Nesting estimation and analysis of threats for Critically Endangered leatherback *Dermochelys coriacea* and Endangered olive ridley *Lepidochelys olivacea* marine turtles nesting in Congo

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Appendix

Nesting seasons of marine turtles are typically characterized by a low number of nests at the start and end, with a peak of nesting approximately in the middle. Generally < 1 nest per week or per month is recorded outside the nesting season. This typical pattern can be modelled using the product of two sigmoid equations, the first ranging from 0 to 1 and the second from 1 to 0. The product shows a 0-1-0 pattern if the transition of the first equation is observed at an abscissa of lower value than the second one (0.1 = 0; 1.1 = 1; 1.0 = 0). For each sigmoid equation we use a modified form of the Verhulst equation (1846) that allows asymmetry to be set:

$$M(d)=\left(1+\left(2^{e^{k}}-1\right)e^{\left(\frac{1}{S}(P-d)\right)}\right)^{-e^{-k}} \qquad (1)$$

where d is the number of days since the start of the nesting season (arbitrarily defined without loss of generality), P includes the dates before and after the peak nesting day when there is an observed maximum rate of change (increase or decrease) in nest numbers, and the change in nest numbers at date P is dependent on S (slope) and K (a parameter that allows the sigmoidal curve to be asymmetrical around the inflection point). $M(d)$ is an intermediate value that has no direct meaning in terms of nest number.

The value of $M(d)$ ranges from 0 to 1 with $M(d) = 0.5$ for $P = d$. The steepness of $M(d)$ at $P = d$ depends on S and K. $M(d)$ is increasing when S is negative (i.e. at the start of the nesting season) and decreasing when S is positive (i.e. at the end of nesting season). Asymmetry around P is determined by a positive or negative value of K. The equation (1) is reduced to a simple logistic equation (i.e. symmetrical around P) when $K = 0$.

The number of nests per night $N(d)$ during the complete nesting season can therefore be expressed as:

$$N(d)=\min+(\max-\min)\cdot\frac{\left(M_1(d)\cdot M_2(d)\right)}{\underset{i}{Max}\left(M_1(i)\cdot M_2(i)\right)} \qquad (2)$$

with $M_1(d)$ and $M_2(d)$ being the first and second halves of the nesting season, respectively, and the index i encompasses all of the nesting season. The difference between the two largely rests on the sign of S: S_1 is negative, S_2 is positive. The parameter *min* is the basal level of nesting outside the nesting season and *max* is the maximum number of nests per night at the peak of the nesting season. We define $l_{x\%}$ as the length of the nesting season, which encompasses all the period in which the nest number is higher than x% of the number of nests observed at the peak of the nesting season.

The entire nesting season can be expressed using equation (2), which is based on eight parameters. The number of parameters can be reduced using the Verhulst equation around P_1 ($K_1 = 0$), P_2 ($K_2 = 0$), or both. The basal level of nests *min* can be fixed to 0. Also, if it is assumed that the beginning and end of the nesting season have similar shapes, this can be expressed by setting $S_1 = -S_2$ and $K_1 = K_2$. The most reduced form of equation 2 uses only four parameters ($min = 0$, $K_1 = K_2 = 0$, $S_1 = -S_2$). In the use of this model for Congo beaches the *min* parameter, which describes the daily number of nests outside the nesting season, is fixed to 0 as no nests are observed during half of the year (GB & NB, pers. obs.). The nesting season boundaries used here are from early September to late April.

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