

FIRST EVIDENCE OF MIGRATION BY LOGGERHEAD SEA TURTLES, *CARETTA CARETTA*, FROM THE EASTERN MEDITERRANEAN TO NORTH AMERICA

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SEA TURTLES
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ABSTRACT. – Loggerhead sea turtles (*Caretta caretta*) frequent very distant areas during their life stages, and information about migratory routes and geographical range is key for planning their conservation. Here we report on the first direct evidence of a loggerhead turtle migrating from the eastern Mediterranean to the North American coast. A juvenile of 57.1 cm curved carapace length was tagged and released from Lampedusa Island, Italy, in 2008 and found dead on the Massachusetts coast in 2012. Its size and first location fit with the current knowledge about Atlantic loggerheads entering the Mediterranean and this finding supports the hypothesis of homing behavior as the explanation for the low genetic flow estimated between the Atlantic and Mediterranean populations.

INTRODUCTION

Loggerhead sea turtles, *Caretta caretta* (Linnaeus 1758) frequent very distant areas during different life stages (Nichols *et al.* 2000, Bolten 2003). Given the scale of movements and the different habitats utilized during their lives, information about migratory routes and geographical range is key for planning sea turtle conservation (Hamann *et al.* 2010). For example, loggerhead turtles born on northwestern Atlantic beaches disperse as far as the eastern Atlantic coasts and some of them enter the Mediterranean Sea (Bolten 2003), where they share foraging grounds with the Mediterranean population (Monzon-Arguello *et al.* 2010, Wallace *et al.* 2010, Carreras *et al.* 2011). Although Mediterranean juveniles and adults disperse widely throughout the eastern and western basins, breeding areas and main foraging grounds concentrate in the eastern basin (Casale & Margaritoulis 2010).

Genetic markers have shown that Atlantic loggerheads occur in high numbers especially in the oceanic zone of the westernmost part of the Mediterranean basin, closer to the Strait of Gibraltar, through which they enter from the Atlantic (Carreras *et al.* 2006, Carreras *et al.* 2011). However, individuals tagged in the Atlantic have been found as far as the central Mediterranean (Bolten *et al.* 1992) and the north Ionian Sea (Manzella *et al.* 1988). Genetic markers have indicated high proportions of Atlantic individuals in the oceanic zone of the Sicily Channel (Laurent *et al.* 1998) as well as their occurrence in the neritic zone of the Tunisian continental shelf, though at a lower pro-

portion (Casale *et al.* 2008). The occurrence of Atlantic loggerheads in other parts of the eastern Mediterranean basin is plausible but has not been adequately assessed yet through genetic approaches.

Since genetic flow from the Atlantic to the Mediterranean is estimated to be low, these Atlantic turtles are thought to return to the Atlantic to breed (Carreras *et al.* 2011). However, the finding that Atlantic turtles frequent neritic foraging grounds (Casale *et al.* 2008) is interesting because tagging studies on multiple populations suggest that neritic juveniles remain in or at least revisit specific areas (Musick & Limpus 1997, Casale *et al.* 2007).

Therefore, the information about backward migration to the Atlantic can contribute to understand the species behavioral patterns associated with fidelity to different habitats at different life stages. One loggerhead tagged in the western Mediterranean (Spain) was found in Cuba (Moncada *et al.* 2010) and loggerheads were satellite tracked from the eastern side of the Strait of Gibraltar to the Atlantic, two of which stopped transmissions in the middle of the North Atlantic while the third reached Nicaragua (Eckert *et al.* 2008). The release area of these turtles was very close to the Atlantic and it is not known how long they had remained in the Mediterranean. One turtle tagged in the eastern Mediterranean (north Ionian Sea) was found on the coast of Portugal, just outside the Mediterranean (Argano *et al.* 1992). Here we report a new finding that contributes to the understanding of the movement patterns of loggerhead turtles between the Atlantic and the Mediterranean.

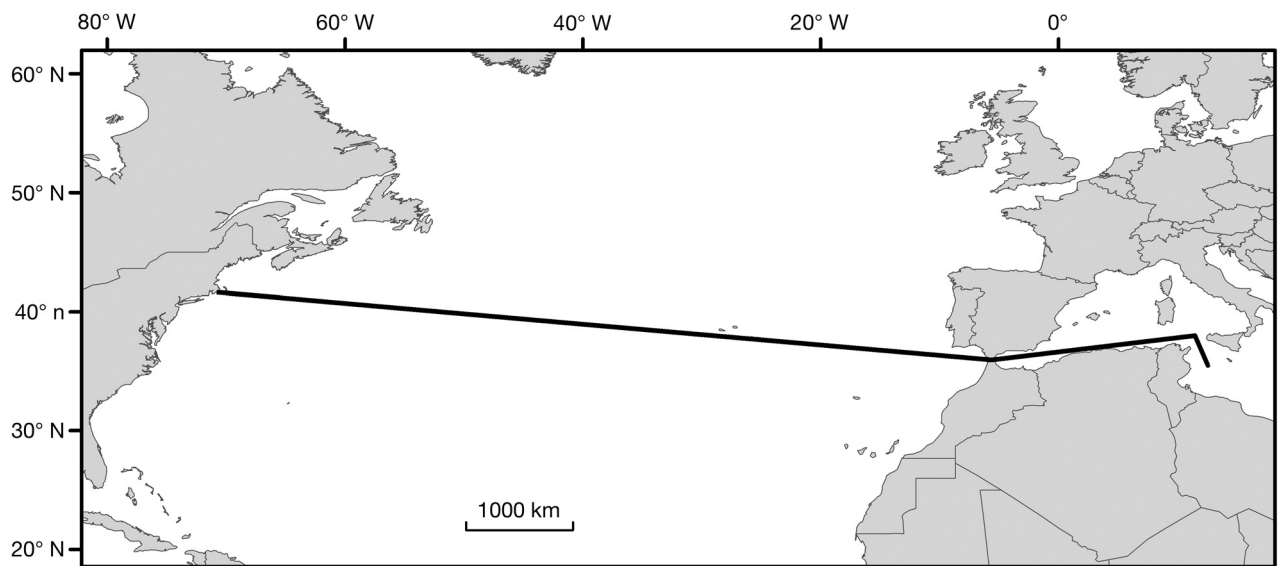


Fig. 1. – Map of the Atlantic Ocean and Mediterranean Sea showing the shortest route of a loggerhead sea turtle (solid line) between release (Lampedusa Island, Italy) and re-encounter (Buzzards Bay, MA, USA) locations.

MATERIALS AND METHODS

Over a 22-year period (1990-2011), a total of 2415 loggerhead turtles were tagged and released from Lampedusa Island (35.49°N, 12.60°E; Fig. 1), with most of them (84 %) tagged in the period 2000-2011. These individuals were originally captured by fishing gear, found stranded, or captured while at the sea surface. Turtles were measured (curved carapace length notch to tip, CCL_{n-t} and minimum straight carapace length, SCL) (Bolten 1999) and tagged with monel or inconel tags (styles 49 or 681, National Band and Tag, Kentucky, USA). Tags had an alphanumeric code and a return address stamped on them and were attached to one or both front flippers.

RESULTS

Turtle 4150A was found floating in the waters around Lampedusa Island, Italy, on 20 August 2008, cured for a longline hook at the Lampedusa sea turtle rescue center, and was released from the shores of Lampedusa (35.48°N, 12.6°E) on 22 September 2008. It measured 57.1 cm CCL and 51.7 cm SCL. It was re-encountered dead on 3 September 2012 (1442 days later) on the western shore of Buzzards Bay, Massachusetts, USA (41.64°N, 70.77°W; Fig. 1). It was moderately decomposed and more than half of the body (the posterior part) was missing. This precluded any useful measurement of the carapace length, because the standard points were missing. The carcass may have floated for a few days before stranding, and it likely died somewhere in Buzzards Bay. This is a busy recreational boating area, and the turtle may have been struck by a boat, although no direct evidence of the cause of death was found. The minimum distance travelled

between the release and re-encounter locations (Fig. 1) is 7400 km (source: Google Earth).

DISCUSSION

The present findings represent the first evidence of a migratory connection of a loggerhead from the Mediterranean to North America. Capture-mark-recapture can only provide release and re-encounter location with no insight of the route. Turtle 4150A may have followed main surface currents of the North Atlantic gyre (Carr 1986, Bolten 2003) toward the Caribbean and then northward along the North American coast, it may have swum directly to North America, or it may have followed more complex routes. Of five turtles satellite-tracked from near the Strait of Gibraltar (Mediterranean or Atlantic coasts of Spain; Table I), three travelled south-west toward the Caribbean and two west toward North America (Cejudo *et al.* 2006, Eckert *et al.* 2008), the latter with a direction point-

Table I. – Five turtles satellite-tracked from near the Strait of Gibraltar (Mediterranean or Atlantic coasts of Spain) (Cejudo *et al.* 2006, Eckert *et al.* 2008) and the turtle (4150A) reported by the present study. * Linear direction (not observed) from the Strait of Gibraltar to the final position.

Turtle	Direction	Final position
Centella	West	mid Atlantic
Malaguena	South-West	mid Atlantic
Cc06	West	mid Atlantic
Cc07	South-West	mid Atlantic
Cc18	South-West	Nicaragua
4150A	West*	MA, USA

ing to the same approximate area where turtle 4150A was found. Of these five turtles only one was tracked across the Atlantic to coastal areas in the Caribbean (Nicaragua), while transmission from the other turtles stopped mid-Atlantic. However, these tracks and the present findings suggest that a direct migratory route is at least possible.

This is also the first evidence of migration from the eastern Mediterranean to the western Atlantic. We hypothesize that turtle 4150A was one of the many Atlantic loggerheads that are thought to enter the Mediterranean and then to return to their natal marine area (Carreras *et al.* 2006). Its size at the time of tagging fits within the known size range of Atlantic turtles in the Mediterranean. The modal size of loggerheads found on the Atlantic coast of northern Europe is about 20 cm SCL (Witt *et al.* 2007), suggesting that Atlantic turtles enter the Mediterranean at this size. The smallest turtle found in the eastern Mediterranean and carrying an mtDNA haplotype endemic to the western Atlantic was in the size range 30-34 cm CCL, (Laurent *et al.* 1998). Turtles tagged and released from Texas and the Azores were re-encountered in the Strait of Sicily and in the north Ionian Sea at 43.5 and 42 cm CCL respectively (Manzella *et al.* 1988, Bolten *et al.* 1992). Turtle 4150A was originally found far from the Strait of Gibraltar at a size of 57.1 cm CCL, and this suggests that it had entered the Mediterranean long before the finding. We do not know when the turtle migrated to North America, but even considering a growth rate of 2-3 cm/yr (Casale *et al.* 2009, Casale *et al.* 2011a, Casale *et al.* 2011b), it was before reaching the adult size of the Atlantic population (range of means of nesting females: 98.9-105.1 cm CCL; Dodd 1988) and probably also of the Mediterranean population (range of means of nesting females: 66.5-84.7 cm CCL; Margaritoulis *et al.* 2003). Its size fits with the estimated size at which most loggerhead turtles recruit to the neritic habitats in the southeastern USA (46-64 cm CCL; Bjorndal *et al.* 2000), with the size of the four turtles tagged or tracked from the western Mediterranean into the Atlantic (68-76 cm CCL; Eckert *et al.* 2008, Moncada *et al.* 2010), and with the average size of turtles moving from the Mediterranean to the Atlantic (54.5 SCL; Revelles *et al.* 2007).

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