Oceanic migration of post-nesting loggerhead sea turtles (*Caretta caretta*) in the northwestern North Pacific tracked by satellite telemetry

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ABSTRACT
Two post-nesting loggerhead turtles which nested at Omaezaki beach, Japan were tracked during 2002 and 2003 in the northwestern North Pacific by satellite telemetry. The first loggerhead was tracked for 265 days from 29 July 2002 to 19 April 2003 with total distance of approximately 9,800 km. The turtle traveled eastward from the Pacific coast of Honshu to offshore after staying near its nesting site for a week. Then it remained in the offshore area around 36-37°N and 155-158°E from the end of September to the middle of November. In late November, the turtle moved eastward again, and turned to the south when it reached 170°E in the middle of December. Finally, it turned westward in February. Tracking of the second loggerhead tagged in 2003 is still in progress, although this loggerhead was released in a subsequent year, its tracks were similar to the first turtle. The relationship between movements of the turtles and oceanographic conditions (sea surface temperature and sea surface currents) were examined. Movement tracks of these turtles correlated with the Kuroshio Extension Current and seasonal changes of temperature in the Transition Region. The Transition Region is known as a highly productive area and may provide an important feeding ground for post-nesting loggerhead turtles.

KEYWORDS: post-nesting loggerhead turtle, satellite telemetry, oceanographic conditions

INTRODUCTION

Loggerhead sea turtles (*Caretta caretta*) are believed to travel great distances during their lives. In the North Pacific, nesting beaches of the loggerhead turtle are located almost exclusively along the middle and southern coast of Japan. Hatchling loggerheads disperses from beaches into the ocean. These juveniles grown to subadults in the eastern North Pacific have been confirmed using genetic analyses (Bowen *et al.*, 1995). Upon reaching adulthood, loggerheads migrate from the oceanic feeding area to nesting beaches in Japan. A portion of the post-nesting loggerhead population migrates for feeding to the East China Sea as documented by tagging-recapture methods (Kamezaki *et al.*, 1997). However, distribution patterns and migration routes of post-nesting loggerhead sea turtles are not well known. The study of migration routes for loggerhead sea turtles is important to demonstrate the seasonal changes in their distribution and feeding grounds.

In the present study, we investigated oceanic migration of post-nesting females by satellite tracking.

In addition, we examined the correlation between their migration routes and oceanographic conditions, sea surface temperature and sea surface currents.

MATERIALS AND METHODS

On 29 July 2002 and 18 July 2003, satellite transmitter (ST-6 and 18, Telonics Inc.) was deployed on two loggerhead turtles at Omaezaki beach, Shizuoka Prefecture, Japan referred to below as No. 1 and No. 2, respectively (Fig. 1). Satellite transmitters were attached with epoxy resin to

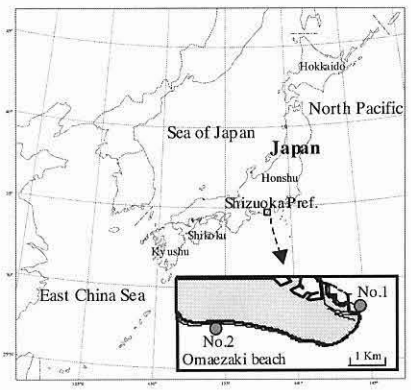

Fig. 1 Location of Omaezaki beach, Shizuoka Pref., Japan. Circles show the location of released points of turtles to the sea.

the carapace of each individual after they nested, and then released to the sea. Their straight carapace length (SCL) was measured with calipers to the nearest 1 cm, and their SCL were 75 and 82 cm, respectively. Tracking of No. 1 finished on 19 April 2003. Tracking of No.2 is still in progress, and here we use the data through October 2003 (Table 1). The loggerhead turtles were tracked using the Argos system, and locations with classes 3, 2, 1, 0, A and B accuracy were used to track. The daily travel distance was defined as the minimum straight line distance between daily mean positions on the sea surface. We used data from the Japan Meteorological Agency for examining the relationship between migration routes of turtles and oceanographic conditions, sea surface temperature and sea surface currents.

Table 1 Information on two loggerheads tracked by transmitter

Name	Strait Carapace length	Number of eggs	Deployment date	Date of last transmission	Duration of tracking days
No.1	75 cm	118	29 July 2002	19 April 2003	265
No.2	82 cm	100	18 July 2003	Continuing	75

RESULTS

Total travel distances of No. 1 and No. 2 were 9,787 and 4,535 km, and daily mean travel distances were 36.9 and 42.0 km, respectively. Maximum daily movement was approximately 200 km. Daily travel distance of each turtle consisted of repeated intervals of long and short distances (Fig. 2). From summer through autumn, both turtles displayed this pattern but after autumn, the movement distances of No. 1 gradually shortened. Although they were released in different years, their tracks were very similar (Fig. 3). We examined the relationship between oceanographic conditions and movement tracks of the turtle. The turtles remained in the area of the nesting site after they were released to the sea and then moved eastward from the Pacific coast of Honshu to offshore. The periods of eastward and offshore movement corresponded to the periods of long daily movement distances which for No. 1 was from mid to late-August, and for No. 2 was from mid-August to early-September (Fig. 2). At that time, the tracks of both turtles followed the Kuroshio Extension Current (Fig. 4). Afterward No.2 remained in the area around 35-36°N and 152-154°E north of the Kuroshio Extension Current where the sea surface temperature was approximately 23 (Fig. 5). Subsequently they moved eastward again, and No. 1 turned to south in the Transition Region around the 170°E (Fig. 6). Finally, it turned westward in the area of the North Equatorial Current with westward direction and weak flow (Fig. 7). Both turtles always remained within the southern part of the Transition Region where the temperature was from 17 to 23°C approximately rather than in the Subarctic and Subtropic Regions.

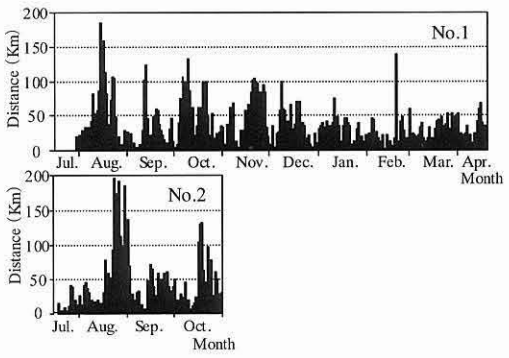

Fig. 2 Changes in daily movement distances of turtle No. 1 and No. 2 calculated by daily average position.

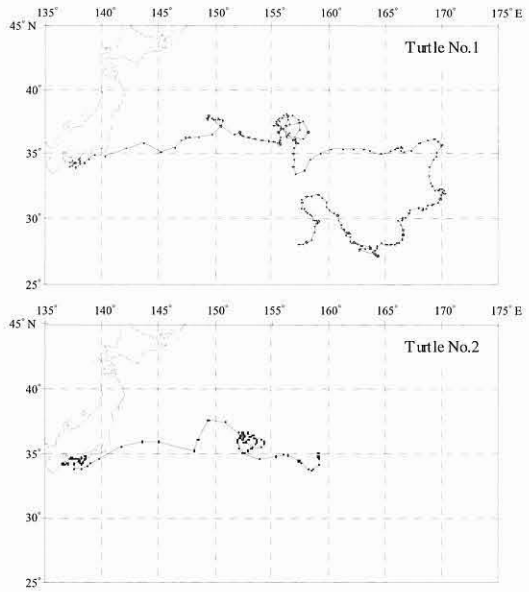

Fig. 3 Complete track lines of two post-nesting loggerhead turtles. The plot shows the daily position of each turtle.

DISCUSSION

The loggerhead turtles released in Omaezaki migrated toward the northwestern North Pacific, and they remained for some time in this region. This indicates that after nesting on beaches in Japan, some post-nesting loggerheads migrate to the northwestern North Pacific, not to the East China Sea. Hatase *et al.* (2002) has shown using stable isotope analyses and satellite telemetry that larger females come from the East China Sea to the nesting beaches in Japan, and smaller females come from the North Pacific. However, it is not clear whether the turtles we tagged (75 and 82 cm SCL) would be considered large or small according to Hatase et al. (2002). Therefore, it is necessary to investigate the migration routes of post-nesting females of various sizes using the satellite telemetry.

In the present study, turtle's daily movement distances were repeatedly long and short. These movement patterns probably related to the speed of flow in the

Kuroshio Extension Current and North Equatorial Current. When No. 1 moved southward from autumn to winter, it probably reflected a change in the location of the southward of Transition Region associated with a decline in sea surface temperature. It is suggested that oceanic movements of post-nesting females were affected by the currents and seasonal changes in sea surface temperature in the southern part of the Transition Region. The Transition Region is known as a highly productive area, and is used by many pelagic fishes and squids as a feeding ground. Our findings suggest that this region may also provide important habitat for post-nesting loggerhead sea turtles.

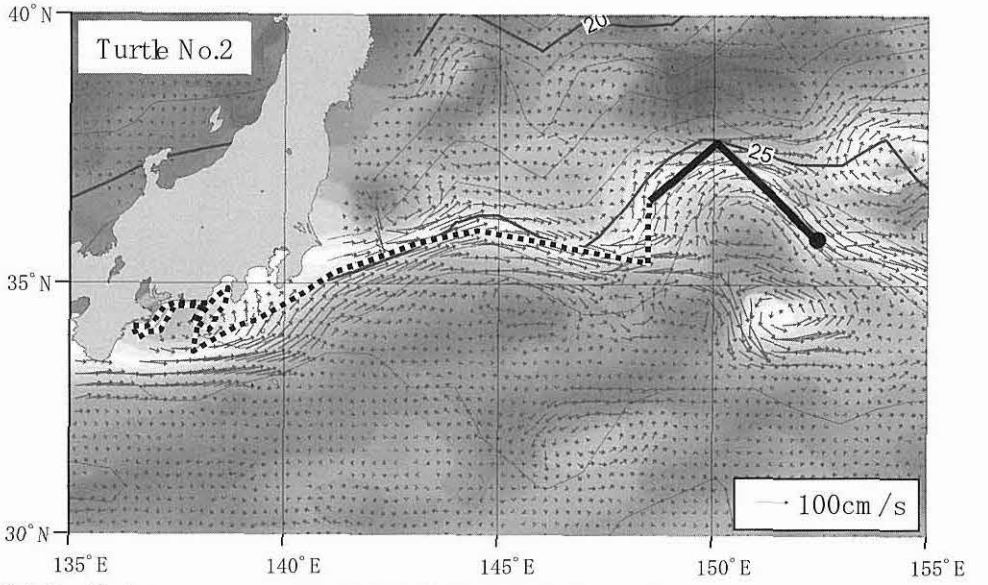

Fig. 4 Relationship between movement track of turtle No. 2 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 29 August to 2 September 2003. The dashed line shows the track from 18 July to 28 August 2003.

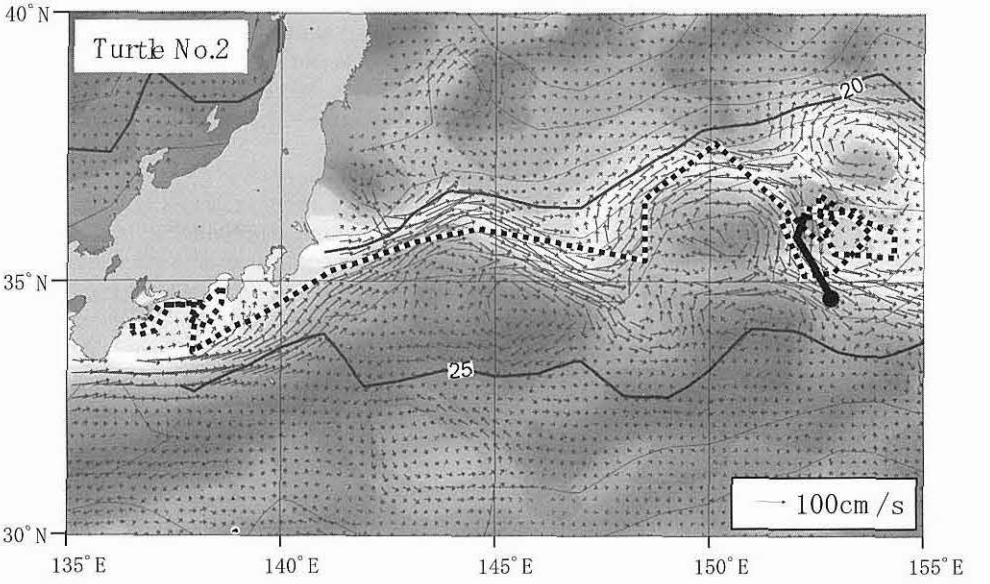

Fig. 5 Relationship between movement track of turtle No. 2 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 13 to 17 October 2003. The dashed line shows the track from 18 July to 12 October 2003.

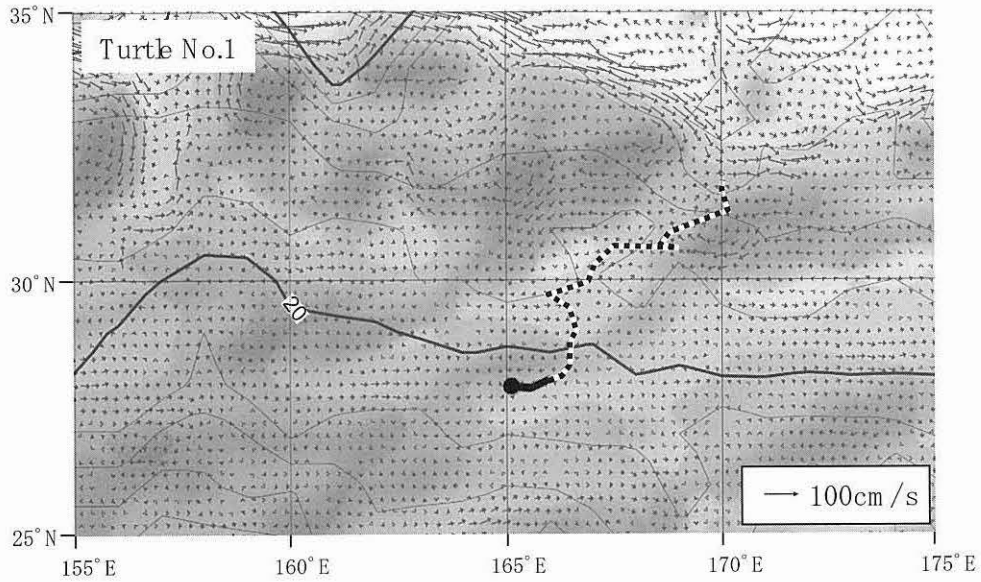

Fig. 6 Relationship between movement track of turtle No.1 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 31 January to 4 February 2003. Dashed line shows the track from 1 to 30 January 2003.

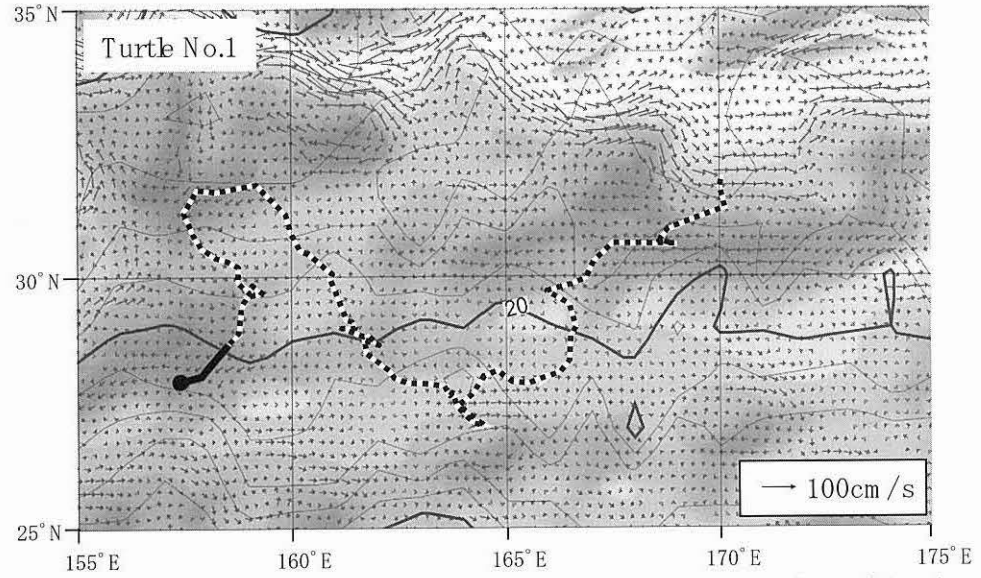

Fig. 7 Relationship between movement track of turtle No.1 (solid line) and oceanographic conditions (sea surface temperature and sea surface current) from 16 to 20 April 2003. Dashed line shows the track from 1 January to 15 April 2003.

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