The reason of decline of leatherback turtles (*Dermochelys coriacea*) in French Guiana : a hypothesis

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Abstract. Beaches of French Guiana host the nests of more than half of the worldwide number of leatherback marine turtle females (*Dermochelys coriacea*). This species has shown a strong decline at other major nesting beaches, which makes the actual trend in French Guiana of major importance. We present the data of nest counts from the 1998 nesting season and show that the French Guiana/Suriname population is also declining. We suggest that the potential cause of this decline could be a two step process that began 25 years ago: since 1973, almost all females nesting in this region were concentrated on the beaches of the Maroni and Mana rivers estuary. These beaches appear to be very bad for nest incubation and therefore the juvenile recruitment in the population was very low. However, this effect could have been masked by the very high longevity of females. Development of industrial fishing performed illegally in the estuary for the past 6-7 years enhanced the adult mortality and could also provok the actual observed decline. We propose several ways to test this hypothesis.

Key words. *Dermochelys coriacea* ; French Guiana ; decline ; fishing ; hatching success.

Introduction

The leatherback turtle (*Dermochelys coriacea*) is the only extant species of the *Dermochelyidae* family. Adults of this species usually weigh around 300 and 400 kg and therefore are the biggest existent chelonians. *Dermochelys coriacea* looks very different from the six other species of sea turtles : adults do not possess keratinous scales on the shell, and most of the shell's osteoderms are neomorphic bones separated from the vertebral column and the ribs by a thick layer of lipidic tissue. Leatherbacks can swim in much cooler water than the other species of sea turtles because of their heavy weight and their important lipidic protection; living adults are seen in Nova Scotia in eastern Canada (James and Martin, 1998) and stranded turtle have been seen in Newfoundland, Wales, Finland or Scotland. Consequently, this species is the reptile with the largest distribution area but it nests only on equatorial or tropical beaches (Pritchard, 1997).

Methods for the estimation of leatherback population size

Leatherbacks are the most pelagic sea turtles, and they swim long distance to feed on jellyfish thousand of kilometres away from their nesting beach. The estimation of the population size is impossible in their aquatic phase. Therefore, the only place where leatherback population can be estimated are nesting beaches when the females come to lay eggs. For this reason, population size are until now mainly estimated using the number of adult females for the different nesting zones.

The most common method used to estimate the nesting female population is to count the yearly number of nests and to state that it is proportional to the number of nesting females. This was the original method and is still performed on almost all leatherback turtles nesting beaches, even when there is suitable identification of the adults. It is also possible to estimate the nesting female population size with the yearly number of nests and knowledge about nesting dynamics. In French Guiana, leatherbacks nest on average 7.5 times per nesting season and the mean time between two nesting seasons is 2.5 years (Girondot and Fretey, 1996). However these data are still controversial for this species (Steyermark et al., 1996) and thus ultimately we used directly the number of nests per year as an index of the female abundance.

Direct estimation using individual identification with Monel tags has been attempted for more than ten years in French Guiana. The retention rate of these tags is low; in French Guiana, close to 50% of the tags are lost after three years (Chevalier and Girondot, 1999). Therefore an accurate number of nesting females is impossible to evaluate using this method.

Evolution of the leatherbacks worldwide population size

In 1982, Pritchard estimated the worldwide leatherback population to be around 115,000 nesting females (Pritchard, 1982). In 1995, this population was estimated to be around 34,500 females with a lower limit of about 26,200 and an upper limit of about 42,900 (Spotila et al., 1996). Even if these estimations used many implicit and unproved assumptions (Pritchard, 1996), it nevertheless suggests a very important decline in the size of the worldwide *Dermochelys coriacea* population.

This worldwide decline was caused by the decrease of several important nesting populations in recent years such as Malaysia, Mexico, Costa Rica or Irian Java (Spotila et al., 1996). In the last available estimation, the leatherback population of French Guiana and Suriname (northeast coast of South America) are 14,500 and 3,500 females respectively (Spotila et al., 1996). Therefore this region hosts approximately the half of the worldwide population for this species. The trend for this population is thus of major interest for this species.

Evolution of the leatherback population size in French Guiana

In the Guianas (French Guiana, Suriname and Guyana), the presence of sea turtles nesting beaches depends on dynamic coastal changes. Nesting beaches appear and disappear with the rhythm of sedimentation, coastal erosion and mud flat displacement. Because of this coastline change, *Dermochelys coriacea* probably do not exhibit a long term fidelity to a particular nesting beach and consequently the leatherbacks nesting in French Guiana are part of a larger population nesting also in Suriname and perhaps in Guyana and Brazil (Chevalier et al., 1999). For 20 years, the major nesting beach of the region was *Ya:lima:po-Awa:la* beach located in French Guiana, at the border with Suriname (figure 1). This beach and all the littoral of the western part of French Guiana are now protected by the newly created Amana Natural Reserve. Galibi beaches which are the most important nesting sites in Suriname are also shown on the figure 1. Matapica, the other nesting beach of Suriname, is located 100 km west of the Galibi beaches.

During the last 20 years, *Ya:lima:po-Awa:la* beach hosted more than 90% of all the leatherbacks nests laid in French Guiana (Girondot and Fretey, 1996). The number of nests on this beach is thus close to the global number of nests for the country. Since 1978, the annual number of nests has been counted on *Ya:lima:po-Awa:la* beach, except for five years. The missing data from these five seasons have impeded a rigorous analysis of the trend of the leatherback number in French Guiana (Chevalier and Girondot, 1998). Strong correlations have been found between the number of nests in French Guiana and the nesting beaches of Suriname that permit the estimation of the missing years on the different beaches (Chevalier and Girondot, 1998).

A statistically significant correlation has been found between the number of leatherbacks nests on Galibi beaches and *Ya:lima:po-Awa:la* beach. This is not surprising because both sites are located near in the same estuary. Another statistically significant correlation was found on the temporal change of the proportion of nests laid in Matapica and the total number of nests in Suriname, which means the Galibi beaches and Matapica beach. This last correlation was certainly caused by a displacement of leatherbacks from Matapica beach to Galibi beaches. The number of nests in *Ya:lima:po-Awa:la* beach during the 1998 nesting season has been established according to the previously published protocol (Chevalier and Girondot, 1998).

Using the counted and calculated data on the yearly number of *Dermochelys coriacea* nests, the evolution of the use on the three main nesting beaches of this region has been evaluated (figure 2). The global trend for these three nesting beaches in this region is very similar. It can be divided in two parts : a strong global increase until 1992 and after, an important decline. The lowest number of nests ever counted on *Ya:lima:po-Awa:la* beach has been observed during the 1998 nesting season and it confirms the decrease (figure 2). But does this decline correspond to a diminution of the population of leatherback of the Guianas?

One of the hypothesis was that the observed decline could be caused by a displacement of the population to another nesting beach in the Guianas. The aerial survey performed along the coast of French Guiana and Suriname during the 1997 and 1998 nesting season and the lack of data about any new important nesting beaches for *Dermochelys coriacea*

in Guyana or the north of Brazil lead us to reject this possibility. No data on exchange of nesting beaches separated by more than 200 km are available for leatherback turtles and the turtles of this species are identified on most nesting beaches. Therefore a displacement of a large part of the population of the French Guiana somewhere else other than in the Guianas is very improbable.

An increase of the mean period between two nesting seasons for a female and/or a decrease of the mean number of nests per female during one nesting season would also have generated a decline of the number of nests observed on the beaches. However, the actual number of nests in 1998 is only one tenth of the number of nests observed during the 1992 nesting season and it is unlikely that such a phenomenon can produce so strong an effect. Thus the decrease of the number of nests on the main leatherback turtle nesting beaches of the Guianas certainly correspond to a decline of the size of the nesting female population. The decline observed on *Ya:lima:po* is perhaps emphasized by the dispersion of nesting to other beaches such as Cayenne Island.

Hypotheses explaining the actual decline

In this part, we discuss the potential causes of the decline of the number of leatherback females nesting in French Guiana and Suriname. However, the majority of their lives is pelagic and remains poorly known. We are aware that the main reason of the actual decline is perhaps far from the Guianas nesting beaches. Particularly, no data are available for juveniles and sub-adults, and it is impossible to state if the decline of the population actually observed is caused by a problem during one of those stages.

The decline of the population may be the consequence of an higher adult mortality or of a lower recruitment in the population. For long-lived species, such as *Dermochelys coriacea* is thought to be, the recruitment has to be very low during a long period to have an effect on adult population size (Heppell, 1997).

The poaching of nesting females and eggs is quasi-null in French Guiana. Even if it is more common in Suriname, it cannot be the main reason of the decline of the leatherback population of the Guianas because French Guiana hosts the large majority of the females for the region.

In French Guiana and also in the eastern part of Suriname the hatching success is very low compared to others leatherbacks nesting beaches. On *Ya:lima:po-Awa:la* beach, the successful nests were estimated between 5 to 11% (Girondot, Tucker and Chevalier, unpublished data) and between 22 to 35% in Galibi (Hoekert et al., 1998) whereas it reaches 47% (1990) and 57% (1991) in Tortugero, Costa-Rica (Leslie et al., 1996). The hatching success for sucessful nests has been estimated around 20% in Galibi beaches in Suriname (Hoekert et al., 1998). The global hatchling success (including all nests) is 75% in Culebra, Puerto Rico (Tucker, 1989), 33% (1990) and 30% (1991) in Tortugero (Leslie et al., 1996) and 67% in St Croix, Virgin Island (Boulon et al., 1996). The low hatching success observed in French Guiana and Suriname could be the consequence of the nesting location in the Maroni and Mana Rivers estuary and is perhaps higher in areas away from the estuary. In the late 1960s, the major leatherback nesting beach in French Guiana, called Ilets Bâches, was located 20 km eastward from *Ya:lima:po*. When this beach disappeared from erosion in 1973 (Pritchard, 1973), the turtles moved to nest

closer from the estuary. This displacement perhaps generated a decline of the hatching success. Even if no data are available on the hatching success in Ilets Bâches, the very low hatching success in *Ya:lima:po* during the last 20 years could have lead to an abnormally low recruitment in the population. However, this effect was masked by the very high longevity of females and no decline of the population was observed.

Stranded turtles have been regularly observed during the last several years in *Ya:lima:po* and Galibi beaches. We suspect accidental capture in fishing nets used in the estuary to be the cause of the death of these females. Three sorts of fishing are carried out in this zone and should be separated for analysis. First, the shrimp fishing has been suspected to be a major cause of the decline of leatherbacks (Chevalier and Girondot, 1998). However, inquests to the local fishermen performed during the 1998 nesting season indicate that the damage by this kind of fishing could have been previously overestimated but also pointed out the lack of data for this region. Second is the net fishing close to the beaches performed by the inhabitants of the Amerindian villages. Even if some turtles are killed by those fishermen, it is certainly not important enough to generate the decline we observe, because of the small number of fishing boats and of the small size of the nets (often less than 100 m) and meshes. The driftnet fishing performed illegally by industrial Surinam companies in French waters is most likely one of the main causes of the actual decline of leatherback population. Nets of 5 to 15 km with large meshes are set off the nesting beaches, most of the time at night so as to not be visible by customs officials. According to the data obtained by interviews with the local fishermen, captures of leatherback turtles are very common in these nets. This industrial Surinam fishing activity has developed in this region at the end of the civil war in Suriname approximately in 1990. This fishing activity has perhaps played a major role in the decline of the leatherback population in the Guianas. Our hypothesis is that the actual decline is a synergistic effect of the higher mortality rate due to this fishing activity and the fact that the recruitment in the population has been drastically low during the last 20 years, from low hatching success of the nests. It is important to note that in this case, the fishermen are not deliberately trying to capture and kill the turtles; indeed, their accidental capture is a nuisance to the fishermen.

Perspectives

The first objective of the scientific work performed on leatherbacks in French Guiana is to improve the monitoring of the population. For this, the priority is to work on the scale of regional nesting sites, which means an important collaboration with the sea turtles conservation projects not only in Suriname, but also in Guyana and Brazil. Because of the littoral dynamics, an aerial survey of coast will be performed annually to prospect the presence of new nesting beaches at least in French Guiana and in Suriname.

The systematic identification of the nesting females by PIT tags has been done during the 1998 nesting season. A first analysis indicates that the large majority of females have been identified: 7900 nests have been layed this year which would have been laid by 7900/7.5=1053 females (standard-deviation 26) and 1138 different females have been identified this year (but a controversy exists about the value of 7.5 nests per female and per nesting season; see Steyermark et al., 1996). This method will allow us to perform a mark/recapture study to follow the population dynamics. First results indicate a strong beach fidelity during a nesting season (Chevalier et al., 1999). However, the beach

fidelity at the scale of different nesting seasons and the origin of turtles who colonize a newly created beach are actually poorly known but would have an important impact on conservation actions.

The second objective of the scientific work on leatherbacks in French Guiana is to pinpoint the reason of the actual decline, allowing us to design appropriate protection measures. The first and certainly the most difficult part will be to estimate the impact of fishing on leatherback turtles. Monitoring of the displacement of nesting females during the nesting season should also be a priority. This will determine the position of the leatherbacks at sea and also where fishing boats may accidentally catch these turtles. In addition, an estimation of the number of accidental catches is needed. The best way would be to have observers on the fishing boats, but it will be very difficult to obtain such a collaboration with the Surinam boats fishing illegally in the French part of the Maroni River estuary. When direct observations are not possible, interviews will have to be performed to estimate the damages generated by the different fishing methods on *Dermochelys coriacea.*

To test if the decline of the adult population might be a consequence of the decrease of the hatching success for 20 years, the hatching success should be studied on different nesting beaches more or less distant from the Maroni River estuary. If the hatching success depends on the distance to the Maroni River estuary and is high on beaches closer to the former Ilets Bâches beach, the hypothesis of the hatching success decline as a cause of the actual population trend would be reinforced. For this study, but also for the estimation of the population size, we will have to follow the different important nesting beaches of French Guiana and not only *Ya:lima:po* beach as has been done for the last 20 years.

The study of *Dermochelys coriacea* and of the potential threats to the survival of this turtle during its pelagic phase is still not well understood. Even if satellite tracking and dataloggers are now advanced enough to allow improvement in our knowledge on this high sea phase, it is very expensive, making this sort of study difficult. The pelagic period of the leatherback turtle will certainly remain the most important question mark in the biology and ecology of this species and perhaps a serious lack in conservation plans.

Conclusion

Dermochelys coriacea is perhaps the most endangered marine turtle, because of the low and rapidly declining worldwide population size. In the Guianas, where more than the half of the world leatherbacks females come to nest, the population is also showing a serious decline. Therefore, uncovering the reasons of the actual decline in French Guiana, but also in Suriname, is the urgent focus of current research, with the goal to design appropriate protection measures. The creation of the Amana Natural Reserve, the collaboration among the different actors of sea turtles conservation in the Guianas and the assistance of nature protection NGOs such as WWF and of different scientists are positive points that we hope will generate a dynamic conservation strategy, which is needed for leatherback turtles in the Guianas.

To conserve the leatherbacks of the Guianas, the first step will be to identify more precisely the reason of the decline and then to perform appropriate conservation actions. The collaboration with fishermen in trying to find a solution to the bycatch problem is certainly one of the priorities in the region. A program is just starting on this topic. For the low hatching success, which is natural, we first want to perform new studies on this topic before designing specific management actions because any action at the embryonic life stage could have a negative impact on the population (Girondot *et al.*, 1998).

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Figure 1 : Localization of the nesting beaches in French Guiana and in east-Suriname. (1) Matapica, (2) Galibi, (3) *Ya:lima:po,* (4) Apo:tïlï, (5) Organabo, (6) Remire-Monjoly.

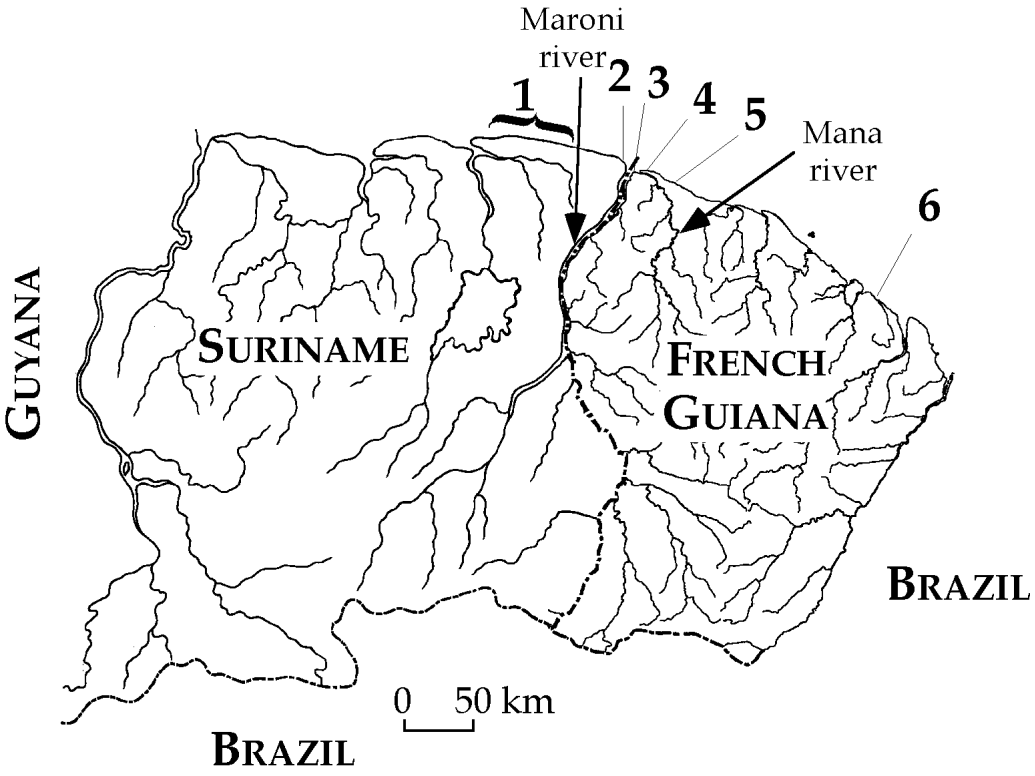

Figure 2 : Evolution of the number of leatherbacks nests on the three main nesting beaches of French Guiana and Suriname since 1967. Values for gray bar are estimated based on other values (see text). The bold lines are a 3 points moving average.