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Sixteen Year (2002-2017) Record of Sea Turtle Strandings on Samandağ Beach, the Eastern Mediterranean Coast of Turkey

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Bektaş Sönmez (2018) Data on stranded sea turtles allow us to obtain information about age classes, temporal and spatial distributions, and mortality rates in turtles. This study aims to investigate life stages, temporal variation in the number of stranded, body size trend, causes of stranding, and scute deviation of stranded sea turtles on Samandağ Beach, the eastern Mediterranean coast of Turkey during 2002-2017. A total of 302 stranded dead turtles were found. Among these, 167 (55.4%) of them were *Chelonia mydas*, 127 (42%) *Caretta caretta*, 2 (0.6%) *Trionyx triunguis*, and 6 individuals (2%) were unidentified. The mean annual stranding values over the years were 10.5 (ranging from 6 to 22) and 7.9 individuals (ranging from 4 to 21) for *C. mydas* and *C. caretta*, respectively. Although the adult green turtles were less stranded, sub-adult and adult stages of the loggerhead turtles were intensively stranded. As the body size of the stranded green turtle has slightly increased, the number of stranded green turtles has decreased over the years. Stranding of loggerhead turtles showed no trend in frequency or body size. The causes of death showed significant differences between the two species as well as among the years. Fishing activities and marine pollution is the main cause of strandings on Samandağ Beach. Oceanic and sub-adult stage individuals were stranded in especially high numbers due to plastic materials. Adult stages in both sea turtle have less carapacial scute deviation. The present study contributes to the stranded data for both sea turtle species in the Mediterranean. Natal origins of the stranded sea turtles on Samandağ Beach should be investigated and a stranding network system should be urgently established.

Key words: Stranded, *Chelonia mydas*, *Caretta caretta*, Samandağ, Eastern Mediterranean.

BACKGROUND

Three species of sea turtles are commonly found in the Mediterranean Sea (Türkozan and Kaska 2010): the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Dermochelys coriacea*), which is considered as a visitor species from the Atlantic Ocean (Candan and Canbolat 2018). The most abundant species in the Mediterranean is the loggerhead and its main nesting areas are Greece, Turkey, Cyprus, and Libya (Canbolat 2004; Casale and Margaritoulis 2010) and main feeding grounds are North Africa and the Adriatic coast (Casale and Margaritoulis 2010; Stokes et al. 2015). The main nesting areas of the green sea turtle are Turkey, Cyprus, and Syria (Canbolat 2004; Casale and Margaritoulis 2010) and the main feeding areas are mainly in the eastern Mediterranean and coast of Libya (Casale and Margaritoulis 2010; Stokes et al. 2015). The total number of the loggerhead and green sea turtle nests on Mediterranean coasts is estimated be approximately 7200 and 1500, respectively (Casale and Margaritoulis 2010). Approximately 30% and 83% of these nests are recorded on coasts of Turkey for the loggerhead

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and the green turtle, respectively (Türkozan et al. 2013). According to the International Union for Conservation of Nature (IUCN) Red List criteria, the Mediterranean subpopulations of the green sea turtle and the loggerhead sea turtle are categorized as under Endangered (EN) and Least Concern (LC) categories, respectively (Seminoff 2004; Casale 2015).

Identification of habitats for endangered species is crucial in maintaining habitat sustainability. Protecting nesting beaches has been a priority because successful nests increase the population, but identifying feeding, mating and wintering habitats in terms of the number of sub-adult and adult populations (within biologically safe boundaries) is also important to protecting these species (Bjorndal 1997). Our knowledge about sea turtles in Turkey is mostly limited to nesting female populations and reproductive outputs. There is little research on biology, habitat use, and threatening factors in marine habitats. Fishery bycatch is one of the most important factors affecting the sea turtle life history, and bycatch rate is very high in the Mediterranean (Casale 2011). Snape et al. (2013) estimated that 1000 sea turtles were caught by fisheries in the eastern Mediterranean, and they reported that about 60% of them died. A high sea turtle bycatch rate by bottom trawlers was reported from the eastern Mediterranean of Turkey (Oruç 2001). In total, 466 green turtles and 142 loggerhead turtles were bycatch by trawling nets between Mersin and Iskenderun (Turkey) during trawling season between 1995 and 1997 (Oruç 2001). Sub-adults made up 81% of these and total lengths were 30-60 cm (Oruç 2001). A similar result was also detected on Samandağ Beach, where 22 green turtles and 3 loggerhead turtles were stranded in the 2002 nesting season and curved carapace length (CCL) values ranged between 23.5 and 80 cm (mean 40.6 cm) (Yalçın-Özdilek and Aureggi 2006).

Data on stranded sea turtles were also reported for nesting beaches of the eastern Mediterranean coast of Turkey. It was reported that 128 green turtles and 142 loggerhead turtles stranded on 10 nesting beaches between 2002 and 2009 (Türkozan et al. 2013). There were 139 stranded sea turtles (102 loggerhead and 37 green turtles) between 2000 and 2016 on Fethiye Göcek Specially Protected Area in west Mediterranean coast of Turkey (Başkale et al. 2018). Most of the stranded loggerheads were assumed to be adults, whereas most of the stranded green turtles were assumed to be sub-adults (Başkale et al. 2018). Key information about the life stages, seasonal distributions, and geographical ranges of sea turtles can be obtained in stranded sea turtles on beaches (Chaloupka et al. 2008; Casale et al. 2010). Moreover, the natal origin of sea turtles can be estimated with information obtained from stranded sea turtles (Türkozan et al. 2018). Strandings can also provide preliminary information for conservation planning, management, and marine habitats of sea turtles and where should be regarded for future management plans. Previous studies on stranding sea turtles on Samandağ Beach was performed by Yalçın Özdilek and Aureggi (2006) and Türkozan et al. (2013). However, these studies reported only some descriptive information about stranding sea turtles. Therefore, this study aimed to examine 5 different topics: (1) life stages of stranded sea turtles, (2) temporal frequency variation trend of stranded sea turtles over the years, (3) body size trend of stranded sea turtles over the years, (4) cause of stranding and (5) scute deviation in different life stages of stranded sea turtles on Samandağ Beach in Turkey.

MATERIALS AND METHODS

Study area

Stranding data were collected on Samandağ Beach (36°07'N, 35°55'E) located on the eastern Mediterranean coast of Turkey during the 2002-2017 nesting seasons (Fig. 1). The nesting season begins in the middle of May and ends in the middle of October on Samandağ Beach. Samandağ Beach is approximately 14 km long; extending from the Çevlik Port in the north to Sabca Promontory in the south. Samandağ has a fishing port with numerous boats, are mainly for fishing, near the north and south end of the beach. Primary fishing methods are bottom trawl, purse seiner, and using small fishing boats (< 12 meters).

Data collection

Stranding data were collected with a roughly equal effort (3-5 people for each year) during monitoring and conservation projects of the sea turtles through direct observations in each year, for a total of 16 years (from 2002-2017). The data collection time in each year was equal and completed between April and October (215 days). An information recording form was created and filled out by a research team for each individual.

Life stage was assessed in 3 stages - oceanic, sub-adult, and adult - based on curved carapace length (CCL) measurements. The loggerhead turtles with CCL ≤ 30 cm were assumed to be in the oceanic stage and less than 4 years old (Casale et al. 2010). Moreover, individuals with CCL ≥ 70 cm were considered adults (Casale et al. 2005; Türkozan et al. 2013). The sub-adult stage was assumed to be between 30 and 70 cm. The hatchling green turtles have an oceanic existence and begin to exhibit benthic foraging at the age of 3-5 years (Reich et al. 2007), and CCL values ≤ 31.5 cm represented an oceanic stage (Türkozan et al. 2013). The individuals with CCL ≥ 85 cm were considered as adults stage (Türkozan et al. 2013). The sub-adult stage was assumed to be between 31.5 and 85 cm. In addition, stranded non-sea turtles were also recorded.

Straight carapace length (SCL) and width (SCW), curved carapace length (CCL) and width (CCW) of each sea turtle were measured and recorded. A caliper was used for linear measurements in SCL and SCW. CCL and CCW values were detected using a tape measure. Data on species, sex, cause of death, the stranded area, life stages, and scute patterns (if possible)

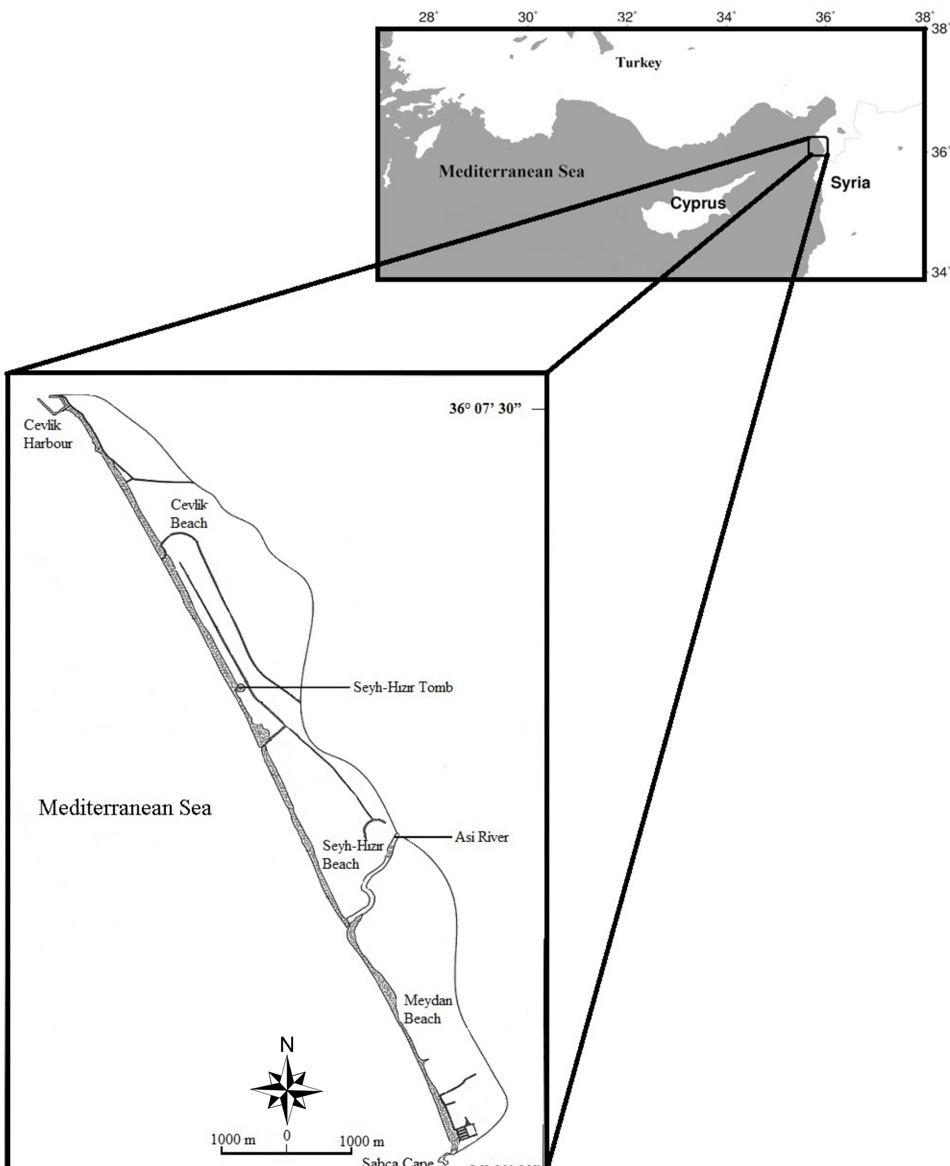

Fig. 1. Map of the study area (highlight shows survey area).

were recorded. Sex of the stranded sea turtles was determined by the tail length and the number of nails on the front flippers. Carapace scute patterns were determined, if possible, before necropsy for both species of stranded sea turtles. The most common (normal) scute pattern arises from 5 vertebrals, 4 pairs of costals and 11 pairs of marginals for green turtles and 5 vertebrals, 5 pairs of costals, and 12 pairs of marginals for loggerhead turtles (Suganuma et al. 1994; Türkozan et al. 2001; Özdemir and Türkozan 2006; Ergene et al. 2011; Sönmez et al. 2011). This scute pattern is the same for each sea turtle species in all individuals from hatchlings to adults, but individual variations in scutation can be observed (Mast and Carr 1989) in all life stages (Suganuma et al. 1994; Ergene et al. 2011). Scute deviation was determined by observing each individual's normal scute patterns. Depending on the presence or absence of scute deviation, the trait was classified as either 1 or 0, respectively. Also, the presence or absence of scute deviation was classified according to their life stages for both stranded sea turtles, in order to the test any differences among the life stages.

Causes of death in sea turtles were determined through a necropsy. When the necropsy was not available or not required, the cause of death was determined by a direct observation. Hooks and other materials were carefully removed from the mouth, esophagus, and intestines. The causes of death in sea turtles were categorized as follows: (1) fishing activities (*e.g.*, hook in jaws, mouth, esophagus, stomach or intestinal, gillnet fishing gear in cloaca or mouth) (Fig. 2a); (2) marine pollution (*e.g.*, entanglement in rope and net, cloth sack or nylon bag and presence of these substances in the digestive system) (Fig. 2b); (3) intentional killing (killed by

Fig. 2. Representative photos of different case of deaths (a: gillnet fishing gear in mouth, b: entanglement in nylon bag and presence of plastic in the digestive system, c: intentional killing (head trauma), d: hit by marine vehicle, e: jackal predation).

heavy objects, specifically by hits on head) (Fig. 2c); (4) hit by marine vehicle (fishing boat, cargo ship, and speedboat) (Fig. 2d); (5) predation (jackal or dog predation on the beach) (Fig. 2e). Although fishing nets, net fragments, and ropes could be used for fishing activities, such debris was considered as marine pollution in the present study. Moreover, entanglement and ingestion of them were also considered as marine pollution (Plotkin and Amos 1990). However, hooks in the jaw, mouth, esophagus, stomach or intestinal system were regarded as a fishing activity. Representative photos of the different cases of deaths described above is shown in figure 2.

Statistical analyses

The stranding data were not normally distributed (Levene's test and Kolmogorov-Smirnov test, all $p < 0.05$). Therefore, non-parametric tests were used. Size frequency distributions and causes of death in both sea turtle species were compared using Mann-Whitney *U* test. Differences in life stages in each sea turtle were tested with Kruskal-Wallis test. The differences in the causes of death in each sea turtle species among the years were tested using the same test. Differences in the frequency distribution of scute deviations were analyzed by Chi-square Fisher's Exact test because the expected count was less than 5.

The percentage of each dataset was calculated by dividing the ratios by overall data, and charts were generated to give these percentages. The percentage of stranding numbers in each year for each sea turtle species was calculated using the following formula, and a chart was generated based on these values. The sum of percentage for each stranded sea turtle species is 100% for all years in the chart.

100* (number of stranding in each year/ number of total strandings in overall years)

The percentage of strandings in each life stage for each sea turtle species was computed using the following formula, and a chart was generated based on these values. The sum of percentage for each stranded sea turtle species is 100% for all life stages in the chart.

100* (number of stranding in each life stage / number of total strandings in overall years)

A percentage distribution chart indicating the causes of death according to years was generated by combining 2 years because there were low numbers of stranded sea turtles in some years. In order to examine temporal variations in the cause of deaths in each category every two years, the percentage of causes of death in each of 2 years was computed using the following formula, and a chart was generated based on these values. The sum of percentage for each stranded sea turtle species is 100% for each two-year category on the chart.

100* (number of each cause of death in two years / number of total causes of death in each of two years)

Total percentage of each cause of death according to years was computed using the following formula, and a chart was generated based on these values. The sum of percentage for each stranded sea turtle species is 100% for all years on the chart.

100* (number of each cause of death in all years / number of total causes of death in all years)

The percentage of scute deviation in each scute pattern for each sea turtle species was calculated with the following formula, and a table was generated based on these values.

100* (number of stranding with scute deviation in each scute pattern / number of total strandings with each scute pattern)

When it was determined that there is at least one scute deviation in each life stage, it was accepted that life stage showed non-normal scute pattern. The percentage of scute deviation in each life stage for each sea turtle species was computed using the following formula, and a chart was generated based on these values. However, chart represents only scute deviant rates in each life stage.

100* (number of stranding with non-normal scute pattern in each life stage/ number of total strandings with scute pattern in all life stages)

Tests for trends in the CCL and the number of stranded sea turtles over the years were performed by means of nonparametric, non-seasonal Mann-Kendall Trend test (Hipel and McLeod 1994). The Mann-Kendall trend test has been used in the long term examination of sea turtles (da Silva et al. 2007; Marcovaldi et al. 2007). In the trend analyses, the Theil-Sen regression and 95% confidence intervals were used to predict the regression constants based on Mann-Kendall Trend test and Kendall correlation coefficient (Sen 1968). Moreover, Theil-Sen trend lines were generated to visualize if there is any trend in the data. The Mann-Kendall tests are based on the calculation of Kendall's tau measure of association between two samples, which is based on the ranks within samples. The computations assume that the observations are independent and data are randomly ordered. However, the existence of positive autocorrelation in the data increases the probability of detecting trends when actually no trends exist or vice versa. Autocorrelation is the similarity of a time series over successive time intervals. It can lead to underestimation of the standard error and predictors can appear as significant when they are not. The null hypothesis of the test is that it does not autocorrelate among the residuals. The null hypothesis is accepted when the computed *p*-value is greater than the significance level of alpha = 0.05.

Hamed and Rao (1998) proposed a modified non-parametric trend test that is suitable for autocorrelated data. They stated that the accuracy of the modified test in terms of its empirical significance level was superior to that of the original Mann-Kendall trend test without any loss of power. The presence of autocorrelation in the residuals of the regression models was tested using the Durbin-Watson statistic. When autocorrelation occurs in the data, the Hamed and Rao method was used for the Mann-Kendall Trend test. The trend test was carried out using XLSTAT 2018 statistical software (Addinsoft, NY, USA). XLSTAT statistical software allows adding and/or removing the effect of autocorrelations with Hamed and Rao method. Other analyses were conducted using SPSS v. 17.0 (SPSS Inc., Chicago, USA) and all means were presented with standard deviation (SD) and min-max values.

RESULTS

A total of 302 stranded turtles were found on Samandağ Beach, the eastern Mediterranean coast of Turkey from 2002 to 2017. There were 167 (55.4%) green turtle, 127 (42%) loggerhead turtle, 2 (0.6%) *Trionyx triunguis*. Six individuals (2%) were unidentified. The mean annual stranding were 10.5 individuals for the green turtle, 7.9 individuals for the loggerhead, and 18.75 for both sea turtles on Samandağ Beach. Percentage distributions of stranded sea turtles among the years are shown in figure 3.

Descriptive statistics of carapace measurements of stranded sea turtles are presented in table 1. One of the most of common measurement in sea turtles is CCL, and it was used as a standard length measurement in this research because there was not enough data for other measurements. The size of CCL showed significant differences between both species (Mann-Whitney U = 4095, Z = -8.139, p = 0.0001). In the green turtle, 11 (6.6%) individuals were adults, 102 (61.5%) were sub-adults, and 53 (31.9%) individuals were in oceanic stage (Fig. 4). All individuals of the green turtles that reached adulthood were females. There were significant differences among life stages of stranded green turtles (χ^2 = 121.432, df = 2, p = 0.0001). Individuals in sub-adult and oceanic stages were intensively stranded on Samandağ Beach between 2002 and 2017.

In the loggerhead turtle, 29 (25.2%) individuals were adults, 81 (70.5%) individuals

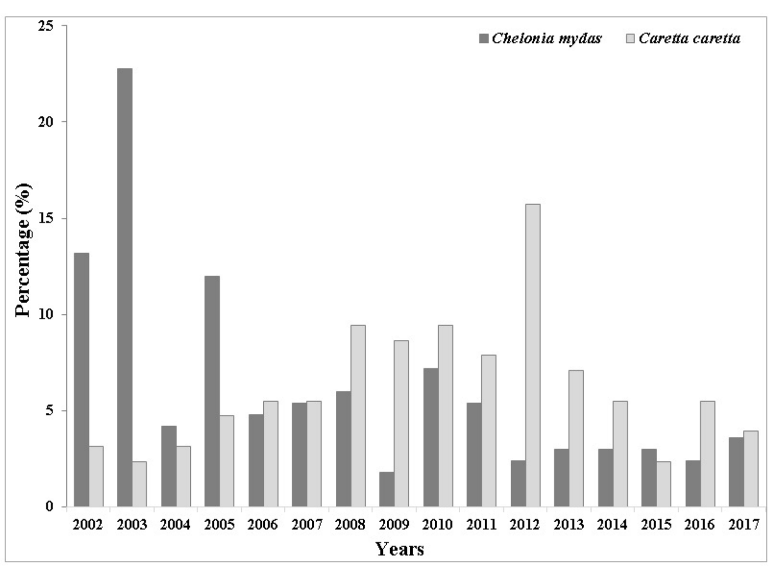

Fig. 3. Yearly percentage of stranded *Caretta caretta* and *Chelonia mydas* individuals on Samandağ Beach between 2002 and 2017 (for each species, the percentage of strandings from all years is 100%).

were sub-adults, and 5 (4.3%) individuals were in the oceanic stage (Fig. 4). Two loggerhead turtles that reached adulthood were males. The loggerhead turtles showed significant differences according to the life stage between 2002 and 2017 on Samandağ Beach (χ^2 = 67.782, *df* = 2, *p* = 0.0001). Unlike with the green turtles, the sub-adult and adult stages of the loggerhead turtles were intensively stranded on Samandağ Beach between 2002 and 2017.

Frequency variations in stranded sea turtles were assessed temporally according to the species. The Durbin Watson test showed no autocorrelation for frequency in the green turtle over the years (*U* = 1.350, *p* = 0.091, *n* = 16). The Mann-Kendall Trend test showed that the number of stranded green turtles tended to decrease over the years (Kendall's tau = -0.468, Sen's slope = -0.775, *n* = 16, *p* = 0.014) (Fig. 5a). However, CCL values in stranded green turtle tended to become slightly larger from 2002 to 2017 (Kendall's tau = 0.181, Sen's slope = 0.080, *n* = 16, *p* = 0.001) (Fig. 5a). CCL values in stranded green turtle over the years did not show an autocorrelation (*U* = 1.833, *p* = 0.142, observation = 166). The Durbin Watson test showed autocorrelation for frequency in the loggerhead turtle over the years (*U* = 0.634, *p* = 0.001, observation = 16). Therefore, the trend of frequency over the years was tested with the Hamed and Rao method in the Mann-Kendall trend test which indicated no tendency over the years in the number of stranded loggerhead turtles (Kendall's tau = 0.366, Sen's slope = 0.50, *n* = 16, *p* = 0.191) (Fig. 5b). The Durbin Watson test showed no autocorrelation for CCL in the stranded loggerhead turtle over the years (*U* = 1.862, *p* = 0.229, observation = 115). Also, the CCL did not showed significantly larger or smaller tendencies from 2002 to 2017 (Kendall's tau = 0.049, Sen's slope = 0.019, *n* = 16, *p* = 0.443) (Fig. 5b).

Causes of deaths in 130 sea turtles were determined on Samandağ Beach, all of them after 2009 because there was no information about it before then. Among these, 50 (38.5%) were

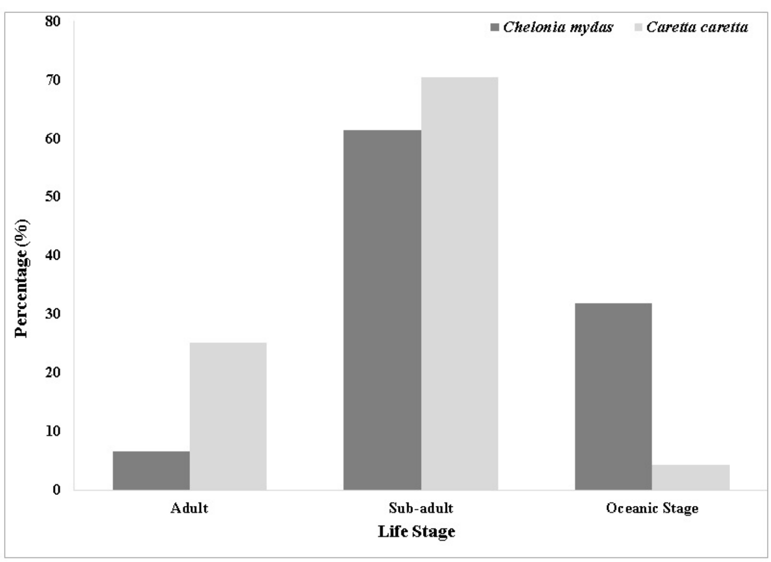

Fig. 4. The percentage of different life stages of stranded *Chelonia mydas* and *Caretta caretta* (for each species, the percentage of strandings from all life stages is 100%).

Table 1. The descriptive statistics of stranding values recorded on Samandağ Beach

	Chelonia mydas			*Caretta caretta*		
	n	Mean ± SD	Range	*n*	Mean ± SD	Range
Curved Carapace Length	166	44.21 ± 19.15	14-106	115	61.45 ± 12.40	13.5-85
Curved Carapace Width	166	39.97 ± 17.23	13-96	115	56 ± 11.64	12.5-80
Straight Carapace Length	55	49.62 ± 20.77	18.5-95	73	57.36 ± 10.69	26-78
Straight Carapace Width	54	40.57 ± 15.69	16.5-73	73	46.94 ± 8.56	21-64

green turtles and 80 (61.5%) were loggerhead turtles. The main cause of death was due to fishing activities (46.9%), followed by marine pollution (27.7%), intentional killing (16.7%), hit by marine vehicles (5.4%), and predation (3.8%). The causes of death showed significant differences between the loggerhead and green turtles (Mann-Whitney U = 1243.5 Z = -3.868, p = 0.0001). The percentage distribution of the causes of death across the years for green turtle is shown in figure 6a. There were significant differences among the years (χ^2 = 14.089, df = 7, p = 0.050). The most frequent cause of death was marine pollution with 28 individuals (56%), followed by intentional killing with 7 individuals (14%), fishing activities with 7 individuals (14%), predation with 5 individuals (10%), and hit by marine vehicles with 3 individuals (6%). The percentage distribution of the causes of death across the years for loggerhead turtle is shown in figure 6b. There were significant differences among the years (χ^2 = 14.529, df = 7, p = 0.043). The most frequent cause of death was fishing activities with 53 individuals (66.25%), followed by intentional killing with 15 individuals (18.75%) (mainly due to the head trauma), marine pollution with 8 individuals (10%), and hit by marine vehicles with 4 individuals (5%).

Totally, 84 stranded green and loggerhead

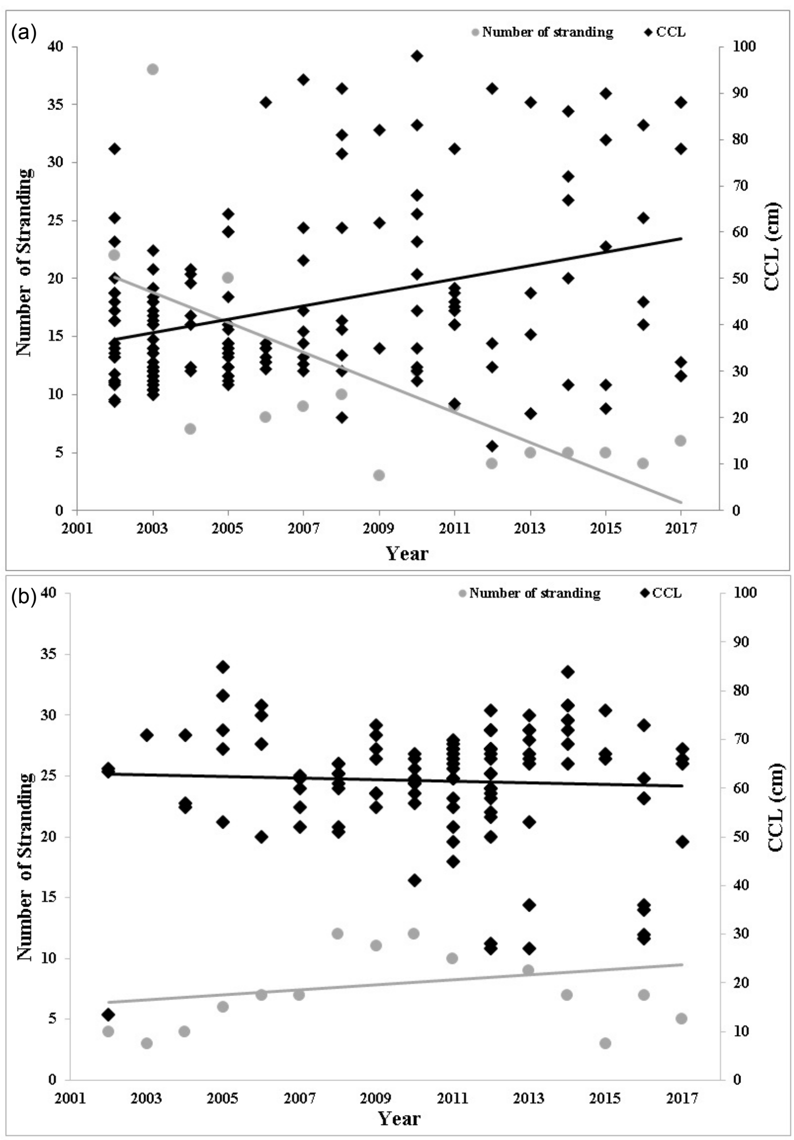

Fig. 5. The temporal change in the number of stranded and CCL values for *Chelonia mydas* (a) and *Caretta caretta* (b) over the years. (Grey dots represent number of stranding, black dots represent curved carapace length (CCL). Black and grey lines are Theil-Sen trend line, see Materials and Methods for details).

turtles were examined for carapacial scute patterns. In the green turtle, the most common carapace scute patterns were 5 vertebral scutes (91.4%), and 4 left and right costal scutes (82.9% and 85.7%, respectively), and 11 right and left marginal scutes (for both 88.6%). In the loggerhead turtle, the most common carapace scute patterns were 5 vertebral scutes (87.8%), 5 left and right costal scutes (91.8% and 98%, respectively), and 12 right and left marginal scutes (95.9% and 100%, respectively). Carapacial scute deviation rates in both sea turtle species are presented in table 2. Carapacial scute deviation rates according to the life stages in both species are shown in figure 7. There were statistically significant differences in scute deviation rates among different life stages in the stranded sea turtle. For example, the Chi-Square Fisher's Exact test revealed significant differences among life stages for right costal scutes in the stranded green turtles (Fisher's Exact = 10.856, p = 0.016). Sub-adult and oceanic stages had more right costal deviations than their adult stage. In stranded loggerhead turtles, both right (Fisher's Exact = 12.273, p = 0.012) and left (Fisher's Exact = 22.712, p = 0.001) costal scutes expressed significant differences among life stages. Moreover, the same result was found in right (Fisher's Exact = 12.093, p = 0.048) and left (Fisher's Exact = 13.520, p = 0.033) marginal scutes. Sub-adult and oceanic stages had more costal and marginal scutes deviations than their adult stage.

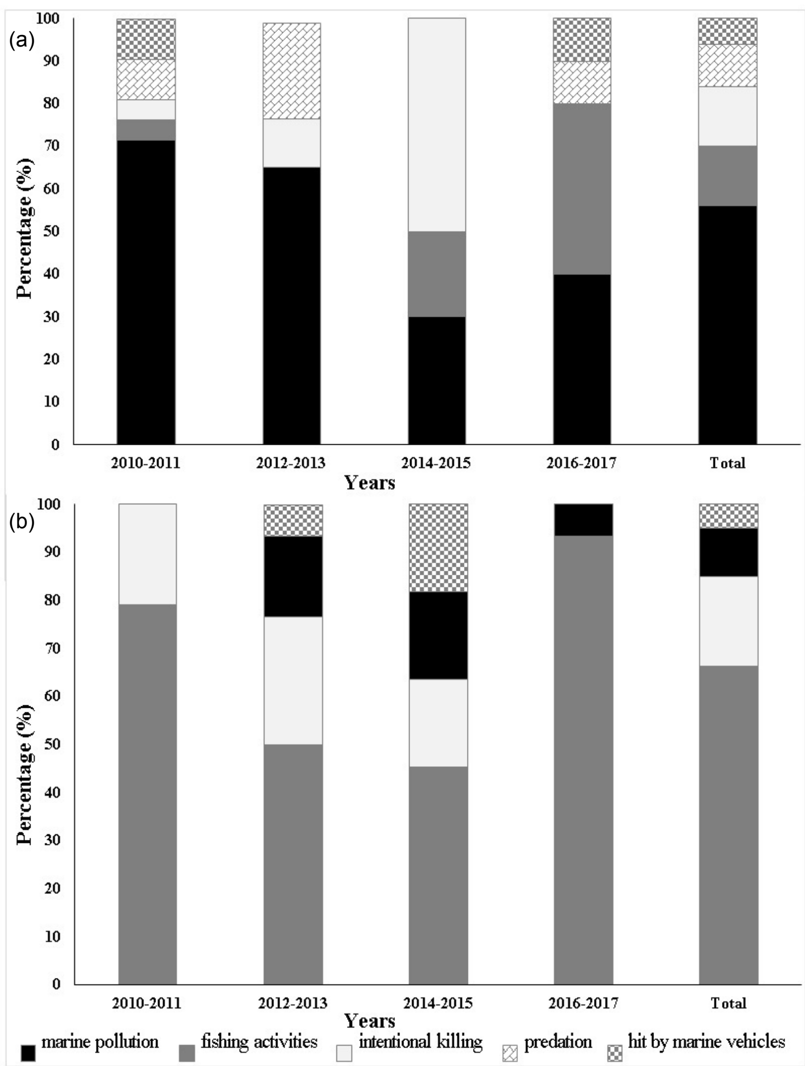

Fig. 6. Percentage distribution of the causes of death for *Chelonia mydas* (a) and *Caretta caretta* (b) across the years (for each species, the percentage of each two years and total years are 100%, and each factor was combined for 2 years due to the low number of stranded in some years).

DISCUSSION

Data on the number of stranded individuals suggests that both sea turtle species were common on Samandağ Beach, Turkey. It turns out that the sample collection season (between April and October) was an appropriate period to determine the stranded value and cause of death. Similarly, Casale et al. (2010) stated that stranded loggerhead turtle recordings were the highest between April and September on the Italian coasts of the Mediterranean from 1980-2008. Moreover, Başkale et al. (2018) stated that both stranded sea turtles recordings peaked between June and August in Fethiye-Göcek Specially Protected Area, Turkey. The result of the present study agrees with results of previous studies.

The mean CCL value in the stranded green turtle was similar to those of previous studies (Baran and Kasparek 1989; Yalçın Özdilek and Aureggi 2006; Türkozan et al. 2013). Although Samandağ Beach is the main nesting area for the green turtles in the Mediterranean Sea, those in the sub-adult and oceanic stages were more intensively stranded than those in the adult stage. A similar result was reported by Türkozan et al. (2013) on the same beach. This result can be explained by the fact that the oceanic and sub-adult green turtles are commonly found in shallow-water neritic habitats (Meylan and Meylan 1999) and they are more exposed to anthropogenic threats. A study on the impact of marine debris ingestion in the stranded green turtles found a negative correlation between the presence of marine debris

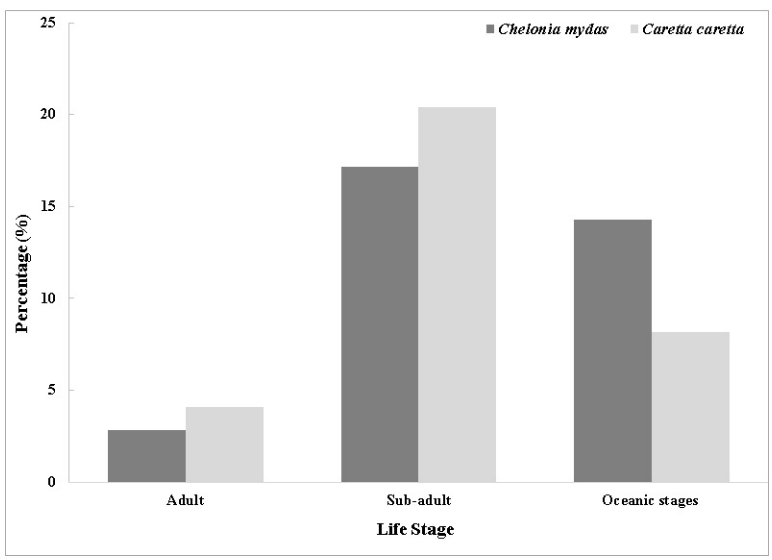

Fig. 7. The percentage of carapacial scute deviation in different life stages of stranded *Chelonia mydas* and *Caretta caretta* (for each species, the ratio represents only scute deviant rate in each life stage).

Table 2. The descriptive statistics of the carapacial scute deviations of stranded sea turtle species (0 = no deviations; 1 = scute deviations)

Scute Pattern	Deviation	*Chelonia mydas* (*n* = 35)	*Caretta caretta* (*n* = 49)
Vertebral	0 (%)	91.4	87.8
	1 (%)	8.6	12.2
Costal (Left)	0 (%)	82.9	91.8
	1 (%)	17.1	8.2
Costal (Right)	0 (%)	85.7	98
	1 (%)	14.3	2
Marginal (Left)	0 (%)	88.6	95.9
	1 (%)	11.4	4.1
Marginal (Right)	0 (%)	88.6	100
	1 (%)	11.4	0

and green turtle's size in the Uruguayan waters between 2005 and 2013 (Velez-Rubio et al. 2018). Moreover, Snape et al. (2013) stated that juvenile green turtles are more sensitive to fishing activities than adults regarding the differences in habitat use patterns. Another possible explanation is that juvenile green turtle individuals are foraging on Samandağ Beach; this is supported by CCL values (mean 40.6 cm) (Yalçın-Özdilek and Aureggi 2006). Juvenile developmental habitat in the eastern Mediterranean might include areas near Samandağ Beach. Based on this information, Samandağ Beach might be a part of the eastern Mediterranean feeding area for the green sea turtles. However, it was also reported that western coasts of the Turkish Mediterranean might be a foraging area for sub-adult green turtles (Türkozan and Durmuş 2000). A recent study found that Fethiye-Göcek Specially Protected Area is covered by seagrass beds that are the main food source for the green turtles (Başkale et al. 2018). According to satellite telemetry studies, the most intensive foraging area for post-nesting green sea turtles was coastal waters of North Africa (especially Libya, Gulf of Bomba, and Gulf of Sirte) (Godley et al. 2002; Stokes et al. 2015). Stranding records on Samandağ Beach may be caused by sea surface currents from south to north in the Mediterranean Sea (Hecht et al. 1988; Türkozan et al. 2013). These sea currents may drift dead turtles in the foraging area (coastal waters of North Africa), and accumulate at Samandağ beach. Because Samandağ Beach located in the Mediterranean shoreline that is on the main path of sea currents (Millot and Taupier-Letage 2005).

Although Samandağ Beach has a low loggerhead nesting abundance, the number of stranded adult and sub-adult individuals is very high. A similar result was reported by Türkozan et al. (2013) on the eastern Mediterranean coast of Turkey. Moreover, Snape et al. (2013) stated that the mean CCL of stranding loggerhead turtle was 65 cm on the North Cyprus beaches, and most of them were adult and sub-adult. Fishery activities are a global major threat to loggerhead turtles, and it is mostly large turtles that are caught in fishing areas in the eastern Mediterranean (Casale 2011). Adult and sub-adult loggerhead turtles, which use the eastern Mediterranean as a feeding ground (Oruç 2001), may be adversely affected by fishing activities. Similarly, the present study found that the most common cause of stranding loggerhead turtles was fishing activities. However, it was claimed that individuals using this foraging area may originally come from distant nesting areas (Türkozan et al. 2018). Moreover, Casale and Mariani (2014) stated that the neighboring Levantine zone is a nursery area for the Mediterranean Sea turtles and individuals that hatched on Turkey's nesting beaches and dispersed to Levantine zones. However, stranded individuals might have a different natal origin (Türkozan et al. 2013). According to a study on the natal origin of stranded loggerhead turtles in the eastern Mediterranean, individuals from eastern feeding grounds came mostly from the western nesting populations of Turkey; based on mixed stock analyses (Türkozan et al. 2018). Samandağ Beach might be one of the eastern feeding areas in the Mediterranean Sea for those hatched on western beaches of Turkey. Therefore, studies on the natal origins of stranded individuals on Samandağ Beach will provide vital information for the survival of both turtle species.

Although the number of stranded green turtles has decreased over the years, the body size (CCL) of the stranded green turtles has shown a weak increase. However, stranding of loggerhead turtles showed no trend in frequency or CCL. Türkozan et al. (2013) reported an increased number of loggerhead strandings, whereas the number of green turtle strandings decreased on ten nesting beaches in the eastern Mediterranean coast. Corsini-Foka et al. (2013) recorded stranded sea turtles from 1984-2011 in Rhodes Island in Greece (140 of the total strandings were dead specimens) and found an increasing trend for both species. The number of green turtle strandings highly increased after 2000 in particular (Corsini-Foka et al. 2013). Similarly, the number of strandings increased for both species during 2000-2016 but the increase was notable only in the last four years (Başkale et al. 2018). A reason for a low stranding numbers in the early years of their study may be due to low awareness. As peoples' awareness increases, accessing stranded turtle information via denunciation might be easier. A decreasing tendency on Samandağ Beach may be related to the increase in local peoples' (*e.g.*, fishers and touristic business owners) awareness regarding sea turtles. Sea turtle conservation efforts on Samandağ Beach began in 2001 and since then peoples' awareness about sea turtles may have increased. Number of stranded green turtles have decreased, but their CCL values have weakly increased over the years. For example, there was an increase in stranded green turtle CCL in Rhodes Island, especially after 2000

(Corsini-Foka et al. 2013). Adults are important for the reproductive output of sea turtle populations (Lewison and Crowder 2007) and the number of nests and eggs in the future may be affected by the variation in adult number. The increase in CCL values on Samandağ Beach over the years may be due to 5 adult individuals predated by jackals or dogs during their egg-laying period, especially after 2012.

The most common causes of strandings on Samandağ Beach are fishing activities and marine pollution. Although the cause of death due to fishing activities shows fluctuations across the years, fishing activities are the most common cause of strandings in the loggerhead turtle on the Samandağ Beach. Sea turtles are mostly captured as a bycatch in trawling, seine fishing, and longline net fishing (Chan et al. 1988; Poiner et al. 1990; Robins 1995). In a review of the last few decades in the Mediterranean Sea, Casale (2011) estimated that annually over 132,000 sea turtles were accidentally captured and one-third of them died. Similarly, high rates of accidentally caught sea turtles by bottom trawlers were reported on the eastern Mediterranean coast of Turkey (Oruç 2001). Fishing activities are the main cause of strandings in Fethiye, specifically in protected areas in the western Mediterranean (Başkale et al. 2018). Fishing gear is also cause stranding in both sea turtle species in Rhodes Island (Corsini-Foka et al. 2013). The fact that fishermen do not have sufficient knowledge or equipment to save accidentally caught turtles may lead to the drowning and death of sea turtles. Fishermen should use a turtle excluder device (TED) to prevent this problem.

Although death from marine pollution has been declining over the years, marine pollution was the main cause of the stranded green turtles on the Samandağ Beach. Rope entanglement is the main problem in the oceanic stage. Nylon bags in the digestive system of oceanic and sub-adult stage stranded green turtles were detected after necroscopy. However, debris were not classified in terms of color, size, and type. Bugoni et al. (2001) found that most of the 38 sub-adult stranded green turtles sampled died due to marine debris such as plastic bags, plastic rope, cloth, and styrofoam. Similar results were found for Mediterranean loggerhead turtles (Lazar and Gracan 2011). Even small quantities of marine debris can cause death in animals due to gut obstruction (Bjorndal et al. 1994). For example, 1.4-3.2 g marine debris could block the digestive tract (Bugoni et al. 2001). Plastics are the most common marine litter in the eastern Mediterranean and there is a large number of plastics and packaging debris in commercial fishing areas (Eryaşar et al. 2014). Cozar et al. (2015) reported that plastic pollution in the Mediterranean Sea was 1934 item/km^2. In a recent study, micro and mesoplastic presence were determined to be 0.376 items/m^2 on average in the eastern Mediterranean Sea (Gündoğdu and Çevik 2017). The density of plastic material in the eastern Mediterranean will adversely affect lives of sea turtles that use the region as a development area. The effect of marine pollution on the marine organisms is an important threat and, therefore, more studies are needed examining the effect of marine plastic debris on the sea turtle populations in the Mediterranean Sea.

Carapical scute deviation has mostly been investigated in sea turtle hatchlings (Mast and Carr 1989; Türkozan et al. 2001; Özdemir and Türkozan 2006; Sönmez et al. 2011), but there are only a limited number of studies about carapace scute deviations in adult sea turtles (Suganuma et al. 1994; Türkozan et al. 2001; Ergene et al. 2011) and there is no study for oceanic and sub-adult stages. Carapacial scute deviation rate in oceanic and sub-adult stages showed more deviations than their adults in both sea turtle species. Adult turtles tended to have fewer scute deviations than hatchlings (Suganuma et al. 1994; Türkozan et al. 2001). Suganuma et al. (1994) recorded that 5% of adult females and 3.3% of males showed scute variation in green turtles. There were variations only in marginal scutes of loggerhead adult female turtles (Türkozan et al. 2001). Similar results were reported by Ergene et al. (2011) for adult green turtles. Özdemir and Türkozan (2006) suggested that the lack of adults with abnormal scute numbers could be explained in two ways: “hatchlings with deviant counts die before they mature, or the plates change to the normal number with growth”. Most of the oceanic and sub-adult stages that have scute deviation probably die before they become an adult due to marine pollution or fishing activities.

In conclusion, all life stages in both sea turtle species were represented in the Samandağ Beach strandings. Although sub-adult and oceanic stages were the most found among stranded green turtles, most loggerheads found were in the sub-adult and adult stages. Samandağ Beach may be a development and/or feeding area for sub-adult individuals for both turtle species. Stranded green turtle numbers have decreased over the years but their CCL values have weakly increased. This increase may have a negative effect on the reproductive output of the green turtle in future. Marine pollution and fishing activities are the most important causes of stranding for both species. Plastic materials are particularly risky for the oceanic and sub-adult stages. Stranded adult sea turtles on Samandağ Beach showed lower carapace scute deviation rates than their oceanic and sub-adult stages. Oceanic and sub-adult stages that showing high rate scute deviation are probably more sensitive to negative conditions in the marine habitat, and they die before they become an adult. Natal origin of stranded sea turtles on Samandağ Beach should be investigated for an effective management action plan in the Mediterranean Sea. Moreover, an effective stranding network system should be urgently established in the Mediterranean Sea. The present study provides long-term data about stranded sea turtles in the eastern Mediterranean coast of Turkey.

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Availability of data and materials: All number of strandings in each category in each year in Supplementary material.

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REFERENCES

Baran I, Kasparek M. 1989. On the whereabouts of immature sea turtles (*Caretta caretta* and *Chelonia mydas*) in the eastern Mediterranean. Zool Middle East **3:**31-36.

Başkale E, Sözbilen D, Katılmış Y, Azmaz M, Kaska Y. 2018. An evaluation of sea turtle strandings in the Fethiye-Göcek Specially Protected Area: An important foraging ground with an increasing mortality rate. Ocean Coast Manage **154:**26-33. doi:10.1016/j.ocecoaman.2018.01.003.

Bjorndal KA. 1997. Foraging ecology and nutrition of sea turtles. *In*: Lutz PL, Musick JA (Eds) The biology of sea turtles. CRC Press, Boca Raton, Florida, USA, pp. 199-231.

Bjorndal KA, Bolten AB, Lagueux CJ. 1994. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. Mar Pollut Bull **28:**154-158.

Bugoni L, Krause L, Petry MV. 2001. Marine debris and human impacts on sea turtles in Southern Brazil. Mar Pollut Bull **42(12):**1330-1334.

Canbolat AF. 2004. A review of sea turtle nesting activity along the Mediterranean coast of Turkey. Biol Conserv **116:**81-91. doi:10.1016/S0006-3207(03)00179-4.

Candan O, Canbolat AF. 2018. New record of a Leatherback (*Dermochelys coriacea*) stranding in Turkey. Biharean Biol **12(1):**56-57.

Casale P. 2011. Sea turtle by-catch in the Mediterranean. Fish and Fisheries **12:**299-316. doi:10.1111/j.1467-2979.2010.00394.x.

Casale P. 2015. *Caretta caretta* (Mediterranean subpopulation). The IUCN red list of threatened species 2015. doi:10.2305/IUCN.UK.2015-4.RLTS.T83644804A83646294.en.

Casale P, Affronte M, Insacco G, Freggi D, Vallini C, Pino d'Astore P, Basso R, Paolillo G, Abbate G, Argano R. 2010. Sea turtle strandings reveal high anthropogenic mortality in Italian waters. Aquat Conserv **20:**611-620.

Casale P, Freggi D, Basso R, Argano R. 2005. Size at male maturity, sexing methods and adult sex ratio in loggerhead turtles (*Caretta caretta*) from Italian waters investigated through tail measurements. Herpetol J **15:**145-148.

Casale P, Margaritoulis D. 2010. Sea turtles in the Mediterranean: distribution, threats and conservation priorities. IUCN, Gland, Switzerland, pp. 1-14.

Casale P, Mariani P. 2014. The first 'lost year' of Mediterranean Sea turtles: dispersal patterns indicate subregional management unit for conservation. Mar Ecol Prog Ser **498:**263-274. doi:10.3354/meps10640.

Chaloupka M, Work TM, Balazs GH, Murakawa SKK, Morris R. 2008. Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago. Mar Biol **154:**887-898.

Chan EH, Liew HC, Mazlan AG. 1988. The incidental capture of sea turtles in fishing gear in Terengganu, Malaysia. Biol Conserv **43(1):**1-7. doi:10.1016/0006-3207(88)90074-2.

Corsini-Foka M, Kondylatos G, Santorinios E. 2013. Increase of sea turtles stranding records in Rhodes Island (eastern Mediterranean Sea): update of a long-term survey. J Mar Biol Assoc UK **93(7):**1991-2002.

Cozar A, Sanz-Martin M, Marti E, Gonzalez-Gordillo JI, Ubeda B, Galvez JA, Irigoien X, Duarte CM. 2015. Plastic accumulation in the Mediterranean sea. PLoS ONE **10:**1-12. doi:10.1371/journal.pone.0121762.

da Silva ACCD, de Castilhos JC, Lopez GG, Barata PCR. 2007. Nesting biology and conservation of the olive ridley sea turtle (*Lepidochelys olivacea*) in Brazil, 1991/1992 to 2002/2003. J Mar Biol Assoc UK **87:**1047-1056. doi:10.1017/S0025315407056378.

Ergene S, Aymak C, Uçar AH. 2011. Carapacial scute variation in green turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*) hatchlings in Alata, Mersin, Turkey. Turk J Zool **35:**343-356. doi:10.3906/zoo-0808-8.

Eryaşar AR, Özbilgin H, Gücü AC, Sakınan S. 2014. Marine debris in bottom trawl catches and their effects on the selectivity grids in the north eastern Mediterranean. Mar Pollut Bull **81(1):**80-84.

Godley BJ, Richardson S, Broderick AC, Coyne MS, Glen F, Hays GC. 2002. Long-term satellite telemetry of the movements and habitat utilisation by green turtles in the Mediterranean. Ecography **25:**352-362.

Gündoğdu S, Çevik C. 2017. Micro and mesoplastics in Northeast Levantine coast of Turkey: the preliminary results from surface samples. Mar Pollut Bull **118:**341-347. doi:10.1016/j.marpolbul.2017.03.002.

Hamed KH, Rao AR. 1998. A modified Mann-Kendall trend test for autocorrelated data. J Hydrol **204:**182-196. doi:10.1016/S0022-1694(97)00125-X.

Hecht A, Pinardi N, Robinson AR. 1988. Currents, water masses, eddies and jets in the Mediterranean levantine basin. J Phys Oceanogr **18:**1320-1353.

Hipel KW, McLeod AI. 1994. Time series modeling of water resources and environmental systems. Elsevier, Amsterdam, the Netherlands.

Lazar B, Gracan R. 2011. Ingestion of marine debris by loggerhead sea turtles, *Caretta caretta*, in the Adriatic Sea. Mar Pollut Bull **62:**43-47.

Lewison RL, Crowder LB. 2007. Putting longline bycatch of sea turtles into perspective. Conserv Biol **21:**79-86.

Marcovaldi MA, Lopez GG, Soares LS, Santos AJB, Bellini C, Barata PCR. 2007. Fifteen years of hawksbill sea turtle (*Eretmochelys imbricata*) nesting in northern Brazil. Chelonian Conserv Biol **6:**223-228.

Mast BR, Carr JL. 1989. Carapacial scute variation in Kemp's Ridley sea turtle (*Lepidochelys kempii*) hatchlings and juveniles. *In*: Caillouet CW, Landry AM (Eds) Proceeding of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. TAMU-SG-89-105, pp. 202-219.

Meylan AB, Meylan PA. 1999. Introduction to the evolution, life history, and biology of sea turtles. *In*: Eckert KL, Bjorndal KA, Abreu-Grobois FA, Donnelly M. (Eds.) Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group, Publ. No. 4, pp. 3-5.

Millot C, Taupier-Letage I. 2005. Circulation in the Mediterranean Sea. The Mediterranean Sea in handbook of environmental chemistry. Springer Berlin, ISBN: 978-3-540-25018-0, Vol 5K: 29-66.

Oruç A. 2001. Trawl fisheries in the eastern Mediterranean and its impact on marine turtles. Zool Middle East **24:**119-125. doi:10.1080/09397140.2001.10637890.

Özdemir B, Türkozan O. 2006. Carapacial scute variation in green turtle, *Chelonia mydas* hatchlings in Northern Cyprus. Turk J Zool **30:**141-146.

Plotkin P, Amos AF. 1990. Effects of anthropogenic debris on sea turtles in the northwestern Gulf of Mexico. *In*: Shomura RS, Godfrey ML (Eds.) Proceedings of the Second International Conference of Marine Debris. Honolulu, Hawaii, NOAA Tech Memo, NMFS, pp. 736-743.

Poiner IR, Buckworth RC, Harris ANM. 1990. Incidental capture and mortality of sea turtles in Australia's northern prawn fishery. Mar Freshwater Res **41(1):**97-110. doi:10.1071/MF9900097.

Reich KJ, Bjorndal KA, Bolten AB. 2007. The 'lost years' of Green turtles: Using stable isotopes to study cryptic life stages. Biol Lett **3:**712-714. doi:10.1098/rsbl.2007.0394.

Robins JB. 1995. Estimated catch and mortality of sea turtles from the east coast otter trawl fishery of Queensland, Australia. Biol Conserv **74(3):**157-167. doi:10.1016/0006-3207(95)00025-Y.

Seminoff JA. 2004. *Chelonia mydas*. The IUCN red list of threatened species 2004: e.T4615A11037468. doi:10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en.

Sen PK. 1968. Estimates of regression coefficient based on Kendall's tau. J Am Stat Assoc **63:**1379-1389.

Snape RTE, Beton D, Broderick AC, Çiçek BA, Fuller WJ, Özden Ö, Godley BJ. 2013. Strand monitoring and anthropological surveys provide insight into marine turtle bycatch in small-scale fisheries of the Eastern Mediterranean. Chelonian Conserv Biol **12:**44-55.

Sönmez B, Turan C, Yalçın Özdilek Ş. 2011. The effect of relocation on the morphology of green turtle, *Chelonia mydas* (Linnaeus, 1758) hatchling on Samandağ beach, Turkey. Zool Middle East **52:**29-38.

Stokes KL, Broderick AC, Canbolat AF, Candan O, Fuller WJ, Glen F, Levy Y, Rees AF, Rilov G. Snape RT, Stott I, Tchernov D, Godley BJ. 2015. Migratory corridors and foraging hotspots: critical habitats identified for Mediterranean green turtles. Divers Distrib **21:**665-674. doi:10.1111/ddi.12317.

Suganuma H, Hopjkoshi K, Tachikawa H. 1994. Scute deviation of green turtle hatchlings from a hatchery in Ogasawara Islands, Japan. *In*: Bjorndal KA, Bolten AB, Johnson DA, Eliazar PJ (Eds) Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS - SEFSC **351:**148.

Türkozan O, Durmuş SH. 2000. A feeding ground for juvenile green turtles, *Chelonia mydas*, on the western coast of Turkey. Bri Herp Soc Bull **71:**1-5.

Türkozan O, Ilgaz Ç, Sak S. 2001. Carapacial scute variation in loggerhead turtles, *Caretta caretta*. Zool Middle East **24:**137-142. doi:10.1080/09397140.2001.10637893.

Türkozan O, Kaska Y. 2010. Turkey. *In*: Casale P, Margaritoulis D (Eds) Sea turtles in the Mediterranean: distribution, threats and conservation priorities. IUCN, Gland, pp. 257-293

Türkozan O, Yalçın Özdilek Ş, Ergene S, Uçar AH, Sönmez B, Yılmaz C, Kaçar Y, Aymak C. 2013. Strandings of loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles along the eastern Mediterranean coast of Turkey. Herpetol J **23:**11-15.

Türkozan O, Yılmaz C, Uçar AH, Carreras C, Ergene S, Aymak C, Karaman S. 2018. Local differentiation in the origin of stranded loggerhead turtles, *Caretta caretta*, within an eastern Turkey foraging area. Ocean Coast Manage **153:**70-75. doi:10.1016/j.ocecoaman.2017.12.011.

Velez-Rubio GM, Teryda N, Asaroff PA, Estrades A, Rodriguez D, Tomas J. 2018. Differential impact of marine debris ingestion during ontogenetic dietary shift of green turtles in Uruguayan waters. Mar Pollut Bull **127:**603-611. doi:10.1016/j.marpolbul.2017.12.053.

Yalçın Özdilek Ş, Aureggi M. 2006. Strandings of juvenile green turtles at Samandağ, Turkey. Chelonian Conserv Biol **5:**152-154. doi:10.2744/1071-8443(2006)5[152:SOJGTA]2.0.CO;2.

Supplementary material

Table S1. The number of causes of death in each category by year in the both stranded sea turtle. (download)