DEVELOPMENT OF THE NEW DEVICES FOR MARINE BIOTELEMETRY

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Abstract We challenged to adopt several micro-electronic devices to measure aquatic lives. The devices included data storage tags, ultrasonic tags, and satellite PTTs for the red sea breams , Adélie penguins *Pygoscelis adeliae*, the Lake Biwa catfish *Silurus biwaensis*, and sea turtles *Caretta caretta*. Based on these results, new devices for marine biotelemetry are under development. They are a visual data storage tag and a magnetic field sensor accelerometer tag. We have a plan to test the prototypes in Thailand coming February.

Keywords: data storage tag, CCD, MR sensor, accelerometer, biotelemetry

Introduction

Recently, due to drastic development of microelectronics, we can use very smart devices to measure behavior of marine lives. We challenged to adopt several micro-electronic devices to measure aquatic lives. The devices included small data storage tags, ultrasonic tags, and satellite PTTs for the red sea breams (Mitsunaga et al., 1999), Adélie penguins *Pygoscelis adeliae* (Arai et al., 2000), the Lake Biwa catfish *Silurus biwaensis* (Takai et al., 1997), and sea turtles *Caretta caretta* (Sakamoto et al. 1997). These techniques were very useful to understand the correlation between ambient fluctuation and their behavior.

Based on the successful results, we attempted to develop two types of new devices for marine biotelemetry. One is a visual data storage tag and the other is a magnetic field sensor accelerometer tag.

In this paper, I introduce our recent research works and a concept of the new data storage tags.

Methods

A data storage tag, PD2GA (Little Leonardo Co. Ltd., Tokyo) originally designed for the Adélie penguin in the Antarctica was attached to a red sea bream. The tag weighed 17.7 g in water, were 20 mm in diameter with 122 m length, and had 32-Mbit flush memories inside to store four channel data including surging and swaying acceleration ($\pm$ 4 gravity), revolution of a screw (revolution per second), and swimming depth (0 – 200m). The acceleration data represented longitudinal and lateral oscillations, respectively. These data were converted into 12-bit digital data and archived by a microprocessor inside. The sampling rate was variable ranging from 0.0078 s to 2.0 s according to the purpose of the experiment. We adopted 0.09375 s for sampling rate of acceleration to estimate tail beat frequency, and every one-second for depth and speed data in this study. The experiment was performed in a fishpond which was a rectangle 125-m by 42-m with 3-m depth. The fishpond had been used for a salt farm then reformed for the fisheries experiments. Therefore, seawater in the pond was drained off after experiments to recovery experimental fishes. An experimental red sea bream weighed 2.6 kg and 53-cm fork length was released in the fishpond at 13:57 5th October 1998 and recovered at 10:21 7th. The data storage tags were attached to the dorsal muscles in front of the dorsal fin.

Results and discussion

We picked out the speed data over 0.5 m s^{-1} since the screw of the tags began to rotate mechanically over around 0.4 m s^{-1}. Forty three times of swimming events were summed up in the data. The 43 events were classified in several patterns as type 1: simply dash over 1 m s^{-1} and stop, type 2: dash over 1 m s^{-1}, moderate swim, and stop, type 3: moderate swim, dash under 1 m s^{-1}, and stop, type 4: moderate swim, dash over 1 m s^{-1}, moderate swim again, and stop, type 5: others.

Why did the red sea bream indicate these patterns? Did the red sea bream see baits, predators, and/or shelters to hide in the water? To answer these questions, we have to see what the red sea bream see in the water. Therefore the visual data storage tag is necessary to reply the questions.

We can calculate swimming distance of the fish by integration of surging acceleration as a simple equation as follows,

$$S_n = S_{n-1} + 1/2\ at^2,$$

S: swimming distance (m)

a: surging acceleration (m/s^2),

t: time (s).

Fig.1 shows observation data of the surging acceleration, swimming speed, and depth, and calculation data of the acceleration. Fig.1-e shows differential between observation depth and calculated distance. The differential may indicate the horizontal moving distance. That is Fig.1-f shows total moving distance of the fish as time elapsed and Fig.1-g shows 2-D position of the fish. This result suggests that we could calculate 3-D position of the fish if we take 3-D acceleration data.

Concept of new devices

We are now developing the new devices such as a visual data storage tag and a magnetic field sensor accelerometer with Allec Electronics Co. Ltd.

The visual data storage tag is installed with CMOS CCD device that can take 100 pictures with 28000 pixels. The dimension of the tag is 92 x 40 x 28 mm^3 with ca. 200g. It has an IrDA interface to transfer pictures to PC. A prototype model has capacity to 100 m pressure.

The magnetic field sensor accelerometer has a MR sensor and two accelerometers in it. The MR sensor can detect 3-D magnetic field to transform into 3-D direction data. We can calculate 3-D position combining the 3-D direction data and 3-D acceleration data. The dimension is 54 mmø x 178 mm. A diagram of its circuit was just completed.

We have a prospect to complete both of the tags in a few months. If everything goes well, we would like to bring the tags to Man-Nai Is. to test with green sea turtles coming February.

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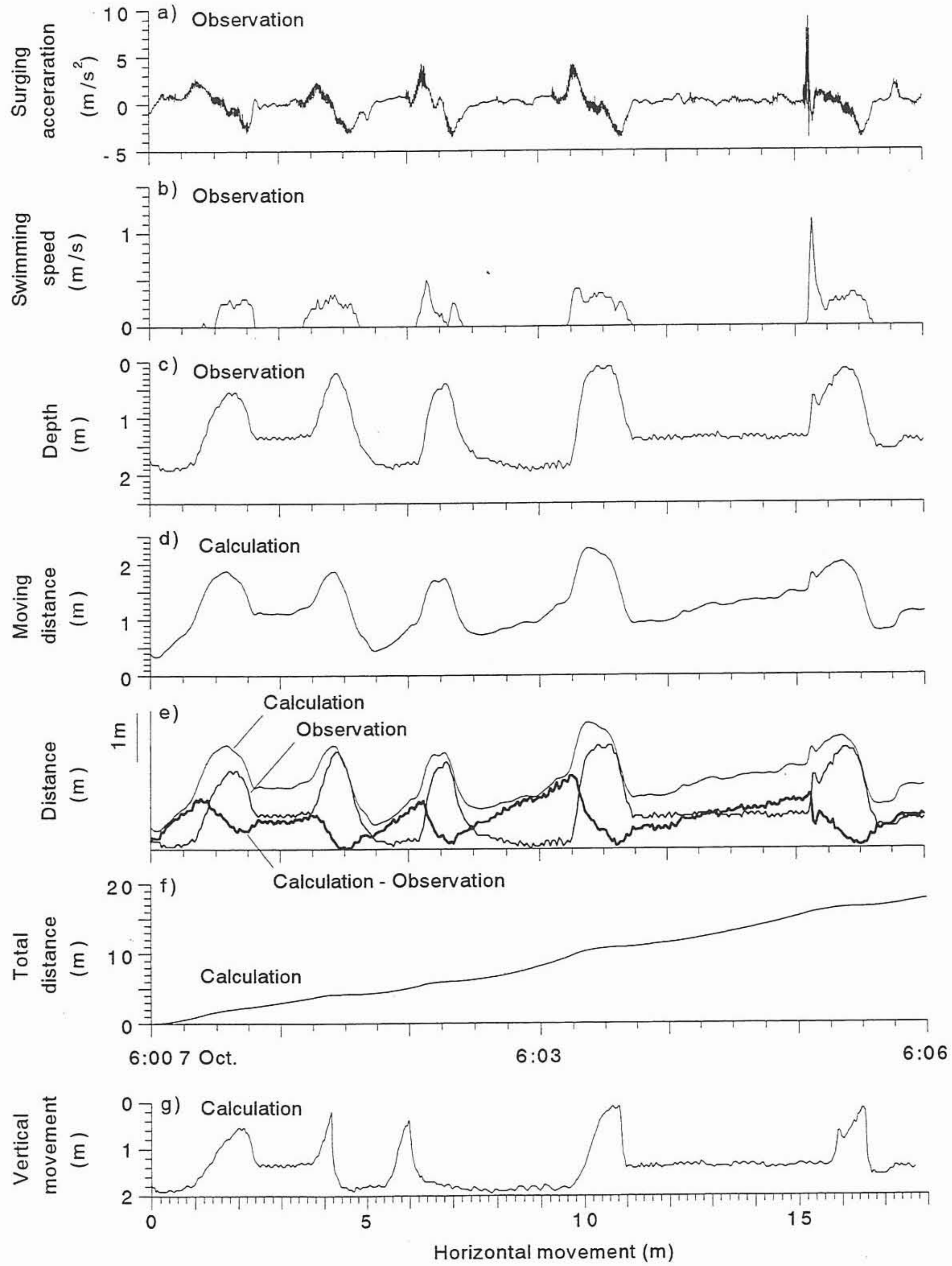
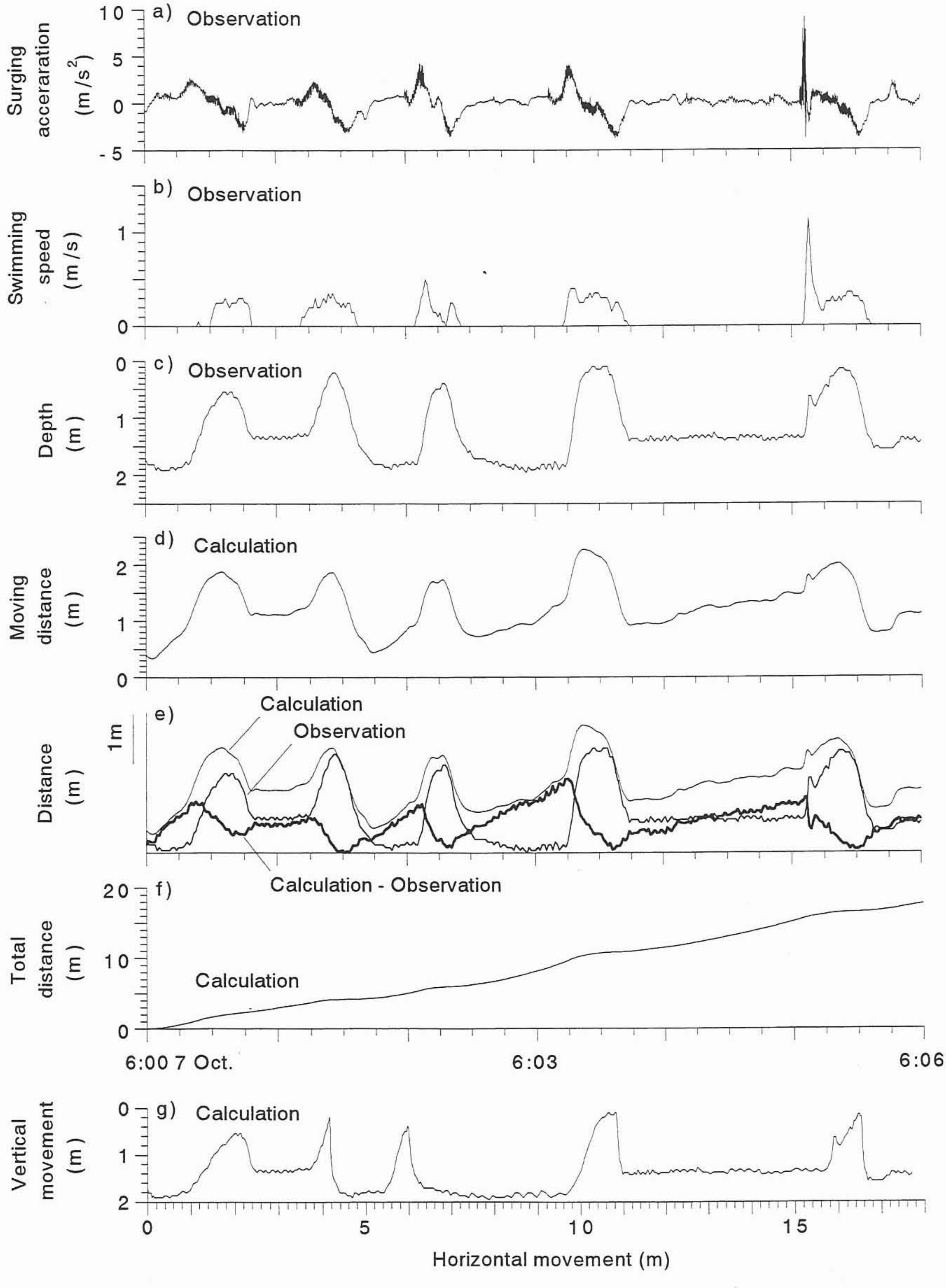


Fig.1. Time series records using a data storage tag attached to a red sea bream. a) – d) show observation data and e)- g) show calculated values from surging acceleration.



Surging acceraration (m/s²)
a) Observation
Swimming speed (m/s)
b) Observation
Depth (m)
c) Observation
Moving distance (m)
d) Calculation
Distance (m)
1m
e)
Calculation
Observation
Calculation - Observation
Total distance (m)
f)
Calculation
6:00 7 Oct.
6:03
6:06
Vertical movement (m)
g) Calculation
Horizontal movement (m)