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MEDITERRANEAN ACTION PLAN

Meeting of Experts on the implementation of the Action Plan for the conservation of Mediterranean marine turtles adopted within MAP

Arta, Greece, 27-29 October 1998

INTERACTION OF MARINE TURTLES WITH FISHERIES IN THE MEDITERRANEAN

UNEP
SPA/RAC - Tunis, 1998

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Document prepared under consultancy for the Regional Activity Centre for Specially Protected Areas (SPA/RAC), by:

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FOREWORD

The present document was prepared at the request of the Regional Activity Centre for Specially Protected Areas (SPA/RAC) for the needs of this meeting of experts on the implementation of the Action Plan for the Conservation of Mediterranean Marine Turtles.

The document were conceived for the following objectives:

- review, analyse and synthesize the currently available knowledge of the impact of fisheries on marine turtle in the Mediterranean;
- point out, whether possible, identifiable trends and eventual gaps of knowledge;
- assist the present meeting in the identification of priority action for the conservation of marine turtles in the Mediterranean proceeding from the current knowledge of the subjects above-mentioned.

A draft version of the document was discussed within a working group of independent experts on the conservation of marine turtles in the Mediterranean which was convened by SPA/RAC in the framework of the preparation of the present meeting. The group met in Tunis on 27 and 28 March 1998 and included, besides SPA/RAC staff and one of the authors of the present report (Mr. G. Gerosa), the following experts: Mr. Mohamed N. BRADAI (INSTM, Tunisia), Mr. Andreas DEMETROPOULOS (MANRE, Cyprus), Mr. Luc LAURENT (BIOINSIGHT, France), Mr. Dimitris MARGARITOULIS (STPS-Greece), Mr. Sedat V. YERLI (Haccepete University, Turkey). Their contribution to the preparation of this document is much acknowledged.

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1.- INTRODUCTION

At present, the impact of accidental catch on sea turtle populations is one of the most urgent problems to be solved in order to ensure the survival of all these species all over the world. 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), the 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 will carry on in the next future to reduce the accidental mortality.

Available information on sea turtle population dynamics showed that the larger (older) is a specimen, the bigger 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 to direct the conservation efforts to the adult and large juvenile stages, when natural conditions on nesting beaches are preserved.

Marine turtles go through two main ecological phases during their life: a pelagic one at the beginning and then a demersal one. Therefore, the specimens which are the most important for their population are those in the second phase; they spend most time in shallow waters on the continental shelf. Exceptions may be when they move between overwintering, feeding and nesting grounds.

Hence, it is very important to assess the fishing effort interacting with large size classes (Laurent *et al.*, 1992); this probably occurs, as proposed by Laurent *et al.* (1996) for trawling, especially in the fisheries of those countries placed in front of relatively large continental shelves; in fact, in these areas captures as well as climatic and trophic conditions suggest the presence of many specimens.

Moreover, different fishing gears 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 synthetic picture of the interaction the fishing activities can have with the Mediterranean marine turtle populations. Data coming from the Mediterranean and elsewhere, concerning capture efficiency and induced mortality of different fishing gears are considered. They are then compared with the presumed marine turtle distribution and with the fishing effort of different countries, in order to propose some priorities to which invest the limited resources of conservation and research projects.

Seen the scarcity and heterogeneity of such information and the difficulty to trace them, the proposed analysis is not to be considered as definitive or complete.

2. LONGLINE

2.1. SURFACE LONGLINE

The surface longline is an old fishing method (it seems to be known since 177 BC in Sicily (Camiñas and de la Serna, 1995)), used all over the world (Hillestad *et al.*, 1982), which is based on the even older capture by means of a hook with a bait inserted in. The hook is a simple tool, but it is still an efficient mean of catching fishes, although it passed through very few changes about the shape and the materials involved in the making.

In spite of the fact that a certain skill and experience seem to be necessary, this fishing method does not need a particularly expensive equipment, unlike the others; the maintenance, too, concerns only the ordinary replacement of lost or damaged hooks and the renewal of any loss of equipment during the fishing. The kinds of boat which can be used (motor-boat generally made of wood), go 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). Some longer metal boats are an exception, for they have a multiple licence to exercise also other fishing methods, such as the trawling. Indeed, the surface longline owes its success and diffusion to its simplicity and cheapness.

In the Mediterranean sea, which is the most famous swordfish reproductive zone (Nakamura, 1985), the surface longline still seems to be a very diffuse method - in particular in the west zone (Camiñas and de la Serna, 1995) -, even though last years rendering obliged some fishermen to convert into other kinds of fishing which guarantee an income less liable to seasonal variations or chance (such as the trawl or the driftnet). Furthermore, the overexploitation of the swordfish stock has heavily reduced the chance of catching (Camiñas and de la Serna, 1995) as well as the average size of the specimen captured (Northridge, 1991).

For what concerns the accidental captures of sea turtles, they seem to be almost entirely located in the west and central parts of the basin (Demetropoulos and Hadjichristophorou, 1995). Due to this last reason, in the following treatment we are going to refer almost exclusively to the results obtained from studies carried on in that part of the Mediterranean.

2.1.1. Target Species

The species intentionally caught in the Mediterranean with the surface longline are two (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).

Besides the target species, many other species are accidentally caught, as it is common in every fishing method (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 the result of these captures goes, as a consequence, to the exclusive detriment of the species themselves. Referring to marine turtles, the fact that this group is threatened with extinction is definitely an aggravating circumstance. Fishermen owe their unpopularity among public opinion just to the accidental capture of non target-species.

2.1.2. The Method

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 concern fundamentally the length of the main fishing line and, as a consequence, a different number of hooks, the kind of bait and small variations in the times of setting and hauling. In other areas too, different from the Mediterranean, the method is subjected to the same kind of alterations (Boggs, 1994). The Hawaiian fisheries show some considerable differences, such as the addition of chemical light sticks as attractants (Balazs and Pooley, 1994).

2.1.3. Equipment

Besides the kind of boat, previously treated, the equipment used by a Mediterranean longliner consists of a nylon monofilament (called "main line"), which goes from a couple of tens of km in length, with less than 1000 hooks (De Metrio *et al.*, 1983) , to 60 km, with even 2400 hooks (Aguilar *et al.*, 1995). Another nylon line 25 m long (called "branch line"), smaller in section and carrying a hook on its distal part, is connected to the main line about every 25 m. Modifications related to the kind of target may occur to this scheme.

For what concerns swordfish fishing - an animal with epi- and mesopelagic characteristics (Nakamura, 1985) -, a float (in Italy replaced by empty plastic bottles) is manually stuck on, every 3-5 hooks, so as to keep the main line on the surface and make the hooks arrive at a depth not below 50-70 m (Boggs, 1994; Bolten *et al.*, 1994). The hooks utilized for this species go from 8 cm (Panou *et al.*, 1992) to 11 cm (De Metrio *et al.*, 1983) and are made of iron (rare exceptions concerning steel hooks have been seen on the Japanese longlines, operating in the Mediterranean international waters).

Albacore fishing is different from the swordfish one because tuna fish prefers deeper waters. Floats are placed every 11-25 hooks, so as to enable these latters to reach a depth of about 350 m (Boggs, 1994); hooks are different too, usually 3-4 cm in size.

Both kinds of fishing are provided with a buoy instead of the float per every kilometre. This buoy carries a stick with two types of signalling apparatus: the first one is a battery lamp emitting a flashing light which allows to have the right position of the main line in every moment and to follow the fishing line during the hauling. The second one, requiring a radar on board, is a reflector of the radar signal, which allows to recover the parts of the longline gone adrift for a breakage of the main line (usually due to the passing of other vessels), besides having the same function as the lamp (when the line is very long).

2.1.4. Bait

Even though the surface longline utilizes several kinds of baits *(Todarodes sagittarius, Sardinella aurita* (Aguilar *et al.*, 1995); *Clupea* sp., *Trachurus mediterraneus* (Panou *et al.*, 1992), pieces of different species of shark proceeding from previous catches (Camiñas and de la Serna, 1995), however the mackerel (*Scomber* sp.) is surely the most widespread species in the Mediterranean for fishing swordfish (Panou *et al.*, 1992; Aguilar, 1995 ; Camiñas and de la Serna, 1995). It is usually embarked still congealed and then it is unfrozen short before the setting (Panou *et al.*, 1992). An entire mackerel is placed on every hook released in the sea (Nédélec and Prado, 1990).

2.1.5. Fishing Activity

Fishing boats use to leave the harbour in the afternoon, preferably those days when the sea is calm or little rough. After a few hours of navigation (it depends on the distance that must be covered) the starting zone for the setting of the surface longline is reached, usually between 0.5 and 12 nautical miles to the coast (Panou *et al.*, 1992). The crew of a ship can count 8 fishermen (Aguilar *et al.*, 1995) but, in some fisheries (Mazzara del Vallo, Italy), this number may be reduced to 3 (which is considered the minimum to carry out the operations required by this method) to cut down the managing costs.

The set of the hooks generally begins in the late afternoon, sometimes at sunset (Aguilar *et al.*, 1995), it goes on for 3-6 hours (according to the length of the main line), and lasts at dead of night. For the sort of bait utilized (mainly the mackerel, a pelagic fish of neritic zones) the areas preferred by fishermen are those presenting a relatively shallow sea-bottom where there is a higher probability that the swordfish could find this species in nature (Nakamura, 1985).

The hauling of the fishing line may start immediately (Panou *et al.*, 1992), after a few hours or even the next morning (Panou *et al.*, 1992). In these last cases, the ship is left drifting (Camiñas and de la Serna, 1995) so that the stream drags both the line and the boat in the same direction. If the ship lost contact with the extremity of the longline, the crew would rapidly effect a reapproaching rigging. The hauling is the longest stage in this fishing method and it may last for 7 hours (Aguilar *et al.*, 1995) or even more (it depends on the sea conditions, the number of caught fishes and the entirety of the main line). Usually this operation is carried out manually, with the unique help of a winch, usually placed on one side of the boat or on stern, over which the main line is made run. The main line and the branches are collected inside a basket, while the hooks are tidily inserted in the round border of the same basket.

If the ship is a low tonnage one and it has not a hold with an ice-box inside, it will immediately return to the harbour to sell the fish. On the contrary, if the boat is provided with an ice-box (which can also be a not electric one, because a lot of ice is usually bought in the harbour before the departure), after a short stay it will start again to set the hooks, so as to fish night and day. In this case, the ship uses to go back to the harbour after 3-4 days (rarely a week) to be able to sell the fish still fresh. An anticipated return may occur due to a meteorological change or a plentiful catch of fish.

2.1.6. Interaction with Marine Turtles

The surface longline bases its capture capability on the probability that a hook has to meet a specimen of the target species. As we said before, to make the hook attracting, fishermen use a bait which must be appetizing so as to induce fish to eat the bait which hides the hook. Once stuck in the fish mouth or oesophagus, the hook will not let the animal escape so then the animal is brought on board during the hauling. The probability that a single hook has to meet the fish is scarce. For this reason, fishing operations take place in zones where the occurrence of target species is presumed (on the basis of personal experience) and the number of hooks used is very high, so as to allow to catch an amount of fish sufficient to get an income.

As underlined before, swordfishes and albacores are not the only ones deceived by this method, but also other animals, such as marine turtles, can be attracted by the bait when passing nearby.

2.1.7. Marine Turtle Species

The available literature shows that the surface longline catches several species of marine turtles: 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).

For what concerns the Mediterranean Sea, it seems that only one of the three species present, *Caretta caretta*, is regularly involved in this kind of fishing capture, while rarely some specimens have been identified as *Dermochelys coriacea* and others (with reservations) as *Chelonia mydas* (Panou *et al.*, 1992).

2.1.7.1. *Dermochelys coriacea*

For it prefers a diet which is rarely based on fish (whether alive or dead) (see Bjorndal, 1997 for a review), *Dermochelys coriacea* may seem to be naturally untouched by this kind of capture. On the contrary, the leatherback turtle indeed appears to be the species that is most affected by this method in the Gulf of Mexico and in the Atlantic (Ogren, 1994; Gerrior, 1996; Witzell, 1996). However, analysing how these specimens are caught in these zones, it comes out that the captures are due to the fact that the turtle wraps itself up in the main line (Gerrior, 1996; Witzell, 1996) or in the branch line (Ogren, 1994; Witzell, 1996) or it remains hooked (Gerrior, 1996), rarely in the mouth (Witzell, 1996). This means that *Dermochelys coriacea* is not interested in nibbling at the hook. The bait probably attracts the turtle curiosity making the animal get entangled 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 chance that the surface longline hooks meet a *Dermochelys coriacea* is near to zero.

2.1.7.2. *Chelonia mydas*

Even though data are scarce in literature, the green turtle seems to be attracted by the bait for feeding, hence it tends to nibble at the hook (Gerrior, 1996). *Chelonia mydas*, except in the juvenile stage when it seems to be omnivorous with a strong tendency to carnivory (Bjorndal, 1985 in Bjorndal, 1997), follows a mainly vegetarian diet, but it very often completes this diet with animal matter, including fish (e.g. Brown and Brown, 1982 ; see also Bjorndal, 1997 for a review). Because of this habit, the green turtle is particularly vulnerable to the longline. In the Mediterranean sea, *Chelonia mydas* appears to be fished very rarely. The only citation is related by Panou *et al.* (1992) for the Greek part of the Ionian Sea, but the identification of the species is exclusively founded on the dimensions of the four specimens turned in. The reasons for the scarce number of specimens caught in the Mediterranean may be connected with the difficult identification of the species by fishermen (who usually refer to the most known and frequent species: *Caretta caretta*) and with the fact that almost all the data collected by this sort of study concern the western part of the basin, leaving out the zone in which this species is more present, or simply with the fact that this species is fished very rarely.

2.1.7.3. *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 annually caught only by the Spanish fishing vessels, off Balearic islands (Mayol, 1986; Camiñas, 1988; Aguilar *et al.*, 1995). Accepting these numbers with caution, no doubt that the loggerhead turtle is the species that is mainly and regularly caught during fishing campaigns with the surface longline (De Metrio and Megalofonu, 1988). Compared to target-fish this species seems to be very attracted by the bait (in particular by the mackerel) which is almost ever bitten and/or swallowed. So the hook ends up in the mouth, in the tongue or in the oesophagus (Argano *et al.*, 1992; Bolten *et al.*, 1994; Aguilar *et al.*, 1995; Witzell, 1996). Seen the scarcity of the accidental captures of leatherback and green turtles, from now on we'll only treat *Caretta caretta*, the species that is most affected by this fishing method. Moreover, the lack of specific studies concerning the eastern zone of the Mediterranean forces us to limit our analysis of the surface longline to the western part of the basin.

2.1.8. Number of Captures

At the moment, maybe due to the lack of specific studies about the other fishing methods used in the Mediterranean Sea, the surface longline appears to be the fishing method that more than the others accidentally catches 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 during the years of study, do not allow to compare the results with the necessary thoroughness (Camiñas, 1988; Panou *et al.*, 1992; Aguilar *et al.*, 1995). Apart from this methodological problem, it seems to be valid the hypothesis, formulated by some authors, that the number of caught specimens is steady neither in space nor in time and that this probably depends on many parameters not studied yet.

For what concerns the numerical discordance of captures between different areas of the Mediterranean, the data related by Aguilar *et al.* (1995) show the highest rate of capture of 9.8 turtles per day for every boat observed in the south-west Mediterranean in the 1990. On the other hand, according to Panou *et al.* (1994), the same rate decreases to 0.16 turtles for every ship's hold in the Greek part of the Ionian sea in the 1993 (Tab 1a). In other words, the Spanish longlines have a chance to fish a *Caretta caretta* 61 times higher than the fleet working in front of the Greek islands of the Ionian. A similar high difference (44 times), even changing unit of measure, comes out comparing the data collected by Greenpeace observers and published in Aguilar *et al.* (1995) with the ones 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 a 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

2.1.9. Mortality Rate

The mortality rate caused by the surface longline can be measured by summing up the two connected moments which follow the capture by the hook. The first one regards the damages caused by the tool to the animal while still in the water, before being turned in. The second one concerns the capability of the specimens released in the sea to survive after the trauma of the capture. To make it clear and to underline the methodological difficulties connected with the collection of the data, the single cases will be treated one by one in this session.

2.1.9.1. Mortality rate before the turning in

Considering that *Caretta caretta* generally nibbles at the hook and that the longline practically fishes on the surface, the animal is able anyway to move and reach the surface to breathe, in spite of its being impeded by the hook. Very different is the situation for those specimens which remain entangled in the fishing lines (as usually happens to leatherback turtles ones) and then, unable to move, drown.

The injury caused by the hook is rarely fatal first. The results obtained by several authors are very diverging: they go 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). Regarding these two percentages as exceptional data, 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)). However, it should be taken into account that 15.6% of the caught specimens presents the hook inserted in the mouth (Aguilar, 1995), which is not a vital point, and that the specimens usually do not die in a few hours, even if seriously damaged by the hook.

2.1.9.2. Mortality rate after the release

Also thanks to effective campaign of sensitization led by NGOs among fishermen, most of them use to turn the turtle in (unless its dimensions are excessive; Argano *et al.*, 1992) and get the hook back from its mouth, although the fishermen themselves consider this method quite dangerous. If the turtle swallows the hook so that it is no longer visible, fishermen (those trained by research programmes) use to cut the branch as near to the turtle's mouth as possible, leaving the hook and part of the line hitched 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 topic. In fact, following a released turtle or foreseeing its fate is actually impossible. In particular, as fishermen use to cut the line in

different ways, resulting in lines of different lengths, 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 heavily injured. Some experiments, tested in Spain, show that the mortality percentage of specimens with hook and line inserted in - kept in tanks and supervised - reaches the 28.9% (Mas and Garcia, 1990; Aguilar *et al.*, 1995). Some other experiences, instead, state that the animals rarely survive after having swallowed the hook of the surface longline, usually together with part of the branch (Bentivegna *et al.*, 1993; Bjorndal *et al.*, 1994).

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

2.1.10. Caught Specimens' Dimensions

At the moment, different behaviours towards hooks with bait, connected with the specimen's dimensions, are not known. The only limit to the captures concerns the specimens smaller than 27 cm (Standard Curve Carapace Lenght) (which, according to the published data, seems to be the lower size-limit involved in this fishing method both in Italy (Argano *et al.*, 1992) and Spain (Aguilar *et al.*, 1995). This limit is due to: first, the dimensional incompatibility between the big hook used by this method and the dimension of the small turtles' mouth (as also confirmed by comparing mean weights of specimens caught by hooks for swordfish and those, smaller, for albacore (De metrio et al., 1983; tables 3 and 4 respectively); second, the well-known turtles behaviour during the first years of life, when they seem to vanish and then reappear near the shore after two or three years.

The great amount of young and subadult specimens caught by the longline (De Metrio *et al.*, 1983; Aguilar *et al.*, 1995) seems to follow a bell-shape course, if analysed through dimensional classes (Panou *et al.*, 1992; Argano *et al.*, 1992). Referring to the hook dimension, this course has an important implication in the ecology of the species, for it seems to show that the population included between 27 and 50 cm (Standard Curve Carapace Lenght) is caught in proportion to its size. The descending part of the curve should be quite carefully representative of the sizes of the specimens present in that area. In fact, all the specimens in this size class probably have a demersal behaviour and therefore they are supposed to have the same chance of meeting a hook.

The scarce percentage of capture related about adults (De Metrio *et al.*, 1983; Argano *et al.*, 1992; Aguilar *et al.*, 1995), also 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 because fishermen usually do not turn the bigger specimens in, as they interfere on board, so that the researchers have no specimens at their disposal (Argano *et al.*, 1992). Alternatively, these findings might reflect a possible different behaviour of specimens in reproductive phase.

Therefore, the surface longline appears to be a selective method connected with the dimension of the specimens, for it catches a larger proportion of the present large-size specimens (> 50 cm) than of the small-size ones.

2.1.11. Sex-Ratio Of The Caught Specimens

Very few data have been collected about this topic. The main difficulty found by fishermen (and by observers on board too) is to distinguish the sex of the immatures (e.g. Wibbels *et al.*, 1987). The only data concern 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 the 1994. A preliminary analysis on the subadults (Casale and Gerosa, unpubl. data) does not show a skewed sex-ratio.

2.1.12. Periods Of Capture

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).

The results referring to May and September, months that only a few works consider with a high capture rate, diverge according to the different authors (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 referring to the fact that the increase of the fishing effort in the Mediterranean reaches its top between May and September, when the meteorological conditions are better (Camiñas and de la Serna, 1995). However, some data show that the accidental capture of *Caretta caretta* goes on in the other months, but the CPUE considerably decreases during the period October-April in the same localities and with the same methodologies (Camiñas and de la Serna, 1995). These last data and an accurate analysis made by Camiñas and de la Serna (1995), seem to confirm the hypothesis by which the Mediterranean population of the loggerhead turtle carries out seasonal movements within the basin (Margaritoulis, 1988; Laurent *et al.*, 1990).

2.2. Bottom Longline

Data concerning this fishing method are very scarce. The differences between bottom and surface longline (described above) are considerable. First of all, the main line lays still a few centimetres from the bottom, thanks to a ballast placed all along the line. Other variations regard the type of hook (generally much smaller), the kind of bait (generally sliced anchovy) and the target (demersal fish).

The capture rate between this kind of fishing and turtles (in particular *Caretta caretta*, seen the kind of utilized bait) is unknown. Bottom longline dangerousness is clearly dependant on the depth where it is placed. Use at a depth of 200-700 m (Bolten *et al.*, 1994) should not arouse any concern. However, in Italy there exist cases showing a much lower depth, where this method is used, and numerous captures of mariturtles (Gerosa and Casale, unpubl. data). The other problem could concern the opportunity of using the term "longline" to indicate the two fishing methods which should require an indipendent treatment, seen the considerable differences.

As far as mortality rate is concerned, it seems to penalize juveniles in particular, for it appears that larger specimens are able to drag the main line with the ballast to the surface to breathe (Gerosa and Casale, unpubl. data).

3. TRAWL

The trawl consists of a net approximately in the shape of a frustum of cone, whose smaller base is closed by a bag, while the larger one is kept open by a beam or otters placed on the lateral extremities. Usually, the mesh dimension of the net gradually decreases from the opening to the terminal bag. The net is trawled by one ship or more, so it is an "active" fishing gear, for it catches all the animals along its way by conveying them in the terminal bag. The types of trawl - though they are many - can be divided into two large classes, whether working in contact with the sea-bottom or not: bottom trawl and midwater (pelagic) trawl (see Nédélec and Prado, 1990). For what concerns marine turtles, the main interaction is due to the bottom trawl, when it operates in not very deep water frequented by those animals. This method catches all the species, but *Eretmochelys imbricata* and *Dermochelys coriacea* in a lesser way (Hillestad *et al.*, 1982). The bottom trawl 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 part and the lower one of the net, even though this lower part is longer in most cases; in the dynamics of the trawl, this makes the adherence to the bottom easier, so as to increase 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 vertical and horizontal sense. The net can be joined to the otters either with ropes or directly. The otters 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 a unique one presenting a fork (a ship can drag more than one net). In particular, the USA bottom trawl for shrimps is directly joined to the otters and towed by a single rope (Ferretti, 1983). The bottom trawl used in Turkey has the opening 0.75-1 m high; it is towed at the maximum speed of 1.5-2 miles/h (references in Oruç *et al.*, 1996). In Tunisia the opening is 1-2 m high and 15 m wide (Laurent and Lescure, 1992).

It has been estimated that the number of turtles killed by this fishing method is greater than the one induced by other kinds of matched anthropic impacts (National Research Council, 1990 in Lutcavage *et al.*, 1997). The reason of such an impact is double: on the one hand, the considerable fishing effort carried out with this method, on the other, the high mortality rate which has been noticed.

3.1. CAPTURE

3.1.1. Depth

The higher is the turtle population density in the operative zone, the bigger is obviously the impact of capture connected with this method. Referring to the stretches of coast frequented by marine turtles, the population density increases with the decreasing of the sea-bottom depth. In fact, *Caretta caretta* and *Chelonia mydas* mostly frequent bottoms less than 50 m deep, 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 so to be expected that the bottom trawl has a different rate of capture as the depth at which it works changes. For example, Epperly *et al.* (1995) report that in South Carolina the relation captures/fishing effort is higher in shallow waters (with a fishing effort led between 6 and 98 m, captures occurred between 9 and 34 m), with a maximum in bottoms less than 20 m deep. In Oman, Hare (1991) noticed an high capture incidence in low bottoms. Caillouet *et al.* (1991) relate a significant relationship between fishing effort in bottoms less than 30 m deep and turtle

strandings, in the Gulf of Mexico. In Tunisia, most turtles are caught by trawl at depths less than 50 m (Bradai, 1994).

3.1.2. Size of Turtles

Due to its features, the bottom trawl catches those specimens which have effected or are bound to effect the transition between the pelagic phase and the demersal one. Because of this, specimens below a certain dimension 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-shape frequency distribution of sizes of the specimens caught (e.g. Epperly *et al.*, 1995) is probably due to the few small size specimens actually present in the demersal population (transition phase).

3.2. MORTALITY

The mortality caused by the trawling is due both to the physical stress exerted over the animal by tons of catch inside the net (e.g. Hare, 1991) and, mainly; to the forced apnea to which the specimens caught in the net are subjected, because the net is kept submerged even for several hours. Specimens can be found alive, dead or comatose. If turtles in the latter condition are not regognized as such and treated as dead ones (i.e. thrown in 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, water temperature.

3.2.1. Duration of trawl

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

In the specimens caught by the trawl, Stabenau *et al.* (1991) pointed out an acidosis considerably higher than the one noticed in the same times of forced apnea in captivity. This suggests that additional factors are involved in the capture by trawl. In fact, the shifting speed of the net, which can be also higher than the maximum speed a caught specimen may reach, forces them to a vigorous swimming, also due to the 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 specimens kept in captivity. According to the recover rates observed, 20 h minimum would be necessary to restore the regular conditions assuming a constant rate, but this period of time may be longer if the recover rate keeps on being concentration-dependent (Lutz and Dunbar-Cooper, 1987). However, in marine turtles it is unknown if the overcoming of the aerobic capacity by the metabolic demand is a normal event during the intentional apnea (Stabenau *et al.*, 1991).

3.2.2. Intensity of fishing effort

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

3.2.3. Water Temperature

Since the oxygen consumption rises with the increase of temperature (Lutz *et al.*, 1989), it is plausible that the maximum time of apnea decreases as the water temperature rises. In fact, it has been noticed that in summer the emerging frequency of *Caretta caretta* is higher than in winter (Renaud and Carpenter, 199). It follows that the duration of the trawl can't be considered apart from the temperature to determine the level of impact. For example, Wibbels (1989) relates a high mortality (45.4%) connected with quite short durations of trawl (30-105 minutes) and alleges it to the water temperature of the sea where the fishing activities were carried out (June, Florida).

3.3. Impact of Trawl on the Mediterranean Sea Turtles

There are several data on sea turtles-trawl interaction in the Mediterranean, most of them from the Eastern Basin (Tab. 2). A big impact of capture is suspected to occur in Tunisia, Egypt, Turkey, Greece and the pool Slovenia-Croatia-Yugoslavia.

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

This difference may be explained by the shorter duration of the trawl in the Mediterranean and the low temperatures checked in periods of catch (e.g. Laurent and Lescure, 1994) (see § 3.2.3.). However, the available durations of the trawl (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 over 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 dead turtles or in a comatose state found in waters (North Carolina) of 18°C maximum, comparable to the ones of about 17°C reported in Tunisia (Gulf of Gabés) by Laurent and Lescure (1994), where all the 15 specimens caught with times longer than 1.5 h have been released in good conditions. In spite of the low temperatures, a mixed group of 16 *Caretta caretta* and 14 *Lepidochelys kempi* presented 5 dead specimens or in a comatose state (16.6%) with trawling times lower than 1h in North Carolina; this has been imputed by the authors to multiple captures (see § 3.2.2.).

Anyway, another factor might have contribute to the low mortality noticed in the Mediterranean. The peculiarity of the Mediterranean samples is given by their mainly consisting of specimens of large dimensions: turtles more than 70 cm long represent the 73.3% of the Tunisian sample (n = 15; *Caretta caretta*; Laurent and Lescure, 1994), the 84% of the Greek one (n = 38; *Caretta caretta*; Margaritoulis *et al.*, 1992), the 52.9% (n = 17) and the 40% (n = 30) (*Caretta caretta* and *Chelonia mydas* respectively; Oruç *et al.*, 1996; based on approximate lenghts), 71.4% (n = 7) and 25.6% (n = 39) (*Caretta caretta* and *Chelonia*

mydas respectively; Oruç *et al.*, 1997; TCCL) of the Turkish one (see also Laurent *et al.* (1996) for a synthetic view of sizes). On the contrary, this percentage was only 13.7% for the group of North Carolina. There actually exist indications that the endurance of apnea, forced by the trawl, rises with the increase of size (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 specimens of large size; the scarce number of specimens directly observed, does not allow a thorough estimate of the winter mortality in specimens of smaller size. Furthermore, trawling activities are carried out in summer too, when the high temperature may considerably reduce the endurance of apnea (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 estimates of mortality. It may be indicative that a relative high mortality has been registered in summer along the coasts of Corsica and continental France (Tab. 2), where the summer temperatures remain anyway lower than the ones of the Gulf of Gabés and mostly of the Egyptian and south-eastern Turkish waters (NOAA, web site), and where most specimens were of small size (cont. France; Laurent, 1991). In Egypt some interviewed fishermen have suggested a 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) registered a high mortality (45.4%) also in specimens of large size, with a minimum duration of trawl with a dead of 75 minutes.

In conclusion, even though in Tunisia summer captures seem to be less than the winter ones (Laurent *et al.*, 1990; Bradai, 1992), in this area and in other ones (especially in the Levantine Basin) a possible higher mortality caused by higher temperatures could provoke a number of deceases equal to or greater than the ones resulting from winter fishing activities.

No doubt that the fishing activity in sea bottoms less than 50 m deep (Tab. 2) contributes very much to the high capture rate checked. Moreover, if specimens of smaller dimensions prefer less deep bottoms for their lower endurance of apnea, a higher mortality rate may result from fishing in these zones. The fact that in south eastern Turkey the trawling moves from deep bottoms in the cold months to low bottoms in the hot ones (Oruç *et al.*, 1996) might be worrying.

Country	Target	Period	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
Egypt		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	*C.c., C.m.*		inquire		Laurent *et al.*, 1996
		Oct-May 1995			0->100	*C.c., C.m..*	1.6% (186)	inquire		Oruç *et al.*, 1996

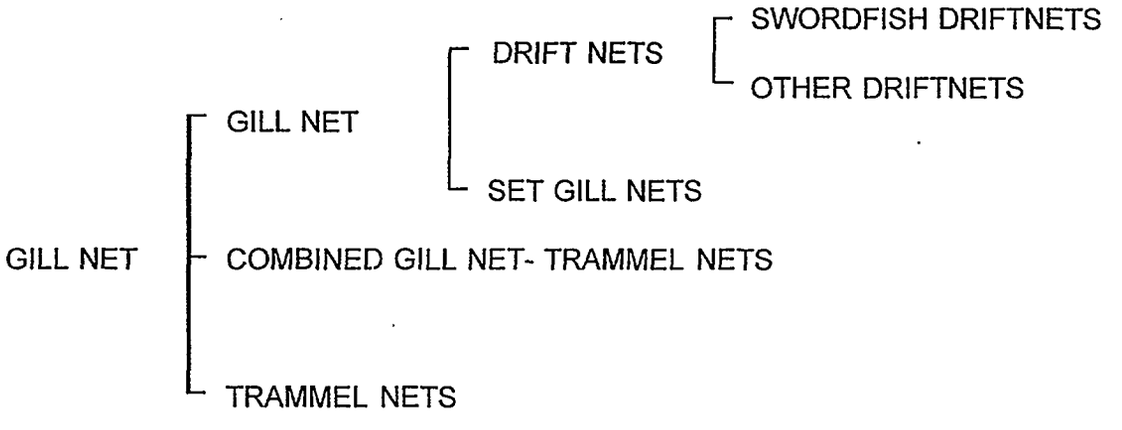
Tab. 2 - Trawl

4. GILL NETS

Gill Nets are the most well-known, clever and old fishing nets (Ferretti, 1983). They have been used for many years in almost all the coast zones, whether as an industrial, an artisanal or even a sport tool.

As more productive gears (like trawl nets or surrounding nets) became available, gill nets underwent a drastic reduction in their use, until the use of synthetic strings instead of the natural ones boosted this gear again in competition. In fact, fishermen were aware of many unexploited zones (like those ones with a very rough bottom or very close to the coast, which are both unsuitable for trawling), where they could catch valuable fish. Furthermore, this gear can be used with every kind of low-cost boats, and it allows to catch large fish in good conditions (Ferretti, 1983). These are the reasons why this gear is very used today.

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



All the gears above are used in the Mediterranean, as they are present in all the coastal zones of the world. In the present work, the different kinds of gill nets will be treated altogether. A different section will be dedicated to drifting nets for swordfish, due to the worries they have induced in the last years.

4.1. GILL NETS (except Swordfish Driftnet)

4.1.1. Target Species

Gill nets can catch almost all the species of an economical importance. Fishermen, thanks to their personal experience and knowledge of fishing areas, are able to catch exactly the target they want, by varying the type or the size of the mesh, the working depth and the season. It was this will of catching particular species that induced fishermen to modify these nets to a little or a great extent, so that today we know nets which are almost species-

specific for fish, molluscs and crustaceans. Such a great improvement of the gear could not avoid to catch accidentally non-target species too, including marine turtles.

4.1.2. The Method

The gill net is a fishing net which is placed vertically so that it fences in or blocks water areas, in order to catch the marine organisms which try to pass through (U, 1981). Such a clear definition actually hides a much greater complexity. In fact, different to other gears, the key word of gill nets is 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, moment of the day, season, differences in the gear).

4.1.3. Interaction with Marine Turtles

Gill Nets could be considered a passive fishing gear: turtles are caught by chance, during their movements. However, Panou *et al.* (1992) report that, according to fishermen, turtles actively try to feed on the fish entangled in the trammel nets, also damaging the gear. Therefore, these nets might represent an active fishing gear, because their catch may be an attraction for turtles, increasing the probability of capturing them.

Drowning is the main reason for the sea turtle mortality induced by these fishing gears: the animals, once entangled in the net, cannot reach the surface to breathe. Thus, there may be some differences in mortality between nets set on the bottom and those ones set near the surface; in fact, these last ones could give more opportunities 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. In fact, these material can cause serious injuries and necrosis.

High mortality and number of captures are reported for shark nets placed near areas where turtles occur (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 > 60 m (fishing effort between 8 and 110 m). In Tunisia Bradai (1993) found a mortality rate of 5.2% (n=58) by trammel nets; the same author (1992) reported two specimens of little size (8.8 and 10 cm ca.). In France, a mortality of 53.7% out of 149 turtles caught at a depth less than 50 m is reported by Laurent (1991). The mortality rate of specimens tagged and then recaptured by set gill nets in different countries was 73.7% (n=19) (Argano *et al.*, 1992). Hence, gill nets seem to be a very dangerous fishing gear. Even though a single net has a little probability to capture a turtle on average, the spread of this gear, also close to high turtle density areas, may represent a big impact on populations.

4.2. SWORDFISH DRIFTNET

"Drift gillnet", or simply "driftnet", indicates a net which is kept more or less vertically in the water column by means of a series of floats, which remain on the surface, and weights hooked on the lower end of the net. Unlike the other nets, to which the description above could correspond, this system is allowed to move with the sea current or wind. Together with other types of nets, the driftnet can be numbered among the simplest and probably oldest fishing methods (the first documented historical record dates back to 177 A.D. (Greece),

describing driftnets made of linen (Di Natale, 1993)), so that it is believed that this technique was developed independently in different parts of the world (Northridge, 1991).

4.2.1. Swordfish Driftnet Problems

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

The most important critics to this fishing method have been divided in different 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 nets has both on non commercial or protected species (among which marine turtles) and the environement;

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

The exaggerate use and the careless lengthening of the nets (up to 60 km) began to worry the different governments both because of the eccessive stress 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 measures independently (for example in 1990 the Spanish Fisheries Administration forbade the use of driftnets in the Alboran sea (Camiñas, 1995b) and afterwards the EC enacted a regulation (EU regulation 345/92) in which netting with more than 2.5 km nets have been banned.

Under the impulse of various pressures, most Mediterranean states have banned the driftnet or are trying to make fishermen change back to other fishing methods considered more selective and less damaging for the environment.

4.2.2. Interactions With Marine Turtles

Even though it is more than fifteen years that this method is concerned, available data and experts' opinions are still very discordant. While the considerable accidental capture of marine mammals is sure, the number of turtle captures is still little known. Data from a research led in the Tyrrhenian Sea and the Ligurean Sea by Di Natale (1995) indicate as an

average for the years 1990/91 a CPUE of 0.005 loggerhead/km of net. The 5 specimens (all belonging to the *Caretta caretta* species) entangled in two years of research carried out between April and September with observers on board of 100 crafts using driftnets, indicate a minimal impact on this species, mainly because they were all released still alive by fishermen (Di Natale, 1995). This last data was also confirmed by Camiñas (1995b). Other data present a much more worrying situation. De Metrio and Megalofonou (1988), who collected data by observers on board and 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 driftnet 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 captures are generally low. Concerning the discordance between the two studies mentioned above it is necessary to consider that the two areas present a very different turtles density (see § 7.). It has to be added that very long walls of netting, which seem to capture turtles mainly in their upper third (Di Natale, 1995), could considerably increase their dangerousness if placed on the migratory routes of specimens moving from feeding zones to reproduction ones and vice versa. Seen the considerable lacks and differences of opinion it is still impossible to exactly quantify the interaction between this fishing method and marine turtles. However, the current tendency of most countries towards a prohibition of the use of swordfish driftnets, not only in the Mediterranean, could bring the problem of the impact of this gear on marine turtle populations to a solution in the near future.

5. INDIRECT MORTALITY

The animals are generally released immediately, cause they are not considered saleable or rather a hindrance to carry out the normal fishing activities (for turtles have the habit to walk around in the boat and bite everything within range when turned upside down) or else - very rarely - because they are considered a species threatened with extinction.

Unfortunately, due to ignorance and/or prejudice, some fishermen use to kill the turtles they catch, as some Greek fishermen (especially gill netters) are supposed to do on the basis of the specimens found stranded (Margaritoulis, *in litt.*). Moreover, an accidental capture - no matter which is the method by means of which it occurs - and the connected direct mortality, may signify a mortality of 100% if the fisherman keeps the animal for personal or commercial use, instead of releasing it.

Sometimes the turtles are killed and eaten on board, especially when some members of the crew regard the turtle as a delicacy, as for some foreign crews on greek (Panou *et al.*, 1992) and Italian vessels. A percentage has never been estimated referring to this case.

In some Mediterranean countries, the rooted traditions connected either with the consumption of 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 the fishermen, who accidentally fish a turtle, to bring the specimen back to the harbour so as to sell it. For instance, in Egypt thousands of turtles are estimated 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 make the value of the product increase, allowing this way unscrupulous fishermen to add this illegal profit to their income, in spite of the great risks connected with it. The impossibility to control this traffic, which mainly develops in the shade and chiefly between trusted people or friends, does not allow to quantify the extension of the phenomenon and its importance.

However, the ten-year experience made in Italy demonstrates that it is possible to restrain the phenomenon with national campaigns of awareness among the public, with direct contacts between researchers and fishermen (see § 8.6.), with national legislations for protection and with coercive measures by control bodies (see § 8.1.).

6. THE MEDITERRANEAN FISHING FLEET

According to the 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 Sicily channel and the Gulf of Gabés (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 what concerns the longline (Fig. 2), the Tyrrhenian seems to be the zone concerned by the biggest fishing effort, followed by the Ionian, the Adriatic, the Libyan and Egyptian coasts. In spite of their incompleteness, also these 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 whole number of vessels (Fig. 3). The zones with the greatest number of working vessels are: Aegean and Ionian (mainly Greek ones), Adriatic (mainly Croatian ones), Gulf of Gabés (Tunisian ones), Tyrrhenian, south western basin (Spanish and Algerian ones) and Libyan coasts. Probably, most of these vessels use gill nets, as it is suggested by the comparison between Figg. 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 most spread gear in the Tunisian fleet (Bradai, *in litt.*).

The comparison between the total of vessels and the GRT (Gross Registered Tonnage) (Figg. 3 and 5), suggests that the Adriatic and the Sicily Channel are concerned by a fishing effort by Italian fisheries bigger than the one deducible from the number of vessels only.

7. ZONES FREQUENTED BY TURTLES

The areas where an 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 winter. Probably, many turtles undertake seasonal migrations in order to be in warmer areas during winter. Adults undertake migrations 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 side 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 winter in the Gulf of Gabés (Tunisia; Laurent *et al.*, 1990; Bradai, 1992) and the presence of many specimens of large size during winter, suggest that this area represents an overwintering zone also for those specimens which frequent other areas during summer (Margaritoulis, 1988; Laurent and Lescure, 1994). The same conditions are present in the southern Peloponnese (Greece), also frequented by immatures of *Chelonia mydas* (Margaritoulis *et al.*, 1992). Furthermore, the winter temperatures in the Gulf of Gabés 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 the activity of specimens caught in waters of about 17°C and the 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 all during the year (Laurent *et al.*, 1996). The high winter temperatures in these areas (NOAA, web site) suggest an active overwintering. Many winter captures are reported in the Adriatic (Lazar and Tvrtkovic, 1995), but in these zones the low winter temperatures probably do not allow the turtles to remain in activity.

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 Gabés (Argano *et al.*, 1992; Gerosa and Casale, unpubl. data) and in the Adriatic (Argano *et al.*, 1992) some captures are signalled during summer. In the Adriatic and in the Aegean some adult females nesting in Greece were found (Margaritoulis, 1988). Furthermore, the northern Ionian (Argano *et al.*, 1992), the Gulf of Lion (Laurent, 1991; Laurent, 1996), the Corsica 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 latter one 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 agreed to international conventions directed to prevent the international trade of turtles and their products (reviewed by Salter, 1995) and adopted national laws to forbid the capture of these animals. This represents a fundamental stage in view of the conservation of these species and it is propedeutic to further initiatives: its effect is to eliminate the demand of turtles by national and international markets, which is the main cause of intentional captures and indirect mortality induced by accidental captures (§ 5.) (Tab. 3).

However, in no way this kind of intervention influences the direct mortality due to accidental captures which, by definition, are not connected with the fisherman's will to operate within the law. On the contrary, the confusion induced by expressions such as "capturing prohibited" gives the fisherman the constant impression of committing a crime while catching these animals, making it harder to carry out sensitization campaigns, which may have an important role in reducing the mortality (see § 8.6.).

8.2. Fishing Effort Limitation

The reduction of the fishing effort is considered the most effective method to preserve the overall marine community (target and non-target species), and it is the most spread one in the Mediterranean: the alternative quotas control for target species is not an optimal instrument (Caddy and Oliver, 1996; Lleonart and Recasens, 1996). It has been seen that for particularly destroying gears (beach seines, towed gears for corals, explosives...) the prohibition or the limitation of use may give good results, such as the turning in more selective and less impacting gears (Lleonart and Recasens, 1996). Furthermore, the reduction of the fishing effort on demersal stocks, in particular by the inshore trawling, represents a main priority in the Mediterranean (Caddy and Oliver, 1996). A reduction of the fishing effort may be obtained by limiting the number of crafts, their total and individual power, and the total fishing time (e.g. months in a year) (Lleonart and Recasens, 1996).

An extremely important factor to consider is the fishing zone in which the effort reductions are enforced. In fact, within the same fishing zone, the effort may range in a non omogeneus way, giving anyway a non sustainable impact in certain areas. For example in Turkey, due to the lack of reductions enforced to different fishing zones within this nation, the collapse of the fishery in the Black Sea will probably bring a shifting of the fishing effort to the Mediteranean (Caddy and Oliver, 1996). In Greece, to optimize the fishing effort reduction, it has been taken in consideration the opportunity of subdividing the fleet in different zones, unlike a licence system which allows the 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 limitations will be efficient to preserve the resources and the by-catch. In connection with it, the free access to every fishing zone within the EC for crafts of the member countries from the end of the 2002 (European Commission, 1994) worries a bit. In this compass, limitations on given areas are still the only way that can be followed.

8.3. Fishing Prohibition In Areas And Seasons

From what we underlined in the previous section, the optimal solution to reduce the fishing effort is to adopt this measure in conformity with the ecology of the species and the habitats to protect. This means geographical and temporal limitations.

For what concerns the first ones, every country protects the zones close to the shore from the trawling so as to preserve seabeds and nurseries (Lleonart and Recasens, 1996); these are usually waters less than 50 m deep. Another kind of protection is to create marine reserves, more effective when connected with a fishing effort reduction in the bordering areas (Lleonart and Recasens, 1996). These coastal limitations are difficult to be made respected; a drastic but expensive solution is to protect the beds of *Posidonia* from the illegal night trawling by placing on the sea bottom obstacles damaging the nets (Caddy and Oliver, 1996).

Season reduction measures may represent an effective method to preserve the species in the most vulnerable period of their life-cycle, even though, unfortunately, the period is often chosen for economical reasons rather than biological ones (Lleonart and Recasens, 1996).

For what concerns marine turtles, it is necessary to point out the most frequented areas and check the season changes. In fact, in certain circumstances adopting total or seasonal reduction measures may be opportune in these areas.

8.4. Gear Modifications

Alternatively or complementarily to fishing effort reduction and fishing prohibition, it may be studied the possibility of modifying the tool so as to improve the selectivity and so reduce the capture rate of sea turtles.

8.4.1. Trawl

The capture of a large amount of by-catch is a general problem connected with the trawl, and it goes far beyond marine turtles. The increase of this method selectivity by means of Bycatch Reduction Devices (BRDs) is of a great interest (Alverson *et al.*, 1994). There actually exist several types of BRDs used in shrimps fishing, such as the Norwegian Nordmore Grate and the USA TEDs. These last ones were brought out to answer to the specific need to reduce the accidental captures of marine turtles (TED: Turtle Excluder Device). It has been then noticed that they can improve the efficiency of the method, by reducing up to 50-70% the quantity of debris and other by-catch entering the net (Weber *et al.*, 1995 in Lutcavage *et al.*, 1997). The function of the TEDs is to deviate the caught turtles towards a proper exit, before they enter the terminal bag together with the catch. TEDs can be divided in hard TEDs and soft TEDs.

Hard TEDs are basically grids made of steel, aluminium or fiberglass; they are placed at the entrance of the terminal bag, and the working angle is a crucial parameter for their efficiency (Mitchell *et al.*, 1995). The several kinds of hard TED mainly differ in the shape of the grid (see Mitchell *et al.*, 1995). The exit hole, whose dimensions must fit the TED, can be placed either on top or bottom of the net. According to fishing conditions, one position can be more favourable than the other one. Furthermore, some other changes to the net are necessary to assure both the escape of turtles and the fishing efficiency: addition and correct placing of given kinds of floats, webbing flaps, accelerator funnels and in certain condition also chafing webbing or roller gears (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, referring both to turtles and catch, may considerably vary if the installing does not fit the kind of net and the fishing conditions (see Mitchell *et al.*, 1995).

The TED has been developed in the USA as a solution to the high sea turtle mortality

induced by shrimps 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 turltes capture, the TED seemed to increase shrimps fishing efficiency too, so that it has been suggested to change its name in Trawler Efficiency Device (Mrosovsky, 1982). While, at the beginning, it was promoted the voluntary use of the TED by fishermen (Oravetz, 1984), from the end of the '80s, legislations more and more rigid have been necessary to make the TED be adopted (e.g. see Oravetz, 1988; Donnelly and Weber, 1988; McDonald, 1990). This happened for the strong opposition of fishermen, complaining about a supposed loss of shrimps and the lower efficiency of the boat due to the TED presence (McDonald, 1990). No doubt that the TED installing means a bigger managing effort for fishermen and the modification of a tool of such a traditional and consolidated use.

Recently Mexico too, under pressure by the USA, made the use of the TED obligatory in the Gulf of Mexico and Caribbean (Olguin *et al.*, 1996) and many countries of the Americas will probably adopt the TED in the next future (Somma, 1996; Frazier, 1997). The interest for the TED is furthermore spread in other countries in the world (Oravetz, 1984; Rao, 1984; Wamukoya, 1996).

Even though there are some indications that the use of the TED has decreased the strandings (up to 90%; Maley, 1995; 44%; Crowder *et al.*, 1995), in other cases the strandings caused by an interaction with the trawl do not seem to have been stopped (Shoop, 1991) or varied (Caillouet *et al.*, 1996; Armstrong and Ruckdeschel, 1996) since the TED has been used. Incorrect installing, trial nets without TED and breach of the law are probable reasons for this phenomenon (Caillouet *et al.*, 1996).

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

For it is selective about the dimensions, the TED is unfortunately difficult to apply when the target species are fish - of bigger dimensions - instead of shrimps. So, even though a specific TED was brought out for summer flounder fishing (*Paralichthys dentatus*) (Mitchell *et al.*, 1995), nowadays functional application of TED is mostly directed to shrimp trawlers. This limitation makes it hard any application of the TED in zones, such as the Mediterranean, where most of trawling activities do not have shrimps as target species (Laurent *et al.*, 1996). In fact, within the Mediterranean countries, only Tunisia and in a lesser way Algeria and Spain show shrimp landings (FAO, 1997).

For it is a compromise between fishing activity and conservation, the possible use and adaptation to different requirements of TED (and of BRDs in general) could allow the sustainable exploitation of marine resources in the future. At least for what concerns marine turtles, the only possible alternative is the prohibition to fish in certain areas and seasons (see § 8.3.).

8.4.2. Longline

Since this gear is rather simple, it is quite difficult to set changes which exclude sea turtles but not target species. Even though at present it seems a problem not easy to overcome, resources should be addressed to study the sea turtle behaviour before and after it nibbles

t the hook, and the dynamic interaction the hook has with turtle's anatomy and physiology. In fact, up to now very few works have dealt with such a topic. One approach, not enough tested yet, bases on the addition of components to the hook (White, 1994). Seen the importance of the interaction of this fishing gear with marine turtles (see §§ 2.1.6, 2.2.) it is hoped that such studies will soon proceed in the above one or 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 applied, limiting the duration of the trawl might considerably reduce the mortality rate. Limitations of this kind too, were 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 gears ("ghost gears", especially nets) proceed in carrying on an unuseful catch as debris (Lutcavage *et al.*, 1997), the correct management of gears should be enhanced, in order to reduce this factor of mortality, as recomended by the "code of conduct for responsible fisheries" (FAO, 1995).

8.6. Awareness for Fishermen

As it comes out from the previous chapters, the role of professional fishermen is surely of fundamental importance inside a conservation programme of marine turtles. The work of this category, often misanderstood by public opinion - which tends to blame fishermen for the problems of the sea - provides a direct and constant contact both with the sea and its inhabitants. The sensitiveness shown by this category in several occasions (Cocco *et al.*, 1988; Argano *et al.*, 1990) and the precious information put at researchers disposal (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) oblige every programme concerning the interaction between turtles and fishing methods to take the collaboration with this category in serious consideration.

The opportunities connected with a direct involving of fishermen can be thus summarised:

- **Supplying the research with data.**
  Thanks to interviews, it is possible to collect data related to both capture and mortality rate connected with any fishing method. On that subject, it has to be said that terms like "low" or "rare" are abused in literature for they do not always correspond to the word that would have been used by researchers in the same case. For example, a mortality rate of 10% could be considered "low" by fishermen, while it may show a worrying percentage to someone involved in conservation of marine turtles. It is always better to prepare these campaigns (based on inteviews with fishermen) inserting questions providing quantifiable answers instead of adjectives. Data can be easily collected directly on board by fishermen prepared by adequate training courses.

- **Accepting observers on board.**
  The best results referring to the collection of data about the interaction between fishing methods and turtles have been obtained by taking specialized observers on motor-trawlers (Aguilar *et al.*, 1995; De Metrio *et al.*, 1983; Panou *et al.*, 1992). In this case, data reliability can be only penalized by the unnatural behaviour of fishermen because they feel like being under observation.

- **Operating on specimens rehabilitation (direct mortality decrease).**
  An adequate preparation of fishermen about operating methods on turtles taken on board, may considerably reduce direct mortality. It is the case of turtles caught in a comatose state in consequence of trawling activities (see § 3.2.). On the other side, for what concerns the longline, both the direct extraction of the hook from the animal mouth (when the hook is visible) and the cutting of the branch as close as possible to the hook, can save many specimens in case of immediate release. Moreover, if the specimen is seriously injured, fishermen could be involved in bringing the turtle ashore so it can be cured in specialized recovering centres (as it already happens in Italy since more than ten years).

- **Discouraging illegal trade (indirect mortality decrease).**
  One of the most important merits that sensitization campaigns may gain (in synergy with watchful and up-to-date legislations on conservation of these species (§ 8.1.)), concerns the possibility of reducing the number of turtles available for illegal trade;

- **Advice on gear maintenance.**
  A series of training courses on the correct use and maintenance of the fishing-tool might save many specimens from both accidental capture and the "ghost gears" induced one (see § 8.5.).

	Interaction	Capture	Direct Mortality	Indirect Mortality
Legislation protecting the species				X
Effort limitation	X			
Fishing prohibition in areas and seasons	X			
Gear modifications		X		
Gear use		X	X	
Awarness for fishermen			X	X

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

9. REDUCING THE MEDITERRANEAN FISHERY-SEA TURTLE INTERACTIONS: AVAILABLE OPTIONS

We are still far from having 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 on sea turtle population dynamics, seasonal migrations within the Mediterranean, areas frequented by different ecological phases, interpopulation exchanges between the Mediterranean and the Atlantic, and the recruitment of the Mediterranean population. The second is a still little amount of data which allow to assess the capture efficiency of different fishing gear and their induced mortality in association with several parameters (of turtles, of the gear and of the environment in which it works).

However, even at this stage it is possible to suggest some priorities in the short time, which are propedeutic to any strategy coming out from results of future researches on this topic.

9.1. Reduction of Indirect Mortality

Naturally, any improvement in the regulations of fishing activities or modifications of the gear are of a little effect if fishermen take economic advantage in catching a turtle. Therefore, the first step is to reduce the demand of these animals by local markets. This goal can be achieved only by the implementation and integration of laws already in force or by the proposal of new laws (see § 8.1.), together with an effective awareness on 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 less than 50 m

As reported above (§§ 1., 3.1.1.), the greatest density of specimens in demersal phase is in shallow waters. Most countries have already got laws which protect areas within 3 nautical miles to the coast or where the sea bottom is less than 50 m deep. In fact, these areas hold a very important and delicate ecosystem: the beds of marine phanerogams (e.g. *Posidonia oceanica*) are an important habitat for organic matter production and are also spawning and nursery zones for many species. The main threat to these habitats is the use of fishing gears working on the bottom (trawls and beach seines). In those countries with laws in force, the observance of them would assure the survival of these habitats, so important for the fishing industry too, and would notably reduce incidental captures 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 hold the highest marine turtle population densities. In most cases, a reduction of fishing effort on wide areas would be a big problem for the local economy and to work out conservation actions would require accurate evaluations of the single situation. However, some areas of little extension are already known which are presumed to hold a high sea turtle density, at least in certain seasons: the nesting sites. These are frequented, mainly in summer, by both adults and hachlings. Thus, in these areas it might be very effective to reduce fishing activities in summer and within a cautelative distance to the coast.

10. EVALUATING THE MEDITERRANEAN FISHERY-SEA TURTLE INTERACTIONS: SOME PRIORITIES

As clearly comes out from the previous sections, available data on Mediterranean fisheries - see turtle interactions are still either scarce and uneven. Research is therefore needed to fill in the existing gaps. Seen the limited resources available for this kined of research projects, it is useful to identify some priorities on the basis of the available information.

Research prioritiy should be allotted to those situations where fishing activities interact with the largest size classes of turtles and/or in areas with a high turtle population density, and where the fishing effort is bigger (that is where fishing activities are supposed to have the greatest impact to sea turtle populations). Furthermore, situations where most of fishing activities are carried out by few countries should be preferred for they give less difficulties in solving rapidly the problem through national regulations.

The continental shelf of the Gulf of Gabés is presumed to be an area frequented by many adult turtles, at least during winter (see § 7.2.). It is possible that in summer all or part of those adults leave this zone, which would become a feeding ground for immatures in this period (see § 7.3.). Even though a low mortality rate was found (Tab. 2), it is necessary to confirm this datum through a larger sample, which allows to evaluate other parameters, such as specimen size, season (see § 3.3.), and distribution of Tunisian and Italian fishing effort.

Another area of great interest is the Adriatic Sea, seen the high number of captures by the fisheries of Croatia, Slovenia and Yugoslavia, especially by trawl during winter, and the possible presence of specimens of large size (Lazar and Tvrtkovic, 1995) (see § 7.2.). Hence, it is urgent to assess the fishing impact in all the seasons and whether this area is frequented by adults or not. In consideration of the big fishing effort of the Italian fisheries in this area (bigger than that from the east Adriatic side; see § 6.), a great interaction with marine turtles can be suspected; thus, it seems to be very important to assess the impact of the Adriatic Italian fisheries.

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

For its characteristics, the Aegean Sea could hold feeding as well as overwintering grounds (see § 7.2., 7.3.), as suggested for Lakonikos Bay (south Peloponnesus; Margaritoulis *et al.*, 1992). Moreover, the coasts around this sea hold several nesting sites (see § 7.1.) and an impact of fishing activities on adults may occur. Hence, a survey should be carried out on the important Greek and Turkish fisheries (see § 6.).

The northern Ionian Sea may represent a feeding area for immatures (see § 7.3.) and the Greek coasts hold important nesting sites. For these reasons fisheries of both the Greek and the Italian side should be studied.

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

The western basin (Alboran Sea, Balearic Islands area, Gulf of Lion, Corsica) seems to hold

summer feeding zones for immatures, most in the pelagic phase (see § 7.3.), except in winter when a low 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 on the seasonal movements of turtles and the zones frequented by them. Moreover, difference in the use/structure of the same gear could give perspectives of improvement of gear's selectivity.

- **mortality rate**. Comparative data (seasons, zones) could give information on the parameters influencing direct mortality.

The above knowledges will together allow to understand where, when and how the limited conservation efforts should be addressed.

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

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

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

A strong co-operation between research and conservation programmes of governmental and non-governmental organizations is necessary, in order to achieve the intermediate goal of improving our knowledge on the sea turtle-fishery interactions in the Mediterranean, and the final goal of reducing the sea turtle mortality due to these interactions. This will be possible only through enhancing communication and data exchange; frequent meetings on this topics should be scheduled.

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LEGENDS TO FIGURES

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, Sicily 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, Sicily 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 Peche, Direction des Peches maritimes et des Cultures marines. Egypt: [1992] FAO, 1992b. Greece: [1992] FAO, 1994. Israel: [1991] FAO, 1994. Italy Adriatic, Ionian, Sicily 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, Sicily 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 Peche, Direction des Peches maritimes et des Cultures marines. Greece: [1992] FAO, 1994. Italy Adriatic, Ionian, Sicily Channel, Tyrrhenian: [1993] ISTAT, 1996. Lebanon, Slovenia: [1992] FAO, 1994. Syria: [1986] FAO, 1994.
?: unknown

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

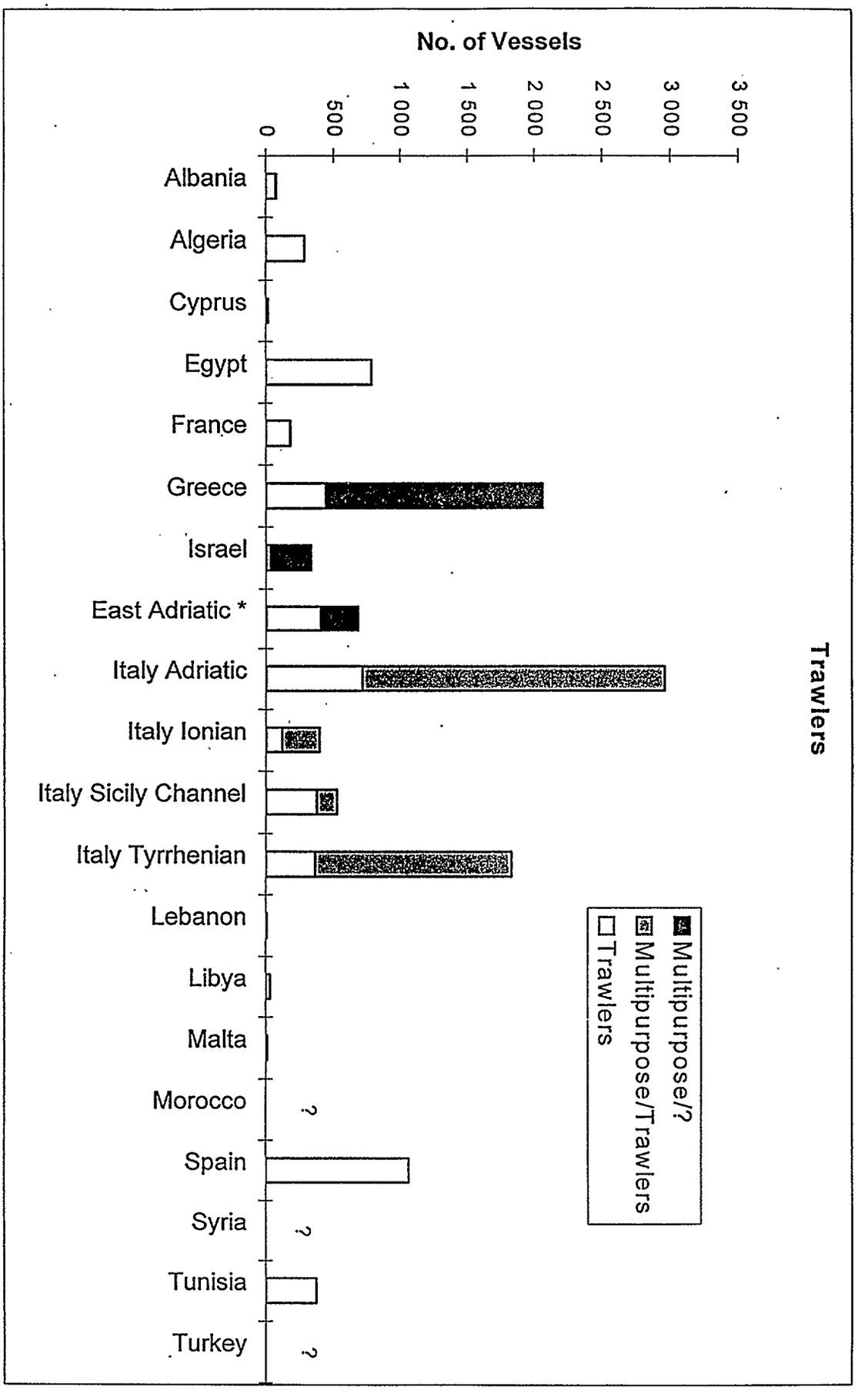

No. of Vessels
0
500
1 000
1 500
2 000
2 500
3 000
3 500
Albania
Algeria
Cyprus
Egypt
France
Greece
Israel
East Adriatic *
Italy Adriatic
Italy Ionian
Italy Sicily Channel
Italy Tyrrhenian
Lebanon
Libya
Malta
Morocco
Spain
Syria
Tunisia
Turkey
?
?
?
Multipurpose/?
Multipurpose/Trawlers
Trawlers
Trawlers

Fig. 1

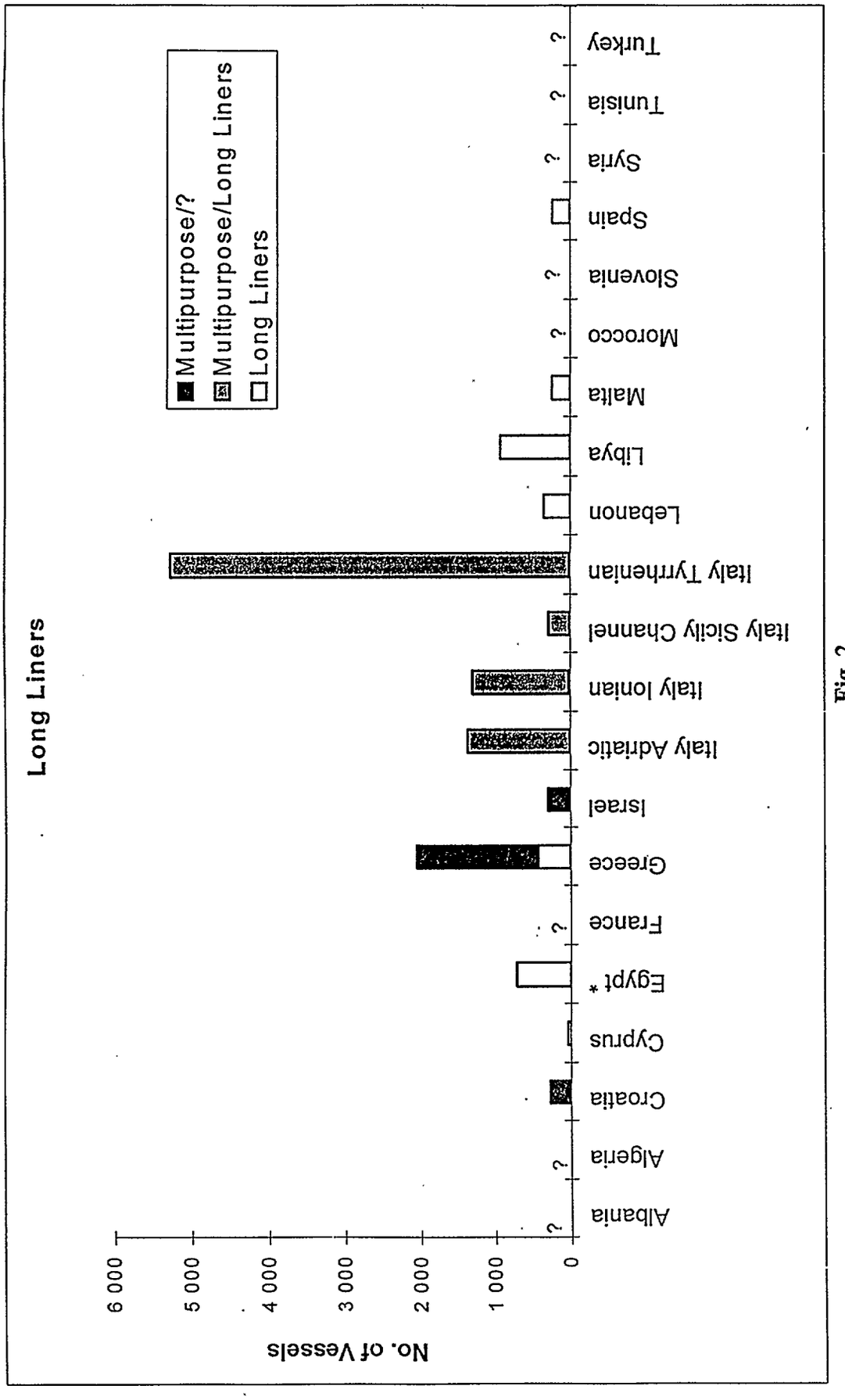

Long Liners
No. of Vessels
6 000
5 000
4 000
3 000
2 000
1 000
0
Albania
Algeria
Croatia
Cyprus
Egypt *
France
Greece
Israel
Italy Adriatic
Italy Ionian
Italy Sicily Channel
Italy Tyrrhenian
Lebanon
Libya
Malta
Morocco
Slovenia
Spain
Syria
Tunisia
Turkey
Multipurpose/?
Multipurpose/Long Liners
Long Liners

Fig. 2

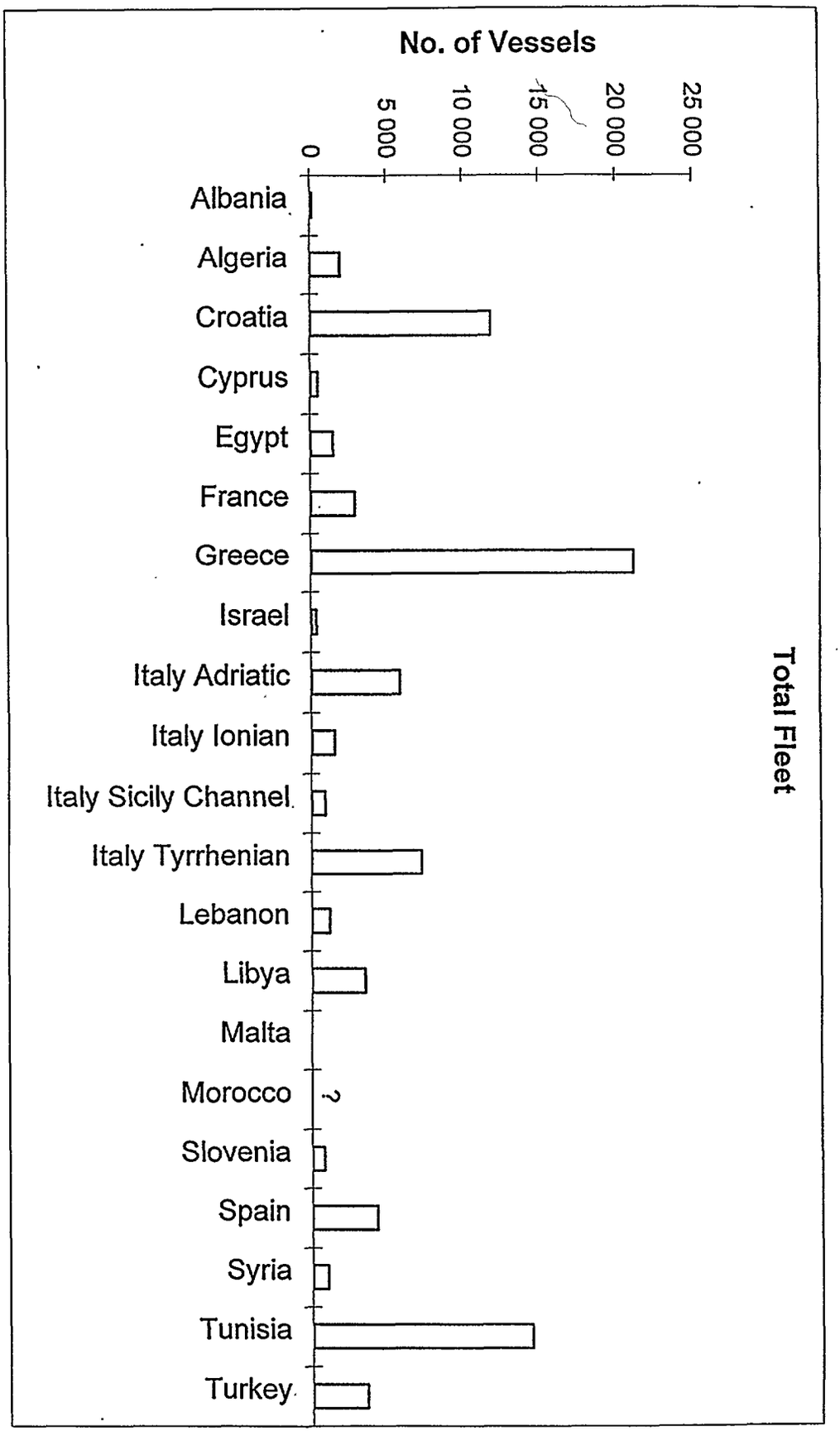

No. of Vessels
0
5 000
10 000
15 000
20 000
25 000
Albania
Algeria
Croatia
Cyprus
Egypt
France
Greece
Israel
Italy Adriatic
Italy Ionian
Italy Sicily Channel
Italy Tyrrhenian
Lebanon
Libya
Malta
Morocco
?
Slovenia
Spain
Syria
Tunisia
Turkey
Total Fleet

Fig. 3

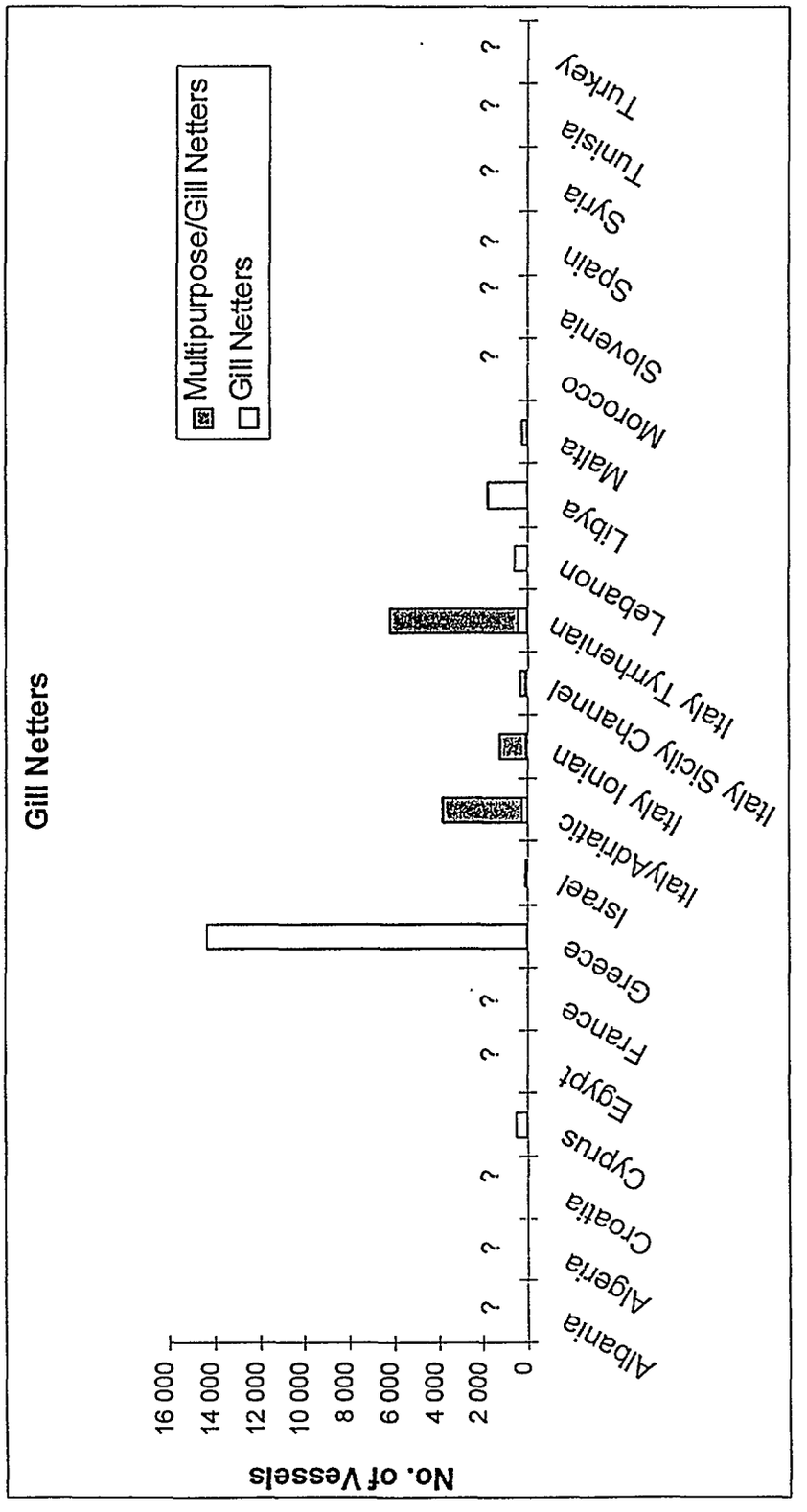

Gill Netters
Multipurpose/Gill Netters
Gill Netters
No. of Vessels
16 000
14 000
12 000
10 000
8 000
6 000
4 000
2 000
0
Albania
Algeria
Croatia
Cyprus
Egypt
France
Greece
Israel
Italy/Adriatic
Italy Ionian
Italy Sicily Channel
Italy Tyrrhenian
Lebanon
Libya
Malta
Morocco
Slovenia
Spain
Syria
Tunisia
Turkey

Fig. 4

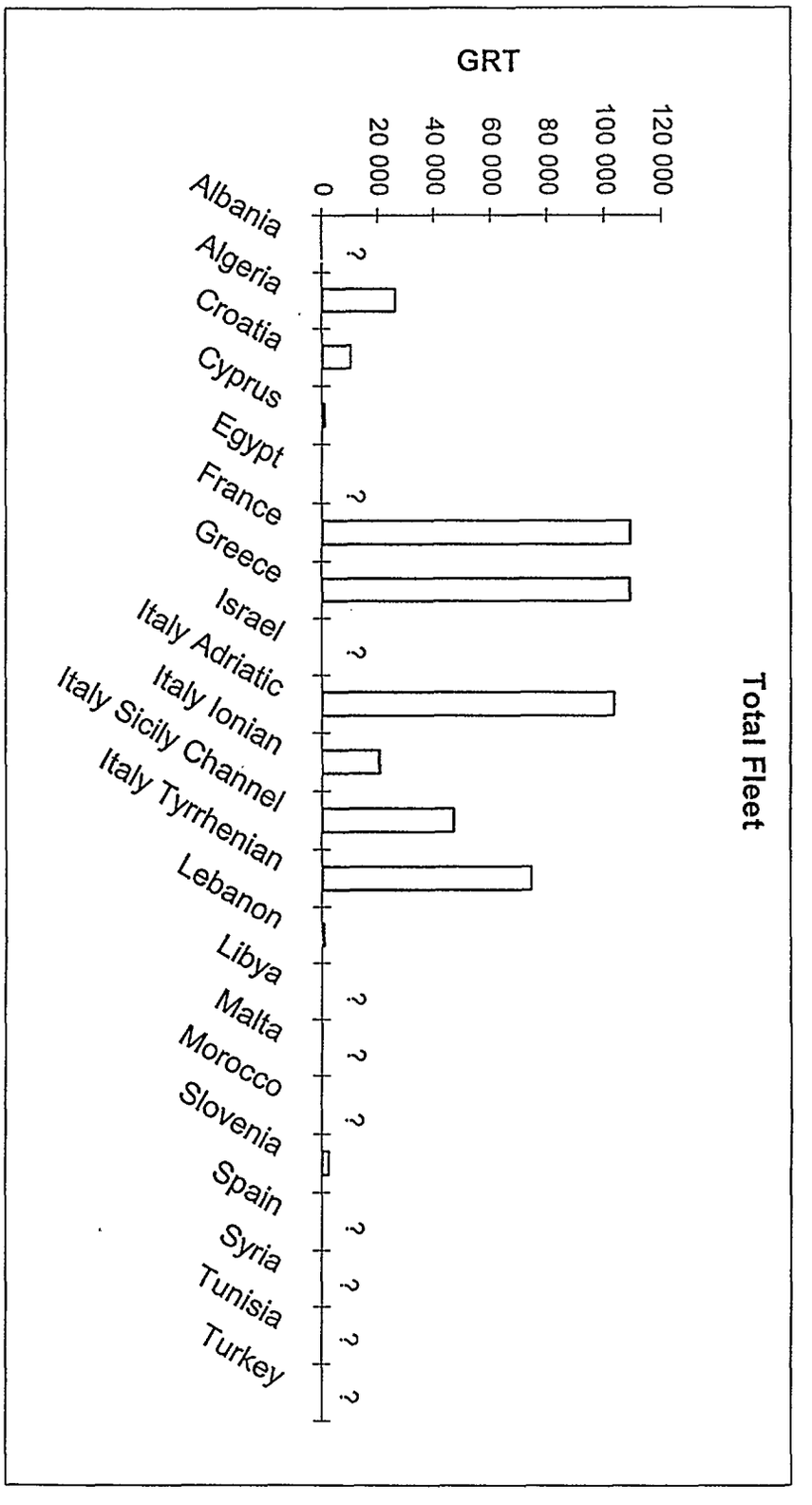
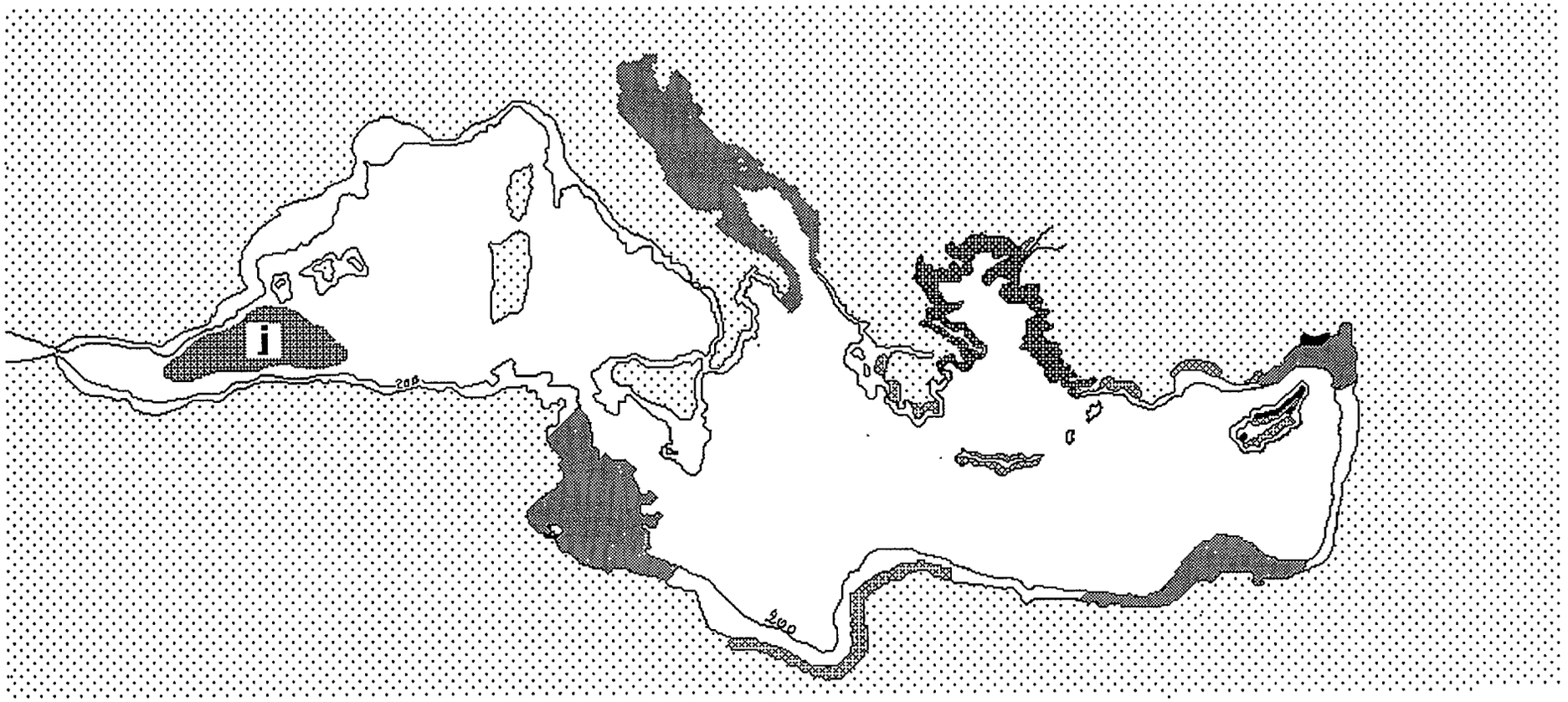

GRT
0
20 000
40 000
60 000
80 000
100 000
120 000
Albania
Algeria
Croatia
Cyprus
Egypt
France
Greece
Israel
Italy Adriatic
Italy Ionian
Italy Sicily Channel
Italy Tyrrhenian
Lebanon
Libya
Malta
Morocco
Slovenia
Spain
Syria
Tunisia
Turkey
Total Fleet

Fig. 5



Main feeding and overwintering areas

Main nesting sites of *Chelonia mydas*

J Mainly frequented by Pelagic juvenils

Main nesting sites of *Caretta caretta*

Main feeding areas

Fig.6