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Loggerhead Turtles Nesting at Rethymno, Greece, Prefer the Aegean Sea as Their Main Foraging Area

Dimitris Margaritoulis & Alan F. Rees

ARCHELON, The Sea Turtle Protection Society of Greece, Solomou 57, GR-10432 Athens, Greece
(E-mail: margaritoulis@archelon.gr)

Adult loggerhead turtles usually have different nesting and foraging areas (i.e. areas where turtles reside during the non-breeding season) (Schroeder *et al.* 2003). It is of great importance to identify the foraging areas of a nesting population as this may assist conservation efforts (Schroeder *et al.* 2003; Broderick *et al.* 2007). Among the established techniques for identifying foraging areas of nesting populations are flipper tagging and satellite tracking.

Flipper tagging has revealed two major foraging areas of female loggerhead turtles nesting in Greece. Indeed, loggerheads after their nesting in Zakynthos Island and Kyparissia Bay, the two largest rookeries in Greece and in the Mediterranean, seem to concentrate mainly in the Adriatic Sea and in the Gulf of Gabès, northern Africa

(Margaritoulis 1988; Margaritoulis *et al.* 2003). This finding was subsequently corroborated by satellite tracking of post-nesting turtles from Zakynthos (Zbinden *et al.* 2008). Satellite tracking has also shown that adult female loggerheads from the northern coast of Cyprus migrate to northern Africa, even following discrete migration routes (Broderick *et al.* 2007).

Rethymno beach, on the northern coast of Crete, is the third most important loggerhead nesting area in Greece with an average of 349.7 nests per season (Margaritoulis *et al.* 2009). The nesting area extends eastwards of the town of Rethymno for about 12 km (from 35.367°N 24.484°E to 35.395°N 24.616°E), of which 10.8 km are suitable for nesting, and it is monitored by ARCHELON every year, from about late May until mid-October, since 1990. However, this population has recently been shown to be in decline with main threats tourist development and erosion of the nesting beach (Margaritoulis *et al.* 2009).

We present herewith recoveries of adult female turtles tagged in Rethymno, including the migration of one satellite tracked turtle, to provide insights into the key foraging areas of this declining nesting population.

Flipper tagging was performed after egg laying at the most turtle frequented beach sectors of the nesting area. Over the years three types of tags were used: Plastic tags (Jumbo by Dalton Supplies Ltd), and monel metal tags (styles No 49 and No 681 by National Band & Tag Co). An effort was made that all turtles be double-tagged, usually with monel tags on front flippers and

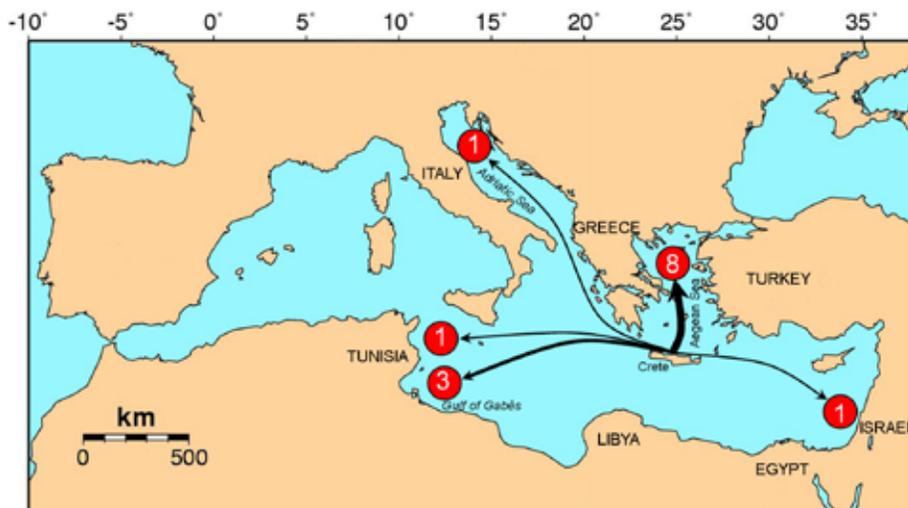


Figure 1. Map showing approximate locations of distant tag returns from turtles tagged while nesting in Rethymno. Arrows do not indicate migration routes.

plastic tags on the rear flippers. In total, 356 loggerhead turtles were tagged at Rethymno in the 20-year period (1990-2009).

On 5 July 2005 a satellite transmitter (A1010, Telonics Inc., Arizona) was applied to a turtle using two-part epoxy (Araldite AW2101) after nesting in Rethymno, and its track was followed through the Argos facility. Data were downloaded and managed using the Satellite Tracking and Analysis Tool of seaturtle.org (STAT, Coyne & Godley 2005). The turtle's route was reconstructed from Argos Location Classes 3-1, A & B. Erroneous locations removed with speed (5km/h) and turning angle (<60°) filters. Resulting locations were interpolated to provide 1 location per day.

Flipper tagged turtles were reported in Greece mainly through the nationwide Sea Turtle Stranding Network operated by ARCHELON, and in other countries by fishermen, concerned individuals and colleagues.

Up to June 2010, seventeen tag returns of turtles tagged in Rethymno were reported in total (Table 1). In one case, only the tag (plastic) was found at sea bottom but, because these tags sink in seawater, it was assumed that the tag was shed off the turtle near the same site (Bodrum, Turkey). Three turtles were recovered at or close to the nesting area; E999 at Rethymno on 8 August, E991 in the harbour of Herakleion (about 60 km east of Rethymno) on 15 May, and E936 (fully decomposed) at Gourmes (about 80 km east of Rethymno) on 1 February. The finding date and the state of carcass of these non-distant tag recoveries suggest that these turtles most likely died while in the region of Rethymno for reproductive purposes; thus they are excluded from further analysis.

Of the fourteen distant recoveries, eight (57.1%) were reported from the Aegean Sea, four (28.6%) from the Gulf of Gabès, one from northern Adriatic and one from Israel (Fig. 1). The elapsed

time, from the turtle's last observation at the nesting beach until tag recovery, ranged from 11 to 868 days (average = 397 days) (Table 1). Most of the recovered turtles (91.7% of the total of known fate) were reported dead, either stranded or floating, with only one captured alive and released (Table 1).

The transmitter on the satellite tracked turtle produced locations for 376 days but position fixes for the turtle were in general poor and irregular. Investigation into detailed movements of the turtle over the working life of the tag could not be made but the turtle's large scale movements can be described. The turtle departed the Rethymno nesting area after 10 July 2005 arriving at Mykonos Island (Cyclades Islands), in the middle of the Aegean Sea, on 10 August where she remained until 23 December. She then moved on to nearby Paros Island where she stayed for approximately 3 weeks. This was followed by further southward movements to Santorini Island where she remained from mid February to the end of March. Less than two weeks later she had arrived back at Mykonos Island where she remained until transmissions ceased in mid July 2006 (Fig. 2).

It is known that recoveries of tagged turtles away from their nesting area mostly occur during their stay at the foraging grounds (Limpus *et al.* 1992). Although tag returns can be biased from various factors, as differences in fishing methods and fishing effort as well as the ability or willingness of fishermen to report tagged turtles, the distant recovery rate of Rethymno turtles (3.9%) is similar to the 3.5% recorded for Zakynthos and Kyparissia Bay turtles (Margaritoulis *et al.* 2003). Furthermore, the overall spatial distribution of distant tag recoveries of Rethymno turtles is more or less similar to the overall distribution of Zakynthos and Kyparissia Bay turtles. Nevertheless, while tag returns from Zakynthos and Kyparissia Bay concentrate by 42% in the Adriatic Sea, by 28% in

ID Tag	Last nesting	Location of tag recovery	Date of recovery	Days elapsed	Method of recovery		Remarks
H3410	12/07/1992	Kettana, Gulf of Gabès, Tunisia	03/10/1992	83	Stranded	D	No external injuries
P4937	26/06/1994	Bodrum, Turkey, Aegean Sea	10/09/1994	76	Tag found	?	Second tag (plastic A282) found at sea bottom
Y5587	04/08/1995	Gulf of Gabès area, Tunisia	20/03/1996	229	Captured	?	Date of letter (not of capture)
Y5592	19/06/1995	Spetses Isl., Greece, Aegean Sea	30/08/1996	438	Stranded	D	Fully decomposed. Broken shell.
H657	16/06/1997	Offshore Ayvalik, Turkey, Aegean Sea	01/11/1999	868	Floating	D	Injury on front left flipper
E989	12/07/1999	Aegina Isl., Greece, Aegean Sea	17/11/1999	128	Stranded	D	A large part of shell was missing
E978	17/06/2000	Lesbos Isl., Greece, Aegean Sea	28/04/2001	315	Stranded	D	Parts of fishing net on flippers
E982	25/07/2000	Offshore Nahariya, Israel	23/02/2002	578	Floating	D	Fully decomposed, longline hook
E991*	19/07/2001	Herakleion (harbour), Island of Crete	15/05/2002	300	Floating	D	Injured on eye and carapace
E803	27/06/2000	Izmir, Turkey, Aegean Sea	19/08/2002	783	Stranded	D	Death estimated about 10 days ago
C6805	18/07/2003	Gulf of Gabès area	16/11/2003	121	Caught & released	A	By Italian trawler based in Lampedusa Island
E936*	11/07/2001	Gourmes, Island of Crete	01/02/2004	935	Stranded	D	Fully decomposed
RE175	24/07/2004	Karystos, Evia Isl., Greece, Aegean Sea	04/08/2004	11	Stranded	D	Recent propeller injuries
E962	17/07/2003	Naxos Isl., Greece, Aegean Sea	22/05/2005	675	Stranded	D	Heavy injury on carapace left side
E999*	20/07/2005	Rethymno, Island of Crete	08/08/2005	19	Stranded	D	Right eye swollen
A682	20/07/2004	Gulf of Trieste, North Adriatic, Slovenia	09/08/2005	385	Floating	D	Caught in stationery gillnet
RE220	15/07/2004	Zarat, Gulf of Gabès, Tunisia	05/12/2006	873	Stranded	D	

Table 1. Recoveries of loggerhead turtles tagged at Rethymno nesting area, Island of Crete, Greece. Note: Asterisks denote recoveries close to the nesting area and these turtles are excluded from further analysis (see text). D = dead, A = alive.

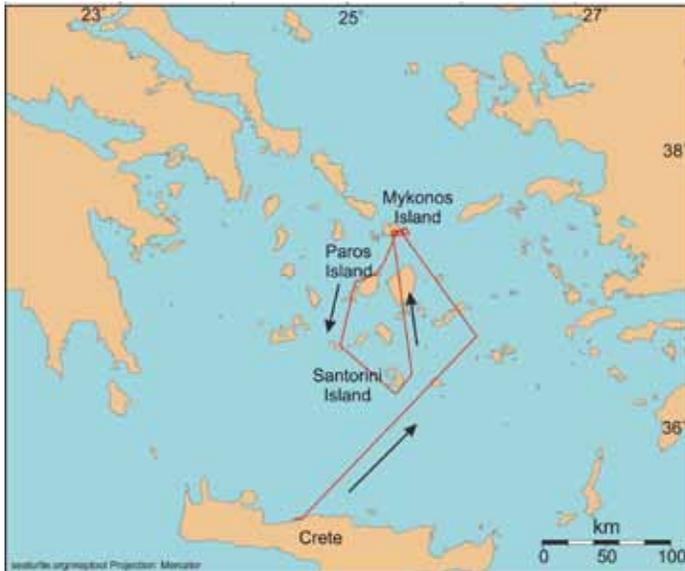


Figure 1. Track of a loggerhead turtle fitted with a satellite transmitter after nesting at Rethymno. The turtle moved to Mykonos Island and over winter completed a circuitous migration south, with extended rest periods at Paros Island and Santorini Island. Northward parts of the track should be regarded as indicative of general route as data during these portions were poor quality and infrequent.

the Gulf of Gabès, and by 21% in the Aegean Sea (Margaritoulis *et al.* 2003), tag returns of Rethymno turtles seem to concentrate mainly in the Aegean Sea (57.1%).

An apparent directed movement into the Aegean Sea was exhibited by the individual RE175 (Tab. 1) which covered the 275 km distance Rethymno-Karystos in 11 days resulting to an estimated overall speed of 25 km/day. Loggerheads tracked from Cyprus (Godley *et al.* 2003) and Italy (Bentivegna 2002) migrated at overall speeds of 1.1-1.3 km/hr which compare well with our result. Further, the satellite tracked turtle moved into the Cyclades Islands where it remained for a full year.

The seemingly general preference of Rethymno turtles for the Aegean Sea does not exclude a segment of the population to use other foraging areas, e.g. Gulf of Gabès, as it is known that loggerheads, in contrast to green turtles, do not seem to possess, in a regional context, very discrete foraging areas (Schroeder *et al.* 2003).

Besides tourist development and beach erosion, noted as major threats at the nesting area of Rethymno, the assessment of the Aegean Sea as a foraging area for a declining sea turtle population may differentiate known threats impacting this population at sea. Indeed, examination of specific fishing methods and fishing periods as well as of fishermen attitudes towards sea turtles in the Aegean Sea may lead to better targeted conservation activities aiming to reverse the noted decline of Rethymno turtles.

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