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Nesting activity of sea turtles, *Caretta caretta* (Linnaeus, 1758) and *Chelonia mydas* (Linnaeus, 1758) (Reptilia, Cheloniidae), at Patara Beach (Antalya, Turkey) over four nesting seasons

Kurtuluş OLGUN*, Emin BOZKURT, Süleyman CEYLAN, Mehmet TURAL, Serdar ÖZCAN, Kazım Şahin KARASÜLEYMANOĞLU, Yusuf GEROĞLU
Department of Biology, Faculty of Science and Art, Adnan Menderes University, Aydın, Turkey

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Abstract: Patara Beach is one of the most important nesting beaches in Turkey for *Caretta caretta*. In this paper, we provide information on the nesting activity, spatial and temporal distribution of nesting, nesting and hatching success, nesting density, incubation duration, clutch size, and predation ratio of sea turtles over four nesting periods, namely 2010, 2012, 2013, and 2014. An average of 179.75 nests were recorded per year, and the overall nesting density was 15.50 nests/km while 68.20 loggerhead sea turtle eggs were recorded per nest. The hatching success was 44.05% from these counted eggs and 38.04% of hatchlings were able to reach the sea. We also observed 3 *Chelonia mydas* nests. The highest nesting activity during our monitoring over the past 20 years was obtained in 2013. The average annual number of turtle nests in Patara over 20 nesting seasons was 94.70.

Key words: *Caretta caretta*, *Chelonia mydas*, Patara, nesting, sea turtles, Turkey

1. Introduction

The loggerhead turtle (*Caretta caretta*) is the most common sea turtle species in the Mediterranean (Groombridge, 1990; Broderick et al., 2002). The major Mediterranean nesting areas for loggerhead turtle are found in Greece, Turkey, Libya, and Cyprus, and minor nesting sites are in Egypt, Lebanon, Israel, Italy, Syria, and Tunisia (Broderick et al., 2002; Margaritoulis et al., 2003).

The green turtle (*Chelonia mydas*) is a well-known species in the eastern Mediterranean. While Turkey, Cyprus, and Syria are the countries with the densest *Chelonia mydas* nesting activity around the Mediterranean, Egypt, Lebanon, and Israel also provide minor nesting grounds (Kasparek et al., 2001; Casale and Margaritoulis, 2010).

The first extensive research of the Turkish Mediterranean coast for turtle nesting areas, primarily focusing on the location and importance of nesting sites, was conducted by Baran and Kasparek (1989). Based on the work of Baran et al. (1992), 17 important nesting beaches were identified along the Turkish Mediterranean coast, from Ekincik in the west through Samandağ in the east. The number of nesting areas in Turkey was upgraded to 20 in the 2003 Sea Turtles Nesting Beaches Estimation Report (Oruç et al., 2003). The number of nesting areas was subsequently raised to 22 and Patara Beach was assessed as a nesting area of secondary importance in terms of nest density (Canbolat, 2004).

Broderick et al. (2002) stated that the number of *C. caretta* females annually nesting on the Mediterranean coast alters between 2280 and 2787, while Casale and Margaritoulis (2010) estimated the number of annual nesting females at 7200 for *C. caretta* and 1500 for *C. mydas*. Türkozan and Kaska (2010) supposed that the average annual number of nests in Turkey was 2145 (29.8% of nests occurred along the Mediterranean) for *C. caretta* and 1252 (83.5% of nests occurred along the Mediterranean) for *C. mydas*.

The first detailed research on the nesting activity of Patara Beach began in 1989 (Yerli, 1990). The highest number of nests was recorded in 2006, with 127 nests (Canbolat et al., 2007), while the lowest number, 33 nests, was found in 1994 (Canbolat, 2004).

The fundamental goal of the present study is to provide information on the nesting activity, temporal and spatial distribution of nests, hatching success, hatchling emergence patterns, incubation duration, and clutch size of marine turtles over four seasons at Patara Beach, Turkey.

* Correspondence: kolgun@adu.edu.tr

2. Materials and methods

2.1. Study area

Patara Beach is located between Kaş (Antalya) and Seydikemer (Muğla). Patara Beach was declared a Special Environmental Protection Area in 1990, and in 2007 the boundaries of the protected area were expanded. The Patara Special Environmental Protection Area covers an area of 189.81 km^2. Patara Beach stretches over 14 km and the approximate width of the beach is 500 m. The Eşen River divides the beach into two sections. The eastern part, named Patara, has the highest nesting density. The western part is called Kumluova and is less appropriate for nesting due to physical structures and a narrow coastal area.

2.2. Field study

We monitored Patara Beach for four nesting seasons, in 2010, 2012, 2013, and 2014. The beginning and end dates of monitoring for each year are shown in Table 1.

Teams of two or three people conducted night (2200 to 0200 hours) and morning (0500 to 1000 hours) patrols. During night patrols we determined whether sea turtles were attempting to lay eggs and recorded nesting sites. During subsequent morning patrols, the shape and the pattern of the tracks left by nesting females were noted and these tracks were marked. The percentage of nesting success (NS) was calculated with the following equation:

$$NS(\%) = \left[\frac{N}{N+T}\right] \times 100$$

In the above equation, N is the number of successful nesting attempts and T is the number of unsuccessful nesting attempts. Identified nests were protected against predators (e.g., fox, *Vulpes vulpes*) by fencing them off with metal grating (72 × 72 cm, mesh size 9 cm). A protective metal grating was placed over the eggs at the center of the egg chamber under the surface. Each nest location was recorded by GPS and the spatial distribution in relation to the tide line was measured with a 50-m measuring tape. Afterwards, turtle tracks were cleared, although we did put identification marks around the nests (e.g., wooden signs).

Nests were checked daily. If we detected predation, we determined the type of predator, the number of predated eggs, and whether any eggs remained in the nest. If eggs remained, we put up protective metal grating again.

During hatchling emergence, the number of hatchling tracks was counted. We counted the number of uninterrupted tracks and interpreted these as belonging to hatchlings that reached the sea. Tracks that were interrupted by tracks of fox, birds, or crabs were interpreted as predation events. After 3 or 4 days from the first emergence of hatchlings, we opened and checked the nests. The numbers of empty egg shells, nonfertilized eggs, still unhatched eggs, and dead and living hatchlings in the nest were determined. We transferred some nests to artificial hatcheries on the beach because of the risks associated with predation, human activities, and sea-level fluctuation.

We applied this methodology twice a week for the Kumluova section and daily for the Patara section. All statistical analyses were conducted with SPSS 22.0. We used Spearman analysis to determine the correlation between years and numbers of nests.

3. Results

In this study, 555.75 loggerhead turtle emergences were recorded per year over the four nesting seasons; 32.34% of these resulted in a nest and the average number of nests was 179.75 per year (116 nests in 2010, 169 nests in 2012, 239 nests in 2013, and 195 nests in 2014). In the Patara part of the beach, 653 nests were positioned (on average 163.25 per year: 113 in 2010, 138 in 2012, 207 in 2013, and 195 in 2014), and 66 nests were positioned in the Kumluova part (on average 22 per year: 3 in 2010, 31 in 2012, and 32 in 2013). The Kumluova part has long wetlands and the predation pressure is higher there than in the Patara part. For this reason, the number of the nests in Patara is higher than in Kumluova.

At the same time, 17 green turtle emergences were recorded, all in Patara. Of these, 3 (17.65%) resulted in a nest and the average number of nests was 0.75 per year (1 in 2010 and 2 in 2012).

Table 1. Starting and end days of field seasons at Patara Beach.

Year	Beginning date of field study	Finishing date of field study	Number of working days
2010	11 June	15 September	97 days
2012	21 May	15 September	118 days
2013	15 May	15 September	123 days
2014	15 May	15 September	123 days

The overall nesting success for *C. caretta* (number of nests / number of emergences) was 32.34% (37.74% in 2010, 30.32% in 2012, 28.93% in 2013, and 36.11% in 2014). The average nesting density of loggerhead turtle was 15.50 nests/km (8.36 in 2010, 12.21 in 2012, 17.07 in 2013, and 13.93 in 2014 for the full 14 km of beach). The number of nests in the Kumluova part (9.18% of all nests for the four seasons) was lower than in the Patara part. The nesting density in the Kumluova part was calculated as 2.75 nests/km for four seasons and in the Patara part as 20.05 nests/km for four seasons in our study.

The nesting season started in the middle of May and ended in third week of August (Figure 1). The peak of nesting occurred in July for *C. caretta*. The average distribution of successful nesting emergences of *C. caretta* over the four seasons was 4.03% in May, 44.93% in June, 45.62% in July, and 5.42% in August. Emergence of hatchlings started in the middle of July and peaked in the middle of August. *C. mydas* nesting occurred on 10 July in 2010 and 24 and 27 June in 2012.

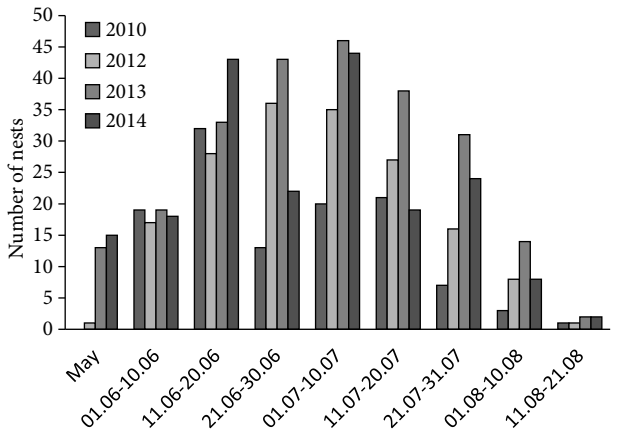

Figure 1. Temporal distribution of nests in four nesting seasons (2010, 2012, 2013, and 2014) at Patara Beach.

Of the annually recorded loggerhead turtle nests we excavated and examined 115 (99.12%) in 2010, 162 (95.86%) in 2012, 224 (93.72%) in 2013, and 190 (97.44%) in 2014. We counted 47,129 loggerhead turtle eggs in 691 nests, with a mean clutch size of 68.20 (0.79 SE, 20.75 SD, range: 12–128 eggs). The 28 remaining nests were not excavated because the incubation period for these nests had not been completed at the end of the fieldwork period. We counted 218 green turtle eggs from the 3 nests, with a mean clutch size of 72.66 (13.35 SE, 23.12 SD, range: 51–97 eggs).

During the four nesting seasons, 20,753 loggerhead turtle eggs produced hatchlings. The overall hatching success of loggerheads was 44.05% (49.73% in 2010, 43.10% in 2012, 41.27% in 2013, and 44.80% in 2014) (Table 2). In total 17,929 hatchlings were able to reach the sea. Hence, the total number of hatchlings that reached the sea represented 38.04% of the total number of eggs laid. Of the 218 green turtles eggs, 121 (55.51%) produced hatchlings and 94 (43.12%) of these were able to reach the sea.

We calculated the mean incubation periods of *C. caretta* nests as 51 days in 2010 (n = 48, range: 45–61), 49 days in 2012 (n = 98, range: 43–63), 50 days in 2013 (n = 92, range: 44–59), and 50 days in 2014 (n = 110, range: 39–66). The shortest and longest incubation periods in the four seasons combined were respectively 39 and 66 days, with a mean of 50 days (n = 348, SE = 0.248). The mean incubation period for *C. mydas* nests was 50 days (n = 3, SE = 3.844, range: 46–58).

Table 2. Hatching success and survival of *Caretta caretta* at Patara Beach over four nesting seasons (N: number of the excavated nests).

	2010		2012		2013		2014		Overall	
	N = 115	%	N = 162	%	N = 224	%	N = 190	%	N = 676	%
Total number of eggs	7762		10,966		15,768		12,633		47,129	
Depredated eggs	2630	33.88	3754	34.23	7259	46.04	4519	35.77	18,162	38.54
Unhatched eggs	315	4.06	287	2.62	162	1.03	195	1.54	959	2.03
Dead embryos	957	12.33	2199	20.05	1839	11.66	2260	17.89	7255	15.38
Hatchlings	3860	49.73	4726	43.10	6508	41.27	5659	44.80	20,753	44.05
Remained in the nest	127	3.29	259	5.48	104	1.60	98	1.73	588	2.83
Depredated or died on the beach	1066	27.62	299	6.33	493	7.58	378	6.68	2236	10.77
Reached the sea	2667	69.09	4168	88.19	5911	90.82	5183	91.59	17,929	86.40

Over the four seasons, 142 (19.75%) *C. caretta* nests were partially predated and 256 (35.61%) were completely predated. In total, 55.36% of nests were affected by predation and 18,162 loggerhead turtle eggs were destroyed by predators. Fox (*Vulpes vulpes*) is the main predator. Other predators are dogs (*Canis lupus*), badgers (*Meles meles*), and wild pigs (*Sus scrofa*). In the 2013 nesting season we observed the first pig predation in Patara. We recorded 2236 dead hatchlings on the beach. Of these dead hatchlings, 49.02% were predated by mammals, 42.76% by crabs (*Ocypode quadrata*), and 6.22% by birds, and 2% did not show signs of predation.

Metal gratings were used against predators for 462 (64.26%) nests. In total, 158 (34.20%) of these nests were depredated after the use of metal gratings. At the same time, we did not use metal gratings for 257 nests, and 211 (82.10%) of these nests were depredated in the first night. Additionally, 168 (23.37%) nests were transferred by our project members further away from the tide line to prevent inundation. Metal gratings were also used for relocated nests. In total, 80.95% of these nests produced hatchlings and hatchling success of these nests was calculated as 61.27%. The hatchling success of the relocated nests was higher than that of natural nests because the predation pressure was lower.

4. Discussion

During the four seasons (2010, 2012, 2013, and 2014), we monitored the 14-km length of the beach and we recorded a total of 719 loggerhead nests, with a mean of 179.75 nests per season. A total of 1894 nests were recorded over 20 years, with a mean of 94.70 nests per year on Patara Beach. There is a strong annual fluctuation in the number of nests, which ranged from a minimum of 33 (1994) to a maximum of 239 (2013), a 624% difference. Comparative data on nesting activities on Patara Beach are available from earlier studies (Table 3).

The reported number of nests shows a significant increase in the last couple of years (Spearman's $r = 0.68$; $P \leq 0.05$) (Figure 2). However, it should be noted that

Table 3. Results of previous nesting studies at Patara Beach.

Year	Number of nests	Kilometers of beach	Reference
1989	93	6.7	Canbolat, 2004
1990	58	6.7	Canbolat, 2004
1992	52	6.7	Canbolat, 2004
1993	85	6.7	Canbolat, 2004
1994	33	6.7	Canbolat, 2004
1996	35	6.7	Canbolat, 2004
1997	52	6.7	Canbolat, 2004
1998	64	6.7	Canbolat, 2004
1999	79	6.7	Canbolat, 2004
2000	85	11.9	Canbolat, 2004
2001	53	9.9	Öz et al., 2006
2002	81	9.8	Öz et al., 2006
2004	72	6.9	Selin, 2004
2005	83	14	Selin, 2005
2006	127	12.1	Canbolat et al., 2007
2008	120	11.7	Öz et al., 2008
2010	117	14	This study
2011	?	?	-
2012	171	14	This study
2013	239	14	This study
2014	195	14	This study

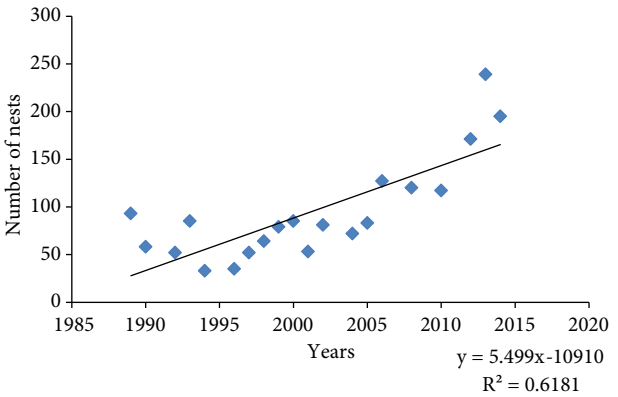

Figure 2. Population trend of sea turtles expressed in number of nests at Patara Beach over 20 seasons (given in Table 3).

no standardized survey method was employed at Patara Beach before 2000. We propose that a standardized field protocol as applied in the present study is a necessity in monitoring Patara Beach.

Canbolat (2004) classified Patara Beach as a nesting ground of secondary importance, holding 3.5% of the total number of nests laid annually on Turkish beaches. Compared to other data in the literature (Casale and Margaritoulis, 2010; Türkozan and Kaska, 2010), Patara Beach represents 2.50% of the total loggerheads nesting around the the Mediterranean and 8.38% of the nesting in Turkey.

The average distance of *C. caretta* nests was calculated as 25.80 m, whereas the average distance of nonnesting emergences was calculated as 20.56 m. The average distance of nests is higher than the average distance of nonnesting emergences. This situation can be affected by the pressure of predators, human activity on the beach, and lights from some hotels.

The nesting success of *C. caretta* over the four seasons that we studied was 32.34%. Previously reported nesting success rates at Patara Beach were 31.10% in 1990 (Kaska, 2003), 52% in 2000 (Kaska et al., 2001), and 25.40% in 2001 (Taşkın and Baran, 2001). Nesting success on other Turkish nesting beaches was 26.50% at Göksu Beach (Durmuş et al., 2011), 24.60% at Dalaman Beach (Kaska et al., 2010), 33.70% at Dalyan (Türkozan and Yılmaz, 2008), and 28.42% at Demre Beach (Ergene et al., 2007). The nesting success that we observed at Patara Beach showed no obvious differences from other years and other Turkish nesting sites.

We calculated the overall nest density as 15.50 nests/km on Patara Beach. Canbolat (2004) stated that the nest density varied between beaches in Turkey from 1.1 nest/km to 50.7 nest/km and calculated the average nest density on Patara Beach as 10.3 nest/km. Previously reported nest densities at Patara Beach were 6.7 nest/km in 2000, 4.0 nest/km in 2001, 7.4 nest/km in 2002, and 10.4 nest/km in 2004 (Ergun, 2005). We calculated the maximum nest density at Patara Beach as 17.07 nest/km in 2013. The nest density at various nesting beaches in the Mediterranean region was reported as 47 nest/km at Dalyan in 2004 and 2005 (Türkozan and Yılmaz, 2008), 6.12 nest/km at Demre Beach in 2006 (Ergene et al., 2007), 15 nest/km at Çıralı Beach over 13 nesting seasons (Türkozan and Kaska, 2010), and 3.4 nest/km at Göksu Beach in 2004 and 2008 (Durmuş et al., 2011) in Turkey; 1033 nest/km at Sekania Beach and 226 nest/km at Zakynthos Beach in Greece (Margaritoulis and Panagopoulou, 2010); and 23.6–30.7 nest/km at El-Mansouri Beach in Lebanon over three seasons (Khalil et al., 2005). We determined that the nest density at Patara Beach was lower than at Dalyan, Çıralı, Sekania, Zakynthos, and El-Mansouri, but higher than at Göksu and Demre. Margaritoulis (2000) suggested that beaches that have over 100 nests with a density of over 6 nest/km should be considered as important nesting areas. In this regard, Patara can be evaluated as one of the important nesting beaches in Turkey.

We calculated that the mean clutch size of *C. caretta* at Patara Beach was 68.20 eggs over four seasons. Previous reports for mean clutch size at Patara Beach were 70 eggs in 1992, 1993, and 1996 (Kaska et al., 1998); 69.5 eggs in 2000 (Kaska et al., 2001); and 80.1 eggs in 2001 (Taşkın and Baran, 2001). Türkozan (2000) reported a mean clutch size of 80.7 eggs in 1995 and 1997 at Fethiye and 78.5 in 1996 and 1997 at Kızılot. Margaritoulis (2005) evaluated Laganas Bay for 19 years and found a mean clutch size of 116.5 eggs. The mean clutch size that we observed was lower than at other beaches and in other years at Patara. Mean clutch sizes vary greatly from year to year and from beach to beach. Margaritoulis (2005) indicated that the differences in mean clutch size among nesting colonies of loggerhead turtles in Greece, Turkey, and Cyprus were affected by the body size of females. A lower mean clutch size and an increase in nesting rate may reflect a higher proportion of young females. A higher number of young females might itself reflect a successful outcome of recent conservation projects.

We found the hatchling success of *C. caretta* as 44.05% in these four nesting seasons. Hatchling success in previous studies at Patara was reported as 37% in 1992 and 41% in 1993 and 1996 (Kaska et al., 1998), 22.35% in 2000 (Kaska et al., 2001), and 50.78% in 2005 (Taşkavak et al., 2006). The mean annual hatchling success of other beaches of the Mediterranean was recorded as 22.9% in 2004 and 2008 at Göksu (Durmuş et al., 2011), 70% in 1993–1996 at Fethiye (Türkozan et al., 1998), 61.7% in 2004 and 2005 at Dalyan (Türkozan and Yılmaz, 2008), 41.79% in 2006 at Demre

(Ergene et al., 2007), 66.6% at Laganas Bay between 1984 and 2002 (Margaritoulis, 2005), and between 75% and 83% in 1992 and 1995 in Northern Cyprus (Broderick and Godley, 1996). When the hatchling success of Patara was compared with those of other Mediterranean beaches, the hatchling success of Patara during these four years was higher than that of Demre and Göksu and lower than that of Laganas Bay, Cyprus, Fethiye, and Dalyan. Predation (Durmuş et al., 2011), coastal erosion (Türkozan et al., 1998), and rise of the sea level (Margaritoulis, 2005) affect hatchling success. The lower hatchling success observed at Patara Beach was caused by high pressure of mammal predation and rising sea level. We can determine the best way to figure out the effect of rising sea level at Patara by relocation of nests.

In our project, we determined that the incubation duration of loggerhead turtle was 50 days (n = 348, SE = 0.248). The mean incubation duration at Patara Beach was reported as 60 days in 1992, 1993, and 1996 (Kaska et al., 1998); 52.1 days in 1997 (Taşkın and Baran, 2001); and 60 days in 2000 (Kaska et al., 2001). The incubation durations at various nesting beaches in Turkey were reported as 53 days at Göksu in 2004 and 2008 (Durmuş et al., 2011), 52.3 days at Dalyan in 2004 and 2005 (Türkozan and Yılmaz, 2008), 52.3 days at Fethiye in 2000 (Kaska et al., 2001), and 47.9 days at Demre in 2006 (Ergene et al., 2007). In addition, the incubation duration was recorded as 55.5 days in Greece (Margaritoulis, 1988), 48.1–53.5 days in Egypt (Campbell et al., 2001), 54 days in Israel (Silberstein and Dmi'el, 1991), and 48 days in Cyprus (Broderick and Godley, 1996). Incubation durations vary greatly from year to year and from beach to beach. We observed that the incubation duration during these four years was lower than that of the previous years before our project. Climate change might reduce the incubation duration at Patara Beach. For this reason, using thermometers in nests might help to observe the reducing of incubation duration. Marcovaldi et al. (1997) suggested that incubation duration could be used as an index of hatchling sex ratio. We also observed a minimum incubation duration of 39 days. That nest was on a sand hill and deeper than the other nests, and the nesting date of that nest was 17 July 2014. Day temperature, height of dry sand, and depth of the nest could affect the incubation duration.

The effects of predation are the main problem for loss of eggs and hatchlings. We observed that 55.36% of nests were depredated in these four studied years at Patara Beach and major predators were foxes and dogs. Nest predation rates at various nesting beaches of the Mediterranean were recorded as 26.9% at Dalyan (Türkozan and Yılmaz, 2008), 33.9% at Göksu (Durmuş et al., 2011), and 48.4% at Kyparissia Bay (Margaritoulis, 2005). However, there was no reported mammalian predation at Laganas Bay (Margaritoulis, 2005). We determined that the main predator was fox at Patara Beach during this study. Predators and predation rates of eggs might show differences from beach to beach: 71.9% of depredated eggs were destroyed by foxes and 19.9% by coleopteran larvae at Fethiye, whereas 68.4% of depredated eggs were destroyed by foxes and dogs and 19.2% by coleopteran larvae at Kızılot (Türkozan, 2000). In addition to the previous studies, we determined that of the depredated hatchlings 49.02% were destroyed by mammals and 42.76% by crabs at Patara Beach during our project. Meanwhile, 69.8% depredated hatchlings were reported at Dalyan Beach in 2004 and 2005 (Türkozan and Yılmaz, 2008). Predators and predation rates vary from beach to beach, and these aspects influence the hatchling success. The main predator are foxes, dogs, crabs, and wild pigs at Patara.

Using metal gratings can decrease the predation rate and increase the hatchling success. For this reason, using metal gratings is important and metal gratings can be 72 × 72 cm for predators. Night patrols also decrease the predation pressure. After these applications, if the predation rate is still increasing, conservation members can establish an incubation area on the beach. Inundation of the tidal zone also affects the hatchling success of sea turtles, and relocation of the nests is important to save these nests and offspring. Finally, in addition to what is mentioned above, further monitoring and conservation studies need to be continued at Patara Beach.

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