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MEDITERRANEAN ACTION PLAN

Meeting of Experts on the implementation of the Action Plans for marine mammals (monk seal and cetaceans) adopted within MAP

Arta, Greece, 29-31 October 1998

INTERACTION OF FISHING ACTIVITIES WITH CETACEAN POPULATIONS IN THE MEDITERRANEAN SEA

UNEP
RAC/SPA - Tunis, 1998

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INTRODUCTION

Fishing is deeply rooted in the Mediterranean tradition and constitutes a socio-economic element that is both important and age old. Small scale coastal fishing is highly developed and is considered as being pursued more intensely than anywhere else in the world, when bearing in mind the surface area of the Mediterranean Sea and the length of its coastline.

The ingenuity of the peoples of the Mediterranean, who perfected specific techniques of small scale fishing, and the industrialising of modern fisheries, have meant that there is now in this sea a wide, diverse range of fishing gear, nets and techniques. This fishing has now extended to take in demersal and pelagic species and operates both near the coast and out in the open sea. Sometimes it becomes specialized, targeting a single species or a restricted group of species of great commercial value.

Among the 22 species of Cetaceans reported in the Mediterranean Sea, 10 are seen as accidental in that they are only mentioned in a few sightings; they enter the Mediterranean via the Strait of Gibraltar and the Suez Canal. The other 12 species are regular, 8 of them being common and 4 much less frequent (Beaubrun, 1994). In the group of common species are the Fin Whale (*Balaenoptera physalus*), the Striped Dolphin (*Stenella coeruleoalba*), the Common Dolphin (*Delphinus delphis*), the Bottlenose Dolphin (*Tursiops truncatus*), Risso's Dolphin (*Grampus griseus*), the black Pilot whale (*Globicephala melas*), the Sperm Whale *(Physeter macrocephalus*) and the Ziphius (*Ziphius cavirostris*). The toothed cetaceans are ichthyophagous and/or teuthophagous, the diet being dictated by feeding habits, sector frequented, season and availability of prey. The Fin Whale is a planktonophagous in the summer and ichthyophagous and teuthophagous in the winter (Beaubrun, 1994).

In the past, direct and indirect deaths of marine mammals caused by fishing activities were relatively few and restricted in place and time. But nowadays the harmful interaction of fishing and cetaceans has reached an alarming level around the world. Tens of thousands of them die each year after being incidentally caught in nets; dolphins and porpoises are the most affected by such capture. All fishing gear are involved, but gill-nets are responsible for most of the incidental captures and the sometimes mass deaths they lead to. Gill-nets, in the wider sense of the term, are used throughout the world, set on the bottom, maintained at the surface or even drifting near the coasts or in the open sea.

About 80,000 cetaceans die every year in the world in gill-nets (Krauss et *al.*, 1997). In the Mediterranean, drifting gill-nets hold the sad record for deadly captures of cetaceans, especially with their increase in size, number and geographical area of use. Cetaceans are not the only victims of fishing gear; non-target fish species, sea birds, turtles and pinnipeds are also incidentally caught by fishing gear; we are speaking here of millions of individuals (Read, 1996).

Fishing impact is also reflected in its effect on stocks of fish and cephalopods, which in most of the Mediterranean areas are being fished extensively. Cetaceans, whose trophic level is comparable to man's, compete with fisheries because resources are dwindling. Cetaceans may damage fishing nets and eat the nets' contents. A direct conflict takes place between cetaceans and fishermen. The fishermen see the cetaceans as rivals and unhesitatingly eliminate them directly.

Studies on cetacean mortality in fishing gear in the Mediterranean did not figure among the routine studies carried out when research on marine mammals was being undertaken. It was therefore hard to find work done on this subject (Northridge, 1984). From the mid 1980s, studies started to investigate this problem and a first assessment was made of incidental catches in passive fishing gear (Di Natale and Notarbartolo, 1994).

1.- Fisheries' activities and interaction with Cetaceans

Fishing gear in the Mediterranean can be divided into two rough categories (Read, 1996). Active fishing gear depend on the net's moving through the water to catch the fish. In this group are the seines (beach seine, purse seine) and trawl nets (demersal, pelagic). Fishing targeted species with passive fishing gear involves the movement of the fish towards the device. In this category are surface gill-nets, seabed gill-nets, Tuna trap-net and longlines. These two categories have differing potential for capturing cetaceans (Read, 1996).

1.1.- Mediterranean fishing fleets and fisheries that threaten Cetaceans

The big number of fishermen and the diversity of the fishing gear they use to exploit halieutic resources means that interaction with cetaceans is observed for most of the fishing gear and in most Mediterranean areas. But bottom set and surface gill-nets constitute the greatest danger to cetaceans in the Mediterranean (Beaubrun, 1994; Di Natale, 1992; Di Natale and Notarbartolo, 1994).

In the Mediterranean, there are two main types of drifting gill-nets: nets to catch small schooling pelagic species which live in shoals (sardine, horse mackerel, etc.) which are set near the coasts. Their mesh is smaller (4-9 cm.) than that of the drift nets for catching large pelagic species such as swordfish or albacore, which are fished far off the coast with 16-52 cm. mesh.

It would appear that in the early 1990s there were no fishing boats from countries not bordering on the Mediterranean operating with drifting gill-nets (Di Natale and Notarbartolo, 1994).

Algeria

Data on fisheries

Little information is available on fisheries using gill-nets. These are localised near the coasts and mainly target hake (*Merlucius merlucius*), sole (*Solea vulgaris*) and other benthic species (Di Natale and Notarbartolo, 1994).

Drift nets are used for fishing swordfish. Fishing boats equipped with this type of net are some 9 metres long. Regulations set down the size of the drift nets with a maximum length of 2.5 km. (CGPM, 1994). Some ten units exploit this fishery localised in the West of Algeria (Di Natale and Notarbartolo, 1994). Big pelagic species are also caught by using longlines (CGPM, 1994).

Interaction with Cetaceans

There is no official data on capture of Cetaceans. Dolphins (Common Dolphin, Striped Dolphin) have been reported as caught in fishing nets (Boutiba, 1994). Cetaceans are protected by law in Algeria.

Cyprus

Data on fisheries
Coastal fishing uses bottom set gill-nets. Fishing of big pelagic species is practised by longlines, targeting swordfish. No boat registered in Cyprus uses drift nets (CGPM, 1994).

Interaction with Cetaceans
No data available.

Egypt

Data on fisheries
Passive fishing is practised with drift nets, trammels and longlines and is concentrated between Alexandria and Port Said (CGPM, 1986).

Interactions with Cetaceans
Di Natale and Notarbartolo (1994) imply that fishing activities in Egypt do not cause significant incidental capture of cetaceans.

France

Data on fisheries
Gill-nets are used near the coasts by over than 1,000 boats whose length is between 3 and 14 metres. Numerous species are sought, both benthic and pelagic (Di Natale and Notarbartolo, 1994).
Fishing boats equipped with drifting gill-nets mainly work around Corsica (CGPM, 1994). They catch swordfish, albacore (*Thunnus alalunga*) and other tuna (Di Natale and Notarbartolo, 1994). It would appear that the number of these boats has been increasing in 1997-1998.

Interaction with Cetaceans
Incidental capture of cetaceans (Striped Dolphin, Common Dolphin, Bottlenose Dolphin, Risso's Dolphin, Minke Whale, Rough-toothed dolphin) have been reported (Di Natale and Notarbartolo, 1994). No incidental catches has been reported for some years (Beaubrun, personal communication). French legislation protects cetaceans.

Greece

Data on fisheries
Gill-nets are used in coastal waters and catch various benthic and pelagic species. The fishing fleet that uses this fishery is made up of some 20,000 boats of various sizes (Di Natale and Notarbartolo, 1994).
Fisheries of drifting gill-nets that target swordfish are localised in the Ionian Sea and in the south west of the Aegean Sea. The units equipped with these nets are 7-8 m. long. The small drift nets catch small thunnidae (Di Natale and Notarbartolo, 1994).

Drifting longlines are used for fishing swordfish and other big scombridae in the Aegean Sea, in the Ionian Sea and sometimes in the Levant Sea (CGPM, 1994).

Interaction with Cetaceans
Small delphinidae are thought to be part of the incidental catch in gill-nets (Di Natale and Notarbartolo, 1994). Greek legislation protects cetaceans.

Italy

Data on fisheries
Italian gill-nets operate in coastal waters and on the continental shelf and target various benthic species. The fishing fleet is heterogeneous and is made up of some 15,000 units 4 16 metres long.
Small drift nets target tuna and mackerel and equip units whose length varies between 4 and 14 metres (Di Natale and Notarbartolo, 1994).
Big pelagic species fishery is the biggest fishery in Italy. The targeted species are bluefin tuna and albacore, but other species of fish may be caught. Italy used to be the country which used the most drift nets in the Mediterranean. In 1992, Italy implemented the European regulations on drift-nets and also forbade the use of drift nets of every size in the Ligurian Sea (except for special cases) (CGPM, 1994; Di Natale and Notarbartolo, 1994).
The Tuna trap-net target bluefin tuna from May to June in shallow coastal waters (Di Natale and Notarbartolo, 1994).

Interactions with Cetaceans
Bottlenose Dolphins, Risso's Dolphins, Striped Dolphins and Sperm Whales have been reported captured in gill-nets (trammels). In driftnet fishing the following species have been reported or suspected captured in fishing gear: Minke whale, Sperm Whale, Ziphius, black Pilot whale, Risso's Dolphin, Bottlenose Dolphin and Striped Dolphin. Di Natale and Notarbartolo (1994) have reckoned that before the ban on drift nets 8,000 cetacean individuals were being caught annually in these nets mostly striped dolphins and an incalculable number of sperm whales. Italian legislation protects cetaceans.

Libya

Data on fisheries
Very little data is available. A Tuna trap-net intended for bluefin tuna and bonito fishing operates from mid-May until late July (CGPM, 1982).

Interaction with Cetaceans
No cetaceans were caught in this Tuna trap-net.

Malta

Data on fisheries
Drifting gill-nets are used in swordfish fishing in the Maltese archipelago. These very long nets,

between 5 and 12 km. long, equip units which measure between 12 and 16 metres (Di Natale and Notarbartolo, 1994).

Interaction with Cetaceans
The longlines for shark fishing use captured dolphins (harpoon and speargun) as bait.

Morocco

Data on fisheries
Drifting gill-net fishing has developed since 1989. Catches are made up of swordfish and other accidental species such as bonito. The fishery used to be made up of 80 units whose lengths varied from 6 to 17 metres. This is a restricted range small scale coastal fishery.
Today, the active fishing Moroccan fleet in the Mediterranean is made up of 45 units. Since 1991, Moroccan regulations have limited the maximum size of drift nets to 2.5 km. This regulation also stipulates that the other fishing fleets have no right to change over to this type of fishing, which is strictly restricted to the longliners which had formerly practised it. The maximum tonnage of these units is set at 15 tonnes gross capacity; one net only will be used by each fishing unit (Lahnin, 1997).
The Tuna trap-net are set up to catch bluefin tuna in the Strait of Gibraltar and in the Sea of Alboran. Three or four Tuna trap-net function regularly. Small scale line fishing is practised in the Strait of Gibraltar and targets adult tuna.

Interaction with Cetaceans
Investigations among professionals have not revealed any captures of marine mammals. Sunfish and turtles are caught and thrown back into the sea alive (Lahnin, 1997). Dolphins stranded on Morocco's Mediterranean shore bear traces of having been caught in nets.
Dolphins captured incidentally in a Tuna trap-net have been released alive.

Spain

Data on fisheries
Gill-nets are used in the coastal sectors, around the islands and on the continental shelf. A great variety of benthic fish is targeted (Di Natale and Notarbartolo, 1994).
Use of the drag net and the gill-net for swordfish fishing has been prohibited. But the gill-net is authorized and regulated for catching small thunnidae (the net must not be longer than 1.5 km.) (CGPM, 1994).
Unauthorized drifting gill-nets continue to be used illegally in the Sea of Alboran and the Strait of Gibraltar. There are some thirty or so boats (over 15 metres in size) which still operate with nets whose size is larger than the maximum set by both Spanish (1.5 km.) and European regulation (2.5 km.) (Silvani et *al.*, 1997). The main species targeted by this fishing are swordfish and other big pelagic species.
One single Tuna trap-net is still in use for fishing bluefin tuna in the Spanish Mediterranean waters.

Interaction with Cetaceans
A lot of dolphins are incidentally caught in the fisheries that fish the big pelagic species.

Drifting gill-nets caused the deaths of over 630 dolphins in 1993 and 1994, in comparable proportions of Common Dolphin and Striped Dolphin in the Strait of Gibraltar and east of this in the Sea of Alboran (Silvani et *al.*, 1997). Captures of Bottlenose Dolphins have also been reported (Di Natale and Notarbartolo, 1994). Cetaceans are protected by Spanish legislation.

Tunisia

Data on fisheries
Gill-nets are set in coastal waters to catch benthic species. These nets also catch small migrating thunnidae (Di Natale and Notarbartolo, 1994; CGPM, 1994).
Drifting gill-nets mainly catch auxide, tuna and striped back bonito (CGPM, 1994). Two Tuna trap-net have been set up on the Tunisian coasts to catch bluefin tuna (Di Natale and Notarbartolo, 1994).

Interaction with Cetaceans
Incidental captures of cetaceans have been reported in fishing gear (Di Natale and Notarbartolo, 1994). Present day interaction mainly concerns gill-nets and spin seines in which dolphins may cause damage. Acoustic methods (dolphin tube) had been used to keep the dolphins off the nets (Ben Naceur and Mhenni, 1995).
Cetacean capture is banned by the Tunisan fishery regulations.

Turkey

Data on fisheries
Gill-nets which operate in the eastern sector of the Aegean Sea target various benthic species (Di Natale and Notarbartolo, 1994). Fishing for pelagics concerns large and small species.
The fishing season for large pelagic species (bluefin tuna and other species) is between late May and late August, using drifting gill-nets (CGPM, 1994).

Interaction with Cetaceans
There is no official data, but we may suspect that there have been captures of Bottlenose Dolphin, Striped Dolphin and Common Dolphin (Di Natale and Notarbartolo, 1994).

Non-Mediterranean Fleets

Fishing boats belonging to non-Mediterranean riparian countries operate in several zones of the Mediterranean sea. Japanese fleet is used to fish adult bluefin tuna and accidentally swordfish. In 1991, ten boats were fishing. This fishing fleet starts fishing in the Strait of Gibraltar in April and moves eastwards, off Sicily and Tunisia. This movement appears to follow the eastward movement of the shoals of targeted fish, which enter the Mediterranean to spawn. These boats leave the Mediterranean after a 2-3 month stay (CGPM, 1994). We have no official data on the interaction of the activity of this fleet with cetaceans in the Mediterranean.

1.2.- Impact of fisheries on Cetaceans

1.2.1.- Fishing gear and species vulnerability

A comparative analysis of the dangers which every fishing gear used in the Mediterranean constitutes for Cetacean species leads to a qualitative approach to this impact (Figure 1). Of the fishing techniques used in the various fisheries, eight have caught a cetacean at least once. Longlines, gill-nets and drift nets (passive fishing) and demersal trawls (active fishing) are the most dangerous and affect the most species, with a maximum of 8 for driftnets (Figure 2). In coastal zones, heavy mortality has been noted with gill-nets and demersal trawls, while on the high seas longlines and drift nets have been the cause for the elimination of cetaceans (Beaubrun, 1994). As well as these fishing gear we must mention those animals which were killed by fishermen using harpoons and spearguns. Four species have fallen victim to this direct elimination: Bottlenose Dolphin, Pilot whale, Striped Dolphin and Sperm Whale.

Drifting gill-nets mobilize fewer fishermen than seabed gill-nets (Table 1), but these fisheries are industrialised, for the commercial value of the targeted species is high. They also cause the mass capture of various species that are not targeted, among which are the Cetaceans. Their being spread at sea to a depth of up to 30-40 metres below the surface, their length, which can be several kilometres long, and their wide mesh, are the main reasons why they are dangerous, increasing the probability of cetaceans being caught. In the waters of the open sea, where drift nets operate, the 'pelagic' cetaceans tend to stay close to the surface. It has been shown that when cetaceans get entangled in these nets this happens in the part of the sea that is near the surface. Drift nets have a direct impact on cetaceans because in most cases they cause death by suffocation of the individuals which have been tangled up in the net. The length of the nets is held directly responsible for this mortality. Despite the ban, drifting gill-nets longer than 2.5 km. are still being used (CGPM, 1994). Certain nets are even longer than 5 km. (Di Natale and Notarbartolo, 1994; Silvani et *al.*, 1997).

Bottom set gill-nets and trammels are dispersed over a large part of the coasts and used all year long. This is the most intense form of fishing, mobilizing most fishermen (Table 1) and targeting a wide range of benthic and pelagic commercial species. The nets are sometimes very long. They threaten coastal species such as the Bottlenose Dolphin (*Tursiops truncatus*), which attack the fish that have been caught and thus damage the nets. Competition and direct conflict with fishermen sometimes lead them to kill dolphins..

In several regions, fishing with Tuna trap-net is a traditional activity. Their number is relatively small (Table 1) and their activity seasonal. Incidental capture of cetaceans which happen there are few in number. In these cases, the animals are taken alive. Cetacean deaths resulting from these captures are negligible.

Abandoned nets drifting at sea may cause cetaceans to be captured. They constitute a perpetual danger since they directly capture cetaceans but may also attract them because of the fish they have trapped.

1.2.2.- Effect of incidental catches on cetacean populations

Measuring the vulnerability of each species of cetaceans in the Mediterranean against the various fishing gear is a tool by which incidental captures of cetaceans in fishing gear can be better distinguished (Fig. 2). Among the 11 species of cetacean that are victims of fishing activities are species termed 'common', plus three 'infrequent' species: the Killer Whale (*Orcinus orca*), the False Killer Whale (*Pseudorca crassidens*) and the Minke Whale (*Balaenoptera acutorostrata*).

The Striped Dolphin is the species most affected by these captures since it is the victim of seven fishing gear and of direct elimination by man. With the Common Dolphin and the Bottlenose Dolphin it constitutes the group most vulnerable to fishing activities. That this is so indicates the continuity of a very old situation (Northridge, 1984). Despite its large size, the Sperm Whale has fallen victim to bottom set gill-nets and drift nets, demersal trawls and longlines.

A quantitative approach to cetacean mortality caused by fishing gear in the Mediterranean, and its impact on populations, is difficult because there are many gaps. The first relates to the knowledge that has been acquired about cetacean populations in the Mediterranean as a whole. All known species have been observed in the western part, probably because of the proximity of the Strait of Gibraltar, through which a large part of the species qualified as infrequent or rare in the Mediterranean pass in transit (Beaubrun, 1994). In the eastern part, there have been fewer sighted species, but there is far less intensive pressure of observation and cetological research than in the western part. Numbers of cetacean populations are still less well known and in many cases rough estimates are used. Knowledge of population numbers and captured cetacean numbers are two basic parameters for measuring the impact of incidental capture.

In the present state of our knowledge, only estimates are provided (Table 2). Impact is measured by taking into account 5 levels in decreasing order: not sustainable, presumed not sustainable, potential, minimal and insignificant (IWC, 1994). This impact is measured for passive fishing gear, whose captures are better known and very much higher than those for active fishing gear.

Stenella coeruleoalba is at present considered the Mediterranean cetacean most threatened by fishing activities. This population figured in 1994 among the world's seven most endangered cetacean populations. The level of mortality through fishing was alarming and judged non sustainable, for the death rate in drift nets was too high. Today, with the appreciable reduction in the number of drift nets and their activity, it is possible that the level of capture may have fallen.

In the Sea of Alboran, use of drift nets has caused the worrying mortality of the Striped Dolphin and the Common Dolphin (Table 2) (Silvani et *al.*, 1997). This threat is even more alarming when one evokes the mortality of the Striped Dolphin in the early 1990s in the western Mediterranean, due to an epizootic caused by a morbillivirus. This epizootic reduced and scattered the population. *Delphinus delphis,* which frequents the north-west Mediterranean far less, is probably confining itself to the southern Mediterranean, and its population is presumed to be declining. These captures operated in the far western part of the Sea of Alboran are not favourable to it.

Furthermore, it has been shown that captures of Delphinidae in drifting gill-nets were made up mostly of young individuals, some of them only a few months old, with adults representing between 10% and 20%. Also, dolphins have often been found caught in the upper part of the net (Silvani et *al.*, 1997).

To extricate cetaceans captured in nets, fishermen cut off the animal's flippers, dorsal fin, and tail and throw it into the sea. These marks and other characteristic scars mean that the death of the animal, once stranded on the shore, can be attributed to fishing. In other cases, the animal is weighed down and sunk (Anonymous, 1992).

The harmful effects of fishing on cetaceans in the Mediterranean assume other forms. The first concerns the present overexploitation of halieutic resources in the Mediterranean. Indeed, many species are at present at an inordinate and unsustainable level of exploitation, among them species that are the cetaceans' prey. Maintaining or increasing the level of halieutic exploitation would lead to an increased threat to the viability of populations and species via diminished availability of preys. Competition between cetaceans and fishermen will tend to increase, and direct mortality of cetaceans due to fishermen is to be feared, because of the high commercial value of the targeted species.

A good number of cetacean species found in the Atlantic use the Strait of Gibraltar to enter the Mediterranean. In fact, most of the species of cetacean described as infrequent or incidental in the Mediterranean Sea pass in transit via the Strait of Gibraltar. Present day observations suggest that exchanges would happen between the Sea of Alboran and the (Atlantic) Ibero Moroccan bay. Drift net fishing on either side of the Strait of Gibraltar must be reviewed in order to lessen the impact on local Common Dolphin and Striped Dolphin populations, and to keep the cetological flux between the Atlantic and the Mediterranean at its normal level.

Faced by the observed fact that when cetaceans are entangled in gill-nets this mostly happens in water near the surface, experiments have been carried out whereby drift nets are kept to a certain depth, thus leaving the upper waters, where most cetaceans move about, clear. The experiment has been conclusive, with a reduction in the number of captured cetaceans, but there has simultaneously been a marked drop in the catch of the targeted fish species.

2.- Main techniques used to reduce the problems of interaction between fishing activities and Cetaceans

There is growing international concern about the incidental catches of cetaceans in fishing gear; research is under way to develop techniques that can bring about a significant drop in the numbers of such captures (Goodson et *al.*, 1994a). The present day level of these captures around the world leads to high mortality, directly harming cetacean populations. This situation becomes alarming when the viability of the populations is threatened, and reaches a climax when it puts dolphins and porpoises at risk of extinction, as is the case for the Californian Porpoise (*Phocoena sinus*) and the Chinese Dolphin (*Lipotes vexillifer*) (Krauss et *al.*, 1997).

In order to reduce to the minimum the present proportion of captures of cetaceans in fishing gear at sea, research is being done that aims at developing and trying out techniques to warn

cetaceans of the presence of nets, using procedures that allow marine mammals to better detect fishing gear.

Sight is invaluable for cetaceans to find their position in the water, especially for those species which do not use echo location. Several observations show that cetaceans are able to see nets, thanks to sight. Yet there are few experiments available that have looked into sight for detecting nets (IWC, 1994). There seems to be more concentration on acoustics, that is, listening/echo location as the favoured sensory skill used by cetaceans to act with regard to their surroundings, particularly to recognise and avoid nets. Acoustics and sight are the sensory skills which relate to the problem of capture in fishing gear (IWC, 1994). Other sensory abilities could play a part, but little work has been devoted to these (Klinowska, 1992; Klinowska and Goodson, 1994).

Passive acoustic or passive listening means making the nets detectable to echo location by increasing their sonar reflectiveness (Dawson, 1991). Several reflectors using materials of various natures and shapes have been tested both in laboratories and at sea. We mention as examples: air-filled tubes, light piping, metallic spheres, polypropylene threads, metallic chains (Au and Jones, 1991; Au, 1994; Dawson, 1994; Silber et *al.*, 1994; Goodson et *al.*, 1994a; Goodson et *al.*, 1994b; Hatakeyama et *al.*, 1994).

Experiments done with modified fishing nets incorporating acoustic reflectors have in certain cases shown a fall in captures of cetaceans compared with nets of the same kind that have not been modified (Dawson, 1994). Air filled tubes seem to have achieved the best results, significantly lowering incidental captures of Dall's porpoises (*Phocoenoides dalli*). The placing of reflectors on or around the net also acts on the nets' performance as regards reducing captures of dolphins or porpoises (Dawson, 1994). But these positive results are not constant; they may differ from one fishing expedition to another, according to the season, or from one year to the next, without the reasons always being known (Hatakeyama, 1994). Also, modifications made to one type of net are not always necessarily applicable to another type of net, and from one fishery to the next (Dawson, 1994).

Use on a large scale of this technique reveals some potential constraints as regards modification of fishing professionals' gill-nets: (i) these modifications must have a reasonably long life expectancy from the point of view of commercial fishing conditions; ii) the modified nets must be easy to handle, light and inexpensive; iii) the modifications should not result in any significant drop in catch levels of targeted commercial species.

If passive acoustics mainly concern marine mammals endowed with sonar and using echolocation, active acoustics or active listening has the advantage of potentially concerning all marine mammals affected by the problem of incidental capture in fishing nets. Acoustic alarms installed near or on nets warn off marine mammals by giving off sounds that are adapted to the species of cetacean targeted (Krauss et *al.*, 1997; Hatakeyama, 1994). The results obtained by use of acoustic alarms seem promising. Among recent results, a significant drop in porpoise (*Phocoena phocoena*) captures on the east coast of the United States has been noted with gill-nets incorporating acoustic alarms, compared to the same kind of net not equipped with alarms (Krauss et *al.*, 1997). Experiments carried out in the Pacific (California) with drift nets for swordfish fishing have shown that nets equipped with acoustic alarms capture 75% fewer grey whales than unmodified drift nets (Highley, 1998). Other encouraging results have been obtained in New Zealand for the threatened dolphin species *Cephalorhynchus hectori* (Highley,

1998), and in Japan for Dall's Porpoise (Hatakeyama, 1994). Results obtained in the United States have been well received by fishing managers, who have authorized the reopening of fisheries that had been closed because of the high proportion of cetacean capture, now requiring that gill-nets equipped with acoustic alarms be used.

Besides the fact of warning cetaceans of the presence of nets, little is known about the process induced by acoustic alarms in order to lead to a significant reduction in incidental captures. The alarm may be a signal, allowing marine mammals to avoid the nets. But it might be the case that acoustic alarms cause a reaction whereby species of prey of cetaceans avoid the nets; this is the case for the herring *(Clupea harengus)*: there has been a drop in the number of herrings caught in nets equipped with acoustic alarms, and this has also happened with regard to their predators, the porpoises (Krauss et *al.*, 1997). It turned out that the captured porpoises were feeding on the herrings just before they became entangled in the nets. The porpoises' prey, which are fish targeted by fishing, avoid the nets, which leads to a fall in incidental captures of those marine mammals which tend to pursue these fish (Krauss et *al.*, 1997).

There have been relatively few direct *in situ* observations of cetaceans near the fishing gear and processes which lead to their being caught in nets (Read, 1996). Certainly, there has been no lack of observations in artificial pools, but experiments done in fisheries are taking on major, irreplaceable importance. Some observations show that cetaceans avoid the area where the net with acoustic alarms is and stay in the sectors where nets with acoustic reflectors are (Dawson et *al.*, 1997), but advanced adoption of the active acoustic technique (acoustic alarms) should be supported by in depth analyses and rigorous checks, testing out the alarms in other situations, where Odontocetes are threatened by gill-nets (Krauss et *al.*, 1997).

Although the results obtained from acoustic alarms are encouraging, it is not uncommon to find certain scientists expressing reserves. These reserves relate to i) causing cetaceans to get used to these acoustic alarms, which will lead to their later ignoring them, ii) possible movements of cetaceans or fish away from sectors where they used to feed, iii) the behaviour of young dolphins and porpoises which would be encouraged to approach and explore the nets, thus increasing the risk of their being entangled in the nets (Highley, 1998).

Use of acoustic alarms involves the idea of net visibility. Several works cited by Dawson (1994) show that little cetaceans are able to "see" non-modified nets at sufficient distances to be able to avoid them. Several reasons can be put forward to explain incidental capture in nets. (1) Dolphins do not use echo location near nets (Dawson, 1994; IWC, 1994). Sonar passivity is due either to the animal's evolution in a familiar environment, or that it is not looking for food, or that there is no communication between individuals, or that within one single group only some of the animals use echo location while the others do not, which would be the case for animals moving as a group. 2) Dolphins detect the net but do not perceive it as an impassable barrier. 3) Dolphins use their sonar but they are concentrating on their prey, caught by the net or in its vicinity (Goodson et *al.*, 1994). The hunting and eating of prey near the net lessen the dolphins' wariness of the net. 4) Dolphins, especially young individuals, are attracted by the net, seeing it as a novelty (IWC,1994).

In the Mediterranean, an experiment aiming to make dolphins move away from the purse seines of 'lamparos' in Tunisian waters has been attempted. A tube called the 'dolphin tube' was successfully tried out in a fishery where dolphins had done some damage inside the nets. It is

a tube closed at both ends and has a conical funnel. To make the dolphins that have been visually sighted move away, the part of the tube with the funnel is submerged, while the other end of the tube is hit with a hammer. Sound waves are thus produced and broadcast underwater. These acoustic waves are disliked by dolphins, and cause them to swim away (Ben Naceur & Mhenni, 1995). This technique has been proved conclusive, and 'dolphin tubes' have been distributed to fishermen. This technique was found not to be useable for gill-nets, and the use of acoustic alarms was envisaged (Ben Naceur & Mhenni, 1995).

To measure and validate the effective reduction of incidental captures obtained by any given technique, it is accepted that one would have to have data about captures in non modified nets of the same type (Dawson et *al.*, 1997). When making investigations among fishermen, a rigorous methodology should be adopted so as to provide reliable data allowing a correct appreciation of the proportion of captures of cetaceans (Lien et *al.*, 1994). Observations made during the fishing expeditions are necessary and provide precious information for better defining of the issues (Silvani et *al.*, 1997).

Conclusions

Fishing activity in the Mediterranean is intense, and there is much overexploitation of halieutic resources there. Fishing action on cetaceans is expressed in many forms there. The most important, and also the most obvious, is their incidental capture in fishing gear. This capture seems to be high in passive fishing nets, especially drifting gill-nets. These had caused the deaths of thousands of marine mammals when their use was not controlled. Fisheries using bottom set gill-nets and trammels, widespread throughout the entire Mediterranean, at present constitute with drift net fisheries the main activities that threaten cetaceans in the Mediterranean.

Demersal and pelagic trawls are perhaps just as threatening as what has already been mentioned, but lack of data prevents us becoming aware of the extent of these threats. In other sectors outside the Mediterranean, these active fishing gear are as much responsible for deaths of cetaceans as are passive fishing gear.

Overexploitation also leads to a scarcity of prey for cetaceans in certain sectors, for fishermen and cetaceans sometimes target the same species. There is a direct clash, and direct mortality could be significant, rising far above the present level. Introduction of gill-net fisheries in areas of transit favoured by cetaceans, such as the Strait of Gibraltar and the Sicilo-Tunisian Strait, constitute a supplementary threat, by reducing cetacean transit between the Mediterranean Sea and the Atlantic, and between the western and eastern parts of the Mediterranean. In the end, modern modes of exploiting applied to the Mediterranean's halieutic resources could lead to a destabilization of the cetacean populations.

To eliminate cetacean deaths it is necessary to have data on numbers and relevant scientific information for both fisheries and cetacean populations. It is also necessary to centralize data on the fisheries of all the fishing fleets that operate in the Mediterranean together, and to bring the information regularly up to date. Moreover, the national services responsible for maritime fishing should step up their attempts to fill out the available information on the numbers of marine mammals that have been victims of incidental capture.

Techniques to reduce incidental capture in nets are being tested, but complementary experiments at sea are necessary before we can hope to see such preventive techniques being generally used. Out of these promising techniques, acoustic alarms seem to have attracted the most attention. Management of fisheries is for the time being the only possibility used generally around the world. This management should intervene by regulating the fishing season, daily length of activity, geographical area exploited and technical features of fishing gear. And is not protection of cetaceans in national law already a priority?

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FIGURES AND TABLES

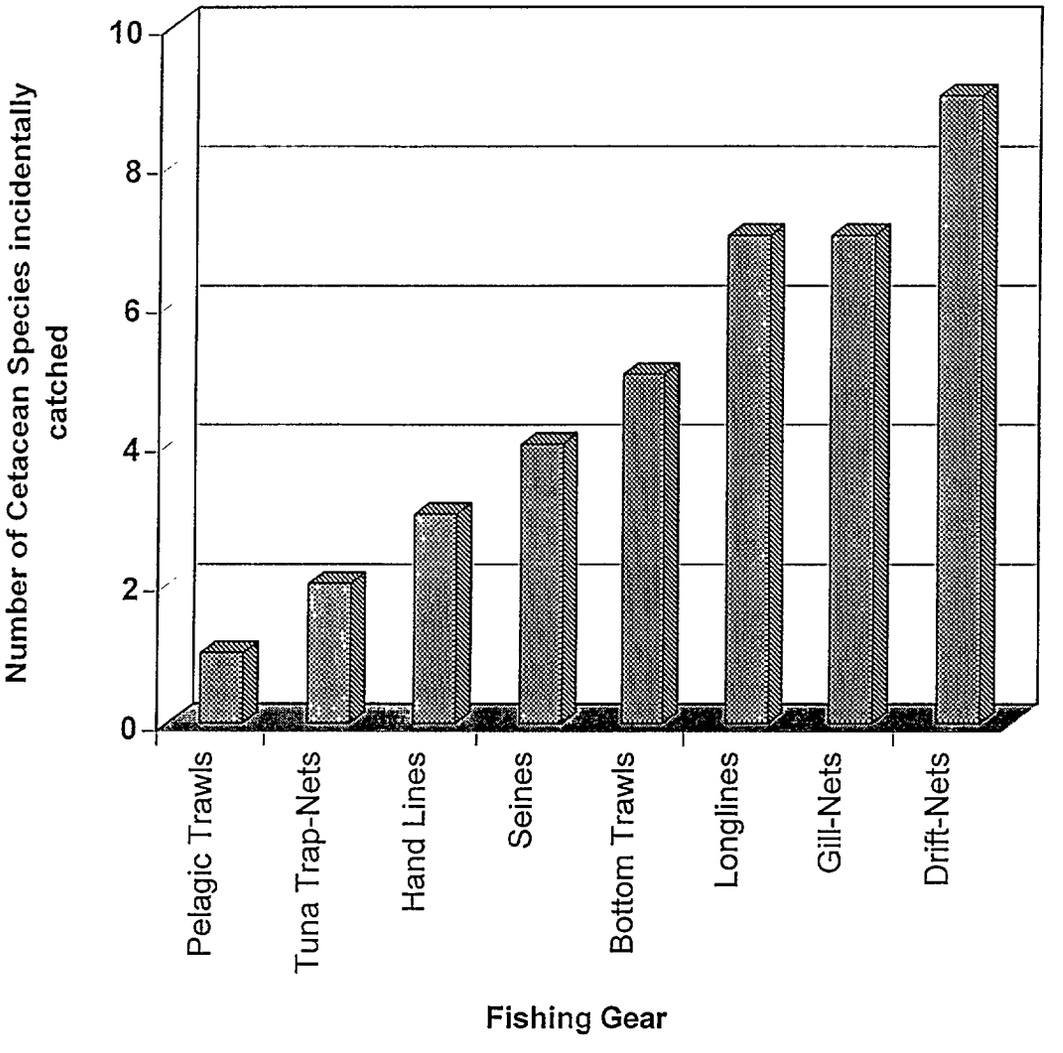

Figure 1: Number of cetacean species incidentally catched by fishing gear in the Mediterranean sea.
(According to data from Beaubrun, 1994)

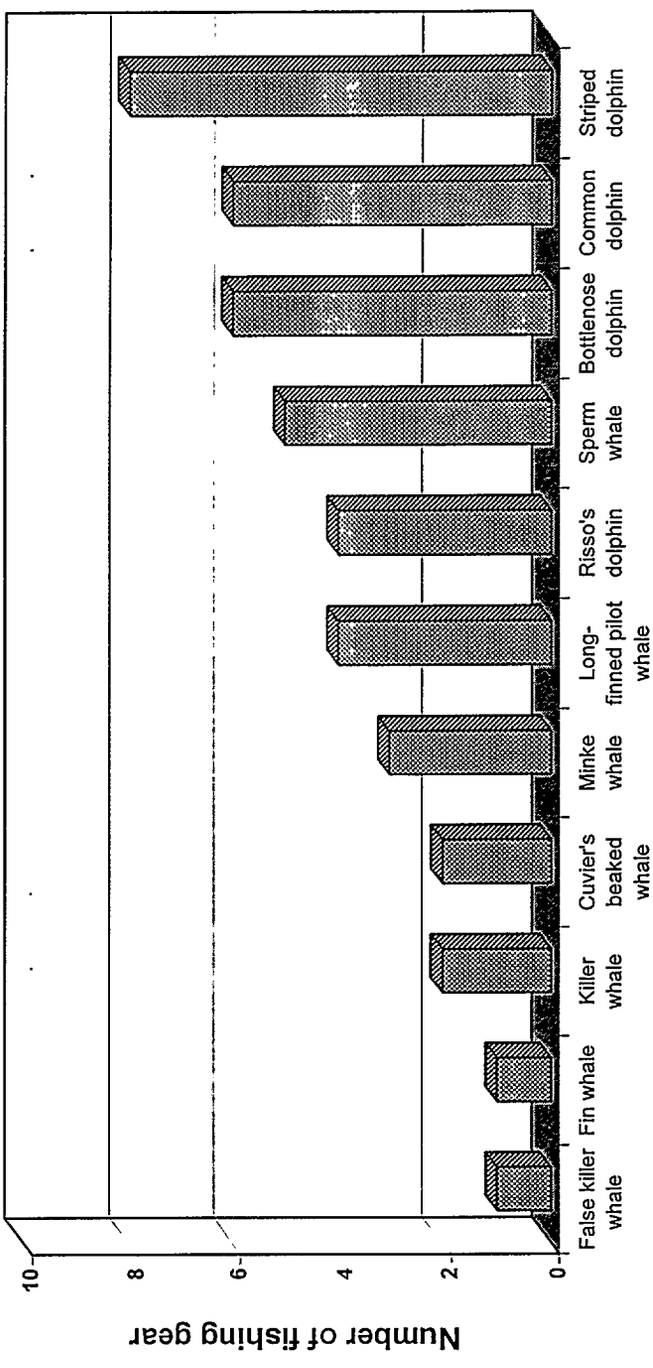

Figure 2: Number of gear in which each of the above 11 species was captured at least once. (According to data from Beaubrun, 1994). Direct elimination of animals were noted for Pilot whale, Sperm Whale, Bottlenose Dolphin and Striped Dolphin.

Table 1: Comparative data on various types of passive fishing gear
Sources: IWC (1994), Di Natale and Notarbartolo (1994) and CGPM reports

	Tuna Trap-nets	Coastal gill-nets	Drifting gill-nets for small pelagic species (coastal fishing)	Drifting gill-nets for big pelagic species (open sea fishing)
Number	> 10 units	50000 -100000 boats	100 - 1000 boats	< 120 boats
Boat size	--	4 - 16 metres	4 - 14 metres	7 – 26 metres
Persons involved	< 1000	> 300000	250 - 3000	300
Number of fishing days	60 - 120 days a year	All year long	10-120 days a year	60 days a year on average
Targeted species	Mainly bluefin tuna and swordfish	Benthic species and small pelagic species	Mackerel and other little tunnidae	Swordfish and albacore
Nature of net	Natural or artificial fibre	Nylon multithread Nylon Monothread Polyamide Multithread Polyamide monothread	Nylon multithread Nylon monothread	Nylon multithread Nylon monothread Polyamide multithread
Net length	--	350 – 3000 metres	200 - 1500 metres	2.5 - 12 km
Net mesh (stretched out)	--	20 – 250 mm	4 - 9 cm	16 – 52 cm

Table 2: Impact of fishing on cetacean populations in the Mediterranean (according to IWC (1994), modified)

Species	Annual mortality through passive fishing	Additional mortality	Population size	Impact of passive fishing
Balaenoptera acutorostrata	< 4	Not known	rare	minimal
Balaenoptera physalus	< 1	Some cases	< 3000	minimal
Delphinus delphis	400 > 150 in the Sea of Alboran	Some cases	- Unknown for the entire Mediterranean Sea - >11800 in the Sea of Alboran	High in the Sea of Alboran
Globicephala melas	50-100	Some cases	Not known	Potential
Grampus griseus	30-100	Some cases	> 3000	Presumed not sustainable
Orcinus orca	< 1	Not known	rare	Minimal
Stenella coeruleoalba	- 5000 c 10000 - > in the Sea of Alboran	Some cases	- 100000 for the entire Mediterranean - > 8800 in the Sea of Alboran	Not sustainable
Tursiops truncatus	110-455	Some cases	> 10000	Presumed not sustainable
Ziphius cavirostris	< 10	Not known	Not known	Not known
Physeter macrocephalus	20-30	Some cases	< 1000	Potential