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Basic study on sonar system development for exploring infaunal bivalves

内生二枚貝探査ソナーシステムの開発に向けた基礎的検討

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## 1. Introduction

The asari clam (Ruditapes philippinarum) is one of the dominant bivalves on Japan's tidal flats. Recently, it has been reported that the catch of clams has decreased in various parts of Japan,[1]but it is difficult to investigate their habitat because they are hidden in sand and mud, and the cause has not been clarified yet. Therefore, it is necessary to develop a method for investigating the distribution status of clams and their secular change for sustainable use. At present, the clam distribution survey is carried out by directly digging the clams and counting them.

However, there are some problems with the conventional survey method, such as surveys at multiple locations are necessary to grasp the accurate distribution status, and it takes a very long time. Therefore, it is not suitable for knowing the change over time in the distribution of clam. Acoustic sensing has been widely applied to detect objects buried under the seabed as one of the efficient sensing methods. For example, the clam survey in the previous study used a system including a single channel transducer with a center frequency of 1 MHz. [2]

We aim to develope sonar system for exploring infaunal bivalves using underwater acoustic technology as a new method. In addition, in order to gain knowledge of system development, the sound field was obtained from simulation and measurement. We examined the visibility in acoustic images using a medium made of glass beads with controlled size.

### 2. Method

#### 2.1 Array probe

The newly developed underwater array probe (**Fig. 1**, manufactured by Japan Probe Co., Ltd., custommade product) has 64 ch transducers with a center frequency of 500 kHz, the specifications of the array probe used in this study are shown in **Table 1** 

	Table I	Information.
	frequency	500kHz
Fig. 1 Array probe.	shape	Concave
	cH number	64
	size	100mm× 98.9mm
	focus length	500mm

#### 2.2 Sound field

Sound fields were obtained by simulation and measurement using array probe. Then, we investigated whether it is appropriate to detect clams using underwater acoustic technology.

In the sound field simulation, the sound pressure from the point source to the observation point is defined by the following formula

$$p(t) = j \frac{\omega \rho_0 Q}{2\pi R} e^{j(\omega t - kR)}$$
(1)

 $\omega$  is the angular velocity,  $\rho_0$  is the water density, Q is the volume velocity, k is the wave number, and R is the distance from the sound source to the observation point.

Experimental set-up for sound field measurement is shown in **Fig. 2**. A water tank filled with water was used. And we got the wave data in the area of 600 mm  $\times$  200 mm.



Fig. 2 Experimental set-up for sound field measurement.

2.3 Acoustic images

Five types of glass beads with different particle sizes (**Table 2**) were used. And we investigated the effect of different particle sizes on the visibility of acoustic images. Therefore, we acquired an acoustic image of the buried aluminum block. Experimental set-up for acoustic images is shown in **Fig. 3**. Glass beads were laid 55 mm deep on the bottom of the glass case, and the aluminum block which had a length of 100 mm, a width of 20 mm, and a height of 20 mm was embedded in the glass case. The glass case was installed in a water tank filled with degassed water.

Then, using the array probe, the right end (0 mm) of the glass case in Fig. 3 was the origin, and the left end (200 mm) was the end point. And it measured at intervals of 5 mm.

Table 2 Five types of glass beads			
Symbol	Grain diameter (µ	m) Grain size scale	
А	38~53	Silt	
В	125~150	Fine sand	
С	250~355	Medium sand	
D	500~710	Coarse sand	
Е	710~1000	Coarse sand	
x y z Pulsar receiver PC S00kHz Array probe(64ch) Degassed water			
[ [ ]		Aluminum block	

Fig. 3 Experimental set-up for acoustic images.

Glass beads

200mm

#### 3. Results and discussion

#### 3.1 Sound field

The area was set to  $200 \times 600 \text{ mm}^2$  to compare the sound fields of the simulation and the measurement. (**Fig. 4**). As a result, it turns out that both are in focus.

The range in which the sound pressure was reduced by 3dB from the maximum value was defined as the focal area. The beam widths for simulation and measurement were 9 mm and 11 mm, respectively. The depth of focus was 587 mm and 480 mm.

Clams usually sneak up to a depth of 100 mm from the surface of the seabed. The typical size is 40 mm  $\times$  30 mm  $\times$  28 mm. Because the beam width is shorter than the size of the clams and the depth of focus is longer than the depth of infiltration, it can be confirmed that the employed acoustic beam is suitable for surveying the distribution of clams using underwater acoustic technology.



Fig. 4 Two dimensional acoustic images.

3.2 Influence of grain size on acoustic images

Two-dimensional acoustic image was constructed based on the acoustic data at the measurement position for each particle size (5 types) (**Fig. 5**).

The acoustic images in this study were measured at the position where the reflection from the aluminum block could be clearly seen. The aluminum block was confirmed in all particle sizes. The upper part of the aluminum block in the five acoustic images represents the surface of the buried layer and the lower part of the aluminum block represents the bottom of the glass case.

The red areas corresponding to the reflected waves from the surface of the aluminum block are smaller in E than those of other conditions of grain sizes. This may be because the attenuations in the glass bead E is increased more than other glass beads.



Fig. 5 Two dimensional acoustic images.

#### 4. Conclusions

As a result of the comparison of the sound fields created by simulation and measurement, it was found that the beam is suitable for grasping the shape of the clam. In addition, we used glass beads of different grain sizes to evaluate the visibility. Then, we were able to confirm the aluminum blocks at all grain sizes. In the future, we intend to verify the clams in actual sea and use the results to establish the system.

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