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Loggerhead Strandings and Captures Along the Southern Spanish Coast: Body Size–Based Differences in Natural Versus Anthropogenic Injury

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ABSTRACT. – **Human and natural factors threaten loggerhead turtle (*Caretta caretta*, Linnaeus 1758) survival in the western Mediterranean basin. Loggerhead stranding data in the south of Spain provide evidence that human activities are having a more detrimental effect on larger-sized loggerhead turtles. The straight carapace length of 162 individuals affected by natural causes averaged 35.15 cm; whereas, that of 179 individuals affected by human-related causes averaged 46.23 cm. The difference was highly significant.**

Immature loggerhead sea turtles (*Caretta caretta*, Linnaeus 1758) that hatch on western Atlantic nesting beaches arrive at eastern Atlantic foraging habitats when they are approximately 20 cm long and 1 to 2 years old (Hays and Marsh 1997; Bjorndal et al. 2000). Some of these juvenile turtles enter the western Mediterranean Sea through the Strait of Gibraltar (between southern Spain and northern Morocco) and the Alboran Sea (Camiñas and De la Serna 1995). These juvenile individuals seem unable to leave through the strait until they reach a carapace size greater than 55 cm due to strong prevailing currents (Camiñas 2006; Revelles et al. 2007a; Eckert et al. 2008), and it is possible that many Atlantic loggerheads remain in the Mediterranean for much longer (Casale et al. 2009). Thus, the western Mediterranean Sea represents an important foraging area for western Atlantic loggerhead nesting stocks (Revelles et al. 2007b). Genetic studies in turtles stranded on the Andalusian coast (South of Spain) and captured in adjacent areas show a clear predominance of individuals from the Atlantic nesting beaches with little contribution of Mediterranean loggerheads (Carreras et al. 2006).

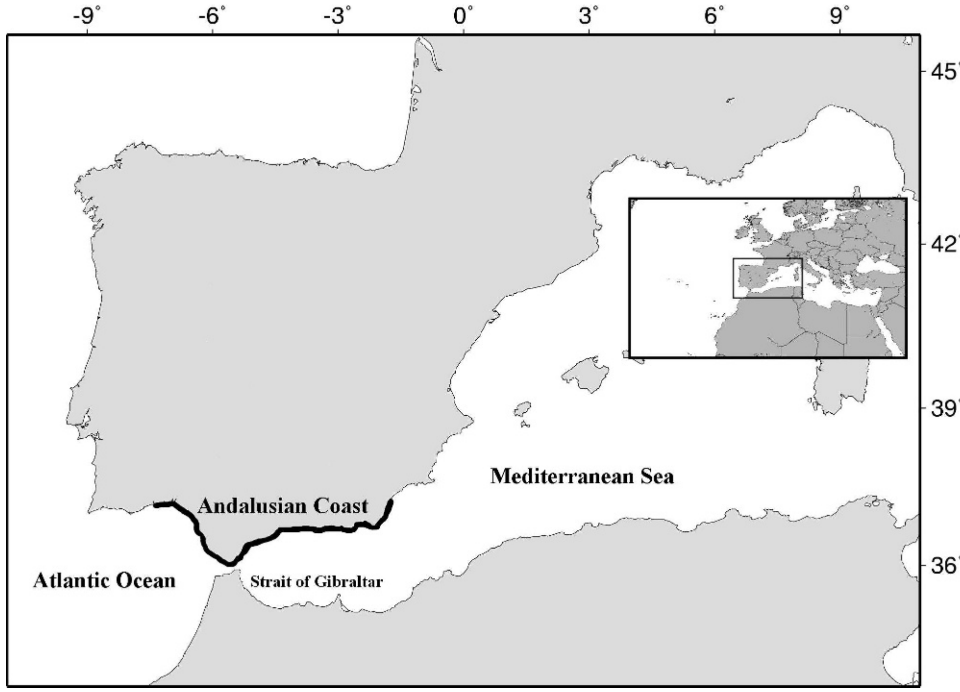

Figure 1. Andalusian coast (map using seaturtle.org/maptool).

Several human factors, such as pollution with heavy metals or the use of drifting longline and trammel nets, have been described as threats to sea turtles in the western Mediterranean basin (Carreras et al. 2003; Báez et al. 2007a, 2007b; Tomás et al. 2008; García-Fernández et al. 2009), and some of these lead to turtles stranding (Bellido et al. 2009). Loggerheads may also be damaged due to natural causes, such as cold-stunning, debilitated turtle syndrome (DTS), or pathologies that marine turtles suffer in the wild (Norton et al. 2004; Alava et al. 2005; Bellido et al. 2007). In addition, some causes of loggerhead damage on the Mediterranean Spanish coast are related to body size. This is the case of turtles stranded showing signs of interaction with longlines, which are larger than others stranded due to other causes along the eastern Spanish coast (Tomás et al. 2008).

Large juveniles and adult loggerheads are more valuable for maintaining this species' populations than are eggs or small juveniles (Crouse et al. 1987; Congdon et al. 1993). In the western Mediterranean basin Casale et al. (2007) estimated through experimental studies that annual mortality is 27% for loggerheads coming from Atlantic nesting beaches. In this context, it is important to check if the negative impact on loggerheads on the southern Spanish coast is biased for size (or for the age of the sea turtles).

In this study, we compared the body size of loggerheads stranded and incidentally captured along the Spanish coast around the Strait of Gibraltar. We also examined the relationship between turtle body size and the prevalence of natural and anthropogenic sources of mortality.

Methods. — The Strait of Gibraltar divides the Andalusian coast (1100 km; lat 37°10′N, long 7°23′W to lat 37°22′N, long 1°37′W) into 2 parts, Atlantic and Mediterranean (Fig. 1). Loggerhead stranding and by-catch data were recorded systematically from 1997 to 2006 by the Threatened Marine Species Recovery Centre of Andalusia (CREMA). CREMA has a volunteer stranding network with a strong presence along the entire Andalusian coast, complemented by local police and scientific groups, which collaborate on finding stranded turtles. This network records dead, sick, or injured turtles stranded on beaches, captured incidentally by fishermen, or found floating dead or in a weakened condition near the coast. It is coordinated via a 24-hour telephone hotline. From 1997 to 2006, a total of 1045 loggerhead turtles were recorded on the Andalusian coast, 910 of them stranded alive or dead on beaches and 135 incidentally captured or collected adrift by fishermen and sailors. We were not able to identify the cause of death or injury in all cases due to the state of decomposition of the carcasses or to the lack of access to animals (Kopsida et al. 2000). Causes of stranding or incidental capture were identified for 341 loggerheads (33%).

Turtles found alive were moved to the recovery center for veterinary examination and rehabilitation. Turtles were clinically evaluated by a team of 2 veterinarians and 2 biologists. The cause of injury was determined by external inspection, radiography, and if the animal died by necropsy. Fresh carcasses were brought to

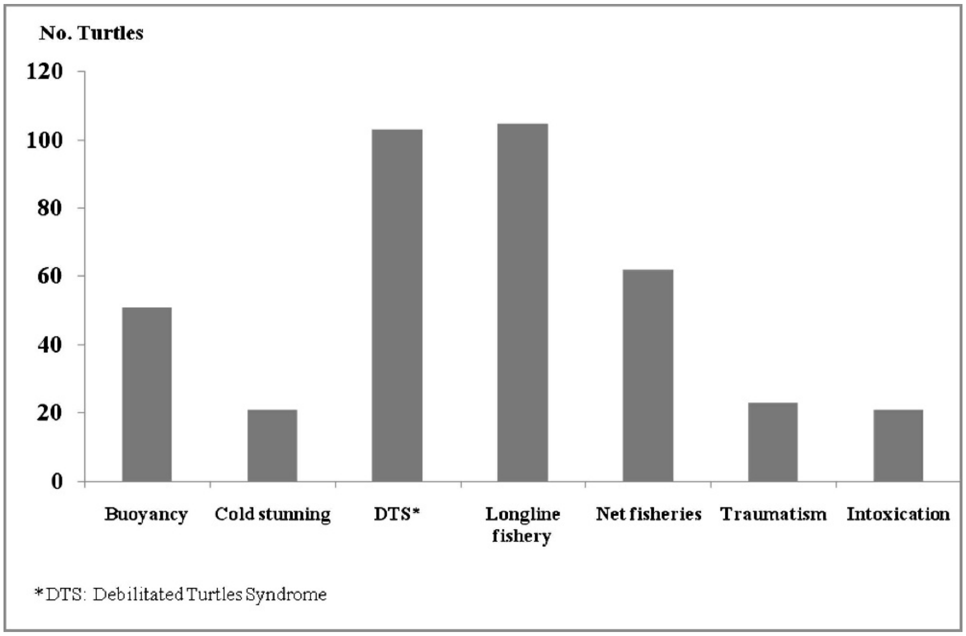

Figure 2. Distribution of loggerhead records on the Andalusian coast during 1997–2006 grouped by cause of damage (n = 341).

the recovery center for necropsy when possible. A trained team performed necropsies of fresh carcasses following a detailed protocol. Dead turtles in an advanced state of decomposition were examined by trained volunteers. The primary cause of death was determined based on complete external and internal examination and gross necropsy.

Turtles showing evidence of anthropogenic impacts were classified into 4 categories: 1) longline fishery (branch lines and/or hooks were found upon examination), 2) net fisheries (nets or marks of nets around flippers or neck), 3) trauma (external wounds caused by boat or propeller strikes), and 4) intoxication (turtles poisoned by ingestion of plastics, oil, and other waterborne contaminants). When anthropogenic causes were not apparent, live turtles were assigned to 1 of 3 natural causes: 1) buoyancy problems, 2) cold stunning, and 3) DTS (emaciated turtles with small barnacles on the skin).

Straight carapace length (SCL) measurements were taken from the 341 loggerheads examined for this study. The SCL data were tested for normality using the Kolmogorov-Smirnov test. The mean SCLs of turtles grouped in different categories were compared using analysis of variance (ANOVA; Sokal and Rohlf 1981) and Fisher's least significant difference (LSD) tests (Meier 2006) when the SCL distribution was normal. When SCL data were not normal, we used a nonparametric Wilcoxon test (Sokal and Rohlf 1981).

Because buoyancy problems may be due to natural (e.g., cold stunning; Bellido et al. 2008) or human (e.g., ingestion of oil or plastics; Lutcavage et al. 1997) causes, we explored the possibility of these problems being related to other causes by comparing the SCL frequency distribution in turtles affected by buoyancy problems to those of turtles with a similar mean SCL affected by other causes using the Kolmogorov-Smirnov test for 2 samples. Means are followed by standard deviation unless otherwise noted.

Results. — The studies were focused on the 341 specimens for which causes of stranding or incidental capture were identified, 294 of them alive and 47 dead. The mean SCL for these turtles was 40.1 ± 14.07 cm. Longlines, net fisheries, and DTS were the main causes in records between 1997 and 2006 (Fig. 2). A total of 162 turtles presented signs of natural causes (buoyancy problems, cold stunning, and DTS combined), with a mean SCL of 35.2 ± 14.01 cm; whereas, 179 turtles presented signs of human causes, with a mean SCL of 46.23 ± 13.31 cm. The SCL data for turtles with natural causes did not have a normal distribution. However, the distribution of all turtles impacted by human causes as

Table 1. Analysis of variance table for testing differences between straight carapace length (SCL) means for the 7 causes of stranding considered.

	Sum of squares	df	Mean square	F	p value
Intergroups	21,230.386	6	3538.398	22.592	2.399389392682 e^{-022}
Intragroups	52,311.319	334	156.621		
Total	73,541.705	341			

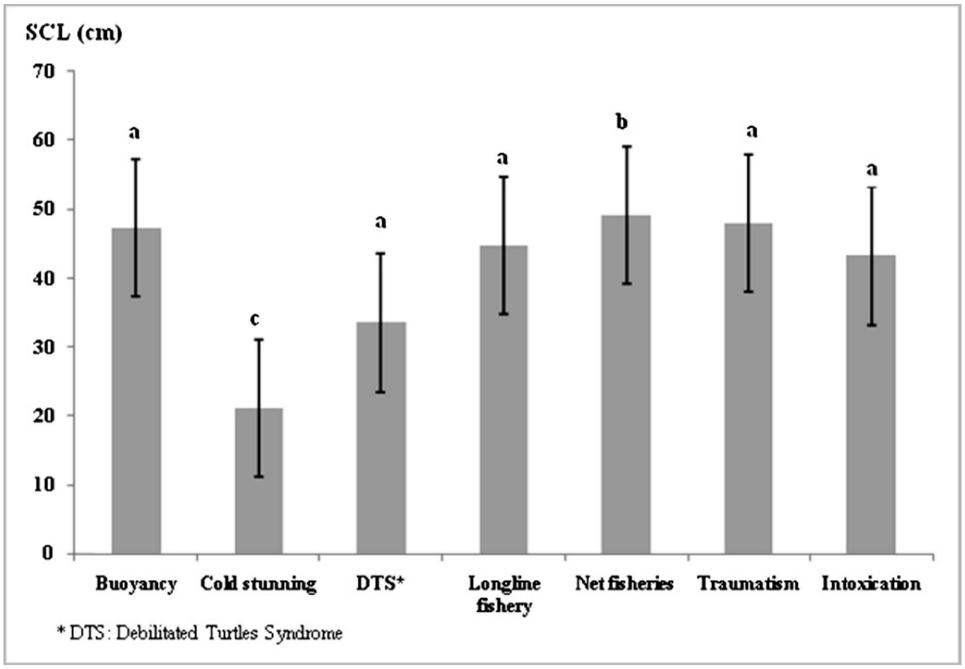

Figure 3. Mean straight carapace length (SCL) taken from all loggerhead turtles (*Caretta caretta*) recorded, grouped by cause of damage. Causes without significant differences in SCL according to the LSD test share the same superscript letter. $n = 341$. Standard deviation is shown as an error bar.

well as the SCL distributions for turtles affected by each of the 7 human causes considered separately were all normal. There was a low incidence of specimens affected by intoxication and trauma among loggerheads on the Andalusian coast, with a nonspecific size distribution (CV for intoxication = 0.38; CV for trauma = 0.30).

Turtles with natural pathologies presented a significantly lower mean SCL than turtles with human-caused pathologies (Wilcoxon W = 20,749.000; $p < 0.001$). Differences between the mean SCL for all 7 causes considered separately were significant (Table 1). Three size groups were found in relation to the cause diagnosed (Fig. 3). Size pattern A (mean SCL = 46.5 ± 14.89 cm) included the largest loggerheads; these were affected by buoyancy problems, longlines, net fisheries, trauma, and intoxication. All the human causes were within this group, as well as natural-cause buoyancy problems. Thus, human activities mainly affect subadults and larger juveniles. Comparison of the SCL frequency distribution of turtles affected by buoyancy problems with those affected due to human causes (Table 2; Fig. 4) showed that the differences were not significant, although they were greater in relation to longlines and practically nonexistent in relation to net fisheries. Size pattern B (mean SCL = 33.5 ± 9.97 cm) included the loggerheads affected by DTS. Finally, pattern C (mean SCL = 21.1 ± 6.46 cm) only included the youngest loggerheads affected by cold stunning symptoms (Fig. 4).

Table 2. Results of the Kolmogorov-Smirnov test comparing straight carapace length (SCL) distributions of loggerheads affected by buoyancy problems versus those affected by other causes. Sample sizes are as follows: 95 turtles captured in longline gear; 47 turtles captured in net fisheries; 38 turtles with buoyancy problems; 23 turtles with some form of trauma; 14 turtles with intoxication.

Comparisons	Z	Significance
Buoyancy vs. net fisheries	0.552	0.921
Buoyancy vs. trauma	0.697	0.716
Buoyancy vs. intoxication	0.878	0.424
Buoyancy vs. longlines	1.344	0.054

Discussion. — The stranding records do not constitute a scientific sampling because strandings are random phenomena, dependent on parameters such as mortality, interaction with human activities, currents, tides, or prevailing winds (Epperly et al. 1996; Hart et al. 2006). In addition, the relation between the number of turtles dead offshore and the numbers of turtles stranded is unknown (Peckham et al. 2008). Nevertheless, the information provided by the strandings deserves a deep study. Live turtles incidentally captured and dead carcasses provided information about age, size, abundance, grow rates, main sources of threat, geographical patterns, or feeding (MacLeod et al. 2004; Chaloupka et al. 2008). It is a responsibility of the scientific community to ensure that this information is properly processed and filed for a better understanding of the species.

The average SCL values of the loggerheads recorded on the southern Spanish coast indicate that immature turtles predominate in this area (Bolten 2003; Kamezaki 2003). Nevertheless, we recorded specimens with an SCL greater than 70 cm that could have been mature loggerheads returning from the Atlantic coast for the second time or more (Eckert et al. 2008).

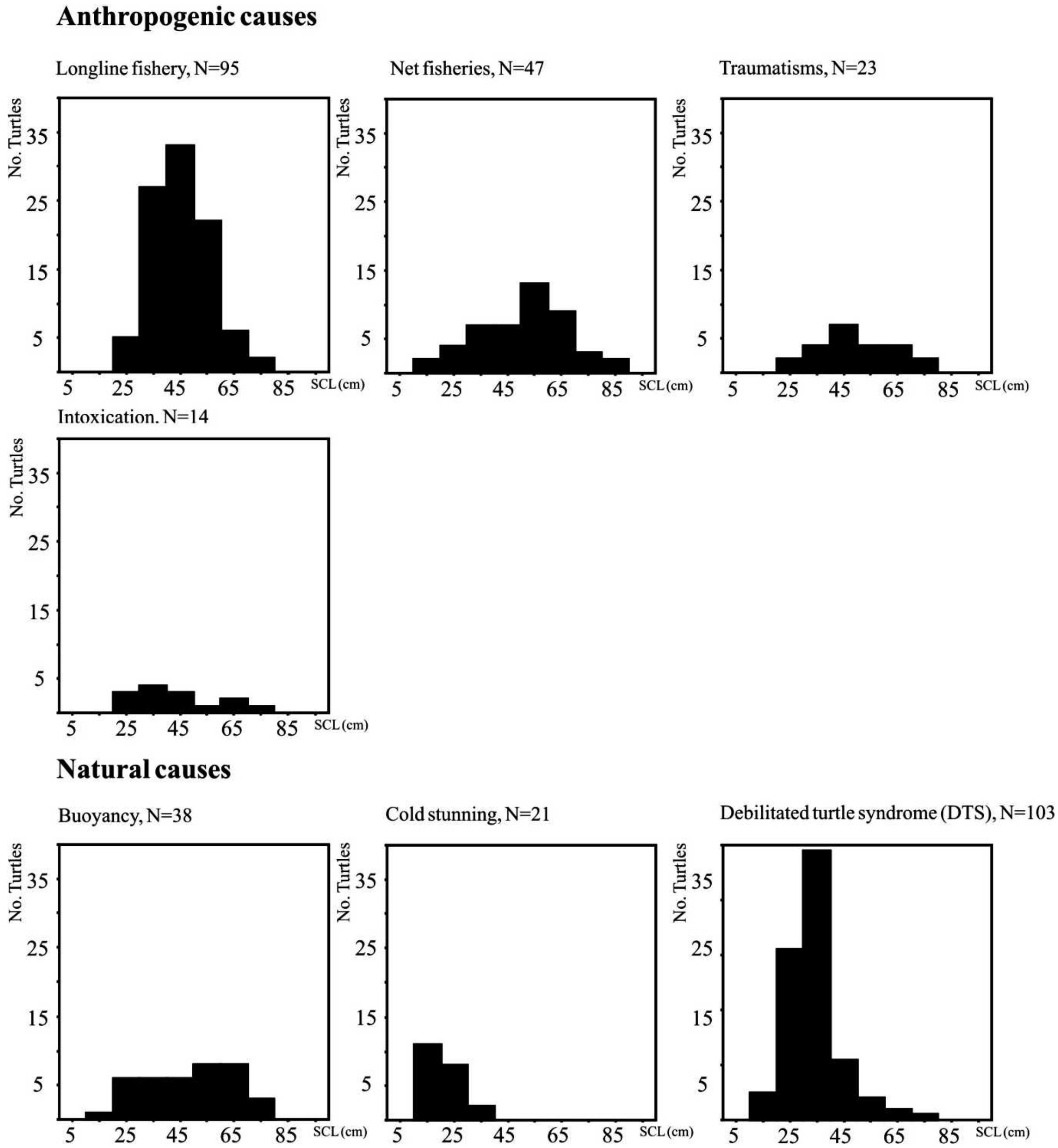

Figure 4. Straight carapace length frequency distribution in turtles stranded on the Andalusian coast or by-caught in marine fisheries.

Turtles affected by net fisheries had a wider SCL range than those affected by longline fisheries. In the southern Spanish coast, a large and heterogeneous fleet uses different sorts of techniques, such as bottom trawling or other artisanal gear (Camiñas 2005). This fleet makes use of both the neritic and pelagic ecosystems and affects smaller turtles living in deep waters and larger individuals living in shallow waters.

On the Spanish coast of the Alboran Sea, which is part of our study area, stranded loggerheads were shown to have a smaller mean SCL than turtles captured by longline fisheries in nearby fishing grounds (Bellido et al. 2007). Laurent et al. (2001) found that loggerheads captured by longline fisheries differed in size as a function of the gear used and target species. Two longline fisheries operate in our study area with 2 different target species: longlines targeting swordfish (*Xiphias gladius*, Linnaeus 1758) and longlines targeting bluefin tuna (*Thunnus thynnus*, Linnaeus 1758). The mean SCL of loggerheads by-caught by longlines targeting swordfish was 49 cm (range = 28 to 71 cm), whereas the mean SCL of loggerheads by-caught in longlines targeting bluefin tuna was 54 cm (range = 36 to 72 cm; Laurent et al. 2001). The hooks used by these fisheries are large, and it is possible that they could only be swallowed by larger turtles; whereas, smaller specimens would not be affected by these fisheries.

Two natural causes, DTS and cold stunning, are more frequent among smaller loggerheads (i.e., those with SCL $<$ 40 cm). Atlantic loggerheads are frequent in shallow waters over the Mediterranean continental shelf, and occupy neritic and pelagic habitats (Casale et al.

2008). In these waters, a pure oceanic/epipelagic stage is restricted to very small loggerhead turtles, which are probably unable to dive to the sea bottom (Casale et al. 2008). According to our results, these smaller turtles suffer less human pressure than larger specimens, and the only significant contributor to their stranding is cold stunning. Bellido et al. (2008) suggested that when loggerheads are cold stunned they may make eco-physiologic use of beaches to avoid cold waters and get warm. We found no significant differences between the size ranges of turtles affected by buoyancy problems and those affected by human causes. The differences were greater regarding longlines and intoxication and slight in relation to net fisheries and trauma. Thus, it is possible that buoyancy problems in the loggerheads stranded on these coasts may mainly be of human origin, the most probable human causes being net fisheries and trauma, although in many cases we cannot establish with certitude the human origin of the buoyancy.

Therefore, it is possible that human activities are having a negative effect on larger specimens, but have little impact on smaller sea turtles. This suggests that when younger loggerheads arrive at the Mediterranean basin they are somewhat vulnerable to human threats, but as they become older they become more exposed to human activities, especially to fisheries. In this way, the survival rate of loggerheads in the Mediterranean basin decreases as their size increases.

Although the western Mediterranean basin has been considered an important pelagic habitat for juvenile and subadult loggerhead sea turtles (Carreras et al. 2006), both pelagic and neritic habitats are used by these turtles in the Mediterranean (Casale et al. 2008). Small loggerheads are more frequent in pelagic waters, while larger specimens prefer neritic waters (Casale et al. 2008). These larger loggerheads in neritic or transitional stages can swim close to the coast in benthic feeding grounds (Eckert et al. 2008), where human activities are more pronounced. Thus, specimens returning to the nesting beaches on the American coast are more vulnerable than young loggerheads arriving at the Mediterranean basin.

This is an important issue since, for long-lived species such as sea turtles, the natural trend is to present high mortality rates in the first period of life and higher survival rates in larger juvenile and adult phases. Thus, the survival rate of larger juveniles has a strong effect on sea turtle population dynamics (Crouse et al. 1987; Heppell et al. 2003; Casale et al. 2007). Thus, it is possible that the damage suffered by loggerheads in the Mediterranean, affecting larger juveniles or adults, may contribute to the drop in the nesting population in areas such as Florida. Understanding the relationship between body size and stranding dynamics may be useful in sea turtle conservation programs, especially in an underrepresented region of the Mediterranean Sea.

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LITERATURE CITED

ALAVA, J.J., JIMÉNEZ, P., PEÑAFIEL, M., AGUIRRE, W., AND AMADOR, P. 2005. Sea turtle strandings and mortality in Ecuador: 1994–1999. Marine Turtle Newsletter 108:4–7.

BÁEZ, J.C., REAL, R., AND CAMIÑAS, J.A. 2007a. Differential distribution within longline transects of loggerhead turtles and swordfish captured by the Spanish Mediterranean surface longline fishery. Journal of the Marine Biological Association of the United Kingdom 87:801–803.

BÁEZ, J.C., REAL, R., GARCÍA-SOTO, C., DE LA SERNA, J.M., MACÍAS, D., AND CAMIÑAS, J.A. 2007b. Loggerhead turtle by-catch depends on distance to the coast, independent of fishing effort: implications for conservation and fisheries management. Marine Ecology Progress Series 338:249–256.

BELLIDO, J.J., BÁEZ, J.C., FARFÁN, M.A., CAMIÑAS, J.A., CASTILLO, J.J., MARTÍN, J.J., MONS, J.L., AND REAL, R. 2007. Comparación de los tamaños de las tortugas bobas (*Caretta caretta*, Linnaeus, 1758) varadas en las costas mediterráneas andaluzas con las de las capturas en el palangre. Munibe 25:202–208.

BELLIDO, J.J., BÁEZ, J.C., SANCHEZ, R.F., CASTILLO, J.J., MARTÍN, J.J., MONS, J.L., AND REAL, R. 2008. Mass strandings of cold-stunned loggerhead turtles in the south Iberian Peninsula: ethological implications. Ethology, Ecology and Evolution 4(20):401–405.

BELLIDO, J.J., CASTILLO, J.J., PINTO, F., MARTÍN, J.J., MONS, J.L., BÁEZ, J.C., AND REAL, R. 2009. Differential geographical trends for loggerhead turtles stranding dead or alive along the Andalusian coast, South Spain. Journal of the Marine Biological Association of the United Kingdom. doi:10.1017/S0025315409990361.

BJORNDAL, K.A., BOLTEN, A.B., AND MARTINS, H.R. 2000. Somatic growth model of juvenile loggerhead sea turtles *Caretta caretta*: duration of pelagic stage. Marine Ecology Progress Series 202:265–272.

BOLTEN, A.B. 2003. Active swimmers-passive drifters: the oceanic juvenile stage of loggerheads in the Atlantic system. In: Bolten, A.B. and Witherington, B.E. (Eds.). Loggerhead Sea Turtles. Washington, DC: Smithsonian Institution Press, pp. 63–78.

CAMIÑAS, J.A. 2006. Biología y comportamiento migratorio de la Tortuga Boba (*Caretta caretta* Linnaeus, 1758) en el Mediterráneo Occidental (Análisis de las interacciones con las flotas pesqueras españolas y propuestas para mejorar la gestión de la especie). Doctoral Thesis, Universidad Complutense de Madrid.

CAMIÑAS, J.A. AND DE LA SERNA, J.M. 1995. The loggerhead distribution in the Western Mediterranean Sea as deduced from the captures by the Spanish Long Line Fishery. Scientia Herpetologica 1995:316–323.

CARRERAS, C., CARDONA, L., AND AGUILAR, A. 2003. Incidental catch of the loggerhead turtle *Caretta caretta* off the Balearic Islands (western Mediterranean). Biological Conservation 117:321–329.

CARRERAS, C., PONT, S., MAFFUCCI, F., PASCUAL, M., BARCELÓ, A., BENTIVEGNA, F., CARDONA, L., ALEGRE, F., SANFÉLIX, M., FERNÁNDEZ, G., AND AGUILAR, A. 2006. Genetic structuring of immature loggerhead sea turtles (*Caretta caretta*) in the Mediterranean Sea reflects water circulation patterns. Marine Biology 149:1269–1279.

CASALE, P., ABBATE, G., FREGGI, D., CONTE, N., OLIVERIO, M., AND ARGANO, R. 2008. Foraging ecology of loggerhead sea turtles *Caretta caretta* in the central Mediterranean Sea: evidence for a relaxed life history model. Marine Ecology Progress Series 372:265–276.

CASALE, P., MAZARIS, A.D., FREGGI, D., BASSO, R., AND ARGANO, R. 2007. Survival probabilities of loggerhead sea turtles (*Caretta caretta*) estimated from capture-mark-recapture data in the Mediterranean Sea. Scientia Marina 71(2):365–372.

CASALE, P., MAZARIS, A.D., FREGGI, D., VALLINI C., AND ARGANO, R. 2009. Growth rates and age at adult size of loggerhead sea turtles (*Caretta caretta*) in the Mediterranean Sea, estimated through capture-mark-recapture records. Scientia Marina 73(3):589–595.

CHALOUPKA, M., WORK, T.M., BALAZS, G.H., MURAKAWA, S.K.K., AND MORRIS, R. 2008. Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago (1982–2003). Marine Biology 154:887–898.

CONGDON, J.D., DUNHAM, A.E., AND VAN LOBEN SELS, R.C. 1993. Delayed sexual maturity and demographics of Blanding turtles (*Emydoidea blandingii*): implication for conservation and management of long-lived organism. Conservation Biology 7:826–833.

CROUSE, D.T., CROWDER, L., AND CASWEL, H. 1987. A staged-based population model for loggerhead sea turtles and implications for conservation. Ecology 68(5):1412–1423.

ECKERT, S.A., MOORE, J.E., DUNN, D.C., SAGARMINAGA, R., ECKERT, K.L., AND HALPIN, P.N. 2008. Modeling loggerhead turtle movement in the Mediterranean: importance of body size and oceanography. Ecological Applications 18(2):290–308.

EPPERLY, S., BRAUN, J., CHESTER, A., CROSS, F., MERRINER, J., TESTER, P., AND CHURCHILL, J. 1996. Beach strandings as an indicator of at sea mortality of sea turtles. Bulletin of Marine Science 59(2):289–297.

GARCÍA-FERNÁNDEZ, A.J., GÓMEZ-RAMÍREZ, P., MARTÍNEZ-LÓPEZ, E., HERNÁNDEZ-GARCÍA, A., MARÍA-MOJICA, P., ROMERO, D., JIMÉNEZ, P., CASTILLO, J.J., AND BELLIDO, J.J. 2009. Heavy metals in tissues from loggerhead turtles (*Caretta caretta*) from the southwestern Mediterranean (Spain). Ecotoxicology and Environmental Safety 72(2):557–563.

HART, K.M., MOORESIDE, P., AND CROWDER, L.B. 2006. Interpreting the spatio-temporal patterns of sea turtle strandings: going with the flow. Biological Conservation 129:283–290.

HAYS, G.C. AND MARSH, R. 1997. Estimating the age of juvenile loggerhead se turtles in the North Atlantic. Canadian Journal of Zoology 75:40–46.

HEPPELL, S.S., CROWDER, L.B., CROUSE, D.T., EPPERLY, S.P., AND FRAZER, N.B. 2003. Population models for Atlantic loggerheads: past, present, and future. In: Bolten, A.B. and Witherington, B.E. (Eds.). Loggerhead Sea Turtles. Washington, DC: Smithsonian Books, pp. 255–273.

KAMEZAKI, N. 2003. The morphological perspective. In: Bolten, A.B. and Witherington, B.E. (Eds.). Loggerhead Sea Turtles. Washington, DC: Smithsonian Books, pp. 28–43.

KOPSIDA, H., MARGARITOULIS, D., AND DIMOPOULOS, D. 2000. What marine turtle strandings can tell us. In: MOSIER, A., FOLEY, A., and BROST, B. (Compilers). Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. Orlando, Florida, pp. 207–209.

LAURENT, L., CAMIÑAS, J.A., CASALE, P., DEFLORIO, M., DE METRIO, G., KAPANTAGAKIS, A., MARGARITOULIS, D., POLITOU, C.Y., AND VALEIRAS, X. 2001. Assessing marine turtle bycatch in European drifting longline and trawl fisheries for identifying fishing regulations. Project-EC-DG Fisheries 98-008. Joint project of BIOINSIGHT, IEO, IMBC, STPS and University of Bari. Villeurbanne, France.

LUTCAVAGE, M.E., PLOTKIN, P., WITHERINGTON, B., AND LUTZ, P. 1997. Human impacts on sea turtle survival. In: Lutz, P.L. and Musick, J.A. (Eds). The Biology of Sea Turtles, Vol I. Marine Sciences Series. Boca Raton, FL: CRC Press, pp. 387–409.

MACLEOD, C., PIERCE, G., AND SANTOS, M. 2004. Geographic and temporal variations in strandings of beaked whales (Ziphiidae) on the coasts of the UK and the Republic of Ireland from 1800–2002. Journal of Cetacean Research and Management 6:79–86.

MEIER, M. 2006. A note on the power of Fisher's least significant difference procedure. Pharmaceutical Statistics 5:253–263.

NORTON, T., KELLER, J.M., PEDEN-KELLER, M., DAY, R.D., STEDMAN, N., SEGARS, A., GREINER, E., HARMS, C., FRICK, M., DODD, M., SCHROEDER, B., SHERIDAN, T., HECKER, B., JACOBSON, E., FOLEY, A., MURPHY, S., CLUSE, W., TEAS, W., AND BRESETTE, M. 2004. Debilitated loggerhead turtle (*Caretta caretta*) syndrome along the southeastern U.S. coast: incidence, pathogenesis, and monitoring. In: Baer, C.K. (Ed.). Proceedings of the American Association of Zoo Veterinarians, American Association of Wildlife Veterinarians, and Wildlife Disease Association, pp. 91–93.

PECKHAM, S.H., MALDONADO-DIAZ, D., KOCH, V., MANCINI, A., GAOS, A., TINKER, M.T., AND NICHOLS, W. 2008. High mortality of loggerhead turtles due to bycatch, human consumption and strandings at Baja California Sur, Mexico, 2003 to 2007. Endangered Species Research 5:171–183

REVELLES, M., CARDONA, L., AGUILAR, A., SANFÉLIX, M., AND FERNÁNDEZ, G. 2007b. Habitat use by immature loggerhead sea turtles in the Algerian basin (western Mediterranean): swimming behaviour, seasonality and dispersal pattern. Marine Biology 151:1501–1515.

REVELLES, M., CARRERAS, C., CARDONA, L., MARCO, A, BENTIVEGNA, F., CASTILLO, J.J., DE MARTINO, G., MONS, J.L., SMITH, M.B., RICO, C., PASCUAL, M., AND AGUILAR, A. 2007a. Evidence for an asymmetric size exchange of loggerhead sea turtles between the Mediterranean and the Atlantic trough the Straits of Gibraltar. Journal of Experimental Marine Biology and Ecology 349:261–271.

SOKAL, R. AND ROHLF, F.J. 1981. Biometry. New York: W.H. Freeman and Company.

TOMÁS, J., GOZALBES, P., RAGA, J.A., AND GODLEY, B.J. 2008. Bycatch of loggerhead sea turtles: insights from 14 years of stranding data. Endangered Species Research 5: 161–169.

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