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ANALYSIS OF TURTLE CONSERVATION ACTIVITIES EFFECTIVENESS ON KELAPA DUA ISLAND, KEPULAUAN SERIBU

ANALISIS EFEKTIVITAS KEGIATAN KONSERVASI PENYU DI PULAU KELAPA DUA, KEPULAUAN SERIBU

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Abstract

The exploitation of turtles has resulted in a decline in the turtle population. The relocation of turtle eggs from nesting habitats is a widely accepted conservation practice. This research aims to analyze the effectiveness of turtle conservation activities on Kelapa Dua Island. The study adopts a mixed-methods approach, collecting primary data through field observations and interviews and secondary data from the Kepulauan Seribu National Park Office (BTNKpS). The collected data includes information on turtle nest monitoring activities, turtle preservation techniques, and the hatching success rate. The research results show that the hawksbill turtle (*Eretmochelys imbricata*) is the most commonly found turtle species. The average hatching success rate over the past six years is 71.98%. This value can still be optimized to reach 80% by establishing hatcheries on the nesting islands or islands near the nesting sites. Through this strategy, monitoring can be conducted more regularly, the turtle egg relocation process can be carried out relatively quickly, and vibrations or shocks to the turtle eggs during transportation can be minimized, thus increasing the hatching success rate. Regular monitoring of the environmental conditions of the artificial nests, including temperature, pH, and humidity, is also essential to improve the hatching percentage.

Keywords: Conservation; Hatching success; Turtle

Abstrak

Eksploitasi penyu telah menyebabkan penurunan populasi penyu. Relokasi telur penyu dari habitat penetasan adalah praktik konservasi yang umum diterima. Penelitian ini bertujuan untuk menganalisis efektivitas kegiatan konservasi penyu di Pulau Kelapa Dua. Studi ini mengadopsi pendekatan metode campuran, mengumpulkan data primer melalui observasi lapangan dan wawancara serta data sekunder dari Balai Taman Nasional Kepulauan Seribu (BTNKpS). Data yang terkumpul meliputi informasi tentang kegiatan pemantauan sarang penyu, teknik pelestarian penyu, dan tingkat keberhasilan penetasan. Hasil penelitian menunjukkan bahwa penyu sisik (Eretmochelys imbricata) merupakan spesies penyu yang paling banyak ditemukan. Tingkat keberhasilan penetasan rata-rata selama enam tahun terakhir adalah 71,98%. Nilai ini masih bisa dioptimalkan hingga mencapai 80% dengan mendirikan hatchery di pulau-pulau peneluran atau pulau-pulau yang berdekatan dengan lokasi peneluran. Melalui strategi ini, pemantauan dapat dilakukan lebih rutin, proses relokasi telur penyu dapat dilakukan dengan relatif cepat, dan getaran atau benturan pada telur penyu selama proses transportasi dapat diminimalkan, sehingga meningkatkan tingkat keberhasilan penetasan. Pemantauan teratur terhadap kondisi lingkungan sarang buatan, termasuk suhu, pH, dan kelembaban, juga penting untuk meningkatkan persentase penetasan.

***Kata Kunci**: Penyu; Konservasi; Hatching success*

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INTRODUCTION

Excessive exploitation and habitat destruction have led to a decline in populations and the extinction of several wildlife species worldwide (Martínez-Estévez et al., 2023). Long-lived species with a slow generation time are susceptible to anthropogenic impacts, and one such species is the turtle (Lotze et al., 2011). Turtles are migratory species, and a significant part of their life is closely tied to coastal habitats, making them vulnerable to human activities such as fishing, pollution, habitat modification, egg harvesting, and adult turtle capture (Miguel et al., 2022). The high economic value of turtles has led to significant trade for consumption (Veríssimo et al., 2020), souvenirs, and medicinal purposes (Nurhayati et al., 2022), resulting in a decline in population numbers.

Turtle protection has been conducted nationally and internationally (Sardeshpande & MacMillan, 2019). Internationally, turtles are included in Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), indicating that the import and export can only be conducted in some instances (Saladin, 2021). Furthermore in 1982, the International Union for Conservation of Nature (IUCN) listed turtles on the red list as endangered species (Fahmi & Rizki, 2022). In Indonesia, turtle conservation is regulated by the Government Regulation of The Republic of Indonesia No.7/1999 on Preserving Flora and Fauna Species. Turtle conservation requires global handling measures and the commitment of many countries, especially those serving as the pathways for turtle distribution.

The relocation of turtle eggs from nesting habitats to protected hatcheries to avoid threats from predators, floods, and tidal erosion to natural nests is a widely accepted conservation practice. It has also been implemented in Indonesia (Evans et al., 2022). Generally, the relocation of turtle eggs is carried out from natural nests to protected hatcheries with standard procedures such as avoiding vibrations and rotation during egg rescue and ensuring that the hatchery conditions replicate the natural nest in terms of shape and depth (Martins et al., 2021). Relocating eggs and caring for hatchlings are conducted at the turtle conservation site, Kelapa Dua Island, part of the National Park Management Unit (SPTN) Region I, Kepulauan Seribu National Park (BTNKpS).

The conservation activities on Kelapa Dua Island include relocating turtle eggs, hatching and rearing, and releasing hatchlings (Sosiawan & Setia, 2023; Indrajaya et al., 2018). Sea turtle conservation on Kelapa Dua Island has been carried out since 2007. During this period, sea turtle exploitation was still occurring on the island, so conservation activities focused on educating the public about the importance of sea turtle conservation. Due to tourism development, Kelapa Dua Island is no longer a turtle nesting island. However, conservation efforts continue by relocating turtle eggs from nesting islands in the SPTN I area and integrating these efforts with tourism activities. These conservation activities are expected to enhance the success of turtle egg hatching and improve the chances of survival in the wild (Dermawan et al., 2009). The effectiveness of turtle conservation activities needs to be assessed because if the conditions and management are not optimal, using hatcheries for conservation purposes may result in more losses than benefits (Tisdell & Wilson, 2005). Relocation activities can lead to changes in physical conditions, such as an unbalanced gender ratio (Liles et al., 2019), low hatching success, morphological differences, and changes in incubation duration (Candan, 2018). Based on these considerations, this research aims to analyze the effectiveness of turtle conservation activities on Kelapa Dua Island, Kepulauan Seribu. The study results can provide input for the National Park authorities in developing sustainable turtle conservation activities.

MATERIALS AND METHODS

This research was conducted in December 2022 at the turtle conservation site, Kelapa Dua Island, Kepulauan Seribu Utara Subdistrict, Kepulauan Seribu Regency, DKI Jakarta. Geographically, Kelapa Dua Island is located at 5°38'57"S 106°34'01"E, bordered by the Java Sea to the north and south, Harapan Island Village to the east, and Panggang Island Village to the south.

This research utilizes a mixed-method approach, combining both quantitative and qualitative methods. The types of data in this study include primary and secondary data. Primary data was obtained through in-depth interviews with the manager of the turtle conservation site on Kelapa Dua

Island and direct observation at the site. Secondary data were collected from the Kepulauan Seribu National Park for 2018–2023. Table 1 shows the details of data collection.

Table 1. Types of data and data collection methods

Data groups	Data	Collection methods
Sea turtle nest monitoring activities	Types of sea turtle	Structured observation, in-depth interview dan secondary data
	Origin of sea turtle eggs	In-depth interview and secondary data
	Number of turtle eggs nest	Secondary data
	Frequency of monitoring	In-depth interview
Sea turtle conservation techniques	Stages of turtle conservation activities	Secondary data and in-depth interview
	Conservation facilities	Structured observation
	Types of sea turtle food	In-depth interview
Hatching success rate	Number of eggs relocated	Secondary data
	Number of eggs that successfully hatched	Secondary data
	Number of eggs that failed to hatch	Secondary data
	Number of hatchlings that died	Secondary data
	Number of hatchlings released	Secondary data
	Hatching rate	Secondary data
	Mortality rate	Secondary data

The data analysis of the research was conducted using descriptive statistical methods. The descriptive statistical analysis method processed secondary data on sea turtle conservation activities. Data related to the number of eggs and hatchlings were presented in tabular form and analyzed by comparing the difference between the number of eggs hatched and the number of hatchlings successfully released to the sea. Hatchling mortality rates were also presented in tables to observe trends over time. The results are then described in sentences and linked to monitoring activities, egg origin, turtle species, and other management activities. This study only focuses on the analysis of conservation activities at the turtle conservation site, and therefore, no direct analysis was conducted on the turtle nesting area.

RESULTS

Sea Turtle Nest Monitoring Activities

In the last six years, most of the turtle eggs found were of the hawksbill turtle species (*Eretmochelys imbricata*). From a total of 45 nests relocated in the last six years, 44 nests were of the hawksbill turtle species (*Eretmochelys imbricata*), and one nest was of the green turtle species (*Chelonia mydas*) (Table 2). These turtle eggs came from monitoring activities and fishing communities that often caught turtles in their nets. Monitoring turtle nests in SPTN I TNKpS was conducted simultaneously with monitoring wildlife (flora and fauna). Routine monitoring was carried out twice a month. Monitoring activities usually took more than one day because the nesting islands were relatively distant from the conservation site. Turtle nest monitoring was conducted during the nesting season, approximately from December to June, with only three islands able to be visited in each monitoring session. Therefore, not all turtle nests from the eight nesting islands (Table 2) could be relocated during the nesting season.

The data shows eight turtle nesting islands in the SPTN I TNKpS area (Table 2). These islands are included in the Core Zone and Utilization Zone. The islands included in the Core Zone are Gosong Rengat Island and Gosong Kapas Island. The Core Zone is a protected area where no changes due to human activities are allowed. The other six islands are included in the Utilization Zone are Yu Timur Island, Yu Barat Island, Kapas Island, Sebaru Kecil Island, Pantara Barat Island, and Melinjo Island. The Utilization Zone is designated for research, education, nature/marine tourism, and species breeding to support research activities, infrastructure development, habitat management, and traditional use (Balai Taman Nasional Kepulauan Seribu, 2023).

Table 2. Number of nests and origin of turtle eggs in SPTN I TNKpS Region 2018-2023 (Balai Taman Nasional Kepulauan Seribu, 2023)

Nesting island	Number of nests					
	2018	2019	2020	2021	2022	2023
Yu Timur Island	5	5	3	4	4	3
Kapas Island	1	1				
Gosong Rengat Island	2	1	2	2	3	1
Pantara Barat Island		1				
Sebaru Kecil Island			1			
Gosong Kapas Island			1			
Melinjo Island			1	1		1
Yu Barat Island					1	1
Total	8	8	8	7	8	6

Based on the research data, the average number of nests successfully relocated in the SPTN I TNKpS area is eight nests per year. This number is lower than other turtle conservation areas in Indonesia, such as in Jeen Womom Papua, where the number of nests can reach 2,000 per year; the turtle conservation area at Perancak Beach Bali can relocate as many as 300–450 nests per year, on Mangkai Island, Kepulauan Anambas as many as 615 nests relocated in 2022 (Sinaga et al., 2024; Roeroe et al., 2023). The need for more relocated nests is due to challenges in monitoring activities, such as unfavorable weather during nesting season and the relatively distant location of nesting islands from the conservation site. The number of nests and the origin of turtle eggs can be seen in Table 2. The managers of the turtle conservation site on Kelapa Dua Island should consider providing conservation facilities on islands near nesting locations and increasing budget allocation for monitoring activities to be more effective, especially during nesting season.

Turtle Conservation Techniques

Generally, turtle conservation activities on Kelapa Dua Island consist of egg relocation, semi-natural hatching, hatchling rearing, and hatchling release. Several hatchlings from semi-natural hatching are raised in conservation areas for educational tourism purposes (Figure 1). The relocation of eggs from natural nests to the conservation hatchery is carried out during monitoring using buckets as containers for the eggs. The buckets used are plastic buckets with 40–50 L volume. The buckets are filled with sand, with the depth adjusted to match the depth of the natural nests. Generally, the nest depth is approximately three-quarters of the total height of the bucket. The eggs in one bucket are typically from a single mother turtle, numbering around 100–150. The buckets are then laid down in an enclosed room. Hatching usually occurs 45–60 days after the eggs are stored. During the incubation period of the turtle eggs, no temperature measurements, sand replacement, or watering of the nests are carried out. Next, the hatchlings that hatch and survive are transferred to rearing tanks. Hatchlings transferred to the rearing tank no longer have umbilical cords, but their water cords are separated and placed in special containers until their water lines are clean. The data collected include, among other things, the date of hatching, the number of hatchlings hatching, the number of eggs hatched with embryos, and the number of eggs laid without embryos.

Figure 1. Turtle egg collection natural nest (a) and semi-natural hatching nests (b) (Source: Balai Taman Nasional Kepulauan Seribu, 2023)

The hatchlings are reared for 3–6 months before being released back into the sea (Figure 2). There are four hatchling-rearing pools with dimensions of 220 cm long, 80 cm wide, and 50 cm deep. Rearing of young and adult turtles is carried out in two large ponds, which are differentiated based on species, namely the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle (*Chelonia mydas*). The green turtle (*Chelonia mydas*) rearing pond is 660 cm long, 90 cm wide, and 50 cm deep. The hawksbill turtle (*Eretmochelys imbricata*) rearing pond is 56 cm long, 220 cm wide, and 70 cm deep.

Figure 2. Rearing pool hatchlings (a), hawksbill turtle (*Eretmochelys imbricata*) (b), and green Turtle (*Chelonia mydas*) (c)

Turtles or hatchlings placed in the rearing tanks be fed daily approximately 10 – 20 % of their body weight with chopped and filleted fish. The technical guidelines do feeding twice a day (morning and evening) for turtle conservation management (Dermawan et al., 2009), using flying fish (*Decapterus* spp.) and trevally (*Selaroides leptolepis*). These two types of fish have high protein content and are suitable for turtle feed. Flying fish contains 22% protein, 1% fat, and 109 calories of energy (Perangin-angin et al., 2021). Likewise, trevally contains 18.8% protein (Nurhayati et al., 2007). These two types of fish are pretty easy to obtain around Kelapa Dua Island because most of the local people work as fishermen. Generally, tiny hatchlings in one pool can consume 0.5 kg of food, while adult turtles can consume 1 kg of food. In a single day, hatchlings and adult turtles can consume 6 kg of food for two meals.

Carrying out a water change once per day for balancing the water going in and out of the circulation system usually after feeding. Pool cleaning is carried out three times a week. This is done to prevent the growth of diseases caused by fungi, as one of the causes of hatchling mortality in the conservation area is fungal infections on the fins, neck, and eyes. Based on technical guidelines for turtle conservation management, no provisions exist on the size of rearing ponds (Dermawan et al., 2009). They clean the tanks daily by scrubbing the inside, occasionally using Porstex or similar cleaning agents. However, the TNKpS turtle conservation managers must regulate the number of hatchlings and turtles in a single pool to prevent them from biting each other. According to the technical guidelines for turtle conservation management (Dermawan et al., 2009), there is no specified maximum number of hatchlings for rearing pools. The number of hatchlings or turtles is adjusted according to the available pool size. Additionally, the provision of hatching containers must be considered if the turtle egg hatching is not conducted semi-naturally in an open location.

After six months, the hatchlings are released back into the sea. The release is usually carried out in their original habitat during monitoring activities by using plastic containers. Generally, each container holds ten hatchlings or two adult turtles. Hatchlings can also be released on the coast of Kelapa Dua Island during special events. The TNKpS turtle conservation managers will collaborate with specific agencies to release hatchlings during these events. After the hatchlings are released, no further monitoring is conducted as tagging activities have not yet been implemented in the TNKpS turtle conservation area.

The turtle conservation area on Kelapa Dua Island is considered safe. The management also supervises educational tourism activities. The number of tourists has increased yearly, reaching 17,951 in 2023. Most visitors come from outside the Thousand Islands on Saturdays and Sundays. Many tourists visiting the conservation area can indirectly stress the turtles. Hence, conservation managers must regulate the number of visitors entering the conservation area.

Hatching Success Rate

The percentage of turtle deaths was also calculated, and fluctuating values were obtained, as shown in Table 3 below. Based on this table, the number of eggs rescued in the SPTN I TNKpS area from 2018 to 2021 decreased before bouncing back in 2022. Moreover, the number of hatchlings released decreased in 2018–2021 and before recovering in 2022. The decrease in numbers was due to the impact of the COVID-19 pandemic, where officer mobility was limited and monitoring was rarely conducted. Based on the calculation results, the average hatching success value for turtle eggs in the SPTN I, TNKpS area over the last six years was 71.98%.

Table 3. Recapitulation number of sea turtles in the SPTN I TNKpS region in 2018-2023 (Balai Taman Nasional Kepulauan Seribu, 2023)

Year	Relocated eggs	Hatchlings released	Dead hatchlings	Hatched eggs	Failed hatch	Hatching success	Mortality rate
2018	1208	862	94	998	210	78,96%	9,41%
2019	1113	802	131	919	194	79,9%	14,26%
2020	1103	590	169	788	315	60,02%	21,45%
2021	844	381	98	499	195	60,93%	19,64%
2022	898	720	106	741	157	78,8%	14,30%
2023	870	530	97	638	232	73,3%	15,20%

DISCUSSION

Based on research findings, the average hatching success rate of turtle eggs on Kelapa Dua Island over the past six years is 71.98%. This figure still needs to be below 80%. According to Samosir et al. (2018), turtle hatchery management is optimal if it achieves a more than 80% hatching success rate). The low hatching rate in turtle conservation areas can be caused by less than optimal handling at the egg collection, transportation, and hatching stages (Phillott et al., 2021).

The relocation of turtle eggs in SPTN I TNKpS on nesting islands far from the conservation site. The significant distance between the nesting islands and the conservation site can pose challenges in relocating turtle eggs. This condition results in longer travel times for relocation. Although turtle eggs are relocated using buckets, which also serve as artificial nests, during the transfer process, vibrations that may occur could potentially damage the embryo membrane of the turtle eggs. This is supported by research by Nasiri et al. (2023), stating that increased time and distance for relocating eggs to the hatching site can reduce hatching success. Another negative factor is the vibrations generated by the transportation used.

Turtle eggs should ideally be relocated within 2 hours after oviposition or nesting (Phillott et al., 2021). The first 2 hours are critical for the formation of the embryo membrane. If relocation is done after 2 hours, the position of the eggs must match their original position during oviposition. This action aims to prevent damage to the embryo membrane. A damaged embryo membrane can result in a significant decrease in the hatching success rate.

The incubation of turtle eggs on Kelapa Dua Island is conducted inside closed buckets stored indoors. Incubation using this technique can affect the optimal temperature and humidity for the success of turtle egg hatching. This is supported by research conducted by Samosir et al. (2018), which indicates that differences in the humidity levels between natural and semi-natural nests can result in an average hatching success rate of 0%. Nest humidity is related to the process of nest watering and sunlight exposure. Continuous nest watering without sunlight exposure can lead to hatching failure (Phillott et al., 2021; Samosir et al., 2018).

The percentage of turtle egg hatching can be optimized to more than 80%. A strategy that could be developed is establishing semi-natural hatcheries directly on nesting islands. According to the Guidelines for Turtle Conservation Management in Southeast Asia (Ahmad et al., 2004), this strategy can effectively enhance hatchling success, primarily if the government focuses on turtle conservation aspects. Nests are built in the supratidal zone, which is located above the highest tide zone and generally not flooded by seawater except during very high tides (Ahmad et al., 2004; Dermawan et al., 2009). This conservation technique is also implemented in other countries, such as Cape Verde and Cousine Island (Seychelles), resulting in consecutive hatching success rates of 85% and 84.6%, respectively (Evans et al., 2022; Martins et al., 2021).

Establishing hatcheries directly on the nesting islands can also facilitate monitoring activities, as the distance between the nesting islands and the conservation site is one of the challenges for monitoring turtle nests. Through this strategy, monitoring can be carried out more regularly, especially during the nesting season, by providing adequate facilities and increasing human resources for intensive supervision and maintenance. However, this strategy would be challenging if the government aims to integrate conservation and ecotourism activities. Most nesting islands are in core zones that do not permit tourism activities. Therefore, another alternative strategy that could be considered if the government intends to integrate turtle conservation and ecotourism is establishing turtle conservation centers on other islands close to nesting islands and not included in core zones.

Based on the table data regarding the number and location of nests, turtle eggs can be found on islands within the Utilization Zone, such as Yu Timur Island, Yu Barat Island, Kapas Island, Sebaru Kecil Island, and Melinjo Island. Currently, these islands remain uninhabited. However, their status as Utilization Zones allows for potential development and marine tourism activities in the future. The government can consider establishing semi-natural hatcheries integrated with tourism activities on these islands. Nest protection from monitor lizard predators can be implemented using interlocking aluminum mesh panels, as demonstrated by (Hof et al., 2020), who successfully proved that using these panels effectively reduced predation of loggerhead turtle nests at Wreck Rock Beach. The 70 mm mesh size is large enough to allow hatchlings to emerge but small enough to prevent access by varanid and mammalian predators.

CONCLUSION

Turtle conservation activities on Kelapa Dua Island have been progressing well but still need optimization. The average hatching success rate over the past five years is 71.98%. This rate can be optimized to reach 80% by establishing hatcheries on the nesting islands or islands near the nesting sites. Through this strategy, monitoring can be conducted more regularly, the turtle egg relocation process can be carried out relatively quickly, and vibrations or shocks to the turtle eggs during transportation can be minimized, thus increasing the hatching success rate. Regular monitoring of the environmental conditions of the artificial nests, including temperature, pH, and humidity, is also essential to improve the hatching percentage. Further research can assess the effectiveness of conservation efforts by comparing the conditions of natural and artificial/semi-natural hatcheries.

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REFERENCES

Ahmad, A., Zulkifli, T., Mahyam, M. I., Solahudin, A. R., & Nor, Z. A. (2004). *A guide to set-up and manage sea turtles hatcheries in the Southeast Asian Region*. Kuala Terengganu: SEAFDEC/MFRDMD.

Balai Taman Nasional Kepulauan Seribu (2023). *Laporan pelestarian penyu di SPTN wilayah i Pulau Kelapa Tahun 2023*. Jakarta: Balai Taman Nasional Kepulauan Seribu.

Candan, O. (2018). Impact of nest relocation on the reproductive success of loggerhead turtles, *Caretta caretta*, in the Göksu Delta, Turkey (*Reptilia: Cheloniidae*). *Zoology in the Middle*

East, *64*(1), 38-46. doi: 10.1080/09397140.2017.1414978.
Dermawan, A., Nuitja, I. N. S., Soedharma, D., Halim, M. H., Kusrini, M. D., Lubis, S. B., … Mashar, A. (2009). *Pedoman teknis pengelolaan konservasi penyu*. Jakarta: Kementerian Kelautan dan Perikanan RI.
Evans, S., Schulze, M. J., Dunlop, S., Dunlop, B., McClelland, J., Hodgkiss, R., & Brown, M. (2022). Investigating the effectiveness of a well-managed hatchery as a tool for hawksbill. *Conservation Science and Practice*, *11*(4), 1-10. doi: 10.1111/csp2.12819.
Fahmi, M. H., & Rizki, F. (2022). Study of turtle conservation Pangumbahan Beach, Sukabumi. *International Journal of Ecophysiology*, *4*(2), 2022-2077. doi: 10.32734/ijoep.v4i2.11391.
Hof, C. A. M., Shuster, G., McLachlan, N., McLachlan, B., Giudice, S., Limpus, C., & Eguchi, T. (2020). Protecting nests of the critically endangered South Pacific loggerhead turtle *Caretta caretta* from goanna *Varanus* spp. predation. *Oryx*, *54*(3), 323-331. doi: 10.1017/S0030605318001564.
Indrajaya, A. N., Daryanto, W. M., Sukmawati, E., & Perrin, C. (2018). Upaya peningkatan pariwisata di Pulau Kelapa Dua Kepulauan Seribu melalui model ecotourism dengan mengoptimasi aktivitas marketing melalui social media. *Prosiding Seminar Hasil Pengabdian Kepada Masyarakat*, *1*(1).
Liles, M. J., Peterson, T. R., Seminoff, J. A., Gaos, A. R., Altamirano, E., Henríquez, A. V., … Peterson, M. J. (2019). Potential limitations of behavioral plasticity and the role of egg relocation in climate change mitigation for a thermally sensitive endangered species. *Ecology and Evolution*, *9*(4), 1603-1622. doi: 10.1002/ece3.4774.
Lotze, H. K., Coll, M., Magera, A. M., Ward-Paige, C., & Airoldi, L. (2011). Recovery of marine animal populations and ecosystems. *Trends in Ecology and Evolution*, *26*(11), 595-605. doi: 10.1016/j.tree.2011.07.008.
Martínez-Estévez, L., Angulo, A. A., Astorga, M. E., Becerra, C. D., Leyva, N. C., Amador, F. C., … Croll, D. A. (2023). Exploring the demography and conservation needs of hawksbill sea turtles *Eretmochelys imbricata* in North-West Mexico. *Oryx*, *57*(3), 392-400. doi: 10.1017/S0030605322000709.
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.
Miguel, R. A. M. S, Anastácio, R., & Pereira, M. J. (2022). Sea turtle nesting: What is known and what are the challenges under a changing climate scenario. *Open Journal of Ecology*, *12*(01), 1-35. doi: 10.4236/oje.2022.121001.
Nasiri, Z., Mohammadi, M., Jebeli, S. A., Gholamalifard, M., & Ghasempouri, S. M. (2023). Hatcheries efficiency for hawksbill sea turtle (*Eretmochelys imbricata*) conservation in the Persian Gulf: Over a decade monitoring of emergence success and incubation period. *Regional Studies in Marine Science*, *64*, 103053. doi: 10.1016/j.rsma.2023.103053.
Nurhayati, T., Salamah, E., & Hidayat, T. (2007). Karakteristik hidrolisat protein ikan selar (*Caranx leptolepis*) yang diproses secara enzimatis. *Buletin Teknologi Hasil Perikanan*, *10*(1), 23-34.
Nurhayati, A., Putra, P. K. D. N. Y., & Supriatna, A. K. (2022). The role of sea turtle conservation education for sustainable marine tourism based on bio-ecoregion (case study in Bali, Indonesia). *Geojournal of Tourism and Geosites*, *41*(2), 477-484. doi: 10.30892/GTG.41219-853.
Perangin-angin, S. A. Br., Kurniasih, R. A., & Swastawati, F. (2021). Kualitas ikan layang (*Decapterus* sp.) asin asap dengan perbedaan lama waktu pengeringan. *Jurnal Ilmu dan Teknologi Perikanan*, *3*(2), 1689-1699.
Phillott, A. D., Kale, N., & Unhale, A. (2021). Are sea turtle hatcheries in India following best practices? *Herpetological Conservation and Biology*, *16*(3), 652-670.
Roeroe, P. K., Prabowo., Wardhana, I. C., Annisa, S., Sofiullah, A., Suprapti, D., … Sitorus, E. N. (2023). *Rencana aksi nasional (ran) konservasi penyu periode ii: 2022-2024*. Jakarta: Kementerian Kelautan dan Perikanan.

Saladin, C. (2021). International environmental law and sea turtles: Anatomy of the legal framework and trade of sea turtles in the Lesser Antilles. *Journal of International Wildlife Law and Policy*, *23*(4), 301-333. doi: 10.1080/13880292.2020.1872164.

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.

Sardeshpande, M., & MacMillan, D. (2019). Sea turtles support sustainable livelihoods at Ostional, Costa Rica. *Oryx*, *53*(1), 81-91. doi: 10.1017/S0030605317001855.

Sinaga, R. R. K., Hanif, A., Kurniawan, F., Roni, S., Laia, D. Y. W., & Hidayati, J. R. (2024). Tingkat keberhasilan penetasan telur penyu hijau (*Chelonia mydas*) dan penyu sisik (*Eretmochelys imbricata*) di Pulau Mangkai Kepulauan Anambas. *Journal of Marine Research*, *13*(1), 92-99. doi: 10.14710/jmr.v13i1.38531.

Sosiawan, T. G., & Setia, T. M. (2023). Translokasi sarang penyu sisik (*Eretmochelys Imbricata*) sebagai upaya perlindungan ekosistem laut di Taman Nasional Kepulauan Seribu. *Gunung Djati Conference Series*, *18*, 124-133.

Tisdell, C., & Wilson, C. (2005). Do open-cycle hatcheries relying on tourism conserve sea turtles? Sri Lankan developments and economic-ecological considerations. *Environmental Management*, *35*(4), 441-452. doi: 10.1007/s00267-004-0049-2.

Veríssimo, D., Vieira, S., Monteiro, D., Hancock, J., & Nuno, A. (2020). Audience research as a cornerstone of demand management interventions for illegal wildlife products: Demarketing sea turtle meat and eggs. *Conservation Science and Practice*, *2*(3), 1-14. doi: 10.1111/csp2.164.