Ann. Zool. Fennici 44: 333–347 ISSN 0003-455X
Helsinki 25 October 2007

Status of sea turtles (*Chelonia mydas* and *Caretta caretta*) on Samandağ Beach, Turkey: a five-year monitoring study

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Received 4 Dec. 2006, revised version received 18 May 2007, accepted 23 Aug. 2007

Yalçın-Özdilek, Ş. 2007: Status of sea turtles (*Chelonia mydas* and *Caretta caretta*) on Samandağ Beach, Turkey: a five-year monitoring study. — *Ann. Zool. Fennici* 44: 333–347.

Samandağ Beach in Turkey is one of the three most important nesting beaches in the eastern Mediterranean for the critically-endangered green turtle (*Chelonia mydas*), and is also a nesting area for the loggerhead turtle (*Caretta caretta*). In this study, the nesting characteristics of green and loggerhead turtles on Samandağ beach were determined during the nesting season from 2001 to 2005. During the five-year monitoring, the mean green and loggerhead turtle nest numbers were 121 (range = 16–325) and 11 (range = 7–20), respectively. The mean ratio of non-nesting emergence to nesting emergence (1.6) was lower than the ratio reported in previous studies. The green-turtle nest density on Samandağ beach (14 km), and Şeyhhızır beach (4.1 km), was 9.3 (range = 1.1–23.2) nests/km and 23.5 nest/km (range = 3.4–64.4), respectively. Loggerhead turtle emergence was randomly distributed, the emergence of green turtles (94.1%), however, was concentrated approx. 3 km north and 3 km south of the Asi River. The emergence of both species took place mainly in July. The average hatching success of green and loggerhead turtles was 70.38% and 71.8%, respectively, with minimum and maximum incubation durations of 43–67 and 44–61 days, respectively.

Introduction

Two endangered sea turtle species, *Caretta caretta* and *Chelonia mydas* (IUCN 2006), nest regularly in the Mediterranean. While the nesting area of *Ca. caretta* is widely distributed along the coasts of Greece and Turkey, and to a lesser extent Cyprus, the nesting area of *Ch. mydas* is restricted to the eastern Mediterranean and Cyprus (Baran & Kasparek 1989, Margaritoulis, 2000). Samandağ Beach in Turkey is one of the most important nesting grounds for *Ch. mydas* in the Mediterranean (Kasparek *et al*. 2001, Broderick *et al*. 2002, Kaska 2003, Margaritoulis *et al*. 2003, Canbolat 2004).

There are large fluctuations in the nesting activity of green turtles from year to year, and any estimate of nesting density or population size based on one year's data may be misleading (Demetropoulos & Hadjichristophorou 1995, Limpus 1996, Hirth 1997, Gerosa *et al*. 1998). Dramatic fluctuations in the number of green turtle nests due to inter-annual variations in weather conditions (Limpus & Nicholas 1987, Broderick *et al*. 2001) cause a biased calculation of the density of population. For this reason, a

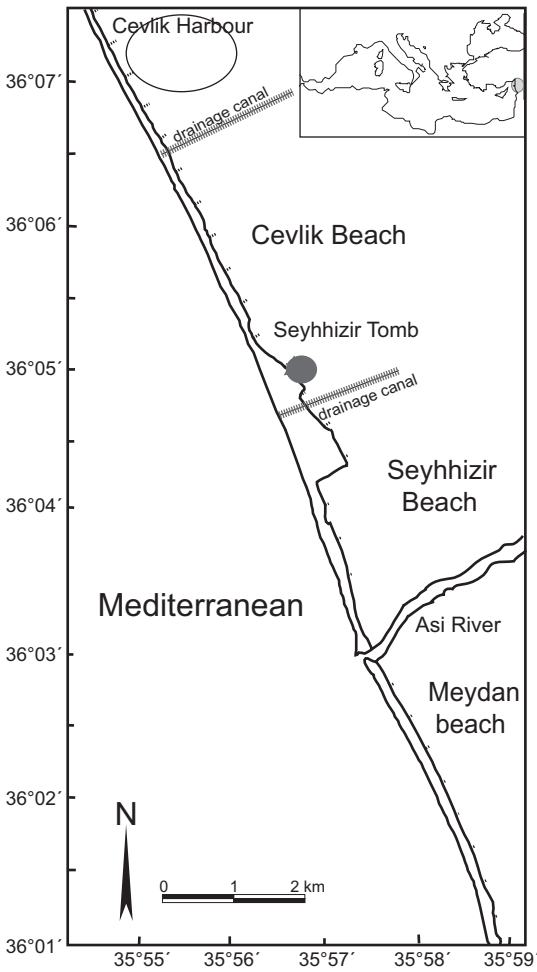

Fig. 1. Study area.

continuous long-term annual monitoring program was proposed by conservation organizations in order to obtain reliable data about green turtles. Previous studies of green turtles on Samandağ Beach conducted over short monitoring periods (Yerli & Demirayak 1996, Durmuş 1998, Yerli & Canbolat 1998a, 1998c, Demirayak 1999, Yalçın 2003, Yalçın-Özdilek & Sönmez 2003) indicated many threats to the green turtle population. These included illegal sand excavation, beach development, incidental catches, and various types of habitat occupation and pollution both at sea and on the beach (Yerli & Demirayak 1996, Durmuş 1998, Yerli & Canbolat 1998a, Yalçın 2003, Yalçın-Özdilek & Yerli 2006, Özdilek *et al*. 2006).

The goal of this study is (1) to provide reliable data about sea turtle nesting and hatching activities on Samandağ Beach based on a five-year monitoring period, (2) to indicate the beach's nesting potential, and (3) to provide data on nest density, emergence, spatial and temporal nest distribution, and hatchling characteristics. In addition, the study will review outcomes of recent conservation studies, particularly those of the last five years, and discuss the need for further conservation efforts. The results of this study should help to fill a gap in our knowledge of green turtles in the Mediterranean.

Material and methods

Study area

Samandağ Beach, which is on the eastern Mediterranean coast near the Syrian border, is approx. 14 km long and bordered by Çevlik harbor to the north and Cape Sabca to the south (Fig. 1). The beach can be subdivided into three sections: (1) Çevlik Beach (approx. 5.5 km long; the first and last two km are used mainly for recreation), (2) Şeyhhızır Beach (4 km in long) between Şeyhhızır Tomb and the Asi River; and (3) Meydan Beach (4.5 km long) south of the river (Fig. 1). Areas behind Şeyhhızır Beach are uninhabited, except in the first two kilometers (referenced as the northern side).

Monitoring

The port of Çevlik to the north was the point from which the beach was divided into 500-m segments (Fig. 1). Three to five people monitored the beaches during the nesting and/or hatching seasons from 2001 to 2005. Details of the working schedule are given in Table 1. The total nesting and non-nesting emergences were recorded. Symmetry of tracks was taken into consideration while determining the species (Pritchard & Mortimer 1999). Tracks were removed after each examination to avoid duplication. The location of nests was identified visually from the body pit and the nest chambers were determined using reed sticks. Each nest location was marked by

planting sticks behind the nest chamber both vertically and horizontally and each nest was checked daily on Şeyhhızır and Çevlik beaches. The nests were excavated and the remains examined about one week after the first hatchlings emerged (Whitmore & Dutton 1985).

Data analyses

Not every emergence results in nesting. The turtle may return to the sea without making any nesting attempt. The number of successful nesting attempts can be called nesting success. A high percentage of nesting success shows effective use of the habitat by sea turtles in terms of ease of nesting without human disturbance and availability of preferred sand properties (Godley *et al*. 2001). The nesting success (NS) percentage was calculated with the following formula:

$$\text{NS}\ (\%) = 100 \times [(N)/(N + T)]$$

where N is the number of nests, and T is the number of tracks without successful nesting.

Since many nests disappeared or could not complete their incubations due to inundation, erosion and human disturbance, in addition to nesting success, the percentage of survivor nests during the incubation period was calculated. The following formula estimates the percentage of survivor nests.

$$\text{Survivor Nest}\ (\%) = 100(S/N)$$

where S is the number of nest that successfully completed incubation, and N is the total number of nests.

Hatching success was calculated as a percentage of hatchlings in a clutch. The days when the first hatching occurred were taken into consideration while calculating the minimum incubation time of both species.

In order to indicate spatial distribution preferences, nesting and non-nesting emergences were grouped within 500-m intervals from the reference point (Çevlik Port). Spearman's ϱ correlation was used to indicate the relationship between years, nesting and non-nesting emergences, and species. The Pearson correlation was

Table 1. Methodology and number of green turtle emergences. * = once every three days, ** = two times in season. N = nesting, H = hatching. Values for *Ca. caretta* are given in parentheses.

Year	Duration	Frequency	Site	Season	Beach length (km)	Number of tracks (without nest)	Number of nests
2001	3 July–15 Sep.	Daily	Şeyhhızır	N & H	4.5	76 (3)	20
	Total				4.5	76 (3)	20
2002	28 June–15 Sep.	Daily	Çevlik	N & H	5.5	20 + (1)	14 + (4)
2002	28 June–15 Sep.	Daily	Şeyhhızır	N & H	4.1	164	92 + (3)
2002	28 June–1 Aug.	Weekly	Meydan	N	4.4	16 + (1)	12
	Total				14	200 + (2)	118 + (7)
2003	8 June–30 Sep.	Daily	Çevlik	N & H	5.5	10 (14)	1 (14)
2003	8 June–30 Sep.	Daily	Şeyhhızır	N & H	4.1	199 (2)	92 (5)
2003	8 June–1 Sep.	*	Meydan	N & H	4.4	92	33 (1)
	Total				14	301 (16)	126 (20)
2004	3 June–30 Sep.	Daily	Çevlik	N & H	5.5	–	13 (6)
2004	3 June–30 Sep.	Daily	Şeyhhızır	N & H	4.1	373 (18)	264 (5)
2004	25 July	Once	Meydan	N	4.4	–	48
	Total				14	373 (18)	325 (11)
2005	1 June–4 Sep.	Daily	Çevlik	N & H	5.5	1 (2)	0 (1)
2005	2 June–4 Sep.	Daily	Şeyhhızır	N & H	4.1	30 (14)	14 (14)
2005	19 July & 26 July	**	Meydan	N	4.4	5	2
	Total				14	36 (16)	16 (15)
	Mean of five-year monitoring					197 (11)	121 (11)

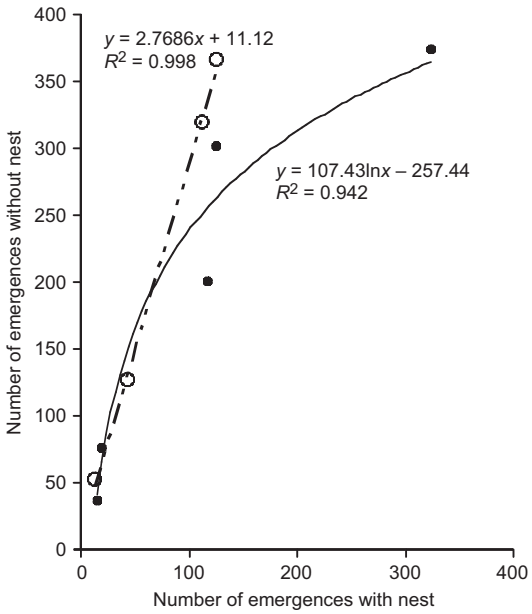

Fig. 2. Correlation of nesting and non-nesting emergences of green turtles. The dashed line and empty circles represent previous study results (Baran & Kasparek 1989, Yerli & Demirayak 1996, Durmuş 1998, Yerli & Canbolat 1998).

used to indicate the relation between the number of nesting and non-nesting emergences of sea turtles. All statistical analyses were conducted using SPSS 10.0 package program.

Results and discussion

Emergences

Green turtles

In total, 1594 green turtle emergences occurred over the five-year monitoring period. Of these, 605 resulted in nesting, with the number of nests per year ranging from 16 to 325. The number of emergences in consequent years did not exhibit a stable pattern and fluctuations were observed (Table 1). Fluctuation in emergence numbers for green turtles has been reported on other beaches (Limpus & Nicholas 1987, Broderick *et al*. 2002). Hughes (1995), Bagley *et al*. (2000), and Weishampel *et al*. (2003) reported that green turtle emergences show a biennial pattern, meaning a "low" year followed by a "high" year. However, this biennial pattern does not fit the emergences of green turtles on Samandağ Beach. Furthermore, there is insufficient data on the emergences of green turtles to theorize about a triennial pattern: a "low" year, followed by three "high" years, again followed by a "low" year. Additional continuous monitoring studies need to be implemented on Samandağ in order to establish the accuracy of this triennial emergence pattern.

Excluding the 2005 data, the number of nests found on Samandağ exceeded the numbers reporetd in earlier studies (Table 2). It is known that the 2005 nesting season was the worst season for green turtles on other beaches in the Mediterranean (personal communication of other researchers on Medturtle list).

The five-year averages of green turtle nesting emergence correlate strongly with the five-year averages of green turtle non-nesting emergences ($r^2 = 0.94$, $p < 0.05$) (Fig. 2). In addition, the rate of green turtle non-nesting emergence and nesting emergence was 1.6 (1.1–4.0). This rate on Samandağ is not as low as the value of 1.1 reported by Weishampel *et al*. (2003) for east-central Florida. Moreover, the non-nesting/nesting emergences ratio on Samandağ was 4.0 in the 2001 nesting season despite the fact that

Table 2. Previous study results of nest numbers on Samandağ Beach.

Beach	Period	Number of nests	Number of tracks	Track/ nest ratio	Reference
Şeyhhızır, Samandağ	July 1988	54	40	1.4	Baran & Kasparek 1989
Samandağ	June–Sep.1994	366	126	2.9	Durmuş 1998
Samandağ	June–Sep. 1994	319	113	2.8	Yerli & Demirayak 1996
Şeyhhızır, Çevlik, Samandağ	June–Sep. 1996	127	44	2.9	Yerli & Canbolat 1998
Samandağ	Aug. 1999	–	21		Demirayak 1999

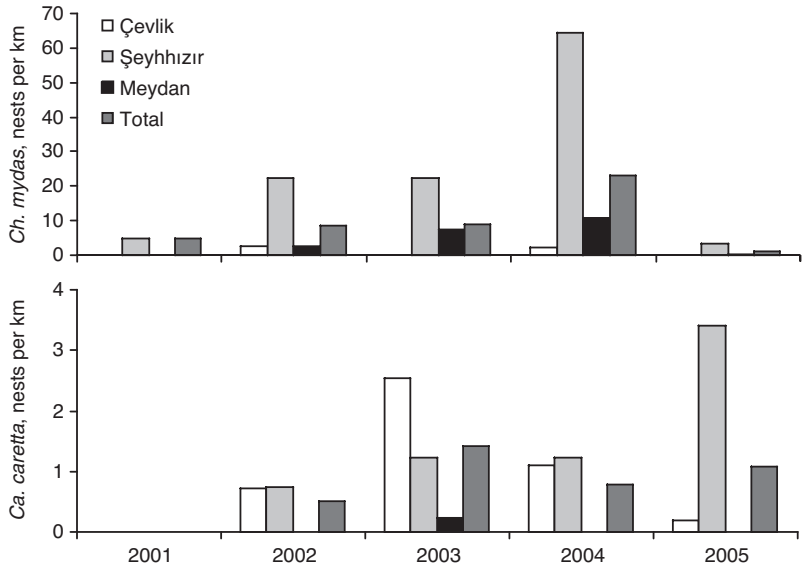

Fig. 3. Nest densities of *Ch. mydas* and *Ca. caretta* during five years of monitoring.

illegal sand extraction was carried out that year. However, the ratio of non-nesting to nesting emergences was lower than that reported from previous years (Fig. 2).

Loggerhead turtles

A total of 53 nesting and 58 non-nesting emergences were counted on Samandağ during the five-year monitoring. The mean annual nesting and non-nesting emergences for loggerhead turtles were 10.6 ± 7.6 and 11.0 ± 7.8, respectively (Table 1). As compared with the nesting beaches of western Turkey, on Samandağ Beach the mean numbers of nesting and non-nesting emergences of loggerhead turtles were low (Baran & Türkozan 1996, Türkozan 2000, Kasparek *et al*. 2001, Broderick *et al*. 2002).

As opposed to *Ch. mydas*, there was no significant correlation between nesting and non-nesting emergences for *Ca. caretta* ($p > 0.05$), which use for nesting various parts of the beach every year (Fig. 3).

Nest density

Green turtles

The average number of nests per km of the entire beach (14 km) was 9.3 ± 8.4 (range = 1.1–23.2). This value may be considered low as compared with that for open-ocean beaches such as that on the Ascension Island (Godley *et al*. 2001). However, the importance of Samandağ Beach due to its green turtle nest density may easily be seen when compared with other Mediterranean beaches used for nesting (Baran & Kasparek 1989, Newbury *et al*. 2002, Canbolat 2004). The mean nest density of *Ch. mydas* (23.5 nest/km, (range = 3.4–64.4) during the five-year monitoring period was higher than that reported by Canbolat (2004) for the Şeyhhızır section (18.7 nests/km) which is the most densely used by green turtles on Samandağ (Fig. 3).

The maximum nest density (64.4 nests/km) was recorded on the Şeyhhızır section of Samandağ Beach in the 2004 nesting season. The lowest nest density was observed in the 2001 and 2005 nesting seasons. These seasons might therefore be considered as "low" seasons in the emergence fluctuations of green turtles on Samandağ.

Loggerhead turtles

The loggerhead-turtle nest density (0.8 ± 0.5) was low as compared with both the nest density of loggerhead turtles on other Mediterranean beaches and the nest density of green turtles on

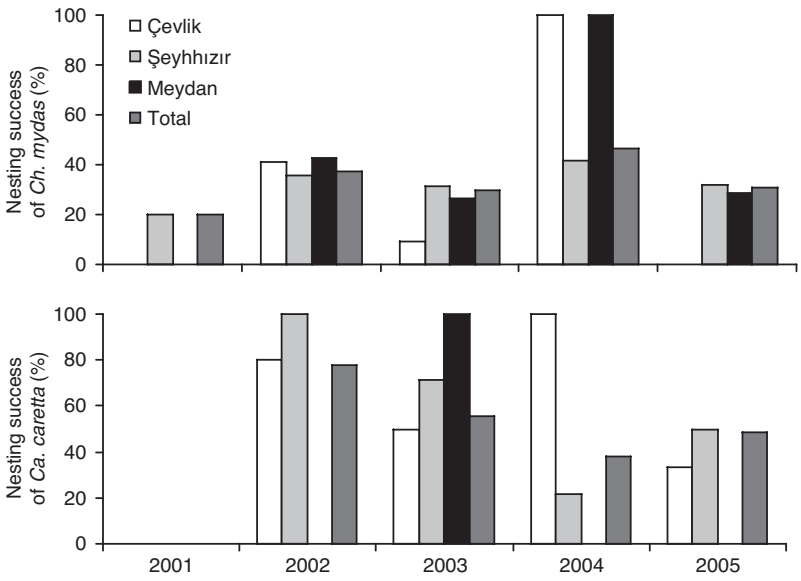

Fig. 4. The nesting success of *Ch. mydas* and *Ca. caretta* during five years of monitoring.

Samandağ Beach (Baran & Türkozan 1996, Çıtak 1998, Yerli & Canbolat, 1998a, 1998b, Baran & Ilgaz 2000, Erdoğan *et al.* 2001, Ilgaz & Baran 2001, Türkozan *et al.* 2003, Canbolat 2004). Maximum nest density — 3.4 nest/km — was observed on the Şeyhhızır section of Samandağ Beach in the 2005 nesting season (Fig. 3).

Nesting success

Green turtles

Our five-year monitoring study indicated that the mean nesting success of green turtles, with some fluctuation, was 33% ± 9.8% (mean ± SD) on Samandağ (Fig. 4). This result is lower than the nesting success of 34.4% and 35% recorded on Samandağ in 1994 and 1998, respectively (Durmuş 1998, Yerli & Canbolat 1998c). The nesting success on Samandağ was also lower than the percentages reported from other two important eastern Mediterranean nesting beaches; Kazanlı, where the nesting success was 40% and 49% in 1994 and 2001, respectively; and Akyatan, where the nesting success was 41% in 1994 (Durmuş 1998, Aureggi 2001). On the Ascension Island, the nesting success was 39% (Gerosa *et al.* 1995, Godley *et al.* 2001).

The nesting success of green turtles was more or less stable on the most favorable section (Şeyhhızır) of Samandağ Beach. However, the nesting success of green turtles showed a peak on the less preferred Çevlik and Meydan sections of the beach in the best season of the five-year monitoring (Fig. 4).

Loggerhead turtles

The mean nesting success of loggerhead turtles on Samandağ Beach was 44% ± 28.6% (mean ± SD). This value was higher than those reported from nesting beaches such as northern Karpaz on Cyprus, Lebanon, and Patara and Dalyan in Turkey (Taşkın & Baran 2001, Ilgaz & Baran 2001, Newbury *et al.* 2002), while lower than values reported from other beaches like Florida Beach, USA (Bagley *et al.* 2000). It is worth noting that the lowest nesting success (21.7%) of loggerhead turtles was recorded in the 2004 nesting season in the Şeyhhızır section of the beach (Fig. 4).

Percentage of survivor nests

Green turtles

Not every nest built completes its incubation, due to factors such as predation, inundation, erosion and suchlike. On the one hand, global

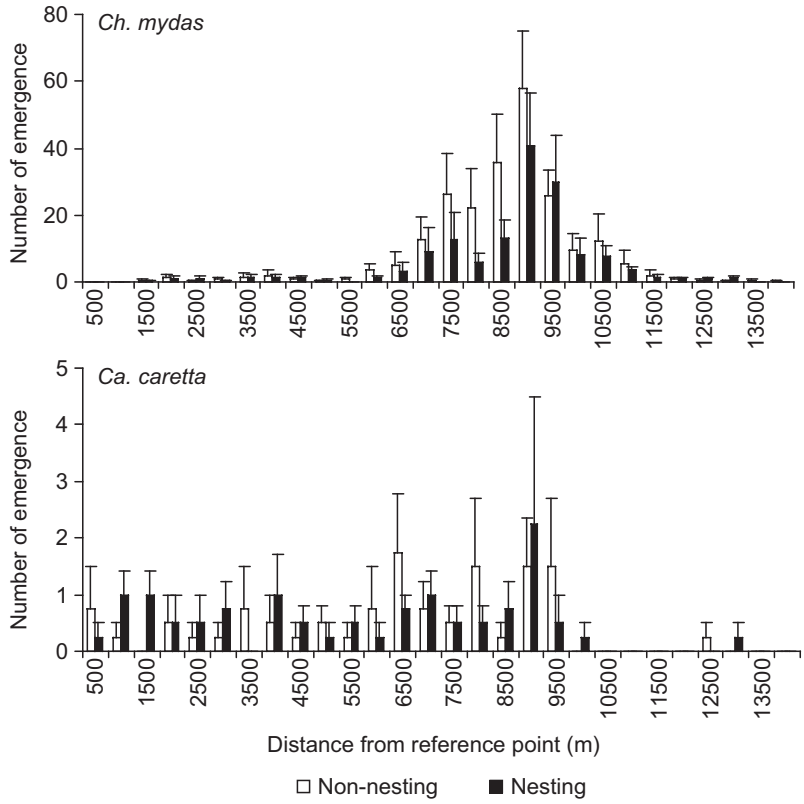

Fig. 5. Spatial distribution of mean annual numbers of emergences with standard error of both species during five years of monitoring.

warming has caused an increase of sea level; on the other hand, dams constructed along rivers limit feeding of beaches. For instance, the five dams on the River Asi, which is a large alluvium transporter, caused a serious narrowing of the entire Samandağ Beach from 1973 to 2001 (Ozaner 1993a, 1993b, 1996). Moreover, Yalçın-Özdilek *et al*. (2007) noticed important depressions behind the beach, particularly in the Çevlik section, caused by illegal sand extraction. Inundation is the most serious risk for green turtle nests and a number of nests disappeared due to erosion and inundation on Samandağ Beach (Yalçın-Özdilek *et al*. 2006a, 2006b). As a result during the five-year monitoring, the mean percentage of survivor nests was 68.1% ± 6.5% (mean ± SD). At present, the number of survivor nests of green turtles on Samandağ were approximately constant over the five years, because the nesting locations of green turtles were found more or less in the same parts of the beach also in the following years (Fig. 5), and these locations had a low risk of inundation. Quantity of survivor nests of green turtles needs to be monitored in consequent years in order to assess the adaptation capabilities of green turtles to changing environmental factors.

Loggerhead turtles

The percentage of survivor nests of loggerhead turtles on Samandağ Beach was 52.3% ± 36.9% (mean ± SD). Nests built on unsuitable parts of the beach disappeared due to inundation and erosion especially in the 2002 and 2003 nesting seasons.

Spatial distribution of emergences

Green turtles

The spatial distribution of the nesting and non-nesting emergences of green turtles was correlated statistically in consecutive years (Fig. 5 and Table 3), showing a non-random distribution along 14-km Samandağ Beach. Both the nesting

(56.9%) and non-nesting (52.5%) emergences of green turtles were concentrated in the 8500–9500 m section (Şeyhhızır) of the beach on the northern and southern sides of the river mouth (Fig. 5).

Şeyhhızır Beach, a virgin section of shoreline far from the impact of human activity, is the most important part of Samandağ Beach with respect to the nesting activity of green turtles. Hendrickson and Alfred (1961) also noted that green turtles used certain parts of the beach for nesting. Kikukawa *et al*. (1999) noted that the nesting success of sea turtles was positively correlated with the distance from human activities.

Significant correlations between the spatial distribution of green turtle nesting and non-nesting emergences per year was recorded in this study (Fig. 5 and Table 3). Sections of the beach used for nesting and those used for non-nesting emergences overlap on Samandağ. It was postulated by Weishampel *et al*. (2003) for both green and loggerhead turtles that once there is an unsuccessful nesting attempt, the turtle returns to the sea and re-emerges on the beach within 500 m of where it originally emerged. In this study, it was true only for green turtles: once there was an unsuccessful emergence, they re-emerged close to the original emergence point.

Loggerhead turtles

Contrary to *Ch. mydas*, there were no statistically significant correlations in the spatial distribution of *Ca. caretta* nesting and non-nesting emergences between years. Members of *Ca. caretta* did not concentrate near the river mouth and used the whole beach for nesting (Fig. 5 and Table 3). Only 25% of all loggerhead turtle non-nesting emergences and 26.4% of loggerhead nesting emergences were concentrated within an 8500–9500 m section of the beach. Weishampel *et al*. (2003) noted that both green and loggerhead turtles showed a non-random distribution in central-east Florida. A non-random distribution was also noted in Tortuguero, South Atlantic (Carr & Carr 1972, Bjorndal *et al*. 1985, Campbell *et al*. 1996, Tiwari *et al*. 2005), the Ascension Islands (Godley *et al*. 2001), the Florida coasts, USA (Antworth *et al*. 2006), Praira do Forte, Brazil (Marcovaldi & Laurent 1996) and Fethiye Beach, Turkey (Baran & Türkozan 1996). The random distribution of loggerhead turtle nests on Samandağ Beach probably resulted from the low number of emergences. Similar to green turtles, a significant correlation between loggerhead nesting and non-nesting emergence was observed only in the 2003 and 2005 nesting seasons (Table

Table 3. Spearman's ϱ correlations of nesting (N.E.) and non-nesting emergences (N.N.E. in consecutive years of *Ch. mydas* and *Ca. caretta*. Significant values are set in boldface.

	Ca. caretta N.E.						*Ca. caretta* N.N.E.					
	2002		2003		2004		2002		2003		2004	
	ϱ	*p*	ϱ	*p*	ϱ	*p*	ϱ	*p*	ϱ	*p*	ϱ	*p*
2003	0.130	0.510					–0.187	0.341				
2004	0.215	0.272	**0.439**	0.019			–0.144	0.466	–0.183	0.352		
2005	–0.047	0.811	–0.161	0.414	–0.177	0.366	0.073	0.712	**–0.456**	0.015	**0.607**	0.001
	Ch. myda N.E.						*Ch. myda* N.N.E.					
	2002		2003		2004		2002		2003		2004	
	ϱ	*p*	ϱ	*p*	ϱ	*p*	ϱ	*p*	ϱ	*p*	ϱ	*p*
2003	**0.642**	0.000					**0.657**	0.000				
2004	**0.646**	0.000	**0.741**	0.000			**0.716**	0.000	**0.629**	0.000		
2005	**0.541**	0.003	**0.576**	0.001	**0.620**	0.000	**0.651**	0.000	**0.655**	0.000	**0.635**	0.000

3) when the emergence numbers of loggerhead turtles were high.

Interspecific spatial distribution

Yalçın-Özdilek and Sönmez (2006) indicated an increase in the green turtle to loggerhead turtle ratio closer to the Asi River, which is the largest river in that region. Correlation between the last four years' nest densities of green and loggerhead turtles on Şeyhhızır beach was not significant ($r = –0.56$, $p = 0.445$). Although in this study some insignificant negative correlations were found between the spatial distributions of both species, significant positive correlations were recorded between the spatial distribution of *Ch. mydas* and *Ca. caretta* in the last year for nesting emergence and in last two years for non-nesting emergence (Table 4). Weishampel *et al.* (2003) also showed a positive correlation, although no interspecific spatial competition, due to temporal variety between the spatial distribution of green and loggerhead turtles in central-east Florida. Temporal distribution of the two species also overlapped on Samandağ in the 2005 nesting season (Fig. 6). From this point of view, the Şeyhhızır section of the beach heavily used for green turtle emergences appeared ideal also for loggerhead turtles. It is worth noting that 100% and 60% of loggerhead turtle nests built in this section survived the 2004 and 2005 nesting seasons, respectively. Loggerhead turtles may have found an opportunity to nest due to the absence of green turtles on this favorable part of Samandağ Beach in the 2005 nesting season. Further long-term monitoring studies are necessary in order to explain patterns of interspecific spatial competition on Samandağ.

Temporal distribution of emergences

Green turtles

Emergences of green turtles on Samandağ were observed to occur mainly in July (Fig. 6). In the 2001 and 2002 nesting seasons, monitoring studies commenced at the end of June and all emergences before that date were recorded on the first day of monitoring. Agglomerations in the number of emergences were therefore observed in the 2001 and 2002 nesting seasons. In total, on Meydan Beach 41 green turtle nests were recorded on 25 July 2004, which was the first day of monitoring. These nests also include those built before 25 July 2004. In addition, the highest number of nests recorded during this monitoring study was 21 green turtle nests built on 13 July 2004 in the Şeyhhızır section of the beach. Temporal distribution of green turtle emergences on Samandağ resembled the results of studies carried out on other Mediterranean beaches (Durmuş 1998, Aureggi 2001).

Table 4. Spearman's ϱ correlations between nesting (N.E.) and non-nesting (N.N.E.) emergences of both species in consecutive years and between green and loggerhead turtle emergence distribution along the Samandağ Beach. Significant values are set in boldface.

	2002		2003		2004		2005	
	ϱ	p	ϱ	p	ϱ	p	ϱ	p
Ch. mydas	**0.843**	0.000	**0.791**	0.000	**0.774**	0.000	**0.573**	0.000
Ca. caretta	0.180	0.359	**0.498**	0.007	0.164	0.405	**0.534**	0.003
	2002		2003		2004		2005	
	ϱ	p	ϱ	p	ϱ	p	ϱ	p
N.E.	–0.223	0.253	–0.355	0.064	–0,073	0.714	**0.457**	0.015
N.N.E.	–0.156	0.427	–0.363	0.058	**0.786**	0.000	**0.485**	0.009

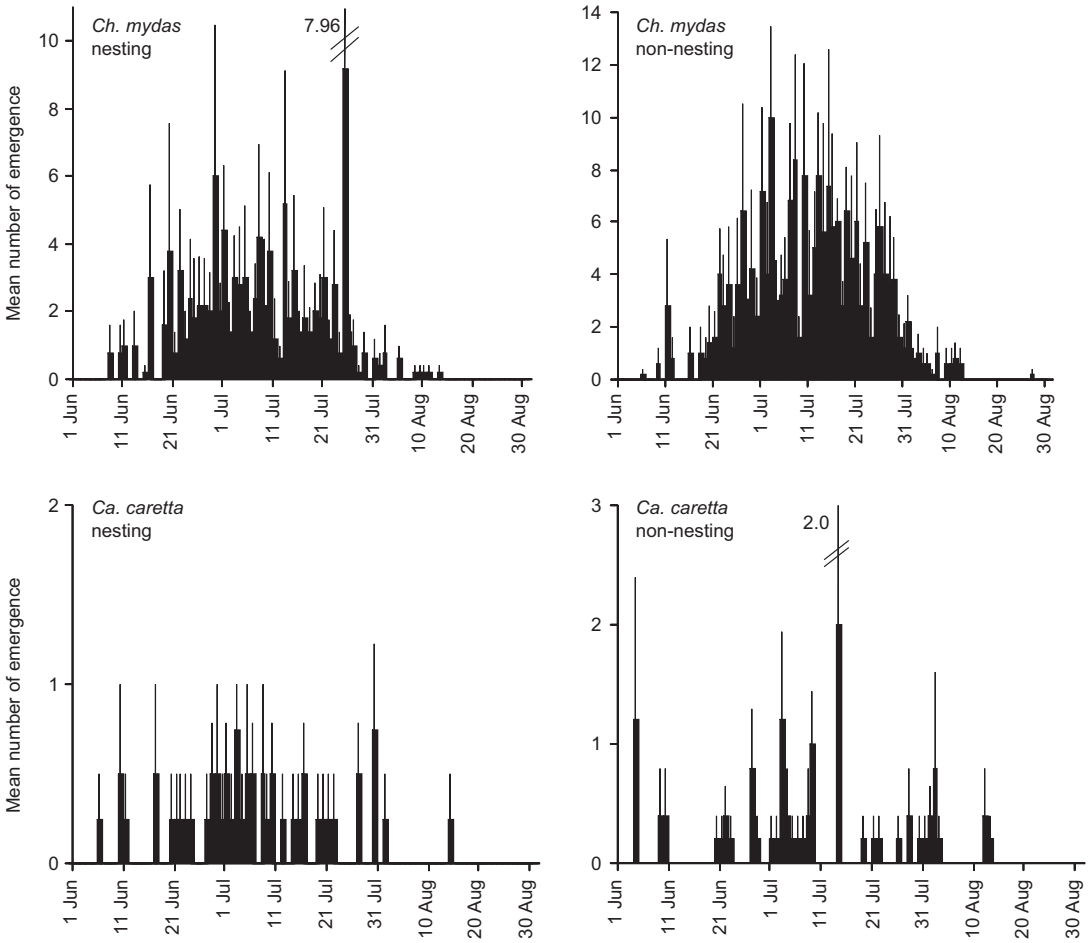

Fig. 6. Temporal distribution of mean number of nesting and non-nesting emergences of green and loggerhead turtles (error bars represent standard errors of five years of data).

Loggerhead turtles

Although loggerhead turtle emergences on Samandağ were generally concentrated in July, the nesting and non-nesting emergences in the 2003 nesting season, and non-nesting emergences only in the 2004 nesting season, were concentrated in June (Fig. 6). Loggerhead emergences did not extend to August except in the 2005 nesting season

Female numbers

Female numbers on Samandağ were estimated by dividing nest numbers by three for green turtles and by two for loggerhead turtles (according to Broderick *et al*. [2002]). On Samandağ, the annual green turtle female number was 40 ± 42 (mean ± SD; range = 5–108). i.e. higher than estimated by Broderick *et al*. (2002) (20–22 females/season). The estimated number of *Ca. caretta* females per season was 5 ± 4 (mean ± SD; range = 4–10).

Hatching success

Green turtles

The hatching success of green turtles on Samandağ varied between 61.5% and 85.6% (mean ± SD = 77.7% ± 9.6%) (Table 5). It was lower than that on Kazanlı Beach, where the

average was found to be 87.7% (Durmuş 1998) and 83.7% (Aureggi 2001). Numerous studies have suggested external factors that may affect hatching success, such as human activity, climatic conditions, predation, and fungal and bacterial diseases (Whitmore & Dutton 1985, Eckert & Eckert 1990, Girondot *et al*. 1990, Magnuson *et al*. 1990, Schouten *et al*. 1997, Hoekert *et al*. 2000, Bouchard & Bjorndal 2000). Flooding of the nest is one of the most important factors reducing hatching success on Samandağ. The low hatching success of green turtles in the 2004 nesting season was mainly due to inundation of about 56 nests by sea water. Not only green turtles but also *Dermochelys coriacea* and *Ca. caretta* nests on different beaches suffered from inundation by seawater which resulted in lower hatching success (Leslie *et al*. 1996, Bilinski *et al*. 2001, Kaska 2003, Öz *et al*. 2004). Ackerman (1977) and Mortimer (1981) showed that moisture content can affect the hatching success of sea turtles and that excessive moisture may decrease the gas diffusion to the nest because of water clogging the sand. Yalçın-Özdilek *et al*. (2006a) found a negative correlation between green turtle hatching success and sand moisture, adding that the hatchlings die in conditions where the sand moisture is higher than 8%.

Loggerhead turtles

The average hatching success of loggerhead turtles on Samandağ was 66.8% ± 13.5% (mean ± SD). In comparison with other Mediterranean nesting beaches, the hatching success of loggerhead turtles on Samandağ was higher than that of loggerhead turtles on Kızılot, Belek (1990–1996), Patara (1990–1996) and Dalyan (1988–1996) beaches in Turkey (Türkozan 2000, Kaska 2003, Türkozan *et al*. 2003). However, it was lower than that on Dalyan Beach (Başkale and Kaska 2003). It is clear that the hatching success of sea turtles varied from beach to beach and in different parts of the beach because of local conditions.

The average hatching success of loggerhead turtles on Samandağ was lower than that of green turtles (Table 5). Aureggi (2001) indicated that the hatching success of loggerhead turtles on Kazanlı was also lower than that of green turtles. According to Türkozan *et al*. (2003) and Yalçın-Özdilek *et al*. (2006a), as opposed to green turtles, there was no correlation between loggerhead hatching success and the moisture of the nest-chamber sand. The reason for this low hatching success should therefore be ascertained by further research.

Duration of incubation

The minimum incubation time of green turtles varied from year to year (Table 5). The estimated duration of incubation of green turtles was 53 days (range = 45–61) i.e. similar to that

Table 5. Hatching characteristics of the two species over five years.

Year	Number of examined nests	Total number of eggs	Eggs per nest	Hatchlings per nest	Hatching success (%)	Mean duration of incubation duration (days) ± SD (range)
Ch. mydas						
2001	14	1773	126.6	108.4	85.6	
2002	82	10021	122.2	105.9	80.3	
2003	104 (59*)	11866	114.1	92.5	77.2	53.1 ± 5.1 (43–64)
2004	261 (142*)	29326	112.4	85.4	61.5	54.6 ± 4.4 (45–67)
2005	10 (9*)	1252	125.2	104.9	83.8	52.0 ± 3.7 (46–55)
Ca. caretta						
2001						
2002	2	136	68.0	68.0	50.0	
2003	8 (3*)	600	75.0	53.4	62.3	54.3 ± 4.5 (50–59)
2004	11 (3*)	832	75.6	56.3	74.4	57.7 ± 3.1 (55–61)
2005	9 (5*)	754	83.8	67.4	80.5	47.6 ± 2.9 (44–51)

* Number of nests for which mean duration of incubation was measured (*see* the last column).

on Kazanlı Beach (Aureggi 2001). However, the duration of incubation of green turtle reported by Durmuş (1998) — 59.8 (range = 53–67) days and 58.3 (range = 51–67) days in the 1993 and 1994 nesting seasons, respectively — was longer than that found in this study. Differences in beach sand characteristics such as sand temperature might have affected the incubation time. The minimum duration of incubation of loggerhead turtles was similar to that reported in previous studies (Maclean *et al*. 1998, Aureggi 2001, Başkale & Kaska 2003, Türkozan *et al*. 2003).

Conservation

The monitoring and conservation of sea turtles on Samandağ started in 2001 with the establishment of a local commission by the Turkish Ministry of the Environment (Ekmekçi & Yalçın-Özdilek 2006). After receiving RAC/SPA training support during the 2002 nesting season, conservation studies continued in the following years. Although an improvement in the situation of sea turtles on Samandağ may have resulted from natural fluctuations, the role of conservation studies, especially continuous and uninterrupted monitoring, cannot be disregarded (Yalçın 2003, Yalçın-Özdilek & Yerli 2006). These conservation efforts included protecting nests and hatchlings, prevention of illegal sand extraction, educating fishermen, improving awareness among residents and the municipality, educational activities, and integrating NGO's into the conservation studies; efforts that continued throughout both the nesting and inter-nesting seasons. To recruit local governmental organizations, NGO's, and a team of university volunteers was the core of the conservation campaign on Samandağ.

Conclusion

Broderick *et al*. (2002) estimated that there were approx. 339–360 female green turtles in all the Mediterranean. Canbolat (2004) indicated the proportion of green turtles nesting on Samandağ as 13%, taking into account the 22 nesting sites in Turkey. This five-year monitoring study indicated a higher relative importance of Samandağ, which actually comprised 17.7% of the green turtle nesting habitat in Turkey. The total female green turtle population in the Mediterranean, therefore, needs to be re-calculated by incorporating data from nesting areas other than Samandağ, such as Latakia in Syria and Alata in Turkey, which have been monitored continuously for the past few years (Ergene *et al*. 2005, Saad *et al*. 2006).

As compared with oceanic beaches, the Mediterranean offers much different conditions to its sea turtles. Because *Ca. caretta* nesting sites in the Mediterranean are notably widespread, individuals of this species are subject to varying environmental conditions (Broderick *et al*. 2002). In contrast to *Ca. caretta*, the *Ch. mydas* nesting habitat is concentrated on few beaches, mainly in the eastern part of the Mediterranean. A restricted nesting habitat may be an advantage or disadvantage for a species in need of conservation. It is an advantage in the sense that better, cheaper, and more effective conservation strategies may be applied in a restricted area; though if conservation strategies are not applied, the species may be at risk of extinction. The nests of *Ch. mydas* are critically endangered in particular parts of the Mediterranean and at specific locations on those beaches. Conservation plans therefore need to be urgently applied to *Ch. mydas* nesting beaches in the Mediterranean including Samandağ. In particular, the 6000–12 000 m section of the beach extending three kilometers on either side of the Asi River needs to be recognized as a protected area.

Acknowledgements

I wish to thank especially the Turkish Scientific and Technical Organization (TÜBİTAK) since this study was partially supported by their projects coded YDABAG-103Y058 and YDABAG-104Y055. I must also express my gratitude to Hatay Environmental and Forestry Directorate, Türkiye Çevre Koruma Vakfı, and Mustafa Kemal University for supporting the monitoring studies. Many thanks also to my hard-working MKU biology department volunteer students led by Bektaş Sönmez, who monitored in the field, and lecturer Graham H. Lee for proof-reading the text.

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