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▶ **To cite this version:**

S. Ferraroli, J.-Y. Georges, P. Gaspar, Y. Le Maho. Endangered species: where leatherback turtles meet fisheries.. Nature, 2004, 429 (6991), pp.521-522. 10.1038/429521a . hal-00117339

HAL Id: hal-00117339
https://hal.science/hal-00117339

Submitted on 1 Dec 2006

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Published in : Nature (2004) Vol.429: 521-522

http://www.nature.com.

Where sea turtles meet fisheries

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Total number of words: 548

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The dramatic worldwide decline in leatherback turtles *Dermochelys coriacea* populations[1] is largely due to high fishing-induced mortality[2] and a reduction of their interaction with fisheries is therefore critical for their survival. The discovery of narrow migration corridors in the Pacific Ocean[3] raised the hope that such restricted key areas could rather easily be protected. But we show here that such corridors do not exist in the North Atlantic Ocean. Still, we identify a few hot spots where leatherbacks meet fisheries and thus where conservation efforts should be focussed.

The Atlantic Ocean beaches host the last major nesting sites for leatherback turtles[1] but their oceanic migration routes are largely unknown. This hinders the development of appropriate, spatially focussed, conservation strategies. We therefore deployed Argos satellite transmitters on leatherback turtles nesting in the Guiana shield (5°5'N, 54°W) and monitored their movements during (n=20 individuals) and after (n=12) nesting seasons from 1999 to 2002.

Migration trajectories (Figure 1) indicate that, unlike in the Pacific[3], leatherbacks disperse widely throughout the North Atlantic Ocean. They follow, at least, two main dispersion patterns: some migrate North, broadly towards the Gulf Stream area, while others disperse to the East and remain in tropical waters.

Turtles migrating North (E,F,G,H) swam with striking constant individual headings (range: 7.1±4.2° to 348.3±4.0°). As they did so, they cut across the whole subtropical gyre, generally moving at cross-angle with the main current. After crossing the Gulf Stream, two individuals (E,G) veered to the East in the highly-productive transition zone between the subtropical and the subpolar gyres. Their behaviour then changed markedly and became closely correlated with local oceanographic conditions as their trajectories curve along oceanic fronts, perfectly

observed in contemporaneous satellite altimeter data. Their velocity concurrently decreased compared to the preceding northwards straight segment (e.g. Turtle G: 0.57±0.03 $m.s^{-1}$, n=183 *versus* 0.68±0.04 $m.s^{-1}$, n=135; t-test t=2.239, P=0.026). This suggests that turtles slow down to forage along productive fronts where their main prey, gelatinous plankton, concentrate[4] but also where pelagic longliners aggregate[5,6] and take a threatening number of sea turtles as bycatch[7].

Other individuals (B,C,D,I,J,L), after a short northward leg up to about 10°N, headed broadly East (range: 52.5±5.4° to 101.9±14.4°), mostly swimming against the westward flowing North Equatorial Current. Two of them (B,C) were tracked far to the East: Turtle B reached Cape Verde Islands before transmission stopped. Turtle C followed the southernmost route, crossing the eastward flowing North Equatorial Counter-Current (roughly between 10°N and 3°N) before reaching the westward flowing South Equatorial Current where she reversed her course, heading West with the current at about 2°N. This turtle most likely fed on the productive frontal areas associated with the equatorial current systems, where large fleets, mostly targeting tropical tunas, operate[8].

During nesting, tracking data show that turtles remain in front of the Maroni river estuary in a 20-km radius area heavily exploited by French Guiana and Surinam fishing fleets targeting brown shrimp *Penaeus subtilis* and red snapper *Lutjanus purpureus*[9]. Unsurprisingly, frequent accidental sea turtles catches are reported for these fleets[10].

The few hot spots where turtles likely encounter coastal or pelagic fishing fleets are thus very different and widely scattered across the Atlantic basin. This stresses the need for developing locally adapted, but basin-wide and internationally coordinated, conservation strategies for preserving the last large population of endangered leatherback turtles.

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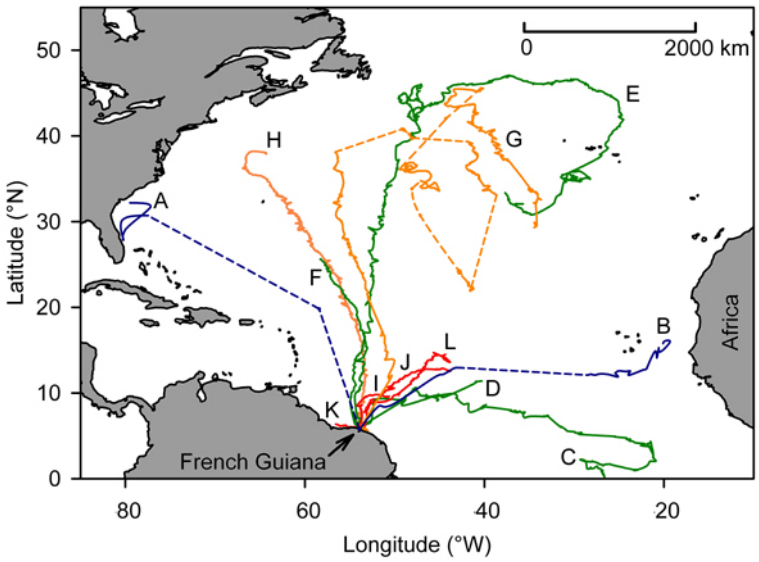
Figure 1. Reconstructed movements of twelve leatherback turtles nesting in the Guiana shield in 1999 (blue), 2000 (green), 2001(orange) and 2002 (red). Dotted lines correspond to segments with irregular locations due to low transmission frequency. Leatherback turtles dispersed widely throughout the North Atlantic Ocean according to at least two main migration patterns: Four individuals headed North and reached the Gulf Stream area where they initiated clockwise circulation, following general ocean circulation, whereas six other individuals headed East swimming mostly opposite to the North Equatorial Current.