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Interaction of Marine Turtles with Fisheries in the Mediterranean

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Note

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1.- INTRODUCTION

At present, the impact of accidental catch on sea turtle populations is one of the most urgent problems that must be solved to ensure the survival of all these species world-wide. In the Mediterranean, too, all marine turtle species are affected by fishing activities, in particular the loggerhead (*Caretta caretta*) and the green (*Chelonia mydas*) turtles, which are more common than the others and are the only ones breeding in this sea. Since the Mediterranean populations of both species seem to be genetically isolated from the Atlantic ones (Bowen *et al*., 1992; Bowen *et al*., 1993; Laurent *et al*., 1993), fishing-induced mortality probably cannot be counterbalanced by immigration. This implies that the survival of the Mediterranean populations of these species depends to a great extent on the conservation effort that the Mediterranean countries carry on in the near future to reduce accidental mortality.

Available information on sea turtle population dynamics has shown that the bigger (older) a specimen is, the greater is its contribution to the demographic growth of the population to which it belongs (Crouse et al., 1987; Laurent et al., 1992; Crowder et al., 1994; Heppell et al., 1996a, b). This means that the main priority is directing conservation efforts at the adult and big juvenile stages, when natural conditions on nesting beaches are preserved.

Marine turtles go through two main ecological phases during their lives, first pelagic and then demersal. The specimens which are the most important for their population are thus those in the second phase; they spend most time in shallow waters on the continental shelf. Exceptions may occur when they move between overwintering, feeding and nesting grounds.

Hence, it is very important to assess the impact of the fishing effort on big turtle classes (Laurent et al., 1992); this probably occurs, as proposed by Laurent et al. (1996) from trawling, especially in the fisheries of those countries lying off relatively large continental shelves; in fact, in these areas, captures, and climatic and trophic conditions, suggest the presence of many specimens.

Moreover, different types of fishing gear may induce different capture and mortality rates and may affect different sea turtle ecological phases (pelagic or demersal); certainly, these are important factors to assess.

The aim of the present report is to give a general picture of the possible interaction of fishing activities and Mediterranean marine turtle populations. Data obtained in the Mediterranean and elsewhere on capture efficiency and the mortality caused by different types of fishing gear is considered. It is then compared with presumed marine turtle distribution and with the fishing effort of different countries, in order to propose some priorities in which the limited resources for conservation and research projects can be invested.

Given the scarcity and heterogeneity of such information and the difficulty involved in acquiring it, the proposed analysis is not to be considered as definitive or complete.

2. LONGLINES

2.1. SURFACE LONGLINES

Use of surface longlines is an old fishing method (apparently known since 177 BC in Sicily (Camiñas and de la Serna, 1995)) used all over the world (Hillestad *et al*., 1982), and based on the even older method of fishing with baited hooks. The hook is a simple but efficient way of catching fish, although it has undergone very few changes as to its shape and the materials of which it is made.

Despite the fact that a certain degree of skill and experience seem to be required, this fishing method does not need particularly expensive equipment, unlike other methods; and maintenance only involves the normal refurbishing of lost or damaged hooks and the replacement of any equipment lost when fishing. The kinds of boat which can be used (motor-boats, generally made of wood), range from only 8 m. long (Santa Maria di Leuca, South Italy; Gerosa, unpubl. data) to 25 m. (Panou *et al*., 1992; Aguilar *et al*., 1995). Longer metal boats constitute an exception, for they have a multiple licence to practice other fishing methods, such as trawling, as well. Indeed, the surface longline owes its success and popularity to the fact that it is simple and cheap.

Judging from current literature, the surface longline used in the Mediterranean seems to be a very homogeneous method (Panou *et al*., 1992; Aguilar *et al*., 1995). The only verifiable differences, according to target species and local traditions, basically concern hook size (from 3 to 11 cm. (De Metrio *et al*., 1983)), length of the main fishing line and, as a consequence, the different number of hooks (from twenty or so km in length, with fewer than 1000 hooks (De Metrio *et al*., 1983), to 60 km, with as many as 2400 hooks (Aguilar *et al*., 1995), the kind of bait (mackerel (*Scomber* sp. (Panou *et al*., 1992; Aguilar, 1995; Camiñas and de la Serna, 1995), *Todarodes sagittarius*, *Sardinella aurita* (Aguilar *et al*., 1995), *Clupea* sp., *Trachurus mediterraneus* (Panou *et al*., 1992), pieces of different species of shark from previous catches (Camiñas and de la Serna, 1995)), and small variations in times of setting and hauling. Another difference which should be stressed concerns steel hooks, seen on Japanese longlines operating in international waters (Gerosa, unpubl. data). In other areas, too, unlike the Mediterranean, the method is subject to the same kind of variation (Boggs, 1994). Hawaiian fisheries show some considerable differences, such as the addition of chemical light sticks to attract fish (Balazs and Pooley, 1994).

The species intentionally caught in the Mediterranean with surface longlines are (in order of importance) swordfish (*Xiphias gladius*) and albacore (*Thunnus alalunga*) (De Metrio *et al*., 1983; Camiñas, 1988; Argano *et al*., 1992; Panou *et al*., 1994; Aguilar, 1995).

In the Mediterranean Sea, which is the most famous reproductive zone for swordfish (Nakamura, 1985), the surface longline still seems to be a very widely-used method -in particular in the western zone (Camiñas and de la Serna, 1995) -, even though over the last few years some fishermen have been forced to change over to other kinds of fishing which guarantee an income that is less vulnerable to seasonal variation or luck (such as the trawl or the drift-net). Furthermore, overexploitation of swordfish stock has heavily reduced the likelihood of catching this fish (Camiñas and de la Serna, 1995), as well as the average size of specimen captured (Northridge, 1991).

As for every fishing method, besides the target species many others are accidentally caught (10% - without turtles - in the Spanish Mediterranean longline fishery (Camiñas and de la Serna, 1995); 3% - only turtles - in the Gulf of Taranto (Cocco, Argano and Basso, 1988)). Most of these, like sharks (Aguilar *et al*., 1995), have no commercial value and these captures merely harm the species themselves. As for marine turtles, the fact that this group is threatened with extinction is definitely an aggravating circumstance. Fishermen owe their unpopularity in the eyes of the public merely to the accidental capture of non target-species.

Accidental capture of sea turtles seems to be almost entirely located in the western and central parts of the basin (Demetropoulos and Hadjichristophorou, 1995). This is why we shall almost exclusively deal with the results obtained from studies carried out in that part of the Mediterranean.

2.1.1. Interaction with marine turtles

The surface longline bases its capture capability on the likelihood of a hook meeting a specimen of the target species. As we said above, to make the hook attractive, fishermen use bait which must be so appetizing that the fish eat the bait, which hides the hook. Once stuck in the fish's mouth or oesophagus, the hook prevents the animal escaping and it is brought on board during the hauling. The probability that a single hook will meet a fish is slight. For this reason, fishing is done in zones where the target species is presumed (on the basis of personal experience) to be, and the number of hooks used is very high, to allow a sufficient quantity of fish to be caught to produce an income.

As has been said, swordfish and albacores are not alone in being deceived by this method; other animals, such as marine turtles, can be attracted by the bait when passing nearby.

2.1.2. Marine turtle species

The available literature shows that surface longlines catch several species of marine turtle: the leatherback turtle (*Dermochelys coriacea*), the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*), the loggerhead turtle (*Caretta caretta*) (Gerrior, 1996), the olive ridley turtle (*Lepidochelys olivacea*) (Thoulag, 1994) and the Kemp's ridley turtle (*Lepidochelys kempi*) (Caillouet, 1994).

As regards the Mediterranean Sea, it seems that only one of the three species present (*Caretta caretta*) is regularly caught with this fishing method, while some rare specimens have been identified as *Dermochelys coriacea* and others (with reservations) as *Chelonia mydas* (Panou *et al*., 1992).

2.1.2.1. Dermochelys coriacea

Since it prefers a diet which is rarely based on fish (whether live or dead) (see Bjorndal, 1997 for a review), Dermochelys coriacea may seem to be naturally immune to this kind of capture. The leatherback turtle, indeed, appears to be the species most affected by this method in the Gulf of Mexico and in the Atlantic (Ogren, 1994; Gerrior, 1996; Witzell, 1996). However, when analysing how these specimens are caught in these zones, it appears that captures are made because turtles get entangled in the main lines (Gerrior, 1996; Witzell, 1996) or the branch lines (Ogren, 1994; Witzell, 1996) or remain hooked (Gerrior, 1996), though rarely by the mouth (Witzell, 1996). This means that Dermochelys coriacea is not interested in nibbling at the hook. The bait probably stimulates the turtle's curiosity and so it gets caught up in the longline. The rare captures reported for the Mediterranean (De Metrio et al., 1983; Crespo et al., 1988) suggest that the density of this species is so low in this sea that the likelihood of surface longline hooks meeting a Dermochelys coriacea is almost nil.

2.1.2.2. Chelonia mydas

Even though published data is scarce, the green turtle, seemingly attracted by the bait for feeding, tends to nibble at the hook (Gerrior, 1996). Chelonia mydas, except in the juvenile stage, when it seems to be omnivorous, with a strong carnivorous tendency (Bjorndal, 1985 in Bjorndal, 1997), prefers a mainly vegetarian diet, but very often supplements this diet with animal matter, including fish (e.g. Brown and Brown, 1982 ; see also Bjorndal, 1997 for a review). This habit makes the green turtle particularly vulnerable to the longline. In the Mediterranean Sea, Chelonia mydas appears to be fished very rarely. The only mention made is by Panou et al. (1992) for the Greek part of the Ionian Sea, but identification of the species is exclusively based on the size of the four specimens turned in. Reasons for the low number of specimens caught in the Mediterranean may be that fishermen have difficulty identifying the species (they usually refer to the best-known and most frequent species: Caretta caretta), that almost all the data collected by this sort of study concerns the western part of the basin only, leaving out the zone in which this species is more present, or simply that this species is very rarely fished.

2.1.2.3. Caretta caretta

Some extrapolations about Caretta caretta show the alarming situation of 35,000 or more loggerhead turtles annually caught in the western and central Mediterranean (Panou et al., 1992), of which 15,000/20,000 specimens or more are caught every year by Spanish fishing vessels alone, off the Balearic Islands (Mayol, 1986; Camiñas, 1988; Aguilar et al., 1995). Even if we approach these numbers with caution, there can be no doubt that the loggerhead turtle is the species that is mainly and regularly caught during fishing campaigns with surface longlines (De Metrio and Megalofonu, 1988). Compared to the target-fish, this species seems to be particularly attracted by the bait (in particular the mackerel) which is almost always bitten and/or swallowed so that the hook ends up in the mouth, tongue or oesophagus (Argano et al., 1992; Bolten et al., 1994; Aguilar et al., 1995; Witzell, 1996). Given that accidental capture of leatherback and green turtles is rare, from here onwards we shall only deal with Caretta caretta, the species most affected by this fishing method. Moreover, the lack of specific studies concerning the eastern zone of the Mediterranean forces us to restrict our analysis of the surface longline to the western part of the basin.

2.1.3. Number of captures

At present, maybe due to the lack of specific studies on the other fishing methods used in the Mediterranean Sea, the surface longline appears to be the fishing method that accidentally catches more marine turtles (Cocco *et al*., 1988; Argano *et al*., 1992; Camiñas and de la Serna, 1995; Camiñas, 1996).

In most cases, the heterogeneity of the data gathered by these authors over years of

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study does not permit results to be compared with the thoroughness necessary (Camiñas, 1988; Panou *et al*., 1992; Aguilar *et al*., 1995). Apart from this methodological problem, it seems that the hypothesis put forward by some authors according to which the number of caught specimens is stable neither in space nor time and probably depends on many parameters not yet studied, is valid.

As regards the numerical discordance of captures in different areas of the Mediterranean, the data produced by Aguilar *et al*. (1995) shows that the highest rate of capture (9.8 turtles per day for every boat) was observed in the south-west Mediterranean in 1990. On the other hand, according to Panou *et al*. (1994), the same rate decreased to 0.16 turtles for every ship's hold in the Greek part of the Ionian Sea in 1993 (Tab. 1a). In other words, the Spanish longlines have a 61 times greater chance of fishing a *Caretta caretta* than the fleet working off the Greek islands of the Ionian. A similar high difference (44 times), even changing the unit of measure, appears when comparing the data collected by Greenpeace observers and published in Aguilar *et al*. (1995) with that gathered by De Metrio *et al*. (1983) in the Italian Ionian Sea (Tab. 1a).

Zone	Year	Capture rate	References
South-west Mediterranean	1990	9.8 turtles per day per boat	Aguilar *et al*., 1995
Greece, Ionian, Sea	1993	0.16 turtles per fishing trip	Panou *et al*., 1994
South-west Mediterranean	1990	CPUE* = 4.47 turtles/1000 hooks	Aguilar *et al*., 1995
South Italy, Ionian Sea	1979	CPUE = 0.101 turtles/1000 hooks	De Metrio *et al*., 1983

**Capture Per Unit Effort*

Tab. 1a

Furthermore, Aguilar *et al*. (1995) as well as De Metrio *et al*. (1983) show that there is considerable variability between the different years of study, even though the rates remain divergent.

Zone	Year	Capture rate	References
South-west Mediterranean	1990	9.8 turtles per day per boat	Aguilar *et al*., 1995
South-west Mediterranean	1991	6.5 turtles per day per boat	Aguilar *et al*., 1995
South Italy, Ionian Sea	1978	CPUE = 0.059 turtles/1000 hooks	De Metrio *et al*., 1983
South Italy, Ionian Sea	1979	CPUE = 0.101 turtles/1000 hooks	De Metrio *et al*., 1983

Tab. 1b

2.1.4. Mortality rate

The mortality rate caused by surface longlines can be measured by adding the two connected stages following capture by the hook. The first concerns the damage caused by the tool to the animal while still in the water, before being turned in. The second concerns the ability of specimens released in the sea to survive after the trauma of capture. To make this clear and to underline the methodological difficulties involved in the collection of data, the two cases will be treated separately in this session.

2.1.4.1. Mortality rate before turning in

As *Caretta caretta* generally nibbles at the hook and as the longline fishes pretty much on the surface, the animal is always able to move and reach the surface to breathe, despite its being impeded by the hook. Very different is the situation for those specimens entangled in fishing lines (as usually happens to leatherback turtles) which, unable to move, drown.

The injury caused by the hook is rarely fatal at first. Very divergent results have been obtained by several authors, varying from a mortality rate of 0% (Ogren, 1994), noticed on board by qualified observers, to the alarming figure of 29.5% (Balazs and Pooley, 1994). Taking these two percentages as exceptional, it is more probable that the mortality rate is about 10% (Gulf of Mexico: 5.9% (Gerrior, 1996); Mediterranean Sea: 0.36% (Aguilar *et al*., 1995), 16.67% (Argano *et al*., 1992)). Available data indicates that 15.6% of caught specimens present the hook inserted in the mouth (Aguilar, 1995), which is not a fatal spot, and that the specimens do not usually die within a few hours, even if seriously hurt by the hook.

2.1.4.2. Mortality rate after release

Thanks to an effective sensitization campaign by NGOs among fishermen, most of these now turn the turtle in (unless it is too big; Argano *et al*., 1992) and retrieve the hook from its mouth, although the fishermen themselves consider this to be quite dangerous. If the turtle swallows the hook so that it is no longer visible, fishermen (those trained by research programmes) cut the branch as near to the turtle's mouth as possible, leaving the hook and part of the line attached to the animal (Argano *et al*., 1992; Panou *et al*., 1992; Bolten *et al*., 1994; Aguilar, 1995; Camiñas, 1995a).

The available literature is full of questions about this point. In fact, following a released turtle or foreseeing its fate is actually impossible. In particular, since fishermen cut the lines in different ways, leaving lines of different length, it is not possible to verify the assumption that a specimen with both the hook and part of the line still inside its body is seriously injured. Some experiments, tested in Spain, show that the mortality rate for specimens with hooks and lines inside them - kept in tanks and supervised - can be 28.9% (Mas and Garcia, 1990; Aguilar *et al*., 1995). Some other experiences, though, show that animals rarely survive after swallowing the hook, and usually part of the branch, of a surface longline (Bentivegna *et al*., 1993; Bjorndal *et al*., 1994).

However, it seems that a certain ability to bear an inserted hook (obviously in non-vital parts) is peculiar to this species: some specimens have been found with several hooks inside them (Argano *et al*., 1992). Moreover, turtles tagged and released with hooks and lines still inside them have been caught again - even 11 years later (Scaravelli, pers. comm.) - by another surface longline (or other fishing gear) or have managed to survive in a tank for many days before release (Aguilar *et al*., 1995). There are finally several cases in which loggerhead turtles have been able to spontaneously expel from the cloaca the hook with the nylon line attached (Mas and Garcia, 1990; Scaravelli, pers. comm.).

2.1.5. Size of caught specimens

At present, different behaviour towards baited hooks, connected with the specimen's size, is not known. The only limit to capture concerns specimens of under 27 cm. (Standard Curve Carapace Length) (which, according to the published data, seems to be the lowest size-limit involved in this fishing method in both Italy (Argano *et al*., 1992) and Spain (Aguilar *et al*., 1995). This limit is due to, first, the incompatibility in size between the big hooks used in this method and the small size of the little turtles' mouths (as also confirmed by comparing mean weights of specimens caught by hooks used for swordfish and those, smaller, for albacore (De Metrio *et al*., 1983; tables 3 and 4 respectively); second, the well-known behaviour of turtles during the first years of their life, when they seem to vanish and then reappear near the shore two or three years later.

Most young and subadult specimens caught by longlines (De Metrio *et al*., 1983; Aguilar *et al*., 1995) seem to follow a bell-shaped curve when they are analysed by size classes (Panou *et al*., 1992; Argano *et al*., 1992). As to size of hook, this curve has important implications for the ecology of the species, for it seems to show that the population falling between 27 and 50 cm. (Standard Curve Carapace Length) is caught in proportion to its size. The falling part of the curve should be fairly representative of the sizes of specimens present in that area. In fact, all the specimens in this size class probably have a demersal behaviour and the same likelihood of meeting a hook.

The low rate of capture related to adults (De Metrio et al., 1983; Argano et al., 1992; Aguilar et al., 1995), even in zones very near to the most important reproductive sites (Panou et al., 1994), seems to confirm that only a meagre percentage of reproducers is present in the population. However, the number of adults may be underestimated in that fishermen do not usually turn the bigger specimens in, since they are a nuisance on board, and therefore researchers have no specimens at their disposal (Argano et al., 1992). Alternatively, these findings might reflect a possible difference in behaviour of specimens in the reproductive phase.

Therefore, the surface longline appears to be a method that selects according to size, for it catches a higher proportion of big specimens present (> 50 cm) than of little ones.

2.1.6. Sex-ratio of caught specimens

Very little data has been collected on this topic. The main difficulty fishermen (and observers on board) have is distinguishing the sex of the immature turtles (e.g. Wibbels *et al*., 1987). The only available data concerns 13 adult specimens (7 males and 6 females), related by Panou *et al*. (1992) and 3 adult specimens (1 male and 2 females), published by Panou *et al*. in 1994. A preliminary analysis on subadults (Casale and Gerosa, unpubl. data) does not show a skewed sex-ratio.

2.1.7. Periods of captur e

In the Mediterranean Sea, the greatest number of captures due to this fishing method is concentrated in the period between June and August (De Metrio *et al*. 1983; Camiñas, 1988; Argano *et al*., 1992; Camiñas *et al*., 1992; Panou *et al*., 1992; Camiñas and de la Serna, 1995).

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The results for May and September, months that only a few works consider to have a high capture rate, differ according to author (De Metrio *et al*., 1983; Argano *et al*., 1992; Panou *et al*., 1992; Camiñas and de la Serna, 1995).

In this computation of time, the number of caught specimens can be explained by the fact that the fishing effort in the Mediterranean peaks between May and September, when meteorological conditions are best (Camiñas and de la Serna, 1995). However, some data shows that accidental capture of *Caretta caretta* goes on in the other months, but the CPUE drops markedly during the October-April period in the same localities and with the same methodologies (Camiñas and de la Serna, 1995). This last piece of data, and a careful analysis made by Camiñas and de la Serna (1995), seem to confirm the hypothesis according to which the Mediterranean population of loggerhead turtles carries out seasonal movements within that basin (Margaritoulis, 1988; Laurent *et al*., 1990).

2.2. BOTTOM LONGLINES

There is very little data on this fishing method. The differences between bottom and surface longlines (described above) are considerable. First of all, the main line lies a few centimetres from the bottom, thanks to ballast placed along the line. Other variations concern the type of hook (generally much smaller), the kind of bait (generally sliced anchovy) and the target (demersal fish).

The capture rate for turtles with this kind of fishing (in particular Caretta caretta, given the kind of bait used) is unknown. The extent to which bottom longlines are dangerous clearly depends on the depth at which they are placed. Use at a depth of 200-700 m. (Bolten et al., 1994) should not arouse concern. However, in Italy there exist cases where this method is used at a much shallower depth, causing numerous captures of marine turtles (Gerosa and Casale, unpubl. data). The other problem could concern the opportuneness of using the term "longline" to indicate two fishing methods which should be treated independently, given their considerable differences.

The mortality rate seems to penalize juvenile turtles particularly, since bigger specimens seem able to drag the main line with its ballast up to the surface to breathe (Gerosa and Casale, unpubl. data).

3. TRAWLS

Trawling uses a net approximately in the shape of a frustum, whose smaller base is closed by a bag, while the larger mouth is kept open by a beam or otter-boards placed at the lateral extremities. Usually, the net's mesh size gradually decreases from the mouth to the terminal bag. The net is trawled by one ship or more, and is an "active" fishing gear in that it catches all the animals in its path, passing them along to the terminal bag. The types of trawl - and there are many - can be divided into two large classes according to whether or not they operate in contact with the sea-bottom: bottom trawling and midwater (pelagic) trawling (see Nédélec and Prado, 1990). For marine turtles, the main interaction comes from the bottom trawling, when this is done in the not very deep water frequented by these animals. This method catches all species, but *Eretmochelys imbricata* and *Dermochelys coriacea* to a lesser extent (Hillestad *et al*., 1982). Bottom trawling is utilized to fish shrimps or demersal fish. Even though the general functioning remains essentially the same, the detailed structure of the tool presents many variations from country to country, due both to autonomous innovations traditionally kept up and to different kinds of target. For example, there can be differences in the asymmetry between the upper and the lower parts of the net, though the lower part is longer in most cases; in the dynamics of trawling, this makes it stick more easily to the bottom, thus increasing the efficiency of capture when the target species are bottom fish.

The proportions between the length and width of the net may vary, both in the vertical and the horizontal direction. The net can be joined to the otter-boards either with ropes or directly. The otter-boards can be connected with the boat either by means of separated ropes (in this case the net is trawled by one or two boats) or by a single forked one (a ship can drag more than one net). In particular, the USA bottom trawl for shrimps is directly joined to the otter-boards and towed by a single rope (Ferretti, 1983). The bottom trawl used in Turkey has the mouth 0.75-1 m. high; it is towed at a maximum speed of 1.5-2 miles/h (references in Oruç *et al*., 1996). In Tunisia the mouth is 1-2 m. high and 15 m. wide (Laurent and Lescure, 1992).

It has been estimated that more turtles are killed by this fishing method than by all other kinds of anthropic impacts put together (National Research Council, 1990 in Lutcavage *et al*., 1997). The reason for such an impact is double: a) the considerable fishing effort carried out with this method, b) the high mortality rate which has been noticed.

3.1. CAPTURE

3.1.1. Depth

The higher the turtle population density in the operative zone, the greater, obviously, is the impact of capture connected with this method. For stretches of coast frequented by marine turtles, population density increases as sea-bottom depth rises. In fact, *Caretta caretta* and *Chelonia mydas* mostly frequent bottoms less than 50 m. deep, and more rarely deeper ones (known records show 233 m. for *Caretta caretta* and 110 m. for *Chelonia mydas*; reviewed by Lutcavage and Lutz (1997)). It is thus to be expected that bottom trawling has a different rate of capture according to depth of operation. For example, Epperly *et al*. (1995) reported that in South Carolina the relation captures/fishing effort was higher in shallow waters (with a fishing effort made between 6 and 98 m., captures occurred between 9 and 34 m), with a maximum for bottoms less than 20 m. deep. In Oman, Hare (1991) noticed an high capture incidence in shallow bottoms. Caillouet *et al*. (1991) found a significant relationship between the fishing effort in bottoms less than 30 m. deep and turtle strandings, in the Gulf of Mexico. In Tunisia, most turtles are caught by trawling at depths of less than 50 m. (Bradai, 1994).

3.1.2. Size of turtle

Due to its special features, bottom trawling catches those specimens which have made or are about to make the transition between the pelagic and the demersal phase. Because of this, specimens of less than a certain size are not caught: 48.7 cm. (Georgia, USA; Kontos and Webster, 1985), 48 cm. (North Carolina, USA; Epperly *et al*., 1995), 32.3 cm. (Tunisia; Laurent *et al*., 1996), 49.4 cm. (Egypt; Laurent *et al*., 1996), 34.5 cm. (France; Laurent, 1996) (*Caretta caretta*; SCCL). Hence, the bell-shaped frequency distribution of sizes of specimens caught (e.g. Epperly *et al*., 1995) is probably due to the small number of little specimens actually present in the demersal population (transition phase).

3.2. MORTALITY

Mortality caused by trawling is due both to the physical stress exerted on the animal by the tons of catch inside the net (e.g. Hare, 1991) and, mainly, to the inevitable apnea to which the specimens caught in the net are subjected, because the net is kept submerged for up to several hours. Specimens can be found alive, dead or comatose. If turtles in the last condition are not recognized as such and are treated as dead (i.e. thrown into the sea), they will die. On the other hand, if they are treated with resuscitation techniques (Stabenau *et al*., 1993) they can often survive.

The mortality rate is connected with three operative parameters: duration of trawl, intensity of the fishing effort in a certain zone, and water temperature.

3.2.1. Duration of trawl

A close relationship has been noticed between duration of trawl and mortality, due to the fact that the trawls work within temporal ranges which include the periods during which turtles can tolerate apnea: Henwood and Stunz (1987) relate a mortality of < 1% within 60 minutes but rapidly increasing thereafter. Applying the relationship found by these authors to known durations of trawl in the Mediterranean (Tab.2), mortality rates would range from 16% to 28% for the mean values, and from < 1% to 42% at either end of the range.

In the specimens caught by the trawl, Stabenau *et al*. (1991) pointed to an acidosis considerably higher than that noticed for the same periods of involuntary apnea in captivity. This suggests that additional factors are involved in the capture by trawl. The changing speed of the net, which can be also greater than the maximum speed a caught specimen may reach, forces them to swim vigorously, and is also linked to escape reaction (Stabenau *et al*., 1991). Lutz and Dunbar-Cooper (1987) relate that specimens of *Caretta caretta*, caught by the trawl, show a concentration of lactic acid 10-80 times higher than that of specimens kept in captivity. According to the recovery rates observed, at least 20 h would be necessary to restore regular conditions assuming a constant rate, but this period of time may be longer if the recovery rate remains concentration-dependent (Lutz and Dunbar-Cooper, 1987). However, in marine turtles it is not known whether the overcoming of the aerobic capacity by the metabolic demand is normal during intentional apnea (Stabenau *et al*., 1991).

3.2.2. Intensity of fishing effort

The long recovery time suggested (§ 3.2.1.), may lead to greater vulnerability of those specimens subjected to multiple catches. The high proportion of marine turtles found in a comatose state in zones of intense fishing activity has been attributed to this (Epperly *et al*., 1995).

3.2.3. Water temperature

Since oxygen consumption rises with the increase of temperature (Lutz *et al*., 1989), it is plausible that the maximum time for apnea decreases as water temperature rises. In fact, it has been noticed that in the summer the frequency at which *Caretta caretta* surfaces is higher than in the winter (Renaud and Carpenter, 1994). It follows that trawl duration cannot be considered independently of temperature to determine the level of impact. For example, Wibbels (1989) relates high mortality (45.4%) connected with quite short durations of trawl (30-105 minutes) and attributes it to the water temperature of the sea where the fishing activities have been carried out (June, in Florida).

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3.3. IMPACT OF TRAWL ON MEDITERRANEAN SEA TURTLES

There is a good deal of data on sea turtle-trawl interaction in the Mediterranean, mostly from the eastern basin (Tab. 2). A big capture impact is suspected in Tunisia, Egypt, Turkey, Greece and the Slovenia-Croatia-Yugoslavia pool.

However, available data on mortality suggests a quite low number of deaths caused by this method (Tab. 2). Hence it may seem that in the Mediterranean trawling could have a modest impact on the population of marine turtles when compared with other causes of mortality - such as indirect mortality (see § 5) and other fishing gear - (Laurent *et al*., 1996), unlike what happens in other geographical areas (e.g. Henwood and Stunz, 1987).

This difference may be explained by the shorter duration of trawling in the Mediterranean and by the low temperatures noted in periods of catch (e.g. Laurent and Lescure, 1994) (see § 3.2.3.). However, available lengths of trawling time (Tab. 2) can be compared with those corresponding to high mortality rates in the USA (Henwood and Stunz, 1987) (see § 3.2.1.). The influence of temperature on the metabolism is more probable (see § 3.2.3.); in fact, most of the mortality estimates in the Mediterranean refer to winter periods (Tab. 2). Epperly *et al*. (1995) relate cases of turtles that are dead or in a comatose state found in waters (North Carolina) of 18 degrees C maximum, comparable to the ones of about 17 degrees C reported in Tunisia (Gulf of Gabés) by Laurent and Lescure (1994), where all 15 specimens caught with periods of more than 1.5 h were released in good physical condition. In spite of the low temperatures, a mixed group of 16 *Caretta caretta* and 14 *Lepidochelys kempi* presented 5 specimens that were dead or in a comatose state (16.6%) with trawling times of less than 1h in North Carolina; this was attributed by the authors to multiple capture (see § 3.2.2.).

Another factor might contribute to the low mortality noticed in the Mediterranean. The peculiarity of the Mediterranean samples is their mainly consisting of big specimens: turtles more than 70 cm. long represent 73.3% of the Tunisian sample (n = 15; *Caretta caretta*; Laurent and Lescure, 1994), 84% of the Greek sample (n = 38; *Caretta caretta*; Margaritoulis *et al*., 1992), 44% of the Croatian (n = 32; *Caretta caretta*; Lazar, 1995), 52.9% (n = 17) and 40% (n = 30) (*Caretta caretta* and *Chelonia mydas* respectively; Oruç *et al*., 1996; based on approximate lengths), 71.4% (n = 7) and 25.6% (n = 39) (*Caretta caretta* and *Chelonia mydas* respectively; Oruç *et al*., 1997; TCCL) of the Turkish sample (see also Laurent *et al*. (1996) for a general view of sizes). On the contrary, this percentage was only 13.7% for the North Carolina group. There actually exist indications that apnea endurance, forced by trawling, rises as size increases (Hillestad *et al*., 1982).

Hence the low mortality noticed in the Mediterranean samples might be the result of low temperatures connected with a high proportion of big specimens; since few specimens were directly observed, a thorough estimate of winter mortality in little specimens cannot be made. Furthermore, trawling activities are carried out in the summer too, when high temperatures may considerably reduce apnea endurance (Wibbels, 1989) in Tunisia (Bradai, 1992), Egypt and Turkey (Laurent *et al*., 1996), and Italy (Gerosa, unpubl. data), countries about which there are no reliable mortality estimates. It may be indicative that relative high mortality has been recorded in the summer along the coasts of Corsica and continental France (Tab. 2), where, however, the summer temperatures remain lower than those in the Gulf of Gabés and most of the Egyptian and south-eastern Turkish waters (NOAA, web site), and where most specimens are small (cont. France; Laurent, 1991). In Egypt some interviewed fishermen have suggested high mortality (10%; Tab. 2). It has to be noticed that in these areas (Gulf of Gabés and Levantine basin) the surface temperature in summer is higher than in June at Cape Canaveral (Florida) (NOAA, web site) where Wibbels (1989) recorded high mortality (45.4%) even for big specimens, with a minimum trawl duration of trawl of 75 minutes.

In conclusion, though in Tunisia there seem to be fewer summer captures than winter ones (Laurent *et al*., 1990; Bradai, 1992), in this area and others (especially in the Levantine basin) a possible higher mortality caused by higher temperatures could provoke a number of deaths that is equal to or greater than those resulting from winter fishing activities.

There is no doubt that fishing activity on sea bottoms less than 50 m. deep (Tab. 2) contributes greatly to the high capture rate noted. Moreover, if these little specimens prefer shallower bottoms, due to their lower apnea endurance, a higher mortality rate may result from fishing in these zones. The fact that in south-eastern Turkey the trawlers move from deep bottoms in the cold months to shallower bottoms in the hot months (Oruç *et al*., 1996) might be worrying.

Country	Target	Periode	Duration of trawl (min) Mean (SD; range; N) or range	Working depth(m)	Depth of capture (m)	Species	Mortality (N)	Method	Captured/ year	Reference
Algeria		not summer		0-100		*Caretta caretta*	«low»	inquire	few (200)	Laurent, 1990
Egypte		all-the-year	186 (52.2; 60-240; 20)			C.c., C.m., D.c.	1-10% (?)	inquire	many	Laurent *et al.*, 1996
France c.		summer			20-80	*Caretta caretta*	3.3% (92)	inquire	few	Laurent, 1991
Corsica		Feb-Sep				*Caretta caretta*	3.7% (27)	inquire		Delaugerre, 1987
Greece		Oct '89-May '90	60-180	36-270		C.c., C.m.		observation	many	Margaritoulis *et al.*, 1992
Slovenia + Croatia + Yugoslavia	fish	Nov-May				*Caretta caretta* (C.m.?)	? «low»	inquire	2500	Lazar and Tvrtkovic, 1995
Tunisia	fish	Jan-Feb 1990			29-42	*Caretta caretta*	0% (15)	obs. + inq		Laurent and Lescure, 1994
.	fish		90-120					?		Laurent and Lescure, 1994
	shrimps	May-July/Oct-Dec		<50				?	2000-2500	Bradai, 1992
									4500-5000	Laurent *et al.*, 1990
Turkey		Jan-Feb 1995	163 (32.2; 90-195; 8)	130		*Caretta caretta*	0% (1)	observation	many	Laurent *et al.*, 1996
		Jan-Feb 1995	117 (37.5; 45-180; 12)	70				observation		Laurent *et al.*, 1996
		all-the-year	180 (35.4; 60-270; 22)			C.c., C.m., D.c.	0% (?)	inquire		Laurent *et al.*, 1996
		winter			20-70			inquire		Laurent *et al.*, 1996
		Oct-May 1995			0->100		1.6% (186)	inquire		Oruç *et al.*, 1996

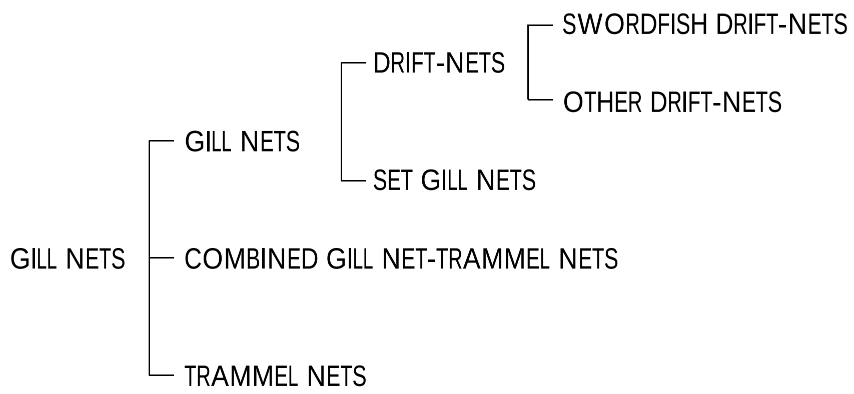
Tab. 2 – Trawl

4. GILL NETS

Gill nets are the best-known, most practical and oldest fishing nets (Ferretti, 1983). They have been used for many years in almost all the coastal zones, whether as an industrial, artisanal or even sports tool.

As more productive gear (like trawl nets or seine nets) became available, far fewer gill nets were used, until the use of synthetic instead of strings brought this gear back into favour again. In fact, fishermen were aware of many unexploited zones (like those with very rough bottoms or very close to the coast, both unsuitable for trawling) where they could catch valuable fish. Furthermore, this gear can be used with every kind of low-cost boat, and allows big fish to be fished in good conditions (Ferretti, 1983). This is why this gear is very much used today.

Local and traditional use over the generations, together with the fishermen's skill and the gear's plasticity, have given rise to many variations which are very difficult to classify. We can follow the classification of Nédélec and Prado (1990) and, for reasons of presentation, separate drifting nets for swordfish from other drift-nets. In this way, the present gill nets can be placed in the following categories:



All the above gear are used in the Mediterranean, and are present in all the coastal zones of the world. In the present work, the different kinds of gill net will be treated together. A different section will be dedicated to drift-nets for swordfish, due to the anxiety they have caused over the last few years.

4.1. GILL NETS (except swordfish drift-nets)

4.1.1. Target species

Gill nets can catch almost all economically important species. Fishermen, thanks to their personal experience and knowledge of fishing areas, are able to catch exactly the target species they want, by varying the type or size of mesh, the working depth and the season. This wish to catch a particular species led fishermen to modify these nets to a greater or lesser extent, so that today we possess nets which are almost species-specific for fish, molluscs and crustaceans. Such an improvement in the gear however could not prevent non-target species, including marine turtles, from being accidentally caught.

4.1.2. Method

The gill net is a fishing net which is placed vertically so that it fences in or blocks off areas of water and catches the marine organisms which try to pass through it (UNI, 1981). Such a clear definition actually hides a much greater complexity. In fact, unlike other gear, the main feature of gill nets is their heterogeneity. As stated above, it is not possible to standardize a method of use without considering all the local parameters (e.g. duration of stay in the water, time of day, season, difference in gear).

4.1.3. Interaction with marine turtles

Gill nets could be considered passive fishing gear: turtles are caught by chance, as they move from place to place. However, Panou *et al*. (1992) report that, according to fishermen, turtles actively try to feed on fish entangled in trammel nets, damaging the gear. Therefore, these nets could constitute active fishing gear, because their catch may be attractive to turtles, thus increasing the probability of their being captured.

Drowning is the main reason for the sea turtle mortality caused by this fishing gear: the animals, once entangled in the net, cannot reach the surface to breathe. Thus, there may be some difference in mortality between nets set on the bottom and those set near the surface; in fact, the latter could offer turtles more opportunity to emerge and breathe.

However, even if a turtle survives and is freed, there still may be a delayed mortality if the fisherman does not free the turtle from all the ropes of the net, which can cause serious injury and necrosis.

High mortality and a large number of captures are reported for shark nets placed near areas where turtles are present (Guinea and Chatto, 1992; Dudley and Cliff, 1993). As far as the Mediterranean is concerned, Delaugerre (1987) reported a mortality rate of 94.4% (n=18) for *Caretta caretta* specimens caught in Corsica by trammel nets placed at depths of > 60 m. (fishing effort between 8 and 110 m.). In Tunisia, Bradai (1993) found a mortality rate of 5.2% (n=58) for trammel nets; the same author (1992) reported two little specimens (c. 8.8 and 10 cm.). In France, a mortality of 53.7% out of 149 turtles caught at a depth of under 50 m. is reported by Laurent (1991). The mortality rate for specimens tagged and then recaptured by set gill nets in different countries was 73.7% (n=19) (Argano *et al*., 1992). More recently a percentage of 83% (n = 6) has been reported in Croatia (Lazar *et al*., in press). Hence, gill nets seem to be very dangerous fishing gear. Though a single net is unlikely to capture a turtle, if use of this gear spreads, particularly near to high turtle density areas, this may have a big impact on populations.

4.2. SWORDFISH DRIFT-NET

The "drift gill net", or simply "drift-net", indicates a net which is kept more or less vertical in the water by means of a set of floats, which remain on the surface, and weights hooked to the lower end of the net. Unlike other nets to which the above description could apply, this system is allowed to drift freely with the current or the wind. Like other types of net, the drift-net is one of the simplest and probably oldest fishing methods (the first documented historical record dates back to 177 A.D. (Greece), describing drift-nets made of linen (Di Natale, 1993)), so that this technique is thought to have developed independently in different parts of the world (Northridge, 1991).

4.2.1. Swordfish drift-net problems

Even though this kind of net was initially believed to be highly selective, the problem of drift-nets was raised in the late '80s because of the growth of the fleets and the lengthening of the nets by Japanese and Taiwanese fishermen, who began hunting tuna fish in the South Pacific with this fishing method. After adopting a declaration (July 1989), an International Convention (Wellington, New Zealand, November 1990) prohibited the use of drift-nets in that part of the Pacific (Northridge, 1991).

The most important criticisms of this fishing method have fallen into various categories:

1. competition with other fishing methods (see Northridge, 1991 for a review);
2. the hindrance caused to the passage of cargo boats and liners by long nets left drifting (Di Natale, 1993);

3. the impact that this kind of net has both on non-commercial or protected species (among them marine turtles).

In the Mediterranean, especially, drift-nets are mainly used by the Italian fishery to catch the swordfish. There is also mention of the use of this method by Taiwanese vessels, that often sail in international Mediterranean waters (Northridge, 1991). This fishing method spread quickly in the '80s under the impulse of the Italian Government, which encouraged fishermen to use the swordfish drift-net instead of the traditional longline, considering the drift-net more selective and less dangerous for the environment. In 1989 there were over 700 boats in Italy using nets that were 12-13 km. long (with extremes of 20 or more km.) with 180-400 mm. mesh and reaching a depth of 28-32 m. (Northridge, 1991). Besides the considerable increase of swordfish capture, some studies have shown an indeterminate number of marine turtles captured, both *Caretta caretta* and *Dermochelys coriacea* (Northridge, 1991). Other fisheries (in Algeria, Morocco, France, Turkey, Spain (Northridge, 1991) and Greece (Panou *et al*. 1994)) have adopted this method, using much shorter nets (3.4 km. with extremes of 10 km.).

The exaggerated use and thoughtless lengthening of nets (up to 60 km.) began to worry various governments because of the excessive pressure on the stock of target species and the number of marine mammals accidently captured (see Northridge, 1991). This new situation forced many states to take steps independently (for example in 1990 the Spanish Fisheries Administration forbade the use of drift-nets in the Alboran Sea (Camiñas, 1995b) and afterwards the EC enacted a regulation (EU regulation 345/92) by which nets longer than 2.5 km. have been banned.

Under various forms of pressure, most Mediterranean states have banned the drift-net or are trying to make fishermen go back to other fishing methods considered more selective and less damaging for the environment.

4.2.2. Interactions with marine turtles

Although this method has been in use for over fifteen years, available data and experts' opinions still conflict. While it is sure that there is considerable accidental capture of marine mammals, the number of turtle captures is still little known. Data from research done in the Tyrrhenian Sea and the Ligurian Sea by Di Natale (1995) shows as an average for the years 1990/91 a CPUE of 0.005 loggerheads/km. of net. That 5 specimens (all belonging to the *Caretta caretta* species) were taken in two years of research done between April and September with observers on board 100 craft using drift-nets, indicates minimal impact on this species, mainly because they were all released alive by fishermen (Di Natale, 1995). This last piece of data was also confirmed by Camiñas (1995b). Other data presents a much more worrying situation. De Metrio and Megalofonou (1988), who collected data gathered by observers on board and by expert fishermen, estimate 16,000 seasonal captures by a small group of 29 vessels operating near the Ionian coast of Calabria with nets up to 12 km. long, and establish a 20-30% mortality rate.

As the drift-net is mainly used in the open sea (far from the places where the density of marine turtles seems to be high), it is reasonable to believe that the number of captures is generally low. Concerning the divergence between the two studies mentioned above it is necessary to consider that the two areas present very different turtle densities (see § 7). It has to be added that the very long walls of netting, which seem to capture turtles mainly in their upper third (Di Natale, 1995), could be considerably more dangerous if placed on the migratory routes of specimens moving from feeding zones to reproduction ones, and vice versa. Given the considerable gaps in our knowledge and differences of opinion, it is still impossible to exactly quantify the interaction between this fishing method and marine turtles. However, the current trend of most countries to banning the use of swordfish driftnets, not only in the Mediterranean, could provide the problem of the impact of this gear on marine turtle populations with a solution in the near future.

5. INDIRECT MORTALITY

The animals are generally released immediately, not being considered saleable, and their presence constituting if anything a hindrance to normal fishing activities (for turtles usually walk around the boat and bite everything they can when turned over); also because they are considered a sign of bad luck, as in some Italian areas (Gerosa, unpubl. data) and in Albania (Haxhiu and Uruci, 1998), or - very rarely - because they are considered as a species threatened with extinction.

Unfortunately, due to ignorance and/or prejudice, some fishermen kill the turtles they catch, as some Greek fishermen (especially gill netters) are supposed, from specimens found stranded, to do (Margaritoulis, in litt.); caught specimens were reported to have been killed and used to feed pigs and hens in Albania (Haxhiu and Uruci, 1998). Moreover, an accidental capture - no matter which method is used or its resultant direct mortality - may signify a mortality of 100% if the fisherman keeps the animal for his personal or commercial use, instead of releasing it.

Sometimes the turtles are killed and eaten on board, especially when some of the crew regard the turtle as a delicacy, as is the case for some foreign crews on Greek (Panou *et al*., 1992) and Italian vessels (Gerosa, unpubl. data). A percentage for turtle mortality has never been estimated for such cases.

In some Mediterranean countries, deep-rooted traditions connected either with the consumption of the blood and meat of marine turtles (e.g., Laurent *et al*., 1996) or the ornamental use of the carapace (Argano *et al*., 1990; Panou *et al*., 1992) induce fishermen who accidentally fish a turtle, to bring the specimen back to harbour to sell it. For instance, in Egypt thousands of turtles are thought to be killed every year (Laurent *et al*., 1996). As long as there is a demand - which probably by far exceeds the supply - there will always exist a black market which will raise the value of the product, allowing unssome fishermen to add this illegal profit to their income, in spite of the great risks involved. The impossibility of controlling this trade, which mainly develops secretly, chiefly between friends or people who know one another, does not allow the extent and importance of the phenomenon to be assessed.

However, a ten-year experiment done in Italy demonstrates that it is possible to restrict the phenomenon by national public-awareness campaigns, direct contact between researchers and fishermen (see § 8.6.), or by national protection laws with coercive measures by monitoring bodies (see § 8.1.).

6. THE MEDITERRANEAN FISHING FLEET

According to available data on the trawler fleet (Fig. 1), the zones concerned by a bigger fishing effort might be: the Adriatic (mainly by Italian fisheries), the Tyrrhenian (by Italian fisheries), the south-western basin (by Spanish and Algerian fisheries), the Sicilian Channel and the Gulf of Gabès (by Tunisian and Italian fisheries), the south-eastern basin (by Egyptian fisheries) and the Ionian (by Italian and Greek fisheries). The Aegean and the north-eastern basin too are likely to suffer from a considerable impact by Greek and Turkish fisheries.

For longlines (Fig. 2), the Tyrrhenian Sea seems to be the zone affected by the biggest fishing effort, followed by the Ionian, the Adriatic, and the Libyan and Egyptian coasts. Although incomplete, available data highlight the importance of the Italian fishing effort for this method.

In some countries, the presence of a great number of boats fishing with coastal / artisanal methods is underlined by the total number of vessels (Fig. 3). The zones with the greatest number of working vessels are: the Aegean and Ionian (mainly Greek ships), the Adriatic (mainly Croatian), the Gulf of Gabès (Tunisian), the Tyrrhenian, the south-western basin (Spanish and Algerian) and the Libyan coasts. Probably, most of these vessels use gill nets, as is suggested by a comparison between Figs. 3 and 4. On the basis of the available data, the most affected zones might be the Aegean, the Tyrrhenian, the Libyan coasts, and the Ionian. Besides, gill nets are the gear most used by the Tunisian fleet (Bradai, *in litt*.).

A comparison between the number of vessels and GRT (Gross Registered Tonnage) (Figs. 3 and 5) suggests that the Adriatic and the Sicilian Channel are affected by a fishing effort by Italian fisheries that is greater than could be deduced from the number of vessels alone.

7. ZONES FREQUENTED BY TURTLES

Areas where a high density of marine turtles is suspected are shown in Fig. 6. These are basically presumed feeding grounds, some frequented only in summer due to climatic reasons, others in all seasons, allowing (or not) an active life during the winter. Probably, many turtles make seasonal migrations to be in warmer areas during winter. Adults migrate to reach nesting sites, too.

7.1. NESTING BEACHES

The main nesting sites are located in Greece (*Caretta caretta*; Margaritoulis *et al*., 1995; Margaritoulis, in press), the Mediterranean coasts of Turkey (*Caretta caretta* and *Chelonia mydas*; Baran and Kasparek, 1989; Gerosa *et al*., 1995) and Cyprus (*Caretta caretta* and *Chelonia mydas*; Demetropoulos and Hadjichristophorou, 1995; Broderick and Godley, 1996). A recent survey suggests that the Libyan coast may be an important nesting area for *Caretta caretta* (Laurent *et al*., 1997).

7.2. OVERWINTERING AREAS

The great number of *Caretta caretta* specimens caught in the winter in the Gulf of Gabès (Tunisia; Laurent *et al*., 1990; Bradai, 1992) and the presence of many big specimens in the winter, suggest that this area represents an overwintering zone for specimens which frequent other areas during the summer (Margaritoulis, 1988; Laurent and Lescure, 1994). The same conditions are present in the southern Peloponnese (Greece), also frequented by immature *Chelonia mydas* (Margaritoulis *et al*., 1992). Furthermore, winter temperatures in the Gulf of Gabès might be high enough to keep turtles in activity: Carr *et al*. (1980) report 15°C maximum for torpid specimens and 18°C for active specimens. Laurent and Lescure (1994) report activity of specimens caught in waters of about 17°C and feeding of other specimens caught in the same period. Also in Turkey and Egypt, the capture of specimens of *Caretta caretta*, *Chelonia mydas* and *Dermochelys coriacea* seems to go on all year round (Laurent *et al*., 1996). High winter temperatures in these areas (NOAA, web site) suggest active overwintering. Many winter captures are reported in the Adriatic (Lazar and Tvrtkovic, 1995), but in these zones low winter temperatures probably prevent turtles to remaining active.

7.3. FEEDING AREAS

Probably, most of the overwintering areas reported above are benthic winter feeding grounds (see above) and all of them may also be benthic summer feeding grounds: in Egypt and Turkey (Laurent *et al*., 1996), in the Gulf of Gabès (Argano *et al*., 1992; Gerosa and Casale, unpubl. data) and in the Adriatic (Argano *et al*., 1992) some captures are signalled during the summer. In the Adriatic and the Aegean some adult females nesting in Greece have been found (Margaritoulis, 1988). Furthermore, the northern Ionian (Argano *et al*., 1992), the Gulf of Lion (Laurent, 1991; Laurent, 1996), the Corsican waters (Delaugerre, 1987; Laurent, 1996) and the westernmost part of the Mediterranean (Balearic Islands, Alboran Sea; Camiñas and de la Serna, 1995) might be summer feeding grounds, at least for immature turtles, the last zone particularly for specimens in the pelagic phase.

8. POSSIBLE WAYS TO REDUCE FISHING-INDUCED SEA TURTLE MORTALITY

8.1. LEGISLATION PROTECTING THE SPECIES

Many countries have agreed to international conventions to prevent the international trade in turtles and their products (reviewed by Salter, 1995) and have adopted national laws to forbid the capture of these animals. This represents a fundamental stage for the conservation of these species, which is also propaedeutic to further initiatives: it eliminates the demand for turtles in national and international markets, the main cause of intentional capture and indirect mortality related to accidental capture (§ 5) (Tab. 3).

However, this kind of intervention in no way influences direct mortality due to accidental capture which, by definition, is not connected with the fisherman's wish to operate within the law. On the contrary, the confusion caused by expressions such as "capturing prohibited" makes the fisherman constantly feel guilty of committing a crime when he catches these animals, thus making sensitization campaigns, which may have an important role in reducing the mortality (see § 8.6.), harder to implement.

8.2. RESTRICTION OF FISHING EFFORT

The reduction of the fishing effort is considered the most effective way of protecting the overall marine community (target and non-target species), and is the one most widespread in the Mediterranean: the alternative (quota control for target species) is not an optimal instrument (Caddy and Oliver, 1996; Lleonart and Recasens, 1996). It has been seen that for particularly destructive gear (beach seines, towed gear for corals, explosives...) prohibiting or restricting their use may give good results, like turning to more selective gear which has less impact (Lleonart and Recasens, 1996). Furthermore, reducing the fishing effort on demersal stocks, in particular by inshore trawling, represents a main priority in the Mediterranean (Caddy and Oliver, 1996). Reduction of the fishing effort may be obtained by limiting the number of craft, their total and individual power, and total fishing time (e.g. months in a year) (Lleonart and Recasens, 1996).

An extremely important factor to bear in mind is the fishing zone in which the reductions of effort are enforced. In fact, within one fishing zone, the effort may be uneven, producing a non-sustainable impact in certain areas. For example in Turkey, due to the lack of reductions enforced in different fishing zones within this country, the collapse of the Black Sea fishery will probably shift the fishing effort to the Mediterranean (Caddy and Oliver, 1996). In Greece, to optimize the reduction of the fishing effort, the opportuneness of subdividing the fleet between different zones has been looked into, unlike the licence system, which allows boats to operate everywhere within the national compass (GFCM, 1992). Obviously, the more these zones reflect the reality of the marine environment, the more the restrictions will be able to preserve the resources and the by-catch. In connection with this, free access to every fishing zone within the EC for craft of member countries from the end of the 2002 (European Commission, 1994) could be worrying. In this field, restrictions on given areas is still the only available option.

8.3. FISHING PROHIBITION BY AREA AND SEASON

As we said above, the optimal solution for reducing the fishing effort is to adopt this measure in conformity with the ecology of the species and the habitats that are to be protected. This means geographical and temporal restrictions.

As regards geographical restrictions, most countries protects the zones close to the shore from trawling to preserve seabeds and nurseries (Lleonart and Recasens, 1996); these are usually waters less than 50 m. deep. Another kind of protection is creating marine reserves, more effective when connected with a reduction of fishing effort in the bordering areas (Lleonart and Recasens, 1996). Since it is difficult to make people respect these coastal restrictions, a drastic but expensive solution is to protect *Posidonia* beds from illegal trawling by putting obstacles that damage the nets on the sea bottom (Caddy and Oliver, 1996).

Seasonal reduction measures may represent an effective way of protecting the species in the most vulnerable period of their life-cycle, even though, unfortunately, the period is often chosen for economic rather than biological reasons (Lleonart and Recasens, 1996).

As for marine turtles, it is necessary to identify the most frequented areas and check seasonal changes. In fact, in certain circumstances it may be opportune to adopt total or seasonal reduction measures in these areas.

8.4. GEAR MODIFICATION

As an alternative or addition to reduction of the fishing effort or prohibition of fishing, the possibility of modifying the tool to improve its selectivity and thus reduce the capture rate of sea turtles could be studied.

Interaction of Marine Turtles with Fisheries in the Mediterranean

8.4.1. Trawl

The capture of a large amount of by-catch is a general problem connected with trawling, affecting much more than marine turtles alone. Improving the selectivity of this method by means of Bycatch Reduction Devices (BRDs) is promising (Alverson *et al*., 1994). There actually exist several types of BRD used in shrimp fishing, such as the Norwegian Nordmore Grate and the USA TEDs. These were designed in response the specific need to reduce accidental capture of marine turtles (TED: Turtle Excluder Device). It was then noticed that they could improve the method's efficiency, by reducing by up to 50-70% the quantity of debris and other by-catch entering the net (Weber *et al*., 1995 in Lutcavage *et al*., 1997). TEDs are used to divert caught turtles towards a special exit, before they have entered the terminal bag along with the catch. TEDs can be divided into hard TEDs and soft TEDs.

Hard TEDs are basically grids made of steel, aluminium or fiberglass and placed at the entrance to the terminal bag; the working angle is a crucial parameter for their efficiency (Mitchell *et al*., 1995). The various kinds of hard TED differ mainly in the shape of the grid (see Mitchell *et al*., 1995). The exit hole, whose dimensions must fit the TED, can be placed either at the top or at the bottom of the net. According to fishing conditions, one position can be more favourable than another. Furthermore, some other changes to the net are necessary to assure both escape of turtles and fishing efficiency: addition and correct placing of given kinds of float, webbing flaps, accelerator funnels and in certain conditions chafing webbing or roller gear (see Mitchell *et al*., 1995).

Soft TEDs consist of flexible large stitch panels. They are more difficult to install than the hard TEDs and their efficiency in terms of turtles and catch may vary considerably if their addition does not suit the kind of net and the fishing conditions (see Mitchell *et al*., 1995).

The TED was developed in the USA as a solution to the high sea turtle mortality caused by shrimp fishing. In 1977 the National Marine Fisheries Service (NMFS) started a research programme which in 1980 led to the first working TED (see Christian and Harrington, 1987). Besides avoiding marine turtles capture, the TED seemed to increase shrimp fishing efficiency, and it was suggested that its name be changed to "Trawler Efficiency Device" (Mrosovsky, 1982). While at the beginning, voluntary use of the TED by fishermen was usual (Oravetz, 1984), from the end of the '80s, increasingly rigid laws have been necessary to get the TEDs adopted (e.g. see Oravetz, 1988; Donnelly and Weber, 1988; McDonald, 1990). This was a result of strong opposition from the fishermen, who complained about a supposed loss of shrimps and the lower efficiency of their boats due to the TED's presence (McDonald, 1990). Certainly, installing a TED means a bigger managing effort for fishermen and the modifying of a tool whose use was traditional and deeply-rooted.

Recently Mexico, too, under pressure from the USA, made use of the TED obligatory in the Gulf of Mexico and the Caribbean (Olguin *et al*., 1996); many countries in the Americas will probably adopt the TED in the near future (Somma, 1996; Frazier, 1997). Other countries have shown an interest in the TED (Oravetz, 1984; Rao, 1984; Wamukoya, 1996).

Despite some indications that use of the TED has decreased strandings (up to 90%, Maley, 1995; 44%, Crowder *et al*., 1995), in other cases strandings caused by interaction with the trawl do not seem to have stopped (Shoop, 1991) or changed (Caillouet *et al*., 1996; Armstrong and Ruckdeschel, 1996) after use of the TED. TEDs incorrectly installed, use of nets without TEDs, and breach of the law are probable reasons for this phenomenon (Caillouet *et al*., 1996).

Apart from almost completely excluding turtles (Christian and Harrington, 1987), the TED has the important function of considerably reducing other by-catch (Christian and Harrington, 1987; Olguin *et al*., 1996). For this reason the importance of the TED goes far beyond the mere conservation of marine turtles, entering the wider field of marine environment protection.

Since its selectivity is based on size, the TED is unfortunately difficult to apply when the target species is fish - of greater size - rather than shrimps. So, even though a specific TED was brought out for summer flounder fishing (*Paralichthys dentatus*) (Mitchell *et al*., 1995), nowadays functional application of TEDs is mostly directed at shrimp trawlers. This restriction makes it hard to use the TED in zones, such as the Mediterranean, where most trawling activities do not have shrimps as the target species (Laurent *et al*., 1996). In fact, among the Mediterranean countries, only Tunisia and to a lesser extent Algeria and Spain show shrimp landings (FAO, 1997).

As a compromise between fishing activity and conservation, the possible use and adaptation to different requirements of the TED (and of BRDs in general) could allow the sustainable exploitation of marine resources in the future. At least where marine turtles are concerned, the only possible alternative is a ban on fishing in certain areas and seasons (see § 8.3.).

8.4.2. Longline

Since this gear is rather simple, it is quite difficult to introduce changes which exclude sea turtles but not target species. Even though at present this problem seems rather tricky, resources should be provided for studying the behaviour of turtles before and after they nibble at the hook, and the dynamic interaction of the hook with the turtle's anatomy and physiology. In fact, up to now very little work has been done on this. One approach, insufficiently tested as yet, is bases on adding things to the hook (White, 1994). Given the importance of the interaction of this fishing gear with marine turtles (see §§ 2.1.6, 2.2.) it is hoped that studies will soon be done on the above, or in other directions.

8.5. GEAR USE

Trawling-induced marine turtle mortality mainly depends on trawl duration (see § 3.2.1.). For this reason, when the TED is not used, restricting trawling duration might considerably reduce the mortality rate. Restrictions of this kind have been adopted in the USA (Anonymous, 1986; Oravetz and Watson, 1988; Wibbels, 1989). The National Research Council (1990 in Epperly *et al*., 1995) recommends a maximum duration of 60 minutes in contact with the bottom in cold waters.

Since lost or abandoned gear ("ghost gear", especially nets) carry on an catching debris uselessly (Lutcavage *et al*., 1997), correct management of gear should be developed, mainly to reduce this mortality factor, as recommended by the "Code of conduct for responsible fisheries" (FAO, 1995).

8.6. AWARENESS FOR FISHERMEN

As emerges in the previous chapters, the role of professional fishermen is certainly of fundamental importance in marine turtle conservation programmes. The work of these people, often misunderstood by the public - which tends to blame fishermen for the problems of the sea - provides direct, constant contact with the sea and with its inhabitants. The sensitiveness shown by fishers on differing occasions (Cocco *et al*., 1988; Argano *et al*., 1990), and the precious information provided to researchers (Argano, 1979; Argano and Baldari, 1983; Delaguerre, 1987; Laurent, 1990; Laurent, 1991; Argano *et al*., 1992; Bradai, 1993; Lazar and Tvrtkovic, 1995; Laurent *et al*., 1996; Oruç *et al*., 1996), means that every programme dealing with the interaction between turtles and fishing methods must pay special attention to collaboration with this type of person.

The opportunities offered by fishermen being directly involved can be summarized in the following terms:

- Supplying data for research:

Thanks to interviews, it is possible to collect data on capture and mortality rate for every fishing method. Here it must be said that terms like "low" or "rare" are misused in literature, not always corresponding to the word that researchers would use in that precise case. For example, a mortality rate of 10% could be considered "low" by fishermen, while it could be a worrying percentage for someone involved in marine turtle conservation. It is always better to prepare these campaigns (based on interviews with fishermen) by inserting questions that produce quantifiable answers rather than adjectives. Data can be easily collected directly on board by fishermen prepared by adequate training courses.

- Accepting observers on board:

The best results as to collection of data about the interaction between fishing methods and turtles have been obtained by having specialized observers on trawlers (Aguilar *et al*., 1995; De Metrio *et al*., 1983; Panou *et al*., 1992). In this case, data reliability can only be undermined by the unnatural behaviour of fishermen who feel as if they are under observation.

- Operating on specimen rehabilitation (direct mortality decrease):

Suitable preparation of fishermen as to methods of dealing with turtles taken on board may considerably reduce direct mortality. This is the case for turtles caught in a comatose state after trawling (see § 3.2.). For longlines, either direct extraction of the hook from the animal's mouth (when the hook is visible) or cutting the branch as close as possible to the hook can save many of the specimens which are immediately release. Moreover, if the specimen is seriously injured, fishermen could be involved in bringing the turtle ashore to be cured in specialized recovery centres (as has happened in Italy for over ten years).

- Discouraging illegal trade (indirect mortality decrease):

One of the most important merits that sensitization campaigns may bring (in synergy with the laws being up-to-date and watchful on conservation of these species (§ 8.1.)) concerns the possibility of reducing the number of turtles available for illegal trade.

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- Advice on gear maintenance:

A series of training courses on the correct use and maintenance of the fishing tools might save many specimens from accidental and "ghost gear" induced capture (see § 8.5.).

	Interaction	Capture	Direct mortality	Indirect mortality
Legislation protecting the species				X
Restriction of fishing effort	X			
Fishing prohibition by area and season	X			
Gear modifications		X		
Gear use		X	X	
Awareness for fishermen			X	X

Tab. 3.: Effects of various conservation measures on phases of accidental capture.

9. REDUCING MEDITERRANEAN FISHERY-SEA TURTLE INTERACTION : AVAILABLE OPTIONS

We are still far from possessing a clear picture of the impact that fishing activities have on Mediterranean marine turtles. This is basically due to two reasons. The first is the lack of a good knowledge of sea turtle population dynamics, seasonal migrations within the Mediterranean, areas frequented at different ecological phases, interpopulation exchanges between the Mediterranean and the Atlantic, and recruitment of the Mediterranean population. The second is the scarcity of data on which to assess the capture efficiency of different fishing gear and mortality caused in association with various parameters (of turtles, of gear, and of the environment in which it operates).

However, even at this stage it is possible to suggest some short-term priorities, which are propedeutic to any strategy emerging from results of future researches in this field.

9.1. REDUCTION OF INDIRECT MORTALITY

Naturally, any improvement in regulating fishing activities or modifying gear is of a little effect if fishermen find catching turtles economically rewarding. Therefore, the first step is to reduce demand for these animals in local markets. This goal can be achieved only by enforcing and integrating laws that already exist or by suggesting new laws (see § 8.1.), together with an effective awareness campaign directed at local people, including fishermen (see § 8.6.). For example, such problems have been identified in Egypt, Tunisia and Turkey (Laurent *et al*., 1996).

9.2. PRESERVATION OF BENTHIC HABITATS AT DEPTHS SHALLOWER THAN 50 M

As reported above (§1, § 3.1.1.), the greatest density of specimens in the demersal phase is found in shallow waters. Most countries already possess laws which protect areas within 3 nautical miles off the coast or where the sea bottom is less than 50 m. deep. In fact, these areas have a very important and delicate ecosystem: beds of marine phanerogams (e.g. *Posidonia oceanica*) are an important habitat for production of organic matter and are also spawning and nursery zones for many species. The main threat to these habitats is the use of fishing gear that operates on the sea-bed (trawls and beach seines). In those countries with laws in force, obeying the law would assure that

these habitats, so important for the fishing industry too, were preserved and would notably reduce incidental capture of sea turtles.

9.3. REDUCTION OF FISHING EFFORT IN AREAS/SEASONS WITH HIGH SEA TURTLE DENSITY

We are just beginning to understand which areas have the highest marine turtle population densities. In most cases, reducing the fishing effort over a wide area would pose a big problem for the local economy, and implementing conservation actions would require accurate evaluations of particular situations. However, some fairly small areas are already known to hold high sea turtle densities, in certain seasons at least: the nesting sites. These are frequented, mainly in the summer, by both adults and hatchlings. Thus, in these areas it might be very effective to reduce fishing activities in the summer and move it to a precautionary distance from the coast.

10. EVALUATING MEDITERRANEAN FISHERY-SEA TURTLE INTERACTION: SOME PRIORITIES

As emerges clearly from the previous sections, available data on Mediterranean fishery - sea turtle interaction is still scarce and uneven. Research is therefore needed to fill in the existing gaps. Given the limited resources available for this kind of research project, it is useful to identify some priorities on the basis of the information available.

Research priority should be given to those situations where fishing activities interact with the biggest classes of turtles and / or in areas with high turtle population density, and where the fishing effort is greatest (where fishing activities are supposed to have the greatest impact on sea turtle populations). Furthermore, situations where most fishing activities are carried out by a few countries only should be preferred, as offering fewer difficulties for the quick solution of the problem via national regulations.

The continental shelf of the Gulf of Gabès is presumed to be an area frequented by many adult turtles, at least during the winter (see § 7.2.). It is possible that in the summer all or some of these adults leave this zone, which would then become a feeding ground for immature turtles (see § 7.3.). Even though a low mortality rate was found (Tab. 2), this data should be confirmed by a larger sample, allowing other parameters, such as specimen size, season (see § 3.3.), and distribution of Tunisian and Italian fishing effort, to be assessed.

Another area of great interest is the Adriatic Sea, given the high number of captures by the fisheries of Croatia, Slovenia and Yugoslavia, especially by trawling during the winter, and the possible presence of big specimens (Lazar and Tvrtkovic, 1995) (see § 7.2.). Hence, it is urgent to assess fishing impact in every season and discover whether this area is frequented by adults or not. Considering the big fishing effort made by Italian fisheries in this area (greater than that on the east Adriatic coast; see § 6.), major interaction with marine turtles can be suspected; thus, it seems very important that the impact of the Adriatic Italian fisheries be assessed.

Many turtles are thought to be captured in the Levantine basin by Egyptian and Turkish fleets (Tab. 2). Direct observation, particularly in the summer, of accidental mortality in Turkish and Egyptian waters, is essential for impact assessment (see § 3.3.). This area is particularly important because it possesses all the *Chelonia mydas* nesting sites in the Mediterranean (see § 7.1.), and probably also the feeding and overwintering areas for this species (see § 7.2., § 7.3.).

Its special features mean that the Aegean Sea could possess feeding as well as overwintering grounds (see § 7.2., § 7.3.), as suggested for Lakonikos Bay (south Peloponnese; Margaritoulis *et al*., 1992). Moreover, the coasts around this sea possess several nesting sites (see § 7.1.) and there may be impact of fishing activities on adults. Hence, a survey should be carried out on the big Greek and Turkish fisheries (see § 6.).

The northern Ionian Sea may constitute a feeding area for immature turtles (see § 7.3.) and the Greek coasts possess important nesting sites. For these reasons Greek and Italian fisheries should be studied.

The Libyan coasts seem to be an important nesting zone for *Caretta caretta* (see § 7.1.), and the widespread use of gill nets and longlines in this area (see § 6.) could be harmful. This should be verified.

The western basin (Alboran Sea, Balearic Islands and around, Gulf of Lion, Corsica) seems to possess summer feeding zones for immature turtles, most of them in the pelagic phase (see § 7.3.), except in the winter when a small number of adults has been found (Camiñas and de la Serna, 1995).

Topics to be addressed by research programmes are:

- capture rate. Comparative data (seasons, zones) could give clues to seasonal movements of turtles and zones frequented by them. Moreover, the difference in the use / structure of the same gear could offer prospects of improving the gear's selectivity;
- mortality rate. Comparative data (seasons, zones) could give information on the parameters influencing direct mortality.

All the above knowledge combined will allow us to understand where, when and how the limited conservation efforts should be directed.

Even though inquiries made of fishermen may give useful preliminary information, research programmes should whenever possible use on board observers; this is the only method which can give final answers based on reliable data. Both of these methods depend on a good relationship of collaboration with fishermen (§ 8.6.).

In order to assess impact on sea turtles, a reliable census of fishing vessels using different gear, by Mediterranean country and by sector within each country, should be obtained.

Improved knowledge of the population structure of Mediterranean loggerhead and green turtles is necessary, i.e. knowing whether or not distinct populations co-exist in the Mediterranean, and the relative importance of the rookeries and feeding/overwintering areas they frequent.

It is necessary to have a high degree of co-operation between the research and conservation programmes of the governmental and non-governmental organizations, in order to achieve the intermediate goal of improving our knowledge on sea turtle-fishery interaction in the Mediterranean, and the final goal of reducing sea turtle mortality due to such interaction. This will be possible only through enhanced communication and data exchange; frequent meetings on this topic should be scheduled.

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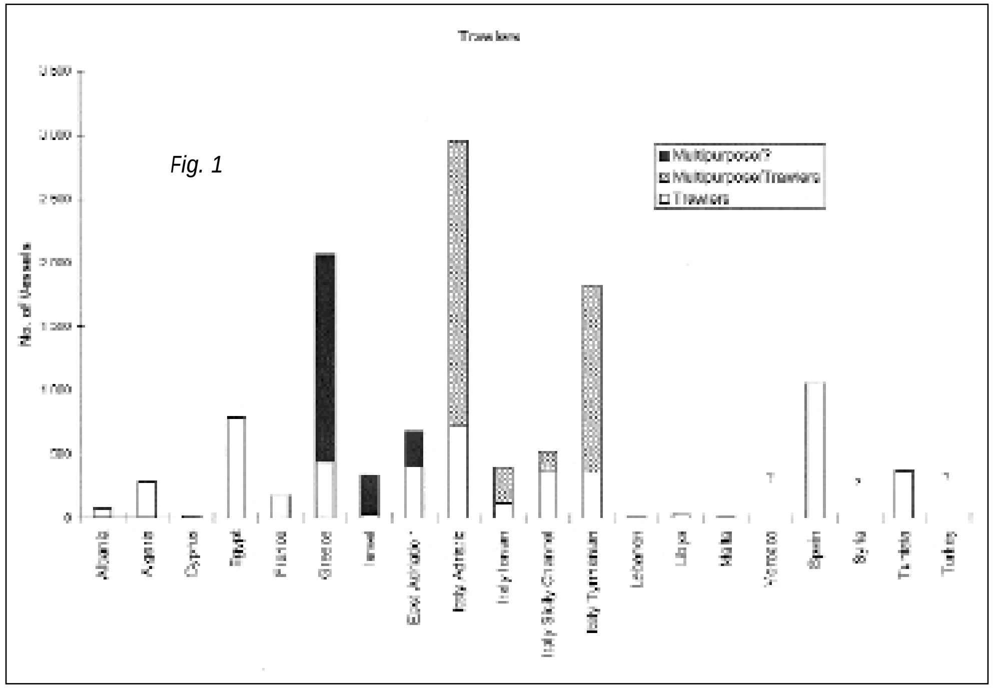

Fig. 1

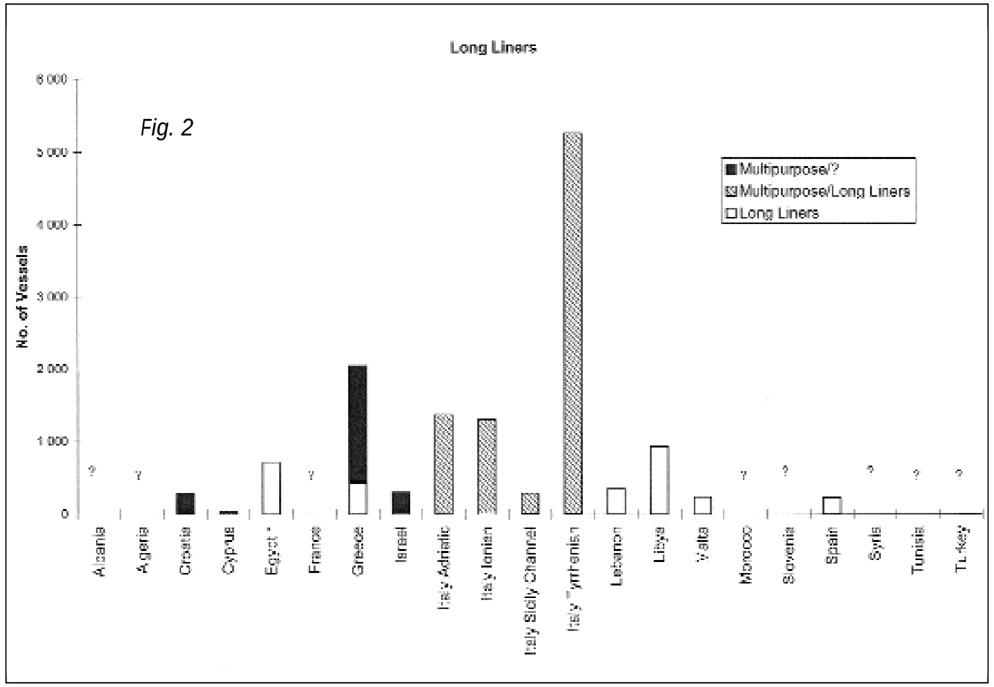

Fig. 2

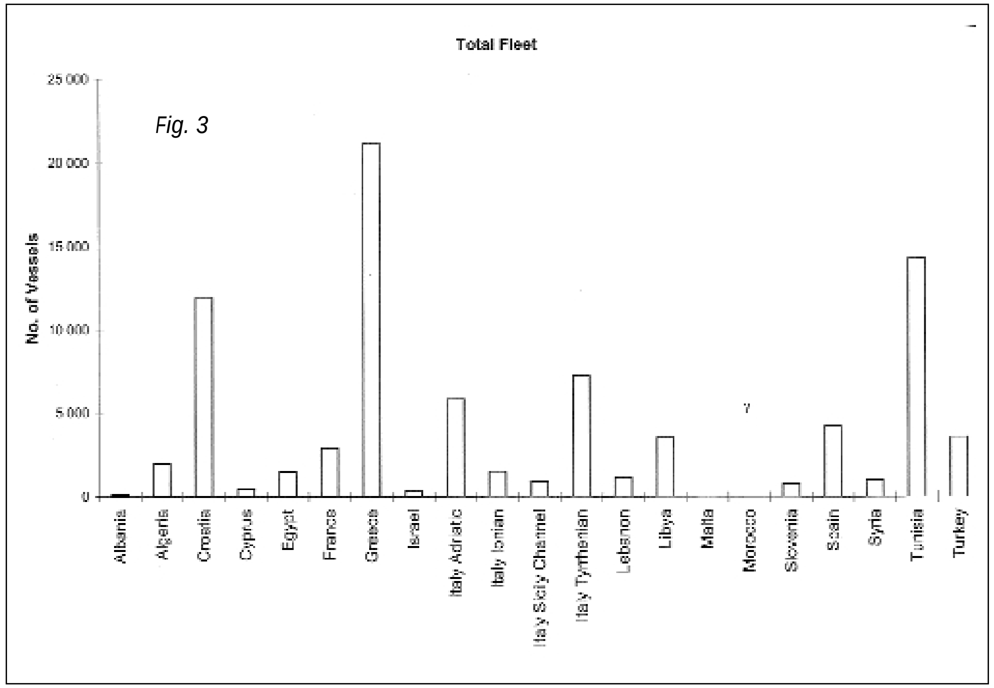

Fig. 3

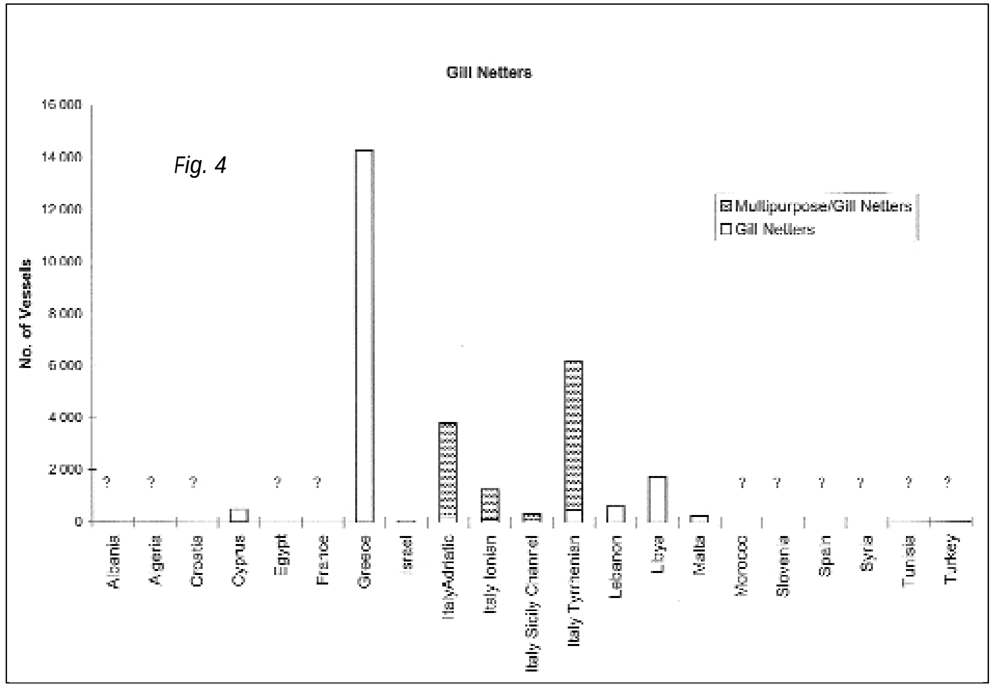

Fig. 4

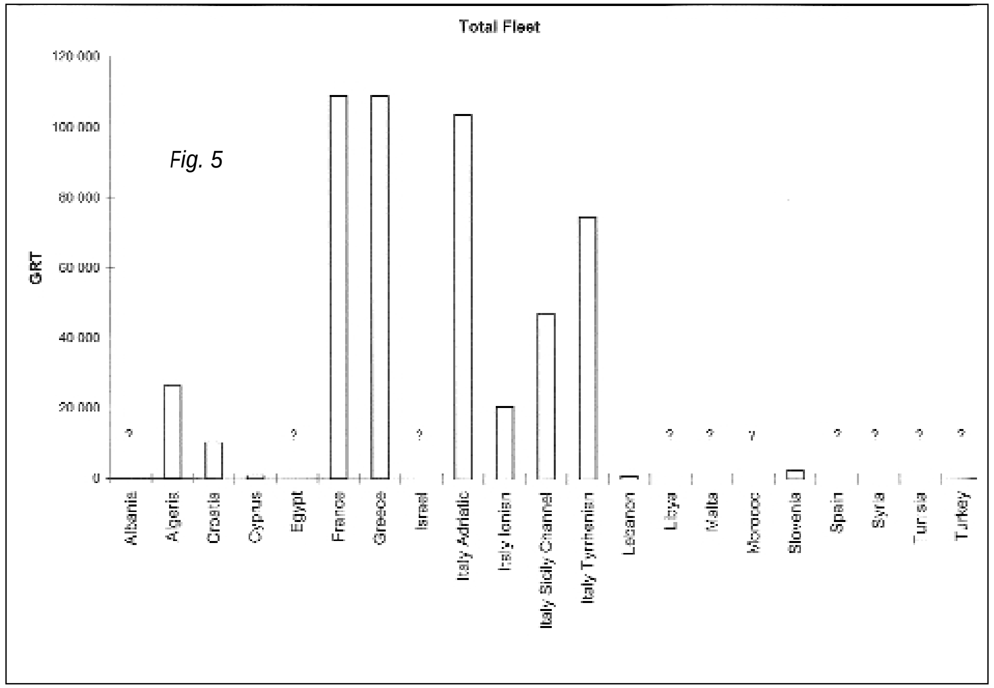

Fig. 1 -Trawlers (No. of Vessels)

Country: [year] source -Albania: [1990] FAO, 1992a. Algeria: [1993] FAO, 1996. Cyprus: [1996] Ministry of Agriculture Natural Resources and Environment, Department of Fisheries. Egypt: [1992] FAO, 1992b. France: Laurent, 1991. Greece: [1992] FAO, 1994. Israel: [1991] FAO, 1994. East Adriatic (Slovenia + Croatia + Yugoslavia): Lazar and Tvrtkovic, 1995 (multipurpose from Croatia only: [1992] FAO, 1994). Italy Adriatic, Ionian, Sicilian Channel, Tyrrhenian: [1993] ISTAT, 1996. Lebanon: [1992] FAO, 1994. Libya: [1993] Lamboeuf and Reynolds 1994. Malta: [1992] FAO, 1994. Spain: Boletin Oficial del Estado 1995. Tunisia: [1995] Farrugio, 1997. ?: unknown*

Fig. 2 -Long Liners (No. of Vessels)

Country: [year] source -Croatia: [1992] FAO, 1994. Cyprus: [1996] Ministry of Agriculture, Natural Resources and Environment, Department of Fisheries. Egypt (all "line vessels"): [1992] FAO, 1992b. Greece: [1992] FAO, 1994. Israel: [1991] FAO, 1994. Italy Adriatic, Ionian, Sicilian Channel, Tyrrhenian: [1993] ISTAT, 1996. Lebanon: [1992] FAO, 1994. Libya: [1993] Lamboeuf and Reynolds 1994. Malta: [1992] FAO, 1994. Spain: Boletin Oficial del Estado 1995. ?: unknown*

Fig. 3 -Total Fleet (No. of Vessels)

Country: [year] source -Albania: [1990] FAO, 1992a. Algeria: [1993] FAO, 1996. Croatia, Cyprus: [1992] FAO, 1994. France: [1996] Ministère de l'Agriculture et de la Pêche, Direction des Pêches maritimes et des Cultures marines. Egypt: [1992] FAO, 1992b. Greece: [1992] FAO, 1994. Israel: [1991] FAO, 1994. Italy Adriatic, Ionian, Sicilian Channel, Tyrrhenian: [1993] ISTAT, 1996. Lebanon: [1992] FAO, 1994. Libya: [1993] Lamboeuf and Reynolds 1994. Malta: [1992] FAO, 1994. Slovenia: [1992] FAO, 1994. Spain: Boletin Oficial del Estado 1995. Syria: [1984, 1986] FAO, 1994. Tunisia: [1995] Farrugio, 1997. Turkey: [1996] State Institute of Statistics, Turkey. ?: unknown

Fig. 4 -Gill Netters (No. of Vessels)

Country: [year] source -Cyprus: [1996] Ministry of Agriculture Natural Resources and Environment, Department of Fisheries. Greece: [1992] FAO, 1994. Israel: [1991] FAO, 1994. Italy Adriatic, Ionian, Sicilian Channel, Tyrrhenian: [1993] ISTAT, 1996. Lebanon: [1992] FAO, 1994. Libya: [1993] Lamboeuf and Reynolds 1994. Malta: [1992] FAO, 1994.. ?: unknown

Fig. 5 -Total Fleet (GRT)

Country: [year] source -Algeria, Croatia, Cyprus: [1992] FAO, 1994. France: [1996] Ministère de l'Agriculture et de la Pêche, Direction des Pêches maritimes et des Cultures marines. Greece: [1992] FAO, 1994. Italy Adriatic, Ionian, Sicilian Channel, Tyrrhenian: [1993] ISTAT, 1996. Lebanon, Slovenia: [1992] FAO, 1994. Syria: [1986] FAO, 1994 ?: unknown

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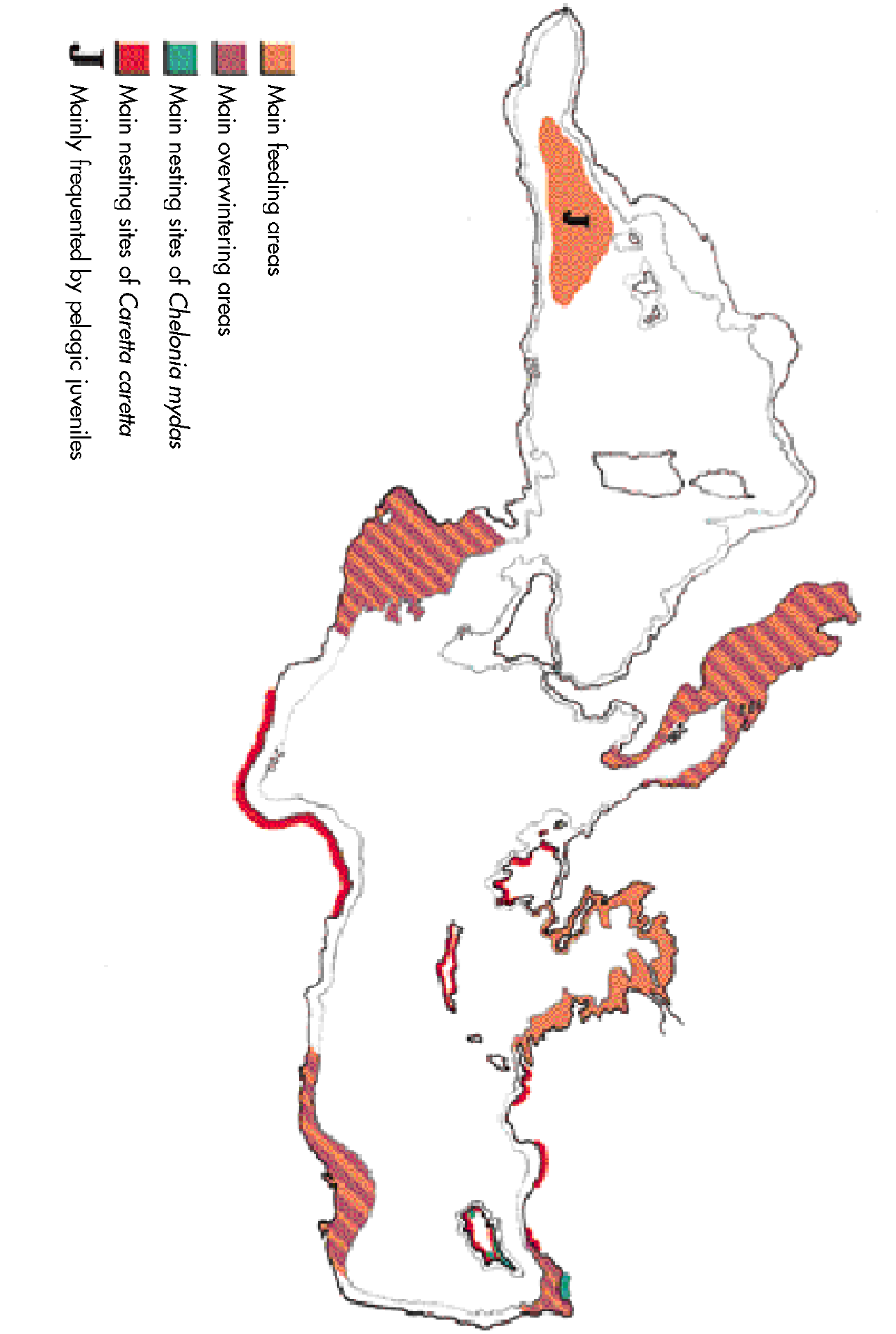


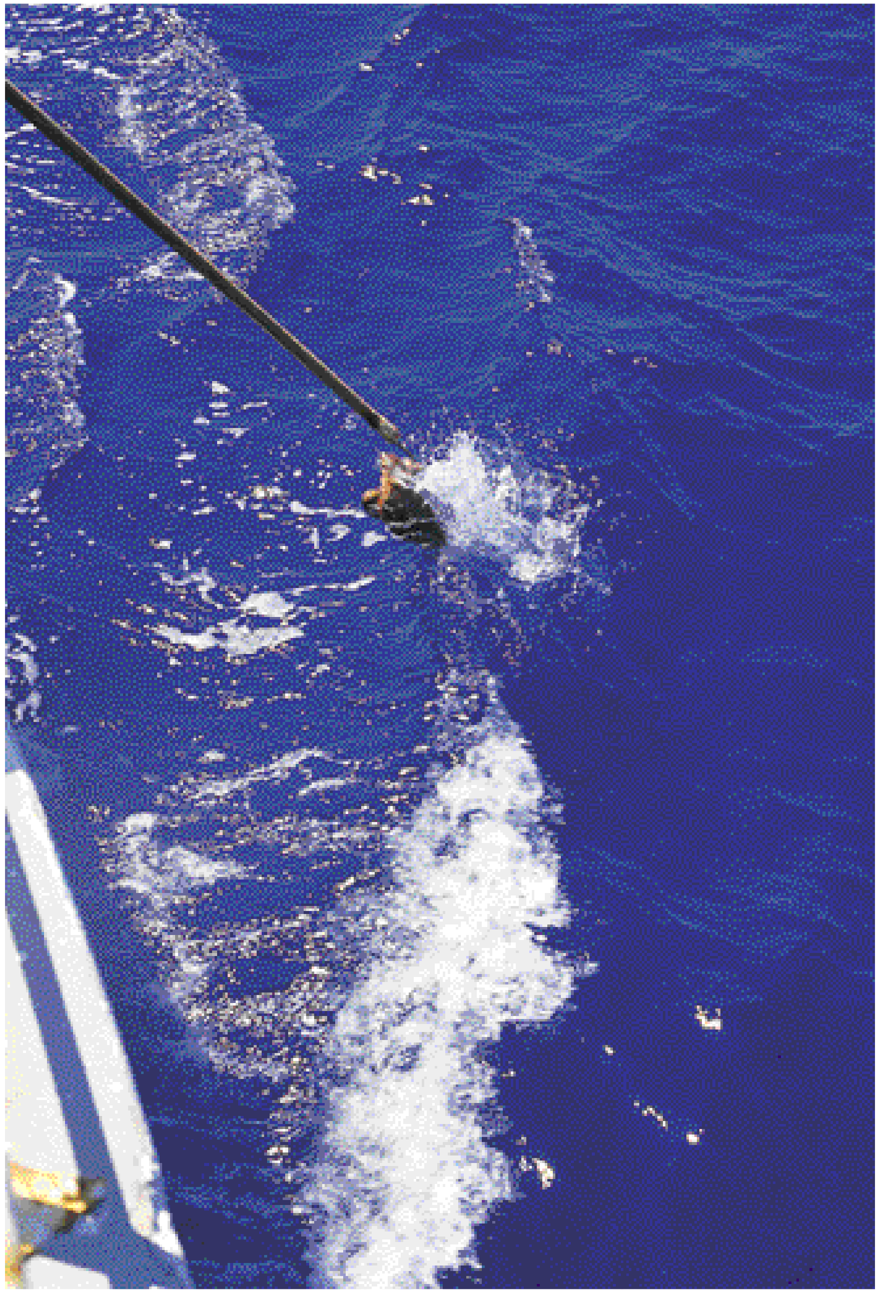
Fig. 6 -Mediterranean areas frequented by marine turtles based on available data

Weight measuring on board of a Caretta caretta specimen caught by trawling (Lampedusa, Italy, 1992)
Photo : Guido Gerosa

Several specimens of Caretta caretta caught by a longliner (Lampedusa, Italy, 1991)
Photo : Guido Gerosa

Caretta caretta with a swordfish hook inserted in its mouth (Lampedusa, Italy, 1992)
Photo : Guido Gerosa

Hatchlings of Chelonia mydas caught by a gill net placed in front of a nesting beach
Photo : Monica Aureggi



Capture of a marine turtle by a grapnel (Gallipoli, Italy, 1987)
Photo : Guido Gerosa

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