Assessment of a hawksbill turtle *(Eretmochelys imbricata)* foraging population in the Derawan archipelago, East Borneo, Indonesia: a pilot study

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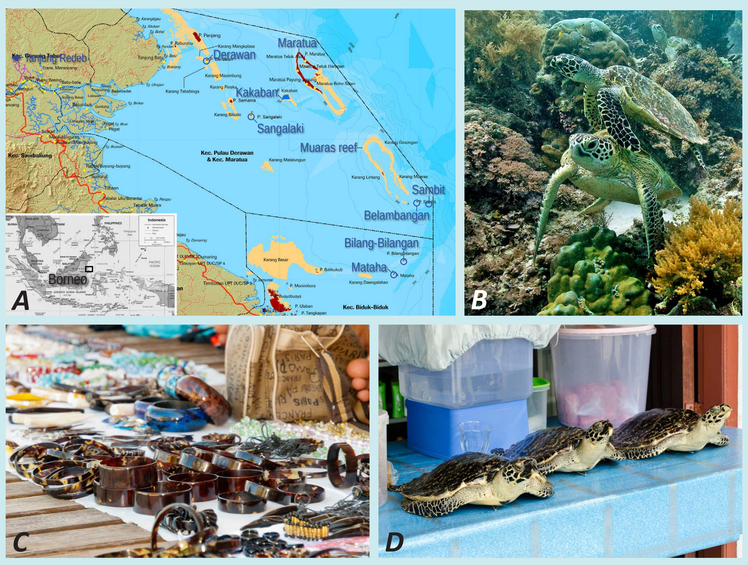
Introduction

The Derawan archipelago off the east coast of Borneo is the largest nesting site of the green turtle in Indonesia. It is less well known, however, that its extended coral reefs also house an important foraging population of the critically endangered hawksbill sea turtle. Unfortunately, despite being officially protected in Indonesia, the archipelago's hawksbills are regularly hunted for their shell or to end up as wall decorations. Turtle products are openly and bluntly sold to tourists on the markets of Derawan, and law enforcement is virtually absent. Thus, protection measures are urgently needed, and in 2014 we started a research and impact mitigation initiative for the hawksbill turtles of the Derawan archipelago.

Despite hawksbills are frequently reported in the area, the actual population size is unknown, as is its trend, its structure, and its spacial distribution in and among the reefs of the archipelago. Further, the actual nesting sites and migration routes of this population are completely unknown. The major goal of the research part of this initiative is to gain sufficient insights into population structure, nesting sites, and general biology of the archipelago's hawksbills to be able to create effective and sustainable conservation strategies on regional and international levels. Between August and October 2014 we conducted a pilot study on and around the inhabited Island of Maratua covering three different approaches to gain first insights into the hawksbill turtle population of the archipelago, and to lay the methodological foundation for future comprehensive studies.



A: The Derawan archipelago in the Berau district of East Kalimantan, Borneo, Indonesia *(square in inset)* belongs to the coral triangle, the region with the world's highest marine biodiversity. ***B:*** Hawksbill and green turtles are resting together in a reef of the Bakungan Islands, which are at the southern end of the large lagoon of Maratua (image courtesy: Petra Minnasch). ***C, D:*** Turtle shell jewellery and stuffed juvenile hawksbill turtles are openly sold to tourists directly at the main road of Derawan despite the officially legally protected status of sea turtles.

Conclusions

1. Mark & recapture study: With scuba dive surveys at night carried out from a fully equipped expedition ship that can stay on sea over an extended time we found an affordable, efficient, and flexible method for in-water capturing of hawksbill turtles in the Derawan archipelago. This will allow us in future to conduct comprehensive mark & recapture studies with high chances of sufficient capturing yield to address important questions about population status, migration routes, and nesting locations of the region's hawksbill turtles.

2. Interviewing study among locals: Interviewing local people revealed important information about the sea turtles of the Derawan archipelago, but also demonstrated the needs as well as the opportunities for timely and adequate involvement of the local people into regional conservation plans.

3. Questionnaire study among recreational divers: Our pilot study indicates that divers are a valuable and underestimated source of information about turtle abundance and dispersal that can significantly supplement and enhance common research approaches.

To our knowledge, our combined study approach is the first of this kind tried in the waters of Southeast Asia, and will be the starting point for a comprehensive conservation and research program for the hawksbill turtles of the Derawan archipelago.

Mark & recapture study

One major objective of this study was to find a suitable and efficient method for in-water capturing of hawksbill turtles that can be applied in future studies. During three weeks of capturing expeditions we tested (1–3) and/or discussed in detail (4) the following capturing methods: 1. catching breathing turtles by direct jump from a slowly cruising small boat ("rodeo method"), 2. systematic snorkelling surveys at the reef edge and hand-catching of turtles, 3. scuba diving with torches at night and hand-catching turtles resting on the sea floor, 4. catching with continuously monitored gill nets.

The "rodeo method" yielded no catches, and due to specific local conditions we judged this method as generally unsuitable for this location. With the snorkelling method we caught five juvenile hawksbill turtles during a total in-water survey time of 35 hours. To test the scuba dive method we hired for one night a suitable expedition ship (local standard wooden boat with diesel engine, length 18 m) together with crew and two local divers including dive equipment. In this single night five hawksbill turtles have been caught, marked, and measured. The setnetting method was thoroughly discussed and calculated, but was considered, compared to scuba diving from an expedition ship, as too inflexible, costly, and also unsafe for the turtles.

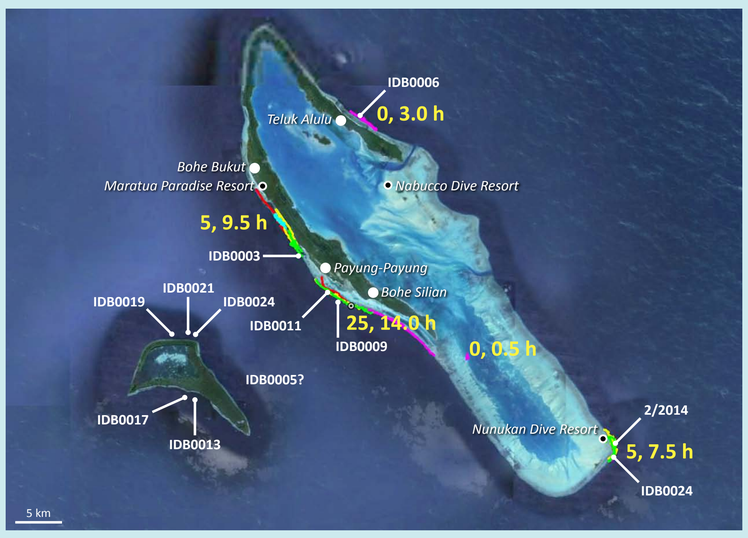
Captured hawksbill turtles have been immediately marked with Inconel 681 tags, and a comprehensive measuring protocol for obtaining following biometric data had been applied (curved carapace length and width, straight carapace length and width, straight midline plastron length, head width, tail length, weight). A small tissue sample (few mm³) was obtained for later for mtDNA haplotype and DNA microsatellite analysis. Every turtle was checked for diseases, parasites, and external injuries. Then, the turtles were photographed and subsequently released.

All captured animals were still in the juvenile or semi-adult stages. However, locals reported that on the coasts of Maratua and Kakaban mature hawksbills are frequently taken by poachers, while on more remote places mature hawksbills are supposed to be still more common. This is one topic we will address in future studies.

Flipper tag right	Flipper tag left	Date	Location	SCLnn (cm)	SCW (cm)	CCLnn (cm)	CCW (cm)	Weight (kg)
n/a[1]	n/a[1]	09.08.2014	Maratua	33.1	29.9	53.9	49.6	3.73
IDB0003	IDB0004	10.09.2014	Maratua	37.0	32.3	39.1	36.9	6.20
IDB0005	n/a[2]	10.09.2014	Kakaban	33.3	29.3	35.5	33.7	4.62
IDB0006	IDB0007	13.09.2014	Maratua	44.7	35.9	46.7	42.4	10.94
IDB0009	IDB0010	16.09.2014	Maratua	49.4	41.9	52.5	49.8	16.02
IDB0011	IDB0012	18.09.2014	Maratua	45.5	37.7	47.3	42.9	11.75
IDB0013	IDB0015	18.09.2014	Kakaban	46.6	38.3	49.6	44.4	11.91
IDB0017	IDB0018	18.09.2014	Kakaban	35.5	29,3	38.0	32.4	4.80
IDB0019	IDB0020	18.09.2014	Kakaban	43.2	33.8	45.5	39.5	9.93
IDB0021	IDB0022	18.09.2014	Kakaban	45.5	36.3	47.8	43.8	11.67
IDB0024	IDB0023	18.09.2014	Kakaban	39.9	34.0	42.6	36.8	7.57
Averages:				**41.2**	**34.4**	**43.6**	**36.8**	**9.01**

Basic data of the hawksbill turtles caught and measured during the fieldwork phase of this study. [1]The animal was not tagged because it was considered too small. [2]Due to its small size the animal received only one Inconel 681 tag. *SCLnn:* straight carapace length notch to notch; *SCW:* straight carapace width; *CCLnn:* curved carapace length notch to notch; *CCW:* curved carapace width.

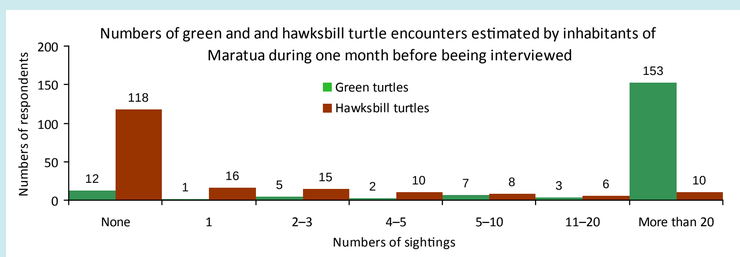
Parts of a standardised photo series of turtle number IDB0009/IDB0010. The images will be included into a turtle data base and will allow to recognise individual turtles from photos of, e.g., recreational divers, or to identify recaptured turtles were tags had been lost.



Locations of turtle catches and snorkelling surveys off the coasts of Maratua (right) and Kakaban (left). Capturing locations had been recorded by GPS, but animal IDB0005 was brought to us by a fisherman who caught it near Kakaban, thus the exact location of capturing is unclear. The coloured lines indicate the snorkelling surveys as recorded by a GPS device on the accompanying boat. The yellow numbers before the commas indicate hawksbill turtle sightings during snorkelling surveys at the respective locations (35 sightings in total). Sightings do not include captured turtles, and might include multiple sightings of same individuals. The numbers after the commas indicate the total survey hours spent at particular locations. *Filled white circles:* villages; *open circles:* dive bases.

Interviewing study among locals

We conducted an interviewing campaign among inhabitants of Maratua aided by a standardised questionnaire to ask people about frequencies, locations, and times of their sea turtle encounters, but also about social and economical situations, fishing practices, and attitudes toward conservational measures. We interviewed 187 persons (about 6% of the island's total population of about 3,200 people; 73.3% males and 25.7% women). The educational level on Maratua appears generally low with 9.8 % of respondents who received no and 71.6% of respondents who received only primary school education. Fishing was stated as the most important income source with 79.9% of the male respondents quoting fishing as their primary profession. Asked for illegal fishing practices 9 and 17 respondents stated to have practiced dynamite and cyanide fishing in the past, respectively. Only 3 respondents admitted to actively hunt hawksbill turtles, but 22.7% declared that they will kill hawksbill turtles that had been accidently caught for selling their shell. In contrast to these statements, 90.4% of the interviewees would appreciate better protection of the sea turtles.



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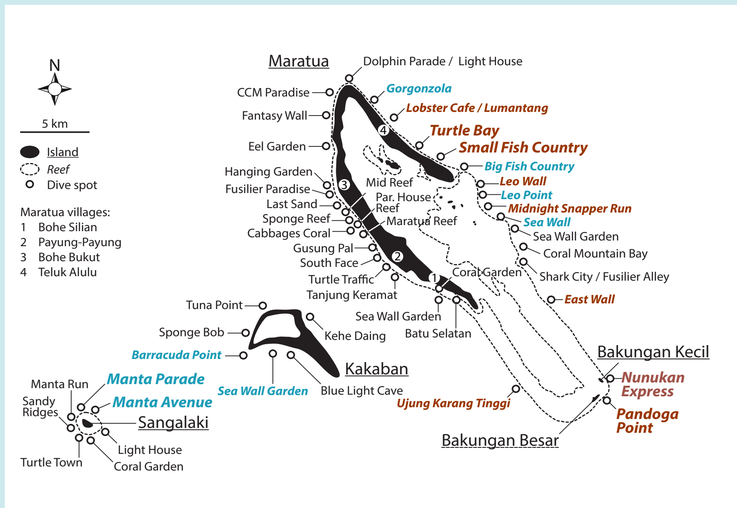
Questionnaire study among divers

Another interesting and important source of information on the occurrence of hawksbill turtles is offered by local dive resorts and recreational divers who spend their holidays there. While interviewing locals can provide a broader overview of the distribution of hawksbills throughout the archipelago, asking the divers can reveal more detailed information on the occurrence of turtles at certain dive locations that are regularly visited by local dive bases; moreover, this way possible temporal and seasonal fluctuations of hawksbill turtle presence at the dive sites could be obtained. Therefore, we developed a questionnaire for recreational divers, which is handed out to them by the managers of collaborating dive resorts together with a small informational brochure, and on which divers can briefly report about species, numbers, dates, and times of their turtle encounters. Filling one questionnaire does not require more than a few minutes, and ideally one questionnaire should be completed after each dive.

During our field work two dive bases on Maratua collaborated to our study (Nabucco and Nunukan Dive Resorts). In this time 12 divers completed 62 questionnaires (1–18 questionnaires per diver, average: 5.6, SD: 4.6). While this study is aimed to be continued over a longer period while involving as much divers as possible, already on location we received valuable data that hint towards possible hot spots of hawksbill turtle abundance off the coast of Maratua. Further, our previous observations have been confirmed that in distinct locations green turtles aggregate in high numbers, while hawksbills were much less abundant, but could be regularly encountered.



Map of Maratua, Kakaban, and Sangalaki showing favoured dive locations. Coloured names indicate dive locations that have been visited at least once by the first 12 divers who collaborated in this study. Locations visited at least three times are indicated by larger bold lettering. Dive location names where hawksbills have been encountered at least once are red, while locations where no encounters have been recorded are blue. Acoording to the reported encounters, the east coast of Maratua and the reefs of Bakungan Kecil and Bakungan Besar appear to be locations with increased hawksbill turtle abundance.

Dive location	# dives	# sightings of hawksbills	# sightings of green turtles	# sightings of unidentified turtles	Ratio of hawksbill turtle sightings per dive
Manta Avenue	4	0	0	0	0
Manta Parade	3	0	0	0	0
Nunukan Express	8	3	76	13	0.4
Pandoga Point	10	1	84	18	0.1
Small Fish Country	8	16	30	33	2.0
Turtle Bay	5	2	12	18	0.4
Sums:	**38**	**22**	**102**	**82**	

Numbers of dives, turtle sightings, and ratios of hawksbill turtle sightings per dive at those locations that had been visited by individuals of the 12 contributing divers at least three times in total. In the north of Sangalaki Island at the locations "Manta Avenue" and Manta Parade" neither green nor hawksbill turtles had been recorded. In contrast, a promising location is "Small Fish Country" off the east coast of Maratua with 16 hawksbill turtle encounters during only 8 dives.