Artificial Lights as a Significant Cause of Morbidity of Leatherback Sea Turtles in Pongara National Park, Gabon

Sharon L. Deem[1], François Boussamba[2], Alex Zogo Nguema[2], Guy-Philippe Sounguet[2], Stephanie Bourgeois[3], Janine Cianciolo[4] & Angela Formia[5]

[1]*Smithsonian National Zoological Park, Washington DC, USA (E-mail: deems@si.edu);* [2]*Aventures Sans Frontières, Libreville, Gabon;*
[3]*Ecole Nationale Veterinaire d'Alfort, Maisons-Alfort, France;* [4]*Exotic Animal Veterinary Services, Saint Petersburg, FL, USA;*
[5]*Wildlife Conservation Society-Gabon, Libreville, Gabon*

Although leatherback sea turtles (*Dermochelys coriacea*) live in oceans throughout the world, it has recently been confirmed that the coast of Central Africa is home to one of the largest leatherback nesting populations (Fretey & Giradin 1988; Sounguet *et al.* in press). The highest density of nesting female leatherback sea turtles occurs in Gabon, which may host as much as 30% of the global nesting population (Sounguet *et al.* in press). Based on aerial surveys, up to 1,500 nests are laid per night during the peak nesting season along the entire coastline (Sounguet *et al.* in press). In addition to leatherbacks, green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*) sea turtles frequent the waters off the coast and have been documented nesting in Gabon (Formia 1999; Fretey 2001; Fretey *et al.* 2002).

One of the primary leatherback nesting beaches in Gabon is located 11 km from the Capital City, Libreville, in the newly established Pongara National Park. The leatherback nesting season in Pongara is October to April with peak nesting occurring in December and January (Aventures Sans Frontières, unpublished data). Approximately 1,800 to 2,000 leatherback nests are laid annually on a 5 km stretch of beach in the northern most area of this Park (00.345441°N, 09.346610°E) (Aventures Sans Frontières, unpublished data).

In addition to the high numbers of nesting leatherback sea turtles in Pongara, the close proximity to Libreville makes it a high priority site for the education of local and international visitors about sea turtle biology, conservation and health. In fact, within walking distance from the nesting beach is Pointe Denis resort area with a growing number of private bungalows and hotels. Artificial light pollution from this resort area has grown significantly during the last five years. In conjunction with development, the potential for sea turtle tours and education for visitors has also increased.

Leatherback sea turtles are listed as critically endangered worldwide (IUCN 2006). Threats to their conservation and health in Pongara National Park and Gabon in general are similar to those in most other regions of the world, and include incidental capture in fisheries, beachfront development, artificial lights, marine and coastal pollution, off-shore oil exploitation, uncontrolled tourism, off-road vehicles, predation, and intentional harvesting (George 1997; Lutcavage *et al.* 1997; Spotila *et al.* 1997; Spotila *et al.* 2000). One unique threat to leatherbacks in the region is the countless logs lost during commercial timber transport, which obstruct the nesting beaches and cause false crawls, nesting below the high tide line and fatal entanglement of females (Laurence *et al.* in press). About 30.5% of the nesting area in Pongara National Park was blocked by logs in the 2002-2004 nesting seasons (Laurence *et al.* in press).

During an initial field season in 2000-2001 to conduct a health assessment of leatherbacks in Gabon (Deem *et al.* 2006), it was noted that lights from Libreville and Pointe Denis appeared to be causing disorientation (turtles crawling on circuitous paths) and misorientation (turtles crawling landward) (Verheijen 1985) in both nesting females and hatchlings in Pongara National Park. During this season, the senior author located one dead adult female leatherback that had walked landward and observed the tracks of thousands of hatchlings that demonstrated both disorientation and misorientation associated with areas of high artificial light pollution. From 2001 to 2005 we recorded an annual mean of 3 deaths of nesting females that wandered into the savanna and an unknown number of hatchlings that succumbed to the effects of artificial lights (Aventures Sans Frontières, unpublished data).

In the 2005-2006 nesting season, we initiated a study to explore the impacts of artificial lights on leatherback sea turtles in Pongara. This initial study was directed at hatchling orientation. Results confirmed that light pollution was playing a role in the misorientation of hatchlings in the Park as 27 of the 41 nests (66%) observed had significant numbers of hatchlings walk in quadrants away from the ocean and towards artificial lights (Bourgeois 2007). This risk of misorientation due to artificial lights was highest in the most open sections of beach (e.g., without logs, erosion and vegetation) and where artificial lights were most evident (Bourgeois 2007).

In the current nesting season, 2006-2007, we have witnessed a growing threat of artificial lights on leatherback nesting females on this 5 km stretch of beach in Pongara National Park. During an 80-day period, we documented 71 misoriented females that walked directly into the savanna and towards the artificial lights of Pointe Denis (Figure 1). Unable to stop these females from walking great distances into the savanna (some up to 500 meters), we moved 68 turtles back to the ocean using ropes, manual labor (Figure 2), and when available, off-road vehicles the following morning. Three turtles (4.2%) died in the savanna before we could locate them. Pathologic findings of these three turtles were suggestive of death due to hyperthermia and dehydration. Additionally, although laboratory diagnostics were not performed, we believe that a large percentage of the turtles we returned to the ocean may not have survived, due to physiologic changes (e.g., dehydration, hypoglycemia, increased cortisol and lactic acid) that made them susceptible to drowning, vehicle strike, and predation.

Based on morning track counts, the percent of nesting females that walked into the savanna following nesting activity was 2-6% on many nights, with a high of 56% on 31 December, which corresponded to increased human activity (e.g., fireworks, increased lights from bungalows and hotels throughout the night) in Pointe Denis. During this 80-day period, we recorded a minimum of 2,024 successful leatherback nests (15 days of track counts are not available; Aventures Sans Frontières, unpublished data). Therefore, 3.6% (71/2024) of leatherback sea turtle nesting events resulted in females that walked into the savanna following nest excavation.

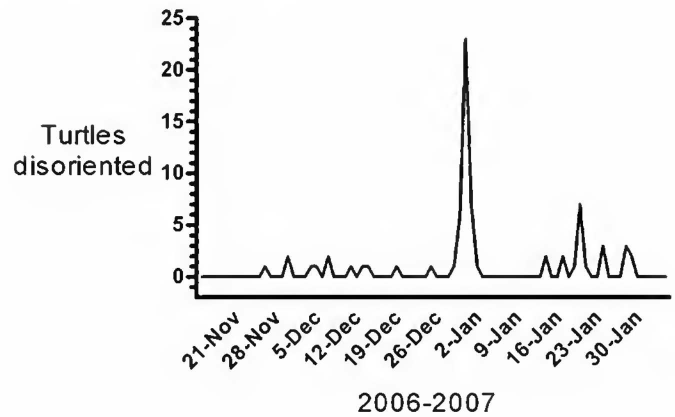

Figure 1. Number of female leatherback turtles that crawled into the savanna, and towards artificial lights, in Pongara National Park, Gabon following nesting activity.

Based on our findings we have taken urgent actions and made recommendations directed at curtailing the immediate impacts of light pollution on leatherback sea turtles on this beach. We obtained emergency funds from the Wildlife Conservation Society, Aventures Sans Frontières, and the American Embassy and currently have two teams of three persons per night patrolling the beach. One person remains with each turtle until it returns to the ocean, ensuring it does not walk into the savanna following nesting activity. We have had great success in moving a number of these females back to the ocean with the "light technique" in which turtles will follow our white light down to the ocean. Additionally, a turtle tarp has been constructed to minimize the tissue damage accrued during transport of females from the savanna to the ocean. Three temporary barriers have also been placed along 250 meters of the beach, at sites with the most tracks indicating hatchlings wandering into the savanna, to minimize loss of hatchlings to the artificial lights.

Although we were forced into a crisis management approach, we emphasise the fundamental need for preventive measures to eliminate or control light impacts at the source. Education programs on light pollution and other threats affecting nesting leatherbacks are underway. We have distributed a brochure on light pollution and turtle-friendly light use to bungalows and hotels at Pointe Denis, and currently have a commercial airing on all local television channels in Gabon which displays leatherback sea turtle conservation in Pongara, highlighting the threat of logs and lights in the region. Finally, we plan to obtain turtle-friendly lights for distribution to home owners and hotels in Pointe Denis. We hope that our conservation actions ensure that we preserve this leatherback sea turtle nesting beach for many years to come. The importance of Pongara National Park for the leatherback females who nest here, the hatchlings that start life here, and the countless people that visit this beach to be inspired and educated on sea turtle biology, health, and conservation is irreplaceable.

Acknowledgments: The authors thank the Cleveland Metroparks Zoo for funding for the writing of this article, Aventures Sans Frontières staff for field work, the Conservateur of Pongara National Park, Madame N'safou Loembé, and the government of Gabon for permission to work in Pongara National Park.

BOURGEOIS, S. 2007. Etude du succès reproductive de la tortue luth (*Dermochelys coriacea*) sur la plage de Pongara au Gabon: Devenir des nids et orientation des nouveau-nées. Thesis, Ecole Nationale Vétérinaire d'Alfort, Maisons-Alfort, France. 147 pp.

DEEM, S.L., E.S. DIERENFELD, G.P. SOUNGET, A.R. ALLEMAN, C. CRAY, R.H. POPPENGA, T.M. NORTON & W.B. KARESH. 2006. Blood values in free-ranging nesting leatherback sea turtles (*Dermochelys coriacea*) on the coast of the Republic of Gabon. Journal of Zoo and Wildlife Medicine 37: 464-471.

FORMIA, A. 1999. Les tortues marines de la Baie de Corisco. Canopée 14:1-2.

FRETEY, J. 2001. Biogeography and Conservation of Marine Turtles of the Atlantic Coast of Africa. CMS Technical Series Publication No. 6, UNEP/CMS Secretariat, Bonn, Germany.

FRETEY, J. & N. GIRADIN. 1988. La nidification de la tortue luth, *Dermochelys coriacea* (Vandelli, 1761) (Chelonii, Dermochelyidae) sur les côtes du Gabon. Journal of African Zoology 102: 125-132.

Figure 2. Workers move a female leatherback turtle found in the savanna 400 meters away from the ocean. Photo credit: John Kelson

FRETEY, J., A. MEYLAN & M. TIWARI. 2002. The occurrence of the hawksbill turtle (*Eretmochelys imbricata*) in West Africa. In: A. Mosier, A. Foley & B. Brost (Eds.), Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NMFS-SEFSC-477. pp. 95-96.

GEORGE, R.H. 1997. Health problems and diseases of sea turtles. In: P.L. Lutz & J.A. Musick (Eds.). The Biology of Sea Turtles, CRC Press, Boca Raton, Florida. pp. 363-385.

IUCN. 2006. Red List of Threatened Species. www.iucnredlist.org.

LAURANCE, W.F., M. FAY, R.J. PARNELL, G.P. SOUNGUET, A. FORMIA & M.E. LEE. In press. Does rainforest logging threaten endangered sea turtles? Oryx.

LUTCAVAGE, M.E., P. PLOTKIN, B. WITHERINGTON & P.L. LUTZ. 1997. Human impacts on sea turtle survival. In: P.L. Lutz & J.A. Musick (Eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida. pp. 387-409.

SOUNGUET, G.P., A. FORMIA & R. PARNELL. In press. Assessment of leatherback nesting in Gabon by aerial survey. In: Proceedings of the 25th International Sea Turtle Symposium.

SPOTILA, J.R., A.E. DUNHAM, A. J. LESLIE, A.C. STEYERMARK, P.T. PLOTKIN & F.V. PALADINO. 1996. Worldwide population decline of Dermochelys coriacea: are leatherback turtles going extinct? Chelonian Conservation Biology 2: 209-222.

SPOTILA, J.R., R.D. REINA, A.C. STEYERMARK, P.T. PLOTKIN, & F.V. PALADINO. 2000. Pacific leatherback turtles face extinction. Nature 405: 529-530.

VERHEIJEN, F.J. 1985. Photopollution: Artificial light optic spatial control systems fail to cope with. Incidents, causation, remedies. Experimental Biology 44: 1-18.

Observations of Marine Turtles in Relation to Seismic Airgun Sound off Angola

Caroline R. Weir

Ketos Ecology, 4 Compton Road, West Charleton, Kingsbridge, Devon TQ7 2BP, U.K. (E-mail: Caroline.Weir@ketosecology.co.uk)

The airgun arrays used during geophysical seismic surveys produce sound with source levels in the region of 220–248 dB re. 1 µPa at 1 m, and peak energy in the 10–200 Hz frequency bandwidth (for seismic survey background information see Gulland & Walker 2001). To date, most studies on the impacts of airgun sound on marine fauna have focussed on species deemed acoustically sensitive such as cetaceans (e.g. Gordon et al. 2004) or economically-important such as commercial fish stocks (e.g. Engås et al. 1996). Guidelines have been developed worldwide to mitigate the potential impacts of airgun sound on marine mammals (Weir & Dolman In Press), including the use of dedicated observers to detect animals close to seismic operations and restricted airgun use, and the implementation of a 'soft start' (or 'ramp up') procedure whereby airgun volume is increased gradually over 20 minutes to enable animals to move away.

Despite being listed as endangered or critically endangered by the IUCN, marine turtle species are included only in the Brazilian (IBAMA 2005) and Canadian (DFO 2005) mitigation guidelines and there has been no airgun-related research on free-ranging turtles. Controlled exposure experiments on captive turtles found an increase in swim speed and erratic behaviour indicative of avoidance, at received airgun sound levels of 166–176 dB re 1 µPa (rms) (O'Hara & Wilcox 1990; McCauley et al. 2000). The limited available data on marine turtle hearing suggest highest auditory sensitivity at frequencies of 250–700 Hz, and some sensitivity to frequencies at least as low as 60 Hz (Ridgway et al. 1969; O'Hara & Wilcox, 1990; Moein-Bartol et al. 1999), overlapping with the higher frequencies produced by airguns.

This paper describes observations of marine turtles during a ten-month seismic survey off Angola on the west coast of Africa, with discussion of turtle responses to airgun sound and recommendations for future surveys. The study area and data collection methods are described by Weir et al. (In press). In summary, two consecutive 3D seismic surveys were carried out by BP Exploration (Angola) Ltd and partners over a 288-day period between 1 August 2004 and 15 May 2005 in a deep-water (1000–3000m) area off northern Angola (5–11°S latitude and 9–13°E longitude). Two airgun arrays fired alternately at approximately 10 sec intervals. Each array comprised 24 Bolt airguns of 30–290 cu. in., producing total volume of either 5085 cu. in. or 3147 cu. in. (Table 1).

Concurrently with marine mammal observations, a single observer located on the ship's helideck (18 m eye height) searched for turtles 360° around the vessel with the naked eye and with 10x42 binoculars. A total of 2769 h was spent on-effort during daylight hours, of which 676.4 h occurred in Beaufort sea state ≤2. Effort logs

Parameter	Survey 1	Survey 2
Survey duration	Aug 2004–Jan 2005	Jan–May 2005
Seismic line duration (h)	8–12	1.5–4
Total airgun volume (cu. in.)	5085	3147
Source amplitude (Bar-m, peak to peak)	109	81
Airgun pressure (psi)	2000	2000
Source depth (m)	8	4
Recorded frequency bandwidth (Hz)	5–70	8–120
Minimum intensity within frequency bandwidth (dB re 1µPa per Hz @ 1 m)	208	203
Firing interval (m)	25	18.75

Table 1. Source parameters utilised during each survey.