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Predation by Mediterranean monk seal on a loggerhead turtle in Greece - see pages 18-23 (photo: S. Touliatou/ARCHELON).
Editorial: It’s The Humans, Stupid!

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While I readily accepted the kind invitation of the guest editors to draft the editorial of this special edition of the Marine Turtle Newsletter, I didn’t realize how difficult my task was. Pondering for an appropriate subject, I had the opportunity to look back at my 35 years of working with, and for the, sea turtles in Greece and also at the many years of liaising with knowledgeable colleagues in the Mediterranean and elsewhere. In my agonizing search for a subject, a persisting question was recurring in my mind: “in a dramatically changing world what will be the future of sea turtles?”

Sea turtle interactions with humans are known since immemorial times, and these interactions have shaped the existing sea turtle populations and the related marine ecosystems, and even the biological aspects of sea turtles as we know them today (Bjornstad & Jackson 2003, Frazier 2003).

In the eastern Mediterranean Sea, green turtles (mainly) have suffered enormous exploitation by humans going back at least 100 years (Sella 1995). The consequences of this exploitation to the turtle populations themselves and also to the related ecosystems, in which these populations were functioning, are not known.

Today, in the Mediterranean, humans are sprawling fast and steadily along its coastal zone with hotels, golf courses, summertime houses, seaside roads, and marinas. This coastal urbanization has gradually eaten into significant habitats and stunning landscapes. Furthermore, some of these constructions are ill-designed, if not illegal, and in many cases cause considerable erosion at nearby nesting beaches. Typical examples of such erosion are found along the northern coast of the Island of Crete, with the nesting beaches of Rethymno and Chania gradually disappearing and the associated turtle populations declining.

By the way, Greece is the only country in Europe, if not in the world, where building of houses is permitted outside planned human settlements. Several of the famed Greek islands have already been badly degraded by the hundreds of villas now speckling the once typically bare island landscapes. Similarly, on the mainland, highly productive fields have been transformed to not-so-productive luxury houses with swimming pools, used only a couple of months per year. This insanity, called “building outside planning” (sic), is legally established and, regrettably, very popular. It is therefore a matter of time that most of the accessible coastline in Greece will be built up.

Someone would argue “Well, this can be a reason for establishing protected areas”. Although this is true in theory, in reality the only nesting area protected by law in Greece is that of Laganas Bay, on the Island of Zakynthos, featuring a National Marine Park. Although, the creation of the Park was admittedly an important milestone in sea turtle conservation in Greece, and also in the Mediterranean because of the regional importance of Zakynthos, the situation is far from being bright in the long run. Indeed, the Park has not yet managed to build up its own resources and is still at the mercy of the financing priorities of the central government. Furthermore, the management responsibilities of the Park are focused primarily on its terrestrial part and, despite its name, much less on the neighbouring marine area. But even if this marine area, used by turtles as their inter-nesting area, would acquire full protection and adequate enforcement, this would not still be enough to safeguard the population because most nesting turtles migrate to far-away foraging areas, such as the Gulf of Gabès and the northern Adriatic, which fall in the jurisdiction of other nations. So far, no binding treaty has been developed to encompass these nations in a supra-national conservation scheme concerning sea turtles.

All other major nesting areas in Greece are actually unprotected, despite being all in the NATURA 2000 Network of the European Union. Kyparissia Bay, the second largest nesting area of loggerheads in the Mediterranean, with a long and wide sandy shore hosting an extensive coastal pine forest, several rivers and magnificent sand dunes, is gradually being degraded and recently found itself under severe pressure to be developed.

Furthermore, overfishing and long-time destructive practices have caused a documented decline of fish landings in the Mediterranean (Garcia et al. 2005). This is not confined only to target species but also to non-commercial fauna as well as to disruption of sensitive habitats because our fisheries are not yet managed in a broader ecosystem context. As a consequence, sea turtles as well as other marine fauna fall victim to a disrupted food-web structures or to resultant antagonism with fishers. More and more turtles are killed every year in Greece from frustrated fishermen struggling for a meagre fish catch. Human activities have distorted the marine ecosystem so much that the monk seals of Zakynthos are forced to eat loggerheads as summertime meals. A holistic approach to integrate fishing activities within the structure and function of marine ecosystems is regrettably lacking.

If we add to these problems the incoming climate change, the overall picture looks increasingly gloomy. Because sea turtles live in a medium with a huge thermal inertia, climate change will impact first humans. Sea turtles, if left alone, would be able, to a certain degree, to adapt to the expected environmental changes by establishing new nesting beaches, to avoid the rising sea water, and by modifying nesting seasons, to overcome biased sex ratios caused by increasing ambient temperatures. Of course, sea turtles will have eventually problems too, but these problems will rather be caused by the expected devastating disorder of the established human “way of life.”

It’s no secret that climate change will create overwhelming disruptions in agriculture and fisheries as well as in the availability of food and water, new diseases will emerge, and all this chaos will unavoidably lead to large-scale human migrations. We cannot even imagine in what ways the humans will react to this scenario, as a result of their disrupted lives. For the time being, and despite the early warnings, people in developed nations carry on with their
business as usual, while those in developing countries struggle to survive day to day and are most likely astonished at the enormous wealth that has been concentrated into the hands of few.

But we shouldn’t be exceptionally pessimistic nor dramatic. Despite the glumness, I can see some hope. First, there is a growing trend at international organizations and in several governments around the globe in working seriously towards ecological and social justice, which are entirely intertwined. Second, there is now an outstanding base of knowledge - produced by many young researchers - upon which management and conservation schemes can be firmly based. Finally, and despite our current efforts to behave carelessly as a species, we can in fact be responsible and ingenious. When circumstances become truly rough we may well rise to a new level of intellect and wisdom, and start at last performing like a proper Homo sapiens.


Reproductive Data of Loggerhead Turtles in Laganas Bay, Zakynthos Island, Greece, 2003-2009

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Laganas Bay on the Island of Zakynthos, Greece, hosts the largest nesting aggregation of the loggerhead turtle (Caretta caretta) in the Mediterranean (Margaritoulis et al. 2003, Margaritoulis 2005). Laganas Bay has a southeastern orientation with a coastline of approximately 20 km, with an opening of about 12 km. The nesting area consists of 5.5 km of suitable nesting habitat which covers six distinct beaches (see Fig. 1 and Table 1). These beaches vary greatly in the degree of development, human use, accessibility, slope, orientation, substrate composition, and color. Detailed descriptions of these beaches, the major problems they face, together with their climatic conditions, appear in Margaritoulis (2005). Because of the importance of Laganas Bay, the National Marine Park of Zakynthos (NMPZ) was established in 1999 and in 2000 a specific Management Agency was formed. The creation of the NMPZ and its Management Agency are major steps forward in the protection of the area, primarily by incorporating local opinions and through promoting a more balanced situation, enforcement of existing regulations, and the implementation of an effective warden scheme on the nesting beaches.

The nesting effort and associated reproductive data in Laganas Bay have been systematically monitored by ARCHELON since 1984; in the last few years the monitoring work has been carried out in cooperation with the NMPZ under a more detailed protocol. Nesting data from 1984 through 2002 have shown no specific population trends probably because of the relatively high inter-annual variability of nesting effort (Margaritoulis 2005). We present here the main reproductive data of the loggerhead turtles in Laganas Bay for the 7-year period 2003-2009.

The basic methodology of the monitoring work is described in Margaritoulis (2005). For the

**Figure 1.** Laganas Bay, Zakynthos Island, Greece, with the six beaches comprising loggerhead nesting habitat: MAR=Marathonissi, LAG=East Laganas; KAL=Kalamaki, SEK=Sekania, DAP=Daphni, GER=Gerakas.)
facilitation of the reader, we provide below a short summary with emphasis on the points in which data collection has been improved.

**Determination of nesting and hatching activity.** Emergence tracks of adult females as well as hatchlings’ tracks were recorded daily during surveys from mid May through mid-October. Each nest’s location was marked by measuring distances to two fixed points at the back of the beach and its distance to the water. Emerged nests were identified by the presence of hatching tracks, and were marked and monitored until their post-hatch excavation. The position of an emerged nest was matched with the position of a laid nest through triangulation measurements. Further, a number of nests were marked during night work by inserting a small coded stone at the bottom of the egg chamber (before egg laying). In this way the identification of a particular nest could be double-checked during post-hatch excavation. In addition, some nests were caged in situ to avoid human disturbances; in these cases the precise location of the egg chamber was effected by hand-digging the sand, in the day following oviposition, until the appearance of the uppermost eggs in the clutch. Nests caged in situ were monitored until emergence and subjected to post-emergence excavation; if nests showed no sign of hatching emergence, they were excavated after about 90 days after egg-laying. Further, a small number of nests were relocated to avoid inundation, but these nests were excluded from the present analysis.

*Clutch size, hatching success, emergence success.* Clutch size, hatching success, and hatchling emergence success were calculated from emerged nests that were neither relocated nor depredated. Emerged nests were usually excavated 10-17 days after the first hatching emergence. Excavation was done by hand and nest contents were sorted as hatched eggs, unhatched eggs and hatchlings (dead or alive). The number of hatched eggs was determined by counting egg shells greater than 50% of a whole egg shell.

Hatchlings found live in the nest were considered as non-viable. By counting the grouped categories of nest contents we calculated: (1) clutch size as the sum of hatched and unhatched eggs, (2) hatching success as the percentage of hatched eggs relative to clutch size, (3) hatchling emergence success as the percentage of eggs, which produced hatchlings able to exit the nest (viable hatchlings), relative to clutch size. A clutch size of 200 or more eggs was excluded from the analysis as assumed to be excavation of two nests laid next to each other, which is not uncommon in beach zones that have the highest nest density.

**Incubation duration.** Incubation duration, i.e. elapsed days from egg-laying until the emergence of the first hatching, was calculated for non-relocated and non-depredated nests with a known date of egg-laying.

**Emerged hatchlings.** The annual number of viable hatchlings produced was calculated, over the entire nesting habitat, by multiplying total the number of hatched nests by the average clutch size and by the average hatchling emergence success of the particular season.

### Table 1. Annual nesting activity per beach at Laganas Bay; E: number of emergences, N: number of nests, NS: nesting success (%), ND: nesting density (nests/km); MAR: Marathonissi, LAG: East Laganas, KAL: Kalamaki, SEK: Sekania, DAP: Daphni, GER: Gerakas. Beach lengths are given in parentheses.

<table>
<thead>
<tr>
<th>Year</th>
<th>MAR (0.4 km)</th>
<th>LAG (2.8 km)</th>
<th>KAL (0.5 km)</th>
<th>SEK (0.6 km)</th>
<th>DAP (0.6 km)</th>
<th>GER (0.6 km)</th>
<th>Total (5.5 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E</td>
<td>N</td>
<td>NS</td>
<td>E</td>
<td>N</td>
<td>NS</td>
<td>E</td>
</tr>
<tr>
<td>2003</td>
<td>276</td>
<td>117</td>
<td>42.4</td>
<td>321</td>
<td>93</td>
<td>29.0</td>
<td>372</td>
</tr>
<tr>
<td>2004</td>
<td>370</td>
<td>158</td>
<td>42.7</td>
<td>511</td>
<td>131</td>
<td>25.6</td>
<td>483</td>
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<tr>
<td>2005</td>
<td>353</td>
<td>82</td>
<td>23.2</td>
<td>468</td>
<td>98</td>
<td>20.9</td>
<td>423</td>
</tr>
<tr>
<td>2006</td>
<td>262</td>
<td>85</td>
<td>32.4</td>
<td>405</td>
<td>107</td>
<td>26.4</td>
<td>366</td>
</tr>
<tr>
<td>2007</td>
<td>271</td>
<td>103</td>
<td>38.0</td>
<td>459</td>
<td>146</td>
<td>31.8</td>
<td>401</td>
</tr>
<tr>
<td>2008</td>
<td>269</td>
<td>100</td>
<td>37.2</td>
<td>438</td>
<td>147</td>
<td>33.6</td>
<td>358</td>
</tr>
<tr>
<td>2009</td>
<td>234</td>
<td>47</td>
<td>20.1</td>
<td>646</td>
<td>159</td>
<td>24.6</td>
<td>226</td>
</tr>
<tr>
<td>Mean</td>
<td>291</td>
<td>99</td>
<td>33</td>
<td>464</td>
<td>126</td>
<td>27</td>
<td>376</td>
</tr>
</tbody>
</table>

### Table 2. Important seasonal dates at Sekania, the most turtle-frequented beach in Laganas Bay. First survey always started on 15 May except 2008 when it started on 16 May. ED: Elapsed days from first nest to first nest emergence.

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Statistical analysis. Mean differences were tested using ANOVA and Student Newman Keuls test (post hoc), for comparisons on clutch sizes and incubation durations. Nesting trends were analysed with Generalised Linear Models (GLM) with Poisson errors and corrected for over dispersion. Analyses were carried out in SPSS v16 and R v2.9 (R Development Core Team, 2009) respectively. The main results are presented below.

Overall nesting activity. Over the 7-year period (2003-2009) 25,724 adult female turtle emergences were recorded, of which 7,084 resulted in egg-laying, along the six nesting beaches of Laganas Bay. The annual number of emergences ranged from 3,412 to 4,505 with an average of 3,674.9 emergences, and the annual number of nests ranged from 824 to 1,370 with an average of 1,012.0 nests (Table 1). A slight downward trend, albeit not significant, was observed in the annual number of both emergences ($t=-1.007, p=0.360$) and nests ($t=-1.200, p=0.284$). Nesting success, i.e. the percentage of emergences resulting in nests, over the entire nesting area varied from 22.8% to 30.4%, with an overall mean value of 27.5% (Table 1). Nesting density over the total beach length of 5.5 km ranged from 149.8 to 249.1 nests/km/season with an average of 184.0 nests/km/season over the 7-year period.

Spatial distribution of nesting. The nesting effort varied greatly from beach to beach; the mean annual number of emergences per beach ranged from 208.4 in Gerakas to 1,627.6 in Sekania and the mean annual number of nests from 65.7 in Gerakas to 539.9 in Sekania (Table 1). The percentage contribution of each individual beach to total nesting in Laganas Bay appears as follows: Marathonissi = 9.8%, East Laganas = 12.4%, Kalamaki = 9.0%, Sekania = 53.3%, Daphni = 9.0%, Gerakas = 6.5%.

Nesting success per beach varied greatly within and among seasons. The lowest values of nesting success were recorded in Daphni (overall mean = 13.0%; range of annual means = 6.0%-18.0%) and the highest values in Marathonissi (overall mean = 33.7%; range of annual means = 20.1%-42.7%) (Table 1). As nesting success depends on both environmental and anthropogenic factors, it is believed that the low success on Daphni is a combination of both. Indeed, from 2006 onwards the Park has established cooperation with local owners at Daphni which resulted in the reduction of some disturbances which in turn have apparently increased nesting success (Table 1); the extreme low of 6% during 2009 was attributed to the bad condition of the beach due to a substantial increase of stones and pebbles. It is noted that Daphni is an unstable beach with its sands being alternately eroded and re-deposited depending on wind and surf action (see also Margaritoulis 2005).

As a result of the varying nesting effort per beach, nesting density is also uneven among the individual beaches; lowest nest concentrations were recorded in East Laganas (mean = 45.3 nests/km; range of annual means = 33.5-57.2 nests/km) and highest concentrations at Sekania (mean = 1313.8 nests/km) and Marathonissi (mean = 267.3 nests/km; range of annual means = 127.0-427.0 nests/km).

Start/end dates of nesting activity and duration of nesting season. For Sekania beach, with the most nesting in the area, the date of first hatching emergence occurred on average at 59.9 days ($\pm 3.6$ SD, range = 55-66) after the first nest (Table 2). The average duration of nesting season over the 7-year period was 88.0 days ($\pm 10.3$ SD, range = 74-104) from first nest to last nest, or 90.9 days ($\pm 9.1$ SD, range = 74-104) from first emergence to last emergence (Table 2).

Within-season evolution of nesting activity. Combining the total nesting effort, for all 7 seasons (2003-2009), we infer the following monthly distribution of nesting: May 0.8%; June 40.0%; July 51.1%; August 7.9%; September 0.1%.

Fate of nests. All emerged nests (i.e. nests that produced hatchlings at the surface of the beach) during the fieldwork period were marked and evaluated. The annual percentage of emerged nests to laid nests ranged from 71.3% to 93.8%, with an overall mean of 87.6% (Table 3). It should be stressed, however, that the recorded numbers of emerged nests represent a minimum because (1) some nests emerged after the end of the fieldwork (about mid-October), and (2) some emerged nests may have escaped detection due to unfavourable beach characteristics (e.g. coarse sand, which does not show hatching tracks well), as well as to adverse weather conditions or human trampling, which may erase hatching tracks. Therefore, the annual number of emerged nests, derived as above, does not imply that the remaining nests did not produce hatchlings, rather it is an indicator of the emergence success for a particular season. Further, it reflects to a certain degree the consistency of the monitoring work, and especially the accurate mapping of nest locations.

To approximate better the overall percentage of nests that did not emerge, we use a sample of nests monitored in situ from egg laying until emergence or, in the case of no emergence, until excavation after about 90 days from egg laying. During 2003-2009, a sample of 561 such nests resulted in 26 nests (4.6%) that did not emerge;...
excavation revealed only unhatched eggs and, in one nest, 4 half-pipped dead hatchlings.

**Clutch size, hatching success, hatchling emergence success.** The mean clutch size per season was 106.7 eggs (range = 103.8-110.5), but with significant differences among seasons (Table 4). Mean annual hatching success ranged from 72.0% to 76.7% whereas hatchling emergence success ranged from 64.6% to 72.3%. Mean values, over the 7-year period, gave 73.6% for hatching success, 68.9% for hatchling emergence success, and 4.7% of within-nest hatchling mortality (Table 4). Main apparent reasons for increased within-nest hatchling mortality were invasion of plant roots, especially of tamarisk trees (*Tamarix* sp.) at East Laganas, flooding of nests by rising of water table, mainly at Gerakas, and deposition of clay, eroded by rainfall from nearby slopes, which after hardening can hinder the emergence of hatchlings, particularly at Sekania and Daphni.

**Emerged hatchlings.** The minimum annual number of viable hatchlings produced ranged from 54,391 to 73,500 with a weighted mean of 65,095 hatchlings per season, over the 7-year period 2003-2009. It should be noted that these figures are considered as underestimates because the numbers of emerged nests, on which the relevant calculations were made, were definitely underestimated. It should also be noted that these numbers represent hatchlings which managed to exit their nests and do not include subsequent mortality.

**Incubation duration.** The overall mean incubation duration, weighted as per contribution of the individual beaches to total nesting, was calculated to be 52.5 days (range = 42-89, n = 3,841 clutches). However, substantial differences were found among the individual beaches. Mean incubation durations shorter than 56.6 days (the pivotal incubation duration assessed by Mrosovsky et al. (2002) in nearby Kyparissia Bay) were recorded at Kalamaki (48.9 days), Daphni (49.3 days), Sekania (50.0 days), and Gerakas (52.2 days). Close to the pivotal incubation duration was East Laganas (56.5 days), while the only beach with incubation duration longer than the pivotal was Marathonissi (64.3 days) (Table 5, Fig. 2). All mean incubation durations per beach were significantly different (p<0.05) from one another with the exception of the durations at Kalamaki and Daphni (Table 5). The effect of this spatial variation of incubation durations on hatchling sex ratios is apparent. Indeed, four beaches in Laganas Bay (i.e. Kalamaki, Daphni, Sekania and Gerakas, totalling 77.8% of all nests deposited in Laganas Bay) produced predominantly female hatchlings; East Laganas beach (12.4% of all nests), being very close to the pivotal incubation duration, produced about 50% females and 50% males; Marathonissi beach (9.8% of all nests) produced predominantly, if not exclusively, male hatchlings (Fig. 2). These results confirm previous data indicating a large spatial variation of incubation durations among the individual beaches of Laganas Bay, with Marathonissi beach characterized by relatively

**Table 5.** Mean incubation periods (days) per beach in Laganas Bay from 2003-2009. Values with the same letter were not significantly different (p>0.05). *Weighted per beach contribution to total nesting.

<table>
<thead>
<tr>
<th>Beach</th>
<th>Mean±SD</th>
<th>Min</th>
<th>Max</th>
<th>n (nests)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marathonissi</td>
<td>64.3±7.3</td>
<td>B</td>
<td>43</td>
<td>89</td>
</tr>
<tr>
<td>East Laganas</td>
<td>56.5±7.3</td>
<td>C</td>
<td>44</td>
<td>88</td>
</tr>
<tr>
<td>Kalamaki</td>
<td>48.9±3.9</td>
<td>A</td>
<td>43</td>
<td>65</td>
</tr>
<tr>
<td>Sekania</td>
<td>50.0±4.5</td>
<td>D</td>
<td>42</td>
<td>77</td>
</tr>
<tr>
<td>Daphni</td>
<td>49.3±4.2</td>
<td>A</td>
<td>43</td>
<td>79</td>
</tr>
<tr>
<td>Gerakas</td>
<td>52.2±4.5</td>
<td>E</td>
<td>43</td>
<td>73</td>
</tr>
<tr>
<td>Overall mean*</td>
<td>52.5</td>
<td></td>
<td>42</td>
<td>89</td>
</tr>
</tbody>
</table>

**Figure 2.** Mean incubation durations ±1 SD per beach in Laganas Bay. The horizontal line represents the pivotal incubation duration (56.6 days) at nearby Kyparissia Bay (Mrosovsky et al. 2002).

**Figure 3.** Evolution of the annual number of nests over the 26-year period (1984-2009) at Laganas Bay, Zakynthos.
low incubation temperatures (Margaritoulis 2005, Zbinden et al. 2007a). In view of the forthcoming global temperature increase, where a greater proportion of female hatchlings is expected, such “cold” beaches may become essential for the survival of the species (Zbinden et al. 2007a).

Previous analyses of data from 1984-2002 have shown high inter-annual variability but no specific trend in the annual number of nests (Margaritoulis 2005). Nesting data in the subsequent 7-year period (2003-2009) show a downward trend, although not significant. If we combine the two periods, a slight downward trend appears over the 26-year period (1984-2009), which, although not statistically significant (t=-1.637, p=0.115), should be looked upon with appropriate concern (Fig. 3).

The recorded decline could be caused by either drifting of nesting to other areas due to disturbances at the nesting beach or problems experienced at sea. Indeed, during most of this 7-year period, with the possible exception of 2004 and 2005 seasons, protection measures at the nesting beaches of Laganas Bay were generally improved. In 2004 and 2005 the Marine Park was largely inactive but ARCHELON kept basic protection measures on the nesting beaches and the situation in general wasn’t much worse than the years before the functioning of the Park. It is known that loggerhead turtles nesting in Laganas Bay are able to change nesting beaches within the Bay (Katselidis et al. 2004, unpublished data), so in case of disturbances at a particular beach they could select a more favourable beach within the Bay. Large-scale drifting of nesting to other areas seems improbable because the nearby major nesting area of southern Kyparissia Bay is closely monitored, including an ongoing tagging project, by ARCHELON; so far very few turtles tagged in Zakynthos have been observed nesting there (Margaritoulis 1998, unpublished data). Therefore a possible explanation of the apparent decline rather should be investigated at sea, both within Laganas Bay and also at the main foraging areas of this population.

From the data collected through ARCHELON’s Stranding Network, in 2007-2009 turtle strandings in Zakynthos have increased with turtles bearing injuries attributed to fishing gear, boat strikes and monk seal predation (unpublished data, Margaritoulis et al. this volume). Further, the number of Turtle-Spotting-Boats, operating in Laganas Bay for turtle watching, has increased greatly without the establishment of a specific regulation or even the adequate enforcement of existing regulations on the part of the NMPZ. These boats frequent the parts of the Bay where turtles concentrate for basking and resting and certainly create a substantial disturbance to turtles in their inter-nesting habitat (Schofield et al. 2007, Zbinden et al. 2007b).

It is known that loggerheads nesting at Zakynthos migrate long distances and occupy distant foraging areas mainly in the Adriatic Sea and in the Gulf of Gabès (Margaritoulis et al. 2003, Lazar et al. 2004, Zbinden et al. 2008). Both these extensive areas are characterized by intense fishing activities interacting with sea turtles (e.g. Casale et al. 2004, Jribi et al. 2007). With indications of a possible long-term population decline, the continued monitoring and protection work at the nesting area must be accompanied by concomitant conservation measures at distant foraging areas to prevent this situation from worsening. Nevertheless, this is apparently a supranational issue, beyond the statutory competence of the NMPZ, requiring a strong involvement of regional political will and cooperation.

**Acknowledgments.** Research permits were provided by the Ministry of Agriculture and the NMPZ. The project would not have been possible without the dedicated effort of field leaders, assistants, and volunteers, too many to name them without fear of omitting some. We also thank the NMPZ personnel and wardens for their cooperation and assistance. The map was drafted by Lenio Margaritoulis. Two anonymous reviewers made valuable comments which improved greatly the final manuscript.


Two endangered marine turtle species, loggerheads (*Caretta caretta*) and greens (*Chelonia mydas*), nest regularly in the Mediterranean (Casale & Margaritoulis 2010). The beach of Samandağ in Turkey is one of the most important nesting grounds for green turtles in the Mediterranean (Kasparek et. al 2001; Broderick et. al 2002; Canbolat 2004), and is also used by loggerhead turtles for nesting. Green and loggerhead turtles also nest along additional stretches of beach near Samandağ. Existing literature has indicated that dramatic fluctuations in green turtle nesting numbers may arise in response to inter-annual variations in weather conditions (Limpus & Nicholas 1987; Broderick et. al. 2001), which may cause bias in calculations of population density (Demetropoulus & Hadjichristophorou 1995; Limpus 1996). For this reason, continuous long-term annual monitoring programs have been proposed by conservation organizations to obtain reliable data about sea turtles (Kasparek et al. 2001). At Samandağ beach, previous studies have been conducted intermittently across short monitoring periods (Yerli & Canbolat 1996; Yerli & Canbolat 1998; Yalçın 2003). There are a few studies about nesting activity of sea turtles at the additional sites near Samandağ (Yalçın-Özdilek & Sönmez 2006). A continuous conservation program was started at Samandağ Beach in 2001 and at the additional sites from 2005 onwards. Here we provide reliable data about sea turtle nesting numbers at Samandağ beach and at the additional sites (Çevlik-Kale).

Samandağ beach is bordered by Çevlik harbour to the North and Cape Sâbeca to the South (Fig. 1). The beach has been divided into three sections; Çevlik beach (approximately 5.5 km long), Şeyh Hzir beach (approximately 4.1 km long), and Meydan beach (approximately 4.4 km long). The Asi river passes between Şeyh Hzir and Meydan beaches. The coastline between Çevlik and Kale, which is termed here as the extension of Samandağ beach, is about 26 km in length (Fig. 1), along which there are five additional small beaches: TRH-1, TRH-2, TRH-3, Kale1, and Kale2. Beach monitoring data were collected during 10 years for Samandağ beach and six years for the extended beaches, following the methodology described in Yalçın-Özdilek & Sonmez (2006) and Yalçın-Özdilek (2007).

Total nesting and non-nesting emergences for both species were recorded and assessed by beach sections for the Samandağ area and for the five additional nesting beaches combined and grouped together as the ‘extended beaches’ (Çevlik-Kale area). Furthermore, we calculated nest density (nest number per km) specifically for Samandağ and Kale beach.

**Green turtles:** Between 2001-2010, 7014 green turtle emergences were recorded at Samandağ Beach (mean = 701.4 ± 590.6 SD, range = 52-1825). Of these emergences, 2411 were nests, ranging from 16 to 621 per year (mean = 241.1 ± 208.1 SD). When considering Samandağ beach by section, the Şeyh Hzir sector had the most nests during the 10 year period (mean = 190 ± 164 SD, range = 14-468), followed by the Meydan sector (mean = 40 ± 29 SD, range = 2-83), and lastly the Çevlik sector (mean = 19 ± 22 SD, range = 1-70). Nest density ranged from 1.1 to 44.3 nests per km for the monitored years (mean = 17.5 ± 14.5 SD; Fig. 2). Şeyh Hzir was the most densely nested sector during the 10 year period (mean = 46.3 ± 39.9 SD, range = 3.4-114.1), followed by the Meydan sector (mean = 8.2 ± 6.8 SD, range = 0-18.9), and lastly the Çevlik sector (mean = 2.7 ± 3.8, range 0-12.7). Human pressure is greatest at the Çevlik sector, followed by Meydan and Şeyh Hzir, respectively. At the Şeyh Hzir and Meydan sectors, nests were primarily concentrated along a 3 km stretch on either side of the north and south parts of the Asi River, which is the least disturbed area of all Samandağ Beach. In general, the majority of nests were laid in July (10 year mean: 59% ± 12.2 SD, range = 45-85%), except for in 2008 and 2009 when the majority of nests were laid in June (2008 = 52% nests, 2009 = 53% nests).

**Loggerhead turtles:** Along the 14 km stretch of Samandağ beach, 205 loggerhead turtle emergences were recorded across the 10 year monitoring period. Of these emergences, 87 were nests, ranging from
Figure 3. Annual number of loggerhead nests (dark grey bars) and total number of emergences (light grey bars) for loggerhead turtles along the Samandağ Beach.

Figure 4. Annual number of green turtle nests (dark grey bars) and emergences (light grey bars) along the five beach sectors distributed between Çevlik and Kale.

Figure 5. Annual number of loggerhead turtle nests (dark grey bars) and emergences (light grey bars) the five beach sectors distributed between Çevlik and Kale.

0 to 20 per year (mean = 10 ± 5.6 SD). Of interest, in 2001 only three non-nesting emergences were observed, and no loggerhead emergences were seen in 2008 (Fig. 3). In 2001, a conservation plan was not in place; hence, illegal sand extraction may have contributed to the low number of green turtles being recorded, and the absence of loggerhead turtles. However, additional human impact was not observed in the 2008 season at Samandağ Beach.

Loggerhead nesting density ranged from 0 to 1.4 nests per km across the 10 year period (mean = 0.7 ± 0.4 SD). When loggerhead turtle nest numbers were classified per section of Samandağ beach, Şeyhhzir had the highest number and density of nests (mean number = 5 ± 4 SD, mean density = 1.2 ± 1 SD), followed by Çevlik (mean number = 3.1 ± 4.4 SD; mean density = 0.6 ± 0.8 SD) and Meydan (mean number = 0.6 ± 1 SD; mean density = 0.1 ± 0.2 SD).

The majority of nests were laid in July (10 year mean = 57.1% ± 27.7 SD, range = 0-83.3), except for in 2003, 2006, 2007 and 2009 when the majority of nests were laid in June (2003 = 63.6% nests; 2006 = 55.6%; 2007 = 50%; 2009 = 60%).

Extended Beach (Çevlik-Kale Beaches): Along the five beach sectors distributed between Çevlik and Kale, 126 green turtle emergences were recorded across a six year monitoring period (2005-2010). Of these emergences, 47 were nests (mean = 7.8 ± 8.3 SD, range = 0-23). Of interest, no green turtle emergences were recorded in the 2010 (Fig. 4). In total, 422 loggerhead turtle emergences were recorded across the six year monitoring period. Of these emergences, 93 were nests (annual mean = 15.5 ± 7.7 SD, range 5-25, Fig. 5). The majority of nests and emergences were recorded at Kale Beach, which is about 1.5 km in length. The nest density per km of loggerhead turtle at this beach was mean = 10.3 ± 5.1 SD, range = 3.3-16.7, indicating its importance for loggerhead nesting in the Eastern Mediterranean. The loggerhead nest density is highest on the western part of Turkey and decreases toward to eastern beaches. The observed nest density of Kale section is higher than that of the adjacent beaches in the eastern part of the Turkey (Canbolat 2004). There is no direct human access to the Kale section due to its distance from villages in the region; hence it is a favourable nesting site for loggerhead turtles.

The results of this long term study indicate that mean annual nest numbers in Samandağ and extended sections are higher than indicated in previous studies based on short term monitoring (Yalçın-Özdilek & Sönmez, 2006, Yalçın-Özdilek & Yerli 2007). Therefore, this area represents one of the most important nesting areas for sea turtles, and a long-term conservation plan should be implemented in this area.

A number of anthropogenic problems threatening sea turtle nesting effort exist at Samandağ Beach. These have been reported in scientific, governmental and public sector literature (Yerli & Demirayak 1996; Yerli & Canbolat 1998; Yalçın 2003; Yalçın-Özdilek & Sönmez 2003; Yalçın-Özdilek & Yerli 2006). In brief, they include illegal sand extraction, litter, flooding and tourism activities. In addition, coastal erosion, which occurs as a consequence of human activities, contributes indirectly and is the main problem in nesting areas.

A conservation plan has been implemented at Samandağ beach for the past 10 years and at the extended beach area for the last six years. The conservation plan principally outlines actions for identifying short term problems and their solutions, and developing long term solutions. The regular daily monitoring of sea turtles during the nesting and hatching seasons serves as a deterrent for illegal sand extraction. In order to improve public awareness, regular and continuous training activities were performed for children, adults, tourists and also fishermen. Unfortunately, even at reduced levels, anthropogenic problems continue to occur, in addition to natural problems such as predation by ghost crabs, foxes and dogs on the nesting beaches. Furthermore, attempts to install wind energy plants near the beaches are in progress. In parallel, facilities for developing tourism activities continue in this region, particularly in the most popular beach sector, with Şeyhhzir and Kale possibly facing increased pressure from tourism in the near future.

The management plan is dependent on the collaboration among governmental, non-governmental and academic organizations, who supply student volunteers to conduct the monitoring work. The daily monitoring program during the nesting season should continue to operate until local inhabitants undertake conservation responsibilities. Particularly, the conservation plan suggests an increase in the contribution of local NGOs to conservation actions in future, and also strongly recommends national and international
collaborations for the sustainable development of tourism activities and installation of energy resources in a sustainable manner in Samandag and extended beach areas.

**Acknowledgements:** The long term study at Samandag was implemented with the assistance of the Samandag Governor, Hatay Directorate of Environmental Ministry and Natural Parks and Nature Protect Division. We are thankful to all these organizations. We also thank Sait Gürsoy and K. Mehmet Ali Sönmez and many other student volunteers for their assistance on the field. We also thank the reviewers for their valuable contributions.

**References:**


**Loggerhead Turtle Bycatch in the Gulf of Gabès, Tunisia: An Overview**

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The loggerhead turtle, Caretta caretta, is considered the most common sea turtle species in the Mediterranean and is therefore included in most international wildlife conservation treaties (Eckert et al. 2000). Groombridge (1990) recommended that this species should be possibly considered as critically endangered for the Mediterranean region.

The main nesting concentrations of the loggerhead turtle in the Mediterranean are confined almost exclusively to the eastern basin (mainly Greece, Cyprus, Libya and Turkey) (Margaritoulis et al. 2003). Demographic studies indicate that the loss of late juveniles (straight carapace length = 30 to 80 cm) and adults has a more dramatic impact on populations than the loss of younger individuals such as eggs, hatchlings and younger juveniles (Crouse et al. 1987). Therefore, although rookery protection has been a priority for marine turtle conservation, this measure will be unsuccessful without the effective protection of large juveniles and adults. In fact, the impact of fishery related mortalities is one of the most important anthropogenic factors for loggerhead turtles in the Mediterranean. An assessment of fisheries interactions and associated mortalities is one of the priorities adopted by the Action Plan for the Conservation of Mediterranean Marine Turtles (RAC/SPA 2001).

More than 150,000 captures per year may take place in the Mediterranean by trawlers, longliners and set netters, with possibly over 50,000 deaths per year. Bycatch is drastically high in the western part of the Mediterranean especially around the Balearic Islands (Aguilar et al. 1995; Caminatas et al. 2001) where there is an occurrence of a high concentration of sea turtles due to the entrance of animals from the Atlantic Ocean via Gibraltar (Argano et al. 1992; Caminatas & De la Serna 1995).

Results obtained from genetic markers (Casale et al. 2008) and tagging programs (Bradai et al. 2009; Bentivegna 2002) lead to the conclusion that the region of the Gulf of Gabes (Figure 1) is an important wintering and feeding area for the loggerhead turtle in the Mediterranean Sea. In this region, a fleet of dozens of fishing vessels, using many kinds of fishing gears (including longline, trawl, gillnet and trammelnet), operating during different seasons and targeting a wide variety of commercially important species, interacts with this endangered species. In order to assess the importance of potential threats for different fishing gears and consequently the possibility to institute alternative approaches to mitigate these threats, many studies have been conducted focusing on turtle fishing gear interactions (Bradai 1992, 1993; Jribi et al. 2007, 2008; Echwikhi et al. 2010a; 2010b).

The first preliminary data on the bycatch of loggerhead turtles in the Gulf of Gabes were obtained from interviews with professional fishermen in numerous ports (Bradai 1992 and 1993). During
interviews, fishermen were asked about gears used by season, number of turtle captured, season of catch, size of turtles, etc. Since 2001, bycatch data have been obtained from records taken by onboard observers during trips conducted in different zones of the Gulf of Gabes (Jribi et al. 2007, 2008; Echwikhi et al. 2010a,b). Data recorded included gear types used, characteristics of gear type, fishing operations and catch characteristics. Information on sea turtles captured included species, geographical position, Curved Carapace Length notch to tip (CCLn−t) and physical condition. To assess the interactions of this species with fishing activities, many catch rates were estimated: number of turtle captured/trip, number of turtles captured/day, number of turtles captured per 1000 hooks for longlines, number of turtles captured/ h*d for trawls (h is the headrope length/30.5 m and d is the haul duration in hour units) and number of turtles captured per km² of net/day for gillnet.

Investigations carried out by Bradai (1993) in 20 ports in the Gulf of Gabes, indicate that incidental capture of loggerhead turtle was registered by many types of fishing gear, such as pelagic and bottom longlines, trawl, gillnets and purse seine. According to fishermen interviewed, the majority of turtles incidentally caught were in good condition, although a few cases of mortality were mentioned from mortality, although a few cases of mortality were mentioned from

**Table 1.** Catch rates recorded (95% C.I.), total capture estimated and mortalities rates registered by different gears in the Gulf of Gabès.

<table>
<thead>
<tr>
<th>Gear Type</th>
<th>Catch Rate</th>
<th>Total Capture</th>
<th>Mortality Rates</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelagic longline</td>
<td>0.823 (0.568-0.158) turtle/1000 hooks</td>
<td>486.48</td>
<td>0%</td>
<td>Jribi et al. 2008</td>
</tr>
<tr>
<td>Pelagic longline</td>
<td>0.806 (0.802–0.810) turtle/1000 hooks</td>
<td>437.086</td>
<td>12.12%</td>
<td>Echwikhi et al. 2010a</td>
</tr>
<tr>
<td>Bottom longline</td>
<td>0.278 (0.179-0.415) turtle/1000 hooks</td>
<td>732.89</td>
<td>33%</td>
<td>Jribi et al. 2008</td>
</tr>
<tr>
<td>Bottom longline</td>
<td>0.333 (0.236-0.591) turtle/1000 hooks</td>
<td>142</td>
<td>43.75%</td>
<td>Unpub. data</td>
</tr>
<tr>
<td>Trawl</td>
<td>0.0063 turtle/h.d</td>
<td>5458±1652</td>
<td>3.33%</td>
<td>Jribi et al. 2007</td>
</tr>
<tr>
<td>Trawl</td>
<td>N/A</td>
<td>2000-2500</td>
<td>N/A</td>
<td>Brada 1992</td>
</tr>
<tr>
<td>Gillnets</td>
<td>0.527 (0.403–0.649)/ km2/day</td>
<td>443.6</td>
<td>69.44%</td>
<td>Echwikhi et al. 2010b</td>
</tr>
</tbody>
</table>

Catch rates registered during studies conducted by onboard observers show variation across gears (Table 1). These data show the importance of interaction of loggerhead turtle with different gears, and suggest a high population density of loggerhead turtles in the Gulf of Gabes. Total loggerhead capture in pelagic longlines is among the highest for sea turtles recorded in the Mediterranean Sea (Jribi et al. 2008; Echwikhi et al. 2010a). The threat caused by pelagic longlines on loggerhead population is not limited to the Gulf of Gabes or the Mediterranean as a whole. Lewison et al. (2004) reported that pelagic longlines are frequently referred to as the major threat to sea turtles worldwide; more than 200,000 loggerheads were taken as bycatch in pelagic longline fisheries during 2000. Sea turtle interactions with bottom longlines have not been well studied in the Mediterranean; this type of gear is used in the Gulf of Gabes and may pose a serious threat to loggerhead turtles.

In the Gulf of Gabes, loggerhead turtles are captured by trawl fishing throughout the year; winter, spring and summer are periods when the catch rates are highest. The study by Jribi et al. (2007) showed that trawlers have a large impact on sea turtles in the Gulf of Gabes. The total catch is among the highest in the Mediterranean (5458±1652) and exceeds previous estimates: 3500–4000 (Laurent et al. 1990) and 2000–2500 (Bradai 1992).

In addition to commercial fishing gear (i.e. trawl and longline), artisanal gillnet fishing poses a high threat to loggerhead turtles (Bradai 1993; Echwikhi et al. 2010b). Studies concerning gillnets in the Mediterranean are rare. Gillnets represent a threat for sea turtles mainly inhabiting coastal waters (Lazar et al. 2004), however the quantification of capture rates in these widely dispersed fisheries is difficult to assess, due to the large number of small fishing vessels dispersed along the entire Mediterranean coastline.

The majority of turtles captured in gillnets were juveniles and subadults classed 50 and 70 cm CCL n−t (Figure 2). Generally, the wide continental shelves of the eastern Mediterranean (Tunisia and Libya; north Adriatic; Egypt; Southeastern Turkey) and especially the Gulf of Gabes, constitute neritic foraging habitat for loggerhead turtles. The coincidence of the departure of some adult turtles to reproduce in the north of the Mediterranean (mainly Greece) and the use of longline and gillnets in the summer period increases the proportion of juveniles captured.
In terms of mortality, the highest rates were registered by gillnet and bottom longlines (Table 1). For bottom longlines, hooks are close to the bottom and the turtles captured were smaller; therefore they might not be able to reach the surface to breath and eventually die by asphyxia. For similar reasons, the high mortality rates associated with gillnets may be a result of the long soak time. This gear is left at sea for one or more days, which is well beyond the apexa tolerance range of turtles (Echwikhi et al. 2010b).

Mortalities rates recorded by pelagic longlines and trawls were the lowest. For the pelagic longlines, hooks were set close to the surface (4 to 5 meters depth), so a captured animal is perhaps more likely to reach the surface to breath. For trawls, the low mortality may be explained essentially by the shorter haul duration (mean: 86.83 min) in the Gulf of Gabes (Jribi et al. 2007).

All studies conducted show that gillnets, trawls and longlines pose a serious threat to loggerhead population in the Gulf of Gabes. This is explained by three reasons: first, these gears caught specimens in the neritic stage (large juveniles and adults), during which increased mortality rates can have a particularly profound effect on loggerhead populations (Laurent et al. 1992). Second, gillnets and longlines are mainly deployed at generally low depths, not exceeding 60m, where loggerhead turtles are generally concentrated (Polovina et al. 2003). Third, the highest fishing effort occurred during the summer months, when these reptiles inhabit inshore waters.

To reduce turtle by catch, different mitigation measures could be adopted. Generic solutions include spatial and temporal restrictions on fishing (especially in locations and during periods of high concentration of turtles) and also reducing the soak time duration for gillnet fisheries. Furthermore, specific solutions could be involved. Echwikhi et al. (2010a) demonstrated that the use of pieces of stingrays as a bait instead of mackerel reduces turtle bycatch with pelagic longline and increased the capture of the target species. However, some stingray species are threatened, thus further research is needed to identify alternative baits from non-threatened species. The use of circle hooks was identified as a promising tool to reduce turtle bycatch with pelagic longline in many fishing areas (Piovano et al. 2009). For gillnet fishery, recently some measures to mitigate sea turtle bycatch have been presented, such eliminating buoys on the float line (Peckham et al. 2009) and illuminating nets (Wang et al. 2009). These techniques should be tested in the Gulf of Gabes and throughout the Mediterranean Sea.

In addition, the role of professional fishermen is certainly of fundamental importance in sea turtle conservation programs. During the different studies, awareness campaigns aimed at fishermen were conducted; these campaigns explain how to treat captured turtles and how to apply recovery techniques to comatose turtles. Injured specimens continue to be occasionally transferred to a specialized rescue center, founded in 2004 at Monastir (near the middle of Tunisia’s coastline).


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

Flipper tagging has revealed two major foraging areas of female loggerhead turtles nesting in Greece. Indeed, loggerheads after their nesting in Zakynthos Island and Kyparissia Bay, the two largest rookeries in Greece and in the Mediterranean, seem to concentrate mainly in the Adriatic Sea and in the Gulf of Gabès, northern Africa (Margaritoulis 1988; Margaritoulis et al. 2003). This finding was subsequently corroborated by satellite tracking of post-nesting turtles from Zakynthos (Zbinden et al. 2008). Satellite tracking has also shown that adult female loggerheads from the northern coast of Cyprus migrate to northern Africa, even following discrete migration routes (Broderick et al. 2007).

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

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

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

**Figure 1.** Map showing approximate locations of distant tag returns from turtles tagged while nesting in Rethymno. Arrows do not indicate migration routes.
plastic tags on the rear flippers. In total, 356 loggerhead turtles were tagged at Rethymno in the 20-year period (1990-2009).

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

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

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

Of the fourteen distant recoveries, eight (57.1%) were reported from northern Adriatic and one from Israel (Fig. 1). Most of the recovered turtles (91.7% of the total of known fate) were reported dead, either stranded or floating, with only one captured alive and released (Table 1).

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

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

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

<table>
<thead>
<tr>
<th>ID Tag</th>
<th>Last nesting</th>
<th>Location of tag recovery</th>
<th>Date of recovery</th>
<th>Days elapsed</th>
<th>Method of recovery</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>H3410</td>
<td>12/07/1992</td>
<td>Kettana, Gulf of Gabès, Tunisia</td>
<td>03/10/1992</td>
<td>83</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>P4937</td>
<td>26/06/1994</td>
<td>Bodrum, Turkey, Aegean Sea</td>
<td>10/09/1994</td>
<td>76</td>
<td>Tag found</td>
<td>?</td>
</tr>
<tr>
<td>Y5587</td>
<td>04/08/1995</td>
<td>Gulf of Gabès area, Tunisia</td>
<td>20/03/1996</td>
<td>229</td>
<td>Captured</td>
<td>?</td>
</tr>
<tr>
<td>H657</td>
<td>16/06/1997</td>
<td>Offshore Ayvalik, Turkey, Aegean Sea</td>
<td>01/11/1999</td>
<td>868</td>
<td>Floating</td>
<td>D</td>
</tr>
<tr>
<td>E989</td>
<td>12/07/1999</td>
<td>Aegina Isl., Greece, Aegean Sea</td>
<td>17/11/1999</td>
<td>128</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>E978</td>
<td>17/06/2000</td>
<td>Lesbos Isl., Greece, Aegean Sea</td>
<td>28/04/2001</td>
<td>315</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>E991*</td>
<td>19/07/2001</td>
<td>Herakleion (harbour), Island of Crete</td>
<td>15/05/2002</td>
<td>300</td>
<td>Floating</td>
<td>D</td>
</tr>
<tr>
<td>E803</td>
<td>27/06/2000</td>
<td>Izmir, Turkey, Aegean Sea</td>
<td>19/08/2002</td>
<td>783</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>C6805</td>
<td>18/07/2003</td>
<td>Gulf of Gabès area</td>
<td>16/11/2003</td>
<td>121</td>
<td>Caught &amp; released</td>
<td>A</td>
</tr>
<tr>
<td>E936*</td>
<td>11/07/2001</td>
<td>Gournes, Island of Crete</td>
<td>01/02/2004</td>
<td>935</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>RE175</td>
<td>24/07/2004</td>
<td>Karystos, Evia Isl., Greece, Aegean Sea</td>
<td>04/08/2004</td>
<td>11</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>E962</td>
<td>17/07/2003</td>
<td>Naxos Isl., Greece, Aegean Sea</td>
<td>22/05/2005</td>
<td>675</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>E999*</td>
<td>20/07/2005</td>
<td>Rethymno, Island of Crete</td>
<td>08/08/2005</td>
<td>19</td>
<td>Stranded</td>
<td>D</td>
</tr>
<tr>
<td>A682</td>
<td>20/07/2004</td>
<td>Gulf of Trieste, North Adriatic, Slovenia</td>
<td>09/08/2005</td>
<td>385</td>
<td>Floating</td>
<td>D</td>
</tr>
<tr>
<td>RE220</td>
<td>15/07/2004</td>
<td>Zarat, Gulf of Gabès, Tunisia</td>
<td>05/12/2006</td>
<td>873</td>
<td>Stranded</td>
<td>D</td>
</tr>
</tbody>
</table>

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Reverse the noted decline of Rethymno turtles. Sea may lead to better targeted conservation activities aiming to as well as of fishermen attitudes towards sea turtles in the Aegean. Indeed, examination of specific fishing methods and fishing periods may differentiate known threats impacting this population at sea. Aegean Sea as a foraging area for a declining sea turtle population threats at the nesting area of Rethymno, the assessment of the regional context, very discrete foraging areas (Schroeder, 2003). Loggerheads, in contrast to green turtles, do not seem to possess, in a use other foraging areas, e.g. Gulf of Gabès, as it is known that the Aegean Sea does not exclude a segment of the population to Islands where it remained for a full year.

Further, the satellite tracked turtle moved into the Cyclades migration south, with extended rest periods at Paros Island and Santorini Island. Northward parts of the track should be regarded as indicative of general route as data during these portions were poor quality and infrequent.

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

The seemingly general preference of Rethymno turtles for the Aegean Sea does not exclude a segment of the population to use other foraging areas, e.g. Gulf of Gabès, as it is known that loggerheads, in contrast to green turtles, do not seem to possess, in a regional context, very discrete foraging areas (Schroeder et al. 2003). Besides tourist development and beach erosion, noted as major threats at the nesting area of Rethymno, the assessment of the Aegean Sea as a foraging area for a declining sea turtle population may differentiate known threats impacting this population at sea. Indeed, examination of specific fishing methods and fishing periods as well as of fishermen attitudes towards sea turtles in the Aegean Sea may lead to better targeted conservation activities aiming to reverse the noted decline of Rethymno turtles.

Acknowledgements: Application of flipper tags and satellite transmitter was done under a research permit by the Ministry of Agriculture. We thank all ARCHELON field leaders, assistants and volunteers who worked long night hours to tag turtles over the years. We thank all those who reported tag recoveries, especially our colleagues Paolo Casale, Daniela Freggi, Imed Iribi, Zeev Kuller, Bojan Lazar, Ertan Taskavak, and Robert Turk. We thank two anonymous reviewers and P. Casale whose considerate remarks assisted in the improvement of the initially submitted draft. Base maps were created using MapTool (www.seaturtle.org/maptool).


Spain has one of the largest trawling fleets in the world, with over 1,000 vessels operating in the Gulf of Cadiz, the Mediterranean Sea and international waters. In 2007 and 2008, the Chelonia Association evaluated the incidental catch of loggerhead turtles (Caretta caretta) in bottom trawlers, and concluded that about 5,000 turtles are caught annually in the Gulf of Cadiz and the Spanish Mediterranean (Bitón 2009). Similar catch rates have been reported for the same gear in other areas of the Mediterranean (Casale et al. 2004; Casale et al. 2007; Jribi et al. 2007). A recent study in the western Mediterranean quantified and highlighted the impact of the trawl fishery on loggerhead turtle stocks in the western Mediterranean (Álvarez de Quevedo et al. 2010). Although more assessment is needed, particularly on mortality rates (Casale et al. 2007), a global reduction in sea turtle by-catch by bottom trawling is urgently needed, and this reduction must be achieved through the use of tools that allow for an international conservation program as well as sustainable fishing of commercial species by local fishermen. A tool used successfully in different trawl fisheries outside of the Mediterranean is the Turtle Excluder Device (TED, see Epperly 2003). However, this tool was initially designed for shrimp fisheries. Some larger species, targeted by Mediterranean trawlers, may be diverted outside the net by the TED, thus decreasing fishermen’s income and reducing the probability of such a device to be adopted by Mediterranean trawl fisheries (Casale et al. 2007 and references therein). Hence, the main objective is to design a TED that will not reduce significantly catches of targeted species, and thus facilitating its adoption by the fisheries in the Mediterranean. The experiences of the French Institute of the Sea (IFREMER) in French Guiana since 1993 demonstrated that the use of TEDs is extremely useful not only to avoid by-catch of turtles but also of other threatened marine vertebrates, principally sharks and mammals (Gueguen 2000). TEDs can also be useful by removing debris from inside the net (Lucchetti et al. 2008).

In June 2009, the Chelonia Association started a preliminary collaborative project with trawl fishermen in the port of Almeria (Andalusia, southeast Spain, 36°50'00"N-2°26'59"W). The association installed one TED in one bottom trawl vessel from this port. The TED was made by the association following technical protocols from IFREMER (France) and NOAA (USA) to mitigate by-catch of several sea turtle species. The structure of the TED was made of stainless steel, measuring 130 cm height and 108 cm wide, with a bar diameter of 5 cm on the outer perimeter and a series of 9 cm gaps between bars. The escape opening for the net was situated directly above the TED to allow the turtles to escape. The TED was easily installed and did not require any changes either to the handling or to the working of the nets used over the sea floor.

In this preliminary study, five sets were observed with the TED installed in the net, three with the TED escape opened and two with the opening sealed. All sets had the same haul duration and were performed in consecutive days of the same week with similar environmental conditions and sea state. The TED did not suffer any damage during fishing operations. Fishermen involved confirmed no remarkable variation in the volume of targeted species caught, mainly crustaceans (Aristeus antennatus, Parapenaeus longirostris and Nephrops norvegicus), between the sets with the escape opened and the ones with the escape closed. Moreover, total catch volumes did not vary between hauls with the TED installed and those without TED installed. However, apparently the TED was responsible for a reduction in catch volume of fishes >9 cm length (the gap width between the vertical bars of the device). These included non-targeted but marketable species, such as monkfish (Lophius piscatorius), mullet (Mullus barbatus), hake (Merluccius merluccius), horse mackerel (Trachurus sp.) and sole (Solea vulgaris). High rates of by-catch were detected for small spotted catshark (Scyliorhinus canicula), eel (Gymnammodytes cicerelus) and herring (Clupea harengus). Despite the large population of C. caretta in the area (Camíñas, 2005), no sea turtle was observed in the five sets.

This first experimental test of the use of TEDs in the Western Mediterranean shows promising results. Nonetheless, the number of sets with different types of bottom trawl nets should be increased to test their effectiveness. More sets and new designs of TEDs will be tested in 2011 in other ports of the Spanish Mediterranean. Since trawl fisheries are responsible for significant by-catch of the endangered loggerhead sea turtle in the Mediterranean (Casale et al. 2007, Álvarez de Quevedo et al. 2010), experiments like the one described here, and others similar undertaken in the Mediterranean (Lucchetti et al. 2008) are of great importance, although more assessment of this and alternative conservation measures are needed.


Sea Turtle Research and Rehabilitation Centre (DEKAMER), Dalyan, Mugla, Turkey

Yakup Kaska1, Barbaros Şahin2, Eyup Başkale1, Fikret Sarı1 & Stefanie Owczarczak3

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3Cornell University, College of Veterinary Medicine, Ithaca, NY USA

Five of the world's seven species of marine turtle occur in the Mediterranean sea, but only two of them nest regularly on the beaches along the Mediterranean coasts: the loggerhead turtle, Caretta caretta, and the green turtle, Chelonia mydas. The non-nesting leatherback turtle, Dermochelys coriacea, is regularly reported in the Mediterranean, while the hawksbill turtle, Eretmochelys imbricata, and the Kemp’s ridley turtle, Lepidochelys kempii, are reported occasionally (Margaritoulis et al. 2003). All five are recognized as globally threatened species, ranked as "Endangered" or “Critically Endangered” (IUCN 2010). According to recent estimates, there may be 2280-2787 female Caretta caretta and 339-360 Chelonia mydas nesting annually in the Mediterranean (Broderick et al. 2002).

On the Turkish coast, using both unpublished information and published data, Türközan & Kaska (2010) calculated that 769-3521 Caretta caretta nests and 452-2051 Chelonia mydas nests are laid annually on 25 different beaches that total 290 km of nesting habitat in Turkey. It is estimated that each female lays an average of 3 nests in a breeding season with each female nesting every 2-3 years (Groombridge 1990). From these statistics it can be estimated that there are approximately 450-900 Caretta caretta and 230-400 Chelonia mydas reproductive females annually visiting the beaches of Turkey. In addition to these nesting females, the bays near the beaches represents feeding grounds for both juvenile loggerhead and green turtles (Türközan & Durmus 2000). Approximately 2500 km of the south-west coastline of Turkey may hold large numbers of juvenile turtles. In the Mediterranean, an estimated 50,000-100,000 adult and juvenile turtles are caught each year on longline hooks and in nets set for fish (Groombridge 1990). It seems that mortalities in the offshore environment is a major problem threatening these animals and precautions should be taken immediately to prevent extinction.

In the 1995-1996 fishing season, Oruç et al. (1996) carried out a preliminary study on the impact of fisheries on sea turtles between the Mersin and Samanadağ areas with 5 trawl boats. They reported a total of 26 loggerheads trapped in the nets. Of the 26 turtles, 42% were caught at depths between 11 and 30 m. In the following season (Oruç et al. 1997), 116 loggerheads were caught by 12 trawl boats. The majority (61%) of the turtles (n=82) measured 31-60 cm, and 89% of the turtles (N=70) were caught at depths of 11-30 m. Ghost nets and fishing lines, and speed boats create threats to both juvenile and adult turtles in the sea as they may become entangled and drown.

In Turkey, seasonal stranding numbers are 50 injured and 100 dead turtles found on the beaches in recent years (Y. Kaska, per. observ.). In an effort to protect the declining numbers of turtles, it is most important to ensure both the survival of as many offspring as possible and reduce these mortalities and cause of injuries.

The reported number of injured sea turtles in Turkey and the growing public demand for treatment and rehabilitation of injured or sick turtles dictated the need for a Sea Turtle Rescue Center (Kaska 2005; Kaska et al. in press). As a result of the second national symposium (Kaska 2008), a protocol was agreed upon between the Directorate of the Conservation of Nature and National Natural Parks and the Environmental Protection Agency for Special Areas of Turkish Ministry of Environment of Forestry, the Municipality of Dalyan, and Pamukkale University. The first official sea turtle rescue center was established in 2009 in Dalyan, Mugla-Turkey. Later in the year, the Higher Educational Council of Turkey officially recognized the rescue center and its constitution was published in the Turkish Official Newspaper. Despite having nesting and foraging grounds along the Mediterranean coast of Turkey, only one turtle rescue centre in the country has been established following the RAC/SPA (2004) guidelines. This center has been set up for year-round activity related to marine turtle rehabilitation and to help educate the public about conservation efforts. Here we present our initial results regarding the main causes of injuries to the sea turtles and how to treat them at the Rescue Centre.

When first alerted about a live but injured turtle, either a team from Ministry of Environment and/or a team from Rescue Center respond and arrange transport for the turtle. During transport, all turtles are kept wet to minimize the dehydration. Upon arrival to the rescue center, turtles are weighed, standard morphometric measures and collected and a body condition score is assigned. A unique file is also created for each individual turtle and updated daily with treatments and lab results. All wounds are assessed based on
the depth and the extent of damage and subsequently debrided and disinfected. Fractures or deep lesions are given first priority. The turtles that have significant injuries are placed in a tank without water to avoid contamination of open wounds. Antibiotics and additional vitamins are administered if deemed necessary. The turtles are fed in the mornings and the water in their tanks is changed daily. The water level is adjusted for each turtle to ensure that each could easily take a breath.

Additionally, injured turtles are cleaned of all external epibionts and later cleaned with Betadine. Depending on the injury, antibiotic creams are used externally, and Vitamin B complex and pain killers are given as IM injection. Also, if deemed necessary we administer antibiotics (enraflaxacin, ampicilin, etc.) for around one week (Mader 2005). If the turtle does not eat by itself, we force-feed the turtle by pushing small pieces of fish and squid into the esophagus. Ringer and/or Dextrose are given to injured turtles that did not eat. Blood samples of injured turtles are collected further assessment and study.

Through the end of October 2009, there were 14 injured turtles admitted to the rescue center. The main problems found on these injured turtles were propeller cuts from boats (n=5), fishing line cuts (n=3), fishing hook ingestion (n=3), speed boat collisions (n=2) and a gun shot wound (n=1). The cure and rehabilitation of the injured turtles took around 6 months, although cases of head injuries take slightly longer.

Fishing hooks and foreign bodies are a common medical problem in sea turtles, especially due to the presence of keratinized papillae in their esophagus. Hooks were removed only if they were causing an obstruction; the rest, including those that were not causing extensive damage to the surrounding soft tissue, were left to be passed naturally through the turtle’s GI tract.

A large effort is underway to increase public awareness because its importance to the overall goal of sea turtle protection is crucial to the survival of the species. An outreach program to the locals, students, tourists and tourist companies was created by DEKAMER. The center provided information to approximately 30,000 visitors during the year of 2009.

In addition to the treatment of sick or injured turtles, the DEKAMER Sea turtle rescue center recognizes that protection of nests on the beach remains vital for the survival of the diminishing numbers of Mediterranean Sea turtles. Therefore, DEKAMER Sea turtle rescue center coordinates regular monitoring of nearby Dalyan beach for nesting activities by accepting volunteers from all around the world. Participating volunteers gain the experience of both helping the injured turtles and protecting nests and hatchlings on the beach during the summer period. Additionally, the DEKAMER center is open to all types of scientific studies, and has the advantage of holding facilities close to a nesting beach.

Overall, this center provides medical treatments to injured and sick sea turtles and provides an efficient environmental education program. Transport of turtles to the Centre is facilitated by its location adjacent to the sea and harbor. There is also an airport just 45 minutes drive-away in Dalaman. The Center is located under the pine trees just behind the beach and a stabilized road access to the Center.


Mediterranean Monk Seals Present an Ongoing Threat for Loggerhead Sea Turtles in Zakynthos

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Laganas Bay, located along the southern coast of Zakynthos Island in the eastern Ionian Sea, contains the largest rookery of the loggerhead sea turtles (*Caretta caretta*) in the Mediterranean, with an average of 1,230 nests per season (Margaritoulis 2005). Turtles of both sexes typically begin to arrive in the Bay in April, while nesting occurs from late May to early August, depending on the year. The loggerhead sea turtle is listed by the International Union for the Conservation of Nature (IUCN) as Endangered (IUCN 2010). In 1999, the National Marine Park of Zakynthos (NMPZ) was established in the wider Laganas Bay with the aim of protecting turtles and their reproductive habitat (Fig. 1).

A resident population of the Critically Endangered (IUCN 2010) Mediterranean monk seal (*Monachus monachus*) uses Zakynthos as a breeding and haul-out area, mainly along the western coast where many seaside caves are found. The estimated minimum size of this population ranges from 18 individuals (Vlachoutsikou & Cebrian 1992) to as few as 8 individuals, as estimated more recently (Karavellas 1995).

During the 1994 nesting season, 8 loggerhead turtles were documented through photographs as well as through a diversity of information such as size measurements, description of external injuries, body condition, and fate of carcasses. In cases where turtles are found injured but alive, they are transferred to ARCHELON’s Sea Turtle Rescue Centre in Glyfada, near Athens, for treatment. Experienced project members are usually available on site because of the existence of ARCHELON’s project at Zakynthos, and thus are able to perform detailed observations and obtain precise measurements of stranded turtles in conjunction with NMPZ wardens. Outside the field work season (Mid-October to mid-May), NMPZ wardens undertake the task of registering and reporting turtle strandings. In the present study we classify the carcasses as per their condition at finding as “fresh” (0-2 days since death), “decay” (3-6 days since death), and “advanced decay” (>6 days since death). During 2010, 21 large loggerhead turtles were recorded stranded or floating in the wider area of Laganas Bay, bearing injuries attributed to predation by monk seals (Table 1, Fig. 1). The temporal distribution of predated turtles was from 01 May to 08 September (131 days). No confirmed predation events were reported before or during 2010.

Since 1984, ARCHELON has conducted a systematic long-term monitoring project of the nesting activity in Laganas Bay; in the last few years, the project has been carried out in association with the NMPZ. Field work, including daily beach surveys and tagging of female turtles, is conducted each year from roughly mid-May until mid-October. In addition, ARCHELON runs the operation of a nationwide Sea Turtle Stranding Network, through which all sea turtle strandings are documented through photographs as well as through a diversity of information such as size measurements, description of external injuries, body condition, and fate of carcasses. In cases where turtles are found injured but alive, they are transferred to ARCHELON’s Sea Turtle Rescue Centre in Glyfada, near Athens, for treatment. Experienced project members are usually available on site because of the existence of ARCHELON’s project at Zakynthos, and thus are able to perform detailed observations and obtain precise measurements of stranded turtles in conjunction with NMPZ wardens. Outside the field work season (Mid-October to mid-May), NMPZ wardens undertake the task of registering and reporting turtle strandings. In the present study we classify the carcasses as per their condition at finding as “fresh” (0-2 days since death), “decay” (3-6 days since death), and “advanced decay” (>6 days since death).

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Similar incidents were noted in subsequent years, but these were considered infrequent and unusual. However, during the 2010 nesting season a remarkable increase of predation events were recorded; these are presented herein.

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after this period. Ten of the predated turtles (47.6% of the total) were reported while in the water and the remaining 11 turtles (52.4% of the total) upon their stranding on land.

Eighteen (85.7%) of the predated turtles were females; only three (14.3%) were males. The size (CCL, notch to tip) of the predated females (mean = 82.7 cm; range = 75.0 - 93.0; n = 18) was within the typical range for nesting females at Zakynthos (Margaritoulis et al. 2003).

All predated turtles were found with opened body cavities, and all were dead except one, which had exposed entrails and died soon afterward (No. 7 in Table 1). Monk seals made single or multiple openings through the ventral side of the turtle, either by tearing off the skin between the plastron and the base of a flipper (Photo 1) or through the throat (Photo 2). Most of the predated turtles bore canine teeth marks on plastral scutes or on the skin around or close to the inflicted opening of the body cavity (Photo 3). Some turtles, although opened at a specific location, also bore teeth marks at other locations, either on the plastron or at the base of a flipper, and these injuries were thought to be unsuccessful attempts by monk seals to gain entry into the body cavity.

Nineteen turtles (90.5% of the total) were opened in the soft area anterior to one or both rear flippers, more specifically in the area between the femoral/anal scutes, the posterior inframarginal scute and the marginals (Photo 1). For simplicity we will hereafter refer to these openings as openings “through a flipper.” Five of these 19 turtles bore also other openings to the body cavity; one was opened at the throat (No. 11), and four (Nos. 4, 16, 20 & 21) were opened at the throat and also through one or both front flippers. The other two cases (9.5% of the total) were opened only at the throat.

Of the 14 turtles opened only through the rear flippers, 13 cases (92.9%) involved only the hind right (HR) flipper, and one case the hind left (HL) flipper (Table 1). It is of interest to note that five turtles (Nos. 4, 5, 6, 7 & 19) bore a more or less similar fresh scratch or cut on their left eye.

The one turtle found alive (No. 7 in Table 1) was transported to ARCHELON’s Rescue Centre in Glyfada. A necropsy revealed that the largest part of the large intestine had been torn off, while the small intestine, the stomach and the esophagus were left in place (Photo 4). Several mature follicles were found in the oviducts of this turtle, indicating that she was in reproductive condition.
<table>
<thead>
<tr>
<th>Date found</th>
<th>Sex</th>
<th>Location</th>
<th>CCL cm</th>
<th>Cond.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1 May</td>
<td>F*</td>
<td>East Laganas</td>
<td>79.0</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and HR flipper.</td>
</tr>
<tr>
<td>2 24 May</td>
<td>M</td>
<td>Marathias beach, Keri</td>
<td>86.0</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and HR flipper; skin ripped off.</td>
</tr>
<tr>
<td>3 26 May</td>
<td>M</td>
<td>Marathonissi beach</td>
<td>82.5</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and HR flipper, skin ripped off revealing flipper muscles, teeth marks on the hanging skin. Entrails were not missing likely because of difficulty due to the male’s concave plastron. Crab (<em>Planes minutus</em>) still on carcass.</td>
</tr>
<tr>
<td>4 3 June</td>
<td>F*</td>
<td>East Laganas beach</td>
<td>88.0</td>
<td>Decay</td>
<td>Opened ventrally between plastron and both hind flippers as well as between plastron and FR flipper; entrails missing. Also opened at the throat. Scratch-cut at left eye.</td>
</tr>
<tr>
<td>5 3 June</td>
<td>F*</td>
<td>Floating off Porto Koukla</td>
<td>85.0</td>
<td>Fresh</td>
<td>Very fresh; no rigor mortis. Opened ventrally between plastron and HR flipper; teeth marks on the hanging skin; skin pulled back over flipper revealing muscles; entrails missing. Foam coming from trachea when mouth was opened. Scratch-cut at left eye.</td>
</tr>
<tr>
<td>6 4 June</td>
<td>F*</td>
<td>East Laganas beach</td>
<td>77.5</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and HR flipper; teeth marks on the hanging skin; skin pulled back revealing flipper muscles; entrails missing.</td>
</tr>
<tr>
<td>7 5 June</td>
<td>F</td>
<td>Floating off East Laganas beach</td>
<td>85.5</td>
<td>Alive</td>
<td>Stranded alive after seen floating; died after 3 h, presumably abandoned by monk seal. Opened ventrally between plastron and HR flipper; teeth marks on skin; flipper muscles exposed; some entrails missing; undeveloped eggs visible. Scratch-cut at left eye.</td>
</tr>
<tr>
<td>8 10 June</td>
<td>F</td>
<td>Floating off Kalamaki</td>
<td>83.0</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and HR flipper; entrails missing.</td>
</tr>
<tr>
<td>9 18 June</td>
<td>F*</td>
<td>Floating off Oasis beach, Marathias</td>
<td>93.0</td>
<td>Advanced decay</td>
<td>Opened ventrally between plastron and HR flipper. Observed from boat and left at sea. CCL taken from tagging database.</td>
</tr>
<tr>
<td>10 21 June</td>
<td>F*</td>
<td>East Laganas beach</td>
<td>89.5</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and HL flipper, teeth marks on skin; flipper muscles exposed; entrails missing. Body opened between plastron and HR flipper but intrusion unsuccessful probably because of a shell deformity. Last observed nesting 11 June.</td>
</tr>
<tr>
<td>11 25 June</td>
<td>F*</td>
<td>East Laganas beach</td>
<td>80.5</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and both hind flippers with teeth marks on the hanging skin; flipper muscles exposed; entrails missing.</td>
</tr>
<tr>
<td>12 27 June</td>
<td>F*</td>
<td>Floating off Porto Koukla</td>
<td>78.5</td>
<td>Decay</td>
<td>Opened ventrally between plastron and HR flipper; teeth marks on skin; flipper muscles exposed; entrails missing. Old propeller cut on carapace. Last observed nesting 12 June.</td>
</tr>
<tr>
<td>13 29 June</td>
<td>F*</td>
<td>Off West Laganas</td>
<td>82.0</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and HR flipper; skin pulled back revealing flipper muscles; entrails missing. Last observed nesting 15 June.</td>
</tr>
<tr>
<td>14 5 July</td>
<td>F*</td>
<td>Marathonissi shore (SW)</td>
<td>88.0</td>
<td>Advanced decay</td>
<td>Opened ventrally between plastron and HR flipper; entrails missing.</td>
</tr>
<tr>
<td>15 13 July</td>
<td>F**</td>
<td>East Laganas beach</td>
<td>79.0</td>
<td>Decay</td>
<td>Opened ventrally between plastron and HR flipper; entrails missing. Last observed nesting 17 June.</td>
</tr>
<tr>
<td>16 13 July</td>
<td>F**</td>
<td>Floating off Aghios Sostis</td>
<td>79.0</td>
<td>Fresh</td>
<td>Opened ventrally between plastron and hind flippers and between plastron and FR flipper with teeth marks on skin; flipper muscles exposed; most entrails missing (only part of lung present). Also, opened at the throat with tongue, trachea and esophagus missing. Teeth marks between plastron and FL flipper, thought to be an unsuccessful intrusion attempt. Last observed nesting 8 July.</td>
</tr>
<tr>
<td>17 1 Aug</td>
<td>F</td>
<td>Gerakas beach</td>
<td>75.0</td>
<td>Decay</td>
<td>Seen floating for several days between Pelouzo and Marathonissi. Head and 3 flippers (FR, FL, HL) missing. Body cavity empty.</td>
</tr>
<tr>
<td>18 2 Aug</td>
<td>F***</td>
<td>Floating off Keri caves</td>
<td>78.0</td>
<td>Fresh</td>
<td>Located by divers in front of a cave inhabited by monk seals. Opened ventrally between plastron and HR flipper; teeth marks on the hanging skin; skin pulled back revealing flipper muscles; most entrails missing, with fully developed eggs. Foam in trachea and when scratched, the turtle bled - freshly dead. Last observed nesting 22 July.</td>
</tr>
<tr>
<td>19 10 Aug</td>
<td>F*</td>
<td>Gerakas beach</td>
<td>90.0</td>
<td>Fresh</td>
<td>Head almost separated from body. Tongue, trachea and esophagus missing; intestines coming out of throat opening. Scratch-cut on left eye. Last observed nesting 9 July.</td>
</tr>
<tr>
<td>20 4 Sept</td>
<td>F</td>
<td>Floating off East Laganas</td>
<td>77.5</td>
<td>Advanced decay</td>
<td>Observed floating in swallow water. Opened ventrally at the base of HR, HL, FL flippers and throat. FR flipper missing but found the next day on the same beach.</td>
</tr>
<tr>
<td>21 8 Sept</td>
<td>M</td>
<td>Floating off Aghios Sostis</td>
<td>76.5</td>
<td>Decay</td>
<td>Found floating 50 m offshore. Opened ventrally at HR, HL, FR flipper and at throat, and at the base of FL flipper. Entrails, tongue, trachea, and esophagus missing. Teeth marks on skin at hind flippers and neck. Most likely to be the turtle observed by divers while it was being predated by a monk seal at Gerakas Cape on 5 September (see text).</td>
</tr>
</tbody>
</table>
Table 1 (overleaf). Loggerhead turtles predated by monk seals in Laganas Bay, Zakynthos, during 2010 (F: Female; M: Male; CCL: Curved carapace length in cm; HR: Hind right; HL: Hind left; FR: Front right; FL: Front left). * tagged at Zakynthos in previous seasons; ** tagged at Zakynthos during 2010; *** tagged at Kyparissia Bay during 2010

Approximately 62.0% of the predated turtles were classified as fresh (including the one turtle found alive), 23.8% as decayed, and 14.2% in advanced decay (Table 1). It is worthwhile to note that all predated turtles had no other fresh injuries besides those inflicted by monk seals. Some of them had old (and healed) external cuts or scars on their shells, frequently seen on nesting turtles. Judging from the “fresh” carcasses, predated turtles were in good physical condition at the time of death as can be ascertained from their external appearance, e.g. normal body weight, no excessive quantities of epibiota (as usually observed in weak or sick animals). Fourteen out of the 18 female turtles (77.7%) bore ARCHELON flipper tags, eleven of which had been tagged in Zakynthos during a previous season (remigrant turtles), and three had been tagged during the 2010 season (neophyte turtles): two at Zakynthos and one at nearby Kyparissia Bay. Seven of the tagged turtles were observed nesting at Laganas Bay in 2010 between 5-32 days before the stranding reports (Table 1). In addition, two female turtles (Nos. 7 & 8) had flipper scars attributed to lost tags. The remaining two female turtles (Nos. 17 & 20) had missing flippers; thus, it cannot be ascertained whether or not these turtles were previously tagged. Therefore, we can conclude that at least 16 of the 18 predated female turtles were definitely within their reproductive period and actively nesting.

All turtle carcasses were buried apart from turtles Nos. 9, 12 & 13. Of these, No. 9 was left at sea with its tags still on, No. 12 was dragged up on a small beach with difficult access, and No. 13 was put in a nylon bag to be taken by the Municipality. The body size, carcass condition, and tag codes of these turtles exclude any possibility of them being confused with subsequently observed carcasses.

Below we present some reliable observations made by persons with adequate knowledge of sea turtles and monk seals, within the area of Laganas Bay during the nesting season of 2010.

On 16 July, an ARCHELON volunteer observed and photographed an adult male turtle in the Bay that bore an injury at the base of the HR flipper, which resembled a predation attempt by a monk seal. Since the turtle appeared to be in good condition as it was actively swimming, diving and feeding at the bottom, it was thought that it had escaped a monk seal attack, having only the external skin ripped off without severe damage to the peritoneum.

On 21 July around 1100h, ARCHELON volunteers observed a monk seal swimming close to the NW shore of Marathonissi Islet. Scuba divers working as underwater tourist guides have repeatedly observed and videotaped a monk seal around Marathonissi Islet. The numerous seaside caves between Marathias Cape and Keri Cape (Fig. 1) provide refuge for at least one monk seal, which has been observed frequently by the divers. They believe it is the same individual that was seen in Marathonissi Islet. This monk seal, which is approximately 3 m long and has a distinctive umbilical patch, was characterized by the divers as “friendly” as it was following the group’s underwater activity from a distance.

On 16 August, the divers observed a juvenile monk seal, approximately 1 m long, off the rocky shores of Marathonissi Islet. On 5 September at about 1600h, the same divers observed from their boat a monk seal “eating out” a turtle offshore at Gerakas Cape (Fig. 1). They recognized the monk seal as the one that they had observed repeatedly at both Marathonissi Islet and Marathias Cape. They watched the monk seal fishing for about 20 minutes and frequently diving. Following a swarm of bubbles the monk seal brought a turtle to the surface – apparently dead – and chewed on the turtle. When the monk seal became aware of the observers, it dragged the turtle towards the rocks where the divers were unable to go in their boat. This turtle was assumed to be No. 21 (Table 1).

Further, a diver was told by a local fisherman that in mid-July he had observed a monk seal “eating out a turtle from behind” (in Greek: na tin koufonei apo ton kolo), close to the rocky shore of Marathonissi Islet.

On 12 September, at about noon, an NMPZ warden in a boat reported a turtle carcass floating about 100 m off Marathia beach. The warden would not approach but he observed that the turtle had a length of 60-70 cm and its intestines were hanging out from behind. When the warden returned with the stranding team to examine the carcass, they couldn’t find it, despite searching the area for about 2 hours.

Our results confirm that monk seals in Zakynthos prey on healthy, large loggerheads during the nesting season. This kind of behavior for the Mediterranean monk seal seems to be unique throughout its current geographical range (see also Fertl & Fulling 2007). For the congeneric Hawaiian monk seal Monachus schauinslandi there has been only one case of a possible maceration of a juvenile green turtle in Hawaii, but not in the way it appears on Zakynthos (G. Balazs, pers. comm.).

The twenty-one predation events reported herein are considered an absolute minimum for monk seal predation, because all were observed in detail and photographed, and no doubt was left as to the cause of death in each case. At Zakynthos during 2010, we recorded several other turtle strandings in which the cause of death could not be reliably identified, mostly because of advanced decomposition. However, it is certain that at least some of these turtles had been predated by monk seals. Further, it is reasonable to assume, as shown by the carcass reported floating on 12 September and eventually not found, that a number of turtle carcasses were not detected as they may have been taken offshore by surface currents or drifted into one of the many inaccessible coves along the rocky coast of western Zakynthos.

Terrestrial wild animals capable of doing this kind of predation do not exist on Zakynthos; the largest wild mammal on the island is the beech marten Martes foina. The possibility of post-mortem scavenging by dogs (the only animal which could inflict similar injuries) can be rejected as such an event was never observed or reported on Zakynthos before. In addition, 10 of the predated turtles (47.6%) were first observed at sea while nine turtles (42.9%) were reported on nesting beaches (i.e. East Laganas, Gerakas and Marathonissi) where night work and early monitoring surveys are conducted, as well as wardening. Further, these beaches are frequented by people during the day and turtle carcasses, if not seen first by ARCHELON and NMPZ personnel, are immediately spotted and reported by beach users. Thus, predation or scavenging by terrestrial animals is improbable. Similarly, we are not aware of other marine animal in Zakynthos waters that could inflict such injuries.
The spatial distribution of predated turtles and monk seal sightings suggests that the monk seal(s), residing between the Capes of Marathias and Keri, is (are) responsible for the recorded predation incidents. Monk seals sighted in Marathoniissi and Gerakas are thought to be seals visiting these locations occasionally from the Capes of Marathias and Keri. This is because at Marathoniissi and Gerakas there are many anthropogenic disturbances, especially during summertime, that drive the seals away temporarily.

A comparison of the carcasses examined in the present study with those documented previously in Margaritoulis et al. (1996) suggested that monk seals have changed their predation technique. Indeed, instead of opening the body cavity by snapping off the posterior plastral scutes, monk seals now seem to prefer tearing the skin between the plastron and rear flippers (in most cases the right rear flipper) or macerating the throat. In attacking the soft area between the plastron and the rear flipper, monk seals seem to pull the skin hard toward the flipper, in most cases the pulled skin is turned inside out around the flipper, revealing the muscles of the flipper (Photo 1). The new predation technique certainly needs less energy on the part of the monk seal.

As soon as the body cavity is opened, monk seals likely pull out the intestines by inserting their muzzle into the opening. This strategy was hypothesized during the necropsy of the individual that was found wounded and alive (No. 7 in Table 1), which was presumably abandoned for some reason by the monk seal. The larger section of the large intestine was torn off and missing but the rest of the digestive system, including small intestine, stomach and esophagus, were still inside the body cavity. In two other cases, it appeared that the monk seal could not insert its muzzle into the body cavity because of a relatively small opening due to a deformed carapace (No. 10) and to a concave plastron of a male turtle (No. 3). It should be noted here that adult monk seals are much bigger than adult loggerhead turtles, and reach a length of approximately 2.5 m and a weight of 250-300 kg (Caltagirone 1995). An inability to reach the entrails, despite an inflicted opening, may trigger the seals to attempt other openings to the body cavity at other locations. This was the case for specimen No. 10, where the monk seal eventually opened the body cavity through the area between the plastron and the quite unusual rear left flipper. It is of interest to note that in cases of intrusion into the body cavity through the rear flippers, the rear right flipper was preferred in 92.9% attacks. This is an indication that these predation events may have been conducted by the same individual monk seal.

When seals attacked the throat of the turtle, they tore the skin there and pulled it toward the head; sometimes the pulled skin covered part of the head. Then, the esophagus, tongue and trachea were pulled out and presumably consumed. Specimens Nos. 17 & 19 (Table 1) were opened only through their throat, as suggested by the heads that were either missing or were barely connected to the body.

Multiple openings to the body cavity either through the flippers or through the throat (see Nos. 4, 11, 16, 20 & 21 in Table 1) may have been made either by the same individual monk seal trying to reach entrails that were inaccessible from the initially inflicted opening or the injuries may have been made by several monk seals.

The large size of the predated turtles may be explained by the monk seal’s predation technique. As mentioned previously, an adult monk seal needs to create a relatively large opening to the turtle’s body cavity in order to succeed in taking the entrails. These large openings could only be made on large turtles.

The need to create an adequate opening may also explain the preference of monk seals for female turtles, at least for attacks through a flipper. Indeed, as observed in case No. 3 (Table 1), the concave plastron of a male turtle may present some difficulty to a monk seal in entering its muzzle into the body cavity. The monk seal preference for male turtles, observed during 1994 (Margaritoulis et al. 1996), can be explicated by the different technique for opening the body cavity that year, i.e. by snapping off plastral scutes. This technique would not limit the size of the opening, which is the case with openings through the rear flippers.

A somewhat persistent feature on the predated turtles was the fresh scratches or cuts on the eyes. In at least five cases (Nos. 4, 5, 6, 7, 19), predated turtles had a clear scratch or cut over their left eye. The cause of these scratches or cuts is not known, although they are connected somehow to the predation incident. Could they be caused by the monk seal’s nails trying to get hold of the turtle in order to be able to open it from below, or by the turtle’s nails trying to shed off the seal’s hold?

In light of the change in predation technique by monk seals during the 2010 season, we intend to retrospectively examine all turtle stranding data from recent years on Zakynthos.

The reasons for this type of predation may involve the noted depletion of marine resources in the area. Indeed, the loss of marine biodiversity caused by fishing pressure is a growing concern worldwide. Unsustainable fishing in the Mediterranean has caused the decline of many fish stocks (Garcia et al. 2005). In Greece, the increasing trend in marine landings for the period 1964-1994, attributed to fleet modernization and expansion of the fisheries, was followed by rapidly declining trends in landings and yields, thus suggesting that fishing had been unsustainable (Stergiou et al. 2007).

Bearzi et al. (2008) attribute the precipitous decline of the short-beaked common dolphin Delphinus delphis in the eastern Ionian Sea to a lack of food because of overfishing. In 1994, the predation of loggerheads by monk seals was attributed to the decline of fish stocks noted locally (Karavellas 1995, Margaritoulis et al. 1996).

Mediterranean monk seals have a greatly varied diet, but feed normally on cephalopods and various species of fish. However, they seem to be opportunistic feeders exploiting the resources that are most abundant at the time (Caltagirone 1995 and references therein). It is therefore hypothesized that the continuing reduction of marine resources are forcing monk seals at Zakynthos to search for other available prey. Unfortunately, loggerhead turtles that concentrate for breeding into Laganas Bay appear to be the newest prey item.

It is estimated that during the 2010 nesting season about 450 female loggerhead turtles nested in Laganas Bay (ARCHELON, unpublished data). The loss of at least 18 reproductively active females, representing 4% of the annual nesting population, is not sustainable in the long run, especially if this is on top of other losses (due to fisheries interaction, boat strikes, etc.) documented regularly in Laganas Bay and around Zakynthos Island. Although it is not known whether the current predation rate will continue in the future, it is recommended, despite the awkward circumstances of a Critically Endangered animal preying on an Endangered one, that the Management Agency of the NMPZ make a serious effort to investigate possible solutions for this unfortunate situation.

Acknowledgements: Field work on Zakynthos was carried out under permits by the Ministry of Environment and the NMPZ. We thank all ARCHELON
field assistants and volunteers, especially Benjamin C. Hawksbee, as well as the NMPZ wardens and personnel, for their valuable help in collecting data for this study. We also thank Paul Tsaros, in charge of ARCHELON’s Rescue Centre, for the necropsy results, and Charikleia Minotou of WWF Greece for conveying monk seal sighting reports. We acknowledge the use of the MapTool program for analysis and graphics (seaturtle.org) and thank Danielle Gault and Alan Rees for producing the map. Finally we thank two anonymous reviewers for their editorial assistance and helpful remarks.


A Review of Potential Marine Habitats for Marine Turtles in Turkey

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Two marine turtle species nest regularly on the Mediterranean coast of Turkey: the loggerhead turtle Caretta caretta and the green turtle Chelonia mydas. Both species are protected under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), Barcelona Convention and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Six of the seven species of marine turtle are recognised as threatened, endangered or critically endangered by IUCN (IUCN SSC, 2008).

Since 1988, twenty important nesting beaches for marine turtles have been identified along the Mediterranean coast of Turkey. These are from west to east: Ekinçik, Dalyan, Dalaman, Fethiye, Patara, Kale, Kumluca, Çıralı, Tekirova, Belek, Kizilot, Demirtas, Gazipasa, Anamur, Goksu Delta, Alata, Kazanlı, Akyatan, Yumurtalık and Samandag. In Turkey, marine turtles are under threat due to loss of nesting habitats, boat traffic/collision and fisheries bycatch.

In Turkey, efforts by marine turtle researchers and conservationists have been focused, for a long time, on marine turtle nesting sites. Therefore, there are limited data on feeding, breeding and wintering sites together with the impacts of fishery related activities on marine turtle populations. Although historically more turtle monitoring effort has focused on beaches, the number of detailed marine biodiversity studies carried out in Specially Protected Areas (SPA) has been increasing, particularly since 2002. During these studies, the occurrence of endangered species and species protected by international conventions are also considered and their presence and abundance is recorded.

Marine turtles are migratory species and they spend all phases of their lives, except for egg-laying in the sea. It is therefore considered that the most effective measure that would enable the species to survive is to minimise human induced risks in both land and marine habitats. Aside from ongoing conservation work, assessing reliable data from dead or alive stranded marine turtles will provide additional information about these animals’ habitats, migration routes, threats, and population trends. In addition to the above, data compiled from marine biodiversity studies, fisheries research and reports on satellite tracking on marine turtles may also provide insights as to the feeding habits as well as wintering and reproduction areas of marine turtles along Turkey’s Aegean and Mediterranean shores.

The compilation of data on turtles at seas in Turkey from various reports reveal some possible foraging areas and/or threats (Table 1). The Kaş-Kekova (Antalya) area appears to serve as a feeding ground for C. caretta, and principal threats include solid waste (plastic bags etc.), long line fishing and ghost fishing gear (abandoned nets and fishing line stuck on the bottom of the sea). Speedboats and long line fishing gear are the main causes of injury or death for marine turtles are found in the Kemer (Antalya) area. In the Eastern
Mediterranean (Bay of Iskenderun), intensive fishery activities have resulted in bycatch. Monitoring studies and observations indicate that the green turtle (C. mydas), which rarely nests in Turkey’s western Mediterranean beaches, has been using this region as a feeding ground. The fact that green turtles are accidentally caught in fishing nets in the Bay of Iskenderun during autumn and winter can be regarded as an indication that part of the population overwinters in this area. It is also observed that some satellite tracked green turtles spend the winter in the Bay of Antalya (Türkecan 2010; Godley et al. 2002). For these areas, fishery regulations and fishing bans need to be reviewed, methods of reducing fisheries bycatch must be promoted, the number of marine protected areas must be increased and capacity building programmes must be accelerated.


DURMUŞ, H. & A. ORUÇ. 2008. Çıralı, Maden Koyu, Beycik Bükü, Special Protected Area (Antalya) 2009- May 2010 Around Kaş, Çukurbağ Peninsula 6 loggerhead (all dead), 1 green (sent to rehabilitation center in Dalyan) Tural et al, in press

Dilek Peninsula-Menderes Delta National Park (Aydn) 2004-2007 Around Kuşadası (Kazıklı Bay, between Kavgolou and Mersinderesi bays), Kuşadası Fisheries Port 5 loggerhead (all dead) Surucu 2007

Datca-Bozburun Specially Protected Area (Mugla) 2003-2004 Kadırga Cape, Karagelme Bay and Samucak Cape loggerhead Okus et al. 2004

Around İskenderun Bay March 2002-February 2003 (trawl nets) İskenderun Bay 7 green turtles Avsar et al. 2006

Lycian Coast (Antalya) July-August 2002 Kaş, Kovan Island and Suluada loggerheads and greens Yokes 2003

Fethiye (Muğla) 1993-1998 Off Fethiye nesting beach and shore 9 juvenile loggerheads (dead) Turkozan & Durmus 2000

Between Iskenderun and Mersin (trawl September-May 1995-96 (a) - 5 boats 160 greens, 26 loggerheads (a) Oruc et al. 1997 by-catch data) 1996-97 (b) - 12 boats 306 greens, 116 loggerheads (b)

Table 1. Summary of studies and monitoring activities undertaken along Turkey’s Aegean and Mediterranean coasts.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Study Period</th>
<th>Location turtles observed</th>
<th>Species</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kemer (Antalya)</td>
<td>2007-2009</td>
<td>Kemer</td>
<td>4 green (1 dead); 1 loggerhead (4 live turtles sent to rehabilitation center in Dalyan)</td>
<td>Oruc et al. 2007; Durmus &amp; Oruc 2008; Durmus &amp; Oruc 2009</td>
</tr>
<tr>
<td>Kaş-Kekova Special Protected Area (Antalya)</td>
<td>2009- May 2010</td>
<td>Around Kaş, Çukurbağ Peninsula</td>
<td>6 loggerhead (all dead), 1 green (sent to rehabilitation center in Dalyan)</td>
<td>Tural et al, in press</td>
</tr>
<tr>
<td>Dilek Peninsula-Menderes Delta National Park (Aydn)</td>
<td>2004-2007</td>
<td>Around Kuşadası (Kazıklı Bay, between Kavgolou and Mersinderesi bays), Kuşadası Fisheries Port</td>
<td>5 loggerhead (all dead)</td>
<td>Surucu 2007</td>
</tr>
<tr>
<td>Datca-Bozburun Specially Protected Area (Mugla)</td>
<td>2003-2004</td>
<td>Kadırga Cape, Karagelme Bay and Samucak Cape</td>
<td>loggerhead</td>
<td>Okus et al. 2004</td>
</tr>
<tr>
<td>Around İskenderun Bay</td>
<td>March 2002-February 2003 (trawl nets)</td>
<td>İskenderun Bay</td>
<td>7 green turtles</td>
<td>Avsar et al. 2006</td>
</tr>
<tr>
<td>Lycian Coast (Antalya)</td>
<td>July-August 2002</td>
<td>Kaş, Kovan Island and Suluada</td>
<td>loggerheads and greens</td>
<td>Yokes 2003</td>
</tr>
<tr>
<td>Fethiye (Muğla)</td>
<td>1993-1998</td>
<td>Off Fethiye nesting beach and shore</td>
<td>9 juvenile loggerheads (dead)</td>
<td>Turkozan &amp; Durmus 2000</td>
</tr>
<tr>
<td>Between Iskenderun and Mersin (trawl September-May 1995-96 (a) - 5 boats</td>
<td>160 greens, 26 loggerheads (a)</td>
<td>Oruc et al. 1997</td>
<td>1996-97 (b) - 12 boats</td>
<td>306 greens, 116 loggerheads (b)</td>
</tr>
</tbody>
</table>


The Adriatic Sea, subdivided into three basins, is the most continental basin of the Mediterranean Sea. It has a surface area of 138,000 km² and various depths: the southern part reaches 1270 m, the central part 200 m and the northern one only 75 m, where large amount of rivers flow along its western coasts (e.g. the Po) influencing water temperature and salinity. The peculiarities of such sandy, shallow and productive waters create an excellent environment exploited by the loggerhead turtle, the most common species of marine turtle and productive waters create an excellent environment exploited by the loggerhead turtle, the most common species of marine turtle.

Unusual Stranding of Live, Small, Debilitated Loggerhead Turtles along the Northwestern Adriatic Coast

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The Adriatic Sea, subdivided into three basins, is the most continental basin of the Mediterranean Sea. It has a surface area of 138,000 km² and various depths: the southern part reaches 1270 m, the central part 200 m and the northern one only 75 m, where large amount of rivers flow along its western coasts (e.g. the Po) influencing water temperature and salinity. The peculiarities of such sandy, shallow and productive waters create an excellent environment exploited by the loggerhead turtle, the most common species of marine turtle throughout the Mediterranean (Margaritoulis et al. 2003). It is known from the literature that adult and sub-adult animals go into the northwestern Adriatic sea, which plays an important role in the biological cycle of Caretta caretta, both in the summer and in the winter time (Vallini et al. 2003, see Fig. 1).

During the summer 2009 and in particular between July 31 and August 24, a strange phenomenon occurred along the north western Adriatic coast: an unexpectedly large number of small loggerhead turtles were found alive in shallow water or stranded, debilitated and completely covered with barnacles. The strange phenomenon was unusual because of the number of animals involved, their small size, and their severe state of debilitation. Consequently, Italian researchers who work on these shores came together to investigate the emergency and attempt to understand its causes.

General physical examination. In total 13 turtles with mean curved notch-to-tip carapace length (CCL n-t) = 19.92 cm ±2.19, range: 17 - 23 cm and an average weight of 1.019 ±0.290 kg were found in the “Sette Lidi” of Comacchio (Ferrara, Italy) within an area of about 11.11 km (frequency = 1.1 animals per km), alive but debilitated. The turtles all displayed signs of the "Debilitated Turtle Syndrome," which has been described elsewhere in larger animals (78.06 cm +/-11.80 CCL n-t, Norton et al. 2008). All Italian turtles were emaciated, debilitated and dehydrated, largely covered by different species of barnacles, seaweeds (Fig 2a) and one crab (Planes minutus). The barnacles completely covered the shell, the plastron (Fig. 2b), the head and flippers so as to deform (Fig. 3a) and to hamper every single movement, particularly swimming. They were also found in the mouth, tongue, and external nostrils, completely filling them. To limit damage to the turtle, barnacle removal was facilitated through placing the animal for two to three days in fresh water.

Biochemical tests. Blood samples were collected from the jugular vein; serum biochemistry was determined for each animal by a Vet Scan 2 automatic analyser (Abaxix). The blood was centrifuged at 3000 rpm for 10 min at 37°C to obtain 0.06 cc of serum and read by spectrophotometry. The parameters analysed were AST (Aspartate aminotransferase), Bilious acid, Urac acid, Glucose, Calcium, Phosphorus, Total protein, Albumins, Globulins, A/G (Albumins/Globulins).

Table 1. Results of the biochemical analysis: Mean values, SD and ranges for all parameters considered, compared with

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Max 1</th>
<th>Min 1</th>
<th>SD</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST (IU/L)</td>
<td>nd</td>
<td>nd</td>
<td>±86.7</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Bilious acid pre</td>
<td>743.5 ±3.5</td>
<td>274.8 ±0.39</td>
<td>µmol/L</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Uric acid (mg/dL)</td>
<td>1.03</td>
<td>&lt;119</td>
<td>mmol/L</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>6.06 ±2.8</td>
<td>131.4</td>
<td>mmol/L</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>2.58 ±0.91</td>
<td>1.58 ±0.3</td>
<td>µmol/L</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>6.64</td>
<td>1.56 ±0.9</td>
<td>mmol/L</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Total protein (g/dL)</td>
<td>59.70 ±0.52</td>
<td>14.00 ±80.4</td>
<td>g/l</td>
<td>2</td>
<td>±0.8 g/dl</td>
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<tr>
<td>Albumins (g/dL)</td>
<td>14.30 ±0.29</td>
<td>0.62</td>
<td>g/l</td>
<td>1</td>
<td>±10.7 g/dl</td>
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<tr>
<td>Globulins (g/dL)</td>
<td>1.26</td>
<td>0.28</td>
<td>g/l</td>
<td>1</td>
<td>±0.9 g/dl</td>
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<tr>
<td>Alb./Glob.</td>
<td>0.53 ±0.19</td>
<td>0.23</td>
<td>g/l</td>
<td>1</td>
<td>±0.5 g/dl</td>
</tr>
<tr>
<td>Potassium (mEq/L)</td>
<td>2.65</td>
<td>±0.67</td>
<td>g/l</td>
<td>nd</td>
<td>nd</td>
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<tr>
<td>Sodium (mEq/L)</td>
<td>145.08</td>
<td>±5.7</td>
<td>g/l</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>CPK (IU/L)</td>
<td>1156.3 ±815.3</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
</tbody>
</table>

References:


Bacterial cultures were carried out on blood samples (N=12, two samples at intervals of about two weeks), and cutaneous (N=3) and pharyngeal swabs (N=12). Samples were sown on culture media selective Thiosulfate Citrate Bile Salts Sucrose (TCBS) Agar, Mac Conkey Agar and Trypticase Soy Agar (TSA) and not selective, Agar Globuli (Blood Agar) and Brain Heart Infusion Broth (BHI), incubated at room temperature for 24/48 hours. BHI was cultured on TCBS and Agar Globuli after 24 hours of incubation.

**Veterinary treatment.** The animals were subjected to antibiotic therapy with Marbofloxacin 2 mg/kg every other day or Enrofloxacin 5 mg/kg up to 10 days of treatment (IM), rehydrating therapy (1/3 Ringer’s solution, 1/3 0.9% physiological solution, 1/3 glucose, IM) and vitamin (B, A-D, E, IM) every 15 days, sunbathing and feeding for an average of 0.04 ± 0.01 kg of food, fish and crustaceans (4% of the percentage of body mass) per day, depending on the weight of each animal. Every other day or weekly as appropriate animals were dabbed with a dilute solution of surgical disinfectant, PVP-I (Iodoprovidone) locally to dry and promote healing of damaged areas by barnacles.

**Abiotic and genetic investigations.** We investigated oceanic parameters of temperature, salinity, surface and bottom oxygen, transparency and chlorophyll, obtained in the period from July to August for the area where the turtles were found and the main streams of Mediterranean and Adriatic, for possible links to the occurrence of these debilitated turtles.

The genetic structure of *Caretta caretta* in the Adriatic Sea was assessed by sequencing a fragment of the mitochondrial DNA 759bp (n=121), and ten loci microsatellites (n=76), and comparing the collected samples with 45 published Atlantic sequences. The aim was to understand whether the Adriatic loggerhead turtles represent a separate genetic unit with respect to the Atlantic samples, and

**Table 2. Bacterial culture results**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Blood sample</th>
<th>Cutaneous swab</th>
<th>Pharyngeal swab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerococcus/</td>
<td>nd</td>
<td>1(H.)</td>
<td>nd</td>
</tr>
<tr>
<td>Lactococcus</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td><em>Aeromonas hydrofila</em></td>
<td>3</td>
<td>nd</td>
<td>7</td>
</tr>
<tr>
<td><em>Aeromonas salmonicida</em></td>
<td>8</td>
<td>1(C.)</td>
<td>nd</td>
</tr>
<tr>
<td><em>Cedecea lapagei</em></td>
<td>2</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Polymorphous bacteria</td>
<td>nd</td>
<td>nd</td>
<td>5</td>
</tr>
<tr>
<td>Pseudomonas</td>
<td>1</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>fluorescens</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td><em>Pseudomonas luteola</em></td>
<td>1</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td><em>Pseudomonas stutzeri</em></td>
<td>1</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td><em>Vibrio paraemolyticus</em></td>
<td>nd</td>
<td>1(C.)</td>
<td>nd</td>
</tr>
<tr>
<td><em>Vibrio vulnificus</em></td>
<td>1</td>
<td>nd</td>
<td>nd</td>
</tr>
</tbody>
</table>

**Table 3. Pairwise distance for mtDNA.** In the lower matrix the Fst values are reported, while in the upper part the significance values are shown.

<table>
<thead>
<tr>
<th></th>
<th>Adriatic 1</th>
<th>Adriatic 2</th>
<th>Atlantic</th>
</tr>
</thead>
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<tr>
<td>Adriatic 1</td>
<td>0.054</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Adriatic 2</td>
<td>0.060</td>
<td>-</td>
<td>0.000</td>
</tr>
<tr>
<td>Atlantic</td>
<td>0.276</td>
<td>0.161</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 4. Genetic variability, number of samples, polymorphic sites, haplotype numbers, nucleotide diversity, and haplotype diversity.**

**Figure 1.** Main distribution of loggerhead turtles in the Mediterranean Sea (from www.seaturtle.org/maptool).

**Figure 2.** Initial appearance (a is dorsal surface, b is ventral surface) of the small debilitated loggerhead turtles.
Adriatic individuals, and the loggerheads that secondly to assess a possible genetic differentiation between the (sampled) stranded alive in summer 2009. Porto Garibaldi; and group two included the 12 loggerhead turtles included 64 samples from individuals caught alive in the area of size (Table 1).

Albumins suggest malnutrition, hepatorenal disease and enteritis considerable weight loss and low total proteins; reduced values of renal suffering and anaemia linked with pale mucous membrane, was still too emaciated to be released at the end of September 2009. an average increase of 0.9±0.65 cm CCL n-t in five animals. One average weight increase of 0.217±0.17 kg. Additionally, there was bacterial cultures. When seven animals were released, they had an days following admission, depending on the negative results of the bacterial cultures. When seven animals were released, they had an average weight increase of 0.217±0.17 kg. Additionally, there was an average increase of 0.9±0.65 cm CCL n-t in five animals. One was still too emaciated to be released at the end of September 2009. The biochemical analyses of the turtles show possible hepatic and renal suffering and anaemia linked with pale mucous membrane, considerable weight loss and low total proteins; reduced values of albumins suggest malnutrition, hepatorenal disease and enteritis (Table 1).

Epibiota. The most commonly present were small and medium-size Platyplas hexastylus (Fabricius, 1978). Other species were present but in low numbers, including Chelonibia caretta (Spengler, 1970), C. patula (Ranzani, 1818, one was full of eggs), and C. testudinaria (Linnaeus, 1758). The frequency of the genus Chelonibia in respect to Platylepas was 1.5-2%. All the barnacles of the genus Chelonibia were small: the biggest Chelonibia caretta was 12 mm, the largest observed C. patula was 13 mm, and the largest C. testudinaria was 17 mm. After exposure to fresh water, mechanical removal of the barnacles was still necessary. Several areas of the plastron, carapace and skin (especially on the flippers) were damaged from embedded barnacles (Figs. 3b-5). Within 30 days, much of the damage caused by the barnacles had healed (Fig. 6).

Bacterial cultures. The most frequent and common bacteria found was Aeromonas and only two turtles were affected by varieties of Vibrio, including V. vulnificus and V. paraemolyticus (Table 2). Four animals were negative for bacterial cultures (including the turtle that died after thirty nine days). In pharyngeal samples, the great growth of opportunistic bacterial flora was not possible to identify. For the two turtles that died during treatment, virological tests from liver and lungs were negative, but the two necropsies revealed, from visual examination, severe anaemia.

Genetic investigations. There was no significant genetic differentiation between the Adriatic groups, but significant separation compared to the Atlantic (Table 3). Haplotype frequency and distribution revealed 5 different haplotypes in the Adriatic region (Table 4). Haplotype CC-A2 was predominant in the two groups of turtles from the Adriatic region: 83% in group one and 67% in group two. Nucleotide diversity was extremely low, possibly indicating that the vast majority of Caretta visiting the Adriatic come from the same nesting site, which is probably in Greece.

Similar cases in the Mediterranean. Considering the oceanic parameters (31 July - 24 August 2009) with the main current of the basins (Fig. 7), during the summer the Adriatic waters are less dense than during winter, with water flow through the Otranto channel, which leads from the centre of the Mediterranean to the Adriatic. From October 2009 to June 2010, observations of small debilitated loggerhead turtles occurred in Greek waters. The ARCHELON Sea Turtle Rehabilitation Centre received several small (12.0 - 28.0 cm CCL) juvenile loggerhead individuals presenting different stages of debilitation. Although only one of them was covered with numerous barnacles, all of them were anaemic and presented different stages of debilitation with the presence of epibions. Most of them were collected in Aegean waters (Fig. 7). Between October and June 2008, eight small, apparently debilitated turtles were also sent to the Rehabilitation Centre, all with <30 cm CCL (Tsoaros, pers. comm.). Similar observations come from Malaga, Spain (Fig. 7), where >100 small debilitated sea turtles were seen in 2001, but few in 2000 and 2002 (Bellido, pers. comm.).

Because of their small size, no tags were applied to the turtles, as recommended by the Mediterranean Action Plan for the Conservation of Sea Turtles (UNEP-MAP-RAC/SPA). This will make it difficult to recognize these animals in the future, if they are encountered again. The main cause of their debilitation remains unknown. The presence of pathogenic bacteria, which are common secondary pathogens, is unlikely the primary cause of the debilitation (Norton, pers. comm.)

The high water temperatures in summer could have supported the proliferation of barnacles, which colonized the turtles in large numbers, and may have contributed to
their weakness. Although the growth rate of the epibions on these turtles is unknown, based on other work with *C. testudinaria* the time from hatching to cyprid (643 µm) takes about nine days (Zardus & Hadfield 2004) and coastal barnacles (genus *Balanus*) reach diameters of 8-10 mm within 3-4 weeks during the summer. Thus it is possible that it took 3-4 weeks for the barnacles on the small turtles to reach the size found (Relini pers. comm.). Considering that all the four species of barnacles are present in Italian waters, and the small size of barnacles found in the samples, it would be interesting to investigate barnacle growth rate as related to water temperature and water productivity.

The basic care of providing plenty of food, antibiotics for most of them, vitamins and rehydration therapy resulted in relatively a relatively short recovery time. The isolation of bacterial pathogens was not conclusive enough to uncover any pathogenic role they may have in *Caretta caretta*.

The size of the debilitated turtles is in the range in which the animals still feed upon pelagic prey in oceanic areas, while the shallow north western Adriatic waters are frequented by larger sub-adults and adults. It is known that the proportion of loggerhead <40 cm in size is greater in the southern portion of the Adriatic basin, compared to northern and central portions of the basin. There is an important nesting site for loggerhead turtle located in the Ionian coast of Greece, and thus the southern portion of the Adriatic basin is likely an important developmental oceanic area for the Greek population (Casale et al, 2005); these small loggerheads may have followed the currents to reach the north western Adriatic coast. Future research on small live loggerheads in this area may further illuminate their origins and behaviors.

**Acknowledgements:** Thanks to the Coast Guard of Porto Garibaldi and the Italian State Forestry Corps of Comacchio for their commendable work and collaboration. To Doc. Marta Zin (Rescue Centre “Il Benvenuto”) for her valuable work with the turtles, to the Doc. Donatella Gelli University of Veterinary Medicine of Padova that is hospitalising one of the little turtles of this work, Thanks to Doc. Caterina Fortuna (ISPRA) and ISPRA for financial support for the genetic investigation, Chiara Natali for laboratory work and Angela Formia for her help at various levels (University of Florence) of the DNA analysis. Thanks to Terry Norton (Georgia Sea Turtle Center), Prof. Giulio Relini for his work on the species determination of barnacles, Doc. Drasko Holcer (Blue World) and Doc. Carmela Cerrelli (Ce.E.A.M.-Aquarium AMP Capo Rizzuto) and Paul Tsaros, (ARCHELON) and Jesus Bellido (Aula del Mar de Malaga) for their collaboration, to C.F. (CP) T.V. Roberto Agostinis for the English review, to the Popular Bank of Milan (BPM) for giving us every year a financial support and to everybody who helped us with these turtles. A special thanks to the reviewers who assisted in making this work ready for publication.


Scalation Patterns of Loggerhead Turtles Nesting in Laganas Bay, Zakynthos Island, Greece

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In turtle, scalation patterns (including scales on the head and scutes on the carapace) provide taxonomic information. Nevertheless, in loggerhead turtles variation in scalation is rather common (Carr 1952 and references therein). Variation in the number of marginal scutes has caused in the past some taxonomic confusion. Specifically, the dissimilar marginal count observed by Deraniyagala (1933), among Atlantic and Indo-Pacific loggerheads, led him to declare the Indo-Pacific loggerhead a separate species (Caretta gigas) and later a subspecies of Caretta caretta (Deraniyagala 1939). This differentiation between Atlantic-Mediterranean and Indo-Pacific loggerheads on the basis of the marginal count was adopted also by Carr (1952). Brongersma (1961) examining marginal scutes in loggerhead specimens from Atlantic, Mediterranean, and Indo-Pacific found little variation among them and concluded that the marginal count is of no value in distinguishing subspecies. Similarly, Hughes & Mentis (1967) and Hughes (1974) working on loggerheads in Tongaland (South Africa) concluded that the Indian Ocean stock differs little in scalation patterns from the Atlantic stock, and because of the wide variation observed they rejected the use of the marginal count alone as a sound taxonomic character. Eventually, after the work of Pritchard (1979) and Pritchard & Trebbau (1984), the subspecies Caretta caretta gigas was rejected.

Hughes & Mentis (1967) noted discrepancies in the marginal counts between loggerhead hatchlings and adults. Brongersma (1975) stated that scute variations are more pronounced in hatchlings because of adverse environmental conditions during incubation, and these hatchlings usually do not survive to adulthood. This has been confirmed by subsequent authors (e.g. Yntema & Mosovsky 1980).

In the Mediterranean Sea there is a paucity of data concerning scalation patterns, especially of adult loggerheads. Capocaccia (1966) studied scalation patterns of loggerhead specimens, mostly juveniles, found in Italian museums or aquaria and thus it is not known whether these specimens belong to the Mediterranean or to the Atlantic stock. As far as can be ascertained, the only work on the variation of carapacial scutes on loggerheads nesting in the Mediterranean was done in Turkey (Turkozan et al. 2001).

Laganas Bay at the southern coast of Zakynthos Island, Greece, holds the largest nesting concentration of loggerheads in the Mediterranean. Since 1982 ARCHELON has conducted a long-term tagging project in Laganas Bay, which provided the opportunity to approach nesting females and observe their scalation patterns over a number of seasons. These observations are presented herein.

Scale and scute counts on nesting loggerheads were done, in varying intensity, over 8 nesting seasons (1983 - 1990) in the course of the routine tagging work at night. Nesting turtles were approached from behind, and after egg-laying they were measured and examined for tags or tagging scars; if they did not bear tags they were tagged. During or shortly after tagging an observer counted all or some, depending on the available time and the state of the turtle, of the following scalation sets: nuchal, vertebrals, supracaudals, costals, marginals, postoculars, and prefrontals. It was not always possible to count all scalation sets on the same individual as the carapace was often covered with sand and/or epibionts (e.g. barnacles, algae) and we generally did not want to further stress nesting turtles by attempting to clean them. Scalation counts on the same turtles, done repeatedly within the same season or among seasons, were combined to avoid pseudoreplication, i.e. to count the same scalation set two or more times for the same individual. To further reinforce this precaution, all counts on “scarred” turtles (i.e. bearing scars attributed to lost flipper tags) were excluded from the analysis.

In total 767 observations of various scalation sets were made over the seasons. These are distributed per season as follows 1983: 191, 1984: 139, 1985: 122, 1986: 31, 1987: 162, 1988: 59, 1989: 50, 1990: 13. By combining the observations of the same individuals and excluding all observations of “scarred” turtles, the total number of observations is reduced to 585 individual turtles. The patterns of the observed scalation sets appear below (see also Table 1).

**Nuchals.** The recorded number of nuchal scutes was 1 or 2. The most common pattern was 1 nuchal, which was recorded in 98.7% of all observed individuals (n=319).

**Vertebrals.** The recorded number of vertebral scutes ranged from 4 to 7. The highest frequency was 5 scutes, observed in 97.7% of all observed individuals (n=311).

**Supracaudals.** The highest frequency was 2 (1 pair), recorded in 97.7% of the observed turtles (n=86). There was one case with 1 merged scute and another case where each supracaudal was fragmented in 2 (see Table 1).

**Costals.** Six combinations of costal scutes were observed with the combination 5–5 being the most frequent, seen in 96.7% of the observed turtles (n=334).

**Marginals.** The two most commonly recorded combinations were 11–11 (42%) and 12–12 (36.8%) in all observed turtles (n=76). It is interesting to note that while the asymmetrical combination 12–11 had a frequency of 9.0%, the opposite combination 11–12 has a frequency of only 1.0%.

**Postoculars.** All observations on postocular scales revealed the same 3–3 combination (n=284 turtles). In a small number of turtles, one or two postoculars (always on both sides) were divided vertically in two, but this does not change the 3-3 combination as the posterior part of the divided scale did not border the eye orbit, and thus by definition it is not considered a true postocular.

**Prefrontals.** The observed combinations of prefrontal scales appear in Table 1. The digit after the addition mark refers to the number of small scales, called inter-prefrontals by Kamezaki (2003), found in the middle of the usually two pairs of main prefrontal scales. The most commonly recorded prefrontal scale combinations were 4 (38.3%) and 4+1 (33.3%) in the observed individuals (n=141). Cases listed as having 5 or 6 as main prefrontals refer to 1 or 2 azygous.
Table 1. Recorded patterns of scalation sets, number of cases and their frequencies (%) on adult female loggerhead turtles nesting in Zakynthos (L: left; R: Right; n: number of turtles). See text for explanations on supracaudals and prefrontals.

<table>
<thead>
<tr>
<th>Scalation set</th>
<th>L - R</th>
<th>n</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuchals (n=319)</td>
<td>1</td>
<td>315</td>
<td>98.7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>Vertebrals (n=311)</td>
<td>4</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>304</td>
<td>97.7</td>
</tr>
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<td></td>
<td>6</td>
<td>4</td>
<td>1.3</td>
</tr>
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<td></td>
<td>7</td>
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<td>0.6</td>
</tr>
<tr>
<td>Supracaudals (n=86)</td>
<td>1</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>2+1</td>
<td>84</td>
<td>97.7</td>
</tr>
<tr>
<td></td>
<td>2+2</td>
<td>1</td>
<td>1.2</td>
</tr>
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<td>Costals (n=334)</td>
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<td>0.6</td>
</tr>
<tr>
<td></td>
<td>4 - 5</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>5 - 5</td>
<td>323</td>
<td>96.7</td>
</tr>
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<td></td>
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<td>3</td>
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<td>Postoculars (n=284)</td>
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<td>100</td>
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<td>Prefrontals (n=141)</td>
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<td>54</td>
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<td>4+1</td>
<td>47</td>
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<td>4+2</td>
<td>21</td>
<td>14.9</td>
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<td>4+3</td>
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<tr>
<td></td>
<td>5+2</td>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>6+1</td>
<td>1</td>
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</tr>
<tr>
<td></td>
<td>7?</td>
<td>2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 2. Patterns of vertebral and costal scutes, sample size and frequency in 290 individual turtles nesting at Zakynthos (LC: left costal; V: vertebral; RC: right costal).

<table>
<thead>
<tr>
<th>LC-V-RC</th>
<th>n</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>4 - 4 - 4</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>4 - 5 - 4</td>
<td>1</td>
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<tr>
<td>5 - 5 - 5</td>
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<td>0.3</td>
</tr>
<tr>
<td>5 - 5 - 5</td>
<td>277</td>
<td>95.5</td>
</tr>
<tr>
<td>5 - 6 - 5</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>5 - 6 - 5</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>6 - 5 - 5</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>6 - 6 - 5</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>5 - 7 - 5</td>
<td>2</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Table 3. Patterns of vertebral, costal and marginal scutes, sample size and frequency in 60 individual turtles nesting at Zakynthos (LM: left marginal; LC: left costal; V: vertebral; RC: right costal; RM: right marginal).

<table>
<thead>
<tr>
<th>LM-LC-V-RC-RM</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 5 - 5 - 5 - 10</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>10 - 5 - 5 - 5 - 11</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>11 - 4 - 4 - 4 - 11</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>11 - 5 - 5 - 5 - 11</td>
<td>19</td>
<td>31.7</td>
</tr>
<tr>
<td>11 - 5 - 5 - 5 - 12</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>11 - 5 - 5 - 6 - 11</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>11 - 6 - 6 - 5 - 11</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>12 - 5 - 5 - 5 - 11</td>
<td>8</td>
<td>13.3</td>
</tr>
<tr>
<td>12 - 5 - 5 - 5 - 12</td>
<td>24</td>
<td>40.0</td>
</tr>
<tr>
<td>12 - 5 - 7 - 5 - 12</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>13 - 5 - 5 - 5 - 13</td>
<td>1</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Combinations of vertebrals and costals. In 290 turtles it was possible to observe, on the same individual turtle, the pattern of both vertebral and costal scutes. The most frequently observed combination was 5-5-5, recorded in 95.5% of the sample (Table 2).

Combinations of vertebrals, costals and marginals. In 60 turtles it was possible to observe, on the same individual, the pattern of vertebral, costal and marginal scutes. The most frequent combinations observed were 12-5-5-5-12 (40.0%) and 11-5-5-5-11 (31.7%, Table 3). The asymmetrical combination 12-5-5-5-11 had a frequency of 13.3%, while the opposite combination 11-5-5-5-12 has a frequency of only 1.7% (Table 3).

Combinations of nuchals, vertebrals, costals, marginals and supracaudals. In 55 turtles it was possible to observe, on the same individual, the pattern of all carapacial scutes: nuchal, vertebral, costal, marginal and supracaudal scutes (Table 4). The most frequent combinations observed were 1-12-5-5-5-12 (38.2%) and 1-11-5-5-5-11-2 (29.1%). The asymmetrical combination 1-12-5-5-5-11-2 appeared in 14.5% of the observed turtles, while the opposite combination 1-11-5-5-5-12-2 appeared only once (Table 4).

Scalation data of nesting loggerheads in Zakynthos over 8 seasons have shown that the most frequent pattern of carapacial scutes was 1 nuchal, 5 vertebrals, 5 pairs of costals, and 2 supracaudals. This pattern conforms, as expected, to similar studies on loggerheads around the world.

The most frequent combinations in marginal scutes, observed in a sample of 76 turtles, were 11-11 and 12-12. Nevertheless, in the samples of 60 and 55 turtles (Tables 3 and 4) where observations of multiple sets of carapacial scutes were performed on the same individuals, the most frequent marginal patterns were 12-12 (40.0% and 38.2% respectively) and 11-11 (31.7% and 29.1% respectively).
These observed patterns are similar to the observations of Turkozan et al. (2001), albeit at much lower frequencies. Indeed, those authors found 12-12 as the predominant marginal count with a frequency of 61.3% over four nesting beaches in Turkey. The above differences indicate once more the instability of the marginal count as a firm morphological character. Although the noted large variation in marginal scutes led several authors (Hughes 1974, Kamezaki 2003) to suggest that the marginal count should not be used as a criterion for classification, it would be interesting to continue or start such long-term observations in various loggerhead rookeries in the Mediterranean and compare the relevant nesting populations.

The number of postocular scales was stable with a 3-3 pattern on all examined individuals (n=284). The 100% stability of the postocular count in the present study has not been observed elsewhere. Deraniyagala (1939) and Kamezaki (2003) state that postoculars in Caretta caretta are 3 or 4, and Hughes (1974) reports a 3-3 postocular count in 91.5% of 47 nesting loggerheads in Tongaland and Natal. This morphological character, apparently not studied adequately worldwide, deserves more examination as it may prove a more stable criterion for classification.

Prefrontal scales showed a wide variation with 38.3% of the observed individuals having 4 scales (2 pairs), 33.3% featuring a pattern 4+1 (2 pairs of main prefrontals incorporating one azygous scale in the middle), and 14.9% with a pattern 4+2 (2 pairs of main prefrontals incorporating two smaller scales in the middle). This generally complies with the typical loggerhead pattern given by Kamezaki (2003).

**Acknowledgements.** We thank all ARCHELON field leaders, assistants and volunteers who staffed tagging teams and assisted in data collection. We also thank an anonymous reviewer who made helpful remarks.

<table>
<thead>
<tr>
<th>N-LM-LC-V-RC-RM-S</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-11-4-4-11-2</td>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>1-10-5-5-5-10-2</td>
<td>1</td>
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</tr>
<tr>
<td>1-10-5-5-5-11-2</td>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>1-11-5-5-5-11-2</td>
<td>16</td>
<td>29.1</td>
</tr>
<tr>
<td>1-11-5-5-5-12-2</td>
<td>1</td>
<td>1.8</td>
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<tr>
<td>1-12-5-5-5-11-2</td>
<td>8</td>
<td>14.5</td>
</tr>
<tr>
<td>1-12-5-5-5-12-2</td>
<td>21</td>
<td>38.2</td>
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<td>1-13-5-5-5-13-2</td>
<td>1</td>
<td>1.8</td>
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<tr>
<td>2-11-5-5-5-11-2</td>
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<td>1.8</td>
</tr>
<tr>
<td>1-12-5-7-5-13-2</td>
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</tr>
<tr>
<td>1-11-6-6-5-11-2</td>
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<td>1.8</td>
</tr>
<tr>
<td>1-11-5-6-5-11-2</td>
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<td>1.8</td>
</tr>
<tr>
<td>1-11-5-5-6-11-2</td>
<td>1</td>
<td>1.8</td>
</tr>
</tbody>
</table>

**Table 4.** Patterns of carapacial scutes, sample size and frequency in 55 individual turtles nesting at Zakynthos (N: nuchal; LM: left marginal; LC: left costal; V: vertebral; RC: right costal; RM: right marginal; S: supracaudal).

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In Turkey, Fethiye is one of the major nesting beaches (Baran & Kasparek 1989) and one of a dozen key Caretta caretta nesting sites (Margaritoulis et al. 2003). The whole bay area is designated as the Fethiye-Göcek Specially Protected Area (Council of Ministers’ Decision 88/13019, 12.06.1988). Researchers of Adnan Menderes University, Dokuz Eylül University, Pamukkale University and the University of Vienna have been carrying out studies and collecting data at Fethiye nesting beaches since the early 1990s. The beach is divided into three sections: Çalış, Yanıklar and Akgöl (Fig. 1, from Ilgaz et al. 2007). Çalış (2.5 km) is separated from the other two beaches by a small rocky peninsula and over about half its length is lined by a concrete wall, topped by a broad promenade with hotels, restaurants, bars, etc. to accommodate tourism. Nesting occurs mostly along the promenade stretch where the beach is sandy and gently sloping. Elsewhere, the beach is steeper and consists of pebbles, but certain stretches are still used for nesting. Yanıklar (4.5 km) is the core nesting site of Fethiye, its width varies between 50-80 m. Akgöl (1 km) is 50 m wide and except for some short yet important stretches of sand at both ends, this beach is less suitable for nesting as about 300-400 m are mostly covered with pebbles.

Threats to the nesting population have been increasing since Baran & Kasparek’s first assessment in 1988, resulting in serious nesting decline since 1993 (Türközan 2000; Oruç et al. 2003; Ilgaz et al. 2007). The number of nests has been declining since first records in the early 1990s: peak 191 nests in 1995, lowest value 58 in 2004 (see Fig. 2 from Ilgaz et al. 2007, for graph of trend and Türközan et al. 2003, for nest numbers).

Fethiye used to be a tourist ‘insider’s tip’ until a broader range of tourists discovered the location’s natural beauty and proximity to tourist attractions such as the Butterfly Valley, marinas, paragliding sites and ancient monuments. Infrastructure developed (including small hotels as well as large, all-inclusive complexes) and Fethiye has now become a standard holiday destination, well advertised by Turkish and international tour operators as an attractive base for well-organised visits and tours. Currently, the majority of visitors are British and the location has also become popular among foreign pensioners buying land to move to warmer climates.

In spite of the drop in nesting, the average number of nests recorded between 1993 and 2004 still makes this beach one of the most important nesting sites in Turkey, as 8.8% of the total nests laid annually are recorded in Fethiye (Ilgaz et al. 2007).

Decline in nesting at Fethiye does not correspond to an observable increase at neighbouring beaches (Ilgaz et al. 2007), indicating poor sea turtle conservation measures in this region. Apart from natural causes, e.g. severe winter storms that cause beach erosion in certain sections, anthropogenic impact is the main cause of this decline – as is the case in many other nesting locations around the Mediterranean. If nesting continues to deteriorate or even cease in Fethiye (see scenarios in Ilgaz et al. 2007), the genetic diversity of loggerhead sea turtles in the Mediterranean will also decrease (Yılmaz et al. 2008) to the detriment of the species’ chance of survival.

The Nesting Beach. The picture one faces upon arrival at Fethiye is that of snack bars, volleyball courts, restaurants and cafes on the nesting beaches, motorised water-sport activities in the sea, wooden walkways directly on the sand and dense rows of beach furniture, which remain in position on a 24-hour basis. Strong lighting is used during the night and visitors freely roam the shores until the small hours. Giant picnics occupy the beach (especially during the weekends), quads and trucks cross the sand, as there is vehicular access to virtually every section. The garbage problem is entirely unsolved, there has been sand removal at Çalış and Yanıklar and fishing occurs directly off all three of Fethiye’s “specially protected” nesting beaches.

The major wetland at Çalış began to be bulldozed in 2004. It was then filled with rubble for the construction of the 553-room ‘Sunset Beach Club Apartments’, which subsequently placed beach furniture, a children’s playground, huge pillows and potted trees on the nesting beach. In 2009, a brand new wooden boat jetty was built in front of the complex. Only a small stretch remains available for nesting between the complex and the adjoining ‘Surf Café’. This snack bar, sports centre and camping ground complex is continuously expanding “its” territory by placing a wall of boulders along the midline of the beach. It has installed continuous rows of sunbeds, umbrellas, wooden walkways and covered the beach with extensive plastic “lawn” carpeting to facilitate bathers, kayakers, wind and kite surfers. Beach bonfires and parties take place every week throughout the summer until late at night. In the few nests still found at either side of the ‘Surf Café’, hatchling disorientation...
due to the light pollution has been observed. In 2001, fourteen rows of about 800 acacia trees, an introduced species known for its extensive rooting, were densely planted along a 150 metre stretch directly over the high-water mark at the edge of the beach where the cobble section ends and the first strip of sand suitable for nesting begins. In 2008, there were at least three new large snack bars on the section of Çalış beach that is not lined by the promenade, with their sun beds and umbrellas impairing nesting.

Over the last 15 years, at Yanıklar, the 165-room ‘Lykia Botanika Hotel’ situated 150 metres behind the beach in the forest, placed 191 sun beds, planted trees and bushes and built walkways, wooden huts and small bars directly on the nesting beach. At night, 25 m from the waterline, the hotel’s disco blasts its music and lights up the beach until the small hours. Its initially small jetty was gradually enlarged and extended to accommodate water sports and tourist boats. The neighbouring 444-room ‘Majesty Club Tuana’ constructed an even larger cement jetty. The area in front of the complex has become a centre of motorized water sports during the day and beach parties and fireworks at night.

There is visible new development at Akgöl and Çalış beaches, and further construction appears likely as tourist numbers rise. Until 2009, few signs informing visitors of the presence of sea turtles and Fethiye’s protected status remained on the beaches. Those that did were in desolate condition and poorly positioned.

Moreover, Turkish Authorities are considering building a shipyard/drydock at Akgöl beach that would permanently and irrevocably destroy this nesting area.

The Bern Convention. In August 2009, alerted by local conservationists about the recorded decline of nesting at Fethiye and the severe degradation of the habitat, MEDASSET submitted a Complaint to the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) at Council of Europe (Strasbourg, France). Three update reports to the Convention followed. Turkey is a Contracting Party to the Convention. The implementation of Recommendation No. 66 (1998) made by the Convention to the Turkish Authorities “on the conservation status of some nesting beaches for marine turtles in Turkey” which includes Fethiye, was discussed at the Bern Convention Standing Committee Meeting in 2010, during which the Turkish Environmental Protection Agency for Special Areas (EPASA) informed of its plans to implement conservation measures in 2011.

The Campaign. A short film, “Turkey’s Sea Turtles in Trouble”, was made in September 2009 by an outstanding, experienced and well-connected former BBC natural history film-maker at the nesting beaches in Dalyan, Iztuzu, Fethiye, Çalış, Yanıklar, Yonca, Akgöl and Sarigerme. The aim of the film is to highlight the successful implementation of conservation measures at Dalyan, while at the same time drawing the viewer’s attention to the lack of protection at the important neighbouring nesting beaches. A shorter version was produced focusing exclusively on Fethiye.

Both versions were made available to the general public through the internet (e.g. YouTube, Facebook, etc.), MEDASSET’s newsletters and website. In November 2009 the Fethiye version was shown at a side event of the 29th Bern Convention Standing Committee Meeting in Bern, Switzerland, in order to draw the delegates’ attention to the issue. The film was subtitled in Turkish and presented at the 3rd Turkish National Sea Turtle Symposium in Mersin, in December 2009 and at the 30th International Annual Symposium on Sea Turtle Biology and Conservation in India, Goa, April 2010.

In January 2010, a campaign letter and a copy of the Fethiye film were sent to the Turkish Ministry of Environment. In March 2010, letters and DVDs were sent to the major international tour operators active in Fethiye, as well as to the local hotels, restaurants and bars that affect the beaches. All were informed of MEDASSET’s actions to address the situation and were provided with information on the corrective measures necessary to protect the turtles. Tour operators were requested to act upon their publicised commitment to environmental protection, to require from their partner businesses at Fethiye that they should adopt sea turtle-friendly behaviour and alter their facilities and activities accordingly. Recipients were informed of the wide distribution of the film and its potential to cause damaging negative publicity, given that tourists are becoming increasingly concerned about the protection of biodiversity and beginning to choose both their destination and their accommodation accordingly. In order to create a process of discussion and dialogue, the businesses were also invited to give interviews during filming planned for the future: “We’ll be back!”

The campaign is ongoing, and to date the EPASA applied some nesting beach conservation measures in 2011 and has included Fethiye in the Global Environment Facility (GEF) project “Strengthening Protected Areas Network of Turkey: Catalyzing Sustainability of Marine and Coastal Protected Areas”. Following MEDASSET’s reports and letters regarding the shipyard/drydock construction, the MTSG Co-chairs and the Bern Convention Standing Committee expressed their objection to the project in writing to the Turkish Authorities.

Sunset Beach Club Apartments replied with a denial of the existence of nesting but pledged to discontinue use of water sports equipment (sic), keep the beach clear at night and free of vehicles at all times. The leading international travel group TUI AG organised the stakeholder meeting “Travellers without boundaries - Kick-off event for implementation of sea turtle protection measures in the Dalaman region” in May 2011, in Sarigerme, to address the issue and developed guest and hotel guidelines in English, Turkish and German for sea turtle protection in Turkey in collaboration with MEDASSET, DEKAMER and the Kaptan June Foundation.

A new approach. The film’s clarity and visual confirmation of all issues described in the letters and the Complaint submitted to the Bern Convention Secretariat, makes it a powerful tool for presenting the case and convincing viewers of the severe degradation of nesting beaches at Fethiye. Apart from helping visitors to become aware of the impacts tourism has on the environment and to think about the true “cost” of their holidays, the film is expected to be a useful leverage tool in the campaign to protect Fethiye’s nesting beaches. The content of “Turkey’s Sea Turtles in Trouble” cannot be contained as it is now in the public domain and therefore outside the control of Turkey’s policy makers, its tourist industry, or its responsible national authorities. By presenting not only the severe impacts that tourism is having on an endangered species and its habitat but also the lack of implementation of conservation measures within a supposedly “specially protected area”, the film has the potential to tarnish their image if the situation is not remedied.

The rise of concepts such as “Responsible Tourism” and “Corporate Social Responsibility” provides additional opportunities to exert pressure. Major tour operators pay lip-service to such
Information concerning sea turtles in Albania has, until recently, been sparse. Groombridge (1990) wrote that nesting had not been reported, but that turtles were likely to be present in Albanian waters. Sea turtles were first studied in recent years by Prof. Idriz Haxhiu (former Tirana University) who worked mostly with local fishermen that caught turtles in their nets in Drini Bay (Haxhiu & Rumano 2005). In 2002-2003 a basic population study was undertaken at Godull using 200 Dalton’s Roto-tags that were provided by the Regional Activity Centre for Specially Protected Areas (RAC/SPA) of the UNEP Mediterranean Action Plan (UNEP/MAP).

In 2005 the Mediterranean Association to Save the Sea Turtles (MEDASSET) conducted a coastal survey to assess the current status of sea turtles and the critically-endangered Mediterranean monk seal (Monachus monachus) in Albanian waters (White et al. 2006). During the month-long voyage all caves and potential reproductive sites for seals were visited; but no seals or signs of them were encountered. At each port fishermen were interviewed about their bycatch and sightings of marine megafauna. It became clear that sea turtle bycatch and sightings were greatest in sea areas north of Durres, especially in Drini Bay, at Godull and Patok (Fig. 1).

With the aims to identify Drini Bay and the wider Patok area as a feeding ground and to build local sea turtle monitoring capacity, MEDASSET launched the 3-year project entitled: Monitoring and Conservation of Important Sea Turtle Feeding Grounds in the Patok Area of Albania 2008-2010. In 2008, the project developed a suitable method for studying turtles and bycatch from Drini Bay and raised awareness locally. In 2009, in parallel to monitoring the sea turtle population and bycatch, the principal objective of the project was to build capacity in Albania that was currently lacking. This included: developing organisational capacity (e.g. CITES export permit process for DNA samples); initiating project management practices in an NGO (Herpetofauna Albanian Society); educational awareness; and most importantly to train university students as field researchers. DNA skin samples were collected and are being analysed by Dr Oguz Turkozan to train university students as field researchers. DNA skin samples were collected and are being analysed by Dr Oguz Turkozan (Adnan Menderes University, Turkey). The first, 2-year, satellite-telemetry programme in Albania was also launched, monitoring the movements of two male and one female loggerhead turtles.

The third and final year’s aim (2010) was to continue monitoring, tagging and DNA sampling, while focusing on training more of Albania’s future researchers, and deepening the knowledge and skills of those already trained. Two MSc biology students from Tirana University are using the project data for their dissertation studies. The most important task however, was to draft and deliver recommendations to the Albanian National Authorities, so that a strategy protecting sea turtles and their habitats throughout Albania and its territorial waters can be adopted and implemented; there is no existing management plan or specific sea turtle protection legislation. Results from the 2008-2009 period are presented here.

Extensive fishing occurs in Drini Bay, with artisanal fishing...
being the main economic activity, especially in its remote southern part. Drini Bay provides a unique opportunity to collect data from loggerhead turtles as they are incidentally captured in the special type of pound net fish-traps called ‘stavnike’, originating in Russia and initially introduced into Albania ~53 years ago. The Patoku fishermen started to use them in 2003. Stavnikes are constructed in shallow water (6-8 m depth) often near to the shore (although one set of traps was nearly 2 km offshore) and operate between May and September (depending on weather conditions). Research involved working with two main groups of fishermen at Patoku that operated stavnikes. Due to their poor financial situation the project contributed to their fuel costs, so that they could bring the turtles ashore for study instead of immediately releasing them back into the sea.

The following types of data were collected from turtles: morphometrics (e.g. curved carapace length CCL), photo-recognition (White 2006, 2007) and flipper-tagging. If turtles had originally been tagged with (Dalton’s) plastic Rototags, these were removed by our researchers and replaced with Stockbrand’s titanium tags. This was done to reduce the risk of entanglement in fishing gear and remain readable for a much longer period. Some Rototags were unreadable after only five years (White pers. obs.).

Sexual development was determined from external tail measurements (Casale et al. 2005; White et al. 2008; 2010). The term ‘adolescent’ is used throughout to indicate juveniles in which developing secondary sexual characteristics are visible, but the animal is yet to mature.

Fish catch was assessed to determine any likely attractants for turtles. Certain environmental parameters were measured each day at Patoku during the summer field-seasons (e.g. water temperature, sea state, cloud-cover) so that a comprehensive understanding of the coastal zone could be achieved. The wind speed and direction were also recorded on most field-days; these would later prove to be important in the plastic pollution study (see below). Data were collected from June to September of each year.

Surveys of potential nesting beaches around Drini Bay were conducted; looking mostly for tracks or signs of nesting activity; local people were interviewed on an ad hoc basis.

**Sea turtle bycatch.** Loggerheads were frequently captured as bycatch (non-target species) in stavnikes; green turtles rarely (White et al. 2008; 2009). Turtles captured incidentally were mostly (99%) obtained from two sets of stavnike fish-traps; one set operated offshore from River Ishmi, the other near River Mati; both of these locations are in the southern half of Drini Bay. The fish-traps mostly worked during May-July; in 2008 both stavnikes were destroyed by heavy seas in late-July; in 2009 Mati stopped on 29 July, Ishmi continued until early-September, but in its final three weeks caught little of anything. A small number (1%) of turtles were captured in gill-nets at Godull and at a stavnike near to Shengjin in the northeastern corner of the bay. Occasionally there were telephoned reports of turtles captured elsewhere.

Most of the bycatch consisted of loggerheads. During the two field-seasons we tagged over 245 loggerheads [Mean CCL = 64.0 ±8.6 cm, n = 211 records; some turtles had carapace-damage and were data-deficient] (White et al. 2008; White et al. 2009). A surprisingly high number (27%) of these animals were males (23 adults & 43 adolescents) (White et al. 2010). One juvenile *Chelonia mydas* was captured in Ishmi stavnike (04/06/2008 CCL = 39 cm. White et al. 2008); and another one (06/10/2009 CCL = 30 cm) was captured by fishermen at Orikum, (Fig. 1); this latter animal was measured and photographed by a project–trained researcher (Mitro pers. com. 2009).

In each field-season (2008-2009), a small number of individual turtles were recaptured in stavnikes (17 in 2008; 10 in 2009). These intra-annual events demonstrate that some turtles appear to remain foraging in the study area; even if only in the summer. One noteworthy fact is that being captured in a trap and then being manhandled for release, or transferred into a small boat and brought ashore for research purposes, did not seem to deter these turtles from foraging in the bay, or re-entering the stavnikes. One individual loggerhead was taken five times in June-July 2008. The first green turtle mentioned above was recaptured after three weeks, showing that it too had probably continued foraging in Drini Bay during this period. Turtles that were recaptured only in the same stavnike always demonstrated a more-localised foraging pattern. There were 13 turtles captured in both Ishmi and Mati traps, which were 4.5 km apart, suggesting that a wider feeding area was being used.
A number of loggerheads (n = 21) were assumed to have remigrated into Drini Bay in different years. These were inter-annual recaptures; however, they may have remained in local waters during the intervening period between captures and were simply not encountered. Their status was determined from flipper-tags, which had all been applied in this area of Albania.

**Temporal occurrence.** The question of when are sea turtles in Drini Bay was a difficult question to answer, primarily because most of our turtles were obtained from stavnikes, which are a summer-only fishery. The stavnike fishermen are working from small flat-bottomed boats, so as soon as the weather begins to deteriorate, the stavnikes are dismantled and the fishermen catch eels Anguilla anguilla in the shallow inner lagoon. So the fishing practices are completely different between summer and winter. There were occasional reports by other fishermen of incidental captures during the winter months; and some of these turtles were measured by Albanian researchers (White et al. 2009).

Three SPOT5 satellite tags (Wildlife Computers) were configured to only report location data (given that many oceanographic parameters are available online, and there are reliable bathymetric marine charts for the Adriatic Sea) and were successfully deployed onto loggerheads on 12 September 2009. The telemetered turtles were an adult-sized female “Shpresa” (Hope) and two adolescent males “Guximtari” (Brave) and “Patoku”. This study will reveal whether these loggerheads remain in Albanian waters during the winter months and the project will generate spatial understanding of the range for this species found in Albania. All three devices were still transmitting as of December 2010. The turtles’ migration maps can be found at: www.seaturtle.org and “Turtle Tracking” at www.medasset.org. Some early findings show that the three animals behaved differently: Shpresa seems to have remained in Drini Bay all winter; Patoku went south to Corfu, but then returned to Drini Bay in late-April; Guximtari headed north to Bosnia-Herzegovina and returned to Drini Bay in July. This is the first direct evidence for the timing of a remigration into Albanian waters.

Some other evidence that might support turtles remaining in local waters over the winter months is that 51% of our captured animals (Saçdanaku 2010) have high loadings of epibiota, especially barnacles (Chelonibia testudinaria and Lepas spp.). Although the planktonic larval-stages settle randomly, some of the loggerheads have a dense pattern of epibiota, including algae and mussels Mytilus galloprovincialis suggesting that they had been dormant on the seabed for some time. The turtles with clean carapaces may have recently arrived from oceanic habitats (Limpus pers. com.), but then they gain epibiota whilst in neritic waters.

**Abiotic factors.** The most important environmental parameter measured was the sea surface temperature (SST); the mean monthly SST was >26.5°C during the period when turtles were captured as bycatch; and so temperature is not a limiting factor for their presence (White et al 2009). There are no direct temperature data for the winter months at Patoku; however, SST at Venice in the northern Adriatic may fall as low as 9°C. Therefore it seems likely that SST in Albanian waters will be somewhere between that in Venice and those reported from the Ionian (White 2007). The possibility of turtles being cold-stunned cannot be ruled out if they stay in Drini Bay over winter; cold stunning events have been recorded in the Adriatic sea (see references in Casale & Margaritoulis 2010).

**Plastic debris.** White et al. (In press-b) reported the extensive problem of anthropogenic litter on all of the beaches in the study area (Drini Bay is 30 km north to south). Large quantities of debris (90% was plastic) covered all beaches; much of it appeared to have spent at least some time in the sea (for methods see White et al. In press-b). The worst-affected areas were at the mouth of Ishmi River (1595 items in a 10m × 10m quadrat), which transports the waste from Tirana into the bay; and the adjacent beaches at Godull (1095 items), where there is an impoverished and isolated fishing community - the plastic debris clearly did not originate from there. The most likely scenario is that the garbage travels down the rivers into the sea, but then the prevailing Maestrali wind (northwest) keeps the debris entrained in the bay, where it is washed up onto the beaches by the waves. Only visible pollution could be assessed during this survey, as we had no equipment or analytical facilities for microbiological sampling; but it seems likely that other inorganic and organic pollutants are present, especially in Ishmi River.

**Nesting activity.** No signs of nesting were observed.

Stavnikes have proved to usually be non-lethal for turtles, as they are able to surface and breathe normally (White et al. 2008). Stavnikes can only be applicable elsewhere as a means of sea turtle bycatch reduction if suitable environmental conditions exist: shallow water depth and soft substratum, weak current-flows and, in particular, a small tidal-range; otherwise the catch, and turtles, will escape over the top of the pound nets.

**Sea turtle habitats in Drini Bay.**

a) **Foraging.** Our research shows that loggerhead turtles use Drini Bay throughout the summer months. The majority (90%) of turtles are untagged, which suggests that these animals either utilise or migrate through the area (Lazar et al. 2000, 2004b). The intra-annual recaptures show that those individual turtles remain in Drini Bay for several months. [In 2010 we obtained direct faecal evidence that benthic foraging occurs; unpublished data]. Of particular importance is the presence of male loggerheads, as little is known about the marine ecology and distribution of male sea turtles, especially in the Mediterranean region (Limpus and Limpus 2003; Margaritoulis et al 2003; Schofield et al. 2006; White 2007; White et al. 2008; In press-a, 2010). A further interesting point is that Albania is not en route to any known nesting beaches – these are mostly in the eastern Mediterranean basin (Ionian & Levantine Seas) – and so if this unusual aggregation of adult males indicates a mating envelope, then females would have to travel northwards to mate, before returning to their nesting beaches in the south. Nesting has not been reported from Albania.

b) **Development.** The presence of so many adolescent males is intriguing (White et al. 2010b), and so perhaps some form of social facilitation exists whereby the young males learn about courtship from the adults; Green (2000) noted that both adult and adolescent male Chelonia mydas acted as ‘attendants’ during his observations of green turtle mating behaviour at Galapagos. The chance for opportunistic sex (‘sneaking’) cannot be discounted, however, it seems doubtful that the still-developing tail of an adolescent male would actually be long enough to bring his cloacal opening into the correct position for copulation to occur (White pers. com. 2010).

c) **Migration corridor.** Turtles moving between the Ionian and Adriatic Seas have to pass through either Italian or Albanian waters (White 2007, Casale 2010, Lazar 2010, Casale & Margaritoulis 2010, Lazar & Ziza 2010).

d) **Wintering.** Our only evidence for possible overwintering is “Shpresa” the telemetered female who remained in Drini Bay
all winter; and the hypothetical assumption derived from the loggerheads with heavy epibiotic loading (barnacles) – i.e. that they remained on the benthos for an extended period.

Recaptures. All of the recaptures had been tagged in Albanian waters, there were no records of turtles with foreign tags, such as those reported by Lazar et al. (2000 & 2004b): loggerheads that were captured in Croatian waters had been tagged at Zakynthos, Greece; and perhaps had travelled to Croatia using the northwards-flowing current from the Ionian Sea into the eastern Adriatic Sea (Orlic et al. 1992). So far only a single report has been received from elsewhere of turtles that were tagged in Albania (report from diver, Gulf of Sire, Libya, November 2010).

Green turtles. The recent review of Chelonia mydas in the Adriatic Sea by Lazar et al. (2004a) examined historical records, museum specimens, and reported the first confirmed record of a green turtle in the eastern Adriatic Sea. This was a dead juvenile from Tripanj, Croatia, that had drowned in a gill-net in 2001. It seems that there was a historical misunderstanding amongst Adriatic fishermen that “larger turtles” were C. mydas and the “smaller ones,” C. caretta; so some of the C. mydas records are believed now to have been C. caretta (Lazar et al. 2004a). Therefore the two live juveniles reported in this paper confirm that C. mydas does venture into eastern Adriatic waters. Gace (unpublished data) reports a further three live C. caretta from Albanian waters during 2003 [31/05/2003 CCL = 27 cm; 14/08/2003 CCL = 29 cm; 03/09/2003 CCL = 67 cm]; Haxhiu (unpublished data) reports about 15 [CCL <50.0 cm] (Haxhiu & Rumano 2005; 2006; Haxhiu, 2010); however, it is now believed that some of these were misidentified C. caretta: oceanic phase loggerheads with very clean carapaces and pale plastrons were assumed to be C. mydas (T. Bino, Ministry of Environment, pers. com.).

Regionally Chelonia mydas nests only in the northeastern Mediterranean; and more usually has a tropical distribution. Margaritoulis et al. (1992) observed small juvenile green turtles that had been captured in trawl-fisheries operating in Lakonikos Bay, southeastern Peloponnese, Greece. Albania had not been included in the range state for C. mydas in the Mediterranean: the authors have now rectified this with CMS (Bonn Convention 1979) using these sightings from Albanian waters.

Acknowledgements. We acknowledge use of the Mapttool programme (SEATURTLE.ORG) for the map in this paper. Special mention goes to Prof. Haxhiu who alerted Lily Venizelos on the existence of sea turtles in Albanian waters during 2003 [31/05/2003 CCL = 27 cm; 14/08/2003 CCL = 29 cm; 03/09/2003 CCL = 67 cm]; Haxhiu reports about 15 [CCL <50.0 cm] (Haxhiu & Rumano 2005; 2006; Haxhiu, 2010); however, it is now believed that some of these were misidentified C. caretta: oceanic phase loggerheads with very clean carapaces and pale plastrons were assumed to be C. mydas (T. Bino, Ministry of Environment, pers. com.).
Sea turtles are marine reptiles that spend most of their lifetime at sea, migrating long distances between their foraging and nesting grounds (Bolten & Balazs 1995; Bjorndal & Bolten 1997; Miller 1997; Musick & Limpus 1997). As hatchlings and small juveniles, passive movements may take turtles hundreds or thousands of kilometers away from their natal and foraging areas (Witherington 2002; Bolten 2003). Upon reaching maturity, sea turtles migrate back to their natal beaches for breeding. Subsequently, adults again undertake long distance migrations to their foraging and wintering grounds (Bolten & Balazs 1995; Bjorndal & Bolten 1997; Miller 1997) and satellite tracking studies on the beach in July (Table 1). The tagging process was not started until after oviposition ended.

Platform terminal transmitters (Kiwisat PTT 101, Sirtrack, New Zealand) were used to track turtle movements. The tags were 190 x 62 x 35 mm, 430 g and powered by two C battery cells, making them capable of transmitting data for 260 days with a one day on and one day off duty schedule. The PTTs were attached to the second vertebral scutes, which were first sanded smooth and cleaned with acetone to eliminate any organic material. A two part epoxy glue (Bison Epoxy Brand) was used for the attachments. Tagged individuals were selected from females encountered while nesting on the beach in July (Table 1). The tagging process was not started until after oviposition ended.

Turtle positions were determined using the Argos system (CLS, France). Location classes 3, 2, 1, 0, A and B reflect the accuracy of the location with 3 being the most accurate and B being the least accurate. The accuracy of classes 3, 2, and 1 are <150 m, <350 m and <1000 m, respectively. Classes 0, A and B have no upper limits of location accuracy. Locations 3, 2, 1, 0 and relevant results from classes A and B were used to evaluate turtle migration routes following nesting.

A total of 189 (Turtle 007) and 269 (Turtle 008) locations were received during the tracking processes (Table 1). Of these 111 (Turtle
Turkey (d=days).

classes for two tracked green turtles from Akyatan Beach, Table 1. Total number of turtle locations and their accuracy

<table>
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<th>End</th>
<th>d.</th>
<th>Z</th>
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<th>2</th>
<th>1</th>
<th>0</th>
<th>A</th>
<th>B</th>
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<td>16 Jan</td>
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<td>170</td>
<td>8</td>
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<td>0</td>
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<td>27 Jul</td>
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</tr>
</tbody>
</table>

Table 1. Total number of turtle locations and their accuracy classes for two tracked green turtles from Akyatan Beach, Turkey (d=days).

and 135 (Turtle 8) locations were useful for reconstructing the migration route (Table 1). Coordinates with location classes of 1, 2, and 3 were primarily used to construct the migration routes. We discarded 0 and Z locations due to inherent errors, and included A and B class locations when they appeared appropriate.

After depositing her last nest on 01 August, one day after the deployment of the tag, Turtle 7 immediately left the nesting area. After travelling 2740 km over 75 days, she reached the Gulf of Sidra, Libya, following the coastlines of Northern Cyprus and Egypt (Fig. 1). She migrated directly to the south until she reached the open sea between Turkey and Cyprus, then she turned southwest along the northern shores of the Karpaz Peninsula, Cyprus. This was the first open sea stage following nesting. Arriving at the Karpaz Peninsula, Turtle 7 followed the coastline of northern and eastern Cyprus. She turned south again for 171 hours and travelled 417 km in the open sea until she arrived at the shores of Alexandria, Egypt. She stayed in the coastal waters of Egypt and Libya during her path westward until she arrived at her foraging grounds around the Gulf of Sidra, Libya (Fig. 1), where she stayed for 95 days until the last transmission.

Turtle 8 started to move in a westward direction immediately after her nesting season ended and 12 days and 351 km of coastal migration later, she reached her foraging grounds at the coastal areas between Manavgat-Alanya, Turkey.

Throughout its migration, Turtle 7 used both coastal areas and the open sea and her activity varied within these habitats. She swam faster in the open sea (mean = 2.27 km/hr; max = 4.1 km/hr; min = 0.96 km/hr) than when she was close to shore (mean= 1.46 km/hr; max= 3.1; min= 0.9). The area between Cyprus and Egypt, which was the longest open sea pathway in her migration route was traversed quicker (speed = 2.44 km/hr) than the coastal pathways in both Cyprus (speed = 1.57 km/hr) and North Africa (speed = 1.47 km/hr) (Table 2).

Our results are similar to the findings of Godley et al. (2002), Broderick et al. (2007) and Rees et al. (2008). Those studies reported that many of the green turtles nesting in Turkey, Cyprus and Syria followed a route from the southeast Cyprus to the Egyptian coasts and mostly chose foraging habitats along Tunisian and Libyan shores where food is available, including the seagrasses Posidonia oceanica and Zostera spp. in both lagoon and coastal waters (Short et al. 2007). The data from bycatch trawl fisheries have shown that the eastern Mediterranean waters of Turkey (Oruç 2001) and the coastal waters of Egypt (Venizelos & Nada 2000) are important foraging areas for green sea turtles. Northern Africa also has warmer waters compared to the northern parts of the Mediterranean; these are generally selected as overwintering areas for Caretta caretta and Chelonia mydas species nesting in both Turkey and Cyprus.

The results of both open sea and coastal speed data show similarity to those presented by Godley et al. (2002), Godley et al. (2003) and Rees et al. (2008) (Table 3).

Whereas sea turtles hatchlings and juveniles appear to follow dominant water currents, the interactions between oceanic currents and adults remain uncertain due to active movements of adult sea turtles in their environment. Turtle 7 did not follow surface currents of the eastern Mediterranean in coastal waters and generally actively swam through eddies in the open sea. Nichols et al. (2000), Godley et al. (2003) and Bentivegna et al. (2007) all emphasized that adult sea turtles make characteristic and independent straight-line movements between their foraging and nesting areas without using currents.

When the Mediterranean surface current maps and the migration route of turtle 7 were overlapped, it was determined that turtle 7 follows a counter-current route to the foraging area along the North African coast. This kind of movement requires more energy to swim. Contrary to this, when the migration pattern of turtle 7 is reversed, the negative impact of the current is eliminated hence less energy is used to migrate back to the nesting grounds. Thus, this female would use less energy for her reproductive migration than for her post-nesting migration, which may be a beneficial strategy as suggested by Luschi et al. (2003). In contrast, turtle 8 moved with

Figure 1. The migration routes of Turtles 7 (dotted line) and 8 (solid line). The triangle shows the release site at the nesting beaches and the solid circles represent the tracking endpoints.
the currents to her foraging area. The shorter distance travelled by turtle 8 may mean reduced energetic costs on the return migration during the next reproductive season.

In the Mediterranean sea, North African shores such as the Tunisian and Libyan coasts, have been highlighted as a wintering area for both Caretta caretta and Chelonia mydas (Godley et al. 2002; Godley et al. 2003; Broderick et al. 2007 Rees et al. 2008). Furthermore there are reports that Turkish coasts are also selected as foraging grounds (Broderick et al. 2007). The data from the two tracked green turtle females that nested in Turkey show that both individuals chose to migrate to the foraging grounds mentioned above. These results emphasize that Turkish shores can serve as nesting areas for green sea turtles along with North African coasts. These results increase our knowledge of green turtle migrations in the Mediterranean and illustrate at least two strategies that post nesting females may use for their migrations to foraging areas in the region.

Acknowledgements: We thank Assoc. Prof. Öğuz Türközan and Kelly Stewart for their additional comments on this study, also Mr. Ali Osman Demirer for his efforts on the mapping processes and the Scientific Research Unit of Hacettepe University for the financial support of the second turtle tracking of the study.


Table 3. Comparison of speed data between different studies on green sea turtles in the east Mediterranean.

<table>
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<th>Open Sea Speed (km/h)</th>
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</tr>
<tr>
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<td>1.2</td>
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</tr>
<tr>
<td>A</td>
<td>1.4</td>
<td>2.7</td>
<td>Godley et al., 2002</td>
</tr>
<tr>
<td>B</td>
<td>1.6</td>
<td>3.2</td>
<td>Godley et al., 2002</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
<td>3.1</td>
<td>Godley et al., 2002</td>
</tr>
<tr>
<td>D</td>
<td>1.8</td>
<td>3.3</td>
<td>Godley et al., 2002</td>
</tr>
<tr>
<td>E</td>
<td>1.8</td>
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<td>Godley et al., 2002</td>
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<td>1.9</td>
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<td>A</td>
<td>1.6</td>
<td>2.1</td>
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The Presence of the Green Turtle, *Chelonia mydas*, in Italian Coastal Waters During the Last Two Decades

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The green turtle, *Chelonia mydas*, is a migratory species which occurs circumglobally in tropical and subtropical waters. According to the most recent global status assessment by the International Union for Conservation of Nature and Natural Resources (IUCN), the green turtle has been classified as endangered in the Red List of Threatened Species with a decreasing population trend (Seminoff 2004). In response to the general alarming situation, conservation plans have been put into action worldwide to reverse the declines in nesting populations. However, for sea turtle management and conservation to be effective, there is a need for reliable population models upon which decisions can be based. For this, estimates of population size and mortality data are required, particularly for less studied life stages such as juveniles, sub-adults, adult male and non-breeding adult females (Hamann et al. 2010).

The Mediterranean Sea hosts breeding areas for the green turtle in the far eastern sector (Kasperek et al. 2001), where an estimated 339-360 females nest annually (Broderick et al. 2002). Compared to historical estimates of nesting females three generations ago, there has been a regional population decline of 93% (Seminoff 2004). Genetic analysis revealed male-mediated gene flow between the Mediterranean and neighbouring ocean basins (Roberts et al. 2004), which does hence not justify the classification of Mediterranean green turtles as a subpopulation (Mrosovsky 2006). Nonetheless, the disappearance of green turtles from this region would constitute a great loss to the biodiversity of this semi-closed marine ecosystem and needs to be met with adequate conservation plans. The current knowledge on the distribution and habitats of green turtles in the Mediterranean is largely focused on the nesting beaches, most of which are located in Turkey and Cyprus (Broderick & Godley 1996; Kasperek et al. 2001), and with limited nesting in Lebanon (Khalil et al. 2009), Syria (Rees et al. 2008, 2009), Israel (Kuller 1999), and Egypt (Kasperek et al. 2001 and references therein). Much less is known about their foraging, overwintering and developmental habitats. Satellite tracking of post-nesting females leaving Cyprus revealed fidelity of these turtles to foraging and overwintering sites along the north African coast, especially in the Gulf of Bomba and western Sirte in Libya (Broderick et al. 2007). Margaritoulis & Teneketzis (2003) identified a neritic developmental habitat in Lakonikos bay of the Western Peloponnesus (Greece) and Lazar et al. (2004) reviewed historical presence of green turtles in the Adriatic Sea, suggesting the southern zone is suitable pelagic habitat for this species. In the Western Mediterranean, green turtles are rare and nesting has never been observed. A recent comprehensive report on sea turtle distribution in the Mediterranean reported only a few sightings in Italy, France, Spain, Morocco and Tunisia (mostly ≤5 per country (Casale & Margaritoulis 2010), but past distribution and abundance data were generally not available.

Although dependent on observer effort, stranding data may provide rough estimates of green turtle distributions and hitherto unknown foraging areas. Here we provide a detailed account on green turtle sightings in the waters around the Italian peninsula and islands. Protruding into the middle of the Mediterranean Sea, Italy divides the eastern from the western basin, and is an inevitable land barrier for turtles originating from nearby eastern habitats and moving in westward direction, whether driven by currents or own active swimming. Moreover, the presence of seagrass beds which are distributed all around the Italian peninsula offer neritic foraging opportunities for this species (Short et al. 2007). For many years, the Centro Studi Cetacei or CSC (Italian Society for Cetacean Studies) has been running a national stranding network and has collected data on green turtles throughout Italy (CSC 2000, 2002a, b, 2004a, b). These data are summarised and analysed for this work together with
<table>
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<tr>
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<th>CCW</th>
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<td>16.667</td>
<td>live</td>
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<td>this study</td>
</tr>
<tr>
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<td>15</td>
<td>3-Aug-99</td>
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<td>by-catch net</td>
<td>CSC 2002a</td>
</tr>
<tr>
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<td>42</td>
<td>40</td>
<td>7#</td>
<td>19-Jun-00</td>
<td>Livorno</td>
<td>43.55</td>
<td>10.3</td>
<td>dead</td>
<td>wounds/lesions/scars</td>
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</tr>
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<td>36.3</td>
<td>8</td>
<td>2-Aug-00</td>
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<td>30.5</td>
<td>5.4</td>
<td>16-Jun-01</td>
<td>Sanremo (Imperia)</td>
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<td>7.767</td>
<td>dead</td>
<td>by-catch, net</td>
<td>CSC 2004a</td>
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<td>4</td>
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</tr>
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<td>n.a.</td>
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<td>live</td>
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<td>this study</td>
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</tbody>
</table>

Table 1. Green turtles found on Italian coasts between 1986 and 2008. CCL = curved carapace length in cm, CCW = curved carapace width in cm, M = mass in kg, Cond. = condition, n.a. = not available, # = estimated, † = deceased 2 d later 1 = number 8 in Lazar et al. 2004, 2 = number 11 in Lazar et al. 2004.

Additional data obtained through collaborations between the Stazione Zoologica Anton Dohrn in Naples (SZN) and other Italian institutes and organizations. The aim of this study is to provide background data on abundances and distribution of green turtles in the region.

Data on green turtle sightings along the Italian coasts were obtained through various sources: the local stranding network of the Stazione Zoologica Anton Dohrn, the stranding records collected by the CSC, and reports and bulletins published primarily in Italian. Data collected by members of the CSC between 1998 and 2002 were compiled by the authors and made also available as annual reports (CSC 2000, 2002b, a, 2004b, a). Species identification was usually made by the authors or by collaborating persons with experience in marine turtles. Whenever available, photo documentation of stranded turtles was used to confirm the species. We excluded all records of green turtle sightings where neither the turtle nor a photo could be inspected by an expert.

Some turtles were recovered by local aquaria, museums or rescue centres; these were either conserved or dissected (dead specimens). Additional data obtained through collaborations between the Stazione Zoologica Anton Dohrn in Naples (SZN) and other Italian institutes and organizations. The aim of this study is to provide background data on abundances and distribution of green turtles in the region.
or cured and rehabilitated (live specimens) for later release back into the sea. At the rescue and rehabilitation centers of the SZN, turtles were kept following maintenance and rehabilitation procedures described in RAC/SPA (2004) and regulated by the Italian Ministero dell’Ambiente e della Tutela del Territorio e del Mare (MATTM). Prior to their release, turtles were tagged in the front flippers with plastic tags (Rototags, Dalton ID Systems Ltd., UK) except for most recently, when Titanium tags (Stockbrands CO PL, Australia) were used.

Usually, standard curved carapace length was taken notch-to-tip with flexible tape measures (NMFS SEFSC 2008). In some situations (e.g. capture on fishing boat, at-sea sightings) turtle sizes were only estimated. Whenever possible, turtles were weighed. At the SZN, body mass was measured to the nearest 0.01 kg with a digital crane scale (model MCW60-HD, Tamagnini, Parma, Italy). For turtles not recovered at the SZN, different balances were used, but details on the type and resolution of these instruments are not available.

A total of 28 (14 live and 14 dead) green turtle sightings were recorded in Italy between 1986 and 2008 (Table 1). Before 1991 sightings of green turtles along the Italian coasts were rare, and no sightings at all were reported between 1991-1996 (Fig. 1). From 1997 onwards, occasional sightings of green turtles became more frequent, with most sightings registered for 1998 (n = 6), followed by 2000 and 2001 (n = 3 each) (Fig. 1). Until today none of the tagged and released turtles has been recaptured and reported elsewhere.

For 15 turtles, the probable causes of stranding were provided (Table 1): 9 were victims to interactions with fishing gear either due to bycatch (6 netted, 1 longline) or entanglement (2); 4 turtles showed wounds or lesions as a possible result of boat impacts and 2 turtles suffered from hypothermia.

Figure 1. Number of green turtle sightings per year along the Italian coasts between 1986-2008.

Table 2. Details on the condition of the green turtles hospitalised temporarily at the Rescue and Rehabilitation Centre of the Stazione Zoologica Anton Dohrn. *= titanium tag.
The occurrence of green turtles in Italian waters showed no discernible trend over the 22 years observation period, making it impossible to compare with increasing water temperatures in the region. The apparent absence of the green turtles between 1991 and 1996 may be a reflection of reduced effort in monitoring or reporting, especially as there was a general lack of collaborative stranding networks during that period. With a regional network in place, we recommend that regular monitoring and reporting continue into the future, so trends can be identified and possibly linked to external factors.

Interestingly, half of the reported turtles were found in the western basin, and mainly in the Tyrrhenian Sea, which indicates that they passed either through the narrow Strait of Messina or they took the longer route through the Sicily channel. The average size of the turtles suggests that they were already capable of active swimming and may have chosen their swimming direction deliberately rather than been transported passively by the surface currents (Revelles et al. 2007). The size distribution of green turtles in Italy corresponds to the size of turtles found in neritic foraging areas in Greece (Margaritoulis & Teneketzis 2003) and the observation of an individual feeding on seagrass further suggests that the turtles were either in the transitional phase or had already entered the neritic developmental phase (Bolten 2003). Judging by the high numbers of local turtle sightings, the Gulf of Taranto and the Gulfs of Naples and Salerno may constitute preferred foraging sites. However, the latter is farthest away from the nesting areas of the green turtle and may be attractive only to individuals that have not yet fully recruited to neritic foraging habitats. Indeed, adult turtles have not been seen in this area at all, which may be due to their high fidelity to both nesting and feeding grounds (Broderick et al. 2007).

An astonishing finding was that of a post-hatchling sized green turtle in Tuscany, about almost 2000 km away from the nearest known green turtle rookery in Turkey (Erdoğan et al. 2001). A recent study has shown that sea turtle hatchlings from Greece are unlikely to enter the Western Mediterranean by passive drifting, and that they would take less than one year to arrive in the Northern Adriatic (Hays et al. 2010). Thus time and current drift could not have been sufficient to transport a hatchling to the North Tyrrhenian from Greece, let alone Turkey. This raises the question of the origin of this specimen and it may be that it came from an undocumented green turtle nest in the Western Mediterranean. Alternatively, this turtle may have been transported and released by someone unaware of the biological implications of his or her actions.

There was a significant seasonal distribution to the reports, with most turtles observed during the summer months and live turtles were hardly ever found during the winter. While loggerhead turtles have been reported to overwinter in both the Tyrrhenian and Adriatic Sea (Hochsheid et al. 2007; Lazar et al. 2003), these waters may become too cold for the green turtle, so that they probably move to the eastern areas, where they find more favourable thermal environments, such as along the north African coast (Bentivegna 2002; Broderick et al. 2007; Godley et al. 2002).

In conclusion, some juvenile green turtles frequent Italian waters, including the western Mediterranean, likely in search of suitable neritic foraging grounds, but are limited to the warmer seasons. With the prospect of further increasing water temperatures, the presence of the green turtle in the western basin could be expected to increase and hence should be monitored thoroughly. To achieve this, it is necessary that a national stranding network is supported by all groups working with sea turtles and that a central data archive is established. Moreover, enhanced international collaboration and awareness programs should help to monitor the fate of marked
individuals in case of recapture. Because monitoring of low abundances in a large area such as 7000 km of coastline of Italy is time-consuming and costly, it may be advisable to focus efforts in small restricted areas during some seasons (e.g. during the summer in the Gulf of Naples/Salerno). The numbers presented in this study do not indicate priority areas for the conservation of the green turtle. However, as actions are being planned and carried out to improve the conservation status of the more abundant loggerhead turtle, which faces similar threats such as fisheries interactions and boat impacts, the green turtle would profit as well by being included in monitoring and conservation programs where both species co-exist.

Acknowledgements. We are grateful to all members of the Centro Studi Cetacei who shared their data for the standing reports of marine turtle and all other persons communicating turtle sightings, in particular Paola Pino D'Astore, Sandra Panzera, Giorgio Cataldini, Carlino Violani. We thank the staff of SZN: Gianfranco Mazza, Giovanni De Martino, Fulvio Maffucci, Francesco Di Liello, Andrea Travaglini, and also Luigi Ferretti and Rosaria Scalesse. The authors wish to acknowledge the use of Maptool software by seaturtle.org for graphics in Figure 2.


Morphologic Characters of Albino Green Turtle (Chelonia mydas) Hatchlings on Samandağ Beach in Turkey

Bektaş Sönmez¹ & Şükran Yalçın Özdílek²

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The green turtle (Chelonia mydas L. 1758) regularly occurs in the Mediterranean, nesting along the coasts of Greece, Northern Cyprus and Turkey (Kasparek et al. 2001). Previous studies indicate that Samandağ Beach (36° 7.500’N 35° 55.100’E) is an important nesting site for green turtles (Yalçın Özdílek 2007). Common abnormalities in sea turtles include super- and sub-numerary scutes, lack of color, head and jaw abnormalities, and twinning (Türkozan & Durmuş 2001). The lack of normal skin and shell pigmentation of hatchlings (often referred to as albinism) is a recessively inherited trait. Albino hatchlings are thought to have reduced survival in the wild (Türkozan & Durmuş 2001). In Northern Cyprus and the southwest Turkey, nearly 1% of the embryos/hatchlings examined exhibited albinism (Kaska & Downie 1999). Albinism in sea turtles has been reported in the Mediterranean and elsewhere (Marcovaldi 1995; Türkozan & Durmuş 2001). However, few if any published data are available concerning size and scale patterns of live albino turtles. This study presents the first morphological measures of living albino green turtle hatchlings from the Northern Mediterranean.

The data were collected on Samandag Beach during the nesting season in 2010. After hatchling emergence, nest chambers were excavated in order to detect clutch size, nest depth, nest diameter and compressed hatchlings. Albino were encountered in the nests during these excavations. Measures of straight carapace length (SCL), straight carapace width (SCW), curved carapace length (CCL), curved carapace width (CCW), fore limb length (FLL) from both left and right, hind limb length (HLL) from both left and right, weight, and scute patterns were compared with the previous records (Bolten 1999, Türkozan et al. 2001, Özdemir & Türkozan 2006). Manual calipers (±0.1 mm), and manual scales (± 1g with Pesola scale) were used for measurements.

We found two live albino turtles during the nest excavations (Figure 1); they were released into the sea after being examined in the laboratory. The nest in which albino was found contained 165 eggs with a hatch rate of 63.6%. This nest contained 60 undeveloped eggs and incubation period was 56 days. The nest was 75 cm in depth and 28 cm in diameter, 65 m far from the high tide line. The rate of carapace scute abnormalities was high (Table1). Vertebral and costal scutes distributions were different compared to common (normal) scute patterns (see Table 1 in Türkozan et al. 2001). The morphometric characteristics of the albino hatchlings (Table 2) were normal in Samandağ Beach. However, the size of the albinos was greater than the mean of non-albino hatchlings on Samandag beach (Sönmez 2010).

Other records of albinism in hatchlings have been recorded in Malaysia and Florida for green and loggerhead turtles (Harrisson 1963; Fletemeyer 1977; Marcovaldi 1995 in Türkozan & Durmuş 2001). However reports of juvenile or adult live albino turtles in the wild are rare: one albino juvenile green sea turtle was reported from Florida, weighing 56 kg (Fletemeyer 1977 in Türkozan & Durmuş, 2001), and a white adult loggerhead was seen nesting in Australia (Limpus 1979).
Scute abnormalities are more commonly observed in albino hatchlings than in normally colored turtles (Kaska & Downie 1999). Hatchling morphology can determine the survival rate in sea turtle (Özdemir et al. 2007). Generally, bigger hatchlings are faster swimmers and are thought to be more likely to escape from predators (Burges et al. 2006). A larger body size may also help hatchlings to escape gape-limited predators and to handle larger prey items successfully, i.e. bigger is better. It may be the case that the albinos we observed have a better advantage to survive in the wild than their smaller counterparts. However, they also likely have some disadvantages, including reduced crypsis and potentially more susceptibility to solar radiation.

Acknowledgements: We thank to Samandağ Governor, Hatay Directorate of Environmental Ministry and Natural Parks and Nature Protect Division. We also thank to Sait Gürsoy and K. Mehmet Ali Sönmez and many other volunteer students.


<table>
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<th>CCW</th>
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<th>LHL</th>
<th>RHL</th>
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<td>0.1</td>
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<tr>
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</table>

Table 2. Descriptive measures of the morphometric variables of live albino green turtle hatchlings from Turkey. SCL/SCW=straight carapace length/width in cm, CCL/CCW=curved carapaced length/width in cm, LFL/RFL=left and right fore limb length in cm, LHL/RHL=left and right hind limb length, and mass is in g.

Global temperatures have warmed by approximately 0.61 °C in the last century, at a rate that has been unprecedented in the last 1000 years (IPCC 2001). There is a large body of literature documenting advances in the phenology (timing of seasonal activities) of many animal and plant species in concert with observed climate change. Most commonly, spring events occur earlier (e.g. arrival at breeding grounds) and/or reproductive seasons end earlier (Pike et al. 2006), but there have also been records of later onset of autumnal events (e.g. delayed migration). Eighty-seven percent of species (from plants to vertebrates) reviewed by Parmesan & Yohe (2003) that exhibited shifts in phenology did so highly significantly in accord with climate change.

However, this future climate change is expected to be heterogeneous, and not all areas will experience warming or similar rates of change in temperature (IPCC 2001b). Therefore, gradual phenological shifts may be not sufficient to detect the direct effect of global warming on some species inhabiting region where heterogeneous change of temperatures are expected. This is the case in the Mediterranean Sea, where the mix between projected water current changes and increased air temperatures will produce a complex change of sea temperatures. In this context, we examined the correlation between proxies of temperature change and phenology to detect impacts of climate change. We expect that such a complex situation will generate variability in temperatures that would translate into variability of observed changes in phenology of the nesting season for marine turtles. Thus, a significant correlation between phenology of nesting and some measure of sea temperatures could reflect the winter use of that region by sea turtles using one particular site for egg laying.

The loggerhead turtle is the most abundant marine turtle species in the Mediterranean. Annually, more than 2,000 females are estimated to nest in the western Mediterranean Basin. The main nesting concentrations are in Greece, Turkey and Cyprus, with some as yet un-quantified nesting in Libya. Minor nesting aggregations have been described in Egypt, Lebanon, Israel, Italy, Syria and Tunisia (Casale & Margaritoulis 2010). Tunisia is the most westerly nesting ground for loggerheads in the southern Mediterranean. Outside of nesting, loggerhead turtles occur throughout the marine areas of the Mediterranean. The highest density of loggerhead turtles appears to occur in the westernmost part of the Mediterranean (from the Alboran Sea to the Balearic Islands), the Sicily Strait, the Ionian Sea, and the wide continental shelves in the north Adriatic, off Tunisia, Libya, Egypt, and southeast Turkey (Casale & Margaritoulis 2010).

In Tunisia, nesting primarily occurs in the two Kuriat Islands (35.8014, 11.0347): Little Kuriat (Kuria Sgira), which is ca. 0.7 km² and Great Kuriat (Kuria Kbira), which is ca. 2.7 km² (Figure 1). The most important nesting beach is located in the west of the Great Kuriat, where researcher and volunteer teams have worked from 1997 to 2010 to record numbers of nests deposited. However, the patrols did not cover the entire nesting season, with monitoring often commencing after the start of the nesting season. Also, in the middle of the 1998 season, some nights were not monitored due to logistical constraints. The occurrence of gaps in effort is common in nest monitoring programs for marine turtles, and complicates the use of indices such as the date the season’s first nest was deposited, or the median nesting date. To get around these limitations, a statistical description of phenology of the nesting season has been developed (Girondot 2010). Even with incomplete information, this method can describe the nesting season by a set of equations and the parameters are fitted by maximum likelihood using negative binomial link. The advantage of the technique is that it facilitates the analysis of heterogeneous field data and produces outputs that are directly comparable.

Modeling the marine turtle nesting season. Understanding t to be an ordinal date, the number of nests deposited per night is modeled using the set of equations (1) (Girondot 2010).

The model requires a maximum of seven parameters that have direct biological or phenological definitions:

- MinB is the mean nightly nest number before the beginning of the nesting season
- MinE is the mean nightly nest number after the end of the nesting season
- Max is the mean number of nests at the peak of the nesting season
- P is the ordinal date of the peak of the nesting season
- F is the number of days that are flat around the day P
- B is the ordinal date of the beginning of the nesting season
- E is the ordinal date of the end of the nesting season

MinB, Max, MinE are scaling parameters and P, F, B and E are shape parameters. Various constraints can be set up to simplify this model: MinB=MinE occurs when there are the same number of nests before

Equation 1

\[
\begin{align*}
    & \text{if } t < B \to MinB \\
    & \text{if } t \in [B, P - F/2) \to \left(1 + \cos\left(\pi(P - F/2 - t)/(P - F/2 - B)\right)\right)/2 (Max - MinB) + MinB \\
    & \text{if } t \in [P - F/2, P + F/2) \to Max \\
    & \text{if } t \in [P + F/2, E) \to \left(1 + \cos\left(\pi(t - P + F/2)/(E - P + F/2)\right)\right)/2 (Max - MinE) + MinE \\
    & \text{if } t > E \to MinE
\end{align*}
\]
and after the nesting season
MinB and/or MinE ≠ 0 (e.g. 10^-9) signifies that no nests occurred outside of the nesting season
P-B=E-P occurs when the shape of the nesting season is symmetric around P

The nesting season is defined as the interval [B, E] and its length is E-B.

Data for loggerhead nesting in Little and Great Kuriat were compiled and entered into the model. When data were available for both Little and Great Kuriat for the same year, a single set of shape parameters (B, P, F, E) was used for both time series and only the Max parameter was series-specific. As no nests are normally deposited for 9 months of the year on these beaches, the model was simplified with MinB=MinE=10^-9. As relatively few nests were deposited on the Kuriat islands, the model was simplified with F=0 and P-B=E-P and constant length E-B.

To test whether there was significant variability in the nesting phenology for loggerhead nesting in the Kuriat Islands, two models were fitted. In the first model, the same shape of nesting season was imposed for all years (i.e. same B, P and E value). This simplest type of model was compared with one in which the seasonality is year-specific. Comparisons were based on AIC value, which is a measure of the goodness of fit of an estimated statistical model. The AIC is not a test of the model in the sense of hypothesis testing; rather it is a test between models and is used for model selection. When the same shape was imposed for all years, the AIC value was 798.43 (17 parameters) whereas when the shape was year-specific, the AIC value was 783.35 (28 parameters). This difference of ΔAIC=15.07 is large and, based on Akaike weight (Burnham & Anderson 1998), the probability that the model with year-specific difference in peak of nesting is the best one among the two tested is p=0.999.

The beginning of the nesting season in the Kuriat Islands was fitted to be between the 29 April and 22 May (depending on the year) and the end of the nesting season was fitted to be between 09 August and 01 September. Note that these dates are defined statistically and are not the actual dates of the first and last nests laid on Kuriat Island. The model-generated annual dates of beginning, ending and nesting peaks for loggerheads in the Kuriat Islands are shown in Table 1.

Table 1. Dates of start, peak and end of the nesting season for loggerheads in the Kuriat Islands, Tunisia.

<table>
<thead>
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<th>Year</th>
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<th>End of season</th>
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Figure 1. Sea surface temperature for the Mediterranean Sea for the coldest (2009) and warmest (2010) April months during the 12 years of analysis. Crosses show the three locations used for SST analysis and the arrow indicates the location of the Kuriat Islands.

Figure 2. Observed dates of the peak of nesting in the Kuriat Islands compared to modeled values, taking into account April mean sea surface temperature in Gulf of Gabes.
(Casale & Margaritoulis 2010). We choose 3 locations where wintering loggerheads are known to occur (Figure 1): Adriatic Sea (42.5°, 15.5°), Greece (37.5°, 20.5°) and the gulf of Gabes in Tunisia (34.5°, 11.5°). These three locations represent a North-South gradient. For each of these locations, the mean monthly sea surface temperature values from January to May were extracted from a database for all the years between 1997 and 2010 (NOAA Optimum Interpolation Sea Surface Temperature V2, Reynolds et al. 2002). Then, generalized linear models (Gaussian identity link) were run to search for a relationship between the date of peak of nesting for one particular year and the monthly sea surface temperature. Only first order interactions between consecutive months were considered. A backward elimination procedure was used to simplify model with the most non-significant parameter removed in each round.

No significant effect on nesting dates in the Kuriat Islands was detected for monthly sea surface temperatures from the Adriatic Sea or Greece. However, a highly significant relationship was found between the date of beginning of nesting in the Kuriat Islands with April mean sea surface temperatures in the Gulf of Gabes (F(1,10)=11.19, p=0.007, Figure 2), which is a known wintering zone for Mediterranean loggerheads (Zbinden et al. 2008).

Based on these results, it is tempting to propose that females nesting in the Kuriat Islands are primarily over-wintering in the Gulf of Gabes. An alternative could be that adult females migrate to the nesting site from distant areas and wait for more conducive conditions before they start to nest. More data, such as from satellite tracking and/or stable isotope analyses, would help illuminate which scenario is more likely. Nevertheless, these results are useful in focusing future research efforts for understanding the behavioral ecology of adult female loggerheads that use the Kuriat Islands for nesting. This analysis also demonstrates the power of the nesting season model (Girondot 2010) to describe the phenology of nesting in marine turtles.
INSTRUCTIONS FOR AUTHORS

The remit of the Marine Turtle Newsletter (MTN) is to provide current information on marine turtle research, biology, conservation and status. A wide range of material will be considered for publication including editorials, articles, notes, letters and announcements. The aim of the MTN is to provide a forum for the exchange of ideas with a fast turn around to ensure that urgent matters are promptly brought to the attention of turtle biologists and conservationists worldwide. The MTN will be published quarterly in January, April, July, and October of each year. Articles, notes and editorials will be peer-reviewed. Announcements may be edited but will be included in the forthcoming issue if submitted prior to the 15th of February, May, August and November respectively. All submissions should be sent to the editors and not the members of the editorial board. A contact address should be given for all authors together with an e-mail or fax number for correspondence regarding the article.

Text
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