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Arta, Greece, 27-29 October 1998

REVIEW AND ANALYSIS OF THE AVAILABLE KNOWLEDGE OF MARINE TURTLE NESTING AND POPULATION DYNAMICS IN THE MEDITERRANEAN

UNEP
SPA/RAC - Tunis, 1998

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FOREWORD

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

The document were conceived for the following objectives:

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

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

CONTENTS

INTRODUCTION

As a relatively small marine area, the Mediterranean Sea has a very special situation in regard to marine turtles in as much as it is characterised by:

- Five of the seven species of sea turtles living in the world are reported: the loggerhead *Caretta caretta*, the green turtle *Chelonia mydas* and the leatherback *Dermochelys coriacea* are common, whereas the hawksbill turtle *Eretmochelys imbricata* and the kemps ridley turtle *Lepidochelys kempii* are occasional.

- Two unique breeding populations, one the loggerhead population may be the third largest in the world, and the other the green turtle population, containing endemic genotypes and significant diversity for this species.

- A traditional exploitation of sea turtles by both fishermen and locals.

- Difficult and complex conservation and management issues resulting from fishing activity, tourism industry, coastal development, and cultural and economic ties with marine turtles.

MEDITERRANEAN MARINE TURTLE NESTING POPULATIONS

Loggerhead

Nesting activity distribution

The nesting distribution by countries within the Mediterranean region is summarised in figure 1. The western and eastern oceanographic basins, which are separated by the channel of Sicily, have two radically different status.

Loggerhead nesting activity occurs only sporadically in the western basin. In Morocco and Algeria no crawl track was found on the long beaches prospected intensively in 1989, indicating that nesting is very likely exceptional in these countries (Laurent 1990). The same conclusion was drawn from marine turtle surveys in Sardinia (Argano *et al.* 1990; Withmore *et al.* 1991). Finally, for the whole western basin the only contemporary proof of a nesting activity is the discovery in September 1990 of one hatchling found dead on a beach located in the south of the Ebro Delta in Spain (Fillela I Subira & Esteban Guinea 1990; Llorente *et al.* 1992/93).

The eastern basin is the primary Mediterranean nesting area where annual nesting activity is spread within the whole zone, except the northernmost areas, i.e. the northern Aegean (Kasparek 1991) and Adriatic Seas (Lazar *et al.* 1998). The largest nesting populations are located in Greece (Margaritoulis 1980, 1982, 1988, 1998; Margaritoulis *et al.* 1995a,b), Turkey (Geldiay *et al.* 1982; Baran & Kasparek 1989a; Canbolat 1991; Erk'akan 1993; Baran & Turkozan 1996; Yerli & Demirayak 1996) and Cyprus (Demetropoulos & Hadjichristophorou 1989, 1995; Broderick & Godley 1996; Maclean *et al.* 1998) (Figure 1). However, recent survey in the last Mediterranean country where the distribution of sea turtle remained unknown for a long time, i.e. Libya, clearly identified that *Caretta caretta* nesting is wide spread and abundant in this country. Along 141.65 km of beaches surveyed once, 176 nests were recorded (Laurent *et al.* 1995). This, strongly indicates that the total number of nests laid along the 1,144 km of the Libyan sandy coastline within the whole nesting season is very high. Indeed, an estimation of this annual nesting activity based on the number of nesting crawl tracks observed in 1995 during single prospectings, shows that

Libya might hold one of the largest loggerhead colony in the Mediterranean (Laurent *et al.* 1995, 1997) (Figure 1).

Very small numbers of females nest annually in Egypt (Kasparek 1993), Syria (Kasparek 1995), Tunisia (Laurent *et al.* 1990; Bradai 1993a, 1995; Bradai & Jribi 1997), Israel (Ashkenazi & Sofer 1988; Silberstein & Razi Dmi el 1991; Kuller 1995) and in Italy on the south coasts of Sicily and on Pelagic Islands (Di Palma 1978; Gramentz 1986, 1989; Di Palma *et al.* 1989; Cocco & Gerosa 1991; Ragonese & Jareb 1992). A small number may nest annually also in Albania (PAP/DMI 1995) and in Lebanon, but rookeries in this countries have yet to be surveyed. In Malta nesting activity was recorded up to the thirty years; nesting population is now extinct (Gramentz 1989).

Major known nesting sites, in terms of number of nests (or nesting crawl tracks) per season, are Zakynthos (3.5 km in length) with 1,499 nests observed during the 1994 season (Margaritoulis & Dimopoulos 1995), Kiparissia Bay (Peloponesus) (10 km) with 700 nests in 1994 (Margaritoulis *et al.* 1995b), Rethymnon (Crete) (10.8 km) with number of nests ranging from 316 to 516 per season (Margaritoulis 1998), Dalyan (Turkey) (3 km) with 235 nests in 1989 (Erkakan 1993) and Alagadi (Cyprus) (2.1 km) with 95 nests in 1994 (Godley & Broderick 1994). However, such a classification is yet more or less indicative because there is still considerable imprecision in measuring the distribution of the nesting activity in Libya and to a lesser extent in Turkey. Furthermore, methodologies and number of monitoring seasons are different among nesting sites.

Until recently the Mediterranean loggerhead nesting population was thought to be small and most of individuals caught by fisheries in the western Mediterranean were considered to originate from the Atlantic (Carr 1987; Groombridge 1990). More detailed investigations of previously neglected nesting areas e.g. in northern Cyprus (Broderick & Godley 1996) and in Greek Islands (Margaritoulis *et al.* 1995a), and especially the discovery of a large nesting population in Libya (Laurent *et al.* 1995), enabled the first holistic estimates of the loggerhead nesting population in the Mediterranean Sea (Figure 1). Taken as a whole, Mediterranean may support the third largest loggerhead population in the world, after those of Oman and the United States (Laurent *et al.* 1995). However, on the basis of large historical catches in Israel and Turkey (Gruvel 1931; Hornell 1935; Anonymous 1967; Hataway 1972; Sella 1982; Geldiay *et al.* 1982), and in Tunisia and Egypt (Argano & Baldari 1983; Laurent *et al.* 1990; Laurent *et al.* 1996), it might be expected that the present Mediterranean nesting population is markedly smaller than in historical times, particularly with respect to populations in Israel, Tunisia, Egypt, Turkey, Cyprus and to a lesser extent Libya.

Population structure

Preliminary mitochondrial DNA studies indicated that rookeries of Greece and Cyprus, share common haplotypes with those of the western Atlantic, but significantly differ in haplotype frequencies (Bowen *et al.* 1993; Laurent *et al.* 1993), showing that they have genetically diverged as a result of low levels of contemporary gene flow with Atlantic colonies. Within Mediterranean, it is likely that population differentiation among nesting areas occurs, as this was recently shown for different nesting sites in Turkey by means of analysis of both mitochondrial and nuclear markers (Schroth *et al.* 1996). This is further supported by the significant differences in the size of nesting females from Greece, Cyprus, Libya and Turkey (Laurent *et al.* 1995; Broderick & Godley 1996).

In conclusions, no large Mediterranean nesting areas have yet been sampled for genetic analyses, preventing to demonstrate that although substantial numbers of turtles from Atlantic breeding populations enter Mediterranean, the whole Mediterranean breeding stock is functionally independent. Mediterranean loggerhead nesting population need to be subjected to further genetic investigation.

Stock composition and life history stage distribution

Analysis of cytochrome b haplotype frequencies in sample from the western basin indicated that numerous individuals caught in Spanish longline fishery are originated from the United States of America and elsewhere in the Atlantic (Laurent *et al.* 1993). This is the first evidence for the transatlantic developmental loggerhead migration suggested by Carr (1987). These molecular findings also confirmed earlier speculation that an entry of Atlantic loggerheads into the Mediterranean may be common (Argano & Baldari 1983; Carr 1987; Laurent 1990a; Bolten *et al.* 1992).

Hatchling and post-hatchling stages are only rarely observed in neritic waters, indicating that they effectively enter an oceanic pelagic developmental phase after leaving nesting beaches. As deduced from analysis of fishing data regarding size of captured individuals, small and medium immature stages use pelagic feeding habitats in the two Mediterranean basins (Table 1). As regards large juvenile and adult stages distribution, the situation is different. Such larger individuals seem to be restricted to the eastern basin (Laurent & Lescure 1994; Laurent *et al.* 1996; Table 1). They are caught by bottom trawl fisheries, at least during winter, as is the case in Tunisia (Bradai 1992; Laurent *et al.* 1990, 1996), in Lakonikos bay (Greece) (Margaritoulis *et al.* 1992), in Iskenderun Bay (Turkey) (Laurent *et al.* 1996; Oruç *et al.* 1997), in Egypt (Laurent *et al.* 1996), and probably in the northern Adriatic (Argano & Cocco in Groombridge 1990; Lazar & Tvrtkovic 1995). Dietary analysis has indicated that loggerheads caught during winter in South Tunisian waters actively feed on benthic invertebrates, mostly gastropods, hermit crabs, holothurians, lamellibranchs and sponges (Laurent & Lescure 1994).

Together these data finally suggest that benthic feeding habitats for large immatures and adult stages are restricted to the eastern basin. We do not known by which stock (Atlantic or Mediterranean) and sub-populations, the pelagic developmental and benthic feeding grounds are exploited. There is therefore an urgent need to assess stock composition in the Mediterranean habitats by using molecular markers.

Green turtle

Nesting activity distribution

The nesting distribution by countries within the Mediterranean region are summarised in figure 2. Green turtle nesting activity has never occurred historically in the western basin and is restricted to the easternmost part of eastern basin. The largest nesting population with only hundreds of nesting females annually is found in Turkey (Geldiay *et al.* 1982; Baran & Kasparek 1989a; Coley & Smart 1992; Gerosa *et al.* 1996; Yerli & Cambolat 1998). Around one hundred nest annually in Cyprus (Demetropoulos & Hadjichristophorou 1989 ; Broderick & Godley 1996). Very small numbers nest annually in Israel (Ashkenazi & Sofer 1988; Silberstein & Razi Dmiel 1991; Kuller 1995). A very small number may nest annually also in Syria (Kasparek 1995), Lebanon and on the eastern Mediterranean Egyptian coasts, but rookeries in this country have yet to be surveyed. A recent survey in Libya indicates that nesting by green turtles on these long sandy coasts should be considered improbable (Laurent *et al.* 1995). On the basis of large historical green turtle catches in Israel and Turkey (Gruvel 1931; Hornell 1935; Anonymous 1967; Hataway 1972; Sella 1982; Geldiay *et al.* 1982) and at present in Egypt (Laurent *et al.* 1996), it might be expected that the present Mediterranean nesting population is markedly smaller than in historical times, particularly with respect to populations in Israel, Cyprus and to a lesser extent Turkey.

Population structure

Cyprus is the only rookery sampled in the Mediterranean for mtDNA analysis (Bowen *et al.* 1992; Encalada *et al.* 1996; Encalada 1996). This colony presents endemic haplotypes showing that it is an independent demographic unit close to isolation in comparison with Atlantic ones. Furthermore, this endemic genetic diversity constitutes a significant portion of the total diversity identified for Atlantic and Mediterranean green turtles (Encalada *et al.* 1996; Encalada 1996). Such a management unit warrants a very high conservation priority. The whole Mediterranean green turtle nesting population need to be subjected to further genetic investigation.

Stock composition and life history stage distribution

Capture of this species in the western basin is exceptional (Mayol 1985; Pascal 1985; Laurent 1990, 1991; Laurent *et al.* 1990, 1997; Raga & Salinas 1990; Basso 1992). In the eastern basin, capture of green turtles in Italy (Basso 1992), Croatia (Lazar & Tvrtkovic 1995), Greece (Margaritoulis *et al.* 1986; Margaritoulis *et al.* 1992), Malta (Gramentz 1989), Tunisia (Laurent *et al.* 1990) and Libya (Laurent *et al.* 1995) is very uncommon, and all but one (Gramentz 1989) of the recorded captures concern immatures. Analysis of distribution of dead turtles washed ashore in Turkey indicated that in comparison with loggerhead, immature green turtles stay more or less around their birth place and reproduction grounds (Baran & Kasparek 1989b). Together these data suggest that pelagic develomental habitats for posthatchling and immature stages as well as benthic feeding habitats for large immatures and adult stages are restricted to the easternmost part of the eastern basin. However, these habitats need to be precisely located in relation to the probable different nesting populations occurring within the Mediterranean.

Leatherback

The species is known to have nested at least at one time in Mediterranean at the end of the 19th century, but such an event has never been recorded since (Lescure *et al.* 1989). Existence of a present Mediterranean nesting population is thus most improbable.

Mediterranean pelagic feeding grounds for this species are exploited by individuals coming from Atlantic populations.

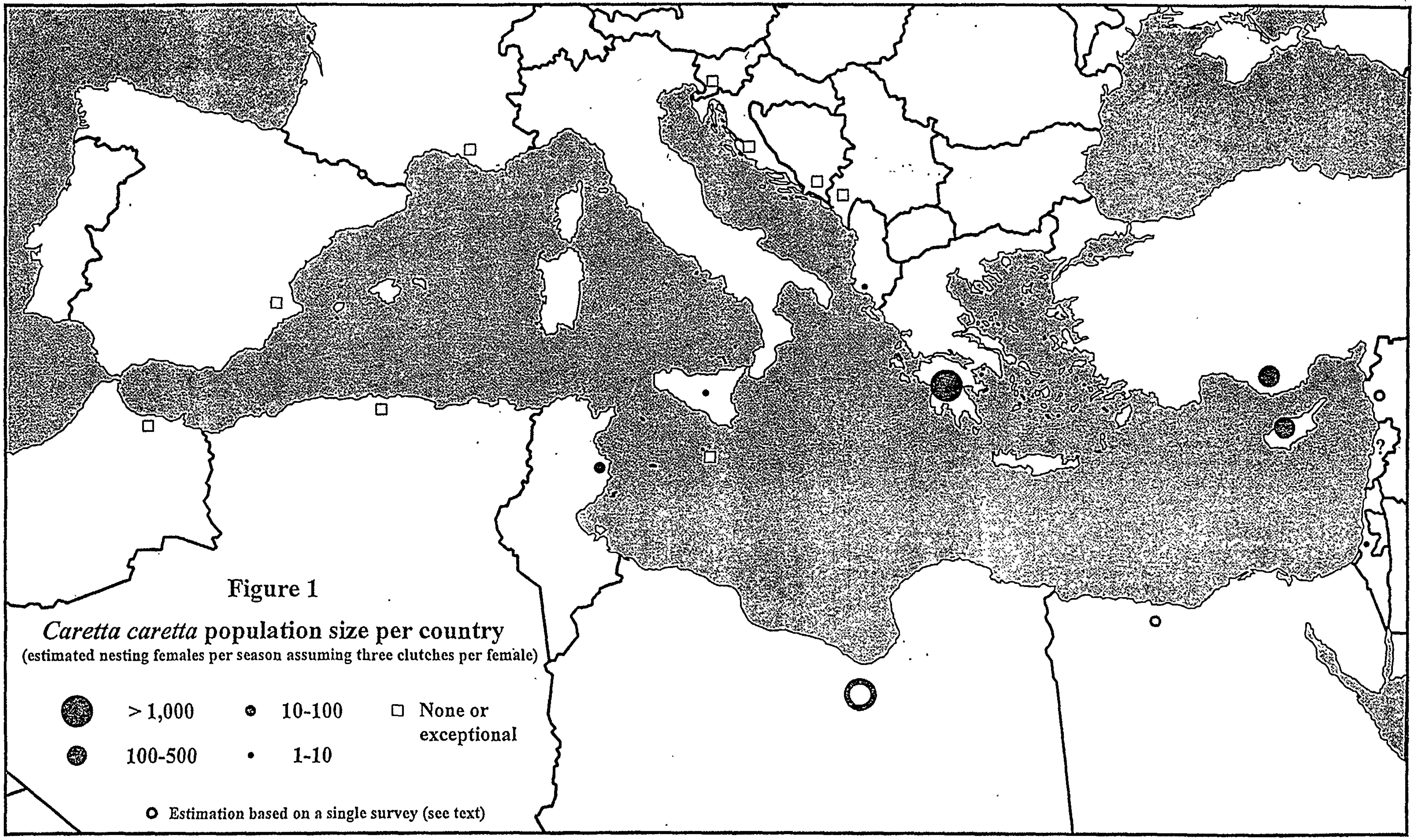

Figure 1

Caretta caretta population size per country
(estimated nesting females per season assuming three clutches per female)

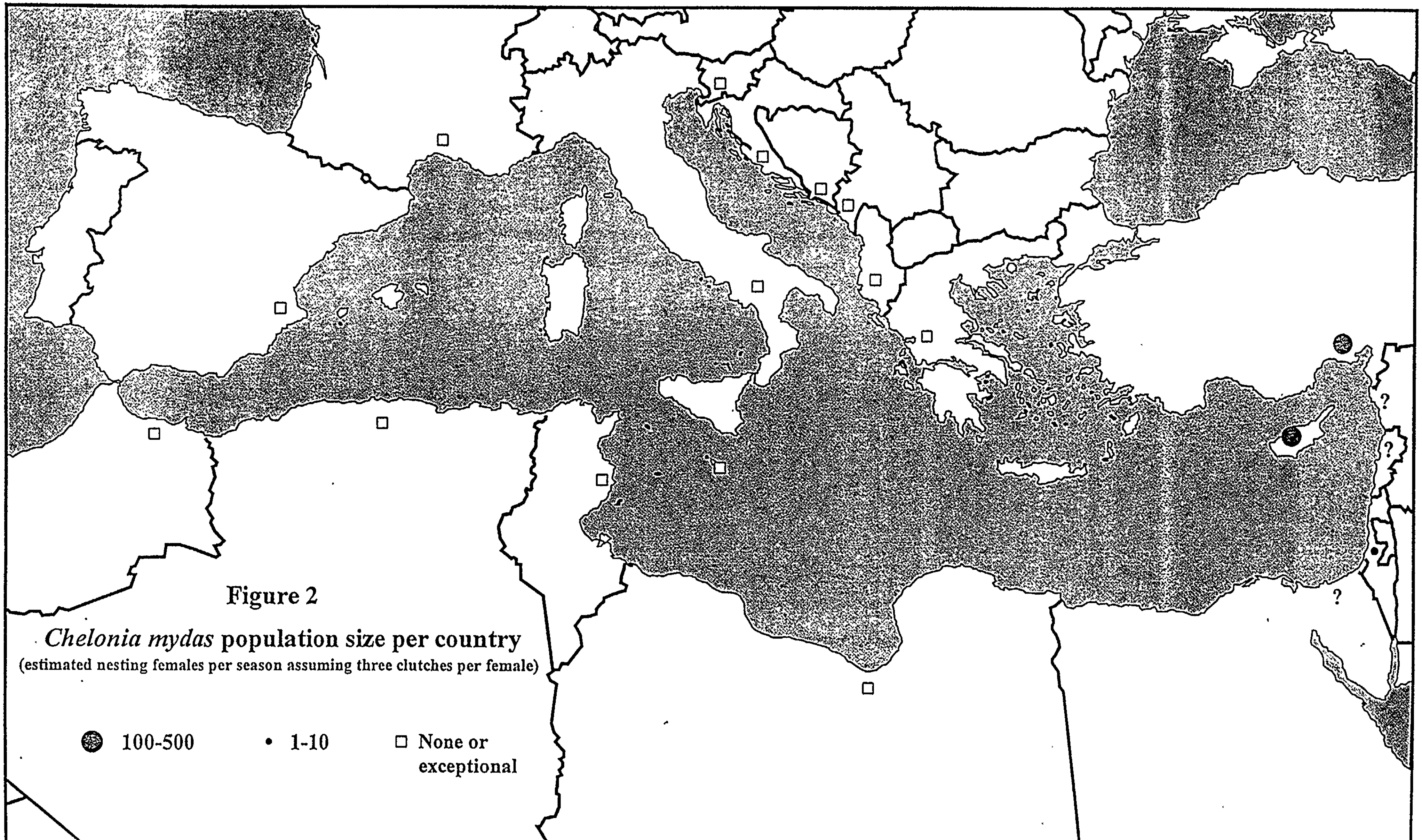

Figure 2

Chelonia mydas **population size per country**

(estimated nesting females per season assuming three clutches per female)

POPULATION DYNAMICS

Reproductive parameters

As with most marine turtle populations, demographic data on the Mediterranean marine turtle populations are very scattered. For example, age at first breeding, annual recruitment into the female adult component, annual proportion of adult females nesting, breeding males data, etc., are totally unknown in the region. Other reproductive parameters were recorded for some populations. Globally, demography of loggerhead has been more investigated than green turtle.

Nesting female size

Loggerhead

Loggerhead females that breed in the Mediterranean region are smaller than anyywhere else in the world (Margaritoulis 1982; Dodd 1988; Broderick & Godley 1996). The differences of size of nesting females from Greece, Cyprus, Libya and Turkey were found to be significant (Laurent *et al.* 1995; Broderick & Godley 1996). Nesting females from Cyprus are the smallest within Mediterranean and in the world (Broderick & Godley 1996).

Green turtle

Nesting females size are known from Kazanli, Akyatan and Samandag in Turkey (Gerosa *et al.* 1996; Yerli & Demirayak 1996) and from Alagadi in Cyprus (Broderick & Godley 1996). As loggerheads, green turtles are smaller than those found in other regions (Broderick & Godley 1996).

Clutch size

This parameter represents the number of eggs per clutch. Usually measured by excavating hatched nests. There is a significant positive correlation between adult body size and clutch size at intraspecific level in marine turtles (Van Buskirk & Crowder 1994). This was shown for Mediterranean loggerheads nesting in Cephalonia (Hays & Speakman 1992).

Loggerhead

Annual mean clutch size has been recorded in numerous nesting sites and ranges from 70.5 (N=131) in Cyprus (Broderick & Godley 1996), to 79.6 (N=356) in Turkey (Yerli & Demirayak 1996), 95.2 (N=14) in Libya (Laurent *et al.* 1995), 115 (N=38) in Cephalonia (Hays & Speakman 1991), 115.4 (N=102) in Zakynthos (Margaritoulis 1987) and 117.7 (N=52) in Kiparisia bay (Margaritoulis 1988).

Green turtle

Annual mean clutch size was estimated at 122.9 from Akyatan (Gerosa *et al.* 1996), 118 (N=111) from Kazanli, 127 (N=90) from Samandag (Yerli & Demirayak 1996) and 112.3 (N=136) from Alagadi in northern Cyprus (Broderick & Godley 1996).

Clutch frequency

This parameter is very informative, enabling to estimate annual nesting females at a nesting site, but it is poorly quantified in the Mediterranean. On Zakynthos, Margaritoulis (1983) reported two females observed nesting three successive times. Hays *et al.* (1991) interpreted satellite telemetry data from one loggerhead on Cephalonia as indicated 4 clutches laid within the breeding season. Possibly 4-5 clutches per season are laid in Cyprus for the green turtle (Demetropoulos & Hadjichristophorou 1995). Broderick & Godley (1996) use a 3 clutches per season for both species to estimate population, without giving precision.

Recruitment rate

This parameter represents the annual recruitment of primiparous (neophytes) into the female adult component. Recruitment into the annual nesting population can be estimated by using the proportion of untagged turtles recorded at a nesting site when nesting population has been studied with saturation tagging for at least three modal remigration intervals. This parameter is unknown in Mediterranean. Margaritoulis & Dimopoulos (1995) provided estimates of proportion of untagged turtles at Zakynthos, but such studies do not involve saturation tagging.

Remigration intervals

Individual *Caretta caretta* and *Chelonia mydas* usually do not nest in consecutive nesting seasons. Remigration intervals are defined as the number of years between consecutive nesting seasons. Remigration intervals corrected for tag loss and annual survival rate enable to estimate proportion of adults nesting each year. Remigration intervals are poorly quantified in the Mediterranean. The mean and modal remigration intervals for loggerhead nesting on Cephalonia were estimated at 2.56 (SE=0.34) and 2 years, respectively (Hays & Sutherland 1991). At Alagadi in northern Cyprus, Broderick & Godley (1996) provided some remigration intervals for both *Caretta* and *Chelonia.*

Natural emergence success

Loggerhead

The natural emergence success is defined as the proportion of eggs in clutches not disturbed by predators that successfully produce emerged hatchlings. Usually only measured with clutches that produced hatchlings i.e. nests totally inundated and eroded are not taken in consideration. This parameter ranges from 54.9% (N=39) in Peloponesus in the 1987 season (Margaritoulis 1988), to 60.1% (N=572) in 1994 in Zakynthos (Margaritoulis & Dimopoulos 1995), 61.2% (N=34) in Göksu delta in Turkey in 1992 (Peters *et al.* 1994) and 71.6% (N=8) in Cephalonia in 1990 (Hays *et al.* 1992).

Green turtle

The only data for this species was provided by Broderick & Godley (1996) and concern mean hatching success for the years 1992-95 estimated to 84.2% (N=341) at Alagadi (Cyprus).

Nest depredation rate

Loggerhead

Nest depredation is a natural phenomenon linked to the ecological diversity of an area, which is observed throughout the Mediterranean. Generally, nests were preyed upon by wild canids: red fox *Vulpes vulpes* and golden jackal *Canis aureus*, and to a lesser extent by the ghost crab *Ocypode cursor.* On Zakynthos, such a source of mortality is close to zero (Margaritoulis & Dimopoulos 1995). On Kiparissia Bay (Peloponesus), 48.8% (N=44) were disturbed by predators in 1987, but only 3 of them were totally destroyed (Margaritoulis 1988). Such a high depredation rate seems usual in Peloponnesus (Margaritoulis *et al.* 1995b). In Libya during the 1995 season, nest depredation was observed along the whole eastern coastline and the rate of nest depredated (partially or totally) detected during single prospectings was 44.8% (Laurent *et al.* 1995). In Cyprus during the 1994 season, 36.0% of nest were affected (Broderick & Godley 1996). At Dalyan, during the 1992 season, 62.5% of the 88 unprotected nests were depredated (Yerli *et al.* 1997). In the Göksu delta, 40.2% of all loggerhead nests (N=117) were depredated by jackals in 1991 (Van Piggelen & Strijbosch 1993), in sharp contrast to 1992, when depredation was recorded to be only minimal (Peters & Verhoeven 1992). This difference was most striking in the core area: 64.0% was depredated in 1991 (Van Piggelen & Strijbosch 1993), whereas not a single nest was affected in 1992 (Peters & Verhoeven 1992).

Green turtle

At Akyatan, nest depredation was found in 41.2 % of nests detected during a first prospecting (Brown & Macdonald 1995), and these authors estimate at more than 75.0% the rate of nest affected at this nesting site. Of the 825 nests recorded in 1994 in Turkey, 16% showed signs of depredation (Yerli & Demirayak 1996). On the basis of a survey conducted in 1995 on Akyatan, Aureggi *et al.* (1998) estimated to 23.8% (N=206) the proportion of depredated nests.

Trends in nesting activity

Loggerhead

No long term census has accurately demonstrated decline in marine turtle nesting activity within the Mediterranean. However, on the basis of anecdotal data, strong decline in the number of clutches has been noticed in Israel (Sella 1982; Silberstein & Dmiel 1991; Kuller 1995), Cyprus (Demetropoulos & Hadjichristophorou 1989), Malta and on Lampedusa Island (Gramentz 1989).

The nesting population of Zakynthos is the only one where there are any long term census data. These data show no apparent trend in the number of clutches laid each year over the past 11 years (Margaritoulis & Dimopoulos 1995).

Green turtle

There are no long term census data for this species in the Mediterranean. Anecdotal historical data indicate that green turtle population in Israel has greatly diminished and continues to decline (Kuller 1995).

Survivorship parameters

No annual survival rate has been estimated for any of the life history stages of marine turtle populations in the Mediterranean: hatchling, posthatchling, juvenile and adult stages.

Body growth

No data is available concerning growth of immatures and adults for Mediterranean marine turtle populations.

Sex Ratio

No data is available concerning sex ratio for Mediterranean marine turtles populations.

Human induced mortality

Fishery related mortality

Bycatch of sea turtles by fisheries induce mortalities caused by fishing gear itself and intentional mortalities owing to consumption and trade by fishermen of the sea turtles captured alive.

Accidental Mortality

Fishery activity is the most important anthropogenic mortality factor known in the Mediterranean. Bottom trawl, longline, driftnet and small coastal fisheries, have a large bycatch of marine turtles causing substantial direct and delayed mortality (Table 2). Direct mortality concerns the immediate death by drowning or severe trauma, while delayed mortality is related to the subsequent death of individuals released in a weak or comatose condition, or wounded.

Although sample sizes for estimating mortality are small and estimates of annual takes represent large extrapolations for which no precision has been calculated (Table 2), these compiled preliminary data rise concern about the compatibility of the present fishing activity in the Mediterranean with the long term conservation of marine turtle populations in this sea.

Intentional mortality

High intentional mortalities are still recorded in the eastern basin where sea turtles captured alive are traditionally used, and may become of economic interest when numerous. This was the case in Palestine, Syria and Turkey at the beginning of the century (Hornell 1935; Sella 1982; Geldiay *et al.* 1982), in Malta up to the sixties (Gramentz 1989), in Tunisia up to 1989 (Laurent *et al.* 1990) and at present in Egypt (Laurent *et al.* 1996).

In Italy sea turtles are known to be eaten and sold (De Metrio & Megalofonou 1988). In Turkey, eating sea turtles seems infrequent, but does exist, notably by fishermen; those unaware of legislation protecting sea turtles represent more than 50% of the fishermen interviewed (N=26) (Laurent *et al.* 1996). In Tunisia, in 1988, an estimated 4,000 to 5,500 loggerheads, most of them being captured by trawling, were sold at fish markets for local consumption. In fish markets, slaughter of sea turtles has been stopped since 1989, but consumption by fishermen and clandestine selling in some localities are still recorded (Laurent *et al.* 1996). For example, Bradai (1993b) revealed that 27.0% of interviewed Tunisian fishermen using small coastal fishing boats (N=149) eat turtle meat. The most critical situation regarding intentional mortality is recorded in Egypt. Indeed, in this country 231 tons of marine turtles were officially landed in 1992 (FAO 1995). Furthermore, both the loggerhead and green turtle are traditionally used for meat and blood consumption by fishermen and other inhabitants, notably in Alexandria. Over 13 days of observations in this city spread in the end of 1995 and beginning of 1996, 35 sea turtles were killed at the fish market, most of them being large immatures or adults with a green turtle fraction estimated at 32.0% (Laurent *et al.* 1996). These data strongly indicate that several thousand individuals are very likely to be slaughtered each year in Egypt (Laurent *et al.* 1996).

Human induced egg depredation

As indicated by Brown & Macdonald (1995) for Akyatan, we do not know whether the high level of egg mortality recorded within the Mediterranean as a result of fox and jackal nest depredation, has prevailed for many years. In other words, an important management question is whether the tourist development (or any other environmental changes) has caused an increase of this present nest depredation by canids in comparison with an historical natural level. For instance, according to Van Piggelen & Strijbosch (1993) garbage attracts jackals to the neighbourhood of village.

Other identified source of mortality

<u>On nesting beaches</u>

Light pollution

Artificial light at nesting beaches can cause mortality in hatchlings by directing them away from the sea. At Göksu delta, Peters & Verhoeven (1994) estimated at 63% the proportion of hatchlings which did not show a correct seaward orientation due to artificial light from an holiday village. On Zakynthos, 20% of the emerged hatchlings on the East of Laganas beach were oriented towards the airport instead of going to the sea (Margaritoulis & Dimopoulos 1995).

Plastic litter covering beaches

Large coverage of beaches by plastic litter as it was recorded in Syria (Kasparek 1995) and in northern coasts of Cyprus (Broderick & Godley 1996), may block the path of hatchling which try to reach the sea. Plastic litter were also reported in Lampedusa (Gerosa 1992) and Akyatan (Gerosa *et al.* 1995).

Vehicle track

Vehicle track on the beach can block or modify the path of emerged hatchlings as it was recorded at Akyatan by Brown & Macdonald (1995) and Gerosa *et al.* (1995), and in Cyprus by Maclean *et al.* (1998).

At sea

Collision with boats

Motorboat traffic, often related to tourism, was found to induce fatal collisions with nesting females near nesting beaches (Venizelos 1993, 1994).

Pollution

Direct and indirect impact of chemical, hydrocarbon and plastic pollution on marine turtle populations is extremely poorly documented in the Mediterranean. Over 20% of loggerhead examined at Malta by Gramentz (1988) were contaminated with plastic and hydrocarbons, suggesting that the number of sea turtles suffering from direct pollution is high.

Area	Fishery		N	Loggerhead size [b] Ranges	Mean	Size class stages [c] J1 %	J2 %	J3 %	70 %	Reference
Spain 1990	Longline	SRS[a]	472	27.0-76.0	47.4	0.4	78.0	21.0	0.6	Aguilar *et al.* 1995
Spain 1991	Longline	SRS[a]	392	35.0-71.0	48.8	0.0	75.0	24.8	0.2	Aguilar *et al.* 1995
Algeria	All fisheries		22	16.9-72.8	54.7	9.1	18.2	68.2	4.5	Laurent 1990
France	Trawl		11	34.5-75.5	48.9	0.0	63.6	27.3	9.1	Laurent 1991, 1996
France	All fisheries		58	27.5-75.5	42.5	15.5	60.4	22.4	1.7	Laurent 1991, 1996
Italy	Trawl		48	19.0-89.0	52.3	18.8	29.1	33.3	18.8	Argano, unpublished
Italy	Longline		656	18.0-95.0	55.4	1.5	32	57.8	8.7	Argano,unpublished
Italy	All fisheries		798	18.0-95.0	54.4	4.0	33.5	53.6	8.9	Argano, unpublished
Malta	Longline		123	23.5-75.5	55.0	3.3	28.4	61.8	6.5	Grametz, unpublished
Malta	All fisheries		186	20.0-75.5	52.3	5.9	38.2	50.0	5.9	Gramentz 1989
Tunisia	Trawl	SRS[a]	15	43.0-90.0	73.4	0.0	6.7	20.0	73.3	Laurent & Lescure 1994
Tunisia	Trawl		80	32.3-91.8	61.3	0.0	28.7	36.3	35.0	Laurent *et al.* 1996
Tunisia	All fisheries		147	17.6-91.8	56.5	5.4	31.3	40.8	22.5	Laurent 1993
Greece	Trawl		38	?	?	?	?	?	84.0	Margaritoulis *et al.* 1992
Turkey	Trawl	SRS[a]	1	61.0	61.0	0.0	0.0	100	0.0	Laurent *et al.* 1996
Egypt	Trawl		27	49.4-86.3	67.0	0.0	3.7	59.3	37.0	Laurent *et al.* 1996
Egypt Gt	Trawl		1	91.0	/	/	/	/	100	Laurent *et al.* 1996
Egypt	All fisheries		52	38.0-86.3	66.2	0.0	13.5	44.2	42.3	Laurent, unpublished
Egypt Gt	All fisheries		21	28.0-95.5	66.8	/	/	/	19	Laurent *et al.* 1996

Table 1: Size of loggerheads and green turtles (Gt) captured by Mediterranean fisheries

[a] Simple Random Sample drawn during onboard observer programme
[b] Standard Curved Carapace Length in cm
[c] % distribution in size class stages J1(>13-32≤), J2(>32-51≤), J3 (>51-70<) and 70 (≥70cm)

Fishing gear Fishery	Fishing zone	Annual number of captures	Direct mortality %	N	References
Trammel nets					
Lobster nets	France Continental	low	100	8	Laurent 1991
Lobster nets	Corsica	low	93.3	15	Delaugerre 1987; Laurent 1996
Fish nets	France Continental	low	28.5	7	Laurent 1991
Fish nets	Corsica	low	75.0	4	Laurent 1996
Sole nets	France Continental	low	53.1	128	Laurent 1991
Gillnets					
	France	low	50.0	6	Laurent 1991
	Italy	?	50.0	?	Argano *et al.* 1992
Drifting longlines					
	Spain 1990	35,637	0.4	673*	Aguilar *et al.* 1995
	Spain 1991	22,000-23,637	0.4	425*	Aguilar *et al.* 1995
			24.4@	45	Aguilar *et al.* 1995; Mas 1996
	Italy (Ionian Sea)	100-1,000	?		De Metrio & Megalofonou 1988
	Malta	1,500-2,500	?		Gramentz 1989
	Greece (Cephalonia)	50	?		Panou *et al.* 1996
	Morocco	3,000	?		Laurent 1990
	Algeria	300	?		Laurent 1990
Drifting nets					
	Italy (Ionian Sea)	16,000	29.0	31*	De Metrio & Megalofonou 1988
	Italie (Ligurian and Tyrrhenian Seas)	low	0.0	5*	Di Natale 1995
	Spain (1994)	117-354 #	3.3	30*	Aguilar 1995
Bottom trawl					
	Greece (Peloponesus)	?	2.6	38	Margaritoulis *et al.* 1992
	Italy	1,000-1,500	?		Argano 1979
	Eastern Adriatic Sea	2,500	?		Lazar & Tvrtkovic 1995
	Tunisia	3,500-4,000	0.0	15*	Laurent & Lescure 1994
	Tunisia	2,000-2,500	0.0	1*	Bradai 1992
	Turkey	high	0.0	1*	Laurent *et al.* 1996
	Turkey	high	0.5	138	Oruç *et al.* 1996
	Turkey	high	0.3	338	Oruç *et al.* 1997
	Egypt	high	?		Laurent *et al.* 1996
	France Continental	low	3.0	97	Laurent 1991, 1996
	Corsica	low	3.8	26	Delaugerre 1987
	Spain	low	?		Aguilar 1995

Table 2: Approximate estimates of annual number of sea turtle captures, and direct mortality in % for different fisheries. N: number of individuals sampled to estimate mortality; @: delayed mortality; *: onboard observations; #: 95% confidence limits.

Note : delayed mortality in trawling activity is unknown.

Population dynamics analysis

Population dynamic bases

Life-history traits of marine turtles are characterised by delayed sexual maturity, high body growth from hatchlings to adults, strong variations in individual growth rates, iteroparity (numerous clutches) with high fecundity, great seasonality in breeding episodes, and a natural mortality strongly declining from egg/hatchling to adult stages.

In case of long-lived species with large delayed maturity which are therefore difficult to study, all the more for sea turtles, a model approach remains the only possible tool for analysing population dynamics, determining key life-history components, identifying which parameters have the greatest impact on population growth and evaluating options for conservation. In Mediterranean, as anywhere else in the world, one of the main problem in improving sea turtle population models remains the lack of good estimates of demographic parameters (Crouse *et al.* 1987).

Population dynamics analyses with demographic models indicate that Chelonians in general and sea turtles in particular are not able to support high levels of mortality in juvenile and adult stages (Crouse *et al.* 1987; Laurent *et al.* 1992; Crowder *et al.* 1994; Heppel *et al.* 1996a,b; Spotila *et al.* 1996). This does not mean that egg/hatchling stage is not a critical one, indeed demographic simulations, shows that population responses to egg/hatchling survivorship is equal to other stage survival, except a large time-lag due to age at maturity. However, population management actions on nesting beaches can not compensate for fishing mortalities in marine habitats. On the other hand, efforts for protecting the natural physical environment of nesting beaches from urbanization and tourism are fundamental and very efficient. With a single action, these efforts enable nesting activity, egg incubation and hatchling emergence to be perennial, and act on a rather long term. They should be carried out within a global framework for protecting marine coastlines hosting or not nesting beaches and safeguarding their biodiversity, and not only as a sea turtle conservation action.

Population dynamics analysis of Mediterranean marine turtles

The only population dynamics analysis based on modelling exercise undertaken in the Mediterranean was the study of Laurent *et al.* (1992). These authors developed a stage-structure matrix model for a Mediterranean loggerhead stock using six stages (4 size-based stages and 2 reproductive status stages). Stage transition was time invariant as for previous matrix models. Laurent *et al.* (1992) concluded from a sensitivity analysis (elasticity) that reducing annual mortality of loggerhead larger than 70cm (SCCL) (large juveniles and adults) was essential for stock viability. The model was based on little empirical demographic information relevant to the stock.

The other conclusion was that accurate estimation of annual adult survival rate in Mediterranean loggerhead population is one of the highest research priorities. This implies the monitoring of tagged nesting females at nesting sites by capture recapture methods (Lebreton *et al.* 1992).

Marine turtle conservation management: a Mediterranean and a long term issue

Mediterranean marine turtle populations must be managed at all their life stages.

Management must address their entire international range, and involve all the human activities interacting directly or indirectly with them. Therefore, marine turtle management has to fundamentally be thought out and undertaken on a Mediterranean scale and not at a level of one life stage in one area.

Such a global approach should also take into consideration the temporal dimension because the generation time of the marine turtle population is very long, at least twice that of the human one, and population response to threats is usually delayed while its correct detection needs amount of time and is labour intensive. Moreover, census of all threats for marine turtles as the discovery of their solutions are far from being achieved, and new marine environmental problems will probably occur in the far future. As part of a long term programme for marine turtle conservation in the Mediterranean, managers should take this situation into consideration and focus their priorities on increasing population growth rate, in order to enable breeding populations to face future conservation issues which will be monitored by next generations of managers.

Mediterranean marine turtle conservation is a shared environmental problem which cannot be solved by a single state or agency. Many of the issues for sea turtle conservation are common throughout the Mediterranean, and individual countries have to share the experience of others, to standardise, to co-ordinate and to unify their actions on the Mediterranean scale when acting locally.

RECOMMENDATIONS

Significant conservation issues

1- Reduce substantially intentional mortalities in Egypt

Intentional mortality in Egypt is likely unsustainable for both Mediterranean loggerhead and green turtle populations.

2- Reduce substantially captures and mortalities in fishery bycatch

If long term conservation of Mediterranean marine turtle populations is to be ensured, urgent sea turtle conservation regulations for trawl and longline fisheries in the Mediterranean need to be identified and implemented. For the Mediterranean marine environment, one of the most important conservation issues is to manage fishing activity in such a way so as to obtain sustainable exploitation of resources and environmental protection of non-target species. There is urgent need for the Mediterranean community as a whole to make policy for resource management, and for the environment, more coherent, and to harmonise fishing methods.

3- Reduce substantially human induced nest depredation

This conservation management action needs to be set up at a Mediterranean level, but can not compensate for fishing mortality in marine habitats, and must not be presented as such.

Significant population monitoring issues

1- Marine turtle management requires several monitored nesting sites

Mediterranean population likely consists of different functionally independent sub-populations i.e. management units, which probably do not share the same pelagic and benthic feeding grounds and consequently do not sustain the same level of human induced mortality.

Therefore, even if Zakynthos is the biggest known nesting ground in terms of nest density per km, it would be unwise to only base Mediterranean policy on the monitoring of this nesting site. In each nesting area, one (or more) nesting site needs to be urgently chosen and annually monitored.

2- Standardize research and demographic parameter estimation methods among monitored nesting sites

In order to compare data between nesting sites and analyse population trends, demographic parameters (clutch frequency, recruitment rate, remigration intervals, emergence success, etc.) need to be estimated according to Mediterranean (and international) standardised methods.

3- Development of models to monitor population responses to management policies

Population models are fundamental tools for understanding population dynamics, guiding demographic research and conservation management policy.

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