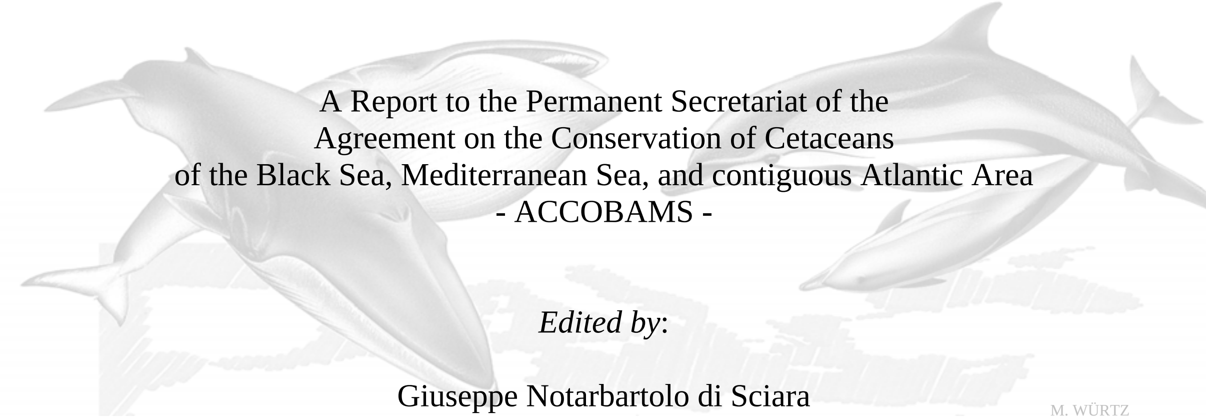
CETACEANS
OF THE MEDITERRANEAN
AND BLACK SEAS

STATE OF KNOWLEDGE
AND CONSERVATION STRATEGIES



A Report to the Permanent Secretariat of the
Agreement on the Conservation of Cetaceans
of the Black Sea, Mediterranean Sea, and contiguous Atlantic Area
- ACCOBAMS -

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Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 1

Summary

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A Report to the ACCOBAMS Interim Secretariat
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This report represents a compendium of the state of knowledge and of possible conservation strategies for cetaceans in the Mediterranean and Black Seas, to provide background information to the Contracting Parties to the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS).

Twenty one species of cetaceans occur in various degrees of abundance in the Mediterranean Sea and in the Black Sea. However, the species that are represented by regularly occurring, resident populations are limited to three in the Black Sea (short-beaked common dolphin, common bottlenose dolphin, and harbour porpoise), and eight in the Mediterranean Sea (fin whale, sperm whale, Cuvier's beaked whale, long-finned pilot whale, Risso's dolphin, common bottlenose dolphin, striped dolphin and short-beaked common dolphin). The status of the harbour porpoise in the Aegean Sea, where a small population unit may be existing, is still unclear. All other species occur occasionally, represented by vagrant individuals from North Atlantic and Red Sea populations. Each species is briefly described in this report, with a listing of its taxonomic position, the available common names in most of the Range States languages, and notes on distribution, habitat and ecology, and population data.

Conserving cetaceans has become an increasing challenge in present times. Cetaceans are long-lived vertebrates, confined to the highest levels in marine trophic webs, and have a very low reproductive rate. They are thus particularly vulnerable to the complex of threats deriving from a variety of human activities. Threats to cetacean survival deriving from human activities can be particularly severe in the Mediterranean and Black Seas, due to the enclosed and semi-enclosed nature of such basins, and to the human density and intensity of activities, particularly in the coastal zone.

Direct killing of cetaceans has been a problem in the past, particularly in the Black Sea, where over 6 million dolphins and porpoises were eliminated in the 20th century alone. By contrast, legal, organised killing of whales and dolphins never took place in the Mediterranean, with the exception of whaling activities which occurred in the first half of the 20th Century in the Strait of Gibraltar. A limited amount of live capture of bottlenose dolphins occurs to date in the Black Sea, catering for the oceanariums industry, however the impact of this on the surviving populations is not known.

Habitat loss and degradation is a major concern in the Agreement area, where the marine environment is heavily impacted by a multitude of different human activities. Factors responsible for cetacean habitat degradation include: (a) pollution from a variety of sources and types (sewage, atmospheric pollution, trace elements, POPs, marine debris, nutrients, oil, radioactive contaminants, biological and genetic pollution); (b) climate change; (c) land-based changes, mostly deriving from agricultural, industrial, and forestry activities; (d) coastal development, including urbanisation, industry, tourism, and dam construction; and (e) direct uses of the marine environment and of its resources, such as marine traffic, fisheries, and aquaculture. The consequences of all these factors on cetacean survival in the region are considered important, however the impacting mechanisms, their complex interactions and their real effects on the populations and their critical habitats are poorly understood.

Interactions between cetaceans and fisheries also affect cetacean conservation in the Agreement area, in three principal ways: (a) accidental mortality deriving from the entanglement and drowning of cetaceans in fishing gear meant to capture different species; (b) direct killing of cetaceans, perceived by some fishermen as competitors and a cause of damage to their gear and catch; (c) depletion of cetacean prey resources through overfishing and illegal fishing practices. Bycatch occurs mostly on pelagic species in the Mediterranean (in pelagic driftnets for swordfish and tuna), whereas in the Black Sea it affects coastal species (in bottom gillnets for turbot, sturgeon and dogfish).

In a marine region where vessel traffic and other human activities are as intense as in the Agreement area, disturbance is also a source of considerable concern for the continued survival of cetacean populations. However, again, the need for a better understanding of the mechanisms affecting cetaceans and their long-term effects on populations appears as imperative. The potential of vessel traffic, collisions with ships, noise from various sources (shipping, industrial, coastal construction, dredging, mineral prospecting, military, etc.), and a growing commercial whale watching industry, to negatively affect the status of cetaceans in the Agreement area is explored and discussed.

Disease, parasites, and toxic algal blooms are natural factors affecting cetacean mortality. These factors, however, may also interact synergistically with habitat degradation factors that are induced by human activities, and thus acquire a much greater impacting importance. A classic example is provided by the recent morbillivirus epizootics, which were a substantial cause of mortality for striped dolphins in the Mediterranean Sea and for short-beaked common dolphins in the Black Sea.

To counteract the effects of such a large number of impacting factors, it is imperative that well-integrated, science-based conservation strategies are devised and implemented. These include the managing of human activities (including fisheries, vessel traffic, whale watching, and activities that cause cetacean habitat degradation and loss) to mitigate negative impacts on cetaceans; granting special protection to areas containing critical cetacean habitats; undertaking targeted research and monitoring programmes; providing for timely responses to emergency situations; finally, promoting training, education and awareness programmes. While all these conservation strategies are worthy of being undertaken, and all cetacean species living in the Agreement area deserve to be protected as well, priorities are suggested in order to provide timely responses to address problems that are known or considered to be most urgent. In particular, four species appear to be in greater risk of declining and disappearing from the Agreement area, and are indicated as deserving the status of "priority species": short-beaked common dolphins in the Mediterranean Sea, harbour porpoises, sperm whales, and common bottlenose dolphins. In addition, 18 priority actions are proposed, based on the considerations presented in this report, which will be presented for consideration to the first Meeting of the ACCOBAMS Parties.

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SECTION 2

Introduction

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This report was envisaged and requested by the Interim Secretariat of ACCOBAMS to provide Contracting Parties with a synopsis of scientific information on the cetacean species living in the Agreement area, and an orientation tool for devising and implementing appropriate conservation strategies. The report does not aim to substitute the many excellent existing textbooks that deal with cetacean biology, ecology and conservation status at the global or at the regional level. Rather, it should be seen as a document written to complement basic knowledge with updated information, and tailored to specifically serve the practical purposes of the Agreement.

To ensure the highest possible level of completeness and authoritativeness, the report was designed as a collection of thematic essays, each being prepared by a researcher currently active in the corresponding field, and having a first-hand experience in the Agreement area. Thus, the many sections of this report are authored by different persons. A moderate amount of editing was done, on style rather than content, to ensure a minimum level of homogeneity throughout. Each author is therefore the sole responsible for what he or she has written.

The main recurring theme throughout the report is that our present knowledge on the status of cetacean populations in the Agreement area, on their threats, and on how such threats affect their survival, is dramatically inadequate, and a major hindrance to appropriate conservation and management measures. Quite frankly, this should not be viewed as a plea made by scientists in hope of securing funds for their research, nor should this awareness of lack of knowledge sound as an un-precautionary excuse for delaying action to some future date. Even a quick glance to the following Sections of this Report (in particular to Sections 17 and 18) should provide convincing arguments that our current ignorance of a number of basic elements of knowledge, and the striking unevenness with which such knowledge is spread across the Agreement area, constitute major obstacles to effective action. However, many useful conservation and management measures can and should be adopted even without the support of exhaustive data, and put to work while targeted research and effective training efforts are undertaken and made to proceed in parallel.

Our species is endowed, among other things, by an unsurpassed capability for environmental destruction, for affecting biological diversity, and for altering the course of evolution. However, it is also true that no other species has demonstrated our capability of examining ourselves and our doings, anticipate what may be happening in the future, adopt a critical stand towards our own actions, and advocate behavioural and policy changes (Meffe *et al.* 1999). As far as environmental issues are concerned, the sustained, *ad infinitum* maintenance of marine biodiversity is inconsistent with the indefinite growth of resource use and encroaching on marine habitats by our species. This, unfortunately, also holds true as far as cetaceans are concerned. At the global level, and within the Agreement area in particular, cetaceans have been adversely affected by direct hunting, by incidental drowning in fishery activities, and by habitat degradation and loss caused by pollution and human development. If we are serious and determined about conserving Mediterranean and Black Sea cetaceans, and conserving marine biodiversity as a whole, we should be available to compromise as far as our current attitude towards the environment and resource use are concerned.

ACCOBAMS has become a reality as a result of a genuine driving force, generated from within the communities who live along the Mediterranean and Black Sea coasts, to protect a visible and highly symbolic element of our natural heritage. Conserving cetaceans in our environment is a formidable challenge. To succeed, we must find ways to reconcile the environmental element with our needs, values and aspirations, and include all stakeholders in this complex, yet necessary process. To impetus to strive towards such a goal, however, is not limited to the intrinsic value of a regional conservation effort. If we will succeed in coexisting peacefully with cetaceans in our beleaguered marine region, we can be confident that cetacean conservation is possible anywhere on this planet

Acknowledgments

Many persons have helped in the preparation of this report by supplying relevant, unpublished information and useful indications. Among these, special thanks are given to Peter G. H. Evans, Caterina Maria Fortuna, Giulia Mo, Chiara Piroddi, Elena Politi, and Randall R. Reeves. In addition, the Editor wishes to thank all Authors for their availability and willingness to devote their valuable skills and attention to time-consuming tasks involved in the preparation of this report. In particular, Giovanni Bearzi, Alexei Birkun and Mark Simmonds were available for reading over parts of the report, and improving it with advice and comments. Without the fundamental and thorough help of Patrick Van Klaveren we would never have succeeded in mastering the formidable computing complexities and difficulties that this huge document file confronted us with. Maria Giovanna Arghittu, Chiara Della Mea, Valentina Rapi helped with the formatting of the document.

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Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 3

Cetacean Species Occurring in the Mediterranean and Black Seas

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Twenty one species of cetaceans occur in various degrees of abundance in the Mediterranean Sea and in the Black Sea. This list corresponds to Annex 1 of the Agreement, with the addition of three species known to have occurred in the Mediterranean in subsequent times. The list also roughly corresponds to the species occurring in the Contiguous Atlantic Area, however we must caution that a considerable number of other species, commonly present throughout the Atlantic Ocean, may occur there. Furthermore, we note that the number of species which are known to occur in the Agreement area is likely to grow with time, as the attention of scientists and laypersons towards cetaceans increases, and considering that species hitherto unreported from the region may occur there occasionally. For this reason, in the Agreement's Annex 1 it was stated that: *"The present Agreement shall also apply to any other cetaceans not already listed in this annex, but which may frequent the Agreement area accidentally or occasionally"*.

In the Black Sea only three small cetacean species, short-beaked common dolphin, common bottlenose dolphin, and harbour porpoise, are represented by regularly occurring populations. A greater diversity characterises the cetacean fauna in the Mediterranean Sea, considering that eight species are regular in the subregion: fin whale, sperm whale, Cuvier's beaked whale, long-finned pilot whale, Risso's dolphin, common bottlenose dolphin, striped dolphin and short-beaked common dolphin. All other species occur occasionally, represented by vagrant individuals from North Atlantic and Red Sea populations.

The list of the species occurring, or known to have occurred, in the Agreement area is given in Table 3.1. Table 3.2 lists many common names of such species, in most of the languages of the riparian countries. A capsule description of all the species listed in these tables follows. For a more detailed treatment of the subject, we refer the reader to recent texts and guides dealing specifically with the region's cetaceans (e.g., Bompar 2000, Notarbartolo di Sciara and Demma 1997).

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scientific name	*Balaenoptera acutorostrata* Lacépède 1804
English common name	minke whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Mysticeti** Family: **Balaenopteridae** Genus**: *Balaenoptera***
world distribution	A cosmopolitan species, present at all latitudes in both hemispheres. Most frequent in cold temperate, sub-polar and polar waters.
distribution in the Mediterranean and Black Seas	Individuals from North Atlantic populations occasionally enter the Mediterranean through the Strait of Gibraltar. Sightings and strandings have been reported off France, Italy, Tunisia, Israel. There is one ancient record of a minke whale stranding in the Black Sea (1880).
habitat and ecology	Found both in neritic and pelagic habitats, most frequently over the continental shelf.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Balaenoptera borealis* Lesson 1828
English common name	sei whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Mysticeti** Family: **Balaenopteridae** Genus**: *Balaenoptera***
world distribution	Circumglobal.
distribution in the Mediterranean and Black Seas	Rare sightings and strandings reported from Spain, Gibraltar, France and possibly Tunisia. Absent from the Black Sea.
habitat and ecology	Mostly found in pelagic, productive waters having temperatures comprised between 8° and 25°C.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Globicephala melas* (Traill 1809)
English common name	long-finned pilot whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**: *Globicephala***
world distribution	Found in cold and medium-temperate waters of the North Atlantic and in the Southern Hemisphere.
distribution in the Mediterranean and Black Seas	Common in the western portion of the Mediterranean basin (Alboràn and Balearic Seas), progressively decreasing in frequency to become quite rare in the Ionian Sea and off western Greece. Its presence in the eastern Mediterranean is doubtful. Absent from the Black Sea.
habitat and ecology	A pelagic species, mostly found offshore of the deepest portion of the continental slope.
population data	No population estimates exist for this species in the Agreement area.

scientific name	*Balaenoptera physalus* (Linnaeus 1758)
English common name	fin whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Mysticeti** Family: **Balaenopteridae** Genus**: *Balaenoptera***
world distribution	Cosmopolitan, but most frequent in cold temperate and sub-polar waters. Known to migrate extensively between cold productive waters (in summer) and tropical waters (in winter).
distribution in the Mediterranean and Black Seas	The commonest large whale species in the Mediterranean Sea, found mostly over deep, offshore waters of the western and central portion of the region, from the waters north and east of the Balearic Islands to the Ionian Sea (included). Less frequent elsewhere, but present throughout the region. Genetic analyses based on both mitochondrial and nuclear DNA indicated differences between the Mediterranean population, thought to be resident, and North Atlantic fin whales. Absent from the Black Sea.
habitat and ecology	Although they are found mainly in deep waters (400-2,500 m depth, most commonly at the deepest end of the range), offshore of the continental shelf edge, fin whales in the Mediterranean can also occur in slope and shelf waters, favouring upwelling and frontal zones with high zooplankton concentrations.
population data	No population estimates exist for the entire region. Line-transect surveys in 1991 and 1992 yielded fin whale population sizes, respectively, in excess of 3,500 individuals over a large portion of the western Mediterranean, and of about 900 individuals in the Corsican-Ligurian-Provençal basin. In the Mediterranean, fin whales are regularly encountered throughout the western and central basins, with seasonal summer concentrations in highly productive portions of the Corsican, Ligurian, Tyrrhenian and Ionian Seas, where they apparently feed on a single euphausiid species, *Meganyctiphanes norvegica*. During winter, fin whales disperse from these areas to a wider range within the Mediterranean, possibly southwards, to yet unknown breeding and calving grounds. They are extremely rare in the Adriatic and Aegean Seas, and in the Levant Basin.

scientific name	*Eubalaena glacialis* (Müller 1776)
English common name	North Atlantic right whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Mysticeti** Family: **Balaenidae** Genus**: *Eubalaena***
world distribution	Once considered a single species inhabiting both the North Atlantic and North Pacific Oceans, today in the North Atlantic it is recognised as a separate species (see Appendix 1). The main nucleus persists with about 300 individuals along the east coast of the North American continent. The north-eastern Atlantic population is probably extinct.
distribution in the Mediterranean and Black Seas	Two certain occurrences of this species were recorded in the Mediterranean Sea in historical times: a sighting in Algeria towards the end of the XVIII Cent., and a stranding in southern Italy in 1877. Absent from the Black Sea.
habitat and ecology	Coastal habits during feeding and breeding seasons. Can cross deep ocean basins when migrating.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Hyperoodon ampullatus* (Forster, 1770)
English common name	northern bottlenose whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Ziphiidae** Genus**: *Hyperoodon***
world distribution	Temperate and sub-polar waters of the North Atlantic Ocean.
distribution in the Mediterranean and Black Seas	No confirmed Mediterranean record for the species exists in the published literature. Unpublished sighting reports from the northern Alboràn Sea.
habitat and ecology	Found mostly beyond the continental shelf, in deep slope and pelagic waters, and over submarine canyons.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Delphinus delphis* Linnaeus 1758
English common name	short-beaked common dolphin
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**: *Delphinus***
world distribution	Widely distributed in warm temperate and tropical waters of the Atlantic, Pacific, and probably Indian oceans.
distribution in the Mediterranean and Black Seas	Once one of the commonest species in most seas, including the Mediterranean Sea (thence its common name). Neritic communities seem to show relatively high levels of site fidelity, while little is known about the movements and range patterns of offshore animals. Recent genetic studies indicate a significant level of divergence between Mediterranean and Atlantic populations; genetic exchange between Atlantic and Mediterranean seems to be limited to the Alboràn Sea, possibly due to local oceanographic features. In the Black Sea it is considered by some authors as an endemic sub-species (*D. d. ponticus*), though more taxonomic studies are needed before this view can be confirmed.
habitat and ecology	Short-beaked common dolphins in the Mediterranean Sea are found both in the pelagic and in the neritic environment, often sharing the former with striped dolphins and the latter with common bottlenose dolphins. Associations between common dolphins and either striped dolphins, Risso's dolphins or bottlenose dolphins have been observed in several places and occasions. Consistent observations conducted in the eastern Ionian Sea are indicative of high levels of site fidelity for a coastal community including less than 100 individuals. In the Black Sea the species is distributed predominantly offshore, but inshore waters are visited when seasonal aggregations of coastal fish prey occur.
population data	There is no overall population estimate for common dolphins anywhere in the Agreement area. According to line-transect surveys conducted in 1991 and 1992 in the western Mediterranean basin, common dolphins were abundant only in the Alboràn Sea, while low sighting frequency in other western Mediterranean areas prevented further estimates. Literature data, photographic documentation and osteological collections indicate that common dolphins once represented a frequent encounter in the Mediterranean Sea. The species, however, has faced a dramatic numerical decline during the last decades, and has almost completely disappeared from large portions of its former range (e.g., the northern Adriatic Sea, the Balearic Sea, Provençal Basin, and Ligurian Sea). Apparently isolated communities can still be observed in northern Sardinia, southern Tyrrhenian Sea, Sicily Channel, eastern Ionian Sea, and northern Aegean Sea. In the Black Sea, the species still appears to be the most abundant despite its over-exploitation up to the early 1980s.

scientific name	*Grampus griseus* (G. Cuvier 1812)
English common name	Risso's dolphin
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**: *Grampus***
world distribution	Circumglobal in temperate and tropical seas, roughly between Lat. 60° N and 60° S.
distribution in the Mediterranean and Black Seas	Common in the Mediterranean from Gibraltar to the Aegean Sea. Its presence in the Levant basin is unknown, but likely. Absent from the Black Sea.
habitat and ecology	Mostly found in deep pelagic waters and in particular over steep shelf slopes and submarine canyons.
population data	No population estimates exist for this species in the Agreement area.

scientific name	*Kogia sima* (Owen 1866)
English common name	dwarf sperm whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Kogiidae** Genus**: *Kogia***
world distribution	Scant data, mostly deriving from the stranding record, indicate a circumglobal distribution, with a clear preference for tropical waters.
distribution in the Mediterranean and Black Seas	One specimen stranded on the Tyrrhenian coast of Italy in 1988. Absent from the Black Sea.
habitat and ecology	A deep water species, found preferably in correspondence of steep continental slopes.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Megaptera novaeangliae* (Borowski 1781)
English common name	humpback whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Mysticeti** Family: **Balaenopteridae** Genus**: *Megaptera***
world distribution	A widely distributed, far-ranging migrant mysticete, found with distinct populations in both hemispheres in the major oceans.
distribution in the Mediterranean and Black Seas	Few certain occurrences in the Mediterranean Sea exist: a juvenile caught in 1885 off Toulon (France); a sighting in 1986 of two individuals off the Balearic Islands; the accidental capture of juvenile in the Gulf of Gabès (Tunisia) in 1992 and of another juvenile off Cavalaire (France) in 1993; and the repeated sightings of a single juvenile in the western Aegean Sea in 2001. Absent from the Black Sea.
habitat and ecology	A highly migratory species, known to undertake extensive voyages between high-latitude feeding grounds (summer) and tropical breeding grounds (winter). Both feeding and breeding occur in shallow neritic zones, while migration routes bring these whales across deep oceanic waters.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Mesoplodon bidens* (Sowerby 1804)
English common name	Sowerby's beaked whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Ziphiidae** Genus**: *Mesoplodon***
world distribution	A North Atlantic species, known mostly from strandings. Most records come from the north-eastern Atlantic shores.
distribution in the Mediterranean and Black Seas	The presence of this species in the Mediterranean is still unconfirmed. Older accounts suggesting strandings of *M. bidens* in the Mediterranean are unconvincing (see Van Bree 1975). Two recent, unpublished strandings may have been *M. bidens*: one in 1996 in southern France of two live individuals, rescued and released without collecting basic identification data, and one in the early 90s off south-western Peloponnese, Greece. Absent from the Black Sea.
habitat and ecology	Probably limited to offshore, deep pelagic waters.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Mesoplodon densirostris* (Blainville 1817)
English common name	Blainville's beaked whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Ziphiidae** Genus**: *Mesoplodon***
world distribution	Circumglobal. Probably the *Mesoplodon* species having the widest distribution.
distribution in the Mediterranean and Black Seas	The only confirmed occurrence of this species in the Mediterranean refers to a stranding in Catalonia in 1980. Absent from the Black Sea.
habitat and ecology	Perhaps one the most pelagic of the Ziphiid species, considering that strandings seem to be most frequently occurring on remote oceanic islands.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Orcinus orca* (Linnaeus 1758)
English common name	killer whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**: *Orcinus***
world distribution	Circumglobal, with a preference for colder waters.
distribution in the Mediterranean and Black Seas	Present only sporadically in the Mediterranean, with a higher incidence in the western part of the basin (Gibraltar, Morocco, Spain, France, Italy, Malta). Only one (uncertain) report from the eastern basin (Israel). Absent from the Black Sea.
habitat and ecology	Although this is one of the mammal species having the widest distribution, from polar to tropical waters, and from inshore bays to the open ocean, it is found preferably in colder waters and over the continental shelf.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Phocoena phocoena* (Linnaeus 1758)
English common name	harbour porpoise
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Phocoenidae** Genus**: *Phocoena***
world distribution	Widely distributed over the continental shelf in cold temperate waters of both the Northern Atlantic and Pacific Oceans, including connected semi-enclosed seas, bays and estuaries.
distribution in the Mediterranean and Black Seas	Today, harbour porpoises appear to be absent from the Mediterranean, with the exception of a limited area in the Northern Aegean Sea, where a small nucleus, of likely pontic origin, seems to be existing. The question of the historical presence of harbour porpoises in the Mediterranean is still controversial. By contrast, harbour porpoises are well known in the Black Sea and connected waters, including the Azov and Marmara Seas. In this subregion a subspecies, *P. p. relicta*, is recognised by some authors, recently supported by genetic evidence.
habitat and ecology	Found in the shallowest portion of the continental shelf, often venturing in bays, inlets, brackish lagoons, estuaries and even rivers.
population data	No reliable abundance estimate is available yet for the Black Sea population.

scientific name	*Physeter macrocephalus (= P. catodon)* Linnaeus 1758
English common name	sperm whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Physeteridae** Genus**: *Physeter***
world distribution	Circumglobal and migratory. Most sperm whales shift towards higher latitudes in spring and summer, returning to temperate and tropical waters in autumn. Adult males range farther towards polar waters than females and young.
distribution in the Mediterranean and Black Seas	Widely distributed in the Mediterranean from the Alboràn Sea to the Levant basin, mostly over steep slope and deep offshore waters. Not infrequent in parts of the Algerian-Ligurian Basin, Tyrrhenian and Ionian Sea, off southern Crete and possibly all along the Aegean Arc; predictably present in the North Aegean Sea during fall; rare in the Sicilian Channel; vagrant in the Adriatic Sea. Absent from the Black Sea.
habitat and ecology	Preferred sperm whale habitat in the Mediterranean includes slope and deep offshore waters, preferably over the continental slope where mesopelagic squid are most abundant. Groups of females with juveniles and mature males can be found together year round in some areas of the Mediterranean.
population data	No information is available on Mediterranean sperm whale population size, nor on the relationship between Mediterranean and Atlantic populations. However, several observations suggest a high degree of isolation.

scientific name	*Pseudorca crassidens* (Owen 1846)
English common name	false killer whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**: *Pseudorca***
world distribution	Widely distributed in warm temperate and tropical waters globally.
distribution in the Mediterranean and Black Seas	A rare species in the Mediterranean, where individuals and pods may stray from the warmer waters of the Atlantic Ocean and perhaps from the Red Sea through the Suez Canal as Lessepsian immigrants. The species has reportedly occurred off Spain, Morocco, Algeria, France, Italy, Greece, Turkey and Egypt. Absent from the Black Sea.
habitat and ecology	A typical inhabitant of the pelagic domain, but often also found over steep slope areas and continental shelf waters.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Sousa chinensis* (Osbeck 1765)
English common name	Indo-Pacific hump-backed dolphin
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**: *Sousa***
world distribution	Tropical Indian Ocean, Red Sea, and Indo-Pacific region up to the eastern coast of Australia and Taiwan.
distribution in the Mediterranean and Black Seas	Individuals are occasionally reported to stray into the Mediterranean (Egypt, Israel) from the Red Sea through the Suez Canal as Lessepsian immigrants. Absent from the Black Sea.
habitat and ecology	A typically neritic species, found over the continental shelf, bays and estuaries and mouths of large rivers.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Stenella coeruleoalba* (Meyen 1833)
English common name	striped dolphin
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus: ***Stenella***
world distribution	Tropical and warm-temperate waters around the world.
distribution in the Mediterranean and Black Seas	The commonest pelagic cetacean in the Mediterranean, found in offshore waters from Gibraltar to the Aegean Sea and the Levant basin. Morphometric studies and genetic analyses indicate differences between north-eastern Atlantic and Mediterranean populations. However, movements reportedly occur across the Gibraltar Strait. Absent from the Black Sea.
habitat and ecology	Typically pelagic, inhabiting preferentially the deep waters off the continental shelf where it feeds on mesopelagic fish, cephalopods and planktonic crustaceans.
population data	There is no overall population estimate for the Mediterranean. Line-transect surveys in 1991 and 1992 yielded population sizes, respectively, of 117,880 individuals over a large portion of the western Mediterranean, and of about 25,600 individuals in the Ligurian-Corsican-Provençal (LCP) basin. Key areas of distribution include the deep offshore waters of the central and western Mediterranean Sea, particularly the LCP basin. Striped dolphins are also frequent in the Ionian Sea and open waters of southern Adriatic Sea. Their abundance appears to be decreasing towards the eastern portion of the Mediterranean basin.

scientific name	*Steno bredanensis* (G. Cuvier in Lesson 1828)
English common name	rough-toothed dolphin
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**:** ***Steno***
world distribution	Circumglobal in tropical and warm-temperate waters, preferably where surface temperature exceeds 25°C.
distribution in the Mediterranean and Black Seas	Rare sightings and strandings reported from France, Italy and Israel. Absent from the Black Sea.
habitat and ecology	Usually found in pelagic waters, beyond the continental slope.
population data	No viable populations are known to live in the Mediterranean and Black Seas.

scientific name	*Tursiops truncatus* (Montagu 1821)
English common name	common bottlenose dolphin
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Delphinidae** Genus**: *Tursiops***
world distribution	A circumglobal, widely distributed dolphin species, including a coastal and a pelagic form, with different morphological and ecological characteristics. Recently its separation from *T. aduncus*, the Indian Ocean bottlenose dolphin, has been recommended (Rice 1998). Found in tropical and temperate waters of all oceans, as well as in semi-enclosed seas such as the Gulf of Mexico, the Gulf of California, and the Mediterranean, Black and Red Seas.
distribution in the Mediterranean and Black Seas	The commonest cetacean over the Mediterranean Sea continental shelf, where its distribution appears to be scattered and fragmented into small units. Key areas of distribution include the Alboràn, Balearic, and Adriatic Seas, the Tunisian and Malta Plateaus, the Aegean Sea, the Turkish straits system and other areas of the continental shelf, including Algerian coastal waters and possibly Middle-East Mediterranean waters. It is widely distributed along the Black Sea continental shelf as well, where, according to some authors, it is represented by the sub-species *T. t. ponticus*
habitat and ecology	In the Agreement area only the coastal form of *T. truncatus* is known. Here it can be found in very shallow waters, sometimes including coastal lagoons and estuaries, as well as in the deepest portion of the continental shelf. Likely depending on food availability, individuals can range offshore, and deep-water sightings have been reported from various areas.
population data	No population estimates exist anywhere in the Agreement area, except for a portion of the eastern Adriatic Sea (Fortuna et al. 2000).

scientific name	*Ziphius cavirostris* G. Cuvier 1823
English common name	Cuvier's beaked whale
taxonomy	Class: **Mammalia** Order: **Cetacea** Sub-order: **Odontoceti** Family: **Ziphiidae** Genus**: *Ziphius***
world distribution	Circumglobal; probably the widest-ranging Ziphiid, absent only from polar waters. Like the other Ziphiid species, its distribution is known mostly through the stranding record.
distribution in the Mediterranean and Black Seas	Well-known cetacean species throughout the Mediterranean subregion, where it is frequently found stranded; however, observations at sea are rare. There is no appreciable difference in its occurrence between the western and eastern basins. Absent from the Black Sea.
habitat and ecology	A typical cetacean of the pelagic and deep slope habitat, with a marked preference for waters overlaying submarine canyons.
population data	No population estimates exist anywhere in the Agreement area.

Table 3.1– Cetacean species occurring, or known to have occurred, in the Agreement area. The shaded rows indicate species that are represented in the Mediterranean or Black Seas by resident populations.

Scientific name	English name	Sub-region	Notes
Balaenoptera acutorostrata	minke whale	Contiguous Atlantic Area	Occurs occasionally in the Mediterranean Sea. One specimen known to have stranded in the Black Sea.
Balaenoptera borealis	sei whale	Contiguous Atlantic Area	Very rare occurrences in the Mediterranean Sea
Balaenoptera physalus	fin whale	Mediterranean Sea Contiguous Atlantic Area	
Delphinus delphis	short-beaked common dolphin	Black Sea Mediterranean Sea Contiguous Atlantic Area	
Eubalaena glacialis	North Atlantic right whale	Contiguous Atlantic Area	Very rare occurrences in the Mediterranean Sea
Globicephala melas	long-finned pilot whale	Mediterranean Sea Contiguous Atlantic Area	
Grampus griseus	Risso's dolphin	Mediterranean Sea Contiguous Atlantic Area	
Hyperoodon ampullatus	northern bottlenose whale	Contiguous Atlantic Area	A few sightings reported in the Alboràn Sea
Kogia sima	dwarf sperm whale	Contiguous Atlantic Area	One individual found stranded in the Mediterranean Sea
Megaptera novaeangliae	humpback whale	Contiguous Atlantic Area	Very rare occurrences in the Mediterranean Sea
Mesoplodon bidens	Sowerby's beaked whale	Contiguous Atlantic Area	Very rare occurrences in the Mediterranean Sea
Mesoplodon densirostris	Blainville's beaked whale	Contiguous Atlantic Area	Possible rare occurrences in the Mediterranean Sea
Orcinus orca	killer whale	Contiguous Atlantic Area	Occurs occasionally in the Mediterranean Sea
Phocoena phocoena	harbour porpoise	Black Sea Contiguous Atlantic Area Mediterranean Sea	Occurrences in the Northern Aegean Sea reported. Uncertain historical presence elsewhere in the Mediterranean Sea.
Physeter macrocephalus	sperm whale	Mediterranean Sea Contiguous Atlantic Area	
Pseudorca crassidens	false killer whale	Contiguous Atlantic Area	Occurs occasionally in the Mediterranean Sea
Sousa chinensis	Indo-Pacific humpbacked dolphin		Known to stray occasionally into the Mediterranean from the Red Sea
Stenella coeruleoalba	striped dolphin	Mediterranean Sea Contiguous Atlantic Area	
Steno bredanensis	rough-toothed dolphin	Contiguous Atlantic Area	Occurs occasionally in the Mediterranean Sea
Tursiops truncatus	common bottlenose dolphin	Black Sea Mediterranean Sea Contiguous Atlantic Area	
Ziphius cavirostris	Cuvier's beaked whale	Mediterranean Sea Contiguous Atlantic Area	

Tab. 3.2 – Common names of cetacean species found in the Agreement area.

Scientific name	Albanian	Arabic	Bulgarian	Croatian	English
Balaenoptera acutorostrata		هركول صغير (harcul saghir)		kljunasti kit	minke whale
Balaenoptera borealis		هركول رودلفي (harcul Rudolphi)		sjeverni kit	sei whale
Balaenoptera physalus	balene ko-kemahde	هركول شائع (harcul chaii)		veliki kit	fin whale
Delphinus delphis	delfin i za-konshem	دلفين شائع (delfin chaii)	karakash	obični dupin, mali dupin	short-beaked common dolphin
Eubalaena glacialis		حوت بيسكاي (hout biscai)		ledni kit	North Atlantic right whale
Globicephala melas		كروي الرأس الشائع (kouraoui arras achaii)		bjelogrli dupin	long-finned pilot whale
Grampus griseus		غرامبوس (ghrambous)		glavati dupin	Risso's dolphin
Hyperoodon ampullatus					northern bottle-nose whale
Kogia sima		عنبر قزم (ambar kism)		patuljasta ul-ješura	dwarf sperm whale
Megaptera novaeangliae		حوت أحدب (hout ahdab)		grbavi kit	humpback whale
Mesoplodon bidens				Sowerbyov kit	Sowerby's beaked whale
Mesoplodon densirostris		حوت بلانفيل ذات المنقار (hout Blainville that alminkar)		Blainvilleov kit	Blainville's beaked whale
Orcinus orca		أركة (arqa)		orka, kit ubojica	killer whale
Phocoena phocoena		خنزير البحر الشائع (khinzir albahr achaii)	mutcur	obalni dupin	harbour porpoise
Physeter macrocephalus	kashalot	عنبر (anbar)		ulješura	sperm whale
Pseudorca crassidens		أركة مزيفة (arqa mouzaïfa)		crni dupin	false killer whale
Sousa chinensis					Indo-pacific hump-backed dolphin
Stenella coeruleoalba		دلفين أزرق و أبيض (delfin azraq wa abyad)		prugasti dupin	striped dolphin
Steno bredanensis		ستينو (steno)		grubozubi dupin	rough-toothed dolphin
Tursiops truncatus	delfin i madh	دلفين كبير (delfin kabir)	puchtun	dobri dupin	common bottle-nose dolphin
Ziphius cavirostris	balene me sqep	زيفيوس (zifius)		Cuvierov kit	Cuvier's beaked whale

Explanatory notes:

1. English names are derived from the list given in the Journal of Cetacean Research and Management (Appendix 3 in 2001 issues; see also Appendix 1 in this Report).
2. The support of the following colleagues for the updating of this table is gratefully acknowledged: A.E. Baldacchino (Maltese), P.-C. Beaubrun (French), A. Birkun, Jr. (Russian and Ukrainian), A. Dede (Turkish), S. El Asmi (Arabic), A. Frantzis (Greek), O. Goffman (Hebrew), Z. Gurielize (Georgian), G. Radu (Romanian), T. Stanev (Bulgarian).

Scientific name	French	Georgian	Greek	Hebrew
Balaenoptera acutorostrata	petit rorqual, rorqual à museau pointu		βόρεια ρυγχοφάλαινα (voreia rynchofálaina)	לויתן גוץ (livyatan gutz)
Balaenoptera borealis	rorqual de Ru-dolphi		βορειοφάλαινα (voreiofálaina)	לויתן צפוני (livyatan tzefoni)
Balaenoptera physalus	rorqual commun		πτεροφάλαινα (pterofálaina)	לויתן מצוי (livyatan matzui)
Delphinus delphis	dauphin commun	tetrgverda delphini	κοινό δελφίνι (koinò délfini)	דולפין מובהק או דולפין מצו (dolphin muvhaq, dolphin matzui)
Eubalaena glacialis	baleine franche		σωστή φάλαινα (sostí fálaina)	בלנה שחורה (balena shechora)
Globicephala melas	globicéphale noir		μαυροδέλφινο (mavrodélfino)	נתב שחור (natav shachor)
Grampus griseus	dauphin de Risso		σταχτοδέλφινο (stachtodélfino)	גרמפוס (grampus)
Hyperoodon ampullatus	hyperoodon boréal		βόρειος υπερωόδοντας (vóreios yperoódontas)	
Kogia sima	cachalot nain		νάνος φυσητήρας (nános fysitíras)	
Megaptera novaeangliae	mégaptère		μεγάπτερη φάλαινα (megápteri fálaina)	לויתן- גדול- סנפיר (livyatan gadol snapir)
Mesoplodon bidens	mesoplodon de Sowerby		δίδοντος μεσοπλόδοντας (dídontos mesoplódontas)	
Mesoplodon densirostris	mesoplodon de Blainville		πυκνόρυγχος μεσοπλόδοντας (pyknórynchos meso-plódontas)	
Orcinus orca	orque, épaulard		όρκα (orka)	קטלן (katlan)
Phocoena pho-coena	marsouin	zgvis gori	φώκαινα (fókaina)	פוקנה (pokena)
Physeter macrocephalus	cachalot		φυσητήρας (fysitíras)	ראשתן (roshtan)
Pseudorca crassidens	faux-orque		ψευδόρκα (psevdórka)	עבשן קטלני (av-shen katlan)
Sousa chinensis	dauphin à bosse indo-pacifique		υβοδέλφινο του Ειρηνικού (yvodélfino tou Eirini-koú)	סוסא (soosa)
Stenella coeruleoalba	dauphin bleu et blanc		ζωνοδέλφινο (zonodélfino)	סטנלה מפוספסת (stenella mefuspeset)
Steno bredanensis	steno, dauphin à bec étroit		στενόρυγχο δελφίνι (stenóryncho delfíni)	דולפין תלום- שינים (dolphin tlum-shinaim)
Tursiops truncatus	grand dauphin, dauphin souf-fleur	aphalina	ρινοδέλφινο (rinodélfino)	דולפינן ים- התיכון (dolphinan yam hatichon)
Ziphius cavirostris	baleine de Cuvier, ziphius		ζιφιός (zifiós)	זיפיוס חלול- חרטום (zifyus chalul chartom)

Scientific name	Italian	Maltese	Portuguese	Romanian
Balaenoptera acutorostrata	balenottera minore	baliena ta' geddumha ppuntat	baleia-anã	
Balaenoptera borealis	balenottera boreale	baliena tan-nofsinhar	baleia-sardinheira	
Balaenoptera physalus	balenottera comune	baliena mbaċċa	baleia-comum	
Delphinus delphis	delfino comune	delfin komuni	golfinho-comum	delfin comun
Eubalaena glacialis	balena franca boreale		baleia-franca	
Globicephala melas	globicefalo	baliena sewda	baleia-piloto, boca-de-panela	
Grampus griseus	grampo	delfin griż	grampo	
Hyperoodon ampullatus	iperodonte boreale			
Kogia sima	cogia di Owen	baliena mmnieħra ċ-att	cachalote-anão	
Megaptera novaeangliae	megattera	baliena tal-ġwienah kbar	megaptera, baleia-corcunda	
Mesoplodon bidens	mesoplodonte di Sowerby	baliena ta' Sowerby	baleia de bico de Sowerby	
Mesoplodon densirostris	mesoplodonte di Blainville	baliena ta' Blainville	baleia de bico de Blainville	
Orcinus orca	orca	orka	orca	
Phocoena phocoena	focena comune	denfil iswed	bôto	porc de mare, marsuin, focena
Physeter macrocephalus	capodoglio	gabdoll	cachalote	
Pseudorca crassidens	pseudorca		falsa-orca	
Sousa chinensis	susa indopacifica			
Stenella coeruleoalba	stenella striata	stenella	golfinho riscado	
Steno bredanensis	steno	delfin tat-tikki	caldeirão	
Tursiops truncatus	tursiope	delfin geddumu qasir	roaz-corvineiro	afalin, delfin mare
Ziphius cavirostris	zifio	baliena ta' Kuvjer	zifio	

Scientific name	Russian	Spanish	Turkish	Ukrainian
Balaenoptera acutorostrata		rorcual aliblanco	mink balinası	
Balaenoptera borealis		rorqual boreal	kuzey balinasi	
Balaenoptera physalus		rorqual común	uzun balina	
Delphinus delphis	белобочка, дельфин-белобочка, обыкновенный дельфин[i] (belobochka, del'fin-belobochka, obyknovennyi del'fin[i])	delfin común	tirtak	білобочка, дельфін-білобочка, звичайний дельфін (bilobochka, del'fin-bilobochka, zvychainyi del'fin)
Eubalaena glacialis		ballena franca	gerçek kukei balinasi	
Globicephala melas		calderón común	siyah yunus	
Grampus griseus		calderón gris	grampus	
Hyperoodon ampullatus				
Kogia sima		cachalote enano	cüce kaşalot	
Megaptera novaeangliae		yubarta	kambur balina	
Mesoplodon bidens		balenato de Sowerby	Sowerby balinasi	
Mesoplodon densirostris		balenato de Blainville	gagali balina	
Orcinus orca		orca	katil balina	
Phocoena phocoena	обыкновенная морская свинья[ii], морская свинья, азовка[iii] (obyknovennaya morskaya svin'ya[ii], morskaya svin'ya, azovka[iii])	marsopa común	mutur	звичайна морська свиня, азовка, пихтун (zvychaina mors'ka svynya, azovka, pykhtoun)
Physeter macrocephalus		cachalote	İspermeçet balinası, kaşalot	
Pseudorca crassidens		falsa orca	yalanci katil balina	
Sousa chinensis		delfin de joroba indo-pacifico	kambur yunus	
Stenella coeruleoalba		delfin listado	çizgili yunus	
Steno bredanensis		delfin de dientes rugosos	kaba dişli yunus	
Tursiops truncatus	афалина, бутылконосый дельфин[iv] (afalina, butylkonosyi del'fin[iv])	delfin mular	afalina	афаліна (afalina)
Ziphius cavirostris		ballenato de Cuvier	Kuvier balinasi	

[i] All three synonyms are similarly used at present; the last name means 'common dolphin'. There are also archaic names which have currently very limited (mainly historical) use: дельфин-ворвон (del'fin-vorvon), остромордый дельфин (ostromordyi del'fin; = 'sharp-beaked dolphin'), тыртак (tyrtak), and белобокая морская свинья (belobokaya morskaya svin'ya; = 'white-sided porpoise').

[ii] Literally 'common marine porpoise'.

[iii] "Azovka" is the most widespread common name for harbour porpoises both in the Azov and Black Seas, but this name cannot be used for this species in other regions of the world. There are also many archaic and local names with limited use: азовский дельфин (azovskii del'fin; = 'Azov's dolphin'), тупомордый дельфин (tupomordyi del'fin; = 'blunt-beaked dolphin'), пыхтун (pykhtoun), пехтун (pekhtoun), чушка (choushka), сапун (sapoun), шутник (shoutnik), свинка (svinka), буртук (burtouk), мутор (moutor), хамсятник (khamsyatnik).

[iv] The last name - butylkonosyi del'fin – a literal translation from 'bottlenose dolphin' – was introduced into Russian in the 1970s-1980s and is now quite popular. Archaic names: незарнак (nezarnak), чёрная морская свинья (chornaya morskaya svin'ya; = 'black porpoise'), офалина (ofalina), афалин (afalin), афелин (afelin).

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 4

Conservation Problems: Overview

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Conserving cetaceans is becoming an increasing challenge in the face of expanding human activities at sea and in the coastal zone. While continued evaluation is necessary for protective measures already implemented, new conservation initiatives must often be devised to confront novel and previously unrecognised threats (Reeves *et al.* in press).

Human activities impact on cetaceans in several ways. For instance, actions may affect the individual, such as a fishing net causing the accidental drowning of a dolphin. If limited to rare instances, however, even such events, drastic as they are at the individual level, may have negligible consequences for the population. By contrast, subtle and often indiscernible effects causing progressive habitat degradation, and influencing the biotic communities at the ecosystem level, may have long-term, irreversible effects; these may cause the decline, displacement or even extirpation of cetacean populations from their critical habitats.

From a definition standpoint, it is important to distinguish between the **impacting factor** (e.g., the noise from an approaching vessel), a **short-term effect on the individual** (e.g., a startle reaction), a **long-term effect on the individual** (e.g., a serious behavioural disruption which, prolonged in time, may affect its survival), and a **long-term effect on the population** (if a large number of individuals is affected). Detecting long-term effects of human activities on populations is one of the principal concerns for cetacean conservation scientists, and remains today a formidable challenge.

Further useful definitions are provided in the recent policy document, "Whale and dolphin conservation in the Great Barrier Reef Marine Park", issued in 2000 by the Great Barrier Reef Marine Park Authority, Australia:

*"Impacts may be **direct**, meaning that they affect the animals directly, or **indirect**, meaning that they affect the animals through their effects on the environment. Impacts range in geographic scope from **localised**, affecting only animals in a limited area, to **global**, affecting cetaceans around the world. The duration of a particular impact may be **short-term**, ceasing within minutes or hours of the causal event or activity, or **long-term**, persisting for months or years. Similarly, effects may be **short-term, long-term** or **permanent** (e.g. permanent injury or death). Impacts that affect one or a few animals are of concern, but particular vigilance is required for impacts that affect many individuals, thereby threatening entire populations and possibly risking species extirpation (loss of a species in an area) or extinction (loss of a species worldwide). Global-level impacts are no less serious than those that operate at a smaller scale (indeed they may be more so) …"*

The ACCOBAMS region, of all the planet's marine environments, is one of the most affected by human activities. Concentration of human populations and activities around the Mediterranean basin presents considerable threats to the marine and coastal environment, impacting on the structure and function of natural ecosystems and on the quality and quantity of natural resources. The situation, however, is likely to be getting worse: "In the future, coastal areas are likely to face increasing pressures, particularly on habitats, natural resources (land, fresh/marine waters and energy), and growth of demand for infrastructures (ports/marinas, transport, wastewater treatment facilities, etc.). Urbanisation, tourism, agriculture, fishing, transport and industry are the major forces of change" (European Environment Agency 1999). The "Blue Plan" estimates that the current resident population of the Mediterranean riparian states (450 million) will rise to 520-570 million in 2030, and is expected to reach 600 million in the year 2050. The Mediterranean Sea, with a scant 0.8% of the world's ocean surface, is exposed to 15% of the world's commercial maritime traffic and to 30% of the world's total of ship-transported oil. The number of fishing vessels has increased by almost 20% from 1980 to 1992. Marine aquaculture production has grown from 78.000 tonnes in 1984 to 248.500 tonnes in 1996. About 60% of urban waste disposed in the Mediterranean is still untreated (European Environment Agency 1999), and it is commonly accepted that the rate of introduction of foreign, often noxious substances from land-based sources into this semi-enclosed basin cannot be overcome by its water turnover rate, estimated at approximately 100 years.

The Black Sea is widely recognized as one of the regional seas most damaged by human activities. The following is an excerpt from the website of the U.N. Black Sea Environment Programme[1]:

"Almost one third of the entire land area of continental Europe drains into this sea. It is an area which includes major parts of seventeen countries, thirteen capital cities and some 160 million persons. The second, third and fourth major European rivers,

[1] http://www.blacksea-environment.org/

the Danube, Dnieper and Don, discharge into this sea while its only connection to the world's oceans is the narrow Bosphorus Strait. The Bosphorus is as little as 70 meters deep and 700 meters wide but the depth of the Black Sea itself exceeds two kilometers in places. Contaminants and nutrients enter the Black Sea via river run-off mainly and by direct discharge from land-based sources. The management of the Black Sea itself is the shared responsibility of the six coastal countries: Bulgaria, Georgia, Romania, Russian Federation, Turkey, and Ukraine. In a period of only three decades (1960's-1980's), the Black Sea has suffered the catastrophic degradation of a major part of its natural resources. Particularly acute problems have arisen as a result of pollution (notably from nutrients, fecal material, solid waste and oil), a catastrophic decline in commercial fish stocks, a severe decrease in tourism and an uncoordinated approach towards coastal zone management. Increased loads of nutrients from rivers and coastal sources caused an overproduction of phytoplankton leading to extensive eutrophication and often extremely low dissolved oxygen concentrations. The entire ecosystem began to collapse. This problem, coupled with pollution and irrational exploitation of fish stocks, started a sharp decline in fisheries resources".

Cetaceans are long-lived vertebrates, confined to the highest levels in marine trophic webs, and have a very low reproductive rate. They are thus particularly vulnerable to the complex of threats deriving from a variety of human activities. These include direct exploitation and capture, by-catch in fisheries activities, competition and culls, habitat loss and degradation, contaminants, and disturbance from increased traffic. In addition to these well-known impacts, new factors, or factors previously unrecognised as significant, must be accounted for today, including: possible effects of global change, reduced prey availability, the contamination of the food web by algal bloom biotoxins, vessel collisions, noise pollution, and disturbance from unregulated, disrespectful whale-watching. Finally, many of such factors may interact positively, ultimately resulting in compound effects further adding to the overall burden.

Threats to cetacean survival deriving from human activities can be particulary severe in the Mediterranean and Black Seas, due to the enclosed and semi-enclosed nature of such basins, and to the human density and intensity of activities, particularly in the coastal zone. Pressure is thus most intense on coastal species, such as bottlenose and common dolphins and harbour porpoises. However, also pelagic species, such as sperm whales and striped dolphins, can be severely affected. However, one of the first difficulties encountered in the attempts to solve Mediterranean whale and dolphin conservation problems is the lack of adequate knowledge of population distribution, size, discreteness, trends, and dynamics for any of the cetacean species (Notarbartolo di Sciara and Gordon 1997; see also Table 17.1).

In the following Sections of this report, the different factors impacting on cetaceans of the Mediterranean and Black Seas will be addressed: direct killing and live capture (Sections 5 and 6), habitat loss and degradation (7 and 8), interactions with fisheries (9 and 10), disturbance (11, 12, 13 and 14), and natural mortality (15 and 16).

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Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 5

Cetacean Direct Killing and Live Capture in the Mediterranean Sea

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Commercial whaling activities

Commercial whaling never took place in the Mediterranean, probably because whales had always been presumed to be too rare to warrant the effort (Toschi 1965). One notable exception to this is represented by the whaling activities carried out in the Strait of Gibraltar and adjacent waters, possibly including the westernmost portion of the Alborán Sea, which begun in 1921. *Balaenoptera physalus* (93%), *B. borealis* and *Physeter macrocephalus* were the object of a very successful, albeit short-lived whaling industry in the Strait area (Cabrera 1925, Tønnessen and Johnsen 1982, Sanpera and Aguilar 1992), with very large numbers of whales captured year-round. By 1926, with over 4,150 fin whales killed in only six years (Sanpera and Aguilar 1992), the population had collapsed, with CPUE values declining from a maximum of 54 whales/catcher/month in 1922 down to only six in 1926 (Clapham and Hatch 2000). In subsequent years the profitability of the operations continued to decline due to lack of whales (Tønnessen and Johnsen 1982). The remnants of this local fin whale population were exploited until the late 1970s by pirate whaling, which harvested hundreds of animals off the coast of the Iberian Peninsula (Best 1992), venturing occasionally perhaps as far as the Strait of Gibraltar (Sanpera and Aguilar 1992). Fin whales were likely extirpated from the Strait area, as demonstrated by the dearth of sightings since the 1960s (Bayed and Beaubrun 1987, Hashmi and Adloff 1991, Walmsley 1996, Cañadas et al. 1999). As proposed by Clapham and Hatch (2000), this probably occurred because the cultural memory of the existence of that habitat was lost within the population.

Occasional killing of cetaceans

Whales were occasionally killed in the Mediterranean Sea during the XIX and first half of the XX Century. Kills took place for museum collections and research (Richard 1936), as target practice by the military (Minà Palumbo 1868, Cornalia 1872, Parona 1896 1908, Anon. 1903, Cagnolaro 1977), and by fishermen who often undertook to chase and kill fin and sperm whales (Lepri 1914, Borri 1927, Bolognari 1949, Tamino 1953, Cyrus 1969). The intent was presumably to extract oil or other valuable products, although the rendering of the carcasses was not always performed successfully, and the bodies were often discarded or left adrift at sea (Damiani 1911, Borri 1927). Today, cetacean mortality due to intentional killing seems to be still an issue, but limited to the smaller species (*Tursiops truncatus, Stenella coeruleoalba* and *Delphinus delphis*). Most of these deaths arise from deliberate slaughter of individuals regarded as vermin by fishermen, and occasionally from the use of cetacean meat for human consumption or bait (UNEP/IUCN 1994). Animals with lethal amputations or gunshots are not infrequent in Mediterranean stranding reports. Although the causes of these deaths can vary, and may include collisions or "sport" killings, the large majority of intentional takes are probably the result of retaliatory measures taken by fishermen against dolphins. Interactions resulting in direct killing of cetaceans have been reported to occur in several Mediterranean areas, both in the past and in the present (*e.g.*, Barone 1895, Brunelli 1932, Duguy *et al.* 1983, Northridge 1984, Holcer 1994). Coastal dolphins – particularly common bottlenose dolphins - are often claimed to steal fish from the nets, scare the fish away, or damage the catch and fishing gear. This may result in actions ranging from a variety of attempts to keep the animals away from the nets, to intentional killings (*e.g.*, in the Balearic Islands, Silvani *et al.* 1992, Gazo *et al.* In press). Deliberate offence may be carried out with guns, harpoons, explosives, or poisoned bait (Barone 1895, Di Natale 1990, Silvani *et al.* 1992, Reeves *et al.* In press). As the evidence of direct killing is mostly provided by a dead cetacean stranded or adrift, it may be difficult to assess with certainty the prime cause that prompted the killing, whether perceived competition, game hunting, or else. However, fishermen from several Mediterranean areas are known to carry various kinds of weapons on board, and many openly declare their hostility towards the dolphins. For instance, in the Italian seas, between 1986-90, 10% of the confirmed causes of death among stranded animals have been related to direct killings. The species that were most frequently affected were the striped dolphin and the common bottlenose dolphin, with a few cases involving other species (Cagnolaro and Notarbartolo di Sciara 1992). Increased common bottlenose dolphin mortality resulting from intentional killing of dolphins competing with local gill and trammel net fisheries has been reported in the Aegean Sea (Mitra *et al.* In press).

Cetacean products are used for human consumption, bait, farm animal consumption, oil, or other uses in many places around the world. In the Mediterranean, the use of cetacean meat for human consumption has been documented by recent reports of carcasses found stranded or adrift, with large portions of muscle tissue removed from the dorsum, mostly belonging to striped, common bottlenose, short-beaked common, and Risso's dolphins and long-finned pilot whales (Di Natale 1990). Along the Italian coasts, a total of 22 cetaceans were found stranded with evidence of bullet or harpoon wounds between 1986 and 1987 (Centro Studi Cetacei 1987), and twelve of them had their dorsal muscular area removed, suggesting use for human consumption. Dolphin meat may be sold to fishmongers and restaurants, particularly in Lazio, Tuscany, Liguria and Sardinia (UNEP/IUCN 1994). In Italy the dolphin fillet known as "musciame" could be found in limited supplies on illegal markets, particularly in Liguria and Tuscany (Di Natale 1990, Cagnolaro and Notarbartolo di Sciara 1992). Dolphin meat has also been used for human consumption in Spain (UNEP/IUCN 1994). Vessels capturing cetaceans for use as bait have also been reported, for instance along the Spanish coasts of Andalusia and Murcia (UNEP/IUCN 1994), but it is unknown whether this practice is still in use. This bait was used in deep sea longline and crustacean fisheries. According to UNEP/IUCN (1994), none of these vessels were exclusively targeting cetaceans. Dolphin meat was also occasionally used as longline bait in Italy (Di Natale and Notarbartolo di Sciara 1994).

Although it may represent an issue in some areas, the use of cetacean meat for human consumption or bait in the Mediterranean appears to involve a small number of animals/fisheries, and today it is unlikely to represent a major threat for any of the cetacean species inhabiting the basin.

Live capture

The capture of small cetaceans for live display in aquaria and research has been seldom carried out in the past in the Mediterranean (for examples, see Greenwood and Taylor 1978, Collet 1984, Johnson 1990), possibly given the lack of appropriate facilities to host these animals along Mediterranean riparian countries until a few decades ago. In recent years large aquaria have become more abundant in the Mediterranean, however due to stricter regulations in most coastal nations and public awareness problems, these have opted for the market importation of captive animals from other marine regions (e.g., Gulf of Mexico and Caribbean, Black Sea). To our knowledge, there is no official record of a cetacean having been captured for live display in the Mediterranean during the past 15 years.

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Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 6

Cetacean Direct Killing and Live Capture in the Black Sea

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Introduction

Less than twenty years ago mass commercial killing remained the principal human activity suppressing Black Sea cetaceans (Smith 1982, Klinowska 1991). All riparian countries, pursuing commercial interests, for many years took part in direct depletion of dolphin (*D. delphis* and *T. truncatus*) and porpoise (*P. phocoena*) populations. Eventually, negative results of such overexploitation became obvious to the governments and intergovernmental organizations, and legal killing was thus completely stopped in the 1980s. However, this was replaced by poaching and capture of wild animals for dolphinaria (Birkun *et al.* 1992). Both these recent "phenomena" still exist, and their impact on cetacean herds seems to be considerable in some areas.

Legal kills in the dolphin-processing industry

Historical origins of the Black Sea cetacean fisheries are unclear. Silantyev (1903) supposed that this activity was a centuries-old tradition of the coastal nations. The first scientific paper pertinent to cetacean fishery in the subregion was published by Rathke (1837) who indicated "numerous dolphin catches off the Crimea and, especially, near Bosporus". Nordmann (1842) confirmed the presence of such hunt in the eastern Black Sea waters off Abkhasia. Juridically permitted cetacean killing ended in the former USSR (present Georgia, Russian Federation and Ukraine), Bulgaria and Romania in 1966 and continued until 1983 in Turkey.

Commercial reasons

In the 19th Century Black Sea cetaceans were killed almost exceptionally for the oil obtained by the melting of their subcutaneous fat (blubber) and sold as the lamp-oil for home lighting; the meat had very limited use as bait in spiny dogfish (*Squalus acanthias*) long-line fishery, and sometimes it was consumed as a food by fishermen (Silantyev 1903). In the ex-USSR the dolphin oil found wide application in the pharmaceutics as the raw material for vitamin-D-containing medicines and in the tanning industry as the currier's oil; it was also used for the manufacturing of paint, varnish, soap, engine and lubricating oil; the muscle was used for tinned meat and sausages, the skin for leather goods, and the residues of cetacean carcasses were utilized for the production of "fish" meal, bone fertilizer and glue (Kleinenberg 1956, Tomilin 1957). Lubricating oils, "Delfinol" vitaminous remedy, shoe polish, leather and dried meat were produced in Bulgaria (Tsvetkov and Boyev 1983). The main products of the Turkish dolphin fisheries were the oil and meal for poultry feed (Berkes 1977, Yel *et al.* 1996, Öztürk 1999); the oil exported to Western Europe was used admittedly for cosmetics (Buckland *et al.* 1992). The available literature does not disclose what products were resulting from the Romanian dolphin-processing industry, however these were probably similar to the other Black Sea industries (Klinowska 1991).

Dolphins and porpoises are piscivorous predators, and that was another reason for their direct killing. In some places they were considered as undesirable rivals or even enemies of pelagic and coastal fisheries. Pseudoscientific estimations of enormous fish volumes allegedly consumed by Black Sea cetaceans were used in the USSR as a justification for mass dolphin killing (see examples in: Zaitsev 1998).

Catching techniques

Purse-seining and shooting were the two principal methods used in Black Sea cetacean fisheries (Silantyev 1903, Kleinenberg 1956, Danilevsky and Tyutyunnikov 1968, Berkes 1977, Yel *et al.* 1996). The non-selective purse seine, enabling to surround at once up to 1,000 and more animals, was the technique most developed in the former USSR, while the fishery by means of fire-arm had been prohibited in that country since 1936 because it usually was accompanied by "too large quantity of wounded and sunk dolphins lost for the utilization" (Kleinenberg 1956). On the contrary, the shooting was mostly cultivated in Turkey where it became the predominant technique during the 1960s-1980s (Yel *et al.* 1996). Berkes (1977), citing Slastenenko (1955), noted that the shooting could result in a 50% loss of the catch by sinking. The high loss rate in the Turkish cetacean fisheries (40-50%) had been noted in the IWC and IUCN documents (IWC 1983, Klinowska 1991).

General statistics and geography

The exact number of Black Sea cetaceans killed and processed in the 19th and 20th centuries is unknown because of poor catch statistics collected by riparian countries. In the 20th century in the former Russian Empire and then in the USSR it undoubtedly exceeded 1.5 million animals of all three species, while other Black Sea states together probably killed about four to five million (Birkun *et al.* 1992, Birkun and Krivokhizhin 1996 b). It is commonly acknowledged that the Black Sea cetacean populations were strongly reduced by the fishery (Zemsky and Yablokov 1974, Smith 1982, Klinowska 1991), and that perhaps they did not recover until now (Birkun and Krivokhizhin 2001). A lack of reliable population estimates (IWC 1983, Buckland *et al.* 1992) does not allow to confirm or reject this assumption.

Bulgaria. In Bulgaria the dolphin fishery is known to have occurred since the end of World War One (Tsvetkov and Boyev 1983) or even from the 19th century (Öztürk 1999), but no statistical data are available up to 1950. It was mentioned only that at the time of World War Two (1941-1945) the Bulgarian cetacean industry has been almost ceased (Danilevsky and Tyutyunnikov 1968). The data relating to the subsequent period are incomplete, contradictory and most likely largely inaccurate.

According to Ivanov and Beverton (1985), cetacean catch in Bulgaria amounted to 1,700 tonnes in 1954 and 2,798 tonnes in 1959. That is no less than 34,000 and 55,960 animals, respectively, assuming 50 kg as the mean weight of an average Black Sea cetacean carcass (Berkes 1977, Ivanov and Beverton 1985, Yel *et al.* 1996). By contrast, Dobrovolov and Joneva (1994), referring to Hristov (1963), inferred a mere 1,000 killed animals as the level (probably annual?) peculiar to 1950-1956. Velikov (1998) declared that during the 1960s the Bulgarian dolphin catch was about 60,000 individuals per year. At the same time, Zemsky (1996) presented yearly numbers of combined Bulgarian and Soviet catch as follows: 1960 – 68,200; 1961 – 60,860; 1962 – 60,860; 1963 – 46,600; 1964 – 8,800; 1965 – 6,200; and 1966 – 6,000 animals. It is difficult to explain the origin of figures (Dobrovolov and Joneva 1994) relating to further period when the cetacean fishery has been already banned *de jure* in Bulgaria: in 1967 – about 4,000 killed dolphins and then until 1994 – 2,000-3,000 killed individuals. It is unclear whether such figures refer to an estimated illegal catch, or to a possible by-catch.

Romania. According to Vasiliu and Dima (1990), in Romania the commercial cetacean killing lasted 33 years, beginning in 1934. That year 667 dolphins and porpoises were taken, alledgedly by means of fishing nets. The peak of the Romanian dolphin fishery (10,500 individuals) occurred in 1937. In 1954 the total catch was about 10 tonnes, and during 1955-1963 it did not exceed 1-2 tonnes per year (Ivanov and Beverton 1985). In the 1960s catches steadily declined despite an increase in fishing effort and financial subsidies from the government (Vasiliu and Dima 1990).

Tsarist Russia and Soviet Union (territories of present Georgia, Russia and Ukraine). Silantyev (1903), referring to Averkiev (1866), reported that in the mid-1860s the cetacean fishery in Abkhasia near Cape Pitsunda (Sukhumi district of the Russian Empire) was performed by more than thirty seasonally immigrating Turkish artisanal crews which produced about 49 tonnes of oil per fishing season. That could be a result of the processing of approx 3,000-6,000 animals, assuming that 8-17 kg of oil could be extracted from one Black Sea cetacean carcass (Silantyev 1903).

During the 1887-1913 period no less than 19 dolphin fisheries sites were situated along the Crimean and Caucasian coasts (Fig. 6.1), and all or almost all Black and Azov Sea ports of Tsarist Russia were involved in dolphin oil trade (Silantyev 1903, Kleinenberg 1956). For example, during nine years (1887-1895), a total of 528 tonnes of oil were exported through the Sukhumi customs alone. Silantyev (1903) estimated that the amounts of 147 and 328 tonnes corresponded, respectively, to the minimum and maximum annual levels of dolphin oil production in the late 1880s to early 1900s on the Caucasian coast from the Kerch Strait to the Russian-Turkish border. Such estimate could correspond to the annual processing of 8,650-41,000 cetaceans, or nearly 25,000 specimens on average. Unknown values of dolphin catches off Crimea and in the Azov Sea prevent the completing of the picture for the entire Russian area at the beginning of the 20th century.

In 1914-1920, during the First World War and Civil War in Russia, the mass killing of Black Sea cetaceans was suspended with one exception. Kleinenberg (1956), referring to Kozlov (1921), referred that the German occupation forces (1918-1919) hunted dolphins in Crimea with machine-guns and supplied Germany with the preserved products processed in the Sevastopol's dolphin processing factory.

The fast development of the Soviet dolphin fisheries began in 1929, under the impetus of the systematic organizing of specialized governmental enterprises and fishing co-operatives, and the establishment of so-called marine mammal processing plants in Sevastopol, Balaklava, Yalta, Novorossiysk, Tuapse and Akhali-Afoni (Fig. 6.1). Such plants were provided with a widely dispersed network of Crimean and Caucasian landing sites to receive and prepare cetacean carcasses. Furthermore, in 1930 the dolphin-processing factory ship "Krasny Kubanets" started its operations in Black Sea waters (Kleinenberg 1956).

Until the mid 1930s the Soviet cetaceans fisheries operated in coastal waters with a maximum offshore distance of about 20 miles. Since 1936, with the introduction of an aerial reconnaissance service (one spotting airplane), the operating area was considerably widened to up to 150 miles offshore, and covered approximately 150,000 square kilometres of sea surface from Cape Sarych in south Crimea to Cape Pitsunda in Abkhasia (Zalkin 1937) (Fig. 6.1). As a result, the level of cetacean catch immediately rose up to unprecedented numbers. For example, in June 1936 over 25,000 individuals were caught in one spot located at a distance of 115 miles from Novorossiysk; 3,000 individuals were killed during one day in August near Yalta; two marine mammal processing plants in Novorossiysk and Yalta have utilized together 44,537 animals in 1935, and 55,195 in 1936 (Zalkin 1937). The absolute annual maximum of the Soviet Black Sea cetacean fisheries intensity – 147,653 individuals (or 7,300 tonnes) – was reached in 1938 (Bodrov *et al.* 1958) (Fig. 6.2).

During the Second World War, which affected the USSR from June 1941 to May 1945, there was a sizeable reduction of dolphin fisheries with a subsequent growth of catches in 1946-1959. In the 1960s the level of catches decreased from year to year in spite of the steady raising of fishing efforts. Finally, during the last three years of legal killing (1964-1966) the annual catch declined to 300-440 tonnes (Danilevsky and Tyutyunnikov 1968, Ivanov and Beverton 1985), corresponding to 5,600-7,400 animals (Smith 1982). The over-exploitation of cetacean populations was considered as an only cause of the notable depression of the dolphin industry before its ban (May 1st, 1966). A total of 1,201,803 individuals of all three Black Sea cetacean species were killed and processed in the Soviet Union during 27 years from 1931 to 1957 (Bodrov *et al.* 1958), with an extra 465,620 animals caught by the USSR and Bulgaria together during the following nine years, in 1958-1966 (Zemsky 1996) (Fig. 6.2).

Turkey. It is uncertain when the Turkish cetacean fisheries began. In the 1830s the occurrence of dolphin catches was reported in Prebosporic area (Rathke 1837). At the beginning of the 1900s Silantyev (1903) contacted hereditary dolphin hunters originated from the Anatolian towns of Rize and Trabzon. Devedjan (1926) listed cetacean hunting amongst the Turkish traditional types of fisheries.

Catch statistics were probably not kept in Turkey in the 19th century, and large information gaps exist until the 1950s. According to published data summarized by Öztürk (1997, 1999), in 1933 the pooled catch of cetaceans was around 111 tonnes (Sarikaya 1975); in 1941 it rose to 3,000-4,000 tonnes and to 4,000 tonnes in 1947 (Ivanov and Beverton 1985). This corresponded roughly to 2,220, 60,000-80,000 and 80,000 animals, respectively, each with a mean weight of 50 kg. In contrast to other Black Sea countries, Turkey intensified its cetacean fisheries during the Second World War. Since 1940 and up to the ban in April 1983, dolphin hunters were provided by the government with free rifles and cut-price ammunition. 250-500 rifles and 250,000-750,000 rounds were distributed each year in the south-eastern coastal area from Sinop to Rize, although cetacean fisheries operated along the entire Turkish Black Sea coast from Igneada to Hopa, in an area exceeding 80 miles offshore (Yel *et al.* 1996, Öztürk 1999) (Fig. 6.1).

In the 1951-1956 period the yearly values of dolphin-processing material ranged from approx 8,500 to 10,000 tonnes (Danilevsky and Tyutyunnikov,1968). This corresponds to an annual level of catch/landing comprised between 157,000 and 185,000 individuals (1951-1957 estimate, Öztürk 1999). In the 1959-1980 period the annual harvest varied between 427 and 8,346 tonnes (Sarikaya 1975, Berkes 1977, Ivanov and Beverton 1985). Similarly to other Black Sea countries, there was a marked decrease of cetacean catch in 1960-1965 (Fig. 6.3). A FAO fisheries mission estimated that a figure of just under 250,000 small cetaceans were taken in Turkey between 1976 and 1981 (Klinowska 1991), within a grand total of 2,017,640 animals eliminated between 1953 and 1982 (Zemsky 1996).

During the last five years before the ban (1979-1983), the annual catch probably did not exceed 6,000-7,000 individuals (Öztürk 1999).

In 1970, in addition to several thousand tonnes of dolphins and porpoises taken from the Black Sea (Fig. 6.3) there was also a relatively small catch in the Marmara (1.5 t) and Aegean (0.5 t) seas (Berkes 1977).

Catch composition

As shown above, the statistics of Black Sea cetacean fisheries were usually expressed as total weight or total numbers in the catch without species differentiation. However, since the 19th century the common dolphin (*D. delphis*) was known as a main target species in the Tsarist Russia and USSR, while the bottlenose dolphin (*T. truncatus*) represented the most rare prey, and the harbour porpoise (*P. phocoena*) had an intermediate commercial importance (Silantyev 1903, Kleinenberg 1956). In the 1930s the average proportion of the three species in the Soviet harvest was: one bottlenose dolphin (0.5%) per 10 harbour porpoises (4.7%) per 200 common dolphins (94.8%) (Zalkin 1940 b). That ratio remained more or less immutable until the mid 1950s (Kleinenberg 1956).* In the late 1950s-early 1960s the common dolphin fraction began to decrease (80-90%), while harbour porpoises became the numerically dominant in 1964-1966, the last three years of mass killing in the former Soviet Union (Danilevsky and Tyutyunnikov 1968). According to these authors, a similar inversion of species composition, likely caused by the devastation of *D. delphis* population, occurred at the same time in Bulgaria. From 1976 to the early 1980s the Turkish harvest consisted mainly of harbour porpoises (80%) with a relatively small quantitiy of common dolphins (15-16%) and bottlenose dolphins (2-3%) (IWC 1983, Klinowska 1991). No information is available on species composition in the Romanian fishery.

The data concerning sex and age composition of cetacean harvests are very limited and relate mostly to the Soviet fishery (Kleinenberg 1956, Danilevsky and Tyutyunnikov 1968). In the 1930s-1950s the catches of common dolphins involved mostly mature males (40-60%), but in 1963-1964 immature individuals of both sexes and pregnant and nursing females became prevalent (70-75% in total). In the harbour porpoise sample of 1,333 carcasses, investigated in March-April 1966 at the Novorossiysk plant, sex ratio was 1:1 (50.1% males and 49.9% females); pregnant and lactating females constituted 36.2% and 1.4%, respectively, of all females examined. Fifty three bottlenose dolphins processed in April 1966 at the same plant included 27 males and 26 females; of these 63% were pregnant and 7.4% were lactating (Danilevsky and Tyutyunnikov 1968).

In Turkey, in 1982-1983, pregnant common dolphin females represented 30% of the total in all inspected cetacean hunts (Yel *et al.* 1996).

Illegal takes

Illegitimate exploitation of marine biological resources is one of the major environmental, economic and social problems concerning the entire Black Sea subregion. The scale of the unauthorized fisheries is not evaluated officially at the national and international level, but at present it possibly exceeds the combined value of all legal coastal fisheries. As a rule, recent poachers are much better equipped than law-abiding fishermen and fish protection officers. The use of modern satellite-navigating, radio-locating and echo-sounding devices, disposable monofilament nets and highly mobile boats with powerful engines enables them to conduct concealed fishing operations in any maritime area, at any time (mainly at night) and under any weather condition. Fortunately, unlawful direct take of cetaceans seems to be limited by the lack of adequate market in the riparian countries. By contrast, cetacean by-catches due to the illegal Black Sea turbot (*Psetta maeotica*) and sturgeon (*Acipenser spp.*) gill-net fishery may have considerable magnitude. Some examples, given below, illustrate these suppositions:

- dolphin hunting was temporarily prohibited in Turkey for 18 months between September 1980 and March 1982. However, in 1981 the “Et Balik Kurumu” factory in Trabzon processed 326 tonnes or 6,519 cetaceans into 121 tonnes of oil and 60 tonnes of “fish” meal (Yel *et al.* 1996); those values exceeded factory's annual production rates recorded in the preceding five and subsequent two years, when the cetacean fishery was permitted. Furthermore, during a joint USSR-US dol-

* The use of Zalkin-Kleinenberg’s formula “1 : 10 : 200” for the estimation of species composition after 1957 (*e.g.* Zemsky, 1996) is methodologically incorrect.

phin sighting survey conducted in June 1981 "a large number of harbour porpoise carcasses were observed floating off the coast of Turkey, with evidence of having been shot" (Buckland *et al.* 1992);

- in 1990 a dead harbour porpoise with bullet wounds in its integument tissues and spine was found stranded on the Crimean coast (Birkun *et al.* 1992). That was a single case amongst 817 cetacean strandings recorded in Ukraine in 1989-1996 (Krivokhizhin and Birkun 1999);
- illegal takes of at least two of the three cetacean species known in the sub-region were reported in Turkey in 1991 (Buckland *et al.* 1992). In particular, 232 harbour porpoises deliberately or incidentally killed by netting were processed in March 1991 in Yakakent, Turkey, for oil, animal feed and fertilizer (Anonymous 1991);
- 194 dead cetaceans together with 18,424 turbots, 143 sturgeons, 401 dogfishes and 1,359 rays were found in 6,416 Turkish poaching nets (about 640 kilometres long in total) confiscated in spring 1991 in Soviet waters (Pasyakin 1991). Numerous illegal visits of Turkish fishing boats to Ukrainian Black Sea area were recorded each year during the last decade (Sedoy *et al.* 2001).

Live capture

No published statistics exist for Black Sea live capture cetacean fisheries. Since the 1960s several hundreds of bottlenose dolphins and some tens of harbour porpoises and common dolphins were taken alive for military, commercial and scientific needs, mostly in the former USSR but also in Romania. The Russian Federation and Ukraine are continuing that practice periodically in Taman Bay (Kerch Strait) and off south Crimea. During the last 15-18 years captures concentrated on *T. truncatus*, the other species being of lesser interest for dolphinaria because of difficulties in their maintenance.

The capture operations, carried out by means of the purse-seining, are sometimes accompanied by the death of cetaceans as a result of strong stress and asphyxia. Most of these cases have not been officially recorded. In spring 1982, 11 of the 38 harbour porpoises caught for the Soviet Navy and academic dolphinaria perished because they were unable to come to the surface to breath (Birkun 1996). The dead individuals were not entangled, but were found in wide underwater pockets in the net formed by local sea currents. At least four bottlenose dolphins (September 1986) and 11 common dolphins (July 1988) have died due to the "live" capturing in Romania (Vasiliu and Dima 1990). According to these authors, in summer 1985 two harbour porpoises were caught by a group of tourists and delivered to the Constantza dolphinarium, where they later died.

At present (August 2001) there are eight dolphinaria in Russia, hosting Black Sea bottlenose dolphins together with other marine mammal species imported mainly from the Far East and Arctic regions. Four of the Russian dolphinaria, located along the Caucasian coast (Bolshoy Utrish [Anapa], Maly Utrish [Novorossiysk], Gelendzhik and Sochi), are supplied with natural sea water. Other four facilities (Moscow, St.-Petersburg, Rostov-na-Donu and Yessentuki) use artificial or semi-artificial salted water. Eight dolphinaria are in operation in Ukraine (Yalta, Partenit [Alushta], Karadag [Feodosia], Odessa, two in Evpatoria and two in Sevastopol). Half of these share common defects (lack of water preparing and sterilizing systems, water circulation too slow, obsolete equipment, and deteriorated constructions). Romania and Bulgaria each possess one dolphinarium, correspondingly, in Constantza (hosting bottlenose dolphins imported from Russia) and Varna (holding the descendants of Caribbean bottlenose dolphins imported from Cuba). A total of 80-120 marine mammals (primarily bottlenose dolphins) are currently maintained in the pools and open air cages of all mentioned facilities. In addition, there is yet another dolphinarium in Georgia (Batumi), but it does not work since the early 1990s, when its bottlenose dolphins were exported to Yugoslavia with further re-export to Malta (Entrup and Cartlidge 1998).

Black Sea countries have no strict legal requirements for the use of captive cetaceans for science, commerce or other purposes. From two to four dozen bottlenose dolphins of reproductive age are captured every year in Russia and sporadically in Ukraine to replace dead animals. The destiny of most captive cetaceans is clear: a short working life for humans, followed by disease and death caused usually by multi-bacterial pneumonia and septicaemia (Birkun *et al.* 1992). No successful breeding programmes and technologies exist for Black Sea cetaceans, although some publications portray the opposite (Bogdanova *et al.* 1996).

During the 1980s and 1990s the exploitation of captive cetaceans intensified, and the number of seasonal dolphinaria for public display and for "swimming with dolphins" programmes has increased. At Soviet times there were translocations of Black Sea military bottlenose dolphins to the facilities in the Japanese and Barents Seas. During the last decade the export of bottlenose dolphins from Russia and Ukraine has expanded, for example, to Argentina, Byelorussia, Chile, Cyprus, Egypt, Hungary, Iran, Israel, Lithuania, Romania, Turkey, United Arab Emirates, Vietnam, and former Yugoslavia countries. It is known that during the touring of cetacean exhibitions, deceased dolphins were sometimes replaced with freshly caught animals (Birkun *et al.* 1992). Further details on the export of Black Sea bottlenose dolphins and their fate are available from the WDCS report (Entrup and Cartlidge 1998)

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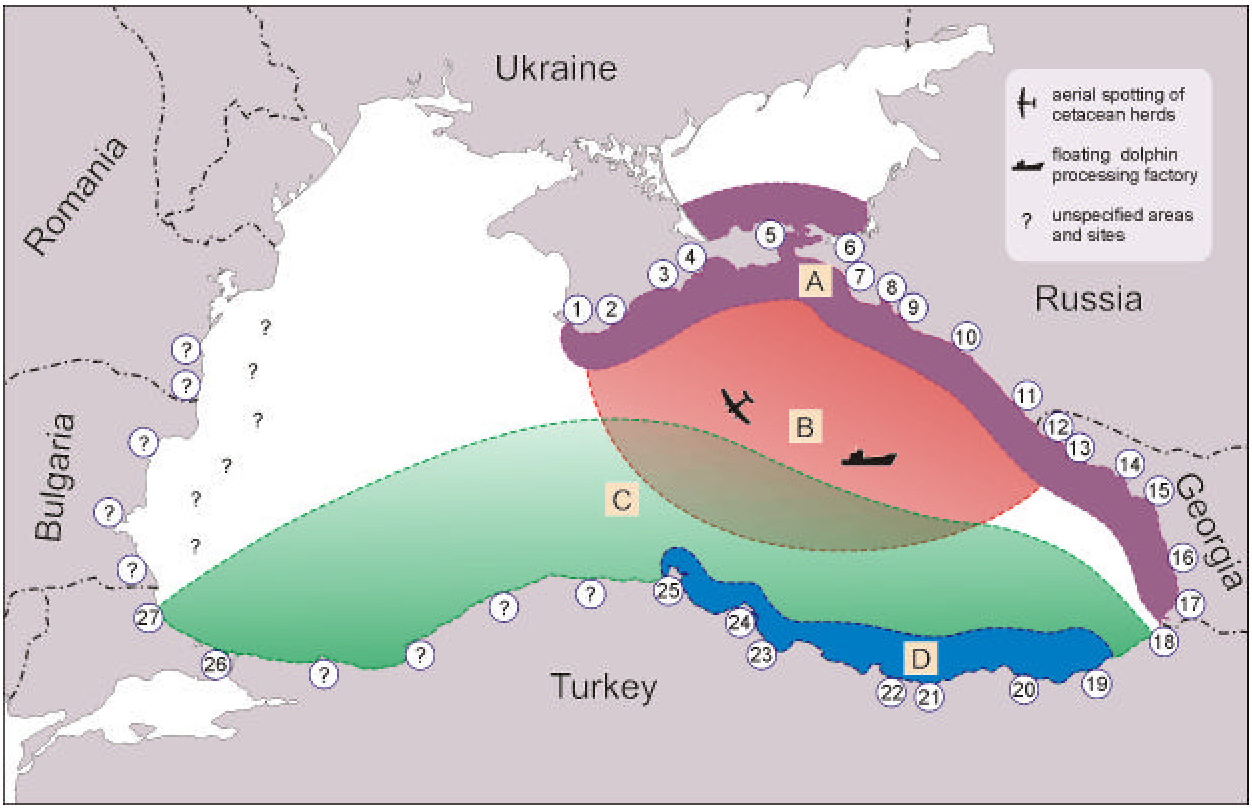

Fig. 6.1 - Former areas and sites of cetacean fisheries and dolphin processing industry in the Black and Azov Seas:

A	Inshore area exploited by the Tsarist Russia and Soviet Union before 1936
B	Additional offshore area exploited by the USSR from 1936 to 1966
C	Entire operating area of Turkish Black Sea cetacean fishery
D	Zone of the most intensive cetacean fishery in Turkey up to 1983

1	Sevastopol and Balaklava	15	Ochamchire
2	Yalta	16	Poti
3	Sudak	17	Batumi
4	Feodosia	18	Hopa
5	Kerch	19	Rize, Pazar, Çayeli and Gündogdu
6	Temryuk (Bugaz)	20	Trabzon, Salacik, Mersin and Çarsibasi
7	Anapa	21	Giresun and Eynesil
8	Novorossiysk	22	Ordu, Persembe, Fatsa and Ünye
9	Gelendzhik	23	Samsun and Yakakent
10	Tuapse and Lazarevskoye	24	Bafra
11	Sochi, Khosta and Adler	25	Sinop
12	Gagra	26	Istanbul
13	Pitsunda and Gudauta	27	Igneada
14	Sukhumi and Akhali-Afoni		

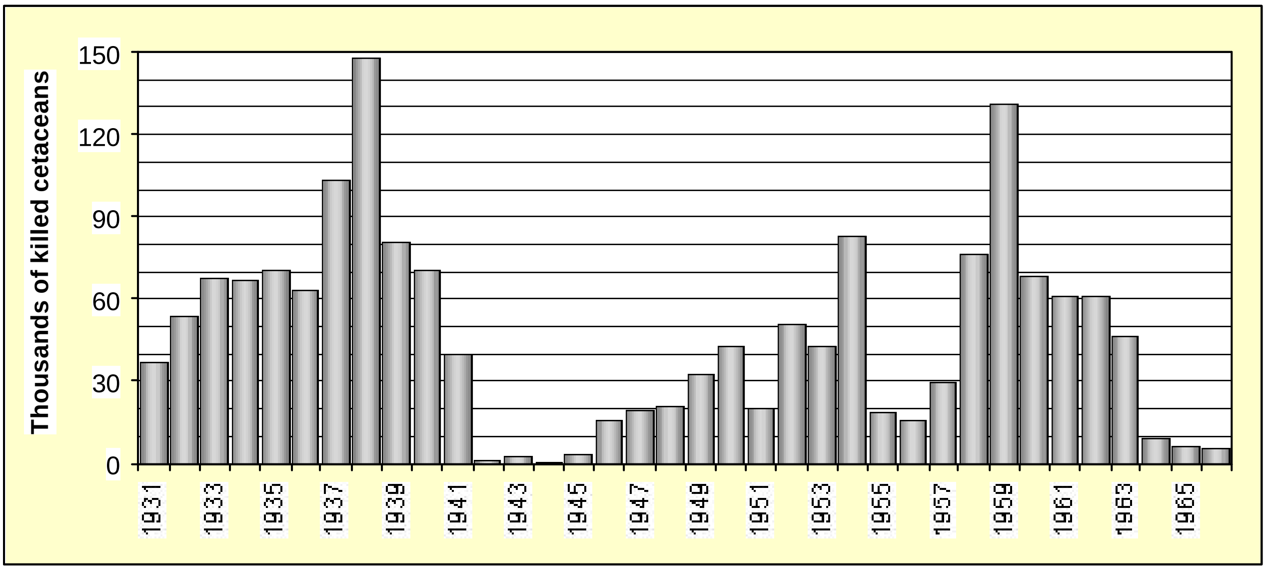

Fig. 6.2 - Yearly numbers of Black Sea cetaceans killed and processed in the former USSR in 1931-1957 (Bodrov *et al.* 1958) and in the USSR and Bulgaria in 1958-1966 (Zemsky 1996).

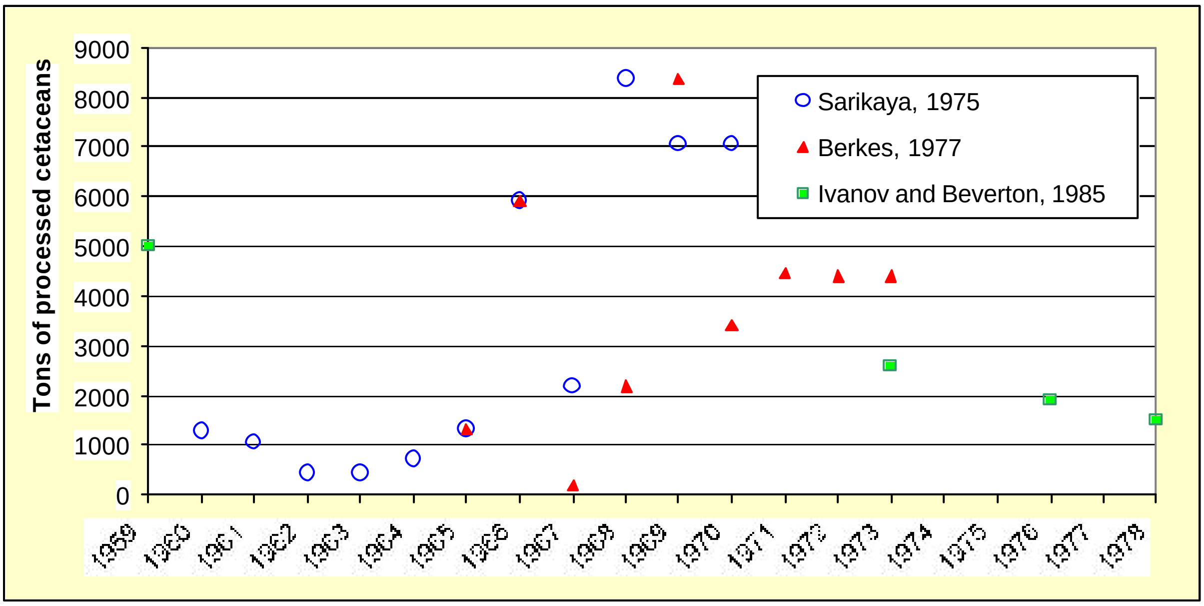

Fig. 6.3 - Estimations of Black Sea cetacean harvests processed in Turkey in 1959-1978.

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 7

Cetacean Habitat Loss and Degradation in the Mediterranean Sea

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Introduction

The Mediterranean is virtually an enclosed sea bounded by Europe, Africa and Asia. It has a surface area of 2.5 million km^2 (UNEP 1996) which equates to only 0.82% of the surface area of the world ocean (Bianchi and Morri 2000). The average depth of the Mediterranean is 1.5km, though it reaches a maximum depth of 4982m in the Hellenic Trench off southwest Greece (UNEP 1996). The shallowest part of the Mediterranean is in the northern Adriatic where it is less than 200m in depth (European Communities 1999). The total volume of the Mediterranean is 3.7 million km^3 (UNEP 1996). From east to west it measures 3800km and the widest point north to south is 900km. The total length of the Mediterranean coastline is about 46,000km, of which 19,000km represent island coastlines (Zerbini *et al*. 1997).

The Mediterranean consists of two main basins, the Western and the Eastern. The former covers 0.85 million km^2 at the sea surface and the latter 1.65 million km^2 (UNEP 1996). The two basins are connected by the Strait of Sicily, which is 150km wide and up to 400m deep. The sill between Gibraltar and Morocco (the Strait of Gibraltar) is 15km wide and up to 290m deep. It is here that the Mediterranean connects to the Atlantic Ocean. The Dardanelles Strait at the Eastern end connects the Mediterranean to the Sea of Marmara which leads to the Black Sea. The Strait is 55m deep (on average) and varies between 1.3km and 7km in width. In the nineteenth century, the Suez Canal was constructed linking the Mediterranean to the Red Sea. The Canal is 120m wide and 12m deep.

Corsica, Sardinia and the Balearic Islands are, morphologically, the most significant islands of the western Mediterranean basin (European Communities 1999). Sicily and Malta are in the central area of the Mediterranean and the eastern basin contains the large islands of Cyprus, Crete and Rhodes as well as some 700 islands and islets in the Aegean archipelago. The coastal zones of the Mediterranean consist mainly of rocky shores with occasional sandy beaches situated where valleys cut through the mountains, coastal plains are surrounded by mountains or where significant rivers flow into the sea. More than 300 rivers flow into the Mediterranean (Stanley 1997). They are mainly short to intermediate in length and many only flow during particular seasons. The majority flow into the northern margin of the Mediterranean.

The Mediterranean has a high level of salinity due, in part, to the slow exchange of water between the Mediterranean and the Atlantic Ocean and Black Sea (UNEP 1996). In the Western Mediterranean, salinity is approximately 38.5g of solid components per kg of deep water and slightly less than this nearer to the surface (Margalef 1985). This relatively high salinity is also partly created by evaporation which exceeds direct rainfall and river flow (Margalef 1985). This defines the Mediterranean as a ‘concentration basin’ (European Communities 1999). The water input to the Mediterranean from a number of rivers has become reduced since the 1950s due to damming and irrigation. The input from the Nile, for example, has declined by over 90%. Enough water flows into the western Mediterranean from the Atlantic and into the Eastern Mediterranean from the Black Sea to make up for the excessive evaporation. By contrast, water exchange via the Suez Canal is minimal. The density of the highly saline water causes it to sink to the bottom and creates an interface of water at the Straits of Gibraltar where the deep Mediterranean water flows into the Atlantic and surface Atlantic water enters the Mediterranean (Margalef 1985).

The Mediterranean does not have very strong tidal movements (Campbell 1982). The northern end of the Adriatic has the most marked tides. However, there are strong currents throughout the Mediterranean, for example, in the Straits of Messina between Italy and Sicily the current can reach 2 metres per second. The Mediterranean can also become quite rough especially when seasonal winds, such as the Mistral, are blowing.

A rough estimate has been made that more than 8,500 species of macroscopic marine animals live in the Mediterranean Sea (Bianchi and Morri 2000). This is somewhere between 4% and 18% of the world’s marine species and remarkable when compared to the fact that the Mediterranean’s area is only 0.82% and its volume 0.32% when compared to the total area and volume of the world oceans. Bianchi and Morri (2000) suggest that this high biodiversity can be explained by two primary factors:

1. The Mediterranean is older than almost any other sea; and
2. It has a complex ecology (i.e. a significant variety of climatic and hydrological environments).

This would also explain why it supports a wide range of marine top predators, including cetaceans and a single (now highly endangered) seal species. Bianchi and Morri (2000) also comment that present day Mediterranean biodiversity is undergoing rapid alteration under the combined pressure of climate change and human impact.

The Blue Plan (a research centre and non-profit making organisation funded by the Mediterranean Action Plan – MAP under the United Nations Environment Programme -UNEP) puts the total population of the Mediterranean countries in the year 2000 at 427 million people (Blue Plan Website 2001). Of these it is estimated that 145 million (34%) live in the coastal regions. This can be broken down to 93.7 people per km^2 compared to 48.7 people per km^2 for the entire population of the Mediterranean countries. The Blue Plan estimates that the population of the coastal states of the Mediterranean will rise to between 520 and 570 million in 2025, to 600 million in 2050 and 700 million by the end of the 21st century (European Communities 1999).

The Mediterranean Sea is used by humans for domestic and industrial waste disposal, plant cooling, marine mining, tourism and recreation, fishing, shipping and mariculture (UNEP 1996).

Inferences that can be drawn from the geography, and physical and chemical nature of this sea and its expanding population include:

1. The increasing population pressures linked to tourism are likely to produce concomitant increases in boat traffic, including leisure craft. This may present problems for cetaceans relating to noise pollution (see Gordon and Moscrop 1996, for a recent review of the significance of noise for cetaceans) and also collision;
2. A growing coastal population with associated industry (including seasonal influx of tourists) creates pollution. This will include sewage, as well as industrial and incidental discharges of chemicals such as the persistent organic pollutants (POPs);
3. Increased coastal building (in part related to tourism) and dredging for building materials and to keep ship-ways clear may directly degrade marine habitats by changing the benthos and introducing high levels of noise into the marine environment (Kemp 1996 considered physical habitat degradation and how it may affect cetaceans in some detail); and
4. Shallow areas with limited water circulation may be especially vulnerable to habitat degradation, for example that caused by chemical pollution discharge. Such waters may also be particularly vulnerable to eutrophication and algal blooms. On a large scale, the shallow Northern Adriatic might be particularly vulnerable to such impacts and, on a smaller scale, many bays, inlets and estuaries could be similarly affected.

The rest of this chapter will consider various categories of habitat degradation and will draw on recently published literature to provide an up to date review of the significance of this issue in the Mediterranean.

Habitat degradation

<u>Pollution and Disease</u>

The issue of natural pathologies is considered in Sections 15 and 16.

Information on Pollutants

Industrial and urban wastes are discharged into the Mediterranean via coastal outfalls, rivers and the atmosphere (UNEP 1996). Liquid waste from urban areas in the Mediterranean coastal region include dirty water (from domestic or industrial washing), detergents, lubricating oils and some solvents. Industrial liquid wastes comprise waste water, oils, detergents, solvents, organic chemicals and heated cooling water.

Urban solid wastes comprise organic matter, paper, glass, wood, textiles, plastics and metals (UNEP 1996). Solid waste from human habitation and socio-economic activity is used for landfill, dumped into the sea or recycled. Industrial solid wastes comprise slag, sludge, dust, combustion ashes and mine tailings. WHO and UNEP/MAP carried out a survey in 1996 on industrial and domestic waste management in the Mediterranean coastal area. This survey indicated that 21% of solid waste is disposed of by composting, 7% by incineration and over 70% by unspecified means.

With increasing urbanisation in the Mediterranean coastal regions, there is an increase in the amount of liquid and solid waste being produced (UNEP 1996). The large numbers of tourists coming to these areas each year also leads to an increase in waste.

Chemical pollution can cause mass mortality of fish stocks, decline or changes in composition of fish populations or entire ecosystems, an increase in fish disease and a decline in growth rates (UNEP 1996). Effects on prey can be expected to have knock-on effects on predators.

Waste Water/Sewage

Every Mediterranean coastal city discharges its effluents (treated or untreated) into the marine environment using sewage outfalls (European Communities 1999). During the tourist seasons there is a huge increase in the amount of waste water and sewage being disposed of.

Based on responses from Albania, Algeria, Croatia, Cyprus, Egypt, France, Greece, Monaco, Slovenia, Spain, Syria and Turkey, the WHO and UNEP/MAP 1996 survey concluded that 33% of the population (of the Mediterranean-basin parts of these countries) had no municipal sewage treatment system (UNEP 1996). 41% of the population had secondary treatment and 26% had primary treatment. Annually, according to the WHO/MAP survey, 3067.11 million m^3/year of untreated waste water is discharged into the Mediterranean (European Communities 1999). This is in comparison to 2830.23 million m^3/year of treated waste water – this water has had its Biological Oxygen Demand (BOD) reduced by between 25% to 95% depending on the treatment method used.

Only 5% of waste water is reused, mainly for irrigation (95%) but also in recreational areas (5%) (UNEP 1996). 85% of the discharged water goes into the sea (directly or indirectly) and 15% is discharged onto the land or used again. Even after primary or secondary treatment, sewage can have a nutrient-based impact on sensitive areas, such as areas where aquaculture is practised.

Moscrop (1993) suggested that cetaceans inhabiting coastal waters might be at risk from infectious agents in sewage. Potential effects include infection with parasites (mainly nematodes), "pox" infection and other viral and bacterial infections. Populations suffering from stress due to factors such as persistent contaminants, noise and disturbance and reductions in prey, may be more susceptible to diseases and pathogens present in sewage. Sewage can also contribute to eutrophication and nutrient enrichment of receiving waters.

Atmospheric Pollution

Air pollution in the region has three relevant aspects (UNEP 1996): Firstly, it may directly affect human (and by inference wildlife) health, weather and climate. Secondly, there may be transfer of pollutants via the atmosphere to other media (including the sea) and, thirdly, is the contribution of the sea to atmospheric pollution.

The European Commission project EROS-2000 (European River-Ocean System) has found that Saharan dust and some heavy metals are predominantly airborne (UNEP 1996). Data from the WMO Global Atmospheric Watch (GAW) suggest that pollutants emitted on the European hinterland can reach the Mediterranean in 24-48 hours (Soudine 1992 cited in UNEP 1996). DYFAMED (Dynamique et Flux Atmosphériques en Méditerranée Occidentale – France) studies have found that atmospheric inputs of pollutants to the Mediterranean Sea vary depending on the season (UNEP 1996).

Martin *et al.* (1989) compared contaminant input to the north-western Mediterranean from rivers and the atmosphere (Martin *et al.* 1989 cited in UNEP 1996). ^{238}plutonium, total phosphorus, ^{241}americium, total nitrogen and ^{137}cæsium predominantly (>50%) enter the Mediterranean via rivers. About 50% of water entering the north-western Mediterranean comes from river and land run-off, and the other 50% by rainfall (i.e. atmospherically). The contribution of cadmium, $^{239+240}$plutonium, dissolved copper, particles, particulate copper, particulate cadmium, particulate lead and dissolved lead are predominantly (>50%) via the atmosphere. Particulate lead and dissolved lead reach the Sea atmospherically (>90%).

Metals

The main trace metals found in the Mediterranean Sea are cadmium, mercury, lead, tin, copper and zinc (UNEP 1996). Levels of trace metals can vary greatly depending on the time and place (inshore, offshore, eastern or western basin) the samples are taken from. The levels of trace metals can be affected by human industrial and mining activity, as well as agricultural and domestic wastes, the combustion of fossil fuels and also by natural factors such as erosion and volcanic and tectonic activities. Levels of trace metals tend to be higher in marine sediments than in sea water. Heavy metals in the Mediterranean Sea arise mainly from natural processes with a limited contribution from human activity (Bryan 1976 and Bernhard 1988, cited in European Communities 1999).

Mediterranean rivers are less contaminated with heavy metals than most rivers in western Europe (European Communities 1999). Most of the heavy metal contamination is in the form of particulates. Reservoirs act as stores for much of the metals originating from human activities and thus prevent them from entering the sea.

Although the Mediterranean basin occupies only 1% of the earth's surface, approximately 65% of the world's mercury resources are located in the Mediterranean basin (UNEP 1996). Mining and chlor-alkali plants contribute to the mercury entering the marine environment. Mercury enters the Mediterranean through domestic and industrial effluents, rivers and the atmosphere, as well as through natural occurrences.

Cadmium comes from copper refining, lead processing, electroplating, solders, batteries, production of alloys, pigments and PCBs and sewage sludges (UNEP 1996). In the open sea cadmium levels have been measured at 0.004 – 0.06 g/l, and in the coastal sea as <0.002 – 0.90 g/l, with the high values tending to be near to cadmium sources such as coastal mining sites and estuaries. Approximately 92,400 tonnes of zinc enters the Mediterranean Sea every year. In comparison, 29,000 tonnes of copper enter the Sea annually.

There have been a number of papers reporting on metals in Mediterranean cetaceans (see Table 7.1 for examples). As elsewhere in the world, coastal dolphins have been found to have high mercury concentrations in liver tissues (e.g. Augier *et al.* 1993). This has to be seen in the context of the fact that cetaceans appear to have protective mechanisms against mercury intoxification and sequester it in liver tissue in a complex with selenium. This ability may relate to the fact that there has always been significant discharges of mercury into the marine systems from active volcanic areas (see for example, Das *et al.* 2000). However, this does not mean that this "detoxification mechanism" cannot be overwhelmed when exposed to unnaturally high concentrations.

Organic Pollutants

Persistent Organic Pollutants (POPs) are organic compounds that are highly resistant to degradation by biological, photolytic or chemical means. They are liable to bioaccumulate, are toxic, and are hazardous to the environment and human health. In the Mediterranean region, these include the organophosphorus compounds (OPs) which are used as pesticides, insecticides, herbicides, fungicides and, industrially, as solvents, lubricants and detergents (UNEP 1996). They are unstable in water but have very high levels of toxicity.

The majority of organohalogen contaminants are used in agriculture and enter the Mediterranean by washing off the land into rivers or directly into the sea via outfalls or runoff (UNEP 1996). Important organohalogens include PCBs, DDT, hexachlorohexane (HCH), hexachlorobenzene (HCB), heptachlor, and the pesticides aldrin, dieldrin and endrin.

Polychlorinated biphenyls (PCBs) are industrial hydrocarbons with a variety of uses, for example as coolants in refrigerants (UNEP 1996). In sea water they can reach levels up to 548ng/1 - 597ng/l in surface water. In sediments PCBs range between <0.1 g/kg d.w. to 16,000 g/kg d.w. In terms of non-mammal marine life, PCBs are found most abundantly in mussels and fish.

DDT is a globally applied insecticide used particularly to control the spread of malaria by mosquitoes (UNEP 1996). Its use has been banned in western Europe, but some countries bordering the Mediterranean still use it. HCHs are highly soluble and are easily washed out of the atmosphere by rain and then enter aquatic plants and animals.

The most common agricultural pesticides in the region are aldrin, dieldrin and endrin (UNEP 1996). The commonest herbicides are atrazine, simazine, alachlor, metolachlor and molinate. These herbicides wash-out from agricultural land to rivers, ending up in estuaries and the sea. These compounds are mainly transported in their dissolved phase. Levels of polar agricultural herbicides for nine rivers, two Greek gulfs and the northern Adriatic Sea are given by Readman *et al.* 1993 (quoted in UNEP 1996).

Reijnders (1996) and Johnston, Stringer and Santillo (1996) consider the general implications for cetaceans worldwide of POPs and heavy metals, identifying likely impact on reproductive and immune systems – considered further below. (Further information concerning lesser known POPs can be found in Simmonds *et al.* 2001).

Marine Debris

Coastal litter includes (in descending order of abundance): plastics, wood, metal (especially food and drink cans), glass, styrofoam, fishing gear, construction materials, rubber, paper, clothes, cardboard and food (UNEP 1996). Litter that floats depends on density and form. Sea-bed litter includes mainly metal, waterlogged wood, glass, fishing gear and some plastics. Litter comes from domestic and industrial sources and is dumped into the sea or coastal rubbish dumps. Beach users leave considerable amounts on beaches, and vessels often dump their rubbish overboard. As a semi-enclosed sea, the Mediterranean suffers from a higher level of marine litter than other open-sea regions. One special category of marine debris is dumped or lost fishing nets, which may continue to entangle cetaceans (Kemp 1996).

Moscrop (1993) commented that the main concerns for cetaceans arising from plastic debris were entanglement (which impedes movement, causes drowning, leads to starvation or reduced fitness, restricts growth or causes cutting wounds in growing animals) and ingestion (possibly because the animals mistake the debris for an item of prey). Ingested debris can cause death or debilitation by blocking the digestive tract. This may reduce the cetaceans urge to eat, and the amount they eat, leading to weight loss and, potentially, starvation. Some ingested plastics may be a source of toxic chemicals.

Moscrop (1993) provides a few examples of reports of ingestion. Brkan (2001) recently reported the death of a juvenile female ziphiid whale off the coast of Croatia due to the ingestion of four plastic bags.

Another discovery of concern is that ubiquitous plastic resin pellets now found on shores worldwide may provide an important medium for toxic chemicals in the marine environment. Mato *et al.* (2001) showed that these pellets accumulate PCBs and DDE from the wider environment and also contain high levels of nonylphenols. Many species of marine organisms ingest these particles making them a potentially important source of pollutants to such organisms, which include vertebrates. The pellets are a raw material for the plastics industry and enter the environment during manufacture and transport.

Nutrient Pollution

Nutrients are not normally regarded as pollutants, but in high concentrations in sea waters can have harmful affects (UNEP 1996). Human activities are estimated to have caused a five-fold increase in river inputs of nitrogen to the oceans and a four-fold increase of phosphorus. This is a global estimation and it can only be hypothesised that similar figures relate to the Mediterranean. Nutrient levels in Mediterranean rivers are approximately four times lower than those in western European rivers (European Communities 1999). The Aegean Sea receives 11,000 tonnes of phosphorus (Polat and Tugrul 1995 cited in UNEP 1996) and 180,000 tonnes of nitrogen annually from the Black Sea. Some of the nitrogen and phosphorus in the aquatic system has its origin in marine sources in the form of fishmeal used in livestock feeds.

The Mediterranean is a nutrient poor sea and so a moderate amount of nutrient discharge (uncontaminated by toxic wastes) can be beneficial (UNEP 1996). However, if uncontrolled, nutrient enrichment can lead to dense phytoplanktonic blooms which decompose and produce unaesthetic conditions. Increases in the growth of phytoplankton (eutrophication) also reduce light penetration which can affect aquatic vegetation growth. Large amounts of phytoplankton can asphyxiate fish by clogging up their gills and by consuming the oxygen in the water produced by decomposing organic matter. Phytoplankton can also block up fishing nets and engine cooling systems and encourage fish to move to new areas. Certain algal blooms, such as *Noctiluca* and *Pyrodinium*, produce toxic 'red tides'. There is growing evidence that red tides and other toxic algal blooms may be a threat to marine wildlife (Simmonds and Mayer 1997).

Mucilaginous algal events may also devastate marine environments. In these events, algae produce "slime" that typically coats and kills sea bed life. The Adriatic has seen a number of such events in recent years.

In 1983, an area of approximately 250 km^2 was affected by eutrophication and significant oxygen deficiencies in the bottom layer, increased oxygen levels in surface waters and massive "marine snow" development (Stachowitsch 1990). Marine snow stems from photosynthetic extracellular release (PER) by phytoplankton and consists largely of polysaccharides, which are released under phosphorus-limited conditions. Marine snow either rises to the surface or settles on the bottom. After only 2 weeks, very few living organisms were recorded in the area and a layer of decaying material covered the sediment. Repeated disturbances, including marine snow events, renewed anoxias and trawling have prevented recovery in the area.

Oil Pollution

The behaviour and effects of oil in the worlds' oceans vary depending on the type of oil and physical characteristics (including temperature) of the particular environment at the particular time (Howarth and Marino 1991). The levels of dissolved/dispersed oil in sea water range from 0 g/l to 5 g/l, with a few values exceeding 10 g/l (UNEP 1996). Tar in sea water ranges from 0.6g/m^2 to 130g/m^2 and, on beaches, from 0.2 to 4388g/m (using the whole beach along the water edge for the metre measurement). Oil enters marine or fresh water habitats through intentional and accidental discharge and is usually associated with marine transportation as well as terrestrial wastes. It can result in the tarring of marine animals and of fishing gear and the degradation of beach quality.

Three-quarters of the 268 accidents listed by REMPEC between 1977 and 1995 involved oil (European Communities 1999). Between 1987 and the end of 1996, approximately 22,000 tonnes of oil entered the Mediterranean Sea because of shipping incidents. During 1991 alone, over 12,000 tonnes of oil were spilled in the Mediterranean. The majority of oils spilled in the Mediterranean in the last few years have been persistent oils. In 1991, the 'Haven' caught fire off the coast of Italy and the cargo of 144,000 tonnes of crude oil was lost. Most of it burnt out, but it is estimated that over 10,000 tonnes entered the sea itself. In August 1990, the 'Sea Spirit' and 'Hesperus' collided west of Gibraltar, outside the Mediterranean. Currents and winds carried the 12,200 tonnes of crude oil into the Mediterranean.

Feathered and furry vertebrates can be severely affected by oil "fouling". It is unlikely that cetaceans would be affected in the same way but high levels of exposure, long-term or repeated exposure might still result in intoxication or chronic conditions, such as irritation of sensitive tissues (Moscrop 1993). The principal concerns for cetaceans would seem to be exposure to the most toxic components of recently spilt oil and also the effect oil can have on their prey.

Radioactive Contaminants

Radioactive contamination does not appear to be a significant problem in the Mediterranean (European Communities 1999). In surface waters the levels of ^{137}Cs (Caesium) and $^{239, 240}$Pu (Plutonium) are decreasing. These radionuclides come from past nuclear weapons testing and the Chernobyl accident. However, cetaceans may accumulate radioactive substances and little (if anything) appears to have been done to calculate levels in their tissues in this region.

Biological/Genetic Pollution

Maritime trade has helped to move marine species from their native habitat to new areas, mainly through the intake and discharge of ballast water from tankers (Kemp 1996). It has been estimated that there are 300 non-indigenous species in the Mediterranean. Most of these have entered from the Red Sea via the Suez Canal. *Caulerpa taxifolia* was allegedly introduced to the Mediterranean in the mid-1980s and, by 1996, covered 1500 hectares of sea-bed along the coast between Toulon, France and Imperia, Italy (Kemp 1996). They seem to interact with the native *Posidonia* beds, which are the natural habitat for hundreds of species of fish.

Cetacean Specific Aspects

There is considerable interest in the development of "biomarkers" to evaluate the risk of pollution exposure in cetaceans and other species. The IWC, for example, has a current programme of investigation underway ("Pollution 2000+") into the significance of pollutants for cetaceans based on this methodology. "Biomarkers" are biochemical or other physiological changes that can be monitored (typically by biopsy or blood sampling) and which indicate that pollution exposure is causing a significant response. Fossi *et al.* (2001) have recently commented on some preliminary studies in the western Ligurian Sea. Biomarker effects were noted in the small cetaceans and fin whales sampled. The use of biomarkers for cetaceans is discussed in Peakall (1999) and Fossi (1998).

In the Mediterranean, cetaceans are amongst those species most highly contaminated by toxic substances such as PCBs, DDT and mercury and other heavy metals (UNEP 1996). As marine top predators in a polluted environment, they are exposed to high levels of persistent and bioaccumulative compounds, mainly via their diet (Colborn and Smolen 1996).

All cetacean calves tend to ingest high concentrations of contaminants through their mother's milk, which is rich in lipids. Baleen whales may be particularly vulnerable during the periods of gestation and lactation because of their rapid development and because their mothers fast during these periods (Colborn and Smolen 1996). Aguilar *et al.* (1982) commented that the "special characteristics" of the Mediterranean make the organochlorine pollution problem more acute.

In the western Mediterranean, striped dolphins (*Stenella coeruleoalba*) have been found carrying extremely high levels of DDTs and PCBs (in fact the highest recorded in a living wild mammal) and moderate to high levels of heavy metals, particularly mercury and selenium (Aguilar 1997). It is likely that these pollutants affect the immune system making the animals more susceptible to disease, such as the 1990-1992 epizootic. This is further discussed below.

There is also a range of chemical compounds, which has not traditionally been considered in analyses of cetaceans tissues. These compounds include the polybrominated compounds (which are chemically similar to the better known PCBs) and the organotins. Focardi *et al.* (2000) have provided the first report of organotins in Mediterranean dolphins. Levels reported in Mediterranean striped dolphins were higher than those reported from *Stenella* species elsewhere in the world. Focardi *et al.* commented that TBT (tributyltin – an antifoulant used in boat paints) – "in addition to certain organochlorines (PCBs, DDTs) may cause immune suppression in dolphins, making them more susceptible to infectious diseases, although this link is yet to be well established."

Data concerning cetacean tissue contaminant concentrations can only shed a little light on potential consequences for the animals concerned. In order to try to evaluate the full significance of the high levels reported, we need to consider research conducted outside of the Mediterranean and on other species. For example, despite their ability to sequester mercury in the liver, some very high mercury levels have been related to liver abnormalities in Atlantic bottlenose dolphins, *Tursiops truncatus* (Rawson *et al.* 1993). More subtle 'signals' of physiological malfunction are also being sought.

Reijnders (1996) provided an overview of likely effects of organic contaminants, which can be summarised as:

- Induction of metabolisation systems which affects metabolism and toxicokinetics of other contaminants; and
- Inhibition of receptor functions by competition for binding sites.

In fact, a number of organochlorine chemicals, including DDT/DDE, are well known disrupters of the endocrine, immune and nervous systems across a range of species (see reviews by Colborn and Smolen 1996 and Reijnders 1996).

The spate of large-scale mortalities that has occurred in marine mammals in recent years has generated considerable interest and new research into immune function and disease in these animals (see Simmonds and Mayer 1997 and Lahvis *et al.* 1995). In an unusual study, where blood was sampled from free-ranging bottlenose dolphins in Florida, USA, a correlation was found between a reduced immune function and concentrations of several contaminants (Lahvis *et al.* 1995).

However, whilst there is widespread concern at the very high levels of organic pollutants found in cetaceans world-wide (with particular focus on the high levels found in small cetaceans living near industrialised coasts), the concentrations at which physiological impacts might start remain controversial.

O'Shea and Brownell (1994) reviewed organochlorine and metal contamination in baleen whales and commented on the conservation implications of these pollutants. Most blubber residue concentrations were typically less than 5ppm, and although sample sizes were generally very small some higher values were recorded. The authors suggested that such levels were unlikely to be "important factors influencing the status and conservation needs of baleen whales." Weisbrod *et al.* (2000), who considered organochlorine exposure in the endangered Northwest Atlantic right whale, *Eubalaena glacialis*, took much the same view. However, such a conclusion now stands to be reassessed in the light of the approaches being applied to other mammals, including humans, and of new toxicological data.

Weisbrod *et al.* (2000) reported total PCB values of 5.7 +/- 8.9 ppm lipid weight and total pesticides of 11.4 +/- 15.4 ppm lipid weight. They compared the total PCB (TPCB) concentrations in right whale biopsy samples with those determined in captive seals, free-ranging seals, and beluga whales, *Delphinapterus leucas*, where – in each case - pollution-related effects have been recognised. In these animals, blubber TPCB concentrations of >20 ppm fresh weight correlate with immune problems and >60 TPCB ppm fresh weight with endocrine and other alterations. If one takes the lower limit (20ppm) as indicative of a level at which physiological problems might start, the observed mean and range of concentrations in the right whales (5.7 +/-8.9 ppm), may not be sufficiently removed from this limit to safely assume that the population is not being impacted. Mink are typically used as pollution exposure models for other wildlife and a biological impact can be found at a concentration as low as >0.02 µPCB/g (Kannan et al 2000). Simmonds (in prep.) discusses these matters further.

Climate Change

The potential impacts of climate change include drought, decline of water quality, floods, desertification, soil erosion, storms, coastal erosion, alteration in seawater temperature/salinity, the rise of sea levels and a reduction in biodiversity (European Communities 1999). Climatic change could cause chemical changes in the marine environment. For example, an increase in atmospheric CO_2 could lead to increased acidity of sea water (MacGarvin and Simmonds 1996). Because of their small size, relatively slow circulation and low level of riverine input, the Mediterranean and Black Seas may be particularly vulnerable to nutrient balance changes relating to climate change.

A mean sea level rise in the Mediterranean region, comparable to a global mean of 96cm by 2100 has been predicted (Jeftic *et al.* 1992, Warrick *et al.* 1996 cited in European Communities 1999). This is based on past trends and projected global increases given by the Intergovernmental Panel on Climate Change's (IPCC) mid-range scenario (European Communities 1999). The areas that will be badly affected include Venice and the river deltas of the Nile and Thessaloniki where subsidence is already occurring. Sea level rise may be lower in the Near East and Alexandria because the land there seems to be rising (Karas 1997 cited in European Communities 1999). The consequences of sea level rise will include an increase in the impact waves have on exposed coasts and harbour installations, increased flooding of estuaries, canals and lagoons and worsening of shore erosion problems (European Communities 1999). Pollution may also be made worse if waste tips and other polluted disposal sites become inundated. During the 20^{th} century, a 30cm rise in relative sea level has contributed to the problems of flooding and damage to the medieval city of Venice (Beniston and Tol 1998). Sea-level rise contributes to beach erosion, which can be a problem in areas where beaches are used recreationally and can increase the likelihood of waves and floods affecting areas of human activities near to the coast.

Increasing seawater temperature can cause changes in Mediterranean biodiversity patterns (Francour *et al.* 1994 cited in Bianchi and Morri 2000). The area of the Mediterranean known as the Ligurian Sea has colder waters than most of the Mediterranean and, therefore, hosts species that favour cold temperate waters (Bianchi and Morri 2000). However, these waters have recently been found to be getting warmer and more warm water species have now been found in this area.

In the eastern Mediterranean, Aegean waters have replaced Adriatic waters in the bottom layers and it is suggested that "this salinity-induced influx resulted from changes in either circulation pattern or large-scale freshwater balance and thus may have a regional climate component" (IWC 1996).

A sea-level rise of 40cm is projected at the delta margins of the rivers Nile, Rhône, Po and Ebro by 2100 AD (Stanley 1997). Potential impacts of climate change in specific areas of the Mediterranean Basin were studied under the UNEP Mediterranean Action Plan (European Communities 1999). The main impacts predicted include coastal erosion, increased salinisation of coastal lakes, rivers and aquifers, increased flooding, decreased soil moisture and fertility and increased soil erosion and salinity. The increased flooding or loss of wetlands is expected in the Deltas of the Ebro (Spain) and Rhône (France) and at Ichkeul-Bizerte, Tunisia. Reduced fisheries yields are predicted in the Deltas of the Ebro and Nile (Egypt). The Rhône delta may see a reduction in agricultural land and an increase in the impact of waves. Dunes are likely to become destabilised in the deltas of the Rhône, Po (Italy) and Nile. The Po delta and Thermaikos Gulf in Greece are likely to see a reduction in the oxygen levels in bottom waters. The tourist season would potentially be extended in areas such as the Thermaikos Gulf, Rhône delta, Cres-Lolinj (Croatia) and the Albanian coast. The Maltese Islands could lose freshwater habitats and the summer drought on the Albanian coast and in Fuka-Matrouh (Egypt) could be extended. Other potential impacts include coastline reshaping, damage to port and coastal city infrastructures, reduced near-shore water mining and primary production and an increase in the incidence of forest fires.

Cetacean Specific Aspects

MacGarvin and Simmonds (1996) commented that "many marine organisms are only able to exist within a certain range of conditions and may not be able to move or adapt if conditions change." Species with a narrow geographical range, such as those living in estuaries, may be particularly susceptible to such problems especially as they are often unable to move through fully saline water to new habitats. Cetaceans are typically regarded as wide-ranging, but they may need to meet particular demands of their biology in particular areas or within certain ranges. Access to adequate prey (in terms of quality as well as quantity) being one example.

Bottlenose dolphins (at least in Northern Europe) appear to have been commonly reported in estuaries (Simmonds 1994) and this may be because of the high productivity of such waters. Anything that affects prey abundance may be expected to affect predators including cetaceans (Agardy 1996). MacGarvin and Simmonds (1996) suggested that "decreases in marine productivity could be caused at the base of marine food webs by changes in water temperature, turbulence, surface salinity and/or nutrient concentrations." Most studies considering climate change impacts on fisheries assume that global warming will decrease the production of surface layer phytoplankton in some coastal areas (Agardy 1996). This will have a knock-on effect on the zooplankton and plankton-feeding fish (MacGarvin and Simmonds 1996). Plankton changes can be expected to affect commercial and non-commercial fish stocks.

Global warming can lead to changes in estuarine salinity which can affect fisheries production in the coastal zone (Agardy 1996). Changes in currents may cause increased pollutant loading and decreasing food quality. Fish and other marine life could be affected by climate change in a number of ways, both positive and negative. They may experience a longer growing season, lower natural winter mortality and faster growth rates. On the other hand, alterations to established reproductive patterns, migration routes and ecosystem relationships, could have negative consequences (IWC 1996).

Climate changes can be expected to cause significant alterations in physical oceanography and the location of features such as water currents which could threaten whale migration patterns if the whales use such features to aid navigation (Emery and Aubrey 1991 cited in Agardy 1996, MacGarvin and Simmonds 1996).

Global warming will affect weather patterns and could lead to increased or decreased rainfall in coastal areas. This will mean increased or decreased levels of run-offs and pollutant loading, potentially leading to reduced water quality in nearshore areas (Agardy 1996). Increased turbidity and decreased water quality can be expected to have a negative impact on coastal cetaceans. Even cetaceans that spend little time in nearshore areas, breed and calve in coastal areas and so will also be affected by increased pollutant levels.

The warming of tropical waters increases the incidence and rate of transmission of pathogens, making cetaceans vulnerable to disease and immune system stress (Agardy 1996). Along with increased pollutant loading and the bioaccumulation of organochlorine and other toxins, this could have a potentially cumulative effect, causing reproductive failure in whale species that are slow to reproduce (Marine Mammal Commission 1996 cited in Agardy 1996).

Global warming may have even more subtle influences such as affecting the transmission of sound, in areas used by whales for communication, by causing changes in current patterns (Agardy 1996).

One factor that may directly exacerbate the effects of climate change is ozone depletion. Whilst ozone thinning is concentrated in polar regions, there is a general depletion world-wide. Ozone depletion causes increased ultraviolet (UV) radiation which will affect cetaceans by changing food abundance, distribution and quality (Agardy 1996). The increase in UV-A and UV-B radiation may also cause cancer in whales or make them more susceptible to disease. It has also been suggested that ozone-related exposure to high radiation levels can cause immune system suppression. There are no records of direct cetacean health problems caused by exposure to UV-B radiation but the link between UV and skin cancer, optical problems and other health problems has been established for some terrestrial mammals (reviewed in IWC 1996). Cetaceans with little skin pigmentation living in areas subject to the occurrence of holes in the ozone layer, may be directly affected by exposure to UV-B radiation (IWC 1996).

MacGarvin and Simmonds (1996) note that the following climate change related factors as likely to affect whales:

- Overall reduction in productivity; and
- Possible shifts in the distribution of prey.

In addition, they add that ozone depletion (causing increased UV radiation) will affect phytoplanktonic species' community composition, as well as being expected to have a negative impact on overall productivity.

They also noted that the apparent rate of climate change is likely to be outside the "evolutionary experience" of existing cetacean species (see also Simmonds and Mayer 1997) and that whale species with complicated life cycles (e.g. long migration routes) are dependent on finding particular resources (which may include particular temperature regimes such as warmer waters for breeding) in particular locations. Climate change related problems might be exacerbated for whales where populations are already at a low level and being significantly negatively impacted by other factors. Agardy (1996) stressed, in addition, that changes in food distribution may mean that whales will have to use more of their energy finding food

Climate-related effects may combine with other factors such as pollution and disease to have significant impacts on cetacean populations. For example, it has been postulated that an unusually warm dry winter precipitated the striped dolphin mortality in 1990-1992 (Simmonds and Mayer 1997). (This is discussed further in the conclusion).

Land based changes

Agriculture

Agriculture in the Mediterranean drainage basin aims to provide enough food for the resident and tourist populations but the growth of urbanisation and the expansion of some forms of industry in the coastal zone have led to a decline in agriculture (UNEP 1996, European Communities 1999). UNEP presently puts the percentage of agriculture in the Gross Domestic Product of the basin as a whole at under 20% and states that food supply from domestic agriculture is falling behind the requirements of population and economic growth.

The traditional techniques of terracing coastal slopes and transporting topsoil upland to prevent soil loss to the sea are not practised so commonly today. This contributes to soil erosion, as does overgrazing and even the annual growth and harvesting of agricultural crops (which prevents the soil from developing a wind or rain resistant structure). The nature of local agricultural practices, with land being divided between a number of different landowners, also makes soil conservation much harder. Run-off waters transport sediments into rivers and ultimately the Mediterranean Sea.

Intense agricultural activity is carried out in the limited coastal plains, often as a result of reclamation of wetlands (European Communities 1999). Agriculture has a more indirect affect on the Mediterranean basin than direct, affecting in particular nutrient inputs and regional weather conditions.

Agricultural activities - such as irrigation, cultivation, pasture, dairy farming, orchards and animal feedlots - are all indirect sources of water pollution (European Communities 1999). Phosphorus, nitrogen, pesticides, metals, pathogens, salts and trace elements enter ground waters, wetlands, rivers and lakes with their final destination being the sea.

The World Bank Social Indicator of Development survey 1996 shows that the use of fertilisers in Egypt, Israel and Cyprus was higher in 1993 than in countries where agricultural practices are more advanced, e.g. in France, Spain and Italy (European Communities 1999). The intensive use of pesticides, including insecticides, herbicides and fungicides has a debilitating effect on ground and surface waters, human health and ecosystems (European Communities 1999). Pesticides reach the marine environment via the atmosphere and through rivers. The Rhône in France, the Ebro in Spain, the Po in Italy, the Axios, Loudias and Aliakmon in Greece and the Nile in Egypt are all responsible for agricultural pollution entering the Mediterranean. Pesticides not only enter through agricultural use but also from industrial discharges where pesticides are being produced.

The largest amounts of pesticides used in the north-western area of the Mediterranean countries, as reported by Fielding *et al.* in 1991 (cited in European Communities 1999) are: 36000 tonnes in France (1990); 33000 tonnes in Italy (1987) and 23700 tonnes in Spain during 1989. In the eastern Mediterranean, Turkey used 34400 tonnes in 1989, Greece 8080 tonnes in 1989 and Yugoslavia used 3300 tonnes in 1992. On the African side, Algeria used 5950 tonnes in 1993, Egypt 13200 in 1990 and Morocco 9400 in 1989.

Industrial Activities

Industry not only occupies land area but uses the land, rivers and sea to dispose of wastes (European Communities 1999). The Mediterranean basin is host to a number of different industrial activities. Some of the main industrial sectors are chemical/petrochemical and metallurgy sectors as well as the treatment of wastes and solvent regeneration, surface treatment of metals, production of paper, paints and plastics, dyeing and printing and tanneries.

The Mediterranean basin has oil and gas refineries in a variety of locations and, as well as dredging for gravel and sand, the drilling for oil and gas is the main reason for submarine mining (European Communities 1999). In 1997, there were 40 major oil refineries in the Mediterranean Region with a combined capacity of over 685,500 billion barrels per day. Industrial developments on the coast of the Mediterranean, also include power-generating plants and desalination plants (UNEP 1996). They use water from the Mediterranean for cooling processes and discharge their waste water into the sea.

Industry can have a direct impact on coastal areas in terms of pollution caused by effluents and air pollution. Indirectly the location of industrial activity attracts further urban and industrial development (European Communities 1999).

Forests

The forests of the Mediterranean coastal region counteract erosion by stabilising soil distribution (UNEP 1996). They also serve as relatively protected, semi-enclosed ecosystems which can conserve genetic resources. However deforestation (caused by massive logging, over use by grazing herds, environmental impacts such as acid rain and increased incidence of forest fires caused by increases in tourism and recreational use of the forests) has become a problem in the area. Deforestation encourages soil erosion and introduces irregularities into the natural system of run-off. Increased sediment loads entering rivers affect species living in estuaries and anadromous species such as salmon. Intensive agriculture has helped allow reforestation to take place in some areas because marginally exploitable land is abandoned.

Cetacean Specific Aspects

Any developments that affect pollution discharges to the Mediterranean or its nutrient balance may affect cetaceans. As noted earlier, as marine top predators they are especially vulnerable to the accumulation in their fatty tissues of certain pesticides, PCBs and similar compounds, and to changes in prey availability and quality.

Coastal development

Urbanization

The rate of urbanisation is following the population trend by increasing steadily (European Communities 1999). In 1965, there were 26 Mediterranean cities with populations of over 750.000 and this had increased to 32 by 1990. The Lebanon provides a telling example where the rural population made up 50% of the country's total population in 1965 and only 13% of the population by 1995. Each year, large numbers of tourists visiting the Mediterranean coastal regions contribute to a significant, if temporary, growth in the population. In 1990, 135 million tourists visited the coastal region and it is estimated that between 235 and 355 million will visit in 2025.

Urbanisation has mainly developed around coastal settlements and ports (UNEP 1996). A decline in the agricultural population and an increase in urban populations have contributed to continuing urbanisation of the coastal area. Such development involves building and public works, energy generation and consumption, transport needs, waste management and so forth.

Urbanisation involves the horizontal use of land with building taking place on agricultural and rural land thus placing pressures on local food production for the increased population (UNEP 1996). In the coastal area, land is built on which might otherwise be designated as a conservation area or used recreationally. Urbanisation also uses land vertically, with the building of skyscrapers, which causes further local water supply and sanitation problems and the creation of microclimates in large cities.

Ensuring adequate water supply can be a problem with increased urbanisation (UNEP 1996). Urbanisation also means an increased use of concrete which prevents rainwater from entering the soil and natural underground water systems and forces it into rivers which can lead to more flooding incidents. Traffic and industry create noise and air pollution in urbanised areas. Coastal construction has an impact on local marine ecosystems especially by altering the drainage and sedimentation pattern in the coastal zone (UNEP 1996).

Population movement to urban centres places a strain on labour and housing markets, public services and efforts to conserve the historical, cultural and architectural heritage (UNEP 1996). Some coastal areas are mountainous and so expansion opportunities are limited which means that increases in the population of towns or cities with limited space can intensify all of these problems.

Major road building has probably peaked in northern Mediterranean countries though there may be more developments in the southern countries (UNEP 1996). Roads may use valuable agricultural or horticultural land and disturb local flora and fauna. Roads attract further development including petrol stations, shops and hotels. Railways have similar effects but are less polluting than road traffic and are more economical energy users. Air transport, notably used to transport tourists between their countries of origin and the Mediterranean, causes air pollution and noise (which affects humans, local fauna and domestic and farm animals).

Tourism

Coastal development is greatly encouraged by tourism especially in regard to the construction of hotels, restaurants, shopping centres, sport facilities, marinas, public services and buildings (UNEP 1996). Tourists can multiply a resort's population several times during the holiday season. This places pressure on local authorities regarding sewage treatment and disposal in particular.

Industry

Industries which need cooling water or receiving water for disposing of wastes prefer to site themselves on the coastal zone (UNEP 1996). Between 1950 and 1980 there was significant development on the northern coastal zone of the Mediterranean, especially in France and Italy. Spain, Turkey, Syria and Egypt followed suit with more modest developments.

Dam Construction

Damming along many of the rivers draining into the Mediterranean has caused a loss of sediment supply to the continental margin during the past few decades (Maldonado 1997). Along with a decline in water discharge, a decline in sediment supply causes delta erosion, salt water intrusion and cropland destruction. Up to 75% of sediment yield in some Mediterranean rivers has been altered as a result of changes induced between river headwaters and the coast (Woodward 1995 cited in Stanley 1997).

Cetacean Specific Aspects

Any coastal development that changes the coastal marine environment – either directly, for example in construction work or indirectly by otherwise affecting other marine life - may have knock-on effects for cetaceans. Whilst those animals that have habitats that include inshore areas may be most vulnerable, inshore areas frequently serve as nursery grounds for fish species and prey may therefore be vulnerable. Kemp (1996) provides a useful review.

Other direct uses of the Mediterranean

Maritime Traffic

It is estimated that approximately 220,000 vessels of over 100 tonnes cross the Mediterranean every year (European Communities 1999). This accounts for 30% of the total merchant shipping in the world and 20% of oil shipping. Every day, about 2000 vessels cruise the Mediterranean, of which up to 300 are oil tankers. There are, on average, 60 maritime accidents in the Mediterranean every year 15 of which involve oil or chemical spills (UNEP 1996). According to REMPEC approximately 200 ferries and passenger vessels are at sea in the Mediterranean at any one time (UNEP 1996). The noise that this creates and its potential to affect cetaceans is discussed in another chapter.

Fishing/Aquaculture

During 1984, 1.1 million tonnes of marine fish, molluscs, crustaceans and anadromous fish were caught by Mediterranean countries (European Communities 1999). This increased to 1.3 million tonnes in 1996. The production of mariculture (marine aquaculture) also increased during that time from 78,180 tonnes in 1984 to 248,460 tonnes in 1996, largely due to the development of cage technologies. Increasing demand for food in the region and decreasing success of fishing fleets might help to explain this growth in fish farming. Fish farmers and marine mammals often come into conflict (see Ross 1988 for a review), principally because these marine top predators may learn to forage at the farms.

Observations carried out in the eastern Ionian Sea along the Greek coastline during summer 2000 followed the daily movements of bottlenose dolphins (Bearzi *et al.* 2001). 5.7% of the observed groups were seen foraging near fish farm cages moored along the coastline for 4.9% of the total observation time (55 hours 33 minutes). The dolphins did not necessarily approach when the farmers were feeding their fish. The increase in nutrient levels caused by fish farming and the provision of food bait in the proximity of the cages were implicated in attracting bottlenose dolphin prey.

Bearzi *et al.* (2001) suggested that coastal fish farming provided a new food source for the local "malnourished" dolphins that were otherwise competing for food with fishermen and other species. At this time, local fishermen claim that the dolphins cause neither direct nor indirect damage to the farming activities, to the caged fish, nor to the cage structures. However, this should be carefully monitored.

The impacts of incidental capture of cetaceans in fishing nets are considered in another chapter.

Cetacean Specific Aspects

Boat disturbance/collisions. One cetacean-specific result of the increasing human population in the Mediterranean, and particularly boat-based touristic activities will be collisions with cetaceans. This is considered further in another chapter. However, by way of an example, we note that of 380 fin whales (*Balaenoptera physalus*) identified during a study conducted between 1990 and 1999 in the summer months, 22 (5.8%) had scars or marks, 15 of which were caused by collisions with boats i.e. 68.2% of the injured whales (Pesante *et al.* 2001). The causes of the injuries on the remaining 7 whales (31.8% of the injured whales) could not be confirmed. As photo-identification of fin whales focuses on the dorsal fin and right side of the animal, scars on other parts of the animals would not have been seen or recorded, so incidence of collision with boats could be much higher. The whales included in this study had survived their collisions. The Italian Stranding Network reported 10 fin whales killed because of boat strikes during 12 years (Centro Studi Cetacei 1986-1997, cited in Pesante *et al.* 2001).

Jahoda *et al.* (2001) have recently reported on responses of fin whales to boat disturbance and tracked the whales using a laser range-finder.

A gross example of boat-based harassment of cetaceans was reported by Miragliuolo *et al.* (2001) to the recent European Cetacean Society Conference. The event took place near the Cuma marine canyon off the Island of Ischia, Italy. A group of Risso's dolphins of 6 adults and 3 calves – which seem to be seasonally resident – "became the target of an ever-increasing number of pleasure boats" in August 2000. The group was eventually "penned" in a bay where about 400 boats were anchored. Between 1pm and 3.20pm the dolphins were surrounded by up to 100 boats with their engines turned on – in a sea depth of only 3 metres. The researchers commented that "all group members showed clear signs of distress and seemed to be unable to orientate. High-speed erratic swimming, collisions with each other, spinning and swimming in circles with short interblow intervals were recorded." They were eventually able to leave the bay after an area was cleared of pleasure boats, but "this kind of dramatic human-dolphin interaction is becoming everyday routine in the busy summer months." The researchers also note that productive submarine canyons may be important in nearshore abundance of cetaceans. This illustrates again the need to better define cetacean habitat needs.

Prey depletion. Further evidence that prey is likely to be affecting cetacean diversity comes from recent and very unusual observations of malnourished bottlenose dolphins in the Eastern Ionian Sea. 11 out of 28 bottlenose dolphins (*Tursiops truncatus*) were classified as "skinny" based on the visibility of their ribs (Politi *et al.* 2001). The authors suggest that this malnutrition could be due to the over-exploitation of fish stocks by trawling fisheries or competition for food with a community of short-beaked common dolphins (*Delphinus delphis*) living in the same area. The researchers note that "Critical habitat requirements…must be assessed to ensure the survival of this coastal dolphin community."

Sightings data have indicated an overall decrease in cetacean diversity and density in the Northern Adriatic where the Tethys Institute has been studying them for 13 years (Bearzi *et al.* 2001). It is suggested that food resource reduction and "dramatic fluctuations" of their prey may provide the primary explanation, alongside pollution, in this degraded sea area.

Conclusions

Critical Habitat

It is clearly very difficult to identify with any degree of certainty which environmental factors are most likely to be causing changes to conservation status when so many may combine to affect cetaceans. Figure 7.1 illustrates the range and levels of interaction of environmental factors. Note that at the level immediately above measurable changes in cetaceans demographics, three "mediators" are identified: "energy intake" (relating to all factors that affect availability, quantity and quality of food); "physiology" (relating to health and reproduction); and "behaviour" (and here the primary concern is disturbance). The future research that is needed to help unravel the habitat-related vulnerabilities of the cetaceans will need to focus on understanding and interpreting these "indicators", as well as defining and measuring critical habitat.

Scientists meeting under the auspices of the IWC's scientific committee have recently been giving consideration to how to evaluate the importance of habitat changes to cetaceans (IWC 2001). The scientists have been considering how to achieve a better understanding of what constitutes the "critical habitat" for cetaceans, how to measure important habitat variables and how to apply models and statistics to them.

Energy Intake. Several examples reviewed above indicate that prey changes are already causing problems for the Mediterranean's cetaceans.

Physiology. Cetaceans reproduction impairment and immune dysfunction have yet to be directly related to environmental change in the Mediterranean. Yet it seems inevitable that they are being affected by the very high contaminant burdens reported from some populations. Early indications from biomarker application support this. Concerns should even extend to the less contaminated baleen whales.

Behaviour. A lot of human activities introduce noise into the marine environment. This can increase with increased numbers of boats related to coastal (including tourist) development and inshore and offshore industry (for example, fish farming or fossil fuel prospecting and extraction). Gordon and Moscrop (1996) provide a useful review. The military use of "active" sonar has recently become an issue of concern and several recent reports in the Mediterranean consider this (Frantzis 1998, Nascetti *et al.* 1996, Rendell and Gordon 1999). Noise is considered further in a separate chapter.

Mass mortality of cetaceans

It is clear that there is an increasing appreciation of the need to understand the nature and synergistic potentials of the environmental factors affecting cetaceans. Witness to this are statements from appropriate international bodies such as UNEP (see for example UNEP 2001) and the awarding of important research awards to scientists working in this important and novel topic area, including Mediterranean scientists (see for example Robinson 2001).

As a final example of both the complexities and the synergies affecting Mediterranean cetaceans, this chapter considers here the 1990-1992 dolphin epizootic.

The extent, duration and severity of epizootics affecting marine mammals may be influenced by pollution, climatic conditions, high population density, and changes in species distribution, as well as the nature of the disease concerned (Simmonds 1992). The Mediterranean provides one of the best examples, to date, of such a phenomenon and this may also serve as a warning for cetacean conservation in the region. The striped dolphins that died during the 1990-1992 epizootic had, on average, higher levels of organochlorine pollutants than those that survived (reviewed in Simmonds and Mayer 1997). The pollutants may have suppressed their immune systems and made them less able to resist the disease. Earlier studies had found average blubber concentrations of 326ppm whereas dolphins from the 1990 epizootic had values exceeding 2500ppm. Kannan *et al.* (1993) considered this in some detail. They commented that "given the extremely high concentrations of PCBs, including the non- and mono-ortho coplanar congeners and of DDT, in striped dolphins affected by the western Mediterranean morbillivirus epizootic, it can be concluded that these pollutants have probably played a role in immuno-suppression. The mono-ortho congeners exert potential long-term toxic effects on marine mammals and they need to be monitored closely in the future."

Of the dolphins that died many had depleted body fat reserves (Aguilar *et al.* 1992). Similarly, an increased number of ectoparasites and epizoites on some of the diseased animals suggested a period of debility and slowed movements (Aznar *et al.* 1994). Aguilar and Raga (1993) suggested that abnormal water temperatures recorded during the winter of 1989-1990 had resulted in reduced marine productivity and therefore a reduction in the abundance of the dolphins' normal prey which accounts for the poor body condition of many of the diseased dolphins. Mobilisation of lipids from blubber generally causes an increase in the concentration of contaminants in the blubber tissue and enhanced organochlorines in circulation (Aguilar 1987). Reproduction may also be compromised by the accumulation of pollutants and therefore, population recovery may be delayed or impossible (Simmonds and Mayer 1997). Munson *et al.* (1998) reported that in addition to high numbers of aborted dolphin foetuses recorded during the epizootic, unusual cystic structures were present in the ovaries of several morbillivirus-infected dolphins with high PCB levels. These "luteinized cysts" occur when ovulation is impeded, which may have been an effect of the infection or could have been induced by PCBs or similar compounds. (Increased levels of PCBs could affect hypothalamic/pituitary function or ovarian responsiveness.) Munson *et al.* noted that such cysts may impede population recovery if found in the surviving dolphins.

Simmonds (1992) commented that "morbillivirus infections are generally fast-acting but the dolphins seemed to have been in poor condition for some time prior to the infection" and summarised the possible relationship between pollution and cetacean epizootics in six key points:

- organochlorines affect the immune and reproduction systems;
- marine mammals accumulate organochlorines in their ample fatty tissues and pass them in substantial quantities to their young;
- marine mammals (particularly small cetaceans) seem to be even more vulnerable to organochlorines than terrestrial mammals;
- sick marine mammals are likely to mobilise their lipid stores – thereby releasing extra quantities of organochlorines into their disease-stressed bodies;
- the frequency of marine mammal die-offs seems to have increased in recent years and they appear to be centred along highly industrialised coasts; and
- levels of implicated substances (i.e. PCBs) are set to increase in coastal waters.

Figure 7.2 shows a schematic of how the Mediterranean epizootic may well have developed and how environmental factors might affect the recovery of the population.

This leads us to our final conclusion with respect to habitat changes. Whilst many changes might be expected to have slow chronic effects on cetaceans and other marine wildlife, it seems likely that synergies will develop between environmental stressors that cause a more rapid reaction. Sometimes populations may be overwhelmed by environmental threats and changes, leading to a swift and deadly outcome, as in the case of the striped dolphin. We do not know precisely how many dolphins died in the epizootic but hundreds of sick and dying animals were recorded on coasts in the western Mediterranean. Over the course of several years the epizootic moved eastwards and affected striped dolphins throughout the region. Monitoring was less easy to the east and a total body count cannot be made.

Marine habitat degradation can only have a negative effect on cetaceans. It is an important reason for their enhanced protection and the development of carefully enforced protected areas that recognise their habitat needs. We should learn the lessons provided to us by the situation of the Mediterranean monk seal now poised on the brink of extinction. If not, the Mediterranean's cetaceans may follow suit.

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Table 7.1 - Recent papers concerning contaminants in cetaceans

Species	Location	Contaminants considered	Organs considered	Reference
Striped dolphins	Mediterranean coasts of central and northern Spain and Balearic Islands	PCBs	Blubber	Aguilar and Borrell (1994)
Striped dolphins	Mediterranean	DDTs, PCBs, mercury, selenium		Aguilar (1997)
Striped dolphin	French Mediterranean coasts	Mercury	Blubber, melon, muscle, skin, brain, heart, kidney, liver, lung, testicles	Augier *et al.* (1993)
Striped dolphin	Mediterranean	PCBs	Blubber	Borrell (1996)
Common dolphin	Western Mediterranean, off Spain	HCB, DDTs, PCBs	Blubber	Borrell *et al.* (1999)
Fin whale	Western Ligurian Sea	Organochlorine contaminants, PCBs, DDT, DDD, DDE	Subcutaneous tissue from the dorsal area	Focardi *et al.* (1991)
Striped dolphin, Bottlenose dolphin, Common dolphin	Western Italian and Greek coasts	BT, TBT, MBT, DBT	Liver, kidney, foetus	Focardi *et al.* (2000)
Bottlenose dolphin, Common dolphin, Striped dolphin, Pilot whale, Risso's dolphin	Corsican Coast	Mercury	Lung, liver, kidney, skin, muscle, bone	Frodello (2000)
Common dolphin	Coast of Andalusia	Heavy metals, organochlorine residues	Liver, kidney, brain	Garcia-Fernandez *et al.* (1999)
Striped dolphins	Northeastern Spanish coasts	PCBs	Melon, cerebrum, cerebellum, lung, liver, kidneys, skeletal muscle	Guitart *et al.* (1996)
Fin whale	Valencian Coast	PCBs, OPs, heavy metals	Blubber, liver, kidney	Hernandez *et al.* (2000)
Striped dolphin, Bottlenose dolphin, Fin whale, Risso’s dolphin, Pilot whale	Italian Coasts, Tyrrhenian Sea, Adriatic Sea, Ligurian Sea	PCDD, PCDF	Liver	Jimenez *et al.* (1999)
Striped dolphin, Bottlenose dolphin, Risso’s dolphin, Pilot whale, Long-finned pilot whale	Italian coasts – Tyrrhenian Sea, Adriatic Sea, Ligurian Sea	PCDDS, PCDFs, PCBs	Liver	Jimenez and Gonzalez (2000)
Striped dolphins	Northeastern Spanish Mediterranean coasts	PCBs, DDT	Blubber	Kannan *et al.* (1993)
Bottlenose dolphins	Italian coast, Adriatic Sea	TBT, MBT, DBT	Liver, blubber	Kannan (1996)
Striped dolphin, Fin whale, Common dolphin, Bottlenose dolphin	Ligurian Sea, Tyrrhenian Sea, Ionian Sea,	DDTs, PCBs	Blubber, skin,	Marsili *et al.* (1996)
Striped dolphins	Coasts of Italy	HCB, DDT, PCBs	Blubber, liver, brain, muscle	Marsili *et al.* (1997)
Fin whales	Mediterranean	PCBs, DDT,	Skin biopsy	Marsili *et al.*

		BPMO		(1998)
Striped dolphins	Coasts of Italy	HCB, DDT, PCBs		Marsili *et al.* (1998)
Striped dolphin, Bottlenose dolphin, Fin whale, Risso's dolphin, Rough-toothed dolphin, Pilot whale	Italian coasts	HCB, DDTs, PCBs, chlorinated hydrocarbon	Blubber, muscle, melon, brain, heart, liver, kidney, testicles, mammary glands, milk	Marsili and Focardi (1996)
Fin whales and Striped dolphins	Mediterranean	PCBs, DDTs	Blubber	Marsili and Focardi (1996)
Striped dolphin	Spanish and Italian coasts Tyrrhenian and Ligurian Seas	Cadmium, copper, Mercury, selenium, zinc	Skin biopsies, muscle, liver, kidney, brain	Monaci *et al.* (1998)
Striped dolphins	Italian coast	PCBs	Liver, blubber	Reich *et al.* (1999)
Risso's dolphin, Cuvier's beaked whale	South Adriatic Sea	Mercury, selenium, cadmium, lead, chromium, methylmercury	Muscle, lung, liver, kidney	Storelli *et al.* (1999)
Risso's dolphin	Adriatic Sea, Italy	PCBs, DDT, HCB,	Blubber, heart, lung, liver, spleen, kidney, stomach, muscle tissue	Storelli (2000)
Bottlenose dolphin	South Adriatic Sea, Apulian coast	Metals, methylmercury, organochlorine, PCBs	Liver, kidney, lung, brain, intestine, heart, uterus, placenta	Storelli & Marcotrigiano (2000)
Bottlenose dolphin, Harbour porpoise	Mediterranean, Black Sea & other seas/oceans	BTs, TBT, DBT, MBT,	Liver	Tanabe (1999)
Dolphins	Aegean sea	CHCs, PCBs, HCH, DDT,	Liver, kidney, spleen, heart, subcutaneous fat tissue	Tirpenou *et al.* (1998)

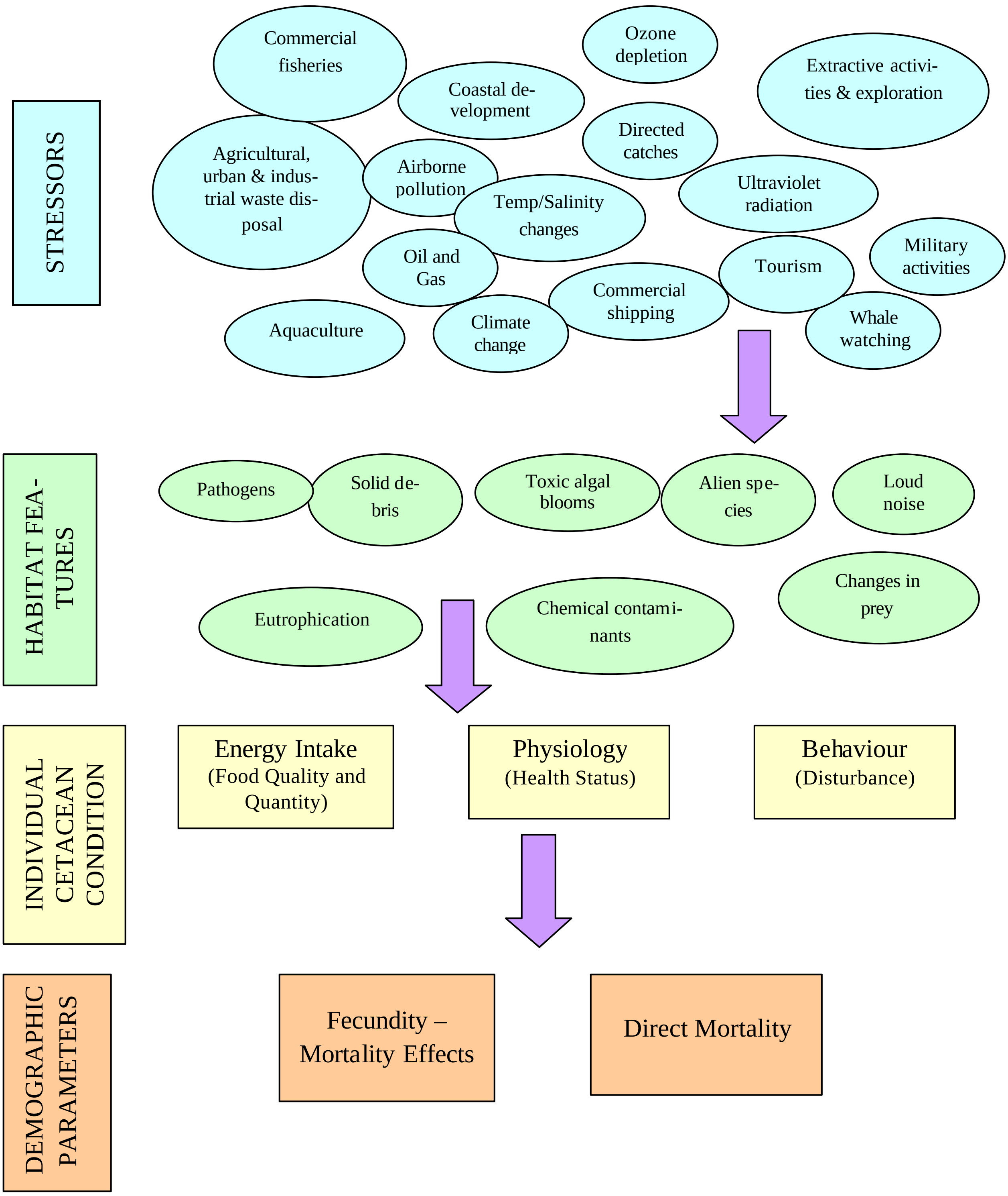

Fig. 7.1 – Variables that may impact cetacean habitats and populations. Cetaceans may potentially be impacted by many factors in their environment – both natural and unnatural. The factors in the ellipses above are intended to identify some of the sources of such factors and some of the factors themselves. These factors may affect the "condition" of individuals and thereby have impacts on populations. The figure is based on one developed in Rome by the meeting of the IWC Scoping Group for a Workshop on Habitat Degradation (IWC in prep.).

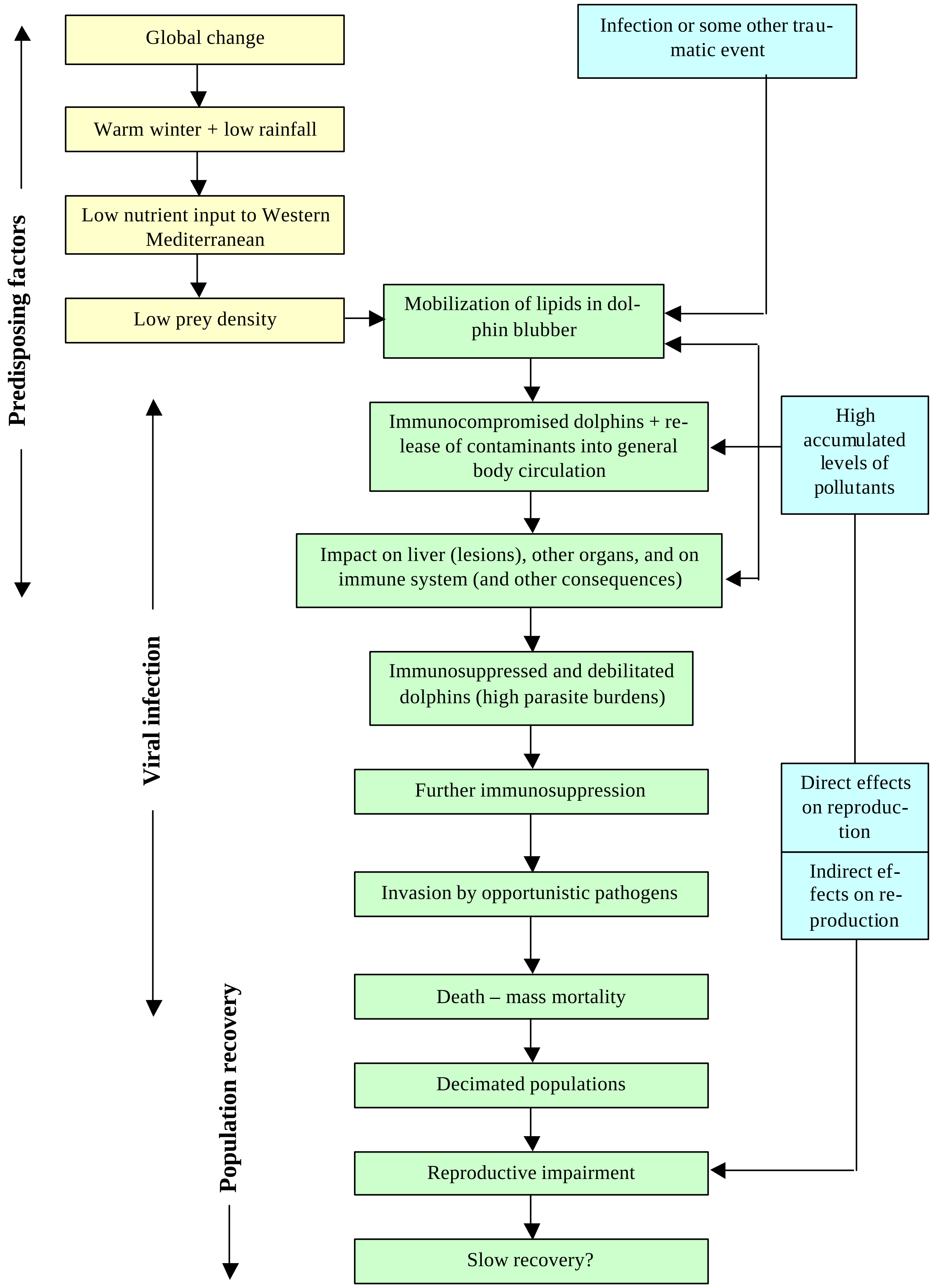

Fig. 7.2 – Events that may have led to the deaths of several thousand striped dolphins in the Mediterranean in 1990-1992 (after Simmonds and Mayer 1997).

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 8

Cetacean Habitat Loss and Degradation in the Black Sea

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Introduction

Early symptoms of progressive deterioration of the Black Sea environment were recorded at the end of the 1960s (Zaitsev 1999). During subsequent decades, the ecological situation in the subregion steadily changed from bad to worse (Mee 1992, 1998, Zaitsev and Mamaev 1997, Zaitsev 1998), and it is only now that the timid gleams of hope appear, suggesting gradual reduction of the environmental distress and partial recovery of the marine ecosystems (Zaitsev 1998, Mee and Topping 1999). No one essential cause of the Black Sea crisis is known, instead manifold human activities in the sea, coastal territories and in the Black Sea basin are identified.

Natural features of the Black Sea environment and ecosystem

Geographical and hydrological peculiarities of the Black Sea and contiguous water bodies have been reviewed repeatedly by authors belonging to different scientific schools and disciplines (*e.g.* Leonov 1960, Sorokin 1982, Vylkanov *et al.* 1983, Zaitsev and Mamaev 1997, Kerestecioglu *et al.* 1998, Readman *et al.* 1999). Despite numerous factual contradictions, their general attitude on natural features of that maritime area could be briefly summarized as follows.

<u>Geographical properties</u>

The Black Sea is one of the most isolated inland seas in the world (Fig. 8.1). It is situated between southeastern Europe and Asia Minor and has a surface area of 420-436 thousand square kilometres and a volume of 537-555 thousand cubic kilometres of water. The average depth is between 1,240 and 1,315 metres, though it reaches a maximum of 2,212 metres. From east to west the sea measures 1,175 kilometres, and the widest distance from north to south is over 610 kilometres. The total length of the coastline is about 4,020-4,340 kilometres. The seafloor is represented by the shelf, continental slope and deep-sea depression. The shelf is significantly wide (up to 200-250 kilometres) in the northwestern part of the sea with a depth varying from zero to 160 metres. In other coastal areas the shelf strip has a similar depth, but considerably less width, from 0.5 to 50 kilometres. Thus, only about one quarter (24-27%) of the sea area has a depth of less than 200 metres. The shelf is slightly inclined offshore; its relief is composed of underwater valleys, canyons and terraces originated due to sediment, abrasive and tectonic activities. The continental slope is tight and steep, descending in some places at an angle of 20-30º. Pelitic muds cover the slope and the deep-sea depression, whereas bottom pebbles, gravel, sand, silt and rocks are common for shelf area. Earthquake epicenters are recorded in the seabed and coastal area on numerous occasions. There are few small islands in the Black Sea; the biggest one and the most distant from the mainland is the Zmeiny isle (0.18 square kilometre) located 35 kilometres off shore. The Crimean peninsula (27,000 square kilometres) protrudes into the sea from the north.

At the northeastern corner, the Black Sea is connected to the Sea of Azov by the Strait of Kerch, which is 41 kilometres long, 4-15 kilometres wide and up to 18 metres deep at its south entrance. Shallow Taman Bay penetrates deep inland in the central section of the eastern strait's shore represented by the Taman peninsula of the Caucasus. The opposite coast of the strait is formed by the Kerch Peninsula which is a constituent part of the Crimea. Sandy Tuzla island at the mouth of Taman bay cuts the Kerch Strait across almost in half and into north (Azov Sea) and south (Black Sea) portions.

The Sea of Azov is about 340 kilometres long and 135 kilometres wide with a surface area of 37-39 thousand square kilometres and a volume of only 320 cubic kilometres. It is the world's shallowest sea with a maximum depth of 13-14 metres in places. The Azov's seafloor, covered by silt and sand, has a generally flat relief. The sea is trapezoid in shape, forming at the northeast the Gulf of Taganrog, a 140-kilometre-long creek with a depth of 0-7 metres. The Arabat Spit, a 112-kilometre-long sand bar, borders the sea at the west. A series of prominent sandy spits is situated on the north coast of the sea. Along the shoreline of both the Black and Azov Seas, mainly on their north and west coasts and in the estuaries of rivers, there are many salty and brackish lakes and lagoons (limans), which are permanently or occasionally connected with the sea through canals and scours perforating the spits. The Sivash Lake, located just to the west of the Arabat Spit and extending longitudinally across almost the entire west coast of the Azov

Sea, is the largest of shallow puddles and marshy inlets linked to the sea.

In the southwest, the Black Sea is connected to the Sea of Marmara (and thus the Dardanelles Strait and the Mediterranean) by the Bosphorus Strait which is over 30 kilometres long, 750-3,700 metres wide and 37-124 metres deep in the midstream. The Sea of Marmara is about 280 kilometres long and nearly 80 kilometres wide. It has a surface area of 11-12 thousand square kilometres and an average depth of 494 metres, reaching a maximum of 1,355 metres in the centre. The sea contains several islands forming two groups. The largest island is Marmara (129 square kilometres) located in front of the entrance to the Dardanelles.

Over 300 rivers flow into the Black and Azov Seas including the second, third and fourth major European rivers, namely the Danube, Dnieper and Don. Some rivers (Danube, Don, Kuban, Kizilirmak and Yeshilirmak) form deltas before their confluence with the sea. The Danube delta (approx 5,920 square kilometres) is the largest wetland in the subregion. According to different estimations, the total catchment area of the Black Sea drainage basin comes to 1,875-2,500 thousand square kilometres covering partially or entirely the territories of 22 countries (Fig. 8.1).

Hydrological peculiarities

The estimated annual volume of river discharge entering the Black Sea fluctuates from 294 to 480 cubic kilometres. Vast quantities of silt are brought down by rivers (in particular, the Danube expels up to 52 million tonnes of sediments per year) causing low transparency of coastal waters especially in the northwestern Black Sea area and in the Sea of Azov. Impressive figures of river run-off explain the higher water level in the Black Sea in comparison with the neighbouring Sea of Marmara (the difference is 53 centimetres on average). The annual volume of atmospheric precipitations in the Black Sea area (119-300 cubic kilometres) is usually lower than the volume of river inflow, but during the rainy season (autumn-winter) the ratio becomes quite the contrary. The annual level of the evaporation in the Black Sea has been calculated between 232 and 484 cubic kilometres. Besides this the general water balance also depends on the intensity of water exchange through the Kerch Strait and Bosphorus.

There are two counter currents in the Kerch Strait: the surface current flowing from the Azov Sea to the Black Sea (22-95 cubic kilometres of water per year), and the lower one moving in the reverse direction (29-70 cubic kilometres per year). The outflow of Black Sea water through the Bosphorus (the surface current of 227-612 cubic kilometres per year) is approximately twice as large as the inflow from the Sea of Marmara (the lower current of 123-312 cubic kilometres per year). The horizontal circulation of Black Sea superficial waters could be roughly described as the two major ring streams rotating counter-clockwise in the western and eastern parts of the basin with a velocity from eight to 18 centimetres per second (Fig. 8.2). The smaller counter-clockwise currents are also peculiar to the northwestern shelf area as well as to the Azov and Marmara Seas. The vertical circulation in the Black Sea is extremely slow – it takes hundreds of years for the waters at the surface to be replaced by near-bottom waters from the deep-sea depression. Daily tidal oscillations in the Black Sea do not exceed several centimetres. Severe storms accompanied by waves up to 5-6 metres high occur most often in winter season.

As a result of huge inflow from rivers, the mean salinity of the Black Sea (18‰, *i.e.* 18 grammes of solid ingredients per one kilogramme of water) is less than a half that of the Mediterranean. It rises up to 21-27‰ at a depth below 300 metres, however it falls seasonally and even as low as 2-8‰ in some spots of the northwestern area. The presence of a halocline at a depth of 100-200 metres is a distinctive hydrological feature of the Black Sea. Azov's waters are lower in salinity (11.7‰ on average), being almost fresh (1-8‰) in the Gulf of Taganrog. At the same time, the waters in the Marmara Sea are more saline than in the Black Sea, averaging 22‰ at the surface with a gradual increase of salinity closer to the bottom and towards the Dardanelles.

The range of water temperatures at the surface of the Black Sea extends from –1.2ºC in winter to +31ºC in summer with the mean annual level varying from 12ºC in the northwest to 16ºC in the southeast of the basin. The thermocline (7.2-8.6ºC) is situated at a depth between 50 and 150 metres. The waters below 500 metres have a constant temperature of about 9ºC. During frosty winters the shallow waters with low salinity become coated with ice. That is more or less typical for the northwestern coastal area and for the Sea of Azov which sometimes (but not every year) gets covered almost completely by ice up to 80-90 centimetres thick. Uncommon freeze-up events have been recorded sporadically along the southwestern coast of the Black Sea and even in the Bosphorus.

The Black Sea is stratified into the superficial layer of oxygenated waters and the deeper column of anoxic waters saturated by high concentrations (0.2-9.6 milligrammes per one litre of water) of dissolved hydrogen sulphide originating from archaic and actual redox processes and probable past geological cataclysms. A boundary or, rather, a transitional interlayer between those strata is relatively stable, it lies at a depth between 100 and 250 metres with some topographic, seasonal and annual fluctuations. Thus, about 87-90% of the Black Sea water volume forms a "dead" zone unfit for aerobic life and inhabited almost exclusively by specific anaerobic bacteria. Consequently, only the upper 10-13% of the water mass represents the most suitable conditions for most marine organisms and, therefore, sustains biodiversity. This general view on the oxygen-dependent stratification of Black Sea habitats does not necessarily hold entirely true. In particular, some aerobic organisms (nematodes) were found in bottom silt sampled at a depth of 600 and even 2,050 metres (Zaitsev *et al.* 1987, Zaitsev 1998). Trotsyuk *et al.* (1988) have discovered a thin, 1-10 metres thick, layer of the oxygenated water just over the seafloor at a depth of about 2,000 metres.

Biological diversity (with special reference to cetaceans)

The Black Sea biodiversity is rather confined in comparison, for instance, with the Mediterranean Sea, owing to the higher degree of geographical isolation of the Black Sea, its low water salinity and cooler environment, as well as because of a large amount of anoxic waters enriched with poisonous hydrogen sulphide. As a result, most thermophilous, halophilous, bathypelagic and bathybenthic organisms inherent to the Mediterranean are absent from the Black Sea. Nevertheless, the specific biological productivity of the Black Sea is higher than that estimated for the Mediterranean (Zenkevich 1963, Greze 1979, Zaitsev 1998). A total of 3,774 species of multicellular organisms are enumerated in the lists of Black Sea flora and fauna (Zaitsev and Mamaev 1997), including 1,619 species of fungi, algae and higher plants, 1,983 species of invertebrates, 168 species of fishes, and four species of mammals (Mordukhay-Boltovskoy 1972, Rass 1987, Petranu 1997, Komakhidze and Mazmanidi 1998, Konsulov 1998, Zaitsev and Alexandrov 1998, Öztürk 1999). Besides, the Black Sea is abundant of a large variety of microscopic hydrobionts (viruses, bacteria, fungi, microalgae, protozoans) including those which are still in need of taxonomic examination.

Depending on the assumed origin of the species, the Black Sea indigenous biota is classified into four groups (Zaitsev and Mamaev 1997):

- Pontian (Caspian) relics that originated from prehistoric brackish basins that used to exist where the Black Sea is now;
- North-Atlantic or Arctic relics supposedly originating from cold seas;
- Mediterranean immigrants, representing the most numerous part of the Black Sea's fauna (80% of the total number of animal species); and
- typically freshwater species - discharged to the sea from rivers.

Three species of cetaceans[1] – the harbour porpoise (*Phocoena phocoena*), the short-beaked common dolphin (*Delphinus delphis*) and the common bottlenose dolphin (*Tursiops truncatus*) – and one pinniped species – the Mediterranean monk seal (*Monachus monachus*) – crown the trophic pyramid of the Black Sea as top predators which have no natural enemies in this basin (Kleinenberg 1956, Geptner *et al.* 1976, Klinowska 1991, Jefferson *et al.* 1993).

Harbor porpoises inhabit the waters of the continental shelf around the entire perimeter of the Black Sea[2]. Seasonally they are common in the Sea of Azov and Kerch Strait (Zalkin 1940a, Kleinenberg 1956, Birkun and Krivokhizhin 1998) as well as in the Sea of Marmara and Bosphorus (Öztürk and Öztürk 1997). Perhaps, both

[1] A fourth cetacean species – the minke whale (*Balaenoptera acutorostrata*) – occasionally visited the Black Sea in the remote past. In May 1880, one individual stranded alive and died on the shore near Batumi, Georgia (Silantyev, 1903). Then, up to 1926, there were 1-2 more cases when unidentified single "big whales" were observed in the Black Sea (Kleinenberg, 1956). Some bones of this whale species (the first cervical vertebra, humerus and a part of rib) were found by means of bottom trawling in the northwestern shelf area (Dulitsky 2001). It is supposed that rare visits of the minke whale to the Black Sea from the Mediterranean may be linked to its prey migration (Van Waerebeek *et al.*, 1999).

[2] There are four recent records (three strandings and one sighting) of single harbour porpoises in the north Aegean Sea (Frantzis, 1997, Frantzis *et al.* 2001), which may be from the Black Sea population.

small seas are important breeding, calving and feeding areas for the Black Sea population, which is isolated from the nearest one in the northeastern Atlantic. Usually harbour porpoises leave the Azov Sea before winter and come back in spring, but sometimes early and rapid ice formation puts obstacles in the way of their migration causing mass mortality events due to ice entrapment (Kleinenberg 1956, Birkun and Krivokhizhin 1997). Porpoises do not avoid waters with low salinity and transparency; thus, they occur in shallow brackish bays and lagoons, and in the Danube, Dnieper and Don rivers quite far from the sea (Zalkin 1940a, Kleinenberg 1956, Geptner *et al.* 1976, Selyunina 2001).

Similarly to the harbour porpoise, the distribution of common bottlenose dolphins can be found across the Black Sea shelf area (Kleinenberg 1956, Geptner *et al.* 1976), occasionally they also occur far offshore (Morozova 1981). The presence of bottlenose dolphins in the Bosphorus, Marmara Sea and Dardanelles has been known for a long time (Kleinenberg 1956) and confirmed again recently (Öztürk and Öztürk 1997). These cetaceans are common also in the Kerch Strait (Kleinenberg 1956, Birkun and Krivokhizhin 1998) and sometimes they visit the Sea of Azov (Zalkin 1940b, Birkun *et al.* 1997). From early spring to late autumn, bottlenose dolphins form compact accumulations in the Kerch Strait and the adjacent Black Sea waters (Kleinenberg 1956, Birkun and Krivokhizhin 1998). Annual autumn migrations of several hundred animals follow from the east towards the south-west along the south coast of the Crimea (Birkun and Krivokhizhin 2000).

Common dolphin herds are distributed predominantly offshore, in the middle part of the Black Sea, and visit inshore waters following seasonal aggregations and mass migrations of small pelagic fishes, mainly sprat and anchovy (Zalkin 1940 b, Kleinenberg 1956, Geptner *et al.* 1976). These cetaceans avoid maritime areas with low water salinity; and this could be an obvious reason why common dolphins do not occur in the Sea of Azov. However, they were observed occasionally in the Kerch Strait (Kleinenberg 1956, Geptner *et al.* 1976). Common dolphins occur also in the Marmara Sea and Bosphorus from February to November (Öztürk and Öztürk 1997), and it is still a question, where do they come from. Cross-relations including both side movements between Black Sea and Mediterranean populations seem to be possible (Van Beneden 1892, Barabasch 1935, Kleinenberg 1956), although no direct evidence was obtained up to now.

In the last three decades, Black Sea biodiversity has been seriously damaged due to the human-associated degradation of the sea proper and its drainage basin. The species composition of most marine communities was modified with the explosive expansion of some organisms and the depression of many others (Petranu 1997, Komakhidze and Mazmanidi 1998, Konsulov 1998, Zaitsev and Alexandrov 1998, Öztürk 1999). The Mediterranean monk seal has disappeared almost completely from the Black and Marmara Seas. Solitary individuals can still be observed sporadically near the Anatolian coast (Kiraç and Savas 1996, Öztürk 1996, 1999) and, perhaps, in the Danube delta (Zaitsev and Mamaev 1997), although there are probably too few animals to allow for any population recovery. Black Sea dolphins and porpoises, drastically affected by commercial direct killing continued till the early 1980s (see Report Section 6), have also been exposed to modern anthropogenic threats which cause the deterioration of habitats, the depletion of food resources and adversely impact cetacean population health.

Human impact on the Black Sea environment

The Black Sea is bordered by six riparian countries - Ukraine to the north, Russia to the northeast, Georgia to the east, Turkey to the south, and Bulgaria and Romania to the west (Fig. 8.2). The Sea of Azov and the Kerch Strait are surrounded by Ukraine and Russia. The Sea of Marmara, Bosphorus and Dardanelles are the internal water bodies of Turkey. Most coastal territories are densely populated and even overpopulated especially during the summer season. According to different estimates, based on the national census statistics, permanent human population distributed along the Black Sea shores came to 16-20 millions in the 1990s, and an extra 4-12 million per year were represented by tourists (Petranu 1997, Zaitsev and Mamaev 1997, Bilyavsky *et al.* 1998, Kerestecioglu *et al.* 1998, Mazmanidi 1998, Öztürk 1999). However, these figures do not include people inhabiting the coasts of the Azov and Marmara Seas, as well as the citizens of Istanbul, the largest Black Sea urban agglomeration situated on both the European and Asian sides of the Bosphorus and containing the resident population of over 7.3 million people

(Kerestecioglu *et al.* 1998) and a great number of migrants and visitors. Total population in the Black Sea catchment area is about 160-171 millions, and the "living activities" of all these people potentially affect the Black Sea environment (Mee 1992, Saving the Black Sea 1993, Readman *et al.* 1999) which is also influenced by atmospheric and other global environmental changes.

Anthropogenic threats to cetacean habitats

The Black Sea and contiguous waters are used for shipping, fishing, aquaculture, mineral exploitation, tourism, recreation, military exercises and waste disposal (Vylkanov *et al.* 1983, Bilyavsky *et al.* 1998, Kerestecioglu *et al.* 1998, Tuncer *et al.* 1998). In addition, the seabed and the catchment area are under permanent pressure from many other human activities, including urban development, industry, hydro- and nuclear energetics, agriculture and land-improvement. At the moment it seems impossible to prepare a comprehensive assessment of all the anthropogenic threats affecting the habitats of the Black Sea cetaceans. However, principal groups of the threats are generally known and could be listed as follows:

- various kinds of pollution;
- physical modification of the seabed, coasts and rivers; and
- irretrievable direct take of natural wealth including the (over)exploitation of marine living resources.

Some human-associated threats pertinent to the two latter groups are considered in the other parts of this report (e.g., Report Sections 10 and 14).

Pollution

Human-associated contamination of the oxygenated water layer is considered as a primary threat and the greatest environmental problem for the Black Sea region (Mee 1992, 1998, Saving the Black Sea 1993, Strategic Action Plan 1996, Black Sea Transboundary Diagnostic Analysis 1997, Mee and Topping 1999). The main sources of chronic seawater pollution are represented by focal land-based outfalls, river run-off, coastal nonpoint (diffuse) sources, atmospheric fall-out, intentional and accidental inputs from vessels (Table 8.1). According to Mee (1992), the threat to the Black Sea from land-based sources is potentially greater than in any other sea of the world. Many coastal municipalities and industries discharge their wastes directly to the sea with inadequate or no treatment (Fig. 8.2). Nevertheless, the rivers of the basin are responsible for most of the pollution (Tuncer *et al.* 1998). They are strongly contaminated with industrial and mining wastes (Readman *et al.* 1999) and transfer a huge amount of nutrients that originate primarily from agriculture (Zaitsev and Mamaev 1997). The impacts of the diffuse coastal, airborne and vessel-sourced pollution are the least investigated, but believed to be significant. Irrespective of sources, anthropogenic pollution of the Black Sea is subdivided into: (a) contamination related to various chemical substances (nutrients, crude oil and petroleum products, persistent synthetic pollutants and trace elements); (b) radioactive contamination; (c) pollution by solid wastes; and (d) biological pollution including microbial contamination and introduction of alien species of marine organisms (Table 8.1). Practically nothing is known about the problem of acoustic (noise) pollution which may cause disturbance of Black Sea cetaceans (see Report Section 14).

Nutrient pollution. In contrast to the Mediterranean, the Black Sea is utterly polluted by organic matter and inorganic nutrients originating from agriculture (fertilizers), animal husbandry, domestic and industrial sewage and from other sources. The excessive loading of sea water with nitrogen- and phosphorus-containing substances is considered as a primary cause of the decline of the shelf ecosystems (Zaitsev 1993, Mee and Topping 1999) and even of the degradation of the Black Sea environment in general (Zaitsev and Mamaev 1997). A large share of nutrients is contributed to the sea by rivers. Some 58% of the dissolved total nitrogen and 66% of the dissolved total phosphorus come from the Danube (Zaitsev and Mamaev 1997). The peak of nutrient inputs has been observed in the 1970s and 1980s. The latter authors, citing Garkavaya *et al.* (1989), note that by the 1980s the rivers transported to the Black Sea an annual average of 55,000 tonnes of phosphates, 340,000 tonnes of nitrates and 10,700,000 tonnes of organic matter. Four rivers running to the Azov Sea (Don, Kuban, Protoka and Kalmius) dicharge every year over 22,000 tonnes of total nitrogen and over 4,500 tonnes of total phosphorus (Black Sea Transboundary Diagnostic Analysis 1997). Detailed additional information on this kind of pollution is presented by Cociasu *et al.* (1999), Mikhailov (1999), and Topping *et al.* (1999).

Enormous inputs of nutrients are causing the eutrophication of coastal shallow waters mainly in the northwestern Black Sea shelf area and in the Sea of Azov (Zaitsev 1993, 1998, 1999, Petranu 1997, Zaitsev and Mamaev 1997). This phenomenon includes the production of algal and zooplanktonic blooms (population bursts of dinoflagellates and some other microalgae, and also protozoan *Noctiluca miliaris* and scyphozoan jelly-fish *Aurelia aurita*); decline of water transparency; oxygen deficiency in the near-bottom water layer; disappearance of benthic phytocenoses at a depth of 10 metres and deeper; mass mortalities of benthic fishes and invertebrates with associated widespread decay of their remains and seaweed residues. Fish mass mortality events have occurred in the Black Sea since the late 1960s. Blooms of dinoflagellates have become annual events in summertime and autumn since the early 1970s. The areas of eutrophication in the northwestern Black Sea (within Ukrainian, Romanian and Bulgarian waters) expanded from 3,500 square kilometres in 1973 to 40,000 squre kilometres in 1990 (Zaitsev 1993) with some reduction of affected areas in the 1990s (Zaitsev 1998). Water hypoxia and anoxia led to sharp depletion of valuable bioresources and decline of biodiversity. It was estimated that between 1972 and 1990 about 60 million tonnes of bottom animals died in the northwestern shelf area due to the lack of oxygen (Zaitsev 1992), and the variety of macrozoobenthic species on the shelf near Danube delta fell from 70 in 1961 to 14 in 1994 (Petranu 1997).

There has been no dedicated research concerning the impact of nutrient pollution on Black Sea cetaceans. The presumed effects of the eutrophication on cetaceans include the depletion of food resources and the collapse of the ecosystem in forage areas (both these effects could be particularly stressful for harbour porpoises and bottlenose dolphins which consume benthic fishes). In addition, the "fertilized" water represents a suitable growth medium for: (a) various bacteria potentially pathogenic for cetaceans, and (b) toxin-producing planktonic species – i.e. *Gonyaulax polyedra*, *Prorocentrum micans* and *Noctiluca miliaris* (Zaitsev 1999) which could cause an accumulation of toxins in cetacean prey.

Oil pollution. Oil pollution in the Black Sea is concentrated predominantly in the coastal area around stationary sources, such as river mouths, sewerage outfalls, harbour and industrial installations. Accidental and operational spillage of oil and petroleum products from vessels contributes to the pollution in both inshore and offshore areas. According to incomplete data presented in the Black Sea Transboundary Diagnostic Analysis (1997), about 111 thousand tonnes of oil are discharged into the Black Sea every year. Thus, Danube's outflow values (53,300 tonnes per year) amount to 50% of the estimated total annual load. Officially registered oil spills from accidents at the sea (136 tonnes per year on average) are relatively small in comparison with inputs from other sources. Significant concentrations of total petroleum hydrocarbons and products of oil degradation were detected in sea water and sediments near the Danube delta, close to the ports of Sevastopol, Ilyichevsk, Varna, Kerch, Sochi, Odessa and in the Prebosphoric area (Bayona *et al.* 1999, Mikhailov 1999, Readman *et al.* 1999) (Fig. 8.2). Those concentrations are roughly comparable to the values recorded in the Mediterranean, although the levels of carcinogenic polycyclic aromatic hydrocarbons in the Black Sea are lower than in the Mediterranean and other regional seas (Bayona *et al.* 1999, Readman *et al.* 1999).

Oil pollution induces deterioration of coastal marine ecosystems and affects the neuston superficial layer causing the elimination of eggs and larvae of mass pelagic fishes (Zaitsev and Mamaev 1997) which constitute a basic diet of Black Sea cetaceans. Fatal experiments on toxic and pathogenic effects of oil (mazout) were conducted on several Black Sea harbour porpoises in the military oceanarium of the former Soviet Union (Lukina *et al.* 1996, Kavtsevich 2000).

Persistent organic pollutants. Important synthetic pollutants are represented in the Black Sea by organohalogens: DDT and its derivatives (DDD, DDE), polychlorinated biphenils (PCBs), hexachlorohexanes (HCHs), hexachlorobenzene (HCB), chlordanes (CHLs), butyltin compounds (BTs), heptachlor, heptachlor epoxide, aldrin, dieldrin, endrin, methoxychlor, and mirex which enter the sea mainly from agriculture, industry and municipal sewage (Table 8.1)[3]. Although

[3] The input from ships sometimes may also be considerable. For instance, in 1976 in Odessa Bay there was an accident involving the vessel "Mozdok" which was loaded with 600 tonnes of DDT and 200 tonnes of HCH (Mikhailov, 1999). Fortunately, most of the freight pre-packed in plastic bags was salvaged from the sunken boat.

there is no evidence of total or widespread contamination of the sea by these substances (most concentrations are comparable with those detected in the Mediterranean), their levels in the sea water and sediments sampled in some coastal areas (near Danube delta, Odessa, Sevastopol, Sochi, close to the Bosphorus and in the Kerch Strait) appear to be quite high (Mikhailov 1999, Readman *et al.* 1999). The latter publication presents the ranking of organohalogen concentrations in Black Sea surficial sediments as follows: DDTs > HCHs > PCBs > HCB > cyclodienes. A similar ranking has been earlier reported for Black Sea fishes and harbour porpoises (Tanabe *et al.* 1997 a). The low DDE/DDT values combined with relatively high concentrations indicate current, certainly illegal DDT usage around the Black Sea (Readman *et al.* 1999) and, particularly, in the Ukraine (Mikhailov 1999) and Turkey (Tuncer *et al.* 1998).

Persistent organic pollutants are lipophilic and liable to bioaccumulation in food webs attaining maximal concentrations in the fat of top predators including marine mammals. To date the contamination of harbour porpoises is better known than that of the two other Black Sea cetacean species. (Table 8.2). Harbour porpoises appear to accumulate higher concentrations of DDTs, HCHs and HCB than the bottlenose and common dolphins (Birkun *et al.* 1992, 1993). They also accumulate PCBs (including toxic coplanar congeners), CHLs, BTs, heptachlor, heptachlor epoxide, aldrin, dieldrin, endrin, methoxychlor and mirex (Tanabe *et al.* 1997 a, b, Madhusree *et al.* 1997, BLASDOL 1999). The contamination of Black Sea harbour porpoises by DDTs and HCHs is higher than that reported for this species elsewhere in the world (Tanabe *et al.* 1997a). The concentrations of S DDTs in the blubber of two Black Sea common dolphins that died from morbilliviral disease was about 50 to 100 times higher than the levels in toothed cetaceans from the North Sea, North Atlantic Ocean and Baltic Sea (Birkun *et al.* 1999).

Trace elements. Contamination by trace elements, including heavy metals, is not a basin-wide problem in the Black Sea but in some coastal areas the surface sediments reveal increased inputs of chromium, lead, copper, zinc, vanadium, cadmium, cobalt, nickel, arsenic, mercury, iron, and manganese (Readman *et al.* 1999, Windom *et al.* 1999). Existing values for cadmium, cobalt, copper and nickel show that these metals occur at higher concentrations in the Black Sea than in the Mediterranean (Windom *et al.* 1999). The known hotspots of trace metal contamination are the outlets of Danube and Dniester rivers, the areas near Odessa, Sevastopol, Yalta and Sochi cities, the Gulf of Taganrog, the Strait of Kerch and the Black Sea immediately adjacent to the Bosphorus. Elevated concentrations of nickel were also found in the eastern part of the Turkish Black Sea.

The concentrations of cadmium, chromium, copper, iron, lead, nickel, selenium, zinc, mercury and some other microelements have been studied in various tissues of over 100 Black Sea harbour porpoises, but only in five common dolphins and 19 bottlenose dolphins (Table 8.2). Generally, low-to-moderate levels of trace metal contamination are peculiar to Black Sea harbour porpoises. For example, the concentrations of mercury are about one order of magnitude lower than in porpoises from the North Sea (BLASDOL 1999, Joiris *et al.* 2001). Low hepatic and renal concentrations of zinc were detected in comparison with harbour porpoises from Belgian coast (Das *et al.* 2001). Harbour porpoises from the Azov Sea seem to be more contaminated by trace elements than individuals sampled in the Black Sea (Glazov and Zhulidov 2001).

Radioactive contamination. The principal sources of radioactive pollution of the Black Sea are: (a) past nuclear weapon tests, carried out in the air in different points of the world in the 1950s-1960s, and (b) the Chernobyl catastrophe, occurred in the USSR in 1986 (Kulebakina 1992, Polikarpov *et al.* 1992, Vakulovsky *et al.* 1994, Osvath and Egorov 1999). As a consequence of those events, the anthropogenic radionuclides (^{137}cæsium, ^{90}strontium, $^{239-240}$plutonium, *etc.*) were introduced to the sea mainly by atmospheric precipitations and rivers, particularly, by the Dnieper and Danube. In the 1990s the Black Sea showed relatively high concentrations of radionuclides in comparison with other marine basins except the Baltic and Irish Seas which were also strongly polluted. Mean concentrations of ^{137}cæsium in the water, sediments and fish were one order of magnitude higher in the Black Sea than in the Mediterranean (Osvath and Egorov 1999). Nevertheless, it is considered that the existing levels of radioactive contamination do not represent radiological problem for Black Sea biota and human population (Zaitsev and Mamaev 1997, Osvath and Egorov 1999).

Güngör and Portakal (1996) have measured concentrations of ^{137}cæsium in Black Sea harbour porpoises stranded and by-caught in Turkey. Among samples examined (Table 8.2), the higher levels of the radionuclide (up to 11-12 Bq/kg) were detected in muscles and kidney, but other tissues were also contaminated.

Marine debris. The Black Sea and its coasts seem to be subject to very high levels of solid wastes, although no formal studies of its extensiveness, sources, patterns and effects have yet been made. Marine dumping of municipal garbage is known in Turkey and Georgia (Mee and Topping 1999). The sites of explosive objects disposal are mapped off the Crimea (Ukraine) and in the Gulf of Taganrog (Russia). Navigation charts reflect also the distribution of sunken vessels and other scrap metal over the shelf area.

Floating litter including plastics and lost fishing nets represent particular threats to cetaceans (Zaitsev 1998) which sometimes ingest inedible things and may get themselves entangled. A number of foreign bodies have been collected from stomachs of Black Sea common dolphins: coal slag, pieces of wood and paper, bird feathers, cherry stones, and even a bunch of roses (Kleinenberg 1956), whereas only pebbles and sand were found in wild bottlenose dolphins and harbour porpoises (Kleinenberg 1956, Krivokhizhin *et al.* 2000). However, many man-made and natural foreign objects have been recorded ingested by captive individuals of both latter species (Rodin *et al.* 1970, Belkovich and Gurevich 1971, Vinogradov *et al.* 1971).

Microbe/faecal pollution. Almost all Black Sea cities and settlements currently discharge their effluents (treated, partially treated or untreated) into the marine environment directly or via rivers. The estimated (probably underestimated) total volume of sewage entering the sea comes to over 571 million cubic metres per year (Bartram *et al.* 1999). Some important sources of faecal pollution were evaluated in the Black Sea Transboundary Diagnostic Analysis (1997) (Fig. 8.2). Between 5% (Bulgaria) and 44% (Ukraine) of seawater samples taken during warm season (May – September) near beaches in different Black Sea countries were significantly contaminated by intestinal bacteria (Bartram *et al.* 1999). In particular, the number of faecal coliforms exceeded 20,000-100,000 per litre and the number of faecal streptococci exceeded 4,000 per litre. In the late 1980s, the concentration of *Escherichia coli* in the seawater near Odessa sometimes rose up to 2,400,000 microbe cells per one litre (Zaitsev 1998). Wide diversity of enterobacteria (*Escherichia*, *Proteus*, *Edwardsiella*, *Klebsiella*, *Citrobacter*, *Enterobacter* and *Salmonella spp.*) and pyogenic cocci (*Staphylococcus spp.*) have been observed in Georgian coastal waters (Zhgenti 1998). Surface waters in the Romanian nearshore area contained high levels of pathogenic fungi (Apas 1995).

Coprostanol – one of principal sterols in human and animal faeces and, therefore, pertinent indicator of faecal pollution – was detected in all samples of superficial sediments collected from the Black Sea (Readman *et al.* 1999). The elevated concentrations of this marker have been recorded near Sochi, Danube delta and Bosphorus. Meantime, coprostanol levels in the Black Sea are comparable or perhaps even lower than those generally encountered in other seas including the Mediterranean.

Pathogens associated with land-based discharges, coastal diffuse sources and liquid wastes incoming from ships represent a potential health risk not only to humans (Strategic Action Plan 1996) but also to cetaceans (Birkun 1994). The cetacean-related effects of microbial pollution are described in another chapter entitled "Natural mortality" (see Report Section 16), although the term "natural" in this context is not quite appropriate because of the mainly anthropogenic origin of faecal contamination.

Introduction of alien species. The accidental introduction of alien species of animals and plants is a major but poorly manageable anthropogenic threat affecting the Black Sea ecosystem (Zaitsev and Mamaev 1997). Marine organisms, causing this kind of biological pollution, usually arrive in the sea from oceanic vessels either as their external "foulings" or in their ballast waters, which often appear to be discharged without preventive treatment. At this time, several species of exotic crabs, barnacles, jellyfishes, molluscs, one species of a polychaete and one species of brown seaweed are known among the newcomers that have invaded the Black Sea and which have become widely distributed here during the 20th century.

The ctenophore (comb jellyfish) *Mnemiopsis leidyi*, accidentally introduced in the early 1980s from North American coastal waters, has reportedly exerted negative impact on the stocks of Black Sea pelagic fishes (mainly anchovy and scad) and, as a consequence, on Black Sea cetaceans which feed on those fishes (Vinogradov 1996). Over only a few years, this raptorial invader has become a dominant species in the Black Sea and also spread to the Azov and Marmara Seas. By the end of the 1980s, its total biomass in the basin was estimated at about 1,000 million tonnes (Vinogradov *et al.* 1989) with a gradual decrease in this value during the 1990s (Mutlu *et al.* 1994). The outbreak of *M. leidyi* in 1988-1990 has led to the depletion of zooplankton forage sources for pelagic fishes and to the large scale consumption of their eggs and larvae; both effects, combined with overfishing, have resulted in a collapse of pelagic fish resources (Zaitsev and Mamaev 1997). There is therefore considerable reason to regard *M. leidyi* as a form of biological pollution which is able to affect Black Sea cetacean populatio ns through the depletion of their feedings stuff.

Another kind of biological intervention in the Black Sea relates to coastal dolphinaria and oceanaria (Table 8.1) which keep exotic species of marine mammals in the nearshore open-air pens; sometimes those constructions do not prevent escapes of captive animals into the open sea. Such cases have been known since the early 1980s in the former USSR and during the last decade in the Russian Federation and Ukraine (Birkun and Krivokhizhin 1996, 2001). The list of spontaneously released cetaceans and pinnipeds include the white whale (= beluga, *Delphinapterus leucas*), the northern fur seal (*Callorhinus ursinus*), the Steller sea lion (*Eumetopias jubatus*), the harbour seal (*Phoca vitulina*), the Caspian seal (*Phoca caspica*) and, perhaps, one or two other pinniped species. The exact number of irrevocably escaped alien marine mammals is unknown, but it probably comes to ? few tens including two belugas which were observed many times in the wild near the Turkish, Romanian, Bulgarian and Ukrainian coasts in the early 1990s. During the last 12-14 years, solitary individuals of otariids have been recorded in the Black and Azov Seas including Karkinitsky, Kazantipsky, Feodosia and Sevastopol bays, the coast of Kerch peninsula, Arabat Spit and beaches of Sochi and Batumi. In April 1988 and April 1989 two different fur seals were recorded near Eregli, Turkey (Kiraç and Savas 1996). According to the observations of local inhabitants and fishermen, in 1995-1998 two or three individuals of true seals (one of them allegedly had a collar) were seen annually in winter and spring in the Kerch Strait at the coast of Tuzla island (Birkun and Krivokhizhin 2001).

The fate of most accidentally released marine mammals and their possible influence on indigenous Black Sea cetaceans and monk seals remain uncertain. Theoretically, spontaneously released exotic marine mammals can be a potential source of various pathogens including infectious agents and parasites which earlier were not known in the Black Sea.

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Table 8.1. Kinds and sources of pollution in the Black Sea

Kinds of pollution	Sources of pollution					
	Stationary land-based outfalls [a]	River run-off [b]	Coastal diffuse sources [c]	Atmospheric fall-out [d]	Ships and marine platforms [e]	Dolphinaria [f]
Contamination with chemicals:						
nutrients and organic matter	+	+	+	+	+	+
oil and petroleum products	+	+	+	+	+	
persistent organic pollutants	+	+	+	+	+	
trace elements	+	+	+	+	+	
Radioactive contamination		+		+		
Marine debris	+	+	+		+	
Biological pollution:						
microbe/faecal contamination	+	+	+		+	+
introduction of exotic species					+	+

[a] – industrial liquid wastes and insufficiently treated or untreated sewage from coastal cities and settlements;
[b] – inputs from the agriculture, industry, mining and municipal sewage from the whole Black Sea drainage area;
[c] – inputs from the agriculture, animal husbandry and unmanaged tourism mainly through the run-off from land (coastal pluvial effluents and ground waters);
[d] – inputs from various sources of air pollution (smokes, fumes, dust, exhaust gases) no matter where in the world;
[e] – dumping of solid waste, explosives and dredged matter; discharge of untreated sewage and ballast waters; oil spills; lost fishing nets; introduction of alien marine organisms owing to the biofouling;
[f] – escapes or intentional release of captive marine mammals; discharge of untreated pool waters.

Table 8.2. Studies on contaminants and microelements in wild Black Sea cetaceans (in chronological order)

Cetacean species	No. of animals	Stranded / By-caught	Period of sampling	Location of sampling	Substances considered	Tissues considered	References
Harbour porpoise	1	Unknown	1988-1990	Karkinitsky bay, Ukraine	Mercury	Muscle, liver	Svetasheva *et al*. (1992)
Common dolphin Bottlenose dolphin Harbour porpoise	2 2 19	Stranded	1990	Crimean coast, Ukraine	S DDTs, S HCHs	Blubber	Birkun *et al.* (1992)
Common dolphin Bottlenose dolphin Harbour porpoise	2 2 19	Stranded	1990	Crimean coast, Ukraine	2,4'-DDE, 4,4'-DDE, 2,4'-DDD, 4,4'-DDD, 2,4'-DDT, 4,4'-DDT, S DDTs, HCB, a-HCH, ß-HCH, ?-HCH, d-HCH, S HCHs	Blubber	Birkun *et al.* (1993)
Harbour porpoise	36	Stranded	1990-1992	Crimean coast, Ukraine	Aluminum, arsenic, barium, tin, bismuth, boron, calcium, silver, chromium, copper, gallium, iron, lead, magnesium, sodium, manganese, nickel, phosphorus, silicium, strontium, titanium, vanadium, zinc, zirconium	Teeth	Birkun and Krivokhizhin (1993)
Harbour porpoise	7	Stranded, by-caught	1993	Turkish coast	Cadmium, chromium, copper, zinc	Muscle, liver, kidney, testis, ovary	Bassari *et al.* (1996)
Harbour porpoise	16	Stranded, by-caught	1993	Turkish coast	^{137}Cæsium	Muscle, liver, kidney, genital organ (?)	Güngör and Portakal (1996)

Cetacean species	No. of animals	Stranded / By-caught	Period of sampling	Location of sampling	Substances considered	Tissues considered	References
Harbour porpoise	49	By-caught	1993	Eastern part of Turkish waters	S PCBs, p,p'-DDE, p ,p'-DDD, p,p'-DDT, o,p'-DDT, S DDTs, a-HCH, ß-HCH, ?-HCH, S HCHs, oxychlordane, *cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, S CHLs, HCB	Blubber	Tanabe *et al.* (1997 a)
Harbour porpoise	11	By-caught	1993	Eastern part of Turkish waters	PCB isomers and congeners, S PCBs	Blubber	Tanabe *et al.* (1997 b)
Harbour porpoise	27	By-caught	1993	Eastern part of Turkish waters	Butyltin compounds (MBT, DBT, TBT) and S BTs	Liver	Madhusree *et al.* (1997)
Common dolphin	2	Stranded	1994	Crimean coast, Ukraine	Cadmium, chromium, copper, iron, lead, mercury (total and organic), nickel, zinc, S PCBs, o,p'-DDE, p,p'-DDT, S DDTs	Liver, kidney, muscle	Holsbeek *et al.* (1997)
Common dolphin	2	Stranded	1994	Crimean coast, Ukraine	Cadmium, chromium, copper, iron, lead, mercury (total and organic), nickel, selenium, zinc S PCBs, p,p'-DDE, p,p'-DDD, o,p'-DDD, p,p'-DDT, S DDTs, a-HCH, lindane, heptachlor, heptachlor epoxide, aldrin, dieldrin, mirex	Muscle, lung, liver, brain, heart, kidney, lymph node, testis, ovary Blubber, muscle, liver, kidney	Birkun *et al.* (1999)
Common dolphin Bottlenose dolphin Harbour porpoise	3 2 84	By-caught Stranded By-caught, stranded	1997-1998	Ukraine (Crimea), Bulgaria, Georgia (Ajaria)	Mercury (total and organic), PCB isomers and congeners, S PCBs, p,p'-DDE, o,p'-DDE, p,p'-DDD, o,p'-DDD, p,p'-DDT, o,p'-DDT, S DDTs, HCB, S HCHs, aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, methoxychlor, mirex	Muscle, liver, blubber, kidney, brain	BLASDOL (1999)

Cetacean species	No. of animals	Stranded / By-caught	Period of sampling	Location of sampling	Substances considered	Tissues considered	References
Harbour porpoise	4	By-caught, stranded	1993	Western part of Turkish waters	Mercury (inorganic and organic)	Muscle, skin, fat, liver, kidney, testis, vibrissae	Readman *et al*. (1999)
Harbour porpoise	46	By-caught	1997-1998	Crimean coast, Ukraine	Cadmium, chromium, copper, iron, lead, nickel, selenium, zinc	Liver, kidney, muscle	Das *et al*. (2001)
Harbour porpoise	74 5	By-caught Stranded	1997-1998	Ukraine (Crimea), Bulgaria, Georgia	Mercury (total and organic)	Liver, kidney, brain, muscle, blubber	Joiris *et al*. (2001)
Bottlenose dolphin Harbour porpoise	17 13	By-caught, stranded	1996-1999	Russia (Black Sea coast) Russia (Black Sea and Azov Sea coast)	Cadmium, chromium, copper, lead, manganese, mercury (total and organic), selenium, zinc	Liver, kidney, muscle, skin (epidermis)	Glazov and Zhulidov (2001)

Fig. 8.1. Black Sea drainage basin (after Zaitsev and Mamaev 1997) and a list of twenty two Basin's countries – potential contributors to Black Sea pollution via their river run-off.

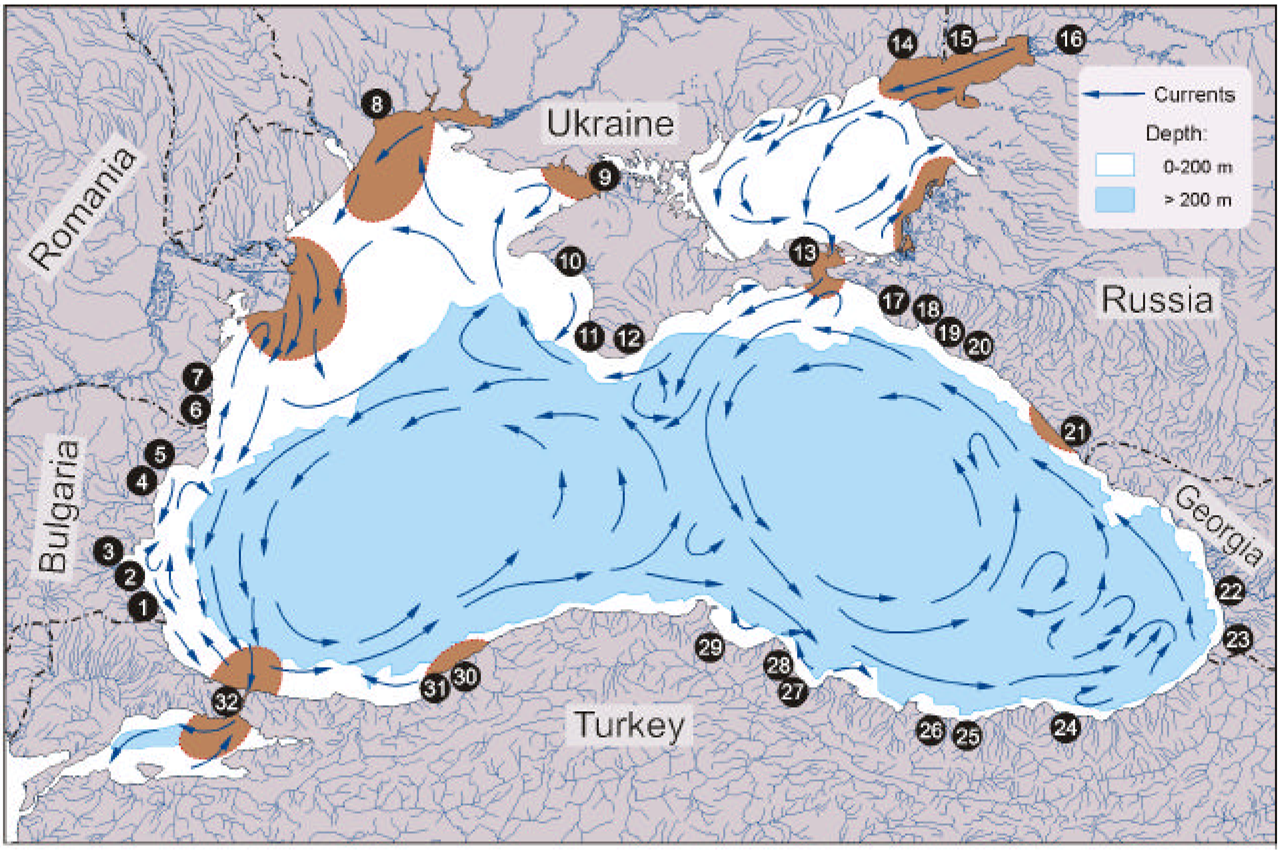

Fig. 8.2. Main land-based sources and hot spots of pollution in the Black Sea subregion (after the Black Sea Transboundary Diagnostic Analysis 1997, Bilyavsky *et al.* 1998, Kerestecioglu *et al.* 1998, Mee and Topping 1999). The surficial sea currents are pictured after Vylkanov *et al.* (1983).

1	Tsarevo	17	Anapa
2	Sozopol	18	Novorossiysk
3	Bourgas	19	Gelendzhik
4	Varna	20	Dzhoubga
5	Balchik	21	Sochi
6	Mangalia	22	Poti
7	Constantza and Mamaia	23	Batumi
8	Odessa and Ilyichevsk	24	Trabzon
9	Krasnoperekopsk	25	Giresun
10	Evpatoria	26	Ordu
11	Sevastopol	27	Samsun
12	Yalta	28	Bafra
13	Kerch	29	Gerze
14	Mariupol	30	Zonguldak
15	Taganrog	31	Eregli
16	Rostov-na-Donu	32	Istanbul

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 9

Interactions between Cetaceans and Fisheries in the Mediterranean Sea

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Overview

Interactions between cetaceans and fisheries in the Mediterranean Sea are probably as old as the first human attempts to catch fish with a net. Countless reports and artefacts from the former Tethys Ocean tell the story of dolphins interacting with fishermen. The earliest reports describe idyllic relationships between dolphins and people, but things changed as fisheries developed. As early as in 1587 a Papal Decree was issued "anathematising the vermin" in response to concerns in France about the effect of dolphins on fisheries (Smith 1995). Eighteenth century reports describe fishermen attempts to keep dolphins away from their nets, by means including loud noises, dynamite, weapons, modifications of fishing techniques and schedules, and large-mesh nets surrounding the fishing nets to protect them from dolphin incursions. The animals were claimed to be "consistently seeking a parasitic life at the poor fishermen's expenses" and requests were repeatedly submitted by fishermen to governmental bodies to reduce dolphin numbers through culling (Barone 1895, Smith 1995).

In some Mediterranean areas, direct killings and bounties for dolphins represented the first human attempts to solve the problem of net depredation[1], a strategy that was supported by several governments for at least one century (Smith 1995). In the 1950s, retaliation measures were still encouraged by State money rewards, resulting in hundreds of dolphins being killed annually in the Adriatic Sea (Holcer 1994).

Although bounties are no longer issued, the overall impact of world fisheries on cetaceans remains extremely high (Reeves *et al.*, In press). Together with deliberate kills, incidental catches of cetaceans in fishing gear also increased with the worldwide development of fisheries. However, it was only in the last few decades that bycatch became one of the major threats to the very survival of several cetacean populations. In the Mediterranean, where most data are sparse or difficult to evaluate, this impact has never been comprehensively assessed. Nevertheless, unsustainable bycatch rates have been reported for several fisheries, and the combined effect of intentional killings, bycatch, reduction of prey resources and fishery-related habitat loss represent a source of concern in many Mediterranean areas.

While it is known that cetaceans have been facing serious problems owing to fisheries in the last half-century (Reeves and Leatherwood 1994), there is no clear evidence that depredation may have risen in recent times. Therefore, it is unclear why the issue appears to be increasingly perceived by Mediterranean fishermen to be causing economic hardship, particularly as far as small-scale, coastal fisheries are concerned. One of the reasons may be that small-scale fisheries in many parts of the Mediterranean have become economically marginal, whether due to the depletion of fish stocks, over-capitalisation, market changes or socio-cultural factors (Reeves *et al.* 2001). Therefore, even relatively small losses to dolphin depredation can now have a proportionally large impact on a fisherman's livelihood. The resulting economic distress may be prompting fishermen to complain about the depredations by dolphins and to perceive these animals as competitors. Moreover, fishermen have learned of new opportunities to gain compensation and have therefore become more vocal about the importance of dolphin interactions in recent times (Reeves *et al.* 2001).

Although approaches to marine mammal control such as culling or harassment have become illegal in most Mediterranean countries, and are no longer viewed as appropriate by most fishing organisations, direct killings are occasionally enacted by individual fishermen. Nevertheless, many fishermen are becoming aware that blaming the dolphins for the ongoing changes within the ecosystem does not represent sensible behaviour. If solutions to the problems of cetacean-fisheries interactions are to be found, these must be based on the comprehension of ecosystem dynamics.

Impact of cetaceans on fisheries. Interactions between cetaceans and coastal fisheries may negatively affect the fisheries through:

- damage to fishing gear in the form of holes torn in the nets as the dolphins attempt to remove fish, or other forms of gear damage caused by cetaceans;
- reduction in the amount or value of the catch as the dolphins mutilate or remove caught fish from nets or longlines;
- reduction in the size or quality of the catch as the dolphins' presence causes fish to flee from the vicinity of the nets;

[1] Referring to "predators taking, or attempting to take, prey that are confined in pens or that have been - or are about to be - caught in fishing gear" (Reeves *et al.* In press).

- time, money, or gear loss by fishermen due to cetaceans interacting with fishing operations, or getting caught in nets;
- a real or perceived ecological competition with cetaceans, based on the conviction that depredation – particularly by dolphins - reduces the amount of fish available to fisheries (Reeves *et al.* 2001).

Beneficial effects may also occur. These may involve dolphins "co-operating" in fishing operations, or otherwise increasing the chances of success of a fishery (*e.g*., Pryor *et al.* 1990). Indirect beneficial effects may include cetaceans making an area more attractive to tourists, thus providing economic advantages (*e.g*., increased request for seafood) that may positively impact local fisheries. More importantly, marine mammals are essential components of healthy ecosystems, and their ecological importance (*e.g.,* Estes *et al.* 1998) is an issue that has been given little consideration until the present day.

The main types of fishing gear used in coastal Mediterranean waters where conflict with dolphins has been reported are bottom-set trammel nets and gillnets. Dolphins also interact with trawl nets, and occasionally with small purse seines targeting pelagic schooling fish (Reeves *et al.* 2001). Although perceived conflict is being reported from a number of Mediterranean areas, there have been few studies aimed at defining the extent of the conflict, and estimating the actual costs to fisheries.

Studies specifically focusing on fishery-dolphin interactions have been initiated in a few Mediterranean areas. In Italy's Asinara Island National Park, north-western Sardinia, an attempt has been made to quantify the impact of dolphin depredation in the trammel net fishery for red mullet (*Mullus surmuletus*) (Cannas *et al.* 1994, Lauriano *et al.*, In press). In two areas of Sicily (Catania and Favignana) a European Commission-sponsored study (project ADEPTs) has been initiated to test the feasibility and efficacy of using pingers to reduce dolphin depredation in trammel and gill net fisheries (Quero *et al.* 2000). Studies conducted by the University of Barcelona in the Balearic Islands from 1992-95 indicated that about 30 bottlenose dolphins were dying annually as a result of entanglement or direct killing by fishermen, in retaliation for depredation on trammel nets and shore-anchored gill nets set for red mullet and cuttlefish (*Sepia officinalis*) (Silvani *et al.* 1992, Gazo *et al.*, In press). Finally, research is underway to evaluate the dynamics of trawl fisheries / bottlenose dolphin interactions off the Israeli coast (Goffman *et al.* 1995, 2001).

In addition to these areas, some information exists on conflicts between cetaceans and fisheries in several Mediterranean areas, including the Thracian Sea (Mitra *et al.*, In press), the Amvrakikos Gulf, Greece (I. Siori and E. Hatzidimitriou, pers. comm.), the Ionian Sea (Tringali *et al.*, In press), the sea area off Tunisia (Lofti 2000), the Tyrrhenian Sea (Consiglio *et al.* 1992, Mussi *et al.* 1998), and the Gibraltar Strait (De Stephanis *et al.* 2000, Pèrez Gimeno *et al.*, In press). In the past, there have also been recorded interactions between false killer whales, *Pseudorca crassidens*, and tuna fisheries in the Messina Strait, Italy (Scordìa 1939).

Overall, most information on the economic effects of dolphin interactions with Mediterranean fisheries is qualitative and inadequately documented. Although it is certain that in some areas fishermen suffer from either gear damage, reduced catch, or time/money loss, no attempt has ever been made to evaluate trends, nor to quantify the costs of such interactions (Reeves *et al.* 2001).

Most interactions having a negative impact on Mediterranean fisheries have involved the common bottlenose dolphin and the short-beaked common dolphin, which are the most abundant coastal cetaceans in the Mediterranean (Notarbartolo di Sciara and Demma 1994). However, it must be considered that Mediterranean common bottlenose and short-beaked common dolphin populations, which are thought to be geographically isolated from those in the Atlantic Ocean (A. Natoli and R. Hoelzel, pers. comm.), have now declined considerably and their numbers are certainly not as high as they used to be only 50 years ago.

Today, the common bottlenose dolphin – that in the basin is typically found on the continental shelf - remains the species involved in most cases of interactions with coastal fisheries, although its populations appear to be increasingly scattered and fragmented into small units.

Interactions with Mediterranean fisheries have also involved the short-beaked common dolphin, but the current extent of such interactions is limited by the fact that the species has faced a dramatic decline in numbers over the past few decades. The forthcoming revised IUCN/SSC action plan recognises that short-beaked common dolphins in the central and eastern Mediterranean have declined precipitously and that conservation action is urgently needed to prevent their extirpation in this region (Reeves *et al.*, In press) . Relic common dolphin sub-populations are still reportedly involved in fishery depredations in coastal portions of the Mediterranean, including Tunisia and Cyprus (UNEP 1998*b*, Reeves *et al.* 2001).

The striped dolphin - by far the most abundant cetacean in the Mediterranean - has a pelagic distribution and largely feeds on non-commercial prey species (Notarbartolo di Sciara and Demma 1994). Therefore, it rarely represents a problem to coastal fisheries, apart from gear damage or time loss for fishermen when the animals get entrapped in fishing gear.

Impact of fisheries on cetaceans. Fisheries can affect cetaceans both directly and indirectly. Effects on the animals may include:

1. bycatch in fishing gear;
2. injury or mortality from retaliatory measures taken by fishermen who may perceive the animals as competitors, or blame them for gear damage or catch reduction;
3. unintentional disturbance by fishery-related operations;
4. reduction of food prey availability or changes in food prey composition/distribution caused by overfishing;
5. habitat loss and/or degradation (*e.g.*, from bottom trawling);
6. short- to long-term modifications in cetacean behaviour leading to emigration, dispersion or reduced reproductive rates as a consequence of direct or indirect interactions with fisheries.

The part that follows specifically focuses on the potential or known impact on Mediterranean cetaceans of the threats listed above, with the exception of item listed as n. 2 (“injury or mortality from retaliatory measures …”), which was dealt with elsewhere in this Report (Notarbartolo di Sciara and Bearzi 2002).

Fishery interactions involving unintentional takes (bycatch)

Before the mid to late 1960s, there was no place in the world where the magnitude of bycatch was considered great enough to threaten a population of cetaceans (Reeves and Leatherwood 1994). We are now only a few decades ahead, but cetacean deaths in various fishing gear occur virtually everywhere, and are often among the main causes of human-related mortality for a number of cetacean species. Incidental captures in fishing gear – the impact of which is often underestimated - certainly represent a serious threat to the survival of many cetacean populations around the world, and in some areas have brought cetacean species or populations close to extinction (IWC 1994, Reeves and Leatherwood 1994, Read 1996).

In the Mediterranean, the problem of incidental mortality in fishing gear has caught the attention of both scientists and the general public due to high-seas driftnet fishing by vessels flying Italian and other flags. A recent European Union ban of driftnetting may result in decreased bycatch rates in portions of the basin, however the problems remains in unregulated waters and in areas where illegal use of driftnets is an issue.

In the Italian seas alone, where an effective cetacean stranding network exists, it has been calculated that 83% of the stranding events occurred between 1986-90, for which the cause of death could be established, resulted from bycatch in driftnets (Cagnolaro and Notarbartolo di Sciara 1992). Although bycatch has been reported for most Mediterranean species, incidental captures in fishing gear have mostly affected sperm whales, common dolphins, bottlenose dolphins, and striped dolphins (Perrin 1988, Di Natale and Notarbartolo di Sciara 1994, Northridge and Hofman 1999).

Entrapment in pelagic driftnets. Pelagic driftnets are long, non-selective nets with strong, loose nylon mesh that can virtually entrap all kinds of large marine animals. Worldwide, these nets have been depleting a number of cetacean populations, including species of all sizes (Read 1996). Driftnet fisheries around the world that have shown to be highly detrimental to cetacean populations include the Japanese North Pacific driftnet fishery for salmon (Ohsumi 1975), the Taiwanese driftnet fishery for shark, tuna, and mackerel off northern Australia (Harwood and Hembree 1987), the French tuna driftnet fishery in the north-eastern Atlantic (Goujon *et al.* 1993), and several others (Northridge and Hofman 1999).

In the Mediterranean, pelagic driftnets are used by the drift gillnet fishery for small pelagic fish, and by the drift gillnet fishery for swordfish and albacore (IWC 1994). The latter involves the use of the most threatening fishing gear used in Mediterranean waters, where the fishery has dramatically impacted several cetacean populations. Multifilament nylon nets for swordfish have 36-52 cm mesh and are 2-40 km long, with a typical length of 12-15 km. Similar nets are used for albacore, with a mesh size of 16-20 cm and a total length of 9-15 km (IWC 1994).

Mediterranean countries with driftnetting fleets reportedly included Algeria, Morocco, Spain, France, Italy, Malta, Greece, and Turkey (Di Natale and Notarbartolo di Sciara 1994, Silvani *et al.* 1999). The number of vessels rapidly increased to over 1,000 by 1990 (IWC 1994). For instance, the Italian driftnet fleet – reported as being the largest in the Mediterranean - had increased by 57% between 1987-90, totalling 700 boats carrying nets up to 22.5 km long. After management measures taken in 1990, the Italian fleet was reduced to 120 units (Di Natale and Notarbartolo di Sciara 1994). Based on fishermen interviews conducted in the southern Tyrrhenian Sea, about 90% of the bycatch was composed of "dolphins", while sperm whales represented the remaining 10%; up to 15 dolphins were reported to die in fishing gear deployed overnight by a single boat in the area (B. Mussi and A. Miragliuolo, pers. comm.)

Due to recent regional legislation, the situation is changing in European Union countries, where driftnets have been be banned starting from 1 January 2002; meanwhile, a decommissioning process of the Italian driftnet fleet is in process. However, the unregulated use of pelagic driftnets by non EU countries (possibly including both Mediterranean and non-Mediterranean nations) represents a source of concern. Moreover, illegal driftnetting is still an issue in some EU countries (*e.g.*, in Italy, Miragliuolo *et al.* 2002). Owing to lack of enforcement measures, in most Mediterranean countries cetacean bycatch in driftnets and deliberate killing of cetaceans caught alive in these nets occur irrespective of national regulations that prohibit the taking of marine mammals (Di Natale and Notarbartolo di Sciara 1994).

It was estimated that in the '90s thousands of Mediterranean cetaceans have died in pelagic driftnets every year, at rates deemed unsustainable (Di Natale 1990, Notarbartolo di Sciara 1990, Cagnolaro and Notarbartolo di Sciara 1992, Di Natale and Notarbartolo di Sciara 1994, IWC 1994, UNEP/IUCN 1994, Forcada and Hammond 1998, Silvani *et al.* 1999). Remarkably, the majority of strandings along the Italian coasts between 1986-90, the cause of which could be related to fishing gear, were caused by driftnets (Cagnolaro and Notarbartolo di Sciara 1992). Sperm whale and striped dolphin populations were reportedly the most impacted, but bycatch also involved Cuvier's beaked whales, long-finned pilot whales, Risso's dolphins, common bottlenose dolphins and short-beaked common dolphins (IWC 1994). Although fin whales may at times be capable of breaking the nets after entanglement and find their way out (Di Natale 1992), even Mediterranean mysticetes may die in pelagic driftnets (Centro Studi Cetacei 1992, IWC 1994).

When driftnet fisheries reached their peak, a total annual bycatch of over 8,000 cetacean specimens (mostly striped dolphins, but including at least 30 sperm whales) was estimated for the Italian Seas alone (Di Natale and Notarbartolo di Sciara 1994), and perhaps up to 10,000 cetacean specimens died annually in the whole Mediterranean (IWC 1994). The current annual toll that cetaceans have to pay to driftnets fisheries is unknown, but remains potentially unsustainable in some areas (*e.g.*, in the Tyrrhenian Sea, Miragliuolo *et al.* 2002). Between 1993-98, it has been reported that 15 of 24 sperm whale strandings in the Balearic Islands where caused by bycatch in driftnets (Làzaro and Martìn 1999).

Entrapment in bottom gillnets. Bottom gillnets have been known to cause incidental entrapment and death of thousands of cetaceans worldwide (Jefferson *et al.* 1992, IWC 1994, Read 1996, Reeves *et al.*, In press). This fishing gear is used in coastal waters up to 200 m deep, and usually targets demersal and bentho-pelagic prey.

Bycatch in bottom gillnets largely affects small coastal cetaceans such as harbour porpoises, bottlenose dolphins (*Tursiops* sp.), humpbacked dolphins (*Sousa* sp.), common dolphins (*Delphinus* sp.), and virtually all riverine cetaceans (IWC 1994, Reeves and Leatherwood 1994, Read 1996). Mortality in gillnets is considered as the main threat to the survival of the vaquita, *Phocoena sinus* (Vidal 1995, D'Agrosa *et al.* 1995) and the Hector's dolphin, *Cephalorhynchus commersoni* (Dawson and Slooten 1993). Conversely, incidental takes of large cetaceans in bottom gillnets are a rare occurrence (Reeves and Leatherwood 1994). Factors that may contribute to the entrapment of cetaceans in gillnets include (Jefferson *et al.* 1992, Lien 1994, Tregenza *et al.*

1997): 1) presence in the nets or in their proximity of organisms representing potential cetacean prey; 2) water turbidity making the fishing gear less visible; 3) ambient noise in the marine environment that may mask or confuse the echoes produced by fishing gear, thus reducing their detectability for echolocating cetaceans; 4) location and three-dimensional position of fishing gear; and 5) cetacean capability to detect the net filaments by means of echolocation. Moreover, lack of experience by juvenile or immature individuals, together with their bent for playful and/or scouting behaviour, may make them more vulnerable to entrapment in gillnets (Mann *et al.* 1995, da Silva 1996, Fertl and Leatherwood 1997).

Bottom gillnet fisheries are very common throughout the Mediterranean basin, with around 50,000-100,000 boats reportedly involved (IWC 1994). Target species are largely represented by demersal and bentho-pelagic fish and crustaceans. Although few entrapments in bottom gillnets have been documented in the Mediterranean, this may be in part due to under-reporting (Di Natale and Notarbartolo di Sciara 1994). Being so widespread throughout the Mediterranean coastline, this fishery may actually result in occasional mortality of coastal species. Incidental catches of short-beaked common dolphins and common bottlenose dolphins in gillnets reportedly occurred in Italy and Turkey, and are suspected to occur in several other Mediterranean countries (Di Natale and Notarbartolo di Sciara 1994, UNEP 1998*a*).

Bycaught cetaceans are usually removed from the nets dead or alive - either by disentangling/cutting the net or by amputation of cetacean fins or flukes. Occasionally, small cetaceans may be brought to the port for human consumption. The proportion of live/dead bycatch is unknown, and remarkably few studies have been conducted to evaluate mortality trends in bottom gillnet fisheries. Scientific data are scarce and for most Mediterranean countries only anecdotal reports exist, making it difficult to assess the current impact of this threat to coastal cetaceans. The 1994 IWC report estimated "likely annual ranges of marine mammal mortality" of 1-10 Risso's dolphins, 0-5 short-beaked common dolphins, 50-200 common bottlenose dolphins, 1-20 striped dolphins and low numbers of other cetacean species in coastal set gillnet fisheries (IWC 1994). However, the incidence of accidental captures in gillnets is reportedly significant in some Mediterranean areas, and it is very likely that the existing estimates are lower than the actual toll (Silvani *et al.* 1992, UNEP/IUCN 1994).

Entrapment in trawl nets. Trawl nets are towed horizontally or obliquely, and consist of a cone-shaped net with a cod-end or bag for collecting fish or other target species. Trawling nets target demersal and bentho-pelagic stocks, as well as mid-water species. Typical target species may include species such as hake, pollock and other groundfish, shrimp, prawn, and a variety of squid (Read 1996).

The significance of cetacean mortality in trawl nets has only recently begun to be recognised (*e.g.*, Jefferson *et al.* 1992, Crespo *et al.* 1994, Couperus 1997, Crespo *et al.* 1997, Dans *et al.* 1997, Fertl and Leatherwood 1997, Crespo *et al.* 2000). Incidental takes of cetaceans exist in most areas where trawling occurs (Fertl and Leatherwood 1997), and several cetacean species are known to become incidentally caught in the nets. A preliminary review of global data indicates that 25 cetacean species (two mysticetes, 23 odontocetes) have died in working trawls or discarded trawling gear (Fertl and Leatherwood 1997). In extra-Mediterranean areas, bycatch in trawl nets may affect species including *Tursiops*, *Delphinus*, *Stenella*, *Lagenorhynchus*, and *Globicephala* (Jefferson *et al.* 1992, Waring *et al.* 1990, Kuiken *et al.* 1994, Read 1996, Tregenza and Collet 1998, Morizur *et al.* 1999). Recent mass strandings of small odontocetes - particularly short-beaked common dolphins and Atlantic white-sided dolphins - on the western and northern coasts of Europe have been related to pelagic trawl fishing, and the potential of these mortality events at the population level has been probably underestimated (Kuiken *et al.* 1994, Berrow and Rogan 1997, Couperus 1997, Tregenza and Collet 1998, Morizur *et al.* 1999). In the U.S. waters of the Mid-Atlantic Bight, *Globicephala* and *Delphinus* have been heavily bycaught by mid-water trawl fisheries for mackerel (*Scomber scombrus*) in the 1980s and early 1990s (Waring *et al.* 1990).

It has been suggested that cetaceans bycaught in trawl nets are probably aware of the net and the boat's activity (Fertl and Leatherwood 1997). In many areas around the world, cetaceans have learned to follow bottom trawlers to take advantage of fish caught by the net, stirred up by the net, attracted by the net, or discarded from the nets after trawling (*e.g.*, Leatherwood 1975, Corkeron *et al.* 1990, Waring *et al.* 1990, Morizur *et al.* 1999, Goffman *et al.* 2001). While these nets may provide a concentrated food source that may be easy to exploit, cetaceans may become entangled in operating nets and this opportunistic feeding behaviour is likely to be responsible for most cetacean captures in trawl nets (Overholtz and Waring 1991, Read 1996). However, there is little systematic knowledge of the behavioural processes that cause cetaceans to be vulnerable to incidental takes in trawls (Fertl and Leatherwood 1997).

Mid-water trawling seems to represent the main threat, because it may target species that represent typical components of cetacean diet. Moreover, these nets are usually dragged at relatively high speeds, with irregular and unpredictable changes of route that increase the chances of entanglement (Fertl and Leatherwood 1997). In both European and U.S. waters the recent development of near-surface trawling (in particular when nets are dragged by two fishing boats) has further increased the risk of incidental captures of cetaceans (Crespo *et al.* 1995, Couperus 1997, Morizur *et al.* 1999).

In the Mediterranean, interactions between trawlers and several cetacean species reportedly occur, the main species involved being the common bottlenose dolphin (Northridge 1984, Consiglio *et al.* 1992, Silvani *et al.* 1992, Gannier 1995, Goffman *et al.* 1995, Marini *et al.* 1995, Casale 1996, Mussi *et al.* 1998, Pace *et al.* 1998, Bearzi *et al.* 1999, Mazzanti, In press). Based on the available data, bycatch in trawling nets appears to be a relatively uncommon occurrence in most Mediterranean areas. However, high mortality rates in bottom trawl nets have been reported from the Mediterranean coast of Israel. Of 67 common bottlenose dolphins found dead stranded or adrift, 26 (39%) were incidentally bycaught in trawl nets (Goffman *et al.* 2001). Contrary to what has been suggested from other areas (Fertl and Leatherwood 1997), bycatch off Israel affects animals regardless of gender and age classes (Goffman *et al.* 1995, 2001).

Goffman *et al.* (2001) make the following observations for common bottlenose dolphins following bottom trawlers off the Mediterranean coast of Israel:

"Foraging is done by a unique method, a learned behaviour, of cutting out segments of fish that protrude from the outer side of the net. The reason may be the change of modern nets from cotton to nylon, which makes them resistant to tear, either by yanking whole fish or by forcing an entry in and/or out of the net. In the past, the dolphins used to badly damage the nets in order to reach the fish, to the point of being shot at by the fishermen. During the last few years, the dolphins have learned (or forced to revert) to feed without damaging the net, however, they apparently also venture into the net and incidental captures still occur (Kerem 2001). Some of the bycaught animals are brought up inside the net and some (about 1/3) are found entangled in the free-floating lazy-line the purpose of which is to secure the net in case the main towing lines break."

Apart from the remarkable incidence of bycatch off the Israeli coast, and possibly in other Mediterranean areas for which data are lacking, the main impact of trawl fisheries on Mediterranean cetaceans – particularly on coastal species feeding on demersal prey such as the common bottlenose dolphin – may be due to direct or indirect food-web interactions and habitat loss rather than bycatch (see in following pages, "Competitive interactions between cetaceans and fisheries").

Entrapment in purse seines. Purse seines are widely used in the world's industrialised fisheries to capture a variety of pelagic species, from tuna to anchovies and sardines. The most dramatic case of interaction between purse seines and cetaceans has occurred – and to some extent still occurs - in the eastern tropical Pacific, where strong affiliation between yellowfin tuna (*Thunnus albacares*) and dolphins has led to extremely high mortality rates - with perhaps as many as seven millions dolphins killed since the late 1950s (Gosliner 1999). In this fishery, the association between tuna and dolphins is used to assist in the location and capture of tuna schools. As dolphins are more easily seen from vessels than tuna, fishermen search for schools of dolphins and, after determining that they are associated with tuna, encircle the entire aggregation with large purse seines. Dolphins may die if they become entangled or trapped in billows of the net. Following regulations to prevent dolphin bycatch, fishermen in the Pacific have been forced to release alive the dolphins that were encircled by the net, but dolphin mortality could still occur when efforts to release them failed, whether due to unpredictable dolphin behaviour, human error, or unfavourable conditions of weather, current speed, or lighting (Gosliner 1999, Reeves *et al.*, In press) Following strict regulations to reduce bycatch, dolphin mortality in Pacific tuna nets has substantially decreased in recent years. However, the past and present impact may be significantly underestimated because of unobserved deaths of nursing calves due to separation from their mothers during fishing (Archer *et al.* 2001).

Fishing with purse seines aimed at tuna appears to be scarcely practiced in the Mediterranean, where purse seining appears to be mostly targeted to small epipelagic schooling fish. In the Italian seas, Di Natale and Notarbartolo di Sciara (1994) reported only ten tuna nets being used, for a total of 1,000 fishermen involved and a fishing period of 60 days per year. Bycatch in purse seines would mainly affect small odontocetes such as striped dolphins, bottlenose dolphins and common dolphins (Di Natale 1983*a*, 1983*b*, 1990, UNEP/IUCN 1994). Rare reports exist of cetaceans bycaught in tuna purse-seine in the Mediterranean (*e.g.*, Magnaghi and Podestà 1987). Overall, the impact of these nets on Mediterranean cetaceans is commonly considered to be negligible (Di Natale and Notarbartolo di Sciara 1994). However, reliable information is completely lacking, and thus an accurate assessment of the impact of tuna purse seine fishing on cetaceans in the Mediterranean is presently impossible.

Entrapment in longlines. Longlines consist of a series of baited hooks attached to a long, horizontal line by short connecting lines. This type of fishing gear can be configured to take a wide variety of fish, from small, bottom-dwelling species to large pelagic species such as swordfish, tuna and sharks. The use of different hook sizes and fishing depths allows fishermen considerable flexibility in their choice of target species. In many areas longlines are important components of coastal and pelagic fisheries (Read 1996).

Cetaceans may get entangled in the line filaments or in other parts of the gear, or get hooked (Green *et al.* 1991, Read 1996). In some areas around the world, mortality related to longline fisheries may be significant (Crespo *et al.* 1997, Reeves *et al.*, in prep.). For instance, in the southern U.S., short-finned pilot whales can get entangled in longline fisheries for swordfish and tuna; most entangled animals are released alive, but it is not known what effects the hooks and/or entanglement may have on their survival after release (Read 1996). In the Yangtze River, China, a bottom longline fishery called 'rolling hooks' kills every year unsustainable numbers of endangered baiji (Perrin *et al.* 1989).

Longlines are commonly used in the Mediterranean for catching tuna, albacore, swordfish and a number of other fish (Di Natale 1990). Although a few cases of incidental catches of cetaceans have been reported, clear evidence is often missing because cetaceans can be released alive at sea by fishermen. Reports of cetaceans caught by longlines include a few striped dolphins, common bottlenose dolphins, Risso's dolphins, false killer whales and sperm whales taken in Italy and Spain (Di Natale and Mangano 1983, Di Natale 1990, Mussi *et al.* 1998). In all these cases, the gear was a surface drifting longline for swordfish.

In the Italian seas, most reports of entanglement in longlines have involved small Odontocetes, particularly striped dolphins, but documented cases exist for Risso’s dolphins (Cataldini and Bello 1987), common bottlenose dolphins, long-finned pilot whales, sperm whales, and a young fin whale (Di Natale 1990, UNEP/IUCN 1994, Centro Studi Cetacei 1987÷1998, Mussi *et al.* 1998). Some individuals (striped dolphins, Risso’s dolphins and common bottlenose dolphins), have been found stranded with hooks in their mouths, or with fishing lines in their larynx, suggesting that in some cases these animals may try to feed on bait or hooked fish. Mussi *et al.* (1998) reported interactions with fisheries using illuminated handlines for squids. These involved small groups of striped dolphins, Risso's dolphins, and long-finned pilot whales waiting near the fishing boats until the light had attracted a great number of squids. Cetaceans would then take profit of the higher prey density and forage near the fishing boats. However, no cetacean bycatch was reported during these interactions.

Comprehensive studies on the potential impact of longlines on cetaceans in the Mediterranean have never been conducted. However, this seems likely to represent a minor threat in the basin.

Entrapment in discarded or abandoned nets. Nets that remain entangled on the sea floor, or that are damaged or worn out, may be discarded or abandoned by fishermen at sea. Gillnets, driftnets or other fishing gear may also be broken or dispersed by storms. These nets can then continue to catch and kill cetaceans and other marine animals for decades, until the net filaments composing the web are degraded (Jefferson *et al.* 1992).

Entanglement in discarded gear is an often overlooked, but potentially important problem. For instance, when proportions of litter were studied on south-eastern Alaska beaches, 76-85% by weight consisted of trawl-web fragments, indicating surprisingly high quantities of nets discarded at sea. Net fragments of all kinds may act as "ghost nets", and may entrap cetaceans and other marine life while they are simply swimming by, or when they are trying to catch food that is entangled or in the proximity of the net. Some of the fragments may have food organisms growing on them, or entrapped by them, and may occasionally be regarded as food by individual cetaceans (Fertl and Leatherwood 1997).

Several reports exist of marine mammals entangled in net fragments or other discarded fishing gear (O'Hara *et al.* 1986, Fertl and Leatherwood 1997). The available data for the Mediterranean do not allow to evaluate the relative importance of this threat, as compared to bycatch in operating fishing gear. However, it is clear that the practice of discarding nets at sea should be prohibited, and measures should be taken to reduce the occurrence of nets and other fishing gear abandoned or lost at sea (*e.g.*, by active removal from the marine environment whenever possible).

Entrapment in tuna traps. Traditional tuna traps were largely used in Italy in the past, and could entrap coastal cetaceans such as common bottlenose dolphins. The animals, taken alive and rarely reported by fishermen, were usually killed together with tuna in the "death chamber". However, this fishing method is becoming increasingly rare in the Mediterranean, and the current impact of these traps on cetaceans is negligible (Di Natale and Notarbartolo di Sciara 1994).

Cetacean interactions with aquaculture facilities. Interactions between dolphins and aquaculture facilities in the Mediterranean appear to be occurring with increasing frequency, possibly owing to: 1) the rapid expansion of fish farming in coastal waters, and 2) opportunistic behaviour shown by the dolphins possibly as a result of decreasing food resources (Reeves *et al.* 2001, Bearzi *et al.*, In press).

In Cyprus, fishermen claim that dolphins have increased spectacularly as a result of the development of aquaculture, which has been rapidly expanding since 1990. Fishermen blame the fish farms for the large numbers of dolphins staying in Cyprus waters throughout the year, and claim that the dolphins are attracted primarily by the large shoals of fish, mainly boque (*Boops boops*), that have appeared in the vicinity of fish farms (UNEP 1998*b*).

Bearzi *et al.* (In press) noted a relative increase in time spent by bottlenose dolphins around coastal fish farms in eastern Ionian Greece after 1999, and observed that increased nutrient levels, complex substrate and provision of food bait in the proximity of the cages may create a favourable environment and attract potential bottlenose dolphin food prey. In 1981-2000 the aquaculture production of marine fish in Greece increased by 300%, largely due to the development of cage technologies in inshore waters (Anonymous 2000, EEA/UNEP 2000).

In north-eastern Sardinia the construction of a floating fish farm has been linked to increased bottlenose dolphin abundance, and dolphin behavioural changes were recorded possibly as a result of high fish density around the farming area (Diaz Lopez *et al.*, In press).

So far, there is no published evidence that cetaceans may cause direct damage or indirect impact (*e.g.*, by inducing stress in farmed fish) to Mediterranean aquaculture facilities, but it must be considered that the possibility that coastal dolphins may one day learn to exploit this relatively new food source (*e.g.*, by jumping into the cages or damaging them to gain access to the farmed fish) represents a source of concern (Bearzi *et al.* In press). Bottlenose dolphins are known for their behavioural flexibility and their capacity to learn new feeding strategies (Shane *et al.* 1986). If dolphins ever learn ways of gaining access to the farmed fish, hostile reactions by fishermen can be expected (Würsig, In press).

Competitive interactions between cetaceans and fisheries

During the last century, and particularly in the last 50 years, overfishing practices have so impoverished the marine environment that present and future generations of cetaceans (and fishermen) are in trouble (Pauly *et al.* 2000). In studying the effects of fishing and trying to manage fisheries, man has apparently ignored changes in food web dynamics, or has not paid enough attention to complex cause-effect relationships. Only the often overwhelming direct effect of reducing the target species has occasionally been studied; indirect effects have been largely neglected (Smith 1995). Complex ecosystem dynamics and/or lack of research may hide cause-effect links, thus leaving room for continued overexploitation. However, the unwise management of resources has impacted the marine environment to the point that, today, everybody acknowledges the need for preservation of the remaining stocks (Kemp 1996).

Fishery trends and the depletion of fish stocks, worldwide. Global totals of the amount of fish caught during the past half-century provide a misleadingly reassuring view of the state of the world's fisheries (Pauly *et al.* 2000). Most scientists now agree that the overall increase in the world fishery production should not be misunderstood for a healthy status of the marine resources. The *growth rate* of the landings has actually declined steadily since 1950, and reached a plateau at the beginning of the 1990's (FAO 1994, 1997*a*, 1998).

It has been pointed out that "aggregate landings from various stocks which are the subject of a fishery-complex may continue to increase despite local overfishing situations, as long as the process of increase through expansion to new areas and resource elements overshadows the process of decrease through overfishing" (FAO 1997*a*). For instance, the increasing catch of small pelagic species has masked the stagnation or impoverishment in take of demersal fish (FAO 1997*a*, Pauly *et al.* 2000), and it has been stressed that "the world fish supply is increasingly relying on low value species, characterised by large fluctuations in year-to-year productivity, hiding the slow but steady degradation of the demersal high value resources" (Garcia and Newton 1994).

Despite increased fishing effort, landings of some of the most important demersal fish (including *Gadus* sp., *Merluccius* sp., *Melanogrammus* sp.) decreased from 5 million tonnes in 1970 to 1.6 million tonnes in 1993, forcing the fishing industry to target other pelagic species on a lower trophic level, such as *Trachurus capensis* and *Engraulis encrasicholus* (FAO 1994). At a global level, the phenomenon has been described as "fishing down marine food webs", which refers to "a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish" (Pauly *et al.* 1998*a*). According to Pauly *et al.* (1998*a*), this leads at first to increasing catches, then to a phase of transition associated with stagnating or declining catches.

A striking intensification of world fisheries has been recorded since 1950, which corresponded to an increase in the proportion of resources subject to declines in productivity (FAO 1997*a*). Recent reviews confirm that, worldwide, an estimated 44% of the major fish stocks are fully exploited and are, therefore, producing catches that have reached their maximum limit. About 16% of fish stocks are overfished, and there is an increasing likelihood that catches might decrease if remedial action is not undertaken to reduce or suppress overfishing. Another 6% appear to be depleted, and only 3% seem to be recovering slowly (FAO 1998). A global production model showed that the demersal high-value species were overfished and that a reduction of at least 30% of fishing effort was required to rebuild the resources. Given that few countries have established effective control of fishing capacity, around 60% of the major world fish resources are considered in urgent need of management action (FAO 1994, 1997*a*). Such a picture is worsened by the fact that evaluating the impact of fishing activities on the marine environment is a difficult issue, as fishing trends are routinely based on landing data (*i.e.*, the catch brought to the fish market). Unfortunately, these data are largely unreliable, as they are affected by biases that cannot be estimated (Earle 1996). For instance, the biomass of discarded fish – that can account for a very high percentage of the catch[2] – is simply ignored.

In conclusion, the available data on world fishery trends show that marine resources have been exploited beyond reasonable limits and to levels deemed unsustainable in most areas (Earle 1996, Kemp 1996, Caddy *et al.* 1998, Christensen and Pauly 1998, Pauly *et al.* 1998*a*, Pauly *et al.* 2000). In a recent article on Science - co-authored by 19 scientists - it was concluded that "ecological extinction caused by overfishing pre-

[2] A global assessment of fisheries bycatch and discards accounted for 33% (range 22-47%) of the total landings (Alverson *et al.* 1994), and it has been pointed out that the sum of fishery-related mortalities occurring as a result of harvesting often involves a significant number of fish in addition to catch and discard, fishing mortality being the aggregate of all catch mortalities including discard, illegal fishing and misreporting (Alverson and Hughes 1996). For accounts of bycatch rates and discards in Mediterranean trawling fisheries see for instance Carbonell *et al.* (1998), Stergiou *et al.* (1998), Vassilopoulou and Papaconstantinou (1998).

cedes all other pervasive human disturbance to coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change" and that the "historical abundances of large consumer species were fantastically large in comparison with recent observations" (Jackson *et al.* 2001).

Fishery trends and the state of Mediterranean fish stocks. Trends similar to those observed at a global scale can be observed in the Mediterranean, where fisheries resources are in a state of over-exploitation driven by rising prices and demand in the past decades. Overfishing and fishing practices largely account for the impact on natural stocks and habitats (EEA/UNEP 2000). According to FAO, the Mediterranean fish stocks have been "fully exploited", with fisheries operating at or close to an optimal yield level, and no expected room for further expansion.

Although Mediterranean fisheries statistics are scarce and unreliable (Stanners and Bourdeau 1995, Earle 1996, FAO 1997*a*), and there is an acute lack of general and historical data (Briand 2000), evidence exists that overfishing and unsustainable harvesting has led to the decline of many fish stocks[3] (Caddy and Griffiths 1990, De Walle *et al.* 1993, Stanners and Bourdeau 1995, FAO 1998, Briand 2000). One of the most pervasive ecological consequences may be the "fishing down marine food webs" phenomenon (Pauly, *et al.* 1998*a*), and it has been recently demonstrated that the mean trophic level of Mediterranean catches has declined significantly and quite steadily since the late 1950s, although fishery landings increased (*e.g.*, Pauly and Palomares 2000, Stergiou and Koulouris 2000). The declining or flattening catch trends in Mediterranean areas are consistent with the observation that these areas have the highest incidence of fully-exploited fish stocks and of stocks that are either overexploited, depleted, or recovering after having been depleted (FAO 1997*a*, 1998). The European Environment Agency also reported that unsustainable harvesting of Mediterranean fish stocks has led to the decline of many, and that demersal fish stocks are usually fully exploited, if not over-exploited, with a general trend towards smaller individual sizes (Stanners and Bourdeau 1995, EEA/UNEP 2000). Small pelagic fish stocks remain highly variable in abundance, depending on environmental conditions (EEA/UNEP 2000).

The effect of this kind of systematic impoverishment of marine food prey resources on cetacean populations is largely unknown (see "Impact of reduced prey availability on cetaceans").

Competition for resources. Human fisheries have the potential to reduce prey availability and affect cetacean food resources (Dayton *et al.* 1995). Such competitive interactions may be both direct, when target prey for cetaceans and fishermen overlap, and indirect, through the human exploitation of resources that may influence the availability of cetacean food prey ("food web competition"; Earle 1996, Trites *et al.* 1997). A case of possible competition between fisheries and marine mammals has been studied in the Pacific Ocean, where it has been suggested that the excessive growth and capitalisation of fishing fleets inevitably result in over-exploitation of the available resources, thus representing a threat to marine mammals. The availability of resources that are important to marine mammals would therefore decrease with an increased exploitation of fish stocks for human consumption (Trites *et al.* 1997).

Cetaceans, in turn, can rely on resources of economic interest and may affect fisheries through direct and "food-web" competition (Earle 1996). The claim that cetaceans compete with fisheries has been used to support economic incentives for commercial hunting, and it was observed that recent initiatives to quantify the impacts of cetaceans on world fisheries have been intended to help build a case in favour of expanded commercial whaling (Reeves *et al.*, In press). However, whilst the deleterious impact of overfishing on several marine ecosystems has been well documented, it is still unclear whether cetacean removal – including the intentional killing of cetaceans charged of net depredation - would eventually benefit the fisheries.

Output obtained from ecosystem models (*e.g.*, Christensen and Pauly 1992) and long-term observations (*e.g.* Estes *et al.* 1998) suggested that removing natural predators from an ecosystem may have unpredictable effects, *i.e.* not those that could be expected based on simplistic predator-prey models. The available data actually indicate

[3] Decreasing catches due to overfishing have been recorded in several Mediterranean subareas, particularly as far as demersal fish are concerned (*e.g.*, Jardas 1985, Papaconstantinou *et al.* 1985*a*, Azzali and Luna 1988, Levi and Andreoli 1989, Bombace 1990, Andreoli *et al.* 1995, Jardas *et al.* 1997, Stergiou *et al.* 1997, Ardizzone *et al.* 1994, Cau *et al.* 1994, De Ranieri *et al.* 1994, Levi 1994).

that fish may be far more important predators of other fish than are marine mammals (Trites 1997, Trites *et al.* 1997, Mangel and Hofman 1999, Trites *et al.* 1999). The ultimate effect of removing natural top predators would be a loss of diversity, physical complexity, productivity and resilience (Naeem *et al.* 1994, Trites 1997).

The understanding of predator-prey interactions and ecosystem functioning therefore represents an essential conservation means, which may allow to evaluate the potential effects of food-web interactions between marine mammals and man (Mohn and Bowen 1996, Estes *et al.* 1998, Pauly *et al.* 1998*b*, Croxall *et al.* 1999). Ecosystem modelling has been proposed in recent years as a viable tool for understanding the complex ecological interactions between cetaceans, fisheries and other ecosystem components (*e.g.*, Smith 1995, Earle 1996). As reported by Reeves *et al.*, (2001), "modelling might elucidate counter-intuitive trends which in turn could help explain why dolphin depredations occur in some areas and not in others".

For instance, a combination of burgeoning fisheries, increased ocean temperature and depletion of marine mammals have been reportedly triggering the collapse of the kelp forest ecosystem in western Alaska (Estes *et al.* 1998). A chain of ecological interactions beginning with reduced or altered fish stocks in the oceanic environment sent pinniped populations to decline; pinniped numbers became so reduced that some of the killer whales who once fed on them expanded their diet to include sea otters (*Enhydra lutris*); this shift in killer whale foraging behaviour prompted the collapse of the sea otter population, which caused a sea urchin population overgrowth; unregulated urchin populations increased rapidly and overgrazed the kelp forests, thus setting into motion a host of effects in the coastal ecosystem. This chain of interactions was probably initiated by anthropogenic changes in the offshore oceanic ecosystem (Estes *et al.* 1998). This remarkable study highlights a number of key points about the way ecosystems work, including the unappreciated importance that uncommon or transient species of top carnivores can have in controlling community structure, and the need for large-scale approaches to ecological research.

Although the idea of multi-species or ecosystem management may be appealing, it has been argued that this level of management is extremely difficult to conceive and implement due to data needs, inherent complexity and dynamism of natural systems, and inadequacy of knowledge about functional relationships (Mangel and Hofman 1999, Reeves *et al.*, In press). As stressed by Okey and Pauly (1999) "just as real-world food webs contain complex interactions among species, so too must scientists and others interact to describe food webs in realistic ways". In the capacity to interact and collaborate in ways that are both multidisciplinary and inspired by a genuine search for truth reside the chances of success of this "ecosystem approach". If given proper development and implementation, software tools such as "Ecopath-Ecosim" (Christensen and Pauly 1992) may greatly benefit future large-scale management.

Today, the lack of comprehensive and reliable fish stock assessments and longitudinal studies aimed at describing and quantifying Mediterranean ecosystem components remains one of the main problems to be addressed by scientists and managers willing to adopt an ecosystem approach. As long as this situation doesn't change "dolphins may often serve as scapegoats for unsustainable fishing practices" (Reeves *et al.* 2001).

Impact of reduced prey availability on cetaceans

Over the last decade, the reduction of food prey resources has been considered by several authors as a threat of primary importance that may have contributed to the decline of some cetacean populations in the Mediterranean (Perrin 1988, Reeves and Leatherwood 1994, UNEP/IUCN 1994, Reeves *et al.*, In press). It is therefore surprising that the issue has been given so little consideration.

As noted in the previous paragraph, one of the reasons that may have discouraged research in this field is that ecosystem dynamics are exceedingly complex, and their investigation requires sophisticated tools, extensive background information, and a multidisciplinary approach. Whilst powerful software tools and analytical approaches have become available in the last several years, research is hampered largely because 1) appropriate datasets are rarely obtainable, 2) expertise in this field is still lacking, and 3) collaboration among scientists from different disciplines (*e.g.*, fishery scientists, fish biologists, marine mammalogists, oceanographers etc.) is not the rule in Mediterranean countries. Perhaps for these and other reasons, most cetacean scientists have been focusing their attention on threats that are less complex and relatively easier to document.

Although complex food-web dynamics are difficult to study, it is clear that reduced prey availability caused by overfishing of Mediterranean fish stocks and other causes, may impact cetaceans in a number of ways. Several Mediterranean cetaceans - particularly coastal species such as short-beaked common dolphins and common bottlenose dolphins - compete for prey species of commercial interest that have been heavily exploited by human fisheries during the last decades. Dolphins, as top predators, can be affected due to a decreased prey biomass or to a reduced mean size or nutritional value of individual prey items.

Moreover, fish distribution may become more scattered, and seasonal and yearly trends of abundance may show wider fluctuations due to the combined effects of overfishing, pollution and environmental variables (FAO 1997*b*, Bombace 1990, Stergiou *et al.* 1997, Degobbis *et al.* 2000). Marine mammals with widespread distributions may react to worsening habitat conditions by leaving their core areas either permanently or temporarily, as changes in the distribution of key prey represent primary factors determining dolphin movements and habitat preferences (Evans 1971, Wells *et al.* 1990, Hanson and Defran 1993, Maze and Würsig 1999). As cetacean feeding preferences are related to prey ecology and availability in their own habitat, diet modifications may occur as a response to fishery exploitation (Northridge 1984, Estes *et al.* 1998). The long-term, population-level, impact of changes in distribution and feeding habits due to reduced prey availability is largely unknown, and deserves further investigation.

Behaviourally flexible cetacean populations affected by a temporarily lower prey abundance, or by shifts in food prey availability, may react in part by devoting more time to foraging or by displaying a wider range of feeding strategies (*e.g.*, Shane 1990, Bräger 1993). The capability of some cetacean species to adapt to fluctuations in the abundance of some prey by feeding on other prey is clearly an important requisite to withstand seasonal and yearly variations in food supply (Northridge 1984). A consistently lower prey availability, however, implies higher energetic costs for the dolphins to secure their daily food intake. This has the potential to affect population fitness by reducing the range of behavioural flexibility that is necessary to react with appropriate strategies to other environmental fluctuations, or to a further worsening of conditions (*e.g.*, further prey reduction, increased human disturbance, etc.).

As stressed by Chapman and Reiss (1999) "the lack of sufficient food to maximise reproductive potential may be the most important regulator of population size in animals". As a general rule, increased time spent searching for food and feeding reduces the time that can be devoted to social and reproductive activities, including mating, weaning, and caring for the offspring, with negative repercussions on reproductive success (Wilson 1979, Valiela 1995). More dramatic effects may be recorded in the long-term, if access to prey resources is consistently impaired by human competition, habitat degradation, or both. This may ultimately result in: 1) increased levels of stress, 2) loss of weight and physical strength accounting for emaciation (*e.g.*, in common bottlenose dolphins: Politi *et al.* 2000) or starvation, 3) reduced reproductive rates, due to behavioural modifications and negative feedback mechanisms, 4) behavioural responses leading to dispersion or emigration towards areas with higher food availability, 5) increased inter- and intra-specific competition and aggressive behaviour (*e.g.*, in common bottlenose dolphins: Ross and Wilson 1996, Patterson *et al.* 1998), 6) increased susceptibility to disease due to reduced immune responses (*e.g.*, in striped dolphins: Aguilar and Raga 1993), and 7) higher mortality rates (Baker 1978, Sinclair 1983, Swingland 1983, Fowler 1987, Apanius 1998, Hofer and East 1998, von Holst 1998).

In addition, reduced food prey availability may increase or exasperate the extent of interactions between cetaceans and fishermen, and expose the former to higher risks of intentional takes and harassment (Northridge 1984, UNEP/IUCN 1994, Fertl and Leatherwood 1997). Unfortunately, no clear evidence is currently available to address this issue. It has been noted (Reeves *et al.* 2001) that conflict occurs in certain areas where target fish stocks are relatively abundant (*e.g.*, in the Asinara Island, Italy) whilst in some other areas where target fish stocks are depleted there is little or no conflict between dolphins and fisheries (*e.g.*, in the Kvarneric, Croatia). The complexity of ecosystem dynamics may be responsible for the lack of simple cause-effect evidence.

Reduced prey availability and nutritional stress may be an issue in the reduced dolphin abundance or mass mortality events observed in several Mediterranean areas. For instance, an unusually high effort devoted to food search has been recorded for Mediterranean common bottlenose dolphin population units that have been consistently studied during the last decade (Politi 1998, Bearzi *et al.* 1999). Approximately 40% of "resident" common bottlenose dolphins in the eastern Ionian Sea, where demersal fish resources have been over-fished (Papaconstantinou *et al.* 1985*a,b*) were reportedly emaciated (Politi *et al.* 2000). In the same area, a decline in short-beaked common dolphin numbers was consistent with the hypothesis of reduced prey availability or increased prey patchiness (Politi and Bearzi, In press). In Mediterranean striped dolphins, inadequate nutrition has been cited possibly having played a role in an epizootic outbreak (Aguilar and Raga 1993) and to be responsible for their extremely elevated age at sexual maturation observed in this region as compared to other conspecific populations inhabiting waters were food resources were more abundant (Calzada *et al.* 1996, Aguilar 2000).

Risky synergies. Several factors other than overfishing may contribute to a reduced prey availability, or induce changes that can affect the marine food webs. For instance, global environmental changes (MacGarvin and Simmonds 1996) may combine with overfishing and habitat contamination to jeopardise ecosystem dynamics. Moreover, the build-up of man-made toxic contaminants may reduce the reproductive success or depress the immune-responses of top predators, including both fish and marine mammals (*e.g.*, Fossi *et al.*, In press).

The impact of man-made toxic compounds on biologic communities is a major source of concern. Many organochlorine compounds, for instance, are responsible for endocrine dysfunctions in a number of organisms, including cetacean preys. By affecting the reproductive success and the sex ratio of a species, contamination may negatively affect fish stocks (Focardi *et al.* 1998, Johnson *et al.* 1988, IEH 1995, Janssen *et al.* 1997, Arcand-Hoy and Benson 1998), with cascade effects on both cetaceans and fisheries.

Finally, it must be observed that contamination and food scarcity may act synergistically, as malnutrition may prompt mobilisation of lipophilic contaminants that are "stored" in the blubber of cetacean species as food reservoir, thus making them more exposed to their toxic effects at a time when they are already debilitated by food scarcity.

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Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 10

Interactions between Cetaceans and Fisheries in the Black Sea

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Introduction

The direct killing and intentional live capture of dolphins and porpoises (see Report Section 6) do not exhaust a pool of problems which are focused on mutual impact of fisheries and Black Sea cetaceans. Both parties – humans and marine mammals – continue to be in the state of peculiar confrontation because they have similar (but rival) vital interests in fish consumption and usually catch their prey in the same areas during the same time. Anecdotal indications of beneficial co-operation between Black Sea fishermen and dolphins have been called in question very long ago (Silantyev 1903), whereas conflicts, causing reciprocal harm to cetaceans and fisheries, are still indicated in all Black Sea countries (Vasiliu and Dima 1990, Birkun *et al.* 1992 1999a, Pavlov *et al.* 1996, Öztürk 1999 a).

Impact of cetaceans on fisheries

Very little reliable information exists concerning the influence of cetaceans on commercial fisheries in the Black Sea and contiguous waters. No special research was carried out except for biassed estimations of yearly amounts of fish allegedly consumed by hypothetical whole populations of dolphins and porpoises (see examples in: Morozova 1981, Zaitsev 1998, Bushuyev 2000). In all estimates, related to the 1940s-1960s, the use of incorrect basic data on daily ration and population size of Black Sea cetaceans resulted in a doubtful conclusion that cetaceans represent the principal threat to fisheries because they are guilty of the depletion of fish resources. Bushuyev (2000) revised those estimates using more realistic figures on cetacean nutrition rates. He came to a view that in the 1980s the annual consumption of fish by cetaceans was considerably less than the annual total harvest of Black Sea fisheries. In spite of the lack of any dependable proof, cetaceans are persistently blamed for damage to fisheries in Turkey (Klinowska 1991, Öztürk 1999 a).

More than 30 fish species have been recorded in stomach contents of cetaceans inhabiting the Black and Azov Seas off the Crimean and Caucasian coasts (waters of present Ukraine, Russia and Georgia). Those studies were conducted on thousands of individuals, deliberately killed in the 1930s-1950s (Zalkin 1940a, b, Kleinenberg 1956, Tomilin 1957), and on over 120 animals, incidentally caught or stranded in the 1990s (Krivokhizhin *et al.* 2000). Certain prey species, recognized as the most important for cetaceans, also appear to be of high priority for the fisheries (Table 10.1). In particular, small benthic (whiting, *Merlangius merlangus euxinus*, and gobies, Gobiidae *gen. spp*.) and pelagic schooling fishes (anchovy, *Engraulis encrasicolus ponticus*, and sprat, *Sprattus sprattus phalaericus*) make up a basic diet of harbour porpoises (*Phocoena phocoena*), but only the latter two species could be considered as the objects of perceived competition between porpoises and fishermen. The same fishes – anchovy and sprat – may cause a conflict of interests between pelagic trawling and common dolphins (*Delphinus delphis*). The feeding needs of bottlenose dolphins (*Tursiops truncatus*) are interacting mainly with the turbot (*Psetta maeotica*) and mullet (*Lisa spp., Mugil cephalus* and *M. so-iuy*) coastal fisheries. No true data are available on the adverse effects of such competitive interactions on fisheries. It is believed that marine mammals do not have essential influence on the abundance of Black Sea anchovy in comparison with the anthropogenic threats affecting its fodder plankton resource (Andrianov and Bulgakova 1996).

Most leaders of fishing cooperatives and ordinary fishermen, interviewed in Ukraine, Russia (A. Birkun, unpubl. data), Bulgaria (T. Stanev, pers. comm.) and Georgia (A. Komakhidze, pers. comm.), do not denounce militant dislike for cetaceans, nor consider them as their serious rivals. Coastal fishermen have no claims against common dolphins, but usually express their discontent with incidental catches of harbour porpoises. Besides, they mention episodes in which bottlenose dolphins raise trouble by damaging their nets or catch, or stealing caught fish from the nets. The same problem is known to be occurring on the Turkish coast (Öztürk 1999 a). No statistics are available on such conflicts and ensuing financial losses, and no appropriate compensation is stipulated for fishermen from their governments. There is no evidence that Black Sea fishermen use acoustic deterrent devices or any other special means to reduce undesirable interactions with cetaceans.

Impact of fisheries on cetaceans

Fisheries could provoke a number of effects on Black Sea cetaceans, including:

- changes (diminution or increase) of foraging possibilities;
- modification of behaviour;
- deterioration of habitats;
- mortality and non-mortal injuries in fishing gear; and
- alteration of distribution, migrations and reproductive ability.

Most direct and indirect effects are still poorly studied and understood, therefore their consideration below must rest largely on particular cases and speculations.

Fisheries-related changes of forage resources. Pelagic and coastal fisheries can affect Black Sea cetacean populations through excessive exploitation of fish species which represent the basic prey of harbour porpoises, common and bottlenose dolphins (Table 10.1). Overfishing, combined with eutrophication and the outburst of a raptorial invader, *Mnemiopsis leidyi* (see Section 8), has already led to the rapid decline of anchovy and sprat abundance. As a result, the total commercial catch of anchovy experienced a 12-fold drop (from an absolute maximum of 468,800 tonnes in the 1987-1988 fishing season to 39,100 tonnes in 1990-1991), while landings of sprat fell nearly by a factor of eight (from 105,200 tonnes in 1989 to 13,800 tonnes in 1993) (Prodanov *et al.* 1997). Negative trends in abundance are also observed in indigenous mullet (*Lisa spp.*, *Mugil cephalus*) and turbot, especially in the northern part of the Black Sea (Zaitsev and Mamaev 1997), where pressure from legal and illegal fisheries is clearly pronounced. Since the late 1980s the Turkish fishing effort in the Black Sea is the most important (Marine Aquaculture 1996, Prodanov *et al.* 1997, Kerestecioglu *et al.* 1998).

Supposedly, the decline of forage resources, resulting in reduced prey availability, has a strong influence mainly on common dolphins and harbour porpoises (Bushuyev 2000). Nevertheless, distinct signs of malnutrition have been observed only in stranded individuals found with locomotor problems caused by severe trauma or infection (Birkun *et al.* 1992, 1999 b).

Deliberately introduced far-east mullet, *Mugil so-iuy*, is an example of the influence of fisheries or, rather, aquaculture on Black Sea cetacean forage resources. The introduction of this species, originated from the Sea of Japan, was carried out during 1972-1984 in the lagoons and coastal waters of the northwestern Black Sea and the Sea of Azov (Zaitsev and Mamaev 1997). Since the late 1980s this fish became abundant and widespread throughout the region, and at present it is caught in all Black Sea countries. Bottlenose dolphins and, to a lesser extent, harbour porpoises have included this new species in their diet (Krivokhizhin *et al.* 2000, Birkun and Krivokhizhin 2001).

Modification of feeding strategy and behaviour. It is known from Ukrainian and Georgian fishermen that marine fishing activities could be attractive for bottlenose and common dolphins, but, perhaps, not for harbour porpoises. Both dolphin species may use fisheries as additional food source and include their visits to fishing boats and stationary nets into their foraging strategy. Common dolphins reportedly interact predominantly with pelagic trawling of schooling fish; very often they hunt just in the immediate proximity to a hauling trawl. Bottlenose dolphins, by contrast, are interested in both active and passive fishing types operating inshore. Solitary individuals of this species were seen more than once foraging within trap nets in the Kerch Strait, and sometimes attempts to chase them away from traps were made by means of noise and oars (V.S. Dikiy, pers. comm.). In spring 1999 one dolphin came every day during several days to a trammel net set near Cape Meganom, southeast Crimea; during each visit, the animal fed on red mullet caught in the net, leaving behind in the mesh only the fish heads (Yu. N. Ivannikov, pers. comm.). Bottlenose dolphins tend to gather around trawling boats, probably attracted by occasional discards (*e.g.*, whiting); thus, cetaceans have an opportunity to take advantage of this non-used resource (S.V. Krivokhizhin, pers. comm.).

A supposed interspecific competition between Black Sea cetaceans caused by a reduction of common forage resources (Morozova 1982, 1986) has not been confirmed until now.

Fisheries-related deterioration of cetacean habitats The impact of fisheries on Black Sea cetacean habitats comprises all negative influences which are peculiar to small- and medium-scale shipping (*e.g.*, sewage, oil and noise pollution; see Sections 8 and 14), but it also includes some specific extra threats. Actually, the widespread distribution of various types of fishing gear can be considered a peculiar kind of marine pollution by solid objects. That is true indeed regarding countless illegal nets and nets which were discarded or abandoned. High concentrations of fixed and floating fishing gear in some coastal areas result in the reduction of habitat space for harbour porpoises and bottlenose dolphins and represents a potential risk of entrapment.

One more problem relates to seafloor trawling. Bottom trawling in the proper sense has been prohibited in the Black Sea at the beginning of the 20th century when its harmful effect on benthic biocoenoses was recognized (Zaitsev *et al.* 1992). In the 1970s the riparian countries virtually recommenced this kind of fisheries under the new name of near-bottom trawling, allegedly specialized in the catching of sprat. However, both near-bottom and pelagic trawls could be easily transformed into bottom trawls (Konsulov 1998), and their modified use in the shelf area seems to be practically uncontrolled today. In other words, at present pelagic trawling obviously plays a role of legal "umbrella" for illegal bottom trawling aimed to the most valuable Black Sea fish – sturgeons and turbot. Pelagic trawls are non-selective fishing gear due to their very small mesh (about 8-10 mm). Thus, their use along the bottom results in the elimination of not only adult, but also young fish of the mentioned long-living species. Besides, the detrimental effect of seafloor trawling also consists in direct mechanical damage inflicted on benthic communities and in the stirring up of sedimented pelitic matter, which causes a decrease of water transparency and buries bottom biocoenoses in neighbouring areas. Zaitsev and Mamaev (1997) have calculated that a 50 m-wide trawl dragged at a speed of three knots will in one hour plough up the top layer of soil over an area of 30 hectares. The magnitude of bottom-trawling impact on cetaceans (including the decrease of forage grounds and prey accessibility) has not been estimated, although *a priori* both inshore species – the harbour porpoise and bottlenose dolphin – should be much more influenced by this kind of fisheries than the common dolphin.

Accidental mortality in fishing gear. The earliest mention of incidental catch (by-catch) of Black Sea cetaceans in fishing operations dates back to the 19th century. Danilevsky (1871) reported such cases in connection with seine-net fishery of shad in the Sea of Azov. Silantyev (1903) considered the entrapment in fixed nets (especially, in bottom nets for turbot) and drag seines as a cause of cetacean accidental mortality along the Caucasian coast. However, no statistics on dolphin and porpoise by-catches were recorded in the Black Sea countries up to the late 1950s (Salnikov 1967).

The regular recording of by-catches began in the former Soviet Union in 1968 and lasted till 1993 (included). During 26 years that was a function of the Fish Protection Service attached to the Ministry of Fisheries of the USSR (until 1991) and to analogous national ministries/committees of Ukraine, Russia and Georgia (since 1991). For a long time the information on cetacean by-catches was available only to narrow ministerial use. Even now a large portion of this data, accumulated in the internal annual reports, is not published; the only brief publications available (Zhuravleva *et al.* 1982, Artov *et al.* 1996, Pavlov *et al.* 1996) are limited to the Black Sea waters off the Crimea and Russian Caucasus, including the Strait of Kerch. During 1984-1990 the incidental capture of cetaceans was also monitored in Romania by the Museum of Natural Sciences in Constantza (Vasiliu and Dima 1990). In 1993-1997 by-catches were recorded along the European coast of Turkey by researchers from the Istanbul University (Öztürk *et al.* 1999 b). The most comprehensive study was carried out for two years (February 1997 – January 1999) simultaneously in Bulgaria, Georgia and Ukraine (BLASDOL 1999, Birkun *et al.* 1999a 2000). It is difficult to compare the results of all these works (Table 10.2) because of different, sometimes unknown research methodology and efforts; however, some preliminary conclusions are possible.

<u>Geographical distribution.</u> Cetacean by-catches occur throughout the Black Sea waters of all six riparian countries. In Russia and Ukraine by-catches take place also in the Azov Sea and Kerch Strait. No direct evidence is available from the Sea of Marmara and Turkish straits, although incidental catches of dolphins and porpoises seem to be very possible in that area of intensive coastal fisheries, and several cetacean strandings, recorded in the Marmara Sea, were suspected as a result of by-catch (Öztürk *et al.* 1999 a).

Most cases of incidental entanglement in fishing nets occur not far from the shore and in the shallow waters of the continental shelf. For instance, by-caught individuals examined in Crimea were found at a depth from few metres to 94 metres (Birkun and Krivokhizhin, unpubl. data). Traditional areas of bottom-set gillnet fishery and, to a lesser extent, pelagic trawling could be considered as the hot spots of cetacean mortality in fishing gear. Some (but obviously not all) fishing sites in which by-catch occurences are frequent were revealed in Russia (coastal area from Anapa to Sochi) and Ukraine (waters off the Crimea near Sevastopol and Feodosia, between Chernomorskoye and Evpatoria) (Pavlov *et al.* 1996, BLASDOL 1999). According to the latter report, in Bulgaria the majority of definite and suspected by-catches were recorded in two areas: from Shabla to Balchik and from Bjala to Cape Emine. In Georgia most cases were concentrated between the mouth of Chorokhi river and the Turkish border.

Species composition. Harbour porpoises almost always represented the major part of cetacean by-catches recorded in different places around the Black Sea (Table 10.2). On the contrary, bottlenose dolphins never predominated in by-catch scores; as far as common dolphins are concerned, only two exceptions are known in 1968 and 1976 when yearly number of common dolphins, by-caught in the Crimean and Caucasian area, was higher than the number of by-caught porpoises. Quite often the annual share of incidentally captured *P. phocoena* mounted to 90-100%, while the shares of *D. delphis* and *T. truncatus* tended to zero.

According to the results of regular studies (Vasiliu and Dima 1990, Pavlov *et al.* 1996, BLASDOL 1999, Öztürk *et al.* 1999 b), during the past decade (1990-1999) a total of 448 accidentally entrapped cetaceans were recorded in the Black Sea, including 425 harbour porpoises (95%), 10 common dolphins (2%) and 13 bottlenose dolphins (3%). In other words, every two tens of by-caught cetaceans consisted of 19 porpoises and one common or bottlenose dolphin. This estimation strongly suggests that the direct impact of Black Sea fisheries is focused mainly on *P. phocoena*, and the intensity of this impact is probably 30-40 times higher compared to the adverse influence of fisheries on the other two species.

The absolute numbers of population losses due to by-catch were not estimated in most Black Sea countries. Supposedly, every year at least 2,000-3,000 harbour porpoises and 200-300 bottlenose dolphins are accidentally caught in Turkey (Öztürk 1999 a, b).

Hazardous gear and seasons. Between the late 1960s and the early 1990s bottom gillnets for turbot (*P. maeotica*) and dogfish (*Squalus acanthias*) caused 98% of known cetacean by-catches in the waters off Crimea and Russian Caucasus; the remaining 2% belonged to bottom gillnets for sturgeons (*Acipenser spp*., *Huso huso*) and labyrinth trap nets (Artov *et al.* 1994). Notably, official statistics in this area is quite incomplete because some legal and numerous illegal nets are not accounted for, moreover, the trawling fleet was almost entirely uncontrolled as far as by-catches are concerned. Thus, “net danger index” (CPUE) values have been calculated for turbot and dogfish fishery only: they averaged, respectively, nine and twelve by-caught cetacean individuals per 100 kilometres of net per year (Pavlov *et al.* 1996).

Vasiliu and Dima (1990) reported that in Romania most incidental catches of harbour porpoises occurred in passive fishing gear (not specified in detail) predominantly in March-May when small schooling fishes, mostly sprat (*S. s. phalaericus*) and anchovy (*E. e. ponticus*), aggregate in the northwestern Black Sea area. The capture of common dolphins coincided with a scad (*Trachurus spp.*) fishery in July-September.

In Turkey all published cases of cetacean by-catch (62 harbour porpoises and one bottlenose dolphin) have occurred in turbot bottom gill nets from April to June (Öztürk *et al.* 1999b). However, there are cursory mentions that harbour porpoises and bottlenose dolphins die in Turkish waters also due to the sturgeon and sole (*Solea spp*.) bottom fisheries, and “frequent instances of accidental capture by gill or trammel nets” are known for common dolphins (Öztürk 1999a). Unfortunately, no evidence has been supplied by the author to illustrate his conviction.

According to BLASDOL (1999), by-catches are most frequent during the year’s second quarter (108 cases, or 68% of the reported total) off the Black Sea west, east and north coasts, with peaks of the accidents in April (Bulgaria), May (Georgia) and June (Ukraine). By-catches, recorded within these risky months, occurred in bottom gill nets for turbot (99 harbour porpoises and five bottlenose dolphins) and trap nets (two bottlenose dolphins). During the other months one bottlenose dolphin and about 40 harbour porpoises were found in turbot nets, and few porpoises (no less than four individuals) in the bottom gill nets for dogfish. All three cases of common dolphin by-catch were caused by pelagic trawling for anchovy in December in the Georgian wintering area of this fish species.

Two additional common dolphin by-catch incidents occurred in November 1995 in Ukraine near Evpatoria during pelagic trawling operations for sprat (Birkun and Krivokhizhin, unpubl. data). A single case of cetacean (harbour porpoise) entrapment in trammel (triple-wall) net was registered in January 1994 in Laspi Bay, south Crimea. In addition, local fishermen reported that bottlenose dolphins and, perhaps, other Black Sea cetaceans were sometimes incidentally caught in purse seines used to catch far-east mullet (*M. so-iuy*) in the Kerch Strait and for the winter fishery for anchovy off the coast of Crimea (A. Chashchin, pers. comm. to S. Krivokhizhin).

Thus, bottom-set gill nets and turbot fishing period between April and June appear the principal fishing gear[1] and season which are hazardous for Black Sea bottlenose dolphins and, especially, for harbour porpoises. Common dolphins are threatened mainly by trawl nets catching schooling pelagic fishes in late Autumn and Winter. Other fishing techniques, including purse seines, trammel and trap nets, seem to be of secondary importance.

Non-mortal injuries and mortality rate. No direct data are available concerning Black Sea cetaceans which after the entrapment manage to break loose from fishing nets without human assistance. Certainly, this kind of unrecorded by-catch should take place, and sudden appearance of ragged holes in nets suggests this idea to fishermen. On the other hand, some free ranging cetaceans, namely bottlenose dolphins, show evident signs of past by-catching. For instance, individuals bearing net marks were sighted repeatedly between Foros and Balaklava, south Crimea, in 1997 and 1998 (Birkun and Krivokhizhin 2000). One dolphin had a loop of rope tightened around the tail stock, while another individual missed the left pectoral fin (S.A. Popov, pers. comm.), probably as a result of traumatic amputation.

Almost all recorded by-catches are lethal. There is no published evidence of any dolphin or porpoise survived in fishing nets in Bulgaria, Georgia, Romania and Turkey. Out of more than 2,000 entrapped cetaceans on record, 99.9% of have died in the nets in Russia and Ukraine in 1968-1993 (Pavlov *et al.* 1996). Only two bottlenose dolphins, entangled with their teeth and tail flukes in trap nets, were released alive in Ukraine in 1997-1999 (BLASDOL 1999). One more successful rescue operation related to the above mentioned harbour porpoise accidentally caught in a trammel net placed in shallow water.

Alteration of cetaceans distribution, migrations and reproduction. As shown above, fisheries degrade and confine living space and feeding resources of Black Sea cetaceans; some fishing operations/installations attract bottlenose and common dolphins providing them with an additional source of food; however, many individuals, especially harbour porpoises, perish from year to year in fishing nets. All these factors are likely to influence cetaceans distribution and migrations, which mainly depend on the distribution, migrations and abundance of prey stocks (Malm 1933, Zalkin 1940a, Kleinenberg 1956, Tomilin 1957). Certainly, solid data are needed to provide a better understanding of the mechanisms involved.

Turbot fishing operations in May – June could be defined not only as a significant anthropogenic factor of Black Sea harbour porpoises mortality, but also as a factor limiting their reproduction output (BLASDOL 1999, Birkun *et al.* 2000). The presence of ner-term pregnant, postpartum and lactating females (respectively, 15, 19 and 50% of the total number of mature by-caught females examined) indicated that the turbot fishing season coincides with porpoise gestation and nursing period. Furthermore, the state of mature male and female gonads (except pregnant individuals) indicated that the breeding period occurs in spring and early summer.

[1] Bottom gill nets are dangerous for Black Sea cetaceans, in particular, because of their very large mesh size: from 8-11 cm (dogfish nets) to 12-15 cm (sturgeon nets) and 18-22 cm (turbot nets). The height of these nets varies between 1.5 and three metres, and their length may reach 70-100 metres. Fishermen usually tie together some tens to 200 nets making a single line.

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Table 10.1. Target fish species of Black Sea cetaceans and commercial fisheries and their relative importance for the consumers: P – primary, S – secondary and U – undefined (non-target species)

Fish species	Consumers			
	Common dolphins	Bottlenose dolphins	Harbour porpoises	Fisheries [f]
Anchovy, *Engraulis encrasicolus ponticus*	P [a, c, d, e]	S [a, c, d]	P [c, d, e], S [b]	P
Sprat, *Sprattus sprattus phalaericus*	P [a, c, d, e]	U	P [e]	P
Whiting, *Merlangius merlangus euxinus*	S [a, c, e]	P [c], S [a]	P [e], S [b]	S
Pelagic pipefishes, Syngnathidae *gen. spp.*	P [c], S [a]	U	U	U
Black Sea turbot, *Psetta maeotica*	U	P [a, c]	U	P
Thornback ray, *Raja clavata*	U	P [a], S [c]	U	S
Mullets, *Lisa spp.*	S [c]	P [d], S [a, c]	S [b]	P
Grey mullet, *Mugil cephalus*	U	P [d], S [a, c]	U	P
Far-east mullet, *Mugil so-iuy*	U	P [e]	S [e]	P
Gobies, Gobiidae *gen. spp.*	U	U	P [a, b, e]	S
Red mullet, *Mullus barbatus ponticus*	S [a, c]	S [a, c]	S [a]	P
Bonito, *Sarda sarda*	S [a]	S [a, c]	U	P
Shad, *Alosa spp.*	S [c]	U	S [b, e]	P
Zander, *Lucioperca lucioperca*	U	S [a]	S [b]	U
Bream, *Abramis brama*	U	S [a]	S [b]	U
Bluefish, *Pomatomus saltator*	S [a, c]	U	U	P
Horse mackerel, *Trachurus spp.*	S [a, c, e]	U	U	P
Garfish, *Belone belone euxini*	S [e]	U	U	S
Mackerel, *Scomber scombrus*	S [c]	U	U	P
Wrasses, Labridae *gen. sp.*	S [c]	U	U	U
Blennies, Blenniidae *gen. sp.*	S [c]	U	U	U
Sea scorpion, *Scorpaena porcus*	U	S [a, c]	U	U
Corb, *Umbrina cirrhosa*	U	S [c]	U	U
Silverside, *Atherina sp.*	U	U	S [b]	U
Flounder, *Platichthys flesus luscus*	U	U	S [b]	S
Snouted sole, *Solea nasuta*	U	U	S [b]	U
Pickarel, *Spicara smaris*	U	U	S [e]	U

[a] – Zalkin (1940 a)
[b] – Zalkin (1940 b)
[c] – Kleinenberg (1956)
[d] – Tomilin (1957)
[e] – Krivokhizhin *et al.* (2000) and S.V. Krivokhizhin (pers. comm.)
[f] – according to Prodanov *et al.* (1997), with additions

Table 10.2. Studies on incidental catch of cetaceans in the Black Sea due to fishing operations

	Russia and Ukraine [a]		Romania [b]		Turkey [c]		Bulgaria [d]		Georgia [d]		Ukraine [d]	
Study period	26 years; 1968-1993		7 years; 1984-1990		1993-1997		2 years; 1977-1999		2 years; 1977-1999		2 years; 1977-1999	
Study area (waters off)	Crimea and north Caucasus		south part of the coast		European coast; from Bulgarian border to Istanbul		entire coastline		Adjaria and Georgia		Crimea	
Length of study area, km	1,637		60				355		100		650	
Number of by-caught cetaceans recorded:	2,086		566		63		14		11		130	
harbour porpoises, *n* (%)	1,685	(80.8)	541	(95.6)	62	(98.4)	13	(92.9)	7	(63.6)	123	(94.6)
common dolphins, *n* (%)	297	(14.2)	22	(3.9)	0	(0.0)	0	(0.0)	3	(27.3)	0	(0.0)
bottlenose dolphins, *n* (%)	104	(5.0)	3	(0.5)	1	(1.6)	1	(7.1)	1	(9.1)	7	(5.4)
Extra data available:												
sex	n.a.		n.a.		n.a.		Yes		Yes		Yes	
age	n.a.		n.a.		n.a.		Yes		Yes		Yes	
measurements	n.a.		n.a.		n.a.		Yes		Yes		Yes	
nutritional state	n.a.		n.a.		n.a.		Yes		Yes		Yes	
state of reproductive system	n.a.		n.a.		n.a.		Yes		Yes		Yes	
stomach contents	n.a.		n.a.		n.a.		Yes [e]		Yes [e]		Yes [e]	
pathological findings	n.a.		n.a.		n.a.		Yes		Yes		Yes	
concentrations of xenobiotics	n.a.		n.a.		n.a.		Yes		Yes		Yes	

[a] – after Pavlov *et al*. (1996), with additions and corrections according to the reports of the Crimean Black Sea Fish Protection Service
[b] – Vasiliu and Dima (1990)
[c] – Öztürk *et al*. (1999 b)
[d] – BLASDOL (1999)
[e] – Krivokhizhin *et al*. (2000)
n.a. – not available

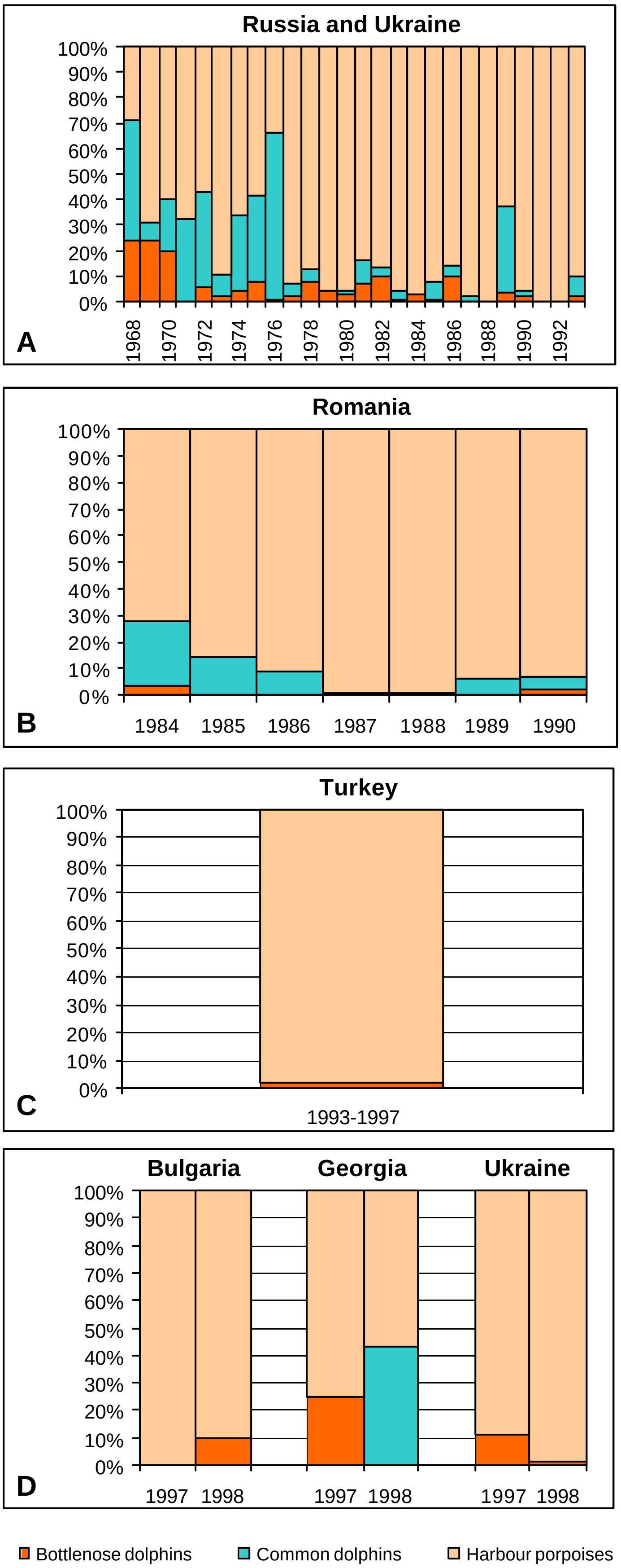

Fig. 10.1. Species composition of cetacean by-catches in the Black Sea. After Pavlov *et al.* 1996 (A), Vasiliu and Dima 1990 (B), Öztürk *et al.*,1999 b (C), and BLASDOL 1999 (D).

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 11

Disturbance to Mediterranean Cetaceans Caused by Vessel Traffic

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Disturbance of cetaceans by sea traffic is a subject that has often, and for a long time, been presented as a probable, important threat but about which very little is known (Parsons *et al.* 1999). Recently this subject has returned to the core of specialists' concerns, with in particular a workshop devoted to ship-cetacean collisions held at the last Congress of the European Cetacean Society (Rome, May 2001). In the case of North Atlantic bowhead whales the problem is so worrying that they for several years now have had a work committee on the subject.

Disturbance caused by sea traffic can be of several orders and different levels of importance according to the species of cetacean, which neither suffer nor react in the same way to the presence of boats.

Essentially, in this Section we shall tackle disturbances due to the presence of a boat, noise being dealt with in chapter Section 13. But these two subjects are closely linked. Similarly, the effects of whale-watching are further developed in chapter Section 12, but we will have to mention the behaviour of boats which are similar to these.

In the first part we shall synthesize the results concerning the direct impacts of the passage of one or several boats on a nearby group of cetaceans, in the short and long term. Then we shall deal with the issue from a spatial point of view, i.e. by assessing the level of exposure to sea traffic of the cetaceans' critical habitats (feeding areas, reproduction areas, resting areas…) and what the consequences of this are. Finally, we shall develop one particular, worrying aspect due to sea traffic: collisions with cetaceans.

What is understood by sea traffic? Sea traffic includes all the craft moving over the surface of the sea. They come under several categories according to their method of propulsion, their speed, their size and their activity, on which their behaviour will depend. Two main categories are essentially borne in mind:

- boats which transport passengers or goods (cargo, tanker, container ship, ferry…), often large (over 100 m long) and travelling at speeds from 14 to over 40 kts. They keep to a precise route which is often identical from one journey to the next all year long, from which they do not deviate.
- Pleasure craft that sails or is motor-driven (sailing boat, yacht…). Their size and speed are very variable. They are likely to change speed and direction at any time. Their seasonal element is important.

Impact on cetacean behaviour

The impact of sea traffic on the animals' behaviour can be analysed at two levels: short term, and long term. It depends on the animals' biological and ecological factors and on the modes of passage and features of the boats.

Many in-field studies have been done to study the animals' interactions with and reactions to one or several boats in various conditions. These studies are usually done from land, sometimes from boats and the research teams themselves. To determine behavioural differences, most of the studies are grounded on the animals' breathing cycle, including the time spent on the surface and that spent diving, the rate of respiration on the surface, the distance and speed of swimming, the direction followed. Most of the writers agree that these criteria are valid (Baker and Herman 1989, Kruse 1991), but Stone *et al.* (1992) note such variability in diving behaviour during the day for the fin whale that they believe it is difficult to rely on this method to determine a change in behaviour in response to a boat.

Alongside this work dedicated to the subject we are concerned with, certain limited events are reported by observers.

As regards long-term effects, studies of captured and recaptured animals based on photo-identification allow us to know whether the individuals return year after year to the same sites at the same periods, or whether they disappear from the area.

Species involved. All species are potentially concerned by impacts due to sea traffic but at different levels according to several parameters. Primordial factors will be the intensity and frequency of exposure to disturbance and the biological importance of the period under consideration. Other things to be considered are the animals' individual characteristics and the features of the habitat.

In the scientific literature we have found articles that more precisely concern the following species:

- sperm whale (Fleming and Sarvas 1999, Magalhães *et al.* 1999);

- bottlenose dolphin (Evans *et al.* 1992, Lütkebohle 1996, Fozzi *et al.* 2001, Liret 2001);
- rorquals (Watkins 1986, Stone *et al.* 1992, Jahoda *et al.* 2001);
- humpback whale (Baker *et al.* 1983, Baker and Herman 1989);
- harbour porpoise (Scheidat and Palka 1996)
- grey whale (Pettis *et al.* 1999);
- small pelagic delphinidae (Bazua-Duran 1999);
- freshwater and estuary species such as Inia geoffrensis (Denkinger *et al.* 1999).

Certain facets of the subject are beginning to be relatively well known, essentially as regards the causes of the disturbances and the animals' short-term responses. But we are still unaware of the biological significance of these disturbances, even when they are infrequent and minor.

Also, too little information is available at the present time on the long term.

We thus are still ignorant of almost everything concerning the long-term biological effects of behavioural changes on individuals or populations.

Short-term impacts

The density of the boats has proved to be very dynamic and variable within a small area, and interactions are particularly visible on this scale of study.

When a boat passes in an area where cetaceans are present, there may be direct, limited interaction. As soon as the 'intruder' object moves away, the animals go back to their activities, after a shorter or longer period.

The fact that there has been a 'reaction' on the part of the animals implies that they are aware of a disturbance of their environment, an intrusion. The main signs that will attract their attention will be the sound produced by the boat, the sight of all or part of the boat, and lastly the tactile sensation (the boat itself or the pressure of water caused by the boat's advance).

The reaction to one of these stimuli takes three main forms: positive, indifferent or negative. It depends on:

- the animal's perception of the stimuli, associating it with something interesting, unimportant or dangerous
- the animal's ability to localise the source of the stimuli in relation to its own position, and to perceive its movement
- the animal's knowledge of the stimulus and of whether this is usual or unusual within this knowledge
- the animal's experience and its current activity.

Determining the type of impact (positive, indifferent or negative) is often grounded on the animal's visible, or sometimes acoustic, behaviour. The behaviour adopted during the passage of a boat (disturbed) will be compared to known 'normal' (undisturbed) behaviour. This determining is subject and limited to our means of investigation and knowledge.

Positive impacts. Some animals stop their current activity to approach the boat, or let it approach them. This is usually the case for small delphinidae like *Tursiops*, which can in particular arrive to enjoy the wave from the stem or the wake (Liret 2001). Hammond *et al.* (1995) report that white-beaked dolphins and harbour porpoises were attracted by their research boat, and that minke whales also seemed to react positively.

Indifference (or, no apparent disturbance). The animals continue their activity or their route without notable change. This is generally a very frequent situation in many studies (Witcher and Odell 1999). Liret (2001) finds up to 77% of cases of 'neutral' response on the part of *Tursiops* approached by boats less than 200m away in a channel.

Negative impacts. The animals stop their surface or vocal activity and change their behaviour, moving away from the source of disturbance to be less exposed. Avoidance strategies may be horizontal (swimming away) and/or vertical (diving).

In most studies the animals wishing to move away from the disturbance will tend to first make themselves less visible, to move away from the source of disturbance or danger, and also sometimes to become unpredictable as to their reappearance. Overall, diving times get longer, times at the surface get shorter, vocalization and jumping are interrupted, the individuals in a group move closer together, the swimming speed is faster and the direction followed is away from the source of disturbance (Edds and Macfarlane 1987, Baker and Herman 1989, Kruse 1991, Polacheck and Thorpe 1990, Evans *et al.* 1992, Lütkebohle 1996, Nowacek *et al.* 1999). The animals' movement may either be rapidly in a straight line, or zigzagging so that their reappearances on the surface cannot be predicted (Notarbartolo di Sciara *et al.* 1996). Some individuals may also dive and remain motionless, waiting on the spot until the boat moves away. Either the animal has had the time to see the phenomenon coming and its reaction is suited and gradual, or it is surprised and will have livelier reactions: sudden diving, violent acceleration. Most animals finding themselves in rather confined spaces, such as shallow bays, tend to move towards more open, deeper waters (Stewart *et al.* 1982, Kruse 1991). Others take refuge in places that are inaccessible or dangerous for boats, with many reefs, for example (Liret 2001). An animal that feels itself to be in great danger may even show aggression towards the 'intruder' (Heimlich-Boran *et al.* 1994).

Each case seems to be special, and the short-term (and small-scale) impacts depend on the characteristics of the two 'protagonists' – cetaceans and boats.

For the cetacean

The types and intensity of boat-cetacean interactions are a function of the species and the individual, i.e. its size, habitat, gregariousness and its age, experience and activity.

A large animal (whale or sperm whale) can be detected from further away, while a small member of the delphinid family is usually not noticed (to approach or avoid it). A little member of the delphinidae is usually quicker off the mark and in terms of pure speed, livelier, quicker to react, but it dives less deeply and needs to come up to the surface more often than a large or medium-sized cetacean.

Coastal species are more exposed to intense sea traffic because of the proximity and frequency of littoral human activities. They may also become more easily used to an experience that is often repeated and less sensitive to the disturbance. Pelagic species meet ships more rarely and confront a lesser concentration of human activity. On the other hand, they will also be less accustomed to this type of encounter and thus more sensitive to the slightest disturbance. Hewitt (1985) puts at 38% the groups of pelagic dolphins (*Stenella attenuata*, *Stenella longirostris* and *Stenella coeruleoalba*) that fled at the approach of a research boat, while Liret (2001) shows that almost 77% of *Tursiops'* responses to the many passages of boats in a port channel are null, and 23% are positive.

An isolated individual is less visible than a whole group but can react more easily because it does not depend on others. A group including females accompanied with their young will be restricted in its reactions by the weakest among them. On the other hand, Jahoda *et al.* (1996) noticed that fin whales in a group seemed more confident or less alarmed than isolated animals. In most cases, an isolated porpoise will tend to be more alert and fearful than animals in groups (Evans *et al.* 1994).

As regards the individual, its age – thus its experience – and its sex and character will affect its way of reacting (Nowacek *et al.* 1999). For example, a young individual is more vulnerable for it will not have the physical abilities required to flee from a threat. Furthermore, it will lack the knowledge and experience which would help it choose the reaction it should adopt. Females seem more fearful than males (Magalhães *et al.* 1999 for sperm whales). Its behaviour and physical condition must also be borne in mind: an animal that is feeding, resting or socializing is less alert, less ready than an animal without a precise occupation and more attentive to its environment (Watkins 1986, Angradi *et al.* 1993, Lütkebohle 1996).

If we wish to assess the impact of sea traffic on cetaceans we must also bear in mind the time of year or of day. Indeed, cetaceans often present marked seasonal or nycthemeral behaviour (Klinowska 1986), with periods or moments essentially devoted to feeding or in which females are accompanied by their newborn. During these times they will probably be more vulnerable and more easily and seriously disturbed by an intrusion. Evans *et al.* (1994) note that harbour porpoises' negative responses are more in place in early rather than late summer, probably since as the summer advances the newborn are less vulnerable and in late summer the adults are more taken up with activities of socializing and reproducing.

For the boat

A boat's impact potential will depend on its physical features (size, propulsion) and its behaviour, including its speed, type of approach and distance from the animals. The number of boats present is also an important factor.

Very often, when a disturbance has been noted, the size and the presence of a motor do not play a major part: the mere presence of the boat is enough to spark off a reaction among the animals. The intensity of the reaction may, however, be influenced by the type of boat.

Kruse (1991) sees no difference in the responses of killer whales as to size of boat or type of motor. The harbour porpoises studied by Evans *et al.* (1994) tend to react negatively to all kinds of boats, although more particularly to speedboats than to yachts. Green *et al.* (1999) note a more marked acceleration of humpbacks when the boats are noisier.

The boat's speed alone generates sound disturbance and can then be seen in terms of time of reaction available, and also in terms of chance of survival during a chase, for example.

Several times jet-skis have been clearly implicated, because being extremely fast and easily manoeuvred they are hard to shake off for certain dolphins (WDCS 2000), they make little noise in the water and easily take the animals, who have very little time to react, by surprise (Evans *et al.* 1992). On the other hand, the *Tursiops* studied by Liret (2001) respond positively in 87% of cases to the passage of a boat at a speed of more than 5 knots, and the duration and distance of the interaction increase if the boat tries to approach the animals. The greater the speed of the boat, the more it attracts dolphins, especially adults. Boats passing slowly, or small boats, do not arouse a positive reaction among the dolphins, apparently because they do not have a sufficiently sizeable stem wave or wake. The subadults are the first and the most often in interaction, while females accompanied by newborn keep their distance.

The distance at which cetaceans detect the boat, and thus its proximity, will more or less determine the type and intensity of the animals' reaction.

These distances are sometimes large, especially for bowhead whales, and Baker *et al.* (1983) show that humpbacks in Hawaii respond predictably to boats at distances of 3 km. Similarly, bowhead whales move off in the opposite direction to the approaching boats when these are between 1 and 4 km. away and try to shake them off at under 1 km. (Richardson *et al.* 1985). Fin whales also respond to boats at a distance of 1 km. or more (Edds and Macfarlane 1987). For little Odontocetes, such as *Tursiops*, Evans *et al.* (1992) show that the animals react between 150 and 300 metres to a boat's approach in a sea that is 3-4 Beaufort, signifying that that is the distance threshold to react negatively in these sea conditions. In his study, Liret (2001) notes that the minimal distance of response is imposed by the type of place: lower in a narrow channel and higher in a more open area.

In all cases, a distance of less than 200 metres is critical, and at under 100 metres the animals are alarmed.

One should know, even if this is not the subject of this paragraph, that the first sign of its presence is the sound emitted by the boat, which the animals perceive at sometimes very great distances. Finley *et al.* (1990) find that the belugas avoid boats which approach at distances of 45-60 km., and seem aware of a boat approaching at a distance of 85 km. Baker *et al.* (1983) note that humpbacks change behaviour in response to boats that are 2-4 km. away. And Evans *et al.* (1992) have measured that the deep sounds of a big boat at high speed could be heard at over 3 km. in a sea in Beaufort 3 state, and at under 500 metres for more discreet, or slower, boats or boats which are essentially air-powered like jet-skis.

It is necessary to draw a distinction between two main cases: that of a boat which passes without changing speed or direction, whatever its size (the case of the very large majority of boats from regular passenger- and goods-transport lines) and that of a boat whose behaviour is active and intrudes on the animals (rather specific to pleasure craft).

Several studies reveal that the animals do not show marked negative behaviour in response to the sea traffic of boats which merely pass in transit on regular lines (Acevedo 1991, Browning and Harland 1999) and are even attracted by them (Angradi *et al.* 1993). Thus Edds and Macfarlane (1986) report that generally speaking the large whales do not react openly and flagrantly to the very large volume of sea traffic that is pretty much constant in the St Lawrence. They think that the animals avoid the contact and proximity of the boats, but only really pay attention if they pursue them. Moreover, a boat which regularly moves over the area frequented by a group of cetaceans generates less reaction (distance of removal and duration before moving back to the area) than a boat of the same type which is present in irregular fashion (Evans *et al.* 1994). This phenomenon is probably due to familiarity (Watkins 1986).

But cetaceans are much more often disturbed by boats trying to get near them (Janik and

Thompson 1996, Witcher and Odell 1999, Cope *et al.* 2000). There seems to be a certain tolerance threshold beyond which the animals' responses are provoked and negative: intrusive behaviour of the boat which approaches too near, bearing directly down on the animals and passing in the midst of or just alongside the group, frequent and sudden changes of speed and direction, starting up the engine, circling around, following or even chasing the animals for several hours.

An important factor is also the number of boats around and the frequency of passage. It is shown that the greater the number of boats the greater the level of disturbance (Cope *et al.* 2000) and the more negative and stressed the reactions.

In almost all cases of disturbance reported, several boats were involved (WDCS 2000, Miragliuolo *et al.* 2001). Kruse (1991) reports that killer whales move off increasingly quickly as increasingly more boats approach them.

This is probably due to the fact that the animals manage to localize and assess, even anticipate, the course of a single boat, especially if it is merely passing, with a constant route and direction. But faced with several ships the animals feel less confident and more threatened, since they are more powerless. The stress is all the greater if the boats are rapid, often change direction and speed, and are very easily manoeuvred around (jet-skis, speedboats…) – i.e. are really unpredictable.

Long-term impacts

The accumulation of short-term disturbances, intensification of traffic, opening of new shipping lines and development of ships' speed particularly may have consequences in the longer term. Long-term impacts can extend over a season and up to several years.

'Direct' negative consequences

- a more or less permanent change of behaviour. Animals that have for years been most exposed to human activities adopt a more discreet, shy overall behaviour than others which are less exposed (Richardson *et al.* 1995)
- temporary or permanent avoidance of certain areas (Hudnall 1978, Baker and Herman 1989, Green 1991)
- the repeated and chronic stress generated by these disturbances may give rise to behavioural and physiological changes (among them a fall in the reproduction rate, lessening of lactation, discrepancy in growth and sexual maturity and weakened resistance to disease)
- the increase in time spent diving and rapidly swimming to avoid the source of the nuisance results in a drop in the effective time spent in vital occupations, such as seeking for food, resting or nursing. This leads to a decline in the animal's general health (lowered metabolic rate, change in circulation and oxygen deficiency) plus a drain on its energy reserves and budget (diving, accelerating and being stressed burns up energy). These phenomena can have repercussions at the level of fertility and the rate of reproduction and adversely affect pregnant and nursing females and the survival of the young. Green and Green (1990) see the increase in maritime traffic as a possible cause of the dwindling reproductive success of *Megaptera* in the last 10 years, the animals having gradually moved to deep waters after being disturbed in their shallow bays where they usually give birth. The same kind of situation has long been reported for grey whales which have abandoned the lagoons used as their reproduction and birthing area (Gilmore and Ewing 1954 in Green and Green 1990). In 1998, the Ocean Mammal Institute (O.M.I.) expressed concern about the case of dolphins (Stenella longirostris) which feed at night and come to rest during the day in a bay which is quiet and sheltered from predators - and which is threatened by sea and land tourist development.

'Indirect' negative consequences

- disturbance of animals in the lower echelons of the trophic chain: fish, cephalopods, and thus food resources for cetaceans;
- degradation and destruction of habitats (the effect of a freighter's propeller could be felt up to 100 metres down, with churning up and dropping of suspended matter and thus less light, plants being pulled out by the upheaval, destruction of reproduction sites for various animals…).

In both cases, cetaceans will have to change their behaviour or even their residence, hoping to find one which satisfies their vital needs.

Familiarity and tolerance threshold

The long-term effects may also be 'positive', especially through animals becoming accustomed to their environment. Animals show an ability to adapt to many phenomena, particularly if these appear gradually. However, different species do not all react in the same way to stimuli, and these reactions change gradually over time, constantly, with increased exposure to these activities.

Thus, according to the study by Watkins (1986) of 25 years' data, after years of exposure to boats the minke whale, which at first frequently reacted positively, has become increasingly indifferent. Fin whales have gone from reactions that were in their majority negative to indifference, and bowhead whales have always apparently presented the same variety of responses with no great change, while the *Megaptera* responses – first highly variable or even negative – have become very positive and interactive. Fleming and Sarvas (1996) note, using respiration and diving parameters, that sperm whales avoided the whale watching boats less at the end of a season than at the start of a season. It is possible that the animals have become used to the repeated approaches, but it is also possible that the most disturbed individuals left the place early and that only the less fearful remain. On the other hand, Kruse (1991) sees no alteration in killer whale responses as the summer season advances, indicating that the animals do not get used to the presence of the boats.

This phenomenon of familiarization and becoming less alert towards the boats is more marked for whales near the coast, in particular in regions of intense traffic and repeated approaches by (whale-watching) boats. Similarly, familiarity over the years is more blatant for local groups, whereas animals passing through, being less exposed to these experiences, have changed little in their response and suffer more disturbance. This adaptation is not only the specificity of some individuals which have become used to the boats but is now observed in the entire population under study (Watkins 1986).

Adaptation to the passage of boats is a fact, but how far are animals able to live in the midst of ever-increasing sea traffic?

Studies of animals captured and recaptured by photo-identification prove that in many places the animals regularly return to areas where they have in fact been subject for years to a certain amount of sea traffic (Watkins 1986, Edds and Macfarlane 1987, Janik and Thompson 1996, Parsons *et al.* 1996). Other studies show, moreover, that certain groups of animals have moved from their habitual places (Owens *et al.* 2001), but the causal factors are not always clear. It is nonetheless certain that the increased intensity of sea traffic plays a part that is not negligible and that many writers are worried about the future of animals confronted with the development of maritime anthropic activities.

In the Mediterranean

In the Mediterranean, few studies are entirely devoted to this subject, but the issue is becoming worrying and is arousing growing interest on the part of managers and scientists. Nonetheless, the first results are consistent with the set of observations made elsewhere in the world.

- Fin whales seem to be rather disturbed by the boats which approach them. They tend to speed up and reduce the rate of blowing, while following a wavering or zigzag avoidance course (Notarbartolo di Sciara *et al.* 1996).
- Observations made by Díaz Lopez *et al.* (2000) differ in the sense that fin whales frequent the waters of the island of Ischia, in Italy, are generally indifferent about boats passing over 100 metres away from them, and react positively if these are nearby.
- Interactions between pleasure craft and animals are increasing in a worrying fashion in certain cases. The observation reported by Miragliuolo *et al.* (2001) instances a resident group of Risso's dolphins harassed for several hours by a number of boats, a phenomenon that seems to be becoming a daily routine in the summer months.
- De Stephanis *et al.* (2000) have shown that little delphinidae (*Stenella coeruleoalba*, *Delphinus delphis*) in the Strait of Gibraltar do not appear to see regular line transports as a danger, a fact also noted by Roussel (1999) in the same area and by Angradi *et al.* (1993) in the Tyrrhenian Sea. They are even rather attracted, particularly by the stem wave. The attraction is stronger when the animals are socializing, average when they are feeding and resting and weak when they are travelling. On the other hand, medium-sized cetaceans react differently to boats than the previous species.
- Bearzi and Ferretti (2001) report observing a Tursiops in a lagoon in Venice, Italy. The animal seems to master its course and not in the slightest to be disturbed by the traffic of passing boats, except when several boats to-

gether attempt to force it to turn and go back to the sea.

To conclude we can say that the phenomenon of interaction between cetaceans and boats varies considerably from one species to the next, one population to the next, according to the area and the characteristics of the sea traffic.

The threats are felt more precisely at the level of individuals, a group or even a sub-population. At the present time in the Mediterranean this kind of disturbance would not threaten populations or species.

Certain solutions can be envisaged to lessen the threats due to sea traffic. Some have already been introduced in areas of risk. These measures inevitably require the involvement and cooperation of all the agents in the marine environment.

Level of exposure of main areas of cetacean concentration

After trying to assess the impacts of the disturbance directly caused by the passage of one or several boats near to an individual or group of cetaceans, we are dealing with the subject from a more spatial point of view. Indeed, some areas are particularly frequented by cetaceans, for reasons of feeding or reproduction, every year. Now, these areas are also subject to fairly intense sea traffic. What is the level of exposure of cetaceans using this area to sea traffic, and what are the consequences of this?

Studies allow the animals' spatio-temporal distribution to be known, as well as the special importance of certain areas for use for feeding, rest or reproduction. They establish the evolution of and changes in this distribution and try to grasp the causal factors: environmental or anthropic?

Alongside these direct observations, certain teams increasingly develop predictive assessments and create models. Trying to explain the presence of the animals as a function of certain environmental factors one can then use this relational knowledge to foresee the distribution of cetaceans in space or time. Lastly, the survey system, and collaborating with the various transport companies and national maritime bodies, allow sea traffic intensity to be mapped. By comparing the distribution of the animals and of human activities it is possible to assess the risks for both.

Direct threats are:

- disturbance of animals in vital places and times (feeding, reproduction, nursing)
- confinement of animals to other, clearly less favourable, areas.

These lead to consequences that are important for the quality of life, even survival and reproduction, of individuals, since the disturbance forces the animals to drain their energy reserves.

Indirect threats especially concern the destruction or degrading of the habitat and its resources, which forces the animals to leave the area.

Little is known about indirect threats. For example, what is the effect of the wake left by a boat? The wake from a freighter (disturbance and churning up of water) can be felt several dozen metres down. That of a high-speed vessel (such as "NGV", *navire à grande vitesse*) is made up of billions of tiny air bubbles which form a kind of curtain, and very hot water rejected by the turbines. Its trace persists for quite a time - in fact the return France-Corsica trip can be done using the visible wake of the outward journey made hours before.

What is the effect of these disturbances on the phytoplankton? What will be the effect with the increase and development of the NGVs?

Space-time distribution of cetaceans

Cetaceans have a very variable use of space. Certain species are rather sedentary, moving around in a fairly big area all year long, whilst others migrate from one area to another as the seasons change.

It is necessary to identify the areas that are regularly occupied and their importance for populations: reproduction and birth areas, feeding areas, determined migration track. Besides this, the animals can occasionally gather in an unusual place when responding to special environmental conditions. For management objectives, for example, sites used by North Atlantic right whales have been listed in 4 big categories: 1) areas used intensively and for long periods of several months (main habitats), 2) areas of intense short-term use, 3) clearly defined migration track and passage, 4) secondary, less well defined migration tracks. This being a migratory population, each of these areas will be more frequented at one time of year than another.

In the Western Mediterranean, cetaceans gather during the summer in the northern part and move in a general cyclonic manner, with secondary movements between the different sectors during the summer (David and Di-Méglio 1999, David 2000, Roussel *et al.* 2000). Moreover, little delphinidae make nycthemeral movements between the coast and the open sea (Gannier and David 1997, Bourreau *et al.* 2000).

Space-time distribution of boats

Generally speaking, the coastal areas experience greater human activity. The industrialized port sites on the littoral give rise to an incessant ballet of comings and goings of all types of merchant shipping. Sometimes ships are induced by force or by necessity (draught) to use a navigation track or channel. Water sports leisure areas are concentrated around boating ports, and most pleasure boats stay near the marinas and the coast.

All merchant shipping takes the most direct routes with the minimum distance to be covered and the minimum time spent at sea. So the ships often go near the coasts they are sailing along. Some smaller units of transport also hug the coast for greater shelter in bad weather. Merchant shipping and pleasure boats must thus move through sensitive or protected areas, including those boats carrying dangerous or very pollutant matter (oil tankers, boats carrying chemicals, gas carriers…).

Moreover, though the merchant shipping traffic varies relatively little during the year, the ferries are usually more frequent in the summer season, when pleasure boating is also at its height.

Lastly, change over the coming years seems to be towards a growth in the human population of the littoral, therefore an increase in the number of registered boats, and a development in the speedboat market (NGVs for commerce and jet-skis for leisure).

Degree of exposure and consequences

Is there overlap between areas of high traffic density and areas that are primordial for cetaceans, and what are the risks and consequences?

For Russel and Knowlton (2001), ‘high-risk management areas’ are those where there is convergence - a strong density of whales or area critical for the population (reproduction or feeding area) situated on boat transit and passage routes; and/or an area with heavy sea traffic on migration tracks. Lastly, vast areas where little is known about distribution will also be taken into account in the management plan.

Animals adapt their behaviour to their environment up to a certain level of exposure which they tolerate. After 13 years had passed, Richardson *et al.* (1995) show that a *Balaena mysticetus* stock, which was at least three times as much exposed to human activities (industrial, boat traffic and air activity) as another stock, developed a clearly more discreet behaviour (longer dives, lower percentage of time spent on the surface and displaying the caudal above the water).

Several in-field studies show that cetaceans leave certain favourite areas temporarily or permanently when the level of sea traffic goes beyond a certain tolerance threshold. Thus, Allen and Read (2000) show that *Tursiops truncatus* use their feeding sites less during periods of high traffic density, such as the weekend. And Schmidt and Hussel (1993) note that harbour porpoises avoid areas which they usually frequent as soon as water sports (jet-ski, parasailing) start up in the summer, especially since this is the time when many newborn cetaceans are present in the groups. Wells and Scott (1997) find a clear correlation between the large number of *Tursiops* seriously wounded by boats and an exceptional period of sea activity: a weekend in full summer season during which a much-prized Grand Prix off-shore race takes place, attracting thousands of spectators in boats. But Liret (2001) reports that a group of sedentary *Tursiops* stayed one entire afternoon in the entrance channel of a port. Now this is also the time of day when the traffic of comings and goings of boats is at its height. The writer, observing no change in the behaviour or positioning of the dolphins, concludes that for the time being there is no negative effect, but that the development of tourism could reach a level that would be harmful to the animals over the coming years.

In the Mediterranean

Most of the phenomena noted in the world are found in the Mediterranean, though few studies have been entirely devoted to this subject.

Studying the distribution of cetaceans on the north-west continental fringe of the Mediterranean, David (2000) shows the variations in relative abundance during one day, with a minimum during the afternoon for several species. An explanatory factor would be pleasure boat traffic, which is at its height at this time of day.

Urquiola *et al.* (2001) remind us that the Gibraltar Strait holds the second place in the world in terms of sea traffic. Every day it is crossed by a large number of boats, including NGVs. Slower ferries do not seem to worry little delphinidae, but can play an important part in the presence of larger cetaceans.

A French-Italian study, 'POSEIDON' (Roussel *et al.* 2000 and 2001), done over four years (1994-1998) in the North-West Mediterranean, compares on 20-minute angle mesh the distribution of cetaceans and human activities (Fig. IV.E.1). It shows that species prefer to frequent certain sectors which may change during the summer. Human activities also offer a clear spatial and temporal component and thus the rate of cover of cetaceans and of human activities varies. The result is that among the various cetacean species, rorquals frequent pelagic areas that are much crossed by transport shipping (ferries and freighters) but little used for other activities (pleasure and fishing). By contrast, *Tursiops* use more coastal areas and are thus led to mix with a lot of active fishing boats.

The issue of interaction between cetaceans and human activity (inclusive of sea traffic) is becoming a priority. One must understand and integrate ecological and economic parameters into the aims of protecting and conserving the marine environment, at least on a national scale (Raga *et al.* 2001).

To conclude, it is certain that all around the world coastal species have become increasingly rare along coasts or in estuaries where they used to abound. Sea traffic, and its various elements, is very probably one of the main reasons for this.

But it is sometimes difficult to define and quantify the part played by this factor in the phenomena observed.

Collisions and their risks

Some ships, by dint of mixing closely with and crossing areas frequented by whales, collide with cetaceans.

Most of the data comes from reports of strandings. It is not easy to determine the causes of an animal's death, particularly if the carcass has remained in the water a long time. In certain cases, collisions are indeed the cause of the animal's death.

This method is inadequate because it involves many angles: unrecognised, unreported, erroneously attributed to a post-mortem collision, the number of recorded cetacean strandings whose cause is a collision is understated compared with reality (Morgan and Patton 1990, Laist *et al.* 2001), particularly so since on ships over 400 feet long most collisions are not noticed by the crew, unless the animal stays caught and pinned to the bulb of the stem, which is possible for long, thin species like rorquals but much less so for others. But one thing must be said: a very great majority of the big cetaceans exhibited in museums show bone fractures that are certainly due to collisions (J.L. Fabre, *pers. comm.*).

Photo-identification can be a good way of determining the rate of live animals displaying scars from contact with a boat, such as, for instance, parallel cuts from propellers, and holes or gashes from stems.

Lastly, the testimony of captains and sea transport companies constitutes information of paramount importance that enables assessments of animals hit to be compiled.

Tregenza *et al.* (2000) present a simple mathematical model indicating the number of cases for which a static animal would be hit or violently displaced by the stem of a passing boat, given the animal's length, average time spent on the surface, the density of animals in the study area, and the length and frequency of the ferry's journeys. They obtain relatively high values, which double in the case of a ferry route that crosses a migration path at right angles. They conclude that if the animals do not avoid the ferries effectively and constantly, the population of *Globicephala* studied could very quickly be decimated. But the model is not totally realistic of what happens at sea.

Risks may be perceived at the level of the individual or the population.

- individual: an animal hit by a boat may come out of it unscathed, slightly hurt, seriously wounded or killed. The long-term effect of a minor collision on the rate of survival is not known;
- population: threats will depend on the number, age and sex of the animals hit, wounded or killed, and the population's conservation status. Certain sedentary Tursiops populations are threatened, and the population now in greatest danger is that of the North Atlantic right whales.

According to Laist *et al.*, (2001), collisions probably have a negligible effect on the status and evolutionary trends of most whale populations, but for little populations or 'isolated or even endemic' groups they can be significant. Clapham (Tethys workshop collision ECS, Rome, 2001) presumes that collisions are a problem at the population level for right whales only, or in extreme circumstances for *Megaptera*, but apparently for no other.

Species involved

Practically all species are involved in collisions with ships but some are involved more than others, from the evidence gathered. Laist *et al.* (2001) have collected data on collisions including 11 large cetacean species, among which the fin whale is most frequently hit. Right, humpback, grey and sperm whales hits are relatively common in some areas. They found comparatively little information on minke, blue, and sei whales, and very rarely on Bryde's and bowhead whales.

Some writers have studied the phenomenon for certain species, in particular:

- the fin whale (Pesante *et al.* 2001)
- the sperm whale (Aguilar *et al.* 2000)
- the killer whale (Visser and Fertl 2000)
- medium-sized cetaceans: minke whale, pilot whale, Cuvier's beaked whale
- the bowhead whale (Knowlton *et al.* 1999)
- the little delphinidae: quicker and livelier, these species are in general less often hit by boats. But exceptional conditions, like an unusual concentration of boats in a confined, shallow place, can clearly increase the risks and cases of collision (Wells and Scott 1997). They can also be either sucked in by the propellers' wash and cavitation, or struck by over-inquisitive little or medium-sized boats, as in the WDCS report (2000) mentioning Delphinus delphis and Tursiops truncatus.

Collisions have been identified as being the major anthropic cause of mortality responsible for at least 16 right whale deaths over the last 30 years, 9 of them in the last 10 years (Russel and Knowlton 2001). If nothing is done to stop the deaths caused by humans, this population will die out. Out of 361 photo-identified and catalogued individuals, 7% present scars due to boat propellers. Females are twice as often hit as males (Marx *et al.* 1998).

Some individuals are more vulnerable than others: the young, females with newborn babies, or individuals with a weakness (disease, physical handicap, being entangled in nets) which forces them to be more often on the surface or restricts their possibilities of flight. Wells and Scott (1997) report that *Tursiops* wounded by boat propellers or stems all fell into one of the above categories. In the records, a high percentage of the right whales and humpback whales hit are young (Deakos *et al.* 1999, Laist *et al.* 2001). The reasons given are the greater time they spend on the surface, and the fact that they are in shallow waters (continental shelf) where many boats pass. It could also mean that as they grow up they learn to avoid boats.

A priori, the populations which are most often hit are those near or on transit routes, concentrated in high-traffic areas, and/or belonging to slow, large species. For individuals, those weaker or more vulnerable than normal, or those fully active and not on alert, would pay the heaviest price.

Already collisions in certain major feeding and reproduction areas have endangered some populations: North Atlantic right whales, humpback whales and grey whales.

Boats involved

Laist *et al.* (2001), in their world-wide synthesis, showed that:

- any type of boat or sailing object may hit cetaceans
- most fatal and serious wounds are caused by boats that are over 80 m long and/or ships moving at a speed higher than 13 knots
- since the 1950s, collisions have been responsible for many strandings when the speed and number of boats in action passes a certain threshold.

Collisions may occur with the boat's stem and its sides. Here we should add all the accidents linked to hydrodynamic forces and to the system of propulsion, including wash, cavitation, and propellers. The hydrodynamic force may indeed play its part for an animal which 'appears' very close to the boat and is not pushed away by the positive force at the stem. This animal may then be attracted to the sides of the boat or the bottom, if it is underneath it, sometimes bringing it very near the propeller. Similarly, an animal that is passive under the water may be in danger of colliding with the bottom of the boat or the sea bed, if the water is not deep. The higher the speed, the greater the sucking forces that the animal must swim against to avoid collision. An animal can therefore get away more easily from a slower boat (Knowlton *et al.* in Russel and Knowlton 2001).

From simulations done by Clyne (in Russel and Knowlton 2001), if a boat's speed increases, this lowers the general rate of collision with a whale. But going into detail, the higher the speed the greater the risk of collision with a stem, rather lower with the boat's sides, and constant with its keel.

The same author also did simulations of the passage of a boat in a 10 km-sided square in which 50 whales pass without the presence of one influencing the movement of the other. The three types of boat tested - a 300 m-long freighter, a 198 m-long container ship and a 22 m-long fishing boat – give very different collision rates. For the freighter, the rate is more than double that of the container ship, and approximately ten times that of the fishing boat. Leaper and Clyne (in Russel and Knowlton 2001) have assessed the potential of boats' avoiding a detected animal on the basis of a simple simulation. It includes basic data on the animals' surface-diving cycle, the process of detecting the animal, and the boat's ability to manoeuvre. The average percentage of successful avoidance varies from 3 to 60% for boats between 500 tonnes (fishing boats) and 160,000 tonnes (tankers). The success of the avoidance manœuvre declines in an almost straight line as the speed increases, this gradient being more marked for small boats. At a speed of 5 knots, the fishing boat successfully avoids the animal in 85% of cases, the tanker in 10% of cases. At 23 knots, this rate drops to 30% for the fishing boat and 3% for the tanker.

The faster the boat, the more severe or fatal are the wounds inflicted on the animal in a collision, for the force of impact is greater (Russel and Knowlton 2001) and the animal has less time to react and less opportunity to flee (Laist *et al.* 2001).

Leaper and Clyne's results (in Russel and Knowlton 2001) also show that when the number of blows at each return to the surface is constant, the rate of detection does not change much if diving time, surface time or boat speed are varied. On the other hand, by increasing the number of observers the rate of detection changes. But in most cases (93%) the animals that were hit had not been seen before, or were seen too late to be avoided (Laist *et al.* 2001).

Another model has been made by Todd and Damon (1999) to determine the angle from the boat's trajectory that is necessary for various species to escape collision. They take as a basis an estimate of the distance at which the approaching boat is detected and the animal's maximum swimming speed. Data on a high-speed NGV boat's acoustic signature, and the (known or estimated) auditory sensitivity and swimming speed of several species is accounted for. To escape, right whales and porpoises need a slightly wider angle (2 degrees) than rorquals (1 degree). This is due to the fact that from the moment the animals detect the boat's noise and swim off at the minimum angle needed to get out of its path, right whales are slower than rorquals. As for porpoises, their auditory spectrum seems less effective for detecting the boat's acoustic signature, thus the reaction time is shorter.

<u>Special cases of small boats:</u>

- jet-skis: they have no draught and can thus go everywhere. They are extremely quick, frequently change direction and make little noise in the water (only audible at 450 metres in a Beaufort force 3 sea, Evans *et al.* 1992). One of these, chasing a group of Tursiops, ended up killing the youngest (WDCS 2000)
- kayaks: soundless, so the animals only notice them when they are practically at their side, causing a big leap and thus certain disturbance (with *Hyperoodon ampullatus*, WDCS 2000; killer whales, Anon. 2001)
- parasail boats: Green (1991) showed that parasail boats displaced animals and their young from favourable waters near the coast.

<u>Special case of NGVs:</u>

The sound produced by a NGV is only tardily heard above the surrounding noise, not far from the nearest point of approach, causing the animals to leap.

On existing transit lines, for example between continental France and Corsica, collisions existed before the advent of high-speed NGVs, but the highly-perfected stabilizing system under the ship's hull is often torn away by the body of the whale that has been hit, causing expensive harm, even damage. Now sea transport companies are working to solve this kind of problem.

Carillo *et al.* (2000) notice that, in the Canary Islands, the upsurge in strandings of animals killed in collisions have over a decade coincided with the setting up of a jet-foil service and the opening of a NGV line. Wounds where a big cetacean is cleanly cut almost in two can only be caused by this kind of ship. Since April 1999, corresponding to the advent of NGVs, Aguilar *et al*. (2000) report that at least seven individuals belonging to a minimum four different species have died in Canary Islands waters because of this kind of ship (*Balaenoptera sp*. probably *B. edeni*, *Ziphius cavirostris*, a medium-sized whale, probably *Globicephala macrorhynchus*, and *Physeter macrocephalus*).

The development of high-potential tourist areas, the high demand for destinations that are hard of access, the wish to constantly save time and make boats pay, mean that over the coming years the number of lines served by rapid ferries will increase everywhere in the world. Many projects are also under way to have merchant shipping benefit from high-speed technology.

Cetaceans seem to have good hearing, but sometimes do not pay attention to what is going on around them, when, for example, they are feeding or sleeping. In those cases, if they are not disturbed and warned by the noise of a motor in their immediate environment they risk a collision. Probably cetaceans do not detect silent boats (sailing ships under sail, kayaks, motor boats drifting) until these are right on top of them.

In the Mediterranean

The issue of collisions in the Mediterranean has become important particularly since the advent of the NGVs. Causes and effects are identical to those described but the impact remains hard to quantify, as do the threats.

Several teams have presented estimates, assessments of animals that have been hit (Pesante *et al.* 2000, Tethys workshop 'collisions' 2001). At the present time it is believed to be the first cause of mortality for fin whales. But little is known still about other species.

- From French strandings between 1972 and 1998, and Italian strandings from 1986 to 1997 (Pesante *et al.* 2000, Laist *et al.* 2001), 12 to 13% of animals were collision victims, and three species are represented: fin whale, minke whale and sperm whale. Among fin whales, 20-22% strandings were caused by collisions, as against 6% for sperm whales and 33% of minke whales (but in fact only 1 individual out of 3 cases).
- In the Mediterranean more generally (Tethys Institute workshop collision ECS 2001), animals whose deaths may be attributed to collisions, all species together, represent 1.2% of strandings (44 individuals out of 2,665). But some species, among them the largest, are at great risk: almost 19% of fin whale and 4.3% of sperm whale strandings are caused by collisions. On the other hand, smaller species, like Globicephala, Tursiops and striped dolphins, only form 0.5 to 1.1% of individuals killed in collisions. Fin whales pay most dearly, representing 50% of the animals hit. In literature and historical data, Tethys reports that 17.6% of stranded individuals were stranded after a collision.
- Regular reports of collisions by local traffic such as ferries between France and Corsica suggest that there are high-risk areas. A captain of one of these ferries thinks he hits at least one whale every year! In the Mediterranean, Pesante *et al.* (2000) currently list five companies operating with high-speed NGVs in the Ligurian Sea, daily crossing the area where whales gather in summer. In Gibraltar too NGVs are already operating, while additional or new lines are expected, particularly between Spain and the Balearics.

We can say, to conclude, that although the real impact of collisions with cetaceans is not known, it is obvious that an increase in traffic and number and speed of boats will be correlated to an increase in the risk of accidents, wounds and deaths for animals. The situation is already critical for populations of large cetaceans.

Solutions exist for increasing detection and avoidance of animals and/or lessening the risks and augmenting the chances of avoidance.

The most complete example of solutions used to protect a cetacean population concerns the case of the North Atlantic right whales (Gerrior and Mantzaris 1999, Russel and Knowlton 2001), which is one of the most threatened populations in the world. Several systems were perfected to monitor individuals and have permanent knowledge of their positions in order to transmit information to ships entering the area to enable these to avoid them.

Aerial and vessel surveys were performed, however their effectiveness was limited by adverse meteorological conditions and high cost (P. Clapham, ECS workshop collision 2001). Passive listening to sounds emitted by whales allows areas where animals are concentrated to be defined, and decisions made within a lapse of time of an hour or a day. But this technique is limited by silent animals. Mapping animals and environmental variables allows the relationships between them to be sought and a predictive distribution model to be made. This model indicates which variable is important for determining the population's distribution and migration patterns, and for quantifying uncertainties. This information, compared to that for sea traffic, leads to an evaluation of the areas where collision risks are highest. The GIS is a tool that can be used to analyse historical, but not real time, data. Studies have been done on the effects of speed in collision risks. One envisaged solution consists of tagging the animals to know, thanks to satellites, their position and movement in real time and to understand their use of the area. But these markers are hard to attach and many difficulties due to their lifetime, their transmission, and the precision of the data, plus the ignorance of how they affect the animals, restrict their feasibility. Studies are under way on acoustic alarms and visual stimuli to alert the animals to the approach of a boat. An active sonar (Miller *et al.* 1999) detecting animals in front of the boat situated at over 100 metres has been perfected, and others will be produced with detection capacities ranging from 700 to 1,000 metres or even beyond (4,000 m.). But what effect does this sonar have on the animals?

Conclusion

The animals live with the evolving parameters of their environment, and have so far managed to adapt. But this tolerance and this adaptation are certainly limited to a certain level. Nowadays, with the exponential growth in the volume, size and speed of vessels (Laist *et al.* 2001), cetaceans are increasingly falling victim to the changes which are happening. The real impacts are not known and are difficult to quantify, but they are certain, and for some populations are threatening in the extreme. This phenomenon is making scientists and managers more aware, but there are many gaps in the knowledge of this and in solutions. Work must be done to remedy this, involving all users of the sea.

Threatened species or populations

All cetacean species are affected at various levels. The big cetaceans especially (fin whales, sperm whales) pay the heaviest price in collisions with big shipping line vessels. And because they are more pelagic, they are less subject to the insistent intrusions of certain tourist boats. Little pelagic delphinidae seem not to see the shipping line vessels as a threat, but coastal species are clearly more exposed to the heavy traffic associated with port areas. They are also more within reach of pleasure boats and more vulnerable to those who approach them disrespectfully.

Each case is a special case, in fact, according to the sedentary nature of the group of animals and the features of the human activity that occurs in the areas frequented by these animals. Sedentary animals which are incessantly and highly exposed can get used to the traffic or move away, while animals that are not much disturbed will suffer greatly from the opening of a new ferry line. Migratory species can cross various sectors, subjected to varying intensities of traffic, without getting used to, or adapting quickly enough to face, these changes. Or perhaps they can pass by without mishap, accustomed to meeting boats on their path and therefore always mistrustful of their approach.

Studies show that cetaceans' use of a site that is greatly exploited by human activities is first and foremost due to the abundance of food resources and that sea traffic nowise alters the level of frequentation and the activity of the group. In fact, the advantages of the availability of resources outweighs the disadvantages caused by the direct disturbance (and sound nuisance) of the sea traffic. Up to a certain threshold, which we must strive to define and which is exclusive to each species, group, habitat, i.e., each situation.

In the Mediterranean particularly, the status of the fin whale is worrying, since it is supposed to be practically endemic (Bérubé *et al.* 1998). The sperm whale is also threatened, by reason of its scarcity. And the status of the minke whale is disquieting because it is not very frequent and little known.

Aggravating factors

An accumulation of various impacts generated by sea traffic (persistence and frequency of disturbances, intensity and concentration in certain sensitive areas, wounds and killings by collisions) can affect the viability of certain threatened populations.

But traffic is only one factor that works in synergy with others, together increasing the risks of disturbance or collision, and the threats hanging over certain populations:

- underwater noise (boats sailing with cavitation of propellers and motors, industrial littoral activities, off-shore facilities being built or in use, military training with underwater fire or explosions, or LFA tests, among others) is very probably an aggravating factor. Either because it directly disturbs the animal by its noise level, or because it gives rise to auditory trauma that impair the ability to hear. It can also have an indirect effect by increasing the surrounding noise, which will hide all close information (a boat bearing down on an animal, an inter-individual communication signal…);
- pollution, lowering the general state of health and thus the energy reserve. Everything that can affect fitness can affect the individuals' ability to reproduce, or the rate of survival for newborn animals, and thus have consequences at population level;
- fishing, particularly overfishing of stocks, thus lessening the resource which leads the animals to move away and gather in some areas that are sometimes near to the coast and to numerous human activities, looking for food. Being more taken up with finding food, they are less alert and more sensitive to disturbance. Becoming entangled in nets, which are factors weakening the animals and lessening their powers of flight;
- the worsening quality of the habitat refers to all those factors which make it favourable for a cetacean species, including abundant prey and temperature. The continual intrusion of boats into these habitats may reduce its quality or displace animals to less favourable areas.

There are four levels of consideration:

- activities which directly threaten the animals' lives
- the individual's health and stress (energy and physiological consideration)
- the population's health and stress
- the quality of the habitat.

To sum up: the presence of boats can disturb social links, lessen the efficiency of the hunt, interfere with important activities (social, rest…), cause physical harm (collision, deafness…). It can also bring about long-term effects such as a drop in the rate of reproduction, higher mortality, avoidance of the area of disturbance, and can threaten the survival of the local population. The animals may also get used to this in the medium or long term. Experiences can probably not be interpolated according to what is happening in some other place. The answers to these questions are difficult and not definitive. So it is better to use a precautionary approach, while also bearing in mind economic and social needs, and continuing to do research to understand this phenomenon better.

Recommendations

Quickly take precautionary steps to minimize identified, known risks:

- Strengthen and enforce the existing laws to protect cetaceans in their natural environment and develop laws and regulations about sensitive areas. It is necessary, in order to undertake the management of traffic-caused risks, to introduce measures that have been deliberated in the long and short term, set limits (in terms of space, density or speed) for sea traffic. Restrictions must be 'dynamic', taken temporarily, and adapted according to the distribution and abundance of the animals (Porter 2001).
- Major educational and public awareness work is needed; educating captains and heads of transport companies.
- Keeping permanent watch during day crossings on the bridge of the ships in order to spot the animals in time to avoid collisions. One person on watch clearly seems to be efficacious, according to the study by Beaubrun *et al.* (2001). Developing night-time and bad weather detection tools (thermic or acoustic systems for detecting whales, Read 2001). Setting up a passive listening network (Moscrop *et al.* 1999, Russel and Knowlton 2001). André *et al.* (2000) and André and Potter (2001) indicate that one of the solutions could come from a passive listening sonar system which would detect the acoustic presence of an animal not only from its vocal emissions but also from the disturbances its mere presence engenders in a normal wave field.
- Establish a clearly-defined programme to examine risk-reduction, costs and benefits and incorporate the best available recent technology to reduce the risks; study environmental and economic impacts. Certain companies are building jet hydrofoils with shock-absorbing

devices to protect the boats and persons on board in case of collision with an animal or an object (marmam-list, information from Joseph E. Blue 2000).

Identify the places and species most concerned by the various threats linked to sea traffic:

- Define the disturbance potential of sea traffic in sensitive areas or those of greatest importance for cetaceans. Assess real and potential threats and impact. Define high-risk areas. Set out the framework for long-term research to improve knowledge about the biological impact on different populations (number of animals hit, age, sex, comparing to birth rate and life expectancy).

Understand how animals react and behave when various sizes and types of boat pass:

- Assess and study more specifically the short and the long-term effects, and the impact of various types of boat.
- Determine precisely the traffic pattern, traffic volumes and course of the routes taken by the various sea users and their evolution trends during the coming years.

Determine which signals the animals respond to:

- Enhancing the natural capability of the animals to detect and avoid vessels would be one of the most promising avenues of research and development.

Study in greater detail the distribution of animals in space and time:

- Determine their relationships with environmental parameters to find out when and where they gather. Develop predictive model of distribution.

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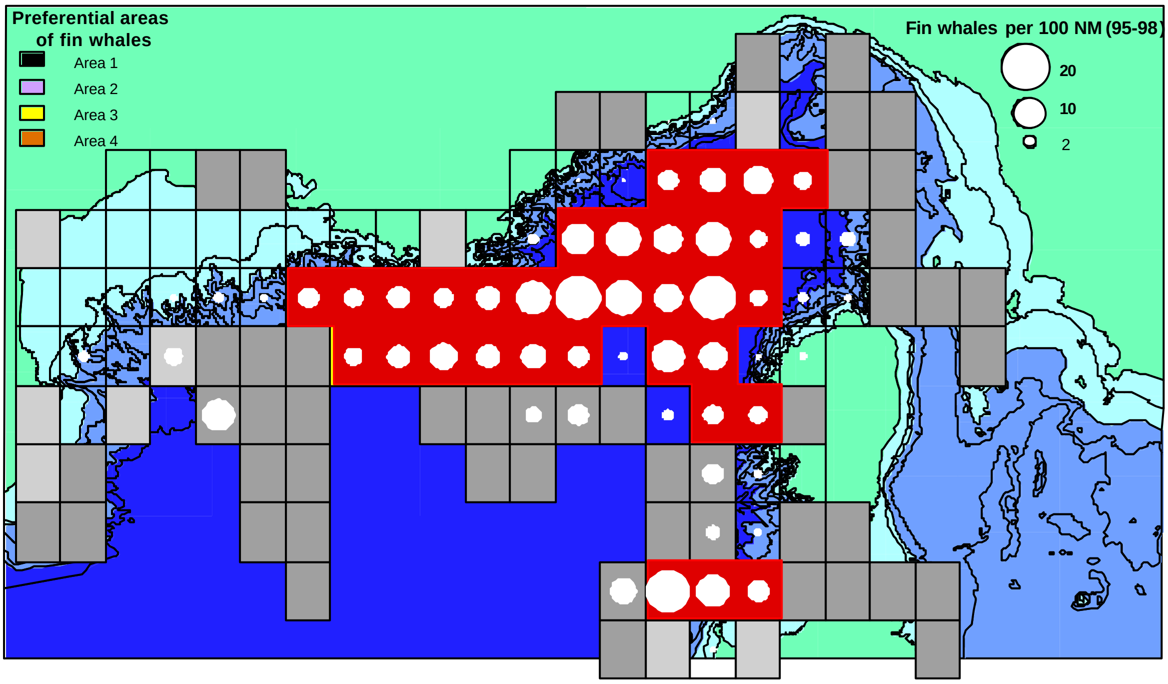

Fig. 11.1 - Fin whales per 100 nautical miles in meshes of 20 minutes of angle.

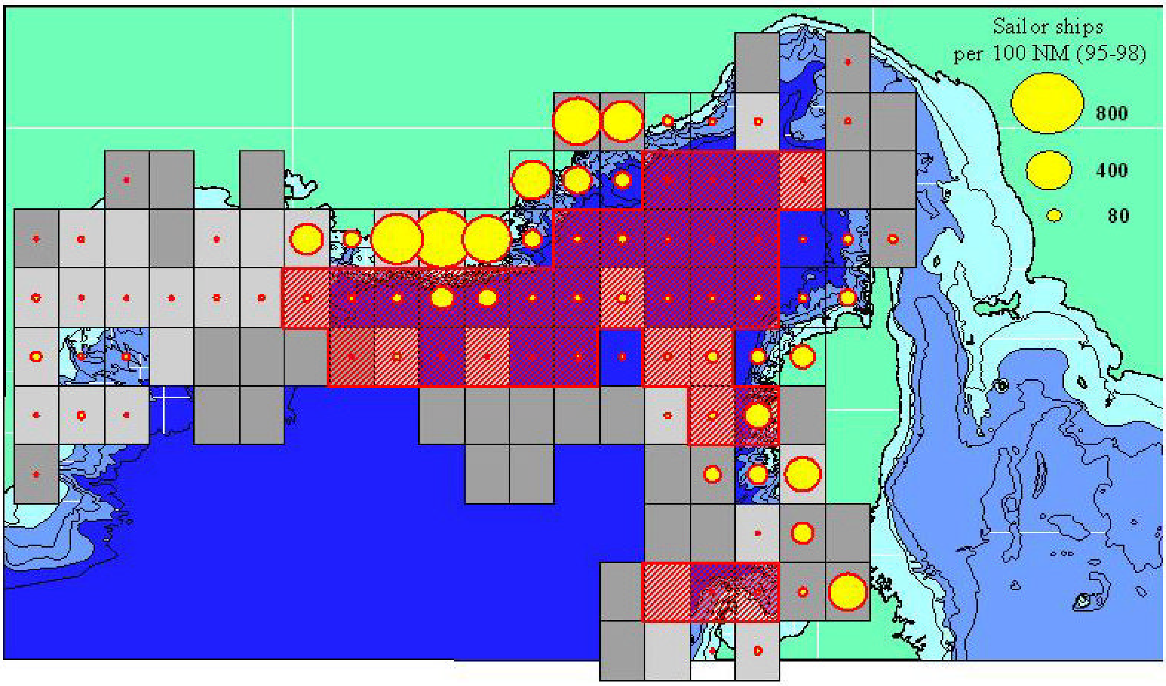

Fig. 11.2 - Sailing ships per 100 nautical miles in meshes of 20 minutes of angle.

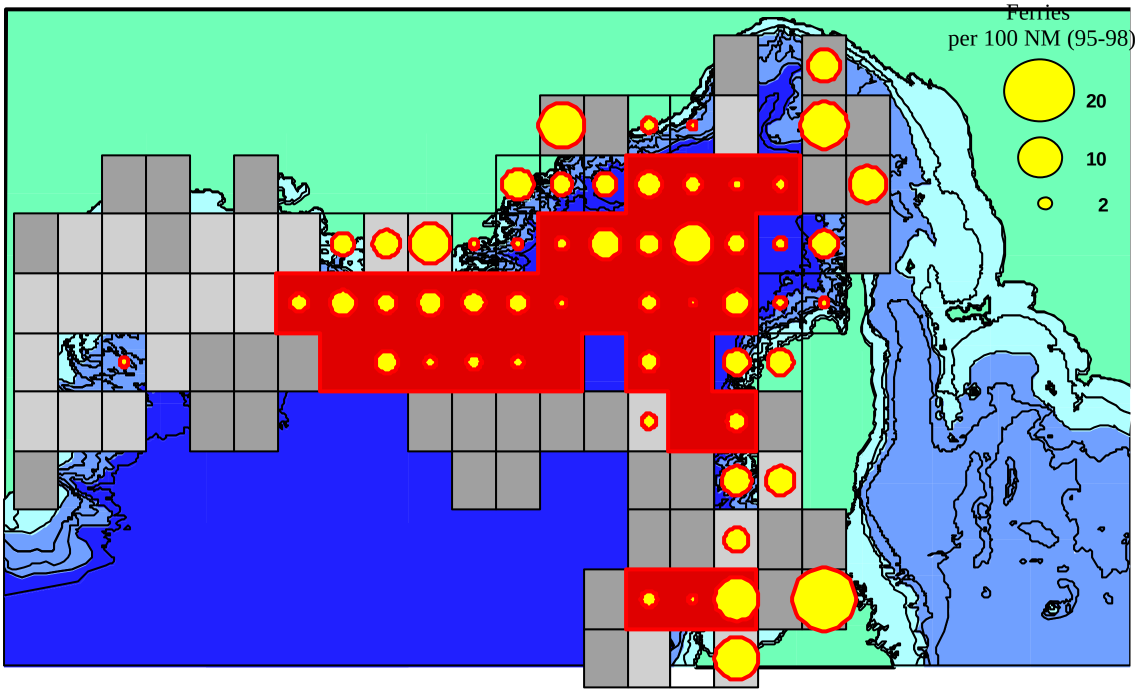

Fig. 11.3 - Ferries and High Speed Ferries per 100 nautical miles in meshes of 20 minutes of angle.

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 12

Disturbance to Mediterranean Cetaceans Caused by Whale Watching

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Introduction

When the desire was felt to develop ecological tourism by allowing the public to discover the biological riches of a site (flora and fauna of a national park, for example), very strict procedures were set up after much thought which started from the time the first visitors' abuse or excesses were detected. It was quickly understood that exploiting a natural heritage constructively and lastingly required extremely special attention, if one wished the activity to flourish and endure.

Looking for, approaching and observing marine mammals for tourist purposes, commonly called 'whale watching', is a relatively recent activity, practised in an environment that is far less well known than the terrestrial field, and on species about whose biology and ecology there is still far more ignorance. That is why, as for the above-mentioned example, there is every reason to take care that the practice and development of whale watching are done sufficiently harmoniously not to endanger the cetacean populations that are the very basis of this type of activity. Uncontrolled development of whale watching could well give rise to results that would be most negative for the species' well-being, even though this activity is often seen as a minor problem for cetaceans compared with other types of harm occasioned by human action (modification of habitats, dwindling stocks of prey species, ever greater sea traffic, multiplication of noise emission, growth of pollution levels, etc.).

Information on whale watching is abundant, scattered and of various origin. It comes from discoveries made and published by the scientific community, or from the many NGO activities, or again from media broadcasts and popularisation. The actors all take over from, and outdo, each other to boast about the merits – or denounce the pernicious effects of – the activity. This succinct report does not therefore claim to be an exhaustive review of the question but tries to raise the essential problems by surveying the issue at world level (on the basis of the main documents that are easily available), showing how the activity's history has evolved and making a summary assessment of present concerns, while focusing on the situation in the Mediterranean, the Black Sea and the contiguous Atlantic area. It is also obvious that we shall only deal with the whale watching activities that consist of being close to a cetacean in its own environment and thus able to cause the animals direct disturbance. However, it should be realized that whale watching is also done from land bases, as for example in South Africa, Argentina, Canada, Australia and the U.S.A., where it is well-developed. Although representing 28% of all whale watching activities (Hoyt 2001) this aspect will not be dealt with because, firstly, its effect on cetaceans is zero and, secondly, no Mediterranean country is doing this at the present time (as far as we are aware).

To make this easier to read and avoid too many references, we shall cite here the six major documents on which we have drawn heavily. These are: three reports from the main whale watching workshops (Monterey, 1988; Montecastello, 1995; Monaco, 1998), two world syntheses on the economic side of whale watching (Hoyt 1995, 2001), and the WDCS (2000) experts' report on gaps in United Kingdom law.

The female bottlenose dolphin Susie, better known by her stage name Flipper (appearing in 88 TV episodes between 1964-68), is certainly to a great degree responsible for the public's present infatuation with cetaceans. As a result of this infectious, runaway fascination since the 1960s, increasingly large numbers of people want to go and approach 'them' in their natural environment, photograph 'them', sail or swim with 'them', touch or feed 'them' or even study 'them'. A public ever-increasing demand has meant that many economic circuits were rapidly created to exploit this resource. The first were mostly situated immediately next to sites where cetaceans were said to be present and accessible, i.e. places where the animals were known to live or where certain species might gather at particular times of year. We mention as examples:

- The coasts of Florida and Australia, especially the very famous site of Monkey Mia, which were among the first to encourage the public to swim in the company of little delphinidae or to feed them
- Lower California (after 1955) and Hawaii (already over 70 specialist ships in 1985), which exploited the grey and humpback whales' migration routes
- The Valdès Peninsula, the Gulf of Mexico, New England and the Gulf of Maine, exploiting right whale feeding and nursing sites

- Or again, among the countries least often cited, the Antarctic (where the first expeditions were organised in 1957) or Alaska (because whale watching regulation measures were already introduced by 1985!), which are major gathering and feeding areas for many species of large and small cetaceans.

Thus, these pioneer activities appeared primarily in geographically restricted areas (gulfs, bays, creeks) and mostly concerned species whose populations are highly threatened, such as the right whale or the grey whale. This was a godsend (small distances to be covered, rare animals to be approached) to promoters of commercial circuits, so much so that these were led to make the dreadful mistake of taking no account of the crucial biological disturbance their activities caused cetaceans: the animals were very often disturbed by their presence over their reproduction or feeding areas, and certain local settled populations were much too much in demand (the belugas of the St Lawrence estuary and killer whales of Puget Sound, for example). Now, we shall see that there is a great deal of scientific proof showing the several harmful effects a badly-managed approach to cetaceans can have, both in space (at the exact time of the approach) and/or in time (over-repetitive approaches on one particular site or on one particular population).

Be that as it may, the very lucrative economic possibilities of this kind of new tourist activity were quickly grasped and from the 1980s on there was a veritable explosion of whale watching around the world. Few countries remained indifferent to this manna, responding to the whims of fashion, and we shall see further on that 87 (Hoyt 2001) countries now offer to the public (in one way or another, but always for financial ends) meetings with cetaceans.

Satisfying an increasingly strong demand, the industry flourished and, simultaneously, two new syndromes appeared among operators: the need to act quickly, and the search for credibility.

As regards speed, professionals quickly felt the need to develop increasingly sophisticated methods to spot and/or approach the animals. The speed factor thus became primordial for better serving the customers: one had to move quickly to be the first on the spot (which resulted in the appearance of increasingly powerful, rapid boats, often even including units that could hold a large number of persons on board). Moving quickly, too, to make more trips when the animals are fairly near the departure stages, and speed to save time in spotting the animals. In the last case, remember that at the present time many tour operators are helped by aeroplanes that have to prospect and inform them of the whereabouts of the cetaceans. And we come to the fact that over the past years many cases have been denounced where boats hit whales that come up to the surface to breathe while the organisers are speeding off to another animal they have sighted. This gave rise, on these sites, to the introduction of restrictive measures (limiting the speed of approach, in particular) that allowed such harm to be avoided and which, further, sullied the full respectability of the operator accused.

As to the credibility the operators wished to possess the better to boast of the merits of the product they were offering, in a context of great competition, it quickly appeared that this could be obtained either by approaching famous scientific teams or by obtaining a certain 'recognition' from the administration. Many enterprises had no trouble making links with the field of research, scientists finding in this process the possibility of considerably augmenting, at little cost, their databanks. Throughout the world, the Mediterranean included, many of them were extremely respectful of the collaboration they had obtained, and we praise them for this. But, however, this attitude is far from being general, and unfortunately we have to say that too many of these bodies forget real collaboration the moment they have gained the principle … while nonetheless continuing to let people believe in it! The situation seems all the more ambiguous in the case of getting 'recognised' by an administration, for it seems that in many countries there is no effective, detailed legislation concerning whale watching, both for the practice of the activity itself and for the level of competence in cetology one should have to practise it. Almost all the 'texts' that an administration has the possibility of referring to are still far too vague, contain too many phrases marked by the conditional tense, and make too much of the 'civic feeling' and the 'goodwill' of the practitioners. Mostly, and when they exist (!), these are just simple recommendations set out in the form of 'codes of good conduct to keep to when approaching a cetacean' in its environment. The entire question remains to know on what criteria these 'credit seals' are really granted, by whom, for whom, and what real credit they can be given.

Further on, we shall return to the various aspects raised by this still imperfect jurisdiction - and we must admit that thought about the setting up of this jurisdiction has greatly advanced these past years in many countries – but let us quickly look at the evolution of the state of our knowledge of cetacean populations. Scientific research in the field of cetology is not new and it was indeed the first work in the field which enabled whale watching to start from the sites thus identified. Certainly not new, but restricted generally speaking until the 1970s to a few teams working in very localised geographical areas or on very precise species. Since the 1980s, the public's increased attraction to cetaceans, along with the fact that sponsors are a little more warm about investing in the field, means that the field of research has not been untouched by development. There are more work sites, teams already there are fuller and many more are being born, as are the NGOs with their differing reasons for research. The positive side of this increase is the unbelievable expansion of our knowledge about whales and dolphins. Technological development is also responsible for this, with cetacean study methods becoming increasingly sophisticated. Results have appeared quickly in many fields: the disturbances cetaceans are confronted with are increasingly often revealed and denounced, the managers increasingly request research circles to evaluate or assess situations, studies programmes blossom (often without the slightest consultation), claiming to approach nearer to the animals (biopsies, photo-identification, tagging…) or to study their reactions to certain events (submission to various sound emissions, for example, or perhaps the results of an approach). Two things have become clear, which do not look good for respect for cetaceans: one, vast gaps in elaborating the programmes agreed on ('Every man for himself' is still often acceptable), two, the fact that the cetacean (more frequently than one would think!) becomes a source of experiments for increasingly intrusive research. There are a host of examples of this throughout the world. The Mediterranean has not been spared, and we shall cite two examples only. Was it not here that we knew about a fin whale that was on the same day and even the same hour desired by two different teams each wishing to do **its** biopsy while a whale watching boat was in the area? And is it not here that people would like to subject animals to repeated sound emissions tests?

This brief glance at the evolution of commercial whale watching and cetological research allows us to show how pernicious and dangerous to cetaceans certain activities are when they develop in an uncontrolled way, with no deep respect for the animal.

And yet in one way or another these activities permit outside persons to discover an environment and its species, the first with a lucrative aim, the second by permitting the work on board to be increased. Here these activities work towards educating the public and may prove to be an excellent way of making it more informed and aware. Since taking part in such activities offers the opportunity of spending time with cetaceans in their natural environment, this obviously helps towards a better knowledge of cetacean populations and, as a consequence, actions being developed to protect them better. Moreover, above and beyond the immediate pleasure of satisfying a desire alone, it especially offers the opportunity to find oneself faced with the beneficial effects of freedom and better understand the importance of respecting the other and its environment, or perhaps better grasping the negative effects nuisances have on wildlife. The public, often very restricted by its civilisation, often does not know about these facts but learns them quickly if correctly taught. It then wishes to respect them and thus becomes an excellent agent for protecting species and areas. Thus, it cannot be denied that whale watching, provided that it causes minimum disturbance (being well done), is a precious eco-tourist tool the development of which must be encouraged for the mutual benefits it gives cetaceans, people and local communities.

These very general thoughts about whale watching are the subject of a more detailed analysis in the next part of this document, but already raise three particularly important questions which we shall try to answer:

1. What is whale watching and who is a whale watcher?
2. Why should laws be passed on the subject?
3. What is a disturbance?

What is whale watching and who is a whale watcher?

The Anglo-Saxon term 'whale watching' is generally used to express a lucrative economic activity where, in return for money, people (whale watchers) are taken to get close to whales and dolphins in the wild. This eco-tourist 'industry' was first and foremost created to make money (for example, look at the www.wdcs.org internet site) but it is now clear that it can be a double-edged sword if practised without any control (see, for example, Notarbartolo di Sciara 1996). The advantages for operators and public would then be greatly reduced by the negative reactions of the animals to the disturbance they would have to face.

It is indeed the disturbance imposed on the cetaceans that can cause changes in their behaviour or their ecology. Certainly, 'industrial' whale watching as an activity whose primary aim is to approach the animals more closely and more often is potentially an undeniable, crucial source of harm and for this reason it is vital that it be supervised. But it is not the sole potential factor for disturbance we must keep an eye on. Many other types of activity, either professional (e.g. scientific research) or not (e.g. sailing), whether done in boats (or similar) or not (e.g. flying objects, parasailing), intentional or not (e.g. a chance meeting with a cetacean), are possible reasons for a nuisance to appear in the immediate sphere of existence of a whale or dolphin. In this case it is obvious that the action itself must be taken into consideration, as well as the means with which it is done, and – especially – the extent to which it is repeated near one animal or one group of animals. We draw attention to the urgency of the need to integrate these three factors in our reflections.

The idea of whale watching must be seen in a wider perspective than restricted to the commercial tour operators alone. From this viewpoint, the one we adopt in this document, the whale watcher becomes any person who has deliberately tried to approach the animals to observe them, or who has chanced to be in the immediate vicinity of one (or more) cetacean/s. These two terms must thus include any intentional or careless act that causes disturbance or persecution of a marine mammal, and the rules that would be made should be applicable to everyone in this situation. Let us point out that most of the current texts are not precise enough on this subject.

Why legislate on the subject? And what is a disturbance?

The answer to the first part of this question is simple. It rapidly seemed vital to make sure that cetaceans were not persecuted.

Indeed, the development of lucrative whale watching unfortunately quickly gave rise to regrettable acts by certain unscrupulous operators. The reason was sometimes the organizers' ignorance of animal biology, but was usually a certain greediness. So petitions were quickly produced asking that the activity be governed by ethical rules. Early on, before immediately launching into repressive legislation, a need was felt to quickly produce information for operators and, later, for the public. But despite the many attempts to do this, the need to take steps to regulate (and thus restrict) action seemed at the present time increasingly unavoidable.

The second part of the question brings us to consider various national laws in force which usually stipulate that cetaceans must be protected from 'harassment' or 'persecution', to avoid the animals being faced with actions that could spark off abnormal behaviour in them.

But who today can give a general definition of normal behaviour? Who can draw the precise line between 'normal' and 'abnormal' behaviour, both in the case of an immediate situation (impact on the individual) or in the long term on a population? Who can set out the criteria that will allow us to say that an animal has gone from one kind of behaviour to the other? It is vital that these questions are considered if we wish to end up with pertinent, realistic legal tools. Our research has taught us that much still remains to be done in this field (cf. for example the 1988 CMC/NMFS report and the 1995 Montecastello report, which already clearly set out the difficulties), even if many works (increasingly numerous) are already tackling the subject very seriously.

Be this as it may, it is clear from our compilation that in the present state of our knowledge the most pertinent indicators for assessing disturbance are:

- changes of route made by animals
- modification of the rate of respiration
- the ratio between time spent on the surface and time spent diving
- certain particular kinds of surface behaviour (trumpet blows, tail slashes, hard tail flicks)
- plus the study of modifications of sound emissions, since it has recently been proved that dolphins' whistling was clearly greater in the presence of whale watching boats (Scarpaci *et al.* 2000). A study of sound exchanges, in addition to the traditional behavioural studies,

would thus be a supplementary means of studying the impact of whale eco-tourism on cetaceans.

On the other hand, it seems to be accepted that a study of the modifications of the make-up of groups, and that of surface feeding behaviour, are much too variable and unpredictable to be reliably linked to disturbance.

The need to reach a correct definition of these criteria had already been widely expressed during the 1988 workshop held in Monterey (CMC/NMFS 1988) and many studies or ideas-sessions were held to try to do this. But in fact the further the work advanced on a subject, the more the difficulty of doing this was seen. The multitude of these new publications dealing with different species, in various sites and at various times of year over the years, showed very clearly that there was a multiplicity of cases. These criteria seem increasingly difficult to reach because it is shown that in the very short term each individual may have different responses to boats (e.g. the case of the humpback whales), that within the same species individuals may display considerable degrees of short-term modification in their behaviour in response to sea traffic (still the humpback whales), or that the responses can be very different according to the kinds of behaviour in which the animals are engaged or according to their age (many cases). Without going into the long-term effects, on an individual or a population, which are still very little known since research has not always been done sufficiently long to be tested. This is why many people suggest looking into terminology like 'disrupt normal behaviour patterns' or, wider still, 'altered behaviour leading to long-term adverse effects'.

Without taking account either of the difficulty of dissociating, during a study, the share of the nuisance coming from the very approach of the boats from that, more insidious and difficult to quantify, due to the increase of the surrounding noise (either from the boat itself or linked to other noises, human-originated or not), or pollution phenomena, or even the changing conditions of the environment (see, for example, Janik and Thompson 1996, Perry 1998, WDCS 2000).

Without taking account either of how to quantify 'getting used to a nuisance', which can happen with some individuals or some populations which, as a reaction, may develop 'friendly' or 'curious' behaviour. Such phenomena have been shown in Lower California (San Ignacio Lagoon) from the mid-1980s for grey whales, and also for New England right whales (see, for example, CMC-NMFS 1988, Beach and Weinrich 1989).

Without, finally, mentioning the aggressive reactions sometimes seen in certain individuals (particularly *Globicephala*) of which it was said that these were apparently due to stress linked to an overabundance of whale watching boats, or again the pictures published in the media showing that these reactions could be a response to rather 'over-enterprising' people swimming with the animals.

To conclude this quick survey, we can say that whale watching is an extremely recent, primarily eco-tourist, activity, which:

- consists of being for one reason or another in the immediate vicinity of a cetacean
- has for some twenty years developed exponentially;
- does not yet have, like all recent activity, appropriate and pertinent laws;
- seems impossible to stop (but should it be?) and whose expansion should thus be controlled;
- may if wrongly practised cause major disturbance to the cetaceans approached;
- and whose effective or potential disturbance still remains largely unknown.

According to the definition of the activity we gave, it seems that three main categories of public are likely to be confronted with it:

- commercial operators;
- research teams and NGOs specialising in cetology;
- occasional whale watchers.

Generally speaking, each of these publics has different reasons to be in the presence of a cetacean, and we will deal with them one after the other in the next part of this document, to inventory:

- the activity and its impact on a global level;
- the particular case of the Mediterranean basin in its wider sense;
- the measures likely to be suggested so that it can be correctly practised.

However, these publics may have identical effects and consequences on cetacean populations, and these 'general' effects will be examined in the 'industrial whale watching' category.

Commercial whale watching

In this kind of activity, it is the lucrative aspect which is dominant. The operators urge people to go off to meet whales in return for money. 'Making money' is thus the primary reason, and although many do this with ethics, respect and a really 'eco-tourist' objective, some are unfortunately more avid and worry very little about the possible harmful effects of their attitude. I shall not even mention the offers that are perfectly incongruous and absolutely lacking in any educational value, like those, for example, of going and taking a few 'sensational' photographs of the massacres of *Globicephala*.

Let me say here that the proportion of these disrespectful people has to be very different according to site or region; to our knowledge, no study has ever taken on this type of analysis.

A 1998 evaluation on a world scale by Hoyt (2001) clearly shows that this activity is developing exponentially (Table 12.1).

Still from the same study, for the period 1991-1998:

- the yearly growth rate in the number of whale watchers was 12.1%
- the annual increase in direct income was 21.4%
- 87 countries and 492 ports practised this activity in 1998.

According to Malcolm (2001), industrial whale watching is the fastest growing tourist sector, and this stupefying growth is continuing. For example, in Iceland the number of operators went from 4 in 1994 to 13 in 1997 (Fisher 1998, in www.wdcs.org). On the south-western coasts of Tenerife alone (Canary Islands) the number of whale watchers rose from 40,000 in 1991 to 1,000,000 in 1998 (Urquiola and de Stephanis 2000) and among the countries with over 5,000 whale watchers a year Taiwan had the highest growth rate in the activity in the period 1994 (when whale watching did not yet exist) to 1998 (30,000 whale watchers) (Hoyt 2001).

We saw above the great educational value this activity can have when it is correctly done, but it is really from the growing mass of people taken out, and the repetitive nature of these operations, that the growing number of cases of disturbance recorded will in all likelihood spring. Now, scientific studies show that this disturbance gives rise to impacts and/or results that are extremely varied.

Impacts of activities

Much has been written on the impacts noted on cetaceans subjected to the presence of a boat. Here we shall only use the main works, to show the host of possible responses noted in cetaceans.

Short-term responses to the presence of a boat are those most widely documented:

- The grey whales of Lower California, escorted or not by a boat, showed no change in their rate of respiration or their swimming speed. But a positive correlation exists between the number of boats around a whale and the threshold of the change of route by the animal, with greater modifications in the presence of pleasure boats than in that of commercial whale watching boats. The animals hold their breath more frequently, giving rise to a reduction in migratory efficiency and an increased energy drain in individuals (Sumich 1983).
- Fin whales frequenting the Gulf of Maine are unaffected by the approach of a boat both in the percentage of time spent on the surface and in the intervals between blows, or the number of blows per hour. But diving duration and the sequences spent on the surface are shortened, and the number of blows per sequence on the surface very significantly reduced, in the presence of a boat (Stone *et al.* 1992). However, bearing in mind the fluctuations observed during the day, the writers state clearly: 'We do not feel that the differences were dramatic enough to be useful for a practical definition of harassment'.
- As a result of a study programme on the impact of whale watching on humpback whales frequenting the Australian coasts, Corkeron (1995) showed that the animals 'were more likely to dive when the boats were within 300 m., and that groups with young calves were less likely to produce surface active behaviour in presence of the vessels'.
- The killer whales of the Greater Puget Sound (Washington State, US) revealed a reduction in resting and sleeping time during the day in the presence of a boat (Osborne, in CSC/NMFS 1988). Still on the killer whales of nearby British Columbia, in the Johnstone Strait (Kruse 1991), it was shown that:
  - animals disturbed by the proximity of a boat swim 1.4 times quicker than others, without phenomena of habituation appearing

- a peak of rapid swimming activities is very clear between 1 p.m. and 3 p.m., the time when whale watching boats are most abundant, and killer whales swim increasingly quickly when the number of approaching boats grows
  - the disturbed animals tend to move west, i.e. leave the Strait area
  - killer whales do not respond differently to the boat's size or to whether the boats have outboard or inboard motors.
- Working on the behaviour of sperm whales in Norway, Fleming and Sarvas (1999) show that:
  - respiration rate is higher when a boat is close
  - although the presence of a boat does not affect the average time spent on the surface, the proportion of shorter periods spent on the surface is indeed higher when a boat is there
  - arguing from the fact that individuals show their tails when diving more often when a boat is close, the writers believe that the 50-250 m distance is that at which sperm whales most often avoid the boat
  - approaching within 50 m of an animal must be completely prohibited since the intervals between the animals' blows are then dramatically reduced
  - the time sperm whales spend on the surface is very much affected by a boat early in the season, while later on the animals seem to get used to it
  - the writers note differences in individual reactions according to the animals.

However, in the Azores, and still on sperm whales, Magalhaes *et al.* (1999) have proved that only the average durations of the intervals between blows of females were affected by the proximity of an observation boat.

A particular *Tursiops* population was followed in the French Atlantic: 17 animals are restricted within a 5 sq. km. territory around the Ile de Sein (Liret 2001). Boat traffic is heavy in this region and the writer states that the animals do not seem to be disturbed by it, except when the boats attempt to approach them. The dolphins then take refuge in sectors where the reefs are sufficiently numerous to put their pursuers off.

In Australia, Crosti and Arcangeli (2001) showed that *Tursiops*, after a whale watching boat had arrived:

- changed their behaviour in 80% of cases, between 3 and 9 minutes after the boat's arrival;
- reduced the frequency of their feeding and resting activities as the number of boats increased;
- tended to break up into smaller groups in the presence of a boat;
- only took up their initial activities sporadically after the boat had gone.

Approaching cetaceans by boat is not the only way of commercial whale watching. Other floating or flying devices are sometimes used by professionals. However, it is usually sailors who use them and therefore we shall mention them in the part on this type of activity.

The animals' long-term reactions due to the persistence or the development of whale watching in the sectors they frequent, and linked to the presence of boats, are very little documented. The main reason for this is that few studies have been done on the subject, and those long ago, on particular populations. But we can mention some references:

- The report brought out by CSC/NMFS (1988) mentions that studies begun long before on cetaceans in certain areas have permitted various behaviour, before (1957-75) and after (1976-82) the whale watching activities started up, to be compared. These works indicate that different species may develop different responses to the phenomenon, which would further complicate analyses of the impact of whale watching. In particular, we learn that:
- minke whales modify their responses from 'positive' during the period before, to 'neutral' during, the whale watching period
- on the other hand, humpback whales have much more 'positive' responses when the whale watching begins
- New England right whales' reproduction does not seem to be affected by the frequency of their encounters with boats. Indeed, no difference has been noticed in encounters of mothers accompanied by their calves, before or after the whale watching has begun, whether the females had three or more calves before the activities start or whether they only had one or two calves before the same period (Kraus 1988).

- For Norwegian sperm whales, Fleming and Sarvas (1999) have just shown that the proportions of shallow dives (in which flukes are not shown at the moment of the dive) had decreased significantly since 1989. The writers suggest that this finding may express the fact that the animals are getting used to the presence of boats, but do not rule out the possibility that it may reflect a better handled approach to the animals by the professionals.

This information on the potential long-term effects of whale watching is rather thin, and research, not originally targeted at this, is not yet really allowing to assess the situation. But there are signs from recent cetological events that imply that several teams are working on the question today, on various time and space scales. We should recognize that here we have restricted our investigation to the effects that really are linked to the presence of a whale watching boat near a cetacean. And we should also accept that it is not necessarily the 'presence itself' of the boat which is held responsible in these works, for it is always hard to draw a distinction between the effects due to the boat or the people on board, and those linked to the noise caused (treated elsewhere), or still others that can be attributed to causes that are still unsuspected. To give an example, we shall cite the mention that has just been made of a new potential source of nuisance never yet (to our knowledge) envisaged: 'When there are numerous boats in the area, especially idling boats, there are a lot of exhaust fumes being spewed out on the surface of the water. When the whale comes up to take a nice big breath of 'fresh air', it instead gets a nice big breath of exhaust fumes. It's hard to say how greatly this affects the animals, but think how breathing polluted air affects us.' (www.whale-museum.org/issues.html Issues affecting the Southern resident Orcas).

Be that as it may, we have found no information giving the slightest proof that whales anywhere in the world have abandoned a site because of whale watching boats. At the most they move off, during the day or seasonally, a short distance away.

The case of the Mediterranean

No written reference has been found concerning the effective impact of commercial whale watching on Mediterranean cetacean populations, although many articles mention this and some NGOs have launched 'preventive' campaigns in this regard.

However, we shall mention certain works insofar as they fall within the general subject.

Gannier and Bourreau (1999) have dealt in the Ligurian Sea with the vulnerability of cetaceans from the angle of the disturbance caused by the determined approach of a boat. The main conclusions of this study are that:

- the fin whale and sperm whale have a strong tendency to indifference;
- dolphins show a lesser tendency to indifference (44-50% according to the species);
- no cetacean species has undergone the excessive, aggressive approach of a boat without interrupting its current activity;
- where there is an aggressive approach to groups including calves, the animals' avoidance reaction often turns into flight (and panic);
- cetaceans tolerate the boat's approach less well when they are resting and are more indifferent when they are in the predation or travelling phase;
- cetaceans do not tolerate the simultaneous approach of several boats well.

Jahoda *et al.* (2001) tackled the impact the approach of a rubber dinghy could have on the behaviour of Mediterranean fin whales. The effects brought to the fore are:

- feeding whales adopt displacement behaviour;
- a 23% increase in the speed of displacement, and a 37.3%reduction in the time spent on the surface;
- an hour after the disturbance, surface behaviour has never completely returned to what it initially was.

These preliminary conclusions fall - more or less and with some variants - within the overall context of what we have learned from other research done elsewhere in the world. The Mediterranean, therefore, hardly deviates from the ensemble of concerns raised by whale watching. And all the more in that, as elsewhere, the development of the activity is happening extremely rapidly and, in the great majority of cases, without any control.

The only appraisals of the activity we have are those made by Hoyt (1995 and 2001), which, for the countries concerned by ACCOBAMS, produced in 1998 the situation described in Table 12.2.

The mind boggles, confronted with these figures! It is indeed certain that they have become considerably fuller since this synthesis, for whale watching is developing here as elsewhere, especially in areas identified as seasonally containing big numbers of cetaceans (the Corso-Liguro-Provençal Sanctuary, to give one example) or as permanently sheltering populations (e.g. Strait of Gibraltar). The example of the extreme western part of the ACCOBAMS area (Sea of Alboràn, Strait of Gibraltar, contiguous Atlantic area), which has just recently been documented (Urquiola and de Stephanis 2000), has quite a lot to say about the speed with which whale watching is growing. In Andalusia (Spain), and over the sectors of the Strait of Gibraltar, Algeciras Bay and the Costa del Sol alone, the number of commercial whale watching boats was 6 in 1998 and 28 in 2000. The year 2001 was very special in this sector because, as had already been noted in the Canary Isles from 1996 on (Urquiola *et al.* 1999), this was the 'turning point' year when small boats were replaced by vessels holding a larger number of passengers. Thus, there, where in 1998 only two boats were operating, holding 30 people, in 2001 there were seven, able to hold 324 passengers (R. de Stephanis *in litt.*). On the other hand, still in this sector, the activity which had so far only been carried on between June and October has just been extended to the winter period. It is true that in this area the probability of approaching cetaceans is high, since 87% of the trips made are 'successful'. It is thus logical that the writers of this study were rather worried in 1999: 'If no effective actions regarding this issue are taken in time, the problems of conservation of cetaceans in the Straits of Gibraltar will become significant.' However, R. de Stephanis (*pers. comm.*) says that professionals in this sector are becoming more aware, since in 2001 they both signed certain agreements among themselves and also by themselves introduced a code of conduct to be respected when practising their activities. Moreover, we are aware that the Spanish Ministry of the Environment is now preparing a decree which should officially, from 2002, regulate the ensemble of activity in the Iberian waters.

<u>Steps to be taken</u>

Commercial whale watching is an activity which can only develop if visitors can be guaranteed a certain threshold of encounters with the animals. Now, at the last Congress of the European Cetacean Society (Rome, 6-10 May 2001), Notarbartolo di Sciara instanced a map where almost all the ports in the Ligurian and/or Tyrrhenian Seas could be considered as potential sites from which the activity could be run (if this was not already the case). This example, and the impacts mentioned above as possibly resulting from this activity if it is badly managed, require that today a complete, detailed, inventory of the profession should quickly be established. Such an assessment is absolutely necessary, partly because it will enable the assessment of exactly the importance of the agent (sites, number of operators and boats, areas and periods of work, target species etc.) and – especially – because, the importance of the activity being clearly identified, this prior stage will enable the most suitable processes to be defined (and quantified) for whale watching to grow harmoniously.

We shall not present here other measures that could be taken to prevent this activity causing too much disturbance to cetaceans, and that would especially concern the processes to be followed leading to an approach that respects the animals. These measures will be dealt with in the part on general conclusions since, as we shall see, they are in fact common to all the publics that have come close to a cetacean, and they concern everybody and anybody.

However, industrial whale watching activities are not restricted to taking people to watch cetaceans. This first aspect only includes trips back and forth in boats, only relates to journeys made at sea, and only generates the 'direct income' category in the tables appearing above. We shall see that this side of the activity is very close to that practised by most NGOs. All whale watching starts with this initial stage, or at least has so started in most cases. So risks of nuisance are fairly low; boats are few in number, and the operators are often people who love the sea and have acquired in the field a certain amount of knowledge about the animals.

But where things start getting seriously worse is when the truly 'lucrative' side of the activity starts to outweigh the strictly eco-tourist side (Malcolm 2001). This phase is quickly reached on the 'old' sites which, under the influence of an ever-growing demand and increasing frequentation, are starting points for a proliferation of related activities (hotels, restaurants, banks, souvenir shops, etc.) and a growing number of boats on which the guides do not always have the neces-

sary cetological skills. Now, the extremely quick growth of this phase is far outstripping the operators' training and awareness. The transformation of relatively scrupulous whale watching into an industrial activity that is hard to control generally happens when these 'all-round novices' appear, and it is vital that this be checked if we wish to minimise 'excesses'. Several studies are under way on this around the world, and the reader can turn, for example, to the internet site :
http://office.geog.uvic.ca/dept/whale/wrimp.html

Scientific whale watching and the NGOs

We have seen that eco-tourist activities developed by the NGOs, and also by teams of scientists, should be taken into consideration in a study on whale watching, even if they were not done with the primary aim of making money. Non-industrial from the economic point of view, these activities do however rely on the fact that the financial participation requested from the eco-volunteers helps to rent boats, thus permitting people to be taken out to sea either for eco-tourism or to take part in research programmes. In both cases, the main thing is the educational contribution given to the public.

Impacts of activities

NGO activities at sea, like research activities, offer the people on board the chance to discover the marine environment by going to meet cetaceans. In this they themselves also constitute an additional source of potential nuisance for the animals if certain rules are not respected. This thought is not new, for the potential problem caused by scientific research had already been addressed in the late '80s, saying that it should be meticulously monitored … even restricted if necessary! (M. Ferrari, in CMC/NMFS 1988).

Their impacts, to this end, therefore join those of the industrial whale watching whose likely consequences we have seen. On the other hand, a glance at this category of operators permits the educational side of whale watching to be rather better approached.

The educational role of the activity is often advocated by professional promoters of eco-tourism, whatever their competence in the matter. These professionals are touching a sensitive chord when they say they are going to help people discover an environment and animals and that they are going to explain to the participants how this environment functions and how we must respect the sea and the living beings it contains. This aim seems quite ambitious and very hard to assess. We believe that a truly educational role can **only** be designed over time, i.e. during long journeys. This is why, here, we have dissociated it from the 'commercial-type activities' which generally happen over very short periods of time, often half a day, even a couple of hours.

There are many associations proposing this 'educational' aim, each with true objectives that are not always clearly expressed, and each applying different processes according to the public that they are more precisely targeting. Formerly (but this continues) a whale watcher could be anybody, of any age. So the public that the activity proposed to satisfy was a wide one! But increasingly NGOs tend to target their publics more precisely, addressing schools, work's councils, groups of friends, or again people seen as 'difficult, disadvantaged, handicapped…'. There seems thus to be a tendency to adapt to 'fashion', perhaps in the hope that the grants they are soliciting can be more easily forthcoming.

Be that as it may, 'the' whale or 'the' dolphin tempt the public to commit itself to an adventure (usually lasting several days, bearing in mind the rates applied), but what happens on board once the people have boarded the ship? Nothing for the moment enables it to be estimated, assessed, controlled, and it is high time the real benefit to the public was analysed in depth. As far as we know, only Orams (2000) has dealt with one of the social aspects that might be linked to whale watching. He showed that in Australia the number of whales seen and their behaviour, the number of passengers on board, the duration of the expedition, the type of boat and sea-sickness played a big part in the satisfaction of the whale watchers. The geographical proximity of the animals was not a major influence, but 35% of whale watchers came back satisfied even if no whale had been sighted.

The educational side of whale watching is also very quickly accepted by managers and the administrations, grounded on findings in terrestrial environments that have been controlled and monitored. But is not starting from the principle that education has really taken place when faced by a situation where there are so many unknowns actually turning a blind eye to the reality of the facts and tasks to be carried out? We think it is high time to take into consideration the true pedagogical aspect of this activity. Educating a public responds to precise norms which take a long time to be finalized and whose contents must evolve. Take the example of the already existing (national or specialised) educational systems: a set, defined, controllable and monitored syllabus, respected by the educators. All the thinking is still to be done here concerning whale watching, for we have found no appropriate bibliographical reference. But we should remember that this anxiety is not recent, since from the 1980s sociological studies were already being requested to assess the fact that whale watching could really be educational and in time beneficial to the whales (CMC/NFMS 1988).

And we should remember too that in many cases some NGOs wish to appear still 'more serious' and increase their fame in the eyes of sponsors or managers and therefore boast that they are participating in scientific research programmes. It is true that some of them do indeed do this, most conscientiously and after the necessary training. Let us thank them here for being so scrupulous. But very few really do, respecting the advocated methodologies, and this should be watched, especially when what they claim to do (generally photo-identification) urges them to get very near the animals!

This leads us to mention the disturbance which certain scientific activities can cause. Not those which are grounded on acoustic methods (whose effects are mentioned elsewhere), but those which mean that boats are led to get extremely close to the cetaceans. We are thinking in particular of two kinds of study, which fall within the general case in that they require getting as close as possible to an animal. The first is the photo-identification of animals, a technique which consists of taking pictures permitting individuals to be recognised by their body marks. This implies often remaining a long time in the animals' immediate living space, and we have found no study that addresses the behavioural changes of animals during or after such practices. And yet this kind of research is very often done, on many cetacean populations around the world. The second kind of scientific activity includes work involving tagging (to follow an animal's movements by satellite or to collect information about life rhythms over short periods), or collecting biopsies (for studies on population genetics, toxicology, or to determine the food diets of individuals). These methods require not only going right up to the animal but also fixing (e.g. sucker tags) or putting a device on part of its body (Argos-type transmitter tags, or darts for biopsies). Very rare are the analyses of the (long- or short-term) impacts such practices (and yet they are extremely intrusive) can have, except as regards the animals' reactions to the 'stings' of the affixed devices. These few works especially mention the additional wounds inflicted on the animals, and which may cause necrosis of the tissues and also sometimes cutaneous reactions (the placing of suckers). We give a very recent example: Geertsen *et al.* (2001) have just shown that harbour porpoise behaviour can be affected in the short term by the placing of diving-recording tags (increased time spent on the surface, changes in dive duration). The longer-term effect has not been shown, since the tag was taken off the animal after one month, after cutaneous problems appeared.

The case of the Mediterranean, and suggestions for steps to be taken

The Mediterranean is no exception to the rule.

There are many NGOs there and for the time being, more or less, they have all found a niche to be exploited which they can show off without meeting too much competition. Each thus seems to have its own originality, whether their aim is educational, scientific, medical, psychological, aesthetic, quite simply naturalist or purely leisure ... and many others.

To be able to develop respectful, harmonious whale watching, we have seen that it was necessary to have identified all its agents (human and cetacean) and understand their intensities in order to decree solutions. But no assessment has ever been made concerning the whale watching activities practised by the NGOs in the region, either about the number of these associations or about their areas of activity or the subjects tackled, and still less about their contribution to the field of education. It thus appears to be necessary that such an assessment be quickly made, and that it be regularly updated, since the NGOs are starting to multiply, at least on the most remarkable sites such as the Liguro-Provençal Sanctuary and also those in the area around the Strait of Gibraltar.

As to the scientific research teams (institutions and NGOs together), we should recognise that they do not yet abound in the Mediterranean, being often hampered in their development by their relatively modest financial means. For the time being, therefore, they do not seem to present a real problem for cetaceans, at least those which confine themselves to applying methodologies that are not intrusive.

But the present infatuation with the latest techniques and the increasingly frequent call for big foreign teams must not leave us indifferent. We must therefore be extremely vigilant faced with the development of research if we wish to avoid possible excesses or slips. Let us go back to the two kinds of work cited above: taking biopsies on live animals, and placing various types of tag. It cannot be denied that such research must be done for the additional knowledge it brings with the aim of protecting species better, but it cannot be done without causing a certain amount of unpleasantness for cetaceans. As an example, take the fact that Mediterranean whales only seem to have very short negative responses to biopsies (Jahoda *et al*. 1996), whereas this observation goes against what has been noted for humpback whales in the Gulf of Maine (Weinrich *et al. 1*992). But it would certainly be most harmful to cetaceans that such work, especially that based on the placing of tags, should be done without any coordination, for that would give rise to a totally useless multiplicity of acts.

Now, at the moment such coordination of research is only in its early stages in the Mediterranean, driven on by the tools that are already in place (the MAP of the UNEP-RAC/SPA, or the CIESM Working Group) or being set up, like ACCOBAMS or those related to the creation of the Liguro-Provençal Sanctuary. These initiatives are to be encouraged and developed to quickly fill in the gaps at this level. And we should be delighted to note that some scientific teams are working together to tackle large-scale issues (see, for example, the http://www.circe-asso.org/ website).

Occasional whale watchers

In the case of occasional whale watching, obviously it is no longer the lucrative or educational sides which are to the fore. Indeed, this is not correctly speaking an activity, but a set of occasions which may result in someone's being in the presence of a whale or a dolphin. We include here a group of fortuitous acts which have usually no direct intentional relation to cetaceans. These cases are however linked to a frequenting of the marine environment and should be mentioned since the Mediterranean and its coasts are one of the most attractive parts of the world to tourists.

Development and impacts of activities

There are a great many unintended possibilities of being in the presence of a cetacean, and every day their number grows as various kinds of devices for sailing or flying over the sea proliferate. It is impossible to mention them all, since this would take us from the simple sailing boat to the air balloons, passing through the helicopters, ultra-light planes, rising parachutes, jet-skis, surfboards or even divers. There is a lot of information about encounters where these devices have caused disturbance to animals.

Today, all the people who are concerned about the impacts of whale watching unanimously recognize that it is especially private boats which cause most problems, plus the activity when it develops in an uncontrolled manner in regions where no measure has yet been decreed. This impact of sailing is not new, and was for example already clearly denounced in 1988 in Alaska (Zimmerman in CMC/NMFS 1988): 'Private recreational boaters may be the greatest offenders in terms of harassing whales. This occurs because there are so many private boats in Alaska, and some of the owners may harass or injure whales when approaching them out of curiosity.' Let us give some examples:

- Several references indicate that whales avoid boats by remaining longer under the surface: the nearer the boat approaches, the longer the soundings, the shorter the intervals of respiration, and the slower the swimming speeds.
- Harbour porpoises show a clear tendency to avoid 'occasional' boats, and their reactions are less frequent confronted by boats on regular lines, indeed daily boats like ferries (Evans *et al.* 1994).
- Remember that the Tursiops of the Ile de Sein (France) hardly appear to be disturbed by boats entering or leaving ports, except when these boats try to approach them, and then they escape (Liret 2001).
- Experience also shows that the same type of boat can engender different reactions on the part of the cetaceans it encounters, according to whether this occurs out at sea or near the coast. This is particularly evident, and the consequences more disturbing, when these boats are sailing in shallow waters where noise can be amplified or reflected.

- Approaching animals in kayaks can also disturb, since this type of boat is very silent. It is noted that resident killer whales, taken up with hunting and feeding at depth, when coming to the surface to breathe, may collide with such boats whose presence they have been unable to detect above them. (www.whale-museum.org/issues.html Issues affecting the Southern resident Orcas).
- As regards jet-skis and parasail, it has in Hawaii long been proved how disastrous are the effects of these two devices (Green 1990): they very clearly frighten away the whales and their calves from waters close to the land where they have come. Moreover, it was as a result of this work, and thus from the early 1990s, that strict legal measures were taken and continue to be introduced, totally prohibiting these two activities on several precisely-identified coastal sites of the island.
- As to disturbance caused by aeroplanes, Richardson *et al.* (1985) showed avoidance reactions in Bowhead Whales when planes approached or circled above the animals at a height of less than 305 metres. And it has been shown that the same animals were less sensitive to the passage of a plane when engaged in feeding, socializing or mating activities (Richardson *et al.* 1995). However, we must admit that most of the studies done on the impact of planes were done from the very planes which were the source of the disturbance. The significance of their conclusions is thus fairly limited, insofar as we do not know what was the exact behaviour of the animals before and after the plane was there (Perry 1998).

<u>The case of the Mediterranean</u>

In the Mediterranean, the archives of NGOs or scientists contain many cases of disturbance caused to cetaceans by 'occasional' whale watchers, but very few of these have been published. It would therefore be very instructive that such documents be collected together for managers to be informed about the range and extent of the causes recorded.

Here we shall only give two examples to show how urgent it is that the appropriate measures be taken.

The first example concerns an alarming case, which has just been aired at the latest European Cetacean Society Conference (Miragliuolo *et al.* 2001). A group of 19 Risso's Dolphins (3 of them newborn) was met by a sailing boat near the Italian island of Ischia on 27 August 2000, on a 300-metre sea bed. This group quickly became the target of an increasing number of boats and, in less than two and a half hours, was surrounded by over 100 boats and had been pushed onto a 3-metre sea bed. The writers say: 'Harassment behaviour by pleasure boaters included heading towards the animals at high speed every time they surfaced, sudden changes of route, and continuous attempts to approach the animals at close quarters to take photographs or 'interact' with them. All group members showed clear signs of distress and seemed to be unable to orientate.' This dramatic interaction was only interrupted when members of StudioMare intervened, and the writers draw attention to the fact that cases of disturbance are recorded every day during the summer months.

We ourselves denounce the second example, because we have often been present at the scene. It concerns *Tursiops* frequenting the Saint Florent area in Corsica, very often met on shallows some minutes' sail from the port. Their extremely regular presence on this site is well known to the people of the region and sailing boats unhesitatingly sail up at aperitif time or each time they go in and out of the port either for pleasure or to show the animals to their guests. The holiday-makers usually arrive very quickly, go round the group at high speed, and often go right in among the dolphins to try and make them jump out of the water. The violence of these scenes generally lasts no longer than a quarter of an hour (since the people are in a hurry!) but the fact that they are repeated throughout the day and the seasons (especially in the summer) alarms us no little as to the long-term consequences of such acts.

We shall end by merely making slight mention of one category of whale watcher, for the time being put into the 'occasional' class, but very recent and seemingly increasingly developing. It is the fishermen (commercial or not) who, for a great variety of reasons, are starting to offer to take people out to sea to watch cetaceans. This phenomenon has already been mentioned at various forums, but no information allows us today to have an idea of its extent. It would be interesting to rapidly make an analysis of this kind of activity which, at present occasional, could quickly take on a commercial hue. Perhaps it could even be suggested and embraced as a redeployment possibility for members of a profession which is today experiencing a lot of problems.

Steps to be taken

Quite obviously and above everything else, the steps to be taken about occasional whale watchers fall within the overall issue of whale watching. These steps form the main part of the following Conclusion, and thus we shall not discuss them here.

However, occasional whale watching - because of the mass and diversity of people it involves - allows a highlighting of how important it is that everyone should be made aware of the consequences of his/her disrespectful acts for the animals. The task is certainly heavy but the durability of cetacean populations depends on it.

Conclusions

We have seen that whale watching in all its forms could be very positive in that it could be a good way of making the public aware and informed. It can also generate jobs and become an important tourist attraction for the areas where it is practised. But some of its negative sides appear once the cetaceans are faced with disturbance resulting from the uncontrolled development of the activity, and we have said how difficult it is to manage this kind of eco-tourism and bring it under control. However, we must be aware that whale watching is not yet viewed favourably everywhere, even if nearly half the countries are already practising it in its commercial angle. Certain people still wonder whether this activity can become a real tool for promoting the protection of threatened species, or whether it in fact represents too great a danger to the animals. Without going into the question that is asked again and again, 'Is it ethical to approach and develop commercial activities round threatened species?'

Identifying the agents

Desiring to manage an activity implies first and foremost a knowledge of both the identities and acts of its agents. Now, we have seen that there are vast gaps in this field of our knowledge, both of the publics involved and of the cetaceans concerned.

As regards the publics, we will not go back to the urgency of taking stock of the situation over the entire area covered by the ACCOBAMS. It is vital that an assessment be made of the categories of whale watching practised in the Mediterranean, the intensities with which these activities are carried on, the sites involved, the periods of the year concerned, and the financial and/or educational contribution generated.

At the level of our knowledge of cetaceans, there too our knowledge is rather thin. Although certain populations are starting to be correctly known (the north and east of the western basin, for example), prospecting there does not cover all the seasons (almost no work done in winter), and nothing at all is known about others (in particular, the southern parts of the two basins). Much remains to be done for a better knowledge of the populations of whales and dolphins there.

It is certain that whale watching developing without control gives rise to disturbance for the animals, sometimes leading to extremely serious situations. We have on the other hand shown how different the impacts of this disturbance can be according to the geographical sites and the species frequenting them. Now, since almost nothing has been done in the Mediterranean and the Black Sea to study these extremely complex phenomena, it is high time that scientists got down to it. To give the main lines of the research to be done, we shall use the suggestions made by Janik and Thompson (1996) at the end of their study on Bottlenose Dolphins, for these are very pertinent for both big and small species and are still topical:

- *'Further studies are needed to assess the influence of boat behaviour on the behaviour of (cetaceans) in this area.'*
- *'Further work is required to determine whether certain individuals or age-classes are more sensitive to boats than others. We were also unable to determine whether (cetaceans) reacted to a boat itself or to its engine-noise.'*
- *'Behavioural studies need to be carried out alongside more detailed research on individual survival, reproductive rates and movements in order to assess whether boat traffic that follows the animals around has a significant impact at the population level.'*
- *'Effects at the population level generally remain unclear.'*
- *'The development of commercial cetacean watching and other increases in boat traffic should be managed carefully, and attempts made to understand its consequences on the animals.'*

It is thus clear that these studies, as Norris and Reeves already pointed out in 1978, must be of two kinds. One, an analysis of the short-term effects on the animals, due essentially to the stress linked to a presence that gives rise to phenomena of avoidance, flight or aggression, the other the long-term effects that can lead to a reduction of a population's biological abilities.

Defining, setting up and monitoring the measures to be respected

Knowing the agents is one thing, identifying and assessing the impacts of man/cetacean interactions is another. However, we have shown that these can cause extremely serious harm to the animals, and as a result to the activity itself, if these interactions happen contrary to all good sense. Now, confronted with the many recorded examples of untimely excess, we have seen that the absolute necessity of introducing measures leading to the animals' being respected has today been unanimously recognized. However, the diverse nature of the difficulties encountered for reaching this goal is great and we shall try to set out its essential elements.

At the Workshop on whale watching held in Montecastello, Italy, in 1995, Leatherwood (in Malcolm and Duffus 1998) presented an exceptionally detailed framework of the various operations to be followed, different stages to be gone through, many paths to be explored and resolved, if quality whale watching was to be attained, i.e. allowing a vision of the developing of an 'industry' that would not cause harm to the animals, the populations or the habitats targeted by these operations (cf. Annex 1). However, the scientific community quickly recognized (and this opinion is still topical in 2001) that the A to Z application of the various stages suggested in this document was totally impracticable in the present state of our knowledge, whatever the area or species concerned. It is crucial to raise this point concerning the gaps in our knowledge when we know what has been done, and the quality of research already done, in particular on certain areas frequented by species seen as being extremely vulnerable. This document, which is commonly called the 'Leatherwood Principle', is thus a tool for reflection of the first importance, which must not be at once rejected but which for the time being remains rather optimistic – if not 'utopian'.

Thirteen years, therefore, after the 1988 (Monterey Workshop) discussions, followed by many others, we have to admit that we are still playing the 'sorcerer's apprentice' as regards decreeing rules or recommendations allowing whale watching to be correctly practised. We are still thus confined to measures that are very general but which can – given the experience acquired by those participating in various specialist forums – prove to be far from inefficacious because of the stamp of common sense they bear. The "Leatherwood Principle" is thus a very long-term one, impossible at present to apply in its entirety. In particular, because we are generally very ignorant about what was happening before whale watching started.

Be that as it may, 4 major guidelines emerged from the Monaco Workshop discussions (Malcolm and Duffus 1998):

- *Research programmes: 'Quick and Dirty' versus long-term*
  Researchers always have cold feet about decreeing measures when basic information is lacking. Now, decision-makers are making increasingly pressing requests faced with the development of the activity and the warning signs coming from various bodies. The question is thus knowing whether it is compatible to decide on 'protective' rules of conduct while (indispensable!) research work is still being done. It seems that the answer is yes, on condition that the scientific world show a little more humility about those complex situations they do not at present completely master. Indeed, in accordance with what principles are some researchers still anxious to overstep – by doing 'invasive' research – the principles they themselves have helped to set out, to be respected by the various categories of sea-users?
- *Need for a more holistic approach*
  It is absolutely necessary for decision-makers, researchers and operators to start working together. For this to happen:
  - work published by researchers must also be quickly made available in accessible terms for everybody
  - managers must be aware of the limits the scientists are running up against
  - and operators must be invited to participate right at the start of the planned discussions. The conjuncture of these three essential items is far from being the case at the moment, but interesting initiatives have recently been started in many sectors, such as, for example, in Canada

(1998) for the whale watching industry in the St Lawrence.

- *Need for experienced help in areas where whale watching is just beginning*
  Whale watching is becoming an increasingly important element in the global tourist sector, and usually it is the infrastructure able to set up …and enforce … the rules which is lacking when the activity begins. It is thus when the activity is just beginning that one has to intervene. Now, we have seen that many countries have long been facing these difficulties and are applying themselves to attempt to solve them. On the other hand, the multiplicity of attempts to do this is there to show that there is no one standard rule to be applied in this field. Countries wishing to develop whale watching domestically are, thus, highly recommended to not fail to call on areas that are more advanced on this subject for advice. This approach allows precious time to be saved in front of an activity which is racing ahead. And each will be able to adapt its needs and its ways of thinking to its economic reality, profiting from the major guidelines recognized by everyone. Obviously it remains to be seen whether the international community can monitor these initiatives … to avoid serious slips in regions where it is known that the responsibility of the concerned country is committed on a planetary scale. Three countries among those which signed the ACCOBAMS have already been engaged for several years now in discussions of this kind: Spain, Italy and Portugal.
- *Problem of enforcement of regulations*
  The need to strengthen regulations is often mentioned at various forums, but it is true that protecting marine mammals is often far from being a priority for many countries, where other activities seem 'nobler' and more lucrative to develop. This is regrettable, for this negligence is grounded on ignorance and the lack of awareness of the possibilities offered. Be that as it may, regulation measures are always long being finalized. But let us remember that in certain regions where the approach was started long ago (e.g. Hawaii) these measures are today 'evolving' in that meetings are held at the end of the observation season (or year) to refine measures according to the new gains in knowledge.

ACCOBAMS and the two Action Plans on Black Sea and Mediterranean Marine Mammals should permit this shortcoming in the regulations in force on the scale of the two basins to be compensated for. Only Spain and Portugal seem for the time being to have made a serious advance in this field, after the development of whale watching that they have experienced in the Canary Islands and the Azores. However, the case of the Mediterranean still remains quite different from elsewhere in that national jurisdictions no longer apply beyond the limit of 12 nautical miles from the coast. This is a particularly important point to stress for almost all the domain frequented by cetaceans is only subject to very wide, pretty unrestrictive, international laws. This is why initiatives like that of Spain to apply the principles of an Exclusive Economic Zone in its Mediterranean waters, or that of setting up a Sanctuary in the Ligurian-Provençal sea (France, Italy and the Principality of Monaco) are to be strongly encouraged and developed.

Code of conduct to observe

Since at international level there is no standard tool bringing together measures to be taken for correct whale watching, and in the absence of detailed regulations that can be directly applied at the present time by various countries, the idea was quickly born that a Code of Conduct to observe in the presence of cetaceans was the initial (and minimum) stage to go through, the moment the activity started. Initiatives to this effect proliferated, since the idea had mostly been adopted by the NGOs, sometimes by bodies, and less often by regions or countries. But introducing such Codes of Conduct is merely a first stage, and many agents would like them to be made into Charters and/or texts of law.

It is obvious that for the time being each of these Codes presents originalities that relate either to the body wishing to enforce them, or the concerned species when some are especially targeted, or, finally, the particular features of a site or area. Be that as it may, these Codes all contain common elements which must be observed when approaching, or being in the presence of, a cetacean. These major elements, which must imperatively be taken into consideration, are set out here succinctly, and Annex 2 (Fig. 12.2) offers the example of the Code in force today for the United Kingdom, and Annex 3 (Fig. 12.3) has a diagram to illustrate the distances and number of boats that must be respected in New England.

- **Norms concern the approach itself to a cetacean and impose:**
  - speed reductions: generally the boat must not be faster than the cetacean
  - noise reductions: certain appliances must be disconnected, but the motors must not be cut so that the animals can localize the boat better
  - respect for the angle of approach: approaches made from ¾ behind and tangential to the cetacean are advocated, and frontal approaches or those made from behind totally prohibited
  - respect for the routes followed: the paths of the boats must not be ambiguous as to the direction followed, and erratic paths must be banned.

- **Norms regulate the distances to which cetaceans are approached:**
  - It is strictly forbidden to go within 30 metres of a cetacean, 50 metres being the figure chosen by many countries
  - The boat is in the approach area when it is between 300 and 30 (or 50) metres from the animal.

- **Norms govern the number of boats that can approach**. It is generally requested that only one boat be present in the approach area. This boat must move off, generally after half an hour or even a quarter of an hour for certain regions, to give way to other boats waiting their turn.

- **Norms take into consideration the biology of the species approached:**
  - No approach can happen if newborn are identified in a group
  - Following the group must stop immediately newborn are identified in it
  - The animals must never be chased, circled or separated
  - Particular vigilance is required when the animals are feeding or socializing
  - Leave it up to the cetaceans to decide whether to approach or move away from a boat.

- Norms recommend that there be *no swimming with* or feeding of cetaceans; this kind of action is even already forbidden in many countries, basically for health reasons.

- Finally, the Codes expressly ask commercial whale watching *tour operators* to have on board each of their boats an experienced, qualified guide to provide better education for the public, make sure that the rules of the Code are correctly applied, and thus guarantee better respect for the animals.

Efficient monitoring

The basic guidelines on the conduct to be observed that we have just seen have so far no legislative value. These 'minimum' rules, often based on the 'precautionary' principle, should however be applied by all kinds of publics concerned closely or less closely by whale watching. Now we have seen that there was a very wide range of these publics – from 'industrial' tour operators to occasional whale watchers, via scientific teams and NGOs. It is thus vital to work on the processes that must be introduced for controlling these activities. Indeed, calling on people to show self-restraint alone has its limits, especially when one is faced by a myriad private boats or by the greed of the suppliers of commercial and lucrative activities. Anyway, this can only be envisaged if all the publics have been made aware, warned, and educated before the whale watching is started. We shall come back to this point.

However that may be, in the very great majority of current situations the means to have any regulation applied on a large scale seems today totally utopian. Despite all this, initiatives to this effect are starting to appear, but all still remain confined to restricted marine areas. In fact, the available means of monitoring are still too limited – and this is general – to hope for true, efficacious monitoring. And yet monitoring and checking are the only mechanisms we have today to avoid the uncontrolled development of a source of nuisance that puts cetaceans at great risk. It is indispensable that governments quickly endow themselves with the capacities for doing this! Here we will mention the alarm bell rung by Baird and his collaborators (Baird *et al*. 1998) at the Monaco Workshop. These writers, working on a small population of Killer Whales established at the boundaries of Canada and the U.S.A., said: '…In addition, large numbers of private recreational boaters, land-based whale watchers, and occasionally aircraft, also engage in whale watching. Despite the existence of boating 'guidelines' in Canada and both 'regulations' and 'guidelines' in the U.S., both the commercial and recreational boaters are largely uncontrolled and unregulated…'. This is especially worrying when one knows how much these two countries have done for whale watching there to be of good quality!

The example of the evolution in the steps taken by Spain in the Canary Islands is also most instructive, since it attempts to face up to an evolution in the whale watching tour operators' ways of thinking (Urquiola *et al*. 1999, Urquiola and de Stephanis 2000). From the beginning of the activities, the need was quickly felt to lay down rules. The operators thus feared sanctions during the first period of time, and tended to respect the regulations, but then they increasingly ignored them. Nowadays violations are increasingly difficult to identify and control (lack of means), while the industry continues to prosper (1 million people per year in the late 1990s). This is why the opinion of the managers is changing enormously faced with the new situation: although formerly they wished to base their decisions on the most complete and reliable scientific information for making the rules, now they are increasingly turning to an interest in educating the activity organizers and sailors and informing the public. Large sums of money are being used for this.

But who is responsible for making the advocated checks?

On board the boats which trade on this activity, this can very well be someone with the necessary qualification (see the following paragraph on how to get this qualification). On the other hand, it becomes more complicated when it is a question of monitoring all the publics. In this case there are many possibilities, linked to the various means the governments have of providing monitoring at sea. Now it often turns out that this additional task cannot be done correctly, for the bodies involved have prerogatives whose extent is limited. Each of these bodies could thus very well contribute to ensure the monitoring, but the need is increasingly felt that this monitoring should be centralized. From this perspective, the idea of setting up a specialized intervention corps has arisen in many countries.

Skills, labels and permits

The terms 'confirmed persons', 'level of competence' and their corollaries 'recognition', 'labels' or 'permits' have often been mentioned in this document. Now, very little information deal with these subjects in the documents we have consulted. It therefore appears that a vast amount of work needs to be done in this field, for it is not enough to say that we know cetaceans because we have often met them at sea, or that one is a qualified operator because one has adhered to a Charter.

It is thus indispensable that processes and tools be defined and quickly introduced to assess the skills (when they are announced) of the people involved, or to be able to acquire these skills when they are lacking. Training course and/or teaching systems could be envisaged, and we must define their programmes and their means of assessment. It is also vital that we identify the bodies or people likely to be able to grant the labels or permits certain agents will need. We are thinking mainly of the whale watching professionals, but also of the scientific teams. Here let us remember that in some countries, like the U.S.A., for example, any research requiring the application of 'intrusive' methods involves obtaining permission. It remains that we must not forget the need felt for closer coordination of research activity. Tools like ACCOBAMS, the MAP or the Liguro-Provençal Sanctuary are already working to press on in this field.

We shall conclude by including here the text of a very recent expert evaluation (WDCS 2000) of the gaps in a country's existing law to protect cetaceans from nuisances and persecution. This document is particularly interesting in that it summarizes, for one country, the main elements of the report we have just made on the impact whale watching can have. The assessment made in this report is most instructive about the state of the art on the subject, for it does indeed concern a part of the world where research in cetology is well developed, where restrictive measures have long been ordered, and where the impact of whale watching activities has been a topical subject of concern for many years now.

"1. There is ample evidence from around the UK that harassment of whales, dolphins and porpoises (collectively known as cetaceans) is a growing problem and that existing legal provisions are inadequate.

2. The consequences for cetaceans are:

i. They may be killed outright or wounded by ship-strikes (dolphins and other ce-

taceans cannot out-pace fast vessels, nor can they dive away to avoid them).

ii. *Schools with calves and injured, deformed or older animals may be especially vulnerable.*

iii. *Harassment may stress cetaceans causing adverse physiological changes and cause them to use up their energy stores. This can be expected to affect their "fitness", including their reproduction and survival.*

iv. *Adverse effects on individuals may have consequences for the whole population.*

v. *In the UK, the status of only one cetacean population is known (the bottlenose dolphins of the Moray Firth) and this population is in decline.*

vi. *Repeated harassment and/or vessel-generated noise pollution may cause cetaceans to be excluded from areas that are important for them and/or affect their normal behaviour, for example hunting and communication.*

3. *Expert review of the existing legislation (principally the Wildlife and Countryside Act 1981) combined with the experiences of people in the field trying to stop cetacean harassment, led to the following recommendations for changes to UK law :*

   i. *Legal underpinning for the new UK cetacean Biodiversity Action plans.*

   ii. *The extension of enforcement powers to marine agencies such as the coastguard (as well as the police).*

   iii. *The creation of a new offence: the intentional or reckless disturbance of cetaceans anywhere in UK waters. (The concept of "reckless disturbance"- as well as intentional disturbance - could be usefully applied to all vulnerable species).*

   iv. *More realistic fines for offenders.*

4. *It is also recommended that local authorities, through the creation of a new byelaw-making power, are given the ability to create exclusion zones for motorised leisure vessels in order to protect marine wildlife ”..*

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Year	Number of whale watchers	Direct income (in US$ million)	Total income (in US$ million)
1981		4.1	14
1988		11-16	38.5-56
1991	4,046,957	77.0	317.9
1994	5,425,506	122.4	504.3
1998	9,020,196	299.5	1,049.0

Table 12.1 – Worldwide development of commercial whale watching (Hoyt 2001).

Country	Start of whale watching	Number of whale watchers (in US$)	Direct income (in US$)	Total income (in US$)
PORTUGAL excluding the Azores	Early '80s	1,398	31,000	87,000
SPAIN + Balearics	Late '80s	25-38,000	550,000	1,925,000
GIBRALTAR	1980	18,750	450,000	2,700,000
FRANCE Atlant. + Med	1983	800	80,000	280,000
MONACO	Early '90s	minimal	minimal	minimal
ITALY +Sardinia	1988	5,300	241,000	543,000
CROATIA	1991	21	15,000	18,000
GREECE +Crete + Aegean Sea	Late '80s	3,678	140,000	261,000
CYPRUS	Late '90s	minimal	minimal	minimal
TURKEY	1994	minimal	minimal	minimal
ISRAEL	Early '90s	300 (1994)	minimal (1994)	minimal (94)
EGYPT	Early '90s	10,000	100,000	425,000

Table 12.2 - Development and extent of commercial whale watching in some ACCOBAMS countries (Hoyt 2001).

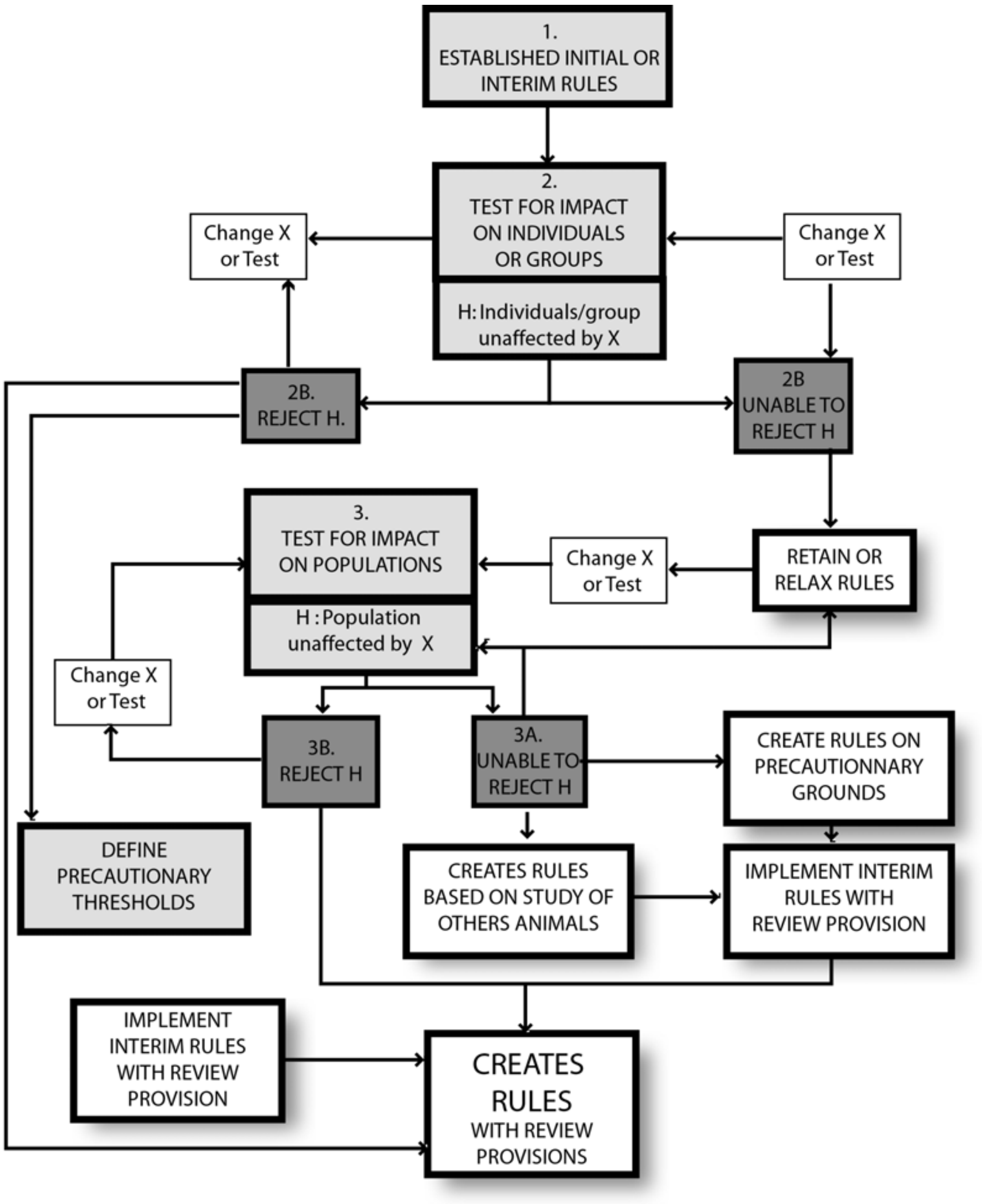

Fig. 12.1 - The “Leatherwood Principle”: decision-making framework for developing whale watching rules (IFAW, Tethys, Europe Conservation 1995)

Department for Environment,
Food and Rural Affairs
Minimising disturbance to Cetaceans
from Whale watching operators

Whale Watching

It is a rare privilege to be able to watch cetaceans (whales, dolphins and porpoises) in their natural environment. The most rewarding encounters occur when they are undisturbed. The following guidelines are designed to minimise stress to individual animals and adverse effects on populations.
Where local guidelines are in place tour operators should follow them (examples are enclosed with this document). Where these are not in place it is recommended that you follow these.

- Maintain slow, steady, forward progress throughout the trip. Deviation towards cetaceans should only occur when they are sighted in open waters with little other boat traffic. Any approach should be slow and at an oblique angle and should not aim closer than 100m.
- If cetaceans are sighted you should slow down gradually to no wake speed (or less than 5 knots) and maintain this speed until well clear.
- Let cetaceans approach you. If cetaceans do choose to approach the vessel or bow-ride, you should maintain a steady speed without changing course. Refrain from altering course to approach them and remember that they may choose not to bow-ride.
- You should move away slowly if you notice signs of disturbance, such as erratic changes in speed and direction or lengthy periods underwater.
- Refrain from driving through, or between, groups of cetaceans.
- You should avoid cetaceans with young.
- You should try to allow a clear escape route for cetaceans.
- Try to plan routes and timetables so there are no more than two boats within 1km of cetaceans. In areas of heavy traffic or in enclosed waters the duration and number of trips should be limited.
- You should consider fitting propeller guards to minimise the risk of injury to cetaceans. Maintain propellers to avoid unnecessary noise disturbance. Where possible, use boats with low engine noise. Be aware of, and attempt to minimise, other possible sources of noise disturbance.
- For the sake of their safety and the health of the cetaceans, passengers and crew should refrain from swimming with, touching, or feeding cetaceans.
- Where possible, the crew of a vessel should include a person who is able to inform the public about the natural history and conservation requirements of cetaceans.
- Remember that it is an offence to dispose of sewage, fuel, oil or litter at sea.

Compliance with the International Regulations for Preventing Collisions at Sea has priority over these guidelines at all times.

Fig. 12.2 - Minimising disturbance to cetaceans from whale watching operators

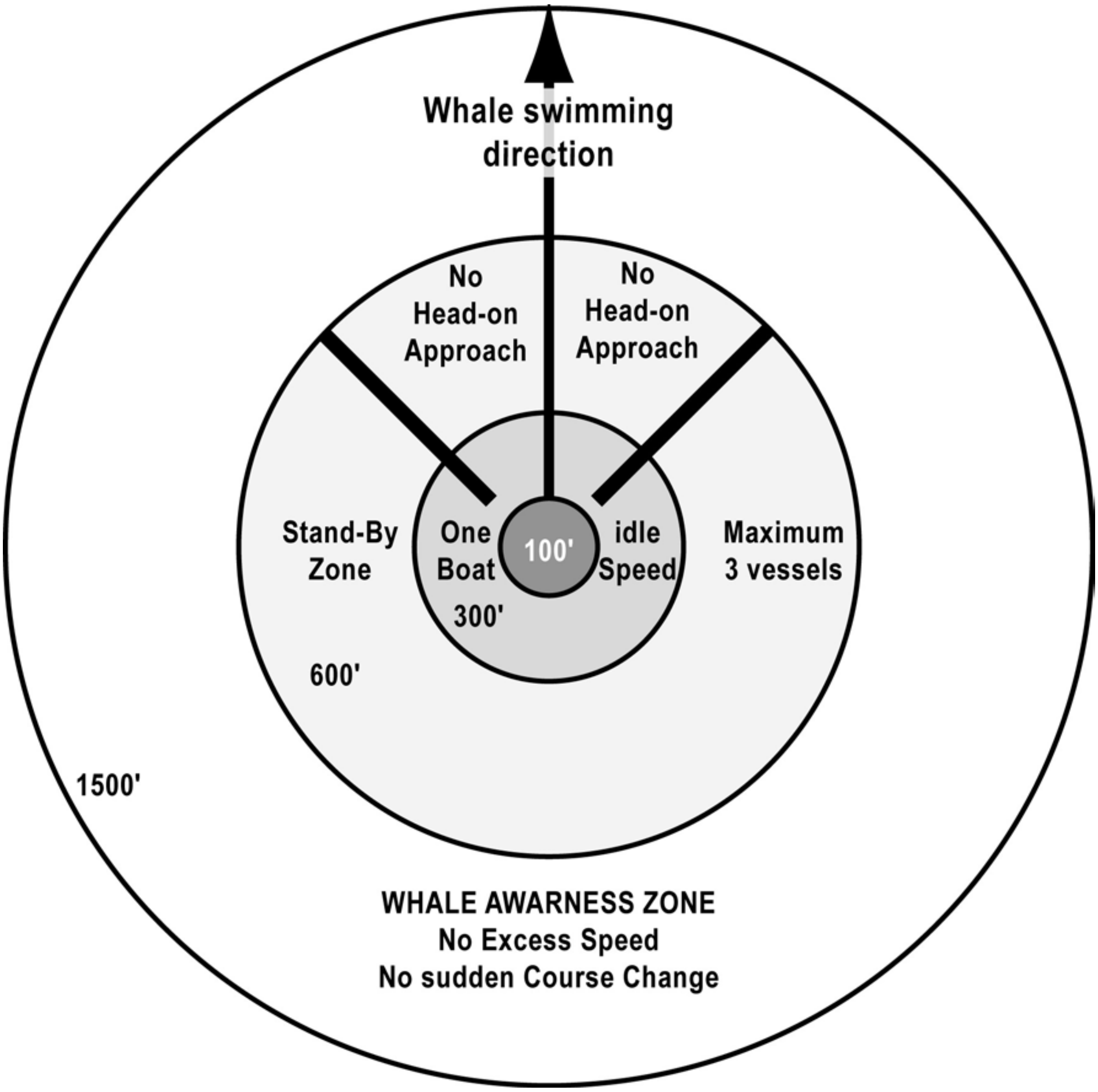

Fig. 12.3 - Diagram of New England Whale watching Guidelines (CMC/NMFS1988)

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 13

Disturbance to Mediterranean Cetaceans Caused by Noise

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Introduction

Sounds underwater. When a sound is emitted by a source, series of compression waves move away from this source and passes through the surrounding media, making the molecules of these media oscillate around their original location by changes of pressure, in the direction of the waves. It is important to note that the way the molecules of a medium will oscillate depends on both natures: that of the sound and that of the medium.

For one given medium, the amplitude of the movement of its molecules is due to the amount of energy of the waves causing fluctuations of pressure, which is called intensity when related to the density of the media, and the "rapidity" of the movement is tied to the frequencies of the waves. In other words, the intensity and the frequency of the sound make the molecules move more or less far away from their original location and vibrate more or less fast respectively, and therefore are the two principal components used as descriptors of the nature of sound. Intensity is measured in decibels (dB), which is a logarithmic scale comparing the intensity of the sound measured to that of a reference sound. It is worth highlighting that this reference value is different for sounds measured in the air and under water, since this difference (roughly, an intensity of x dB in the water will be equivalent to an intensity of x-26 dB in the air) has been cause of confusion in the literature (Chapman and Ellis 1998). In this report, all intensities cited will take into account the water reference value. Otherwise, frequency is measured in hertz (Hz), corresponding to the number of cycles accomplished per second by the waves. The nature of the medium plays a critical role in the propagation of sound. It has previously been said that intensity of sound is related to the density of the medium. So is the wavelength, which is the product of its frequency and the speed of sound in the medium, the latter being also directly linked to the density of the medium. Given that sound travels five times faster in the water than in the air, this means that a sound will be heard much farther in the water. Moreover, it is well known that the absorption of a sound depends on its frequency, as well as it depends on the characteristics of the media. In seawater, a high frequency sound of 100 kHz looses 36 dB in intensity per km, while the intensity of a medium or low frequency sound (< 1 kHz) does not decrease of more than 0.04 dB per km. In this medium, measures of emission intensity are usually made (or inferred) at a distance of one meter of the source. On another side, water masses are numerous and so are their physical characteristics: temperature, salinity, pressure defining their density, turbidity, and so on. Thus, the direction and the distance at which a sound may propagate are likely to vary according to the water masses it goes through, or refracts, or reflects. The combination of all makes sound propagation calculations very complicated. Nevertheless, some areas in the ocean are known to be quite remarkable acoustically speaking. Notably, particular conditions occur at certain depths (from 1,000 m in the tropics to a few hundred meters closer to the poles) in water masses causing the sound speed to be minimum. These water masses are called deep sound channel because they trap the sound and concentrate it, allowing a greater propagation. On the other hand, some areas at the surface are relatively protected zones from noise, whereas in others sounds converge (Richardson *et al.* 1995, Moscrop and Swift 1999).

Natural and human-made sounds. Even outside the convergence zones, the world ocean is a noisy place. Considering the natural-made sounds only, the ambient noise at surface near 100 Hz may reach 60-80 dB (it is strongly weather-dependant). This natural background noise expand at least over 1 Hz to 100 kHz and has a lot of sources, including earthquakes and sea ice at low frequencies; waves, din of rain on the surface and biological sources such as croaker fishes, pistol shrimps and marine mammals at medium frequencies; finally, molecular agitation prevails at very high frequencies. Nowadays, one has to add the human-made noise, or anthropogenic noise, which has been estimated by Ross in 1976 to rise between the 50's and 1975 the total background level of 10 dB in the northern hemisphere - the same author predicted at this time another 5 dB increase until the end of the century. Anthropogenic noise is due to explosions, seismic activities, military sonar, exploitation of oil and gas industry, vessels traffic, scientific research, fishing activities and recreational craft. It covers also the wide frequency bands mentioned above for natural sources. Because of the strong development of industries, transports, etc..., ambient man-made noise is even louder in the northern hemisphere, and concentrates particularly in coastal areas. Nevertheless, when we consider both ambient, permanent noise and local, temporary noises, the amount of anthropogenic sounds is likely to threat cetaceans worldwide.

Generalities on sounds and cetaceans. The process by which sound waves interact with surrounding media has been briefly reviewed. If one of these media is an animal, oscillations created in its body allow it to hear the sound. In addition, we have seen that sound propagation underwater was much greater than in the air contrary to vision. Thus, it is no surprise that cetaceans have evolved to rely principally upon their acoustic senses, i.e. hearing, communication and echolocation involving most of their vital functions (navigation, detection of preys and predators, social communication involving in its turn reproduction, care of calves, social cohesion within the group...). Therefore, cetaceans as a whole are very sensitive to sound, either in terms of ecological fitness or of received intensity and frequency. When getting slightly more into details, the larger a cetacean is, the lower the frequencies it uses. Ketten (1992, 1998 in SACLANTCEN) stated that four groups of cetaceans can be distinguished with respects to their acoustic abilities:

- the mysticetes producing dominant signals below 1 kHz. It is the case of one common species in the Mediterranean, the fin whale (*Balaenoptera physalus*);
- the largest odontocetes producing dominant signals below 3 kHz: the sperm whale (*Physeter macrocephalus*), the Cuvier's beaked whale (*Ziphius cavirostris*), and the long-finned pilot whale (*Globicephala melas*);
- the mid-sized odontocetes with signals in the range above 40-80 kHz: the bottlenose dolphin (*Tursiops truncatus*) and the Risso's dolphin (*Grampus griseus*);
- the smallest odontocetes with signals in the range above 80 kHz: the striped dolphin (*Stenella coeruleoalba),* the common dolphin (*Delphinus delphis*) and the harbour porpoise (*Phocoena phocoena*) which is common in the Black Sea.

Impact of sound on cetaceans. If oscillations generated by sound in their body make them very well adapted to their environment when received intensity is normally acceptable for them, such vibrations can have disastrous effects when received intensity brake up their ability limits.

In spite of a certain lack of knowledge, due to insufficient research, and to the difficulties in judging noise effects in isolation from other threats, several effects of noise on cetaceans have been reported, ranging from local and short disturbance to death. The most problematic point is that it is not clear to what extent these effects have long-term implications for cetaceans populations. However, current information suggests that anthropogenic noise has the potential to affect cetaceans in a number of ways which reduce fitness at the level of individuals, populations and species. These ways have been compiled by Simmonds and Dolman (1999):

- Physical: non-auditory (damage to body tissue, induction of air bubble growth and tissue bends) and auditory (gross damage to ears, permanent hearing threshold shift, temporary hearing threshold shift);
- Perceptual: masking of communication with conspecifics, masking of other biologically important noises, interference with ability to acoustically interpret environment, adaptive shifting of vocalisations (with efficiency and energetic consequences);
- Behavioural: gross interruption of normal behaviour (i.e. behaviour acutely changed for a period of time), behaviour modified (i.e. behaviour continues but is less effective/efficient), displacement from area (short or long term);
- Chronic/Stress: decreased ability of individual, increased potential for impacts from negative cumulative effects (e.g. chemical pollutants combined with noise-induced stress), sensitisation to noise (or other stresses) - exacerbating other effects, habituation to noise - causing animals to remain close to damaging noise sources;
- Indirect effects : reduced availability of preys (this effect is not moved on in the present report).

Consequently, physiological consequences are various: energetic implications, stress, hearing impairment (auditory damage and masking), non-auditory physical damages, strandings. In addition, noise can also alter feeding, foraging, resting, socialising and breeding behaviours, and the detrimental impact is likely to be particularly severe in cases where cetaceans are temporarily or permanently displaced from areas that are important for feeding or breeding.

Synergetic effects with other pollution sources are also suspected, as for instance in the case of permanent threshold shift due to heavy shipping noise, increasing the probability of collisions with vessels (André *et al.* 1997). It is well known too that long-term stress-mediated effects due to noise include lower resistance to disease (Geraci and St-Aubin 1980). For areas where chemical pollution is heavy, this may cause several pathological effects, ranging from the death of an individual to the reduction of effectiveness of the immunological defences of entire populations. Perry (1998) highlighted that synergetic effects of noise, chemical pollution, shipping disturbance and over-exploitation of natural resources are likely to have the most severe impacts for cetaceans populations in coastal areas.

Evaluation of noise effects. It remains very complicated to determine, characterise and assess effects of noise. Cetacean behaviour varies naturally according to numerous factors, such as the animal's age, sex and state of activity, as well as environmental influences such as the location, season and time of the day. The significance of a particular acoustic signal, and the way an animal responds to it, may vary according to any of these factors. This means that it is very difficult to establish a baseline against which effects of disturbance can be compared (Perry 1998). In addition, it is rarely known if a behavioural change is a response to a specific noise, rather than to a visual or other disturbance (Richardson *et al.* 1995). Moreover, evidence of causal effects of a particular - and, obviously, even more of a permanent - sound on the physiology of the animal has appeared to be a very controversial matter, as it is almost impossible to demonstrate it statistically (for example, see below the discussion on LFAS) because of the lack of data. In 1998, Ketten stressed that "existing data are insufficient to accurately predict any but the grossest acoustic impacts on marine mammals". In the past three years, methods have evolved and several studies were conducted, but this problem currently remains strong. Now, research work aims at determining ranges of threshold intensities received by animals at the most relevant frequencies and what is the kind of effect in function to the distance of the cetacean from the emitting source, all of that depending on the species affected.

Anyway, literature describes disruption of cetacean behaviour and physiological impacts due to noise from recreational boats, shipping, industrial activities, seismic exploration, oceanographic tests, sonar, acoustic deterrents and aircraft. In this paper, anthropogenic sources of sound and their effects on cetaceans will be reviewed by professional human activity, detailing both general and Mediterranean cases according to the current knowledge, and mitigation recommendations will be proposed.

Traffic noise: shipping, pleasure boats and whale watching

Although being gathered under the same broad word “traffic”, these three categories are well different. In this chapter, we will consider them in two paragraphs with respect to their coastal and deep-sea area occurrence, the first paragraph being separated in two parts, according to the main frequency (high or low) of the sounds they emit. These distinctions have been made because of conservation implication meanings, principally referring to the species affected, to the kind of effect and to the probable duration of disturbance.

Neritic areas. Coastal areas are places where man-made ambient noise is the loudest, notably around harbours. In the Sado estuary (Portugal), Dos Santos *et al.* (1995) recorded a minimum level of ambient noise of 122 dB, the maximum reaching 151 dB near the harbour. Noise is mainly due to the intense traffic converging to such places, to be linked to three socio-professional origins: fisheries, concerning boats displacements to or from their fishing grounds and only considered in this chapter as routing small or mid-sized boats (< 50 m long); recreational tourism, related or not to cetaceans observation; and commerce ships (and aircraft), either for passengers or merchandise transport. The first two categories generally have highly seasonal activities and produce high-frequency sounds, whereas the third one is rather permanent and produce low-frequency sounds. This means that they may have very distinct impacts on cetaceans, but the combination of all in the same areas will affect all cetaceans species and populations – transient or resident – living in neritic areas.

Low frequencies. Though large vessels are transient as they indeed pass through coastal zone, both an effect of concentration along regular and predictable lanes and the large audible range of the noise they make induce a potential disturbance on wide time and space scales.

The impact of fast-ferries on bottlenose dolphins was studied by Browning and Harland (1999). Measuring sound emitted by a water-jet propelled catamaran, they found two peaks of intensity, the first caused by machinery over 130 dB (at a distance of 900 m) around 500 Hz, and the second much less intense above 10 kHz, produced by the displacement of water behind the ship. They did not detect any disturbance on bottlenose dolphins, whether by behaviour disruption or by displacement from the area. On the other hand, grey whales (*Eschrichtius robustus*) left calving lagoons while they were subject to human disturbance, including intense shipping and continuous dredging, and came back several years later, only once shipping has ceased, very presumably as a response to noise disturbance (Reeves 1977, Bryant *et al.* 1984). Glockner-Ferrari and Ferrari (1985, in Perry 1998) attributed a consistent decrease in the percentage of humpback whales (*Megaptera novaeangliae*) mothers and calves to high level of boating and aircraft. When investigating the response of belugas vocal behaviour to ferries noise, Lesage *et al.* (1999) concluded that this kind of traffic was unlikely to have serious impacts on communication among belugas (*Delphinapterus leucas*), because much of the noise emitted by these vessels is concentrated at frequencies < 1 kHz, where belugas sensitivity is quite poor. Nevertheless, they observed several changes of vocal behaviour when vessels were close to the animals, such as changes in calling rates, a tendency to emit calls repetitively, an increase of call duration and an upward shift in the frequency range used to vocalise. André *et al.* (1997) reported cell damage in the ears of two sperm whales, consistent with the effects of permanent threshold shift, suggesting that this might have been caused by long-term exposure to noise from continuous shipping activity.

High frequencies. All of the numerous kinds of boats producing high-frequency sounds have quite limited sizes – unable to support a very powerful engine – and quite limited autonomies, thus moving only within a small range (few nautical miles) from the coast. So, all are resident in neritic areas, but again have to be discriminated with respect to the "passing" character they could have for cetaceans. Practically, high-frequency noise has very little propagation abilities, and therefore participates only little to ambient noise, except in the close vicinity of the source. Thus in this case, the distance cetaceans are from the noise source plays a major role. Thereby, whale-watching boats will be distinguished from the rest of the traffic, since, on one hand, their destination are cetaceans themselves and, on the other hand, they spend a long time close to the animals.

Evans *et al.* (1992) experimented the reaction of bottlenose dolphins to various pleasure boats. They measured intensities at a distance of 3 m of the noise source and audible ranges under sea state 3 condition (keep in mind that all range values increase if sea state declines). They found that jet ski (650 cc.) had the lowest intensity (83 dB at low speed and 90 dB at high speed), thanks to its water-jet propulsion system, followed by the inflatable (6 hp outboard engine), the rigid speed boat (90 hp outboard engine) and finally the lobster fishing boat (240 hp inboard engine). In all cases, cavitation (air bubbles that form and collapse near the blades after speed has reached a critical level) is the most significant source of noise above 2 kHz. Jet ski can be heard by a bottlenose dolphin up to 450 m, inflatable about 1 km away, the speed boat from 800 m (low speed) to 1800 m (high speed), and the fishing boat from 1.1 km (low speed) to 3.1 km (high speed). The general reaction of dolphins was to make longer dives and to move away from the source. Conversely, responses of dolphins were greater to jet ski because the noise produced rises above the ambient level only close to the dolphins, creating a more sudden and startling noise which is likely to frighten them more than that of the larger boat. Moreover, they can be more scared when the craft changes direction erratically, especially when it orients directly toward them. These results are confirmed by Lesage *et al.* (1999) studying responses of belugas to a small motorboat, that showed that this species reacts more to small boats moving erratically than to large vessels moving on a predictable path. They also found that, because of their frequencies, sounds emitted by small boats would be expected to interfere with communication among animals.

In the last fifteen years, whale-watching has exponentially increased all over the world, involving in 1995 5.4 million persons (Hoyt 1996).

Literature about possible disturbances and regulation of this activity is now abundant. Some examples give a good idea of what can bring about whale-watching if it is not conducted in a responsible manner : surfacing frequencies of bottlenose dolphins decreased significantly in response to a whale-watching boat attempting to remain close to the dolphins, while they showed little reactions to other boats in the area (Janik and Thompson 1996); examples of unusual aggressive behaviour of short-finned pilot whales (*Globicephala macrorhynchus*) were observed in response to a large number of whale-watching boats (Heimlich-Boran *et al.* 1994); sperm whales avoided whale-watching operators at a distance of 2 km. (Cawthorn 1992).

Oceanic areas. In offshore areas, sounds from small, high-frequency boats are rare events and then can be overlooked. On the contrary, large vessels traffic increases year after year and is by far the greatest anthropogenic contributor to ocean noise in the frequency band below 100 Hz (Clark 1999). Cargo ships, super tankers and ferries produce low-frequency noise, coming mainly from their propellers, reaching very high levels of intensities (around 190 dB at source for super tankers and very large container ships, 160-170 dB at source for ferries, according to Richardson *et al.* 1995).

Investigating the effects on low-frequency (< 1000 Hz) loud sounds (>140 dB estimated received intensity in certain cases) on foraging largest whales (blue whales *Balaenoptera musculus* and fin whales), Croll *et al.* (2001) found no obvious responses of whales to the sounds and suggested that cumulative effects of anthropogenic low-frequency noise over larger temporal and spatial scales may be of more importance than what it was possible to study in this survey. On the other hand, Bauer *et al.* (1993) reported that swimming speed, respiration and social behaviours of humpback whales were affected by vessel traffic, in particular with respect to vessel number, speed and proximity. Using a software model, Erbe and Farmer (2000) estimated that the zone of disturbance of an ice-breaker on belugas was slightly smaller than its audible range (35-78 km., depending on locations). They added that propeller cavitation noise accounted for all long-range effects. Masking of communication was predicted up to a minimal distance of 14 km, and temporary hearing damage can occur if a beluga stays within 1-4 km of the boat for at least 20 min.

The Mediterranean case. The Mediterranean is subjected to a huge traffic. Over 80,000 vessels cross the Straits of Gibraltar each year, concerning 75 % of the international volume (De Stephanis *et al.* 2000). In addition, recreational craft and fisheries are very well developed in the northern regions. In spite of a very important cause of concern as highlighted by Von Bismarck *et al.* (1999), very few data exist on its noise pollution significance. Nevertheless, the considerations described in the general case are likely to apply here, with the possible exception of the masking effect, as habituated animals to an intense traffic noise may react differently in comparison to others inhabiting quieter areas.

Perez *et al.* (2000) investigated the effects of the acoustic pollution produced by a heavy maritime traffic (mostly commercial ships, then fishing fleets and pleasure boats) in the Alboran Sea. They used both acoustic (estimating intensities of ship noise and cetaceans sounds on a scale of 0-5) and visual (recording simultaneously numbers of boats and cetaceans) methods. Visual results demonstrated that cetaceans do not completely avoid passing vessels. However, they found a negative correlation between cetaceans clicks and whistles and ship noise, what can be interpreted either as a response by small cetaceans to shipping noise, or as ship noise masking the analyst's ability to detect cetaceans sounds. In the two cases, they concluded that cetaceans possibilities to explore their environment through sound production (in the first case by a decrease of their calls) and reception (in the second case by masking of sounds to be received) could be greatly reduced.

Industrial noise

Industrial activities generate a great variety of sounds, some of them reaching very high levels of intensity. Periods of sound emission range from several days up to several years according to the activity. Once again data are scarce, except for oil and gas exploitation (exploration made by seismic surveys will be treated in the scientific part), and for acoustic devices used by fisheries which have been very recently implemented and studied.

Oil and gas exploitation. Exploitation of oil and gas requires a huge material investment. Platforms and pipes are constructed, drills are positioned and holes are bored into the seabed rock. All structures are then to be destroyed with TNT. Drilling and dredging rigs put out loud low-frequency sounds over a long-term scale. Even when the rig may be idle, numerous supply ships and transport helicopters are in activity (and may be of more influence on marine life than the rig itself) so that the noise emitted is continuous.

Playback studies have shown that most bowhead whales (*Balaena mysticetus*) avoid drill ship or dredging noise with broad-band (20-1000 Hz) received levels around 115 dB. In case of typical drilling and dredging vessels, such levels occur at 3-11 km (Richardson *et al.* 1990). Higher noise is endured if the only migration route requires close approach to the sound projector (Richardson and Greene 1993, in Perry 1998). It has recently been demonstrated that spatial distribution of bowhead whales was highly correlated to distance from the drilling rig, indicating that the presence of the rig resulted in a significant temporary loss in available habitat (Schick and Durban 2000). Grey whales reacted in a similar way when 3500 individuals responded to playback of an oil platform noise (Malme *et al.* 1983). Avoidance responses began at broad-band received levels of 110 dB, and proportions of animals showing avoidance increased with sound intensities, reaching over 80 % at received levels higher than 130 dB. According to our knowledge, no studies have investigated odontocetes reaction to such kind of noise.

Sonars and Pingers associated with fisheries. Echo-sounders, functioning as directional sonar, are widely used in fish and depth detection on board of many fishing boats. Ed Harland, in a communication to Nick Tregenza (2001), drew attention on them as a source of noise pollution: 'the source levels of the echo-sounders vary between 200 dB and 240 dB, depending on frequency, model and application. Frequencies vary from 30 kHz for the big fishing boats units that double as fish-finders to 200 kHz for the small boat units. Beam width of the units is typically 30 degrees, but varies considerably depending on frequency and application'. The effect on marine mammals has not yet been documented, but in many countries odontocetes are observed very close to fishing boats when they are in activity.

To prevent marine mammals from net entanglement (for protected species particularly) or to keep them away from aquaculture farms, various methods have been employed, and among them one solution has consisted of putting acoustic devices (pingers) on nets and cages. These devices have been designed to emit sounds at the audible frequencies range of pinnipeds and small odontocetes, in order to alarm them of a potential danger (in this case pingers are called Acoustic Deterrent Devices, ADD) or to harm them (thereby called Acoustic Harassment Devices, AHD). ADD tend to have shrill-sounding frequencies (generally 12-17 kHz, but can range up to 160 kHz), with intensity levels at source between 120 and 140 dB, and to be brief (e.g. 300 ms pulses), while AHD are usually set around 10 kHz and produce very loud intensity pulses of about 190 dB at source (Perry 1998, NRDC 1999, Würsig and Gailey 2001). They have been found to be effective in several controlled experiments (Anderson *et al.* 2001) and to show reasonable success in certain areas considering the species for which they have been designed (harbour porpoises *Phocoena phocoena*, Hector's dolphins *Cephalorhynchus hectori*), and thus they are enjoying widespread use (Würsig and Gailey 2001).

Despite their relative success, pingers are very controversial. First of all, habituation of cetaceans is often related. Effectively, once the deterrent effect has been acknowledged by the animals, they generally return and the loud sounds can even condition cetaceans to perceive the acoustic signal as a "dinner bell" (Mate and Harvey 1987). Secondly, non-target species are affected too : the case is recently reported with killer whales (*Orcinus orca*) that may have been displaced from their regular movements avoiding ensonified bays and channels in long term as a result of AHD emissions aiming at deterring harbour seals *Phoca vitulina* (Morton and Symonds, in Würsig and Gailey 2001). Finally, the strongest critic is that pingers add new man-made sounds to ambient noise, and dramatically change the acoustic world of all marine species, not only that of cetaceans. Particularly, the aversive effect provokes not only acoustical reactions such as reducing or stopping echolocation (Tregenza 2001), but has also been proved to make cetaceans abandon "pingered" areas (within 2 miles of a single AHD in the case of harbour porpoises), degrading many miles of quality habitat (Olesiuk *et al.* 1996).

Others. Industrial sources of noise are diverse underwater, but until now they have not been considered as a subject matter of research in itself. Hence, the following examples rather come from opportunistic data or studies made available in the literature.

The most documented of those sources appeared to be blasting. For instance, Ketten *et al.* (1993) found that two humpback whales having died in fishing gear near blasting had damaged ears, whilst two other individuals, similarly killed in gear from areas where there were no industrial activities, showed no signs of ear damage. With respect to the same species, Lien *et al.* (1995) reported an unusually high percentage of ear damage during post-mortem examinations from individuals found dead in a area of intense industrial noise due to blasting, drilling and dredging, this noise reaching 140-150 dB at source between 20 and 400 Hz. On the other hand, an experiment conducted by Madsen and Mohl (2000) on sperm whale encountered no behavioural reaction to the discharge of eight detonators from any of the six individuals studied, with estimated received levels of some 180 dB. Again, Maggi *et al.* (1998) monitored a series of blasting in conjunction to the construction of a pipeline and found no confirmation of injuries of the cetaceans sighted in a radius of 0.66 nautical mile from the blasting point. The disposition and distribution of charges was acutely managed so that low sound pressure levels were recorded at distances of 70 meters from the blasting point.

Finally, two other sources of industrial noise are related: Bryant *et al.* (1984) showed that grey whales abandoned calving lagoons in response to the intense activity associated to a salt-production plant. Harbour infrastructures constructions generate sounds of high intensities at low and mid-frequencies, as documented by Würsig *et al.* (2000) for percussive hammering piling in order to create a wharf.

The Mediterranean case. Oil and gas exploitation is not very developed at this time in the Mediterranean, but this could change completely in the next years. Effectively, a geologist of Total-Fina-Elf, one of the major companies worldwide, recently highlighted the need to invest in the exploration of new fuel reserves, and the United States Geological Service found last year good indices of oil and gas reserves in the western Mediterranean that could be economically profitable (Pujol Gebelli 2001).

Moreover, Azzali (1999) indicated that oil and gas exploration was to be conduct in some areas of the Adriatic Sea in the immediate future. To prevent its possible effects on marine life from remaining controversial, Azzali *et al.* (2000) presented a study assessing pre-impact baselines on marine mammals and small pelagic fishes of the entire Adriatic Sea, with three focus topics: to identify "hot spots" where these animals have been found to congregate, to estimate the potential risk levels in those areas, and to provide a data base to evaluate the short- and long-term effects of the oil activity on marine mammals. For this purpose, they divided the area in 50 blocks of 30x30 nautical miles each, to be classified as of high, medium and low risk. They found that spatial distribution of cetaceans (using acoustic and visual methods) and small pelagic fishes (using acoustic methods) were cross-correlated, and gave the seasonal (winter/summer) variations of cetaceans and fishes distribution on a ten years scale (from 1988 to 1998). As a conclusion, the total number of high level risk blocks was 27, of which 2 are of concern only for small pelagic fishes, 16 for dolphins (bottlenose, striped and common) all-year round, 5 for dolphins in winter, 1 for dolphins in summer and 3 because of the presence of cetaceans species considered rare in the Adriatic.

Considering now the fisheries activities, entanglements of various species are known since a long time in the Mediterranean, as well as damage to the nets by dolphins (generally by bottlenose dolphins), provoking often conflicting interactions between fishermen and cetaceans. Direct kills have been reported, and Tunisian fishermen developed in 1993 a mechanical wave generator to keep dolphins away from the nets (Ben Naceur Lofti 2000). This device gave satisfactory results before habituation of dolphins. Pingers are not yet established in the area and could become frequent in the next future, but their effect are still to be proved, as in the following example around the Balearic Islands.

A recent project has been started by Gazo *et al.* (2001) to assess the effectiveness and practicality of using pingers to keep bottlenose dolphins away from fishing nets and, by the way, to reduce entanglement and damage to the gears. They monitored three experimental sets of nets: the first was equipped with pingers transmitting 8 different frequencies ranging from 20 to 160 kHz – without precisions on the intensity emitted – with an inter-pingers distance of 150 m, the second was equipped with non-operative pingers and the last had no pingers at all. To establish the effectiveness of the devices, fish catches, dolphins sightings and damage to the nets were evaluated. The preliminary results were inconclusive with regards to the effectiveness of the pingers.

No literature has been found on other industrial activities and their effects on cetaceans in the Mediterranean.

<u>Scientific noise</u>

Noise pollution is involved during research surveys in three scientific fields: geology, climate change oceanography and cetology. While the latter produce a great variety of sounds at (normally) moderate intensities, the formers put out very loud low-frequency sounds. The time scales at which operate these noise sources are variable, from the short-term to the long-term (several years).

Controlled Exposure Experiments (CEE) and playbacks on cetaceans. In order to improve the knowledge on cause-effect relationships between sound production (both natural and man-made) and cetaceans behaviour, scientists can use active techniques which consist of emitting specific sounds toward the animals in a controlled context. In the case of anthropogenic noise pollution, these surveys hope to fill in the gaps concerning mostly the lack of data on identification of behavioural responses to specific kinds of sound, the assessment of species auditory thresholds at different impact levels and the estimates of secure distances from noise source ranges. But even if these studies have an objective of animals conservation, they clearly add new anthropogenic noise and some of them have the potential to strongly affect target and non-target individuals.

In very recent series of workshops on CEE where numerous researchers specialised in acoustics were present, some guidelines on "why" and "how" CEE should be conducted have been proposed. Part of them are the following: the main advantage of CEE is its statistical power and the possibilities it allows researchers to control many factors such as age, sex, history of individual, location, time season, etc…and overall to quickly investigate a variety of exposure scenarios; CEE should stop quickly after behavioural response, take into account the sources of variation in response, identify acute behavioural and physiological parameters to be measured, prioritise species and individuals as focal animals for exposure experiments, control for the effects of the observation and playback vessels and measure masking. Anyway, CEE only allow short-term and well-known behaviours to be investigated (Gordon and Thompson 2001). Some critics and questions can be addressed, principally with reference to the current lack of knowledge on many aspects of the biology and ecology of cetacean species: the main assumption is that behavioural responses will occur before physiological damage, which may be a false statement in the case of unknown threshold shifts; moreover, it has been well recognised that no measured response does not necessary imply no impact; non-target species may have lower safe thresholds; can we conduct experiments anywhere (in protected areas for example)? Will all researchers follow these basic guidelines ? An example of this last point is given by the work aiming to determine masked temporary threshold shifts, for which bottlenose dolphins and belugas were exposed to 1 second tones as intense as 190-200 dB (Schlundt *et al.* 2000), which is equivalent to the sounds produced by AHD. Is such study worth, even if it concluded that small levels of temporary threshold shifts may be fully recovered ?

Seismic surveys and Acoustic Thermography. Seismic surveys are used to detect geologic layers composition under seabed, and are therefore largely employed by geologist scientists and petroleum companies for oil and gas exploration. The process produces intense low frequency sounds, often using arrays of airguns and sometimes explosives. The intensity required for these sounds is to enable deep penetration of the earth's surface and show reflection off rock layer (WDCS/CCSA). Duration of studies is usually of several months. Pulses are emitted every few seconds, with an intensity at source depending on the size of the air-gun array (Perry 1998), but generally comprised between 242 and 252 dB for a multiple airgun array and about 226 dB for a single airgun (Würsig and Evans, in press). McCauley (1994) indicates that, dependant on the sound propagation characteristics of the area, intensity only decreases to 180 dB at 1 km and to tensity only decreases to 180 dB at 1 km and to approximately 150 dB within 10 km of source. Goold and Fish (1998) added that seismic power (from a 2120 cubic inches airgun, which is less than typically used by prospecting companies) dominated the entire recorded bandwidth of 200 Hz - 22 kHz at ranges of up to 2 km of the sound source, even if the background level was yet far in excess of ambient noise because of the ship propeller, engine, …

Effects of seismic surveys on cetaceans are well documented and appear to show the second most dramatic responses of all types of noise pollution for any species considered, after the military sonar. Sperm whales were found to be displaced to a distance of 60 km of the sound source by Mate *et al.* (1994) and they stopped vocalising more than 300 km away from relatively weak seismic pulses (Bowles *et al.* 1994). 10 % of grey whales showed avoidance at 164 dB received level, 50 % at 170 dB and 90 % at 180 dB (Malme *et al.* 1983). Ljungblad *et al.* (1988) observed initial behavioural changes of bowhead whales more than 8 km away from the seismic source, at received levels of 142-157 dB. Common dolphins avoided an area of 1-2 km around the sound source – cited before in the Goold and Fish study – (Goold 1996) and these authors estimate the sound to be audible to dolphins at a distance of at least 8 km. Evans *et al.* (1993) found a significant decrease in the population of small cetaceans after seismic exploration, although the possibility of seasonal movements can not be ruled out.

Acoustic thermography of the oceans is widespread. It investigates temperature changes, aiming at giving proves of the greenhouse effect through the increase of temperature. Studies are hence planned on a long-term basis, over several years or decades and over a long range distance scale, the ocean basins. The process involved is very similar to that of seismic studies, although its principle is different. Low-frequency regular pulses are directed toward the open sea instead of the sea floor, using the deep sound channel to cross entire basins. Speed of sound, dependant on temperature, is measured and then monitored over years to assess long-term temperature fluctuations (Munk and Wunsch 1979). In addition, source intensities are considerably lower than those used in seismic pulses, around 200 dB, and most of the sound energy is kept trapped in the channel. Orders of magnitude in both time and space scales are considered the main threat for marine life. Major effects were expected to concern deep-divers such as teutophagous species, since these animals often enter the deep sound channel to feed upon bathyal preys. Effectively, sperm and long-finned pilot whales were found to be completely silent during such operations in areas where they were heard before and 48 hours after the thermographic study (Bowles *et al.* 1994). Aerial surveys showed that humpback and sperm whales were distributed significantly further away from the source, on the contrary to pacific white-sided dolphins (*Lagenorynchus obliquidens*) and grey whales (Calambokidis *et al.* 1998). Hearing thresholds of captive false killer whale (*Pseudorca crassidens*) and Risso's dolphin to such pulses of 1 second duration were measured by Au *et al.* (1997) who found relatively high received levels of about 140 dB.

The Mediterranean case. Very few data exist on playback experiments and CEE in the Mediterranean. On another side, an important program is to be implemented in the Ligurian Sea under the leadership of J. Gordon and P. Tyack, in collaboration with the ICRAM and the Tethys Research Institute. The primary research objective is to determine what characteristics of exposure to specific sounds evoke behavioural responses of marine mammals. Target individuals will be exposed to received levels between 120-160 dB, and will be subject to section-cup tagging. In addition to the eight common species of the Mediterranean, rough-toothed dolphin (*Steno bredanensis*) and *Kogia* spp. have been defined as target species. This project will surely fillin some gaps in our current knowledge, but it is disturbing that the sole permit, to our knowledge, required by the principal investigator to the U.S. National Marine Fisheries Service allow some animals to be taken by harassment (NMFS 2000a).

Seismic activities have already been performed in the Mediterranean by oceanographers and geologists, but no data exist on their effect on cetaceans. On the other hand, as it has been mentioned in the precedent chapter, the western Mediterranean is likely to become the place of seismic activities for oil and gas exploration within the next decade (Pujol Gebelli 2001). Estimates of oil and gas reserves in the seabed rock of the area (between the Balearic to Corsica and Sardinia Islands, and between French and Italian to Algerian coasts) reveal that the probable existence of 1 to 15 oil fields and of 60 to 140 gas deposits. The expected productivity could reach 50 to 2500 millions of oil barrels and 600,000 to 3,600,000 millions of cubic feet of gas. At a median depth of 5 km for oil and 6 km for gas, they would require extremely powerful sounds to be investigated and found.

Military noise

When dealing with this subject, the main obvious basic problematic matters are first to be warned about what will happen and then to obtain data. If the first step is quite accessible on land, as militaries organisations have to prevent civil population from accidents, it remains very difficult at sea and almost all operations are hidden. It is no surprise then that military exercises have occurred for many years, but their effects on marine life are just being tested. As far as cetaceans are concerned, it began with numerous strandings reported just after navies have tested powerful low frequency active sonar (LFAS) employed to detect foreign submarines. This has captured scientific and public attention, and the topic is now well discussed, allowing knowledge to filling important gaps. The following two parts are then distinguished in this chapter:

General exercises. Parsons *et al.* (2000) provided information on several military activities, including sonar, torpedo testing, missile firing ranges and training exercises. Frequency bandwidth and average source intensities are some available data on sonar and differ with the type: search and surveillance sonar ranges 2-57 kHz and has a source intensity of 230 dB, mine and obstacle avoidance sonar ranges 25-200 kHz for 220 dB and weapon mounted sonar ranges 15-200 kHz for 200 dB (LFAS will be detailed below). In addition to sonar, communication system between two submarines has a source level of 180-200 dB within 5-11 kHz. Torpedoes have been documented to be a cause of mortality of a large number of whales during the Falklands conflict (Gardner 1996 in Parsons *et al.* 2000). Military artillery usually produce noise levels in excess of 180 dB, but some missile firing ranges put out broadband frequencies at a source level in excess of 270 dB. Such sound sources could cause auditory damage to cetaceans at distances of several km and disturbance at distances of tens of km. Training exercises often involve the participation of numerous warships, jets, submarines, landing draft, power boats and sonobouys, producing a large amount of noise with various types of sounds. These sounds have the potential to affect all species of cetaceans, although deep-divers such as beaked whales presumably may be the most sensitive to military effects (McLeod 1999). Only one response of cetaceans to general military activities was documented, by Parsons *et al.* (2000) who reported a significant decrease in minke whale (*Balaenoptera acutorostrata*) and harbour porpoises occurrence during training exercises.

Low Frequency Active Sonar. This system has been imagined and set up during the cold war, with the aim to detect at very long ranges of distance (hundreds of nautical miles) foreign silent submarines. To reach such long ranges, low frequency (100-1000 Hz) very loud (up to 235 dB) pure tones are emitted from a string of sound elements suspended 50 m or more below a specially equipped ship (NRDC 1999, NOAA 2000). Sounds of 1 minute or more are usually produced repeatedly (every 10-15 min), and using principles of refraction on different layers (surface, bottom or deep sound channel), can still reach intensities of 140 dB 300 nautical miles away from the source.

Some effects of LFAS on cetaceans remain controversial due to insufficient data, but they have been considered, as a whole, to be of major concern and to range from strong behavioural disruption to death. What raised up attention on this noise source are at least three distinct atypical mass strandings of several species, mostly of beaked whales (especially Cuvier's), occurring the same day or a few days after navies had tested LFAS (Vonk and Martin-Mantel 1989, Frantzis and Cebrian 1998, MARMAM 2000). These mass strandings were called atypical because animals were not found on shore grouped in one location, but there were rather numerous lone individuals in several points. In one case, animals were alive when stranded but necropsies showed no abnormalities, so that the relationship with the LFAS test could not be proved (see *the Mediterranean case* for details). The demonstration of the relationship has been achieved four years later (on March 2000) when all of 17 individuals but one, belonging to at least 4 species

(Cuvier's and dense beaked whales *Mesoplodon densirostris*, Atlantic spotted dolphin *Stenella attenuata*, minke whale), stranded the same day. Balcomb (2001) showed, by combining both theoretical calculations and necropsies of the animals, that the LFAS, through the resonance phenomenon in airspace of the beaked whales, was responsible of the cetaceans deaths. He explained that when whales dive deep to forage, the pressure makes the air volume pass from their lungs to other body parts, especially in cavities close to the inner ear. Effectively, the air volume contained in the body decreases when pressure increases. The resonance frequency changing with the air volume, it will change with the pressure, and, in the case of the airspace of a Cuvier's beaked whale at a depth of 500 m, it reaches 290 Hz, in the middle of the range of a LFAS emission. When the sonar is active, sound passes through these airspaces, compressing and decompressing the air volume, causing thereby haemorrhages. Balcomb found such lesions in the four whales necropsied, hence corroborating theoretical calculations. He also found the aversive and/or physiological damage impact distances to range from 20 to 100 km from the sound source. With the help of photoidentification work, he added that this species was reasonably common in the area before the tests, but only saw two individuals in the next year, these individuals being new for the region. According to Balcomb, it is likely that no ancient resident survived the test.

Apart from physical damage, some strong behavioural reactions were reported, mainly resulting of playback or CEE experiments, but are still not regarded as sufficient proves by the navies. Male humpback whales were found to modify their sexual displays when exposed to a maximum received level of 150 dB (Miller *et al.* 2000); grey whales deviated from their migration paths, the deviation being greater as sound intensity increases (Tyack and Clark 1998); blue, fin and sperm reacted to LFAS by decreasing and even ceasing calls, as far as 20 km for the latter species (Watkins *et al.* 1993, Clark *et al.* 1998).

The Mediterranean case. No information is available with respect to general exercises, apart from one mention of three missile firing ranges in the Straits of Gibraltar (De Stephanis *et al.* 2000), indicating a possible threat for in this area. In contrast, effect of sonar on cetaceans is now quite well identified, as in the general case. The following study give an example of a behavioural response: while surveying acoustics of cetaceans in the Ligurian Sea, Rendell and Gordon (1999) heard a military sonar, regularly for one month and a half and on some occasions loud enough to stop crew from sleeping, but they never saw it, suggesting a minimal distance of about 15 nautical miles. The sounds were emitted in a regular pattern and repeated every 41 seconds, with main energy around 4 kHz. During this period, the authors encountered and stayed with a pod of long-finned pilot whales, recording their vocalisations. They found that the overall rate of calling was significantly higher during and just after sonar pulses, clearly indicating a short-term response of pilot whales to the sonar. Certain whistle types showed temporal correlation with the sonar, whilst others did not. According to the authors, possible interpretations range from curiosity to fear, and although it was impossible to make a choice between the different possibilities because of the lack of knowledge on pilot whales vocal behaviour, it was clear that the animals appeared not to have habituate to the signals after at least several hours of exposure (possibly more than a month).

Physiological damage of LFAS have been thoroughly discussed as a major source of concern, both by scientists and by military organisms. The 12th May 1996, Frantzis and Cebrian (1998) recorded a very rare event: an atypical mass stranding of 12 Cuvier's beaked whales in the Kyparissiakos Gulf (Greece). Since 1963, strandings of more than 4 individuals of this species have only been reported seven times worldwide, and in the area, the average number of whales stranded was 0.7 per half-year. In one week, the whales stranded alive and died after some time, spreading along 38 km of coast, being separated at a mean distance of 3.5 km. In addition, a dead animal stranded on a beach 57 km away from the closest other strandings. No apparent abnormalities were found from the eight necropsies carried out and the stomach contents indicated recent feeding. The general robust condition of the animals and the absence of scars added to their sudden end excluded the possibilities of pathogenic and chemical factors, as well as a direct cause involving fisheries interaction. No tectonic nor geophysical events were reported, so that the only possible cause remaining was the test in the area of LFAS performed by the NATO from the 11th to the 15th May 1996. The test generated sounds of over 230 dB in frequencies ranging from 250 to 3000 Hz. Behavioural responses already known to high intensities acoustic transmissions (escape reaction, startle effect, ..) are likely to be the mechanism that drove the whales ashore, especially if they were found between the coast and the source when emission began. Taking the past 16.5 previous years into account, the authors calculated that the probability of a mass stranding occurring for other reasons was less than 0.07 %. They therefore concluded that if pure coincidence could not be ruled out, it seemed very improbable that the two events were independent.

The SACLANTCEN-NATO Special Report (1998) of this event indicated that an acoustic link can neither be clearly established nor eliminated as a direct cause. The panel considered that, because of the lack of a comprehensive necropsy and complete tissue analyses, the possibility of a pathological cause can not be eliminated too. The panel hence strongly recommended that appropriate environment assessment procedures be implemented as soon as possible and also noted that the lack of adequate anatomical data on the stranded animals, particularly auditory and other tissue analyses, was a serious obstacle. It finally recommended that proper specimen collection be supported to ensure complete necropsy in the future. In an unclassified document (SACLANTCEN), it is revealed that between 1981 and 1996, 11 trials have been conducted by NATO in the Mediterranean.

As a final word, Balcomb (2001), applying calculations he made for the mass stranding of March 2000 cited in the general case, answered that the panel missed the crucial point of matching resonance in critical airspaces. Then he added that, taking into account the sonar impact at received level well below 180 dB related in the NATO report (this level corresponding to what the panel assumed to be the lower threshold temporary shift for Cuvier' beaked whale) and the calculations made by NATO concerning the propagation loss in intensity for the 1996 test, the received level of the first whale to strand was approximately 150 dB. His conclusion is that aversion and/or physiological damage evidently and repeatedly occurs in beaked whales at received levels of somewhat between 150 and 180 dB of either low frequency or mid-frequency sonar signals in the normal whales habitat. These levels are well below those assessed by Nascetti *et al.* in 1996, without taking into account the resonance phenomenon: they estimated that the danger received level for fin and sperm whale was 210 dB, the safe level being around 170 dB for both species and the non-interference level at 150 dB for sperm whale.

Mitigation

To limit spreading and intensity of noise in the world ocean, measures can be implemented. These measures are of different kinds and involve various responsibilities, but almost all are feasible without putting in danger the professional activity concerned. Richardson and Würsig (1995) spelled out some of them:

- To ensure that, from a purely technical point of view, the equipment be as silent as possible. In the case of a vessel, propeller shrouding that has been used to silence ships of war is an example, as is also acoustic isolation of the generators from the hull and of engine trains from drive shafts and propellers. A simple regular maintenance of blades can greatly reduce cavitation. Lowering of the vessel speed may play an important role in reducing the background noise.
- To organise seasonal and daily timing of the industrial activities the most possible in accordance with migrations and movements of the animals. Staggering out the sound production so that it does not occur throughout the day can also be helpful if cetaceans in the area have been proved not to be attracted by changes in the duty cycle.
- Changes of location can sometimes be efficient measures with only minimum increase in expense of fuel and time.
- Adjustment of operational procedures can help for mitigation, as for example by monitoring the area for cetaceans: if animals are present, the activity has to be delayed. This has been widely used, but if not conducted both acoustically and visually simultaneously by trained observers could reveal meaningless.

Würsig *et al.* (2000) investigated a new technique consisting of creating a curtain of air bubbles into a perforated rubber hose surrounding a pile driver employed to build a wharf. Sounds that were bubble-screened were lowered by about

3-5 dB at distances of 250 to 1000 m, within 100-25600 Hz. Although the technique remain to be comprehensively studied, it shows promise.

Concerning whale-watching and given the weak propagation of high frequency sounds, regulation rules generally adopted are sufficient to preserve cetaceans from noise disturbance: the operators have to maintain a respectable distance from the animals, they should limit erratic movements and apply caution to not change speed and bearing suddenly.

Quieter alternatives for traditional drilling include semi submersible ships with machinery lying well above the surface, special floating rigs known as caissons, artificial islands, or finally platforms mounted directly on the ocean floor (Richardson *et al.* 1995).

In the case of LFAS, it appears that any mitigation measure can be regarded as really efficient. NATO (SACLANTCEN) and NMFS (2000b) mitigation proposition have been strongly rejected by both acousticians and biologist scientists (Balcomb 2001, Blue 2001, Rendell 2001). Considering that the need of a so much powerful sonar is not obvious and is at least not yet a priority, another system, less intrusive, could be developed instead: an example is a passive sonar the Advanced Deployed Systems, program which was ready for testing in 1998 (NRDC 2000).

Conclusions

Noise pollution and its effects vary according to the sound source which depends on the socio-professional activity performed. This report has briefly reviewed what effect is or could be linked to anthropogenic activities. Table IV.E.1 summarises these effects qualitatively, indicating for each activity the type of the effect, the category of species affected, the range of distance from the noise source, the range of time involved and the Mediterranean status concerning this effect.

An important point is the dramatic lack of knowledge on this topic. Perry (1998) urges that there is an immediate need of research on the establishment of audiograms in relation to low-frequency sounds, the assessment of functional significance of communication and distances over which it operates, the establishment of the impact of short and long-term behavioural disruption, including abandonment of important feeding and breeding habitats, energetic implications and the effects of stress, on post-mortem examinations of stranded animals, particularly of inner ear structure and airspace cavities.

Finally, it is worth remembering the fact that cetaceans themselves also mitigate against noise disturbance, as efficiently as they are able to. Changes of behaviour such as adjusting echolocation, deviating migration routes, moving away from their initial habitat show the need they have to face and to adapt adequately to situations humans are responsible of. The issue of sound has only recently been investigated concerning cetaceans. We believe that this is one of the major cause of concern for these animals, if not the major one, with regards to the importance it has for them in their daily life as well as in their adaptive fitness at all levels, from the individual to the species. This is a much less "evident" problem than many others that cetaceans and marine life in general have to face, but we think that waves displacements have always been, and will always be, the major regulator of the ocean.

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Table 13.1 - Summary of the effects of anthropogenic sound sources reported on cetaceans according to the current knowledge, with an evaluation of the Mediterranean case.

Anthropogenic activity		**Type of effect reported**	**Group of species affected**	**Propagation of sounds**	**Duration of emissions**	**Mediterranean status**
Traffic	Large vessels	masking, stress, auditory damage: temporary and permanent threshold shifts, displacement	mysticetes and large odontocetes	medium and long ranges	short-term in itself, long-term as a whole	important concern
	Small boats		all odontocetes	short ranges	short-term except whale-watching and busy areas	
Industry	Oil & gas exploitation	displacement	mysticetes	long ranges	long-term	small current concern, possible important concern in the future
	Sonar & pingers	displacement, temporary and permanent threshold shifts, chronic (habituation)	mid-sized and small odontocetes	short ranges	short-term to long-term	
	Others	gross damage to ears	mysticetes	short and medium ranges	short-term to long-term	
Scientific	CEE	behavioural disruption, temporary threshold shifts	all species	short and medium ranges	short-term	small current concern, possible important concern in the future
	Seismic surveys	displacement, masking, possible physical damage	all species	long ranges	long-term	
Military	General exercises	displacement, possible auditory damage	all species	long ranges	short-term	important concern
	LFAS	physical damage: non-auditory and auditory, behavioural disruption	all species	long ranges	short-term	

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 14

Disturbance to Cetaceans in the Black Sea

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Introduction

The disturbance is mentioned as a limiting factor for Black Sea cetacean populations in few publications (Birkun *et al.* 1992, Birkun and Krivokhizhin 1996 c 2001, Öztürk 1999) based on a general, quite approximate understanding of the problem. Until now no special research project has investigated human activities (other than direct killing, fishery, pollution and maintenance in captivity) likely to disturb marine mammals in this maritime area. There are no systematic data on effects of man-made noise and vessel collisions on cetaceans. At the same time it is clear that potential sources of disturbance exist.

Maritime traffic

It is evident that the shipping lanes crossing the Black and Azov Seas in various directions (Fig. 14.1) coincide with cetacean habitats and migration pathways. Traffic is more concentrated in coastal waters over the continental shelf; thus, shipping impact on both inshore species – harbour porpoise (*P. phocoena*) and common bottlenose dolphin (*T. truncatus*) – seems to be having a more pronounced influence than on offshore short-beaked common dolphin (*D. delphis*). Traffic density has a strong tendency to increase in the areas close to harbours; therefore, the levels of operational activity of the existent ports may be adopted as a major criterion for the estimation of their disturbing capability.

Among the numerous ports located in the Black Sea and adjacent waters, four harbour agglomerations and shipping lane crossings play obviously the most important role in cetaceans disturbance and could be denoted as the hot-spots affecting cetacean distribution and migrations (Fig. 14.1):

- The Bosphorus shipping junction with the adjacent areas in the Black and Marmara Seas (Turkey);
- The Kerch Strait shipping junction with the adjacent areas in the Black and Azov Seas (Russia and Ukraine);
- The North-western harbour agglomeration including ports in Odessa Bay and estuaries of Dnieper, Dniester and South Boug rivers (Ukraine);
- The North-eastern harbour agglomeration including ports in Taganrog Gulf, lower Don and its delta (Russia and Ukraine).

The Strait of Bosphorus (about 30 kilometres long, 750-3700 metres wide and 37-124 metres deep in the midstream), along with the Marmara Sea and Dardanelles, is a single marine path interconnecting the Mediterranean and Black Seas. The strait and adjacent areas are abundant in harbours, piers, ferry stations and anchorages associated to the Istanbul megalopolis. Intensive lengthwise and transverse traffic and swift currents make navigation difficult here and cause continual threat of collisions. Some 40,000 ships passing through the Bosphorus annually, and innumerable local smaller craft, can put obstacles in the way of migratory animals (Zaitsev 1998). Harbour porpoises, bottlenose and common dolphins are known to visit this narrow strait (Öztürk and Öztürk 1997) moving between neighbouring seas. It is supposed that a number of cetaceans passing through the Bosphorus has a trend to decrease from year to year due to heavy maritime traffic forming a barrier to the migration (Öztürk 1999).

Another marine biological corridor and at the same time an important shipping junction is the Strait of Kerch (41 kilometres long, 4-15 kilometres wide and up to 15 metres deep in the fairway), which links the Sea of Azov and the Black Sea. Two port complexes are situated along the Ukrainian and Russian shores of the strait. They are connected by ferry line and operate the whole year. About 10,000 vessels sailing through the strait each year are considered as a source of disturbance for migrating fishes (Zaitsev 1998). All three species of Black Sea cetaceans were described here in the past as well; also, a yearly movement is known of harbour porpoise herds from the Black Sea to the Sea of Azov in spring and backwards before winter (Zalkin 1940, Kleinenberg 1956). The presence of *P. phocoena* and *T. truncatus* in the strait has been confirmed in 1997 and 2001, whereas no *D. delphis* individuals were sighted those years (Birkun and Krivokhizhin 1998, Birkun *et al.* 2002).

In accordance with its transportation capacity, the north-western harbour agglomeration is the second shipping centre in the Black Sea subregion after Bosphorus junction. It includes a series of ports in the Odessa province of Ukraine and also marine and river transport facilities in the estuaries of Dnieper, Dniester and South Boug which are navigable rivers. In the late 1990s the Odessa port complex handled almost 30 million tons of cargo annually, and about 10 million tons of oil were exported each year through its oil terminal (Bilyavsky *et al.* 1998).

Cetaceans are well known in Odessa Bay and adjacent waters (Bushuev *et al.* 2001), and sometimes occur inside the harbours with a risk for animals safety (B.G. Alexandrov, pers. comm.). Harbour porpoises are not rare in the Dnieper and South Boug estuaries, as well as in the Dnieper itself and its lower tributaries (Selyunina 2001). In 2000 a group of four common bottlenose dolphins was observed in the Dnieper above Kherson (S.M. Chorny, pers. comm.).

The fourth hot spot – the north-eastern harbour agglomeration – consists of Ukrainian and Russian ports located in Taganrog Gulf of the Azov Sea and in the lower Don. Two main directions of ship traffic converge here: one from the Black Sea through the Kerch Strait and a second from the Russian large rivers and canal system linking the Sea of Azov with the centre of European Russia, the Caspian and Baltic Seas. Local ports operate mainly during the warm season because of unfavourable ice conditions in winter. The harbour porpoise is the only cetacean species known in these almost fresh waters; occasionally it was observed in the Don river (Geptner *et al.* 1976).

In addition to the clusters of harbours mentioned above, other shipping facilities can be a source of heightened disturbance of the cetaceans. These include especially the multi-activity ports located in Varna (Bulgaria), Constantza (Romania), Danube Delta (Romania and Ukraine), Sevastopol (Ukraine, with the base of Russian Black Sea Navy), Novorossiysk (Russia), Batumi (Georgia), Trabzon, Samsun and Zonguldak (Turkey) (Fig. 14.1).

The shipping in the Black Sea has an annual tendency to increase from spring to autumn with a summer maximum due to the sharp enhancement of small scale cabotage traffic and marine tourism. Most domestic and international passenger lines operate in the warm season only. Peaks of fishing fleet navigation occur in spring-early summer (gill net fishery) and autumn (pelagic trawling). According to economic indices (Bilyavsky *et al.* 1998, Kerestecioglu *et al.* 1998), the highest level of Black Sea marine traffic intensity has been achieved in 1985-1992, subsequently decreasing till the mid 1990s. However, further development of shipping facilities and the increase in vessel exchange between seas is expected (Strategic Action Plan 1996).

Channel dredging and marine dumping of removed sediments

An obvious source of disturbance for Black Sea harbour porpoises and bottlenose dolphins is the dumping of bottom sediments removed due to the dredging of navigation canals and the reconstruction of ports. Dredging and dumping works cause noise pollution and lead to the decline in water transparency, destruction and silting of benthic biocoenoses, and, thereby, to the reduction of cetacean foraging capabilities. These disturbing activities are more intense in the shallow waters of the north-western shelf of the Black Sea, and also in the Azov Sea, estuaries of big rivers (Danube, Dnieper, Dniester, South Boug, Don, Kuban) and Kerch Strait. According to Bilyavsky *et al.* (1998), there are more than 30 dumping sites in the Black Sea coastal zone, and ten of them are in the north-western area, where five million cubic metres of soil have been dumped annually by the USSR (since 1963) and Ukraine (since 1991). In the Kerch Strait 21 million cubic metres of soil were dumped from 1991 to 1997. In Romania from the mid 1980s to mid 1990s up to 6-7 million cubic metres of sediments have been removed each year in order to enlarge the port of Constantza, and about one million cubic metres were dredged annually from the entry of the Sulina channel connected with the Danube (Petranu 1997). The rate of sediment accumulation at Black Sea dumping sites exceeds the natural sedimentation rate by more than 1000 times (Bilyavsky *et al.* 1998).

Sand extraction

Sand extraction from the sea bottom for the building industry is widespread in the north-western Black Sea shelf, the Sea of Azov and in some other sites (*e.g.*, entrance to Donuzlav Lake in the Crimea). As a disturbing factor this activity is similar to the dredging mentioned above, but it does not result in marine dumping. Millions tons of the sand are extracted in Dzharylgachsky, Karkinitsky and Tendrovsky bays and from Odessa, Dniester and Shagany sandy banks located in Ukrainian waters (Zaitsev 1998).

Offshore gas and oil exploitation

This kind of human activity can disturb cetaceans in different stages of its technological chain

– from geological and geophysical reconnaissance of deposits by means of trial boring and undersea bursts, to industrial transportation of extracted gas and oil by bottom pipelines. Drilling and seismic exploration is widely spread on the Black Sea shelf. Bulgaria, Romania and Ukraine have started commercial gas and oil extraction from the sea bottom approximately 40 years ago. Major centres of this industry, which can be considered as hot-spots of manifold risk for the marine environment, are situated in the shallow north-western part of the Black Sea and in the north-western corner of the Sea of Azov. In 1980-1990s Ukraine exploited seven gas and gas condense deposits in the Black Sea and three gas deposits in the Azov Sea. In addition, it was officially announced that 150 more sites on the Ukrainian shelf, with a total area of 70,500 square kilometres, are currently on offer for further exploitation (Bilyavsky *et al.* 1998).

In August 1982 the explosion of an offshore drilling platform in the Azov Sea caused the death of over 2,000 harbour porpoises (Yukhov 1993, Birkun and Krivokhizhin 1996 c). That accident was not investigated by marine mammal biologists; the number of perished animals, which were found stranded on the coast, is derived from the internal report of the Crimean Black Sea Fish Protection Service.

Military activities

Since the Second World War, which affected the subregion from 1941 to 1944, no armed conflict occurred in the Black Sea; however, the long-term after-effects of past battles (in particular, the wide dispersal along the shelf of sunken armaments) represent a latent threat to marine wildlife even in the present day. Large amounts of destroyed and lost weapons are disposed mainly along the northern part of the Black and Azov Seas. The dumping sites for explosives (five areas off south-western and eastern Crimea, Ukraine) are indicated in navigation charts in depths ranging from 80 to 1300 metres. Several former mined areas in which mines could still be hazardous are located in shallow waters of Taganrog Gulf (Russia).

In post-war time a peak of military escalation occurred between the mid 1960s and mid 1980s, involving a reinforcement of the USSR Navy; in that occasion special marine areas (the firing practice sites, target ranges, proving and training grounds) were set up in the Black and Azov Seas. Some of these "entry prohibited areas" continue to be exploitable for war games, other manoeuvres and exercises. High frequency irradiation and noise pollution from naval ships, submarines and navy-co-operating aviation are also included in the list of major environmental problems related to military activities in the Black Sea (Bilyavsky *et al.* 1998). In December 1977 an underwater explosion (124 tons in TNT-equivalent) was set off in order to destroy an anti-submarine cruiser wrecked in 1974 not far from Sevastopol, at a depth of 130 metres (Leibovich 1996).

Since the early 1960s, the USSR Navy showed particular interest in Black Sea cetaceans. A military oceanarium was established in June 1965 and began its activities in Kazachya Bay of Sevastopol in April 1966 (Zhbanov 1996). Now this state institution operates as a research centre depending on the Ministry of Defence and National Academy of Science of the Ukraine (Lukina *et al.* 2001). During the 1980s the Romanian Navy captured cetaceans on repeated occasions for the civil dolphinarium in Constantza (Vasiliu and Dima 1990). Direct taking of dolphins and porpoises from the wild and their maintenance in captivity for various needs are described in another chapter (see Section 6).

Scientific research and dolphin watching activities

Eco-tourism is still in its infancy in the subregion, and there is no commercial whale-watching in the Black and Azov Seas. In 1995-1998 a series of cetacean sightings surveys was carried out in coastal Black Sea waters off the Crimean peninsula and in the Kerch Strait by means of sailing and motor yachts which covered over 10,370 kilometres (Birkun and Krivokhizhin 2000). The boats sometimes exerted an attractive influence on bottlenose and common dolphins (animals joined the moving yachts and escorted them), but never on harbour porpoises which preferred to keep themselves aloof or disappear. It was noticed that a sporting boat is not so interesting for bottlenose dolphins as a fishing one, especially when it pulls a trawl.

The disturbance may also be caused by small flying vehicles such as motor hydro-deltaplanes which became popular in many touristic places. According to the first experience acquired in 1997 (Birkun, unpublished data), bottlenose dolphins do not react on the objects flying above them at a height over 50 metres with a speed of 90 kilometres per hour. In the Azov Sea a group of eight harbour porpoises stopped swimming when the distance between motor deltaplane and the animals reduced to approx 0.5 km. All individuals took an almost vertical position underwater with their heads just below sea surface. The animals did not show other signs of anxiety during one circle around them at a height of 200 metres, but they were scared by the shadow of the wing and immediately disappeared when the deltaplane came down to 50 metres.

Rescue and release

Cetaceans rescue and release events, in spite of their obvious benevolence, usually are stressful and may cause a damage to the animals. During the 1994 morbillivirus epizootic five common dolphins, stranded alive in Crimea, were transported by voluntary rescuers to the open sea and released; their fate is unknown (Birkun *et al.* 1999). Three other individuals taken to nearby rehabilitation centres died in captivity within three to 72 hours of arrival. It is very possible that added stress and traumatic lesions caused by capture, transportation and veterinary manipulations hastened the lethal outcome of those mortally diseased cetaceans.

Three supposedly successful rescue operations were carried out in Ukraine: one in 1994 (involving a by-caught harbour porpoise, Laspi Bay, Crimea), one in 1997 (a sick bottlenose dolphin, Laspi Bay, Crimea), and another in 2000 (a traumatized common dolphin, Odessa). After veterinary examination and first aid, the animals were released without further monitoring in the wild. It is thus unclear whether the released cetaceans recovered and re-adapted to their natural environment, and if and how this affected their free ranging relatives.

Both questions are important also when considering intentional and spontaneous release of captive cetaceans. For instance, in 1996 two Black Sea bottlenose dolphins were purposely released in Taman Bay (Kerch Strait, Russia) (Veit *et al.* 1997). One of them (a male) had spent six years in the "Dolphin Reef Eilat" in the Red Sea (Israel), while the other (a female) has been caught three months before release. A fair amount of bottlenose dolphins escaped from the military oceanarium (Zhbanov 1996) and other Ukrainian and Russian facilities. Frequent escapes of captive exotic marine mammals, including pinnipeds and belugas (*Delphinapterus leucas*) (Birkun and Krivokhizhin 1996 a 2001), may cause other kinds of disturbance or biological pollution (see "Introduction of alien species", Section 8).

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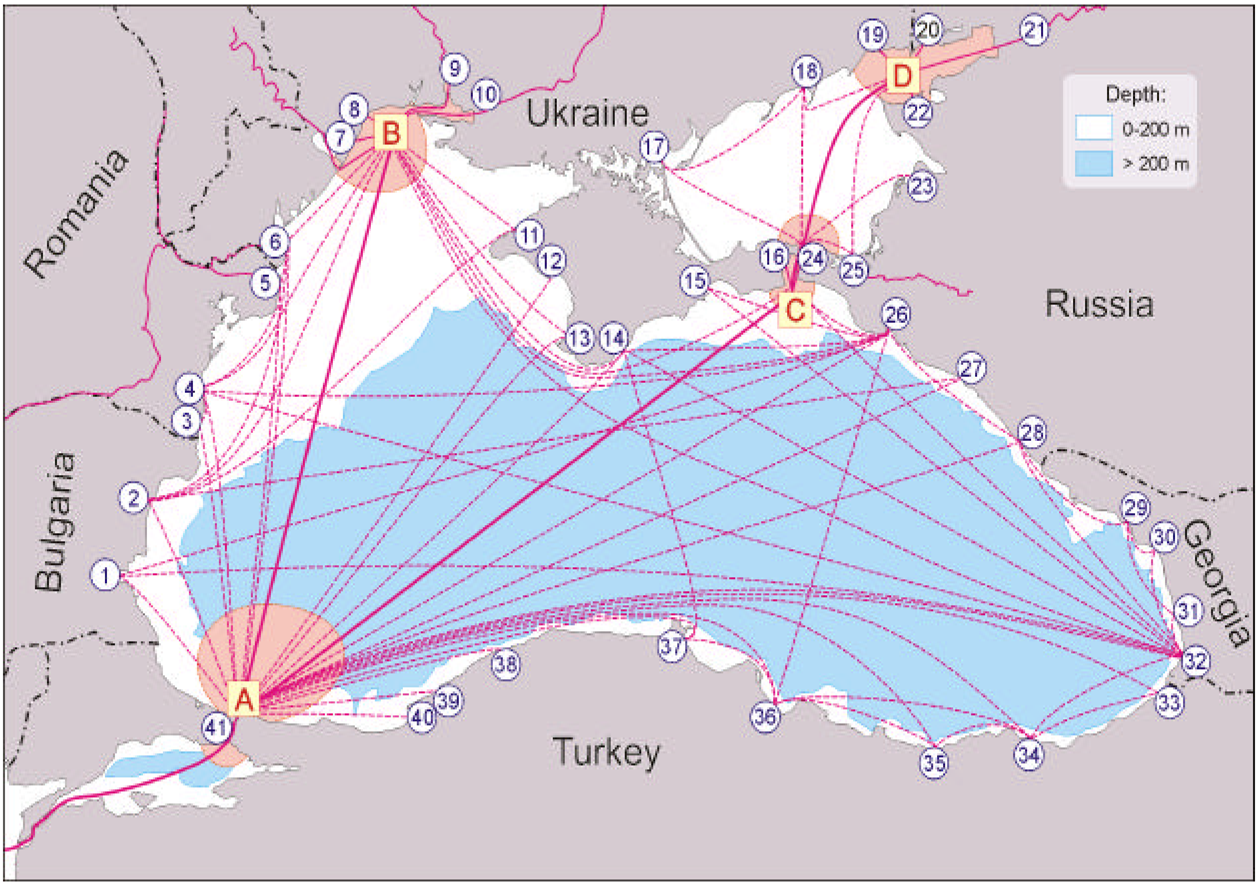

Fig. 14.1 - Main harbors, traffic directions and shipping hot spots in the Black and Azov Seas.

A	Bosphorus shipping junction	C	Kerch Strait shipping junction
B	North-western harbor agglomeration	D	North-eastern harbor agglomeration

1	Burgas	15	Feodosia	29	Sukhumi
2	Varna	16	Kerch	30	Ochamchire
3	Mangalia	17	Genichesk	31	Poti
4	Constantza	18	Berdyansk	32	Batumi
5	Sulina	19	Mariupol	33	Hopa
6	Ust'-Dunaysk	20	Taganrog	34	Trabzon
7	Il'ichevsk	21	Rostov-na-Donu	35	Giresun
8	Odessa	22	Yeysk	36	Samsun
9	Nikolayev	23	Primorsko-Akhtarsk	37	Sinop
10	Kherson	24	Port Kavkaz	38	Amasra (Bartin)
11	Chernomorskoye	25	Temryuk	39	Zonguldak
12	Evpatoria	26	Novorossiysk	40	Eregli
13	Sevastopol	27	Tuapse	41	Istanbul
14	Yalta	28	Sochi		

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 15

Natural Mortality Factors Affecting Cetaceans in the Mediterranean Sea

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Problem of definition: are natural causes really natural?

Although it is sometimes easy to establish that the cause of mortality is due to human action, e.g. a whale's collision with a ship, it is on the other hand almost always impossible to affirm that a death is natural. A fatal viral infection may be the result of an immunity deficiency resulting from pollution. Accidents when giving birth may be due to disturbance. And what about a dolphin which plays with a plastic bag, ingests it accidentally and then dies? Would he not have done the same playing with natural bodies carried by the sea?

A death is thus seen as natural when it does not seem to be linked to any non-natural factor, something extremely complex and often impossible to prove.

Death is the result of various parameters that have combined or opposite effects, and these parameters may escape notice if the investigation is not carried far enough. Here, the epidemic which affected the Mediterranean population of striped dolphins in the early 1990s is significant. Very quickly a morbillivirus was seen as responsible for the rise of the epidemic. The cause thus seemed natural. But going a bit further with their investigations, researchers discovered that this virus was only fatal for animals with high immunity deficiency (Kannan *et al.* 1993). Blood rates with extremely high PCB rating – these are substances which are known for their immunosuppressive effects – indicate this type of pollution as a co-factor in the rise of the epidemic. Environmental factors like lack of food, itself possibly linked to a rise in water temperature, might have led them to mobilize their fatty reserves, bringing into circulation the PCBs previously stored in the fat (Kannan *et al.* 1993). But these environmental variables are themselves modified by human activities (e.g., climate warming).

Through this example we can see how the further the investigations are pressed, the more the interpretation of dolphin death can be alternatively attributed to natural or other causes bound up in a complex process.

So why draw this distinction?

Because in terms of conservation of species and natural balances, this distinction is of the greatest importance. Although it does not seem desirable, except in extreme cases, to act on the natural factors which regulate populations, we must however keep the non-natural factors at a level which is tolerable for the affected population. Thus, certain fishing techniques, use of such a product or of such a sonar, could be the subject of regulation or even a ban if they have an alarming share in the responsibility for the mortality of one or several species. That is why many substances, like the DDTs, have been withdrawn from sale in many countries, and why the use of drift-nets is now prohibited by European Community law.

Hazards of life

Predation

Most cetaceans have few natural enemies, apart from the smallest species. Throughout the world, the main predators are certain big sharks and transient killer whales.

In the Mediterranean, the problem is restricted because of the rarity of possible predator species (Bearzi *et al.* 1997). But certain big sharks, including the great white shark, are present in the Mediterranean and prey on small cetaceans (four young *Stenella* in the stomach of a white shark caught at Sète on 10 January 1991) (J.M. Bompar *in litt.*).

Transient killer whales attack virtually any species of marine mammal, from porpoises to the blue whale. In the Mediterranean, where the species is not abundant, there has been some mention of predation on little dolphins and on *Ziphius* (Casinos and Vericad 1976, Notarbartolo di Sciara 1987).

Stenella, in dire panic, have twice thrown themselves on a beach in north-western Spain, apparently to escape from killer whales (Nores and Perez 1988); similar cases could occur in the Mediterranean, especially in the Sea of Alboran, where the killer whale is not rare.

In what is almost predation behaviour, some Bottlenose Dolphins kill little cetaceans by striking them violently, provoking broken ribs and burst spleen or kidneys (Jepson and Baker 1998a, Alonso *et al.* 2000). The reasons for this behaviour are not really known; it has never been reported in the Black Sea, where Tursiops and Porpoises cohabit, or in the rest of the Mediterranean between the bottlenose dolphin and another fairly small cetacean.

For most cetaceans, catching their food is usually not a dangerous activity. Accidents are the stuff of anecdote, like that enormous fishbone stuck in the tongue of a Bottlenose Dolphin, which caused an abscess (Var, France, 6.4.1988) (J. Besson *in litt.*).

Pursuit of prey may sometimes be the cause of a navigation accident. A killer whale was stranded in Majorca on 26 December 1941, pursuing a school of dolphins (Casinos and Vericad 1976).

Ingesting foreign bodies of natural origin is marginal and rarely serious. This food behaviour problem may be induced by confusing something (plastic bags) with usual food, a neurological disorder (particularly a morbillivirus), gastric ulcers, young individuals' lack of experience, a game, or a famine episode. Most of the time the foreign body is macro-waste and not a natural cause of mortality. But the ingestion of bird feathers, stones, sand, and weed has been noticed, usually without much direct consequence on the animal's health (Gonzalez *et al.* 2000). A striped dolphin which took refuge in Embiez port (Var, France) for 12 days ingested 360 grammes of *Posidonia*, oleander leaves, and various kinds of waste. The whole mass totally obstructed the digestive tract, and oleander is extremely toxic (Dhermain 2001).

Accidents when giving birth

There are known cases of pathological pregnancy and multiparous births in many cetacean species (Jepson *et al.* 1998b), like those 3 fœtuses in a Mediterranean fin whale (Besson *et al.* 1982).

Fœtal monstrosities are rarely seen in cetaceans. Birth in the open sea makes it extremely difficult to discover a malformed runt. A newly-born two-headed bottlenose dolphin was found south of Bastia (Corsica) on 24 June 2001 (Cesarini *et al.* 2002). These pathological births or pregnancies can be fatal to the mother.

Solidarity with the leader or a stranded companion

An entire group of cetaceans can be stranded around a sick companion, refusing to leave it until it dies, particularly for species with tightly-knit groups: sperm whales, killer whales, false killer whales, pilot whales, Risso's dolphins.

From 11 to 13 November 1989, a group of pilot whales stopped in the Gulf of Saint Tropez before suddenly disappearing. The next day, a corpse was found exactly where the group had stopped (Bompar 2000). On 17 April 1994, five Risso's dolphins were stranded in front of the Ebro delta round a female with serious respiratory difficulties. When the female was taken away to be put in a care centre, the other Risso's dolphins went back to the high seas without any problem (Alegre *et al.* 1995). Mass strandings of pilot whales were described in the Mediterranean in the last century, and should probably be related to this sociological phenomenon: 72 individuals stranded in September 1827 in Calvi, Corsica, 150 in Majorca on 21 December 1860, and 17 in La Nouvelle, Aude, on 19 February 1864 (Bompar 2000).

Environmental traps

Trapped by ice. Dozens of porpoises are sometimes trapped by ice in a dead end in the Azov Sea instead of being able to migrate to the south of the Black Sea (Birkun Jr. and Krivokhizhin 1997).

Navigational error in the shallows. Pelagic species that have 'got lost' in sandy shallows with gentle slopes with whose sonar echo they are unfamiliar might be surprised and stranded on shallows (Dudock Van Heel 1974).

The presence of a pelagic cetacean immediately off the coast does not automatically mean that the animal has involuntarily lost its way or that it will inevitably get stranded. Many reasons may explain its presence (curiosity, prospecting, disease, etc.), but the fact is that sometimes the animal is stranded. The accidental stranding of a live cetacean in good health is one of the rare cases where a rescue intervention can be crowned with success and must be urgently undertaken.

Striped dolphins regularly remain prisoners in basins of deep water surrounded by shallows of *Posidonia* and seem incapable of getting back to the open sea without help, especially if there is a fuss around them. A coordinated intervention of divers and inflatable craft, acting calmly, controlling the public's curiosity and sufficiently familiar with the cetaceans' behaviour to be able to anticipate their reactions, is often decisive (Bompar 1996).

A young fin whale calf was stranded in a metre of water off the mouth of the Great Rhone in the Camargue on 17 October 1996. It was strapped and pulled off to the sea thanks to major logistical means.

The cetacean's sonar system can be seriously harmed by the parasite *Crassicauda grampicola*, which provokes a very destructive exacerbated inflammatory reaction. And sometimes cetaceans prefer stranding to having to stay on the surface to breathe, and voluntarily seek the shallows. How often can they get out of them by themselves? Nobody knows.

Abnormalities in the Earth's magnetic field. In certain regions, strandings of live animals happen where the lines of the earth's electro-magnetic field are at right angles to the shore (Klinowska 1991a, 1991b). No similar study has been suggested for the Mediterranean, and other work done elsewhere in the world does not confirm this hypothesis (Brabyn and Frew 1994).

Pathology: diseases of cetaceans

Non-infectious diseases

Few studies have been done in a strictly Mediterranean context.

Food poisoning

Poisoning by various phytotoxins, described for several cetaceans, has been treated with prudence by certain writers (Gol'din and Birkun 1998). No mention is made of this for the Mediterranean *sensu stricto*. The phenomenon happens after a proliferation of a dinoflagellate phytoplanktonic alga containing toxins. Eaten by phytophagous fish, themselves predated by carnivorous fish, the toxins are concentrated along the food chain. The fish seem less sensitive to the toxin than the mammals (among them, humans) which eat the fish. At the end of the chain, the symptoms observed are varied: acute digestive troubles, or neuro-muscular disorders, even paralysis, or acute pneumopathy.

Various phenomena lead to the proliferation of dinoflagellates (red tide), such as an increase in nitrate waste near the shore (untreated waste water or leaching of over-fertilized agricultural soils), particularly in hot regions. The Mediterranean's industrialized or agricultural shores are thus potentially concerned.

During the summer of 1997, a mass mortality decimated the ranks of the only viable colony of Mediterranean monk seals *Monachus monachus*, wiping out 71% of the adults of the Cap Blanc peninsula population on the Mauritanian coasts, where there are now probably only 90 individuals (Aguilar 1997). Many factors may have intervened in this ecological catastrophe, but it is very probable that most of the mortality observed could be attributed to poisoning by toxins produced by dinoflagellates. The last Mediterranean populations of this famous mammal are thus extremely vulnerable to this factor.

Degenerative ailments

Elderly individuals present lesions caused by wear and tear and by degeneracy that are not necessarily fatal: vertebral arthrosis which can get so bad that it knits together the cervical vertebrae and the cranium (Van Bree and Duguy 1970); teeth being worn away (Toussaint 1977), cetaceans that are blind but otherwise in perfect health.

Tumorous pathology

Cancers are reputedly extremely rare in cetaceans living in an unpolluted natural environment, whereas the beluga of the St Lawrence in Canada present a large number of cancerous lesions associated with high concentrations of pesticides and heavy metals in the tissues (De Guise *et al.* 1994).

A squamous cutaneous carcinoma was described on a Stenella stranded in Spain (Calzada and Domingo 1990).

Large-scale methodical research was done (half a thousand autopsies on dolphins in Peru, for example, an equivalent number on British and German porpoises) permitting a great variety of tumours of the reproductive apparatus to be described, such as ovarian cysts and vaginal stones. Although not automatically fatal, these lesions have at least some effect on the concerned female's reproductive abilities (Van Bressem *et al.* 1998, Jepsen *et al.* 1998b, Siebert 1998). Studies of this extent are lacking for the Mediterranean.

Infectious diseases

Parasitology (Fig. 15.1)

Since cetaceans live in the marine environment, their parasites have to face up to difficult conditions to complete their life cycles. Parasites' strategies in most cases limit themselves to two main principles: a cycle that confines itself to the same host with contamination by proximity (the case for many ectoparasites), or one that is heteroxenous with several intermediary hosts and sometimes several paratenic hosts with a strategy of contamination by maximum dispersion (the case for many meso- and endoparasites).

There are no real parasite specificities for species developing in the Mediterranean. For cetaceans, the main parasite species are mostly cosmopolitan.

Epizoa and ectoparasites

As well as the commensal *Balaenophilus unisetus*, present between the whalebones of rorquals, and which feeds on micro-organisms, cetaceans are hosts to other species of non-pathogenic organisms such as certain species of Cirripedia crustaceans. *Conchoderma auritum,* a small 5-15 cm. crustacean, has been found on many species of Odontocetes, and also of *Balaenopteridae*. *C. auritum* fixes onto hard substrata such as the animal's teeth or gums. Although it is not pathogenic, it seems that it is involved in loosening the teeth or causing cracks in the jaws. *Xenobalanus globicipitis* is a non-pathogenic epizootic crustacean that fixes onto the trailing edges of dolphins' fins. When cetaceans are stranded, quite often the only thing that is found is the whitish shell still stuck in the host's epidermis.

The main cetacean ectoparasites are all crustaceans. The Pennellas, *Pennella sp*., are little-known Copepoda that are frequently parasites of big cetaceans. The female parasites dig into the cutaneous fat of the host, usually near the muscle, developing an anchor with three cephalic horns, and feed off the surrounding tissues. The pathological impact is limited to a local reaction. The *Cyamidae*, or 'whale fleas', are Amphipoda that are specific of the Odontocetes and Mysticeta. These are monoxenous parasites without an active swimming stage. Certain species of Cyamidae are specific of species, such as *Cyamus catodonti* or *Neocyamus physeteris* specific of the sperm whale, *Physeter macrocephalus*. Transmission occurs during bodily contact made between cetaceans. The Cyamidae dwell in the natural orifices or in wounds where they take refuge. They provoke small cutaneous lesions likely to become infected with a secondary infection, but the pathological impact remains limited.

Meso- and endoparasites

Most of these parasites, whatever their class, have a common strategy and an indirect cycle. Cetaceans are contaminated by their food, traditionally made up of fish.

Parasites of the digestive tract

Anisakis sp., a Nematode, and *Pholeter gastrophilus,* a Trematode, are very frequently found in the stomachs of Odontocetes. The first is well known, for it is cosmopolitan, and human beings can be contaminated by ingesting the larvae, usually in fish, even if this represents an epidemiological dead end. *Anisakis* are found free or attached to the mucous membrane most usually of the mechanical stomach, in which they are likely to provoke ulcers, exceptionally perforating. *Pholeter* is a fluke that can be seen in cysts of the chemical and pyloric mucous membrane of stomachs. These cysts, rarely obstructive, present a channel along which the parasite eggs are sent. Studies on fish in the market confirm the considerable frequency (sometimes 100%) with which *Anisakis* occurs. For dolphins, the occurrence varies from 30 to 60%, with more frequent infestations in adults. These parasites provoke lesions that are rarely likely in themselves to cause death but work towards weakening the populations.

In the intestine, several Cestode species may be found, but the easiest to identify is *Strobilocephalus triangularis*, a parasite of dolphins' (particularly *Stenella coeruleoalba*) rectums. Its major feature is an enormous scolex that it sticks in the mucous membrane, provoking a local inflammatory reaction that is usually very slight.

A family of flukes that are specific to cetaceans, the *Campulidae*, are regularly found in the liver or pancreas of cetaceans. They provoke lesions characteristic of fibrosis of the canals and parenchyma that can impair the animal's general health.

Parasites of the respiratory system

A specific family to cetaceans, the *Pseudaliidae*, parasitises the respiratory tracts. These Nematodes, close to the respiratory strongyles of the ovine race and pigs, may sometimes be found in impressive quantity in the bronchia and bronchioles. The wormy bronchopneumonia engendered, aggravated by the absence of the coughing reflex, may be fatal. porpoises, *Phocoena phocoena*, and also many dolphin species are frequently parasitised by this kind of strongyles.

Parasites of the urogenital system

Close to the Spirura Nematodes of domestic animals, the *Crassicaudidae* exclusively parasitise cetaceans. The parasite species are not specific to the host-species but rather to their micro-habitat. *Crassicauda boopis* parasites the rorquals' kidneys, but *Crassicauda carbonelli* parasites the dolphins' penises, while *Crassicauda grampicola* parasites the dolphins' mammary glands. *Placentonema gigantisima* is the biggest known parasite, specialised in the placenta of sperm whales. As well as their immediate pathogenic aspects (obstruction, fibrosis), these parasites can have an impact on populations (weakening young nurselings, reproductive difficulties).

Soft tissue parasites

The most common are cysts of the plerocercoides larvae of Cestodes. Cetaceans are intermediary hosts for these parasites, the definitive hosts most probably being sharks. *Phyllobothrium delphini* parasitises the fat of Odontocetes in the ano-genital area. *Monorygma grimaldii* parasitises the mesozoa of the peritoneal organs. These parasites have a low pathological impact unless they cause lesions to the epididymic or ovarian parenchyma, for example.

Parasites of the nervous and sensory systems

These parasites are rare but also exceptionally sought. Whether the Trematode *Nasitrema*, never yet found in the Mediterranean, or the Nematode *Crassicauda*, these two parasites usually frequent the air sinuses of the Odontocetes. But by erratic migration (the first), or an exuberant inflammatory reaction on the part of the host (the second) these parasites can provoke irreversible, spectacular lesions of the cerebral hemispheres or the tympanic sacs. *Crassicauda* is known for *Grampus* or *Tursiops*, in which considerable osteolytic lesions of the bones of the cranium have been found, able to cause death.

Conclusion

Cetaceans are rather less parasitised than land mammals. Few of the parasites identified have an important pathogenic action. But the *Anisakis* in the stomach, the *Pseudaliidae* in the respiratory system, and if possible the *Crassicaudidae* either in the urogenital sphere or near the cranium should be systematically researched.

Mycology

Infections due to pathogenic fungi are not very common for cetaceans in the natural environment. Lobo's Disease, a basically tropical infection due to *Loboa loboi*, provokes invasive cutaneous lesions that can be transmitted to humans during autopsies.

Cetaceans' health conditions are decisive in the development of mycotic infections. Thus, cases of pulmonary aspergillosis have been found on striped dolphins infected by the morbillivirus epidemic.

Other anecdotal mycoses are especially described in captivity: *Candida albicans* candidosis, *Trichophyton sp*. ringworm, *Rhizopusmycosis* necrosant orchitis (Siebert *et al.* 1998).

Bacteriology

A major cause of mortality in captivity, bacterial infections are rarer in wild Mediterranean cetaceans. Certain infectious agents are highly pathogenic (*Erysipelothrix, Nocardia, Burkholdesia pseudomallei, Clostridium*), while many others are opportunistic germs: bacteria that are isolated during post-mortem examinations are not necessarily the primary cause of the death, many of them merely developing on an organism that is weakened by an infection, or after a physiological, parasitic or traumatic problem (e.g. pulmonary seat of infection consecutive to fractures of the ribs that have perforated a lung). But they do contribute to a worsening of the general condition.

Populations exposed to high levels of pollution, particularly PCB, DDT, butyl-derivatives, mercury derivatives which are very probably immunosuppressive, show a higher prevalence of suppurative seats of infection than populations living in protected areas (De Guise 1996, Pecetti *et al.* 1999, Wunschmann *et al.* 2001).

Little systematic bacteriological research has been done in the Mediterranean, but knowledge gained elsewhere can probably be transposed, for many of the germs are cosmopolitan. Getting results implies a research effort that keeps pace with ambitions: for example, for the time being, no analysis of Brucellosis has been found positive on the half-dozen dolphins tested in Mediterranean France (Moutou, *pers. comm.*); for the Spanish coasts, 24 serologies of 4 species have supplied 2 *Stenella* and 1 *Tursiops* that tested positive (Van Bressem *et al.* 2001), while in Canada 2,470 serologies of 14 different species were done, giving some hundred positive results, a third of which were for cetaceans (Nielsen *et al.* 2001). A medical adage has it: you only find what you are looking for, you only look for what you know.

Five germs must be especially mentioned, because of the possible human contamination, particularly during autopsies:

Erysipelothrix rhusiopathiae, frequently isolated in many cetaceans, supposedly contaminated by ingestion of infected crabs or fish. Two clinical forms: *acute septicaemic* and *subacute cutaneous* (Berny 1998). Human contamination is frequent if the autopsy is not carried out in rigorously aseptic conditions.

Burkholdesia pseudomallei, formerly *Pseudomonas pseudomallei*, an enzootic that is chronic in South-East Asia, but sometimes met with in captivity in Europe. Its presence in the Mediterranean is not known. It provokes acute pneumonia followed by fatal septicaemia, including for humans.

Brucella maris, discovered in 1994 on several marine mammals in Great Britain (Foster 1996), and in fact present in many marine mammal species around the world. Its presence in the Mediterranean has just been confirmed in Spain on two Striped dolphins and one bottlenose dolphin, a low prevalence compared with 100% of the adults examined in Peru! (Van Bressem *et al.* 2001). As for most other species of the genus *Brucella*, the germ may be responsible for cetacean abortions (Miller *et al.* 1999). During an accident in a laboratory, a researcher was contaminated by this new form of brucellosis (Brew *et al. 1*999) and other technicians presented symptoms that were suggestive after carrying out many autopsies on positive animals (Van Bressem *et al.* 2001). A certain transmission to humans is thus possible.

Vibrio spp., many species described for cetaceans, sometimes implicated in septicaemias. Human contamination is also possible during manipulation.

Nocardia spp., of which one serious case on a striped dolphin was described in the Girona area in Spain (Degollada *et al. 1*996).

In addition to these five major pathogenic agents, many other infections are known:

- pulmonary infections are a major dominant of cetacean pathology, encouraged by the respiratory system's being adapted to diving (De Guise 1996, Berny 1998)

- cutaneous infections on wounds of live stranded dolphins

- muscular infections are facilitated in cetaceans by the special features linked to diving, providing an extremely favourable terrain for the development of anaerobic germs. The points of entry are bites (intraspecific attacks) or wounds made by rocks (stranding of a live cetacean) that can be complicated by tetanus (Fernandez 2000)

- digestive infections are facilitated by the ingestion of foreign bodies, massive parasitism aggravated by stress and the accumulation of pollutant substances

- cardio-circulatory infections are usually complications of septicaemia

- genital infections are quite common. Infectious vaginitis, often associated with struvital vaginal stones, do not seem to affect the females' health. Infections of the penis and testicles for males are more often complicated by septicaemia. Cetaceans' intense sexual activity may have an important role in spreading these venereal diseases (Van Bressem *et al.* 1998, Jepsen *et al.* 1998b, Siebert 1998)

- urinary infections, however, appear to be rare.

Virology

Viruses are infectious agents that are much more constantly pathogenic than bacteria. Laboratory tests are done to:

- isolate and then identify the virus with electronic microscopes
- immunological doses, where reagents exist.

The presence of antiviral antibodies does not mean that the animal is ill at the moment of the test, but that it has been in contact with the virus during its lifetime. A kinetics of antibodies obviously cannot be envisaged on strandings. Thus the serological results must be considered from the viewpoint of memorials and necropsic symptoms or of the detection of viral antigens in the cetacean's tissues.

The spectacular epidemics recorded in the last few years have stimulated intense research work on the morbillivirus. Few other virological studies have been done in the Mediterranean outside this disease. Many viruses have been isolated for various cetaceans: *Poxvirus*, provoking benign cutaneous lesions (tatoo) like chickenpox that can potentially be passed on to humans (Van Bressem and Van Waerebeek 1996), observed in the Mediterranean in several species (Cabezon *et al.* 2000); *Calicivirus*, described for several cetacean species, provoking 1-3 cm.-diameter cutaneous vesicles that after bursting leave scars that remain without pigmentation. Abortions described. Not necessarily very pathogenic for cetaceans; potential agents of viral hepatitis but never found associated with pathologies for cetaceans; *Herpesvirus*, provoking varied disorders: gastric ulcers, interstitial pneumonia, encephalitis (Kennedy *et al.* 1992), infection of the genital tract (Ross *et al.* 1994); *Papillomavirus*, responsible for the proliferation of invasive confluent small verrucous lesions on the skin and the digestive mucous membranes (Bossart *et al.* 1996), and the genital mucous membranes, where they can hinder reproduction (Cassonnet *et al.* 1998); and other species that are perhaps not very pathogenic: *Adenovirus* and *Hepadnavirus* (Bossart *et al.* 1990); *Influenzavirus* (Geraci *et al.* 1982); *Picornavirus*.

As for other health problems, the influence of a polluted environment is decisive, and many factors act simultaneously to set up an explosive epidemic phenomenon. The study of the *Morbillivirus* epidemic which appeared in 1990 in the Western Mediterranean is particularly instructive on the many-factored nature of the unleashing of an epidemic. (see Fig. 15.2)

In July 1990, mass deaths of *Stenella coeruleoalba* striped dolphins were noticed on the Spanish coasts, soon spreading to the entire Western Mediterranean basin and the next year to the Central basin (Italian and Greek coasts) before reaching the Eastern basin in 1992 and the Black Sea in 1994. Some cases were found west of Gibraltar from the first year on, but the disease did not propagate itself in epidemic form in the Atlantic. Throughout the progress in the Mediterranean the same scenario was repeated from place to place: a rapid increase in the number of stranded dolphins, an epidemic peak and then a decline in the number of strandings, in most cases the entire process lasting from 3 to 4 months (Dhermain *et al.* 1994). In all, over 1,200 corpses were collected during the epidemic, and these figures do not reveal the whole tale (lack of prospecting, carcasses lost at sea, sunk or eaten by sharks). (Raga *et al.* 1992, Bompar *et al.* 1992, Bortolotto *et al.* 1992, Cebrian 1995, Birkun *et al.* 1999).

Today, from the season following the epidemiological peak, strandings that can be attributed to morbillivirus have become infrequent again in the Mediterranean. Strandings of moribund dolphins are a little more frequent than formerly, but nothing like the hundreds recorded when the epidemic was at its height. The 1990 epizootic was replaced by a chronic morbillivirus infection that caused subacute infectious lesions of the central nervous system (Domingo *et al.* 1995).

Symptomatology

The morbillivirus provokes neurological and pulmonary disorders that cause an unusually high number of live animals to be stranded. Most seem to be exhausted, shaken by shivering, affected by nervous troubles: some throw themselves onto the rocks to the extent that they break the rostrum while others are apathetic. Breathing is difficult and irregular. Some cases of digestive problems (diarrhoea, vomiting).

Attempts to take them forcibly back to the open sea were made here and there but always failed. Various forms of veterinary care were always useless.

On autopsy, pulmonary lesions (bronchiolar-interstitial pneumonia) and neurological lesions (encephalitis) are the most important.

Associated secondary lesions are very common: aspergillus, toxoplasmosis, actinomycosis, encouraged by immunosuppression consequent on infestation by the Morbillivirus and/or contamination by PCB and DDT: (Domingo *et al.* 1992).

Sex ratio and age ratio

Males and females are indifferently affected. Mature adults and new-born individuals whose nursing mothers are dead and/or easily infected alongside them, are the most affected.

Causal factor and encouraging factors

The causal agent of the disease is a Morbillivirus, isolated in the first months of the epidemic and new to science. Since 1987, new epidemics and the discovery of new viral agents have made the Morbilliviruses modern viruses (Moutou 1995). We mention in particular the mass deaths of Lake Baikal seals in 1987 (Canine Distemper Virus) and the North Sea seals in 1988 (17,000 dead). In summer 1997 a mass mortality decimated the ranks of the one viable colony of Mediterranean monk seals *Monachus monachus*, wiping out 71% of adults of the Cap Blanc peninsula population. Osterhaus *et al.* (1997) showed the presence of the Morbillivirus on Mauritanian seals and on some Greek seals in the Aegean Sea. (Monk Seal Morbillivirus MSMV).

Certain atypical morbilliviruses (on horses in Queensland, on pigs in Malaysia) are at the origin of a form of encephalitis fatal to humans.

The *Morbillivirus* is thus the *causal agent*, directly responsible for the disease. It essentially provokes lesions of the respiratory apparatus (interstitial pneumonia) and of the nervous system (encephalitis) as well as a generalised congestion of the organs. But its pathogenic power is only fully unleashed if it meets a terrain that is favourable to the spreading of the disease. A whole set of favourable factors explain the importance of the development of this epidemic:

a) An examination of the subjects stranded in Spain during the first 70 days of the epidemic shows that they were in bad physical condition.

b) Aguilar and Raga (1990) suggest that the peak of primary planktonic productivity did not occur in spring 1990 off Spain, reducing the food resources of fish, and therefore of dolphins, in the sector under consideration.

c) Abnormally high PCB levels were detected on dolphins stranded in France – and especially in Spain – (94 to 670 ppm), sometimes rising above 1,000 ppm, which represents one of the highest values ever found for a wild mammal. High concentrations of DDT (22 to 230 ppm) were also recorded (Kannan *et al.* 1993). In France, Augier *et al.* (1991) showed high cadmium, copper and mercury contaminations. On species on which they had been tested these pollutants cause hepatic lesions, affect reproduction, and are immunosuppressive. It is accepted that the same holds good for cetaceans.

d) The parasite load of dolphins suffering from the morbillivirus is particularly heavy. Fifteen parasite and epizootic species have been recorded, among these one localisation new to science, with very high prevalences for many parasites; disproportionate inflammatory reactions (Aznar *et al.* 1995); parasites that are absolutely unusual for striped dolphins, even for cetaceans (Raga *et al.* 1992, Fernandez *et al.* 1991); parasites that are usually associated with slow-swimming species, indicating that the dolphins were moving abnormally slowly, doubtless because of their disease. Several dolphins developed extremely serious secondary infections due to fungi (aspergillus), bacteria (antinomycosis) or sporozoa (toxoplasmosis).

e) The progress of the disease was also encouraged by the exchange of individuals between groups or temporary gatherings on feeding grounds (Bompar *et al.* 1991).

Later studies have shown that many, if not all, species were sensitive to the morbillivirus and yet only the striped dolphins, it seems, were concerned by this epidemic. Why? Firstly, perhaps because there were so many of them. Viral epidemics occur in high-density populations (e.g. North Sea Seals), certain writers seeing these epidemics as a natural population-regulating factor (Harwood *et al.* 1990)! This hypothesis could moreover be strengthened by the infecting of the common dolphin, a vicariant of *Stenella* in the Black Sea.

Osterhaus *et al.* (1995) think that infection by morbilliviruses evolves normally in enzootic fashion both for seals and cetaceans. Most species of Atlantic Ocean cetaceans are carriers of the Morbillivirus. Those which live gregariously, like the pilot whales and false killer whales, are in permanent contact with the virus, passing it from one member of the community to the next, and although the rate of infestation is very high (92% of individuals tested), the disease remains very mild because the populations are naturally and regularly protected against this everyday companion. The infection only takes on a dramatic epidemic character if the virus meets an unscathed population that is rarely in contact with this pathogenic agent (Duignan *et al.* 1995), *a fortiori* if their immunity defences have been weakened by other encouraging factors.

Population exchanges between groups, even temporary gatherings in multi-specific or not pelagic groups, explain quite well prevalences of the infection in different population studies across the Atlantic (Duignan *et al.* 1996).

Consequences for the *Stenella coeruleoalba* population

In the absence of a precise assessment of *Stenella* numbers in the western basin before 1990, and of the true numbers of dead dolphins during the epidemic, it is impossible to grasp the impact of this epidemic on the overall population.

Between July 1990 and September 1991, at least 800 carcasses were counted on the shores of the Western Mediterranean, and over 1,200 for the whole epidemic in the Mediterranean, and this figure only reflects part of the mortality, which (according to some) may be 10 to 50 times higher.

The only indications we possess on the consequences of the epidemic relate to the size of *Stenella* groups, which went down sharply after the epidemic. This reflects the high mortality of the population and suggests that the survivors did not immediately regroup to bring the groups up to their original strength.

The first counting campaigns, carried out in 1991, indicate an absolute figure of 68,000 to 215,000 striped dolphins for the Western Mediterranean (Forcada *et al.* 1994), i.e. a population that was still abundant and preponderant over other species in every sector.

Thus, a viral epidemic, however impressive, must not systematically be seen as an ecological catastrophe. When a virus affects a healthy population with a sizeable genetic diversity, there will always be enough resistant individuals to make up within a few years – possibly by increased reproductive success – the losses due to the disease. Cetaceans are certainly disadvantaged from this point of view for recovering the size of their original populations since they can only produce one baby per adult female every 2-3 years.

The problem arises when disease, usually of human origin, affects a species which, for various reasons , has very low population levels (like the monk seal) or has very little genetic variety (endemic sub-populations on restricted territories), or again when the individuals are made artificially fragile by outside agents, such as immunosuppressant pollutant substances, or when the environment's capacities no longer permit survivors to quickly fight their way back again. Here the Morbillivirus epidemic that hit the Mediterranean striped dolphins in 1990-1992 reveals the pollution thresholds of the Sea that nourishes us, and permits us to sound the alarm, in the interests of us all.

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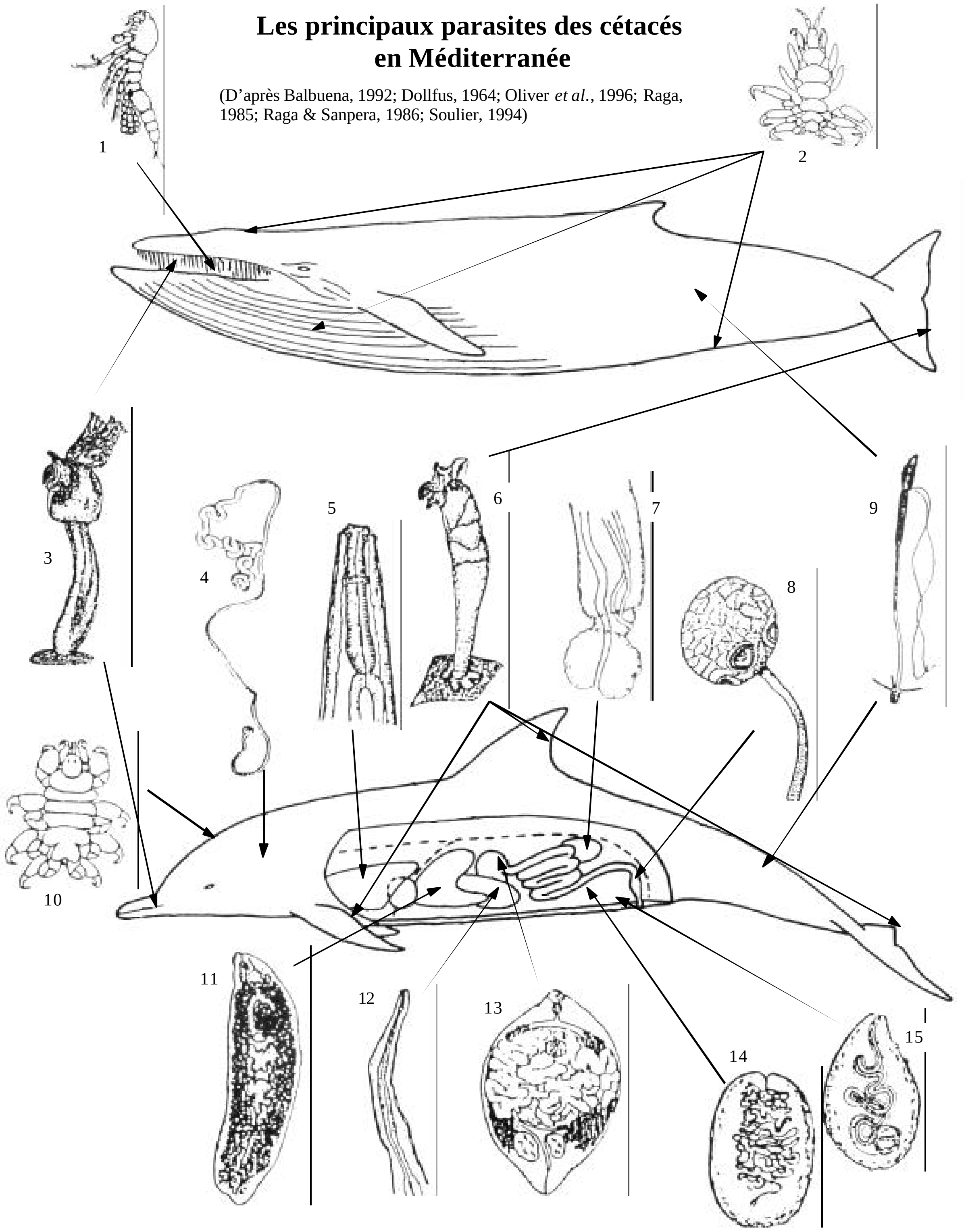

1-*Balenophilus unisetus*; 2-*Cyamus balaenoptera*; 3-*Conchoderma auritum*; 4-*Crassicauda sp*.; 5-*Pseudaliidae*; 6-*Xenobalanus globicipitis*; 7-*Crassicauda anthonyi*; 8-*Strobilocephalus triangularis*; 9-*Pennella sp*.; 10-*Syncyamus aequus*; 11-*Campulidae*; 12-*Anisakidae*; 13 *Pholeter gastrophilus*; 14-*Monorygma grimaldii (larvae)*; 15-*Phyllobothrium delphini (larvae)*

Fig. 15.1 – Main cetacean parasites in the Mediterranean.

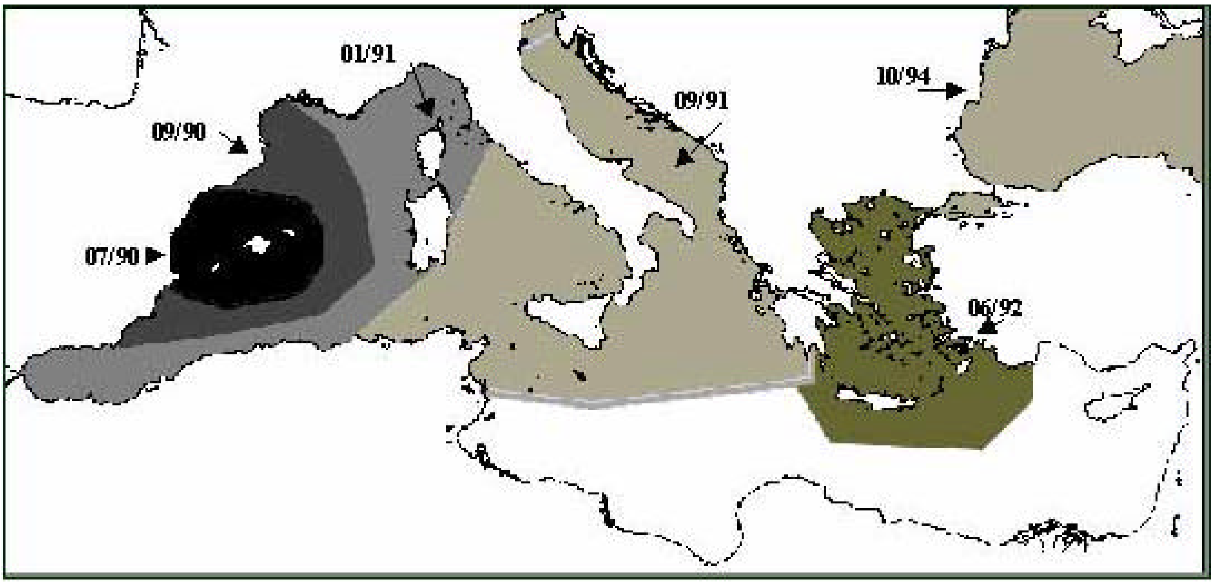

Fig. 15.2 – Progress of the Morbillivirus epidemic in the Mediterranean, 1990-1992. Taken from Raga and Aguilar 1992a, Bompar *et al.* 1992, Bortolotto *et al.* 1992, Cebrian 1992, and Birkun *et al.* 1999. The various shadings show the maximum extent of the epidemic in July 1990, September 1990, January 1991, September 1991, June 1992 and October 1994.

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 16

Natural Mortality Factors Affecting Cetaceans in the Black Sea

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Introduction

Normal mortality rates are not known for Black Sea populations of the harbour porpoise (*P. phocoena*), short-beaked common dolphin (*D. delphis*) and common bottlenose dolphin (*T. truncatus*). Some natural pathogens and conditions are known to induce lethal diseases and injuries which appeared sporadically or in the form of die-offs affecting from one to all three cetacean species (Delamure 1955, Kleinenberg 1956, Birkun *et al.* 1992a, 1992b, 1999b, Birkun 1996b, Birkun and Krivokhizhin 1997). According to the yearly dynamics of cetacean strandings recorded in the Crimea (Krivokhizhin and Birkun 1999), since 1989 there were four recognizable peaks of cetacean natural mortality in the Black Sea and one in the Sea of Azov. The pathological findings and causes of death are presented below according to their aetiology.

Virus infections

The outbreak of morbilliviral disease occurred among common dolphins in July–September 1994 (Birkun *et al.* 1996, 1999 b). A total of 47 animals of this species – more than in previous or subsequent quarters of 1989-1998 – were recorded washed ashore in Ukraine, Bulgaria, Romania and Russia (no information on cetacean strandings was available from Georgia and Turkey). The lesions found in the lungs, brain and immunocompetent organs were consistent with classic pathological signs of morbilliviral disease, and the specific immunoperoxidase test, polymerase chain reaction and electron microscopical examination confirmed a *Morbillivirus sp.* as the primary cause of those lesions.

It was supposed that morbilliviral infection has spread to the Black Sea from the Mediterranean (Birkun *et al.* 1999 b), where it affected striped dolphins (*Stenella coeruleoalba*) in 1990-1992 (Aguilar and Raga 1993). Alternatively, the Black Sea has possibly been a persistent focus of cetacean morbilliviral infection during indefinably long time before the common dolphins epizootic. The following two considerations may present indirect proof of this assumption:

- serum antibodies against *Parainfluenza II* and *Parainfluenza III viruses* were detected, respectively, in 10% and 2% of bottlenose dolphins kept in the Sevastopol's military oceanarium in the early 1980s (Gulov 1984). Both parainfluenza viruses and morbilliviruses belong to the same family Paramyxoviridae, therefore antigenic crossing between them is possible. Thus, an infectious contact between cetaceans and morbilliviruses is not excluded in those cases;
- morbillivirus-specific antibody titres were indicated in Black Sea bottlenose dolphins maintained in the Tel Aviv's Luna Park in 1994 (M. Garcia-Hartmann, pers. comm.). The animals could not be infected in Israel; obviously, they came in contact with the pathogen in the wild or at previous place of captivity in the Black Sea. Anyway, infectious interaction with a morbillivirus occurred before the common dolphins epizootic.

Continuous circulation of morbilliviruses among Black Sea cetaceans has been confirmed by the examination of 73 harbour porpoises by-caught in 1997-1998 in Ukraine, Bulgaria and Georgia (Müller *et al.* 2000): 52% of tested blood serums showed positive porpoise morbillivirus-neutralizing antibody titres, whereas no manifested lesions specific for morbilliviral disease were detected, and all samples of lung, brain and spleen tissue were negative for morbillivirus antigen. Further persistence of morbilliviruses in the Black Sea environment is supposed; it may be a cause of future mass mortality events threatening cetacean populations (Birkun *et al.* 2000).

Serum antibodies of *Influenza A2 virus* (strain "Khabarovsk") and to *Flavivirus* (acarine encephalitis virus, strain "Sofiin") were detected in captive bottlenose dolphins maintained in Sevastopol (Gulov *et al.* 1982, Gulov 1984). In addition, 17% of wild bottlenose dolphins examined were seropositive to *Flavivirus* too. Both viruses were not isolated, and any symptoms of a sickness were not recorded in those cases.

Bacterial diseases

Current knowledge on bacteria infecting free ranging Black Sea cetaceans is rather limited. In particular, almost nothing is known about bacterial microflora in common dolphins (Table 16.1). Between the 1960s and the 1980s the screening of various antibacterial serum antibodies was carried out in several tens of bottlenose dolphins and harbour porpoises which were sampled just after their live capture for dolphinaria (Lukyanenko 1964, GABION 1983, Gulov 1984, Kilesso *et al.* 1986, Lvova *et al.* 1986, Reichuk *et al.* 1986, Yushchenko *et al.* 1986). As a result, diagnostic titres of antibodies to obligatory and optional pathogens (*Leptospira*, *Salmonella*, *Yersinia*, *Chlamydia*, *Listeria* and *Erysipelothrix spp*.) were detected in some cases, although bacterial cultures were not isolated and no specific lesions were found by means of routine veterinary examination. Nevertheless, Black Sea cetaceans could be hypothesized as potential victims, carriers and reservoirs ("ecological niches") of leptospirosis, salmonelloses, yersiniosis, chlamydiosis, listeriosis and erysipelas. The role of these bacterial infections in cetacean natural morbidity and mortality is not well understood until now, however fatal cases of erysipelas (Nifontov 1969, Rodin *et al.* 1970, GABION 1983) and listeriosis (Oleinik and Gulov 1981, Gulov 1984) have been recorded amongst captive animals which died usually due to the septicaemia.

Inshore species of cetaceans (*P. phocoena* and *T. truncatus*) are considered as targets for polymicrobial anthropogenic pollution of the Black Sea (Birkun 1994). A number of opportunistic bacteria, originated most probably from untreated sewage, were isolated from the skin, respiratory tract and internal organs of wild bottlenose dolphins and harbour porpoises investigated *post mortem* and alive (Birkun *et al.* 1988, Birkun and Miloserdova 1989, BLASDOL 1999) (Table 16.1). Those organisms, belonging to intestinal microflora (*Alcaligenes*, *Escherichia*, *Klebsiella*, *Serratia*, *Edwardsiella* and *Proteus spp.*), halophilic aquatic bacteria (*Vibrio* and *Aeromonas spp*.) and pyogenic cocci (*Staphylococcus* and *Streptococcus spp.*), may cause local and generalized secondary infections in the weakened individuals primarily compromised by helminth infestation, non-infectious pathology or trauma (Birkun and Miloserdova 1989). Two mass mortality events observed simultaneously in Ukraine, Russia and Bulgaria in 1989 and 1990 could be convincing examples of this (Birkun *et al.* 1992a, 1992b, Krivokhizhin and Birkun 1999). Within both die-offs, the majority (80%) of 271 harbour porpoises recorded stranded in Crimea were immature individuals, and all examined animals suffered severe purulent broncho-pneumonia which was a consequence of initial pulmonary nematodosis complicated by bacterial superinfection. The porpoises probably had a heightened sensitivity to facultative pathogens, since necropsied specimens demonstrated definite histological signs of the immunodeficiency; and high concentrations of immunosuppressing chlorinated hydrocarbons (DDTs and hexachlorocyclohexanes) were detected in their blubber (Birkun *et al.* 1992 a 1993).

Multi-microbial pollution of coastal waters causes a permanent risk of mixed-infectious injuries (mainly pneumonias and septicaemias), when two and more species of opportunistic bacteria and fungi are involved in pathological process. It was shown that *Staphylococcus aureus* in combination with various enterobacteria (most often with *Proteus mirabilis*) constitutes a continual threat for wild and captive Black Sea cetaceans (YEVLAKH-2 1986, Birkun *et al.* 1990a, Birkun 1994). In such cases the development of local suppurative inflammation and generalization of septic lesions are accompanied by immune response and immunopathological reactions to the antigens pertaining to different members of morbid bacterial associations.

Microalgal vegetation

Microphytic algae, predominantly diatoms (Bacillariophyta), are known to produce a fouling film over the skin of captive bottlenose dolphins maintained in Russian and Ukrainian dolphinaria. The pathogenic significance of this cosmetic defect continues to be a point of discussion (Birkun and Goldin 1997, Goldin and Birkun 1999). Meantime, pronounced microalgal vegetation on the skin surface is a reliable indicator of feeble health in captive cetaceans and/or unfavourable zootechnical and veterinary conditions (*e.g.*, limited room hindering animals mobility, stagnant and polluted water, *etc*.) in the places of their captivity. Visible algal film has never been recorded in wild Black Sea cetaceans, but sparse cells of the diatoms (*Licmophora sp.* and *Nitzschia hybrida* f. *hyalina*) were detected in skin scrapes collected from few newly captured bottlenose dolphins (Goldin 1996, 1997).

Numerous cells of non-parasitic dinoflagellates (Dinophyta) and unidentified unicellular seaweeds were found in blowhole swabs of bottlenose dolphins and belugas (*D. leucas*) kept together in the open-air sea pen in Laspi Bay, south Crimea (Krivokhizhin and Birkun, unpublished data). Unfortunately, no data are available on cetaceans-applied effects of Black Sea dinoflagellates and their toxins, although "red tides" caused by blooms of these microalgae became common in the subregion since the 1970s (Zaitsev and Alexandrov 1998).

Mycoses

Black Sea bottlenose dolphins and harbour porpoises can be contaminated by microscopic fungi which may cause secondary infections of integumentary tissues (superficial mycoses or dermatomycoses) and internal organs (deep or systemic mycoses). No information has been published on mycological features of Black Sea common dolphins.

According to the research conducted in the former Soviet Union, opportunistic fungi, invading cetacean skin and allegedly inducing superficial mycoses, are represented by the genera *Alternaria*, *Rhodotorula*, *Cladosporium* and *Mortierella*, which were isolated from harbour porpoises and bottlenose dolphins (Zakharova and Zagoruyko 1978, Zakharova *et al.* 1978a, Zakharova and Dralkin 1985), and also by *Trichophyton*, *Rhombophytum* and *Hyphomyces* recorded in bottlenose dolphins only (Tomilin and Bliznyuk 1981, Zakharova *et al.* 1982).

Different species of yeasts belonging to the genus *Candida* were detected in epidermal smears taken from wild harbour porpoises; in particular, four species (*C. albicans*, *C. brumptii*, *C. guilliermondii* and *C. krusei*) were isolated from visually normal skin and one species (*C. utilis*) from mycotic plaque (Birkun and Miloserdova 1989). Maculated, papulous and ulcerative dermatites, caused by fungi and bacterial-mycotic associations, are widely spread in both inshore cetacean species. For example, 30 individuals from 38 harbour porpoises (79%), examined in March-April 1982 in the waters off Crimea, had typical skin lesions which sometimes covered up to one third of body surface (Birkun and Oleinik 1984). In 1997-1998 similar lesions were recorded in 21 from 84 by-caught and stranded porpoises (25%) necropsied in Ukraine, Bulgaria and Georgia (BLASDOL 1999). There is no direct evidence that dermatomycoses themselves lead to lethal end, but they usually open a gateway for further microbe intrusion and promote systemic dissemination of pathogens.

Deep mycoses were reported in captive bottlenose dolphins: one case of pyonecrotic broncho-pneumonia caused by *Aspergillus fumigatus* (pulmonary aspergillosis) (Oleinik *et al.* 1982) and two cases of chronic sepsis caused by *Candida sp.* (systemic candidiasis) (Gulov 1984) have resulted in the animals' death. Another strain of *Candida sp*. was isolated from the lung tissue of a wild harbour porpoise incidentally died in fishing net (BLASDOL 1999).

Parasitic diseases

Protozoan infections are unknown in Black Sea cetaceans. A single case of external macroparasitism – focal ulcerative dermatitis caused by unidentified settled crustaceans – has been briefly reported in a harbour porpoise (Zakharova *et al.* 1978b). The internal macroparasites of Black Sea dolphins and porpoises are represented by 14 species of helminths, including flukes (Trematoda; four species), tapeworms (Cestoda; two species) and roundworms (Nematoda; eight species) (Table 16.2). The life circles are not investigated for all of them, so plural aquatic organisms, involved in cetaceans food chains, may be potential intermediate hosts and sources for marine mammals infestation.

<u>Trematodoses.</u> The liver flukes, *Campula palliata*, were found in bile ducts of common dolphins (Delamure 1955), and two other trematode species, *Braunina cordiformis* and *Synthesium tursionis*, were recorded in the gastrointestinal tract of bottlenose dolphins (Delamure *et al.* 1963, Delamure and Serdyukov 1966). All the infrequent findings of the above parasites occurred in the 1950s-1960s when helminthological studies were advanced in the Soviet Union because of on-going cetacean fishery providing almost unlimited opportunities for the sampling. Nevertheless, the proper roles of these helminths in the pathology and mortality of Black Sea cetaceans remain unclear.

The stomach fluke, *Pholeter gastrophilus*, a causative agent of chronic deforming gastritis (pholeterosis), has been reported in harbour porpoises (Greze *et al.* 1975), common and bottlenose dolphins (Krivokhizhin 1992, Krivokhizhin and Birkun 1994). According to Krivokhizhin (2000), the extent of this invasion reached 41-63% in stranded and by-caught cetaceans examined in 1989-1999. In cases with pronounced granulomatous, sclerotic and necrotic lesions in the gastric wall, the pholeterosis can be complicated by pyloric stenosis and presumably by gastric bleeding and perforation which may lead to the animal's death.

<u>Cestodoses.</u> Both species of intestinal tapeworms, *Diphyllobothrium latum* and *D. stemmacephalum*, were historically the first parasites reported in harbour porpoises and Black Sea cetaceans in general (Borcea 1935). Since then no further record confirmed the presence of *D. latum* in cetaceans bowels, whereas *D. stemmacepha-*

lum was repeatedly detected not only in harbour porpoises (Delamure 1971a, Radulesku *et al.* 1974, Krivokhizhin and Botsman 1990, Krivokhizhin and Birkun 1994), but also in bottlenose dolphins (Delamure 1971b, Krivokhizhin 2000). The diphyllobothriosis is characterized by relatively low diffusion (8-13% of stranded and by-caught cetaceans are infected) and low to moderate intensity (1-14 worms per host) of parasitic invasion (S.V. Krivokhizhin, pers. comm.). Death may be caused by intestinal occlusion (ileus, volvulus) due to the bundling of twisted helminths in the gut's lumen. Some specimens of *D. stemmacephalum* attain a length of 4-5 metres (Delamure 1971b, Krivokhizhin and Botsman 1990).

Nematodoses. The significance of lungworms (fam. Pseudaliidae) in Black Sea cetaceans mortality has been summarized by Krivokhizhin (1997). In the 1940s-1950s pulmonary nematodosis induced by *Skrjabinalius cryptocephalus* was obviously the main factor of natural mortality in common dolphins (Kleinenberg 1956). According to Delamure (1955), 29% of 604 killed dolphins examined in 1948 were infected by this parasite, and seven stranded individuals had severe, indeed fatal, verminous pneumonia caused by numerous (up to 227 in one lung) worms. Another nematode, *Halocercus kleinenbergi*, was also described in common dolphins as a pathogen affecting respiratory tissue, small bronchi and blood vessels (Delamure 1951, 1955). However, no signs of *S. cryptocephalus* and no identifiable specimens of *H. kleinenbergi* were found in lungs of 30 stranded and by-caught common dolphins examined in 1989-1999 (Krivokhizhin 1997, 2000, BLASDOL 1999). In the meantime, seven animals (23%) contained small spiral, sometimes incapsulated calcifications in lung parenchyma, a probable consequence of *H. kleinenbergi* invasion.

Another two lungworms, *Halocercus taurica* and *H. invaginatus* (= *H. ponticus*), were recognized as etiological factors of pulmonary nematodosis (halocercosis) in harbour porpoises (Delamure 1955, Temirova and Usik 1968). The maximum rate of *Halocercus spp*. invasion (100%) was first recorded in 1982 in eleven porpoises died due to negligent live capture operation (Birkun and Oleinik 1984). Two further forms of tissue injury were described in those cases: (a) pure (aseptic) verminous bronchopneumonia consisting in granulomatous, necrotic and fibrotic lesions with a calcification of dead nematodes; and (b) verminous bronchopneumonia complicated by secondary bacterial infection resulting in suppurative destruction of host's tissues and parasites. The last form of the disease was diagnosed as the most realistic cause of death in all 39 stranded harbour porpoises necropsied during the cetacean die-offs in 1989 and 1990 (Birkun *et al.* 1992b, Krivokhizhin 1997). Moreover, the halocercosis seems to be an important circumstance limiting *P. phocoena* population also beyond mass mortality events. In particular, 99% of 104 stranded and by-caught individuals examined in 1997-1999 had specific mild to severe lung lesions (Birkun *et al.* 2000). *H. taurica* and *H. invaginatus* may invade harbour porpoises both together and separately; they were found, correspondingly, in 35% and 85% of 122 carcasses investigated in 1989-1999 (Krivokhizhin 2000).

One nematode species, *Stenurus ovatus*, is known for a long time as a lung parasite of Black Sea bottlenose dolphins (Delamure 1945), but any knowledge of the extent of this invasion and an opinion on the role of this helminth in cetacean mortality have not been published before the 1990s (Krivokhizhin 1997). Delamure (1955) has mentioned *S. ovatus* in a blowhole, bronchi and blood vessels. Among eight stranded bottlenose dolphins examined in 1989-1999 there was one animal with the parasites in bronchi and calcified residues, probably originated from nematodes, in the lung tissue; two more individuals had calcifications only (Krivokhizhin 1997, 2000). In all those cases, chronic bronchopneumonia combined with focal purulent bronchitis and alveolitis suggested associative participation of helminths and pyogenic microflora in the development of tissue injury.

Cranial air sinuses, the inner ear and supracranial airways are the most common locations of the harbour porpoise's nematode *Stenurus minor* (Delamure 1941, Radulesku *et al.* 1974, Birkun and Oleinik 1984, Krivokhizhin and Birkun 1994, Krivokhizhin 2000), although the worms have been also found in the trachea, bronchi and, occasionally, in the brain, oral cavity, stomach and duodenum of killed, stranded and incidentally caught cetaceans (Delamure 1945, 1955, Krivokhizhin and Botsman 1990, Krivokhizhin 1997, Krivokhizhin and Shibanova 1999, Shibanova and Krivokhizhin 2000). For decades the prevalence of *S. minor* invasion remained at the highest level (100%) without fluctuations. In other words, till now nobody has recorded even one Black Sea harbour porpoise free from these parasites. The intensity of invasion is also impressive: up to 11,328 worms were counted in one host (Krivokhizhin and Botsman 1990). No statistical difference in the invasion rate was found between males and females or between immature and mature porpoises (Shibanova and Krivokhizhin 2000). The pathological role of *S. minor* continues to be uncertain. The enormous infestation of the inner ear (stenurosis or verminous otitis) was supposed to cause a harm to the cetaceans' hearing and navigation capabilities (Delamure 1955, Kleinenberg 1956), however the reported unsteady local lesions, represented by erosions and haemorrhages (Delamure 1955, Birkun and Oleinik 1984), are not sufficient evidence to confirm that opinion.

The first finding of spirurids *Crassicauda sp.* in Black Sea cetaceans has been recorded in 1989 in a harbour porpoise stranded on the Crimean coast (Krivokhizhin 1989). During the 1990s these worms were repeatedly found in porpoises, and also in common and bottlenose dolphins (Birkun *et al.* 1992a, Krivokhizhin 1992, Birkun and Krivokhizhin 1993, Krivokhizhin and Birkun 1994, Birkun *et al.* 1999a). After prolonged consultations (J.A. Raga pers. comm., A.S. Skryabin pers. comm.) the nematodes have been preliminary attributed to *Crassicauda grampicola* (Krivokhizhin 2000). The parasites were always located in cranial sinuses (predominantly in pterygoid sinus) and in the inner ear, and usually caused osteolytic lesions in the surrounding skull bones with their perforation, in particular, to cranial cavity. Reactive focal meningitis has been observed in some cases. Based on the data collected during eleven years (1989-1999), crassicaudosis affects 2% of harbour porpoises, 8% of common dolphins and 25% of bottlenose dolphins (Krivokhizhin 2000). The intensity of the invasion did not exceed four nematodes per host (S.V. Krivokhizhin, pers. comm.). It is thought that this infection may lead to cetacean live strandings and lethal end.

The stomach roundworm, *Anisakis simplex*, was recorded by Borcea (1935) in a single harbour porpoise without any description of gastric or other lesions. Although that finding remains unconfirmed, *A. simplex* is still included in the list of Black Sea cetacean parasites (Greze *et al.* 1975, Krivokhizhin 2000).

Nematode larvae (fam. Pseudaliidae) resistent to digestive enzymes were detected in high concentrations (11,000-430,000 per millilitre) in the intestinal contents sampled from seven harbour porpoises (Krivokhizhin and Botsman 1990). In one specimen, similar larvae were present alive in the blood collected from mesenteric veins which were obstructed by multiple parasitic emboli (Birkun *et al. 1*992b, Shibanova and Krivokhizhin 2000). In other two cases, solitary semi-necrotized and partly calcified larvae were detected penetrating the intestinal wall. These findings considered together point to a possible way of host reinvasion by pseudaliids (*Halocercus spp.*, *S. minor*) through the alimentary tract.

Unspecified parasitic lesions. Unidentified helminths were extracted from tumour-like formations located in the bottlenose dolphin's skin (Zakharova *et al.* 1978 b). Parasitic residues were detected in histological slides of brain tissue and skin in two different harbour porpoises (Birkun and Oleinik 1984). Microscopic calcifications, presumably originated from necrotized helminths, were found in the kidneys of two porpoises and of one bottlenose dolphin (BLASDOL 1999).

Miscellaneous injuries

Multifarious disease conditions and injuries found occasionally in Black Sea cetaceans (Table 16.3) were not attributed to the above-mentioned types of pathologies, although most inflammatory lesions in integument tissues and internal organs could be possibly caused by known (but not isolated) viruses, bacteria, fungi and helminths. The current knowledge on non-infectious diseases (*e.g.*, tumours, arteriosclerosis) and congenital anomalies is very limited. Parallel skin scars caused by intraspecific interaction are the most frequent traumatic lesions recorded in bottlenose and common dolphins.

Environmental hazards

Cetacean mass mortality as a result of unfavourable hydrometeorological conditions is a rare phenomenon reported in the Azov Sea. There is only one well-known cause for these events: an extraordinarily rapid formation of ice preventing harbour porpoises from migrating into the warmer waters of the Black Sea through the Kerch Strait. Azov's mass mortalities as a result of ice entrapment were noted in 1941, 1944-1945 (Kleinenberg 1956), 1950 and 1993 (Birkun and Krivokhizhin 1997). Stormy weather was supposed as a probably important mortality factor for newborn bottlenose dolphins and harbour porpoises (Zalkin 1940 b, Kleinenberg 1956).

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Table 16.1 - Bacterial cultures (BC) and antibacterial antibodies (AA) detected in wild Black Sea cetaceans

Bacteria	Common dolphins	Bottlenose dolphins	Harbour porpoises	Uncertain cetaceans [a]
Leptospira interrogans		AA [d, g]	AA [d, g]	
Pseudomonas putida		BC [k]		
Pseudomonas alcaligenes		BC [j, k]		
Flavobacterium lutescens		BC [j, k]		
Alcaligenes faecalis		BC [j, k]		
Escherichia coli		BC [j, k]	BC [l]	
Salmonella typhi			AA [b]	
Salmonella schottmuelleri			AA [b]	
Salmonella enteritidis			AA [b]	
Salmonella spp.				AA [e]
Citrobacter freundii	BC [k]			
Klebsiella pneumoniae		BC [j, k]		
Klebsiella sp.	BC [k]			
Serratia liquefaciens			BC [k]	
Edwardsiella tarda			BC [k, l]	
Proteus vulgaris			BC [l]	
Proteus mirabilis		BC [k]; AA [h]		BC [l]
Yersinia enterocolitica				AA [i]
Vibrio proteolyticus		BC [j, k]	BC [l]	
Aeromonas hydrophila		BC [j, k]		
Aeromonas caviae		BC [j, k]; AA [h]		AA [b]
Chlamydia spp.			AA [f]	
Micrococcus luteus		BC [j, k]		
Staphylococcus aureus		BC [j, k]; AA [h]	BC [m]	BC [l]
Staphylococcus epidermidis		BC [j, k]	BC [j, k, l]	
Staphylococcus saprophyticus		BC [j, k]	BC [j, k]	
Streptococcus pyogenes			BC [m]	
Sarcina spp.		BC [m]	BC [l]	
Bacillus anthracoides			BC [l]	
Bacillus licheniformis		BC [j, k]		
Bacillus spp.		BC [j]	BC [l]	
Listeria monocytogenes				AA [d]
Erysipelothrix rhusiopathiae		AA [c]		AA [d]
Corynebacterium spp.		BC [m]	BC [k]	

[a] - bottlenose dolphins and/or harbour porpoises, but exactly not common dolphins
[b] - Lukyanenko (1964)
[c] - GABION (1983)
[d] - Gulov (1984)
[e] - Kilesso *et al*. (1986)
[f] - Lvova *et al*. (1986)
[g] - Reichuk *et al*. (1986)
[h] - YEVLAKH-2 (1986)
[i] - Yushchenko *et al*. (1986)
[j] - Birkun *et al*. (1988)
[k] - Birkun and Miloserdova (1989)
[l] - BLASDOL (1999)
[m] - unpublished data

Table 16.2 - Helminths of Black Sea cetaceans

Parasites	Common dolphins	Bottlenose dolphins	Harbour porpoises
Trematodes			
Campula palliata	+ [d]		
Braunina cordiformis		+ [f]	
Synthesium tursionis		+ [g]	
Pholeter gastrophilus	+ [k, l]	+ [k, l]	+ [i]
Cestodes			
Diphyllobothrium latum			+ [a]
Diphyllobothrium stemmacephalum		+ [d, h]	+ [a]
Nematodes			
Anisakis simplex			+ [a]
Halocercus kleinenbergi	+ [e]		
Halocercus taurica			+ [c]
Halocercus invaginatus (= *H. ponticus*)			+ [d]
Skrjabinalius cryptocephalus	+ [c]		
Stenurus ovatus		+ [d]	
Stenurus minor			+ [b]
Crassicauda sp. (*C. grampicola*?)	+ [k, l]	+ [k, l]	+ [j]

First mentionings:

[a] - Borcea (1935)
[b] - Delamure (1941)
[c] - Skrjabin (1942)
[d] - Delamure (1945)
[e] - Delamure (1951)
[f] - Delamure *et al*. (1963)
[g] - Delamure and Serdyukov (1966)
[h] - Delamure (1971 b)
[i] - Greze *et al*. (1975)
[j] - Krivokhizhin (1989)
[k] - Birkun *et al*. (1992 a)
[l] - Krivokhizhin (1992)

Table 16.3 - Miscellaneous pathological findings related to disease processes and anomalies in wild Black Sea cetaceans (infectious and parasitic injuries with known etiology are not included)

Pathological findings	Common dolphins	Bottlenose dolphins	Harbour porpoises
Respiratory system			
Foreign bodies (fishes, seaweed) in the airways	+ [n, p, s]		+ [s]
Cyst of nasal cavity			+ [u]
Purulent and necrotic broncho-pneumonia and bronchitis	+ [n, q, r, s]	+ [s]	+ [s]
Interstitial pneumonia	+ [s]		+ [s]
Chronic abscesses	+ [u]	+ [u]	+ [u]
Cyst of the lung	+ [m]		
Pulmonary anthracosis			+ [s]
Mineral grains in alveoli	+ [r]		
Serous pleuritis and focal thickening of visceral pleura			+ [s]
Pleural and pleura-pericardial adhesions	+ [n]		
Digestive system			
Worn teeth	+ [s]	+ [a, i, m, s]	+ [s]
Broken-off teeth		+ [s]	
Loss of tooth (teeth)		+ [s]	+ [s]
Caries			+ [s]
Anomalies of teeth			+ [s]
Necrotic (ulcerative) stomatitis, glossitis and pharyngitis	+ [q, r]	+ [s]	+ [s]
Foreign bodies in the stomach	+ [i]	+ [i]	+ [t]
Acute gastritis (incl. Erosions and ulcers)	+ [u]	+ [u]	+ [o, m, s]
Chronic gastric ulcers	+ [u]	+ [u]	+ [u]
Gastric tumour (carcinoma?)	+ [u]		
Necrotic gastroenteritis and chronic enteritis	+ [q, r]	+ [s]	+ [s]
Hepatitis (incl. cholangitis and pericholangitis)	+ [m, q, r, s]	+ [s]	+ [s]
Cyst of the liver			+ [s]
Liver degeneration (lipidosis of hepatocytes)	+ [r]		+ [k, s]
Hepatic cirrhosis (periportal fibrosis)	+ [u]		+ [s]
Focal thickening and scars of liver capsule	+ [u]		+ [s]
Focal pancreatitis		+ [s]	+ [s]
Cardiovascular system			
Focal myocarditis			+ [s]
Cor pulmonale (hypertrophy of right ventricle's wall and furcate heart apex)			+ [s]
Epicardium-pericardial adhesions	+ [u]		
Arteriosclerosis of aorta		+ [s]	+ [s]
Nervous and endocrine systems			
Focal leptomeningitis and encephalitis			+ [s]
Atypical adrenal gland (quadrangular or spindle-shaped)			+ [s]
Cysts of adrenals			+ [s]
Foci of suppurative inflammation in adrenals		+ [s]	
Calcifications in adrenal stroma			
Adrenal haemorrhages	+ [n, r]		+ [s]
Urogenital system			
Interstitial nephritis	+ [r]	+ [s]	+ [k, s]
Renal and ureteral calculi (nephro- and ureterolithiasis)	+ [i]		
Cyst of the kidney			+ [s]

Pathological findings	Common dolphins	Bottlenose dolphins	Harbour porpoises
Focal fibrosis in renal cortex			+ [s]
Anomaly of kidney (islets of embryonal tissue)			+ [k]
Dilatation of the ureter			+ [u]
Vaginal calculi	+ [f, g, h, i]		
Testicular fibroma	+ [r]		
Immune system			
Suppurative and necrotic splenitis	+ [s]	+ [s]	+ [s]
Siderotic nodules in the spleen	+ [r]		
Anomaly of spleen (long vascular bundle)			+ [s]
Fibrous atrophy and lymphoid depletion of the spleen and lymph nodes	+ [q, r, s]	+ [s]	+ [s]
Suppurative lymphadenitis	+ [n, r, s]	+ [s]	+ [k, o, s]
Anthracosis of pulmonary lymphnode			+ [s]
Integument			
Skin scars	+ [s]	+ [j, s]	+ [k, o, s]
Hypo- and hyperpigmented epidermal spots		+ [j]	+ [k]
Albinism (partial or total)	+ [b]	+ [s]	+ [c, d, i]
Unspecified dermatites	+ [r]	+ [s]	+ [s]
Subcutaneous haematomas			+ [l, o]
Hypodermic abscesses			+ [k, s]
Emaciation (thin blubber layer)	+ [m, r]		+ [s]
Bones and muscles			
Signs of former fractures (ribs, vertebrae, low jaw)	+ [m]		+ [o, s]
Lordoscoliosis and kyphoscoliosis	+ [m]	+ [u]	+ [u]
Atrophy of back muscles	+ [m, r]		+ [u]
Rudimentary hind extremities	+ [e]		
Digit-like appendices on pectoral fins	+ [s]		
Anomalies of ribs (additional bones and joints)			+ [u]
Other localizations			
Polycystosis (multiple cysts in lungs, kidney, testicles and epididymes)			+ [o]
Jaundice (with the yellowing of eye sclera, oral cavity, blubber, internal organs, intima of blood vessels)	+ [u]		
Ascites	+ [r]		+ [s]
Benign mesenchymal tumours of peritoneum			+ [s]
Mesenteric abscesses			+ [s]
Peritoneal interorganic (*e.g.*, hepato-gastric) adhesions	+ [u]		

[a] - Silantyev (1903)
[b] - Malm (1933)
[c] - Kleinenberg (1936)
[d] - Zalkin (1938)
[e] - Sleptsov (1939)
[f] - Sleptsov (1941)
[g] - Sokolov (1953)
[h] - Sokolov (1954)
[i] - Kleinenberg (1956)
[j] - Belkovich *et al.* (1978)
[k] - Birkun and Oleinik (1984)
[l] - Zemsky *et al.* (1986)
[m] - Birkun *et al.* (1990 b)
[n] - Krivokhizhin and Birkun (1991)
[o] - Birkun *et al.* (1992 b)
[p] - Birkun (1996 a)
[q] - Birkun *et al.* (1996)
[r] - Birkun *et al.* (1999 b)
[s] - BLASDOL (1999)
[t] - Krivokhizhin *et al.* (2000)
[u] - unpublished data

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 17

Overview of Known or Presumed Impacts on the Different Species of Cetaceans in the Mediterranean and Black Seas

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Two main approaches exist for the evaluation of the status of cetaceans with respect to human threats: the threat-based approach and the population-based approach (Whitehead *et al.* 2000). Both approaches have at the same time merits and drawbacks. We suggest that by combining the available information together into a species-impact table, a comparison between the two approaches and the types of indication that can be derived can provide useful insight.

Table 17.1 (the "species-impact" table) was created with the intent of providing an overview of the impacts from the various threat factors on the different species in the Agreement area. Impacts were subdivided into two main categories: those liable to be causing "mortality and damages inflicted by human activities", and the components of "habitat degradation and loss". Four possible scores were given: (1) impacts known or presumed to be of primary importance, (2) impacts known or presumed to be of secondary importance, (3) impacts likely to be insignificant, and (4) impacts for which there is insufficient data, thus needing further research. Scores in each cell were contributed separately by each of us on the basis of published knowledge integrated by our personal experience and opinion, and where divergences existed consensus was reached through discussion. Obviously the procedure that was followed to construct the table could not rest on objective data. Therefore, the information provided should be only viewed as a first indication having an orientation value, deriving from our collective judgement, to be replaced as soon as possible with data collected according to rigorously designed protocols.

The following definitions were used:

Intentional and direct takes: killing or capture of cetaceans for use of products for human consumption or other, live capture, hostile acts provoked by actual or perceived damage to fishing activities, sport, and no apparent reason.

Accidental takes in fishery activities: mortality or damage[1] inflicted through the accidental entanglement in fishing gear of all types (including passive and active nets, longlines, traps, discarded or lost nets and lines, gear accessories, etc.) and illegal fishing practices (e.g., use of dynamite).

Collisions and accidents with vessels: mortality or damage inflicted through collisions with the hull, prow, propeller blades, rudder or any other part of a vessel.

Prey depletion: depletion of food resources caused by the direct and indirect effects of fishing activities and overfishing.

Contamination by xenobiotic compounds: accumulation in the body tissues (mostly through the food web) of xenobiotics (including POPs and trace elements) known to adversely affect mammalian functions and health.

Oil pollution: mortality or damage deriving from contamination, contact or ingestion of hydrocarbons deriving from oil spills and oil derivates at sea.

Ingestion of solid debris: mortality or damage deriving from the ingestion of foreign objects and materials, such as plastic, wood, textiles, etc. (in general obstructing part of the digestive tract).

Acoustic pollution: mortality or damage deriving from exposure to impulsive or prolonged man-made sound reaching noxious intensity and/or frequency levels.

Disturbance: behavioural disruption through intentional or non-intentional approaches, likely to induce long-term effects in the population.

Ecosystem and climate change: likeliness that the population will be affected by changes in the ecosystem, which may be deriving from climate change or from other man-made factors, including eutrophication, harmful algal blooms, prey depletion resulting from habitat degradation, alien species invasions, etc.

Epizootics: susceptibility of the population to mass mortality events deriving from the spread of epizootic disease.

By examining table 17.1 along the species rows, we can see that for some species (e.g., striped, bottlenose and common dolphin in the Mediterranean, harbour porpoise in the Black Sea) the number of factors having a known or presumed impact of primary importance is high (=2). For other species the number of factors for which data are insufficient is too high to enable any reasonable inference (e.g., sperm whale, Cuvier's beaked whale, pilot whale, Risso's dolphin, harbour porpoise in the Mediterranean).

It is important to note that it is impossible to derive from the table an indication on which species is most endangered, given that a single factor for one species may have a greater impact on its survival than a sum of factors on another. We must thus warn against a potential misuse of the information contained in the table. It is of paramount importance to consider, while attempting to assess and evaluate the complex of impacts

[1] For "**damage**" we intend physical trauma, pathological effects, physiological disruption, behavioural disruption, or displacement/extirpation from the species' critical habitat in the Agreement area.

any single species is subjected to in the study area, a multiplicity of elements, including the status of the population itself based on data on population size, trends and parameters, and the biological and ecological effects that each impact, alone and in conjunction with the others, has on the survival of the individuals and of the population as a whole. The importance can never be stressed enough of considering the composite effects deriving from the combination of different impacting factors, and thus the need of adopting a holistic approach when considering threats. Furthermore, we note that many impacting factors (e.g., bycatch, disturbance, direct kills, etc.) are quite patchily distributed throughout the Agreement area, being present and possibly acute locally, and inexistent in other portions. Conditions, however, are dynamic and may change rapidly across the region as human activities evolve and modify. Although single impactors may be only significant for a portion of a population today, we have chosen to emphasize their potential importance at the regional scale. This population-based approach is very useful for the establishment of management priorities on a regional basis, and will be again discussed in Section 18 of this report.

Examining the single impacts in table 17.1, it is clear that for some impacts the available information is sufficient to provide an initial idea of their relative importance (e.g., intentional takes, collisions, solid debris, disturbance), whereas in other cases our ability to make any assessment is nil due to lack of information or to the intrinsic complexity of the considered factor (e.g., oil pollution, noise, ecosystem and climate change, epizootics). For some of these factors their inclusion in the table is thus largely justified as a means of emphasizing our state of ignorance, thereby attracting attention on research needs and priorities. This problem can be exemplified by the complexity of the threat posed by epizootics. Both Mediterranean striped dolphins and Black Sea common dolphins suffered morbillivirus epizootic some years ago. On this basis, these species can be considered at risk as far as this threat is concerned. However, since almost all individuals in these populations were probably infected by the virus, those which survived overcame the disease by producing antibodies. Taking this into account we can thus arrive to the opposite conclusion, i.e. that these populations are currently protected against suffering another morbillivirus epizootic (although not against an epizootic caused by another agent), so their risk could be scored as lower than for other species. The matter, however, is further complicated considering that the individuals that survived the epizootic years ago are now progressively being replaced by younger individuals that were never exposed to the morbillivirus; so the risk for these populations is again steadily increasing; eventually, when the "old" generation will be completely replaced, the risk of suffering a morbillivirus epizootic will be again high. Furthermore, other aspects connected with epizootics, including for example the incidence of triggering factors (immunosuppressing pollutants, decreased food availability, etc.), are very difficult to assess and probably very different among species or even populations.

Impacts like accidental takes in fishery activities, contaminants, and disturbance are perceived as very diffused across species, both in the Mediterranean and in the Black Sea. Other impacts, by contrast, seem to be more limited, such as collisions (only affecting the largest species), and direct takes (only for the smaller species). Fishery bycatches and contamination by xenobiotics are perceived as primary factors impacting a greater number of species, while intentional takes, ingestion of solid debris and disturbance are seen as been largely of secondary importance.

The massive number of cells for which we felt that insufficient data are available, however, makes most first-glance assessments an ineffectual exercise, and points forcefully towards the urgent need for targeted research. In particular we want to emphasize that among the types of information which are still unavailable, and yet of paramount importance for an accurate assessment of the levels of each threat, a prime position is occupied by knowledge on population sizes. The need to obtain at least an order of magnitude for the sizes of the cetacean populations of all species in the Agreement area is strikingly evident. Such knowledge should eventually enable the evaluation of possible population declines due to the different impacting factors, and ultimately elucidate the relative importance of such factors by applying criteria analogous to those adopted by IUCN for evaluating species status and assess extinction risks (Anon. 2000).

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Table 17.1 - The "Species-Impact" Table

SPECIES		KNOWN OR PRESUMED IMPACTS										
		Mortality and damages inflicted by human activities			Habitat degradation and loss							
		Intentional and direct takes	Accidental takes in fishery activities	Collisions and accidents with vessels	Prey depletion	Contamination by xenobiotic compounds	Oil pollution	Solid debris	Noise	Disturbance	Ecosystem and climate change	Epizootics
Fin whale				■	?		?		?	▒	?	?
Sperm whale			■	■	?	?	?	?	?	▒	?	?
Cuvier's beaked whale			?		?	?	?	▒	■	▒	?	?
Long-finned pilot whale			■		?	?	?	?	?	▒	?	?
Risso's dolphin			?		?	?	?		?	▒	?	?
Striped dolphin		▒	■		▒	■	?	?	?	▒	?	?
Common bottlenose dolphin	MED. S.	■	▒		■	■	?		?	▒	?	?
	BLACK S.	▒	▒			▒	?	▒	?	▒	■	?
Short-beaked common dolphin	MED. S.	?	▒		■	■	?		?	▒	?	?
	BLACK S.		▒		▒	▒	?		?		▒	?
Harbour porpoise	MED. S.	?	?		?	?	?	?	?	?	?	?
	BLACK S.	?	■		▒	■	?		?	■	■	?

■ Impact known or presumed to be of primary importance

▒ Impact known or presumed to be of secondary importance

☐ Impact likely to be insignificant

? Insufficient data, need for targeted research

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 18

Conservation Needs and Strategies

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GENERAL CONSIDERATIONS

This section of the report is conceived to provide baseline information needed by managers and decision makers in the process of devising and implementing policies and strategies to ensure cetacean conservation and, wherever necessary, recovery in the Mediterranean and Black Seas.

Policies should be developed to form a basis for the management of human activities affecting, or likely to affect, cetaceans in the Agreement area. Such policies will:

- provide the appropriate framework for the development of remedial measures, guidelines and codes of conduct to regulate or manage human activities impacting on cetaceans;
- give priority to conserving those species or populations identified as having the least favourable conservation status;
- stimulate the undertaking of research in areas or for species for which there is a dearth of data;
- indicate the need for impact assessments to provide a basis for either allowing or prohibiting the continuation or the future development of activities that may affect cetaceans or their habitat in the Agreement area, including fisheries, vessel traffic, military operations, offshore exploration and exploitation, nautical sports, tourism and whale watching;
- establish the conditions under which such activities may be conducted.

In implementing these policies it will be particularly important to take into account and act synergistically with other bodies playing a role in cetacean conservation. These include: (a) national governments that are already actively endeavouring in cetacean conservation policies and measures, (b) non-governmental organisations that are active in the field of marine protection, and (c) international agreements and conventions. Of these, the following are particularly relevant to the issue of cetacean conservation: the parent convention to ACCOBAMS, the Convention on Migratory Species (CMS, the Bonn Convention); the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention); the Barcelona Convention (which includes, among others, a Protocol concerning Specially Protected Areas of Mediterranean Importance and Biological Diversity containing precise obligations for the Contracting Parties); the Convention on the Protection of the Black Sea against Pollution (Bucharest Convention); the Convention on Biological Diversity (CBD); the World Heritage Convention; and the Convention on the Regulation of Whaling. In particular, as far as the Black Sea is concerned, all governments of the riparian countries have adopted a "Strategic Action Plan for the Rehabilitation and Protection of the Black Sea" (Istanbul, 1996) which promotes concerted policy actions aimed to the reduction of pollution, the management of living resources, and the sustainable human development in the subregion. The box below contains a quotation from that document (Section "Biological diversity protection", Paragraph 62) devoted to special measures for Black Sea marine mammals conservation.

A number of different strategies aimed at the achievement and maintenance of the favourable conservation status of cetaceans in the Agreement area are discussed in the following sections, as outlined in the Conservation Plan (Annex 2 of the Agreement). These include:

1. managing human activities (including fisheries, vessel traffic, whale watching, and activities that cause cetacean habitat degradation and loss) to mitigate negative impacts on cetaceans;
2. granting special protection to areas containing critical cetacean habitats;
3. undertaking targeted research and monitoring programmes;
4. providing for timely responses to emergency situations;
5. promotion of training, education and awareness programmes;
6. finally, with a special consideration for the complex and different weight of the various factors impacting on the different species present in the Agreement area (Table 17.1, Section 17), a number of actions are proposed as having priority importance in the coming years.

Strategic Action Plan for the Rehabilitation and Protection of the Black Sea
(Adopted by the Ministers of Environment on behalf of Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine, Istanbul, 31 October 1996)

Paragraph 62. With the aim of restoring populations of marine mammals, the following measures shall be taken:

a) A ban on the hunting of marine mammals will be enforced by all Black Sea states with immediate effect;

b) Regular population assessments of marine mammals shall be conducted and the first assessment will be completed in 1998. It is advised that these assessments be coordinated by the Istanbul Commission, through its Advisory Group on the Conservation of Biological Diversity;

c) The Centre for the Conservation of Biological Diversity in Butumi, Georgia, shall be provided with the necessary equipment in order to function as a regional rehabilitation centre for captive marine mammals;

d) National centres and sanctuaries for the rehabilitation of marine mammals shall be strengthened;

e) Consideration shall be given to modify fishing practices in order to avoid catching marine mammals, as by-catch, during normal operations. It is recommended that the Istanbul Commission, through its Advisory Groups on the Conservation of Biodiversity and its Interim Advisory Group on Fisheries, develop a strategy for the reduction of by-catches of marine mammals.

MANAGING HUMAN ACTIVITIES TO MINIMISE AND MITIGATE NEGATIVE IMPACTS ON CETACEANS

Article 2 of the Conservation Plan (Annex 2) of the Agreement states: "*Parties shall, in co-operation with relevant international organizations, collect and analyse data on direct and indirect interactions between humans and cetaceans in relation to inter alia fishing, industrial and touristic activities, and land-based and maritime pollution. When necessary, Parties shall take appropriate remedial measures and shall develop guidelines and/or codes of conduct to regulate or manage such activities*." The following sections address in detail such recommendation.

A. Mitigation of the negative effects of interactions with fisheries

At the present moment, a system of fisheries policy which is common to the entire region does not exist. Rather, there is one policy common to the four EU member states, and separate policies for the remaining nations. Adopting a common policy on a basin-wide, or region-wide scale would be highly desirable under many aspects, not least as far as cetacean conservation is concerned. Other policy aspects that would significantly benefit marine (and therefore cetacean) conservation in the Agreement area include the adoption, wherever possible, of a community-based system of resource use, and of an ecosystem-based management approach. Furthermore, the current lack of reliable, detailed and regularly updated information on fishery activities in the Agreement area (including, among many other things, cetacean bycatch levels) is a major hindrance to effective management (Caddy 1998). This would involve, among other things, the promotion of co-ordinated, multidisciplinary research and monitoring to provide baseline biological information and to shed light onto ecosystem functioning.

Fishery activities, being particularly intense in the Agreement area (see Section 4.4), may negatively affect cetacean survival in three main ways: (a) by causing mortality or damage through accidental entanglement in active or discarded fishing gear, (b) by subtracting prey through overfishing, and (c) by causing direct mortality or damage through intentional kills deriving from competitive interactions (the use of cetacean meat as fishing bait or as food being probably irrelevant in the area). These three main factors possess different modalities and dynamics and must be treated separately.

Bycatch - One of the main problems in this field is lack of reliable information. Data on cetacean bycatch is not collected on a regular basis in any fishery in the Agreement area, and too often relevant knowledge is intentionally and carefully concealed by fishermen. Even if they were available, however, bycatch levels data cannot be evaluated in terms of impact on the populations since population size data are almost totally absent in the region. Bycatch levels and fisheries effects have thus been based often on guess-based extrapolations, in some cases to the detriment of the fishermen themselves.

Pelagic driftnets for swordfish and albacore are responsible for the greatest numbers of bycaught cetaceans in the Mediterranean, while bottom gillnets for turbot, sturgeon and dogfish are the most harmful in the Black Sea subregion. The ban on driftnets from European Union fleets (effective 1 Jan. 2002) does not solve the problem on a regional basis, since many non-EU nations have meanwhile apparently been increasing their driftnet effort. However, we could not find reliable information on this subject. A high priority in this field is thus to gather detailed information on effort and bycatch wherever fishing with driftnets and bottom gillnets still occurs, and assess the levels of bycatch in function of the size of the by-caught populations in the different areas.

Other fishing methods known to cause accidental capture of cetaceans in the area include purse seines (mostly for tuna), trawling, longlines, trammel and trap nets, including traditional coastal tuna traps ("tonnare"). Again, the obvious priority here is to acquire detailed knowledge on cetacean bycatch in the different gears, and compare each with bycatch in the driftnets and bottom gillnets and with total bycatch.

Once bycatch levels are known for single populations for which sizes are also known, it will be possible to assess for each population the limits within which removal through bycatch is safe (e.g., potential biological removal, PBR; see Wade 1998).

In those cases in which bycatch levels will exceed such limits, reduction measures are needed. These may include:

<u>Setting bycatch limits above which the fishery is closed</u>.

<u>Adoption of time/area fishing closures</u>. The success of such strategy depends on a detailed knowledge of dynamics of the fishery and of the biology and behaviour of the cetacean species involved (Reeves *et al.*, in prep.). Time/area closures are likely to be successful particularly when the bycatch problem is highly localised and predictable in time and space (Murray *et al.* 2000).

<u>Encouraging alternative ways of fishing</u>. This may involve technological changes and gear improvement to enhance selectivity, and training of fishermen on the use of devices or procedures to reduce bycatch. Recently, the deployment of acoustic warning devices ("pingers")[1] to prevent cetacean entanglement in gillnets has been effective in reducing bycatch rates in some fisheries and for certain cetacean species. However, it must be clear that although alarms may have an important conservation role, their use in a particular area and fishery should be conditional on: (a) demonstration of long-term effectiveness through controlled scientific experiments, (b) completion of field trials to address practical issues related to implementation, and (c) establishment of a long-term scientific monitoring programme, preferably involving independent on-board observers (Reeves *et al.* 2001). Moreover, acoustic warning devices should not be regarded as a panacea for solving all by-catch problems. Their use by fishermen can create new problems or exacerbate old ones. Perhaps most importantly, it can lead people to believe that continued fishing is "safe" in an area where an endangered cetacean population is at risk (Reeves *et al.* 2001).

<u>Promotion of eco-compatible mariculture (fish farming) as an alternative source of competitive fish products for fish markets in the Agreement area</u>. In particular, this long-range strategy should be directed to the gradual substitution of active fisheries with modern fish cultivation technologies presenting far lesser threats to cetaceans, as well as reducing competition levels between dolphins and fisheries and preventing of prey depletion through overfishing.

<u>Identifying the environmental, biological and technological reasons why bycatches occur</u> is another important direction of action (Hall 1995).

[1] It is quite important to understand that acoustic devices used to address the various problems of cetacean-fisheries interactions fall into two very distinct functional classes. "Pingers" are **<u>low-level</u>** devices that are used to **<u>warn</u>** cetaceans about the presence of a net in the area, so that the animal increases its attention level and hopefully avoids becoming entangled. **<u>Acoustic deterrents devices (ADD)</u>** and **<u>acoustic harassment devices (AHD)</u>** are high-level instruments originally developed to actively displace pinnipeds from aquaculture installations by producing a noxious sound; ADDs and AHDs are increasingly considered as possible ways to keep dolphins away from coastal fishery operations in the Mediterranean.

Regulations should be introduced and implemented to prevent fishing gear from being discarded or left adrift at sea.

Incidental mortality can also be reduced through rescue and release efforts. It is thus important, in such cases, to require the immediate release of cetaceans caught incidentally in fishing gear in conditions that assure their survival. Efforts to rescue cetaceans bycaught in fishing nets may be difficult and risky for both the entrapped cetaceans and their rescuers, but they are often successful. Such attempts may not only address the welfare of the individual animal entangled, but also represent a significant contribution to the conservation of a threatened species, and provide benefits in terms of public awareness and education. However, rescue efforts of all kinds are not equally justified and it is important to weigh the potential conservation, animal welfare, and scientific benefits against the possible negative outcomes (Reeves *et al*., in prep.).

Finally, education programmes benefiting fishermen and well-designed public awareness campaigns are also an essential component of any mitigating strategy.

Competition between dolphins and fisheries - The problem of small-scale coastal fisheries being damaged by depredation from dolphins, a condition apparently on the increase in many Mediterranean and Black Sea locations, certainly needs a close attention. In this case, unlike in the bycatch problem, it is the fishermen who are affected and damaged in the first place, however in the end cetaceans also lose as fishermen embark on various retaliatory actions that often result in dolphin mortality or damage. The dynamics of such depredatory activities by dolphins are far from being understood: within the Mediterranean there are areas in which dolphins and fishermen coexist peacefully, while in other, often adjacent areas interactions are quite problematic.

Government agencies and international bodies should begin developing and articulating management goals for mitigation of fishery-dolphin conflicts so that it will be possible to make meaningful evaluations of the effectiveness of any adopted measure.

The first aspect to address in this case clearly involves the elucidation of interaction mechanisms through targeted research and monitoring programmes. Very little quantitative information exists on the nature and extent of interactions between dolphins and small-scale commercial fisheries in the Mediterranean, the costs of such interactions to the fisheries, or the effects of such interactions on dolphin populations. Such quantitative data are entire lacking in the Black Sea subregion. A complete inventory of the sites where interaction problems exist should be compiled, and site-specific studies should be carried out focussing on the characteristics of particular fisheries and on the ecology and behaviour of 'local' dolphin population(s). More information is needed on the characteristics of the depredating dolphins, particularly on their identity, age and sex; this should be achieved through photo-identification studies and the monitoring of dolphin distribution, abundance and mortality in the interaction areas.

Acoustic devices (AHDs), designed to deter dolphins from approaching and depredating nets, have been regarded as a possible solution to the problem, and may be useful in some cases. However, they have the potential to damage the hearing of dolphins and other animals and to cause other impacts, such as habitat exclusion. Furthermore, the effects of acoustic exposure are highly species-specific and depend on each species' frequency sensitivity, and on the received level of the sound. To address this issue and discuss possible solutions and implications of the use of AHDs in Mediterranean coastal fisheries, an international Workshop was convened by ICRAM in Rome in May 2001 (Reeves *et al*. 2001). Available data suggest that ultrasonic, low-intensity devices are most likely to be effective for deterring odontocetes while having the least probability of causing harm to other species. The Rome Workshop concluded that, given (a) what is currently known about the physiology and behaviour of Mediterranean coastal dolphins, (b) the potential for excluding dolphins from habitat (and consequent implications for the health of local dolphin populations) and (c) the potential for negative effects on monk seals and other endangered marine fauna, high-intensity acoustic devices such as those currently marketed as AHDs and used to deter pinnipeds from aquaculture operations are inappropriate for use in alleviating conflict between dolphins and fisheries (or aquaculture operations) in the Mediterranean. This conclusion applies irrespective of the potentially high, or even prohibitive, costs of deploying these devices in the Mediterranean context. Furthermore, use of AHDs in the Mediterranean may contravene current national and international regulations.

The Workshop also noted that non-acoustic means of reducing conflicts between dolphins and fisheries hold considerable promise and deserve detailed evaluation. These include, among others, the experimentation of non-acoustic aversion techniques, the devising of fishing techniques that are less liable to attract dolphins, the development of dolphin watching activities to complement revenues from fishing and convert the presence of dolphins from damaging to value, and the adoption of compensation schemes.

Prey depletion through overfishing - Given the generalised state of depletion of fishery resources in the Mediterranean and Black Seas, a likely consequence in many areas is that ichthyophagous and teuthophagous cetacean populations are affected (see Sections 9 and 10)

Clearly, fisheries management in the Mediterranean and Black Seas is a far-reaching issue that raises major social, economic and environmental concerns involving relevant portions of three continents, and goes well beyond the limited scope of a report concerned with the conservation of a single taxon of marine endangered species. The problem of inadequate fisheries management in the Mediterranean and Black Seas should be addressed and solved on other tables, and all we can remark here is discouragement in noting what little, if any, progress is being made in this field at the present time.

One essential component of such management involves the collection and dissemination of reliable data, and this should include an adequate effort to understand predator-prey interactions and ecosystem functioning. Such data, applied to ecosystem modelling, would certainly help to elucidate the complex ecological interactions between cetaceans, fisheries and other ecosystem components.

B. Mitigation of disturbance

Disturbance from vessel traffic and collisions. Vessel traffic is most intense in the Agreement area, as a reflection of the large volume of its coastal and marine economic activities and the high levels of its human coastal populations. It is obviously unlikely that significant traffic reduction will occur specifically to decrease danger to cetaceans and other marine life. However, mitigating measures can be envisaged to reduce such danger. These include:

Monitoring, research and risk assessment. Accurate data on the seasonal and geographic distribution of traffic, and its volumes, routes, typologies, and possible evolution trends in the Agreement area are, to the best of our knowledge, unavailable at the moment in an organised, usable format. Such information, coupled with information on cetacean distribution and habitat use, would allow a first evaluation of a cause-effect relationship between marine traffic and cetaceans in terms of intensity of exposure. Furthermore, research on the possible long-term effects of traffic disturbance on cetacean populations survival, through behavioural and physiological change, loss of energy intake, and area displacement, should be undertaken to elucidate this still quite poorly understood aspect.

Where impacts from traffic are known or suspected, recommendations (and possibly, in critical habitat, regulations) can be envisaged and provided to shipping operators in terms of minimum approach distances, speed limits when near cetaceans, and the following of pre-determined routes. Areas containing known cetacean critical habitats may be subjected to limited access.

Recommendation and regulation should be accompanied by appropriate awareness and education campaigns, to inform user groups of the potential impact of traffic on cetaceans and to provide codes of conduct to minimise disturbance.

Collisions between vessels and cetaceans are an extreme consequence of the impact of vessel traffic on cetaceans, and very often result in physical damage to both the cetacean and the vessel involved, and thus a source of cetacean mortality. Given the perceived increasing importance that this threat is acquiring in the Agreement area, the theme of collisions should receive special attention. The case of the North Atlantic right whale provides a relevant illustration on how the problem of collisions between vessels and individuals from the world's most endangered whale species has been addressed elsewhere (Marine Mammal Commission 1999). Off the east coast of the U.S. the movements of individual whales are being monitored and communicated to ships in their vicinity; underwater listening stations have been set up to identify areas of concentration; the species' distribution has been correlated with oceanographic features to produce GIS-based distributional predictive models; and, finally, a variety of active acoustic devices to detect animals in front of the ships are being developed and tested.

All measures listed above, aimed at mitigating the negative effects of vessel traffic on cetaceans, will also contribute to address the collision issue.

Of particular importance are of course actions involving the collection of detailed and complete information on collision events and on their modalities and dynamics, and accurate awareness and involvement activities targeting ship captains and crew.

In addition, the following actions can also be envisaged where collision problems are known to be substantive:

Solutions aimed at a general decrease of risk in special areas. Zones containing critical habitat of cetaceans susceptible to be impacted by colliding vessels should be identified (also on the basis of mathematical models designed to predict risk levels) and delimited, and speed and/or tracks controlled within those limits, in the hypothesis (to be tested) that whales may become used to localised presence of traffic and pay more attention in the appropriate locations.

Solutions aimed at increasing the potential by the vessels of detecting and avoiding the whales. These include the creation of an information network among vessels to inform operators about the position of whale concentrations, based on both sighting and passive acoustic data provided by research teams; the establishment of permanent watches on the bridge during daylight, and the development of tools to enhance visual detection during the night and rough weather; the development of active acoustic devices (e.g., subsurface sonar) enabling the detection of whales in vicinity of the track line, at a useful distance. However, we must remark that active sonar devices have been regarded as technical fixes to solve collision problems on high-speed ferries in many parts of the world. Many problems exist in this respect (e.g., the tendency of sound to bend downwards in thermally stratified waters, thus reducing detection range to unworkable conditions; the small acoustic reflectivity of a whale body; concern about further ensonification of the whales' environment).

Solutions aimed at increasing the potential by the whales of detecting and avoiding vessels. This seems a most promising approach, since whales are certainly the most interested parties in avoiding a collision, and appear to excel in the art of naturally avoiding contact with vessels whenever they are aware of their presence. A better understanding of the vessel detection capabilities by the whales and of the exact reasons for their failure to do so effectively, ultimately leading to a collision, is a fundamental steppingstone in this direction. The problem very likely resides in the characteristics of the sound produced by the vessel and perceived underwater by the whales, which may be inadequate to convey the necessary information on distance, bearing, and speed of approach of the vessel itself. Once such knowledge is gained, conceivably the sound produced by the vessel could be modified or enhanced to provide more meaningful spatial information to the whales, improve their detection capabilities and allow their safe manoeuvring and avoidance.

Disturbance from whale watching activities - Whale watching (here intended as encompassing all types of cetacean watching, thereby including dolphin watching) is an activity which is gaining increasing popularity in many parts of the world, Mediterranean included, and likely to develop in the future also in the Black Sea. We believe that it is an activity which should be encouraged, given the substantial educational and economic assets that can be derived from it, which will ultimately benefit cetacean conservation; however, whale watching must be carefully managed to avoid distress and damage to the targeted cetacean populations.

From the management standpoint, whale watching can be divided into two broad categories: commercial whale watching, usually conducted aboard larger passenger vessels, and amateur whale watching, taking place mostly from private pleasure craft. Commercial whale watching is easier to manage and control than amateur whale watching. Managers and decision makers should be particularly concerned about the correct and rational management of whale watching in areas where this activity is new or in its early stage of development, and where the cetacean populations involved are naïve, such as in most of the suitable whale watching locations in the Agreement area.

Whale watching management regimes are being developed in many parts of the world; a useful review is provided by Carlson (1996). Common management measures include minimum approach distances, maximum speed and the prohibition of chasing whales, altering the whales' behaviour or separating a whale from its group, limits to noise production in air and in water, and a limitation to the number of vessels around a whale or group of whales at any time. In the following box a series of basic principles related to the management of whale watching was proposed by the Scientific Committee of the International Whaling Commission in 1996. We suggest that these principles should be adopted as a starting point for the preparation of both guidelines, codes of conduct and regulations of whale watching in the Agreement area.

A critical aspect of managing whale watching is the determination of the 'carrying capacity', or the amount of whale watching that is sustainable by the population involved over the long term. Carrying capacity is tightly related to a number of factors, including the behavioural and ecological characteristics of the whale population, the operational characteristics of the whale watching industry, and to the environmental variables of a specific area. The following management steps are advised before whale watching activities become firmly established, with the implementation of major capital investment and commercial scale promotions.

First, basic knowledge of the biology and ecology of the species involved (e.g., population parameters, behaviour, seasonal changes, and frequency of occurrence) , as well as the local ecological conditions (e.g., local currents, weather, and distance from shore), should be made available before the start of operations. These preliminary data will be necessary for an initial, rough evaluation of the potential impact of whale watching activities, and should be later followed by the acquisition of more detailed knowledge on the differential susceptibility of cetaceans to disturbance depending on their age, sex and individual variability. The ultimate goal of this research is to gain information on possible impacts of whale watching at the population level.

Second, guidelines and voluntary codes of conduct based on common sense and existing scientific knowledge should be made available to both commercial operations and pleasure boaters likely to engage in amateur whale watching. Operators should be encouraged to adopt such guidelines, and should explicitly inform their customers about this by both making available printed versions of the code of conduct they have adopted on board their vessels and demonstrating with their behaviour that this code is being followed. This would help to expose incorrect conduct in presence of whales to public judgment, comment by the media, and peer pressure, while the same factors would serve to reward respectful behaviour. Unlike commercial operators, amateur whale watchers are controllable to a much lesser degree.

Third, binding laws and regulations should be promulgated by national authorities wherever whale watching becomes an established practice. Regulations should always be accompanied by monitoring of the activities, enforcement, and the possibility for law enforcing agents to provide sanctions to the offenders. In addition to traditional top-down enforcement through respect of the law, bottom-up mechanisms should be encouraged to place on the consumers a large part of the burden of control. In this respect the adoption of "ecolabels" and the establishment of operators' associations clearly committed to optimal standards may have substantial influence on the overall conduct and sustainability of operations in a given area.

Fourth, an accurate inventory of activities and operators should be kept from the outset of commercial operations in any given area. This should include the establishment of databases on categories of whale watching operations, and data on effort, areas, times, numbers of passengers, income, animals encountered, *etc*. An accurate monitoring of operations, coupled with analyses of economic and social performance, should be performed in conjunction with scientific monitoring. It is in fact quite important that commercial whale watching will provide opportunities for both research and education, as this will at the same time contribute to minimise the impact and optimise results. To achieve this, the presence of trained research and education personnel on board should be highly encouraged on small operations, and made compulsory on larger enterprises.

The box below contains three general principles for whale watching developed in 1996 by the Scientific Committee of the International Whaling Commission. The first principle is directed primarily at managers, the second and third mainly at operators.

General Principles for whale watching determined by the Scientific Committee of the IWC

1) Manage the development of whale watching to minimise the risk of adverse impacts:

(a) implement as appropriate measures to regulate platform numbers and size, activity, frequency and length of exposure in encounters with individuals and groups of whales; management measures may include closed seasons or areas where required to provide additional protection; ideally, undertake an early assessment of the numbers, distribution and other characteristics of the target population/s in an area;
(b) monitor the effectiveness of management provisions and modify them as required to accommodate new information;
(c) where new whale watching operations are evolving, start cautiously, moderating activity until sufficient information is available on which to base any further development;
(d) implement scientific research and population monitoring and collection of information on operations, target cetaceans and possible impacts, including those on the acoustic environment, as an early and integral component of management;
(e) develop training programs for operators and crew on the biology and behaviour of target species, whale watching operations, and the management provisions in effect;
(f) encourage the provision of accurate and informative material to whale watchers, to:
- develop an informed and supportive public;
- encourage development of realistic expectations of encounters and avoid disappointment and pressure for increasingly risky behaviour.

2) Design, maintain and operate platforms to minimise the risk of adverse effects on cetaceans, including disturbance from noise:.

(a) vessels, engines and other equipment should be designed, maintained, and operated during whale watching, to reduce as far as practicable adverse impacts on the target species and their environment;
(b) cetacean species may respond differently to low and high frequency sounds, relative sound intensity or rapid changes in sound;
(c) vessel operators should be aware of the acoustic characteristics of the target species and of their vessel under operating conditions; particularly of the need to reduce as far as possible production of potentially disturbing sound;
(d) vessel design and operation should minimise the risk of injury to cetaceans should contact occur; for example, shrouding of propellers can reduce both noise and risk of injury;
(e) operators should be able to keep track of whales during an encounter.

3) Allow the cetaceans to control the nature and duration of 'interactions':.

(a) operators should have a sound understanding of the behaviour of the cetaceans and be aware of behavioural changes which may indicate disturbance;
(b) in approaching or accompanying cetaceans, maximum platform speed should be determined relative to that of the cetacean, and should not exceed it once on station;
(c) use appropriate angles and distances of approach; species may react differently, and most existing guidelines preclude head-on approaches;
(d) friendly whale behaviour should be welcomed, but not cultivated; do not instigate direct contact with a platform;
(e) avoid sudden changes in speed, direction or noise;
(f) do not alter platform speed or direction to counteract avoidance behaviour by cetaceans;
(g) do not pursue, head off, or encircle cetaceans or cause groups to separate;
(h) approaches to mother/calf pairs and solitary calves and juveniles should be undertaken with special care; there may be an increased risk of disturbance to these animals, or risk of injury if vessels are approached by calves;
(i) cetaceans should be able to detect a platform at all times; while quiet operations are desirable, attempts to eliminate all noise may result in cetaceans being startled by a platform which has approached undetected; rough seas may elevate background noise to levels at which vessels are less detectable.

Disturbance from research and documentation activities - Even modern, benign research, which refrains from lethal methods, can be invasive at times, and may lead to serious disturbance to the animals through harassment and direct damage. Potential harassing activities include, among others, close approaches for photo-identification, tagging & tracking, biopsy sampling, and experimenting with active acoustic techniques. Although a line must be drawn between non-lethal, yet clearly invasive research, such as that which involves the live capture of animals or the remote implant of large telemetry devices, and much less invasive techniques like photo-identification, it is important to invoke the greatest caution whenever animals need to be approached and affected by human presence.

It is important to note that research programmes involving the above listed methods are badly needed, in particular from the conservation standpoint. A large part of the scant knowledge on Mediterranean cetaceans was collected by such methods, thereby providing essential elements of strength to current conservation efforts. However, even the collection of minuscule skin and blubber biopsies performed by professional researchers can have unwanted, negative effects on the animals (e.g., Bearzi 2000). Therefore, all guarantees should be provided that: (a) research projects involving even mildly invasive techniques provide data clearly needed to address conservation issues, and (b) researchers undertaking such projects are knowledgeable, competent professionals, fully aware of the disruptive potential of their activities, and committed to appropriate dissemination of the results of their efforts through widely available scientific and technical media.

Similarly, photographers and film-makers engaging in documentary efforts on cetaceans and cetacean issues in the Agreement area can provide products that are quite useful to the cause of cetacean conservation through popularisation of scientific issues and awareness campaigns. Also in this case, however, it is important to ensure that: (a) the documentary material adequately conveys the conservation message, and (b) photographers and film crews are well-prepared, environment-concerned professionals, able to guarantee that their products are of high quality and have a reasonable expectation of wide diffusion.

In order to fulfil such requirements, it is important that an authority for issuing research and filming permits be provided for within the Agreement's purview. According to the Article II, Paragraph 2 of ACCOBAMS, the deliberate taking of cetaceans may take place only in emergency situations or, "after having obtained the advice of the Scientific Committee, for the purpose of non-lethal *in situ* research aimed at maintaining a favourable conservation status for cetaceans". The issuing of such permits should certainly be subjected to an assessment based on science and ethics.

It should be noted, however, that an objective evaluation of the impact of such activities should be considered within the general context of the overall impact of human activities on any given cetacean population. Activities from other groups of users of the sea, politically stronger than researchers or photographers, may carry a much heavier impact on cetaceans; it is thus important that regulatory attention be tuned according to the level of damage any activity may cause, rather than according to considerations of political opportunity.

Noise disturbance - According to the Barcelona and Bucharest Conventions, marine pollution includes energy alongside with substances introduced by humans into the marine environment. The conventions thus provide a legal basis for the regulation of underwater noise emissions in the Mediterranean and Black Seas.

Underwater noise is produced in the Agreement area by a variety of human activities which are largely at the basis of the region's economy. It is thus clearly unrealistic to expect that noise levels in the Mediterranean and Black Seas can be easily brought back to natural conditions. However, a number of options exist, and should be addressed, to strive for the reduction to tolerable levels of underwater noise and deriving disturbance to marine life. Strategies should be followed in terms of: (a) monitoring and research, (b) awareness, and (c) specific mitigation measures.

<u>Monitoring and research.</u> Very little, if anything, is known concerning the characteristics of underwater noise (e.g., spatial and temporal distribution, levels, frequencies, etc.) in the Agreement area. Monitoring of noise characteristics should be performed diffusely, and "hotspots of noisiness" should be mapped and checked against the presence of cetacean critical habitats. Activities that introduce high-level sound (e.g., explosions, oil & gas prospecting and drilling, military sonar) in areas that are inhabited by cetaceans should be monitored, inventoried, and assessed for their impact. A particular attention should be

given to areas and seasons that are of special importance to cetaceans. Studies can then be conducted to assess possible impacts of noise on communication, behaviour, and physiology of the concerned populations.

Awareness. Getting decision makers and the public at large to realise that underwater noise is an important issue in marine conservation, and particularly as far as cetaceans are concerned, is another essential step towards the proper addressing of the problem and the implementation of effective mitigation measures. It is thus important that scientific findings in this field be appropriately and correctly disseminated to reach the wider audience.

Mitigation measures. Shipping noise is largely due to the movement through water and cavitation of the ships' propellers. Regular maintenance of blades can reduce noise and cavitation as well as fuel consumption and travel efficiency, and should be highly encouraged. Effects of activities that involve the underwater use of explosives and of high-level impulsive sound (e.g., airgun, military sonar, coastal constructions, drilling) can often be mitigated if special precautions or technological innovations are used. For example, disposal through explosion of World War II ordnance located on the sea bed in Italy has been experimentally performed within curtains of air bubbles, thereby significantly reducing pressure wave propagation in the surroundings (Nascetti 1996). Other promising experiments involving the use of air bubble curtains also took place in Hong Kong, to reduce near-field noise levels in the vicinity of Indo-Pacific hump-backed dolphins (Würsig *et al.* 2000). Mitigation procedures, rules and policies were developed by NATO concerning the use of loud sonar devices after a mass stranding of Cuvier's beaked whales in Greece; such stranding, which was synchronous with nearby military exercises and experiments, suggested a very likely cause-effect relationship between the two events (D'Amico 1998). These high level sounds are liable to temporarily displace animals from an area or even cause hearing damage to the animals, so an assessment of the importance of that area for cetaceans is needed before operations start. Even if the area doesn't contain critical habitats for cetaceans, progressively scaling up the level of noise will warn cetaceans eventually present within range and allow them to distance themselves from the source before harmful levels will reach them. Finally, with sufficient knowledge of the ecology and habits of the involved cetaceans populations, military, industrial and prospecting activities can be seasonally timed to minimise impact.

C. Improvement of the quality of the marine environment

In a heavily populated region such as the Agreement area, where perspectives exist for further substantial increases in human population size and exploitation, addressing the problem of the quality of the marine environment, for cetaceans as well as for humans or any other living being, seems more a question of mitigating damage than one of solving the problem. There is increasing, compelling evidence that pollutants seriously affect both the health and survival of a wide range of living organisms, including ourselves. Too often still, particularly in the Agreement area, short-term economic considerations are made to prevail on basic human rights, environmental needs, and even economic convenience in the long-term. To address this problem and steer towards a condition of improvement, both management actions and research efforts can be proposed.

Management actions. A large number of international agreements and conventions exist which aim at the reduction and halt of the dispersion in the environment of noxious substances. Among these, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and various International Maritime Organisation (IMO) Conventions in the field of marine safety and prevention of marine pollution, are of primary importance. As far as the Mediterranean and Black Seas are concerned, of particular relevance are, respectively, the Barcelona Convention and the Bucharest Convention, with related Protocols. Protocols to the Barcelona Convention which are particularly relevant to the quality of the marine environment include the so called "Dumping Protocol", the "Oil pollution Protocol", the "Land-based sources Protocol", and the "Transboundary waste Protocol". Similarly, the Bucharest Convention include the following Protocols: the "Protocol on protection of the Black Sea marine environment against pollution from land based sources", the "Protocol on cooperation in combating pollution of the Black Sea marine environment by oil and other harmful substances in emergency situations", and the "Protocol on the protection of the

Black Sea marine environment against pollution by dumping". All these legal instruments (some of which still need to enter into force), once appropriately incorporated into the national legal systems of the Agreement's riparian States and into practice, will pave the way for significant improvement. Coastal habitats are obviously far more at risk than pelagic habitats, although contamination through bioaccumulation of POPs (persistent organic pollutants) in the food web is ubiquitous and pervasive. Therefore, integrated coastal zone management will hopefully promote a more rational use of coastal space and resources, bringing about an improvement of the environmental conditions.

Research. We now know a lot more than just a few years ago about the nature, composition and scale of marine pollution, and thus on what cetaceans are exposed to. However we still know very little about what the real effects of such pollution are on the survival of cetacean populations, on what is the relationship between exposure, individual health, and population survival, and on how synergies may develop between environmental stressors that will cause rapid negative reactions and effects. Quite a bit of research effort still needs to be undertaken through biomarker studies and new investigation technologies to shed light on mechanisms connecting toxicological, physiological and pathological issues in cetacean populations. Finally, critical habitats for cetacean populations, particularly as far as coastal species are concerned, need to be identified, to enable to devote special attention to these populations' basic needs in terms of food quality and quantity, environmental health, and levels of disturbance.

ESTABLISHMENT OF MARINE PROTECTED AREAS

Marine protected areas (MPAs) are increasingly recognised as a primary tool for the conservation of marine habitats and biodiversity (Agardy 1997). Whether MPAs can also effectively protect large, wide-ranging species, such as cetaceans, has been the subject of debate (Reeves 2001, Evans and Urquiola Pascual 2001). Clearly, it is rare that an MPA can be established to encompass a marine surface wide enough to contain the entire range of even the most sedentary of cetacean populations, and the implementation of problem-targeted management actions, more than area protection, obviously seems, in the case of cetaceans, a more effective conservation strategy. However, cases exist in which area protection can be an effective cetacean conservation tool, particularly when a combination of strategies, inclusive of problem-oriented actions, are implemented.

As far as protection of cetaceans is concerned, MPAs can either: (a) be established with the primary objective of conserving cetacean populations, or (b) they may have a more general set of objectives, including, among others, the conservation of cetacean populations, or finally, (c) they may contain cetacean habitat within their boundaries, and could thus serve the function of cetacean conservation if specific management objectives are set. Many coastal MPAs in the Mediterranean and Black Seas subregions fall into this last category. For instance, over 60 protected areas and sites are already established along the coastline of the Black and Azov Seas (Fig. 18.1), and an additional 40 areas are proposed for future protection (Fig. 18.2). The list of Mediterranean coastal MPAs is also very impressive. It is thus necessary to ensure that sufficient awareness exists among MPA managers and practitioners in the Agreement area concerning the presence of cetacean critical habitat within their premises, so that cetacean conservation measures are implemented, with the appropriate science-based support. Furthermore, it is important to create and maintain an overall inventory of the existent coastal MPAs, to help assess and enhance their real and potential effectiveness as far as cetacean conservation is concerned. Such regional network of MPAs, cooperating on a concerted basis in accordance with a common cetacean monitoring and conservation protocol, should be a second, important step to be undertaken.

Specially protected areas to protect cetaceans, where specific threats can be best controlled, can be created in the Agreement area once critical habitats of the various cetacean populations have been identified, and the effects of threats known. This could be best achieved through zoning mechanisms, providing that the ecology and behaviour of the population to be protected is known in sufficient detail. Such specially protected areas can be established within the framework of the Protocol for Specially Protected Areas and Biological Diversity (also known as the

"SPA" Protocol) of the Barcelona Convention, or of other appropriate instruments. As a less drastic measure, time/area fishing closures could be envisaged where bycatch is the greatest concern, and where the problem is highly localised and predictable in time and space. In this case, however, control and enforcement becomes more problematic.

At present the only MPA in the Agreement Area which was specifically created to protect cetaceans is the "International Sanctuary for Mediterranean Marine Mammals", also known as "Ligurian Sea sanctuary" (Notarbartolo di Sciara 2001), created by France, Italy and Monaco in 1999 and recently established as a SPAMI within the framework of the Barcelona Convention (Fig. 18.3). The Ligurian Sea sanctuary is special because it is the first worldwide example of an international MPA specifically designed to protect cetaceans, and also because, unlike any other protected area in it seeks to address the problem of protecting offshore waters. This problem presents unusual MPA design and management challenges, given that in pelagic ecosystems the desirable habitat conditions and the concentrations of key prey resources for cetaceans are known to shift in space and time (Hyrenbach *et al.* 2000).

We must caution that MPAs should not be considered a panacea, as their effectiveness must rest on concurrent measures to be fully realised. In many cases activities known to be harmful to cetaceans are permitted within MPAs: for example, pelagic driftnets in the Ligurian Sea sanctuary and the use of AHDs in the Egadi Islands MPA (western Sicily). MPAs may thus run the risk of giving a false impression of having granted protection to cetaceans, while the animals remain at risk in the absence of vigorous education, monitoring, and enforcement. It is thus of paramount importance that MPAs are established with a firm conservation commitment, and ensuring the involvement of different user groups (e.g., nature tourism operators and fishermen) who may ultimately benefit from the MPA itself.

SUPPORT TO CONSERVATION THROUGH RESEARCH ACTIVITIES

In the Conservation Plan of the Agreement the need is clearly acknowledged for the organisation of co-ordinated, concerted research on cetaceans and promotion of the development of new techniques to enhance their conservation. Research should include the monitoring of the status and trends of species covered by the Agreement, especially those in poorly known areas, or species for which little data are available, in order to facilitate the elaboration of conservation measures.

Although we must note that lack of sufficient information cannot serve as an excuse to delay action, it is clear that lack of solid scientific knowledge on cetacean ecology, biology and threats in the Agreement area is one of the greatest crippling factors in the way of effective conservation efforts (see the "Species/Impact" Table in Section 17, Table 17.1, and related discussion).

The overarching goal of research is therefore to provide the science-based information needed to inform appropriate and timely conservation and management measures. For best results, research strategies must be co-ordinated at the regional level with clear priorities provided, and national research should be comprehended as much as possible within such co-ordination design. Finally, the multidisciplinary and ecosystem-based aspects of research must be privileged.

Research efforts should aim in three different directions: (a) to know the "capital" that we wish to protect, (b) to know the factors that are eroding such capital, and (c) to develop conservation procedures and techniques.

Knowledge of cetacean populations - Initially, easy and cheap studies of the distribution and relative abundance of the different species in the region should be undertaken in "virgin" areas. Unfortunately, even this basic knowledge is lacking from most of the Agreement area.

After that initial step, solid population data must be secured:

- Describe the eventual subdivision of each species present in the area into discrete populations; map the geographic distribution of each population; assess degrees of gene flow across populations.
- Assess population sizes and trends.
- Determine demographic parameters.
- Describe population ecology and habits.
- Critical habitats for each population must be detected and mapped, and location of habitat, size, and characteristics provided.

Knowledge of threats to cetaceans - Mortality factors (e.g., direct killings, bycatch in fisheries, collisions, intoxications, epizootics) must be known, and mortality events monitored, to estimate the contribution of each factor to total mortality of the population.

Habitat degradation factors, mostly deriving from the contamination of the marine environment with anthropogenic substances (e.g., POPs, hydrocarbons, nutrients, solid debris, *etc*.), as well as from land-based infectious agents, must be assessed. These are particularly difficult to evaluate because of the importance of synergistic action among factors, and because what really matters is the long-term population effects of such action, rather than the exposure levels.

Depletion of food resources through overfishing and illegal fishing must be assessed, and compared to the feeding requirements of the population. Updated, reliable fishery data on catch and effort should be readily available to evaluate what is being removed, at what rate, with what means, when and where. Data should be fed into ecosystem models to predict trends and replacement rates.

Noise and overall disturbance levels (including vessel traffic, offshore mineral resource exploration and exploitation, military exercises, whale watching and invasive research) within the population range must be known. Updated information on the space and time distribution of maritime traffic (commercial, military, pleasure, research and prospecting, *etc*.), and of whale watching operations, must be collected. The final objective is the evaluation of the long-term effects of these factors on the population.

Mechanisms at the base of conflicting interactions between coastal cetaceans and small scale, artisanal fisheries must be fully understood.

Climate and ecosystem change signals should be detected and described, and the possible effects of such change on the population should be monitored.

Development of countermeasures and support - Impact assessments must be performed whenever new activities likely to impact on cetaceans are planned, to provide a basis for decisions and a source of indications for management.

Technological innovation (e.g., to enhance fishing gear selectivity and cetacean avoidance, to enhance vessel collision avoidance, to decrease vessel noise and whale watching vessel impact, *etc*.) must be stimulated.

Science-based proposals must be brought forth for the establishment of special MPAs, and MPA management must be science-based as well.

Science-based training, education and awareness activities must be promoted.

Research methods - A very large body of literature and excellent texts (for a recent example see Mann *et al.* 2000) exist that review research methods useful to cetacean conservation efforts. What follows is only a brief, schematised and non-exhaustive summary.

Sighting surveys. These can range from basic cruises designed to describe relative abundance (sighting frequencies) and distribution, to long-term, effort-intensive longitudinal studies of single populations or sub-populations based on photo-identification techniques, and finally to dedicated, line-transect surveys to generate density data and to derive absolute population estimates.

Radio and acoustic tagging and tracking of a sample of individuals within a population, using archival and/or transponder tags, to extract information on identity, position (and therefore on horizontal movements, migration patterns, home range and extent of movements within such range), depth, speed and movement patterns, oceanographic data, visual and acoustic environment, and physiology of the tagged individuals. Short-term, passive tracking of individual cetaceans in the vicinity of a research platform has also been performed using laser range-finders linked to a Global Positioning System (GPS).

Acoustics. Monitoring presence, absence and seasonal variation thereof of vocalising cetaceans, within a portion or entirety of their population range, can be performed through passive acoustics by means of listening devices located on moving ships, buoys or bottom-mounted. The same systems can be used to monitor sound and noise levels in the marine environment.

Remote collection of skin and blubber biopsies from free ranging individuals can be used to evaluate contaminant loads, detoxifying capabilities (through biomarker studies), genetic properties, and trophic level (through stable isotope analysis). A promising research avenue consists in the culturing of cells secured through biopsies, to apply biomarker techniques to tissues grown in the lab.

Stranding networks are needed to monitor levels and composition of strandings and bycatch along the Agreement's coastal area. A systematic programme of necropsies should be implemented to increase knowledge on current pathologies, predict and control epizootics, assess mortality causes, and store and disseminate tissue and organ samples for pathological, contaminant and genetic studies.

RESPONSE TO EMERGENCY SITUATIONS

During the past few decades major cetacean mortality events have occurred with an apparent increasing frequency in various parts of the world, which have attracted the attention of the scientific community. Mass mortalities over a wide geographic range, such as the Mediterranean striped dolphin and the Black Sea short-beaked common dolphin epizootics, have also occurred within the Agreement area. Given the poor environmental state of the region, similar catastrophic events, as well as emergency situations involving major pollution incidents affecting cetacean critical habitat, are quite likely to occur. It is thus of fundamental importance that an emergency task force be established under the Agreement purview, formed by international experts, to assist in the development and implementation of emergency measures for cetaceans covered by the Agreement when exceptionally unfavourable or endangering conditions occur.

In particular, as stated in the Conservation Plan (Art. 5 and 6), the Task Force should facilitate: (a) the preparation of emergency plans to be implemented in case of threats to cetaceans in the Agreement area, such as major pollution events, important strandings or epizootics; (b) the evaluation of capacities necessary for rescue operations for wounded or sick cetaceans; (c) the compilation of a synthesis of veterinary recommendations for the rescue, rehabilitation and release of cetaceans; (d) the development and implementation of training programmes on responses to emergency situations, transport and first aid techniques, and release of rehabilitated animals; and (e) the preparation of guidelines and of a code of conduct governing the function of centres or laboratories involved in this work, also considering the risks to natural populations when decisions are made to return cetaceans to the wild.

Whenever necessary and if requested by the ACCOBAMS Secretariat, the Task Force should convene and send a team of experts on site to asses the situation and provide advice and assistance to national groups. To help this process, an inventory should be made of the facilities existing in the Agreement area, having experience the capability of maintaining marine mammals.

CAPACITY BUILDING AND EDUCATION

This Section refers to two different aspects of knowledge, which are both essential to the enhancement of the conservation process: capacity building (*i.e.*, the creation of specialist abilities) and education and awareness programmes targeting the wider public.

Capacity building. The essence of capacity building consists in the enhancement of professional capabilities by combining targeted educational programmes with infrastructural improvement (Reeves *et al.*, in press). This is an aspect presenting huge heterogeneity in the region, with large gaps in the levels of training and facilities among different portions of the Agreement area. Since it is essential that expertise for cetacean conservation efforts be provided by local scientists in their own regions, capacity building remains one of the highest priorities of ACCOBAMS. It is highly recommended that:

- Simple lectures by foreign experts may only serve as an initial step for a broad exposure to problem-solving approaches, use of available technology, data collecting and analysis techniques, and to discuss possible applications of such procedures in "virgin" areas. The main value provided by effort of this type is that it may provide the stimulus to embark on more focussed activities.
- Longer-term training through scholarship programmes to study and acquire experience abroad can be quite effective, providing that the recipients of these programmes will have the possibility, once they return at their home country, to apply their knowledge in well-designed, officially recognised and sufficiently funded research or conservation activities. Unfortunately, this is rarely the case; too often trainees return home only to face unemployment or the obligate choice of a different profession, while on the other hand substantial funding, provided with the best of intentions by international donor organisations, dissipates "through the cracks" without providing the expected results due to lack of the necessary local competences. It is thus of funda-

mental importance that (a) training programmes abroad, (b) funding of major conservation programmes by international donors and (c) a long-term commitment by local decision makers and administrations be made to work together in a co-ordinated effort, clearly targeted to the implantation of stable, long-lived research and management structures and abilities.

Training efforts should be incorporated into the production of real-life results of actual research projects or management plans. Collaborative research programmes conducted in the Agreement area present an ideal terrain in which to promote and experiment with training and technology transfer. Thus, bilateral and multilateral projects, involving teams having different levels of expertise from different portions of the Agreement area, should have higher priority. Workshops to address conservation issues peculiar to subsets of the Agreement area will reinforce and upgrade local capacities, strengthen working relationships, help with the identification and agreement on priorities, coordinate research activities, standardise methodology, and enhance the analytical skills of participants (Reeves *et al.*, in press). The participation to such workshops by government representatives would provide a much needed link with the local management authorities.

A major problem faced by scientists in areas where a tradition of cetacean research is in the process of being developed is access to all the needed literature and scientific documentation. In such areas it often happens that scientific libraries are unavailable, or insufficiently equipped with specialised, updated literature, or their access may be problematic. By taking advantage from the recent, remarkable progress being made in remote access to bibliographic material stored electronically, efforts should be made to create in each Agreement riparian country at least one specialised information and documentation centre where text and reprints can be accessed. Furthermore, support should be given to existing libraries containing significant bibliographic collections on cetacean science, in order to ensure continued updating and expansion, facilitate access to information to the local scientific community, and provide a framework for capacity building that will encourage documented cetacean research in the Agreement area. Library databases should be managed in the context of a network that facilitates cross-library research and exchange of materials.

A series of *ad hoc* documentation tools should be prepared, and made widely available to the scientific community throughout the Agreement area. These should include, among others: (a) lists of national authorities, research and rescue centres, scientists and non-governmental organisations concerned with cetacean conservation; (b) a directory of existing protected or managed areas for the conservation of cetaceans; and (c) a directory of national and international legislation concerning cetaceans.

Education. Education and awareness campaigns are critical elements of effective management, and need to be prepared and implemented at the highest professional level. The greater public needs to be constantly informed about the status of cetaceans in their region of residence, the possible effects of human activities on their well-being, and ways to improve their chances of survival. Awareness on the very existence of cetaceans, on their possible and real threats, and on actions that can be taken to ensure their survival is still very low in the Agreement area, and very inhomogeneous in its distribution. Education and awareness can be achieved both by ensuring that the media operators are trained and updated on cetacean conservation matters, and that educational material and programmes are constantly developed and appropriately disseminated. Such activities are particularly suited to a number of Non-Governmental Organisations concerned with cetacean conservation, and best results can be achieved through a co-operative effort between institutions and NGOs.

CONCLUSIONS AND RECOMMENDATIONS

While all the conservation strategies previously listed and described in this Section are worthy of being undertaken, and all cetacean species living in the Agreement area deserve to be protected as well, priorities must be defined in order to provide timely responses to address problems that are known or considered to be most urgent.

Priority species. Based on the available knowledge, populations belonging to the following species (listed in alphabetical order) are known or presumed to be at greater risk of declining and disappearing from the Agreement area:

Delphinus delphis, short-beaked common dolphin in the Mediterranean Sea;

Phocoena phocoena, harbour porpoise;

Physeter macrocephalus, sperm whale;

Tursiops truncatus, common bottlenose dolphin.

It is therefore highly recommended that urgent measures be undertaken to address the conservation status of such populations.

Priority actions. During the CIESM Meeting in Monte Carlo, on 27 September 2001, a workshop was organised to discuss priorities for cetacean conservation in the Mediterranean and Black Seas. An initial list of priorities, agreed upon in that occasion, is presented in Appendix 2. The following list represents a further elaboration of the Monte Carlo proposal, and its adaptation to a narrow (2002-2006) time frame (please note: items in this list are not presented in order of importance).

- Development of criteria and provision of *ad hoc* support for the harmonisation of commercial whale watching regulations with science-based knowledge on the protection needs of the involved cetacean populations.
- Investigation of competitive interactions between coastal dolphins and artisanal fisheries.
- Creation of a cetacean bycatch database (first phase).
- Development and implementation of pilot conservation and management actions in well-defined key areas containing critical habitat for populations belonging to priority species.
- Workshop on methods for the evaluation of habitat degradation and its effect on cetacean populations.
- Conservation plan for cetaceans in the Black Sea.
- Conservation plan for short-beaked common dolphins (*Delphinus delphis*) in the Mediterranean Sea.
- Conservation plan for common bottlenose dolphins (*Tursiops truncatus*) in the Mediterranean Sea.
- Basin-wide Mediterranean sperm whale (*Physeter macrocephalus*) survey.
- Identification of Mediterranean sites of conservation importance for fin whales (*Balaenoptera physalus*) in addition to the Ligurian-Corsican-Provençal Basin, and assess the functional relationships of such sites to the LCP Basin with respect to the species' habitat needs.
- Development of photo-identification databases and programmes encompassing the entire ACCOBAMS area.
- Establishment and implementation of a long-term training programme on cetacean research, monitoring and conservation/management techniques and procedures.
- Development of an educational tool for the organisation of research projects and basic technical studies.
- Creation of a sub-regional directory of national authorities, research and rescue centres, scientists and governmental and non-governmental organisations concerned with the Agreement's objectives.
- Support to the implementation of national stranding networks, and their co-ordination into a wider regional network.
- Development of a network of specialised bibliographic collections and databases.
- Establishment of a system of tissue banks.
- Establishment of a Task Force for special mortality events.

A brief description of each item, including an indication of the types of activity, of the time-frame and of the expense involved, will be provided to the First Meeting of the ACCOBAMS Parties in a separate document. Detailed project proposals will be successively required, once their implementation will be decided and funding assured.

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Fig. 18.1 – Coastal protected areas already established in the Black Sea subregion:

1 Ropotamo River nature reserve
2 Lake Atanasovsko nature reserve
3 Kamchia biosphere reserve
4 Cape Kaliakra nature reserve
5 Lake Shabla protection area
6 Lake Durankulak protection area
7 Danube Delta biosphere reserve
8 Dunaiskie Plavni biosphere reserve
9 Tiligulskiy landscape park
10 Kinburn Spit landscape park
11 Chernomorskiy biosphere reserve
12 Dzharylgach reservation
13 Karkinitskiy ornithological reservation
14 Lebyazhyi Ostrova branch of the Krymskiy nature Reserve
15 Bakal Spit local reservation
16 Dzhangul landscape and aquatic reservation
17 Atlesh landscape and aquatic reservation
18 Lake Donuzlav local reservation
19 Nikolayevka Coast protection site
20 Cape Lukull inshore aquatic reservation
21 Kazachya Bay reservation
22 Cape Fiolent landscape and aquatic reservation
23 Cape Aia reservation
24 Cape Sarych inshore aquatic reservation
25 Yalta mountain and forest nature reserve
26 Ifigenia Rock protection site
27 Diva and Koshka inshore aquatic reservation
28 Cape Ai-Todor landscape and aquatic reservation
29 Cape Martyan nature reserve
30 Adalary Isles protection site
31 Ayudag landscape and aquatic reservation
32 Cape Plaka landscape and aquatic reservation
33 Kuchuk-Lambat local reservation
34 Landscape and aquatic reservation between Solnechnogorskoye and Malorechenskoye
35 Kanaka reservation
36 Karaul-Oba landscape and aquatic reservation
37 Novy Svet botanic reservation
38 Inshore aquatic reservation between Novy Svet and Sudak
39 Cape Alchak local reservation
40 Karadag nature reserve
41 Cape Chauda landscape and aquatic reservation
42 Opuk nature reserve
43 Cape Khroni inshore aquatic reservation
44 Karalarskiy local reservation
45 Kazantip nature reserve
46 Arabat landscape and aquatic reservation
47 Azovo-Sivashskiy national nature park
48 Stepanovskaya Spit hydrologic reservation
49 Obitochnaya Spit reservation
50 Berdyanskaya Spit reservation
51 Meotida landscape park
52 Don Delta protection area
53 Cape Utrish reservation
54 Lake Abrau reservation
55 Sochi national nature park
56 Pitsunda–Mussera biosphere reserve
57 Kolkheti nature reserve
58 Çamburnu protection area
59 Simenlik (Yesilirmak Delta) reserve
60 Haci Osman Ormani protection area
61 Kizilirmak Delta nature reserve
62 Sarikum protection area
63 Mert Lake reserve (Igneada Saka Longozu)

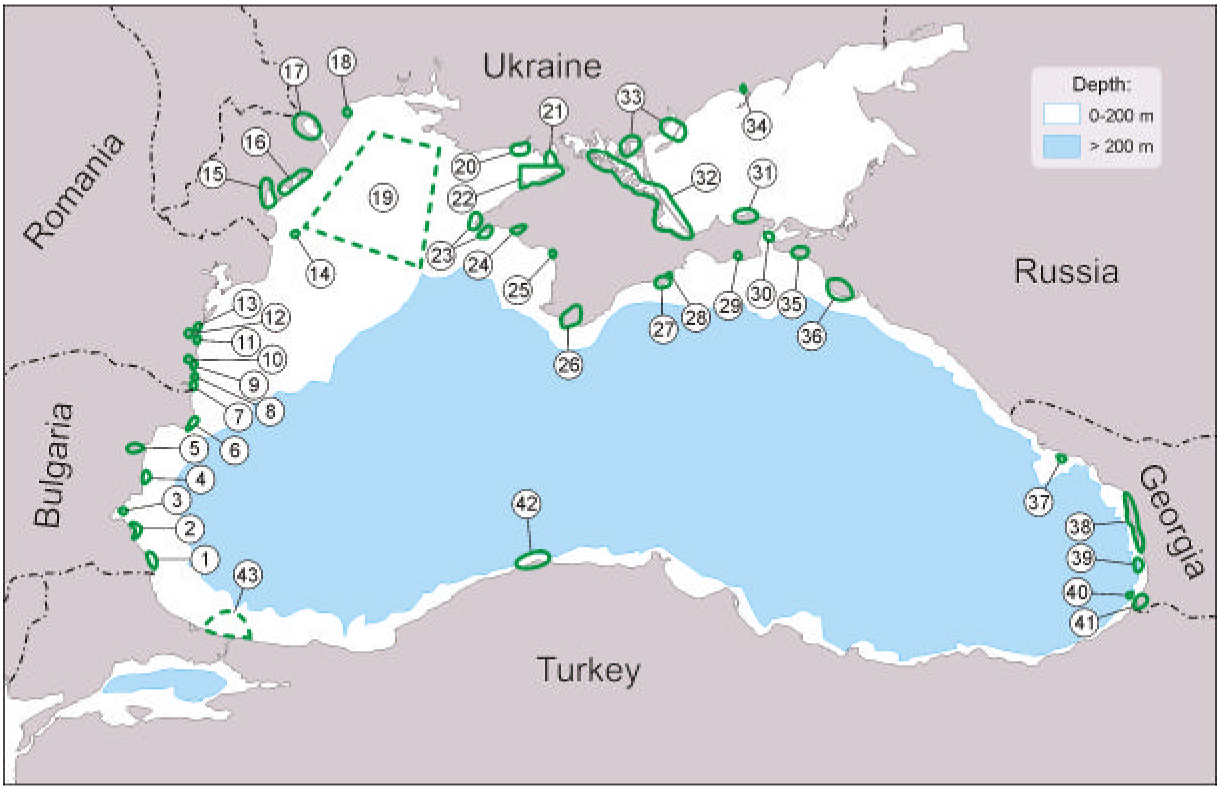

Fig. 18.2 – Proposed Black Sea coastal and marine protected areas which are not established yet:

1 Marine protection area from Ahtopol to the Rezovo river's mouth
2 Marine protection area from Primorsko to Ropotamo river
3 Cocketrice Bank marine protection area
4 Marine protection area from Byala to Shkorpilovtsi
5 Varna Bay and Varna Lake protection area
6 Marine protection area from cape Kaliakra to Kamen Bryag
7 Marine protection area from Vama Veche to 2 Mai
8 Marine protection area from Costinesti to Olimp
9 Cape Tuzla nature reserve
10 Lake Tekirghiol nature reserve
11 Mamaia Bay marine protection area
12 Lake Siutghiol nature reserve
13 Cape Midia nature reserve
14 Zmeiny Island nature reserve
15 Lake Sasyk protection area
16 Tuzly Liman protection area
17 Dniester Estuary national nature park
18 Cape Bolshoy Fontan reservate
19 Zernov's *Phillophora* Field marine protection area
20 Dzharylgach national nature park
21 Karkinitskiy Bay marine reserve
22 Lebyazhyi Ostrova biosphere reserve
23 Tarkhankut nature reserve
24 Donuzlav protection area
25 Lake Kyzyl-Yar protection area
26 Sevastopol national nature park
27 Cape Meganom protection area
28 Tikhaya (Lisya) Bay reservation
29 Uzunlarskoye Lake protection area
30 Tuzla Island protection area
31 Karalarskiy nature reserve
32 Sivashskiy national nature park
33 Priazovskiy national nature park
34 Obitochnaya Estuary protection area
35 Kiziltashskiy Lagoon protection area
36 Abrau Peninsula national park
37 Gudauta Bank protection area
38 Kolkheti national park
39 Supsa marine protection area
40 Batumi Bank marine protection area
41 Adjara national park
42 Doganyurt–Cide marine reserve
43 Prebosphoric marine reserve

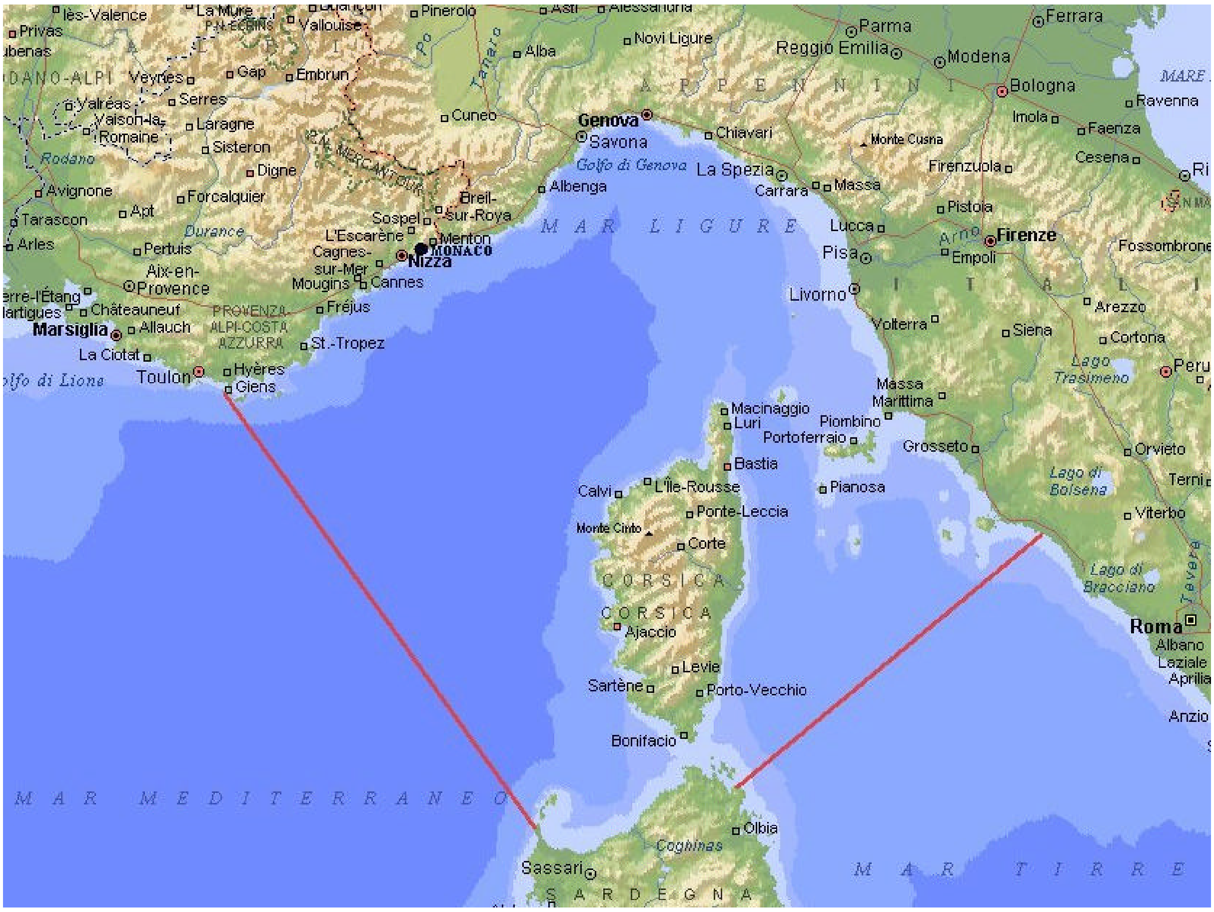

Fig. 18.3 – The “Ligurian Sea sanctuary”

Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies

SECTION 19

Appendices

A Report to the ACCOBAMS Interim Secretariat
Edited by Giuseppe Notarbartolo di Sciara
Monaco, February 2002
With the financial support of
Coopération Internationale pour l'Environnement et le Développement, Principauté de Monaco

Appendix 1

Classification of the Order Cetacea as adopted by the International Whaling Commission (Journal of Cetacean Research and Management 2001)

	Scientific name	Common name
Suborder Mysticeti (baleen whales or mysticetes)		
Family Balaenidae		
	Eubalaena australis	southern right whale
	Eubalaena glacialis	North Atlantic right whale
	Eubalaena japonica	North Pacific right whale
	Balaena mysticetus	bowhead whale
Family Neobalaenidae		
	Caperea marginata	pygmy right whale
Family Eschrichtiidae		
	Eschrichtius robustus	gray whale
Family Balaenopteridae		
	Balaenoptera acutorostrata	common minke whale
	Balaenoptera bonaerensis	Antarctic minke whale
	Balaenoptera borealis	sei whale
	Balaenoptera edeni *	Bryde's whale
	Balaenoptera musculus	blue whale
	Balaenoptera physalus	fin whale
	Megaptera novaeangliae	humpback whale
Suborder Odontoceti (toothed whales or odontocetes)		
Family Physeteridae		
	Physeter macrocephalus	sperm whale
Family Kogiidae		
	Kogia breviceps	pygmy sperm whale
	Kogia sima	dwarf sperm whale
Family Platanistidae		
	Platanista gangetica gangetica	South Asian river dolphin
Family Pontoporiidae		
	Pontoporia blainvillei	franciscana
Family Lipotidae		
	Lipotes vexillifer	baiji
Family Iniidae		
	Inia geoffrensis	boto
Family Monodontidae		
	Delphinapterus leucas	white whale
	Monodon monoceros	narwhal
Family Phocoenidae		
	Phocoena phocoena	harbour porpoise
	Phocoena spinipinnis	Burmeister's porpoise
	Phocoena sinus	vaquita
	Phocoena dioptrica	spectacled porpoise
	Neophocaena phocaenoides	finless porpoise
	Phocoenoides dalli	Dall's porpoise
Family Delphinidae		
	Steno bredanensis	rough-toothed dolphin
	Sousa chinensis	Indo-Pacific hump-backed dolphin
	Sousa teuszii	Atlantic hump-backed dolphin
	Sotalia fluviatilis	tucuxi
	Lagenorhynchus albirostris	white-beaked dolphin
	Lagenorhynchus acutus	Atlantic white-sided dolphin

	Lagenorhynchus obscurus	dusky dolphin
	Lagenorhynchus obliquidens	Pacific white-sided dolphin
	Lagenorhynchus cruciger	hourglass dolphin
	Lagenorhynchus australis	Peale's dolphin
	Grampus griseus	Risso's dolphin
	Tursiops truncatus	Common bottlenose dolphin
	Tursiops aduncus	Indo-Pacific bottlenose dolphin
	Stenella frontalis	Atlantic spotted dolphin
	Stenella attenuata	pantropical spotted dolphin
	Stenella longirostris	spinner dolphin
	Stenella clymene	clymene dolphin
	Stenella coeruleoalba	striped dolphin
	Delphinus delphis	common dolphin
	Delphinus capensis	long-beaked common dolphin
	Lagenodelphis hosei	Fraser's dolphin
	Lissodelphis borealis	northern right whale dolphin
	Lissodelphis peronii	southern right whale dolphin
	Cephalorhynchus commersonii	Commerson's dolphin
	Cephalorhynchus eutropia	Chilean dolphin
	Cephalorhynchus heavisidii	Heaviside's dolphin
	Cephalorhynchus hectori	Hector's dolphin
	Peponocephala electra	melon-headed whale
	Feresa attenuata	pygmy killer whale
	Pseudorca crassidens	false killer whale
	Orcinus orca	killer whale
	Globicephala melas	long-finned pilot whale
	Globicephala macrorhynchus	short-finned pilot whale
	Orcaella brevirostris	Irrawaddy dolphin
Family Ziphiidae		
	Tasmacetus shepherdi	Shepherd's beaked whale
	Berardius bairdii	Baird's beaked whale
	Berardius arnuxii	Arnoux's beaked whale
	Mesoplodon pacificus	Longman's beaked whale
	Mesoplodon bidens	Sowerby's beaked whale
	Mesoplodon densirostris	Blainville's beaked whale
	Mesoplodon europaeus	Gervais' beaked whale
	Mesoplodon layardii	strap-toothed whale
	Mesoplodon hectori	Hector's beaked whale
	Mesoplodon grayi	Gray's beaked whale
	Mesoplodon stejnegeri	Stejneger's beaked whale
	Mesoplodon bowdoini	Andrews' beaked whale
	Mesoplodon mirus	True's beaked whale
	Mesoplodon gingkodens	ginkgo-toothed beaked whale
	Mesoplodon carlhubbsi	Hubbs' beaked whale
	Mesoplodon peruvianus	pygmy beaked whale
	Mesoplodon bahamondi	Bahamonde’s beaked whale
	Ziphius cavirostris	Cuvier's beaked whale
	Hyperoodon ampullatus	northern bottlenose whale
	Hyperoodon planifrons	southern bottlenose whale

* includes more than one species, but the nomenclature is still unsettled

Appendix 2

Conservation priorities for Mediterranean and Black Sea cetaceans
Items for discussion at a CIESM Round Table
Monte Carlo, 27 September 2001

1 - Species-oriented actions

- Assess abundance and threats to persistence of harbour porpoises in the Black Sea and surrounding waters;
- Investigate the distribution, abundance, population structure, and factors threatening the conservation of short-beaked common dolphins;
- Investigate the distribution and abundance of bottlenose dolphins, and evaluate threats to their survival;
- Conduct a basin-wide assessment of sperm whale abundance and distribution in the Mediterranean Sea;
- Identify critical habitats for selected species, and verify if such habitats may be best protected through the creation of specific protected areas:
    - sperm whales along the "Aegean Arch";
    - fin whales in the Ligurian Sea;
    - common dolphins (wherever they occur predictably);
    - bottlenose dolphins (in known hotspots).

2 - Geographic-oriented actions

- Identify areas where knowledge on abundance and distribution of cetaceans is absent, and organise surveys to generate initial baseline knowledge (e.g.: Aegean Sea, Levantine Basin, portions of the Black Sea, Gulf of Sirte, etc.)

3 - Problem/topic-oriented actions

- Interactions with fisheries
    - Develop and test approaches to reducing conflicts between dolphins and small-scale fisheries and aquaculture operations in the Mediterranean and Black Seas, including addressing the issues involved in the use of acoustic deterrence
    - Monitor cetacean bycatch in the Accobams area
    - Address the problem of the depletion of cetacean prey through human activities. Organise an orientation workshop on the issue
- Whale watching
    - Organise a first workshop aimed at the harmonisation of whale watching activities throughout the ACCOBAMS region (including: regional inventory of operations, development of a code of conduct, regulations, control, etc.)
- Strandings
    - Provide support to the implementation of national stranding networks
    - Promote training of pathologists
    - Establish a system of tissue banks
    - Set up a task force for special mortality events
- Capacity building
    - Organise sub-regional training courses in:
        - Survey techniques
        - Pathology
    - Organise a system for the dissemination of appropriate scientific documentation.

Appendix 3

Resolution adopted at the First Meeting of the Parties of ACCOBAMS, 1 March 2002

RESOLUTION 1.9

INTERNATIONAL IMPLEMENTATION PRIORITIES FOR 2002-2006

The Meeting of the Parties to the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area,

Aware that resources for the implementation of the Agreement (information, research expertise and funds) are unequally distributed throughout the Agreement area, and that an effective implementation of the Agreement will require strong international co-operation;

Aware that scientific research in the Agreement area is essential to identify the populations having the least favourable conservation status and to address the conservation priorities;

Considering that Parties, particularly developing countries and countries with economies in transition, require a clear prioritisation of conservation and research activities in order to apply their limited resources most effectively,

Further considering that bilateral and multilateral donors will be greatly assisted in their allocation of funds for international co-operation, by a clear prioritisation of needs,

Recalling that Article IX.3. calls for voluntary contributions in order to increase the funds available for monitoring, research and training and projects relating to conservation;

Recalling Resolution 1.7 establishing a Supplementary Conservation Fund;

Recalling that Article IX.4. encourages Parties to provide technical and financial support on a bilateral or multilateral basis to assist Range States which are developing countries or countries with economies in transition to implement the provisions of the Agreement;

1. *Notes* the particular importance for the Agreement of focusing on known scientific gaps (both thematic and geographic), and of identifying remaining gaps;

2. *Adopts* the international implementation priorities for 2002-2006, as in annex I, without prejudice to the pursuance of existing conservation actions;

3. *Urges* Parties and specialised international Organisations to develop international co-operation projects for the implementation of the Agreement, in line with the priorities listed in annex I, and to keep the Agreement Secretariat fully informed of progress;

4. *Recommends* that the creation or extension of databases, for example under items 3, 11 and 16 of Annex of the present document, be co-ordinated to maximize synergies with existing databases such as the Global Register of Migratory Species (GROMS) of CMS and information held by the UNEP – World Conservation Monitoring Centre (UNEP-WCMC).

5. *Further urges* Parties, the Agreement Secretariat and specialised International Organisations to seek innovative mechanisms and partnerships in particular with fishermen and other relevant professionals, to enable implementation of the Conservation Plan and the priorities listed in annex I.

This could include joint ventures, twinning arrangements, secondment and exchange programmes, corporate sector sponsorships and species adoption programmes;

6. *Requests* bilateral and multilateral donors to provide financial assistance to Range States for the implementation of the Agreement, by supporting implementation of its priorities using the financial mechanism of the Agreement;

7. *Instructs* the Agreement Secretariat to disseminate the international implementation priorities for 2002-2006, to co-ordinate closely with related Conventions and International Organizations, in particular CIESM and "ACCOBAMS' Partners", for their implementation, to seek appropriate donors, and, following the recommendations of the Sub-Regional Co-ordination Units and the Scientific Committee, to bring to each session of the Meeting of the Parties reports on progress with implementation and an updated list of priorities.

8. *Calls on* the Scientific Committee to further develop the actions needed to implement the priorities listed and described in Annex 1, fully bearing in mind all the Resolutions agreed on at this Meeting of the Parties.

ANNEX 1

INTERNATIONAL IMPLEMENTATION PRIORITIES FOR 2002-2006

prepared by
Giuseppe Notarbartolo di Sciara, consultant[1]
under contract to the Interim Agreement Secretariat

The following list of 18 priority actions was prepared to assist Contracting Parties to implement priorities for international cooperation during the period 2002-2006. This list was generated by extracting from, and modifying, a broader list of activities, developed during a CIESM Workshop which was held in Monte Carlo in September 2001. With the intent of optimising effort among concurrent international organisations, some of the actions proposed here are inspired by, and partly coincide with, similar conservation actions proposed in the most recent Cetacean Action Plan of the World Conservation Union *(R.R. Reeves, B.D. Smith, E. Crespo, G. Notarbartolo di Sciara. In press. Dolphins, whales, and porpoises: status, threats, and conservation action plan for cetaceans. IUCN, Gland).*

The order in which actions are listed in this document does not imply priority. Rather, actions are arranged following the order in which conservation measures are listed in the Conservation Plan (Annex 2 of the Agreement). For each action, references to the corresponding paragraphs of the Conservation Plan and to the budget item in Doc. MOP1/17 are presented to the left of the activity's title. For each item the types of activity involved are listed, along with the projected timescale. An indicative budget is indicated as well, mostly for an initial two-year period, corresponding to the figures quoted in Doc.MOP1/17, and in some cases concerning the action's first phase. Whenever possible, the budget for the completion of the action is also indicated. Detailed project proposals will be successively required, once their funding and implementation will be assured.

[1] Comments and suggestions by Giovanni Bearzi, Alexei Birkun, Jr., J. Antonio Raga, and Mark Simmonds are gratefully acknowledged.

International Implementation Priorities, 2002 – 2006

List of Actions

1. Development of criteria and provision of *ad hoc* support for the harmonisation of commercial whale watching regulations with science-based knowledge on the protection needs of the involved cetacean populations.
2. Investigation of competitive interactions between coastal dolphins and artisanal fisheries.
3. Creation of a cetacean bycatch database (first phase).
4. Development and implementation of pilot conservation and management actions in well-defined key areas containing critical habitat for populations belonging to priority species.
5. Workshop on methods for the evaluation of habitat degradation and its effect on cetacean populations.
6. Conservation plan for cetaceans in the Black Sea.
7. Conservation plan for short-beaked common dolphins (*Delphinus delphis*) in the Mediterranean Sea.
8. Conservation plan for common bottlenose dolphins (*Tursiops truncatus*) in the Mediterranean Sea.
9. Basin-wide Mediterranean sperm whale (*Physeter macrocephalus*) survey.
10. Identification of Mediterranean sites of conservation importance for fin whales (*Balaenoptera physalus*) in addition to the Ligurian-Corsican-Provençal (CLP) basin, and assessment of the functional relationships of such sites to the LCP basin with respect to the species' habitat needs.
11. Development of photo-identification databases and programmes encompassing the entire ACCOBAMS Area.
12. Establishment and implementation of a long-term training programme on cetacean research, monitoring and conservation/management techniques and procedures.
13. Development of an educational tool for the organisation of research projects and basic technical studies.
14. Creation of sub-regional directories of national authorities, research and rescue centers, scientists, governmental and non-governmental organisations concerned with the Agreement's objectives.
15. Support to the implementation of national stranding networks, and their co-ordination into a wider regional network.
16. Development of a network of specialised bibliographic collections and databases.
17. Establishment of a system of tissue banks.
18. Establishment of a Task Force for special mortality events.

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
1	1	912	**Development of criteria and provision of *ad hoc* support for the harmonisation of commercial whale watching regulations with science-based knowledge on the protection needs of the involved cetacean populations**

As commercial whale watching operations develop in the Agreement area, it is anticipated, as well as desirable, that regulatory measures will be prepared and implemented by the concerned countries, to ensure that such development proceeds in a sustainable and respectful fashion. Although all whale watching regulations share a common matrix, which depends on the nature of this activity, it is important that regulations be framed within the specific ecological and biological context in which they apply. Cetacean populations may show varying degrees of susceptibility to disturbance depending on their species-specific behavioural traits, behavioural state, socio-ecological context, overall level of disturbance from other causes, degree of habituation, etc. Guidelines should be developed to assist countries in adapting regulations to the needs of the populations targeted by whale watching, and *ad hoc* scientific support should be provided to allow the development and implementation of adaptive whale watching management. In addition, to assist in this process, a centralised inventory of commercial whale watching operations in the Agreement area should be established and maintained.

Activities:	desk study, consultations, centralised inventory
Possible synergies:	4
Duration:	guidelines: 1 year; scientific support: ongoing.
Indicative budget:	guidelines and scientific support (2002): € 4,000 scientific support (2003-2004): € 4,000 scientific support (2005-2006): € 4,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
2	2	921	**Investigation of competitive interactions between coastal dolphins and artisanal fisheries**

A workshop sponsored by Italy in Rome in May 2001 investigated and evaluated efforts by fishermen and others to deter dolphins from nets. It was concluded that although the problem of dolphin depredation has become a major issue in the eyes of Mediterranean fishermen, and therefore deserves to be addressed in a responsible manner by government agencies and conservation groups, there is a danger that the ad hoc and even experimental use of noise-making deterrence devices could have unintended adverse effects on other species, as well as prove ineffective for reducing fishery-dolphin conflicts. The workshop produced a series of recommendations for research and development, and concluded that high-intensity acoustic devices that are typically used to keep pinnipeds away from aquaculture facilities are inappropriate for use in alleviating conflicts between dolphins and fisheries in the Mediterranean.

This project would consist in the implementation of the recommendations made by the Rome workshop. In particular, in addition to obtaining detailed quantitative information on the characteristics of common bottlenose and short-beaked common dolphin populations in the Mediterranean (see Actions 7 and 8), data should be collected on the spatial, seasonal, and operational features of small-scale coastal trammel and gillnet fisheries in the region. Identification of a small number of exemplary «problem areas» where overlap occurs (i.e., high dolphin densities matched with high levels of fishing activity) should be followed by rigorous site-specific pilot studies to characterise and quantify the costs of dolphin depredation. Where serious problems are found to exist, rigorous tests of potential solutions should be conducted after extensive consultations with fishermen as well as technical experts. It is important that due consideration be given to the real or potential adverse side effects of any mitigation approach. Non-acoustic means of reducing conflicts, such as changes in methods of gear deployment, the use of quieter engines, the introduction of compensation or insurance mechanisms and the development of parallel dolphin watching activities, all hold promise and deserve to be evaluated.

Activities:	field surveys in 2-3 pilot areas, desk study, fishermen interviews, research, consultations

Possible synergies:	3, 4, 7, 8
Duration:	4 years
Indicative budget:	2002-2004: € 48,000; 2005-2006: € 60,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
3	2	922	**Creation of a cetacean bycatch database (first phase)**

Cetacean mortality through accidental capture and drowning in fishing gear – most notably, pelagic driftnets in the Mediterranean and bottom gillnets in the Black Sea - is considered a major conservation concern in the Agreement area. However, very little data exist on bycatch numbers and rates, on species and fishing gear involved, and on the geographical and seasonal variability of bycatch events. Such information is of fundamental importance, among other things, if bycatch rates are to be related to population sizes, thereby assessing whether mortality deriving from fishery activities is sustainable or not. The goal of this action is to facilitate the incorporation of reporting of cetacean bycatch incidents into fishery management practice throughout the Agreement Member States, and to encourage the use of independent observers aboard vessels to collect unbiased data. The project involves the establishment of a bycatch Task Force under the purview of the Agreement, which will coordinate efforts during an initial 3-year pilot phase in three experimental areas (ideally, one in a northern Mediterranean country, one in a southern Mediterranean country, and one in a Black Sea country). Procedures learned during this pilot phase may then be applied in the remaining portion of the Agreement area. The bycatch Task Force should: (a) work in close contact with the fishery management authorities of the selected countries; (b) provide technical support, data quality control, training, awareness building, advice and recommendations as needed; and (c) help in the creation of the first nucleus of a centralised bycatch database. Cooperation with the appropriate effort currently undertaken by the European Commission to monitor cetacean bycatch in European waters is strongly recommended.

Activities:	coordination, consultations, training, awareness programmes, database
Possible synergies:	2, 4, 15
Duration:	3 years (first phase)
Indicative budget:	€ 12,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
4	3	931	**Development and implementation of pilot conservation and management actions in well-defined key areas containing critical habitat for populations belonging to priority species**[2]

In spite of the recent growth of scientific knowledge and attention on cetacean ecology in the Agreement area, and of the awareness of the survival threats these mammals are subject to, evidence is accumulating that some populations are declining in numbers and becoming increasingly fragmented within their shrinking range. Particular concern exists for short-beaked common dolphins in the Mediterranean, as well as for harbour porpoises, common bottlenose dolphins, and sperm whales. In some well-known instances, relic population units of these species are presently seen to be undergoing dramatic reductions in their numbers, and are thought likely to disappear soon if prompt measures are not taken. This action proposes to select four areas, each of them containing critical habitat for one of the four priority species, in which pilot conservation and management projects be developed and implemented immediately. Areas should be selected on the basis of sufficient available knowledge and characteristics of the area allowing the creation of a model, which can then be applied to other similar situations in the Agreement area. The following areas show particular promise as possible candidates: (a) the coastal waters surrounding the island of Kalamos, western Greece (short-beaked common dolphins); (b) the coastal area of southern Crimea, Ukraine, comprised between Cape Sarych and Cape Khersones (harbour porpoises and Black Sea common bottlenose dolphins); (c) the offshore waters of southern Crete, Greece (sperm whales); and (d) the waters of the Loœinj-Ères Archipelago, Croatia (Mediterranean common bottlenose dolphins). Conservation measures should involve the establishment of ad hoc protected areas encompassing critical habitat for the target species and the adoption of experimental management

[2] *Delphinus delphis, Phocoena phocoena, Physeter macrocephalus, Tursiops truncatus.*

plans with the involvement of local people and user groups; measures should include intensive monitoring of the cetacean population, targeted research, regulation of impacting human activities, education efforts directed at the local fishing communities and recreational users, and promotion of more compatible, alternative activities (e.g., whale watching) and resource uses.

Activities:	desk study, field studies, consultations, awareness and education campaigns, area protection
Possible synergies:	1, 2, 6, 7, 8, 9
Duration:	ongoing
Indicative budget:	2002-2004: € 80,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
5	3	932	**Workshop on methods for the evaluation of habitat degradation and its effect on cetacean populations**

Physical and biological habitat degradation represents one of the greatest concerns for the conservation of cetaceans in the Agreement area. However, very little is known in terms of the real mechanisms at work, and how habitat degradation does impact on populations. To address the problem, a workshop is proposed to determine and help develop a framework and methodology to assess the significance for cetaceans of changes in their habitats, and to facilitate the eventual development of a research plan for the evaluation and quantification of cetacean habitat degradation in specific case studies. A scooping meeting for the preparation of such workshop, having the Mediterranean Sea as its focus, was conducted in 2001 under the auspices of the IWC, with funds from Italy and the UK. The workshop would focus on the following three points: (a) review available information on cetaceans and their habitats in the Agreement area and, in particular, studies that allow the comparisons to be made between segments of populations that appear to be responding to different levels of environmental stress; also, review available information on studies of major perturbations of cetacean habitat; (b) review and develop the concept of cetacean critical habitat and the development of quantifiable indices that may be applied to it; and (c) review and develop modelling approaches as part of a framework and methodology to assess the significance of changes in these parameters, with a view to developing a strategy for monitoring critical habitat quality, identifying thresholds which may affect cetaceans, assessing proposals for activities that might affect cetacean habitat, and, thereby, helping the Agreement in its work to conserve cetacean populations.

Activities:	Consultations, commissioning of papers, three-day workshop (25 partic.), workshop report
Duration:	1 year
Indicative budget:	€ 50.000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
6	4	941	**Conservation plan for cetaceans in the Black Sea**

This project envisages the co-operation between ACCOBAMS and the Black Sea Commission to prepare a proposal to be submitted to the GEF, concerning a comprehensive conservation and management plan for Black Sea cetaceans. The plan should include efforts to fill the existing knowledge gaps concerning the distribution, abundance, population structure, and factors threatening the conservation of the three species involved, as well as management measures such as the establishment of specially protected areas, the development and implementation of regulations to increase sustainability of human activities in the subregion, and the organisation of training, education and awareness initiatives.

Activities:	consultations, proposal writing and submission
Possible synergies	3, 4, 5, 12, 13, 15,
Duration:	1 year
Indicative budget:	-

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
7	4	942	**Conservation plan for short-beaked common dolphins (*Delphinus delphis*) in the Mediterranean Sea**

Short-beaked common dolphins in the Mediterranean have undergone a dramatic decline in abundance during the last few decades, and have almost completely disappeared from large portions of their former range. Recent line-transect surveys resulted in an estimate of about 15,000 common dolphins in the southwestern Alboràn Sea, but abundance was not estimated for the rest of the western Mediterranean due to the low number of sightings. Regions where common dolphins no longer occur include the northern Adriatic Sea, the Balearic Sea, and the Ligurian-Corsican-Provençal basin. Currently, the main threats facing common dolphins in the subregion possibly include accidental killing in fishing gear, reduced availability of prey due to overfishing and habitat degradation, and the effects of toxic contaminants. While epizootics and reproductive disorders appear to have affected striped dolphins primarily, common dolphins may also be at risk because of their similarly high contaminant burdens. As a first step towards the implementation of a conservation plan for the species, a comprehensive assessment of its status and problems in the subregion should be prepared, leading to the identification of critical habitats and to determine distribution and abundance throughout the study area. This project would entail a series of localised surveys, with a priority in the eastern Mediterranean, aimed at the identification of existing remaining concentrations. Standard methods should be used so that results can be compared over time and from one region to another. Biopsies should be collected for genetic and contaminant analyses. Samples should be archived in a central repository, and collaborative studies should be initiated to better understand population structure and identify regional differences in contaminant exposure. For the first phase of the project it is proposed that a steering committee be established with the task of completing the preparation of the project, including the elaboration of organisation, logistic, scientific, technical and financial aspects. It is envisaged that the complete proposal will be presented for approval to MOP2.

Activities:	consultations, planning, proposal writing, fundraising
Possible synergies:	3, 4, 5, 6, 8, 9, 11, 15, 17
Duration:	3 years
Indicative budget:	€ 12,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
8	4	943	**Conservation plan for common bottlenose dolphins (*Tursiops truncatus*) in the Mediterranean Sea**

In the Mediterranean Sea, common bottlenose dolphins occur in scattered inshore communities of perhaps 50-150 individuals, and the gaps between them appear to be constantly increasing. Conservation threats are roughly similar to those facing short-beaked common dolphins and other small cetaceans of the region, except that common bottlenose dolphins in the Mediterranean Sea may be particularly vulnerable to human activities due to their near-shore occurrence and the fragmented character of their population structure. Incidental kills in trammel and gillnets occur frequently in some areas, probably at unsustainable rates. Overfishing of demersal fish may have affected the prey base for common bottlenose dolphins in some areas. Direct kills resulting from competitive interactions between common bottlenose dolphins and artisanal coastal fisheries are also a source of increasing concern. A series of population assessments across the Mediterranean subregion should be organised, where common bottlenose dolphins are known to occur, combined with larger-scale but less intensive surveys to identify previously unknown «hotspots» of occurrence. A comprehensive map of common bottlenose dolphin presence along the Mediterranean continental shelf should be created, with the identification of concentration zones (where critical habitat is likely to occur) and gaps. Photo-identification data should also be collected during the surveys, to help the creation of a pan-Mediterranean catalogue. Surveys should be designed to obtain data suitable for subsequent assessment of the species distribution and relative sighting frequency over time (e.g., consistent surveys conducted at 3-year intervals). Existing information and data recorded by research groups (either published or unpublished) should be inventoried in a comprehensive database, and made available to the wider community. Collection and analysis of time series data indicative of population trends should be favoured. Finally, efforts should be directed to monitor incidental catches and direct kills, and to investigate the possible role of contaminants and of nutritional stress from reduced availability of suitable prey. For the first phase of the project it is proposed that a steering committee be established with the task of completing the preparation of the plan, including the elaboration of the organisation, logistic, scientific, technical and financial aspects. It is envisaged that the complete proposal will be presented for approval to MOP2.

Activities:	consultations, planning, proposal writing, fundraising
Possible synergies:	2, 3, 4, 5, 6, 7, 11, 15, 17
Duration:	3 years
Indicative budget:	€ 12,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
9	4	944	**Basin-wide Mediterranean sperm whale (*Physeter macrocephalus*) survey (first phase)**

In the Mediterranean, sperm whales occur primarily in deep offshore waters of the Alboràn, Ligurian-Corsican-Provençal, Tyrrhenian, Ionian, Aegean and Levantine Seas. Differences in vocal repertoire, year-round observations of all age-classes and both sexes in the eastern Mediterranean, and the scarcity of sightings in the Strait of Gibraltar, provide circumstantial evidence of demographic isolation from sperm whales in the North Atlantic. Although no estimates of abundance are available, encounter rates for sperm whales have been unexpectedly low during recent years, in striking contrast with older accounts of localised abundance of this whale species in portions of the Mediterranean. A possible decrease of sperm whales in the region may have been caused by a number of factors: (a) a large number of sperm whales have been found drowned in the high seas driftnet fishery for swordfish, and (b) noise and disturbance from intense traffic, mineral prospecting, military operations, and dynamite fishing has been constantly increasing in the Mediterranean in recent decades. A comprehensive survey is urgently needed to assess abundance, distribution and presence of critical habitat of sperm whales in the Mediterranean. This project would be implemented most effectively using a combination of visual and acoustic techniques. It is suggested to divide the Mediterranean into a number of cells (possibly 10-15) that could each be covered by one vessel equipped with a towed hydrophone array within a four-week period, and then to conduct simultaneous surveys of these cells from platforms of opportunity (e.g., sailing vessels), in July, when the seas are calmest. While the surveys will be specifically targeted to determine sperm whale abundance, distribution, habitat use, and critical habitat, they will create a unique opportunity for obtaining other useful results, such as the gathering of knowledge on presence, distribution and sighting frequencies of other cetacean species in Mediterranean pelagic and slope areas where observations have never been carried out; the project would also entail the involvement of a conspicuous number of trainees in a major, region-wide research effort. In an initial phase is proposed that a steering committee be established with the task of completing the preparation of the project, including the elaboration of the needed organisational, logistic, scientific, technical and financial aspects. It is envisaged that the complete proposal will be presented for approval to MOP2, and that the surveys be possibly conducted in July 2005.

Activities:	consultations, planning, proposal writing, fundraising
Possible synergies:	4, 7, 8, 10, 11, 12
Duration:	2 years
Indicative budget:	€ 8,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
10	4	Not budgeted	**Identification of Mediterranean sites of conservation importance for fin whales (*Balaenoptera physalus*) in addition to the Ligurian-Corsican-Provençal (CLP) basin, and assessment of the functional relationships of such sites to the CLP basin with respect to the species' habitat needs**

Fin whales, represented in the Mediterranean by a genetically distinct population thought to reside year-round in the subregion, are found in greatest concentrations in the Ligurian-Corsican-Provençal (CLP) basin; here an international cetacean sanctuary was recently established by France, Italy and Monaco, and a SPAMI declared by the Contracting Parties of the Barcelona Convention. In the LCP basin fin whales gather during summer to feed, and a portion of the population is known to remain there throughout winter. However, fin whales are wide-ranging migratory mammals, and it is not known where they move to when they depart from the LCP basin. Data on fin whale distribution and habitat use in the Mediterranean, outside of the LCP basin and throughout the year, are incomplete; lack of knowledge on the location(s) of habitat critical for the species' breeding and nursing is particularly disturbing. Aim of this project is to help elucidate details of habitat use and movement patterns of fin whales in the Mediterranean outside of the LCP basin, to help enhancing the species' conservation status. Data on fin whale presence and relative abundance during summer throughout the subregion will be gathered through visual sightings as a by-product of Action 9 (basin-wide sperm whale survey). In addition, long-term tracking with satellite tags should be performed on an adequate sample of individuals, to detect seasonal movement patterns and identify possible autumn and winter destination areas. Although no budget was proposed on this account for the 2002-2004 period, this action was included in the list in consideration of the uncertain conservation status of this whale species, and to highlight the potential for synergies between ACCOBAMS and other concerned organisations in the common effort to conserve Mediterranean fin whales.

Activities:	consultations, field study involving satellite tagging
Possible synergies:	9
Duration:	4 years

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
11	4	Not budgeted	**Development of photo-identification databases and programmes encompassing the entire ACCOBAMS Area**

Studying free-ranging cetacean populations using photo-identification techniques has become a common, powerful research practice during the past decade in many areas of the world, including portions of the Agreement area. Such studies have proven, among other things, to hold considerable conservation value. Recently, a three-year programme, «Europhlukes», was funded by the European Commission with the goals of developing an European cetacean photo-id system as a support tool for marine research and conservation, to initiate a European network which will link providers with end-users of the European cetacean photo-id system, and to ensure future growth and maintenance of the system and its databases. Although a budget for this action could not be secured for the 2002-2004 period, it is highly recommended that an operational link be established between ACCOBAMS and the «Europhlukes» project management, to explore possibilities for future co-operative effort, for the extension of the programme to non-European partners within the Agreement Range States, and to help ensuring the indefinite continuation of this worthy initiative after the European project is terminated.

Activities:	consultations, meetings
Possible synergies:	4, 6, 7, 8, 9, 10, 12, 13
Duration:	ongoing

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
12	5	951	**Establishment and implementation of a long-term training programme on cetacean research, monitoring and conservation/management techniques and procedures**

Cetacean research and monitoring techniques have made considerable progress in recent decades, and provide significant support to the conservation and management effort. While such techniques are currently consistently applied, and even developed, in portions of the Agreement area, they are largely ignored elsewhere. Diffusing research and monitoring abilities throughout the region thus seems like a timely challenge and one of the highest priorities as far as cetacean conservation is concerned. The problem to be addressed is twofold: (a) transmitting knowledge through appropriate, effective and long-lasting training procedures, and (b) ensuring that such hard-gained knowledge is put to good, long-term use once the trainees endeavour to apply it at home. Accordingly, this activity will firstly consist in the organisation of field-based training courses in areas providing ideal research facilities and opportunities, to teach standard research techniques and provide selected participants with a hands-on experience. Secondly, follow-up support to the selected trainees in their countries, to assist with the development and implementation of research and conservation projects, will have to be provided through a co-operative effort between the Agreement Secretariat, or the appropriate Co-ordinating Unit, and the concerned Contracting Party.

Activities:	contracts to teaching and training organisations, travel, participation in national and international research programmes
Possible synergies:	4, 6, 7, 8, 9,
Duration:	ongoing
Indicative budget:	2002-2004: € 60,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
13	5	952	**Development of an educational tool for the organisation of research projects and basic technical studies**

Several countries have indicated their need for guidance and training in research and monitoring techniques and procedures. The budget covers the production and distribution of a «pedagogic kit» based on a prototype, the basic elements of which have been identified by the Interim Secretariat. Items contained in the kit should include a basic scientific background on cetaceans, a description and identification guide of the species living in the Agreement area, protocols for the approach and observation of cetaceans at sea, sampling protocols and basic instructions for intervention in the case of strandings, a selection of legal documentation, a list of MPAs, training and education opportunities, and a list of useful addresses.

Activities:	kit preparation and distribution
Possible synergies:	12, 14
Duration:	2 years
Indicative budget:	€ 42,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
14	5	961	**Creation of sub-regional directories of national authorities, research and rescue centres, scientists, governmental and non-governmental organisations concerned with the Agreement's objectives**

Since a Mediterranean directory was already prepared through a co-operation between the RAC/SPA, the Tethys Research Institute and the Interim Secretariat, only the costs of updating the existing directory, extending it to the Black Sea and contiguous Atlantic area publishing it are covered here.

Activities:	desk study, correspondence, directory preparation and diffusion
Duration:	1 year (2003)
Indicative budget:	€ 2,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
15	5	962	**Support to the implementation of national stranding networks, and their co-ordination into a wider regional network**

Cetacean strandings create an important opportunity for the gathering of much needed knowledge on natural and human-induced mortality of cetacean populations, and provide an available source for precious additional information, among other things, on the biology, pathology, toxicology and population genetics of the concerned species. Stranding networks exist in the Agreement area, each of them having various degrees of the extent of their spatial and temporal coverage, efficiency, and institutional involvement. Goals of this action are to: (a) improve the efficiency, when needed, of national stranding networks, (b) help extending the appropriate know-how to countries where strandings are currently not monitored, and (c) create the basis for the establishment of a wider network at the regional level. As a first step, a coordination mechanism should be established, consisting of a centralised cetacean stranding database managed for the Agreement Secretariat, to promote the exchange of information on cetacean strandings among the Agreement Range States. A number of additional steps are proposed: (a) the promotion of an ACCOBAMS-RAC/SPA agreement, to take the best advantage of the Mediterranean Database of Cetacean Strandings (MEDACES; (b) its widening, through the Agreement secretariat, to include the Black sea data; (c) the organisation of specialised training; (d) the establishment of an appropriate interface with a regional system of tissue banks; (d) the creation of a website; and (f) the publication and diffusion of a comprehensive stranding protocol and of an ethical code.

Activities:	database, website, consultations, training, desk study
Possible synergies:	3, 5, 6, 7, 8, 12, 13, 14, 17, 18
Duration:	ongoing
Indicative budget:	2002-2004: € 12,000
	2004-2006: € 28,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
16	5	964	**Development of a network of specialised bibliographic collections and databases**

One of the greatest hindrances to the region-wide development of a cetacean science tradition - a fundamental prerequisite to conservation and, ultimately, to the fulfilment of the purposes of the Agreement - is the diffused current unavailability of up-to-date specialised literature in most Range States' scientific and academic environment. This action proposes the establishment of a working group, which should include specialised librarian expertise, to examine the current availability of pertinent bibliographic material across the Agreement area, to strengthen existing facilities, and to identify locations where additional specialised libraries should be established. Support should be provided to existing libraries containing significant cetological bibliographic collections, to ensure continued updating and expansion, to facilitate access to information to the local scientific community, and to provide a framework for capacity building that will encourage documented cetacean research in the Agreement area. Modern document transfer and exchange technology should be adopted and promoted, and library databases should be managed within the context of a network that facilitates cross-library research and exchange of materials.

Activities:	consultations, desk study, bibliographic database, website
Possible synergies:	3, 11, 12, 13, 14, 15, 17
Duration:	ongoing

Indicative budget: 2002-2004: € 114,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
17	5	965	**Establishment of a system of tissue banks**

Central repositories of cetacean tissues, mostly deriving from strandings, bycaught animals and biopsies (also known as «tissue banks») have the potential of greatly enhancing the current capabilities of the scientific community of understanding pathological and toxicological mechanisms leading to the development of critical conservation events at the regional level. At the present moment, two tissue banks are being established in the Mediterranean subregion, one in Spain (University of Barcelona), with a focus on pollutants, and one in Italy (University of Padova), with a focus on pathology. Goal of this action is to assist in the co-ordination between existing initiatives, and promote the enlargement of the geographical scope of the bank system to the entire Agreement area, Black Sea included.

Activities: consultations
Possible synergies: 3, 5, 6,7, 8, 14, 15
Duration: ongoing
Indicative budget: € 4,000

Action n°	Cons. Plan Art. n°	Budget item n°	Title:
18	6	971	**Establishment of a Task Force for special mortality events**

In recent years the Agreement area has been the scene of major cetacean mortality events, involving mass strandings over wide geographical areas, which have evoked great concern and have attracted considerable attention from the scientific community. To face possible new mortality outbreaks, as well as major accidental events affecting cetacean populations or their critical habitats, the establishment of a Task Force for marine mammal mortality and special events, formed by international experts, is highly recommended. When necessary, and if requested by the Secretariat, the Task Force will convene and arrange for a small team of experts to assess the situation on the ground and advise national groups. The development of intervention protocols and of code of conducts to be followed in case of emergency situations should also be included within the tasks of such group.

Activities: consultations, task force, meetings, desk study, travel
Possible synergies: 12, 13, 14, 15
Duration: ongoing
Indicative budget: € 12,000