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Development and Experiment of Bio-Tracking System in Deep Sea

深海バイオトラッキングシステムの開発と実験

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1. Introduction

In order to track time-seriese positions of benthic lifes in deep sea of off-Tohoku area continuously , bio-tracking system (BTS) has been developed in JAMSTEC. The scientifice pourpose is research on ecosystem of aquatic resources The main targets are snow crab and Kitchiji rockfish.

The BTS is consists of small acoustic pinger, which is attached to the target and transmit coded acoustic signal periodically, and base station, which receives and records the acoustic signal. In this paper, the designe and configuration of BTS, and ocean experiments are introduced.

2. Specifications of Bio-Tracking System

Table I shows the specifications of the BTS. The main systems, the pinger and the receiver, are developed by AquaSound Inc., a Japanese company. There are two types of small pinger, the differences are the size and the source level. **Figs. 1** show pictures pingers attached on snow crabs. The acoustic signal is codec by Gold codes of 32 patterns. A pressure sensor and a temperature sensor are equipped with the pingers. One transmission of acoustic signal is consist of three pulses. The sensor data is informed as interval time of the three pulses. Receiver system on the base station receives the acoustic signal with four hydrophones, detects the signal, and records detecting results. Direction of arrival of the acoustic signal can be calculated with the difference between the detected times by four receivers.

3. Estimation of Performance

The acoustic signal is correlated with replica signal in the receiver system. In order to save power consumption, the signal is A/D converted with 1-bit ADC, and correlated as 1-bit digital signal in an ASIC. **Figs. 2** (a) and (b) are results of 1000 times simulation, in which AWGN was added and correlation process was simulated. (a) shows peak level of correlation output, and dotted lines represents ± standard deviation. (b) shows standard deviation of error of peak detection time.

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Table I. Specifications of BTS

Items	Values
Size of pinger	ϕ9.5 x 43 mm ϕ11.5 x 43 mm
Carrier frequency	62.5 kHz
Modulation	Phase shift keying
Code	31-bits Gold code
Sensors on pinger	Pressure sensor and temperature sensor
Source level	155 dBμPa@1m 160 dBμPa@1m
Receiver array	4 channels
Sensors on receiver	Attitude sensor and compass
Peripheral devices on base station	Pinger, transponder, ROV homer, Radio beacon, and Flasher
Depth rating	2000 m
Duration	Max. 1 year

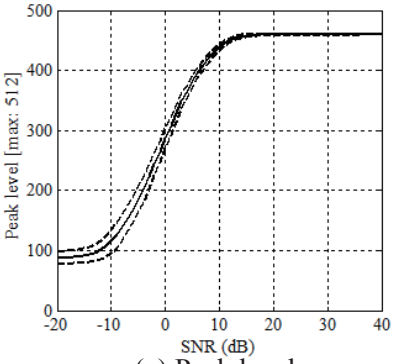
(a) (b)

Figs. 1 Pictures of pinger attached on snow crab.

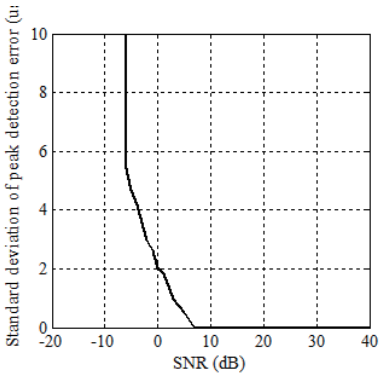
In these two figs., we set the detection threshold as around 200, and can detect the signal at greater than -5 dB for the SNR. Fig. 2 (c) shows relationship between the SNR and range. Two cases, noise level is 50 and 60 dBμPa/ √Hz, were considered. In this scope, detectable range can be assumed as about 300 - 600 meters.

4. Experiments

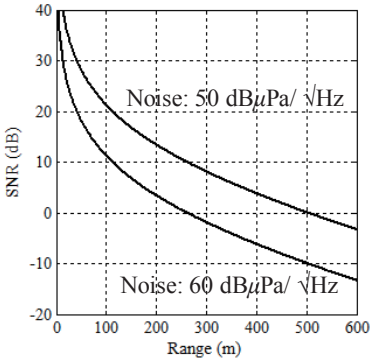
Here detectable range are considered with experimental results. **Fig. 3** shows a picture of the base station. Hydrophones were set at corners of the upper face of triangle pole and center. The height of the hydrophones were about 1 meter. **Figs. 4** show experimental result in shallow water, depth was 80 m, in Suruga Bay. (a) is time-series



(a) Peak level.



(b) Detection time error.



(c) Range vs SNR.

Figs. 2 Performance estimation by simulation.

Fig. 3 A picture of base station.

detection result of five pingers hanged from a boat which is moving away from the base station. The plot level in this figure represents summation of peak levels of four hydrophones. (b) shows distance between the pingers and the base station. Detectable range in this case seems about 300 - 400 meters. (c) shows detection result of a pinger which stayed stably at 480 meters off the base station, and the height was about 1 meter. The pinger is detectable, however, it seems to depend ambient environment.

Figs. 5 show experimental result in deep water, depth was 440 m, off Tohoku. (a) is detection result of ten pingers attached on snow crabs. The targets were stocked at about 200 meters off the base station. It seems to be difficult to have stable detection. It could be due to that the snow crabs hag the bottom. On the other hand, (b) shows detection result of pinger which stayed stably at 300 meters off the base station and the height was about 1 meter. And it is detected well. Detectable condition is need to be considered.

Acknowledgment

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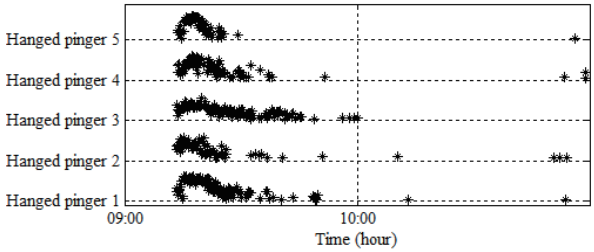
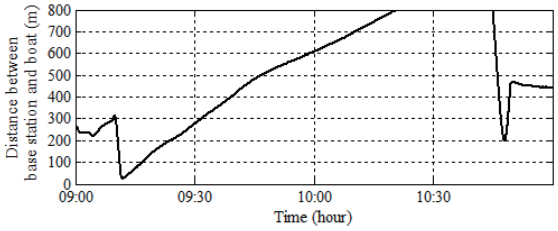
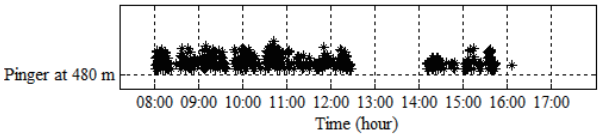


(a) Detection result of moving pinger.

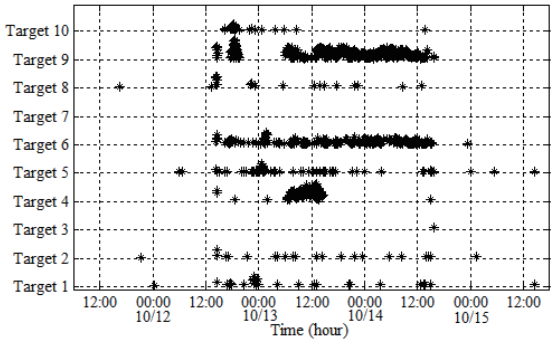


(b) Distance between pingers and base station.

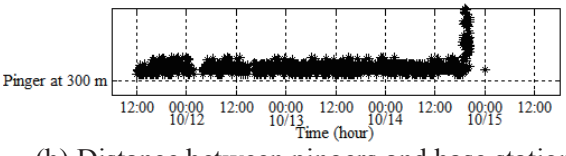


(c) Detection result of stable pinger.

Figs. 4 Experiment in shallow water.



(a) Detection result of pingers attached on crabs.



(b) Distance between pingers and base station.

Figs. 5 Experiment in deep water off Tohoku.