ÖGH Herpetozoa
Austrian Herpetological Society

Herpetozoa 33: 113–120 (2020)
DOI 10.3897/herpetozoa.33.e48541

First study of sea turtle strandings in Algeria (western Mediterranean) and associated threats: 2016–2017

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Academic editor: Günter Gollmann ♦ **Received** 29 January 2019 ♦ **Accepted** 5 May 2020 ♦ **Published** 28 May 2020

Abstract

Between December 2015 and December 2017 a total of 63 sea turtles were recorded as being stranded along the Algerian coast. The loggerhead sea turtle *Caretta caretta* was the most commonly stranded species (n = 44) (69.8%), followed by the leatherback *Dermochelys coriacea* (n = 18) (28.6%) and the green turtle *Chelonia mydas* (n = 1). There was a slight dominance of the adult size class for stranded loggerhead turtles, while, for the leatherback, late juveniles and adults prevailed. Most loggerhead turtles stranded during the summer months (July and August), whereas most leatherbacks stranded during winter. The breakdown of the strandings by region shows a slight dominance along the western and central shores for *C. caretta* and a clear dominance in the west for *D. coriacea*.
The primary cause of death was determined in 50.8% of the stranded turtles. Regarding the evidence of interactions with humans the major cause of stranding in loggerhead turtles was incidental catch by artisanal fisheries, followed by boats' collisions. The main causes of leatherback strandings were boats' collisions. Algerian data show that human activities affect loggerhead turtles and also prove a significant presence of the leatherback turtle on this coast.

Key Words

Algerian coast, *Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, Mediterranean Sea

Introduction

Systematic gathering of data on stranded sea turtles represents an opportunity for scientists to understand mortality factors, such as by-catch, and can provide information about distribution patterns (Casale et al. 2010). Sea turtles are slow growing and have a long lifespan. This is due to their complex life history patterns which encompass a diversity of ecosystems (Bolten 2003). Seven species of sea turtles representing two families, Cheloniidae and Dermochelyidae, are the only living members of what has been a large and diverse marine radiation of cryptodiran turtles.

Three species of sea turtles are frequently found in the Mediterranean: leatherback turtles (*Dermochelys coriacea*) are widely distributed in the Mediterranean, along with loggerhead turtles (*Caretta caretta*), and green turtles (*Chelonia mydas*) (Casale et al. 2018). Only the last two species have been detected breeding in the basin. Loggerhead turtles and leatherback turtles are classified under the 'vulnerable' species category (Wallace et al. 2013; Casale and Tucker 2017), whereas the green turtle is listed as endangered (Seminoff 2004). The survival of sea turtles is threatened due to their slow reproductive dynamics as a result of delayed sexual maturity and high natural mortality rate of early juveniles. However, the biggest challenges that sea turtles face currently are due to anthropogenic threats in terrestrial habitats, such as coastal development, erosion and beach armoring, driving on the beach, and in marine habitats, including the interaction with fisheries, human exploitation, marine debris, pollution, and boat collisions (Casale et al. 2018). Along the Algerian coast, the presence of these marine reptiles has been mentioned in old literature. The loggerhead turtle was considered to be a common visitor to Algerian coasts (Doumergue 1901). Poiret (1789) considered the leatherback as a very common marine life species which resided at the barbary coasts. The presence of the green turtle in these coasts was, however, not described in the literature. The Algerian Basin is now considered as a foraging ground for both the Mediterranean and Atlantic stock of the *Caretta caretta* species (Clusa et al. 2014), and also for the leatherback (Casale et al. 2003). Hence, further research was required to better understand biology and conservation of these species frequently present on Algerian coasts, and to develop a strategy to mitigate the effects of anthropogenic threats in these waters.

The present study reports for the first time records on sea turtle strandings on the Algerian coasts over a two-year period (2016–2017) in order to gain knowledge about threats to these species. Especially since the Algerian population has grown strongly in recent decades, reaching 40.6 million inhabitants in 2015, concentrated in a fringe of approximately 150 km, along the Mediterranean coast. More than 130 million people frequented the beaches during summer while fishing in this country has developed strongly and been modernized over the last decade (Wiefels 2014).

Study area

According to Eriksson (1965), the western Mediterranean is considered a vast ocean-type basin, in which the Algerian-provincial basin is the largest. The Algerian coast, stretching across more than 1600 km, from the east to the west makes up approximately 3.4% of the total Mediterranean coast. This continental margin borders the southern part of the large Algiers-Provencal basin, an important morphological part of the Western Mediterranean Sea (Leclaire 1972). The present study was conducted along the Algerian coast from the far East of Altaref (36.940920N, 8.642120W) to the far West of Tlemcen (35.085006N, 2.211779E) (Fig.1).

Data collection

In the present study, stranded sea turtles were defined as those that had been washed ashore, dead or alive, or were found floating dead or alive (generally in a weakened condition) in coastal waters.

The sex was determined in nineteen loggerhead turtles using the tail length for adult individuals and examining the gonads at necropsy when it was possible. However, the sex for the leatherback turtles could not be determined due to difficulties in recovering the carcasses and limitations in the necropsies performed *in situ*, at the site of strand-

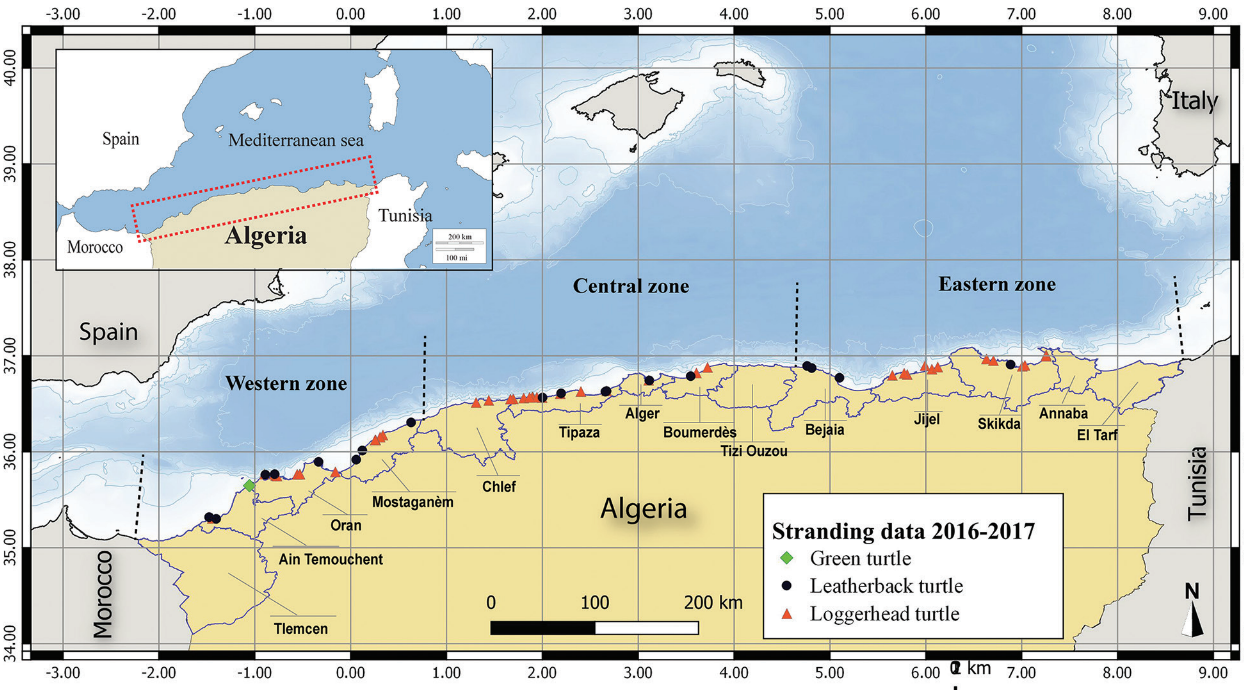

Figure 1. Map showing the subdivision of the three zones considered in this study: Western, Central and Eastern zone, and the distribution of stranding sea turtles Caretta caretta (brown circle), *Dermochelys coriacea* (black circle) and *Chelonia mydas* (green circle) along Algerian coast (2016–2017).

ing. Necropsies were performed on seventeen and four carcasses of stranded *C. caretta* and *D. coriacea*, respectively. The cause of stranding was determined through this necropsy and direct visual observation. We also collected samples (stomach contents, humerus, tissues muscle, kidney, liver) which were frozen for further research.

The coastline was subdivided in 14 stranding areas, according to the administrative division and grouped in three sectors: western region (Tlemcen, Aintemouchent, Oran, Mostaganem), center region (Chlef, Tipaza, Algiers, Boumerdese, Tizi Ouzou) and the eastern region (Bijaia, Jijel, Skikda, Annaba, Altaref) (Fig. 1).

The year was divided into four seasons: winter (January to March), spring (April to June), summer (July to September), and autumn (October to December).

Records of marine turtles found stranded in this study were collected from December 2015 to December 2017, both months inclusive. Data were collected through two methodologies: firstly, as systematic surveys on beaches and other areas of difficult access (rocky areas). We performed these surveys periodically almost every day with the help of 20 volunteers. Most of them were part of fishing communities or people who lived near the coast. The coordination between the teams took place through telephone calls.

The second methodology consisted of an opportunist effort of surveys by receiving information through different sources and going to the stranding location to gather data. We received alerts regularly from diverse sources such as the coast guard, the national gendarmerie, people living in coastal villages, fishermen, civil protection, diving clubs, environmental associations, the National Center for Fisheries and Aquaculture Research (CNRDPA), University Oran 1, University Annaba Badji Mokhtar, social networks, and others. Both methodologies were adopted on the western and central coasts. Only the opportunist survey was adopted on the eastern coast.

This difference in the survey effort was mainly due to two factors: first, the University to which the team belonged is located to the west, second the east coast is characterized by isolated beaches. Therefore, strandings in the eastern part probably were underestimated.

The data on dead turtles were collected according to the established stranding protocols (Wyneken 2001), namely: species identification, curved carapace length notch to tip (CCL), and general biometric measurements (standard length, curved carapace width, head width) using a soft millimetric tape (Wyneken 2001). No complete records of CCL were obtained in 4 *C. caretta* turtles because the measurements were taken by unqualified persons. The CCL values were grouped by size-classes using the Sturges' rule to visualize their distribution (Sturges 1926). For loggerheads, a carapace length (CCL) of 70 cm was used to distinguish juveniles from adults, since this was the threshold for nesting females and adult males with secondary sexual characteristics in the Mediterranean considered in the literature (Margaritoulis et al. 2003; Casale et al. 2005; Casale et al. 2009). For leatherback turtles, we used a size class CCL < 125 to provide information about the juveniles, because this is the minimum carapace size for nesting leatherbacks at the nearest nesting sites (Stewart et al. 2007).

In the present study, we considered all types of evidence from human interactions that could be linked to the causes for stranding. The causes of stranding were classified into four categories as below: 1) Incidental catch: including bycatch in fishing nets, fishing line or hook detected in the mouth; 2) Collision with boats; directly crashed turtle carapace, injuries in carapace or severed body parts; 3) Marine debris: intestinal impactions; 4) Undetermined cause of stranding; when no apparent cause of death was observed due to the advanced state of decomposition of the stranded carcass.

Statistical analysis

Data on turtle size and strandings were tested for normality and homoscedasticity. The data were normally distributed (Shapiro–Wilk D test, all $P > 0.05$). We used a one-way analysis of variance (ANOVA), to see if the size of turtles differed among seasons and regions. We used also a t-test to determine whether there was a significant difference in size and category of sex and status. The results were considered significant for the $p < 0.05$ level. We used the software package IBM SPSS Statistics 25. After collection at GPS locations, we used ARC GIS 10.2 to draw maps and show the distribution of stranded turtles.

Results

A total of 63 stranded sea turtles were found during the study period: 44 (69.8%) *C. caretta*, 18 (28.6%) *D. coriacea* and one *C. mydas* (1.6%) (Table1). The CCL of the *C. caretta* ranged between 43 and 93.5 cm, with a mean of 71.18 ± 12.73 SD cm. The CCL of *D. coriacea* ranged between 86 and 137 cm, with a mean of 120.25 ± 14.59 SD cm. The length of the *C. mydas* was CCL = 42 cm. The majority of the stranded loggerheads ranged between 66

Table 1. Number of marine turtle strandings in 14 localities during 2016–2017 of the Algerian coast.

		Caretta caretta		*Dermochelys coriacea*		*Chelonia mydas*	
Area	**Locality**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
West	Tlemcen	–	–	–	–	–	–
Center	Ain temouchent	1	–	2	–	–	–
East	Oran	6	2	3	–	1	–
	Mostaganem	5	2	3	–	–	–
	Chlef	2	1	–	–	–	–
	Tipaza	8	2	2	1	–	–
	Algiers	1	1	–	1	–	–
	Boumerdese	–	1	–	1	–	–
	Tizi ouzou	–	–	–	–	–	–
	Bejaia	–	–	1	1	–	–
	Jijel	4	2	1	–	–	–
	Skikda	3	3	1	1	–	–
	Annaba	–	–	–	–	–	–
	Altarf	–	–	–	–	–	–
N		30	14	13	5	1	0

and 81 cm (Fig. 2). For *D. coriacea* turtle strandings most turtle measurements fell between 111 and 140 cm (Fig. 3). We found no significant differences in size between dead and live turtles in both species *C. caretta* (T test, t = 1.26 p > 0.05) and *D. coriacea* (t = 0.017, p > 0.05). Live stranded loggerheads accounted for only 6.8% of all the recorded stranding events. Live leatherbacks were 5.6% of all the stranded leatherbacks. Males and females of *C. caretta* did not differ in size (t = 1.10, p > 0.05). Concerning sex, we identified 3 male loggerheads (6.8%), 16 female loggerheads (36.4%), and 25 (56.8%) from which we could not determine the sex. We found more strandings in year 2016, with n = 42 (66.66%) as compared to 2017, where n = 21 (33.33%) for both species.

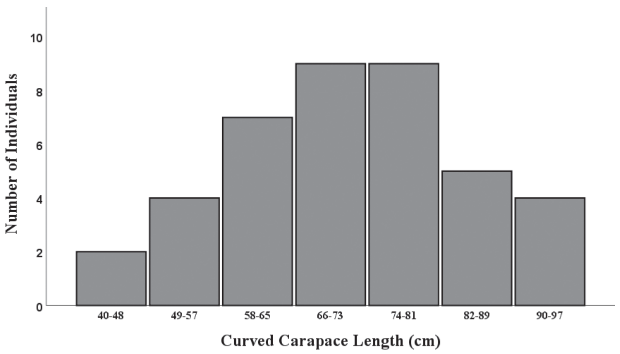

Figure 2. The size frequency distribution of marine turtle *Caretta caretta* strandings along the Algerian coast (2016–2017).

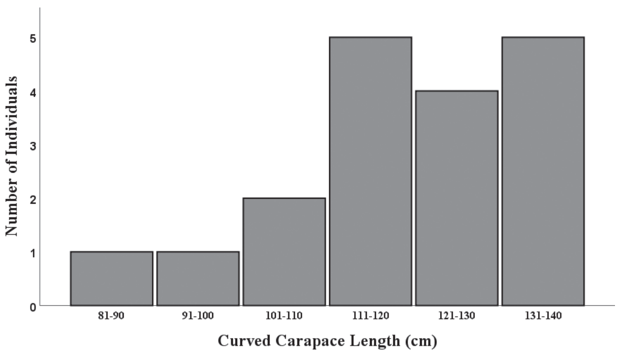

Figure 3. The size frequency distribution of marine turtle *Dermochelys coriacea* strandings along the Algerian coast (2016–2017).

There was no significant difference in CCL among seasons for both loggerhead turtles (ANOVA, F = 0.084, p > 0.05) and leatherbacks (F = 2.063, p > 0.05). The CCL of sea turtles stranded according to the sex, status (alive/dead), regions and season is shown in Table 2. No significant difference was found in CCL according to regions for both, loggerhead turtles (ANOVA, F = 2.74, p > 0.05) and leatherbacks (F = 1.50, p > 0.05). From 44 stranded loggerhead, n = 16 (36.36%) were found in the west, the same value in the center. For the *D. coriacea* a high percentage of stranding was found in the western area, n = 8 (44.4%). The distribution of the stranding data for loggerheads and leatherbacks on the basis of regions and seasons is shown in Figures 4, 5, respectively.

The percentage of loggerheads turtle strandings was relatively homogenous between adults 57.5% and juveniles 42.5%. The leatherback turtles stranded show an equality of late juveniles and adults along the Algerian coast (Table 3). From the 44 stranded loggerhead turtles, we could not identify the cause of stranding of 19 (45.5%) of the turtles. Human interactions linked to the causes for stranding were incidental catch with artisanal fishing (set and drift net) (n = 15, 34.1%), followed by boat collisions (n = 9, 20.5%), and marine debris ingestion (n = 1, 2.3%).

Among the 18 leatherback stranded, no sign of anthropogenic interaction was reported in n = 12 (66.7%) while the carcasses were in very good condition. Three had injuries in carapace or severed body parts (16.7%), presumably due to impacts with boats, and two had intestinal impactions (11.1%), with plastic bags. Only one was released alive after it had been bycaught by an on set net (5.6%). Getting entangled in a fishing net was the cause of stranding of the green turtle.

Discussion

The majority of turtles stranded during the studied period were loggerheads. The frequency of stranding illustrates the regular presence of *C. caretta* and *D. coriacea* in the Algerian coastal waters, and accidentally, the green turtle. The latter species was considered ‘rare’ in this area and

Table 2. Curved carapace length notch to tip (CCL in cm) of sea turtles stranded along the Algerian coast (2016–2017) according to sex and status. N – Number of sea turtles stranded. SD – standard deviation.

			Caretta caretta			*Dermochelys coriacea*		
			N	**Mean ± SD**	**Range**	**N**	**Mean ± SD**	**Range**
CCL	Sex	Male	3	84.83 ± 5,55	79.2–90.3	–	–	–
	Status	Female	16	79.11 ± 8,55	68.2–93.5	–	–	–
	Region	Undter	21	63.19 ± 10,62	43–87	–	–	–
	Season	Dead	33	72.34 ± 11,35	53–93.5	17	120.26 ± 11.35	86–137
		Alive	7	65.71 ± 17,98	43–93	1	–	–
		West	13	66.52 ± 13,70	45–90.3	8	119 ± 14.48	92–134
		Center	15	71.38 ± 11,45	43–88	5	115.3 ± 18.78	86–134
		East	12	75.98 ± 12,33	61–93.5	5	125.8 ± 10.77	114–137
		Winter	10	69.77 ± 12,04	45–91.5	7	120.21 ± 15.80	92–137
		Spring	10	71.01 ± 15.32	43–93.5	2	129 ± 4.24	126–132
		Summer	12	72.58 ± 13,87	53–93	3	132 ± 2.30	130–134
		Autumn	8	71.07 ± 10,27	58–5–85	6	111.16 ± 14.03	86–129

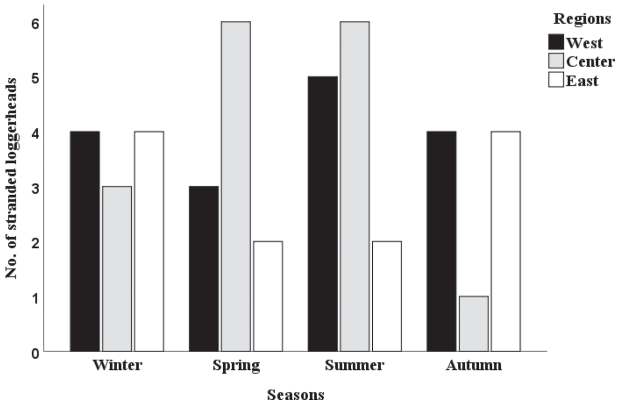

Figure 4. The distribution of the strandings loggerheads on the basis of regions and seasons along the Algerian coast (2016–2017).

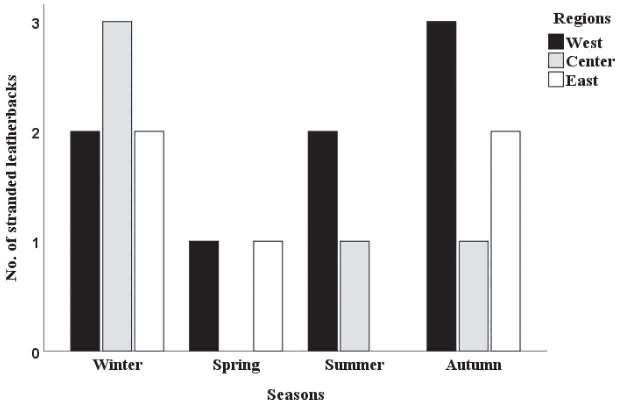

Figure 5. The distribution of the strandings leatherbacks on the basis of regions and seasons along the Algerian coast (2016–2017).

Table 3. The life stage stranding data of loggerhead and leatherback according to the regions along the Algerian coast (2016–2017). N – Number of sea turtles stranded.

			Caretta caretta				*Dermochelys coriacea*			
			West	Center	East	T%	West	Center	East	T%
Stage	Juveniles	N	8	4	5	17	4	3	2	9
Total	Adults	Total%	20%	10%	12.5%	42.5%	22.2%	16.7%	11.1%	50%
		N	5	11	7	23	4	2	3	9
		Total%	12.5%	27.5%	17.5%	57.5%	22.2%	11.1%	16.7%	50%
		N	13	15	12	40	8	5	5	18
		Total%	32.5%	37.5%	30%	100%	44.4%	27.8%	27.8%	100%

has Atlantic origins, entering the Mediterranean through the Gibraltar Strait (Carreras et al. 2014).

Caretta caretta

We noted that most of the strandings corresponded to dead individuals (84,1%). This high mortality rate was mainly a result of interaction of loggerheads and small scale fishery that frequently employ fishing gear with high bycatch rates such as set and drift net. Small boats that do not exceed 6 meters in length represent 65.4% of all fishing fleets in the country (Berrah 2018). The impact of bycatch on sea turtle populations depends on the fishing areas (Clusa et al. 2016), which explains the heterogeneity of sizes along this coast. Similar heterogeneity in size was reported around the western Mediterranean Sea (Casale et al. 2011; Piovano et al. 2011; Guarino et al. 2020). Small size turtles spend most of their time in oceanic waters (Cardona et al. 2005; Revelles et al. 2007b) which makes them vulnerable to swordfish driftnets; this technique is applied more on the west and central coast, while large size turtles, feeding mainly in neritic areas (Casale and Margaritoulis 2010; Casale 2011), are exposed to small-scale fishing which operates closer to the coast. We noticed injuries on 8 turtles, revealing intentional killings (about 20 cm injuries between the plastron and the carapace). This phenomenon was explained by a few fishermen. They mentioned that turtles found stuck in fishing gear, whether alive or dead, would be pierced and drowned by them in the sea to avoid prosecution, as fishermen knew this species was protected by Algerian law.

Strandings were more common during summer. This probably coincided with the increase in fishing activities. Our data agree with the observations of Jribi et al. (2007) in the Gulf of Gabes (Tunisia), Tomás et al. (2008) in the Valencian Community (Spain) and Caracappa et al. (2018) in the Sicilian coast. The frequency of stranding in the three regions of the Algerian coast was almost identical, with a slight dominance in the center and the west. This can be explained by the influence of the pattern of the Algerian currents and water masses and the importance of the Algerian basin as feeding areas for sea turtles of Atlantic and Mediterranean origin (Carreras et al. 2006; Revelles et al. 2007a; Clusa et al. 2016). Clusa et al. (2016) suggests that immature loggerhead sea turtles entering the western Mediterranean from the Atlantic and the eastern Mediterranean remain linked to particular water masses. The slight dominance of strandings in west and central regions is probably due to the geographic leaning of the survey, which favored the western and central region. Stranding distribution demonstrates that the central and eastern region includes more adult turtles. These findings can be explained by the current potential colonization of the Western Mediterranean by nesting females coming from the Atlantic (Carreras et al. 2018). This hypothesis was supported by a predictability model of the distribution of nesting sites around the Mediterranean basin for the loggerhead turtle (Pike 2013). While the distribution of juveniles on a large scale in the West region can be explained by the presence of a population of Atlantic origin (mostly juvenile), coming from Florida, the abundance of this population decreases downstream, from the Algerian basin to the Adriatic Sea (Carreras et al. 2006, 2011; Clusa et al. 2014).

The slight dominance of *C. caretta* stranding in the eastern Algerian coast during autumn and winter can be explained by the migrations of this species to remain in warmer marine areas by following the direction of the Algerian current, which flows near the North African coast (Millot and Taupier-Letage 2005). This behavior appears to have been triggered by a change in temperature and food availability (Bentivegna 2002). Apart from that, the almost homogeneous spatial and temporal distribution of the loggerhead population on the Algerian coasts may indicate that this population shows a permanent presence in the Algerian basin, without any influence of seasonality (Revelles et al. 2007a).

Our study shows that fisheries interactions are the most important cause of strandings. This finding is consistent with other reports elsewhere in the Mediterranean (Casale et al. 2008; Tomás et al. 2008; Guarino et al. 2020). This species is still experiencing the heaviest mortality record. On the western Mediterranean Sea, the situation continues to be worrying, despite efforts to modernize fishing on the Spanish coast to reduce interaction with sea turtles during the last 10 years (Báez et al. 2019). In Algeria, the situation is still unclear as there is no study on this interaction, and most of the fishing gear is still artisanal, while most of *C. caretta*, which had interaction with fisheries in this study, were caught by set or drift net. The collision with boats is another important source of mortality with these marine reptiles (Casale et al. 2010).

Dermochelys coriacea

The highest number of leatherback strandings occurred during autumn and winter, consistent with results from the Alborean Sea and the Balearic Sea in the Western Mediterranean (Camiňas 1998). The probable cause could be the presence of the species in this area in search of food. According to Dodge et al. (2011) and Seminoff et al. (2012) the prey of leatherback consists mostly of Cnidaria, class Scyphozoa including *Pelagia noctiluca*. The swarms of *P. noctiluca* follow the progression of the Atlantic surface water current to enter the Mediterranean Sea and cross the North African Coast in the late autumn and early winter (Licandro et al. 2010). Moreover, we are already aware that the effect of currents largely determines the movements of turtles (Luschi et al. 2003). According to these data we can hypothesize that strandings along the Algerian coast occur from west to east and leatherbacks enter the Mediterranean in autumn and winter following the pattern of the current and their prey.

Despite the different components in this survey, the stranding of a leatherback turtle on the Algerian coast remains a special event and, unlike the loggerhead turtle, it hardly goes unnoticed. Therefore, the dominance in the number of strandings on the west and central coast is close to reality. This dominance is explained by the proximity of this area to the strait of Gibraltar (Casale et al. 2003) through which these turtles would enter the Mediterranean Sea. The size of most of the leatherback turtles stranded was over 90 cm CCL. Therefore, we suggest that these turtles do not leave the tropical waters until they reach a size of about 100 cm CCL, due to thermal stress (Eckert 2002), hence reaching the Mediterranean at late juvenile and adult sizes. We could not identify the cause of stranding in 66.7% of cases, most of which had intact carcasses. It is difficult to know what type of human interactions have more impact on this species. It is quite possible that they were caught by fishing net and were suffocated. Casale et al. (2013) suggest that set/drift nets and unspecified nets are responsible for most of the incidental catch of this species in the Mediterranean Sea. Otherwise the low interaction with fishing gears may be due to the composition of the fleet which is generally artisanal and operates in coastal waters.

Conclusion

From our survey, it appears that loggerheads on the Algerian coast coming from the Atlantic (as shown by previous genetic studies) and moving east with the main currents will face anthropogenic threats.

The present study cannot provide detailed information about the primary cause of mortality, apart from those caused by fisheries or boat collisions. This is due to a low number of necropsies and the lack of information about the interaction with fishing gear.

When discussing the status of the leatherback turtles on this coast, this study shows a significant presence of this species. Additionally, this species also suffers from human interaction, given the large number of strandings over two years of study.

Acknowledgments

This article is offered in memory of my professor Boutiba Zitouni, who died 3 years ago, Professor at University of Oran 1, one of the famous Mediterranean marine specialists. The authors would like to thank Jesús Tomás for his comments which improved the quality of the paper**.** We also thank all the staff members of our LRSE laboratory, I also thank Amina Tifoura, PhD student at the University of Algiers. I am deeply indebted to the Chief Commander of the Civil Protection Unit of Cherchel Bahiri for his involvement in the conservation of sea turtles. A big thanks to all those who have contributed to this work in various ways.

References

Báez JS, García-Barcelona S, Camiñas JA, Macías D (2019) Fishery strategy affects the loggerhead sea turtle mortality trend due to the longline bycatch. Fisheries Research 212: 21– 28. https://doi.org/10.1016/j.fishres.2018.11.032

Bentivegna F (2002) Intra-Mediterranean migrations of loggerhead sea turtles (*Caretta caretta*) monitored by satellite telemetry. Marine Biology 141(4): 795–800. https://doi.org/10.1007/s00227-002-0856-z

Berrah MK (2018) Les principaux indicateurs du secteur de la pêche (2018) Direction Technique chargée des Statistiques Régionales et de la Cartographie.

Bolten AB (2003) Variation in Sea Turtle life history patterns: neritic vs. oceanic developmental stages. In: Lutz PL, Musick JA, Wyneken J (Eds) The Biology of Sea Turtles (Vol. II). CRC Press, Boca Raton, 243–257. https://doi.org/10.1201/9781420040807.ch9

Camiňas JA (1998) Is the leatherback (*Dermochelys coriacea* VANDELL1, 1761) a permanent species in the Mediterranean Sea? Rapport de la Commission Internationale pour l'exploration Scientifique de la Mer Méditerranée 35 (1998): 388–389.

Caracappa S, Persichetti MF, Piazza A, Caracappa G, Gentile A, Marineo S, Crucitti D, Arculeo M (2018) Incidental catch of loggerhead sea turtles (*Caretta caretta*) along the Sicilian coasts by longline fishery. PeerJ 6: e5392: 1–13. https://doi.org/10.7717/peerj.5392

Cardona L, Revelles M, Carreras C, San Félix M, Gazo M, Aguilar A (2005) Western Mediterranean immature loggerhead turtles: habitat use in spring and summer assessed through satellite tracking and aerial surveys. Marine Biology 147: 583–591. https://doi.org/10.1007/s00227-005-1578-9

Carreras C, Pascual M, Cardona L, Marco A, Bellido JJ, Castillo JJ, Tomás J, Raga JA, Sanfélix M, Fernández G, Aguilar A (2011) Living together but remaining apart: Atlantic and Mediterranean loggerhead sea turtles (*Caretta caretta*) in shared feeding grounds. Journal of Heredity 102(6): 666–677. https://doi.org/10.1093/jhered/esr089

Carreras C, Pascual M, Tomás J, Marco A, Hochscheid S, Castillo JJ, Gozalbes P, Parga M, Piovano S, Cardona, L (2018) Sporadic nesting reveals long distance colonisation in the philopatric loggerhead sea turtle (*Caretta caretta*). Scientific Reports 8(1): 1435. https://doi.org/10.1038/s41598-018-19887-w

Carreras C, Pont S, Maffucci F, Pascual M, Barceló A, Bentivegna F, Cardona L, Alegre F, Sanfélix M, Fernández G, Aguilar A (2006) Genetic structuring of immature loggerhead sea turtles (*Caretta caretta*) in the Mediterranean Sea reflects water circulation patterns. Marine Biology 149(5): 1269–1279. https://doi.org/10.1007/s00227-006-0282-8

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

Casale P, Affronte M, Insacco G, Freggi D, Vallini C, D'astore PP, Basso R, Paolillo G, Abbate G, Argano R (2010) Sea turtle strandings reveal high anthropogenic mortality in Italian waters. Aquatic Conservation: Marine and Freshwater Ecosystems 20(6): 611–620. https://doi.org/10.1002/aqc.1133

Casale P, Broderick AC, Camiñas JA, Cardona L, Carreras C, Andreas Demetropoulos A, Fuller WJ, Brendan J, Godley BJ, Hochscheid S, Kaska Y, Lazar B, Margaritoulis D, Panagopoulou A, Rees AF, Tomás J, Türkozan O (2018) Mediterranean sea turtles: current knowledge and priorities for conservation and research. Endangered Species Research 36: 229–267. https://doi.org/10.3354/esr00901

Casale P, Freggi D, Basso R, Argano R (2005) Size at male maturity, sexing methods and adult sex ratio in loggerhead turtles (*Caretta caretta*) from Italian waters investigated through tail measurements. Herpetological Journal 15(3): 145–148.

Casale P, Freggi D, Rocco M (2008) Mortality induced by drifting longline hooks and branchlines in loggerhead sea turtles, estimated through observation in captivity. Aquatic Conservation: Marine and Freshwater Ecosystems 18(6): 945–954. https://doi.org/10.1002/aqc.894

Casale P, Margaritoulis D (2010) Sea turtles in the Mediterranean: distribution, threats and conservation priorities. IUCN, Gland.

Casale P, Mazaris AD, Freggi D (2011) Estimation of age at maturity of loggerhead sea turtles *Caretta caretta* in the Mediterannean using length frequency data. Endangered Species Research 13: 123–129. https://doi.org/10.3354/esr00319

Casale P, Nicolosi P, Freggi D, Turchetto M, Argano R (2003) Leatherback turtles (*Dermochelys coriacea*) in Italy and in the Mediterranean basin. Herpetological Journal 13(3): 135–139.

Casale P, Pino d'Astore P, Argano R (2009) Age at size and growth rates of early juvenile loggerhead sea turtles (*Caretta caretta*) in the Mediterranean based on length frequency analysis. Herpetological Journal 19(1): 29–33.

Casale P, Tucker AD (2017) *Caretta caretta.* (amended version of 2015 assessment) The IUCN Red List of Threatened Species 2017: e.T3897A119333622. https://doi.org/10.2305/IUCN.UK.2017-2.RLTS.T3897A119333622.en

Clusa M, Carreras C, Pascual M, Gaughran SJ, Piovano S, Avolio D, Ollano G, Fernández G, Tomás G, Raga JA, Aguilar A, Cardona L (2016) Potential bycatch impact on distinct sea turtle populations is dependent on fishing ground rather than gear type in the Mediterranean Sea. Marine Biology 163(5): 1–122. https://doi.org/10.1007/s00227-016-2875-1

Clusa M, Carreras C, Pascual M, Gaughran SJ, Piovano S, Giacoma C, Fernández G, Levy Y, Tomás J, Raga JA, Maffucci F, Hochscheid S, Aguilar A, Cardona L (2014) Fine-scale distribution of juvenile Atlantic and Mediterranean loggerhead turtles (*Caretta caretta*) in the Mediterranean Sea. Marine Biology 161(3): 509–519. https://doi.org/10.1007/s00227-013-2353-y

Dodge KL, Logan JM, Lutcavage ME (2011) Foraging ecology of leatherback sea turtles in the western North Atlantic determined through multi-tissue stable isotope analyses. Marine Biology 158: 2813–2824. ttps://doi.org/10.1007/s00227-011-1780-x

Doumergue F (1901) Essai sur la faune erpétologique de l'Oranie: avec des tableaux analytiques et des notions pour la détermination de tous les reptiles & batraciens du Maroc, de l'Algérie et de la Tunisie. L. Fouque, 404 pp. https://doi.org/10.5962/bhl.title.9100

Eckert SA (2002) Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. Marine Ecology Progress Series 230: 289–293. https://doi.org/10.3354/meps230289

Eriksson KG (1965) The sediment core n 210 from the Mediterranean Sea. Reports of the Swedish Deep-Sea Expedition, (1947–1948) (vol. VIII), fasc. 5: 397–588.

Goy J, Morand P, Etienne M (1989) Long-term fluctuations of *Pelagia noctiluca* (Cnidaria, Scyphomedusa) in the western Mediterranean Sea. Prediction by climatic variables. Deep-Sea Research 36: 269–279. https://doi.org/10.1016/0198-0149(89)90138-6

Guarino FM, Nocera FD, Pollaro F, Galiero G, Iaccarino D, Iovino D, Mezzasalma M, Petraccioli A, Odierna G, Maio N (2020) Skeletochronology, age at maturity and cause of mortality of loggerhead sea turtles *Caretta caretta* stranded along the beaches of Campania (south-western Italy, western Mediterranean Sea). Herpetozoa 33: 39–51. https://doi.org/10.3897/herpetozoa.33.e47543

Jribi I, Bradai MN, Bouain A (2007) Impact of trawl fishery on marine turtles in the Gulf of Gabes, Tunisia. Herpetological Journal 17(2): 110–114.

Karaa S, Jribi I, Bouain A, Girondot M, Bradaie MN (2013) On the occurrence of Leatherback Turtles *Dermochelys coriacea* (VANDELLI, 1761), in Tunisian waters (Central Mediterranean Sea). Herpetozoa 26: 65–75.

Leclaire L (1972) La sédimentation holocène sur le versant méridional du bassin AlgéroBaléares (Pré-continent Algérien). Mémoires du Muséum National d'Histoire Naturelle, Paris, Nouvelles série, C, Science de la terre. Tome XXIV, Fascicule unique, 391 pp.

Licandro P, Conway DVP, Daly Yahia MN, Fernandez de Puelles, ML, Gasparini S, Hecq JH, Tranter P, Kirby RR (2010) A blooming jellyfish in the northeast Atlantic and Mediterranean. Biology Letters 6(5): 688–691. https://doi.org/10.1098/rsbl.2010.0150

Luschi P, Hays GC, Papi F (2003) A review of long distance movements by marine turtles, and the possible role of ocean currents. Oikos 103(2): 293–302. https://doi.org/10.1034/j.1600-0706.2003.12123.x

Margaritoulis D, Argano R, Baran I, Bentivegna F, Bradai MN, Camiñas JA, Casale P, Metrio GD, Demetropoulos A, Gerosa G, Godley B, Houghton J, Laurent L, Lazar YB (2003) Loggerhead turtles in the Mediterranean: Present knowledge and conservation perspectives. In: Bolten AB, Witherington BE (Eds) Ecology and Conservation of Loggerhead sea Turtles. Smithsonian Institution Press, Washington,

Millot C, Taupier-Letage I (2005) Circulation in the Mediterranean Sea. The handbook of environmental chemistry. Springer, Berlin 1: 29–66. https://doi.org/10.1007/b107143

Olson DB, Hitchcock GL, Mariano AJ, Ashjian CJ, Peng Ge, Nero RW, Podestá GP (1994) Life on the edge: marine life and fronts. Oceanography 7(2): 52–60. https://doi.org/10.5670/oceanog.1994.03

Pike DA (2013) Climate influences the global distribution of sea turtle nesting. Global Ecology and Biogeography 22: 555–566. https://doi.org/10.1111/geb.12025

Piovano S, Clusa M, Carreras C, Giacoma C, Pascual M, Cardona L (2011) Different growth rates between loggerhead sea turtles (*Caretta caretta*) of Mediterranean and Atlantic origin in the Mediterranean Sea. Marine Biology 158: 2577–2587. https://doi.org/10.1007/s00227-011-1759-7

Poiret JLM (1789) Voyage en Barbarie, ou lettres écrites de l'ancienne Numidie pendant les années 1785 et 1786, sur la religion, les coutumes et les moeurs des Maures et les ArabesBedouins (Vol. 1). Chez JBF Née de la Rochelle. https://doi.org/10.5962/bhl.title.13598

Revelles M, Cardona L, Aguilar A, San Félix M, Fernández G (2007a) Habitat use by immature loggerhead sea turtles in the Algerian Basin (western Mediterranean): swimming behaviour, seasonality and dispersal pattern. Marine Biology 151(4): 1501–1515. https://doi.org/10.1007/s00227-006-0602-z

Revelles M, Isern-Fontanet J, Cardona L, San Félix M, Carreras C, Aguilar A (2007b) Mesoscale eddies, surface circulation and the scale of habitat selection by immature loggerhead sea turtles. Journal of Experimental Marine Biology and Ecology 347: 41–57. https://doi.org/10.1016/j.jembe.2007.03.013

Seminoff JA, Benson SR, Arthur KE, Dutton PH, Eguchi Tapilatu TR, Popp BN (2012) Stable isotope tracking of endangered sea turtles: Validation with satellite telemetry and δ15N analysis of amino acids. PLoS ONE 7(5): e37403. https://doi.org/10.1371/journal.pone.0037403

Seminoff JA (2004) *Chelonia mydas*. The IUCN Red List of Threatened Species 2004: e.T4615A11037468. https://doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en

Sturges HA (1926) The Choice of a Class Interval. Journal of the American Statistical Association 21(153): 65–66. https://doi.org/10.1080/01621459.1926.10502161

Stewart K, Johnson C, Godfrey MH (2007) The minimum size of leatherbacks at reproductive maturity, with a review of sizes for nesting females from the Indian, Atlantic and Pacific Ocean basins. Herpetological Journal 17(2): 123–128.

Tomás J, Gozalbes P, Raga JA, Godley BJ (2008) Bycatch of loggerhead sea turtles: insights from 14 years of stranding data. Endangered Species Research 5 (2–3): 167–169. https://doi.org/10.3354/esr00116

Wallace BP, Tiwari M, Girondot M (2013) *Dermochelys coriacea*. The IUCN Red List of Threatened Species 2013: e.T6494A43526147. https://doi.org/10.2305/IUCN.UK.2013-2.RLTS.T6494A43526147.en

Wiefels R (2014) L'industrie de la Pêche et de l'Aquaculture en Algérie. Projet d'Appui à la Formulation de la Stratégie Nationale de Développement de la Pêche et de l'Aquaculture (2015–2020). PNUD, FAO, 36 pp.

Wyneken J (2001) The Anatomy of sea turtles. U.S. Departement of Commerce NOAA Technecal Memorandun NMFS – SEFSC-470, 172 pp.