Project for the preparation of a Strategic Action Plan for the conservation of biological Diversity in the Mediterranean Region
(SAP BIO)

Effects of fishing practices on the Mediterranean sea :

Impact on marine sensitive habitats and species, technical solution and recommendations

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Project for the Preparation of a Strategic Action Plan for the Conservation of Biological Diversity in the Mediterranean Region (SAP BIO)

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Impact on marine sensitive habitats and species, technical solution and recommendations

RAC/SPA - Regional Activity Centre for Specially Protected Areas
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Foreword

This document is intended as a contribution to the action plans undertaken to limit the impact of fishing activities on biological diversity in the Mediterranean under the Strategic Action Plan for Biodiversity (SAP Biodiversity), which is expected to provide a logical basis for implementing the 1995 Specially Protected Areas Protocol (Barcelona Convention).

The work has been structured around a set of self-contained sections dealing with the main threats to marine biodiversity (including both vulnerable species and habitats) arising from fishing gear or practices in use in Mediterranean waters. The issues have been dealt with in two sections, one on fishing impacts on vulnerable species and habitats, and the other on specific aspects related to selected fishing gear and practices of special interest in the Mediterranean. General single-species issues related to the overfishing of commercial species have been deliberately omitted from the analysis, since they are the object of extensive studies elsewhere and a great deal of attention is paid to them in other forums.

The authors have prepared an apparently classic analysis, useful for practical purposes, but tried to avoid the pitfall of a purely reductionistic dissecting of reality, aware of transversal or even higher-level issues connecting many of the individual questions analysed. An attempt has been made to give due weight to these interrelations as well as the overall effects of fishing on the structure or functioning of the ecosystems (resulting from both past and present practices) throughout the different sections of this document. The document's chief merit is that it collates reliable information from different sources on the different effects on the ecosystem of fishing in the Mediterranean, and provides a coherent picture of the overall impact of fishing on regional biodiversity. Most of this integrative vision is specifically addressed in the Conclusion.

This work focuses on the Mediterranean, discarding unnecessary or redundant information from other areas of the world, even if this has been better studied. Where information related to some of the major issues is scarce, special attention has been devoted to the few studies available, given their qualitative importance. The aim has been, thus, to produce a specifically Mediterranean document.

The document includes - precise descriptions of fishing practices susceptible to have a negative effect on the bio-diversity and/or on the environment, - assessment, as far as possible, of the impact; - proposals for specific technical solutions for problems encountered in Mediterranean Sea and recommendations for their implementation. It also considers professional opinion concerning the impact of fisheries and the needs in term of information/awareness, training and extension.

If the literature on fishing effects has become abundant since about ten years, the information on the fishing techniques which are concerned by this problem is scarce or partial. Often scientists forget to give a good description of the gear and the fishing practices and comparisons are often made between techniques of quite different characteristics as it is impossible to correctly quantify the effects.

However more and more studies, mainly funded by EU, are carried out but they are not already published. There is, in particular, not much published material concerning the fisheries of the south and east part of Mediterranean Sea.

Recommendations would have to be made to countries for them providing exhaustive description of the different fishing technique used in their fisheries and simple typology of the fishing activity. On this last point, times series on evolution of fishing capacity would be useful.

Furthermore, it would be of great interest that an international survey using same statistical methods is carried out on the whole Mediterranean Sea, including for assessment of the discards.

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1. INTRODUCTION

The protocol concerning Special Protected Areas and Biological Diversity in the Mediterranean Sea, which was adopted within the Barcelona Convention in 1995, encourages the Parties to undertake the necessary measures for environment conservation and a sustainable use of biological diversity. While fishing is not the only human factor that acts on marine ecosystem, in the aim of the preparation of a Strategic Action Plan for Biological Diversity (SAP Bio), it is essential to document as far as possible the impact of fisheries on the environment.

This working document is a contribution to the knowledge on the role played by fishing technology and a study on the possibilities to correct the potentially most negative effects.

After a review of the main elements mentioned in the literature regarding impacts of fisheries, the document tries to identify for the main fisheries, the technical characteristics of gears and the fishing practices which may cause damage to the ecosystems; mitigating measures which may be applied to the context of the Mediterranean fisheries are proposed. The last part is dedicated to a general discussion on management of the Mediterranean small-scale fisheries in relation with their impact on environment.

2.GENERAL SITUATION IN MEDITERRANEAN SEA

2.1.Main features of the Mediterranean fisheries

The Mediterranean Sea is characterised by a high level of bio-diversity that is concentrated mainly between 0 and 50 meters depth, and only 9 % of the total amount of species live below 1000 meters depth. The continental shelf which is the area where most of the fisheries are carried out is about 750 000 km^2 in surface up to 200 m depth and its average width is hardly 9 nautical miles.

The information on catches is provided by the fishery Authorities and/or statistic administration of the different countries, mainly by the registration of the landings, from fish auctions or from other trading sources. However, because much fish is sold directly for local consumption and insufficient statistic network, the landings are largely underestimated for most fisheries; in addition, not all the catches are landed, a so called by-catch is discarded at sea. Consequently, the total catches (what is taken from natural resources) are definitively substantially more than statistics on landings show.

Nevertheless, if assuming that official statistics are recording most of the commercial transactions regarding fish products from fisheries in the various countries, the annual overall landings for the Mediterranean Sea (Black Sea excluded) would be estimated to around 1,1 millions of MT.

After a steady increase before the eighties, the catch in the Mediterranean Sea seems to be levelling now; 59.5 % of this catch is produced by EU countries (Spain, France and Italy) and more than 70 % from countries of the Western and Central Basins of the Mediterranean Sea. With more than 100 species, demersal fishes represent 40 to 45% of the whole catch; pelagic fishes is also about 45% of the total but with much lower number of species (European pilchard, anchovy, bluefin tuna, albacore, swordfish,).

The information regarding fishing fleets is even worse. Many small boats, in many small-scale fisheries, those without engine in particular, are not registered. The information on the capacity (tonnage, power) is often missing or even wrong regarding bigger vessels. Nevertheless, according to the some figures of these 10 last years, 84 000 to 100 000 fishing units would be in operation, consisting in about 85 % small inshore boats 14 % trawlers and purse seiners and 1% advocated to various activities (Breuil 1997). Around 63 % of the fishing vessels are owned by countries of the Western and Central Basins and 53 % by EU countries (Spain, France and Italy). Except for some offshore fisheries targeting large pelagic fishes or deep crustaceans, most of the Mediterranean fleets are coastal fishing and consequently 70% of the total catch would be taken by vessels no more than 15 tonnes GRT (Caddy 1996).

Although there is no recent available time series on the sizes of the fishing fleet, data from various studies show a general trend to increase in the number of vessels (and therefore in fishing capacity) in most of the countries, at least until the beginning of the nineties (Caddy 1996). The apparent stabilization of the total number of vessels for the last ten years would take into account a significant reduction of the EU fishing fleet (12 %); however, it can be assumed that the effective fishing capacity has strongly increased thanks to improvements in fishing technology.

This is true in particular for fisheries targeting species for which the demand is high on international markets (tuna, hake, red mullet, clams,) where the vessel equipment (e.g.

prospecting, processing, fishing materials and facilities) has often been modernised thanks to subsidies.

As a matter of fact, a general increase in fishing effort on the high value species has been observed. If for a majority of these species the landings have sustained constant increases so far, (for instance, landings of hake, swordfish, deep-water shrimp, tuna), a few other has already shown strong declines as most of elasmobranchs, red coral, sponges and crawfish (Fiorentini et al. 1997).

The Scientific Advisory Committee of the GFCM noted in its session of March 1999 (GFCM 1999) that the overall level of fishery production of the Mediterranean had increased by about 50 % from 1977 to the present. This characteristic of the Mediterranean production might be not due to an increased effort alone but might partly respond to an increasing nutrient contribution, especially in northern Mediterranean under the influence of the rivers. (Caddy 1997; 2000).

The most targeted species already present obvious signs of too intensive exploitation. The evolution of available cpue (capture per unit of effort) measurements and biological indicators such as a reduction of individual fish sizes leads to think that most of the commercial fish stocks would have to be considered as fully exploited or overexploited (GFCM 2000).

The other matters of concern for the exploitation of commercial species are the amount of catch of juveniles and discarding. The durability of some fisheries are essentially based on targeted catches of juveniles of some species (GFCM 1999). The increase in commercial fishery production over the last 50 years has been accompanied by an increase of incidental catches and discarding of a number of species. The equivalent of, approximately, one quarter of the marine commercial catch destined for human consumption would be discarded at sea. (Pascoe 1997).

There are at least four main reasons for discarding :

1. The first one is the catch of non commercial species due to insufficient selectivity of the fishing operations; there is most of the time some by-catch and the amount of discarding depends on market opportunities for such by-products.

2. (E.g. shrimps fisheries) : The lack of sufficient storage volume or chilling facilities explains the discard of low-value by-catches when they are caught in too large quantities by small boats or larger vessels specialised in a mono-specific fishery.

3. A deterioration of the quality of a part of the catch, target or by-catch species, during the fishing operations can be a third cause of discarding; the amount of this kind of discarding depends on the type of fishing gear in use, the skill of the crew and weather conditions.

4. Last, the existing legislation may also be in certain cases an important factor which explains discarding: Minimum landing sizes regulations which aim to reduce the capture of juvenile fish, practically lead to increase the discards of undersized fishes, except when, as it is common in countries on the Mediterranean Sea, there are markets for the juveniles fishes.

Discarding, in general, is blamed to alter the estimation of the relative abundance of species. The amount of discards remains largely unknown. Fishing mortality is consequently underestimated and risks of overfishing for stocks increase. The effect of discarding greatly depends on the frequency of the discards, the spatial distribution of these and finally the ability of the ecosystem to assimilate them. About half of the fishes being discarded floats and are scavenged mainly by birds during the day as well as by dolphins and sharks during the night. The other half sinks and is preyed upon in mid-water by sharks and, on the bottom, by teleostei, sharks, crustaceans and all kind of benthic scavengers; discards are probably responsible for attracting scavengers within the areas. Normally, discarded dead fishes or invertebrates are quickly eaten/recycled, however, if the discard in a limited area is very high, it may overwhelm scavengers population capacity and the recycling of the remains may result in environmental diseases (Papaconstantinou and Labropoulou 2000).

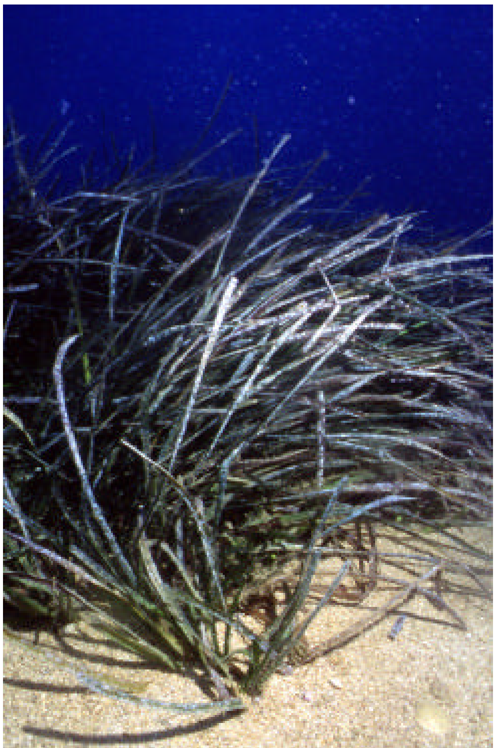
2.2.Overview of the impact on the ecosystem

The impact of fishing on vulnerable fish groups and habitats concerns both demersal and pelagic fisheries.

2.2.1. The impact on the seabeds

2.2.1.1. Seagrass beds

Certain benthic plants play an important role in stabilizing sediments. The loss of such plants can lead to sediment erosion by waves and currents that make it difficult for them to re-establish. Seagrass meadows are, to many aspects, exceptional seabed bottoms. The species the situation of which raises more concern is the endemic angiosperm species Posidonia oceanica which is the most common one in the Mediterranean Sea. This species inhabits large areas of coastal seabed down to depths of 40 m in optimal conditions and covers a total surface of about 20,000 square nautical miles, that is 2% of the surface area of the littoral sea (Ardizzone et al. 2000; Bethoux and Copin-Montegut 1986). Seagrass beds are spatially complex and biologically productive ecosystems that provide habitats and food resources for a diversified fish fauna and act as an important nursery area for many species (Harmelin-Vivien 1982). Red mullets (Mullus spp.) are among the commercial species recruited in seagrasses, and are most abundant in summer and autumn, depending on the species (Jiménez et al. 1997). Furthermore these meadows contribute to the protection of the shore against the erosion of current by trapping the sediment within the leaves of the grass. The most extensive meadows are off Libya, Tunisia, Sicily, Sardinia, Corsica and in the Hyères bay (France).



Posidonia oceanica meadows, a biologically productive ecosystem that provide habitats and food resources for a diversified fauna. International concern about the conservation of seagrass beds led to a ban on bottom trawling. A.Bouajina © RAC/SPA

Over the last few years it was observed that Posidonia was in regression. Meadows regress significantly for two main reasons, anthropic changes in sediment structure and composition, and the direct mechanical impact of fishing (Ardizzone et al. 2000). and of boats anchoring (the mooring chain and the anchor itself). The later is becoming a major cause of degradation in regions where nautical tourism is increasing as in open anchoring sites of NW Mediterranean Sea.Bottom trawling has the most dramatic consequences on Posidonia, though other fishing practices such as dynamite fishing may also be destructive at a more local level.

International concern about the conservation of this particular habitat led to the banning of trawling on seagrasses in EC waters (Regulation No 1626/94), and the listing and designation of Posidonia beds in Annex 1 of the EC Habitats Directive as special conservation areas.

Trawling impacts on seagrass beds by both suspending sediments and directly damaging vegetal mass. Sediment suspension affects macrophyte photosynthesis by decreasing light intensity. This is believed to have contributed to the disappearance of sea-grass meadows, and to affect fish recruitment and the quality of juvenile feeding areas in the Mediterranean Spanish coast (Sánchez-Jerez and Ramos-Espla 1996).

The quantification of the short-term impact of otter-trawling on Posidonia beds has been extensively studied only in Murcia (south-eastern Spain), home to an important trawling fleet (Martín et al. 1997; Jiménez et al. 1997; Ramos Espla et al. 1997). Trawling is the main agent causing the degradation of deep seagrasses off this part of Spain, where up to 40% of the total Posidonia surface is highly damaged (Sánchez Lizaso et al. 1990).

There, comparison of the structure of a Posidonia bed in a non-trawled area to that of a heavily fished one shows profound changes in the latter, where the surface area occupied by dead shoots was much higher than in the undisturbed seagrass 85.2% and 5.9% respectively. Experimental trawling hauls show that a medium-size typical trawler would root out an estimated 99,200 and 363,300 Posidonia shoots per hour in the disturbed and undisturbed areas respectively. The mechanical impact of the gear was higher in the most degraded area, otter doors causing a continuous furrow on the bed because of the loss of complexity and consistency of the bottom. The relative effect of the gear thus in turn depends on the state of conservation of the grass. Whereas otter doors were responsible for rooting out 93% of Posidonia shoots in the healthiest seagrass, their contribution was limited to only 51% in the damaged area because the meadow there was also vulnerable to other parts of the gear. Differences in fish assemblages inhabiting healthy and disturbed Posidonia beds have been recorded and point to major changes in the structure of demersal communities caused by otter-trawling. Whilst ichthyofauna typical of deeper detritic bottoms (Pagellus erythrinus, Triglidae...) or of sandy or muddy-sandy bottoms (Lithognathus mormyrus, Blenius ocellatus...) are found in the degraded seagrass, they seldom occur in a well-preserved Posidonia bed. The contrary applies to some typical species inhabiting seagrasses (Labrus merula, Symphodus rostratus...) or hard bottoms (Muraena helena, Chromis chromis). The effects of trawling on the megabenthos in Posidonia beds are also very evident. These include the reduction or elimination of species typical of hard bottoms and their replacement by ubiquitous species and others typical of sandy/muddy bottoms, as a result of the sediments being enriched with finer particles. Other effects were the increased numbers of active filter feeders and sedimentivorous species, such as solitary ascidians (Microcosmus spp.) and holothurians, perhaps because of the raised concentration of organic matter in the water and sediment. The higher catch of macrobenthos in disturbed seagrasses could also reflect an increase in the vulnerability of benthos to trawling in the latter habitats.

The negative effects of trawling on seagrasses have been confirmed by studies done in other parts of the Mediterranean. Ardizzone et al. (2000) concluded that degradation of Posidonia beds in the Middle Tyrrhenian Sea, on the Italian coast, was caused by both increased water turbidity due to anthropic causes and bottom trawling, the latter affecting non-rocky, trawlable bottoms. Seagrass beds in southern Tunisian waters are trawled for penaeid shrimps, whose early life stages are associated with this habitat (Caddy 2000).

Dynamite fishing still occurs in some Mediterranean waters and is not good news for seagrass beds. Although strictly prohibited in Algeria, it is practised close to the shore at shallow depths (0-10 m) (A. Nouar, pers. comm.). Poacher fishermen target salema (Sarpa salpa) shoals and cause extensive damage to rocky bottoms and coastal seagrass beds.

The negative physical impact of the above reported fishing practices aside, the fishing of seagrass communities significantly affects trophic webs and, therefore, ecosystem structure and function. A comparison of fished and protected Posidonia beds in France and Italy pointed to a decrease in top predators, mainly Scorpaenidae and Serranidae feeding on fish and large crustaceans, and to a parallel increase in mesocarnivores (Labridae), probably because of the lower predation pressure of the former, more susceptible to fishing (Harmelin-Vivien 2000). The decrease in the mean weight, density and biomass of fish in the exploited seagrass, as well as the higher indices of animal diversity found in the reserves have been reported in several studies (Buia et al. 1999; Harmelin-Vivien 2000; Francour 1999).

CONCLUSION

Many of the studies referred to above found a direct relationship between the health of the seagrass ecosystem and the level of effective protection. Most of them also point to its important ecological function and its vulnerability to physical damage and the fishing mortality associated with human exploitation. Seagrasses must therefore be protected from bottom trawling and other destructive practices, and fishing pressure reduced as much as possible; current regulations banning trawling on Posidonia beds in most Mediterranean coastal areas need to be enforced and greater areas of seagrasses included in marine protected areas totally closed to fishing. Campaigns to build awareness together with effective monitoring and surveillance are other useful tools. Additional technical measures such as the deployment of artificial reefs (if justified) could offer further protection.

2.2.1.2. The physical impact of fishing on other seabeds

Seagrasses are exceptional seabed bottoms. The vast majority of Mediterranean seabed surfaces lack such a massive vegetal cover and are muddy, sandy or, in some places, rocky. The nature of the seabed provides the substrate to different habitats for specific ecosystems, a large variety of which is found in coastal waters. These apparently modest habitats, far from being lifeless, are inhabited by complex biological communities, often part of fragile ecosystems. Current fishing practices, notably trawling on seabed sediments, profoundly disturb the physical support system and undermine the structure and functioning of the benthic ecosystem.

There is not a large literature quantifying, or even describing, the physical impact of fishing activities on the seabed in Mediterranean. However, there is a general consensus to admit that some fishing causes various physical perturbations of the bottom. Soft and hard bottom habitats are fished differently, the effects of fishing on them are different and the information available distinguishes between them: they are therefore described separately below.

Hard bottoms

Hard substrates generally support rich epi-faunal communities, particularly in shallow waters. There is little information on the impact of anthropogenic disturbance on Mediterranean sub-tidal hard bottoms. These systems are characterised by high habitat complexity and, consequently, high biodiversity indices. Such habitats are, in many areas, deeply threatened. For example, the removal of boulders induces destruction of substrates which are necessary for the settlement of fixed species and juveniles. Fraschetti et al. (1999) conducted a field survey off the Apulian coast (south-eastern Italy), an area with a large rocky surface, aiming at correlating spatial biodiversity with damage derived from date mussel (Lithophaga lithophaga) fisheries, based on the demolition of substrates by commercial divers. Signs of damage--a high degree of desertification--were detected in all zones; the high spatial heterogeneity shown by natural communities was taken as a potential symptom of stress, and related to intensive date mussel harvesting practices. Desertification of long stretches of rocky shore is caused by the destruction of habitats and the associated communities, combined with grazing by sea urchins (Fanelli et al. 1994). Other destructive fishing practices are also locally important in some areas. Illegal dynamite fishing along the entire Algerian coast affects rocky bottoms down to a depth of 10 m (A. Nouar, pers. comm.).

The St Andrew Cross, an iron bar hung with chains, used for harvesting coral (Corallium rubrum) is a well-known and highly destructive gear deployed on Mediterranean rocky bottoms. Since being banned in EU waters in 1994 (Council Regulation No 1626/94), it has been abandoned in many places in favour of divers, who cause more localised impact on rock epifauna (Caddy 2000). Standard otter-trawling also harms rocky bottoms, thanks to special rolling devices that prevent the gear from being damaged. This happens off north-western Spain in rocky fishing grounds rich in sparid fish, is spite of being legally banned.

The rocky bottom is affected by destructive fishing practices as the St Andrew Cross used for harvesting coral.
The Corallium rubrum is among the threatened species of the Mediterranean sea.
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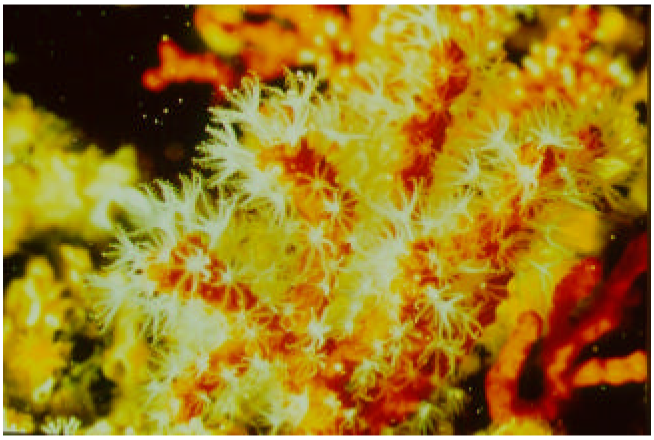

Soft bottoms

Heavy fishing disturbs muddy and sandy bottoms, causing dramatic changes in the structure of both the physical support system and the related biological assemblages. As synthesised by Pranovi et al. (2000), 'trawls and dredges scrape or plough the seabed, resuspend sediment, change grain size and sediment texture, destroy bedforms, and remove or scatter non-target species'. To these effects can be added the increase in the amount of suspended nutrients and organic matter (Jones 1992). Highly impacting bottom fishing (trawling, dredging...) mainly affects shelf areas. In the Mediterranean basin deep trawling fisheries targeting Norway lobsters or red shrimps also affects slope muddy bottoms. In general, muddy sediments, which form in high depositional areas with low external disturbance, are much more sensitive to trawling disturbance than more dynamic, coarser sediments; trawl doors penetrate them more deeply than other sediments, with potentially greater effects on infaunal species (Ball et al. 2000).

An Italian fleet with hydraulic dredges, otter and 'rapido' trawls (Ardizzone 1994) exploits a large trawlable shelf area in the north-western Adriatic. The latter gear is similar to the beam trawl, and is used in the Adriatic for fishing scallops in sandy offshore areas and flat-fish in muddy inshore areas, though it also catches small fish (Pranovi et al. 2000; Giovanardi et al. 1998). The study carried out by Pranovi et al. (2000) on the short-term impact of this gear on the sea bottom revealed that it causes extensive damage, digging and furrowing the sediment to a depth of 6 cm. Negative effects on the structure of the macrobenthos community were recorded: these included the increase in the abundance and biomass of taxa a week after the perturbation because of the increase in the trophic availability that benefited a few opportunistic scavenger species. Commercial exploitation appears to result in cumulative disturbance as evidenced by the higher biomass of scavenger Crustacea and Echinodermata at the expense of Porifera, Mollusca and Annelida. Commercial fishing may therefore be selecting epibenthic species most able to cope with physical disturbance by gear and endure the discard process. Experimental studies seem to conclude that 'rapido' trawling causes greater short-term disturbance on macrobenthos in muddy areas than in sandy bottoms, although short-lived fauna associated with the former recovers quite rapidly (within two weeks) (Pranovi et al. 1998).

Bottom fishing has deeply affected some Mediterranean invertebrate species, the endemic sponge Axinella cannabina or the bryozoan Hornera lichenoides (De Ambrosio 1998). Otter-trawling fisheries on muddy bottoms targeting shrimp Parapenaeus longirostris in Algeria destroy the benthic community associated with the seapen (Funiculina quadrangularis, Anthozoa) (A. Nouar, pers. comm.). The hydraulic dredge (known in Italian as 'cannellara'), which ploughs sediment to a depth of 20-30 cm is particularly destructive (Relini et al. 1999). This fishing practice is especially common in the Adriatic Sea (50 boats in Monfalcone, Venice and Chioggia) and takes shelled molluscs such as the sword razor shell (Ensis minor), smooth callista (Callista chione), the striped venus (Chamelea gallina) and the golden carpet shell (Paphia aurea). The use of hydraulic dredges to catch warty venus (Venus verrucosa), a species inhabiting detritic, conchiferous or sandy bottoms and Posidonia beds, was banned in Italy in 1992 because of the extensive damage it inflicted. In the south-western Adriatic, the smooth scallop (Chlamys glabra) fishery operating on coastal detritic bottoms inside the Gulf of Manfredonia makes big discards--395 kg from only an hour's dredging--principally of green sea urchins (Psammechinus microtuberculatus), molluscs and crustaceans (Vaccarella et al. 1998).

Deep slope fisheries targeting high value crustacean species operate out of Spain, Italy, Algeria and Tunisia, fishing down to a depth of 1000 m in the north-western Mediterranean red shrimp (Aristeus antennatus and Aristeomorpha foliacea) fishery. Although there is no information on the effects of deep sea trawling on muddy bottoms in the Mediterranean (or anywhere else in the world), the few authors who touch on the subject warn of the extreme vulnerability of such sea beds to physical disturbance. It appears that recovery rates are much slower and the impacts of trawling may be very long lasting (many years or even decades) in deep water, where the fauna is less adaptable to changes in sediment regime and external disturbance (Jones 1992; Ball et al. 2000). Otter trawling in red shrimp grounds is injurious to the Isidella elongata facies of the bathyal mud biocenosis. This octocorallian species is very much affected by fishing (A. Nouar, pers. comm.; Sardà 1997).

The ecosystem effects related to the use of bottom gear may extend far beyond the direct, straightforward impacts discussed above. Eutrophic processes may be enhanced leading to hypoxia in sensitive soft bottom areas (as in the northern Adriatic) and the quantity of hydrogen sulphide released from sediments may increase (Caddy 2000). The anthropic re-suspension of sediment enriched in organic matter can eliminate macrophyte, benthos and demersal fish approaching their hypoxia tolerance limit; the changed ecosystem structure favours species adapted or tolerant to hypoxic conditions. Trawling and dredging can also play a part affecting the intensity and duration of naturally occurring seasonal hypoxic crises in some places. These fishing practices, carried out in hypoxic conditions in the Adriatic, can exacerbate the summer killings of young shellfish. Trawling can also remove large-bodied, long-lived macrobenthic species and subsequently reduce the bioturbation zone (Ball et al. 2000). This could increase the danger of eutrophication and result in longer recovery rates (Rumohr et al. 1996). On the other hand, studies carried out on muddy seabeds off the Catalan coast (north-western Mediterranean) showed that otter-trawling operations produce short-term changes in the biomass of taxa within the trawled area. Some pointed to simple depletion caused by the gear catch (i.e. the cases of Scyliorhinnus canicula and Merluccius merluccius) and others to the concentration of scavenging species (i.e. Arnoglossus laterna, Cepola rubescens, Squilla mantis, Liocarcinus depurator) attracted by an increased food supply as a result of the mechanical killing of benthic fauna (Demestre et al. 2000). This, typical of scavenger response, lasted only about four days. These results suggest that fishing disturbance may cause shifts in the benthic community structure that particularly affect mobile scavenging species, probably the most food-limited group in muddy seabed environments.

Sandy bottom covered with Cymodocea nodosa. In the picture, The labride Xyrichtys novacula, a characteristic fish of this habitat.
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CONCLUSION

The impact of fishing on the seabed concerns mostly the use of bottom trawling gears, namely otter trawls, beam trawls and dredges, together with some aggressive practices affecting rocky bottoms such as dynamite fishing and fishing for coral and date mussels. Although it is clear that the latter should be minimised, given the documented damage they cause to seabed bottoms and benthic communities, an ecosystem-based management of the former is difficult since their harmful effects are inherent in their use. The creation of networks of marine reserves totally closed to bottom trawling could help to rebuild degraded benthic communities in adjacent fished areas in the future. Seasonal rotation of fishing grounds through establishing temporal closures could benefit bottoms too, since the likelihood of permanent change in bottom communities is proportional to the frequency of gear disturbance, as pointed out by Jones (1992). Ecosystem changes, in any case, should be avoided and the effect of fishing on bottoms and associated communities should be strictly monitored. Bottom trawling in eutrophic areas, prone to anoxia, is a matter of special concern: fishing practices should be significantly limited, at least in the most critical areas and/or seasons. The ecosystem effects of trawling on deep muddy bottoms, i.e. in red shrimp or Norway lobster fisheries, also deserves special attention given the high vulnerability of deep muddy bottom communities to external disturbance.

2.2.2. The impact of fishing on chondrichthyans

86 species of Elasmobranchs occur in the Mediterranean Sea of which 1 Holocephale and 45 species of sharks. International concern over the conservation of shark, ray and chimera (chondrichthyan) populations has been growing during recent years. This group has been revealed as especially vulnerable to human exploitation, fishing mortality resulting from both direct fisheries as well as high by-catches as a consequence of the use of low-selective gear. A decreasing trend in the abundance of these species in different areas has already been documented (Bonfil 1994). Condrichthyans by nature of their k-selected life history strategies i.e. slow growth and delayed maturation, long reproductive cycles (for example, incubation in Squalls lasts up to 22 months), low fecundity and long life spans, and their generally high position in tropic food webs, are more likely to be affected by intense fishing activity than most osteichtyans (Stevens et al. 2000; Castro et al. 1999). In addition, there is a lack of knowledge regarding many of these species. Carcharodon carcharias (great white shark), Cetorhinus maximus and Mobula mobular are cited (in the protocol on the Special Protected Areas into the Convention of Barcelona) among the most severely threatened Mediterranean species. hus, although numerical assessments of the great white shark are sketchy or absent, that it seems there has been a general decline of the catch and incidental catches in the Mediterranean waters resulting from various demersal fisheries. In this context, it is not surprising that after reviewing the status of some important shark fisheries, Castro et al. (1999) concluded that the history of shark fisheries indicates that intensive fisheries are not sustainable and that the complete collapse of the fishery is not rare.

For several authors, the declining trend of chondrichthyan populations is obvious in most of the Mediterranean fisheries in Tyrrhenian Sea, Gulf of Lions, Alboran Sea or Malta (Serena and Abella 1999, Aldebert 1997, Stevens et al. 2000). While some specific fishing activities targeting these species exist, most individuals are commonly caught as by-catch in bottom trawl, on longlines and in swordfish drifnets. They are usually discarded or marketed at a minimal commercial value.

In the case of chondrichthyans, it seems that increased survival of juveniles rather than increased fecundity provides greater resilience to fishing pressure (Brander 1981), highlighting this as the key factor for the conservation of these species.

Some international initiatives have been undertaken to deal with the problems related to the conservation of this group. They include the creation of a Shark Specialist Group by the Species Survival Commission of the IUCN, and the agreement at the FAO Meeting held in Rome in October 1998 to set up an International Plan of Action for the Conservation and Management of Sharks. CITES commissioned a study on the status of and trade in sharks which resulted in the creation of a Technical Working Group in FAO on sharks. The CITES Convention held in Nairobi in April 2000, however, rejected the inclusion of white shark (Carcharodon carcharias) in Appendix I and basking shark (Cetorhinus maximus) and whale shark (Rhincodon typus) in Appendix II. In the Mediterranean, only Malta has adopted legislative measures to protect white and basking sharks.

The world-wide consensus on the serious threats posed by fishing for the conservation of elasmobranch species is consistent with the information available on the Mediterranean. Demersal and pelagic fisheries are described separately given the different species involved and the corresponding impacting activities.

2.2.2.1. Impact of demersal fisheries

The impact of demersal fishing on Mediterranean elasmobranch populations relates to both direct fishing and the high by-catches due to the low selectivity of fishing practices.

Analyses of historical data on experimental surveys and fishery landings have proved useful in detecting clear population declines in some Mediterranean regions. A study based on historical data from both bottom trawl surveys and commercial landing statistics in the Golfe du Lion points to the clear decline of demersal elasmobranch species populations since the 1960s (Aldebert 1997). The area is exploited by a large trawling fleet (more than 200 vessels, accounting for 2/3 of the total catch) as well as by other small-scale fleets using various gear. Results from experimental trawl surveys indicate that the decline of elasmobrancii started on the continental shelf, and recently extended to the slope. Only 13 of the 25 species recorded in the years 1957-60 were still caught in the period 1994-95, a reduction in the number of chondrichthyan species of about 50%.

It is worth noting that the decreasing species were mainly fish with some economic value. This is the case for small sharks such as the smooth-hounds Mustelus mustelus and M. asterias, the smallspotted catshark (Scyliorhinus stellaris) and the longnose spurdog (Squalus blainvillei), as well as most of the rays. The latter seem to display a special vulnerability to fishing since only two, the starry ray, Raja asterias, and the thornback ray, R. clavata, of the ten species commercially exploited in the Golfe du Lion were still present in the last surveys; these were the most initially abundant species. Analyses of data on commercial landings led to convergent results i.e. longnosed skate, Raja oxyrinchus, a species reaching maturity at a length of 120 cm in the Mediterranean, disappeared from landings as early as 1976.

Evidence for the population decline of chondrichtyan species in the North Tyrrhenian Sea is also conspicuous. A series of historical data indicates that sharks and rays formed a bigger part of catches in the 50s than they do today, to the point that some fisheries directed at species then abundant such as the picked dogfish (Squalus acanthias) and M. mustelus have disappeared, as well as some species of Dasyatidae and Rhinobatidae (Serena and Abella 1999).

BOX 1

Rays: species specially vulnerable to fishing

In the Northern Tyrrhenian Sea, where a sizeable trawling fleet operates, rays are reported to be among the most important components of the fish assemblages caught by the local beam trawling 'rapido' fleet harvesting in shallow waters. The corresponding catches by the otter-trawling fleet are less important. Catches are especially sizeable in the region of Viareggio where high discards of juvenile specimens of the most abundant ray species there, R. asterias, not exceeding 28 cm (maturity is reached at a size ranging between 50-60 cm, depending on the sex), are known to occur although the population seems to be stable. The most important catches of ray in Italian waters correspond to R. clavata, a species abundant in trawling grounds whose juvenile fraction suffers high fishing mortality. Data on this species in the North Tyrrhenian suggests a very high exploitation level. The case of the brown ray (R. miraletus) is not very different.

Sources: Serena and Abella 1999 ; Relini et al. 1999.

This declining trend concerning chondrichthyan populations seems not to be exclusive to this region of the NW Mediterranean: similar situations have been reported concerning areas as distant as the Alboran Sea and the waters surrounding Malta (Aldebert 1997; Stevens et al. 2000). Ray species appear to be especially vulnerable to fishing (see Box 1).

Italian demersal fleets discard high levels of juvenile blackmouth catshark (Galeus melastomus) and smallspotted catshark (Scyliorhinus canicula), species captured with bottom trawl nets at different depths (Relini et al. 1999). The former is mainly caught as a by-catch in the Norway lobster and red shrimp fisheries. Improved gear selectivity based on an increased mesh size has been suggested as a way of reducing these undesirable catches. In the case of G. melastomus, a significant reduction of fishing in the nursery areas may also be necessary, especially in the well-known area located in the Northern Tyrrhenian Sea between Gorgona and Capraia at depths around 200 m. Another species, S. blainvillei, was formerly quite common in the Northern Tyrrhenian Sea, whereas at present the population has been considerably reduced because of the high by-catches by the bottom trawl fisheries. As far as other minor species are concerned, S. acanthias and M. mustelus are captured in Italian waters using traditional bottom nets, as well as longlines and gillnets. The gulper shark (Centrophorus granulosus) is caught as a by-catch of traditional bottom trawl nets in slope fisheries.

Chondrichthyan species, mainly involving species of Raja, Scyliorhinus, Squalus and Oxynotus genera also account for the bulk of discards produced by the Greek trawling fleet operating in the Cyclades area in the Aegean Sea (Vassilopoulou and Papaconstantinou 1998).

Demersal Mediterranean fisheries also impact on large pelagic species such as the white shark (Carcharodon carcharias), a species listed in the Barcelona Convention (Annex II) and Bern Convention (Appendix II) and represented by a very low-density population in the Mediterranean. The Sicilian Channel waters, however, are considered as a major area of abundance and reproduction of white sharks within the entire NE Atlantic/Mediterranean region (Fergusson 1996). This species seems to have been in general decline in Mediterranean waters since 1960.

Given the vulnerability of the enclosed Mediterranean population, incidental catches are of special concern. Fergusson et al. (1999) report that large individuals are incidentally entangled in bottom gillnets set close to Filfla Islet and off Marsaloxlokk in Malta, at seabed depths of 15 to 30 m; the same authors refer to white shark catches in similar circumstances in Sicily, Greece and Turkey in recent years. Young--including young of the year--white sharks are also caught elsewhere in the Mediterranean, off Algeria, France and in the North

Aegean. The majority of these catches, however, originate from the Sicilian Channel during high summer, being due to trawlers based in Sicily (Fergusson 1998).

2.2.2.2. Impact of pelagic fisheries

Large pelagic elasmobranchii are regularly caught in the Mediterranean, mainly as a by-catch in the longline swordfish (Xiphias gladius) fishery. Some of these species are landed and marketed.

The blue shark (Prionace glauca) is perhaps the most impacted species, though because of its relatively high fecundity (Compagno 1984) it seems to rank high on the scale of shark species resilient to fishing (Smith et al. 1998). The ratio of by-catches varies depending on the area (see Box 2).

Surface fisheries targeting large pelagics in the Mediterranean also entail incidental catches of white shark (Carcharodon carcharias). The bluefin tuna (Thunnus thynnus) longline fishery operating from Marsaxlokk in Malta reports by-catches of neonatal white sharks in international waters near Lampedusa and Libya (Fergusson et al. 1999). Similarly, the swordfish longline fleet based at Mazara del Vallo, Sicily is also known to catch neonatal specimens incidentally (Fergusson 1998). All of them come from the breeding ground located in the Sicilian Channel. Adult individuals are also caught in the vicinity of Filfla Islet by the pelagic line fleet based at the Maltese port of Wied-iz-Zurrieq, while other specimens fall into tuna traps, 'tonnara', in bays along northern Malta.

Pelagic or bentopelagic stingrays (Dasyatis spp.) are also important victims of certain pelagic Mediterranean fisheries. In the longline fleet (about 27 units using 'palamito da pesce spada') fishing in the former Santuario dei Cetacei in the western central Ligurian Sea, pelagic stingray (D. violacea) largely dominate the fraction of the non-commercial by-catch, being caught in large numbers.

Even some specimens of devil fish (Mobula mobular), a species listed in Annex II of the Barcelona Convention, are regularly caught in this fishery. D. violacea has also been reported to be a victim of Spanish fleets in the swordfish longline fishery in the south-western Mediterranean (Aguilar et al. 1992).

Together with longlines, driftnets are still responsible for considerable mortality in pelagic elasmobranch species, which frequently get entangled in them. In Algeria, where this fishery is carried out despite being legally banned, catches of blue shark, and to a lesser extent of other species of the Alopiidae and Carcharhinidae families, are known to occur (A. Nouar, per. com.).

Important commercial catches of A. vulpinus and blue shark, as well as minor discards of D. violacea, M. mobular and even basking shark (Cethorhinus maximus, listed in Annex II of the Bern Convention) have also been reported for the driftnet fishery operating in the Ligurian Sea (Di Natale et al. 1992).

BOX 2

Impact of longlines on large pelagic elasmobranchii

The swordfish/blue shark ratio for the Ionian longline fleet in Italian waters from 1978-1981 was as low as 1.6:1, pointing to very high shark catches; in other areas the relative weight of shark by-catch was somewhat minor. This was the case in the Southern Adriatic (3.4:1) and in the protected area formerly known as Santuario dei Cetacei in the western-central Ligurian Sea, where the ratio was only 18-20:1, perhaps reflecting a low density of the species there, where high densities of other apical predators are recorded. Much lower numbers of other elasmobranch species such as the thresher shark (*Alopias vulpinus*), the shortfin mako (*Isurus oxyrinchus*) and the porbeagle (*Lamna nasus*) are also part of the commercial fraction of the longline by-catch in the latter protected area. The monitoring of landings from the Spanish Mediterranean swordfish fishery (longlines) at ports between Alicante and Algeciras (S Spain) conducted during summer 1998, revealed that blue shark made up about one-quarter of total landings; more than 500 individuals were recorded. Furthermore, finning, the cutting of the shark fin and the discarding of the rest of the animal, is probably practised on the Mediterranean high seas by longline fleets making long trips. Blue shark game fishing is also a matter for concern, especially in the Adriatic Sea, where a nursery area is known to exist and large amounts of juveniles are caught.

Sources: Orsi Relini, in press ; Orsi Relini et al. 1999 ; Raymakers and Lynham 1999.

CONCLUSION

Most recent studies show that Mediterranean fisheries are not an exception in the context of the general trend of decline shown by elasmobranch populations and their related fisheries around the world. Information on rays and other demersal species deserves special concern, since they have proved to be highly vulnerable to fishing. The high elasmobranch by-catches (and even commercial catches) associated with many pelagic fisheries, notably long-lining, also appear to be a potential danger for several species e.g. blue shark, white shark and stingrays.

In this context, there should be accurate monitoring of catches and assessing of the impacted populations to decide how and where to launch measures effective in reducing fishing mortality on target or by-catch chondrichthyan species.

Given the usually high trophic level of these species, the conservation of the diversity of this group of important predators (some of them apical), is essential for the health of the ecosystems, since population changes could be passed down in a cascade with unpredictable effects on many tropic webs. Establishing marine protected areas in nursery grounds or in areas of special interest, completely eliminating the most impacting gear such as driftnets, and improving the selectivity of surface long-lining and bottom trawling in order to reduce by-catches are among the necessary shortest-term measures.

Because of the role of apex predator played by many elasmobranch species, a systemic management leading to the adequate conservation of the whole ecosystems, including healthy levels of other fish populations, appears to be necessary. This would apply to the case of the meagre Mediterranean white shark population, which is thought to suffer from the overfishing of its main prey species, large pelagic fishes such as bluefin tuna (Fergusson et al. 1999). Finally, the overall management policy regarding the exploitating of elasmobranch populations, including commercial fisheries, and the related commercialisation processes should perhaps be revised in the light of the latest indicators that point to current practices being non-sustainable.

Chondrichthyans have been revealed as especially vulnerable to harmful exploitation and fishing mortality: blue sharks as a by-catch in the longline swordfish fishery.
F. Garibaldi © RAC/SPA

2.2.3. Seabirds interactions

Very little attention had been paid until recently to the impact of Mediterranean fisheries on seabird populations. However, studies carried out in the last years, mainly in the NW Mediterranean region, have revealed strong and complex interactions of world-wide interest. The effects of fishing on bird populations may be directly responsible for mortality as when caused by low-selective fishing practices, or more indirectly as in the role of external perturbation that fundamentally affects food supplies and subsequently leads to major modifications in trophic habits, demographic parameters and inter-specific relationships. The main impact of trawling on seabirds consists in fish discarding in some coastal fisheries: the fishes which are discarded are becoming the main source of feeding for the gulls and the Mediterranean shearwater.

The key feature affecting seabird populations is precisely the mortality rates. Procellariiforms, as well as Pelecaniforms and Laridae species are generally long-lived and their populations are highly sensitive to changes in survival. The additional mortality induced by accidental captures in fisheries is therefore a significant danger to them (Lebreton 2000). Certain fishing activities such as longlining both drifting in mid-water and bottom one are pointed out as being an important cause of incidental mortality; entanglement of shags (Phalacrocorax aristotelis) in gillnets may also be a problem.

BirdLife started a Program for the Conservation of Sea Birds in 1997 as a result of the resolution on Incidental Mortality of Sea Birds in Long-lines, adopted by the IUCN at its First World Conservation Congress. The inventory of the breeding status and distribution of 14 species of seabirds has been carried out in 17 countries of the Mediterranean Sea. Although there is no urgent concern for most of the birds of the Mediterranean marine and coastal areas, a few species are now perceived as endangered. Three Mediterranean seabird species are currently covered by specific Action Plans designed by BirdLife International, approved by the Ornis Committee (EU DG Environment) and endorsed by the Bern Convention's Standing Committee. They include the Audouin's gull (Larus audouinii) of which the populations of Sardinia, Corsica, Spain and Algeria are the most important; the Balearic shearwater (Puffinus mauretanicus) and the Mediterranean shag (Phalacrocorax aristotelis desmaresti) of which Croatia, Corsica, Sardinia and Balearic islands hold important breeding populations.

In 1999 the FAO Committee of Fisheries (COFI) designed an International Plan of Action-Seabirds on accidental bird catches in longlines, open to the voluntary adhesion of all countries with longline fleets.

The information available on the Mediterranean basin will be presented in two different categories (direct and indirect effects), following the criteria found in Tasker et al. (2000), and given the diversity of fishing effects recorded on seabird populations.

2.2.3.1. Direct effects of fisheries

These refer to seabird by-catches related to impacting fishing practices, notably long-lining. Data on mortality levels exists only for Spanish fisheries, Spain being only one of the 12 Mediterranean countries known to undertake longline fishing. (Cooper et al. 2000).

A specific study addressing the impact of longlines on Mediterranean seabird species has recently been carried out in the Spanish fishery around the Columbretes Islands, in the NW Mediterranean (Martí 1998). A local fleet using both bottom and surface longlines operates there, targetting hake and swordfish respectively. On-board observations during the summer months revealed that six different species preyed on the baited hooks during the process of line setting. These included Cory's shearwater (Calonectris diomedea), the Balearic shearwater (Puffinus mauretanicus), the Atlantic gannet (Sula bassana), Audouin's gull (Larus audouinii) and the yellow-legged gull (Larus cachinans). In addition, fishermen referred to the capture of specimens of great skua (Stercorarius skua) and Mediterranean shag (Phalacrocorax aristotelis desmaresti). Incidental catches affected mostly Cory's shearwater, accounting for 77% of the total bird by-catch, followed by the yellow-legged gull (14%) and the Atlantic gannet (9%). The incidence was higher for bottom long-lining (0.72 birds caught per 1000 hooks, against only 0.22 for surface long-lining). Although the average capture rate for the overall fleet was estimated to be 0.44 individuals per gear setting, sporadic massive catches are known to happen: 200 Balearic shearwater were reported to have been caught during a single bottom longline setting in 1997. Several reasons point to both shearwater species as the most impacted seabirds in this fishery. So, whilst Cory's is the most affected in numerical terms, the Balearic shearwater is a Balearic endemic species facing a regressive trend, half its global population wintering in the area of the study. Concerning the former, fishing mortality caused by long-lining on the populations breeding in the Columbretes Is. and the Balearic Is. has been estimated at 550 and 1300 individuals respectively (Aguilar 1998). The high sensitivity of Cory's shearwater to high levels of mortality on the adult population make these figures a matter of concern since 60% of individuals hooked are adults (Martí 1998). All the evidence points to the non-sustainability of present by-catch rates (Cooper et al. 2000).

Another study based on the monitoring of 557 fishing operations carried out in 1999 and 2000 by the Spanish surface longline fleet in the Western Mediterranean also showed that Cory's shearwater, together with the yellow-legged gull, accounted for almost the totality of by-catches (20 out of the total 21 birds caught), which also took place mainly during the setting of the gear (Valeiras and Camiñas 2000).

Other information regarding longline fisheries from Greece and Malta confirms the results of the Spanish studies, in the sense that C. diomedea appears to be the seabird species most affected by this fishing practice in the Mediterranean (Cooper et al. 2000).

Nets also cause mortality in seabird species, since both Audouin's gull and the yellow-legged gull have been reported to get entangled in nylon mesh in the Chafarinas Islands, the small Spanish archipelago off Morocco (De Juana and De Juana 1984).

2.2.3.2. Indirect effects of fisheries

The effects of fishing-induced changes in food availability on seabird populations have been studied most closely in the NW Mediterranean. This region is characterised by being inhabited by the bulk of the world population of the rare Audouin's gull (Larus audouinii), of which the largest colony in the world--accounting for 62% of the global breeding population of 18,690 pairs--is found in the Ebro Delta, in the Iberian Peninsula (Martínez 2000). This species, a specialist predator on shoaling clupeoids, relies heavily on discards. An important fleet of both otter trawlers and purse seiners operates in the vicinity of the Ebro Delta, supplying the seabird species breeding there with additional food (see Box 3).

BOX 3

The use of discards by seabirds

An extensive study on the use of discards by seabirds was carried out in the Ebro Delta region and in the Island of Mallorca. In the former area, because of the illegal fishing of anchovy by trawlers, a high amount of sardines are discarded, which together with flatfish make up half the total discards (estimated at between 15-45% of catches, and at 41% of fish landed). This resource is mainly exploited by the Audouin's gull, which is the most abundant species and, to a lesser extent, by the yellow-legged gull (Larus cachinnnans) and other gulls, terns and shearwaters. The field survey indicated that birds took 72% of total fish specimens discarded.

Source: Oro and Ruiz 1997.

By contrast, in the Mallorca fishery, with fleets mainly targeting shrimp on the slope bottoms, 40% of discards were crustaceans and boar fish (Capros aper), groups that are often rejected by scavenging birds.

Estimations based on energy requirements show that discards in the Ebro Delta region are enough to sustain the populations of scavenging seabird species, which is not the case in Mallorca. Discards are also known to constitute the main forage resource for the lesser black-backed gull (Larus fuscus) in the Ebro Delta colony (Oro 1996). Closed seasons for trawling fleets based around the Ebro Delta overlap the breeding season of scavenging birds and negatively affect their breeding performance as reported for the lesser black-backed gull (Oro 1996), the yellow-legged gull (Oro et al. 1995) and Audouin's gull (Oro et al. 1996). Abelló et al., (2000), based on the attendance of seabirds at experimental trawl haulings on the Mediterranean Iberian coast, confirmed the importance of trawl discards for Cory’s shearwater (Calonectris diomedea), the Balearic shearwater (Puffinus mauretanicus), Audouin's gull and the yellow-legged gull.

Purse seine fleets fishing at night affect the trophic availability of seabirds. A study carried out in the same area around the important bird sanctuary of the Ebro Delta shows that the different species exploit the opportunities offered by this fleet in different ways. Whereas the yellow-legged gull, Cory's shearwater and the Balearic shearwater occasionally benefit from direct predation on discards, this is of limited importance given the low volume generated; Audouin's gull is a nocturnal species that specialises in capturing small pelagic fish and takes direct advantage of the fishing operation to capture the fish attracted by the lights or concentrated by the gear (Arcos et al. 2000). This association with purse seine fleets has also been confirmed by González-Solís (2000) for the yellow-legged gull and Audouin's gull around the Chafarinas Islands, where bottom trawl and purse seine fisheries operate. The two species have a similar diet there and account for as much as 60% of epipelagic fish when both fleets are active simultaneously.

More attention must be paid to the impact of Mediterranean fisheries on seabird populations. A. Demetropoulos © RAC/SPA.

CONCLUSION

Longline fishing is evidently the main cause of seabird mortality in Mediterranean fisheries. Bottom and surface longlining are both implicated since bird mortality is associated with the process of longline setting and is independent of the depth targeted by the gear.

The above study on the Columbretes fishery concludes that nocturnal setting prevents bird predation of bait, and reports that this measure, which involves a change in fishing habits, has already been implemented spontaneously by fishermen in the area in order to prevent the negative economic consequences arising from the interaction with birds. This appears to be the most realistic remedy for artisanal fisheries, though its efficacy is reduced on full-moon nights. Other complementary measures, such as training lines with floats attached to frighten birds away, are also in use in that region to some effect. As for the industrial fleets, i.e. large surface longlines targeting large pelagics potentially affording higher investments, Martí (1998) acknowledges the feasibility of using pipe devices, that is the Mustad design, which allow the underwater setting of lines, precluding any possibility of bait predation by birds.

Tackling the issue of the impact of fisheries on seabirds related to the increase in food availability appears to be very difficult since there is apparently no clear consensus on what human effects are positive or negative at ecosystem level. The above-reported case of trawling discards in the Ebro Delta is a good example of this. While some authors refer to the negative effects of closed seasons on several gull species, it should be pointed out that seabirds there benefit largely from discards arising from an illegal fishing activity (since the use of trawling to catch small pelagics is forbidden in Spain). Moreover, the very discards constitute a negative effect of fishing on the overall ecosystem that should be minimised. Demersal populations in the region are heavily fished or even overfished and limitations on fishing are urgently needed (Lleonart 1990; Irazola et al. 1996).

The distinction between direct (fishing mortality) and indirect (trophic availability) effects of fishing is nonetheless somewhat vague, highlighting the complexity that underlies ecosystems. In two very different Mediterranean areas, the NW Mediterranean and the Alboran Sea, the predatory behaviour of the yellow-legged gull on Audouin's gull (even adults) was reported to increase following the elimination of discards caused by temporary fishing moratoria (González-Solís 2000; Martínez-Abraín et al. 2000). Martí (1998) noted that the majority of Audouin's gulls caught by the longline fleet operating around the Columbretes Is. were caught during the trawling closed season, suggesting that trawling moratoria could enhance the incidence of longline by-catches.

2.2.4. Turtle interactions

The loggerhead turtle (Caretta caretta), green turtle (Chelonia mydas) and leatherback turtle (Dermochelys coriacea) are the most common turtle species in the Mediterranean, though only the former two are known to nest on Mediterranean beaches (Demetropoulos and Hadjichristophorou 1995). All three are endangered species (UNEP/IUCN 1990). It is estimated that only 300-400 green turtle females and about 2000 loggerheads nest annually in the Mediterranean (Groombridge 1990), the latter making between 3000-4000 nests every year (Groombridge 1989 & UNEP/IUCN 1990). Total adult populations are somewhat higher given that most of the individuals do not breed every year. In the case of the loggerhead, an additional contingent of individuals of Atlantic origin is known to migrate into the W Mediterranean across the Gibraltar Strait during the first half of the year (Camiñas 1997a, b). A third nesting species, not strictly marine, the Nile soft-shelled turtle (Trionix triunguis) is found in a few coastal wetlands in the eastern Mediterranean. The 1991 Bern Convention on the Conservation of European Wildlife and Natural Habitats recommended to the Council of Europe that this sub-tropical species be given better protection.

Turkey is a key country regarding the total number of nesting females for the three mentioned species breeding in the Mediterranean, though fishing practices around the entire basin affect their populations.

A demographic model for the Mediterranean population of loggerhead turtle showed that adult survival was the main factor affecting population growth rates, fecundity being less significant (Laurent et al. 1992). This emphasises the importance of limiting fishing by-catches of these species.

International concern about the general decline of the marine turtle population in the Mediterranean led the parties to the Barcelona Convention to adopt an Action Plan for the Conservation of Mediterranean Turtles in 1989, acknowledging that catches by fishermen are the most serious threat to the turtles at sea, and that the conservation of the green turtle deserved special priority.

Mediterranean fisheries have an enormous impact on the local turtle stock: more than 60,000 turtles are caught annually as a result of fishing practices, with mortality rates ranging from 10% to 50% of individuals caught (Lee and Poland 1998). All the turtle species being found in the Mediterranean waters are somehow affected by fishing activities. Although bottom trawls and bottom and surface set nets are responsible of some catches (Gerosa and Casale 1998), longlining (Crespo J. and al. 1988; Camiñas J.A. 1998), and driftnetting are considered as the main mortality threats.

The problems related to the interaction between fisheries and turtles in the Mediterranean are, to a large extent, common to the different species. However, local features can affect breeding or wintering populations of turtle differently in different areas. These, and other considerations related to the status of different populations, suggest the convenience of reporting separately on each of the most important species.

2.2.4.1. Loggerhead turtle

The loggerhead turtle (Caretta caretta) is the most abundant turtle species breeding in Mediterranean waters. The Ionian Sea constitutes its major breeding ground, the coasts of western Greece being of paramount importance. The gulf of Laganas, in the island of Zakynthos, has one of the highest densities of nests in the world and the beaches of the island of Kefalonia and other Ionian islands, as well as the west coast of the Peloponesus (Margaritoulis and Dimopoulos 1995; Margaritoulis et al. 1995) are also important. Other nesting areas are found in Turkey, Cyprus, Tunisia, Egypt and Libya (Demetropoulos 1998; Laurent et al. 1995).

The loggerhead turtles, the most abundant species, migrate during a pelagic phase from the coastal spawning areas towards the western Mediterranean Sea, around the Balearic Islands in particular, where they feed during the summer months before returning to wintering areas (Camiñas J.A. 1996). During this last period, they spend most of their time in the superficial waters of the continental shelf.

Surface longline and driftnet fleets operating in the Mediterranean are the major threats to the survival of this species, although bottom trawls and gillnets are responsible for some catches (see Box 4).

Loggerhead turtles caretta caretta are caught by surface longline fleets: C. caretta with a swordfish hook inserted in its mouth. G.Gerosa © RAC/SPA

Loggerhead turtles have been caught in high numbers by the Italian and Maltese surface longline fleets, the former mostly operating in the Gulf of Taranto, the south Adriatic and the Aegean Sea, including those targeting albacore (Camiñas and De la Serna 1995; Panou et al. 1999; De Metrio et al. 1997). Turtles are also victims of fishing by-catches in Tunisian waters, which are thought to be important wintering grounds for the species (Panou et al. 1999). Longline fleets annually catch an estimated 4,000 individuals there (Salter 1995; Demetropoulos 1998).

Loggerheads also get entangled in driftnets, as reported by Di Natale (1995) for the Italian driftnet fishery having place in the Ligurian and Tyrrhenian Seas (catch rates of 0.057 and 0.046 loggerhead per day and vessel, respectively). Around 40% of turtle catches occur in July. About 16,000 turtles were estimated to be caught annually by an Italian driftnet fleet operating in the Ionian Sea in the 80s (De Metrio and Megalofonou 1988). As for the Spanish swordfish driftnet fleet operating in the Alboran Sea until 1994, loggerhead turtles constituted 0.32% of the catch in 1992 and 0.92% in 1994 (Silvani et al. 1999). An estimated 236 animals were caught incidentally in 1994, being released alive at sea. Further on-board observations regarding this Spanish driftnet fishery showed that important catches of loggerhead in the Mediterranean side of the Gibraltar Strait were recorded through July and August, when an important migration from the Mediterranean towards the Atlantic takes place (Camiñas 1995; 1997a).

Fixed nets also cause turtle mortality since turtles get caught in them when trying to feed on the entrapped fish, as happens in Kefalonia (Sugget and Houghton 1998). Loggerhead captures by trawlers and purse seiners have also been reported for the Spanish Mediterranean coast (Camiñas 1997c). Small annual catches of turtles (a mean of 1.5 individuals per year and boat) by the Spanish tuna purse seine fleet don't seem to be a mortality factor since turtles are released alive (University of Barcelona 1995). Total annual by-catches by the Tunisian small-scale fleet (comprising fixed nets, purse seines, bottom and surface longlines, and tuna fishing gear) operating in the Gulf of Gabès are estimated at 5,000 individuals (Bradai 1995). Another 2,000-2,500 turtles are caught by the trawling fleet, composed of 300 units, AND illegal small trawlers are thought to capture additional hundreds to thousands of individuals annually. The highest catch rates in the region correspond to bottom longliners (an average of nearly 23 turtles per boat and year).

Experimental studies on mortality rates of individuals injured by fishing gear show that 20-30% of the turtles caught by the longline Spanish fleets may die (Aguilar et al. 1992). It is remarkable that 80% of specimens caught in this fishery are released with the hook still fixed in the mouth, pharynx or oesophagus (Camiñas and Valeiras 2000). Furthermore, the probability of drowning in the gear seems to be higher for turtles caught by the albacore longline fleet than for those captured in the swordfish fishery. Other studies report mortality affecting 10% to 50% of the individuals incidentally caught (Lee and Poland 1998). On the other hand, some observations seem to point to a rather fast degradation of non-stainless hooks in the mouths of the turtles released (2-3 months) (Panou et al. 1999). An estimated 30% of turtles caught entangled in the Italian driftnet fishery have drowned (De Metrio and Megalofonou 1988).

Finally it is worth mentioning that experimental tagging is likely to make turtles more vulnerable to fishing by increasing the chance of entanglement (Suget and Houghton 1998) as has been reported for the loggerhead population of Kefalonia.

BOX 4

Surface longlines: major threat to the survival of Caretta caretta

1. A study addressing the by-catch of turtles by the swordfish longline fleet based at Kefalonia, which operates mainly in the Central and South Ionian Sea, lasting from 1989 to 1995, showed that each vessel caught an average of 7.7 loggerhead turtles every year. Although the nesting season in that area coincides with the peak of the swordfish fishery, 77% of individuals caught were immature, highlighting the especial vulnerability of this group to fishing (though Salter (1995) suggests that this fact could reflect the capture of adults by driftnets). Extrapolating the data to the total professional Greek longline fleet in the Ionian Sea (which accounts for more than 50% of the total Greek fishing effort in western Greece), an estimated figure of 280 turtles caught per year is obtained. The additional impact of the 30-50 Italian driftnet vessels operating in the same area gives a total estimated annual by-catch of 600 individuals.

2. A former study referring to the Spanish longline fleet targeting swordfish in the South Western Mediterranean (up to 60-80 vessels in the summer months, in the early 90s) suggested that turtle by-catches in this region are dramatically higher. Rates as high as 6.5-9.8 turtles per day and boat were recorded in 1990 and 1991, allowing for an estimated total catch of from 22,000 to 35,000 individuals each year, 66% of catches being concentrated in two months alone (July and August). Estimates of total catches by the Spanish longline fleet in the Mediterranean for the period 1988-1996 oscillate from 1,953 individuals in 1993 to 23,888 in 1990. By-catches by the foreign industrial longline fleets operating in the area (Japanese, flag of convenience,) could give even higher figures.

3. A recent survey carried out from July to December 1999 to assess the by-catch by the Spanish longline fleets targeting swordfish and albacore in the Mediterranean, under a EC DG XIV research project, showed that 280 fishing hauls yielded a total by-catch of 496 loggerhead turtles. The albacore fishery (with hooks set deeper in the sea) resulted in higher by-catch rates: 1.05 turtles per 1,000 hooks, against 0.33 from swordfish longlining. All the individuals caught in the South Western Mediterranean are juveniles, reflecting the demographic structure of the population in the W Mediterranean, where adult individuals are only found, in small numbers, in winter. It is important to note that individuals caught by the Spanish longline fleet have two different origins: Atlantic individuals entering the Mediterranean during the spring, and others belonging to the Central and Eastern Mediterranean breeding populations. Both groups migrate into the Western Mediterranean feeding grounds in spring and summer.

Sources: Panou et al. 1999; Aguilar et al. 1992; Camiñas 1997b ; Camiñas and Valeiras 2000; Camiñas 1997a, b

2.2.4.2. Green turtle

The green turtle (Chelonia mydas) is represented in the Mediterranean waters by a reduced population nesting on only a handful of beaches in Cyprus and Turkey. The local stock seems to be the remnant of a former larger population. Present recruitment rates are probably much lower than deaths related to fishing, and this could lead to the virtual collapse of the population in the near future (Demetropoulos 1998). The Turkish localities of Kazanli, Akyatan and Samandag, with about 1,000 nests made annually and scattered along more than 40 km of beaches, are the most important nesting areas for this species in the Mediterranean (Groombridge 1990). Fishing activities, especially in the two former areas cause significant mortality at sea (Demirayak 1999). A fleet of trawlers, longliners and small-scale boats using nets operates intensively, even within the fishing-restricted coastal strip, off Kazantli. Fishermen blame turtles for the damage they supposedly cause to their nets and dead specimens are often washed ashore. Fishermen from Karatas, the main port near the Akyatan nesting ground report numerous turtle captures, even in winter. Trawlers there also violate the three-mile coastal limit and seriously impact the green turtle population. Five trawling boats alone operating over 28 weeks have been reported as catching a total 160 green turtles as well as 26 additional loggerhead turtles.

The green turtle is also sporadically caught as a by-catch in fisheries from other areas, for example by the Greek longline fleet operating in the Ionian Sea (Panou et al. 1999). Schrichter MEDASSET.

A survey based on interviews with artisanal fishermen (using both nets and longlines) in northern Cyprus and on the Turkish Mediterranean coast yielded estimated by-catches of 4 and 2.5 turtles per boat and year respectively, giving a total minimum estimate of about 2,000 turtles for the whole region (Godley et al. 1998). Even though 90% of the specimens were reported as having been caught alive, an unknown fraction of them could have been killed on board as fishermen perceive turtles as a nuisance. The authors of the report suggest that green turtles could possibly account for a significant proportion of turtles caught; this is worrying given their demographic status.

2.2.4.3. Other species

The Nile soft-shelled turtle (Tryonix triunguis) is an endangered species found in only three major populations: in the wetlands of Dalyan and the Dalaman area, in south-western Anatolia, and the Alexandre River in Israel (Kasparek and Kinzelbach 1991). The two former Turkish populations were discovered in the early 70s (Basoglu 1973), and a new locality for the species has recently been reported in Patara. Populations are extremely low, consisting of only 50 adult individuals in Dalyan and a further 75-125 adults and sub-adults in Dalaman. Fishermen catch them at sea and usually kill them deliberately as happens in the Cucurova region and the Göksu delta (Kasparek 1999) because of the damage they cause to the nets. This poses a major threat to the species. Fishermen from the Karatas harbour acknowledge that a remarkable amount of soft-shelled turtles are taken as a by-catch, and that they are commonly killed because they are seen as dangerous (Demirayak 1999).

The leatherback turtle (Dermochelys coriacea) is also sporadically caught by the fleets operating in the Mediterranean. Cumulative evidence points to the existence of a reduced non-breeding population distributed over the whole Mediterranean Basin, where the species appears to be common or regular (Camiñas 1998). Some incidental captures were reported in Tunisian waters during the 90s, mostly by trammel nets, bottom trawls and driftnets (Bradai and El Abed 1998). Swordfish longlines appeared to be responsible for most of the incidental catches recorded in western Mediterranean waters (Crespo et al. 1988; Camiñas 1998), though some additional captures were caused until the mid 90s by the activity of the former Spanish swordfish driftnet fishery in the Alboran Sea (Camiñas 1995). Monitoring of 15 longline vessels targeting swordfish in Spanish waters showed a catch of two specimens during two months of activity in the summer of 1991 (Aguilar et al. 1992). Two further individuals were entangled in longlines in the course of 217 fishing operations in 1999 (Camiñas and Valeiras 2000). This species is also taken as a by-catch in Italian longline albacore fisheries (De Metrio et al. 1997).

CONCLUSION

Fishing in the Mediterranean basin is clearly a major threat to marine turtle populations. The especial vulnerability of these species to high mortality rates of adults and sub-adults makes the maximisation of the survival of individuals at sea a priority, and this could be achieved by reducing the mortality caused by fishing gear.

In surface longline fisheries, the hook should be removed whenever possible and the individuals immediately released; fishermen's collaboration is essential. Specimens caught and released alive with hooks in their oesophagi or stomachs don't necessarily survive. Turtles are not gastronomically appreciated in Greece (in contrast to some areas of Italy--the Apulian coast--and Egypt), but as stated by Panou et al. (1999) there is a danger that Greek crews, increasingly composed of foreign fishermen, may change this. The delay in the total extirpation of driftnets from European waters, particularly Greek and Italian, and the continued and growing use of driftnets in key turtle conservation areas in waters off the North African coast and Turkey are further matters for concern. Turtles discarded from driftnets can also die because of anoxic brain damage as a result of prolonged immersion (Lee and Poland 1998). This and other above-mentioned factors point to the reduction of by-catches as the only effective way to eliminate fishing mortality. Special restrictive fishing measures affecting large pelagic fisheries could be applied in areas described in recent years with big populations of immature and adult loggerheads.

More specific measures should be taken in the vicinity of nesting beaches to prevent capture of adults. This is particularly urgent for the green turtle because of its small breeding stock. Various fishing practices--even artisanal fleets--in these areas cause turtle mortality and fishing restrictions are frequently violated in most coastal waters. In this context, the Standing Committee of the Bern Convention recommended that the Turkish Government strictly control the fisheries in the three main green turtle nesting beaches (document T-PVS (98) 62). The Turkish authorities have repeatedly been asked (from as early as 1994) to completely ban fishing at the Kazanli area during the nesting period, with little success to date. The improvement of trawling gear by means of turtle excluding devices (TED), in use in several tropical regions (Villaseñor 1997), could be an effective measure in some cases where the impact of trawling on turtles is high (i.e. the Gulf of Gabès). Reducing trawl times is effective in reducing turtle mortality; trawls not exceeding 60 minutes give a turtle mortality rate in the gear close to 0%, but this rises to 50% if fishing time increases to 200 minutes (Henwood and Stuntz 1987). Kasparev (1999) recommends stopping all kinds of fishing around Dalaman (including nets, lines, guns and dynamite) in order to protect the small local population of the soft-shelled Nile turtle. In addition, methods for experimental tagging should be improved so as to reduce potential harmful effects such as entanglement in nets.

Finally, campaigns designed to raise the awareness of stakeholders, primarily fishermen, should be undertaken along all the Mediterranean coasts to promote turtle-friendly fishing practices.

2.2.5. Cetacean interactions

Among 22 cetacean species which have been reported in Mediterranean waters 10 are only occasional visitors coming from the Atlantic. (Duguy et al. 1983a; Beaubrun 1998). They range in size from the small common (Delphinus delphis) and striped (Stenella coeruleoalba) dolphins to large whales such as the sperm whale (Physeter catodon) and the fin whale (Balaenoptera physalus). In general, both the diversity and the abundance of cetaceans are higher in the western basin.

The state of conservation and the size of the different populations are highly variable, depending on species and regions. The striped dolphin is the most abundant cetacean species in the western Mediterranean, with an estimated population of 117,880 individuals in 1991 (Forcada et al. 1994; Bayed 1998). A study of the distribution of this population, however, revealed important geographic heterogeneities, often related to specific oceanographic conditions resulting in higher food availability (Forcada and Hammond 1998). The most important population is found in the north-west Mediterranean, in the Ligurian Sea and Provençal Basin (42 604 dolphins). The other outstanding area for the species, in terms of population density, is the Alboran Sea, especially its western part neighbouring the Strait of Gibraltar. The common dolphin, in contrast, has become increasingly rare in north-western Mediterranean waters since the early 70s; its population in the western Mediterranean is concentrated in the Alboran Sea (with a population estimated at 14 736 individuals in 1991-92). The coastal strip of Morocco and Algeria seem to be a particularly important area for the species (Bayet and Beaubrun 1987). Maximum concentrations of fin whale in the Mediterranean are again recorded in the Ligurian-Provençal Basin, where its summer population was estimated at 1,012 specimens in 1992 (Notarbartolo di Sciara 1994). There are probably only a few hundred sperm whales in the Mediterranean (Di Natale 1995). Other less abundant species include the Harbour porpoise (Phocoena phocoena), whose population outside the Black Sea has declined to the verge of extinction, though some sightings point to its presence off the North African coasts.

This variety of species of different sizes, displaying different life histories, together with the equally high diversity of gear and fishing practices found in the Mediterranean, lead to complex interactions between cetacean populations and fisheries. Stenella coeruleoalba, Delphinus delphis, Tursiops truncatus and Physeter macrocephalus are known to have frequent and various interactions with fishing fleets. These interactions are mainly reported in fisheries with driftnets and set nets and, to a lesser extent, purse seine. On the other hand, as many other predating species, dolphins are practically attracted by fish catching operations which are for them opportunities for feeding easily. Unfortunately, such practice may sometimes lead to deliberate killing of dolphins by fishermen irritated by the damage they may cause to their gear.

As for marine turtles and monk seals, a specific Action Plan for the Conservation of Cetaceans in the Mediterranean Sea was adopted under the auspices of the Barcelona

Convention in 1991. The reduction or depletion of food resources, incidental catches in fishing gears and deliberate killings are recognised as some of the most serious threats to cetaceans in the Mediterranean. The Action Plan called on all parties to adopt and implement legislation to prohibit the deliberate taking of cetaceans, the prohibition of driftnets longer than 2.5 km and the discarding of fishing gears at sea, and required the safe release of cetaceans caught accidentally. Contracting parties also agreed to promote the creation of a network of protected areas and marine sanctuaries in co-operation with RAC/SPA. The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) has been signed by 14 states. Among other measures, its conservation plan (Annex 2) envisages the implementing of measures to minimise the adverse effects of fisheries with an explicit emphasis on driftnets.

This section focuses on the most indisputable effects of fishing on the Mediterranean cetacean population. The issue of massive natural or pollution-related deaths, such as those of striped dolphins in the Mediterranean in the early 90s following viral epizootic events, is deliberately avoided since it falls outside the scope of this work.

Cetacean populations suffer principally from the direct mortality caused by fishing gear whilst small cetaceans also compete for the fish taken in nets; furthermore, fishermen deliberately kill dolphins to reduce the damage these inflict on their gear. The most significant issue (in terms of both quantitative incidence and potential effect on cetacean populations), however, is the mortality derived from fishing by-catches, which is largely due to drifnetting practices. Information on the different interactions between cetaceans and fisheries is given below, with emphasis on the specific features of different fishing practices related to cetacean mortality.

2.2.5.1. Driftnets impact

There is a general consensus about the high figures for cetacean by-catches and the very high mortality of individuals entangled in Mediterranean swordfish fisheries using driftnets. 37 cetaceans were caught in the Ligurian Sea in the summer of 1988 alone (Podestà and Magnaghi 1989). Di Natale (1995) studied the activity of the Italian driftnet fleet operating there and in the Tyrrhenian Sea in the early 90s (1990-92). On-board monitoring of 100 commercial trips revealed the entanglement of 15 cetaceans 13 striped dolphins, one Cuvier's beaked whale (Ziphius cavirostris) and one pilot whale (Globicephala melaena); only two animals could be released alive. The estimated catch rate was much higher in the Ligurian Sea (0.29 cetaceans per fishing day and vessel, against 0.08 in the Tyrrhenian Sea). In the Ligurian Sea again, 35 fishing operations alone harvesting 144 swordfish accounted for by-catches of 10 cetaceans belonging to 3 different species (Di Natale et al. 1992). These high incidental captures of marine mammals, related to the important numbers of cetaceans in the area, led in 1992 to a driftnet-free "Santuario dei Cetacei" in the Ligurian Sea waters being established.

An estimated 1,682 cetaceans were taken by the whole Italian driftnet fishery in 1991 (Di Natale 1995), including 1,363 striped dolphins 132 pilot whales, 62 other delphinids, 79 Risso's dolphins (Grampus griseus), 35 bottlenose dolphins (Tursiops truncatus), 8 sperm whales 2 Cuvier's beaked whales and 1 fin whale. The fishing effort of this fleet was concentrated mainly in the Tyrrhenian and Sardinian Seas during 1990-91, and an estimated 946 striped dolphins were captured there. The author concluded from these figures that the most impacted species appeared to be the striped dolphin, the sperm whale, the pilot whale and Risso's dolphin. Other studies on the impact of the Italian driftnet fishery confirm these high figures for cetacean by-catches, even pointing to the capture of species uncommon in

Mediterranean waters, such as the minke whale (Balaenoptera acutorostrata) (Di Natale and Mangano 1981).

Other authors confirm that sperm whales are especially impacted by driftnets in the Mediterranean waters. A study of stranded animals found on Italian coasts (Nortarbartolo de Sciara 1989, cited in Aguilar et al. 1991) attributed the death of 24 sperm whales and 126 other cetaceans between 1986-89 to driftnets. 20 sperm whales were recorded caught by Italian driftnet boats between 1978 and 1982 (Di Natale and Mangano 1983), leading the authors to state that 'the incidence of human activities on the mortality of the sperm whale in the Italian seas is very high'. The high incidence of sperm whales stranded on the Spanish Iberian and Balearic coasts showing signs of entanglement in Italian driftnets (12 individuals from May 1993 to June 1994, most of them calves, of which only 3 could be released alive; University of Barcelona 1995) suggests that this problem applies wherever driftnet fleets operate.

The Italian driftnet fleets, although important, are not the only ones operating in the Mediterranean, as described in some detail in Section 2.4 of this report. The relative impact of other poorly monitored fleets on cetacean populations is likely to be of a similar order. Minke whales are known to have been driftnet victims in North African waters (Ktari-Chakroun 1980) and dolphins and perhaps even harbour porpoises are by-catch victims in current illegal driftnet fishing off Algeria (A. Nouar, pers. comm.). The Moroccan driftnet fleet probably has a very high impact on common and striped dolphin populations. Whereas both species are particularly abundant in the Alboran Sea (Forcada and Hammond 1998), the common dolphin population there is the most important in the whole of the western Mediterranean. North African waters are also the last home of the harbour porpoise in the Mediterranean (excluding the Black Sea). Silvani et al. (1999) reported on the Spanish driftnet fleet operating until 1994 in these Alboran Sea waters and their study is of particular interest given the absence of specific information on the incidental catches by the Moroccan fleet. The Spanish fleet was composed of 27 boat and worked in areas of high concentrations of both dolphin species. Mortality for the two species combined was estimated at 366 individuals in 1993 and 289 in 1994, with approximately equal numbers for each species. Almost all were already dead when brought on board. The resulting by-catch rate of dolphins was 0.1 individuals per km of net set per fishing operation. Most of the common dolphins caught were extremely young calves and the majority of striped dolphins were juveniles; being less experienced, younger animals are more likely to get entangled in driftnets than adults. Similar figures probably obtain for the important Moroccan driftnet fishery.

Current mortality levels for striped dolphins in the Mediterranean have been considered potentially unsustainable by the International Whaling Commission (IWC 1994). Incidental catches of common dolphins in the Alboran Sea and Strait of Gibraltar may have caused a significant decline in numbers (Forcada and Hammond 1998). On the other hand, the peculiar head shape of the sperm whale seems to make this species especially prone to entanglement in driftnets. The recorded or estimated rates of incidental catches are of special concern given its small Mediterranean population (probably a few hundred individuals).

2.2.5.2. Purse seines impact

Fishing for bluefin tuna by local purse seine fleets in Mediterranean waters doesn't, as a general rule, involve the practice of setting nets around cetaceans, in contrast to the well-known case of the yellowfin purse seine fishery in the eastern tropical Pacific Ocean (Donahue and Edwards 1996). Subsequently, the information available for the Mediterranean seems to confirm that dolphins are not being massively caught in purse seine operations directed at tuna. Interviews with fishermen in the small Spanish tuna fleet in the Mediterranean suggest very few dolphin catches (estimated at 6 individuals each year, all of them being released alive; University of Barcelona 1995). Fishermen from other fleets in the area, on the contrary, claim that dolphin catches by this tuna purse seine fleet are sizeable. Some reports point to occasional catches in other Mediterranean regions. Di Natale (1983a) reported the capture of 21 striped dolphins in two separate incidents in the Ligurian Sea involving tuna purse seine nets. Magnaghi and Podesta (1987) reported another incidental capture of 8 striped dolphins in the same area, off San Remo in the Ligurian Sea. Tuna purse seiners have also been reported to catch pilot whales and other delphinidae sporadically (Di Natale 1990).

The activity of the more widespread purse seine fleets targeting small pelagic fish in the Mediterranean does not seem to lead to the high dolphin mortalities caused by driftnets (Silvani et al. 1992; Di Natale 1990), although Aguilar et al. (1991) described frequent accidental by-catches of common and stripped dolphins by purse seiners off the coasts of southern Spain, southern Italy and northern Africa (see Box 5).

BOX 5

Purse seine: a major threat to the survival of dolphin populations

The Spanish purse seine fleet targeting small pelagic species (sardine and anchovy) in the Alboran Sea appears to be especially impacting on dolphin populations: a field study conducted under an EU-funded project yielded a related estimated mortality of about 300 dolphins annually, the majority of them common dolphins. This Spanish purse seine fleet, however, may catch as many as 5,700 individuals annually, though the majority of these are released alive. This dolphin by-catch is exceptionally high in the context of Spanish purse seine fleets in the Mediterranean, an exceptionality that has been explained by the disappearance or strong decline of common dolphins, the most abundant small cetacean in inshore waters, along the rest of the Spanish Mediterranean coast. Striped dolphin, much less abundant than common dolphin in shelf waters, are less likely to interact with coastal fisheries, though estimations indicate that a further 100 striped dolphins might perish annually in the Spanish purse seine fishery in Catalonia and the Golfe du Lion .

Source: University of Barcelona 1995.

2.2.5.3. Other gear impact

A 5-year field survey in Italian waters around the Pontino Campano archipelago (Southern Tyrrhenian Sea) revealed that local cetacean populations interacted with several gear for trophic purposes (Mussi et al. 1998). Striped dolphins, Risso's dolphins, long-finned pilot whales and sperm whales were observed taking advantage of the squid fishery using illuminated handlines by preying on the squids attracted by the lights. Striped and bottlenose dolphins also fed opportunistically around and in trawl nets, especially at the end of the haul. Bottlenose dolphins were also observed feeding on the bottom gillnets set by artisanal fishermen around the islands of Ventonene and Ischia, and ripping them badly. Catalan fishermen report dolphins feeding around trawl nets and preying on fish caught in trammel nets.

Reports on incidental captures point to the entanglement of sperm whales, Risso's dolphins, common dolphins and bottlenose dolphins in artisanal fixed nets (gillnets and trammel nets) (Di Natale and Mangano 1983; Di Natale 1983bc; Duguy et al. 1983b). Duguy et al. refer to striped, common and bottlenose dolphins and a few fin whales incidentally caught by trawlers off France and Italy, and to striped dolphin, false killer whale (Pseudorca crassidens), Risso's dolphin, and fin and sperm whale killed by surface longlines in Italian and Spanish waters. More recently, Mussi et al. (1998) referred to the case of another sperm whale found entangled in a surface longline in southern Tyrrhenian waters. The Spanish surface longline fleet operating in the Mediterranean is estimated to entangle between 12 to 32 cetaceans a year, mostly common and striped dolphins and pilot whales. With an estimated mortality rate of 10% 1 to 3 individuals would be killed yearly (University of Barcelona 1995). Other less common gears might also involve the incidental capture of cetaceans, as shown by the sporadic records of killer whales entering tuna traps and then being killed by fishermen off southern Spain (University of Barcelona 1995). Di Natale and Mangano (1983) also reported the killing by explosives of a sperm whale in Italian waters.

The pilot whale (Globicephala melas) one of the species of cetaceans of the Mediterranean sea.
A wide variety of interactions exists between cetacean populations and fishing fleets in the Mediterranean.
G.TORCHIA

2.2.5.4. Other fishing-related interactions

Human consumption of dolphin meat in the Mediterranean (as in some Italian and Spanish localities; Aguilar et al. 1991) has been recorded, though it is far from being common or usual. Conversely, the deliberate killing of cetaceans, mostly dolphins, appears to be closely related to fisheries in one way or another. Dolphins, especially bottlenose dolphins, are considered as a pest by artisanal fishermen in many parts of the Mediterranean and blamed for the destruction of nets (gillnets or trammel nets) when preying on trapped fish. Aguilar et al. (1991) confirm that bottlenose dolphins often destroy trammel nets; Greek, Turkish (Cilician Basin) and Balearic small-scale fishermen are annoyed by the costs associated with damage to gear caused by dolphins (Northridge and Pillery 1985; Yediler and Gücü 1997; M. Gazo, pers. comm.). The only significant conflict involving small-scale fisheries and dolphins along the entire Spanish Mediterranean coast is in the Balearic Islands, home to the largest bottlenose dolphin population in the region: important damage to trammel nets and gillnets has been reported. An estimated 30 bottlenose dolphins die every year, most of them deliberately killed by Balearic fishermen (though a few deaths result from incidental entanglements), a rate that may not be sustainable given the reduced population there (estimated at only a few hundred) (University of Barcelona 1995). Fishermen have also killed large numbers of cetaceans in Malta (Aguilar et al. 1991) and there are records of dolphins stranded in Italy showing signs of having been killed by fishermen (Anonymous 1987). Duguy et al. (1983b) reported that shooting was one of the main causes of common and bottlenose dolphin mortality in French waters, the latter being the most conflictual species.

The use of dolphin meat as bait for fishing gear, for example in the Andalusian ports of Garrucha and Algeciras in the Alboran Sea (Aguilar et al. 1991; University of Barcelona 1995) is yet another fishing-related interaction that contributes to cetacean mortality. Dolphin meat appears to be particularly suitable for shrimp fishing with traps. An estimated 180-260 dolphins (common and striped) are killed illegally every year for this purpose (University of Barcelona 1995). Dynamite fishing, quite a common illegal practice in some places, inhibits the normal feeding behaviour of the bottlenose dolphin in Lebanese waters (Evans 1987). The use of dynamite in purse seine fishing (to push small pelagic shoals upwards) is currently practised off Algeria (A. Nouar, pers. comm.) and probably in many other waters.

CONCLUSION

The information available describes a wide variety of interactions between cetacean populations and fishing fleets in the Mediterranean, involving almost every kind of major fishing gears commonly in use. However, driftnet fisheries and, to a much lesser extent, small-scale fisheries using fixed nets and purse seine fisheries appear to account for the highest impact and are also responsible for the highest rates of direct human-induced marine mammal mortality.

Driftnet fisheries are clearly inherently harmful to cetacean populations, and a major factor of direct mortality in Mediterranean waters. As described in detail in Section 2.4, a sizeable international fleet still operates in the Mediterranean, although the current provisions of the United Nations, the European Union and the General Fisheries Commission for the Mediterranean call for the limiting or even the eradicating of this fishing practice. The disappearance of driftnet fleets from the Mediterranean is the most desirable option, but even immediate short-term measures limiting this practice in the most sensitive areas would be a useful interim measure. In 1999 the Governments of France, Italy, and Monaco jointly declared the creation of a 100,000-sq. km whale sanctuary in the Ligurian Sea, the first example of an international marine protected area in the northern hemisphere. Driftnetting will be totally banned there in the near future. The Alboran Sea and the waters off the North African coasts urgently need and would benefit from similar measures. Their outstanding importance for cetacean populations (including the biggest common dolphin population in the western Mediterranean), and the existence of rapidly-growing driftnet fleets (whose impact is totally unknown), are reason enough for implementing precautionary conservation measures. Striped dolphin by-catches by Italian driftnets in Balearic waters, where the population appears to be low, are also a matter of concern, as is the current fishing-induced sperm whale mortality rate; this species particularly would benefit greatly from measures restricting driftnet fishing.

Fishermen in small-scale fisheries need to be encouraged and motivated not to kill dolphins. A pilot project on the use of acoustic devices or pingers to prevent dolphin predation from nets is about to begin in Balearic waters, organised by the University of Barcelona with the support of the Balearic government and fishermen's associations (M. Gazo, pers. comm.). Overfishing here may increase the dolphin pressure on fishing nets, as happens with the monk seal in Greek and Turkish waters. More systemic approaches focussing on rebuilding the degraded ecosystems could benefit both fishermen and cetacean populations directly. Among other management measures, the effective enforcement of dynamite fishing bans once more appears to be necessary for the conservation of cetaceans (mostly dolphins) in some Mediterranean areas. Solutions to local conflicts, such as putting an end to the illegal use of dolphin meat as bait in two Spanish ports, need immediate attention.

Adequate monitoring of the fleets in the recently rapidly-growing Mediterranean tuna purse seine fishery is advisable to ensure that its activity doesn't unduly affect dolphin populations. The most important fleets, such as the French one, responsible for massive tuna catches need watching most closely. The results of inquiries in the Spanish ports referred to above suggest that monitoring the activity of other Mediterranean purse seine fleets that target small pelagic fish, especially in areas with important common dolphin populations, the species potentially more vulnerable to this fishery (i.e. those operating in North African coasts) is necessary. The University of Barcelona (1995) has also pointed out that the potential impact of mid-water pelagic trawling for small pelagics on cetacean populations by a French fleet in the Golfe du Lion and in other Mediterranean areas (i.e. Italy) should be assessed.

It is arguable whether the lack of significant interactions between cetaceans and fisheries in some Mediterranean regions is due to the very reduced populations there, or to low-impact fishing practices. Purse seine fleets have been reported as having a significant impact on the common dolphin in the western Mediterranean only in the Alboran Sea, where the biggest population lives. Conflicts between artisanal fisheries and bottlenose dolphins are also limited to areas with the highest populations of the species, such as the Balearic waters. Conservation policies focusing on the recovery of cetacean populations should probably take into account the potential fishing interactions that might eventually emerge, thus simultaneously tackling the issue of responsible fisheries. Educational programmes for fishermen, focusing on building awareness of cetacean conservation and providing them with basic guidelines on how to reduce both cetacean by-catches and mortality, are essential.

2.2.6. Pinnipedian interactions

The Mediterranean monk seal (Monachus monachus) is a highly endangered species whose distribution has shrunk considerably over the last decades. It is the world's most endangered phocid seal. The bulk of the world population (about 380-500 individuals) is currently limited to only two nuclei, one in the eastern Mediterranean and the other in the north-east Atlantic, off the coast of north-west Africa, being 246-300 seals bcated in Greece (Cebrian 1998a).
The seal is listed as critically endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN) and is also included in Appendix I of the Convention on International Trade in Endangered Species (CITES).

Monachus monachus : This Mediterranean monk seal is a highly endangered. D. Cebrian

It is also covered by the UNEP Bonn Convention on Migratory Species and the Bern Convention on the Conservation of European Wildlife and Natural Habitats. An Action Plan for the Management of the Mediterranean Monk Seal was adopted in 1987, launched under the Barcelona Convention.

All studies report that the Mediterranean monk seal population, consisting of only a few scattered groups of individuals breeding in the last isolated, undisturbed caves, is suffering a rapid decline. Two thirds of the world's largest surviving population, located on the Côte des Phoques in the Western Sahara, died off in 1997, victim of an epidemic. The remaining seals are extremely vulnerable and all evidence points to fishing as one of the main agents pushing the species to the brink of extinction, especially in the case of the eastern Mediterranean population (Cebrian et al. 1995; Johnson and Lavigne 1998). These are shallow-water-divers and their deepest dives are not usually more than 100 m. These seals feed on fish, octopus and shellfish. With deliberated killing by fishermen as main cause of mortality, entanglement in bottom set nets appear to be for monk seal an important cause of incidental death by drowning (Cebrian et al. 1995). Illegal practice of explosive fishing, as recently reported in Greek and Turkish waters, is also a cause of lethal injury (Cebrian et al. 1995 ; Anonymous 1999).

2.2.6.1. Entanglement

The impact of fishing practices on monk seal population has a largely twofold origin: direct mortality caused by incidental entanglement in fishing gear and deliberate killing by fishermen, and food scarcity related to the overfishing and subsequent depletion of fish populations. It has been argued that trophic limitation triggered by overfishing encourages seals to prey more heavily on fish entrapped in nets, thus increasing the interaction between seals and gear (and fishermen) (Boudouresque & Lefevre 1991). Tourism, resulting in a rising seasonal demand for fish, would increase seal attacks on nets and the subsequent mortality associated with entanglements and deliberate killing (Panou et al. 1993; Karavellas 1994). However, a long-term research on the matter establish that heavy interaction is provoked by proximity of net setting to seal caves, the energetic contribution of netted fish to the seal diet being negligible. Hence, the very spread above arguments, not supported by quantified results, is not ecologically valid so far (Cebrian 1998a)

Johnson and Karamanlidis (2000) include a review of how monk seals get trapped in fishing gear, partially included among the following lines. Monk seals may get entangled and drown in fishing nets more often than is generally assumed; although the analysis of historical records shows that seals can be injured by many kinds of fishing gear, including purse seiners (Cebrian et al. 1995; Kiraç and Savas 1996; Cebrian 1998a) and longlines (Cebrian 1998a), they appear to be more vulnerable to static gear (static nets set on the bottom) and abandoned nets (ghost fishing effect). As many as 23% of seal deaths recorded in the Greek Ionian Islands were due to entanglement (Panou et al. 1993). The figures for the whole Greek seas give a figure of 21% (Cebrian 1998a), Berkes et al. (1979), Kiraç and Savas (1996) and Yediler and Gücü (1997) report a total 38 seal deaths between 1965 and 1994 in Mediterranean and Turkish Black Sea waters, 8 of them due to drowning by entanglement in nets 16 killed by fishermen (1 of them as a result of dynamite fishing) and another 11 killed by dolphin hunters. Entanglement also appears to be a major mortality factor in Moroccan waters, and responsible for 27 of the 40 seal deaths (67.5%) reported during the 80s (Anonymous 1990).

Incidental entanglement as an agent of extinction is exemplified in the small colony inhabiting the cave known as the Grotta del Bue Marino, in the Tyrrhenian Island of Gorgona: all 8 specimens perished entangled in the nets of a local fisherman during the 1980s (Guarrera 1999). A differential vulnerability to entanglement in nets has been suggested for adult and young monk seals in the Cilician Basin, off Turkey (Yediler and Gücü 1997). Whereas the trammel and gill nets used there may not be strong enough to trap adults, four pups were found entangled in fishing nets during a five-year period (Anonymous 1999a). Abandoned nets have caused significant seal mortality in the small population inhabiting the Desertas Is. in the Atlantic (Anselin and van der Elst 1988).

2.2.6.2. Intentional killing by fishermen

The analysis of the 130 monk seal deaths recorded in the last 10 years carried out by the NGO MOm (Anonymous 1999b) shows that deliberate killing is the major direct threat to adult monk seals. According to Cebrian et al. (1995) incidence of killings on the species decreased in Greece after the country joined the E.U. in 1981 and its legal protection was granted by European laws. Killings significantly decreased from 80% to 47% after legal protection, in a sample of 107 seals, but are still unsustainable for the species. The annual incidence of killing by man in Greece is between 4,3% and 5,5%. Killing by man alone, without considering other causes, is enough to vanish the species from Greece in less than 33 years, according to population dynamic models (Cebrian 1998a).

Seals are perceived as a nuisance in many places, as in the Cilician Basin, and are ranked high among pests, together with dolphins and turtles, by fishermen because of the netted fish the seals consume and the damage they cause to the nets (Yediler and Gücü 1997). Seals can reduce nets to shreds, often leaving a characteristic three-hole pattern (Berkes 1982) (see Box 6).

Three main actors seem to play a role in the interaction between seals and fisheries, namely small-scale fisheries, medium-scale fisheries (trawlers and purse seiners) and seals. Whilst the conflictive relationships between fishing and seals are limited mainly to small-scale fleets using nets, medium-scale fleets worsen the situation because they are largely responsible for the overexploitation of fishing grounds. Illegal fishing by trawler fleets within the 3-mile coastal limit reserved for artisanal fleets, as reported for the Cilician Basin waters where a small monk seal population is found along the Anatolian coasts (Oztürk 1992), is also common. Overfishing exacerbates the conflict between small-scale fishermen and monk seals, because the reduction on catch along the last years make any eventual interaction (seals, dolphins, moray eels, etc) more severe to the fisher economy (Cebrian et al. 1995). Particularly destructive fishing practices also affect seals: illegal dynamite fishing in Kefallonia contributes to the scarcity of resources for the local monk seal population. Johnson and Karamanlidis (2000) also refer to fishing with chemicals and the capture of small fry for aquaculture seed as negative harvesting practices that threaten fish resources in the monk seal's range in the eastern Mediterranean.

The illegal but widespread practice of dynamite fishing has an overall negative effect on the ecosystem as mentioned above, and injures and kills monk seals directly; several deaths, some of them very recent, due to this practice have been reported in Greek and Turkish waters (Cebrian and Vlachoutsikou 1991; Cebrian et al. 1995; Anonymous 1999b).

BOX 6

The deliberate killing of monk seal: a common practice in the Mediterranean

Studies carried out in the Ionian Sea showed that the gear most damaged by seals were, in order of importance, inshore trammel nets, offshore trammel nets and gillnets; bottom longlines were much less affected. Fishermen report that seals attack nets mostly within 20-30 m of the surface (Cebrian 1998a). Deliberate killing of monk seals is a common practice in most of its range, and may have a considerable local impact: six individuals were killed in the Aydincik region (Cilician coast, Turkey) in 1994 alone. Sooting played an important role on its extinction in some areas of Croatia (Cebrian 1995). In general, fishermen's attitudes to monk seals depend on the extent to which they perceive fishing as a capital-intensive economic activity. Thus many fishermen in the Aegean Sea believe that killing seals brings bad luck whilst younger fishermen who have invested heavily in fishing equipment seem to display the most aggressive, even cruel behaviour (Yediler and Gücü 1997). In this context, it is worth mentioning that the length of net per fisherman increased by 5 along the coast off south-west Turkey between 1950 and 1980 (Berkes 1982) and a similar phenomenon was recorded in Greece (Cebrian et al. 1995). Depletion of fishing resources by fisheries in Sporades Marine Park, Greece has been mentioned as a problem of concern for the species in the area (Cebrian & Anagnostopoulou 1995). Aquaculture exploitations are also related to the deliberate killing of monk seals, at least in the Bodrum peninsula, Turkey, and the Dodecanese, Greece (Cebrian 1998b), and exacerbate the impact of small-scale fishermen. Aquaculture businesses apparently prefer to shoot seals rather than set predator nets that limit the damage seals can cause because it is cheaper to do so.

Sources: Panou et al. 1993; Cebrian 1995; Cebrian & Anagnostopoulou 1995; Cebrian et al. 1995; Yediler and Gücü 1997; Berkes 1982; Cebrian 1998a; Cebrian 1998b; Anonymous 1999 b; Johnson and Karamanlidis 2000.

CONCLUSION

According to population dynamic models, net-related mortality is enough itself to cause the seal extinction in the Mediterranean (Cebrian 1998a). Given the critical status of the Mediterranean monk seal remnant population, the only acceptable level of fishing-related mortality in the region is 0. Actions must be taken to prevent deliberate killings by fishermen and incidental entanglements in nets and to manage fisheries so as to prevent overfishing and rebuild depleted food resources (Johnson and Karamanlidis 2000). The participation of small-scale fishermen appears to be essential.

Initiatives undertaken in recent years suggest that an integrated approach, comprising the protection of ecosystems through marine protected areas and the involvement of local artisanal fishermen, is likely to be most effective; this includes increasing artisanal fishermen's awareness that they themselves, as well as the seals, are victims of the overfishing driven by commercial fisheries, mostly by medium-scale fleets.

The financial compensation of fishermen affected by seal attacks in the way of direct cash reparation is considered by scholars, after sociological studies, a waste of money; being mandatory gear insurances and participative shoals conservation much more effective measure to be implemented (Cebrian et al. 1995; Cebrian and Anagnostopoulou 1995). It appears also necessary to address information campaigns to destroy negative myths about seals. One such myth is that the wild seal population consumes a huge amount of fish; in fact, the entire Greek Aegean monk seal population existing twenty years ago was estimated to consume 750 kg of fish daily (Ronald 1984). Even more remarkable is the myth that they take much fish from nets. Cebrian (1998a) estimated that a Greek seal population of 18 individuals was taking much less than 19,4 Kg of fish from nets by month, year around. This is hardly 1 Kg/month by seal.

SAD-AFA's Central Aegean Programme started in 1992 as the Foça Pilot Project, operating in association with the local community and the Turkish Ministry of the Environment, and covers the NW corner of the Bay of Izmir. Industrial fishing is prohibited there and the data suggests that the project is succeeding in its goal of recovering fish stocks (Johnson and Karamanlidis 2000). Implementing more restrictive measures such as banning small fry fishing for aquaculture seed or the seasonal prohibition of the lampara fishery in the Bay of Izmir is still a priority. In the context of the Cilician Basin Project, the Turkish Ministry of Agriculture has banned all types of trawl and purse seine fishing in 15 square miles covering seal habitats. Small areas surrounding breeding caves have special protection as no-fishing zones. Other technical measures such as the improvement of fishing nets and the development of techniques for repelling seals from fishing equipment are envisaged by that Action Plan for the Management of the Mediterranean Monk Seal.

To sum up, whereas some specific measures such as the enforcement of current regulations banning dynamite fishing and other highly damaging fishing practices known to affect monk seals should clearly be undertaken, the overall problem of monk seal conservation in the Mediterranean is clearly related to the sustainable management of entire marine ecosystems, in which monk seals are apex predators. Marine reserves, no-fishing zones and the involvement of artisanal fishermen--including educational programmes--are fundamental tools in ecosystem-based fisheries management.

3.Assessment of the impact of the main fishing techniques

The effects of fishing on ecosystem are due both to the technical characteristics of the fishing gears and to fishing practices. More than 45 fishing techniques are used within the Mediterranean fisheries. A distinction is made between active and passive fishing methods. This distinction provides all its meaning when potential impact of fishing gears is considered.

Schematically, when active fishing methods are used, the displacement of the gear allow to catch animals which are not enough able to flee away, while, with passive fishing methods, the catch opportunities depend on natural or induced displacements of the prey.

The first category includes two main methods: encircling fish or towing a gear.

Encircling obviously consists in encircling a school of fish by a large net specifically designed for it. This method is employed in several Mediterranean fisheries, in various forms, the most common being purse seining.

The second method refers to the towing of fishing gears, in mid-water or on the bottom, by hand or by the means of one or two vessels. Dredging and trawling (with beam trawls, otter trawls or pair trawls) belong to this category and there are various types of these among the common Mediterranean fishing techniques.

Mostly used in Mediterranean Sea in small-scale fisheries, the passive fishing methods, making the second category, include the utilisation of a lot of gears, pots and traps, set nets, drift-nets and lines. Those considered as the most impacting are set nets, driftnets and longlines.

However, it is worth observing that the above-mentioned distinctions or classifications are theoretical and that the large diversity of the fishing practices in the Mediterranean Sea facilitates neither the definition nor the management of each fishing technique.

3.1.Trawling

Trawls are schematically nets of conical form, the aperture of which is maintained, vertically, by floats and ballast, horizontally, by the use of divergent board ("otter-board"), a horizontal beam or the traction, side by side, of two vessels. In the Mediterranean Sea, the three types exist: otter trawls, beam trawls and pair trawls.

The effectiveness of the gears on the resource globally depends on dimensions of the opening of the conical net and on its ability to retain the preys in the aft part (selectivity). The impact on ecosystem also includes for bottom trawls a physical impact on the seabed in particular due to all the rigging devices.

3.1.1. Otter bottom trawling

Regarding bottom trawling in Mediterranean Sea, two main types of gears can be distinguished:

- Two panels/faces trawls which normally fit to the capture of benthic animals living close to the bottom as flatfish, red mullet, shrimp, in particular but also demersal fishes as hake. Most of the traditional Mediterranean trawls belong to this type, including the Italian "volantina" or the Spanish "huelvano", with a vertical opening which, in general, does not exceed 2 meters while, new models of two faces trawls allow higher vertical opening reaching up to 5 meters; such trawls are sometimes known as "semi-pelagic" trawl or "rete franchese";

- Four panels/faces trawls have normally very high vertical opening commonly reaching 20 to 25 m; these trawls are mostly used for catching mid-water/pelagic species but also when used near the bottom, demersal fishes.

Both types use mainly doors for the horizontal opening except when the gear is towed by two vessels (pair-trawlers). Furthermore, their bag/codend should have, in principle, a meshsize according to local legislation.

Bottom trawling fleets predominate in many Mediterranean fisheries, being responsible for a high share of total catch and, in many cases, yielding the highest earnings among all the fishing sub-sectors. The high profitability of this fishing practice is largely due to its low selectivity with respect to sizes and species caught, and to the high harvests generated. Bottom trawling production in the Mediterranean Sea is essentially multi-specific. Mono-specific trawl fisheries are very rare and, practically, limited to deep shrimp trawl fisheries or mid-water fisheries targeting small pelagic fishes. Trawlers have dramatic effects on the ecosystem, including physical damage to the seabed and the degradation of associated communities, the overfishing of demersal resources, and the changes in the structure and functioning of marine ecosystems derived from the depletion of populations and the huge amount of by-catches and associated discards (Bottom trawling is frequently blamed for being the main source of discards).

3.1.1.1. Size selectivity on commercial species

Undersized fishes

The high marketability of small fish in many countries encourages the targeting of the juvenile fraction of some species, often in violation of laws regarding minimum sizes. Demersal populations are consequently overfished, shallow areas (within the 3-mile coastal limit or on bottoms less than 50 m deep, depending on the country) are illegally trawled and small, illegal mesh sizes are used.

The use of small and illegal mesh sizes in codend is certainly a common practice for many artisan fisheries but poorly reported in the literature. For example, though the UE regulation impose a minimum codend mesh size of 40 mm, the mesh size that is used in the commercial bottom trawl fishery in Greece is 28 mm. On the other hand, the codend mesh size of the French mid-water trawls used theoretically for small pelagic fish, is 24 mm but the gear may be use during a day trip to catch also hake

Because of the traditional large interest for small fishes, massive catches of undersized fish are seasonally carried out in some bottom trawl fisheries as for example the well-known massive harvest of undersized red mullet, which are caught on shallow grounds in autumn in the gulf of Lions or in the Adriatic Sea.

One important reason is the choice of too small mesh size codend. In the Ligurian Sea, mesh size currently used for red mullet (Mullus barbatus) defines a length of first capture smaller than the legal size. (Voltani and Abella 2001).

In most fisheries, the bulk of trawler catch for hake is of length size smaller than at first maturity. The use of 28 mm mesh size codend in commercial bottom trawl fishery in Greece results in catch of significant quantities of juveniles of commercial species; these are either discarded or illegally landed (as for hake). The recent increase of mesh size from 28 to 40 mm is said not having practically changed the length at first capture (Karlou-Riga and Vrantzas 2001).

Resources in hake of the gulf of Lion constitute a shared stock between a composed French-Spanish fleet of trawlers, gillnetters and longliners. Data from the late 80s clearly shows that the trawling fishery exploited the juvenile fraction of the population since the mean size of catches was only 17.9 cm, which strongly contrasted with the 48.2 cm corresponding to longline catches (Lleonart 1990). While the stock is far to produce its optimal biologic output, it does not seem to be overexploited, in spite of a high fishing mortality rate for juveniles.

According to Papaconstantinou and Labropoulou (2000) young hake are concentrated in waters of less of 200 m deep in the Aegean Sea. Surveys conducted in waters deeper than 500 m in the Ionian Sea suggest that bottom trawling at these depths would not harm the hake population because the catch consists of large commercial specimen.

The discards in Mediterranean bottom trawl fisheries lower selectivity are very significant.
Relini © RAC/SPA

3.1.1.2. Quantification of discarding in Mediterranean bottom trawl fisheries

Information on discards in Mediterranean trawl fisheries confirms the magnitude of the problem According to different observations in several Mediterranean fisheries, trawling is responsible for the bulk of the discards (Carbonell et al. 1997; Stergiou et al. 1998). Discards in Mediterranean trawl fisheries for demersal species vary considerably in amount and composition, depending on ecological (season, bottom type and depth), technical (gear and fishing operation), economic (glutting of markets in low value species) and legal constraints (fish size regulation) (see Box 7).

High discard levels have been reported for many Mediterranean trawl fisheries. Total annual discards in Sicily during the 80s were estimated at around 70,000 t, accounting for an average of 44-72% of catch (Charbonnier 1990). The monitoring of fleets operating in three major Greek fishing grounds (Ionian Sea, Cyclades Islands and Thracian Sea) in 1988-97 yielded discard estimations of 40%, 55% and 25% of the total catch of fish, crustaceans and cephalopods, respectively (Machias et al. 1999). Field studies carried out in 1995 showed that the fraction discarded by the trawl fleet operating in the Cyclades area, in the Aegean Sea, amounted to 59% of the total catch in bottoms less than 150 m deep, 63% in bottoms 150-200 m deep, and 37% in grounds deeper than 300m (Vassilopoulou and Papaconstantinou 1998). On the whole, discards in the Hellenic commercial trawl fishery are estimated to account for 45% of total catch (Stergiou et al. 1998). The 'rapido' beam trawler fleet (56 units) based in Chioggia in the Adriatic Sea produces qualitatively heterogeneous discards depending on the species target. Whilst pectinid fishing involves the exploitation of sandy bottoms offshore and discards consist of echinoderms (32% in weight), crustaceans (26%), molluscs (23%) and porifers (15%), flat-fish fishing is carried out on muddy coastal areas, where molluscs and crustaceans account for the bulk of discards (60% and 30%, respectively).

Trends of developing deep-water fisheries are increasing in several countries in the Mediterranean Sea. Italy, Greece, Spain are particularly concerned by this development (Gordon et al. 1998). In these fisheries, data provided by enquiries on commercial vessels landings or experimental survey carried out in European countries, show sometimes high discard levels, concerning both commercial and no-commercial species (see Box 8)

Surveys carried out in the Ionian Sea showed that discarding may be more important in deeper waters because of the catch of larger quantities of non-commercial fish; discarding amounting to 56.2 to 76.9 % were found when fishing on 300 – 750 m deep (Tursi A. et al. in Gordon et al. 1998)

In Spain, the slope bottoms of Catalan coasts and Baleaaric islands are exploited by trawlers targeting red shrimp (Aristeus antennatus) and Norway lobster (Nephrops norvegicus). Sampling on board of trawlers fleet off Alicante operating on the upper slope (230-611 m) give 94 % of species discarded representing 34.6% of the total catch (Soriano and Sánchez-Lizaso 2000). The low selectivity of trawling is highlighted by data from this fishery showing that up to 95 species are taken; 12 of these account themselves for nearly 89% of the total, and 89 of them are dscarded. In the Balearic islands, for the fishery, working at 280-720 m deep, discards average 42 % of the total catch, (Moranta et al. 2000). 66% of discards of these deep-sea crustacean fisheries correspond to undersized marketable species. Longer tows, to compensate for the reduced biomass, seem to result in lower selectivity by the mesh and higher discard rates.

BOX 7

Western Mediterranean bottom trawl fisheries: a high magnitude of discards

The first regional study addressing the magnitude of discards in the western Mediterranean involved the monitoring of fishing fleets in 7 ports (6 Spanish and 1 Italian). Combined data gave discard estimations ranging from 23-67% of total catch in bottoms less than 150 m deep 13-62% in bottoms 150 to 350 m deep and 14-43% in slope bottoms deeper than 350 m. Data from a single locality, the Catalan port of Vilanova i la Geltru (north-west Mediterranean), illustrates this high quantitative variability. Monitoring of the fleet there revealed that the annual average of discards ranged between 13% and 39% of the total catch for small boats (< 150 hp) and between 17% and 48% for larger boats (> 150 hp), depending on the depths exploited. The amount discarded, however, peaked at 75.4% and 66.6%, respectively, in the case of larger boats operating in spring and smaller ones operating in the summer on shelf bottoms (< 150-m depth).

Sources: Carbonell 1997; Carbonell et al. 1998.

Discarding can also involve important commercial species, especially smallest size classes (See Box 8). Although a proportion of discards in Mediterranean trawling fisheries may survive, there is little helpful data on which to base quantitative estimates. Observations derived from experiments on aquaria carried out on board point to the low mortality of crustaceans caught as a by-catch in Catalan trawl fisheries, whereas survival rates of fish are highly heterogeneous and vary strongly according to the species (i.e. 0% for Trachurus spp. and 100% in Scyliorhinus canicula) (Sanchez 2000).

Another study of by-catch survival in the 'rapido' fleet operating in the northern Adriatic showed low mortality in all taxa examined during the three to four hours following capture (Pranovi et al. 1999).

3.1.1.3. Impact of discards on demersal ecosystems

The impact of discards goes far beyond single-species demographic effects, since discarded biomass can alter ecosystem structure by favouring scavengers (Moranta et al. 2000). The consequences of the fishing-driven increase in food supply stemming from discards have seldom been addressed by specific studies.

The only work dealing with this issue in the Mediterranean is based on photographic surveys carried out off the Catalan coast in the north-western Mediterranean, and focuses on the estimation of the consumption rate of fishery discards by scavengers (Bozzano and Sardà, submitted). The study used a baited camera, which was set on the sea floor at a depth of 100 and 300 m in two areas subjected to trawling with continual discards. Eight fish and nine crustacean species were recorded feeding on the bait, and the benthic snake eel Ophicthus rufus was the main scavenger species, followed by isopods (i.e. Cyrolana borealis) and amphipods (i.e. Schopelocheirus hopei). Sporadic scavenging behaviour was even reported for common fish species such as Spicara spp. and Trachurus spp. Discarded material seems to enter demersal food webs quite quickly, as suggested by the high consumption rates recorded. In all cases the bait was fully consumed within 24 hours, and consumption rates reached maximum levels in deep bottoms at night. The authors concluded that the prevalence of O. rufus indicated an environment dominated by a monospecific scavenger guild, whose competitors and predators have probably been eliminated by fishing activity. This conclusion is particularly interesting since it highlights the multiple effects of fishing on complex systems such as communities and ecosystems: fishing can favour a single species within the demersal ecosystem by both removing its competitors and independently increasing its food availability through discards.

BOX 8

Discards of commercial species

Discards of commercial species in Greek waters are reported to range from 0% for red mullet (Mullus surmuletus) to 10% for hake (Merluccius merluccius) and shrimp Parapenaeus longirostris (Machias et al. 1999). The bulk of discards (66%) in the Balearic deep sea crustacean fisheries at the depth of 300 m referred-to above correspond to undersized marketable species. The study of hake discards (Merluccius merluccius), forkbeard (Phycis blenoides) and poor cod (Trisopterus minutus capelanus) in the trawl fishery of the northern Tyrrhenian Sea reveals that they can reach high levels, depending on the species, the season and the depth exploited. The maximum estimate of discards was 34.1% of total catch (in weight) for hake, 41% for forkbeard and 39% for poor cod, whereas total annual mean discards in the traditional trawl fishery amounted to 39%, 65% and 57% respectively in numbers of individuals. All individuals under 10 cm are discarded in all three species.

Source: Sartor et al. 1999.

Trawl selectivity is theoretically determined by mesh size codend. However, fishermen are using several devices which may alter the selectivity given by the mesh size. As for example round traps fixed transversally around the codend to limit its extension or, various types of strengthening devices added to reduce risks of rupture of the codend as apron placed under the codend or external protecting cover.

Observations carried out on bottom trawling for red shrimp (Aristeomorpha foliacea and Aristeus antennatus) in Italian waters of Ionian Sea give a percentage of discards amounting, on average, to 66,6 % of the total catch when using 40 mm codend, and to 59.8 % with a 50 mm codend (Tursi A. et al. in Gordon et al. 1998). According to other selectivity experiments (Stergiou. et al. 1997) the mesh size of 40 mm does not appear sufficiently selective in most of the fisheries. The increase in mesh size could reduce the impact of fishing on the deep-water environment in limiting the amount of discards. However the adoption of greater mesh size seems to be difficult to apply when trawler activity is shared as along the Calabrian coast, both on deep-water shrimps beyond 400 m of depth and rose shrimp and hake on the continental shelf edge and even red mullet in very shallow waters (Tursi et al. in Gordon et al. 1998). In general, it appears impossible to obtain satisfactory result in selectivity in using a single mesh for multi-species fisheries as Mediterranean bottom trawling (Petrakis and Stergiou 1997).

The trawl speed is not only very important in respect to the efficiency of the fishing gear but also influences species and length of fish selection by affecting the vertical opening of the trawl and the opening of the mesh in the codend. The towing speed is therefore a major factor affecting selectivity.

The duration of the haul is also important and affects the selectivity performances: Long tows normally result in lower selectivity (and, possibly, higher discard rates) because codend mesh opening may be hidden behind large quantity of fish, mesh can be progressively plugged up by enmeshmed fishes, the fishes caught at the beginning of the haul are more or less crushed by the latest one. In certain areas, stone and gravel inside the codend will also affect the selectivity.

To reduce the quantity of bycatch having to be discarded later, various types of bycatch excluding devices can be installed on trawls as square-mesh codends, separator panel or sorting grids. The use of several models of such devices probed in Atlantic and Mediterranean fisheries practically leaded to reductions of discarding (to varying levels according to fisheries and specific local conditions).

Because diamond mesh tend to reduce their opening when the speed or the weight in the codend increase, square mesh catch considerably less small fish than an ordinary codend with diamond mesh of the same size as underwater video observation and several experiment proved it (Stergiou. et al. 1997; Petrakis and Stergiou 1997).

Separator trawls operate by segregating species entering into the trawl either according their specific behavioural reactions to the gear or their morphological differences. The typical design as it may be found in many shrimp fisheries consists in a single panel inserted horizontally splitting trawl totally or partially, in two levels.

The degree of separation would also allow for the use of different mesh sizes in the separator trawl such as it is possible to have a mesh size in the lower codend suited to keep Nephrops and one another in the upper panel large enough to allow the escape of juveniles gadoids. The rigging and position of the panel is nevertheless critical to the success of gear.

Selection sorting grids operate by physically restricting the passage of unwanted by catch and guiding it out through some form of escape hole or exit. The grid may be inserted either inclining forwards or back wards with the escape hole inserted in the bottom or top of the netting depending on the configuration. However inclining grids with bottom escape holes have been found to be more efficient in releasing unwanted by-catch and debris, but the loss of commercial target species has been shown greater with this orientation.

There are several documented problems associated with the use of grids. It is not rare that a certain percentage of the target species is lost, due either to poor installation of the grid or if weed and debris mask a part of the grid. Large grids can cause practical handling problems, due to their physical size and weight and the use of net-drum for shooting and hauling the trawl has been conducted to investigate in semi-flexible materials for the construction of grids.

Research on into the effectiveness of grids has been conducted in many parts of the world including the Mediterranean Sea. As for example, the use of grids in deepwater shrimp fisheries led by-catch drop to less than 3 % of the total.

Social and political reasons may difficult the application of these devices for most of Mediterranean fisheries mainly for small and traditional vessels. Initially fishermen may be reluctant to embrace such devices, claiming that such devices result in the short term loss of commercial species and income. Although these selectivity devices are clearly a long –term economic value to the fisheries, there is a lack of data to assess the economic impacts of technical measures of selectivity.

Box 9

Recapitulation on Bottom Trawling discards

There is compelling evidence that discards by Mediterranean unselective trawling fleets are significant. The effect on marine communities is twofold:

- At a single-species level, the population dynamics of a species are altered,
- At the ecosystem level, profound changes occur because of the disruption of food webs.

Ecosystem modifications are triggered by the change in the biomass and demographic structure of the different species as well as by the increasing food supply for scavenger and opportunistic species. It is worth noting that the latter can result in the trophic connection of separate sub-systems (i.e. pelagic and benthic), making ecosystem consequences even more dramatic.

Although bottom trawling is inherently rather unselective, by-catches and discards can be minimised. Trawling can be limited and technical measures can be introduced to improve selectivity. Trawl selectivity within an area depends on many factors, ranging from the depth exploited or the kind of bottom, to the season. Most impacting scenarios could be avoided by restricting trawling both spatially and temporally. In this context, current provisions banning trawling in coastal waters less than 50 m deep or 3 miles offshore should be enforced effectively. Trawling gear could be made more selective by using higher mesh sizes or incorporating special excluding devices, such as those based on rigid grids. The former solution may be difficult to apply in Mediterranean waters for social and political reasons, but the development and compulsory use of excluding devices increasing selectivity (such as those in use in some North Atlantic waters) deserves attention. Alternatively, the use of a square mesh can also improve selectivity. It is convenient to mention here that shorter trawling hauls are known to reduce discard rates.

Partial solutions and technical improvements notwithstanding, the banning of bottom trawling in large marine protected areas throughout the Mediterranean Basin appears to be the only way of maintaining a sample set of demersal ecosystems free of the damage caused by this widespread fishing practice. These areas would moreover be very useful as a basic reference guide to healthy bottom communities in the context of a future ecosystem-based management of Mediterranean fisheries.

Souces : Stergiou et al. 1998, Moranta et al. 2000.

3.1.1.4. Bottom Trawling and Sensitive Species & Habitats

Marine mammals

Incidental catches of marine mammals by bottom trawling are rarely reported. Stripped dolphins may be sometimes caught when they are foraging their food around and in trawl nets (Duguy et al. 1983).

Elasmobranchs

Assessment of elasmobranchs discarding by trawling fleet are diversely reported. Sharks and rays are more or less discarded according to the commercial interest they can have at the moment of their landings. In trawling fisheries they are never targeted but large individuals of some species may constitute complement of the daily income of smaller trawlers. Nevertheless a large quantity of younger specimen of sharks or rays is discarded (Relini et al. 1999) especially when they make the larger part of the by-catch of some specialised fisheries as Norway lobster and red shrimp fisheries.

The general increase in trawl fishing effort and impact on the habitats of elasmobranchs have led to the decline of some species of the continental shelf and of the slope. According to historical data from both bottom trawl surveys and commercial landing statistics in the Gulf of Lions, Aldebert (1997) indicate a general reduction in number of chondrichtyans of about 50 % occurring in the last 30 years. The most affected species are for the small sharks the smooth-hounds Mustelus mustelus and M. asterias, the smallspotted catshark (Scyliorhinus stellaris) and the longnose spur dog (Squalus blainvillei). On other hand, ray species are especially vulnerable to bottom trawling and high discards of juveniles specimens of the most abundant species (Raya asterias, R. clavata) are reported in Italy (Relini et al. 1999, Serena and Abella 1999) in gulf of Lions (Aldebert 1997). According to this last author, the longnose skate, Raja oxyrinchus disappeared from landings in the Gulf of Lions as early as 1976.

Concerning species which are identified as threatened, data are scarce and too recent to get an opinion of the real impact of bottom trawling. Fergusson (1998) reports that the majority of catches of white shark (Carcharodon carcharias) is due to Sicilian trawlers operating in summer in the Strait of Sicily. In rare circumstances, catches may be occurred in other trawl fisheries as in Malta waters, Tyrrhenian Sea and even in Gulf of Lions (Oliver G., personal com.).

A comprehensible description of the distribution of chondrichtians in Italian fisheries was made by Relini et al. (2000) from data collected during 22 trawl surveys on fishing grounds from 5 to 700 m depth. Among 44 identified species (of which 1 olocephale 17 squalids 26 rajids) CPUE in number per hour were low for Dasyatis sp. (0.2/h to 10.7/h) and Mobula mobular (1.4/h) with a low occurrence ratio(0.83- 14 %) and high for Galeus melanostomus (214/h), Scyliorhinus canicula (109/h) and Chimaera (61/h) with high occurrence ratio (60 – 84 %). From these observation we can conclude that most of sting rays (Dasyatis sp.) living in depths from 0 –50 m undoubtedly appears to be threatened by intense activities of bottom trawling on the shelf. While chimaera and small squalidae living in depths between 200 –500 m are mainly affected by deep-shrimp trawling.

Turtles

Incidental catch of turtle by bottom trawls are suspected in area of largest distribution of marine turtles such as coasts of Spain, Gulf of Gabes in Tunisia and Turkish waters. However few formal observations have been reported so far (Camiñas 1997c, Bradai 1995) very likely because most of these incidental catches occur in winter when trawlers are fishing illegally in coastal areas, within the three miles limit, closed to nesting ground. In Tunisia, the trawling fishery for shallow waters for shrimps would be responsible of large catch of turtles (hundreds to thousands of individuals annually according to Bradai 1995).

Though we have not any technical description, the incidental catch probably occur in most of cases during the towing operation, when turtles are foraging on the bottom, during its wintering phase. When towing time do not exceed 2 to 3 hours risks in mortality are generally low. According to Henwood and Stuntz (1987) trawling haul not exceeding 60 minutes gives a turtle mortality rate in the gear close to 0%, but this rises to 50% if fishing time increases to 200 minutes. Therefore, with some elementary handling precaution, reducing towing time, avoiding nesting grounds are certainly simple and efficient measures to reduce mortality rate.

Nevertheless, though it is difficult to assess the importance of incidental catch of turtle by bottom trawl, the improvement of the gear with the addition of some turtle excluding device (TED) placed at the entrance of the codend, as already in use in several tropical regions (Villaseñor 1997), may definitively be suitable in areas where the impact of trawling on turtles is suspected to be high.

TED may be of various types and designs: either rigid device as metallic or plastic grids or funnels or smooth devices as “net panel excluder”. The choice depends on local fishing conditions, on trawler dimensions (encumbrance on fishing deck) and on usual catch: Certain models are more efficient than others, according to the nature and quantity of the catch and usual by-catch, presence of sediment and/or debris in the catch. The exit for turtle is placed either on the upper or on the lower part of the trawl, depending on fishing conditions.

Difficulties in the use of TED may occur on one hand during the setting and hauling of the trawl and the retrieving of the codend and on other hand, during the towing by entanglement of the grid, opening obstruction, plugging by sediment or fish deteriorating of the excluder device.

Correct design, good control of the setting operation can avoid entanglement of TED in the trawl webbing. The use of material of low quality for the grid may become a serious problem when the nets are operated on hard bottoms: The TED may be easily deformed and deteriorated. If the risk of plugging by by-catch and sediment is important, the use of rigid TED is recommended because of their efficiency in trash elimination. These rigid models are, in general, more easily accepted by the fishermen and control and surveillance are easier than when smooth devices are installed. When the quantity of small fish is very large, in certain areas or seasons, with the risk of enmeshment of many fish in the codend, it is convenient to install some excluder device effective for small fish exclusion as “fish eye” (e.g. FLORID model).

Finally, but not least, the use of TED, as any by-catch reduction device, normally reduces workload and time for sorting the catch and, in general, improves the quality of target catch. Consequently, the use of TED, obviously, has economic consequences which must be carefully assessed to elaborate the correct strategy for obtaining the agreement of fishermen to use such device.

Seabirds

Trawling does not cause direct mortality to the seabirds but there is some impact on seabirds’ populations resulting from the discarding. The important fleet of otter trawlers which operates in the vicinity in NW Mediterranean sea rejects every day, mainly in coastal waters, a large quantity of by-catch which makes additional food for the seabird around. This food supply benefits mainly seagulls, terns and shearwaters (Box 10).

BOX 10

Seabirds strongly dependent on discarding by trawlers

Several studies carried out in Catalan Sea indicated that seabirds which are originally predators mainly on shoaling clupeids have become strongly dependent on discarding by trawlers. A consequence, among other is that a closed season for trawling activities may negatively affect the breeding performance of a certain seabird population being dependent on discarded fish for food. At the opposite, the increase in food availability with more trawlers fishing and, therefore, discarding potential food has undoubtedly contributed to the large development of some seabird scavenger populations at the expense of the other populations breeding in the areas.

Souces : Oro 1996 ; Oro et Ruiz 1997 ; Abelló et al. 2000 ; Martínez 2000.

Sea-beds

It is obvious that gear which are designed to catch effectively bottom or demersal fish and shellfish have to scrape the seabed. Any fishing gear which is towed over the seabed will in some degree disturb the sediment and resident communities. The level of this impact depends on one hand, on the physical characteristics of the gear (materials and weights) and the conditions of its utilization (speed and duration) and, on the other, on the type of sediment and the benthos on it.

Trawling has a direct physical effect on the seabed wherever the ground rope, chains and bobbins, sweeps, doors and any chaffing mats or parts of the net bag contact the bottom. The gear affects physically the seabed by scraping and ploughing: It may lead to physical destruction of bottom structure and sediment re-suspension. There have been several studies by fishing gear technologists aiming to assess and measure the physical pressure imposed by particular parts of a trawl gear; more recently acoustic methods have been developed for evaluating changes to sediment structures (Schwinghamer et al. 1996)

Trawl doors used to keep the net open horizontally, tend to leave grooves on the bottom, depending on the hardness of the substrate versus their weight (the material the doors are made of). Not surprisingly, penetration in soft mud will be greater than into hard-packed sands and effects on infaunal benthos may alter accordingly (Hall. 1999). To prevent the otter boards from digging too deep into soft sediment (sand, mud) they are fitted with wide metal shoes, however, the common average is a digging in amounting up to 10-15 cm.

Standard otter trawling may also harm rocky bottoms thanks to special rolling devices, rollers, which are, more and more, mounted on the groundropes to prevent the trawl net from being damaged. However, the impact to bottom habitat of this type of rigging is not obvious: The use of large rollers allows many bottom organisms to escape unharmed under the net. Nevertheless, the passage of a trawl on the seabed leads to direct mortality of some benthic species creating a potential source of food for predators and scavengers. High resolution video images of sediment surfaces before and after otter trawling show that intensive trawling can reduce the overall roughness of the seabed (Schwinghamer et al. 1996), change the overall sediment characteristics and, on sand or mud, increase the suspended particulate load.

Indirect effects on seabed are related to the stress imposed to the benthos (Jones 1992). Trawling, with heavy trawl doors, is responsible for bringing bottom sediments into suspension. The mud clouds so created have, undoubtedly, an herding effect on fishes but may also affect the settlement and feeding of the benthic communities. However, the exact and full consequences on the ecosystem of putting sediment into suspension are not known.

Deep-bottoms

Deep bottom fisheries of Spain, Italy, Algeria and Tunisia are targeting Norway lobster (Nephrops norvegicus) or red shrimps (Aristeus antennatus and Aristeomorpha foliacea) on slope, down to a depth of 1000 m. The potential negative effects of such deep water fisheries have not been fully assessed yet. As in lower depth, the physical contacts with deep reef structures is likely to damage the epifaunal community. Deep bottoms are generally muddy with some patches of corals on the edge of the slopes of the canyons. Side-scan sonar pictures of otter door furrows show the evidence of a severe physical impact. In general, the benthic communities in deep waters are often extremely vulnerable to physical perturbations. It is therefore suspected, although there is no information on the effects of deep sea trawling on muddy bottoms in the Mediterranean or anywhere in the world, that the recovery after impacts of trawling might take long time in deep water.

Seagrass

Otter trawling is considered the main cause of regression of the Posidonia beds off the southeastern Iberian Peninsula (Martin et al.,1997).

The impact on seagrass by trawling will indirectly affect fish recruitment by perturbing areas which are often nurseries and privileged areas for juvenile of commercial fishes (Sánchez-Jerez and Ramos-Espla 1996). There was not much specific research so far on consequences on stock population. However, several studies comparing the situations of fished and protected, un-fished, Posidonia beds in France and Italy (Buia et al. 1999; Harmelin-Vivien 2000; Francour 1999) reveal a decrease in the mean weight, density and biomass of fish in the exploited seagrass.

Length and weight of the groundrope and weight and contact surface of the otter-boards, considered in relation to the towing speed, are the most physical parameters of the friction forces of trawl on seabed. A recent study on the impact of towed fishing gear on the prairies of Posidonia oceanica off the coast of Spain shows that in a dense prairie the trawl doors contribute mainly to the erosion of Posidonia while in the degraded prairies, the groundrope penetrating more easily in the substratum can pull up the rhizomes of the plants (ESGEMAR 1995). In addition, the degradation of Posidonia beds is amplified by the increase of water turbidity due to the passage of trawl doors (Ardizzone et al. 2000). These elements are those which could be worked on to reduce the potential damage to seagrass beds; for instance, the use of plastic bobbins on the groundrope may mitigate the impact of heavy components towed on the meadows.

3.1.2. Pelagic trawling

Pelagic trawling use higher vertical opening nets than for bottom trawling. This type of trawl is fit and rigged to operate in mid-water for the capture of small pelagic species (sardines anchovy). The nets consist in general in four panels. The front parts of pelagic trawls are, in general, made from large meshes or long rope to progressively lead fish schools toward the posterior part of the nets with smaller meshes. The codend meshsize is about 20 mm in stretched length. The control of the fishing depth and of the vertical opening requires the use of an echo sounder fixed on headline. One or two vessels (pair trawlers) can drag it. Pelagic trawling may be carried out either during the day on pelagic school often situated near to the bottom or during the night on surface school (mainly in pair trawlers configuration) or on scattered fish.

Pelagic trawl nets are mainly used in the Gulf of Lions by the French, in the north of Adriatic by the Italian ("volanti") and in Tunisia. There is no information already published or, even, available on by-catch. Nevertheless, recent observations on commercial catches of French pelagic trawlers operating in Gulf of Lions show only 2,3 % of by-catch. However, though pelagic trawling is, in general, targeting small pelagic species, the small size of the mesh in the codend, can make that by-catch of undersized gadidae may sometimes be important when the pelagic trawl is towed not far from the bottom. If pelagic trawling may incidentally catch some individuals of protected elasmobranchs and commercial pelagic sharks (Alopias vulpinus and Prionace glauca), these captures are in general limited. The total landings of elasmobranchs represent only 0.45 % of the 28141 MT total catches form Mediterranean Sea which are auctioned in France and the annual landings of Alopias vulpinus made by French trawlers in Gulf of Lions hardly reach about 10-13 MT. For this species the maximum catch arises between May and August during the bulk of the activity of pelagic trawling.

3.1.3. Beam trawling and Rapido

Beam trawl has horizontal and vertical openings fixed. Its horizontal opening is determined by a pole, in wood or metal, the length of which can be ten meters or more. Tickler chains are often fixed in front of the beam trawl across the entrance to prevent boulders from getting into the bag. There are different types of beam trawl used in Mediterranean Sea. They are generally used in shallow waters by small units within some small-scale fisheries. "Provençal" (from the Southeast of France) "gangui" and Catalan (NW Spain) "ganguils", Greek "kankava" for sponges, Italian "rapido" for the sole and Sicilian "gangamo" for prawns and sea urchins are the most common examples. When using this type of fishing gear the impact on the seabed and benthos results mainly from the hoop-like trawl heads (which gives the vertical opening) with their shoes/skates and, to a lesser extent, from the beam. But, in general, problems are related to the weight of the whole gear which is towed on the bottom.

Unfortunately, very few informations are reported on the activities and impact of the related fisheries. Because they are used in shallow waters, they are often blamed to provoke important perturbation on nurseries bottom (rocks and seaweed meadows) and to catch young fishes and coastal flatfishes in important quantities (Serena and Abella 1999). Monk seals are sometimes trapped in these gears (Cebrian & Vlachoutsikou 1994; Cebrian 1998b). In the Provençal French fishery using "gangui", the target species are scorpaenidae, red mullets and other high value species used in traditional dishes. Because the technique is practised on seabed with Posidonia, its use was decided to be banned in 2002.

The "Rapido" is a beam trawl, used in the Adriatic Sea for fishing scallops in sandy offshore areas and flatfish in muddy inshore areas. The gear consists of a box dredge of 3 m wide and 170 kg weight, rigged with teeth of 5-7 cm long and a lower leading edge and net bag to collect the catch (Giovanardi et al. 1998). An inclined wooden board is fitted to the front of the metallic frame to act as depressor, keep the gear in contact with seabed and, even more, press it on the bottom to facilitate the penetration of the teeth in the sediment. A single vessel may tow four "rapido" simultaneously. The towing speed is about 5 knots.

The “Rapido” is one of the most effective, and to a certain extent, most popular, types of fishing gear in Italy. About 56 “rapido” are used off the fishing port of Chioggia in Adriatic (the highest number in the region) to exploit flatfishes, e.g. soles, and pectinids stocks. The fishermen are often specialized in the exploitation of a certain part only of resource (Pranovi et al. 2000; Giovanardi et al. 1998). Flatfishes, sole in particular, are exploited in shallow waters between 3 and 5 nautical miles offshore. Scallops (Pecten jacobeus and Aequipecten opercularis), and Chlamys spp. are concentrated in patchy beds on detritic bottoms (“maerl”) and their main densities occur at 40-50 m depth on sandy grounds, at some distance from the coast.

In the Adriatic Sea, the rapido fishery is forbidden within the 3-miles limit and closed as all other trawling during 45 days in summer (“fermo biologico”) for the protection of the juveniles and the increase of the recruitment. The exploitation is characterised by a strong depletion of the stock of scallops due the combined effects of overfishing and benthic anoxia. From 1200 MT in 1986, scallop landings dropped to 160 MT in 1990 and reach to day less of 500 MT. In connection to this it is worth mentioning that on the most productive grounds in Croatian territorial waters, fishing with rapido is allowed only in restricted areas and during a brief season.

The physical effect of rapido on the bottom is very similar to the impact of some toothed dredge models used in England or in France: It essentially affects the superficial layer of sediments. On sandy bottoms for scallops) (Hall-Spencer et al. 1999; Pranovi et al. 2000) the gear produces parallel and flat tracks which remain clearly visible after a week. The images of video recording reveal that the rapido (skids, teeth and the rubber mesh of the belly) remains in contact with the seabed, scraping and ploughing it. The teeth on the lower hedge of the entrance of the rapido are driven into sandy sediments up to about 2 cm deep and these mix the surface layer, suspending sediment in the drag of the gear. The re-suspension of sand is amplified by the effect of the deflector and the high speed. It is reported (Giovanardi et al. 1998) that certain models of rapido used in muddy area for sole dig deeper into the sediment, making furrows of 5-7 cm of depth and, even, after multiple passages, up to 10-13 cm deep. Although, these furrows are completely filled after 2 weeks (Giovanardi et al. 1998), the immediate disturbance on macrobenthos epifauna in a muddy area is certainly greater than sandy bottoms (Pranovi et al. 1998), according to the deeper penetration of the teeth in the bottom.

In commercial fishing conditions, the successive ways through of “rapido” trawl, presumably modify in a long run the physical structure of the bottom and have consequently an influence on settlement and colonisation of the epifauna. Moreover, in making a selection of certain species which are able to resist to physical disturbance even after several ways through of the gear and/or to the stress when being sorted out from the catch on the deck of the vessel, the “rapido” activity induces long -term modifications in the epi-benthic community structure.

In this type of fishery, commercial catches are generally in low proportion in weight. The 'rapido' fishing produces qualitatively heterogeneous discards, often higher than 75 % of the total catch which reflects the fact that the fishing effort is targeting certain species and, obviously, depends on the nature of the sea bottom exploited (Box 11).

It is worth observing that reducing some of the negative impact on the bottom of "rapido" will not be easy. The rapido fishing technique now in use results from long empirical developments and continuous adjustments and changes to maximise the efficiency in the specific conditions of a given fishery.

The selectivity of the “rapido” used for scallop was tested in Northern Adriatic Sea, by means of a cover net (20 mm mesh size) fixed at the codend (40 mm mesh size). For more fragile species like brittle star (Ophiura ophiura,) the number of damaged individuals found in the cover was double of those retained in the codend. Survival experiments carried out immediately after haul showed a short –term (3-4 hours) mortality in species collected (Invertebrates as well bony fishes) (Pranovi *et al.* 1999a). In the case of muddy bottom the net webbing of a “rapido” may be practically obstructed after few minutes of dragging which leads to “blinding” the normal mesh size selectivity.

BOX 11

The impact of Rapido

Observations on the impact of rapido used for scallop in North Adriatic give 2 % of commercial catches for 16 % of by-catch and 82 % of dead materials (shells, stone, litter). It practically means that for each kilo of scallop more than 15kg of other benthic organisms are removed from their habitat. A normal commercial haul of 40-50 min would land something as 2 MT of benthos on deck. The commercial fraction is due mostly to Pecten jacobeus and by catch to cephalopods as Sepia officinalis. In addition, 59 % of scallops are small undersized individuals and 13 % of commercial-sized showed slight damage.

When flatfish is targeted (with 60 mm codend meshsize) on muddy coastal areas of the southern end of Venice Lagoon (North Adriatic Basin), molluscs (60%) and crustaceans (30%) constitute the main part of discards while in scallop fisheries operating on sandy bottoms (with 80 mm codend meshsize) there is in the by-catch a relative dominance of echinoderms (32% in weight), crustaceans (26%) molluscs (23%), and sponges (15%).

On another hand, study of by-catch survival in the 'rapido' fleet operating in the northern Adriatic showed low mortality in all species examined during the three to four hours following capture.

Souces : Pranovi et al. 1999 ; 1999 a.

3.2.Dredges

The dredge is a fishing gear towed on the bottom by boat or, for smaller one, by hand which penetrate in the seabed for extracting certain organisms from sand or mud. . They are used to target epi or infaunal species such as scallops, clams oysters. The dredges are of various types: from small to large (mechanised) ones but they normally have in common a blade, with or without teeth, which help digging the sediment, extracting and collecting molluscs. The catch is collected in a bag often made in metallic wire ("basket"). There are not a lot of differences between some type of beam trawl and dredges though these last ones are designed to dig further into the substratum than beam trawls.

Manual dredges are widely in use on Mediterranean coasts. They can be trawled by boat but without mechanised help for the separation of molluscs from the sediment. Among them, we can cite the French "arsellière , clovissière" gear used in coastal area or in Thau Laguna, the "vongolara manuale" used in Adriatic and various type of "rastrello" used for the catch of Tellina sp., Donax sp; in Adriatic Sea and in Tyrrhenian Sea (Feretti 2000). In the gulf of Manfredonia (south-western Adriatic Sea), boats targeting are the smooth scallop (Chlamys glabra) on chalk weed bottom from 12 to 16 m of depth. are using twined dredges ("cassa"). Each dredge is made of an iron rectangular mouth devoid of teeth, weighing 15 kg, carrying a 2.5 m long bag with a 50 mm mesh size(Vaccarella et al. 1998). Usually each haul, at about 1.5 knots, lasts from 20 to 30 minutes. As for rapido, the net webbing making the bag of the dredge 'cassa' type is, in many cases, quickly clogged and selection within the catch is often essentially limited to the sorting on board by fishermen. After sorting, the crew discard young scallops and snails of low commercial values.

Mechanised dredges have a blade for digging the bottom and a mechanical system to allow the separation of molluscs from sand and mud. The technique of mechanised dredging which is essentially used in Italy is hydraulic dredging which appeared in the Adriatic in late sixties. Froglia and Boligni (1987) provided good description of this technique. The gear ("draga turbosoffiante") is a parallelepiped of 3 m width and 2 m in length, weighting about 800 kg. The dredge uses jets of water or air to create a venture effect which lift on board for further sorting, sediment, target and non-target species. Today, in Adriatic Sea, around 50 boats are using this gear for striped venus or "vongole" (Chamelea gallinea) and other shelled molluscs as sword razor shells (Ensis minor). The main selection is made by the opening of metallic meshes which is fitted to the target species.

The procedure of fishing operation is quite different of the other dredges types. This technique requires specific deck arrangement and auxiliaries: winch and stern gantry to haul the dredge and 2-3 crewmembers. The boat is anchored on suitable ground (sands, muddy sands, depth 3-12 m) with the stern anchor and 250- 300 m of steel cable. The dredge is then lowered and towed on the bottom by the winch in successive hauls the boats remaining anchored on a same place. During these operations, under-pressure water is injected by means of hose that connects the dredge to a centrifugal water pump on board or submersible. Two adjustable sled runners prevent dredge from digging too deep into the bottom. In "vongole" fishery, the dredge is designed to dig up to 4-6 cm only; for razor clams, the hydraulic dredge ('cannellara') may plough up to 20-30 cm in depth in the sediment. After the use of this gear a series of 30 or more burrowing tracks up to 2-3 m width and 100 m long are observed on the bottom around the anchoring point.

For dredges as for trawl the magnitude of the impact depends on the dimensions of the gear, its weight, the speed of towing (and currents) and the nature of the bottom. In general, the use of manual dredges without teeth and the lower speed is known as disturbing the bottom much less than toothed dredges and probably also leading to less destruction of shellfishes (Vacarella et al. 1998). By the displacement of rocks, digging effect, re-suspension of the finest part of the sediment, the dredges clearly have a physical impact on the seabed. This impact is obviously becoming more and more severe with the repetition of the operation on a given fishing ground. Indeed, the dredges, the hydraulic dredges in particular, are the most incriminated fishing gear for their potentially negative environment impact. Several studies analyse the effect of these gear: by Pranovi and Giovanardi 1995; Pranovi et al. 1998; Vacarella et al. 1998; Giovanardi et al. 1994. Compared to hydraulic dredging, manual dredging has an effect on the bottom which is lighter : Where the hydraulic dredge produces furrows 10 cm deep or more, the use of a manual dredge lets practically no marks on the bottom after its passage (Pranovi and Giovanardi 1995).

Moreover, the disturbance caused by the hydraulic dredge is also more severe than the one caused by ‘rapido’. The recovery processes in disturbed areas by hydraulic dredges used for clams take at least 60 days against only 15 days for “rapido”.

The disturbing action has the same features rearrangement of bottoms with production of furrows and re-suspension of the sediment. Observations of effects of water jet dredging for clams Ensis spp. on the seabed and benthos show that the sediment in fished tracks remained fluidised beyond this period. Nevertheless, because of the low speed of the gear on the bottom (1 to 2 knots) this technique has relatively less devastating effects on epi-fauna than other dredge and do not have persistent effects on the most of the in-faunal community. The majority of these species are adapted morphologically and behaviourally to a dynamic environment, and are not greatly affected by the dredge (Tuck et al. 2000; Hall et al. 1990).

It is worth observing on a fishing ground being intensively exploited with dredges that after successive passages of the gear, certain species such as “striped venus” or “vongole” (Chamalea gallinea) tend to sink deeper in the sediment while others, such as razor clams (Ensis sp.), stay at the same depth. Furthermore, the sediment on the "vongole" area takes much time “to recover”, while in the razor clams area the reconstitution of the sediment is faster. On the "vongole" area, the slow recovering starts with a new colonisation of species living in sand as Phanerogame that makes the substrate more homogeneous, while in the clams area, the colonisation starts mainly with annelids (Vacarella in Feretti 2000).

In general, more severe damages resulting from dredging are those provoked on the submarine meadows, since the passage of such gears often causes an irreversible regression of the vegetal cover. In Italy, because of serious damage observed on the seabeds (detritic or Posidonia beds), the use of hydraulic dredges for catching warty venus (Venus verrucosa) was banned in 1992 in waters less than 3 meters in depth and authorized with a maximum hydraulic pressure of 1,8 bar.

The assessment of environmental impact of dredge on other types of bottom appears to be rather complex and indeed, further studies would be necessary to assess the reality of the damages caused by this technique. However, technical measures such as limitation of the pulling strength of the vessel and for instance the pressure of hydraulic pump used for hydraulic dredging are certainly among efficient means for regulating the effort deployed on the ecosystem and should, however, be implemented, even if they are uneasy to control.

3.3.Seine

Beach seine is a term designing a type of coastal fishing gears common to all Mediterranean countries. Known in Italy as 'sciabica', in Spain as 'jabiga', in France as 'senne' they are generally used to catch schools of fish coming closed to the coast in shallow waters (less of 20 m).

They consist in strips of several pieces of net of different mesh sizes with small mesh panel placed in the central part and larger meshes panels on both sides. The central part with small meshes makes in general a bag where the catch is collected while the panels with larger meshes on each side constitute the two wings of the seine. The net webbings are framed with a floatline fixed on its upper edge and a leadline on its lower edge. There are various types of seine: with or without bag (similar to the trawl codend) and with different lengths, from 100 to 400 m. The smaller meshes can be up to 40 mm but also very small, to around 3 mm. The difference between the beach seine and another encircling net is more the operation of the gear, from and to the coast for the former than in the designs (Feretti M. 2000).

Seine can be hauled from vessel ("sciabica da natante") with net hauler or from the beach (sciabica da spiaggia). The hauling of long beach seine to the shore requires much people in general (obviously, a number of people increasing with the overall dimensions of the seine). The need for having a certain, large in many cases, number of people involved explains the social importance that such a fishing method can play at the level of villages or communities depending on fisheries for their living.

The seines in use in shallow waters are blamed to cause important damages to the coastal ecosystem for two main reasons: Firstly, because of the amount of juveniles in most of the catches and because of the friction on the sea-bed during the fishing operations. Regarding the juveniles within the catches, it is worth observing that some of the beach seines are designed specifically for targeting small fish such as small Sardina pilchardus fry ("bianchetto" in Italian or "poutine" in French), Alphia minuta ("rosetto" in Italian, "chanquete" in Spanish, "nauna" in French), or sand eel (Gymnammodytes cicerellus) ('cicerello' in Italian, "lançon" in French). Several descriptions of the seine utilisation in the Mediterranean Sea are found in the literature.

Below there is a brief description of a beach seine fishery for Sardina pilchardus fry ("bianchetto") in the North West of the Ionian Sea (Crotone) : Small beach seines with a total length of around 100 meters and very small mesh size in the bag, less than 3 mm are used. These are set in shallow waters, less than 10 meters, by small vessels with low power outboard engine (15 -20 hp) (Carbonara et al. 1999). The fishing operations do not last more than 20 min. The captures vary between 2 and some more than 35 kg within one day and most of it consist in juveniles of S. pilchardus, so called "bianchetto". Small quantities of juveniles of triglidae may occur in by-catch (Casavola et al. 1999b).

Another example concerns the transparent goby (Alpha minuta) which is found on sandy or muddy bottom or on meadows in coastal protected areas, estuaries and up to 70 meters in depth.

In the Gulf of Manfredonia (Adriatic waters) a fishery for transparent goby is authorized with beach seine from January to March. The composition of the catches which was observed (Casavola et al. 1999a) consisted in 53.7% of goby, small sardine (39.7%) and juvenile of anchovy (less of 10%).

From the observations between 1980 and 1983 in the area of Malaga, (SW of Spain) it was found that the catches from "seine for chanquete" (Alpha minuta) included 39 species, of which almost half of the fishes were at juveniles stages. Although the total catches were in majority less of 10 kg per set, the analysis reveals that the by-catches, in addition to "chanquetta", include, according to the seasons, young sparidae or young red mullets and, occasionally, rays (Anonymous 1985).

For a number of scientists the banning of beach seines is essential for the conservation of demersal and inshore diversity (Stergiou et al. 1996). Several attempts of eliminating these practices were made in the past but the prohibitions did not last enough for being in a position to observe concrete positive results. The difficulty is the social role that this fishing technique plays in some specific regions (such as Malaga, French and Italian Liguria) with consumption of juveniles being part of regional tradition. Several countries as Greece have banned the use of this technique. In other countries, beach seining is not prohibited but its practice is often submitted to restrictive regulations, as for example limiting the fishing season to 2 months maximum.

3.4. Purse seining

The purse seine is essentially a long strip made of a series of panels of different mesh sizes with floats on its upper edge and weights and purse rings attached to the lower edge. The panel with the smallest mesh size and the strongest twine, so called the "bunt" is generally situated at one of the extremity of the net to be used for concentrate the catch.

For bluefin tuna fishing, the net is up 2 km in length with a practical height of 80 m. while for small pelagic fishes such as sardines or anchovy, the net does not exceed 600 m in length and 30 m in depth. Purse seiners locate pelagic fish schools from experience, in consideration of the meteorological situation (temperature of the seawater), by seabirds presence or acoustic means and set their net for encircling the aggregated fish. The fish are definitively caught by pursing the lower part of the net thanks to a cable passed through purse rings. Then the catch is concentrated in the bunt by hauling progressively the net on board the vessel and, finally, the fish is brought on board by using a kind of large scoop net (brailer). If the first stages of fishing operation do not take more than 20 min., the hauling phase and catch retrieval usually takes more than one hour.

Tuna fishing operations normally take place during the day while purse seining for small pelagic is practised night or day.

Purse seining has theoretically the potential advantage of allowing, in principle, the catch of particular, recognized school of species which are targeted whereas a pelagic trawl may pass through several schools of different species. Consequently, purse seine will theoretically have a more selective effect than the later. For pelagic fishes which have a tendency to schooling within similar-sized individuals, the fact is that experienced fishermen are, in many cases and to a certain extent, able to know the average or the range of size of fish prior to initiating operations to catch them. Nevertheless other species may be also present within the targeted schools. If an incidental by-catch can, to a certain extent, be removed from a tuna purse seine without too great difficulties, the success of a such operation is more difficult during a night setting of a sardine purse seine.

On other hand, the pressure of the market may encourage the catching and retaining of young bluefin or juvenile swordfish by tuna purse seining fleets. These illegal practices may sometimes result in important and uncounted catches mainly during summertime.

Limited data are reported in the literature regarding potential impact of tuna purse seining. According to some skippers and crews a few turtles are, regularly, caught by purse seiners when operating off the Balearic Islands, however, they can, normally, be released alive.

Except for some striped dolphins sporadically caught in Ligurian Sea, there is only few reports (Magnaghi and Podestà 1987; Di Natale 1990) concerning entrapment of marine mammals in tuna purse seines, though some exceptions exist (see section 2.2.5.2.). Indeed, in contrast to the well-known case of the yellowfin purse seine fishery in the eastern tropical Pacific Ocean, no interaction between cetaceans and bluefin tuna has ever been observed. The rare individuals which may, incidentally, be caught have no risk of drowning and normally are easily removed alive from the purse seine.

Conversely, incidental catches of dolphins with purse seining for small pelagic are described in areas where the cetaceans are abundant such as the Alboran Sea, southern Italy or in North African coasts. However, these purse seining activities do not seem to lead to high mortality of dolphin in comparison to what result from driftnetting (Silvani et al. 1992; Di Natale 1990).

Purse seining is also blamed to affect indirectly the seabirds which fly around the purse seiners for capturing fish attracted by the lights of the vessel or feeding on discarding (Arcos et al. 2000; González-Solís 2000).

3.5. Drift longlining

Drift longlining, is much in use in the Mediterranean Sea for swordfish (Xiphias gladius), albacore (Thunnus alalunga) and bluefin tuna (Thunnus thynnus) (Camiñas and De la Serna 1995). Pelagic longlining in Mediterranean waters inflicts considerable mortality on elasmobranchs, marine turtles and seabirds taken as by-catch or even (in the case of the former) target species. It is obvious, however, that large pelagics, the objective of this fishery, is the group most impacted by this gear. The main species targeted in the Mediterranean are swordfish (Xiphias gladius), bluefin tuna (Thunnus thynnus) and to a lesser extent, albacore (Thunnus alalunga); the two former are listed as endangered species in the 1996 IUCN Red List. Bluefin tuna and swordfish are also exceptional in the Mediterranean context as being the only species whose populations are subjected to an international TAC-based management regime. The overall issue of the sustainable management of their populations is beyond the scope of this report, and the discussion below focuses instead on the selectivity of surface longline fisheries operating in Mediterranean waters, since this affects the immature, small-sized fraction of their dwindling populations, and the degree of compliance with current international legislation.

It is estimated that more than 1200 longliners are now operating in Mediterranean waters, vessels flagging coastal states of the Mediterranean Sea and from outside the region. Information collected from various sources shows that the technical characteristics of the lines are more or less the same on various vessels for a given target species.

Whatever the target is, the fishing gear consists in a mainline ranging 20 to 65 km in length, generally in monofilament of nylon, with numerous regularly spaced branchlines in single or double monofilament with baited hooks. The gear is maintained under the surface, at a selected depth by floats tied to the mainline, buoys on the surface and buoy-lines, at regular interval. To facilitate the retrieval of the longline, the buoys at the extremities of the mainline are equipped with a flag, a flashing light and, sometimes, a radar reflector.

Pelagic longlining in Mediterranean waters inflicts considerable mortality on different marine organisms.
F. Garibaldi © RAC/SPA

The hook size, the diameter of mainline and branchline, the space between branchlines, and the nature of the bait make the main differences between the models of longline used for swordfish, albacore or bluefin tuna:

- Because the target fishes are generally smaller, branchlines and mainline used for fishing albacore have smaller diameters (0.8 and 1.2 mm) than the lines for bluefin tuna or swordfish;

- The intervals between branchlines on the mainline are smaller for albacore (11 –15 m) than for swordfish or bluefin (35 to 50 m); this makes that on a given length of line, there are more hooks on the gear used for albacore than on the one used for tuna or swordfish;

- Larger hook size are used for swordfish (7 - 10 cm), smaller ones (3 - 5 cm) are used for albacore and a medium size (5 - 6 cm) or circle hooks are preferred for bluefin tuna,

- Regarding the bait, for small fish such as albacore and young swordfish, sardine is mainly used while mackerel and squid are preferred for larger fish such as swordfish and bluefin tuna.

The longline is generally shot before dawn and the retrieval usually start before sunrise. The depth of fishing, which mainly depends on the length of the buoy-lines, the length of branch lines and the speed of shooting and currents in mid-water, if any, ranges from the water surface layers to the depth of 25-30 metres. The soaking time practically depends on the gear length, the sea conditions for fishing operations and the time to be allocated to the fish caught.

The international scientist community is worried about the high level of juveniles catches of swordfish (under 120 cm) in Mediterranean and the scarcity of large fish in the landing and has recommended in particular to place care in reducing fishing mortality of class 0 individual.

Albacore longlining fisheries are in particular blamed to catch in large quantity small swordfish, weighing less than 3 kg, specially in autumn when they are abundant (Di Natale et al. 1996, De Metrio et al. 1997) (Box 12).

The hooks employed for the albacore fishery are very small and certainly not sufficiently selective for swordfish whose young individuals are abundantly caught in autumn (De Metrio 1988). Although there is no perfect evidence for fish size-selective effect of hook size, smaller hooks give, in general, higher catch rates than larger hooks. The reasons are the fact that a fish normally bites more easily on a small hook and that smaller hooks are thinner and therefore penetrate the flesh more easily.

With the shape and the size of the hook, several other factors may affect the catching efficiency of a longline hook, but the size and the type of the bait seem to be the most important (Bjordal and Lokkeborg 1996). It is therefore possible to reduce the proportion of small fish in longline catches by increasing the width of the gap (the distance between the point and the shank of the hook) or the size of the bait. To increase artificially the size of this last one Lokkeborg and Bjordal (1995) suggest to attach a plastic body to the shank of the hooks above the point. This device moulded in a circular form (4cm long 2cm deep 2 cm wide) and used in combination with a small bait may appear as a large item to the fish. The experiments carried out by the authors suggest however a better visual attractant effect for pelagic longlining than for bottom gear.

BOX 12

Impact of the albacore fisheries on swordfish and bluefin tuna stocks

A survey carried out by De Metrio et al. (1997) on in the Ionian and South Tyrrhenian Seas during the fishing season 1995 showed that the number of young swordfishes and bluefin tunas (class 0) reach respectively 53.2 % and 10.1 % of fish caught. According to the authors, a large number of swordfish which are incidentally caught, probably escapes to the control at landing. The use of longlining for albacore in areas where concentration of young swordfish is high can constitute a serious proble. If 70% of the total annual catch is taken at the peak of the season, from May to September, smaller specimens are caught during the autumn months, when fishing is carried out in more coastal areas and off certain islands (e.g. for the Balearic Islands).

As a matter of fact, any fishing activity taking place in autumn and in coastal areas, as when longlining for albacore in such conditions, seems to be a potential source of problems with incidental catches of young swordfish. The selectivity of longline fishing in the Mediterranean with respect to ICCAT's minimum legal sizes for swordfish and bluefin tuna are a matter of concern. The percentage of legally undersized swordfish with respect to current EU legislation (< 120 cm LJFL) caught by Spanish longliners in the Mediterranean was 81-83% in 1992-94 (Anonymous 1995, cited in Raymakers and Lynham 1999). A recent study commissioned by TRAFFIC and WWF confirmed the previous figures, and demonstrated the Spanish longline fleets' non-compliance with its international and EU legal obligations (Raymakers and Lynham 1999). The study, based on observers at the main Mediterranean Spanish ports from June to September 1998, showed that 86% of a sample of 2,097 swordfish landed from 171 vessels had been illegally fished (<120 cm., and probably <25 kg). This sample represented about 7.5% of the 1991-95 annual average of swordfish caught by Spanish fleets in the Mediterranean. As for bluefin tuna 210 out of a sample of 254 individuals (or 83% of the total) landed by 10 longline vessels were below the minimum legal size of 6.4 kg. In the southern and central Tyrrhenian Sea, the mean weights of caught swordfish were 16.8 kg and 12 kg respectively, and Sicily 17.5 kg. These values contrast sharply with the current minimum weight of 25 kg recommended by ICCAT. The fact is that the Italian longlining fleet is effectively known to operate near the coast in the Strait of Sicily during the autumn. In Greek waters, however, the fishing of swordfish is prohibited by law from October to January.
Albacore longlining also has negative consequences on swordfish and bluefin tuna populations. Di Natale et al. (1996) report small-hooked surface longlines targeting albacore in western Italian waters catching very small swordfish, weighing less than 3 kg. De Metrio et al. (1997) investigated the catches of the albacore longline fleets operating in 1995 in the Gulf of Taranto (north Ionian Sea), the eastern coast of Sicily (south Ionian) and the north Sicilian coast (south Tyrrhenian), an area fished by a fleet of nearly 150 vessels. Comparisons of landings at ports and catches on board revealed that most swordfish catches were not reported at the ports. Catches of young (class 0) swordfish and bluefin tuna were estimated at 53.2% and 10.1% respectively of total catch in numbers of individuals, a fact which which points to high absolute catches.

Catches within swordfish longlining fisheries also include juveniles, particularly when small fishes are targeted using smaller hooks and small sardines as bait. In Greece, according to several authors the majority of swordfish are less than 3 years old (under 130 cm) and this phenomenon is even stronger in the SW Aegean Sea. It was observed that large quantities of young fish are caught when small right hooks of 3 cm long are used while these are only marginal with larger right hooks of 9 to 10 cm long.

Sources : Anonymous 1995 De Metrio et al. 1997 ; De Metrio et al. 1998 ; Camiñas et De la Serna 1995 ; Raymakers et Lynham 1999 ; Di Natale et al. 1996 ; Panou et al. 1999.

For targeting specifically albacore and preventing very small swordfish captures in western Italian waters the fishing operations have anyway to be in deeper waters and preferentially to avoid areas where juveniles are numerous. Closing the longlining fishery for certain seasons in certain areas may be the solution for preventing catches of too small fish.

The fleet targeting bluefin tuna, which is the same being involved in swordfish longlining are using a Japanese longline style, including thicker mainline (3;5-4 mm in diameter), longer branchlines (around 40 m), greater intervals between them (around 50 m) and the use of Japanese type curved hooks with short shank of 4.5 cm long and the point bent towards the shank. The branchline is fixed on a ring mounted on the extremity of the shank to provide a better mobility to the hook (Box 13).

BOX 13

Brief summary of the main longlining fleets and fishing grounds

A variety of medium-scale and industrial pelagic longlining fleets operate in Mediterranean waters, ranging from local coastal state fleets to large industrial foreign fleets, whether Japanese, flag of convenience (FoC), or even unflagged 'pirate' fleets. FoC and pirate fleets are estimated at about 100 units (GFCM 1997). Surface longline gear, including that used by local Mediterranean fleets, is deployed in large areas, line lengths of 50-60 km (bearing several thousand hooks) not being rare. Longline fleets in quest of their highly migratory target fish species, even local ones, are highly mobile, covering virtually the whole Mediterranean basin. A significant part of the catch is taken in international waters, more than 12 miles offshore.

The Spanish longline fleet operates from the Strait of Gibraltar (5ºW) to 7ºE near Sardinia, and from 42ºN to the Algerian coast (Camiñas and De la Serna 1995). In the early 90s a Spanish fleet of 30 longlines operated throughout the year in the south-western Mediterranean. In the summer months, when the swordfish fishery peaks, the number of Spanish boats rose to 60-80. This local fishing effort was complemented by about 30 Japanese and 30 FoG longliners (Aguilar et al. 1992). Overall, some 145 Spanish longliners target swordfish in Mediterranean waters and a further 100 artisanal boats operate in coastal waters during the summer. 70% of total yearly effort in this fishery is concentrated in the summer and autumn. By-catch, excluding turtles, accounts for 10% of total landings in weight (Camiñas and De la Serna 1995).

Italian longlining fleets targeting swordfish and albacore are based mostly in Sicily, Puglia, Sardinia, Campania and Liguria, and comprise more than 1,500 boats operating mainly in the Gulf of Taranto, the south Adriatic and the Aegean Sea (Camiñas and De la Serna 1995). About 27 longline units operated in 1997 in the vicinity of the Santuario dei Cetaceii, in the Western Central Ligurian Sea, where driftnets have been banned since 1992. These fleets, however, are able to reach much more distant grounds. In 1992, the Sicilian fleet operated from Crete and Cyprus in waters close to Egypt and the rest of the North African coast (Cavallaro and Luca 1996). Italian longline fleets are also known to reach Iberian waters during the autumn. In the central southern Tyrrhenian Sea, swordfish have historically been fished with driftnets ('spadara') but an important longline fishery has recently been established at Mazzara del Vallo in the Strait of Sicily (Di Natale et al. 1996).

The Greek National Statistic Service includes longlining in the broad category of 'coastal fisheries' and although no specific figures are available, it is estimated that the swordfish fishery accounts for more than 50% of the total professional fishing effort by Greek fleets in western Greece (Panou et al. 1999). 47 longline boats were known to be based in the Ionian Islands and the Epirus coastal region alone in the mid 80's. Camiñas and De la Serna (1995) gave a total figure of 400 boats from 70 ports being involved in the Greek swordfish fishery in 1991. The main fleets, concentrating 50% of total Greek production, are based in Kalymos (south-east Aegean) and Chania (Crete). 70% of the total annual catch is taken at the peak of the season, from May to September, in an area covering the Aegean Sea, the Ionian Sea and even the Levant Sea. About 180 vessels are involved in albacore fishing in the central and northern Adriatic.

Summary on pelagic longline selectivity

Apart from harming important groups taken as by-catch, pelagic longlining in Mediterranean waters is clearly unselective with respect to non-target undersized fractions of the populations that are the object of the fishery. Some data even point to immature large pelagic fish constituting the bulk of surface longline fisheries. This applies mainly to swordfish and, to a lesser extent, bluefin tuna. Regardless of whether small specimens are caught because of the intrinsic action of the gear or merely reflect the overfishing of populations known to be at low levels, action could be undertaken to minimise the negative impact of present longline practices :

?? the creation of no-fishing zones in strategic areas and seasons, for example spawning and nursery grounds or coastal areas in the autumn, could be considered as recommended also by the authors of the TRAFFIC-WWF study,

?? the extension of the Spanish fisheries jurisdiction to a vast region in the western Mediterranean (Royal Decree 1315/1997) provides an opportunity to enforce EU Regulations (derived from ICCAT Recommendations) and implement other new measures in these formerly international waters.

This section does not set out to deal with the issue of the monospecific management of large pelagic populations, but it is clear that pelagic longlining in the Mediterranean induces high levels of mortality in several ecologically-valuable and biologically-vulnerable species as well as in non-target, legally protected fractions of swordfish and tuna populations, to the extent that the fishery might just as well be targeting this latter group. Large pelagic species are apex predators and key players in Mediterranean pelagic ecosystem; conservation of these species appears to be essential to keep ecosystems healthy. Overfishing of pelagic apex predators (bonito and mackerel) in the Black Sea may have triggered a trophic cascade effect working down to lower trophic levels, making the system less resilient to external changes (Daskalov 1999). The well-known Mnemiopsis invasion led to the collapse of fisheries in the late 80s. All the evidence strongly suggests that current policies should be revised in favour of an ecosystem-based management of large pelagic fisheries and the related surface longlining fishing practices.

3.5.1. Incidental catch of elasmobranches

The potential impact of the albacore longline fishing with several species being taken as by-catch, including turtles, sharks, as well as young swordfishes and other species of Teleostei had been described in the gulf of Taranto by several authors since the beginning of the 80s. The activities of the Italian large pelagic fishing were investigated in 1998 within a EU project, to evaluate the incidental catches of sharks (De Metrio et al. 2000). Most of the catches of sharks consisted in blue shark (Prionace glauca). In the Ligurian waters, blue shark represents 85 % in number of by-catches observed in the landing of swordfish longlining fishery (Orsi Relini et al. 1998). The same situation was found to in the Spanish swordfish fishery (Raymakers and Lynham 1999).

The catch number of sharks for 1000 hooks are however relatively low (0.4 –1.5). In respect to the proportion of blue shark within the total catch, it is higher in longlining for swordfish, about 12 to 20 %, than for albacore. A few other elasmobranch species are also caught as by-catch, such as the thresher shark (Alopias vulpinus), the shortfin mako (Isurus oxyrinchus) and the porbeagle (Lamna nasus) (Orsi Relini et al. 1999).

Incidental catches of young white shark (Carcharodon carcharias) are also reported within the Maltese longline fishery for the bluefin tuna (Thunnus thynnus).

Blue shark (Prionace glauca) represents in Mediterranean Sea, a resource well exploited by the artisanal fisheries while, when long fishing trips are carried out by industrial fisheries, sharks are often discarded. Blue shark is a pelagic species living from the surface down to at least 150m. Highly nomadic, it is mainly present in waters of 7 to 16°C of temperature and sometimes up to 25 °C. It may swim in the deeper Southern Mediterranean waters, during the high summer. Preferring offshore clear and deep blue waters, Blue shark makes inshore incursions, particularly at night. In nursery zone, as Northern Adriatic waters, juveniles may be frequent in waters less than 50m deep, during the summer months. Preferentially feeding on small pelagic fish and squid, they are opportunistic scavengers of floating marine mammal carcasses and fishing vessels discards, following ships for great distances. Their feeding activity is probably throughout all the day but seems to increase at night. In Atlantic the highest density of shark population seems to coincide, when discards are abundant and competition with top predators is reduced.

Stingrays, mainly Dasyatis violacea, are regularly caught in several drifting longlining fisheries in the Western Central Ligurian Sea being about 9-10 % of catch (in number of fish) or 0.4 to 3.1 individuals/1000 hooks: Orsi Relini et al. reported in 1998 that a fishing effort of 36450 hooks set over 7 fishing seasons had led to the discarding of 85 stingrays. On other hand some specimens of the protected species Mobula mobular are regularly caught by longlining in the Ligurian Sea and in the South Western Mediterranean (Aguilar et al. 1992, Orsi Relini et al 1998).

Technical solutions for preventing catch of elasmobranchs must be searched in both design and rigging of the longlines and in studying the behaviour of the concerned (as target or by-catch) species. The use of branchline in monofilament, the design and size of the hooks and the depth to which the line is set are the main elements which have to be considered.

As for example for the Blue shark, which is the most common species of sharks in Mediterranean, solutions must be to avoid the areas during, the season and at the depth where this species (and particularly the juveniles) is the most abundant (e.g. NW Adriatic sea in summertime). Therefore, because blue sharks are met more frequently in inshore waters at night, it is useful to avoid longlines setting too close to the shelf. Moreover, for swordfish longline fishing, there would be a great interest to experiment daylight setting in deeper waters than in the traditional way, to avoid both blue shark, turtle and young swordfish and to reach the adult swordfish foraging during the day under the thermocline.

In last, avoiding to throw out of board garbage and discards at sea on a fishing area is an essential precaution to do not attract scavengers as blue shark on the catch.

3.5.2. Incidental catch of seabirds

Longlining is considered to be the main cause of seabird mortality within the fishery activities in Mediterranean Sea. Several species of seabirds use to feed on the baits of the longlines. Although several species of seabirds may be incidentally caught on longlines, the Cory’s shearwater (C. diomedea) and Audouin’ seagulls populations are very likely the most affected by this fishing technique (Cooper et al. 2000, Marti and Belda Perez 1998).

According to the literature, these incidental catches occur mainly not far from breeding areas where seabird concentrations are important such as Columbretes Islands, in the NW Mediterranean where, in addition, a fleet of swordfish and hake longliners are operating. Incidental catches of seabirds are reported within both swordfish and hake longlining fisheries but the risk is higher within hake bottom longlining fishery (0.72 birds caught per 1000 hooks, against only 0.22 for swordfish surface longlining fishery). The high levels of mortality on adults of certain seabird species resulting from such incidental catches are now a serious concern in respect to the survival of their populations and technical solutions are urgently required.

Observations carried out on hake bottom longlining and swordfish surface longlining fisheries show that most seabirds are caught during the setting of the longlines (Valeiras and Camiñas 2000), within the brief time before the baited hook sinks beyond the birds' reach. Once a bird has swallowed a hook or if it has been entangled in the line, it is pulled underwater by the sinking longline and drowned. The critical distance from the stern (where baited hooks are still over, on or just below the surface) is between 50 m to 150 m; further astern, baits tend to be too deep for seabirds' reach. Some birds are also caught during the hauling of the longlines but they can often be released alive.

Experience from longline fishing in Australia and Japan has shown that a number of different mitigation measures can effectively reduce the incidental catch of seabirds when longlines are used (Datzell 2000).

- Night setting, avoiding setting during full-moon nights, punctured swim-bladders to ease the sinking of the bait and furthermore extra weight fixed on the line to take the hooks rapidly out of reach of seabirds are the simplest and the most effective ways to prevent interactions and are easy to apply, including by the smallest fishing units. In USA, some fishermen also dye their bait blue to make it more cryptic when it enters the water.

- Streamers, floats and broomsticks can be towed behind the vessel to discourage birds from catching baited hooks before the longline has completely sunk. It is worth mentioning that, in respect to such devices, "Tori lines" are widely used in Pacific waters. A number of studies were carried out for assessing carefully the 'tori line' effectiveness in the Southern Pacific, on New Zealand fisheries in particular (Duckworth in Datzell 2000): this effectiveness obviously depends on a proper design of the device, how it is deployed and, also, weather conditions during the setting.

- Many industrial tuna/large pelagic longliners are using bait-throwing machines for increasing the speed of setting and setting more hooks and also, to help the sinking of the bait (in reducing the tension on the main line). The use of such equipment practically reduces the time during which the baited hooks are accessible to seabird and, therefore, the chances of incidental catches.

- A last solution was found to this problem: Setting the longline directly beneath the surface through a tunnel placed behind in the stern of the vessel so that the baited hooks are made physically unavailable to the birds (Bjordal and Lokkeborg 1996).

3.5.3. Incidental catch of turtles

Loggerhead turtle (Caretta caretta) is by far the main sensitive species captured in pelagic longlining fisheries in the Mediterranean Sea, as reported in several documents, (Metrio G. and P. Megalofonou 1988; Camiñas and De la Serna 1995; De Metrio et al. 1997; Panou et al. 1999).

In the Ionian Sea a considerable number of Loggerhead turtles are caught, every year, during their mating and nesting season by Greek swordfish vessels. The estimate is up to 280 turtles being caught every year in the entire Greek Ionian Sea, amateur and small scale, coastal, and sport fishing not being taken into consideration (Panou et al. 1999). The majority of these would be immature.

A large number of marine turtles, mainly Caretta caretta, appears in the gulf of Taranto (Italy) in summer and autumn for trophic and reproduction reasons. Their presence coincides with the fishing period for swordfish and albacore with longlines and driftnets. Incidental catch amounting to about 1 turtle per boat and per year is reported (De Metrio and Megalofonou 1988).

The Alboran Sea and the Gibraltar Strait beside are areas of transit between Mediterranean Sea and Atlantic, so loggerhead turtles migrate, from Atlantic to Mediterranean at the beginning of spring and, from Mediterranean to the Atlantic during summer and autumn. Several documents report catches of turtles by longliners targeting swordfish in Spanish waters, during summer time with rate reaching up to 9.8 turtles per day and per boat (Aguilar et al. 1992; Camiñas and Valeiras 2000). The catch rate of turtle is estimated in swordfish bnglining fisheries in general, to 0.33 per 1,000 hooks.
Within the albacore longlining fisheries (with hooks set deeper in the sea) higher by-catch rates are found: 1.05 turtles per 1,000 hooks. Furthermore, the probability for the turtle of drowning when hooked on the longline seems to be higher on deeper lines used for albacore than on swordfish longlines closer to the surface (Camiñas and Valeiras 2000).

Several observers have largely described the mechanism of the capture of turtle on longlines. When a turtle encounters a longline, it may wish to take the bait on the hook and be caught in different ways: When the animal is only tangled in the line or “lightly hooked” in the mouth or by the beak, the line or the hook can be removed without severe injury. At the opposite, a deeply ingested hook cannot be removed without causing further harm and the usual practice consists in cutting the line as close to the mouth as possible and immediately releasing the turtles overboard. The estimate is that 80% of turtles caught on longline are released with the hook still fixed in the mouth, pharynx or oesophagus (Camiñas and Valeiras 2000).

Although the turtle are therefore released in live, studies on post-catch mortality of hard-shelled turtles show that 33-40% of the individuals caught will probably die within less of one month (Aguilar et al. 1992). If substantial wounds (cuts, constriction, bleeding) may result from entanglement in a longline, the post-catch mortality of the turtle would result more from the ingestion of hook. In particular, during line retrieval, when hooked turtle is dragged through the water column and hoisted aboard, the hook embedded into the soft tissue of the gastro-intestinal tract may lead to further internal injury and haemorrhage (Dalzell 2000).

If the hook does not pierce an organ, it can pass through to the colon, or even be expelled by the turtle (Aguilar et al. 1995). Leatherbacks are less resistant than loggerheads and ingestion of hooks and lines generally inflict them more damage mainly because of their weight, in particular when they are hauled on board or during their attempt to escape.

Fishing gear design and characteristics as well as animal behaviour versus to the gear, environmental conditions and management measures are elements to be considered for reducing both the numbers of interactions between turtles and longlines and hooks and the mortality which may result from such interactions. Practically the following recommendations can be made:

- To avoid areas, seasons and times of day where turtles occur in large concentration for foraging or breeding. It was observed that sea turtles tend to aggregate in areas typically fished by longliners targeting swordfish: they are taking advantage of high productivity food availability associated with particular oceanographic features. Several studies showed that surface water temperature is an important factor in respect to the by-catch rates of leatherbacks and loggerheads. For all species combined, lower temperature is associated with lower by-catch rate of turtles (Hoey and Moore 1999). Once again, for avoiding by-catch of swordfish juveniles and blue shark, setting swordfish longlines during the day, in deep waters, should be tested.

- To avoid, as far as possible, the attraction of the turtle by the gear. Sea turtles are known to be strongly attracted to brightly coloured objects (Arenas and Hall 1992) and, therefore, may be attracted by coloured floats and buoys used on longlines. A study carried out in Hawaiian Islands (URS 2001) showed that there is a tendency for more turtles to be caught on hooks closest to buoys. This observation suggests - to take care of hooking the branchlines more away, as far as possible, from floats and buoys, - to counter-shade buoys and floats at the surface to reduce their visibility from below. Blue-dyed squids as bait, having less visibility, have been shown to reduce both seabirds and turtles by-catch.

- Another suggestion concerns situation where turtles are feeding near the surface; they can pick up the baits of longlines set near the surface or catch baits during the setting. This observation suggests to minimize, as far as possible, the time during which baited hooks are close or not far from the surface. This suggests weighting the mainline. In addition, the faster the mainline is shot, the deeper it will sink because of the sagging of the line between floats and, therefore, the use of a line-shooter may also be a solution, in particular, with very long longlines. Once again, having blue-dyed squids as bait, may reduce chances of hooking during the setting of the line. Practically, in the case of loggerhead turtles, since it was observed that their mean diving depth is between 9 and 22 meters, the risk is more likely at such depths. The solution is to take care of keeping the baited hooks below about 25 meters in depth: The longline has to be rigged in such a way that the hooks on the closest branchlines to the buoys which are also the closest to the surface are not at less than about 25 meters depth.

- To reduce risks of turtle drowning on the lines, shorter soak times should, as far as possible, be adopted for longlines. A low percentage of caught turtles are reported dead; however, sea turtles can be drowned if hooking or entanglements with line prevent them from reaching the surface to breathe. This occurs at any time during longline fishing, including the setting and hauling of the line when the turtle meets a line that is too short or too heavy to allow reaching the surface. Leaving more space between two adjacent branchlines may also avoid entanglements of animals involving the two branchlines.

- If a turtle is incidentally caught, the hook should be removed whenever possible (when the hook is not too deep in the throat) and the animal immediately released. For such operation, fishermen's collaboration is, obviously, essential. Trained personnel aboard boats fishing with hooks must be able to remove the hook from turtle as quickly and carefully as possible to avoid injury or mortality. If the hook cannot be removed (e.g. the hook is deeply ingested) there should be on board a line clipper (for 2 mm monofilament or braided twine) to cut the line as close to the hook as possible (For practical reason, it is convenient that the cutting blade is securely fastened to a pole of about 2 meters in length). A wire cutter may also be useful to cut the hook itself.

- At the same time, effective de-hooking systems should be developed that allow fishermen to remove hooks from turtles being superficially-hooked without bringing them onboard the vessel. Anyway, if a turtle incidentally caught has to be hoisted onto the deck, much care should be taken: There should be on the vessel a “sea turtle dip net” including a bag about 1 m2 opening and 1 m depth made of a net webbing with no more than 6 cm mesh size, supporting a minimum of 34 kg and with a handle about 1 fathom long.

- A variety of hooks are used in longlining. However in Mediterranean swordfish longlining fishery, style J-shaped type is commonly used. Changing fishhooks may both reduce by-catch and risk of mortality. A change to the use of circle hook in Hawaiian longline fisheries for swordfish gave encouraging results with reduction of the risk of turtle being deeply hooked and, therefore, the risk of serious injury. The use of corrosive hook which does not last forever on an animal is also something to encourage.

- Finally, proper information and motivation of fishermen is essential, as well as their practical training in turtle handling and technique of resuscitation.

3.5.4. Incidental catch of marine mammals

A comprehensive report of all available information on incidental catch of cetaceans was published in 1992 by Di Natale. Cetaceans as fin whales (Balaenoptera physalus), sperm whales (Physeter macrocephalus), false killer whales (Pseudorca crassidens), Cuvier's beaked whales (Ziphius cavirostris), Risso's dolphins (Grampus griseus), bottlenose dolphins (Tursiops truncatus) and striped dolphins (Stenella coerulealba) appear as incidental catch in longlining. Everywhere all drifting longlining fisheries may have interaction problems with cetaceans according to the large distribution and the migratory behaviour of the various species. Also monk seals are incidentally caught with longlines in Greece, fact which constitutes a further threat for the species (Cebrian et al. 1995; Cebrian 1998a).

3.6. Bottom longlining

Not much problems of environmental impact due to bottom longlining have been reported so far. However, for instance, the highest rate of incidental captures of turtles on lines is due to bottom longlining in Tunisia waters with an average of nearly 23 turtles per longliner and per year (Bradai 1995).

A study on the influence of longlining on seabirds in the area of the Marine Reserve of Columbretes Islands (NW Spanish Mediterranean waters) shows a number of incidental captures of birds bigger within the bottom longlining fisheries (0,72 to 1.78 birds/1000 hooks), than when surface/pelagic longlines are used (0,22 to 0.49 birds/1000 hooks) (Marti and Belda-Perez 1998).

The bottom longlining which is used off Columbretes Islands is targeting hake. The main characteristics of the longlines are: 7 to 8 km in length, with about 1500 –2000 hooks of 3/0-4/0 in size, with sardine (12 -17 cm long) as bait. The line is set at 5-6 knots. Among the 26 setting which were observed the incidental catches were found being maximum between 6 and 9 a.m. and between 4 and 7 p.m. 5,9 bait per 1000 hooks were eaten (meaning some economic loss!). The distance from the stern of the vessel where seabirds are attempting to catch the bait on hooks is between 15 – 35 m.

It is worth mentioning that when using surface longlines, the attacks by seabirds are, in general, farther from the vessel, between about 40 and 70 m. The difference compared to the situation when using bottom longlines results from the fact that surface longlines are normally set at greater speed making more waves and eddies at the stern. The turbulences and the lower number of hooks by length reduce the accessibility of the baited hooks to the birds and consequently the number of bird attacks (while, in bottom longlining, the smaller space between hooks and the higher number of set hooks set for a given time increase the chances of bird attacks). In addition, while the bottom longline sinks faster, the number of depredation and bird catch is, in general, greater than with midwater drifting longlines. One another explanation of this difference of catch would be found in the fact that hooks used for hake are smaller (n°3/0) than for swordfish (n°5/0) and can consequently be more easily swallowed by the seabirds.

Having seabirds stealing baits on the longline during the setting is a certain preoccupation for the fishermen, in general, more than seabird protection!). In the area of the Columbretes Islands, two measures are sometimes applied by the fishermen: Reducing the visibility of the bait by doing the setting at night and the use of "scarebird" system. The first one is the most common and which offers the best result. The main drawbacks are the increase of no commercial by-catch species, the lost of bait by nocturnal scavengers (in particular in bottom longlining). Deterring devices are also used but with less efficiency, consisting in trailing a buoy behind the stern of the vessel immediately after the first bird attacks. The main disadvantages are the quick familiarization of the birds to this scaring system and its inefficiency when the birds are in few numbers. In last, making noise (foghorn, cracker) is also a deterring technique which is sometimes used with more or less success, depending of the bird species

More sophisticated techniques would be used like in Norwegian industrial longlining (scare-line), however, it is worth observing that bottom longlining in Mediterranean Sea (as off the Columbretes and Balearic Islands) is, in general, carried out at small or medium-scale and that a number of the technical measures mentioned above might hardly be applicable because of generating additional costs.

3.7. Static nets

The most common fishing gears used in the Mediterranean small-scale fisheries are static nets, particularly trammel nets and gillnets. At the beginning of the eighties, because of the introduction of cheaper synthetic material coming from Asia, their use spread quickly everywhere within the Mediterranean small-scale fisheries. Easier to set and less cumbersome than traps, safer than longlines and above all much more efficient, gillnets and trammel nets progressively replaced various other static gears for various targeted species. Nearly all gillnets and trammel nets now in used are made from nylon. Monofilament nylon twine for making these nets proved in many cases increasing the effectiveness compared to multifilament twine; however, it is now forbidden in some countries such as in Greece.

The gillnets and trammel nets are very often set before sunset and hauled after dawn, generally lasting less than 10 hours at sea. However for crawfish, the soaking time may be between 2 to 5 days. According the target species, these static nets may be used from very shallow waters (e.g. red mullet trammel nets) to deeper bottoms one e.g. for bluntnose shark. The length of net set every day obviously depends on the size of the vessel (the space available on board) and the number of crew; in general, it does not exceed 6 to 8 km, on the larger vessels.

Comparing to mobile bottom fishing gears (e.g. trawls, dredges) the effects on seabed are insignificant and concern relative low quantities of fixed bottom fauna in small areas and which can be removed and destroyed mainly during the hauling process of the net fleets.

Static nets are the most common fishing gears used in the Mediterranean small-scale fisheries.
D. Cebarian

3.7.1. By catch discards and selectivity

Catch process for static nets is based on a combination of enmeshment of the fish in one of meshes of the net webbing and entanglement of its body in the net panels. The first catch mode, enmeshment, plays the main role in the relation between the fish size and the mesh size, the second increasing the efficiency of the former on the larger and smaller fishes. The two above mentioned components practically allow, according to their arrangement, to design fishing gear being highly selective for certain species and size of fish.

Static nets are usually highly selective. It is difficult to make comparisons regarding the effectiveness of various types of fishing gear having different catch process. However observations made on different commercial fisheries on the same area show that in most of fisheries using static nets, the proportion of undersized caught fishes is generally lower than when mobile/towed fishing gears are used. The investigations carried out on twelve fisheries using static nets (with different mesh sizes, dimensions and rigging) within the Greek, Italian, Spanish and French small scale fisheries show a low level of undersized fish, in general (e.g. no more than 1 –3 % for hake gillnetting) (Sacchi et al. 1998). Different types of net can, in turn, also differ deeply as to intra- and interspecific selectivity. A comparative study of catches in 8 types of net gear (both beach seines and static gill and trammel nets) in the Aegean Sea revealed that large meshed trammel nets yielded the biggest commercial catches as a proportion of total catch (Stergiou et al. 1996). The relative selectivity of trawl nets, bottom longlines and gillnets operating on slope bottoms (between 200-700 m) in the southern Adriatic Sea was analysed with respect to 3 demersal species: blackmouth catshark (Galeus melastomus), rockfish (Helicolenus dactylopterus) and blue whiting (Micromesistius poutassou). The results showed that gillnets ('rete ad imbrocco') were always the most positive selective gear for size of individuals caught. The modal length of blackmouth catshark caught by gillnets, for instance, was 54 cm, contrasting sharply with only 16 cm reported for trawl nets (Ungaro et al. 1999).

Other selectivity studies comparing different mesh sizes or types of static nets (trammel, gillnet), carried out these last ten years in different Mediterranean countries (Sbrana et al. 1999, Sacchi et al.,1998) observed that, for a given gear type, the number of species caught increases when the mesh size decreases; The hanging of the net webbing (on the frame ropes, floatlines and leadlines) also affects the effectiveness of the static nets so that when the hanging staples are too tight, the space between the net panel and the bottom line is reduced and favour unwanted catch of benthic species (e.g. groundfishes, starfishes, sea urchins). More specifically, Sbrana et al. (1999) carried out a comparative study of interspecific selectivity with three kinds of static net, monofilament gillnets, trammel nets with a monofilament inner panel and entirely multifilament trammel nets, and also tested the effect of different mesh sizes. The study concluded that whereas the number of species caught was negatively correlated with mesh size of a given gear type, inter-specific selectivity decreased from gillnets to trammel nets; the trammel nets with 3 multifilament nets were the less selective of all. However, the target species in the Sardinian cuttlefish (Seppia officinalis) fishery using trammel nets constituted up to 78% of the total catch weight (Cuccu et al. 1999).

The amounts of the discarding are very variable and depends of several external, immediate, factors such as the quantities of the by-catch as a whole, including in comparison to the quantity of the “main catch”/target, the immediate opportunities on local markets and expected value, the skill of the crew. Except the exceptional case of the crawfish trammel nets which can stay at sea more than 5 days before being hauled, most of Mediterranean static nets are not left enough time at sea for allowing that substantial quantities of fish are degraded by scavengers.

BOX 14

Importance of artisanal gear

The diversity and economic importance of artisanal gears in small-scale fisheries are essential features of Mediterranean fishing. Stergiou et al. (1996) consider that small-scale fishing is socioeconomically more important than trawling and purse seining in Greece since it occupies 87.5% of all boats, 57.5% of total fishing power (in HP) and produces near half of the total wholesale value of catch. The heterogeneity of gear and target species makes it difficult to reach any general conclusions as to the impact of these small-scale practices on the ecosystem. Factors such as the season of the year and the characteristics of the area exploited (depth, type of bottom etc.) further complicate the picture. Some trends emerge nonetheless, such as the higher selectivity of some gear and the negative effects of other artisanal practices. Ghost fishing by abandoned or discarded small-scale gear is another issue of potential importance in the Mediterranean.

Souces : Stergiou et al. (1996).

3.7.2. Incidental catch of elasmobranchs

There are a few fisheries with static nest targeting sharks such as in the North of the Adriatic Sea, for Mustelus spp. and Squalus spp. (Vacchi M., G.Notarbartolo Di Sciara 2000). Although sharks are, in general, of low importance in most of the catch of the Mediterranean static nets fisheries, they can represent more important by-catch in hake gillnet fishing (between 11% and 14% of the total catch number), mainly including small commercial shark (Galeus melastomus and Scyliorhinus canicula). In the later fishery, the by-catch also includes 0,8 % of Chimaera monstrosa (Sacchi et al.,1998). The proportion of sharks or other elasmobranchs in the catch of static nets may be by far bigger in deeper waters. Evidence is given by the experimental fishing carried out in several hundreds meters deep waters off Sardinia, in 1991 – 92 (areas which are not frequented by fishing fleets so far): The catches of elasmobranchs was 75% of the captures in weight; the most abundant species was a shark, Centrophorus granulosus (Addis et al. 1998).

The majority of the Cetorhinus maximus taken in the Liguria Sea and North Tyrrhenian area is incidental catch in fisheries using static nets, in spring (Serena and Vacchi 1996).

Fergusson et al. (1999) report that large white sharks (Carcharodon carcharias) can incidentally entangle themselves in bottom gillnets set on 15 to 30 m depth close to Filfla Island and off Marsaloxlokk in Malta; the same authors also mention catches of white shark in similar types of nets in Sicily, Greece and Turkey. Incidental catches of one-year juvenile of the same species are also reported elsewhere in the Mediterranean Sea, off Algeria, France and in the North of the Aegean Sea.

Small sharks as dogfish are mainly caught by enmeshment but generally large sharks and /or fast swimming sharks are often caught in net by wrapping. To avoid these incidental catches while maintaining the target it is important to reduce the entanglement mode. As for other by-catch problems, the increase of hanging ratio can be useful. With this aim, basing their observations on experiments carried out in North Carolina on coastal bottom gillnets, Thorpe et al., (2001) suggest to increase the tension in the net panel by increasing both the leadline weight and the floats buoyancy.

3.7.3. Incidental catch of seabirds

Incidental catches of seabirds seem to occur sometimes essentially in coastal waters as reported by De Juana (1984) in bottom entangling nets off the Chafarinas Islands.

To scare seabirds, a white seine netting (called “bird strip”) of 1,5 fathoms in height may be installed between the floatline and the net webbing itself: seabirds can perceive the gear as a barrier and therefore can avoid it.

3.7.4. Incidental catch of turtles

Sea turtles may also get entangled in gillnets or trammel nets in coastal waters when trying to feed on enmeshed fishes, as it is reported in Kefalonia Island (Ionian Sea) (Sugget and Houghton 1998). Off Northern Cyprus and the Turkish Mediterranean coasts. about 2000 turtles, minimum, are estimated to be caught every year in set nets or longlines (or 2.5 to 4 turtles per boat) (Godley et al. 1998). Regarding the French coasts areas, Laurent (1991) points out the important mortality of turtles due to incidental catches by trammel nets set on the bottom for sole and scorpionfish. These nets are set from 0 to 50 m deep at less 500 m of the shore.

The solutions to reduce risks of turtle drowning seem to be - to set the nets deeper than the depth the turtles can reach and - to avoid too long soaking time.

3.7.5. Incidental catch of marine mammals

Various species of marine mammals mainly, Risso’s dolphins, common dolphins and bottlenose dolphins were reported as incidental captures by entanglement in static fixed nets (Anonymous 1994, Di Natale and Mangano 1983; Di Natale 1983bc; Duguy et al. 1983b). Mangano 1983; Di Natale 1983bc; Duguy et al. 1983b). The highest annual mortality range due to coastal gillnet fisheries is observed for bottlenose dolphins (50 - 200). As far as the most endangered species are concerned, up to five monk seals and three whales are estimated to die annually drowned by entanglement in coastal bottom nets. It is worth noting that of the height humpback whale (Megaptera novaeangliae) which have been reported visiting the Mediterranean Sea, three were found dead by entangling in bottom gillnets.

As for turtle, problems occur when the marine mammals come to feed on fish enmeshed or entangled in the net webbing of a bottom static net. When a marine mammal rubs itself on the webbing, rips, more or less severe, may appear on its skin. If the mammal is entangled in the static net, it dies by drowning.

When a marine mammal get entangled in a static net, it may die and, at the same time, the fishing gear is often severely damaged or even destroyed. It is practically difficult to assess the incidental mortality of marine mammals and fishing gear destruction because fishermen are generally reluctant to give information on this type of incident. However, observations were made (Consiglio et al. 1992) on damage caused by schools of bottle-nose dolphins on static nets set close to the North- East coasts of Sardinia, in shallow waters (In this area, fishermen are using trammel nets in spring and summer for bottom fish and gillnets in winter for small pelagic fishes): About one hour after the trammel nets had been set, a group of dolphins came for tearing out caught fish, making large tears in the net; their activity continued until the nets were almost emptied. Similar occurrences were reported in different areas where the dolphin activity is important. Same problems and damages caused by seals were also reported and the entanglement problem is so important as to be enough by itself to provoke the extinction of the monk seal in the Mediterranean (Cebrian et al. 1995, Cebrian 1998a).

Except avoiding the areas where marine mammals have activities (Cebrian 1997, Cebrian 1998a) there is no very efficient and simple solution today to prevent attacks of static nets by dolphins or seals. Monk seal damages to nets (and consequent risk of entanglements) in seal breeding areas have been proved to decrease from a maximum of 10% of the total net settings besides the seal caves to 1% at 10 nautical miles from them. This could be the key for their conservation through banning of net settings close to seal caves (Cebrian 1998a). Acoustic repellent devices (10 to 20 kilohertz of frequency) are used with some success for sea lions in the Pacific, but experiences are lacking on seals and they could be an additional threat for the Mediterranean species. More research is still to be conducted, in the Mediterranean Sea, in particular.

3.7.6. Ghost fishing

Loss or forsaking of gear is a common situation to all the Mediterranean fisheries but ghost fishing is mainly related to the use of gillnets, trammel nets and traps (passive gear). Their massive use in many small-scale Mediterranean fisheries makes ghost fishing by abandoned or discarded gear a potentially important problem in Mediterranean waters but has attracted scant attention. The interest of the scientific community for this problem is too recent and studies too limited for being in a position to assess completely the risk. Until now, only two studies both funded by EC have been recently carried out in the Mediterranean Sea on this subject (Costa Cl. com. pers.; FANTARED 2 Project).

Ghost fishing by abandoned or discarded gear creates a potentially important problem in Mediterranean waters. A. Bouajina © RAC/SPA

Over the last decades, the dramatic increase of the use of gillnets and trammel nets in all small-scale fisheries, has obviously increased the risks of loss of gear and, therefore, ghost fishing.

A net may be lost for several reasons: being hooked to the bottom, a marker (e.g. buoy) or signal being lost, deterioration by trawl (by any active/mobile fishing gear) or other activities at sea. Because of the impossibility to retrieve it or simply because of fishermen' negligence, a whole fishing gear or a piece of net may be abandoned.
Experiments were therefore carried out these last years in Italy, Portugal (Erzini et al. 1997) and recently on French and Ligurian coasts to assess the importance of net loss and potential consequences on resources and environment (see Box 15).

First results show that the main causes of loss are a passive fishing gear being hooked by a trawl, "loss of depth" when setting a gear on a slope or hooking at hard bottom and a wreck.

While the recent improvement in the positioning of nets and traps thank to the use of advanced positioning system such as GPS has considerably reduced the potential risks when marker or signal have been lost, the estimate is that the loss of gears could amount to around 10 % of the net set per year, in the most critical cases. Moreover, the rate of loss of gear differs, for a given fishing technique, from fishery to fishery: It depends on the environmental characteristics of the fishing grounds (currents, weather, bottom nature) and the fishing practices and if there are many other marine activities (trawling, maritime transport, tourism) on the same fishing area or not.

BOX 15

Ghost fishing

An experimental study of gillnet and trammel net ghost fishing in shallow (15-18 m) rocky bottoms in the Atlantic waters off the coast of the Algarve in southern Portugal was carried out. The results of the study indicated that abandoned gillnets yielded more catches than trammel nets, as measured by the mean number of fish caught by 100m-length pieces of net after 120 days of deployment on the bottom (gillnets: 344 fish specimens entangled; trammel nets: 221 fishes trapped). Whilst catches decreased gradually over time, nets continued to catch fish 4 months after the experiments had started. Osteichthyes were the most numerous group among the 39 species recorded, accounting for 88.8% of total specimens in numbers. The other groups included molluscs, gastropods and crustaceans. Sparidae species, however, made up about 33% of total catch in numbers. There is evidence suggesting that nets lost in deep water may have an even longer effective fishing lifetime, running to years. This is a matter for concern since some deep gillnet fisheries (such as the Italian 'rete ad imbrocco' in the southern Adriatic) operate in Mediterranean waters.

The results of the above-mentioned study also implicated ghost fishing in disturbing demersal food-webs in a similar way to that reported for trawl discards. The authors described considerable scavenging pressure on trapped fish by octopuses, cuttlefish, conger eels, moray eels and wrasses (Coris julis), which could have led to the actual fishing capacity of discarded nets being underestimated.

Source: Erzini et al. (1997).

Underwater observation of various types of gillnets and trammel nets shows that such passive nets are losing gradually their fishing efficiency; the reasons are, in general, - a progressive reduction of their height resulting from entanglement and - the development of fouling on the different parts of net which weighs it down and makes it more visible.

The rate of the progressive decrease of effectiveness depends on various parameters such as material of net construction, bottom nature, depth, current and meteorological conditions in general in the fishing area. Practically, the total loss of fishing efficiency may take between few days for a trammel in shallow waters and set on sandy grounds to several months for net set in deeper waters with low current and low biological fixation (fouling). Consequently the impact of ghost netting on ecosystem is extremely variable. However, as a rule, the development of important population of invertebrate scavengers around abandoned gear should be mentioned.

The present conditions of fishing in Mediterranean Sea do not make, in general, nets loss (and ghost fishing) a major threat. However, the consequences of nets lost in deeper waters should be considered seriously if, as suggested by observations made on Scandinavian deep gillnets fisheries, there is, then, a risk of long effective (ghost) fishing running to years. The prohibition of drift-netting in European countries could lead to an increase of deep bottom netting for Merluccius merluccius, for Pagellus bogaraveo and for deep crustaceans. Precautionary measures should therefore be taken from now on. These measures could include improvements to the design and construction of the fishing gear, fishing effort limitation and access restriction (closed season, marine reserves, etc.).

Some technical measures would be in particular advisable as the use of biodegradable twine for the hanging of the net webbing at least on the floatline to allowing the release of the floatline in the event of long immersion and/or the fixation of "retrieval device" on each fleet.

To avoid risk of net loss by bottom hooking, simple modifications in net construction can be efficient as the use of thinner footropes which can break easily, larger hanging ratio (more of 50 %) reducing the slackness of the net webbing and large bottom staple to take it far from the bottom.

In shallow waters, because pieces of net webbing may remain partially deployed over a long period of time, gillnets or trammel nets being hooked on reef bottoms or on wrecks are serious risks for all animals foraging in their vicinity such as seabirds, turtle and monk seal (Yediler and Gücü 1997). The interdiction of setting nets on specific areas where such potentially endangered species are known being numerous may be an effective measure of protection.

BOX 16

Overview on Small Scale Fisheries

The high diversity of artisanal gear (and species targeted) and the importance of small-scale fisheries in many Mediterranean coastal waters introduce considerable additional complexity to the overall issue of the ecosystem-based management of Mediterranean fisheries. In this context, Stergiou et al. (1996), referring to Greek small-scale fisheries, stated that 'management strategies based on single species calculations will be of limited value', and advocated the promising alternative approach of a management regime based on marine harvest refuges. This holistic approach overcomes, in part, the problems related to the variable intraspecific and interspecific selectivity of different gear and other variable factors such as bottom type, depth of setting, seasons and the phenomenon of ghost fishing.

There is sufficient scientific consensus to support the total banning of some artisanal gear in Mediterranean waters. Beach seines should have been eradicated from EU Mediterranean waters from January 2002. All fishing with coastal seines was devised to be prohibited by 2001 in Turkish Aegean waters, as has long been demanded by many local artisanal fishermen (Anonymous 1999b). Game fishing is a superfluous non-commercial practice and must be prevented from inflicting any additional damage on vulnerable species such as swordfish and bluefin tuna.

In general terms, and leaving managerial issues aside, many artisanal fisheries (such as static or bottom longlines) are probably more selective than trawling practices, and therefore a preferable, much less ecosystem-impacting, alternative, provided that discarding gear at sea can be stopped

Sources: Stergiou et al. (1996), (Anonymous 1999b).

3.8.Driftnet

In the Mediterranean Sea, as in other areas, this fishing method is essentially targeting pelagic fishes. Several types of driftnet are used in Mediterranean Sea which are designed for different target species, small pelagic fishes such as mackerel or sardine or largest pelagic such as bluefin and swordfish (Feretti et al. 1994).

When setting a fleet of driftnets, a vessel, normally, changes directions several times for maintaining some slackness of the net webbing in the bed of current (the net fleet occupies therefore a front which is often about a third of its length only). However, some current may mix up net webbings and ropes and, consequently, decrease the net efficiency. This risk has, to a large extent, justified the use of large driftnet fleet in swordfish and tuna fisheries (Costa Cl. 1991).

While by 2002 the large West European fleets of gillnetters (about 800 vessels in 1995) were required to stop their fishing with driftnets, an important fleet still remains in European countries as well as in North Africa and Turkey; the estimate is a total of about 700 vessels but this number is now increasing with the purchase of driftnets from European driftnetters, in particular in Italy, Greece or France. This development is a matter of concern for several authors and their on-going analyses are of particular interest.

The outstanding impact of by-catches by surface swordfish driftnet fleets on many vulnerable groups inhabiting Mediterranean waters, makes a summary of the present status of these fleets desirable. The controversial issue of driftnets has been extensively discussed and an extensive literature is already available (see Paul 1994, for a global, world-wide account of this issue).

The Italian Mediterranean driftnet fleet of at least 650 vessels in 1996, using nets that are on average 10-12 km long, has long been at the centre of the debate, though it is not the only one operating in Mediterranean waters. Driftnet fleets continue their activities despite successive international initiatives banning or limiting this low-selective fishing practice (swordfish represent only 18% of the Italian driftnet catch in numbers, but nearly 50% in weight; Di Natale 1996). Resolutions 44/225 and 46/215, adopted in 1989 and 1991 by the General Assembly of the United Nations recommended imposing a moratorium on all large-scale pelagic driftnet fishing by 30 June 1992. European Regulation (EC) No. 345/92 prohibited driftnet fishing in the Mediterranean with nets over 2.5 km long, as did the General Fisheries Commission for the Mediterranean (GFCM) in 1997 under Resolution 97/1, a binding recommendation. Effective moves to restructure the Italian driftnet fleet have been made since the adoption of European Regulation (EC) No. 1239/98 and later regulations totally banning the use of driftnets by Community fishing vessels within and outside Community waters from 1 January 2002.

Some fleets indeed limited driftnet fishing in Mediterranean waters during this long political process, whilst others grew rapidly. The Spanish Mediterranean swordfish driftnet fleet is an example of the former. In 1993-94 27 boats illegally deployed nets 3-5 km long on the Mediterranean side of the Gibraltar Straits (Silvani et al. 1999). This fishery was particularly unselective, with swordfish catches accounting for only 5-7% of total catch in numbers, which was mostly sunfish (*Mola mola*) (71-93%) and other species such as dolphins and turtles (see the respective sections above). After 1994, these boats stopped using large-scale driftnets and changed target species. Other fleets, on the contrary, have continued to expand, in some cases taking advantage of gear supplied from reconverted fleets. This is the case of the North African countries and Turkey, despite national laws banning large-scale swordfish driftnetting in most of them. Italian and Greek fishermen are known to be selling their equipment to Turkish fishermen (A.C. Gücü, pers. comm.). Reliable unofficial sources estimate the driftnet fleet now operating in the Mediterranean at a minimum of 700 vessels, half of them Moroccan (more than 50 are based at the port of Nador alone; University of Barcelona 1995). In addition to this huge North African fleet, the other major fleets involved are Italian (at least 150 vessels still exist), Turkish and French. The two latter illegal fleets consist of more than 100 units each. The French vessels use nets longer than 7 km.

Drifnet : An example of unselective fishing gear in the Mediterranean.
M.Relini © RAC/SPA

In conclusion, sufficient legal instruments exist to tackle the issue of driftnet fishing in the Mediterranean. Money is also available to convert the EU's affected fleets. It is, as is so often the case, a matter of political will.

General observations which are available in the literature regarding the potential impact of driftnets on certain groups of threatened species are given below.

3.8.1. Incidental catch of elasmobranchs

By-catch and discarding of large pelagic sharks as baskin shark (Cethorhinus maximus,) white shark (Carcharodon carcharias) were reported in different drift net fisheries, off the North African coast and in the Ligurian Sea (Di Natale, et al. 1992). Incidental catches of stingrays were also reported by the same later author as well important commercial catches of thresher shark (Alopia vulpinus) and blue shark (Prionace glauca).

3.8.2. Incidental catch of seabirds

Incidental catch of seabirds plunging on driftnets are reported during setting time when the vessels are operating close to the coast. For the common shags (Phalacrocorax aristotelis) this cause of mortality might be the main reason of the population decline (Northridge and Di Natale 1991).

In the USA, the Washington Sea Grant Program is now supporting a research program on innovative by-catch reduction devices to reduce, in particular, the incidental catches of seabirds in salmon sockeye gillnets and, also, incidents between fishery activities and coastal marine mammals. Several acoustic pingers (1 to 10 kilohertz of frequencies) have been successfully tested so far in this program.

3.8.3. Incidental catch of turtles

Loggerhead (Caretta caretta) were reported getting entangled in driftnets used within Italian driftnet fisheries in the Ligurian and Tyrrhenian Seas and in Ionian Sea, during the swordfish fishing season, which is from April to September (Di Natale 1995; De Metrio and Megalofonou 1988). From the catch of 29 swordfish drifnetters of Calabria coasts (Italy), the above mentioned authors estimated that about 16 000 turtles are caught per season in the Ionian Sea.

Mortality results at 30 % of turtles caught, mainly composed of small to middle –sized specimens. One vessel with 12000 metres of drifting gillnet was catching from 3 to 50 specimens on an average in one trip. (De Metrio and Megalofonou 1988).

Incidental catches of Caretta caretta were also reported within the Spanish driftnetting fishery for swordfish in the Gibraltar Strait, from May to September, when these are migrating with the target fish (from W to E during May to July and from E to W during August to September) . From May 1989 to July 1993, 38 turtles were observed being entangled (Caminas 1997b). In spite of a relative low level of incidental catch of turtle (0, 92 %, Silvani et al. 1999) by each vessel, the total might have been important when considering the large driftnet effort which was deployed during this period.

Being incidentally entangled in a net webbing causes a severe physiological disturbance (lactate accumulation) to turtles, in general, as this was observed on entangled Kemp's ridley sea turtles (Hoopes L. A. et al. 2000). This stress associated with multiple forced immersions easily explains the observed rate of mortality.

3.8.4. Incidental catch of marine mammals

The by-catch of cetaceans in the Italian driftnet fishery is reported to be about 0.8 % in number and 8.89 % in weight of the total catches. In the Mediterranean Spanish driftnet fishery of Alboran Sea a by-catch rate of dolphins amounting to 0.1 individuals per km of net set per fishing operation was observed (Forcada and Hammond 1998). The highest by-catch rate concerns the striped dolphin, Stenella coeruleoalba (which is also the most common dolphin in the Mediterranean) (Di Natale 1997). Entanglements of other larger marine mammals were also reported: sperm whale (Physeter macrocephalus), Cuvier's beaked whale (Ziphius cavirostris), pilot whale (Globicephala melaena) and minke whale (Balaenoptera acurostrata). In the Ligurian Sanctuary, large cetaceans are sometimes found, living but unable to sink, with entangled pieces of nets, which may be drifting abandoned nets but also can be remains of drifnet not completely removed by the crew of gill-netters (Beaubrun, Pers. com.).

While the large marine mammals can, in most cases, be released alive (Di Natale 1992 a 1992 b 1995), small cetaceans such as striped dolphin die in a few minutes after the entanglement. It is well known that the most vulnerable are the young calves due to their short experience in obstacle detection. At the opposite, the bottlenose dolphins (Tursiops truncatus) have very few interactions with driftnets because the Mediterranean populations of this species are essentially coastal (Beaubrun 1998).

Because problems were reported wherever driftnets are used, it is agreed that a risk of incidental catch of marine mammals exists with the last remaining driftnet fisheries in North African waters (Ktari-Chakroun 1980). While common and striped dolphin are particularly abundant in the Alboran Sea, it is suspected that the Moroccan driftnetting fleet probably has a very high impact on these marine mammal populations.

3.9.Traps and Trapnets

The impacts on ecosystem of these types of fixed fishing gears are poorly reported in the literature and concern few items.

Traps and pots are typical fishing gears of traditional Mediterranean fisheries but have been more or less abandoned for the benefit of more productive techniques as static nets. These techniques today remain mainly for octopus, crawfish, shrimp and occasionally in few areas for seabream fishing. They are generally practised at small scale, excepted the Spanish trap fishery for deep red shrimp (Plesionika edwarsii) which is carried out by about vessels of more 20 m long, working between Balearic islands and the South Western coast of Spain. They daily set more of 600 traps on bottom of 200-250 m depth. The ecosystem impact is as for bottom static net essentially regarding problem of loss and risk of ghost fishing.

It is worth mentioning that trapnet fishing for tuna ("tonnara", "almadraba", "madrague") knows a renewal of interest now thanks to the high price paid for the largest bluefin tunas. Their activities seem to affect essentially large cetaceans (Anonymous 1994) and sharks (e.g. white shark). These animals are occasionally caught but in most of time are released in live.

Traps are typical fishing gears of traditional Mediterranean fisheries.
D.ceberian © RAC/SPA

3.10.Other types of interactions with fishing

3.10.1. Monk seal, turtle, seabirds, dolphins and other competitors with human activities

The progressive settlement of more and more human activities all along the coast of the Mediterranean Sea has resulted in the increasing of conflicts with different users of coastal space. Natural habitats of several groups of species are now suffering from perturbation and surface reduction.

For some authors overfishing has exacerbated fishing impact effect on these species in reducing food availability and for others there is the beginning of a domestication due to the settlement of human activities in their vicinity which makes their foraging habit depending on dead preys as discards, or captured fishes.

Marine mammals, seabirds or turtles feeding around fishing gear and preying on fish caught in the gear are reported as occurring in most of the Mediterranean waters (Yediler and Gücü 1997; Aguilar et al. 1991; Boudouresque and Lefevre 1991; Duguy et al. 1983; Cebrian et al. 1995).

In this action, a conflict of interest may take place between fishermen carrying out fishing operation to catch fish and groups of endangered species which are trying to feed on it. On one hand the protected marine animals have the risk of being incidentally caught and careful attention is required from fishermen to prevent it and on the other hand the attitude of certain protected species versus fishing gear and operations may cause so important damage to the gear and/or to the capture that fishermen consider them as a pest which should be eliminated. In such situation, the fact is that dolphins, turtles, monk seals and seabirds are frequently, deliberately, killed. It is demonstrated that this would be the most important cause of mortality for monk seals (Cebrian et al. 1995; Cebrian 1998a) and perhaps for dolphins.

Consumption of dolphin meat is a tradition in some places in Mediterranean (for instance, in some Italian and Spanish localities). The use of dolphin meat as bait for fishing gears is also reported (Aguilar et al. 1991); dolphin meat appears to be particularly suitable for shrimp fishing with traps. Between 180 and 260 dolphins (common and striped) would be killed, illegally, every year for this purpose (University of Barcelona 1995).

Dynamite fishing, though it is clearly illegal everywhere in the Mediterranean, is also reported as a cause of mortality for some cetaceans (Di Natale and Mangano 1983) and also monk seal (Cebrian et al. 1995; Cebrian 1998a).

Regarding suitable mitigating measures, a general protection of the breeding areas should be recommended with prohibition of all fishing activities in the vicinity of these areas. Such basic measure may, obviously, be reinforced with the development of specific repelling devices but its use must be carefully evaluated in the case of endangered species.

3.10.2. Problems related to recreational fishing activities

Nearly 140 million people live along the Mediterranean Sea's 45 000 km of coastline. An equal number of tourists floods certain areas from May to October every year for holidays and this has led to a growing development in recreational fishing activities. Most popular are angling, handline and longline fishing. In some place, set net and traps fishing may be also important. Competition for space and resource are frequent sources of conflict between recreational and professional fishermen. Professional fishermen state that recreational fisheries are responsible for the illegal market of catches and sport fishermen blamed the others for overfishing. Game fishing is a growing leisure activity in many Mediterranean waters, and probably has a significant impact on some species, for example bluefin tuna and swordfish, whose low age classes suffer particularly. Rod and reel sport fishing for large pelagic is in particular most frequently accused of significant catch of juveniles of swordfish (De Metrio 1987) and blue shark (Orsi Relini 2000). As many as 380,000 juvenile swordfish are estimated to be caught annually by non-commercial fishermen in Calabria (De Metrio et al. 1997) and in the whole Italian waters about 650 000 juvenile swordfish are estimated to be annually caught. The impact of this activity on marine populations and ecosystems in the Mediterranean remains to be adequately addressed

Whatever, the importance of the pressure on the living resources and marine environment of the recreational fishing need to be more precisely assessed and more effectively controlled with for instance the introduction of a specific license system and limitation of the use of some fishing gears.

3.10.3. Problems related to aquaculture

Because of the increase of the demand for fish and on another hand the diminution of the landings from fisheries, the growth of aquaculture has become today an economic priority. Nevertheless, the development of aquaculture in the coastal environment has drawn various problems regarding cohabitation with other marine activities and impact on ecosystems.

The installation of intensive fish farming is blamed, in particular, for inducing around significant alterations to Posidonia oceanica meadows. The alterations would result from two main factors: - the increase in turbidity of the water which reduces the light for sea grass development and - excessive enrichment of sediment with organic matter due to the incomplete consumption of the food supplied to cultivated species (Pergent et al. 1999). For above mentioned reasons, the setting up of fish farms can better be recommended in areas which benefit of strong water circulation at the bottom to disperse particles or in offshore waters far from marine meadows. Such precautions have already led to develop certain specific types of structure taking into account the environmental constraints.

Another aspect to consider is that aquaculture installations may attract varied animals (seabirds, cetaceans, seals and turtles) of which some species may be becoming active predators and can cause severe damages to the breeding cages. This kind of problems can be particularly critical on an economic point of view for small-scale fish farming activities. In Turkey the attacks from marine mammals have raised an exasperation from fishermen who now often prefer kill the animals deliberately than to improve the protection to their equipment (Anonymous 1999). In some Aegean islands, illegal bounties are offered to kill seals for this reason (Cebrian 1998b). Nevertheless, the common solution of adding a protection net surrounding each cage ('double nets protections') is an efficient and simple technique for the prevention of attacks from predators. Scaring devices, as acoustic repellents are also use in some areas (as on US Pacific coasts against sea lions and harbour porpoises) with some success. This technique is however effective only on small groups of species and deserves further improvements and researches on the behaviour of the attracted animals.

In last, in spite of higher investment and some marine legislation problems, off-shore and/or deep-sea aquaculture appears to be a potential solution for most difficulties posed by the expansion of coastal aquaculture (conflicts with other marine activities, breeding animals, coastal pollution, etc).

4. DISCUSSION ON THE ECOSYSTEM IMPACT AND MANAGEMENT PROBLEMS

4.1. Current state of Mediterranean fishing fleets

The Mediterranean fisheries are commonly described as mainly small-scale type. As such, in most of the traditional Mediterranean fisheries involve small enterprises, with small capital led by an artisan who, often, owns the production tool (vessel plus fishing gear) and control, to a certain extent the commercialisation network for his products. The fish market network essentially concerns the diversified (in term of fish species) and fluctuating (in term of quantities) demand from local consumers. To satisfy the demand the fishermen practically need, in general, to use several types of fishing gear for various seasonal activities. The small-scale fishing enterprises so common in the Mediterranean Sea have individually limited capacity but the large number of these operating in coastal waters is finally making a substantial pressure on resources and environment.

With the exception of a few tuna companies, there are no industrial fisheries in the Mediterranean Sea. However, fisheries for certain species having large markets are sometimes referred as “industrial”, for instance: sardine and/or anchovy fishing fleets, bluefin tuna and/or swordfish fishing fleets or shrimp fishing fleets. At the difference from small-scale fisheries, the industrial characters of these fisheries appear in - the specialization of the vessels on only few fishing techniques (longlining or purse seining or mid-water trawling or deep-water trawling, etc.), - the high level of technology for fishing and catch processing and - contractual agreement concerning the fish production. Face to the increasing demand in fish products, governments and regions provided large subsidies for the modernization and the restructuring of their fleets and their market networks. Practically, this politics benefited more to the development of the “industrial “ sector than to the small-scale one and, since the eighties, there has been, in most of the countries a dramatic decrease in the number of small vessels for small-scale activities.

Today, in spite of efforts of modernisation and with an annual landing of 4.7 MT per fishermen (Breuil 1997) the fish production from the Mediterranean Sea is still in strong deficit, hardly providing 26 % of the whole of consumption of the Mediterranean countries.

However, there is undoubtedly no way for increasing production: the majority of demersal fish species are already over-fished (as demonstrated by the average size of the fish now caught), most exploited deep-water species are considered be highly vulnerable to overfishing, large pelagic fishes are also fully exploited and high demand in small pelagic fishes cannot at this time be satisfied.

4.2.Situation of the protection of threatened species

55 species of animals have been identified as endangered or threatened species. The threats and potential nuisances which may result from all kinds of human activities to these species are numerous. If most of the above mentioned threats and potential nuisances have are broadly been identified, accurate assessment of impacts and related risks have still to be undertaken. In this respect, attention must be drawn to the necessary precaution with which direct and indirect potential impacts on marine populations and, in particular, threatened species should be evaluated. There is no doubt that actual fishing activities have a certain incidental negative impact and that certain threats exist, however, it would be exaggerated and unreasonable to formally affirm that the existence of protected species is definitively affected. In most of the cases, knowledge on the health of the actual concerned population have still to be completed (Beaubrun 1998). Concerning the impact of fishing activities themselves, it is worth observing that if the total number of killed animals, as reported in the literature, can be considered as rather high for certain species, the number of incidental catch (whatever species is considered) per unit of fishing effort for each fishing technique is low, in general. However, the matter has definitively to be taken seriously and all efforts must be done for proper impact assessment.

Most of the Mediterranean countries already adopted national legal measures for the protection of certain endangered species, such as the recent Maltese legislation for the protection of white and basking sharks. However, these rules stay often without effect mainly because they are not really applied. The geographic dispersion of the fleet, the low scale of most of fisheries and the incidental character of the catch of endangered species do not encourage the regional fisheries administration to exercise the requisite controls. Because many of these species make problems to fishermen during their operations or allow illegal, non-declared profits for them (e.g. illegal trade of turtle shell and meat), any enforcement which would be only based on legal obligation appears not realist. Consequently, to raise the awareness of the professionals/fishermen and convince them, communication campaigns have of course to be organized; even more, in this matter it is clear that long educational program to the fishermen are necessary.

4.3.Efficiency of technical measures on fishing capacity

For the conservation and rational exploitation of commercial fish species, the "managers", fishery authorities, should have at their disposal mechanisms or tools that allow to control the fishing effort and fishing mortality of the exploited resource. Several such tools are available and may be divided into two specific types:

- Input controls which include closed areas, closed seasons, limits on fishing time, number of vessels authorized in the fishery, and characteristics of the fishing gears and equipment used;

- Output controls place limitations on the weight of the catch, or quota, that may be taken, the minimum size of the fish, species, sex or sexual maturity of fish that may be legally harvested.

In many fisheries both types of control (inputs and outputs) are used at the same time, completing each other (Mac Alister Elliot and Partners Ltd. 2001). Many of these measures already exist in most of Mediterranean fisheries such as limitation on - the number of fishing authorizations (e.g. licence for bluefin tuna), - engine power and/or tonnage of the vessel, - fishing time (e.g. interdiction of fishing during week-end), - some specific technical characteristic of the fishing gear e.g. minimum legal mesh size, - size of the fish (minimum legal size authorized for landing) or - species which can be landed or the reproductive status of certain crustaceans.

However, unfortunately, because of the large dispersion of fishing fleets, the extreme diversity of fishing techniques in use and the fact that the catch (or part of it) is in many cases sold directly without record, controls are in most of the fisheries and countries ineffective and insufficient. Furthermore, the modernization of fishing equipment, in general, has dramatically increased the fishing efficiency of individual fishing vessels, in particular, specialized fishing units (such as trawlers, purse seiners or drifting longliners). These fleets consequently make today fishing capacities greatly superior to official estimates, which are based only on the declared value of the main engine power of tonnage capacity. Accurate information on fleet capacity and distribution should be consequently available to serve as the basis for defining fishing effort parameters.

Moreover, limitation of mesh size and size of fish appear both, at the same time, being impossible to apply in the case of multi-species fisheries (which are a large majority among the Mediterranean fisheries); these practically lead to increasing the discards or the development of illegal market for undersized fishes.

It is also difficult to adopt management schemes based on limitations of captures as with the establishment of TAC: There are in the Mediterranean Sea many different species which have high economic value and having many different TAC to be managed at the same time would practically be very difficult. Only bluefin tuna fisheries benefit of such a management measure in Mediterranean Sea, increasingly undermined due to the emergence of the new tuna farming practices, still largely unregulated.

4.Improvement of fishing gear selectivity including practices

Stewart (1999) has made the review of recent developments in gear design and the possibilities of gear modifications to limit the effects of fishing on ecosystem and in particular to improve their selectivity. The two methods that most of Mediterranean countries adopted to improve the selectivity of their exploitation of living resources are mesh size regulation and the interdiction to land certain species or small sizes of certain fish. While these measures are, in principle, easily controllable, they are not correctly applied and are therefore worthless: there are, in most of the fisheries large by-catches of undersized fishes and protected species. In the case of bottom trawling and regarding hake population, the mesh sizes currently in use allow too small size of first capture (8-9 cm) that is much lower than legal size of this species (20 cm). However, if the adoption of a bigger mesh size (about 55 mm) would produce a significant improvement in Y/R, there would be important short-term economic losses as regards to the catch of several other species.

Discarding at sea is a very common practice for many reasons such as mesh size or fish size regulations or market demand at the landing place.

In the cases of fisheries with clear target species, the use of insufficient selective fishing gear makes that during their fishing operations, such vessels discard important quantities of their by-catch.

More research on fishing techniques, gear modifications, fishing technology, in general, is definitively needed to reduce the undesired retention of small sized individuals or non-commercial species (Abella and Serena 2001).

Better knowledge of the actual practices, including, in particular, by-catches and discards is also necessary and the sustainability of such activities, including with consideration to the environmental impact, has to be carefully studied.

Developing gear technologies and/or new fishing strategies are also necessary for reducing significantly the risks of catching endangered species or at least, reducing the immediate or delayed mortality rates of these. As for example, researches on repellent devices to prevent turtles or marine mammals to encounter a fishing gear or aquaculture installation must be developed.

4.5.The banning and limitation of some fishing techniques

Most of the solutions to mitigate the potentially negative impact of certain fishing techniques must be found in improving their selectivity and, if necessary, limiting the number of gear and related effort (access limits, fishing permits, through licence system). The first systems of license were instituted in Mediterranean Sea to counter the trawling expansion. The banning of bottom trawling in certain marine protected areas such as seagrass meadows or the use of bottom static nets on wrecks or coral reefs are useful measures to be considered seriously.

4.6.Temporal closure

Closed time or seasons prohibiting certain specific fishing activities during the restricted period, are particularly effective measures for protecting ecosystem components during critical stages. As example, the French trawlers are not allowed to go at sea during the week-ends and the tuna purse seiners must stop fishing from the 1st to the 30h of July anywhere in Mediterranean. Such measures are very effic ient because the relevant control can be made directly from the fishery harbours.

Combined with seasonal closures, area closures appear to be particularly suitable for the reduction of some unwanted effects such as high fishing pressure on juveniles; if temporary, the closure for juveniles protection will have to be defined according to their density on fishing grounds. Seasonal and/or area closures may also aim at preserving a specific habitat or a particular species. In the later case, the limitations have, of course, to be applied, at the same time, to all fisheries and fishing practices which are able to catch the species to protect. The 4-year closure of the trawl fishing in the Gulf of Castelammare (Sicily) is one of example of this type of fisheries management measure which has allowed to increase the average of the catch by approximately 25 times (Pipitone et al. 1996). Nevertheless, the effectiveness of such measure is difficult to prove because of biological exchanges beyond the limits of the protected areas. The development of a methodology for a quantitative and qualitative cost-benefits analysis of such management measures would nevertheless be particularly useful (Lembo and Spedicato in GFCM 2000).

4.7.Marine Protected Areas, reserves and artificial reefs

There were in the Mediterranean Sea, in 1996, 47 Specially Protected Areas (SPA) including 15 exclusively marine spaces and 32 mixed land and marine spaces (UNEP 1996). Primarily, created in the aim of preserving flora and fauna of particular area of human aggression, there is to day a growing consensus on the interest for developing new management concepts based on Marine Protected Areas (MPAs) or marine reserves. This idea is supported by the feeling that it is possible, at the same time, to preserve threatened species and to sustain commercial fishing combining both conservation and fisheries policies.

However, MPAs provide refuges in space rather in number and to ensure the preservation of their exploitable fish resources, traditional fisheries management tools (e.g. for) are needed. The establishment of MPAs should be consequently accompanied by some technical measures including fishing effort limitation, selectivity improvement of fishing gears in term of species and/or sizes, limiting access for certain fishing techniques and if necessary, for certain periods. In addition, the building of artificial reefs inside or near by a marine reserve are effective protections against the utilization by fishermen of harmful fishing techniques. On other hand, consensus between policy-makers, scientists and users is an essential factor contributing to the success of MPAs (Sumaila et al. 2000). Therefore, it is essential that fishermen are involved early in the decision-making process for the design of the MPAs and the associated regulation, because of their thorough knowledge of the fishing grounds and to prevent risks of conflict resulting from unavoidable changes in fishing practices and activities.

A marine reserve is set up using arguments that benthic habitats will be conserved and fish stocks will be enhanced. Although, there are elements suggesting that marine reserves benefit to fisheries, the effectiveness of MPAs is in some cases questionable. If control and protection of species and habitat and enforcement are theoretically simplified by the defined, limited, size of MPAs, many scientists consider that the existing MPAs are often too little to assure stable populations for all species. The main difficulty is in the definition of the boundaries of most of marine ecosystems (Gislason et al. 2000). Because biological processes of a particular locality depend on inputs and outputs over the borders and migration patterns are not constrained by arbitrary boundaries, the status of protected species and habitat is often depending from the external fishing pressure and environmental conditions.

Marine Protected Areas must be established for clear, limited and realistic purposes, chosen to the elements which are need in priority to be restricted or controlled. In that context, Marine Protected Areas could be used:

- For protection of habitat : areas where juvenile fish are abundant (e.g. depths ranges where juveniles of Norway lobster are found; Sardà in GFCM 2000) or breeding areas for turtles, seabirds or monk seal (as an example, in the Hawaiian Islands where a permanent Protected Species Zone was established for reducing interactions between seals and the longline fishery),
- The protection of particular species or groups of species which are considered as rare, vulnerable or ecologically important (Monachus monachus, marine turtles, Posidonia oceanica, ...) and
- For research: e.g. comparison of ecological interactions in fished and un-fished marine environments and communities; control site for fishing effects studies, impact assessment on the seabeds (Jennings and Kaiser 1998).

Because human activities and environmental conditions are changing with the time, it would be desirable to adapt/adjust the management of existing Marine Protected Areas based on regular assessments of effectiveness of the strategy according to the achievement of the overall objectives. Seasonal rotation of fishing grounds through establishing successive temporary closures should, in principle, preserve the status of the sea-beds since the likelihood of permanent changes in bottom communities is proportional to the frequency of gear disturbance (Jones; 1992).

4.8.Educational programmes

The level of impact is due not only to the fishing gear characteristics but also as much to the practices developed by the fishermen in the fisheries. Consequently, a potential negative impact can be corrected by fishing gear modification but also by inducing changes in fishing habits. In addition, technical measures should be designed taking into account their potential acceptability by fishermen. For a better acceptability, it is often preferable that the initiative comes from the traditional users of the areas when they have recognized the need to protect their resources. The agreement of the fishermen is easily obtained if they perceive that voluntary adoption will guarantee (or, better, may increase) their earnings and fish stocks conservation for ensuring industry sustainability. Consequently, it is very essential that awareness/educational programmes are designed for fishermen and public to be carried out before or at least, at the same time any new protection measures is established. The experience has shown, in recent years, that the participation of fishermen to the analysis of local or regional management problems and solutions, is likely to be the most effective strategy. In connection to such observation, the establishment of “Fishermen advisory groups” would be recommended for the design and implementation of any program for ecosystem protection.

Because the knowledge regarding the effects of fishing on ecosystems is still, in general, very limited, it is, in many cases, rather difficult to convince fishermen of the well-founded of preserving the quality and diversity of certain marine ecosystems. In this respect, a widely-held opinion among the fishermen is that fishing grounds should be prepared (as a farmer is doing for a fallow field!) by massive destruction of epibionths and other bottom faun of non-commercial interest. As a matter of fact, it is worth observing that such practices are known to be systematically used within a few deep-shrimp fisheries and dredges fisheries.

Skippers education programs are definitively worth being conducted regarding the necessary protection of endangered species, the advantage to adopt technical measures for improving the selectivity of fishing gears and fishing practices concerning fish species and sizes and the limitation of potential physical damage to the environment. Particular attention should be brought on interest of training program regarding techniques for releasing endangered species alive.

In last, because the public opinion plays today an important role in the policy decision, it is very important to put sufficient effort in the proper extension of scientific studies by means of Public awareness campaigns, video production, publication and media programs.

4.9.Remedies to the effects on the ecosystem of fishing in the mediterranean from a systemic perspective

Most of the major effects of fishing recorded around the world occur in Mediterranean ecosystems too. They vary from local effects on the sea bottom caused by harmful trawler gear to large-scale impacts on cetacean populations arising from animals becoming entangled in long driftnets. This variety is due to three principle factors:

- ?? the huge diversity of fishing gear and practices (most of them artisanal),
- ?? the very high intensity of fishing,
- ?? and major biological diversity, demonstrated by the Mediterranean presence of a vast array of vulnerable species, including emblematic seals, whales, turtles and sharks.

The case-by-case approach adopted in this document notwithstanding, it should be emphasised that the impact of fishing goes far beyond the mere effects caused on single populations of target and by-catch species, or the degradation of the physical support system. Fishing profoundly affects the complex structure of ecosystems, altering their internal functioning. A measure of human appropriation of marine biological production, the percentage of the primary production required to sustain a given fishery (%PPR), has been estimated on a global basis by Pauly and Christensen (1995). The results obtained indicated a much higher ecological footprint for fishing than expected: up to 35.3% in the case of world non-tropical shelves. Another ecological index, the average trophic level of the fishery (TL), indicates fishing impact on the structure of marine food webs over time. Pauly et al. (1998) described the existence of a global 'fishing down marine food webs effect' (FDMFW) based on the steadily decreasing trend of TL values of catches recorded for the period 1950-94, also verified in the Mediterranean. The lack of correspondence between harvesting on lower TLs and the expected increase of catches points to the disruption of major energy pathways and subsequent decrease in yield that results from the structural and functional degradation of the ecosystem. Well-structured ecosystems maintain healthy predator population levels, tend to be more energy-efficient and more resilient to external disturbance, and are the bases for sustainable fisheries.

Some recent attempts to evaluate the overall effect on the ecosystem of fishing in specific areas of the Mediterranean appear to reach the same conclusions as those above. Claims concerning the role of the increase in biological production due to the anthropic nutrient enrichment of waters add some uncertainty to the interpretations.

Tudela (2000) estimated a %PPR for the mixed pelagic/demersal fishery operating off the central Catalan coast (north-eastern Spain) on the shelf and the slope down to 1000 m as slightly more than 40% of total primary production. This figure takes both discards and misreporting of catches into account. Such a huge level of human appropriation, one of the highest ever recorded, together with the stagnation of landings despite the growth of fishing capacity and the fact that the fishery works at moderately low trophic levels implies the full, and ecologically unsustainable, exploitation of the ecosystem. The author warned about the possible loss of ecosystem resilience in these conditions. Stergiou and Koulouris (2000), using official landing statistics for the eastern Mediterranean basin, studied the evolution of mean TLs of catches during the last 30 years, looking for a local FDMFW effect. Results showed that at least in the main part of the Aegean Sea the mean trophic level has decreased in recent years, and the authors concluded that the present pattern of harvesting is not sustainable. In any case, such a high level of ecosystem exploitation is liable to disrupt food-webs, and prevent the ecosystem from supporting healthy populations of apex predator species. This phenomenon may underlie many of the conflicts reported in previous sections and point to the need for combining both conservation policies for specific threatened species (i.e. monk seal) and sustainable fishery policies, allowing ecosystems to rebuild themselves.
This reduction of the mean TL of an exploited community may be intentional from the start, as exemplified by fishermen in southern Sicily: they customarily 'clean the sea' by repeatedly trawling a new fishing ground to eliminate sharks and other undesirable species (Badalamenti, pers. comm.). Conversely, the creation of marine protected areas (MPA) in which fishing is banned has proved useful for rebuilding the diversity of exploited communities: the mean TL of fish assemblages in seagrass beds has risen following protection along the French Mediterranean coast (Harmelin-Vivien, pers. comm.).

It has been suggested that the increase in primary production in the north-western Mediterranean in recent years may have been having a positive effect on fisheries production in the region (Caddy 1997; 2000). This hypothesis, if confirmed, could provide a mechanism to counter the reduction in fishery production due to ecosystem overexploitation, as explained above. In the Mediterranean, the relationship between the overall increase in fishery production and the decrease in the mean TL of catches would be compatible with such a bottom-up effect, as demonstrated by the upward trend of the FIB index relating both parameters, although there are other explanations (Pauly, pers. comm.). However, meta-analyses of data from mesocosm-based experiments and natural marine ecosystems from all over the world show a general weak coupling of N loading and phytoplankton productivity with higher trophic levels, implying that anthropogenic nutrient loading is unlikely to result in increased fish biomass, regardless of local conditions and the magnitude of nutrient enrichment (Micheli 1999). In the absence of a specific study, these conclusions seem to severely challenge the validity of the former hypothesis.

It could be inferred from the evidence presented above that the effects of fishing in the Mediterranean go far beyond the isolated impacts on overfished target species, vulnerable non-commercial groups or sensitive habitats. The effects on the ecosystem of fishing in the Mediterranean are also clear at systemic level, as highlighted by the massive ecological footprint of fishing or the marked effects on the food-web structure. A holistic approach should therefore be adopted if the overall changes to the structure and the functioning of marine ecosystems caused by fishing are to be remedied. These changes directly affect important ecosystem properties such as its resilience to human interference.

There is a growing consensus on the potential use of marine reserves or marine protected areas (MPAs) as a precautionary tool for the systemic management of fisheries (Roberts 1997; Hall 1998; Lauck et al. 1998; Hastings and Botsford 1999). The use of this approach in the Mediterranean appears to be promising, given the preliminary results of some limited experiments with marine reserves (see above). The idea of rebuilding degraded ecosystems, mostly through MPAs is gaining ground in the scientific community (Pitcher and Pauly 1998). These authors think the goal should be not to conserve ecosystems in their current state but rather to reconstruct past, healthier states that existed prior to their extensive modification by man. This approach would be of particular interest in the Mediterranean, given the profound transformation of the marine ecosystems due to centuries of intense human exploitation. As suggested in the respective sections of this document, these precautionary ecosystem-based measures should be accompanied by:

- general improvements in both intra- and interspecific selectivity of gear and fishing practices,
- minimising the physical damage these cause to the supporting environment,
- and parallel educational programmes for fishermen.

Public subsidies diverted to these measures, which in some cases would involve the eradication of, or tight restrictions on, especially harmful fishing practices, would probably result in the improvement of fisheries and their related ecosystems.

5. CONCLUSION

The general increase of human activities around the Mediterranean Sea, including fishing pressure, is largely responsible of the major threats on the survival of endangered species or marine habitat which are fragile. Most of the major negative impacts resulting from fishing having been recorded around the world occur in Mediterranean ecosystems. The wide development of more and more effective harvesting technology has played a key role in increases in exploitations and led in some areas and for the most important commercial species to overfishing situations. Although species collapses seem having been relatively few so far, the increase of fishing effort and intensity of the exploitation on a few selected species having high value on the market or for which the demand (and price) is increasing is a serious concern. However, further increase in effort is unlikely to result in increased long-term yield, at least for the above mentioned species.

The high diversity of small-scale fishing gears in use, of landed species and the importance of small-scale fisheries, in general, in the Mediterranean coastal waters make the management of Mediterranean fisheries extremely complex, being necessary the development of a new ecosystem-based management approach, specifically tailored to the region.

In conclusion, a reductionist approach alone may not prove sufficient to tackle the issue of the satisfactory conservation of Mediterranean ecosystems and their biological diversity. Furthermore, conservation policies that target vulnerable species or habitats shouldn't be separated from fisheries management policies, given that they have essentially the same goal. From the cases reported in this document it becomes clear that apart from the issues linked to technical aspects, such as those concerning harmful gear or fishing practices, overfishing is a central problem that underlies many of the other problems. Many instances have been reported showing how intensive fishing exacerbates interactions between vulnerable groups and fisheries. The development and enforcement of integrated precautionary policies appears to be absolutely necessary.

Many reasons are making essential to find solutions to maintain a large variety of traditional fishing gear, practices and fisheries now within the sector. A balanced exploitation of natural resources with the use of various fishing gears and practices is crucial for the conservation of the biological diversity. The diversity of fishing gear and practices just reflects social and cultural specificity of the countries on the Mediterranean Sea. The sustainable use of the marine ecosystems for human benefit can only be ensured by measures combining ecological concerns and socio-economic requirements.

Because the general interest and objectives are finally the same, conservation policy regarding endangered species or habitats and fisheries management should not be considered separately.

A progressive approach based on consensus agreements between all the users of the sea on general conservation objectives regarding the Mediterranean ecosystems would be certainly the most realistic policy/arrangement.

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List of Acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
APCMMT	Action Plan for the Conservation of Mediterranean Marine Turtles
CE	Council of Europe
CITES	Convention on International Trade in Endangered Species
COFI	Committee on Fisheries
EC	European Council
EU	European Union
FAO	Food and Agriculture Organization
FDMFW	Fishing Down Marine Food Webs Effects
FIB	Fishery is Balanced
Fo C	Flag of Convenience
GFCM	General Fishing Commission in the Mediterranean
IUCN	International Union for the Conservation of Nature, also known as World Conservation Union
IWC	International Whaling Commission
LJFL	Lower Jaw - Fork Length
MPA	Marine Protected Areas
Mo U	Memorandum of Understanding
PPR	Primary Production Required
RAC/SPA	Regional Activity Centre for Specially Protected Areas
SAD-AFA's	Sualty Arastyrmalaly Dernegi – Akdeniz Foku Arastyrma Grubu
TAC	Total Admissible Catch
TED	Turtle Excluding Devices

TL	Trophic Level
TRAFFIC	Trade Record Area of Flora and Fauna In Commerce
UNEP	United Nations Environment Programme
WWF	World Wide Fund for Nature, previously World Wildlife Fund and still World Wildlife in the USA

The Regional Activity Centre for Specially Protected Areas (RAC/SPA) constitutes one of the institutional components of the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP), co-ordinated under the supervision of the MAP Co-ordinating Unit. The Centre was set up in 1985 to assist Mediterranean countries in implementing the Protocol on specially protected areas and biological diversity. The Centre aims at assisting Mediterranean countries to establish and manage marine and coastal protected areas and to conserve biological diversity.

Among the Centre's activities is a project for preparing a **Strategic Action Plan for the Conservation of Marine and Coastal Biological Diversity in the Mediterranean Region** -SAP BIO Project - (1 January 2001 - 31 December 2003).

Starting from an assessment at national and regional level of the state of marine and coastal biodiversity, based on existing scientific data, and taking into account the Jakarta Mandate (developed within the framework of the Convention on Biological Diversity) and the Protocol on Specially Protected Areas and Biological Diversity, the SAP BIO Project aims at analysing the negative factors that affect marine and coastal biodiversity, or the lack of information, and identifying concrete remedial action. Integration of the actions decided on at national, sub-regional and regional level, along with detailed investment portfolios, involvement of stakeholders, and the development of approaches and principles, will become the Strategic Action Plan for Biodiversity. In addition to this strategy, which is the final document of the processes, within the framework of the SAP BIO Project, a series of national and regional reports is being prepared.

The present document is part of this series.

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