Overwintering behavior of green sea turtles (*Chelonia mydas*) in a temperate habitat

Soojin Jang[1], Kyunsik Jo[2], Mi Yeon Kim[1], Byeong Yeob Kim[3], Geroge H. Balazs[4], Connie Ka Yan NG5, George Schillinger[6], Michelle María Early Capistrán[7], Jibin Im[2] and Taewon Kim[2]

[1]Marine Animal Research and Conservation, Jeju, Republic of Korea, [2]Department of Ocean Science, Inha University, 100 Inha-ro, Michuhol-gu, Incheon, Republic of Korea. [3]Department of Marine Industry and Maritime Policy, Jeju National University, Jeju City 63243, Republic of Korea, [4]Golden Honu Services of Oceania, Honolulu, HI, USA, [5]Department of Chemistry and State Key Laboratory of Marine Pollution, City University of Hong Kong, Kowloon Tong, Hong Kong Special Administrative Region, People's Republic of China, [6]Upwell Turtles, Monterey, CA, United Sates of America, [7]Woods Institute for the Environment, Stanford University, Stanford, CA, United States of America **Email: kesha00@gmail (Soojin Jang), ktwon@inha.ac.kr (Taewon Kim)**

INTRODUCTIONS

A sea turtle is an animal with a body temperature closely affected by the external environment. When local water temperatures drop below 14 ℃ in winter, green sea turtles migrate to warmer areas or remain dormant, changing their diving behaviors. In previous research (Jang *et al*. 2018), they are observed year-round in the Sea of Jeju Island, the southern part of the Republic of Korea, and it was confirmed that some juveniles spend winter around the Jeju coast.

In this research, we used Iridium GPS transmitters to identifiy the wintering sites of sea turtles using the Jeju region of the Republic of Korea and investigate the diving patterns.

MATERIALS AND METHODS

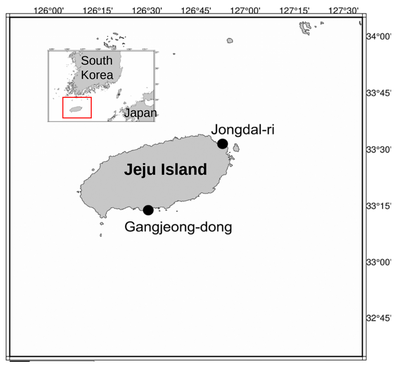


Fig. 1 Sea turtle release and release point

A total of four sea turtles were caught incidentally and rescued by pound nets installed around Jeju Island from 2019 to 2020.

Morphometric measurements were taken prior to deployment the iridium transmitter (SeaTrkr 4370-4). The deployment was applied to the carapace of each sea turtle using polyester resin and thin glass fiber. The sea turtles were released near the capture point when the polyester resin hardened sufficiently.

All transmitters were programmed to collect GPS data every two hours and water temperature every hour.

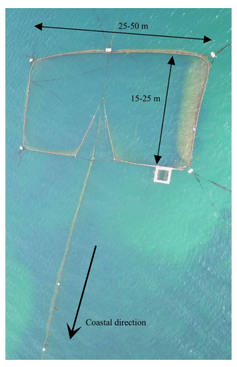
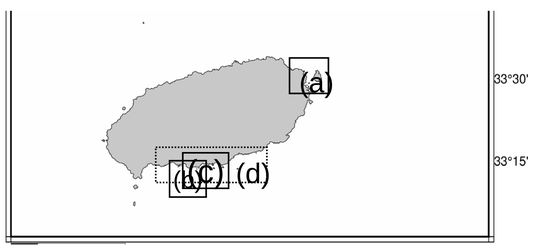


Fig. 2 Pound net of Jeju Island

KDE analysis was used to identify the range of habitats and core habitats using ArcGIS Pro and regression analysis was performed using SPSS 26 to determine the correlation between the water temperature and the dive duration in the area where sea turtles are used

RESULTS



The KDEs for these four sea turtles were calculated and found to be between 0.021 and 6.411 (1.907 ± 3.025) in a range of different habitats (95% KDE) (figure 3, table 3). The core habitat range (50% KDE) ranged from 0.001 to 0.942 (0.264 ± 0.454), from about 4.76% to 14.69%.

Fig. 3 The map for kernel density estimate (KDE) analysis for 4 green sea turtles during stay around Jeju Island. The Habitat area (95% KDE) is a light gray area, and the core area (50% KDE) is marked in dark purple.

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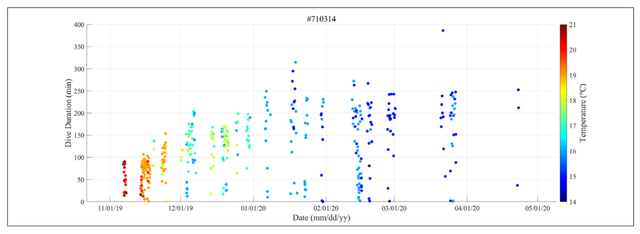
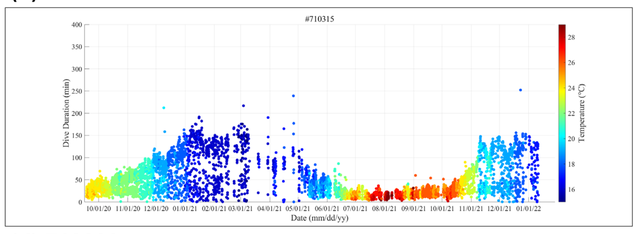
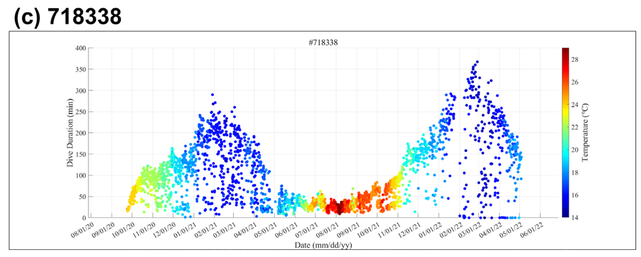


(b) 718315



(c) 718338



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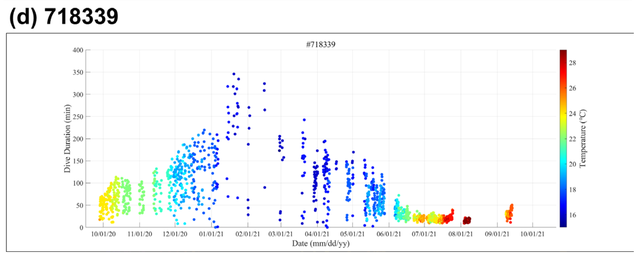

Fig. 4 The dive duration (min) of sea turtles according to temperature. The color of each dot represents the water temperature.

Four sea turtles showed a maximum dive duration at the seawater temperature at 13~16 ℃. A dive duration of more than 100 minutes did not appear between July and August. The average dive duration was 33.35 (± 21.02) minutes, and the maximum dive duration was 367.4 minutes (table 2). Dive duration strongly correlated with temperature ($p < 0.001$, $F = 1247.779$, $R^2 = 0.334$).

Table 1. Satellite tracking details for 4 green sea turtles tagged in Jeju Island from 2019 ($n = 1$) and 2020 ($n = 3$).

ID	Tracking period	Tracking days	SCL (cm)	Travel distance		Dive duration		Temperature range (℃)	Releasing location
				Total (km)	Daily (km)	Max (min)	Mean (± SD) (min)		
718314	2019 Nov 11 ~ 2020 Apr 22	163	84.3	21.0	0.12	272.08	80.66 (± 60.18)	13 ~ 21	Jongdal-ri
710315	2020 Sep 17 ~ 2022 Jan 11	481	49.9	425.63	0.88	189.28	33.49 (± 35.73)	15 ~ 29	Gangjeong-dong
718338	2020 Sep 24 ~ 2022 May 04	587	50.6	390.23	1.01	367.4	51.37 (± 41.20)	14 ~29	Gangjeong-dong
718339	2020 Sep 28 ~ 2021 Sep 15	352	72.5	220.34	0.63	308.48	27.28 (± 37.82)	15 ~ 29	Gangjeong-dong

DICUSSIONS

The green sea turtle (*Chelonia mydas*) is a tropical or subtropical species, that enters dormancy at the low seawater temperature limit of 14°C (Godley *et al*. 2002). The seawater temperatures drop close to the turtle's temperature limit on Jeju Island in winter. Nevertheless, according to the result, sea turtles overwintering on Jeju Island have been steadily identified. They stayed in the area from the coast at a relatively low water depth (within 30 m) for individuals who were wintering around Jeju Island.

The habitat use range (95% KDE) of wintering individuals in Jeju Island was not far from the location they were bycaught, and it was found to be relatively small in size, and mainly used in a narrow area. Although the core area was divided into several spaces, each area was minimal.

Our results suggest that the coast of Jeju Island could function as a seasonal feeding ground for sea turtles of various ages and as a potential residence and wintering ground for green sea turtles. Identifying habitat areas continuously, including the wintering areas of free-ranging sea turtles, is essential ecological information for establishing effective management strategies for sea turtle conservation.

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