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INCIDENTAL CATCHES OF MARINE TURTLES IN SURFACE LONG LINE FISHERY IN THE IONIAN SEA, GREECE

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Abstract Incidental by-catches of marine turtles on surface long lines for fishing swordfish were regularly recorded for seven consecutive years (1989-1995) for a total of five vessels based in Kefalonia isl., Ionian Sea, Greece. Altogether, 157 Loggerhead turtles were caught in 142 out of a total of 785 fishing trips (18.1%). On average, 0.2 turtles were caught per fishing trip and 7.7 turtles per year and vessel. The great majority of the animals (77%) were small sized or subadults; only 15% were adult animals. A decline in the frequency of incidental catches over the total period of investigation is indicated. Swordfish fishery may affect less severely the turtle population in the Greek Ionian Sea than loss of nesting habitat and mortality caused by other factors.

Περίληψη Κατά το διάστημα επτά ετών (1989-1995) έγινε τακτική καταγραφή των τυχαίων συλλήψεων θαλάσσιων χελωνών σε παραγάδια αφρού για ξιφίες από συνολικά πέντε σκάφη με έδρα την Κεφαλονιά στο Ιόνιο πέλαγος. Στο σύνολο, 157 χελώνες *Caretta caretta* πιάστηκαν σε 142 από τα 785 ταξίδια που πραγματοποιήθηκαν (18,1%). Κατά μέσον όρο πιάστηκαν 0,2 χελώνες ανά ταξίδι και 7,7 χελώνες ανά σκάφος και έτος. Η μεγάλη πλειοψηφία των χελωνών που πιάστηκαν (77%) ήταν χελώνες μικρού μεγέθους ή νεαρά ζώα και μόνον το 15% ήταν ενήλικες χελώνες. Κατά την διάρκεια των επτά ετών φαίνεται να υπάρχει μείωση στην συχνότητα συλλήψεων. Η αλιεία ξιφία φαίνεται να έχει μικρότερη επίδραση στον πληθυσμό των χελωνών από την συρρίκνωση των περιοχών φωλιάσματος και από την θνησιμότητα από άλλους παράγοντες.

INTRODUCTION

The three principal species of Mediterranean marine turtles, the Loggerhead turtle, *Caretta caretta*, the Green turtle, *Chelonia mydas*, and the Leatherback turtle, *Dermochelys coriacea*, are all considered as endangered, and high priority is given to their protection (UNEP/IUCN 1990). The Loggerhead turtle is the most common marine turtle in the Mediterranean Sea and the only species known to nest in western Greece. One of its most important nesting areas is the Ionian Sea in Greece (see Fig.1. in the Gulf of Laganas in Zakynthos island, nest density is among the top three in the world (MARINOS 1981, MARGARITOULIS 1982, MARGARITOULIS & DIMOPOULOS 1995). But the animals nesting on beaches of other islands of the area, Kefalonia island in particular, and of the western coasts of Peloponnese may also form a significant percentage of the total population in the Mediterranean (MARGARITOULIS 1989, SUTHERLAND 1990, MARGARITOULIS & *et al.* 1995).

The two other species have as yet rarely been recorded in Greece, and nesting does most probably not occur in this part of the Mediterranean (MARGARITOULIS 1986, MARGARITOULIS *et al.* 1986). Almost nothing is known about their distribution and abun-

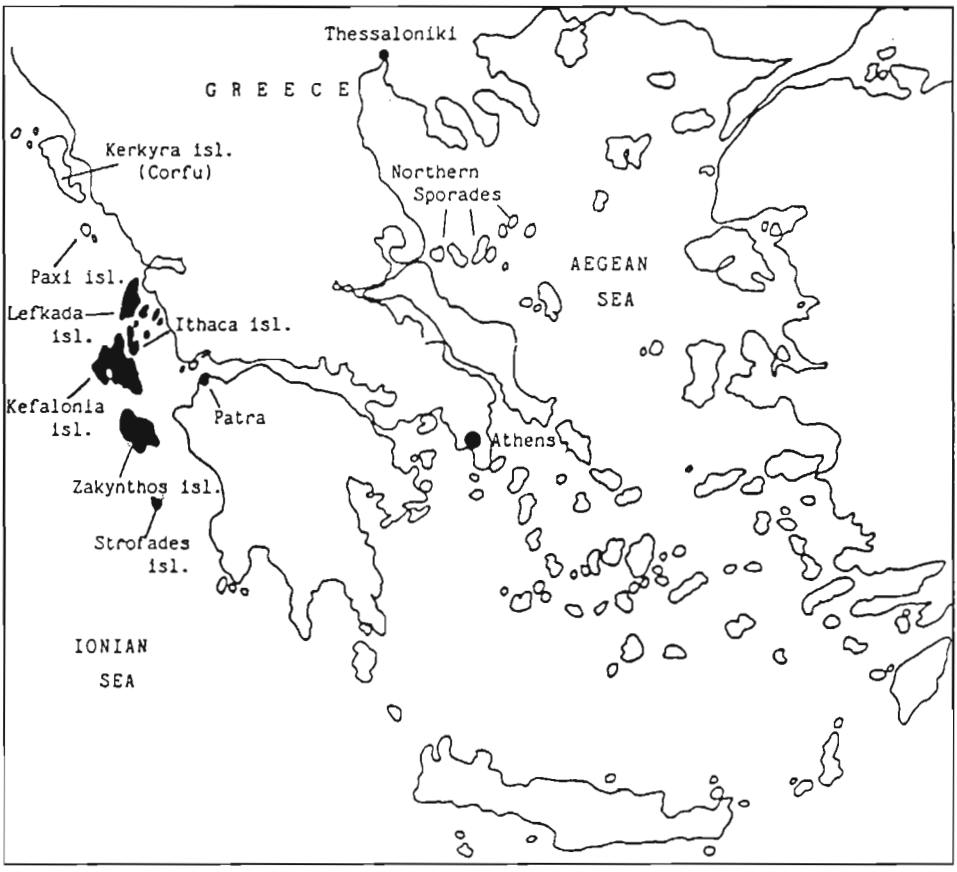

Fig.1 Greece and the study area

dance in the Greek Ionian Sea. However, the lack of information may be due to the low obervers' effort at sea since Green turtles have been recorded in the adjacent waters of the lagoon of Messolongi (MARGARITOULIS *et al.* 1986) and in S.Peloponnese (MARGARITOULIS *et al.* 1991), and Leatherbacks have been recorded in the Gulf of Taranto, Italy, in the northwestern part of the Ionian Sea (DE METRIO *et al.* 1983, DE METRIO & MEGALOFONOU 1988).

During the last fifteen years, conservation projects throughout the Mediterranean focused mainly on the protection of nesting beaches, the habitat where the turtles are most vulnerable, and on the monitoring of nesting populations including the tagging of egg-laying turtles. However, our knowledge about the main threats in the turtles' principal habitat, the sea, is rather limited. Interaction with fisheries is certainly a major threat: turtles are often caught in fishing gear incidental to other fishing activities. Incidental by-catches of turtles occur mainly in drift net fishing and in surface long line fishing for swordfish (*Xiphias gladius*) and albacore (*Thunnus alalunga*). The impact of drift net fishery on turtles is difficult to assess but may be considerable. At least about 30 Italian vessels operate

tles is difficult to assess but may be considerable. At least about 30 Italian vessels operate in the entire Ionian Sea with drift nets from Apulia and Calabria alone: about 30% of the estimated 16,000 turtles caught annually in these nets drown (DE METRIO & MEGALOFONOU 1988).

Incidental catches of turtles during long line fishing has been monitored mainly in the western and central Mediterranean. Between 15,000 and 20,000 turtles or more are caught annually by Spanish vessels off the Balearic islands alone, primarily Loggerheads (MAYOL 1986, REY *et al.* 1986, CAMINAS 1988, CAMINAS & DE LA SERNA 1995). Italian and Maltese fishermen catch similarly large numbers of turtles in long lines, mainly in the Adriatic and Ionian Seas (DE METRIO *et al.* 1983, DE METRIO & MEGALOFONOU 1988). The turtles either swallow the hook with the bait intended for the swordfish or the animal is hooked by the mouth cavity (MUNTINGH 1988, PANOU & MOSCHONAS 1990). While turtles may survive this experience, the mortality so caused is widely unknown but may be between 15% and 50% (DE METRIO & MEGALOFONOU 1988, MAS & GARCIA 1990, MAYOL 1990, AGUILAR *et al.* 1992).

Data from the eastern Mediterranean are scarce. Our knowledge about the impact of traditional coastal fisheries (mainly static nets and bottom long lines) and of hawl seines and purse seines is rather limited (MARINOS 1981, PANOU 1988, MARGARITOULIS *et al.* 1991). In the Ionian Sea, Greece, swordfish fishery started in the early 80's (DE METRIO *et al.* 1988, PANOU 1988). In the mid-80s, a total number of 47 swordfish boats were registered in the entire area including the Ionian islands and the mainland coasts of Epirus, NW. Greece (DE METRIO *et al.* 1988). Almost half of them were small scale coastal vessels with a length of up to 10 metres. In 1985-86, the first three large vessels of the Ionian Sea were build in Kefalonia island for exclusive swordfish fishing (14m and upwards). In the following years, seven more vessels of at least 10 metres based in Kefalonia and eight vessels based in the neighbouring island of Lefkada and in Kyllini, W. Peloponnese, started fishing exclusively swordfish. No swordfish is being fished by Zakynthian vessels or vessels from Patra and the rest of W. Peloponnese. Swordfish fishing is less developed in the northern part of W. Greece and vessels larger than 12-14m do not exist. Except for three vessels based in Kyllini and using drift nets, only long lines are used by the Greek crews in this area.

It seemed worthwile to assess the impact of swordfish fishery on Loggerhead turtles in one of their main concentration areas during the nesting season that coincides with the peak of the swordfish fishing season. Within that frame, the long-term monitoring of incidental catches was launched in the Greek Central and South Ionian Sea in 1989 (PANOU & MOSCHONAS 1990). Parallel to the assessment of the impact of swordfish fishery on marine turtles in general, other aims of the study were the collection of valuable data on the composition of the entire Loggerhead turtle population in the Greek Ionian Sea including the fraction that never comes ashore for nesting, and on spatial and temporal distribution patterns.

In this study, the overall results of the seven-year investigation are presented. Aspects on distribution patterns are not considered here but will be subject of a second publication.

MATERIAL AND METHODS

Fishing trips and catches of turtles were recorded over the period of seven consecutive years (1989-1995) for a total of five off-shore professional swordfish vessels of 10-20m length based in Kefalonia island, Central Ionian Sea, Greece (PANOU & MOSCHONAS 1990, PANOU *et al.* 1992, 1993, 1994, 1995). In 1991 and 1992, three more vessels participated in the project but the data are not included here since data acquisition by those vessels was not regular. Only vessels that were fishing exclusively swordfish were taken into consideration in this study since fishing capacity in small scale purely coastal vessels and amateur vessels is reduced and swordfish is being fished only occasionally. Unfortunately, from 1993 onwards, three of the participating vessels either stopped fishing swordfish or the owners had to sell their vessels due to the extremely small catches they had in previous years.

Unfortunately, no numbers on swordfish vessels are available by the Greek National Statistical Service since these vessels are included in the overall number of vessels in the branch of the so-called "coastal fisheries" (i.e. nets, bottom long lines beach seines, etc.) Moreover, the composition of the swordfish fleet changed in each year. However, the participating vessels represented in each year of the study about 50% of all professional swordfish vessels based in Kefalonia island and about 15-30% of the Greek vessels of the same type operating throughout the Central and South Ionian Sea. Swordfish fishery in the study area represents more than 50% of the total professional fishing effort by Greek vessels in western Greece.

For fishing swordfish, surface long lines of 10-50km length were set in the evening, usually 0,5-12.0 miles off shore, and hauled-in immediately after setting or in the next morning (usually 400-1000 hooks per fishing trip). Sometimes, the long lines were left in the sea for one or two days because of adverse weather conditions. Settings were made throughout the Central and South Ionian Sea (see Fig.1). Fishing activity was concentrated in the northwestern and southern parts of Kefalonia, in the channel between Kefalonia and Zakynthos and along the western and southern coasts of Zakynthos but some fishing trips were made also in the area east of Ithaca island and in the area of the small islands of Strofades, south of Zakynthos. Mainly frozen atlantic mackerel (*Scomber scomber*) but sometimes also pilchard (*Clupea pilchardus*) and shad (*Clupea finta*) were used as bait. Mainly, two different sizes of hooks (non-stainless material) were used: No. 2 of about 8cm length and No. 3 of about 7cm length. Smaller hooks such as No. 4 to No. 6 are used only in small scale purely coastal vessels. The fishing season covered a maximum of seven months (March to September). From October through to January, the fishing of swordfish is prohibited by Greek law. In February, weather conditions mostly do not allow fishing. Some vessels started fishing as early as March-April, and others stopped before the end of the fishing season because of lack of available crew members, adverse weather conditions, damage to the engine, etc.

Each setting was separately recorded by the captain of the vessel on a single chart along with data about the hauling-in sites and the prevailing weather conditions. Whenever a turtle was caught, the position was recorded and the turtle's size was esti-

mated since it was not possible to haul in the animals. In case the turtle was an adult animal (size of about 75cm and bigger), the sex was recorded according to the length of the tail. All turtles were released alive with the hook in the mouth or throat by cutting the nylon line while hauling in. In some cases concerning small animals that do not weigh much, the turtle was hauled-in and the hook was removed from the mouth before releasing it. In one case, the turtle was not hooked but the flipper was entangled in the nylon line.

The catch per unit of effort (CPUE: captures per 1000 hooks per unit of time) has not been taken into consideration in this investigation since the absence of reference values in most of the related publications does not allow comparisons.

RESULTS

In Table 1, the data on incidental catches of turtles over the period 1989-1995 are summarized. Catches were registered throughout the study area regardless of the vicinity of nesting beaches and including the off-shore waters of the Ionian islands. None of the caught turtles had a tag although hundreds of mature female turtles have been tagged throughout the study area in each nesting season during the last ten years. Only four turtles (2.5%) were captured with an older hook in their mouth indicating that they had survived a recent interaction with long lines.

Both annual values the percentage of trips with at least one turtle and the average number of turtles per trip appear to decrease in the course of the total period of investigation. Both parameters are independent from each other as also of the frequency in data acquisition. Indeed, in 1990, both values were at highest. By contrast, the lowest values were registered in 1994 followed by those in 1995. Accordingly, the average annual number of turtles per vessel appears to decrease as well with the lowest values in 1994 and 1995. The data obtained in 1989, the first year of investigation, with only one participating vessel may not necessarily be indicative.

Table 1 Incidental catches of Loggerhead turtles in swordfish long lines, Ionian Sea, Greece; 1989 - 1995: Data on catch numbers. * Data in 1989 are to be considered as indicative since only one vessel participated.

Year	1989*	1990	1991	1992	1993	1994	1995	TOTAL
No. of vessels	1	3	5	5	2	2	2	Annual mean 2.9
No. of performed fishing trips	54	171	193	176	81	60	50	785
No. of trips with turtles	9	43	35	33	12	5	5	142
No. of caught turtles	11	49	38	36	13	5	5	157
Percentage of trips with at least one turtle	16.7%	25.1%	18.1%	18.8%	14.8%	8.3%	10.0%	18.1%
Average No. of turtles/trip	0.20	0.28	0.19	0.20	0.16	0.08	0.10	0.20
Average No. of turtles/vessel	11	16.3	7.6	7.2	6.5	2.5	2.5	Annual mean 7.7

Table 2 Incidental catches of marine turtles in swordfish long lines, Ionian Sea, Greece; 1989 - 1995: Data on size and sex.

Year	1989	1990	1991	1992	1993	1994	1995	TOTAL
Total no. of caught turtles	11	49	38	36	13	5	5	157 (100%)
Young turtles (20 - 54 cm)	9	39	16	15	4	1	---	84 (54%)
Subadults (55 - 74 cm)	2	4	13	8	6	3	---	36 (23%)
Adult size (75 cm)	---	2	8	5	3	1	5	24 (15%)
Unknown size	---	4	1	8	---	---	---	13 (8%)
Total adults	---	2	8	5	3	1	5	24 (100%)
Adult males	---	---	2	2	1	---	1	6 (25%)
Adult size short tailed turtles	---	---	5	2	2	1	4	14 (58%)
Unknown sex	---	2	1	1	---	---	---	4 (17%)

In most cases, only single turtles were caught on the same long line. Two turtles together were caught in 11 cases (7.7%) and three turtles together in 2 cases (1.4%). In the two last years of the study, only single catches were registered.

The great majority of the animals (156 out of 157) were Loggerhead turtles. Only in one case, the animal might have been a Green turtle because it was reported that the animal had "teeth" in its mouth. In general, sightings of Green turtles at sea have been reported from the area (MARGARITOULIS *et al.* 1986; Ch. Raftopoulos 1994, pers. comm.). In this case, it was not possible to identify the species with certainty, due to the lack of photographs. Different to the situation in the Gulf of Taranto (DE METRIO *et al.* 1983, DE METRIO & MEGALOFONOU 1988), Leatherback turtles were never recorded during swordfish fishing while the presence of the species in waters of Kefalonia was reported twice in 1993 and once in 1995 (S. Kourkoulakos, Y. Mourelatos, S. Katsambiris, pers. comm.).

In Table 2, data about the size and sex of the caught turtles are summarized. The size varied considerably. Most of the turtles were young animals followed by subadults while adult turtles were caught rarely. Thus, the great majority (77%) were immature animals.

In most cases, the sex of the caught turtles could not be determined because the animals were immature. From all cases of adult animals of known sex, the great majority were females (Table 2).

DISCUSSION

Loggerhead turtles are long-lived animals with long migratory routes throughout the Mediterranean Sea and with possibly irregular migration patterns. The data presented here can therefore be considered as only preliminary. Long term monitoring schemes are needed in order to fully assess the impact of swordfish fishery on Loggerhead turtles in the study area.

The data obtained so far indicate that a considerable number of Loggerhead turtles is being caught annually in the study area by the Greek professional swordfish vessels alone. Taking into consideration that, over the total period of study, up to ten such vessels based in Kefalonia island have been operating in each fishing season, a mean of up to 80 turtles may have been caught annually by these vessels. This number may be roughly as much as the total female population nesting every year on Kefalonia (PANOU & MOSCHONAS 1990, SUTHERLAND 1990, pers. obs.). Accordingly, a mean of up to 140 turtles may get caught annually throughout the study area and about 280 in the entire Greek Ionian Sea, amateur and small scale coastal vessels not taken into consideration. But at least 30 and up to 50 more Italian vessels were also operating in the Greek Ionian Sea in each fishing season using mostly drift nets. Thus, the total annual number of incidental captures by professional vessels may have been at least about 600 animals or more if the impact of driftnetting on turtles proves to be considerably higher than the impact of long line fishery.

However, relatively few turtles are caught in the study area compared with the large numbers of catches reported from the central and western Mediterranean. One reason may simply be the relatively small number of vessels operating in this area and, accordingly, small numbers of turtles caught in the long lines. Since the mating and nesting season of Loggerhead turtles in the Greek Ionian Sea largely coincides with the fishing season for swordfish (the period of data acquisition) one would expect the captures of adult animals per unit of effort (CPUE) to be among the highest values within the Mediterranean Sea. At least during the mating/nesting season, the concentration of adult turtles of both sexes should reach its maximum: the animals mate in the shallow waters off the nesting beaches few weeks before egglaying. During autumn, winter and early spring, the distribution of the species is largely unknown. It has been suggested that the turtles may hibernate in north African waters, Tunisia in particular (GROOMBRIDGE 1989), but a number of own sightings and reports of turtles in Kefalonia and Ithaca as also captures of turtles in trawlers and beach seines in S. Peloponnese (MARGARITOULIS *et al.* 1991) during winter suggest that at least some individuals do not always migrate. Unfortunately, a comparison of the figures between the different areas of the Mediterranean is not possible since no CPUE values are given in most of the studies in other parts of the region.

In fact however, the great majority of caught turtles were immature animals. These findings may reflect different behaviour patterns, feeding habits for instance, in the various age classes at least while adults are mating and nesting. The fact that captures of both adult and immature turtles were registered throughout the study area regardless of the vicinity of nesting beaches supports this assumption. Small sized turtles were mostly reg-

istered also in the swordfish fishery in the central and western Mediterranean (DE METRIO & MEGALOFONOU 1988, LAURENT 1988, AGUILAR *et al.* 1992, CAMINAS & DE LA SERNA 1995). But, of course, the situation in the western Mediterranean is not directly comparable with the study area since no nesting sites are known in the vicinity. The distribution patterns of turtles in their marine habitat in time and space is as yet largely unknown and further detailed investigation is urgently needed. This applies in particular to immature animals and adult males, those fractions of the total population that are least investigated.

Our data varied considerably from year to year possibly indicating irregular changes in distribution patterns. However, overlaying these temporal fluctuations, a gradual decline in the overall frequency of incidental catches is indicated through the parallel decline of two independent parameters: the annual average percentage of trips with at least one turtle and the number of turtles caught per fishing trip (Table 1). Within this context it may be noted that captures of single turtles were registered only in the last two years of the study. It is not known if the reduced frequency in catches is due to a real reduction in population density or to - largely unknown - temporal fluctuations in the turtles' distribution. Here again, long-term studies taking into account all relevant parameters are needed in order to substantiate a true reduction of the population.

The absence of captures of tagged turtles may be due to the small sample size of adult female animals that were caught. No other fraction of the population is being tagged on the nesting beaches by the various conservation groups working in the study area. Thus, the great majority of small sized immature animals captured in long lines could not have been tagged at all. The same may apply to the fact that few animals were caught with an old hook in the mouth although, in each fishing season, a considerable number of turtles are released without removing the hooks. Another explication for the small numbers of animals with old hooks may be that the non-stainless hooks possibly errode within a short time. All fishermen state that the hooks used in surface long lines errode within two or three months.

In general, swordfish fishery might be less severely affecting the turtle population of the study area than loss of nesting habitat and mortality caused by other factors, drift net fishing in particular. One reason may simply be the relatively low total fishing efffort in the area. Furthermore, hooked turtles do not necessarily drown: contrary to the situation in drift nets, they are able to breathe while caught on the floating long line. Over the total period of investigation, corpses of dead animals were rarely found on beaches of the study area. It may be noted here, that the absence of corpses may be partly due to the fact that turtles caught in drift nets of the Italian vessels that were fishing in the area during most of the study period are often used for exploitation (see below).

Nevertheless, turtle mortality caused by incidental catches in long lines is still a largely unknown aspect in turtle conservation. The impact of swordfish fishery needs to be thoroughly investigated parallel to the impact of other fishery branches in order to design appropriate protection measures.

A major factor for the conservation of turtles in their marine habitat is the attitude of the fishermen towards them. Among the crews of swordfish boats from Kefalonia there has been a positive attitude towards endangered species even before the launching of var-

ious awareness programmes (Panou, unpub. data). It is primarily this attitude that lead to the conception of the present project by the principal authors, and to the willingness of the co-authors to participate. The participation of fishermen in the present project - largely on a voluntary basis - has yielded significant results while greatly promoting the sensitization of the local public throughout the study area. It is indicative for their positive attitude and for the gradual improvement in data registration achieved in the course of the study that, in the last three years of investigation, the size and, for adults, the sex of the animals were registered in all cases. In the first years of the study, these parameters were not always taken into account (Table 2). Within that context it is worth mentioning that, additional to the above data, cetacean sightings and swordfish catches are being registered as well (PIROUNAKIS *et al.* this volume, Panou unpubl. data).

The attitude of seamen in the rest of the country is largely neutral since, in Greece, turtles are not exploited for their meat and eggs (PANOU 1988, UNEP/IUCN 1990). However, an increasing number of hired crew members comes from countries where turtles are traditionally consumed (i.e. Egypt and, partly, Italy where turtles are considered a delicacy). This trend could lead to an increase of killings of turtles caught on vessels with such crews.

A severe threat to all species of marine turtles is most likely posed by drift nets which were heavily used in the entire Ionian Sea mainly up to 1992. The impact of drift nets is possibly considerably higher compared to the impact of long line fishery. Drift nets have now largely been prohibited by EU regulations but the legislation, at least in the Ionian Sea, is not fully enforced for both Greek and Italian vessels. The use of such gear in one of the Loggerhead's main nesting areas, in combination with the loss of nesting sites, and mortality caused by other factors may prove to be fatal for this species.

In a demographic model of the Mediterranean Loggerhead population (LAURENT *et al.* 1992) it was shown that the main factor affecting population growth rate is adult survival; fecundity is less important. Thus, conservation measures such as the protection of nesting habitat and the reduction of natural or anthropogenic mortality of hatchlings are, probably, not sufficient to ensure the survival of the species. Within that frame, the reduction of mortality at sea, adult mortality in particular, is of great importance. It is urgently needed to design and implement effective protection measures in the coastal and pelagic zones of the Ionian Sea aiming at the conservation of the Loggerhead turtle and other endangered species.

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