# Detection of Sea Turtle's Pushing-up Behaviour with Acceleration Data Logger

Okamoto Jun[1], Shiode Daisuke[1], Uchida Keiichi[1], Hasegawa Kohei[1], Miyamoto Yoshinnori[1], Hu Fuxiang[1], Tokai Tadashi[1]

[1] Tokyo University of Marine Science and Technology, Tokyo, Japan

## Abstract

*When sea turtles accidently enter into a fully-submerged bag net, they tend to push up the upper net in need of fresh air. In this study, we tried to detect pushing-up behaviours of green turtles in an experimental bag net (8m*8m*2.1m) with a tri-axial acceleration data logger. Four green turtles (SSCL: 58.1-71.2cm) were applied. Behaviour of each green turtle in the net was recorded by an underwater video camera, and the number and duration of successive pushing-up behaviours were confirmed. Detection of pushing-up behaviour was attempted by filtering the time series attitude angle and the ODBA (Overall Dynamic Body Acceleration) of the turtle which were converted from the static surge acceleration or the tri-axial dynamic acceleration. The total number of pushing-up behaviours was 38 times and the total duration was 284 seconds. The most accurate threshold of 35 degrees in attitude angle and 2.0 m/s$^2$ in ODBA detected 82% of all the pushing-up behaviours although it contained non pushing-up behaviours such as quick changes in swimming direction. It also detected 54% out of the whole duration time. Data from geomagnetic direction and depth sensor would improve precision of the detection in a field experiment.*

***Keywords**: acceleration, attitude angle, ODBA, pushing-up behaviour, sea turtle*

## Introduction

By-catch mortality of sea turtles in set nets with a fully-submerged bag net is becoming a problem in recent years [1]. To reduce by-catch mortality of sea turtles in set nets, a new system for releasing sea turtles has been developed [2]. This system consists of a turtle releasing device (TRD) and a slope on an upper net of a bag net. When sea turtles accidently enter into a fully-submerged bag net, they tend to push up the upper net in need of fresh air [2]. By taking this movement, sea turtles can open the door and escape on its own (Fig.1). Therefore, pushing-up of sea turtles is very important behaviour for developing the turtle releasing system.

Underwater video camera is one of the useful tools to observe such sea turtle's behaviour. However, a fully-submerged bag net of a large scaled set net is often set in deep water, and it is difficult to obtain clear and bright visual data [3]. The bio-logging method using acceleration data logger is often used for measuring sea turtle behaviours. Iwata *et al*. (2009) detected northern fur seal's stroke out from the time series data of acceleration [4], and Okuyama *et al*. (2010) also detected feeding behaviour of loggerhead turtles by the acceleration data logger earned from the lower jaw of it [5]. In this study, a tri-axial acceleration data logger was applied to detect sea turtle's pushing-up behaviour in an experimental bag net.

Fig.1 Photo showing sea turtle's pushing-up behaviour.

## Material and Methods

### *Experiment Methods*

The experiment was performed at the outdoor tank (10*10*2.1m) of Yaeyama laboratory of Seikai National Fisheries Research Institute in Japan through August 3rd to 5th in 2013. The experimental bag net used in this experiment was comprised of quadratic-prism shaped upper panels of 20 degrees angle on a box-shaped net (8*8m, 1.6m high in total) and the TRD attached on the top of the upper net [2].

Four green turtles *Chleonia mydas* (SSCL: 58.1-71.2cm) were used in this experiment. An acceleration data logger (W1000-3MPD3GT; 26mm in diameter, 175mm in length; Little Leonardo Co.), which recorded tri-axial

acceleration (Sway, Surge, Heave), was set on the back part of the turtle's carapace as the surge axis of the data logger was parallel to the body axis of the turtle (Fig.2). One green turtle equipped with the data logger was put into the bag net by a diver, and its behaviour inside the bag net was recorded until it could escape through the TRD. The behaviour of the turtle was also recorded by an underwater video camera (HX-WA30; Panasonic Co.) by a diver. This experiment was conducted under a safe condition with divers ready to rescue the sea turtle in case of trouble.

Fig.2 Photo of acceleration data logger attached to the back part of the carapace. Surge axis of the data logger was put to be paralleled to the body axis of the sea turtle.

### *Analysis Methods*

From the video movie, number and time of pushing-up behaviour of each turtle were confirmed. In this study, pushing-up behaviour was defined as the behaviour of sea turtle's touching and pushing-up the upper net of the bag net, and the duration as time from the moment of sea turtle's touching the upper net first to the moment of the attitude becoming horizontal again. A consecutive pushing-up behaviour was counted as one pushing-up behaviour, and the duration of it was recorded. When there was an interval of more than 4 seconds between two consecutive pushing-up behaviours, they were categorized as different pushing-up behaviour. IGOR Pro 6.2 and its function Ethographer (Wave Metrics Co.) were used for the acceleration data analyses [6]. The time series data of acceleration was separated into static acceleration and dynamic acceleration using CWT Filter contained in the Ethographer.

Green turtles took pushing-up behaviour with the body axis nearly vertical and with their front flippers stroking hard. Therefore, we tried to detect pushing-up behaviours using two factors: the attitude angle and ODBA (Overall Dynamic Body Acceleration) [7]. The attitude angle of the turtle was calculated from the static acceleration of the surge axis. The ODBA was calculated by adding up the absolute value of the dynamic acceleration of the three axes [7]. When the turtles took pushing-up behaviour, their attitude angle was around 40 degrees or more, and ODBA value rarely showed more than 2.0m/s$^2$ in their normal swimming. Therefore, pushing-up behaviours were tried to detect by filtering the time series data of the attitude angle and ODBA with using thresholds set for each data (attitude angle: 30, 35, 40, 45, 50 degrees; ODBA: 2.0, 2.5, 3.0 m/s$^2$). Detection rate and match rate were calculated by following equations with using the number of behaviours detected as pushing-up *NP*, the number of actual pushing-up behaviour *NAP*, and the number of pushing-up behaviours detected correctly *NPC*, in order to determine the best filtering threshold [8],

Detection Rate (%) = NP / NAP・100,

Match Rate (%) = NPC / NAP・100.

The detection rate exceeded 100% in some cases, because behaviour detected as pushing-up contained non-pushing-up (wrong detection). The match rate will be larger when more numbers of pushing-up behaviour are detected correctly. In this study, an index of match rate of duration was also obtained by following equation in order to evaluate detected duration of pushing-up behaviour DP with using duration of actual pushing-up behaviour DAP in consecutive pushing-up behaviour,

Match rate of duration (%) = DP / DAP・100.

## Result

Data from eight experiments was used for the analyses. The total number of pushing-up behaviour from the video observation was 38 times and the total duration was 284 seconds in these eight experiments. The result of the detection rate and the match rate is showed on Table 1. The highest match rate was 82% obtained by the threshold of 30 degrees in attitude angle and 2.0m/s$^2$ (represented as 30/2.0 below), and the threshold of 35 degrees in attitude angle and 2.0m/s$^2$ (represented as 35/2.0 below). Although these two thresholds showed the same match rate, 35/2.0 detected less non-pushing-up behaviour compared to 30/2.0 threshold. The result of the match rate of duration calculated by these thresholds is showed on Table 2. The threshold 30/2.0 detected the duration of 162 sec out of 284 sec in total, and the match rate was 56.4% while it was 54.2% in the case of 35/2.0.

Table 1. Result of detection rate and match rate

| Attitude Angle (degrees) | ODBA ($m/s^2$) | Number of pushing-up behaviours | Number of behaviours detected | Number of behaviours matched | Detection Rate (%) | Match Rate (%) |
|---|---|---|---|---|---|---|
| 30 | 2.0 | 38 | 50 | 31 | 132 | 82 |
| 30 | 2.5 | 38 | 39 | 28 | 103 | 74 |
| 30 | 3.0 | 38 | 32 | 26 | 84 | 68 |
| 35 | 2.0 | 38 | 44 | 31 | 116 | 82 |
| 35 | 2.5 | 38 | 35 | 27 | 92 | 71 |
| 35 | 3.0 | 38 | 28 | 24 | 74 | 63 |
| 40 | 2.0 | 38 | 42 | 30 | 111 | 79 |
| 40 | 2.5 | 38 | 31 | 26 | 82 | 68 |
| 40 | 3.0 | 38 | 25 | 23 | 66 | 61 |
| 45 | 2.0 | 38 | 37 | 28 | 97 | 74 |
| 45 | 2.5 | 38 | 28 | 24 | 74 | 63 |
| 45 | 3.0 | 38 | 24 | 21 | 63 | 55 |
| 50 | 2.0 | 38 | 33 | 25 | 87 | 66 |
| 50 | 2.5 | 38 | 25 | 21 | 66 | 55 |
| 50 | 3.0 | 38 | 20 | 18 | 53 | 47 |

Table 2. Result of match rate of duration.

| Experiment No. | Duration (sec) | Matched Duration (sec) | |
|---|---|---|---|
| | | 35/2.0 | 30/2.0 |
| 1 | 29 | 18 | 21 |
| 2 | 14 | 11 | 11 |
| 3 | 54 | 32 | 32 |
| 4 | 36 | 24 | 25 |
| 5 | 71 | 38 | 39 |
| 6 | 31 | 16 | 16 |
| 7 | 36 | 14 | 15 |
| 8 | 13 | 3 | 3 |
| Sum | 284 | 156 | 162 |
| Match Rate (%) | | 54.2 | 56.4 |

## Discussion

About 80% of pushing-up behaviour was successfully detected by the data obtained from the acceleration data logger. While the threshold of 35/2.0 and 30/2.0 had same match rate, 35/2.0 detected less number of non-pushing-up behaviours. For the development of the turtle releasing system, the information about the time and place of sea turtle's pushing-up will be more important. Consequently, the threshold of 35 degrees in attitude angle and 2.0m/s$^2$ in ODBA is the most suitable threshold for detecting sea turtle's pushing-up behaviours. In this study, there were some numbers of wrong detection even with the best threshold. For example, behaviour like quick change in swimming direction was often wrongly detected as pushing-up behaviour. On the other hand, some pushing-up behaviours were not correctly detected. These were filtered by one threshold but could not be filtered by the other threshold. In order to reduce wrong detection like these, it might be effective to add data of the geomagnetic direction to the filtering threshold. This threshold was not used in this study due to turbulent in magnetic field around the experiment site, because the tank was composed of steel. Moreover, depth data would be also a useful factor since the pushing-up movements are usually taken in the upper part of the net. It is necessary to consider more appropriate factors and its threshold.

## Conclusions

In this study, sea turtle's pushing-up behaviour was detected by filtering the attitude angle and ODBA data from the acceleration data logger. It was able to detect 82% of all pushing-up behaviour and match around 55% in its duration. By improving the detection accuracy, it is hoped to comprehend sea turtle's behaviour inside the full-scaled bag net of the set net in fishing ground.

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