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論文要旨 (博士)

論文題目	アカウミガメの繁殖活動に影響を与える砂浜環境に関する研究 —表浜海岸を対象として—
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(要旨 1,200字程度)

本研究では、良好な砂浜環境の指標種としてアカウミガメを設定し、その繁殖活動に焦点を当て、砂浜幅や海浜植生などといった砂浜環境との関係を調べた。これらの結果をもとに、環境と調和した砂浜海岸の保全・再生について提言した。

第1章では、研究対象種であるアカウミガメの生態、減少要因、保全の重要性および研究対象海岸の概要等について整理した。

第2章では、現地調査の概要について整理するとともに、2008年～2014年の期間における豊橋・湖西市域で確認されたウミガメの上陸回数についてとりまとめた。

第3章では、表浜海岸に訪れるウミガメの繁殖活動を「上陸」・「産卵」・「ふ化・脱出」の3ステージに分類し、現地調査からウミガメの繁殖活動に適した砂浜環境について検証した。上陸ステージにおいては、潜堤が設置された正面の砂浜ではウミガメの上陸密度が粗になる傾向や潜堤群と潜堤群の間に上陸が集中する傾向が明らかとなった。産卵ステージにおいては、2008年～2010年の期間、豊橋市域に上陸したウミガメ327例の移動痕跡を元に各個体の挙動を分析した結果、未産卵で帰海したウミガメ110例のうち、半数の55例は人工構造物（消波堤・消波工）が原因で、帰海したことが明らかになった。また、産卵場として選択した環境を分析した結果、海浜植物の存在やそれらの地下茎や根の発達に伴う地形変化（急峻な砂浜勾配の形成）が産卵のトリガーになる可能性を示した。さらに、上陸後の移動距離の計測結果から、表浜海岸に上陸するウミガメにとって産卵のために必要とされる砂浜幅は、最短でも40m以上必要であることが示された。ふ化・脱出ステージにおいては、砂中温度が高温化し、胚が32℃以上の温度に長時間曝されると、ふ化率の低下を招き、特にふ卵期間後期の暴露時間に左右されることが示された。一方、砂中温度の低温下がふ化率に及ぼす影響については、初期に24℃以下の低い砂中温度を経験しても、中期～後期にかけて砂中温度が上昇すればふ化率の低下は避けられることが明らかとなった。

第4章では、表浜海岸のうち、地形変化等の情報が蓄積されている豊橋市内の3海岸を対象に、砂浜幅や標高といった環境要素の現況を分析し、ウミガメの産卵成功率等を向上させるための改善策について検証した。その結果、ウミガメにとって好適な産卵・ふ卵範囲は消波ブロックの陸側に存在し、ブロックを越えられないウミガメには利用不可能であることや、ブロックの海側エリアは標高が低く、台風等の高波浪時には産卵巣が水没したりする可能性が高いことが分かった。ブロックのセットバックや堆砂を促し、ブロックを埋没させる等の対策を講じることで、ウミガメが容易に浜奥へと移動できるようになり、産卵成功率が向上すると考えられる。

第5章では、ウミガメの産卵に配慮し、既設の消波ブロックを陸側に移設し、緩傾斜堤へと改良したエコ・コースト事業について検証した。当該事業地内におけるウミガメの産卵状況については、同期間における豊橋市全域の産卵成功率よりも高い値を示し、産卵個体の平均移動距離も豊橋市域の平均移動距離よりも長いことが明らかとなった。

第6章では、本研究で得られた知見を体系的にとりまとめ、環境的な側面から海岸の保全目標を設定するための諸量を明らかにした。

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A b s t r a c t

Title	Study on environmental factors of sandy beach affecting the reproductive activity of loggerhead sea turtles (<i>Caretta caretta</i>) at Omotehama Coast
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(800 words)

The sandy beaches of Enshu Coast (Omotehama), located on the Atsumi Peninsula in the center of Japan, support a large nesting habitat for the endangered loggerhead sea turtle (*Caretta caretta*). It is important that this coast is located nearly at the northern limit of the North Pacific Ocean and that the sandy beaches provide a suitable environment for turtle oviposition.

The reproductive activity of loggerhead sea turtles can be classified into three stages: landing, oviposition, and hatching emergence. The purpose of this study is to investigate the influence of various environmental factors such as beach width, beach elevation, artificial structures, and sand temperature on the three stages of the reproductive activity of loggerhead sea turtles on the beach.

Submerged breakwaters have been constructed in the western part of Toyohashi area and may affect the landing activities of loggerhead turtles. The number of landings was found to be smaller on the beach in front of the submerged breakwaters than in the other areas of the beach without breakwaters. The breakwaters clearly obstructed turtle landings in this area. Because the breakwaters protect the beach from erosion, further consideration may be necessary, e.g., shortening the dike and widening the distance between dikes on coastal managements.

Most egg depositions occur between the mean high tide lines and vegetation lines. In the coastal area of Toyohashi, many precast armor units (blocks) were placed in the middle of the beach for shore protection. These blocks sometimes interrupt the turtle landings and ovipositing activities. The field sign called "turtle tracks" created by turtle landings gives a lot of information on various turtle behaviors after their landing. Analysis of turtle tracks revealed that among the sea turtles that failed to oviposit, half were unable to oviposit because of the blocks. Investigation of the landing distance of sea turtles with GPS and measuring tapes also revealed that the necessary beach width is more than 40 m from the high tide level on the beach. In general, sea turtles lay eggs around the border between the sandy beach and vegetation area or deeper in the vegetation zone to protect eggs from wind and waves. Blocks disrupt the path from the foreshore to backshore and prevent turtles from approaching their ideal nesting area. The frequency and rate of using the vegetation zone for nesting on the basis of the data from the Kosai area (where no blocks were installed) were investigated in 2009–2011 and 2013–2014. Almost 50% of the turtles selected the vegetation area for nesting. In addition, turtles tended to lay eggs after having climbed over the steep slope formed by an underground stem and the root of the plant where they decided on a suitable nest site.

To understand the nest productivity of loggerhead sea turtles, we collected sand temperature data using loggers, measured depths of egg chambers, investigated the hatching/emerging success rate (in situ and in relocated nests), and recorded nest incubation lengths at the Omotehama Coast from 2008 to 2010. Our results showed that the distance between the top and bottom of the nests was uniform despite the various depths of nests. A significant negative correlation of the emergence success rate was observed when the sand temperature over 32°C exceeded 150 hours of the cumulative exposure time. In contrast, no significant correlation was observed when the sand temperature was lower than 24°C.

The beach is restored by reforming the coastal facilities in Toyohashi city. This action is called the Eco-coast project. This project was the first trial in Japan and was conducted on the basis of a consensus among stakeholders such as the local government, community residents, and Non-Profit Organizations. After removing the precast units, the shoreline distance has been gradually increasing; however, the sectional area has been gradually decreasing. The coastal topography and behavior of sea turtles tended to change toward those of natural beaches and the oviposition rate increased. Vegetation was damaged by the Eco-coast project because of transferring the blocks. To investigate the recovery of the vegetation, the belt transect method was performed in this area in 2013–2014. The coastal vegetation has recovered in less than five years and is stable in the area that is at an elevation of more than 4 m. It was confirmed that the Eco-coast project restores the function of the sandy beach judging from the ovipositional viewpoint of the sea turtle nesting. On the other hand, some new problems have occurred such as depredation because of the wild animals and light pollution because of an increase in coastal users. It is necessary to take countermeasures for depredation and light pollution with continuous monitoring because it is known that the depredation increases every year and artificial lighting obstructs the turtles' oviposition. To live in harmony with wildlife, it is necessary to continue monitoring and to give feedback after the project.

By analyzing the reproductive activity of sea turtles, we succeeded in obtaining some data to maintain a better condition of sandy beaches from an environmental point of view.