Omni-Akuatika, 20 (2): 86 - 99, 2024
ISSN: 1858-3873 print / 2476-9347 online

Research Article

journal homepage: http://ojs.omniakuatika.net

A Study on Characteristics of Semi-Natural Hatchery Habitat for Olive Ridley Sea Turtle *Lepidochelys olivacea* (Eschscholtz, 1829) Conservation: A Case Study of Batu Hiu Beach, Pangandaran, West Java, Indonesia

Thallita Nasywa Faddilah[1*], Zahidah Hasan[1], Mochamad Candra Wirawan Arief[1], Titin Herawati[2]

[1]Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Jatinangor, Sumedang, West Java, Indonesia.
[2]Study Program of Marine Conservation, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Jatinangor, Sumedang, West Java, Indonesia

**Corresponding author: thallita19001@mail.unpad.ac.id*

Received 13 February 2024; Revised 27 November 2024; Accepted 5 December 2024; Available online 13 December 2024; Published 13 December 2024

ABSTRACT

Sea turtle populations have declined due to habitat destruction and the widespread collection of eggs for commercial purposes. This study assessed the characteristics and suitability of semi-natural hatchery habitats for Olive Ridley Sea Turtles (*Lepidochelys olivacea*) at Batu Hiu Beach, Pangandaran, West Java, Indonesia, from June 1-July 31, 2023. The survey method and purposive sampling were employed to determine nesting sites based on turtle landing points. Biophysical habitat measurements were analyzed descriptively and statistically using one-way ANOVA and Tukey's post hoc test to compare sand temperature, sand humidity, and air humidity. An *L. olivacea* landed at site 4, laying 73 eggs in a natural nest with 34 cm nest depth and 24 cm nest diameter. Semi-natural nests measured 37 cm nest depth and 26 cm in nest diameter. The sand type at Batu Hiu Beach was characterized by black sand grains and fine sand substrate with a percentage of 51.02%. The temperature within the hatchery ranged from 25.3°C to 42.1°C. with average of 29.7 ± 1.88 °C. The sand humidity in the hatchery ranged from 2% to 14%, with an average daily humidity of 10 ± 0.22 %. The air humidity within the hatchery ranged from 56% to 94%, with a daily average of 85 ± 0.05 %. Based on all the analyzed parameters, the hatchery at Batu Hiu Sea Turtle Preservation were suitable with the nest criteria by Technical Guidelines for Sea Turtle Conservation Management by DKP for the hatching of *L. olivacea* eggs, with a hatching success rate of 85%.

Keywords: *Lepidochelys olivacea*, temperature, humidity, sand type, hatching success

ABSTRAK

Populasi penyu telah menurun akibat kerusakan habitat dan pengambilan telur penyu untuk diperjualbelikan. Penelitian ini mengkaji karakteristik dan kesesuaian habitat penetasan semi-alami untuk Penyu Lekang (*Lepidochelys olivacea*) di Pantai Batu Hiu, Pangandaran, Jawa Barat, Indonesia, pada 1 Juni hingga 31 Juli 2023. Metode survei dan teknik purposive sampling digunakan untuk menentukan lokasi bersarang berdasarkan titik pendaratan penyu. Pengukuran habitat biofisik dianalisis secara deskriptif dan statistik menggunakan ANOVA satu arah dan uji post hoc Tukey untuk membandingkan suhu pasir, kelembapan pasir, dan kelembapan udara. Seekor penyu lekang (*L. olivacea*) mendarat di stasiun 4 dan bertelur sebanyak 73 butir. Kedalaman sarang alami untuk peneluran penyu adalah 34 cm dengan diameter sarang 24 cm. Sedangkan kedalaman sarang pada bak semi-alami yang berada di kawasan konservasi adalah 37 cm dengan diameter sarang 26 cm. Jenis pasir di Pantai Batu Hiu memiliki karakteristik butiran pasir berwarna hitam dan substrat pasir halus dengan persentase sebesar 51,02%. Suhu pada bak penetasan berkisar antara 25,3°C hingga 42,1°C dengan rata-rata 29,7 ± 1,88°C. Kelembapan pasir pada bak penetasan berkisar antara 2% hingga 14%, dengan rata-rata kelembapan harian 10 ± 0.22 %. Kelembapan udara di dalam tempat penetasan berkisar antara 56% hingga 94%, dengan rata-rata harian sebesar 85 ± 0.05 %. Berdasarkan seluruh parameter yang dianalisis, bak penetasan di Pelestarian Penyu Batu Hiu layak untuk penetasan telur *L. olivacea* berdasarkan kriteria pada Pedoman Teknis Pengelolaan Konservasi Penyu oleh DKP, dengan tingkat keberhasilan penetasan sebesar 85%.

Kata kunci: *Lepidochelys olivacea*, suhu, kelembapan, jenis pasir, tingkat keberhasilan

http://dx.doi.org/10.20884/1.oa.2024.20.2.1146

1. Introduction

Among the seven species of sea turtles distributed globally, six of them are found inhabiting the waters of Indonesia. According to Dahuri (2003), the types of sea turtles found in Indonesian are the green sea turtle (*Chelonia mydas*), the hawksbill sea turtle (*Eretmochelys imbricata*), the loggerhead sea turtle (*Caretta caretta*), the leatherback sea turtle (*Dermochelys coriacea*), the leatherback sea turtle (*Dermochelys coriacea*), olive ridley sea turtle (*Lepidochelys olivacea*), and flatback sea turtle (*Natator depressus*). The Olive Ridley Turtle, *Lepidochelys olivacea*, was last evaluated for the IUCN Red List of Threatened Species in 2008. It is classified as Vulnerable (Abreu-Grobois and Plotkin, 2008).

For over 100 million years, sea turtles have been crucial to the health of the world's oceans. Their contributions include sustaining vibrant coral reef ecosystems and transferring vital nutrients from the sea to beaches and coastal dunes (Wilson et al., 2010). Even with reduced populations, sea turtles have many important roles in the ocean ecosystems. Green sea turtles help maintain healthy seagrass beds by grazing, which increased the productivity and nutrient content of the seagrass (Thayer et al., 1984). Hawksbill sea turtles prevent sponges from dominating reef communities, thereby supporting coral growth and preserving the structure of coral reef ecosystems (Leon and Bjorndal, 2002). Leatherbacks sea turtle, as major jellyfish predators, play a crucial ecological role in balancing marine food webs (Gibbons and Richardson, 2009). Additionally, sea turtle eggs supply nutrients that enhance vegetation, species distribution, and shoreline stability, creating essential habitats for other marine life and aiding nutrient cycling from sea to land (Purcell et al., 2007).

One of the significant nesting sites for sea turtles is located along the southern coast of Java Island. Several areas on this coast, including Pangandaran in West Java, are recognized as important habitats for sea turtles to lay their eggs (ProFauna-Indonesia, 2005). The Batu Hiu Beach area is identified as one of the beaches for sea turtle landing and nesting in Pangandaran. In accordance with West Java Provincial Regulation Number 5 of 2019 (Perda Jawa Barat 2019), this area is included in the sub-zone of natural tourism for beaches/coasts and small islands with the code “KPU-W-P3K-72).”. Batu Hiu Beach is also designated as a coastal area within the migration space of marine biota, particularly turtle biota, with the code “AL-MB-P-07)”.

However, based on the Batu Hiu Sea Turtle Conservation Center Data Report, there was a decrease in landings and nesting in the Batu Hiu beach area since 2018. According to the report, the number of sea turtle landings and nesting has decreased annually. In 2014, only 6 sea turtles nested, followed by 5 sea turtles in 2015, 4 sea turtles in 2016, 2 sea turtles in 2017, and none in 2018. The trend continued with 3 sea turtles nesting in 2019, 1 sea turtle in 2020, 2 sea turtles in both 2021 and 2022, and only 1 sea turtle nesting in 2023.

Based on results of analyses in the field, the landing and nesting activities at Batu Hiu Beach have decreased due to the unsupportive environment of Batu Hiu Beach. A preliminary study conducted by Sinaga (2016) identified one of the main factors contributing to the decrease in sea turtle landing and nesting activity on the Batu Hiu coast. The study highlighted that coastal abrasion since 2014 has altered the beach slope due to abrasion, significantly impacting the suitability of the beach as a nesting habitat. Moreover,Batu Hiu Beach is one of the tourist destinations in the Pangandaran area. The construction of new roads and the extensive clearing of pandanus vegetation have damaged the natural nesting habitat of sea turtles. Additionally, at night, there were fishermen activities at sea where fishermen use lights on their boats to catched lobster larvae, locally known as "benur." These lights could disturb sea turtles that were attempting to land and nest. Sea turtles are sensitive to light and disturbances from predators such as monitor lizards, stray dogs, and wild boars. Light, particularly artificial lighting, often disrupts female sea turtles during their nesting and egg-laying activities. Additionally, light can interfere with the ability of newly hatched hatchlings to navigate back to the ocean (Lorne and Salmon 2007; Bourgeois et al., 2009; Berry et al., 2013; Kamrowski et al., 2015).

Sea turtles were highly sensitive to environmental disturbances. If disturbed while nesting, they may perform a false crawl. A false crawl occurs when a female sea turtle comes ashore to search for a suitable nesting site, sometimes digging a nest, but ultimately returns to the sea without laying eggs (Leech, 2008). According to Damanhuri (2007), sea turtles need a good and suitable environmental area to use as a nesting place. There are several biophysical environmental factors for sea turtle nesting, such as a location that is easy to reach from the sea, a fairly high nest position, relatively loose and medium-sized beach sand, not too dense sand substrate (has good air circulation) The composition of sand substrate within a nest significantly influences both the temperature and humidity of the substrate. If the sand mostly composed of fine and densely grains, the range of temperature and humidity tends to be relatively narrower, thus potentially impacting the development of the eggs (Hermawan 1992). One of the factors that influences the hatching success rate of sea turtle eggs is temperature. If the temperature is too low, below 24°C it can result in a long of the incubation period of the eggs, whereas if the temperature is too high, above 33°C, it can result in the death of the hatchlings. According to Yusuf (2000), the temperature required for embryonic growth ranges from 24°C to 33°C. Budiantoro *et al.,* (2019) and Martins *et al.,* (2022) highlighted that heavy rainfall significantly impacts nest humidity and hatching success. Rainfall increases water absorption in the sand, leading to wetter nests, as seen in the Bantul Hatchery, Yogyakarta, where high rainfall reduced the hatching success rate to 23.92%. Apart from excessive rainfall, long dry seasons can also be a factor causing egg hatching failure (Djohar 1987).

In addition to temperature, egg relocation also affects egg hatching success. According to Brand (1999), nests relocated with the wrong process can reduce hatching success compared to nests in natural locations (beach). Sea turtles eggs relocation is typically conducted by transferring eggs from natural nests to protected hatcheries, following standard procedures to prevent vibrations or rotation and ensure hatchery conditions replicate the natural nest's shape and depth (Martins et al., 2021).

Then the relocation of eggs to a semi-natural nest should be conducted approximately one hour after the sea turtles lays the eggs in the natural nest. The number of eggs and the depth of the nest also influence the hatching success of sea turtle eggs (Mardiana et al., 2013). Research conducted by Muliani et al., (2020) regarding the suitability of turtle nesting habitat characteristics in the coastal area of Gelumpang Sulu Timur Village, Dewantara District, North Aceh Regency obtained results that were very suitable for supporting turtle nesting activities with sand temperatures between 29-32°C and humidity ranging from 21-28%. Previous research conducted by Sinaga (2016) examined the landing habitat of the flatback turtle (*Natator depressus*) at Batu Hiu Beach, Pangandaran. The study detailed the characteristics of the flatback sea turtle's nesting habitat and identified the factors that influence the conditions of this nesting habitat, specifically for the flatback sea turtle. Research on the suitability of semi-natural hatchery with natural nests at Batu Hiu has not been conducted. This research aimed to determine the characteristics and suitability of semi-natural hatchery habitat located in the Raksa Bintana Foundation with the conditions of natural nests on Batu Hiu Beach.

2. Materials and methods

The research was conducted over three months period from May 17 to July 31st 2023. This three-month research was carried out during the landing and nesting of the sea turtles until all the eggs in the semi-natural hatchery hatched. The research was carried out in the Batu Hiu Beach area and the Hatchery at Batu Hiu Sea Turtle Conservation Center, Raksa Bintana Foundation. This research used descriptive comparative analysis and sampling sites used a purposive sampling technique by determining location points according to sea turtle landing and nesting points.

2.1. Sampling sites

Sites of research can be seen in Figure 1. There were 4 monitoring sites were identified as landing and nesting points for sea turtles based on assessments by the Raksa Bintana Foundation and reports from the local community. Raksa Bintana and the local community regularly conducted monitoring to track sea turtle landings, and these sites were considered potential locations for sea turtle landings and nesting. However, out of the four research stations, only one stations of landing was recorded. The relocation of sea turtle eggs from natural nests to semi-natural nests is carried out according with the methods outlined in the Technical Guidelines for Sea Turtle Conservation Management (DKP, 2009).

2.2. Data Collection

The suitability level of semi-natural nests is adjusted to match the conditions of natural spawning nests. The parameters that influence the suitability level in semi-natural nests include nest depth and diameter, nest temperature, nest humidity, and the air humidity around the nest.

2.2.1. Nest Depth and Nest Diameter

Measurements of the nest depth and diameter of sea turtle nests were conducted after the sea turtle lay eggs. These measurements were carried out in accordance

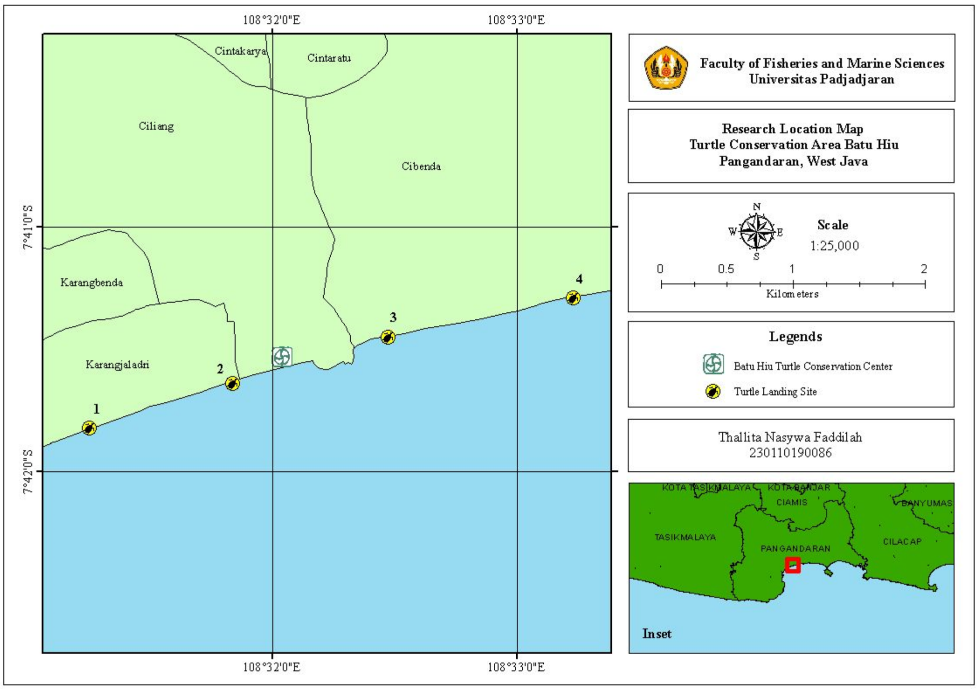

Figure 1. Map of the Research Sites in the Batu Hiu Beach Area, Pangandaran, West Java, Indonesia. (The map highlights four sea turtle landings sites and The Semi-Natural Hatchery at Batu Hiu Turtle Conservation Center).

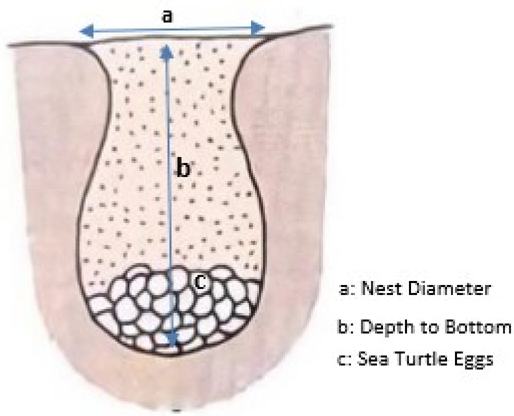

Figure 2. Sea Turtle Nest Measurements

with the Technical Guidelines for Sea Turtle Conservation Management by DKP (2009). The diameter was measured based on the width of the nest's surface, while the depth was measured from the surface of the nest to bottom (depth to bottom), The depth and diameter of the nest were measured used a roll meter. Illustration of sea turtle nestmeasurements showed in Figure 2.

2.2.2. Size and Type of Sediment Grains

Sand samples were collected compositely from three points on the edges (right and left) of the nest and the center of the nest with a sample weight of 100 grams each sites. The samples were then analyzed using a sieve shaker at the Laboratory of the Faculty of Geological Engineering, Universitas Padjadjaran. The procedures carried out were adapted to research conducted by Benni et al. (2018).

After the sieving results were obtained, the substrate size data was analyzed using Microsoft Excel software version 16.0 and statistical analysis using Gradistat software version 9.1 (Blott and Pye, 2001). Furthermore, the final results were classified based on the Wentworth-Udden Scale. The following is a classification table based on the Wenworth-Udden Scale (1922) in Table 1.

The percentage of remaining sand in each sieve is calculated using the formula for dry

Table 1. Wenworth-Udden (1922) Scale Classification

No.	Sediment Type	Substrate Diameter	
		(mm)	(φ)
1.	*Boulder*	>256	(< -8)
2.	*Cobble*	256 – 64	(-8 – -6)
3.	*Pebbie*	64-4	(-6 – -2)
4.	*Granule/Gravel*	4 – 2	(-2 – -1)
5.	*Very coarse sand*	2 – 1	(-1 – -0)
6.	*Coarse sand*	1-0,5	(1 – 2)
7.	*Medium sand*	0,5-0,25	(1 – 2)
8.	*Fine sand*	0,25 – 0,125	(2 – 3)
9.	*Very fine sand*	0,125 – 0,062	(3 – 4)
10.	*Silt*	0,062 – 0,004	(4 – 8)
11.	*Clay/Mud*	<0,004	(>8)

φ(*phi)*: conversion formula from φ to particle size (mm) is diameter (mm)=$2^{-\phi}$

sieve analysis by Department of Roads in Manual of Standard Tests on Aggregates (2016):

$$W = \left(\frac{X_1}{W_r}\right) \times 100$$

Description:
W = Individual percentage retained
X1 = Weight of oven dry aggregate retained on individual sieve or pan
W1= Total weight of original dry sample

To find the main sediment constituent material, the largest percentage of each sieve by looking at the diameter of the sieve which is listed on the sieve itself. After obtaining the percentage results from each sieve, the sediment can then be classified based on the Wentworth-Udden classification scale.

2.2.3. Measurement of Temperature, Sand Humidity and Air Humidity

Measurements of sand temperature used a digital thermometer. Furthermore, measurements of the sand humidity used a soil tester, Then the measurements of air humidity measured used a digital hygrometer. Those parameters were carried out three times a day, at 07.30 WIB, 13.30 WIB and 22.30 WIB. The timing of data collection was adjusted to the tidal data in the Pangandaran area and looked at previous research (Benni et al., 2018). Measurements in the hatchery were carried out every day from the time the eggs on the beach (natural nest) are relocated to the semi-natural hatchery location until the eggs hatched.

2.3. Data Analysis

2.3.1. Temperature, Sand Humidity and Air Humidity

The sand temperature, sand humidity, and air humidity data analyzed statistically using One-Way ANOVA to test whether there are significant differences in sand temperature, sand humidity, and air humidity within the semi-natural hatchery at three different times of day. Measurements were conducted over 45 consecutive days at 7:30 AM, 1:30 PM, and 10:30 PM each day. One-Way ANOVA is appropriate for this study, as it can evaluate changes based on time within the same experimental conditions in environmental variables which tend to fluctuate based on daily conditions or other external factors (Tabachnick & Fidell, 2013; Field, 2018). The statistical data analyzed using SPSS software version 22.

2.3.2. Hatching Success

In hatching success, several categories of eggs and hatchlings that were observed based on the guidelines set by the DKP (2009). Moreover, the total number of eggs and hatchability were calculated using the formula (Sheavtiyan et al., 2014):

$$\text{Hatching Success (\%)} = \frac{\sum S}{S+UD+UHT+UH+P} \times 100$$

Description: ∑S (Shell) is total eggshells; S (Shell) is total eggshells after hatching; UD (Undeveloped) is eggs that failed to develop and show no signs of blood vessel formation; UHT (Unhatched Term) is eggs that failed to hatch but show visible blood vessels, indicating partial development; UH (Unhatched) is fully developed hatchlings that were ready to emerge but died within the eggshell; and P (Predators) is eggs damaged by predators.

3. Results and Discussion

3.1. Observation of Sea Turtles Landings

Throughout the year 2023, only one sea turtle landing was recorded. Based on information provided by fishermen who are part of the Sea Turtle Fighter Community Group, there was sea turtle landed and nesting on Wednesday, June 14, 2023, at 03:00 at sites 4, located at coordinates 7° 41' 17.26"S and 108°

33' 14.04"E. The Olive Ridley sea turtle (*L. olivacea*) typically nests in tropical, wooded areas. However, at Station 4 of Batu Hiu Beach, sea turtles nest in an area with relatively sparse vegetation and and were not tightly closed. This finding aligned with research by Onny et al. (2020) at Sosadale Beach, Rote-Ndao, East Nusa Tenggara, which showed that nests located far from vegetation were more numerous than those near vegetation. The bevaviour of *L. olivacea* can nest in open areas without vegetation or shade, with little influence from the presence of vegetation.

The fishermen were at the landing site to monitoring the nesting process until its complete and for the sea turtle return to the sea. The nesting sea turtle was identified as an Olive Ridley (*L. olivacea*), which commonly referred to as gray sea turtle by the local community around Batu Hiu Beach. Based on information obtained from local fishermen, the sea turtles laying eggs were identified as Olive Ridley turtles, as indicated by their morphological characteristics, which include a smaller size compared to the average size of green sea turtles that nesting. Additionally, it can be seen from the deeper body shape and a flatter carapace. This aligned to Dumasari (2014) statement that olive ridley sea turtles actually resemble Kemp's ridley sea turtles, but olive ridley turtles have a deeper body and a flatter carapace. The species identification can also be determined from their tracks, nest sizes, and nesting habits. The measured track width at the landing and nesting site was 80 cm. This is accordance with the DKP (2009) identification, which states that the track width of the Olive Ridley sea turtle (*L. olivacea*) is 80 cm, characterized by shallow cuts and asymmetrical diagonal marks on its front flippers. The landing and nesting tracks of the Olive Ridley sea turtle (*L. olivacea*) are illustrated in Figure 3.

3.2. The Measurements of Nest Depth and Nest Diameter

The size of the depth of the semi-natural nest is adjusted to the type of sea turtle eggs that will be relocated in the semi-natural hatchery based on recommendations from DKP (2009) the nest depth of the Olive Ridley sea turtle (*L. olivacea*) ranged from 37-38 cm with a nest diameter of 20- 21 cm. Then another research conducted by Muliani et al., (2022) which was carried out at Gelumpang Village Beach, East Sulu, Dewantara District, North Aceh Regency, the *L. olivacea* nest had the depth and diameter ranged from 42-45 cm and the nest diameter between 25- 27 cm. This aligned with Nuitja (1992) statement that in the nest depth ranged of 20-30 cm there are temperature fluctuations at that depth and there is higher heating in sea turtle eggs which results in the embryonic process taking place more quickly. Furthermore, the depth of the nest should be adjusted to the recommendations of the DKP (2009), the depth of the nest in the range of 37-38 cm.

3.3. Size and Type of Sand Sediment Grains

Based on the analysis results, it is known that the type of sand or sand substrate type at Batu Hiu Beach has the characteristics of black sand grains and has a fine sand substrate type. Fine sand has the highest percentage value at

(a) (b)

Figure 3. Landing and Nesting Tracks of Olive Ridley Sea Turtles (*L. olivacea*) at Sites 4 Batu Hiu Beach on Wednesday, 14th June 2023 (a). Front side; (b) Side view

all observation sites, the natural nest conditions. The highest percentage was in Sites 4 with substrate fine sand category at 69.70%. Moreover, the very coarse sand category was not found at Station 2 but recorded the highest percentage at Station 3, with a value of 3.51%. Furthermore, the granule or gravel category was only found at Sites 4 in all observation sites with a percentage of 0.9%. Based on the results of substrate analysis, the results showed that the substrate in the semi-natural hatchery was dominated by fine sand substrate category. The processed sediment is then analyzed using the Wenworth-Udden (1922) scale (Table 2).

From Table 2, it can be seen that the largest percentage was found in hatchery with substrate category fine sand particles with a percentage of 51.02% with a sand grain size in the range of 0.25-0.125 mm. The results of the analysis of the type of sand substrate in the Batu Hiu Beach area are suitable for being a landing and nesting location for turtles, especially the Olive Ridley sea turtle (*L. olivacea*). This is in accordance with the statement by DKP (2009) that the characteristics of the nesting habitat for olive ridley sea turtles (*L. olivacea*) consist of black sand grains which have a mineral content of more than 70%.

Based on the research conducted by Sinaga (2016), it was found that the type of sand substrate at Batu Hiu Beach consists of clay mud sand. At one of the sites, the composition was 61% sand, 38% silt, and 1% clay. Fine-grained sand particles, particularly those between 0.12–0.25 mm, are often preferred for nesting because they provide the stability and proper aeration required for successful hatching. This statement was also supported by Nuitja (1992), who stated that the texture of nesting areas for sea turtles consisted of 90% sand with fine to medium grain diameters. The suitable sand texture for sea turtle nesting ranged between 0.18–0.21 mm. Based on research conducted by Malarvirzhi et al., (2023), sand types dominated by coarse sand to fine sand, with sorting characteristics from very well-sorted to poorly sorted, were identified as suitable substrates for nesting sites of olive ridley sea turtles.

3.4. Sand Temperature

Based on the results of measurements carried out in semi-natural hatchery in conservation areas during an incubation interval of 45 days, nests in hatchery have a temperature ranged in the nest between 25.3 – 42.11°C. The daily average value of sand temperature in the semi-natural hatchery above 27.4°C and below 29.7. °C. Sand temperature of hatchery can be seen at Figure 4.

Table 2. The classification results of sediment types based on Wenworth-Udden (1922) Scale Classification

Sediment Type	Size, mm	Substrate Content at Sites (%)					
		Hatchery	1	2	3	4	Average
Boulder	>256 (<-8)	0	0	0	0	0	0
Cobble	256 – 64 (-8 – -6)	0	0	0	0	0	0
Pebbie	64-4 (-6 – -2)	0	0	0	0	0	0
Granule/Gravel	4 – 2 (-2 – -1)	0	0	0	0	0.9	0
Very coarse sand	2 – 1 (-1 – -0)	0.02	0.07	0	3.51	0.01	0.72
Coarse sand	1-0.5 (1 – 2)	14.25	34.67	19.85	38.41	20.12	25.46
Medium sand	0.5-0.25 (1 – 2)	0.60	0.90	0.06	12.87	0.13	2.92
Fine sand	0.25 – 0.125 (2 – 3)	51.02	60.56	11.18	40.54	69.70	46.6
Very fine sand	0.125 – 0.062 3 – 4	30.84	0.41	65.68	0.35	4.10	19.64
Silt	0.062 – 0.004 (4 – 8)	0.03	0.03	0.10	0.02	0.66	0.16
Clay/Mud	<0.004 (>8)	0	0	0	0	0	0

Based on the results of the analysis on the graph, the measurements showed temperature fluctuations caused by weather factors. There were fluctuations in sand temperature, such as on day 14, when the temperature at 07:30 was 28.1°C, at 13:30 was 42.1°C, and at 22:30 was 31.5°C. Additionally, on day 26, the night time temperature was 0.3°C higher than the day time temperature. On day 26, the temperature at 07:30 was 27.5°C, at 13:30 was 32°C, and at 22:30 was 32.3°C. This could be attributed to partly cloudy weather conditions. According to Pelland & McKenney (2006), cloud cover can obstruct and affect insulation (incoming solar radiation); when clouds block the sun, the amount of sunlight reaching the Earth's surface decreases, resulting in a drop in temperature during the day. The sand temperature in the semi-natural hatchery was influenced by several factors including the intensity of sunlight and rainfall during the egg incubation period. According to Budiantoro et al., (2019) high rainfall caused semi-natural sea turtle nests to become wet resulting in a low hatching rate of only 23.92% in the Bantul Hatcheries, Yogyakarta.

Another research by Howard et al., (2014) indicated that both sand temperature and moisture levels have significant impacts on the developmental success of sea turtle embryos. Rising sand temperatures, largely attributed to climate change, tend to speed up the incubation process, but if these temperatures exceed the optimal threshold generally above 35°C, there was an increased risk of embryonic mortality. These high temperatures pose a critical challenge for the survival of turtle hatchlings, as they may disrupt the balance required for healthy development.

The results of the analysis using One-Way ANOVA and Tukey post hoc test indicate a significant difference in temperature at each measurement time. This finding suggests that sand temperatures in the nest fluctuate throughout the day, with each time point showing distinct temperature levels. These temperature variations may be influenced by environmental factors such as sunlight exposure, weather conditions, and shading. Shading had a significant effect on sand temperatures at nest depth with sand temperature being 1 °C warmer in the least shade treatment and 1.9 °C warmer in the no shade treatment compared to the most shade treatment (Wood et al., 2014).

3.5. Sand Humidity

Based on the results of measurements carried out in semi-natural hatchery in conservation areas during an incubation interval of 45 days, nests in hatchery have a range of sand humidity in the nest between 2%-14%. The average value of sand humidity in semi-natural hatchery can be seen in Figure 5.

Based on the displayed graph data, there were significant fluctuations in sand humidity, such as on day 25, when the humidity at 07:30 was 5%, at 13:30 was 2%, and at 22:30 was 10%. The sand humidity during the day was very low due to clear weather conditions and

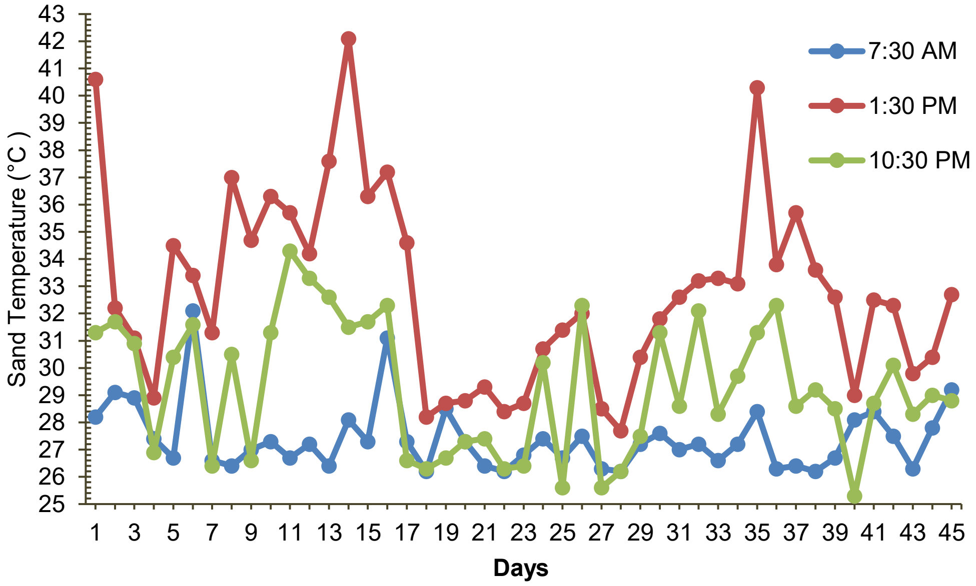

Figure 4. Daily Variation of Sand Temperature in the Hatchery at Three times of the Day

high sunlight intensity. The black color of the sand in the containers contributed to the rapid distribution of heat in the sand. The presence of black sand in the hatchery was identified as a contributing factor to the rapid heat distribution in the sand. Dark-colored sand absorb more solar radiation compared to light-colored sand, resulting in higher temperatures for eggs. Consequently, eggs in darker sand are exposed to more intense heat, potentially affecting their hatching success (Hays et al., 2001).

This is in accordance with research conducted by Yunus et al. (2022) namely the average nest humidity results obtained from observations of olive ridley sea turtle egg nests (L. olivaceae) with a depth of 30 cm in Tanjung Mampie, West Sulawesi was 7.42% Meanwhile, the average humidity of nests with a depth of 30 cm in semi-natural nests on Mampie Beach is 10.09%. The humidity conditions of the nest in the hatchery are in the normal range. This is confirmed by the statement by Limpus (1995) that eggs that are incubated in sand with a humidity percentage of 3% -12% will experience normal embryonic development. Therefore, it can be concluded that the sand within the hatchery provides a highly suitable environment for sea turtles to lay their eggs.

The results of the One-Way ANOVA and Tukey post hoc test indicate a significant difference in sample times. No significant difference was observed between the samples taken at 07:30 WIB and 22:30 WIB; however, these times differ significantly from the samples taken at 13:30 WIB. This variation may be influenced by weather conditions and rainfall. On several mornings and evenings during the sampling period, there was heavy rain which may have affected humidity levels. According to Martins et al. (2022), natural factors such as high rainfall can impact nest humidity levels by increasing water absorption in the nest sand.

3.6. Air Humidity

The results of measurements carried out in semi-natural hatchery in sea turtle conservation areas during an incubation interval of 45 days, air humidity conditions in the hatchery were between 56%-94%. The average value of air humidity in semi-natural hatchery showed in Figure 6.

Based on the displayed graph data, there were significant fluctuations in air humidity, such as on day 6, when the humidity at 07:30 was 80%, at 13:30 was 56%, and at 22:30 was 79%. Additionally, the highest humidity occurred on day 19, with an air humidity of 94%. The high air humidity was attributed to heavy rainfall. The air humidity in the semi-natural hatchery ranged from 56% to 94%. Daily average of air humidity at hatchery above 70% and below 95%. The air humidity is high due to the weather factor which is heavy rain. The results of the One-Way ANOVA and Tukey post hoc test indicate a significant difference in sample times. No significant difference was observed between the samples taken at 07:30 WIB and 22:30 WIB; however, these times differ significantly from the samples taken at 13:30 WIB. This air humidity value exceeds research

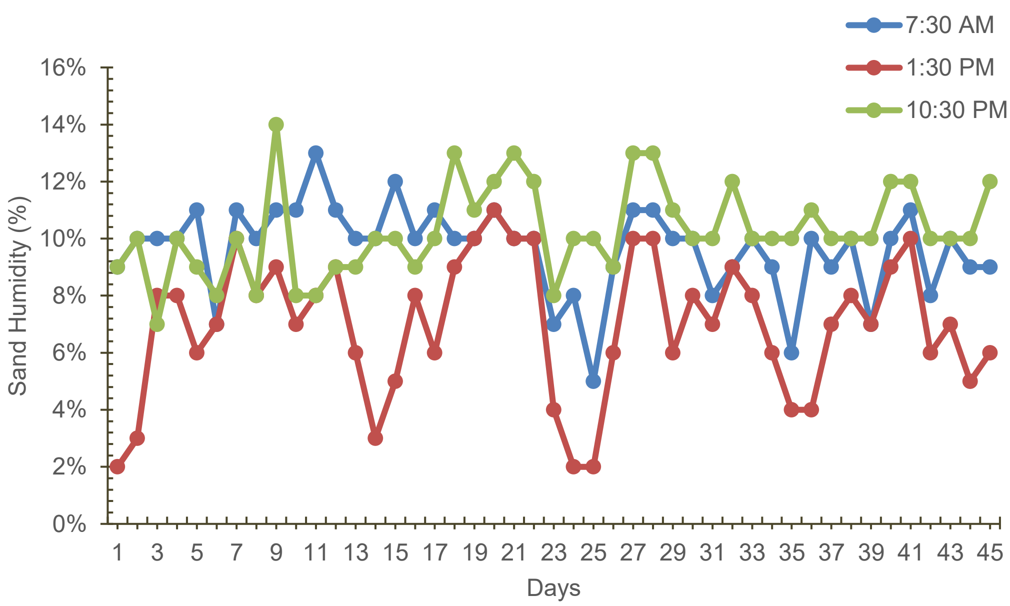

Figure 5. Daily Variation of Sand Humidity in the Hatchery at Three times of the Day

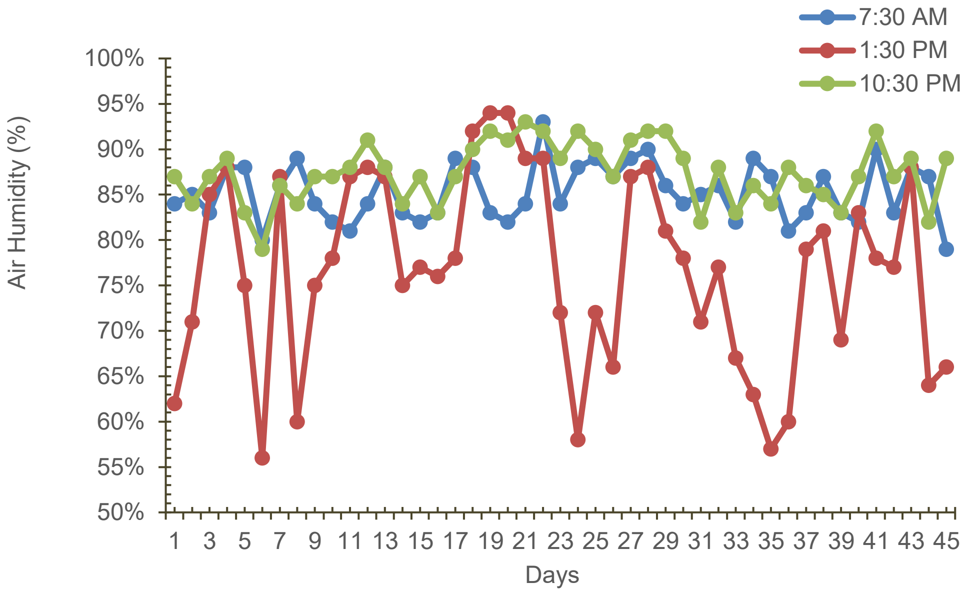

Figure 6. Daily Variation of Air Humidity in the Hatchery at Three times of the Day

conducted by Afandy and Widiastutik (2020) air humidity ranges from 85% to 89%. The air humidity was considered good, because air circulation will run well if the surface of the hatching sand media has cavities that are large enough for environmental air outside the nest to pass through to enter the nest. An environment that is too dry results in a higher percentage of deaths, because turtle eggs are very sensitive to drought (Laloë et al. 2017). Air humidity conditions in semi-natural hatchery have a value of 83.1 ± 0.06%, where these conditions are quite suitable as a location for hatching sea turtle eggs.

3.7. Hatching Success

There were 73 *L. olivacea* eggs that relocated to semi-natural hatchery at the Raksa Bintana Foundation. Not all of the *L. olivacea* eggs that were buried in semi-natural hatchery hatched into hatchlings, only 62 eggs managed to hatch into hatchlings or baby sea turtles. Eggs and hatchlings that have hatched are analyzed and categorized based on technical guidelines DKP (2009) for calculating sea turtle egg hatching numbers in accordance with research conducted by Sheavtiyan et al., (2014) and the DKP (2009). Eggs and hatchlings that have been categorized are in Table 3.

From Table 3, out of a total of 11 failed eggs, 1 hatchling died in the nest (D). Furthermore, there were 4 eggs that had hatched but had died in their egg shells or part of their bodies had come out of the egg shells (UH). There were also 6 eggs that failed to develop with the characteristics of no visible blood vessels and only egg yolk (UD). Some hatchlings that have successfully hatched but die in the nest because the hatchlings have difficulty getting out of the nest. Apart from that, the number of hatchlings that hatched is also a factor in the death of hatchlings in the nest. This is because the hatchlings leave the nest by resting on each other. The more hatchlings that hatched, the easier it will be for the hatchlings to reach the surface of the nest and vice versa.

The percentage of success in hatching *L. olivacea* eggs in semi-natural nest hatchery was 85%. This percentage was higher than the results of research conducted by Umama et al., (2020) where the hatching success of *L. olivacea* eggs hatching in semi-natural nests was 75% at Boom Beach, Banyuwangi. In addition, the hatching percentage of *L. olivacea* eggs based on research by Yunus et al. (2022) at Mampie Beach showed a high hatching rate in natural nests with an average percentage of 76.20%.

The difference in hatching success rates compared to the previous research conducted by Samosir (2018) is due to the sand in semi-natural nests having a pH below 4.5, which is classified as highly acidic. This acidity results from the lack of sand replacement during each hatching period, whereas the sand in the semi-natural hatching tanks at Yayasan Raksa Bintana Batu Hiu is replaced every three months. Additionally, the factor of depth also affects the success of egg hatching because variations in depth can affect temperature and

Table 3. Hatching Success at semi-natural Hatchery Raksa Bintana Foundation.

No.	Classification	Eggs
1.	Total Eggs	73
2.	Shell (S)	62
3.	Live in nest (L)	-
4.	Dead in nest (D)	1
5.	Unhatched term (UHT)	-
6.	Unhatched (UH)	4
7.	Undeveloped (UD)	6
	Hatching Success (HS %)	85%

(i) (ii) (iii)

Figure 7. (i) (a) Undeveloped Eggs only egg yolk (UD); (ii) Sea turtles eggs were broken; (b) Unhatched, (Fully developed hatchlings that were ready to emerge but died within the eggshell) (UH); (iii) (c) Dead in nest, were hatchlings that died in the nest

humidity, which can disrupt the incubation of eggs. The deeper the nest, the more difficult it was for hatchlings to reach the surface. Hatchlings require amount of energy to climb to the surface, thus increasing the possibility that they may suffocate before reaching the surface. Some eggs that failed to hatch may have also been infertile or unfertilized. Approximately 12% of the total *L. olivacea* eggs in Costa Rica were infertile eggs (O'Brien, 2018). Based on the results of research conducted at the semi-natural hatchery of the Raksa Bintana Foundation, the location of the semi-natural hatchery in the conservation area was found to be a suitable and relatively good hatching location.

4. Conclusion

The research concluded that all parameters, including nest shape, nest depth, nest diameter, type of sand, sand temperature, sand humidity and air humidity in semi-natural hatchery are in accordance with natural nest conditions for hatching Olive Ridley turtle eggs (L. olivacea) with a hatching success rate of 85%. Meanwhile, 15% of hatching failures are due to eggs that fail to develop or are infertile, and to the weak condition of hatchlings, which prevents them from reaching the surface. There are several threats that could cause a decrease in sea turtle landings and nesting in the Batu Hiu Beach area because the Batu Hiu area because there are fishing activities at night which can disrupt sea turtle landings. One of the efforts to increase the sea turtles population is by relocating eggs from the beach to conservation sites, such as the sea turtle conservation center program by the Raksa Bintana Foundation at Batu Hiu. At these semi-naturals sites, the eggs can be incubated until they hatch and then released back into the open sea.

Acknowledgements

Gratitude is extended to Raksa Bintana Foundation, Batu Hiu Pangandaran for granting permission and providing assistance in this research.

References

Abakumov, A. I., & Kozitskaya, I. S. (2023). Mathematical Model of Phytoplankton Interspecific Competition for Food Resource. *Mathematical Biology and Bioinformatics*, *18*(12), 568–579. https://doi.org/10.17537/2023.18.568

Abreu-Grobois, A and Plotkin, P. (IUCN SSC Marine Turtle Specialist Group). 2008. Lepidochelys olivacea. The IUCN Red List of Threatened Species 2008: e.T11534A3292503. https://dx.doi.org/10.2305/IUCN.UK.2008. RLTS.T11534A3292503.en . Accessed on 26 June 2024.

Afandy, Y. A., & Widiastutik, R. 2020. RPZ-Management and Zoning Plan - Regional Marine Conservation Area, Waters in the Pangandaran Regency, West Java Province, Marine and Fisheries Service of West Java Province.

Benni, B., Adi, W., & Kurniawan, K. 2018. Analysis of the Characteristics of Natural Sea Turtle Nesting Sites. Akuatik: Journal of Aquatic Resources. 11(2): 1–6. https://doi.org/10.33019/akuatik.v11i2.237

Berry, M., Booth, D.T., Limpus, C.J. 2013. Artificial lighting and disrupted sea-finding behaviour in hatchling loggerhead turtles (Caretta caretta) on the Woongarra coast, south-east Queensland, Australia. Australian Journal of Zoology. 61: 137-145. https://doi.org/10.1071/ZO13028

Blott, S.J., and Pye, K. 2001. GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth Surface Processes and Landforms. 26:1237-1248.

Bourgeois, S., Gilot-Fromont, E., Viallefont, A., Boussamba, F., Deem, S.L. 2009. Influence of artificial lights, logs and erosion on leatherback sea turtle hatchling orientation at Pongara National Park, Gabon. Biological Conservation. 142: 85-93. https://doi.org/10.1016/j.biocon.2008.09.028

Brand, G. E. (Ed.). 1999. Guidelines for marine turtle nest protection and egg relocation conservation projects. World Society for the Protection of Animals. http://www.seaturtle.org/library/BrandGE_1999_Guidlinesformarineturtlenestprotect.pdf

Budiantoro, A., Retnaningdyah, C., Hakim, L., Leksono, A. S. 2019. Characteristics of Olive Ridley Sea Turtle (Lepidochelys olivacea) Nesting beaches and hatcheries in Bantul, Yogyakarta, Indonesia. Biodiversitas. 20(11): 3119–3125. https://doi.org/10.13057/biodiv/d201103

Dahuri, R. 2003. Marine Biodiversity: An Asset for Sustainable Development of Indonesia. Gramedia Pustaka Utama, Jakarta.1-412.

Damanhuri, D. 2007. Pola Jejak Penyu di Pulau Karabak Ketek, Kawasan Konservasi Laut Daerah (KKLD), Sumatera Barat. SIGMATEK. 1(2): 115.

Damanhuri, H., Putra, A., & Troa, R. A. 2019. Bio-Physical Characteristics of Sea Turtle Nesting Beaches on Pulau Laut-Sekatung, Natuna Regency–Riau Islands Province. Proceedings of the National Master Symposium. 2: 1–15.

Darmawan, R. 1997. Pengaruh Waktu Pemindahan Telur dari Sarang Alami ke Sarang Semi Alami terhadap Keberhasilan Penetasan Telur Penyu Lekang (Lepidochelys olivacea). Prosiding Workshop Penelitan dan Pengelolaan Penyu di Indonesia. Bogor.

Department of Roads. 2016. Manual of Standard Tests on Aggregates. Government of Nepal Ministry of Physical Infrastructure and Transport,

Djohar. 1987. Green Sea Turtle (Chelonia mydas) Nesting Behavior as a Source of Learning Animal Behavior. Cakrawala Pendidikan. 6(1): 78–89.

DKP RI. 2009. Technical Guidelines for Sea Turtle Conservation Management. Ministry of Marine Affairs and Fisheries RI, Directorate of Conservation and Marine National Parks, Directorate General of Marine, Coastal and Small Islands.

Dumasari, S. 2014. Analysis of Olive Ridley Turtle Habitat in East Java. Brawijaya University. Thesis.

Field, A. 2018. Discovering Statistics Using IBM SPSS Statistics (5th Edition). SAGE Publications.

Gibbons, M.J. and Richardson, A.J. 2009. Patterns of jellyfish abundance in the North Atlantic. Hydrobiologia 616:51-65.

Hays, G.C., Ashworth, J.S., Barnsley, M.J., Broderick, A.C., Emery, D.R., Godley, B.J., Henwood, A., Jones, E.L. 2001. The importance of sand albedo for the thermal conditions on sea turtle nesting beaches. Oikos. CrossRef. 93: 87–94

Hendrix, H., Pérez-Espona, S. A. 2024. Systematic Review of Population Monitoring Studies of Sea Turtles and Its Application to Conservation. Diversity. 16(3): 177. https://doi.org/10.3390/d16030177

Hermawan, D. 1992. Study of hawksbill turtle nesting habitat (Eretmochelys Imbricata) on the eastern and western islands of eastern islands Seribu National Park Jakarta. Faculty of Fisheries Department of Aquatic Resources Management. Institut Pertanian Bogor, Bogor.

Howard, R., Bell, I., & Pike, D. A. 2014. Thermal tolerances of sea turtle embryos: Current understanding and future directions. *Endangered Species Research. 26*: 75-86. http://dx.doi.org/10.3354/esr00636

Kamrowski, R.L., Limpus, C., Pendoley, K., Hamann, M. 2015. Influence of industrial light pollution on the sea-finding behaviour of flatback turtle hatchlings. Wildlife Research. 41: 421-434. https://doi.org/10.1071/WR14155

Laloë, J. O., Cozens, J., Renom, B., Taxonera, A., & Hays, G. C. 2017. Climate change and temperature-linked hatchling mortality at a globally important sea turtle nesting site. Global Change Biology. 23(11): 4922–4931. https://doi.org/10.1111/gcb.13765

Leech, A. 2008. False Crawls by Loggerhead Sea Turtles in Palm Beach County, Florida. Thesis, Wilkes Honors College of Florida Atlantic University. 22 p.

Leon, Y.M. and Bjorndal, K.A. 2002. Selective feeding in the hawksbill turtle, an important predator in coral reef ecosystems. Marine Ecology Progress Series 245: 249-258.

Limpus C.J. 1995. Conservation of marine turtles in the Indo-Pacific Region. Australian Nature Conservation Agency, Australia.

Lorne, J,K., Salmon, M. 2007. Effects of exposure to artificial lighting on orientation of hatchling sea turtles on the beach and in the ocean. Endangered Species Research. 3: 23-30. https://doi. org/10.3354/esr003023

Malarvizhi, A., Ilaamurughu, M.M. and Mohan, P.M. 2023. The Probable Cause for Nesting Pattern of Olive Ridley (Lepidochelys olivacea) at Ramnagar Beach, North East Coast of Andaman Island, India. Open Journal of Marine Science. 13: 7-27. https://doi.org/10.4236/ojms.2023.131002 %

Mardiana, E., Pratomo, A., & Irawan, H. 2013. Success Rate of Green Sea Turtle (Chelonia mydas) Egg Hatching on Wie Tambelan Island in Lagoi. Jurnal UMRAH (Universitas Maritim Raja Ali Haji). 12: 1–7.

Martins, S., Patino, J., Abella, E., de Santos Loureiro, N., Clarke, L. J., & Marco, A. 2022.Potential Impacts of Sea Level Rise and Beach Flooding on Reproduction of Sea Turtles. Journal Elsevier : Climate Change Ecology. 3: 100053. https://doi.org/10.1016/j.ecochg.2022.100053

Martins, S., Ferreira-Veiga, N., Rodrigues, Z., Querido, A., de Santos Loureiro, N., Freire, K., ... Marco, A. 2021. Hatchery efficiency as a conservation tool in threatened sea turtle rookeries with high embryonic mortality. Ocean and Coastal Management, 212. doi: 10.1016/j.ocecoaman.2021.105807

Muliani, M., Erlangga, E., Mutia, M., Ayuzar, E., & Mahdaliana, M. 2022. Characteristics of Turtle (Lepidochelys olivaceae) Nesting Ground in Gelumpang Sulu Timur Village, Dewantara Sub-district, North Aceh Regency. Journal of Biology and Nuclear Learning. 8(2): 302–316. https://doi.org/10.36987/jpbn.v8i2.2547

Nuitja, I. N. S. 1992. Biology and Ecology of Sea Turtle Conservation. IPB Press.1-128

O'Brien, N. 2018. A Correlation Study of the Nest Incubation Period and Hatchling Development and Success Rate for Olive Ridley Sea Turtles (Lepidochelys olivacea) Turtle Conservation: Playa Junquillal, Costa Rica. Honors Research Projects. 23: 762.

Onny, M. D. A., Zangri, K., Ermelinda, M., Fransiskus, K. D. M., & A. V. 2020. Physical Characteristics of Beaches and Distribution of Natural Olive Ridley Sea Turtle (Lepidochelys olivacea) Nests on Sosadale Beach, Rote-Ndao, East Nusa Tenggara. Biofaal Journal. 1(2): 55–65. https://doi.org/10.30598/biofaal.v1i2pp55-65

Pelland, S., & McKenney, D. W. 2006. The Development of Photovoltaic Resource Maps forfor Canada. Annual Conference of the Solar Energy Society of Canada. 31: 1-8.

Perda Jawa Barat. 2019. West Java Provincial Regulation Number 5 of 2019 Concerning Zoning Plans for Coastal Areas and Small Islands of West Java Province. 1-166. https://peraturan.bpk.go.id/Details/228343/pergub-prov-jawa-barat-no-5-tahun-2019

ProFauna-Indonesia. 2005. Investigation Report on Sea Turtle Trade in the Southern Coast of Java. 1-14.

Purcell, J.E., Shin-ichi, U., Wen-Tseng, L. 2007. Anthropogenic causes of jellyfish blooms and their direct consequences for humans: A review. Mar. Ecol. Prog. Ser. 350: 153-174.

Samosir, S. H., Hernawati, T., Yudhana, A., &

Haditanojo, W. 2018. The Difference Between Natural with Semi-Natural Nest Conduct the Incubation Period and Hatching Rate of Lekang Turtle's Egg (Lepidocheliys olivacea) in Boom Seashore Banyuwangi. Jurnal Medik Veteriner. 1(2): 33–37.

Sheavtiyan, T., Setyawati, T. R., & Lovadi, I. 2014. Success Rate of Green Sea Turtle (Chelonia mydas, Linnaeus 1758) Egg Hatching at Sebubus Beach, Sambas Regency. Protobiont Journal. 3(1): 46–54.

Sinaga, J. R. 2016. Habitat Study of Flatback Turtle (Natator depressus) Nesting at Batu Hiu Beach, Pangandaran Regency. Bachelor Thesis. Jenderal Soedirman University.1-64.

Tabachnick, B. G., & Fidell, L. S. 2013. Using Multivariate Statistics (6th Edition). Pearson Education. New Jersey 07458 1018 p.

Thayer, G.W., Bjorndal K.A., Ogden, J.C., Williams, S.L., Zieman, J.C. 1984. Role of larger herbivores in seagrass communities: Functional ecology of seagrass ecosystems: A perspective on plant-animal interactions. Estuaries. 7(4): 351-376.

Umama, A. R., Restiadi, T. I., Prastiya, R. A., Safitri, E., Saputro, A. L., Yudhana, A., & Haditanojo, W. 2020. Success Rate of Olive Ridley Sea Turtle (Lepidochelys olivacea) Egg Hatching in Semi-Natural Nests at Boom Beach, Banyuwangi, 2018 Period. Veterinary Medical Journal. 3(1): 17. https://doi.org/10.20473/jmv.vol3.iss1.2020.17-24

Wentworth-Udden, C.K. 1922. A Scale of Grade and Class Terms for Clastic Sediments. Journal of Geology. 30: 377–394.

Wilson, E. ., Miller, K. ., Allison, D., & Magliocca, M. 2010. Why Healthy Oceans Need Sea Turtles: The Importance of Sea Turtles to Marine Ecosystems. OCEANA Protecting the World's Oceans. oceana.org/seaturtles

Wood, A., Booth, D. T., & Limpus, C. J. 2014. Sun exposure, nest temperature and loggerhead turtle hatchlings: Implications for beach shading management strategies at sea turtle rookeries. Journal of Experimental Marine Biology and Ecology. 451: 105–114. doi:10.1016/j.jembe.2013.11.005

Yunus, B., Yanuarita, D., & Parawansa, B. S. 2022. Physical Condition of Spawning Habitat for Olive Ridley Turtle (Lepidochelys olivacea) in Coastal Waters of Polewali Mandar Regency, Makassar Strait. International Journal of Social Relevance & Concern. 10(1): 58–71. https://doi.org/10.26821/ijsrc.10.1.2022.100108

Yusuf, A. 2000. Mengenal Penyu. Yayasan Alam Lestari. Jakarta