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Potential and Problems of Green Turtle (*Chelonia mydas*) Spawning Habitat on Pangumbahan Beach, West Java

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ABSTRACT
Green turtles in Pangumbahan Beach face several challenges, including a declining population, low hatching success of eggs, and difficulties faced by hatchlings during their release into the sea. This study aimed to determine the potential and problems based on fluctuations in the number of turtles in the nesting habitat and the success rate of hatching eggs and hatchlings released into the sea. The data used were released from 2008 to 2022, with descriptive data analysis. The results showed that the estimated number of female green turtles that will land is 3,970. The number of green turtles that laid eggs was recorded as 24,279, which means that 38% of those that came did not lay eggs. The hatching rate is low (57%), below 80%, and the number of hatchlings is only 71087-27400, in contrast to 2008 when the number of hatchlings released was extremely high at 192729. Considering this condition, there must be a solution to overcome the problem of green turtle sustainability.

INTRODUCTION

Turtles are one of the ancient animals that are still alive on Earth. In Indonesia, 6 out of 7 species of turtles in the world are found; the six species are from two families (Cheloniidae and Dermochelyidae), namely the olive ridley turtle (*Lepidochelys olivacea*), green turtle (*Chelonia mydas*), latback turtle (*Natator depressus*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*) and leatherback turtle (*Dermochelis coriaceae*). Turtle resources in Indonesia have a protected status based on Law Number 5 of 1990 concerning the conservation of biological natural resources and their ecosystems and Government Regulation Number 7 of 1999 concerning the protection of plant and animal species. One of the dominant turtles found is the green turtle, which is found on Pangumbahan Beach in Pangumbahan Village, Ciracap District, Sukabumi Regency. Five types of turtles land along Pangumbahan Beach, namely

loggerhead turtles, loggerhead turtles, hawksbill turtles, leatherback turtles, and the most dominant green turtles **(Ismane *et al*., 2018)**.

Pengumbahan Beach is one of the beaches on the south coast of West Java, which also develops the potential for turtle tourism and is quite famous **(Wajhillah *et al*., 2018)**. The turtle resource-based tourism offered is a hatchling release tour because there is the potential for turtle nests and eggs, as well as the ability of hatchlings to hatch at semi-natural spawning locations. The Regional Government of Sukabumi Regency manages Pangumbahan Beach since this beach has strategic value related to efforts to preserve green turtles **(Harahap *et al*., 2015)**. However, the development of this tourism, if the area is not managed with the principle of prudence (oriented to the concept of conservation), will have an impact on problems such as the decline in the turtle population, the decrease in the number of eggs and the success of hatching turtle eggs, as well as the decrease in the number of hatchlings released into the sea. Turtles are sensitive to sound, vibration, and light, hence turtles avoid areas that are intensive for human activity **(Samuel *et al*., 2005; Afif & Yulianda, 2020)**.

This study aimed to determine the potential and problems based on fluctuations in the number of turtles in the spawning habitat, the success rate of egg hatching, and hatchlings released into the sea. The expected benefit of this study is that the information produced can be used as a basis for management in green turtle conservation activities on Pangumbahan Beach.

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MATERIALS AND METHODS

Location and time of research

This research was carried out in 2022 in the Conservation Area on Pangumbahan Beach, located in Gunung Batu Village, Ciracap District, Sukabumi Regency, with a position of 7º 17 '08" - 7º 21' 50" South Latitude and 106º 23' 40 " - 106º 24' 10" East Longitude. The beach's length is 2.30 m, and its width ranges from 89 to 126m (Fig. 1).

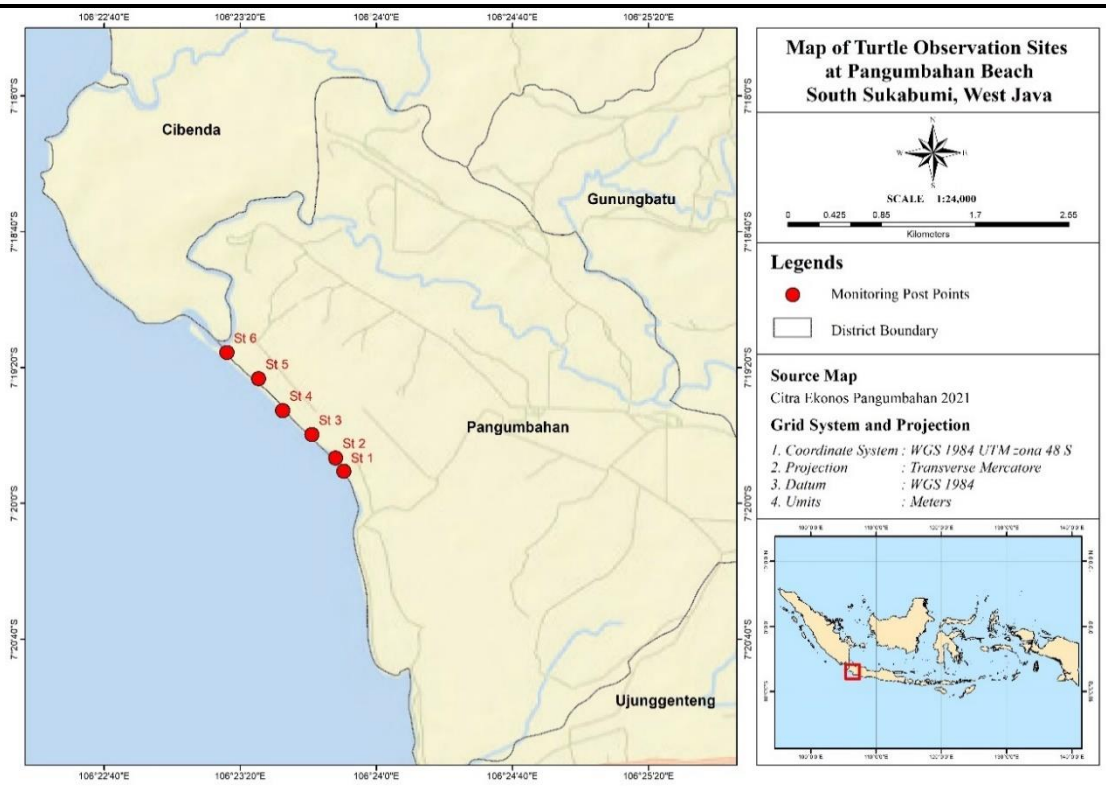

Fig. 1. The research location on Pangumbahan Beach, Sukabumi, West Java

Data collection and parameters measured

Data sources for the research on the potential and challenges of green turtle nesting habitats at Pangumbahan Beach include the following:

1. Research conducted by the Fish Resources Recovery Research Institute of the Ministry of Marine Affairs and Fisheries from 2008 to 2010.
2. Records from the Pangumbahan Beach Coastal Park Service Unit, under the Department of Marine Affairs and Fisheries (DKP) of West Java Province, spanning from 2008 to 2022.
3. Logbook data from area management officers, covering the years 2008 to 2018.
4. Supporting data on turtle habitat conditions—including vegetation, beach width, general area description, nesting area boundaries, causes of habitat degradation, and other issues—were obtained through direct interviews with local communities, following the *Survey Project Guidelines* issued by UNEP/CMS **(Pilcher & Kwan, 2012)**.
5. Literature reviews and prior research conducted by other researchers.

The key parameters measured in this study were the number of green turtles nesting per time unit, the number of eggs laid, and the number of hatchlings released on Pangumbahan Beach from 2008 to 2022.

Data analysis

The data and information collected were then analyzed descriptively. Descriptive statistics summarize data in an organized manner by outlining relationships between variables within a sample or population **(Kaur *et al.*, 2018)**. Descriptive analysis relies on research-generated information to explain a specific phenomenon **(Purba & Simanjuntak, 2012)**. In this study, the analysis focused on the distribution of key variables: the number of green turtles nesting, the number of eggs laid, hatching success, the number of hatchlings released, and an estimation of the total population of nesting female turtles **(Sönmez *et al.*, 2021)** with the formula:

$$Total\ number\ of\ nest\ female = \frac{Total\ nest\ count}{CF * (Total\frac{years}{RI})}$$

Where:

CF = clutch frequency
(using CF of 2.9 (range = 2.0-3.1 for green turtles in the Mediterranean **(Broderick *et al.*, 2002)**)

RI = remigration interval
(as in the Mediterranean, for green turtles, it is 3 years **(Broderick *et al.*, 2002)**)

RESULTS AND DISCUSSION

Number of green turtles laying eggs

The number of green turtles laying eggs during 2008-2022 shows a downward trend. However, when looking at the conditions per time, the activity of the number of green turtles laying eggs from 2008-2016 fluctuated in the range of 575-3160 per year (average +/- standard deviation) but with a downward trend. The average value is 1559 eggs; the mean is 1508, with a standard error value of 118.5. Furthermore, in the 2017-2022 period, the trend increased (Fig. 2). The average number of turtle eggs produced from nests on Pangumbahan Beach was 1707, with a mean value of 1867 eggs and an error value to see the propagation of 101.2.

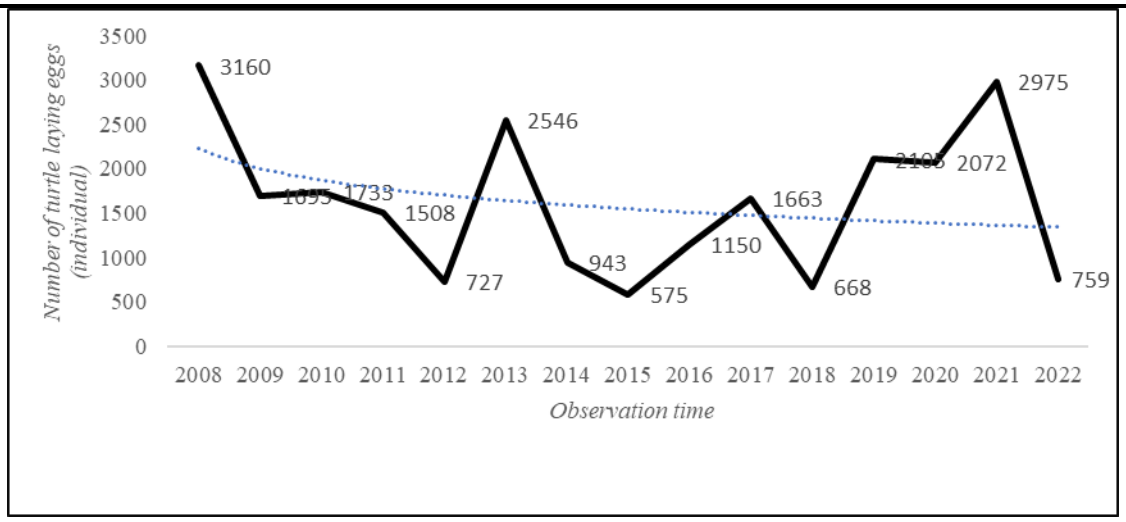

Fig. 2. Number of green turtles laying eggs on Pangumbahan Beach in 2008-2022

The decline in the presence of green turtles in 2008-2016 is suspected to be caused by 1) changes in beach conditions due to the increase in tourist facilities and infrastructure, 2) mobility of vehicles transporting fish catches at night, 3) lighting by lobster seed fishermen, and 4) other community activities such as sand mining around the beach. The research results on Pangumbahan Beach found that of the six selected stations along Pangandaran Beach, and it was found that tourist activities in the afternoon night were still found along Pangumbahan Beach, and human activities also occurred at night in the sea **(Rismawati *et al*., 2022)**. Many fishing boats use many lights on their boats in the waters in front of Pangumbahan Beach, and some are even close to the coast. As it is known that green turtles are sensitive to light, this is certainly a nuisance for turtles that will lay eggs. Another factor is coastal vegetation; green turtles lay their eggs close to the vegetation in search of a sense of security. It was explained in the study that vegetation conditions, beach slopes, and predators support the safety of turtles in laying eggs **(Panjaitan *et al*., 2012; Alfath, 2017; Irfansyah, 2018)**. The current condition needs to restore vegetation, especially on the beach of station 1, which is a part of the beach that is not suitable as a habitat for green turtle eggs due to the absence of vegetation cover and a location that is too close to the road **(Panjaitan *et al*., 2012)**. A slope that is not too steep is the right location for turtles to make a nest since seawater does not enter the nest **(Irfansyah, 2018)**. According to **Panjaitan *et al*. (2012)**, in the spawning habitat at Pangumbahan Beach, stations 1 to 5 are still classified as suitable as green turtle spawning habitats since they have a slope below 30^{o}, while station 6 is no longer suitable as a habitat for green turtle eggs since it has a slope above 30^{o}.

The frequency of green turtles in 2017-2021 tends to increase, which is suspected to be the impact of improved management. The management was after being designated the Pangumbahan Turtle Coastal Park as the Ciletuh Pelabuhan Ratu National Geopark as part of the Ciletuh Pelabuhan Ratu Global Geopark (CPUGG) on April 17, 2018.

However, in 2022, it was found that the number of eggs has decreased. To overcome these problems, the government, through community support through the establishment of the Sukabumi Turtle Conservation Group (KPPS), which enacts a ban on hunting turtles, stealing and selling turtle eggs, and ensuring the safety of turtles during migration to the nesting beach. Also supported by the policies issued by the Governor of West Java during the Covid-19 period, West Java Governor Regulation No. 443/Kep.189-Hukham/2020 concerning the status of a particular state of emergency disaster due to the Coronavirus Disease 19 (Covid-19) outbreak in West Java, which was followed up with the Sukabumi Regent Decree No. 41 of 2020 which states that visits to tourist areas are closed in 2020-2021 as a follow-up to the Regent Regulation (PERBUP) of Sukabumi Regency Number 29 2020 concerning the Implementation of Large-Scale Social Restrictions in Handling Corona Virus Disease 2019.

Estimation of female green turtles present at Pangumbahan Beach

The estimated number of female green turtles that landed in 2008-2022 is 39070 heads. The number of green turtles that laid eggs during 2008-2022 was recorded at 24279 heads. Thus, it is known that 1479 or 38% of green turtles came to Pangumbahan Beach (spawning habitat) but failed to lay eggs. The failure of green turtles to lay eggs is caused by several factors, including physical, biological, and predatory. Physical threats include human activities (sounds, light, and vibrations of people walking), biological threats (low coastal vegetation cover), and predators (snakes, dogs, monitor lizards).

Number of eggs and percentage of hatching success of green turtle eggs

The highest number of turtle eggs in 2008 was 256,115 eggs. Meanwhile, the lowest number of eggs was found in 2022, at 36,636 eggs (Fig. 3). The decrease in turtle eggs is suspected to be due to a decrease in nesting mothers in 2008-2022 (Table 1). In fact, according to estimates, the population of female turtles in the nesting habitat is 39070 heads. The estimated number of nesting female turtles was calculated based on an average clutch size of 110 eggs, with each female laying approximately four clutches per nesting season and a remigration interval of 3 years. However, only 24279 nesting and laying eggs are present, meaning that as many as 1479 or 38% of green turtles come to Pangumbahan Beach (nesting habitat) but fail to lay eggs. The decline in egg production is suspected to be related to the decline in green turtles. In addition to theft and predators, semi-natural incubation systems can also result in unsuccessful egg hatching, as eggs are thought to be weak when moving from natural nests to semi-natural nests, allegedly not strong **(Fitri & Herawati, 2023)**.

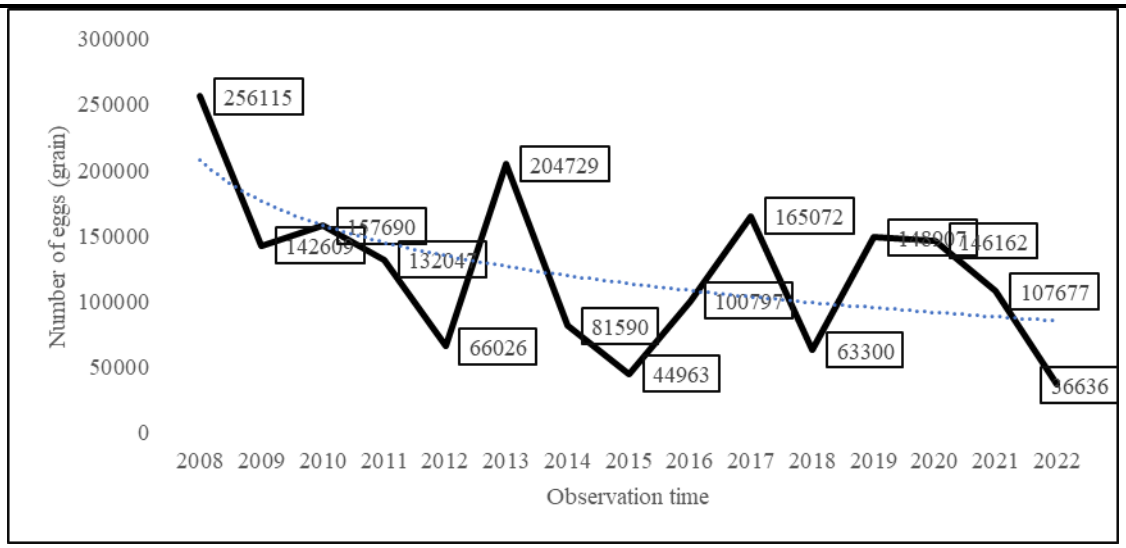

Fig. 3. Number of green turtle eggs at Pangumbahan Beach in 2008-2022

Table 1. The number of green turtle eggs and the percentage of hatching success of eggs and hatchlings released into the seas

Year	Nests (unit)	Total eggs (grain)	Eggs/Nest (grain)	Hatchlings released (individu)	Hatching success (%)	Eggs fail to hatch (grain-%)	
2008	3.160	256.115	81	192.729	75,3	63.386	24,7
2009	1.695	142.609	84	88.199	61,8	54.410	38,2
2010	1.733	157.690	91	123.503	78,3	34.187	21,7
2011	1.508	132.047	88	106.329	80,5	25.718	19,5
2012	727	66.026	91	57.499	87,1	8.527	12,9
2013	2.546	204.729	80	190.533	93,1	14.196	6,9
2014	943	81.590	87	74.271	91,0	7.319	9,0
2015	575	44.963	78	39.067	86,9	5.896	13,1
2016	1.150	100.797	88	73.792	73,2	27.005	26,8
2017	1.663	165.072	99	122.757	74,4	42.315	25,6
2018	668	63.300	95	50.560	79,9	12.740	20,1
2019	2.105	148.907	71	117.194	78,7	31.713	21,3
2020	2.072	146.162	71	128.223	87,7	17.939	12,3
2021	2.975	107.677	36	71.087	66,0	36.590	34,0
2022	759	36.636	48	27.400	74,8	9.236	25,2

Green turtle hatchery activities on Pangumbahan Beach were carried out in a semi-natural hatchery area (officers move turtle eggs from natural nests to semi-natural nests). The success of hatching turtle eggs at Pangumbahan Beach in 2008-2022 (Table 1) ranged from 66.0 - 93.1%. The high hatching success rate of turtle eggs ranges from 80-98%, while in Pangumbahan, the incidence of a high hatching rate of green turtle eggs is

only 43%, meaning that 57% of the hatching success rate during the period 2008-2022 is still low **(Mardiana *et al*., 2013; Sheavtiyan & Lovadi, 2014)**. The low hatching success rate (43%) in Pangumbahan may not only be caused by egg relocation, but also by various other environmental factors. Several studies have shown that non-optimal incubation temperatures, poor sand quality (too moist, too dense, or too dry), and predation by ants or other animals can affect embryo development and reduce hatching success **(Eiby & Booth, 2011)**. When compared to other nesting sites in Southeast Asia such as Sukamade Beach (Indonesia) or Terengganu (Malaysia) that report hatching success rates of around 70- 90% **(Chan, 2013; Putera *et al*., 2015)**, the 43% rate in Pangumbahan suggests possible environmental constraints or weaknesses in captive management that need to be further evaluated.

Green turtles generally prefer to lay their eggs in locations that are easy to reach but safe from disturbances. Turtles tend to choose places among vegetated areas. According to **Roemantyo *et al*. (2012)**, Pangumbahan Beach has two main vegetation formations, namely a) the Pescaprae Formation, which consists of grass and shrubs, and b) the Barringtonia Formation, which consists of woody plants or trees. This plant is a type of vine whose roots can bind sand. Currently, the width of the beach in Pangumbahan only ranges from 89- 126m; in 2008-2010, the width of the beach ranged from 200- 250m **(Nastiti *et al*., 2008)**. This reduces space for places to be present on the beach to lay eggs **(Hidayatulloh *et al*., 2021)**. The reduction in beach width is caused by friction or erosion of the beach. Coastal erosion refers to the loss of soil in coastal areas **(Dianawati, 2016)**. A reduction in the width of the beach by 1m results in a decrease in the presence of 3 turtles/year **(Panjaitan *et al*., 2012)**. Two factors cause the reduction of beach width, namely (1) natural phenomena (earthquakes, tsunamis, extreme waves, sea waves, volcanic eruptions, floods, sea level rise, landslides, coastal erosion, tornadoes) and (2) humans, namely sand mining, ponds/fish farming **(Permatasari, 2021)**. The protection of Pangumbahan Beach can be pursued through the cessation of sand mining, the regulation of green turtle ecotourism activities, and the replanting of coastal vegetation. The manager has tried to restore spawning habitats and institutional social and social habitats. Some of the efforts from the manager in restoring the green turtle spawning habitat include increasing security, namely the construction of monitoring towers at Posts 1, 2, and 5, in addition to making efforts to improve coastal vegetation, comply with the SOP (Standard Operation Procedure) for green turtle ecotourism, and minimize sand mining and control of development around Pangumbahan Beach.

Released hatchlings

The number of hatchlings released in the 2008-2022 period tends to decrease, in line with the number of green turtles laying eggs and the number of eggs (Fig. 4). The hatchlings released into the wild result from hatching eggs on semi-natural hatching media. Officers release hatchlings in the morning or evening to educate the

community/tourists **(Wiadnyana & Nastiti, 2015; Wajhillah *et al*., 2018)**. Hatchlings have a marine instinct, which means that after they are released, they head to the sea as their habitat. Therefore, hatched hatchlings are urged to be directly released into the wild.

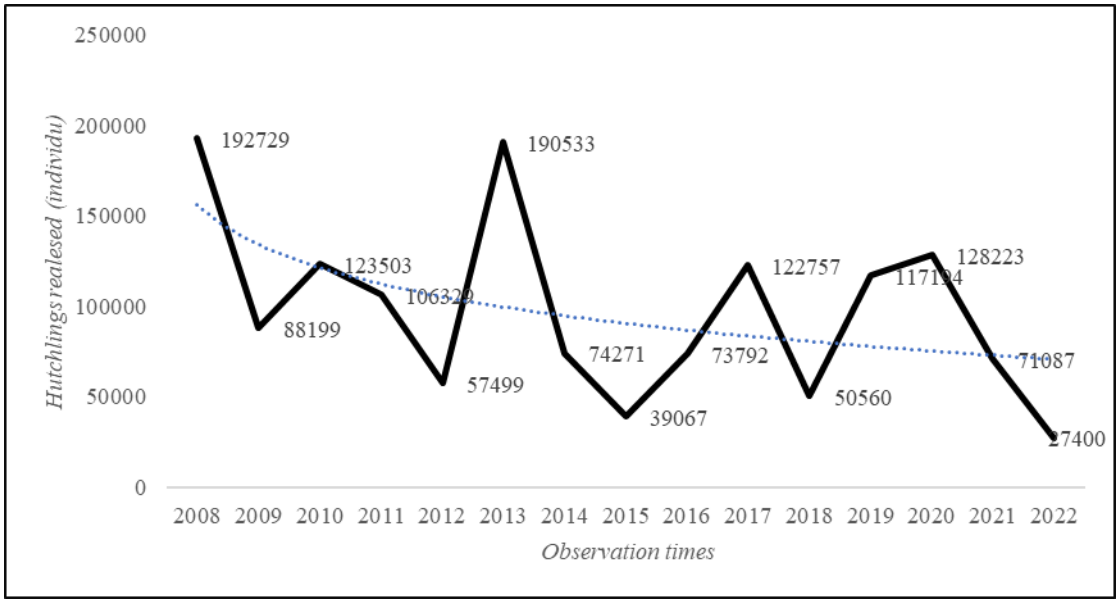

Fig. 4. Number of hatchlings released into the sea

The significant fluctuation of the decline is in line with the fluctuation in the decrease in the number of turtles laying eggs based on the number of eggs successfully obtained from the nest and brought to the hatchery site. This condition is due to the weak awareness of coastal area users about turtles' survival, both in using fishery resources and how the community maintains coastal vegetation along Pangumbahan Beach. The study results explained that to ensure the sustainability of protected areas as turtle habitats, coastal flora management must be carried out to meet optimal conditions. Socialisation about the importance of coastal vegetation in supporting turtle habitat also needs to be improved so that the community and tourists can be aware of it. The community, as an interested subject, must participate in regional management. In addition, to ensure security in protected areas, the village government must develop village policies or regulations **(Rochmah, 2022)**.

Problems of green turtle spawning habitat on Pangumbahan Beach

Since the transfer of private managers to the government in 2008, the government as a manager has decided that it is no longer allowed to utilize or interfere with the conservation of turtles, but the community has not fully supported it, and the degradation of nesting habitats (beaches, vegetation), and predators has occurred. Some of the problems in the turtle spawning habitat area are as follows: decrease in the number of female turtles that migrate to the spawning beach; decrease in the number of turtle eggs;

decreased hatching success; low vegetation cover; the width of the beach is decreasing; low awareness of the public, including tourists; and lack of existing institutional functions.

As is known, green turtles are vibration-sensitive animals that see objects in front of them at angles of 30 and 180 degrees laterally and adapt well to light with an angle of 150° and a wavelength of 520nm (blue-green) **(Nuitja, 1992)**. Stimuli such as light, heat, sound, temperature, pressure, gravity, and chemicals elicit a response within the turtle's body and can be felt simultaneously to signal danger. Therefore, the turtle then turns around to avoid risk, which impacts the disorientation of its nesting area **(Hochscheid *et al.*, 2022)**. The decrease in the presence of green turtles on Pangumbahan Beach is due to ecotourism activities, where vibrations originate from the trail of each visitor; the use of flashlights or lights can interfere with turtle activities at the time of laying eggs. In addition, the light from the baby lobster catching activity, where the light effect of the baby lobster fishing boat spreads about 500m in front of the nearest spawning beach (Fig. 5). The appropriate light range for turtle spawning sites is 0-3 lux **(Santos *et al.*, 2010)**. Light from the full moon does not interfere with turtles when they go up to lay eggs. However, light from other sources, such as house lights or fishing lights and flashlights, can disturb green turtles and cancel their eggs, as happened in the Marine Nature Tourism Park in the waters of Sangalaki Island in East Kalimantan **(Basyari *et al.*, 2011)**.

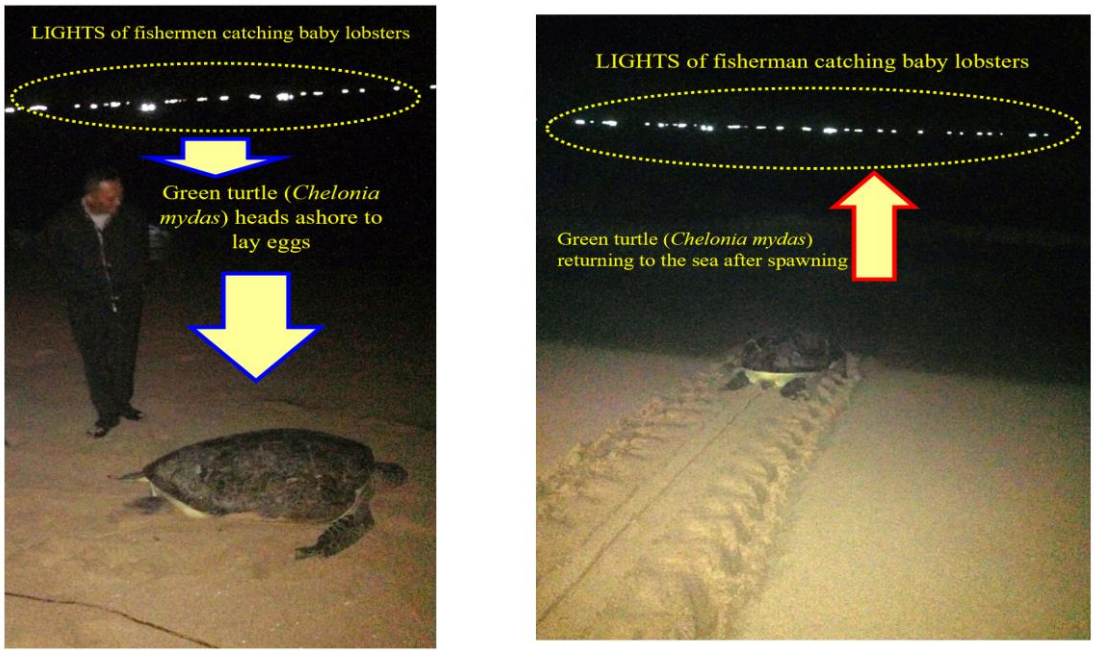

Fig. 5. Light from baby lobster-catching activities in front of the spawning beach in Pangumbahan since 2014/2015

Based on information from the conservation area manager of the Pangumbahan Beach Coastal Park Service Unit, baby lobster fishing activities were carried out starting in 2014/2015, with as many as 350 boats operating. The boat is equipped with a waiter, and the baby lobster fishing net is submerged in the water column. At night, it is equipped with a light/light. This condition causes turtles that want to migrate to the beach to lay eggs to be blocked by baby lobster fishing nets. This activity is mainly carried out at night using intense lighting to attract lobster seeds, indirectly increasing light pollution around the nesting area. Based on annual data, the number of turtle nests declined sharply from 2.546 nests in 2013 to only 1.150 nests in 2016, showing a strong negative correlation between increased boating activity and decreased nesting activity. This is in line with a study by **Salmon (2003)**, which showed that artificial light on beaches can interfere with female turtle navigation and reduce nesting rates.

Several efforts are needed to deal with these problems, such as replanting vegetation to provide safety for turtles that are laying eggs and protecting erosion beaches, conducting research to obtain semi-natural nest technology in improving hatchery success, as well as conducting socialisation and forum group discussion between the government and the community and existing institutions (Turtle Conservation Groups) to enhance awareness of maintaining turtle conservation. It also provides technical guidance for human resources in institutions and the community.

CONCLUSION

Pangumbahan Beach is a potential area for green turtle spawning. The estimated population of female green turtles (*Chelonia mydas*) that landed in 2008-2022 is 39070 heads. The number of green turtles that laid eggs during 2008-2022 was recorded at only 24279 heads, or 1479 or 38% of green turtles that came to Pangumbahan Beach (spawning habitat) failed to lay eggs. The egg hatching rate is low (below 80%), only around 57% during 2008-2022. The population of green turtles (*Chelonia mydas*) in the nesting habitat, the number of turtle eggs, hatching success, and hatchling release on Pangumbahan Beach in 2008-2022 have decreased. The manager has made efforts in the form of SOPs for improvement, but has not been welcomed by the community. Managers must collaborate with relevant agencies to solve the problems, including protecting and rehabilitating nesting habitats, strengthening monitoring systems and databases, increasing public awareness and capacity, and cross-sector collaboration in implementing sustainable sea turtle conservation strategies.

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