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A review and reappraisal of research in some previously unsurveyed Mediterranean marine turtle nesting sites, 1990-2001

Lily Venizelos, Kalliopi Papapavlou, Marc-Antoine Dunais and Calliope Lagonika

MEDASSET (The Mediterranean Association to Save the Sea Turtles), Licavitou 1(c), 106 72, Athens, Greece
Corresponding author : L. Venizelos, e-mail : medasset@hol.gr

ABSTRACT. One of MEDASSET's main objectives has been the assessment of coastal areas on a pan-Mediterranean scale in a search for potential nesting sites of *Caretta caretta* (loggerhead turtle) and *Chelonia mydas* (green turtle), the only two marine turtle species known to reproduce in the Mediterranean. The specific characteristics of each coastal region were logged, as turtles cannot be successfully protected unless all their reproductive habitats are known. If any important turtle nesting sites were found, recommendations for implementation of protective measures were made to the States involved, followed by efforts towards the implementation of protective legislation and conservation measures. These surveys took place in Sardinia, Italy (1990 & 1991), the North Aegean (mainland and islands), Greece (1991), the western part of the Egyptian Mediterranean coast (1993), Syria (1991), Libya (1995 & 1998) and Lebanon (2001). This review sums up data resulting from these pioneering studies and re-evaluates it in the light of more recent information regarding marine turtle nesting and conservation in the Mediterranean.

KEY WORDS : marine turtles, Mediterranean, coastal assessment, conservation, nesting beach

INTRODUCTION

The Mediterranean region hosts breeding populations of two of the seven marine turtle species that occur in the world : *Caretta caretta* (L., 1758) (Reptilia : Cheloniidae) nests widely within the eastern basin and North Africa, whereas the green turtle *Chelonia mydas* (L., 1758) (Reptilia : Cheloniidae) nests in a more restricted range, mainly comprising Turkey and Cyprus. In the early '90s both species were reported as declining (GROOMBRIDGE, 1990**)** with the Mediterranean green turtle population being reported recently as "critically endangered" (HILTON-TAYLOR, 2000).

Today, comprehensive long-term field data on nesting numbers for *C. caretta* in several Mediterranean areas are not available, although there are some reviews that concentrate on the conservation aspect (MARGARITOULIS et al., 2003 ; LAURENT, 1998). An overall estimation of the population status of *C. mydas* and *C. caretta* in the Mediterranean was recently presented in BRODERICK et al. (2002) and KASPAREK et al. (2001) ; for *C. mydas*, high variation between annual nesting numbers does not seem to indicate any particular trend regarding changes in the nesting population size.

Since its formation in 1988, MEDASSET has been committed to safeguarding the Mediterranean marine turtle populations through scientific research and conservation activities. Following the principle that "….there is no other basis for sound political decisions than the best available scientific evidence…" (BRUNDTLAND 1997), surveys in various Mediterranean countries have been conducted either in order to search for new nesting beaches or to assess the status of known ones, with respect to conservation priorities for marine turtles.

The purpose of this paper is to provide a summary of all research surveys funded or co-funded by MEDASSET in the past 12 years that aimed to locate new nesting beaches. The majority of these projects were also co-funded by the European Community, UNEP-MAP (United Nations Environment Program – Mediterranean Action Plan) and/or others. In the light of more recent information, the importance of past data can now be evaluated more objectively. Knowledge of marine turtle populations in several less-researched Mediterranean areas may thus become more clearly appraised, focusing attention for future research and conservation efforts.

MATERIAL AND METHODS

Data from past surveys funded or co-funded by MEDASSET have been provided from the organisation's archives after reviewing published and, in some cases, unpublished information (Table 1). In order to reappraise this information we next considered accessible published scientific literature originating from more recent surveys conducted within the same geographical area. It became obvious that the fieldwork protocol differed greatly between surveys and/or years, in each case varying according to the particular constraints that researchers faced : however, in all cases "nesting evidence" was standardized to include either direct observations of oviposition and/or indirect signs such as nesting tracks, false tracks, nests, eggs/egg shells and/or hatchlings. It should be emphasised that most of these pioneering projects

TABLE 1

Summary of marine turtle nesting surveys along less explored areas of the Mediterranean, 1991-2001

	Sardinia, 1990	Sardinia, 1991	North Aegean Sea, 1991	Syria (entire coastline), 1991	Egypt (between Alexandria and El-Salum), 1993	Egypt (entire coastline), 1998	Libya (NE coastline), 1995	Libya (Sirte - Misratah), 1996	Libya (NW coastline), 1998	Lebanon, 2001
Length of surveyed coastline	750 km (S. Anna to Murtas with emphasis on the Gulf of Orosei)	70 km (beaches prioritised according to the 1990 results)	2078 km (664 km of sandy beaches surveyed in detail)	193 km (79,5 km of sandy beaches surveyed in detail)	602 km (255 km of sandy beaches surveyed in detail)	616.5 km of sandy beaches	1195 km (141.65 km of sandy beaches surveyed in detail)	209 km (186.3 km of sandy beaches surveyed in detail)	407 km (105.7 km of sandy beaches surveyed in detail)	200 km (30.2 km of sandy beaches surveyed in detail)
Survey season	July–August 1990	July 1991	June–August, 1991	June 1991	June–July, 1993	May-August, 1998	June-July, 1995	summer 1996	July 1998	late spring – summer 2001
Survey duration	13 days (July 24th– August 7th	10 days	28 days	10 days (20th–30th June)	29 days	103 days (20thMay - 1stSeptem.)	21 days (16th June–7th July)		16 days (1st–16th July)	17 days (May – June), 2 days (July), 13 days (23rd July - 5th of August)
Survey type[a]	b, c, fp	fp	fp	fp	fp		c, fp		c, fp	b, fp
Nesting evidence	none	none	1 false track close to Mirina, Limnos	25 tracks (18 nests) between Latakia and Jablah (15.5 km) 2 false tracks between Tartous and the Syrian-Lebanese border (28.5 km)	10 *C. caretta* tracks, apparently evenly distributed over the surveyed area one dead *C. caretta* hatchling	3 *C. caretta* tracks on the northwest coastline several *C. caretta* and *C. mydas* nests on the N.Sinai coast	>300 *C. caretta* tracks (176 nests) (most of them found along Oum-el-Frais, Ras-el-Aweija, East Sirte and N.Bengazi beaches)	66 *C. caretta* tracks 2 dead *C. mydas* hatchlings	15 *C.caretta* tracks	nests/tracks in : El-Mansouri, Qasmiye, Mahmoudiye, Adloun and Damour. In El-Mansouri both *C.caretta* and *C.mydas* were identified as nesting species. additional nesting sites reported by fishermen.
Literature	VENIZELOS 1993; WHITMORE *et al*. 1991	VENIZELOS 1993; WHITMORE *et al*. 1991	Venizelos 1993; Kasparek 1991	Kasparek 1995; Kasparek 1994; Venizelos 1993	Venizelos & Kasparek 1996, Kasparek 1993	CAMPBELL *et al.* 2001 and references therein	LAURENT *et al*. 1995	LAURENT *et al*. 1999	LAURENT *et al*. 1999	DEMIRAYAK *et al*, 2003
Project funded by:	MEDASSET under an E.C. Contract No. 6610(90) 4313	MEDASSET under an E.C. Contract No. 6610(90) 4313	MEDASSET under an E.C. Contract No. 6610(90) 4313	MEDASSET, Herpetofauna Conservation International (HCI)	MEDASSET, RAC/SPA (UNEP/MAP), National Institute of Oceanography and Fisheries (Alexandria, Egypt)	Darwin Initiative programme (UK)	RAC/SPA(UNEP/MAP)MEDASSET, TCEP (Libya), Marine Biology Research Centre (Tajura, Libya), WWF International		RAC/SPA(UNEP/MAP), TCEP (Libya), Marine Biology Research Centre (Libya), MEDASSET, WWFInternational	MEDASSET, RAC/SPA(UNEP/MAP), Lebanese Ministry of the Environment

a.b: boat, c: car, fp: foot patrols

intended to survey Mediterranean areas where little or no marine turtle nesting data were available. As a result, researchers were interested in providing primary evidence of nesting – if any – rather than monitoring nesting numbers or producing other quantitative information. Field data on nesting population size or other reproduction parameters are therefore lacking herein.

The non-parametric Spearman rank correlation coefficient was used to assess correlation in temporal variation of *C. caretta* nesting densities along different coastal sections in the Mediterranean (Fig.1, Fig.2 ; Table 2). Data for Kyparissia – Greece were adapted after MARGARITOULIS & REES (2001). Data in Cyprus were adapted after GODLEY et al. (1998) ; BRODERICK et al. (1997) ; GODLEY & KELLY (1996) ; BRODERICK & GODLEY (1995) ; GODLEY & BRODERICK (1994) and BRODERICK & GODLEY 1993. According to GODLEY et al. (1998), the methodology of nest number assessment has changed little through this time period so primary data on nesting numbers is considered as being already standardised. Coastal zone lengths were taken after GODLEY & BRODERICK (1992) ; these zones include virtually the same beaches from one year to the other (BRODERICK & GODLEY, 1993).

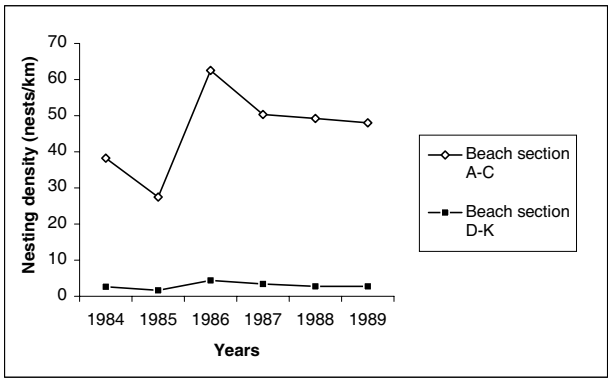

Fig. 1. – Nesting density comparison between adjacent beach sections in Kyparissia, Peloponnisos-Greece (data after MARGARITOULIS & REES 2001).

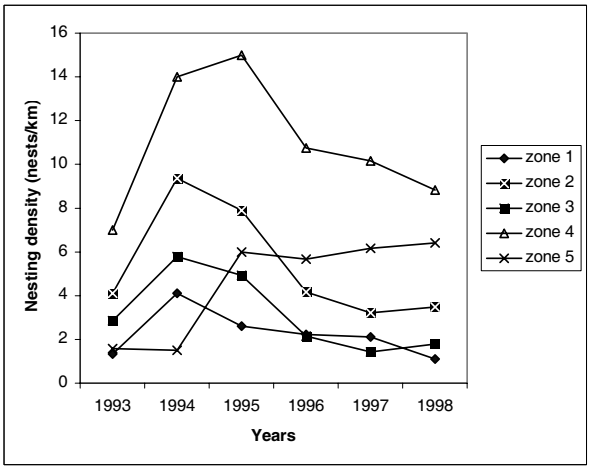

Fig. 2. – Nesting density comparisons between adjacent coastal zones along the northern shore of Cyprus (data after references mentioned in text)

TABLE 2

Spearman rank correlation coefficients r_s for nesting density comparisons between adjacent coastal zones along the northern shore of Cyprus shown in Fig.2. Significant values (n=6, $p<0.05$) are shaded in grey.

	zone 1	zone 2	zone 3	zone 4	zone 5
zone 1		0.8286	0.715	0.886	-0.6
zone 2			0.99	0.715	-0.714
zone 3				0.543	-0.77
zone 4					-0.2

Application of rank correlation on marine turtle nesting data may raise the point of temporal pseudo-replication, as the compared "replicates" (in this case, nesting densities as estimated in different zones for each year) are not truly independent (KREBS, 1989) ; the fact that individual marine turtles return to nest every 2-3 years to the same geographical zone (MILLER, 1997) gives rise to dependent data along the entire time series. Yet, it is assumed that, as this is a general phenomenon in marine turtle populations, the same bias will be reflected along any time series of marine turtle nesting density data, so the correlation analysis may proceed by ignoring it.

RESULTS

Sardinia - Italy, 1990 and 1991

This short term EC project was undertaken in the absence of any previous comprehensive survey for nesting in Sardinia and in the light of increasing pressures from tourism along the coastline. Past reports had indicated scarce nesting of *C. caretta* in the western part of Sardinia, and in the east within the Gulf of Orosei (GROOMBRIDGE, 1990 and references therein). The survey was repeated in July 1991. No evidence of nesting activity was recorded in either survey despite evaluation of a few beaches (especially in East Sardinia) as potential nesting sites (Table 1). Fishermen confirmed a continuing presence of adult and sub-adult *C. caretta* offshore.

There has been no recent information to confirm *C. caretta* nesting in Sardinia and it is now considered improbable. As individual *C. caretta* recorded in the Gulf of Naples showed movements that extended well over 2000 km, (BENTIVEGNA, 2002), it is possible that turtles observed along the Sardinian coast could be from populations nesting in other parts of the basin. Although turtle nesting in the Western Mediterranean is almost non-existent nowadays, a recent report has indicated nesting activity of *C. caretta* on the Spanish Mediterranean coast (TOMÁS et al., 2003).

Northern Aegean Sea (mainland and islands) 1991

During the summer of 1991, 2078 km of the North Aegean coast were surveyed for *C. caretta* nesting, including the islands of Thassos, Limnos, Lesvos and Samothraki (Table 1). Further surveys were carried out in July and August on beaches considered most suitable for nesting ; dune systems and coastal pollution were also recorded. Despite the presence of potentially suitable sites, the only nesting evidence found was a false track recorded on the island of Limnos: the authors speculated

that despite the presence of apparently suitable beaches, unfavourable climatic conditions may deter turtles from nesting. Five young loggerheads (carapace length 20-25 cm) found dead in the area indicated, however, that a nearby shallow water area could be a foraging site for juveniles.

A later survey also reports no indication of *C. caretta* nesting in the Northern Aegean mainland and islands (MARGARITOULIS et al., 1995 ; MARGARITOULIS & DRETAKIS, 1991). Recent estimates of the overall nesting activity of *C. caretta* in Greece contain no reference to nesting in that area (MARGARITOULIS, 2000). Occasional "diffuse" nesting, however, may occur but on a very small scale.

Syria, 1991

The entire Syrian coast was surveyed for the first time in June 1991 (Table 1). Most evidence of nesting was recorded between Jablah and Latakia. The predation rate was 100%, mostly due to stray dogs and humans. Sea-borne plastic garbage contamination was found, as well as raw sewage being piped directly into the sea.

To our knowledge, since the 1991 survey no comparative data have appeared. Information on nesting species in Syria is still speculative.

Egypt (northwest coast), 1993

A comprehensive survey with ground patrols along the western part of the Egyptian Mediterranean coastline took place in June and July 1993 (Table 1). Despite several informal reports by fishermen and others of *C. caretta* occurrence in the sea, nesting evidence was scarce. This research indicated the exploitation of both *C. caretta* and *C. mydas* products in Alexandria and contributed to the formulation of Egypt's first conservation law 4/1994, which includes protection of marine turtles.

The entire Egyptian coastline, including the part between Alexandria and El-Salum, was reassessed for nesting evidence in 1998 (data reviewed in CAMPBELL et al., 2001). Fieldwork confirmed the 1993 survey conclusion, that nesting activity at the north-western part of the Egyptian Mediterranean coast is negligible, whereas most nesting occurs in the area to the east of Port Said (North Sinai) (Table 1).

Enforcement of the law against trade in marine turtle products in Egypt has now increased following a recent campaign by MEDASSET and local NGOs (VENIZELOS & NADA, 2000).

Libya 1995 & 1998

The north-eastern part of the Libyan coast, between Sirte and the Egyptian border (1195 km) was inspected during June - July 1995, the first survey of the area outside the Kouf National Park (SCHLEICH 1987). The majority of the beaches were inspected only once with evidence of *C. caretta* nesting (Table 1). The authors speculated, after extrapolating from the data collected, that the total annual number of *C. caretta* nests made in Libya could be estimated at around 9000 nests per season (LAURENT & AL, 1995). The northwest part of the Libyan coast between Misratah and the Tunisian border was inspected in July 1998 (Table 1). This report also included primary data that had originated from an independent survey undertaken in 1996 between Sirte and Misratah (in LAURENT et al., 1999) (Table 1).

The extrapolation method applied in 1995 to deduce marine turtle nesting numbers along the whole Libyan coast (LAURENT et al., 1995) has since been criticised (see "discussion"). Three beaches along the eastern part were resurveyed in 1999 (HADDOUD & EL GOMATI, in press).

Lebanon 2001

During summer 2001, an assessment was carried out in order to locate potential nesting sites along the Lebanon coast (Table 1). Evidence of marine turtle nesting was recorded for five sites: On one of these, nesting by both *C. caretta* and *C.mydas* was confirmed. Egg predation especially by canids was heavy at all sites. A number of beaches where past nesting had been reported, were found to be the subject of severe erosion, and in some cases had disappeared completely; sand extraction from beaches, dunes, offshore sand dredging and unplanned sediment removal from river beds for construction and military purposes were seen as definitive causes of erosion along the Lebanese coast. Sea-borne garbage pollution was also recorded in some areas.

DISCUSSION

Through several years of research, we have achieved greater insight into the nesting beaches of *Caretta caretta* and *Chelonia mydas* (Fig. 3). Although Greece and Turkey host a large percentage of the Mediterranean *C. caretta* nesting population (MARGARITOULIS**,** 2000 ; YERLI & DEMIRAYAK**,** 1996) and *C. mydas* nesting sites are mainly confined to Cyprus and Turkey (KASPAREK et al., 2001**),** there is now substantial evidence of small nesting populations for both species in other countries of the Mediterranean.

In Sardinia, the absence of any signs of nesting activity suggests that nesting there is improbable although fishermen commonly report

C. caretta by-catch. Nesting in the northern Aegean is equally unlikely. Evidence from Syria is confined to the 1993 data, which is insufficient for adequate classification of the beaches; further research is advisable, especially in view of the encouraging recent discovery of *C. mydas* nesting on the neighbouring Lebanon coast, and the important nesting beaches over the Turkish border. In Egypt, it appears that few turtles nest to the west of Alexandria, and small numbers of *C. caretta* and *C. mydas* breed in Sinai, although offshore populations are reportedly significant.

The situation in Libya remains debatable. Past assessments that employed extrapolation to determine the status of the nesting population of *C. caretta* (LAURENT et al., 1995 ; 1999)*,* have attracted criticism as this methodology implies random or regularly spaced nesting in order to give rise to realistic estimations, and opposes the general trend of aggregated emergence and nesting observed in long-term datasets. *C. caretta* for example, displays a highly aggregated distribution of nesting in Kyparissia**,**

Greece (Fig.1) and temporal variation in nesting density correlates positively between beaches, indicating a consistent trend in time and non-random nesting (r_s = 1, p<0.05). *C. caretta* nesting density comparisons between adjacent coastal zones along the northern shore of Cyprus also indicate a similar trend, although not in all cases (Fig.2, Table 2). Analogous patterns are reported from other geographical areas e.g. Florida, U.S.A. (MATTISON et al., 1994) and Turkey (TÜRKOZAN & BARAN, 1996). Except for some cases of sporadic nesting, we are not aware of any data from within the Mediterranean indicating random or regularly spaced nesting patterns. Therefore, we feel that there is insufficient evidence to employ extrapolation of nesting densities from one beach to another; nesting numbers produced in this way are, in our opinion, unrealistic (see also comments in MARGARITOULIS & REES, 2001).

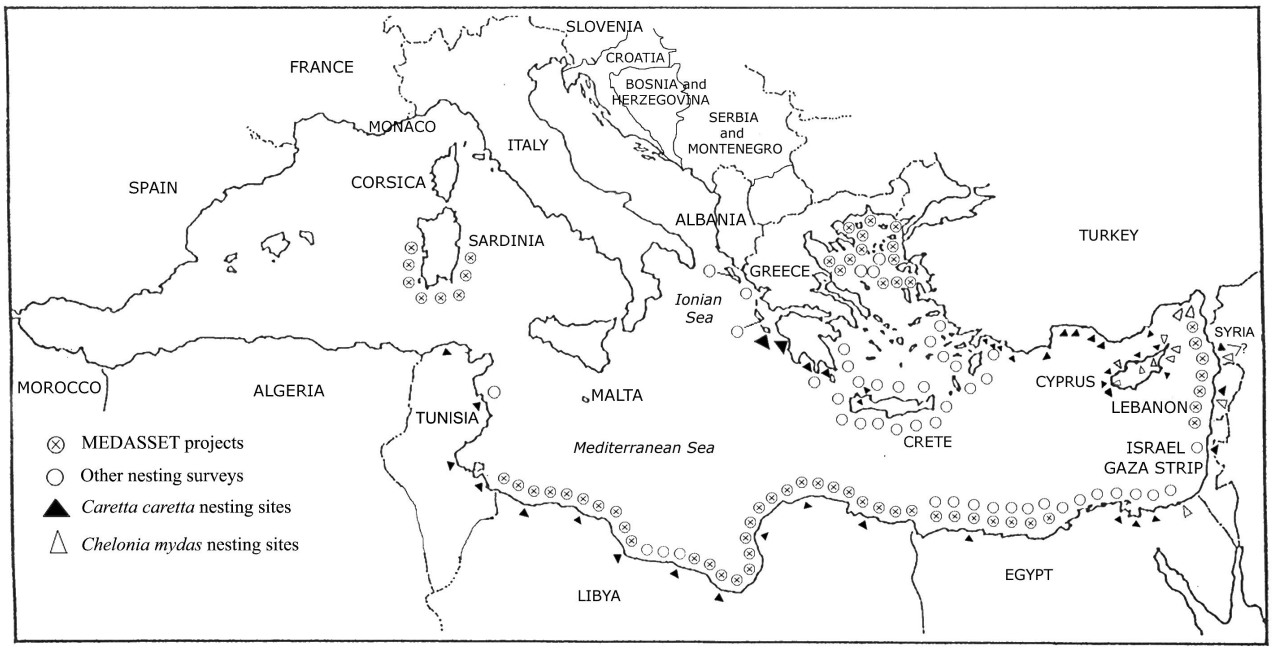

Fig. 3. – Marine turtle nesting surveys in the Mediterranean (drawing not to scale).

With the exception of the major loggerhead nesting sites in Greece, important nesting sites in Cyprus (BRODERICK & GODLEY, 1996, DEMETROPOULOS & HATZIHRISTOFOROU, 1995) and certain beaches in Turkey (YERLI & DEMIRAYAK, 1996), we are aware of only a few long–term projects monitoring marine turtle nesting in the Mediterranean. It is suggested that research should shift towards more elaborate research projects with standardized monitoring procedures for the rest of the significant breeding sites within the basin, with further studies of pelagic populations. Conservation priorities include enforcement of protective legislation, management of nesting areas, protection of foraging and wintering areas and migratory routes, and a limit to the impact of fisheries (Action Plan for the Conservation of Mediterranean Marine Turtles, UNEP/MAP-RAC/SPA). These efforts, however, are undermined by difficulties in the implementation of protective legislation, and lack of knowledge of foraging area ecology and the pelagic stages of these species. It is especially important that international cooperation efforts should go beyond mere protection of nesting beaches : Foraging habitats of the Mediterranean populations are marginally known but recent satellite data agree with older information, mainly derived indirectly from artisanal fisheries by-catch (VENIZELOS & NADA, 2000), showing that North Africa is probably an important foraging area where turtles may hold distinct home ranges (GODLEY & AL, 2002).

Although they very rarely change their nesting site, marine turtles are known to occasionally migrate to other nesting beaches as a result of disturbance (MARGARITOULIS, 1998) or natural causes. Because of the possibility of natural disasters etc. wiping out a nesting area, it is of paramount importance that the future viability of marine turtle populations in the Mediterranean does not solely rely on the few major rookeries, but includes protection of some areas with comparatively low nesting numbers such as the Kuriat Islands in Tunisia, where 13 nests were recorded in 2000 (JRIBI et al., 2002). There is an urgent need to establish zones of maximum protection at intervals around the entire Mediterranean coastline on beaches favourable to turtle nesting, and in important pelagic foraging areas. A well-managed international network of protected areas would go a long way towards assuring the survival of all life stages of marine turtles. Currently, an attempt is being made to set up a Mediterranean Sea Turtle Conservation Network in a regional effort to enhance collaboration between sea turtle research and conservation organizations around the Mediterranean.

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