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The evaluation of nest relocation method as a conservation strategy for saving sea turtle populations in the North Coast of Manokwari – Papua Barat Province – Indonesia

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ABSTRACT

A network of sea turtle conservation groups, under the scientific guidance of the Sea Turtle Protection Program of Research Center for Pacific Marine Resources – University of Papua, monitors and protects sea turtle nests laid on north Manokwari beaches. The group relocates freshly laid nests that are threatened by poachers and possible inundation by high tides. Nest relocation may have negative effects: it may reduce hatching success, alter sex ratio, and reduce hatchling fitness. Thus an evaluation of hatching success of relocated nests to hatcheries under the protection of the Papua Barat Sea Turtle Protection Program is warranted. Using 2015–2016 data, provided by the local sea turtle conservation group, hatching success of relocated nests was evaluated. The evaluation of hatching success showed a tendency of significant sea turtle hatchlings hatching from relocated nests in hatcheries. Results of the evaluation indicate that nest relocation is a viable option, however it is recommended to only relocate nests that are at a high risk from poaching, predation and erosion from high tides. Nest relocation recommendations with the evaluation results: use nest relocation as a current viable resort, only relocate nests that will be in high-risk due to poaching, predation and potential over-washed by high tides.

Key words : *Sea turtle conservation, Threatened, Relocation, Hatching success, Poaching, Predation.*

Introduction

Sea turtle nesting season in the north coast of Manokwari occurs in the boreal summer between March and July (Tapilatu *et al.*, 2017). Sea turtle eggs, hatchlings, and nesting female sea turtles encounter numerous threats on the nesting beaches. The threats listed in Tapilatu *et al.*, (2017) include poaching and egg collection, human presence, beach erosion, artificial lighting, recreational activities, plant roots and tidal inundation. Opportunistic poaching of nesting females continues to occur at nesting beaches at Bird's Head seascape (Tapilatu *et al.*, 2017). Poachers wait for an adult female to emerge from the sea to nest, drag the animal inland and invert it to ensure it cannot escape. The captured turtle is killed immediately or moved to a village and killed at a later time. In general, the local people

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are law-abiding and reluctant to break the law, however many impoverished poachers may use sea turtles to feed their family. Law enforcement is inadequate due to the isolated location of the nesting beaches, lack of law enforcement personnel, and lack of funding. In the nearby cities of Manokwari and Sorong, there is a demand for sea turtle meat and eggs. A mature green turtle can garner approximately 500,000 IDR ($50.00 USD), whereas in a small village, the same sea turtle would only be worth 50,000 IDR ($5.00 USD) or less. There is little to no market for sea turtle eggs in villages, therefore any eggs poached are eaten by the family of the collectors or shipped to market in nearby cities. The majority of egg collectors are people from villages adjacent to nesting beaches. Extra income from selling sea turtle meat and eggs can be significant to families in Bird's Head because the national average per capita income is approximately 35,000,000 IDR ($3,500.00 USD)(World Bank 2013).

Working under scientific protocol, the conservation group based in Mubraidiba village monitors, manages and protects sea turtles nests. The protection program maintains a small conservation group to manage nesting habitats, collect data on nesting activity, and deal with the numerous threats that sea turtle face in in north of Manokwari. Due to intensive poaching of eggs, the conservation group focuses on relocating newly laid nests to shaded hatcheries built in Warbefor in 2015 and Mubraidiba in 2016. The relocation of nests in hatcheries is a conservation technique used for reducing threats to eggs and hatcheries of marine turtles. Mortimer (1999) stated that hatheries should be used as a last option. This is due to the potential negative effect of hatcheries such as sex ratio alteration (Godfrey and Mrosovsky, 1999) or reduction of hatching success relative to natural nests (Limpus *et al.*, 1979; Mortimer 1999). On the other hand, other publications have suggested that increasing hatchling production through nest relocation can have positive impacts on population size (Dutton *et al.*, 2005; Mazaris *et al.*, 2005).

Assessments of positive and negative impacts of nest relocation traditionally are superficial. Normally, comparisons of hatching success are made between relocated nests and *in-situ* nests (nests left in place). However, due to the high rate of poaching at the nesting beach, the comparison can not be done and then abandoned, therefore we attempted to investigate seasonal changes in hatchling success between the 2015 and 2016 nesting seasons in the hatchery. The good thing we attempted to look seasonal changes in hatching success over nesting season between 2015-2016 in the hatchery. Finally, we were able to locate temperature dataloggers at hatchery sites and a nest of green turtle in the hatchery in 2016 nesting season as a sex-ratio indicator. The objective of this study was to assess the management technique of sea turtle nest relocation in north of Manokwari between 2015 and 2016. To assess and examine the impacts of next relocation, focusing on hatchling success and sand temperature. To make the assessment and examine the impacts of nest relocation, the evaluation looked in hatching success and sand and nest temperature. Ultimately, based on our findings, we aimed to provide recommendations for nest relocation techniques that can be applied to other nesting beaches facing similar threats. The last goal was to formulate a series of nest relocation reccomendations in the north coast of Bird's Head and its application to other nesting beaches with similar issues at Bird's Head Seascape – Papua Indonesia.

Materials and Methods

Nesting Areas in the North of Manokwari

The north coast of Manokwari nesting area for sea turtles (Tapilatu *et al.*, 2017) consists of ~50km of beaches (Fig. 1). Nesting beaches are not continues and separated by villages, terrain composed of cliffs, rocky outcroppings, perennial rivers, and/or estuaries. There are 12 villages and these beaches are subject to seasonal patterns of erosion and accretion. Changes in the currents brought on by the monsoons that begin in September can cause major erosion often removes the beach until accretion begins again in March.

The local sea turtle conservation group based in Mubraidiba village in the north coast of Manokwari supplied the data for the evaluation. The source of data was the conservation group's annual relocation reports from 2015 to 2016. The data for the evaluation only included nesting activities of sea turtles on the north coast of Manokwari reported to hotline provided by the conservation group and the Research Center for Pacific Marine Resources of University of Papua.

Hatching success

The evaluation assessed hatching success, incuba-

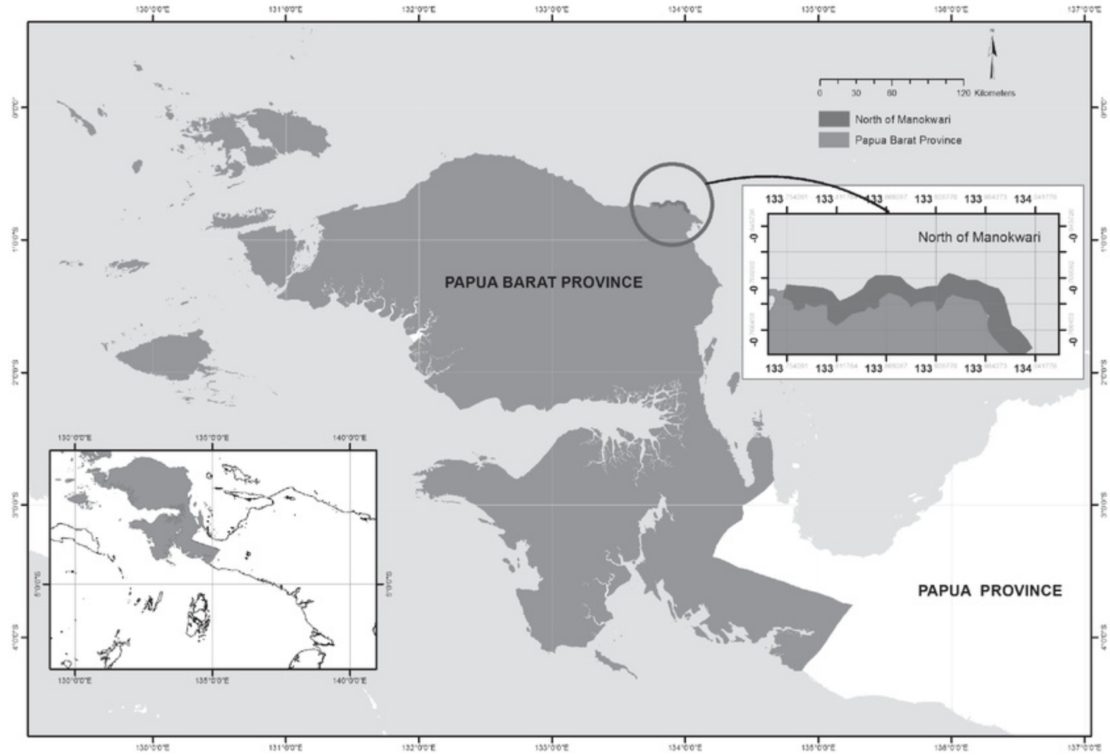

Fig. 1. Map showing sea turtle nesting area at north coast of Manokwari

tion duration, sand and incubation temperature with the following variables: sea turtle species, date of nest laid, date of nest relocated, date of nest reburied, date of hatching, hatching success, daily sand temperature of hatchery, and daily nest temperature during incubation. The data set also included nest inventory data of following variables: TE = The total number of whole eggshells (>50%); UE = The number of unhatched eggs; DH = The number of dead hatchlings in the nest cavity; and LH = The number of live hatchlings emerged from eggs, but did not leave the nest. Hatching success was calculated by dividing hatched egg shells (>50% intact) with total number of eggs (for hard-shelled turtles) and with total yolked eggs (for leatherback turtle)(Eckert and Eckert, 1990). Numbers of yolkless eggs were also recorded but not included in calculating hatching success for leatherback nests (Tapilatu, 2014). The number of nests relocated and hatching success data from the north beach of Manokwari were used to calculate the hatchling output (hatchlings that were produced from relocated nests). For each year (2015-2016), hatching success and hatchling production were calculated. Overall hatching success was compared between 2015 and 2016 or between hatchery sites using Mann-Whitney tests and ANOVA, respectively; hatching success values were also compared between Jamursba-Medi and Wermon using the Mann-Whitney test. If assumptions of normality and equal variance were violated, nonparametric tests were used (Wilcoxon signed ranks test and Mann-Whitney test).

Daily sand and incubation temperatures

A type of temperature data loggers (HOBO Pendants, Onset Computer Corporation, Pocassete, MA) were used to record sand in the hatchery in 2016 and nest temperatures. These data loggers accurately record temperatures to approximately ± 0.3-0.4°C. The data loggers were programmed in the laboratory to record temperature every hour.

Due to limited availability of data loggers availability, data loggers were used during the 2016 nesting season in the hatchery at Mubraidiba. No data loggers were placed in the hatchery built at Warbefor in 2015. Further, to investigate potential variation in incubation temperatures within the hatcheries, two dataloggers were placed in two different cement blocks. In order to monitor sand temperature in the hatchery, two data loggers were placed in the middle portion of each of the two cement blocks filled with clean sand in the hatchery between 11 May and 20 September 2016. The data loggers were buried at a depth of 40cm during 2016 nesting season in the hatchery. This depth was chosen to approximate the mid nest depth of hard-shelled turtle nests on the nesting beach. The sand and nest temperature data were downloaded using HOBOWARE software and then exported to Microsoft Excel. The hourly sand temperature data were averaged to obtain mean daily sand temperatures.

To investigate whether there was a relationship between incubation temperatures and hatching success, a temperature data logger was also used to record incubation temperatures of a relocated nest within the hatchery in 2016. A data logger was placed in the center of the nest when a nest was opportunistically selected and relocated. Sand temperature data in the Block one and Block 2 within the hatchery in Mubraidiba in 2016 were compared using a paired t-test and Wilcoxon signed ranks test, respectively. To determine whether sand temperatures varied among months in the hatchery, monthly temperatures were compared using an analysis of variance (ANOVA) test followed by the Scheffe's pairwise comparison test. For all variables, equality of variances was tested using a Levene's test, and normality of data was determined by a Kolmogorov-Smirnov test. Data were analyzed using SPSS 14.0 and Minitab 13.0. Alpha level was set at 0.05.

In addition, to evaluate the effect of nest temperature on potential hatchling sex ratio, the mean nest temperature during middle third of incubation was calculated from sampled nest and compared to pivotal temperature. Previous studies indicate that mean nest temperature during the middle third of incubation represents an accurate method for predicting sex ratio in nest that do not experience large daily fluctuations in temperature (Georges *et al.*, 1994; Georges *et al.*, 2004).

Results

Sea turtle species and Beach/Village origin

Four species of sea turtle use these beaches for nesting. The number or proportion of nests is dominated by Green (*Chelonia mydas*) sea turtle at both years (Table 1). Other sea turtle species such as Leatherback (*Dermochelys coriacea*), Olive-ridley (*Lepidochelys olivaceae*) and Hawksbill (*Eretmochelys imbricata*) were also nested in the area with small number/proportion.

Along the nesting beach on the north coast of Manokwari, nests of sea turtles reported by local villagers/fishermen and subsequently relocated to eggs hatcheries were originated from different section/nearby villages (Table 2). Mostly nests relocated were originally from Warbefor (38.2%) in 2015 and Sibuni (19.3%) in 2016 (Table 2).

Hatching success and incubation duration

The hatching success was relatively high for all sea turtle species with the exception for leatherback sea turtle in Mubraidiba hatchery in 2016 (Table 3). There was a significant different in hatching success between relocation sites and years (Warbefor 2015: overall mean = 83.2.5%, SD = 9.4%, range = 56.0%–95.8%, n = 34; Mubraidiba 2016: overall mean = 88.1%, SD = 12.8%, range =13.0%–98.3%, n = 73; Mann-Whitney test; $p < 0.001$). Overall hatching

Table 1. Number/Proportion of sea turtle nest reported and relocated to egg hatchery

Hatchery location and year	Warbefor: 2015		Mubraidiba: 2016	
Sea turtle species	Number	Proportion (%)	Number	Proportion (%)
Green	30	88.2	61	83.6
Leatherback	2	5.9	3	4.1
Olive-Ridley	2	5.9	7	9.6
Hawksbill	0	0	2	2.7
Total	34		73	

Table 2. Number/Proportion of the origin of sea turtles nests reported

Hatchery location and year	Warbefor: 2015		Mubraidiba: 2016	
Beach section/village	Number	Proportion (%)	Number	Proportion (%)
Bremi	7	20.6	2	2.7
Inyei	6	17.6	9	12.3
Jonggom	0	0	1	1.4
Mandopi	1	2.9	0	0
Menyes	1	2.9	1	1.4
Minyeofoka	0	0	5	6.8
Mubraidiba	4	11.7	4	5.5
Mumbri Rimour	0	0	6	8.2
Mubri Weriori	1	2.9	8	10.9
Saroy	0	0	2	2.7
Sibuni	1	2.9	14	19.3
Singgibeba	0	0	3	4.1
Undi	0	0	6	8.2
Warbefor	13	38.2	12	16.4
Total	34		73	

Table 3. Hatching success and incubation duration of relocated nests in Warbefor (2015) and Mubraidiba (2016)

Hatchery location and year	Warbefor: 2015		Mubraidiba: 2016	
	Hatching success (%) (Mean, SD, Range)	Incubation duration (days) (Mean, SD, Range)	Hatching success (%) (Mean, SD, Range)	Incubation duration (days) (Mean, SD, Range)
Green	83.7, 9.3, 56.0-95.8	52.7, 2.3, 50-56	89.9, 4.6, 79.4-98.3	52.7, 2.2, 49-55
Leatherback	81.6, 8.7, 75.5-87.8	61.0, 1.4, 60-62	43.0, 44.3, 13.0-93.8	59.3, 1.2, 58-60
Olive-Ridley	76.9, 15.7, 65.8-88.0	54.5, 0.7, 54-55	92.9, 3.9, 85.6-95.8	51.7, 1.1, 50-53
Hawksbill	-	-	91.0, 8.0, 85.3-96.6	52.0, 1.4, 51-53
Overall	83.2, 9.4, 56.0-95.8		88.1, 12.8, 13.0-98.3	

success of leatherback nests (mean = 58.5%, SD = 38.0%, range = 12.9% - 93.8%) was significantly lower than green, olive ridley and hawksbill nests (Green: mean = 87.9%, SD = 7.1%, range = 56.0%–98.3%, n =91; Olive Ridley: mean =89.3%, SD = 9.5%, range = 65.8%–95.8%, n = 9; Hawksbill: mean = 90.9%, SD =7.9%, range = 85.3%–96.6%, n = 2; Mann-Whitney tests; $p < 0.05$), but not between green, olive ridley and hawksbill (Mann-Whitney tests; $p = 0.89$, $p = 0.51$, $p = 0.72$). In addition, the incubation duration for leatherback is relatively longer in than other hard-shell turtle species (Table 3).

Table 4. Mean sand temperature (°C) at 40cm in the hatchery of Mubraidiba recorded from 11 May – 20 September 2016

Months	Block-1 (Mean±SD, Range)	Block-2 (Mean±SD, Range)
May	30.3±0.2, 29.9-30.5	30.2±0.1, 30.1-30.3
June	29.2±0.2, 29.5-30.3	30.0±0.2, 29.4-30.3
July	29.3±0.2, 28.5-30.2	29.3±0.1, 29.2-29.3
August	29.4±0.4, 28.5-30.2	29.5±0.3, 29.0-30.0
September	29.6±0.1, 29.4-29.7	29.5±0.1, 29.5-29.7

Overall, sand temperatures fluctuated between 28.5° and 30.5°C (Table 4). No significant difference in daily mean sand temperature occurred between the two blocks within the hatchery (paired t-test; $t = -0.59$, $p = 0.58$). However, mean sand temperatures differed among months (ANOVA; $F = 14.83$, $p < 0.05$), with temperatures in May being significantly warmer than June, July, August, and September (Scheffe's; $p < 0.05$).

Discussion

In north coast of Manokwari, the primary reason for nest relocation is to save nests from poaching and being consumed by terrestrial predators. The small-scale implementation of egg hatcheries could be a pivotal step in preventing the decline of sea turtle population(s) in the area in which most marine turtle populations in the Indo Pacific region are severely depleted (Limpus 1994, 1997). For example, sea turtle populations in Papua - Indonesia have experienced a dramatic decline in nesting numbers in recent decades (Tapilatu *et al.*, 2017). In addition, the Pacific leatherback has declined by 95% over the past 30 years (Spotila *et al.*, 2000). Tapilatu *et al.* (2013) found that the estimated annual number of leatherback nests at Jamursba Medi beach of the Bird's Head region, Indonesia has declined 78.3% over the past 27 years. In the Pacific region, the decline of sea turtle population(s) was primarily caused by excessive harvesting of eggs and nesting females (Meylan and Donnely 1999; Chaloupka 2001; Seminoff 2002; Horikoshi *et al.*, 1994; Trinidad and Wilson 2000; Gardner and Nichols 2001; Tapilatu *et al.*, 2013; Tapilatu and Ballamu 2015), incidental fishery bycatch (Cheng and Chen 1997; Chaloupka 2003), and development of coastal areas (Sharma 2000; Matsuzawa *et al.*, 2002).

Sea turtle eggs have a relatively low reproductive value but they are of obvious importance for the maintenance and recovery of sea turtle populations (Crouse *et al.*, 1987, Heppel 1997). For example, the long-term protection of eggs by creation of efficient hatcheries has resulted in increasing number of leatherbacks nesting in the Caribbean (Dutton *et al.*, 2005). In addition, the protection of eggs in hatcheries has significantly contributed to the gradual recovery of the Kemp's Ridley sea turtle population, which was on the brink of extinction in the mid 1980s (Marquez *et al.*, 1996). A variety of other examples have been reported in which egg hatcheries have been used in sea turtle conservation programs including Sandy Point, St Croix (Boulon *et al.*, 1996), Krofajapasi, Suriname (Whitmore and Dutton 1985), Rantau Abang, Malaysia (Chua 1988; Chua and Furtado 1988), Rancho Nuevo, Mexico (Marquez *et al.*, 1996) and Guatemala (Higginson and Vasquez 1989). Thus, improving hatching success through the use of egg hatcheries can represent a critical component in the recovery strategy for endangered sea turtles. Since other nesting aggregations have plummeted, Papua's nesting aggregation is of even greater importance to ensure the recovery of sea turtles in the Pacific region.

The thermal tolerance range for sea turtle embryos is estimated to lie between 25° and 35°C (Ackerman 1997) or between 24° and 32°C (Yntema and Mrosovsky 1982), and the pivotal temperatures tend to cluster around 29°C (Mrosovsky 1994). The pivotal temperature may vary with species and locale. For example, the pivotal temperatures for leatherbacks have been estimated at 29.25-30.50°C in Suriname and French Guiana (Mrosovsky *et al.* 1984; Dutton *et al.*, 1985, Godfrey *et al.*, 1996, Chevalier *et al.*, 1999), in Malaysia (Chan and Liew 1995), and in Costa Rica (Binckley *et al.*, 1998). The sand temperatures at hatchery in Mubraidiba, may be within the thermal tolerance of these sea turtle embryos, resulting in the high hatching success observed in clutches; overall mean observed hatching success in a clutch should hatchery Warbefor hatchery in 2015 was 83.2% (SD =9.4, range =56.0%–95.8%, n = 34) and Mubraidiba hathery in 2016 was 88.1% (SD =12.8, range =13.0%–98.3%, n = 73). Ideal sand temperatures at both hatcheries could possibly be one of the factors contributing to a higher probability of egg survival. However, low hatching success was observed in clutches of leatherback in 2016 even though low hatching success is characteristic of leatherbacks despite high fertility rates (Bell *et al.* 2003), and may result from a complex interaction between egg position and its microenvironment (Wallace *et al.*, 2004).

Sexual differentiation in sea turtles is strongly influenced by ambient incubation temperature or TSD (Standora and Spotila, 1985, Mrosovsky, 1994). Specifically, the sustained temperature to which the embryo is exposed during the middle trimester of incubation determines the eventual gonadal differentiation and sex of the hatchling (Wibbels, 2003). Overall mean sand temperatures at two blocks of hatchery at Mubraidiba in 2016 were typically near the pivotal temperature for sea tutles for the nesting season in 2016 (Table 4). In addition, in the sampled nest monitored with a datalogger, mean temperatures of *in situ* nests during the middle third of incubation (Figure 2) were above the pivotal temperature suggesting female-biased sex ratios. Thus, collectively these results support the hypothesis that female-biased sex ratios may predominate on the hatchery of Mubraidiba. The female-biased sex ratios were also observed in other nesting beaches at Bird' s Head Seascape (Tapilatu and Tiwari, 2007, Tapilatu 2014, Tapilatu and Ballamu, 2015). The result revealed the impact of metabolic heating on incubation temperatures (Figure 2). Nest temperature is determined by sand temperature and the amount of metabolic heat from developing embryo (Ackerman, 1997). During the initial portion of incubation period, nest temperatures were similar to the

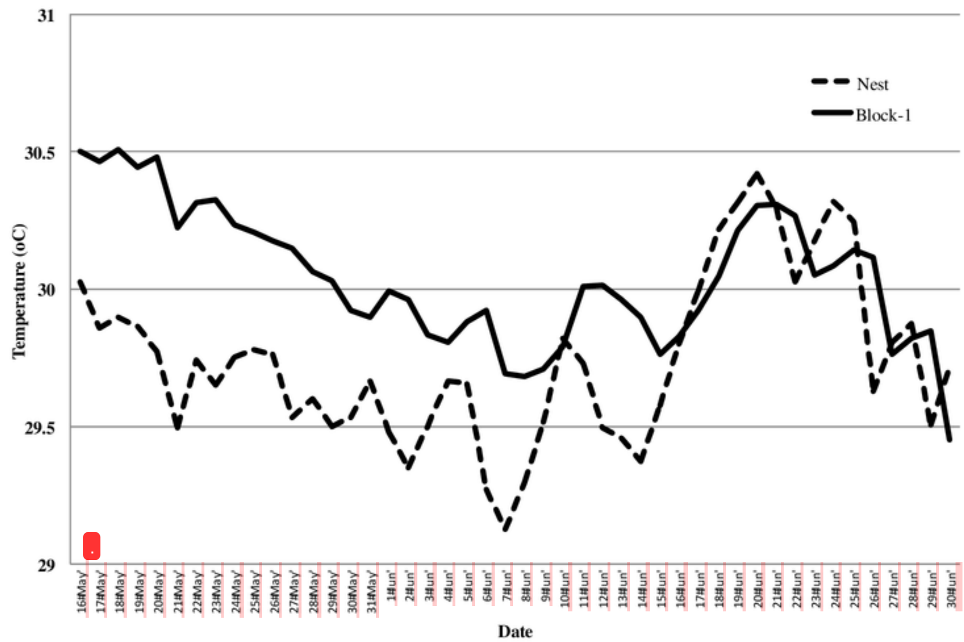

Fig. 2. Sand and nest temperature in hatchery.

adjacent sand temperatures. Then the metabolic heat production from the embryos begins to heat the nest above the surrounding sand temperature by the start of the final third of incubation, so that by the time of hatching nest temperatures were 0.07–0.23°C warmer than sand temperatures. An increase in nest temperature above surrounding sand temperature due to the metabolic heat produced by developing embryos during late incubation is commonly reported in sea turtle nests (Bustard 1972, Booth and Astill 2001; Broderick *et al.*, 2001, Godley *et al.*, 2002). However, the increase in nest temperatures due to metabolic heating may not impact sex ratios since sex is determined during the middle third of incubation (Yntema and Mrosovsky 1982, Merchant-Larios *et al.*, 1997, Wibbels, 2003).

In conclusion, an effective science-based management plan that focuses on protecting eggs and significantly increasing hatchling output on the nesting beaches is a critical component in the recovery of this species. The implementation of such a plan requires the identification of major threats and how those threats can be addressed both technically and socio-economically. In Indonesia, national laws that prohibit the poaching or killing of sea turtles and the collection of eggs with the exception of green turtles (*Cheloniamydas*) in specific areas. Further, some species of sea turtles in Indonesia are also protected under CITES laws banning any international trade of the species, alive or dead (Sarti Martinez 2000, Seminoff 2004, Abreu-Grobois and Plotkin 2007, Mortimer and Donnelly 2010). Although laws are already in place for the protection of sea turtles in Indonesia, poaching continues to be an alternative means for food resources and income. In the past, extensive exploitation of eggs and individual sea turtles was recorded at Bird's Head Seascape (Tapilatu *et al.*, 2017). Currently, egg harvest at north coast of Manokwari is still occurring as indicated by occasional egg collection. It was thought that the conservation program in the north coast of Manokwari through the effort of nest relocation may have reduced the level of egg collection since 2015. Poaching of eggs and individual sea turtles will need to be minimized and even zeroed through an effective outreach and awareness program. The Research Center for Pacific Marine Resources (RCPMR) at University of Papua (UNIPA) based in Manokwari has set regular outreach and awareness program at coastal villages in the north coast since early 2015. The awareness in 2015 was combined with the supervision of local conservation group based in Mubraidiba in relocation of threatened nests. In addition, predation by domestic dog will need to be controlled through the captivity to deter animals from accessing nests on the beach. Finally, involvement of the local people and community group is crucial to the success and persistence of this nesting population.

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References

Abreu-Grobois, A. and Plotkin, P. 2007. MSTG global assessment of olive ridley turtles for the IUCN Red List. Available at: www. iucn-mtsg. org/red_list/ (accessed on 31 August 2007).

Ackerman, R. 1997. The nest environment and the embryonic development of sea turtles. Pages 83-106 *in* P. Lutz and J. Musick, editors. The biology of sea turtles. CRC Press, Boca Raton, FL.

Bell, B.A., Spotila, J.R., Paladino, F.V. and Reina, R.D. 2003. Low reproductive success of leatherback turtles, Dermochelys coriacea, is due to high embryonic mortality. *Biological Conservation.* 115 : 131–138.

Binckley, C.A., Spotila, J.R., Wilson, K.S. and Paladino, F.V. 1998. Sex determination and sex ratios of Pacific leatherback turtles, Dermochelys coriacea. *Copeia.* 291-300.

Booth, D.T. and Astill K. 2001. Incubation temperature, energy expenditure and hatchling size in the green turtle (*Chelonia mydas*), a species with temperature-sensitive sex determination. *Australian Journal of Zoology.* 49 : 389-396.

Boulon, R.H., Dutton, P.H. and McDonald, D.L. 1996. Leatherback turtles (*Dermochelys coriacea*) on St Croix, U.S. Virgin Islands: fifteen years of conservation. *Chelonian Conservation and Biology.* 2 : 141-147.

Broderick A C, Godley BJ and Hays GC. 2001. Metabolic heating and the prediction of sex ratios for green turtles (*Chelonia mydas*). *Physiological and Biochemical Zoology.* 74 : 161-170.

Bustard, R. 1972. Sea turtles: natural history and conservation.

Chaloupka, M. 2001. Historical trends, seasonality and spatial synchrony in green turtle egg production. *Biol. Conserv.* 101 : 263-279.

Chaloupka, M. 2003. Stochastic simulation modelling of loggerhead sea turtle population dynamics given exposure to competing mortality risks in the western South Pacific. In Bolten AB, Witherington BE (eds). Loggerhead sea turtles, pp. 274-294. Washington, DC, Smithsonian Books.

Chan, E.H. and Liew, H.C. 1995. Incubation temperatures and sex-ratios in the Malaysian leatherback turtle (*Dermochelys coriacea*). *Biological Conservation.* 74 : 169-174.

Cheng, I.J. and Chen, T.H. 1997. The incidental capture of five species of sea turtles by coastal setnet fisheries in the eastern waters of Taiwan. *Biol. Conserv.* 82: 235-239.

Chevalier, J., Godfrey, M.H. and Girondot, M. 1999. Significant difference of temperature-dependent sex determination between French Guiana (Atlantic) and Playa Grande (Costa-Rica, Pacific) leatherbacks (*Dermochelys coriacea*). *Annales des Sciences Naturelles - Zoologie et Biologie Animale.* 20 : 147-152.

Chua, T.H. 1988. Nesting population and frequency of visits in *Dermochelys coriacea* in Malaysia. *Journal of Herpetology.* 22 : 192-207.

Chua, T.H. and Furtado, J.I. 1988. Nesting frequency and clutch size in *Dermochelys coriacea* in Malaysia. *Journal of Herpetology.* 22 : 208-218.

Crouse, D.T., Crowder, L.B. and Caswell, H. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation. *Ecology.* 68 : 1412-1423.

Dutton, D.L., Dutton, P.H., Chaloupka, M. and Boulon, R.H. 2005. Increase of a Caribbean leatherback turtle *Dermochelys coriacea* nesting population linked to long term nest protection. *Biological Conservation.* 126: 186-194.

Dutton, P.H., Whitmore, C.P. and Mrosovsky, N. 1985. Masculinization of leatherback turtle *Dermochelys coriacea* hatchlings from eggs incubated in styrofoam boxes. *Biological Conservation.* 31 : 249-264.

Eckert, K.L. and Eckert, S.A. 1990. Embryo mortality and hatch success in *in situ* and translocated leatherback sea turtle (*Dermochelys coriacea*) eggs. *Biological Conservation.* 53 : 37-46.

Gardner, S.C. and Nichols, W.J. 2001. Assessment of sea turtle mortality rates in the Bahia Magdalena region, Baja California Sur, Mexico. *Chelonian Conserv. Biol.* 4 : 197-199.

Georges, A., Doody, S., Beggs, K. and Young, J. 2004. Thermal models of TSD under laboratory and field conditions. Temperature-dependent sex determination in vertebrates. Smithsonian Books, Washington, DC:79-89.

Georges, A., Limpus, C. and Stoutjesdijk, R. 1994. Hatchling sex in the marine turtle Caretta caretta is determined by proportion of development at a temperature, not daily duration of exposure. *Journal of Experimental Zoology.* 270 : 432-444.

Godfrey, M.H. and Mrosovsky, N. 1999. Estimating hatchling sex ratios, p. 136-138. In K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (Editors), Research and Management Techniques for the Conservation of Marine Turtles. IUCN/SSC Marine Turtle Specialist Group Publ. No. 4.

Godfrey, M.H., Mrosovsky, N. and Barreto, R. 1996. Estimating past and present sex ratios of sea turtles in Suriname. *Canadian Journal of Zoology.* 74 : 267-277.

Godley, B.J., Broderick, A.C., Glen, F. and Hays, G.C. 2002. Temperature-dependent sex determination of Ascension Island green turtles. *Marine Ecology Progress Series.* 226:115-124.

Heppel, S. 1997. On the importance of eggs. *Marine Turtle Newsletter.* 76:6-8.

Higginson, J. and Vasquez, F. 1989. Hatchery Design and the Production of Female Hatchlings. *Marine Turtle Newsletter.* 44 : 7-12.

Horikoshi, K., Suganuma, H., Tachikawa, H., Sato, F., Yamaguchi, M. 1994. Decline of Ogasawara green turtle population in Japan. In Bjorndal KA, Bolten AB, Johnson DA, Eliazar PJ (eds). Proc. 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351, pp. 235-237.

Limpus, C. 1997. Marine Turtle Populations of Southeast Asia and Western Pacific Region: Distribution and Status. Workshop Proceeding Marine Turtle Research and Management in Indonesia. Wetland International-Indonesia Program. pp. 37-72.

Limpus, C.J., Baker, V. and Miller, J.D. 1979. Movement induced mortality of loggerhead eggs. Herpetologica (1979): 335-338.

Limpus. C.J. 1994. Current declines in South East Asian turtle populations. In Proceedings of the 13th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-341.pp. 89-91.

Márquez, M., Byles, R.A., Burchfield, P., Sanchez, M., Diaz, J., Carrasco, M.A., Leo, A.S. and Jimenez, M.C. 1996. Good news! Rising numbers of Kemp's ridleys nest at Rancho Nuevo, Tamaulipas, México. *Marine Turtle Newsletter.* 73 : 2-5.

Matsuzawa, Y., Sato, K., Sakamoto, W. and Bjorndal, K.A. 2002. Seasonal fluctuations in sand temperature: effects on the incubation period and mortality of loggerhead sea turtle (*Caretta caretta*) pre-emergent hatchlings in Minabe, Japan. *Mar. Biol.* 14: 639- 646.

Mazaris, A.D., Fiksen, Ø, and Matsinos, Y.G. 2005. Using an individual-based model for assessment of sea turtle population viability. *Population Ecology.* 47(3): 179-191.

Merchant-Larios H, Ruiz-Ramirez S, Moreno-Mendoza N, and Marmolejo-Valencia A. 1997. Correlation among thermosensitive period, estradiol response, and gonad differentiation in the sea turtle Lepidochelys olivacea. *Gen Comp Endocrinol.* 107 : 373-385.

Meylan, A.B. and Donnelly, M. 1999. Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN Red List of Threatened Animals. *Chelonian Conserv. Biol.* 3 : 200-224.

Mortimer, J.A. 1999. Reducing Threats to Eggs and Hatchlings: Hatcheries, p.175-178. In K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (Editors), Research and Management Techniques for the Conservation of Marine Turtles. IUCN/SSC Marine Turtle Specialist Group Publ. No. 4.

Mortimer, J.A. and Donnelly, M. 2010. *Eretmochelys imbricata*. IUCN Red List of Threatened Species v 1.

Mrosovsky, N. 1994. Sex ratios of sea turtles. Journal of Experimental Zoology 270:16-27.

Mrosovsky, N., Dutton, P.H. and Whitmore, C.P. 1984. Sex ratios of two species of sea turtle nesting in Suriname. *Canadian Journal of Zoology.* 62 : 2227-2239.

Sarti Martinez, A. L. 2000. *Dermochelys coriacea*. IUCN 2002. 2002 IUCN Red List of Threatened Species.

Seminoff, J. A. 2004. *Chelonia mydas*. IUCN 2006. 2006 IUCN Red List of Threatened Species.

Seminoff, J.A., Resendiz, A., Nichols, W.J. and Jones, T.T. 2002. Growth rates of wild green turtles (*Chelonia mydas*) at a temperate foraging area in the Gulf of California, Mexico. Copeia (2002): 610-617.

Sharma, D.S.K. 2000. Impacts from development, nesting population trends and the future of marine turtles at Paku-Kertih, Terengganu. In H. Kalb H, Wibbels T (eds). Proc. 19th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-443, pp. 88-92.

Spotila, J.R., Reina, R.D., Steyermark, A.C., Plotkin, P.T, Paladino, F.V. 2000. Pacific leatherback turtles face extinction. *Nature.* 405 : 529-530.

Standora, E.A. and Spotila, J.R. 1985. Temperature dependent sex determination in sea turtles. *Copeia.* 711-722.

Tapilatu, R.F. and Ballamu, F. 2015. Nest temperatures of the Piai and Sayang Islands green turtle (*Chelonia mydas*) rookeries, Raja Ampat Papua, Indonesia: Implications for hatchling sex ratios. *Biodiversitas* 16(1) : 102-107.

Tapilatu, R.F. and Tiwari, M. 2007. Leatherback turtle, *Dermochelys coriacea*, hatching success at Jamursba-Medi and Wermon beaches in Papua, Indonesia. *Chelonian Conservation and Biology.* 6: 154-158.

Tapilatu, R.F., Dutton, P.H., Tiwari, M., Wibbels, T., Ferdinandus, H.V., Iwanggin, W.G. and Nugroho, B.H. 2013. Long-term decline of the western Pacific leatherback, *Dermochelys coriacea*: a globally important sea turtle population. Ecosphere 4:art25.

Tapilatu, R.F., Wona, H. and Batubara, P.P. 2017. Status of sea turtle populations and its conservation at Bird's Head Seascape, Western Papua, Indonesia. *Biodiversitas* 18 (1) : 129-136.

Tapilatu, R.F. 2014. The Conservation of the Western Pacific Leatherback Sea Turtle (Dermochelys coriacea) at Bird's Head Peninsula, Papua Barat - Indonesia. PhD Dissertation - University of Alabama at Birmingham (UAB).

Trinidad, H. and Wilson, J. 2000. The bioeconomics of sea turtle conservation and use in Mexico: history of exploitation and conservation policies for the olive ridley (*Lepidochelys olivacea*). In Microbehavior and Macroresults: Proc. Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade.

Wallace, B.P., Sotherland, P.R., Spotila, J.R., Reina, R.D, Franks, B.F. and Paladino, F.V. 2004. Biotic and abiotic factors affect the nest environment of embryonic leatherback turtles, *Dermochelys coriacea*. *Physiological and Biochemical Zoology*. 77 : 423–432.

Whitmore, C.P. and Dutton, P.H. 1985. Infertility, embryonic mortality and nest-site selection in leatherback and green sea turtles in Suriname. *Biological Conservation.* 34 : 251-272.

Wibbels, T. 2003. Critical approaches to sex determination in Sea Turtles. In: Lutz, P.L, Musick, J.A and Wyneken J (Eds.). The Biology of Sea Turtles Volume II. Boca Raton, FL: CRC Press, pp. 103 – 134.

World Bank. 2013. GDP per capita.

Yntema, C.L. and Mrosovsky, N. 1982. Critical periods and pivotal temperatures for sexual differentiation in loggerhead sea turtles. *Canadian Journal of Zoology*. 60 : 1012–1016.

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