Green turtles *(Chelonia mydas)* in the Berau Archipelago, Indonesia: Population assessment, nesting activities, and protection status

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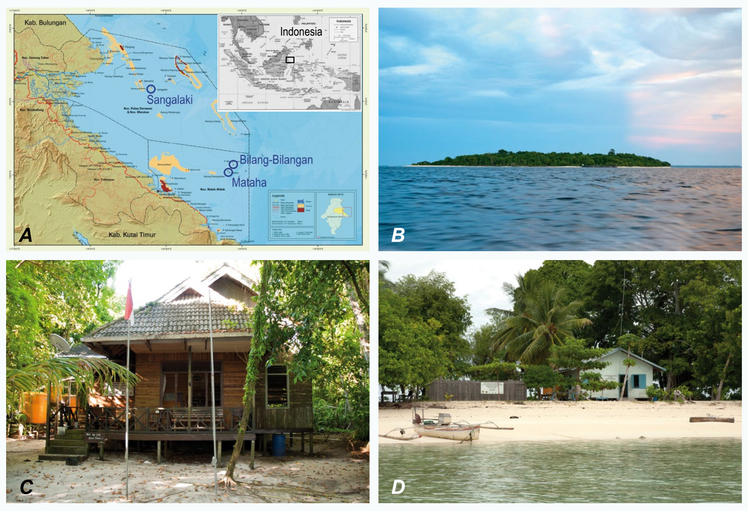
Introduction

The Berau or Derawan archipelago at the eastern shores of East Kalimantan (island of Borneo, Indonesia) comprises 31 islands of which most are not inhabited. Nine of these islands are major nesting sites of the green turtle, with three of them (Sangalaki, Bilang-Bilangan, and Mataha) contributing to about 75% of the total nesting activities (Adnyana et al. 2008). Recently, the population of yearly nesting females in the Derawan archipelago was estimated between 1800 and 2015 individuals (Seminoff 2004, Spotila 2004). The population is critically endangered as a result of commercial egg collection in which over several decades nearly 100% of all eggs were harvested, which was legal until 1999. This lead to a substantial decline of the green turtle population to less than 9% of the numbers of the 1940s. In 1999, the TURTLE FOUNDATION was set up as a private initiative to protect nesting beaches against illegal egg collection. Since 2002 the island of Sangalaki, and since 2008 the islands of Bilang-Bilangan and Mataha are fully protected by the TURTLE FOUNDATION which organises stuff of 15 locally hired rangers who are patrolling the beaches every day. Data of various aspects of nesting activities were collected and evaluated.

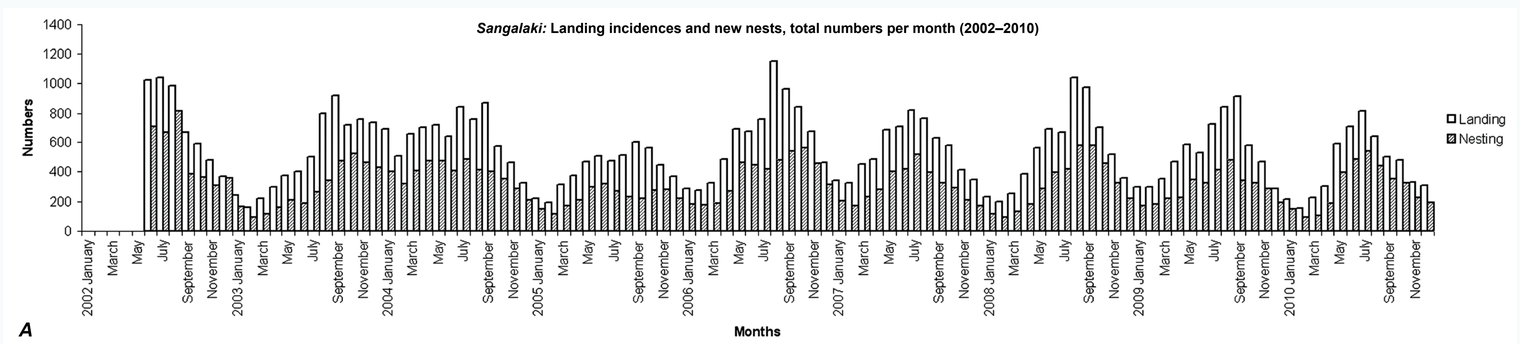


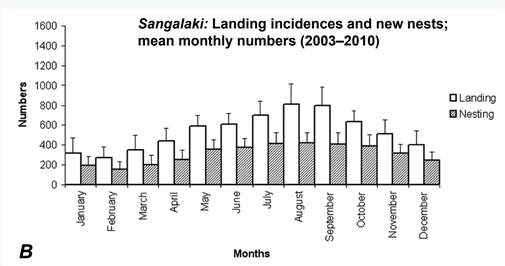
A: The Derawan archipelago in the Berau district of East Kalimantan, Borneo, Indonesia *(square* in *inset)* belongs to a region with highest marine biodiversity, the coral triangle. ***B:*** The project island Sangalaki (about 18 ha). ***C*** Ranger station on Sangalaki. ***D:*** Ranger station on Mataha; on the left the fenced hatchery is visible.

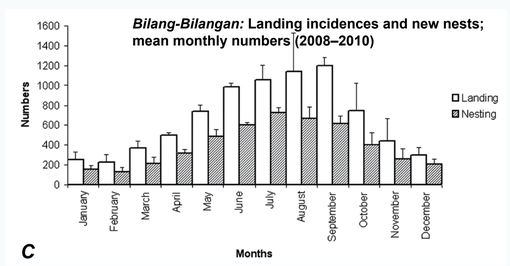
Methods

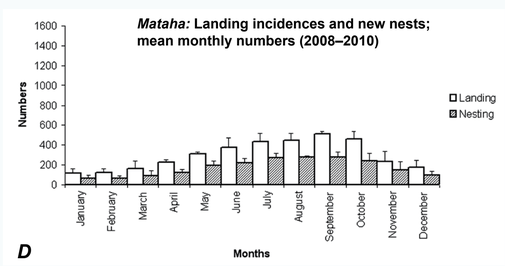
Every day on all three project islands, the beaches were patrolled three times (morning, late afternoon, night at low tide). During beach patrolling, data of various aspects of nesting activities were collected.
The numbers and locations of landing females and new nests were determined by counting new tracks and nests. Nests were detected by typical characteristics; in doubt, possible nests were probed with a blunt steel rod. For every nest, position and date of egg lying was determined. Hatched nests were excavated to count empty shells, undeveloped eggs, developed but not hatched eggs, dead hatchlings, and deformed hatchlings with no chance of survival. Upon these numbers the quantities of live hatchlings per nest and hatching success were determined. Nests that were threatened by inundation or other reasons were either relocated to a saver place or incubated in a fenced hatchery. Data were transferred into Excel, and raw data sheets were reformatted in a standardised manner to allow for semi-automatic evaluation with macros written in Visual Basic for Applications. Sample counting and determination of mean values with standard deviations (SDs) were performed in Excel. Statistical analyses (comparisons of means with One-Way ANOVA and Tukey HSD *post hoc* tests) were performed in SPSS 11; significance levels were defined as $p<0.05$ if not stated otherwise.

Population assessment

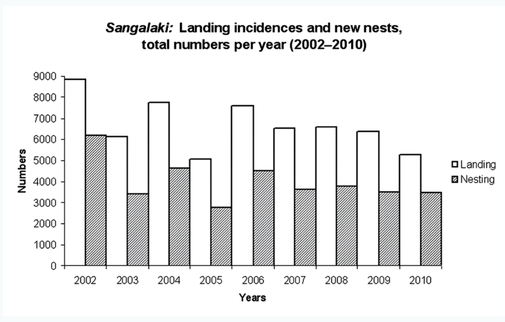






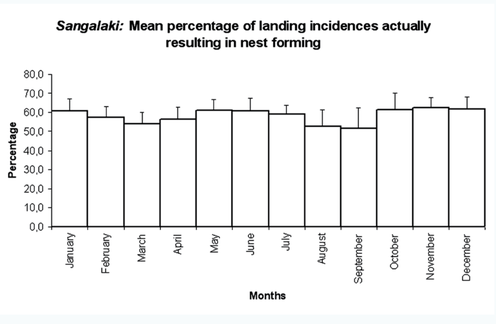


A: For Sangalaki, total numbers of turtle emergences and new nests were summarised for each month and plotted against the years 2002–2010 (2002: data available since June). Nesting occurred over the whole year, but there is a clear seasonality with peaks in the dryer months (June–October). ***B, C, D:*** Monthly means and SDs of turtle emergences and nests (***B:*** Sangalaki, 9 years; ***C*** and ***D*** Bilang-Bilangan and Mataha, respectively; 3 years each). The seasonality is clearly visible and shows the same course on all islands. Although the peaks are subjected to considerable variation (Sangalaki nesting peaks: 1x June, 3x July, 3x August, 1x October), the low season regularly occured in February (Sangalaki nesting troughs: 7x February, 1x January). The yearly average of new nests formed on Sangalaki was 3,717, on Bilang-Bilangan 4,752, and on Mataha 2,059, thus leading to an average number of 10,528 nests formed on all three islands per year.



On Sangalaki, the total numbers of landing and nesting incidences per year between 2002 and 2010 show a considerable fluctuation, but there is no clear tendency visible. The differences in monthly means of new nests between the years were significant for 2002 against 2003, 2005, 2007, 2009, 2010; however, data for 2002 were only available from June to December (in the diagram, monthly numbers of 2002 were extrapolated to the full year). Nesting numbers were nearly equal between 2008 and 2010; this was also the case for Bilang-Bilangan and Mataha.

Nesting behaviour



Throughout the observation period, about 58.2% (n=56,413) of all turtle landings on Sangalaki actually resulted in nest forming. There was a tendency of lower nest forming rates (more "false crawls") in the dry seasons (visible in August and September; the difference in September is significant against December). This tendency was also visible in the respective data of Bilang-Bilangan and Mataha. We assume that dry sand in the hot months often hampers nest forming efforts of the turtles, because the holes are collapsing while digging.

Acknowledgements

We are extremely grateful to all foundations, institutions, companies, and private sponsors who contributed to the TURTLE FOUNDATION; without their financial help the permanent protection of the project islands against illegal egg collection would not have been possible. Special thank is dedicated to our rangers, who spend so much time on the lonely islands in sake for protecting the turtles for our next generations.

Conclusions

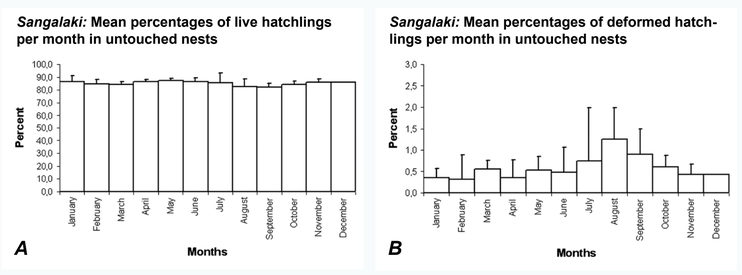
About 3,190 green turtle females are nesting every year in the Derawan archipelago (average of 10,528 nests per year on all project islands divided by average nesting frequency of 4.4 per female and season in the archipelago [Adnyana et al. 2008], and corrected by 25% of the whole Derawan green turtle female population assumed to nest on other islands [Adnyana 2003]). This number is considerably higher than supposed so far (Seminoff 2004), and ranks the Derawan archipelago at the 8th place of the most important nesting site of green turtles in the world (comparison: data of Seminoff 2004).

However, it should not been forgotten that in the 1940s about 36,000 females were estimated to nest in the Derawan archipelago every year (Schulz 1984), thus implicating a population decline of more than 91% within the last 60–70 years. Further, due to extensive egg collection activities in the last decades, we expect a further population decline in the next years. A decline was not evident within the observation period, but normal seasonal fluctuations are likely to obscure a long term trend.

Further conservation efforts of the TURTLE FOUNDATION aim to protect all nesting islands against egg poaching, while sea patrolling will be directed against poaching of juvenile and mature animals, and against illegal and destructive fishing practices.

Hatching success

Nests that are to close to the high tide line are threatened by inundation and would then be lost. Those nests were either relocated (about 13%; all numbers here are given for Sangalaki) or transferred into a fenced hatchery (about 7%); hence, about 80% of the nests were left in place ("untouched nests"). For all freshly hatched nests found, hatching success and reasons for hatching failures were determined. Mean hatching success for untouched nests was 85.1% (±4.1% SD, n=13,123), for relocated nests 82.3% (±5.3% SD, n=1,238), and for nests in hatchery 80.7% (±11.1% SD, n=695); differences were not significant.



A, B: For every nest, we calculated the live hatchling rate by "empty shells" *minus* "dead hatchlings" *minus* "deformed hatchlings"; total number of eggs (in untouched nests) was "empty shells" *plus* "undeveloped eggs" *plus* "developed but not hatched eggs". In untouched nests on Sangalaki, we counted averages (±SD) of 85.1% (±4.1%) live hatchlings, 0.5% (±0.4%) dead hatchlings, 9.6% (±2.6%) undeveloped eggs, 4.3% (±2.1%) developed but not hatched eggs, and 0.6% (±0.6%) deformed hatchlings (n=13,123 nests). In averages between same months from 2002–2010, fluctuations between percentages of live hatchlings were only faint with no significant differences ***(A)***. This was also the case for dead hatchlings, undeveloped eggs and developed but not hatched eggs. The proportion of deformed hatchlings significantly increased in the dryer months from July to October (ANOVA, differences of August and September between other months was only detectable with LSD *post hoc* due to considerable variations between the years).

Protection status

We calculated an average of about **871,000** turtles hatching on Sangalaki, Bilang-Bilangan, and Mataha every year. This leads to a number of about **4,462,000** green turtle hatchlings saved by the protection efforts of the TURTLE FOUNDATION between 2002 and 2010. Without protection, most if not all of them would not have been able to reach the sea. However, other islands on which altogether about 25% of the green turtle females of the Derawan archipelago nest (Adnyana 2003), are still unprotected against illegal egg poaching. Further, juvenile and adult turtles are heavily threatened by poaching and destructive fishing practices employing dynamite, cyanide, and unattended drift nets.

Calculation of animals saved by the protection efforts of the TURTLE FOUNDATION

	Mean no. of nests per year	Corrected by nest losses (1.5%)	x mean no. of eggs per nest (98.9)[2]	Corrected by hatching success (85.0%)[3]	Years of protection	Saved hatchlings 2002–2010	Saved mature adults 2002–2010[4]
Sangalaki	3,717	3,661	362,097	307,783	9	2,770,043	
B-Bilangan	4,752	4,681	462,923	393,485	3	1,180,454	
Mataha	2,059	2,028	200,581	170,493	3	511,480	
Sum:	10,528	10,370	1,025,601	**871,761**		**4,461,978**	**4,462**

[1] Derived from untouched nests on Sangalaki; [2] derived from relocated nests on Sangalaki; [3] derived from untouched nests on Sangalaki; [4] assuming a survival rate of 1:1000

Literature cited

Adnyana W (2003): Preliminary assessment of green turtle population. Report to WWF Indonesia Turtle Program. 21 pp. ***Adnyana W, Pet Soede L, Gearheart G, Halim M (2008):*** Status of green turtle *(Chelonia mydas)* nesting and foraging populations of Berau, East Kalimantan, Indonesia, including results from tagging and telemetry. Indian Ocean Turtle Newsletter 7, 2–11. ***Schulz JP (1984):*** Turtle conservation strategy in Indonesia. IUCN/WWF Report. ***Seminoff JA (2004):*** MSTG global assessment of green turtles *(Chelonia mydas)* for the IUCN Red List. IUCN Species Survival Commission, April 2004. ***Spotila JR (2004):*** Sea Turtles: A complete guide to their biology, behavior, and conservation. John Hopkins University Press, Baltimore.