disturb them too much. The consequences of whale-watching on the whales themselves are not yet known, and it is often a less important problem when compared with other human activities (shipping, increasing noise pollution, oil spills and pollution in general, fishing, etc.).

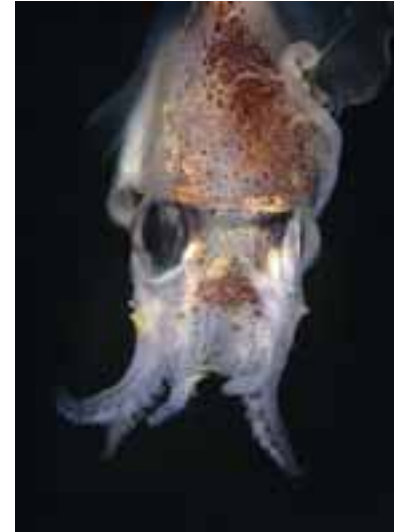
Whale-watching involves a large number of people, both customers and workers. They are divided into three groups, according to their aims:

- tourist operators: profit is the main goal;
- research-workers or non-profit organisations: their existence depends on the presence and contribution of volunteers, necessary in order to afford the cost of boats and research; educational and scientific aspects should be promoted;
- occasional whale-watchers.

At present, in the Mediterranean, although whale-watching is not regulated, a code of conduct has been created, listing the principal rules to be followed. Guidelines, now in force in many countries, to lessen the impact on whales by people who want to watch them (see box, page 120) should serve as an example, although there are no official regulations yet. This means that, in order to become a sustainable activity in the near future, whale-watching must be conducted with minimal disturbance to the animals due to the presence of boats and the damage they may cause, so that the advantages and benefits of whale-watching overcome its disadvantages. Obviously, during whale-watching trips, many other marine organisms, such as jellyfish, fish, sharks, turtles and birds, may all be observed.

### ■ Legislative references

The main reason for the creation of protected marine areas is the conservation of biodiversity, particularly at species and habitat level. It is therefore indispensable and a top priority to have available lists of Mediterranean species and habitats that require safeguarding because of their natural,



The small cephalopod *Heteroteuthis dispar*

ecological, cultural, aesthetic or economic value or because they are rare, vulnerable and at risk of extinction. Unfortunately, the most important European regulation, the Habitats Directive on the conservation of natural and semi-natural habitats, as well as the wild flora and fauna (92/43 EEC, implemented in Italian legislation with DPR no. 357 of 8/9/97) the sea is practically non-existent, and so references to species and habitats are either rare or entirely absent.

The subject becomes even more problematic passing to the pelagic domain: the ways to extend the Directive to offshore environments are still under discussion. For the moment, all marine mammals and reptiles in the pelagic domain are protected species, in addition to the birds, which are covered by a specific Directive (79/409/EEC) on the conservation of wild birds, implemented in Italy with law no. 157 of 11/02/92. Practically all birds are protected by this Directive, which has more than once been modified.

The Barcelona Convention of 1995 is of major interest for the Mediterranean, and aimed at protection of the marine and littoral environments of *Mare Nostrum*. As well as various protocols regarding pollution, one deals with the protection of marine biodiversity: the protocol on the specially protected areas and biodiversity in the Mediterranean (SPA/BIO), was implemented by Italian legislation with law no. 175 of 25/05/99. This protocol, although not having the



A basking shark (*Cetorhinus maximus*) swimming on the surface

sanctioning powers of the Habitats Directive, in any case fills the gaps in the latter as regards both marine habitats and species.

It is enough to consider that there are 61 marine habitats worthy of close protection in the Barcelona Convention, whereas there are only 9 in the Directive 92/43; it is the same for marine plants and non-homioiothermic animals.

Under the Barcelona Convention it is possible to set up a specially protected area of Mediterranean interest (ASPIM or SPAMI), which must be approved by all the Mediterranean countries signatories to the the Barcelona Convention. The Sanctuary for Mediterranean Marine Mammals has gained the important ASPIM recognition, which means that all Mediterranean countries agree on the protection of the Sanctuary and not just the three signatories of the agreement. Maintenance of ASPIM etiquette also obliges the Sanctuary to provide itself with an efficient and dynamic management plan.

Among the numerous international agreements and conventions on the conservation of nature, including that of the sea, one is specific to cetaceans: the Agreement (within the ambit of the 1979 Bonn Convention) on the Conservation of Cetaceans in the Black Sea, Mediterranean and Adjacent Atlantic Area (ACCOBAMS), signed in Monaco on 24/11/1996 and only implemented by Italy in 2005 with law no. 27 of 10/02/05.



A sperm whale blowing



## Suggestions for teaching

GIULIO RELINI

127

### ■ Life in the pelagic environment

- Aims: to learn the concepts of adaptation and evolution of organisms living in the pelagic environment: respiration, swimming, movement, floating.
- Level: intermediate students (11–13 years old) and/or first two years of upper school (14–16 years old), according to students' general level of knowledge.



Beached velellas

- Equipment: reference books and photographs, textbooks on planktonic and nektonic organisms, nets for plankton, containers for collecting samples of sea water and organisms. Liquid fixatives (alcohol, formalin). Binocular stereomicroscope, pH-meter or litmus paper, binoculars, cameras and, if possible, video-cameras.
- Collaborators: members of an organisation authorised to use a boat to take tourists to watch whales. However, as it is difficult to observe these animals in the open sea (on some days, there are no good sightings, even in excellent meteo-marine conditions), guided visits should be arranged to a large aquarium and a Museum of Natural History. Such visits are to be viewed as preliminary to the sea trip.
- Schedule: study may be arranged in the following steps, although not necessarily in the suggested order - except for the sea outing which, to be effective, should come last, before conclusions are drawn. Preparation in class, visits to a beach, a museum and an aquarium, sea trip, and conclusions (discussion) in class.

### IN CLASS

#### *Preparation*

Preparatory work in the classroom is very important for the success of all activities and particularly of excursions.

Many aquariums contain sharks

In the classroom, students can gain basic information about pelagic life, the differences between benthic and pelagic life, various adaptations, trophic structure, and the roles played by food, light and photosynthesis.

Explain to pupils why the sea is salty and what its principal components are (e.g., evaporation of one litre of sea water). Help them prepare a list of the most important living organisms, and make up cards or tables for identifying the animals during excursions.

Make a distinction between fish and cetaceans, which are mammals (see page on sea trip).

Arrange to have available guides, manuals with coloured drawings and photographs, and indications of the basic characteristics required to identify a species.

Materials and tools to be used during excursions should be prepared in advance.

#### *Final activities*

Draw up conclusions and summaries immediately after each activity (visits to museums and aquariums) and leave final conclusions until after the sea trip.

After the sea excursion, tasks may be divided up over several days. The first task, if possible the day after the excursion, should be used to examine water samples under a binocular microscope, to search for living organisms - if this



Stranded krill

could not be done on board, during the excursion, or immediately after disembarking.

On the same day, prepare water samples for evaporation, gather all notes and observations written on board, and have photos developed and printed.

In the following days, examine the evaporated water samples and collect pictures and photos, complete with captions, in an album.

To complete class activity, students can prepare reports and/or posters, showing the conclusions reached during the sea excursion and what they learned about the pelagic domain. If they have a film, it can be edited with comments and music.

#### **EXCURSION TO A BEACH**

Most beached organisms belong to the pelagic domain, and one way of getting to know and collect them is to go to a sandy beach – a pebbly beach is less suitable, because the organisms are damaged as the pebbles are tumbled about by the waves.

Obviously, on a beach, it is easier to find algae, remains of sea-grasses (*Posidonia*), and benthic animals, in addition to man-made or terrestrial objects such as reeds, branches and leaves, but there are also pelagic animals, some of which settle on floating objects.

Schedule this excursion according to sea conditions and, if possible, after a



A stranded velevella (*Velella velella*)



Stranded velevellas

storm, or when beached organisms (jellyfish, velellas, small crustaceans, euphausiids, myctophid fish) can be found.

In order to collect organisms, visit the beach before dawn, because at first light seagulls examine the shore and eat anything edible at once. This very early inspection may be carried out by teachers or school collaborators, including students' parents, in order to collect material.

*Necessary materials:* plastic bags of various sizes, rubber bands, cans, tweezers and scoops, bowls, cameras and/or video-cameras.

Preservative liquids, e.g., formalin or alcohol, are for teachers' use only.

#### ORGANISATION OF OBSERVATIONS

Warn students not to tread on beached organisms. First walk a certain distance, according to the length of the beach and the quantity of beached organisms.

Collect the organisms and put some of them in cans or bowls filled with sea water in order to observe them better. Point out pelagic animals and explain how they differ from benthic ones and their different adaptation to the environment.

In the case of massive beachings after a storm, try to make a quantitative estimate (number of individuals per m<sup>2</sup> or fraction). Examine all beached objects (reeds, plastic, pieces of wood) to see if any organisms have settled on



Group of pilot whales

them - particularly, goose and/or acorn barnacles. Estimate the quantity of man-made objects (presumed weight, number per m<sup>2</sup>). Explain how these objects, by causing obvious pollution and alterations to the environment, are the means of transport of many organisms, which may travel great distances on currents.

#### VISIT TO A MUSEUM

Visiting a Museum of Natural History is an opportunity to know the main classes of pelagic organisms, although most of the specimens will have lost their natural colours (e.g., jellyfish, salps, etc.).

Draw students' attention to adaptations of pelagic and benthic type. Compare fish and cetaceans (shape, skeleton, fins, breathing apertures). Point out the characteristics which differentiate selachians, bony fish, and cetaceans (see pag 132). Use material prepared in class to identify the main organisms.

Before the visit, ask for any information (brochures, leaflets, etc.) available from the Museum, in order to prepare for the visit as well as possible.

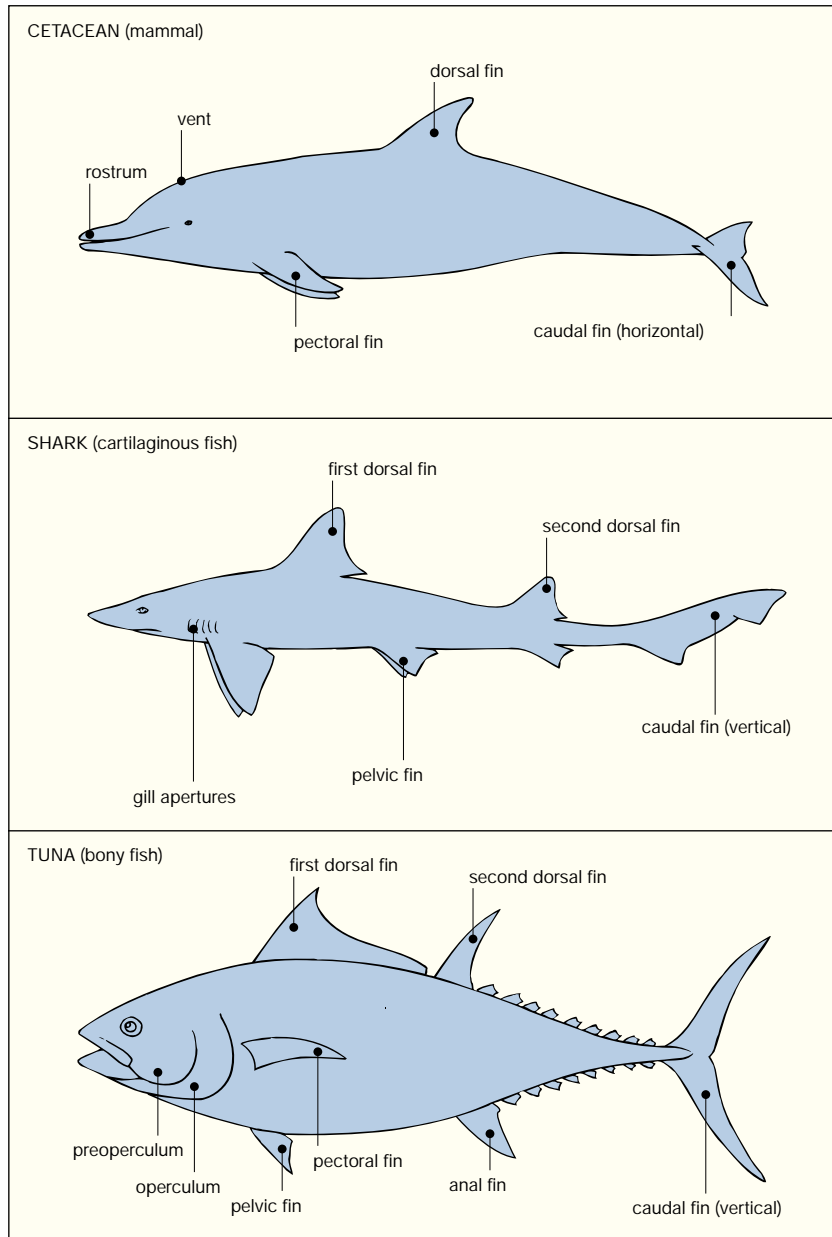
#### VISIT TO AN AQUARIUM

For this visit too, prepare in advance by studying illustrative material and, in particular, any teaching material, with special attention to pelagic life.

Study of morphology, structure, etc., made first in the museum, can be



Many large pelagic species are on display in the Aquarium at Genoa



Some external morphological characters of cetaceans and fish, used to distinguish the two animal groups

complemented in the aquarium, with discussions on the movement, method of breathing and sometimes even the feeding habits of pelagic animals.

In some aquariums, jellyfish and occasionally even their life-cycle can be watched through special glass panels. Ask the aquarium staff if students may be taken on a conducted tour of the laboratories and, if possible, to the area where the food chain is reconstructed by growing microalgae, *Artemia* larvae, rotifers, etc..



The crustacean *Acanthephyra*

#### BOAT TRIP

This is the most interesting and exciting part, but it must be prepared properly, so that the best results can be achieved even on a day with very few sightings. It is advisable to contact an organisation licensed to take tourists whale-watching, particularly in the Ligurian Sea, because trained staff know the areas where frequent sightings can be expected, and they work with nature guides who can give basic information on cetaceans (on the Internet, the entry "whale watching" will provide much useful information on choosing the right kind of boat). Decide on several stops, in order to collect samples of water, plankton and floating objects.

#### Equipment

Appropriate clothing (for sun or rain), food and drinks (according to the length of the excursion), binoculars, cameras and/or video-cameras, containers for samples of water and plankton, nets for plankton (very easily made using an old pair of pantyhose, or part of a mosquito net for larger organisms), and a landing net with a long handle for recovering floating objects. A bottle of alcohol or formalin in which to fix organisms (for teachers' use only!). As alcohol 70% is used as it is (without dilution) to fix organisms, a certain quantity is necessary. Formalin is used diluted to 5% in sea water, i.e., 5 cc of formalin in 95 cc of sea water. Formalin can be neutralised by filtering it through a layer of calcium carbonate or simply by putting pieces of marble or eggshell in the bottle. Material (reference books, or manuals) to identify organisms, and illustrations of the most frequently found organisms, like the material prepared in class, can be very useful.



The stalk barnacle *Conchoderma virgatum*

be stopped in areas of greater density. Catch some of the organisms using a long-handled landing net and put them in a bowl of sea water, or better still in a large glass container: observe them against a dark background (even a jacket or a backpack will do). Use prepared illustrative materials.

The presence of macroplankton depends on the season and is unpredictable. Sometimes it lasts for several days: get advance information before organising the excursion.

Also observable will be verellas (locally called in Italian "St. Peter's boats" or "St. John's boats") and, more rarely, the dangerous jellyfish *Physalia physalis* ("Portuguese man-of-war").

Sightings of floating objects, turtles, fish and cetaceans, must be described more accurately.

#### Floating objects

Natural or man-made floating objects (pieces of wood, cork, pumice, lumps of tar, the ubiquitous plastic, as both bags and containers) are the substrate of settlement or the means of transport for very many organisms, some belonging to the benthic domain. Examples are: barnacles, serpulids, hydroids and ascidians, among sessile fauna; and amphipods, isopods and annelids, among vagile fauna. Easily found pelagic organisms are goose barnacles and, in particular, *Lepas pectinata*, which sometimes settles in

#### Sightings

On board, pupils must be seated so that they will have a good view while still respecting safety regulations.

Teachers and escorts should agree with the crew and, in particular, with the nature guides, on how to manage and comment on sightings and arrange samplings.

Birds: the easiest to spot - apart from seagulls, which can already be seen in the harbour and its surroundings - are shearwaters (use illustrative materials prepared for their identification).

Macroplankton: large jellyfish, salp chains, siphonophores and ctenophores, if present in transparent waters, are very impressive. Ask for the boat to

large numbers on any type of floating substrate. The crab *Planes* is carried passively by turtles or floating objects. Be careful when picking up any objects on which a crab might be, to avoid letting the animal fall; make sure it is safely inside the net.

In the case of large objects, such as wooden or plastic boxes, tree-trunks or branches, barrels, sheets of plastic, etc. - particularly if the plastic is black - approach cautiously, to see the fish which gather underneath them to profit by the shade (some types of fishing exploit this behaviour on the part of fish). Fish behaving in this way are pilotfish (*Naucrates ductor*), juveniles of grouper (*Polyprion americanus*) and greater amberjack (*Seriola dumeril*), dolphin fish (*Coryphaena hippurus*) and two less well-known but very interesting species, *Schedophilus ovalis* and *S. medusophagus* - the latter is a large jelly plankton eater, and eats jellyfish in particular.

Use illustrative material, identify species, and estimate their numbers and size.

#### Census of floating objects

Students can count the floating objects in a certain area of the sea, and separate them into their various types. Counting can be made from both sides of the boat to a distance of 5, 10 or more metres, depending on sea conditions.



Pilot fish (*Naucrates ductor*)



The stalk barnacle *Lepas pectinata*, one of the commonest organisms which settle on floating objects

### Turtles

It is easy to identify turtles, but less easy to do so at species level. The most frequent is *Caretta caretta*, which can sometimes be found resting on the surface. This behaviour is sometimes understood wrongly – for instance, it is believed that the animal is in difficulties. The worst thing to do is to bring it ashore to “save” it. Instead, if it really is injured, or entangled in nets or plastic, or if its mouth is blocked by nylon or plastic, it must be taken to the nearest specialised turtle rescue centre (Aquarium of Naples, Aquarium of Genova).



Some barnacles of the genus *Chelonibia* living on the turtle *Caretta caretta*

### Fins on the horizon

If we see a fin sticking out of the surface of the water, we immediately want to know who it belongs to! First of all, does it belong to a bony fish, a shark, or a whale? The chances of identifying it correctly depend on distance, light, and time of observation. The bony fish most easily found and identified is the sunfish (*Mola mola*). When it swims on the surface of the water, its fin emerges and waves from side to side. Sometimes specimens lie on one side, as if they were sunbathing. These are usually juveniles, 30–60 cm in length. Adults may reach 3 m in length and weigh 1.5 tons - the record for the largest bony fish currently living.

A shark swimming just under the surface of the water shows part of its dorsal fin and the upper lobe of its tail fin. This characteristic distinguishes a shark from a cetacean because fish (both bony and cartilaginous) have vertical tail fins, while cetaceans have horizontal ones and swim differently. These features can be clearly observed during a visit to an aquarium or museum of natural history.

Sometimes tunny-fish (also called tuna) jump out of the water and, if they are large, may be confused with dolphins. Generally, dolphins (mammals) surface frequently, because they have to breathe atmospheric air, whereas tuna (fish), which breathe through their gills, do not need to come to the surface and rarely emerge while they are being watched.

To see cetaceans in the open sea is one of the most exciting and gratifying events of our lives, but we must be ready to make the best of this opportunity, especially if it is short-lasting, not forgetting to follow the whale-watching code

of conduct, which is very important in order to avoid any disturbance to these mammals. The rules are listed on page 120 and are always displayed on the boats of authorised organisations, whose members and staff have really understood that their job does not mean exclusively profit, but that they also have educational aims and must help make people aware of the necessity of protecting cetaceans and their environment.

Identifying cetaceans is based on their morphologic characteristics and behaviour.

The first include the animal's size, dorsal fin, head, colour and breathing (blow-hole). The second involves the direction and speed of movement, way of swimming (partially or totally on the surface, and leaping, called *breaching*), grouping and group characteristics (number of individuals, scattered, together, in pairs, or with young) and main activity of the moment (resting, feeding, mating, moving).

Obviously, camera or video-camera recordings allow students to view at least some of these features as often as they wish. Do not forget to note the date and time of sighting and write it on the back of the photograph, unless your camera already has a system for dating. Cetologists advise using 7x50 binoculars and telephoto lens not exceeding 135-200 mm focal length.

Sightings are classified into three main types:

1. One or more individuals moving;



A shortfin mako shark (*Isurus oxyrinchus*)

2. A group of dolphins comes to swim near the prow of the boat;  
3. A group is resting.

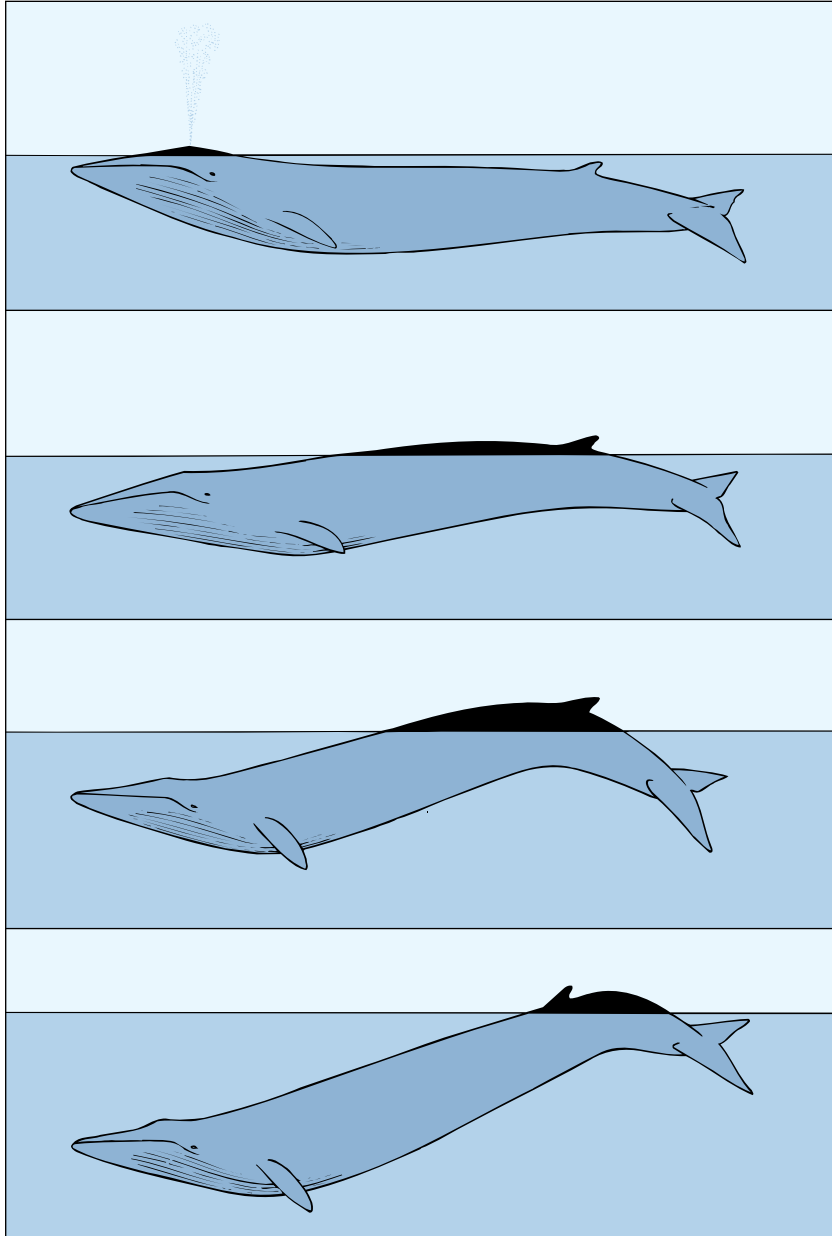
In the first case, approach the animals, bearing in mind the rules for correct behaviour. If possible, sail parallel to them (never cross their route) and, if possible, against the sun. If they dive, try to guess where they will re-emerge, basing your assumption on their direction while they were on the surface.

A school of dolphins playing near the prow of the ship and vying with it is a wonderful spectacle. To make it last as long as possible, do not scare the animals with sudden movements or loud noises, and keep a constant speed without abrupt turns. Point out to the students how dolphins turn on one side to look better at those sitting on the prow watching them. This is an amazing occasion on which to watch how they swim, to admire their speed and agility, to note their breathing, and also to take unforgettable photos and video shots.

If you are lucky enough to have a close encounter of the third kind and if the animals are not scared, you can stay with them, with the ship's engine off, for hours. It is an extraordinary opportunity to watch the animals' behaviour and the structure of their group. Some of them - mainly juveniles, which are more curious - will approach the boat and put their heads out of the water in order to see you better. Look at the youngest ones (generally lighter in colour), which are always near their mothers or surrounded by a group of adults.



Sperm whale diving



Profiles of cetaceans: fin whale during breathing phase and subsequent immersion phase

### *How to identify cetaceans*

Some cetaceans are very easy to identify, and the illustrative material prepared in class is also very useful - in addition, of course, to manuals on cetaceans, which are now numerous and easily found in any bookshop. Listed below are indications on how to identify these animals.

#### Size

It is not always easy to determine the animal's size, but it does make its identification simpler, as the Mediterranean cetaceans are subdivided into three groups: large (more than 10 m long), medium (between 10 and 4 m long) and small (less than 4 m long). The emerging part of the animal's body is often less than half its total length. Bear this detail in mind and, to help size estimation, compare the emerging part of the body with the length of your boat. Obviously, the nearer the animal and the clearer and calmer the water, the easier your estimate will be.

#### Blowing

Note the shape, direction and position of the blowhole with respect to the snout.

#### Head

Profile (side view) and shape, the beak and its shape, and the melon (a rounded mass of blubber, or fat, between the blowhole and the end of the snout).

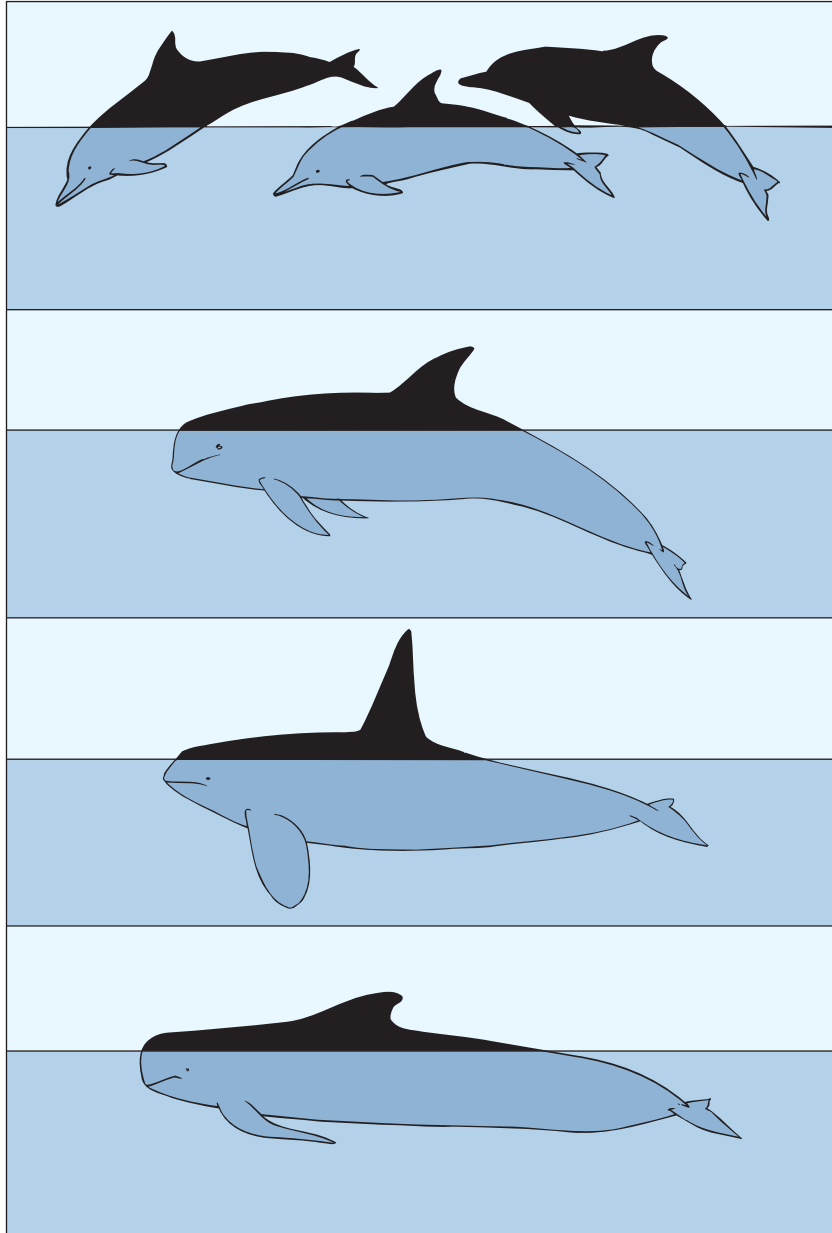
#### Colour

The colours of the back and pectoral fins, hue, markings and shades on flanks are important in distinguishing between bottlenose dolphin, striped dolphin and common dolphin. Remember that colour may be misleading, due to the relative positions of the observer and the sun.

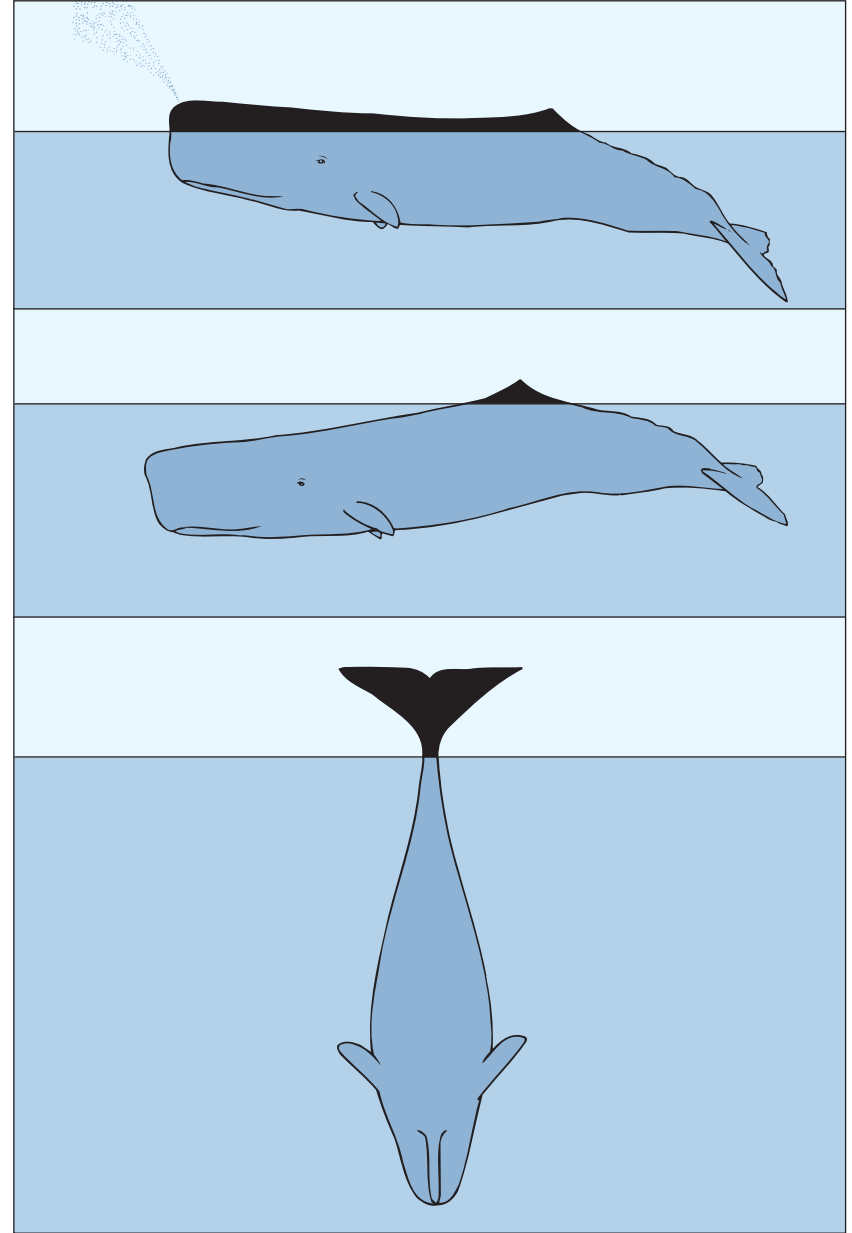
All these pieces of information, combined, will allow you to identify the animal exactly.



Bottlenose dolphin



Profiles of cetaceans: striped dolphins jumping on the surface, Risso's dolphin, killer whale and pilot whale



Profiles of cetaceans: sperm whale breathing on the surface, and in the typical position prior to diving

If the animal is more than 10 m long, it is a fin whale or sperm whale, easy to distinguish by its dorsal fin, which is typically curved in the former and of a smooth triangle shape in the latter. The blow of the fin whale is vertical, high, and backwards with respect to the snout; that of the sperm whale is oblique, low and spread out, emitted at the visible tip of the snout. Also, when on the surface, the sperm whale generally swims very slowly and blows often. When it wants to dive, it bends its back and draws its tail completely out of the water; the fin whale never does this. If the sighted animal is 4-10 m long (unless it is a juvenile of the former species), you have the following possibilities: you may be seeing a killer whale, minke whale, Cuvier's beaked whale, pilot whale, or false killer whale. Except for the pilot whale, these cetaceans are rare or very rare in the Mediterranean. The pilot whale, which may reach 5-6 m in length, is easily recognisable, due to its round head (from which its scientific name derives), dark colour, and a kind of whitish bib under the chin and between the pectoral fins, nearly always present in adults. The killer whale is unmistakable, thanks to its long dorsal fin and black-and-white colouring. The distinctive feature of the minke whale is the white stripe of the pectoral fins, although this animal does not always allow people to approach it for better observation. Cuvier's beaked whale has a small dorsal fin, triangular in shape and set well back, and colour ranging from grey to light brown, with whitish patches and narrow markings. If the animal is less than 4 m long, you may have met the following species:



Striped dolphin

- Risso's dolphin, recognisable by its round head and absence of beak (the projection of the mouth resembling a beak), greyish colour (paler in juveniles) and typical white markings.
- Bottlenose dolphin, with a beaked head and melon, and colours ranging from dark grey on the back to light grey on sides and whitish on the belly.
- Striped dolphin, a smaller dolphin than the above species, with a more projecting beak than the bottlenose dolphin and characteristic striped lines on its sides. It is the commonest dolphin and the easiest to encounter.
- Common dolphin, in spite of its name, is even less numerous than striped dolphin in Italian seas. It is not easy to distinguish it from the striped dolphin, and you must look carefully for the flank markings and the large yellow ochre patch, again on the flanks.

#### Sampling

During the boat trip, it is best to stop frequently to take samples of water, plankton and other organisms which can be netted. If there is a binocular stereomicroscope on board, immediately examine the water and plankton samples. If they have to be transported to the laboratory, use a refrigerated container or at least one in which you can preserve the water temperature of the moment of sampling. As planktonic organisms are very delicate and difficult to keep alive, it is better for some samples to be fixed in formalin 5% and sea water, for later examination in class.



The large sunfish (*Mola mola*) may often be seen on the surface

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## Glossary

> Accidental: used of species not normally occurring in the studied area; possible specimens are unusual (see occasional).

> Alien: a species occurring in an area to which it is not native.

> Allopatric: used of populations, species or taxa occupying different and disjunct geographical areas (cf. sympatric).

> Appendicularians: group of pelagic tunicates, small in size (0.5-10 cm). They have specialised glands on their heads that secrete mucus which the animals inflate to serve as domiciles for themselves.

> Autotroph: capable of synthesising complex organic substances from simple inorganic substrates using light or chemical energy (photosynthesis, chemosynthesis).

> Bathypelagic: living in deep water below the level of light penetration but above the abyssal zone, between 1000 and 4000 m.

> Benthos: those organisms attached to, living on, in or near the sea bed, river bed or lake floor.

> Benthophagic: organism that eats benthos.

> Benthonic: benthic organism.

> Bernoulli Effect: when a fluid passes through a narrowing area, the cross-section it passes through is reduced and as a result its velocity increases. The Bernoulli Theory states that, at that point, the pressure in the fluid must decrease. The lowering of the pressure causes deep water to be drawn upwards. In oceanography, this is known as "Bernoulli aspiration".

> Biomass: any quantitative estimate of the total mass of organisms comprising all or part of a population or any other specified unit, or within a given area at a given time; measured as volume, mass (live, dead dry or ash-free weight) or energy (calories).

> Bioness: a multiple-net sampler for plankton made of a set of nets that can be opened or closed by an operator.

> Biosonar: the peculiar faculty of many Vertebrates (including cetaceans and bats), consisting of uttering particular sounds, whose echoes allow the animal which produced them to locate the objects present in the surrounding area, using only acoustic perception.

> Carotenoids: water-insoluble pigments, ranging from yellow to deep red in colour.

> Cephalopods: class of the mollusc phylum, comprising about 700 species, all marine, including nautilus, cuttlefish, squid and octopus.

> Cetology: the study of cetaceans.

> Chlorophyll: pigment able to transform sunlight into chemical energy. Chlorophyll occurs in all algae.

> Cladocerans: small crustaceans, part of the class Branchiopoda, characterised by a single-valve carapace.

> Cnidarians: invertebrate animals belonging to > Coelenterata, characterised by cnidoblast (stinging) cells.

> Coastal: animal species living in coastal waters, generally between 0 and 200 m depth (see also neritic, pelagic).

> Coelenterates: all metazoans which are both ctenophores and cnidarians.

> Community: any group of vegetal or animal organisms that co-occur in the same habitat or area and interact through trophic and spatial relationships.

> Continental shelf: the shallow gradually sloping seabed around a continental margin, not usually deeper than 200 m, formed by submergence of part of the continent.

> Continental slope: the steeply sloping seabed leading from the outer edge of the continental shelf to the continental rise, with an average angle of slope of about 4° and a maximum of about 20° near the upper margin.

> Copepods: class of crustaceans comprising about 7,500 species, mainly marine. Calanoid copepods are the most important planktonic herbivores in marine trophic chains.

> Cosmopolitan: having a worldwide distribution, effect or influence.

> CTD: oceanographic instrument equipped with sensors, used to measure conductivity, temperature and depth of the water column.

> Ctenophores: coelenterata, lacking the characteristic cnidocytes (stinging cells).

> Cyanobacteria: predominantly photosynthetic prokaryotic organisms containing a blue pigment in addition to chlorophyll. They occur singly or in colonies in diverse habitats; important as phytoplankton.

> Cyclonic circulation: horizontal rotation of a volume of air about an area of low atmospheric pressure. Cyclones circulate counterclockwise in the northern hemisphere and clockwise in the southern hemisphere.

> Demersal: living at or near the bottom of a sea or lake but having the capacity for active swimming.

> Diatom: group of single-celled algae, having cell walls of silica called frustules.

> Dinoflagellates: unicellular groups of algae equipped with two flagella, able to move on two perpendicular levels.

> Doliolids: small pelagic tunicates belonging to the class Thaliacea.

> Drift net: a large fishing-net buoyed up by floats and carried along with the current or tide or, more often, towed by the boat to which it is attached.

> Ecological niche: the ecological role of a species in a community, i.e., its activities and relationships with other species of the community. It has no spatial meaning.

> Ecosystem: a community of organisms and their

physical environment interacting as an ecological unit; the entire biological and physical content of a biotope.

- > Elasmobranchs: a group of fish with a cartilaginous skeleton and 5-7 pairs of gills.
- > Enzyme: any of numerous proteins or conjugated proteins produced by living organisms and functioning as biochemical catalysts.
- > Epipelagic: organism that lives in the upper water column, extending from the surface to about 200 m.
- > Euphausiacea: order of the crustaceans characterised by lack of the gill chamber and the first three thoracic appendices, not transformed into mouth appendices. They include about 90 species, all marine and planktonic. Among the latter, some, generally known as krill, form the principal food of many whales and dolphins.
- > Euphotic: the uppermost layer of a body of water that receives sufficient light for photosynthesis. The vertical extension depends on water transparency.
- > Eutrophic: pertaining to waters rich in the mineral nutrients required by green plants. Environment sufficiently rich in nutrients to sustain good primary production. Also used to mean pollution, i.e., an environment excessively rich in nutrients, which may cause anoxia (lack of oxygen).
- > Flagellates: unicellular organisms equipped with a flagellum.
- > Food chain: a sequence of organisms on successive trophic levels within a community, through which energy is transferred by feeding. Energy enters the food chain during fixation by primary producers and passes to herbivores and then to carnivores.
- > Front: the boundary zone between two air or water masses differing in properties such as density, pressure, temperature or salinity.
- > Gastropods: group of molluscs, usually with a strongly calcareous univalve shell.
- > Gemmation: asexual reproduction by budding of a group of cells which later separates partially or completely from the parent to form a new individual.
- > Habitat: the locality, site and particular type of local environment occupied by an organism.
- > Heterotroph: an organism that cannot synthesise its own food and is dependent on complex organic substances for nutrition.
- > Holoplankton: organisms which are permanent members of plankton, which remain free-swimming through all stages of their life-cycle.
- > Hyponeuuston: organisms living immediately below the surface film of a body of water.
- > Ichthyophagous: feeding on fish.
- > IKMT (Isaacs-Kidd midwater trawl): special pelagic net with wide aperture, used to catch macroplankton and micronekton.
- > Isolines: lines linking points of equal temperature, salinity and density in different parts of the water body, known as isotherms, isohalines and isopycnals, respectively.
- > Isopycnal: a line on a chart or map connecting points of equal density.
- > Isotherm: a line on a chart or map connecting

points of equal temperature. It is useful to show the spatial changes of temperature in a certain area.

- > Krill: see Euphausiacea.
- > Longline: fishing gear formed of a number of connected vertical lines, set at the bottom of a drift net, each bearing a large number of baited hooks and equipped with floats.
- > Macrofauna: animals of larger size. Sizes are different for plankton, i.e., macroplankton is between 2 and 20 cm; macrobenthos is composed of organisms larger than 1 cm (according to some scholars, 0.5 cm).
- > Macroplankton: large planktonic organisms (20-200 mm).
- > Meroplankton: organisms that are planktonic for only part of their life-cycle, usually the larval stage.
- > Mesopelagic: organism that lives in the pelagic zone of intermediate depth, 200-1000 m.
- > Mesotrophication: the intermediary condition between oligotrophication and eutrophication.
- > Metazoans: multicellular animals.
- > Microbial loop: the role that microbes play in the marine ecosystem carbon cycle. A factor of the pelagic trophic web in which dissolved organic matter is used by picoplankton (0.2-2 µm) and nanoplankton (2-20 µm) and returns to the main part of the trophic web. Also: a flux of energy passing through phytoplankton, dissolved organic matter, bacteria, protozoans, and zooplankton.
- > Microfauna: microscopic or very small animals, i.e., between 20 and 200 µm in size for plankton.
- > Nanoflagellates: flagellates smaller than 20 µm.
- > Nekton: those actively swimming pelagic organisms able to move independently of water currents, sometimes making long journeys.
- > Nematocysts: stinging cells of cnidarians.
- > Neritic: pertaining to the shallow waters overlying the continental shelf.
- > Nudibranchs: molluscs of the class Gastropoda lacking a shell (except two families).
- > Nursery: area where juveniles of several species are reared.
- > Nycthemeral migrations: generally vertical movements of organisms following a night/day cycle (darkness/light).
- > Occasional species: a species which may be found from time to time in a particular habitat or community, but which is not a permanent member of the association.
- > Oligotrophic: waters that have low levels of mineral nutrients.
- > Ontogenetic migration: the occupation by an animal of different habitats at different stages of development.
- > Parthenogenesis: the development of an individual from a female gamete without fertilisation by a male gamete.
- > Pelagic: used of organisms inhabiting the open waters of an ocean or lake.
- > Peritrophic membrane: membrane around the mouth opening.
- > Photophore: a light-producing organ, found especially in marine fish, which emits light from specialised structures or derives light from symbiotic luminescent bacteria.
- > Photosynthesis: the process in green plants and

- certain other organisms by means of which carbohydrates are synthesised from carbon dioxide and water using light as an energy source.
- > Phytoplankton: minute, free-floating aquatic plants; the vegetable components of plankton.
- > Plankton: organisms which are unable to maintain their position or distribution independent of the movement of water.
- > Planktophagous: feeding on plankton.
- > Primary production: the assimilation of organic matter by autotrophs.
- > Prymnesiophyta: group of single-celled algae characterised by an appendix different in structure from a flagellum. Those covered with calcareous plates are called coccoliths.
- > Pelagic driftnet: driftnet used mainly to catch large pelagic fish, allowed to drift on the surface instead of being anchored to the bottom. It may be more than 60 km long. As it is not selective and has destructive potential, especially for cetaceans, the United Nations recently recommended banning it.
- > Polypoid stage: sessile stage (fixed on substrate) of cylindrical form of cnidarians.
- > Protozoa: single-celled animals.
- > Purse seine: large single-panel multi-sectioned net used to encircle pelagic fish, the bottom of which is then drawn together to enclose them.
- > Resident: living permanently in a particular place, non-migratory. The opposite of migratory.
- > Sexual dimorphism: difference in characteristics between individuals of different sex in the same species.
- > Siphonophores: group of hydrozoans of the phylum Cnidaria. They are exclusively pelagic, transparent, and very delicate.
- > Species: a group of individuals sharing the same morphologic, biologic and genetic characters which live in an area and can reproduce, with young that can, in turn, procreate.
- > Stock: a population or a group of individuals of one species within a specified area subject to commercial exploitation.
- > Sympatric: used of populations, species or taxa occurring together in the same geographical area.
- > Taxon (plur. taxa): a category or group of any rank, such as a phylum, order, family, genus, or species.
- > Taxonomy: the theory and practice of describing, naming and classifying organisms.
- > Teleost: large diverse group of bony fish, with only one branchial hole and visible rayed fins.
- > Teutophagous: organism which eats mollusc cephalopods.
- > Thermocline: a boundary region in the sea between two layers of water of different temperature, in which temperature changes sharply with depth. In summer, when masses of water form layers of different temperatures, the thermocline is the area where a slight change in depth causes a sharp variation in temperature.
- > Thermohaline: characteristic of water masses: includes temperature, salinity and, therefore, density (which depends on the former two).
- > Thermohaline circulation: induced by the difference in temperature and salinity (and density)

between adjacent masses of water.

- > Trophic chain: also called food chain. Representation of the passage of energy among populations of an ecologic community, from autotrophs to top predators.
- > Tuna purse-seine: recently developed method of fishing (1960s), generally carried out with large ships catching whole schools of tuna by a large encircling net plunged around the school.
- > Tunicates: group of marine chordates attached to the substrate, vagrant, alone or in colonies, characterised by a membrane shaped like a tunic (Asciacea, Talliacea) or a jelly-like matrix (Appendicularia).
- > Umbrella: the bell-shaped upper part of jellyfish.
- > Upwelling: an upward movement of cold nutrient-rich water from ocean depths.
- > Velella: small blue coelenterate resembling a miniature sailing boat and living on the surface of the sea.
- > Zooplankton: animal plankton.

- IAbrealia verany* - 68  
*Abrealiopsis morisii* - 68  
*Abylopsis tetragona* - 50, 51, 54, 56  
*Acanthephyra* - 133  
*Acanthephyra eximia* - 65  
*Acanthephyra pelagica* - 54, 65, 98  
*Aequorea forskalea* - 58  
Albacore - 69  
Alca torda - 83  
Alder - 85  
*Alepisaurus ferox* - 73  
Alle alle - 83  
*Alopias vulpinus* - 76  
*Anas clypeata* - 86  
*Anas querquedula* - 86  
Anchovy - 69, 93, 113  
*Ancistrocheirus lesueurii* - 98  
*Ancistroteuthis lichtensteini* - 68, 98  
Appendicularian - 47, 48, 59  
Arctic skua - 87  
Arctic tern - 88  
*Arctozenus* - 73  
*Argonauta argo* - 67, 68, 98  
*Argyropelecus* - 73  
Artemia - 133  
*Asterionella japonica* - 36  
Atlantic bonito - 69  
Atlantic pomfret - 73  
Audouin's gull - 86  
*Auxis rochei* - 69  
*Balaenoptera acutorostrata* - 91  
*Balaenoptera borealis* - 91  
*Balaenoptera physalus* - 6, 60, 94  
Balearic shearwater - 82  
Barnacle - 131, 134, 136, 137  
Basking shark - 77, 124  
*Bathophilus* - 73  
*Benthoosema* - 73  
*Beroe ovata* - 59  
*Biddulphia mobilensis* - 36  
Black tern - 88  
Blackfish - 71, 73  
Black-headed gull - 86  
Black-necked grebe - 83  
Black-throated diver - 83  
Blue shark - 74, 97, 98  
Blue whale - 94  
Bluefin tuna - 11, 60, 69, 75, 108, 111, 113  
Bluefish - 69  
*Borostomias* - 73  
Bottlenose dolphin - 67, 89, 122, 141, 145  
*Brachiotethis risei* - 98  
*Brama* - 73  
*Brama brama* - 73, 99  
Bulwer's petrel - 69  
*Bulweria bulwerii* - 82  
*Calanus helgolandicus* - 45, 51  
*Calonectris diomedea* - 81  
*Candacia armata* - 46  
*Carcharhinus brachyurus* - 76  
*Carcharhinus falciformis* - 76  
*Carcharhinus plumbeus* - 76  
*Carcharodon carcharias* - 76  
*Caretta caretta* - 78, 79, 102, 110, 137  
Caspian tern - 88  
*Cavolinia inflexa* - 51, 56  
*Centrolophus* - 73  
*Centrolophus niger* - 71, 73  
*Centropages typicus* - 49  
*Ceratium declinatum* - 34  
*Ceratium furca* - 37  
*Ceratium fusus* - 37  
*Ceratium tripos* - 37  
*Ceratoscopelus* - 73  
*Ceratoscopelus maderensis* - 99  
*Cestum veneris* - 59  
*Cetorhinus maximus* - 53, 77, 124  
*Chaetoceros* - 36  
*Chaetoceros curvisetus* - 36  
*Chauliodus* - 73  
*Chauliodus sloani* - 75  
*Chelonia mydas* - 79, 80  
*Chelonibia* - 137  
*Chelophyes appendiculata* - 50, 51, 54, 56  
*Chiroteuthis veranii* - 68, 98  
*Chlidonias hybridus* - 88  
*Chlidonias leucopterus* - 88  
*Chlidonias niger* - 88  
*Chrysomitra* - 58  
*Chtenopteryx sicula* - 68  
Cirriped - 46, 79  
*Clausocalanus* - 48, 49, 50  
*Clausocalanus arcuicornis* - 48  
*Clausocalanus furcatus* - 48  
*Clausocalanus mastigophorus* - 48  
*Clausocalanus paululus* - 48, 49  
*Clausocalanus pergens* - 48, 49  
*Clio cuspidata* - 54  
*Clio pyramidata* - 51, 54, 56  
Common dolphin - 67, 89, 141, 145  
Common gull - 86  
Common scoter - 85  
Common tern - 87, 88  
*Conchoderma virgatum* - 134  
Copper shark - 76  
Cormorant - 83, 85  
Cory's shearwater - 81  
*Coryphaena equiselis* - 69  
*Coryphaena hippurus* - 69, 135  
*Cotylorhiza tuberculata* - 7, 59  
Crab - 79, 135  
Ctenophore - 121  
*Cubiceps* - 73  
*Cubiceps capensis* - 73  
Cuvier's beaked whale - 67, 89, 95, 97, 118, 144  
*Cyclothone* - 55, 73  
*Cyclothone braueri* - 56  
*Cyclothone pygmaea* - 56  
*Cymbulia peronii* - 51, 54  
*Delphinus delphis* - 65, 68, 97  
*Dermostichus coriacea* - 60, 79  
Devil ray - 73, 77  
*Diaphus* - 73, 99  
*Diogenichthys* - 73  
*Diogenichthys atlanticus* - 73  
Diver - 83  
Dolphin - 114, 118, 137, 139  
Dolphin fish - 69, 135  
Dwarf sperm whale - 91  
Eider - 85  
*Electrona* - 73  
*Electrona rissoi* - 99  
*Engraulis encrasicolus* - 99  
*Euchaeta acuta* - 51  
*Euchirella rostrata* - 49  
*Eucopeia hanseni* - 54  
*Eucopeia unguiculata* - 56  
*Euphausia brevis* - 56  
*Euphausia hemigibba* - 56  
*Euphausia krohnii* - 56  
*Euthynnus alletteratus* - 69  
*Evadne tergestina* - 46  
*Evermannella* - 73  
False killer whale - 91, 144  
Fin whale - 6, 64, 62, 63, 73, 89, 91, 92, 94, 95, 118, 121, 122, 140, 144  
Fiona - 57  
Flying fish - 53  
*Fratercula arctica* - 83  
*Funchalia* - 65  
*Funchalia villosa* - 65  
*Funchalia woodwardi* - 65, 99  
*Galiteuthis armata* - 68, 98  
Gannet - 82  
Garganey - 86  
*Gavia arctica* - 83  
*Gavia immer* - 83  
*Gavia stellata* - 83  
*Gelochelidon nilotica* - 88  
*Gennadas* - 65  
*Gennadas elegans* - 54, 56, 65  
Gervais's beaked whale - 91  
Glaucous gull - 87

*Glaucus* - 57  
*Globicephala melaena* - **90**  
*Gonichthys* - 73  
*Goniiodoma* - 73  
*Gonostoma* - 73  
*Gonyaulax* - 37  
*Grampus griseus* - **95**  
 Great black-backed - 87  
 Great crested grebe - 83  
 Great hammerhead - 76  
 Great northern diver - 83  
 Great white shark - 76  
 Greater amberjack - **104, 135**  
 Greater argonaut - **67**  
 Grebe - 83  
 Green sea turtle - 79, **80**  
 Grouper - 135  
 Guillemot - 83  
 Gull-billed tern - 88  
 Half-naked hatchetfish - **75**  
 Herring gull - 86  
*Heterorhabdus papilliger* - 49  
*Heteroteuthis dispar* - 68, **99, 123**  
*Histioteuthis bonnellii* - 8, 68, **98**  
*Histioteuthis reversa* - 68, **98**  
 Humpback whale - 91  
*Hydrobates pelagicus* - 81  
*Hygophum* - 73  
*Hyperoglyphe* - 73  
*Hyperoglyphe perciformes* - 73  
 Iceland gull - 87  
*Ichthyococcus* - 73  
*Ichthyococcus ovatus* - **75**  
*Illex coindetii* - 68  
 Imperial blackfish - **72, 73**  
*Isurus oxyrinchus* - **138**  
 Ivory gull - 87  
*Janthina* - 57  
 Jellyfish - **7, 47, 52, 53, 55, 75, 116, 123, 130, 131, 133, 134, 135**  
 Jewell squid - 8, 68  
*Katsuwonus pelamis* - 69  
 Killer whale - 91, **142, 144**  
 King eider - 86  
 Kittiwake - **87**  
*Kogia simus* - 91  
*Lamna nasus* - 76  
*Lampanyctus* - 73  
*Lampris* - 73  
*Lampris guttatus* - 73  
*Larus argentatus* - 86  
*Larus atricilla* - 87  
*Larus audouinii* - 86  
*Larus cachinnans* - 86  
*Larus canus* - 86  
*Larus fuscus* - 86  
*Larus genei* - 87  
*Larus glaucooides* - 87  
*Larus hyperboreus* - 87  
*Larus marinus* - 87  
*Larus melanocephalus* - 86  
*Larus minutus* - 86  
*Larus ridibundus* - **86**  
 Laughing gull - 87  
 Leach's storm-petrel - 82  
 Leatherback sea turtle - 79  
*Lensia conoidea* - 51, 56  
*Lepas pectinata* - 134, **136**  
*Lepidopus* - 73  
*Leptocylindrus danicus* - 36  
 Lesser black-backed gull - 86  
*Lestidiops* - 73  
*Leucothea multicornis* - 59  
 Levantine shearwater - 81  
 Lightfish - **75**  
 Little auk - 83  
 Little grebe - 83, **85**  
 Little gull - 86  
 Little tern - 87  
 Little tuna - 69  
*Lobianchia* - 73  
 Long-tailed skua - 87  
*Lophotus* - 73  
*Lucicutia* - 50  
 Luvar - 73  
*Luvarus* - 73  
*Luvarus imperialis* - 73  
 Mackerel - 109  
*Maurilicus* - 73  
 Mediterranean gull - 86  
 Mediterranean monk seal - 88  
*Meganyctiphanes norvegica* - 54, 55, 56, **60, 62, 99, 101**  
*Megaptera novaeangliae* - 91  
*Melanitta fusca* - 85  
*Melanitta nigra* - 85  
*Mergus serrator* - 85  
*Mesocalanus tenuicornis* - 49  
*Mesoplodon europaeus* - 91  
*Microstoma* - 73  
 Minke whale - 89, 121, 144  
*Mobula mobular* - 60, 73  
*Mola mola* - **30, 60, 69, 99, 137, 145**  
*Monachus monachus* - 88  
*Morus bassanus* - **82**  
*Myctophum* - 73  
*Myctophum punctatum* - **99**  
*Nansenia* - 73  
*Naucrates ductor* - **135**  
*Nematoscelis megalops* - 54, 56  
*Nemichthys* - 73  
*Neocalanus gracilis* - 51  
*Nitzschia delicatissima* - 36  
*Nitzschia seriata* - 36  
*Notoscopelus* - 73  
*Notoscopelus elongatus* - **99**  
 Oarfish - 53, 73  
*Oceanites oceanicus* - 82  
*Oceanodroma leucorhoa* - 82  
*Oceanodroma monorhis* - 82  
*Octopoteuthis sicula* - **98**  
*Octopus defillippi* - 67, 68  
*Ocythoe tuberculata* - 67, **98**  
 Oilfish - 73  
*Oithona* - 48, 50  
*Oithona helgolandica* - **48**  
*Ommastrephes bartramii* - 68  
*Oncaea* - 48, 50  
*Onychoteuthis banksii* - 68, **98**

Opah - 73  
*Opisthoteuthis calypso* - 68  
*Orcinus orca* - 91  
*Oryctolagus cuniculus* - 81  
 Osprey - 88  
*Pagophila eburnea* - 87  
*Pandion haliaetus* - 88  
*Paracalanus* - 50  
*Paralepis* - 73  
*Pasiphaea multidentata* - 54, 65, **98**  
*Pasiphaea sivado* - 64, 65, **99**  
*Pegea confoederata* - 56  
*Pelagia* - **59**  
*Pelagia noctiluca* - 52, 53, 54, 58, **59**  
*Pelidium* - 37  
*Phalacrocorax aristotelis* - **84, 85**  
*Phalacrocorax carbo* - 83  
*Phronima sedentaria* - 54, **99**  
*Phronima semilunata* - 54  
*Physalia physalis* - 134  
*Physeter macrocephalus* - **117**  
*Planes* - 135  
 Pilot whale - 63, 67, 89, **90, 95, 97, 119, 122, 130, 142, 144**  
*Planus* - 135  
*Pleuromamma abdominalis* - 51  
*Pleuromamma gracilis* - 49, 51  
*Podiceps auritus* - 83  
*Podiceps cristatus* - 83  
*Podiceps grisegena* - 83  
*Podiceps nigricollis* - **83**  
*Polyprion americanus* - 135  
 Pomarine skua - 87  
*Pomatomus saltator* - 69  
 Porbeagle - 76  
 Portuguese man-of-war - 134  
*Posidonia* - 129  
*Prionace glauca* - **74**  
*Pseudorca crassidens* - **91**  
*Pteroctopus tetracirrhus* - 67, 68  
*Pteroplatytrygon violacea* - **76, 77**  
 Puffin - 83  
*Puffinus griseus* - 82  
*Puffinus mauretanicus* - 82  
*Puffinus yelkouan* - 81  
*Purrosoma atlanticum* - 49, 51, 54  
 Rabbit - 81  
 Razorbill - 83  
 Red-breasted merganser - 85  
 Red-necked grebe - 83  
 Red-throated diver - 83  
*Regalecus* - 73  
*Regalecus glesne* - 73  
*Rhizostoma pulmo* - **58, 59, 116**  
*Rissa tridactyla* - **87**  
 Risso's dolphin - 67, 89, **95, 97, 142, 145**  
 Roseate tern - 88  
 Rough-toothed dolphin - 91  
*Ruvettus* - 73

*Ruvettus pretiosus* - 73  
 Salp - **47, 53, 55, 59, 60, 75, 131, 134**  
*Salpa fusiformis* - **53, 54, 55, 56**  
 Sandbar shark - 76  
 Sandwich tern - 87  
*Sarda sarda* - 69  
 Sardine - 69, 108  
*Scaerurgus unicirrhus* - 67, 68  
*Schedophilus* - 73  
*Schedophilus medusophagus* - 135  
*Schedophilus ovalis* - **72, 73, 135**  
*Scina crassicornis* - 54  
*Scomberesox saurus* - **99**  
 Sea turtle - **78, 79, 137**  
 Seagull - 87, 130, 134  
 Sei whale - 91  
*Sergestes* - 65, **99**  
*Sergestes arachnipodus* - 54, 65  
*Sergestes arcticus* - 54, 55, 65  
*Sergestes sargassi* - 65  
*Sergestes vigilax* - 65  
*Sergia* - 65  
*Sergia robustus* - 54, **65**  
*Seriola* - **100**  
*Seriola dumerilli* - **104, 135**  
 Shag - **84, 85**  
 Shark - 11, 53, 70, 77, 97, 123, **126, 132, 137**  
 Shearwater - 134  
 Shortfin mako - 76, **138**  
 Shoveler - 86  
 Shrimp - 93  
 Silky shark - 76  
*Skeletonema costatum* - 36  
 Skipjack tuna - 69  
 Slavonian grebe - 83  
 Slender-billed gull - 87  
 Sloane's viperfish - **75**  
 Smooth hammerhead - 76  
*Solmissus albescens* - **50, 51, 56**  
*Somateria mollissima* - 85  
*Somateria spectabilis* - 86  
 Sooty shearwater - 82  
 Sperm whale - 67, 68, 89, 97, **117, 122, 125, 139, 143, 144**  
*Sphyrna viridensis* - **70**  
*Sphyrna mokarran* - 76  
*Sphyrna zygaena* - 76  
 Sprat - 69  
 Squid - 70, 109  
 St. John's boat see velella - 57, 134  
 St. Peter's boat see velella - 57, 134  
*Stenella coeruleoalba* - 65, 68, **93, 97, 98, 113**  
*Steno bredanensis* - 91  
*Stercorarius longicaudus* - 87  
*Stercorarius parasiticus* - 87  
*Stercorarius pomarinus* - 87  
*Sterna albifrons* - 87  
*Sterna caspia* - 88

*Sterna dougallii* - 88  
*Sterna hirundo* - 87, **88**  
*Sterna paradisea* - 88  
*Sterna sandvicensis* - 87  
 Stingray - **76, 77**  
*Stoloteuthis leucoptera* - 68  
 Storm petrel - 81, 82  
 Striped dolphin - 63, 65, 67, 70, 89, 91, **93, 98, 113, 118, 122, 141, 142, 144, 145**  
*Styliola subula* - 56  
*Stylocheiron longicorne* - 56  
 Sunfish - **30, 53, 69, 137, 145**  
 Swinhoe's storm-petrel - 82  
 Swordfish - 11, 65, 69, 70, 75, 97, 98, 101, **105, 106, 107, 108, 109, 111**  
*Symbolophorus* - 73  
*Symbolophorus veranyi* - **99**  
*Synechococcus* - 36  
*Tachybaptus ruficollis* - 83, **85**  
*Temora stylifera* - 45  
 Tern - 87  
*Tetrapturus albidus* - 69  
*Tetrapturus belone* - 69  
*Thalassionema nitzschoides* - **37**  
*Thalassiosira* - 36  
*Thalassiosira rotula* - **32**  
*Thalassiothrix frauenfeldii* - 36  
*Thalia democratica* - **50, 56**  
 Thresher shark - 76  
*Thunnus alalunga* - 69  
*Thunnus thynnus* - **11, 69, 99**  
*Thysanoteuthis rhombus* - **98**  
*Todarodes sagittatus* - 68, **99**  
*Trachipterus* - 73  
*Tremoctopus gracilis* - **66**  
*Tremoctopus violaceus* - 67, **98**  
*Trichiurus* - 73  
 Tuna - 11, 69, 70, 97, 101, 105, 106, **108, 113, 115, 132, 137**  
 Tunny-fish see tuna - 137  
*Tursiops truncatus* - **89**  
 Turtle - 53, 58, 79, 105, 123, 134, 135, 137  
*Uria aalge* - 83  
*Valencienellus* - 73  
 Velella - 53, **57, 58, 127, 129, 130, 134**  
*Velella velella* - **57, 129**  
 Velvet scoter - 85  
*Vinciguerra* - 73  
 Whale - 92, 94, 118, 121, 123  
 Whiskered tern - 88  
 White glass shrimp - 65  
 White-winged black tern - 88  
 Wilson's storm-petrel - 82  
*Xiphias gladius* - 69, **107**  
 Yellow-legged gull - 86  
 Yellowmouth barracuda - **70**  
*Ziphius cavirostris* - **118**  
 Zu - 73

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