International Conference on Sensor, Sensor System and Actuator

PROCEEDING
East Hall, 28 May - 2014
Institut Teknologi Bandung

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Proceeding

International Conference on Sensor, Sensor System and Actuator (ICSSA 2014)

Bandung, 28 May 2014

http://portal.fi.itb.ac.id/icssa2014

Preface

The 1st International Conference on Sensor, Sensor System and Actuator (ICSSA 2014) will be held on May 28, 2014, Bandung. The conference will highlight recent and significant advances in research and development in the field of sensor, sensor system and actuator. It will cover all aspects of theory and practice.

The goal of ICSSA 2014 is to bring together the researchers to share ideas, problems and solution relating to the development in the field of sensor, sensor system and actuator.

The scopes of research results to be presented and discussed in this conference covers **Sensor and Transducers, Networked Sensor, Sensor System, Sensor Materials, Micro Sensor, Industrial Applications and other related topics.**

After the oral presentations and discussion on May 28, all papers will be peer-reviewed. Selected papers will be published in the Journal of Engineering and Technological Sciences.

On behalf of all the participants of ICSSA 2014, we would like to deeply thanks to the Faculty of Mathematics and Natural Sciences (ITB), Faculty of Industrial Technology (ITB) for sponsoring this program. Our sincere thanks also go to CITA-ITB, HFI, HimII for their supports.

Bandung, May 2014

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Conference Venue

East Hall, Institut Teknologi Bandung
Jl. Ganesa 10 Bandung

Schedule of Sessions

Wednesday, 28 May 2014

07.00 - 08.30	**Registration** **Front Desk**
08.30 - 09.00	**Opening Ceremony and Photo Session** **Hall**

09.00 - 09.15	**Coffee Break**

Plenary Session	**Hall**
09.15 - 09.40	**Photo and X-Rays Induced Optical Luminescence Study of Glass Scintillators** Prof. Dr. Jakrapong Kaewkao (NRPU, Thailand)
09.40 – 10.05	**Carbon Based Thin Film Materials Deposited by HWIP-PECVD Method for Sensor Applications** Prof. Dr. Toto Winata (ITB, INA)
10.05 – 10.30	**Glancing Angle Deposited Nanostructure Metal Oxide Film for Sensing Applications** Dr. Mati Horprathum (NSTDA,Thailand)
10.30 – 10.55	**Blood Flow Measurement by Thermal Analysis of Human Skin** Prof. Dr. Martin Liess (HS-RM, Germany)

Plenary Session	**Hall**
10.55 - 11.20	**Electronic Nose Based on Array of Metal Oxide Semiconductor Sensors as Classifier of Roasted Robusta Coffee** Dr. Kuwat Triyana (UGM, INA)
11.20 - 11.45	**Measurement and Visualization of Steam Buoyant Jet using Ultrasonic Transducer** Prof. Dr. Deddy Kurniady (ITB, INA)

11.45 - 13.00	**Lunch Break**

Plenary Session	**Hall**
13.00 – 13.25	**Shadow stereoscopy: Sensing and playing with 3D shadows** Dr. Gea O.F. Parikesit (UGM, INA)
13.25– 13.50	**On-line System of tsunami sensor and early warning based on TCP/IP Protocol** Dr. Yono Hadi Pramono (ITS, INA)

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14.05 – 14.20	ICSSA-005	ICSSA-006	ICSSA-007	ICSSA-008
14.20 – 14.35	ICSSA-009	ICSSA-010	ICSSA-011	ICSSA-012
14.35 – 14.50	ICSSA-013	ICSSA-014	ICSSA-015	ICSSA-016
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15.20 – 15.35	ICSSA-025	ICSSA-026	ICSSA-027	ICSSA-028
15.35 – 15.50	ICSSA-029	ICSSA-030	ICSSA-031	

15.50 - 16.20	**Coffee Break**

16.20 - 17.00	**ISASS Meeting**

17.00 – 17.30	**HFI-Instrumentation Meeting**

19.00 – 20.00	**Dinner and Closing Ceremony**

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ICSSA-002 : Suwarno
ICSSA-003 : Firdaus
ICSSA-004 : Medilla K.
ICSSA-005 : Sisdarmanto Adinandra
ICSSA-006 : Edi Sanjaya
ICSSA-007 : R.Reinaldo
ICSSA-008 : InuSuprianto
ICSSA-009 : Henry M. Manik
ICSSA-010 : Moh.Yasin
ICSSA-011 : Kittipong Seingsanor
ICSSA-012 : Valendry Harvenda
ICSSA-013 : W. Rachniyom
ICSSA-014 : W. Chaiphaksa
ICSSA-015 : Daw Yangnoy

ICSSA-016 : Budhi Anto
ICSSA-017 : Setyawan P. Sakti
ICSSA-018 : Iis Hamsir Ayub Wahab
ICSSA-019 : Ary P. Nurmansah
ICSSA-020 : Erna Risfaula
ICSSA-021 : Mohd Kamarulzaki M.
ICSSA-022 : Cancelled
ICSSA-023 : Tito Yuwono
ICSSA-024 : Endra Susila
ICSSA-025 : Melania S Muntini
ICSSA-026 : Lazuardi Umar
ICSSA-027 : Rahmondia N. Setiadi
ICSSA-028 : Ambran Hartono
ICSSA-029 : Mitra Djamal
ICSSA-030 : Ramli
ICSSA-031 : Zaki Su'ud

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SONAR TRANSDUCER CHARACTERISTICS FOR UNDERWATER DETECTION

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Abstract. This paper presents the results of a study on sonar transducer characteristics for detection and quantification purpose. The main objectives was to provide Sonar tool for the evaluation of underwater target. The echo signal of the underwater target using quantified Sonar system operated at 200 kHz. Sonar algorithm designed and implemented for processing underwater acoustic data.

Keywords—detection, sonar, target, transducer, underwater;

1. Introduction

The development of underwater electroacoustic transducers expanded rapidly during the twentieth century, and continues to be a growing field of knowledge, with many significant applications, one that combines mechanics, electricity, magnetism, solid state physics and acoustics. In the most general sense, a transducer is a process or a device that converts energy from one form to another. Thus an electroacoustic transducer converts electrical energy to acoustical energy or vice versa [1] . The term SONAR (SOund Navigation And Ranging) is used for the process of detecting and locating objects by receiving the sounds they emit (passive sonar), or by receiving the echoes reflected from them when they are insonified in echo-ranging (active sonar).

The function of an electroacoustic transducer is to radiate sound into a medium such as air or water or to detect sound that was radiated into the medium. The transducer responses are measures of a transducer’s ability to perform these functions [2]. They are defined as the transducer output per unit of input as a function of frequency. Transducers generally radiate sound in a directional manner which changes with frequency and with distance from the transducer. At a given frequency the far field is the region beyond which the directional characteristics become independent of distance, and the sound pressure becomes inversely proportional to distance.

Sound is an important tool for gaining insight into phenomena and processes in underwater environments. In the ocean, the theory of sound is essential in such broad applications as military operations, geological exploration, and biological surveys. Unlike electromagnetic waves, acoustic pressure waves are able to propagate long distances in water.

The typical frequency range used in underwater acoustics is 10 Hz to 1 MHz, with the lower frequencies able to travel many kilometers. An important aspect of the field is acoustic scattering, that is, understanding how sound reacts to boundaries and obstacles in its path. With SONAR (Sound navigation and ranging)—a method for marine vessels to navigate, communicate, and detect one another—as its most well-known application, acoustic scattering includes the study of the reflection, diffraction, and transmission of sound incident upon a particular object. This analysis can often convey detailed information about the nature of the object such as its shape, size, or material properties. Knowledge of scattering mechanisms is important in such diverse applications as mine detection and investigating zooplankton populations. There is a vast literature on the subject of underwater acoustic scattering [3; 4]. In sonar instrument, a sound pulse is transmitted by a sonar system and the time of arrival of the echo provides a measure of the height of the sonar above the bottom. However, the shape and duration of the echo are often very different from the original pulse and these distortions contain information about the sea bottom [5].

Single beam monostatic sonar have been the tool for underwater organism and its habitat observation [6]. This instrument is simple to uses and widespread on all vessels. The shape of received echo give a lot of information such as bottom hardness and roughness. New developed techniques of underwater acoustic signal analysis allow to differentiate all collected data and distinguished habitats using various signal processing methods.

2 Methodology

Sonar instrument principle is shown in Fig. 1. The transmitter and transducer generate the transmit pulse; the same transducer then receives the echo, which includes signal (backscatter information) and noise. A transmit/receive switch provides appropriate connections during the transmit/receive cycle (ping). The received echo is filtered using signal processing tools. Its upper frequency sets the sample rate required by the A/D converter, which transforms the analogue signal to a digital signal or data stream. A detector and low-pass digital filter follow to remove the carrier and higher frequency components, including the out-of-band portion of the remaining noise; a smooth echo envelope results. Finally, decimation may be used to reduce the data rate, often in a process that includes digital filtering. The resulting digital signal stored on disk and displayed as an echogram, serving as the raw material for sediment classification. Transmitter and receiver characteristics must be stable over time, and environmental conditions, such as temperature, moisture, and vibration to record backscatter information.

The sonar measurement incorporates the characteristics and geometry of the single beam sonar such as the transducer's beam pattern, its depth and with respect to vertical, the characteristics of the transmitted sound pulse, and the roll and pitch angles of the platform to which the transducer is mounted; and environmental factors: spherical spreading and absorption losses as the signal propagates through the water column, backscattering of the signal at the water–sediment interface, and by inhomogeneities in the sediment volume.

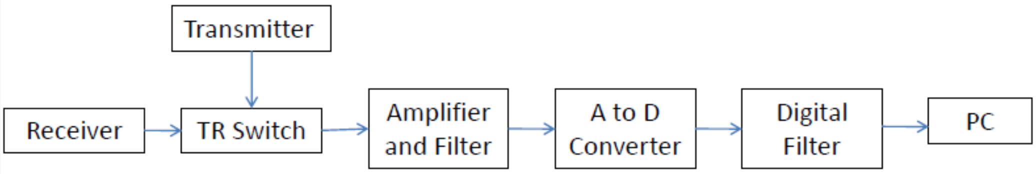

Fig. 1. Diagram of single beam sonar instrument

Sonar Equations

Acoustical techniques using Sonar instrument are routinely used for investigations of aquatic organisms. Echo integration and echo counting are the common methods for biomass assessment in oceans, lakes and rivers [8]. The established methods are all based on the echo formation process, theoretically described by the wellknown sonar equation [9] involving the transmitted pulse, the transmission loss through the medium, the acoustical scattering by the target and how the echo is sensed and measured by the receiver.

The sonar equation for the backscattering from a resolved target, the received echo excess, *EE*, for an active sound system can be expressed as:

$$EE = SL - 2TL + TS + DI - NL \qquad (1)$$

where *SL* is the source level, *TL* is the one way transmission loss including the spherical spreading and the absorption, *TS* is the target strength, *DI* is the sonar directivity index, and *NL* is the ambient noise level. For unresolved targets, the corresponding *EE* has a slightly different form:

$$EE = SL - 2TL + SV + \Psi - NL \qquad (2)$$

where SV is the volume backscattering strength, where SV = 10 log Sv, which is Sv is the volume backscattering coefficient. Ψ is the logarithmic form of the equivalent beam angle measured by :

$$\psi = \int_{\theta=0}^{\pi} \int_{\phi=0}^{2\pi} b^2(\theta,\phi)\sin(\theta) \bullet d\theta\, d\phi \tag{3}$$

where θ and Φ are spherical polar coordinates used to determine the direction of a point (P) relative to the origin (O) of the transducer, θ is the angle of OP from the acoustic axis, ϕ is the azimuthal angle of OP projected onto the plane of the transducer face, and b is the beam pattern, defined in terms of intensity. The entire beam patterns is used in the integration, from $\theta = 0$ to π and from $\phi = 0$ to 2π. Values for ψ are supplied by some manufacturers and can be modified in analysis software. Some manufacturers report equivalent beam angle in steradians.

Sonar transducer should have a measured beam pattern showing the magnitude of the main lobe and associated side lobes. Performed by the manufacturer, these transducer-specific measurements also provide measures for Ψ (equivalent beam angle) and the 3 dB angle used in data collection and processing. The active radius (a) of a circular transducer, the half-intensity beam angle ($\theta_3 dB$), and the equivalent beam angle (Ψ) are related and can be calculated from each other through the following equations (when ka>10) :

$$a = \frac{1.6}{k \bullet \sin(\frac{\theta_{3\mathrm{dB}}}{2})} \tag{4}$$

where $\theta_3 dB$ is the half-power beam angle (°), k is the wave number

$$[k = \frac{2\pi}{\lambda}] \tag{5}$$

and λ is the wavelength (m)

The quantities of Ψ and DI can be determined by standard target calibration by measuring echo level $EL = EE + NL$. For sonar systems, the transmission loss (TL) is compensated by time vary gain (TVG) defined by

$$TL = 20 \log_{10} r + \alpha r \tag{6}$$

for resolved target, and

$$TL = 10 \log_{10} r + \alpha r \tag{7}$$

for unresolved target, where r is range in meters and α is the absorption coefficient (dB/km).

Consider a simplified acoustic system (Fig. 2) where a narrowband monostatic sonar at incident angle (θ_i) to the seabed with transmitting sensitivity $b(\varphi,\phi)$ and receiving sensitivity $b'(\varphi,\phi)$ (where φ and ϕ are the angles relative to the beam axis) axis), emits a short sinusoidal pulse of duration τ and average source intensity $I_s(\theta_i)$, measured at a unit distance from the source. The pulse propagates through an unbounded medium spherically, spreading and being absorbed and refracted. At a range *R*, the pulse interacts with the seabed and insonifies an area S of random homogeneous distribution of scatterers producing surface reverberation $s_s(\theta_i)$ at any one instant of time. Neglecting volume scatter within the seabed, a part of the signal is backscattered towards the source as the sum of random scatterers emanating from a large number of elemental areas dS within the area S.

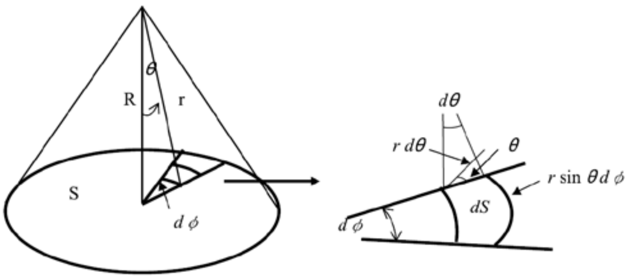

Fig. 2. Monostatic sonar system measurement

For target strength (TS) measurement,

$$TS = -RS - SL + (2*TL) + \mathit{Voltage(returned)} - AVG + \alpha - AG \quad (8)$$

$$\mathit{Voltage\ (returned)} = 20*\log10\,(count*maxVolt)/(maxCount) \quad (9)$$

RS is receiving sensitivity, SL is source level, AVG is array gain voltage, and AG is amplifier gain.

Results and Discussion

The operating frequency of sonar transducer is 200 kHz. The primary beam width is about 4^o. The array is circular, then its radius can be determined from the formula relating the product of wave number *k* and radius *a*. The product of ka is about 50, and the directivity index at 200 kHz is 20 log ka = 32 dB. The output power P is specified as being at least 30 dB.

If 1 watt of acoustic power is transmitted omnidirectionally, then the intensity at a distance of 1 meter is 1 watt per 4π square meters or 0.08 watts per square meters. For the standard pressure reference of an rms level of 1 microPascal (1 μ Pa), the intensity in sea water is [10]

$$I_0 = \frac{p^2}{\rho c} = \frac{(10^{-6})^2}{1.5 \times 10^6} = 6.67 \times 10^{-19}\ \mathrm{W/m^2} \tag{10}$$

The sound pressure level (SL) for a 1 watt omnisource is given by

$$\mathrm{SL} = 10 \log\left(\frac{I}{I_0}\right) = 10 \log\left(\frac{0.08}{6.67 \times 10^{-19}}\right) = 170.8\ \mathrm{dB} \tag{11}$$

Then, the acoustic power is measured by

$$\mathrm{SL} = 10 \log \mathrm{Pa} + \mathrm{DI} + 170.8 \tag{12}$$

or about 230 dB re 1 µPa at 1 m.

Since ka = 50, and k = 2π / λ, where λ is the wavelength at the 200 kHz, namely 75 cm, a is about 15 cm. The nearfield distance from $R = \pi a^2/\lambda$ is 1.8 m, which is consistent with the minimum depth of operation, namely 2 m, as given in the manufacturer's specifications. This distance will vary with the hydrographic condition. The beam width (BW) for large ka is given by $BW = 3.2/ka$ radians $= 58\,\lambda/D$ degrees, where D = 2a is the piston diameter.

The absorption coefficient (α) using Francois and Garrison formula [7] for temperature 27^{o} C and salinity 33 ppt is about 0.0029 dB/m. The absorption at 20 m, namely α R is about 0.058 dB. Changes in hydrographic conditions will change the value of α.

Figure 3 show the sonar pulse transmitting form underwater transducer. Echo envelope of sonar is shown in Figure 4. Sonar directivity and calculated directivity is shown in Figure 5. Comparison of measurement directivity of ring surface scattering (RSS) was compared with Chotiros model [5]. From this figure, the RSS directivity is quiet similar with the model. The signal echo from underwater target and its spectrum is shown in Fig. 6. Figure 7 show the measurement and Urick model for Target Strength value.

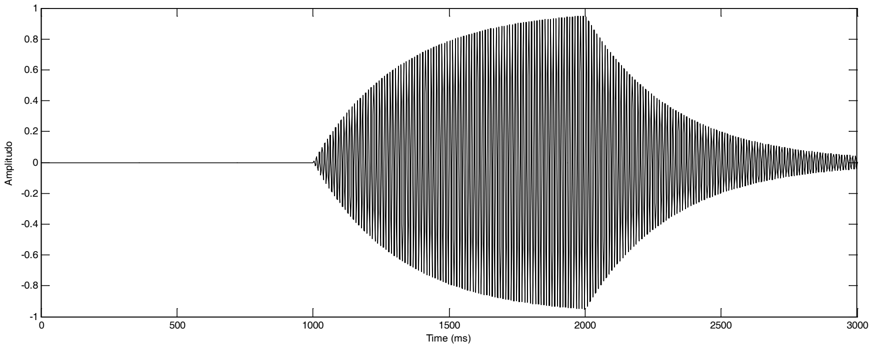

Fig. 3. Transmitted sonar pulse

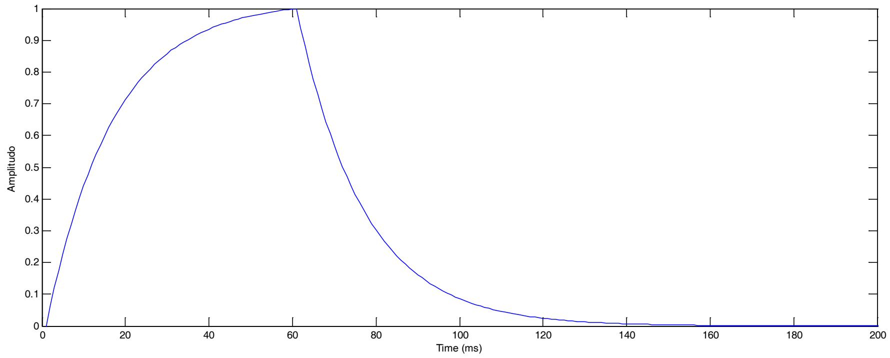

Fig. 4. Echo envelope of sonar

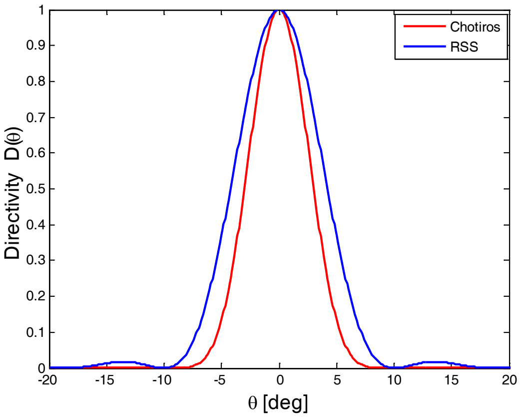

Fig. 4 Directivity function of sonar transducer

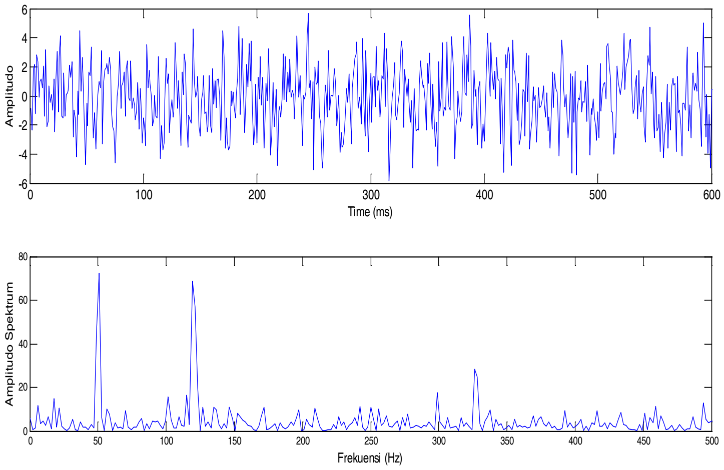

Fig. 5. Signal echo (upper) and its spectrum (lower)

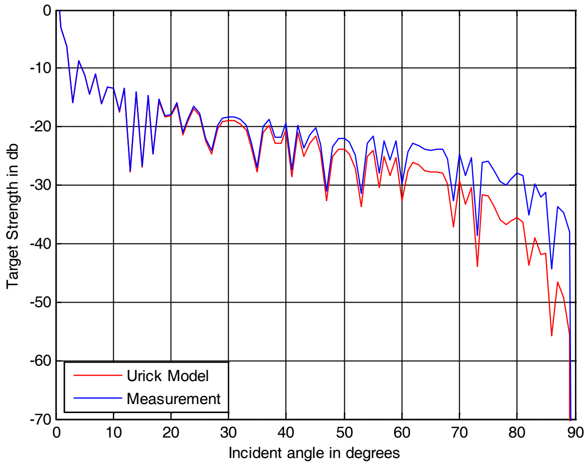

Fig. 6. Measurement and model of target strength

Figure 7 show the backscattering signal from underwater object, shown in raw SV value against depth. The highest raw SV is detected as seabed (at 120 m depth) and other is water column at 80-100 m depth.

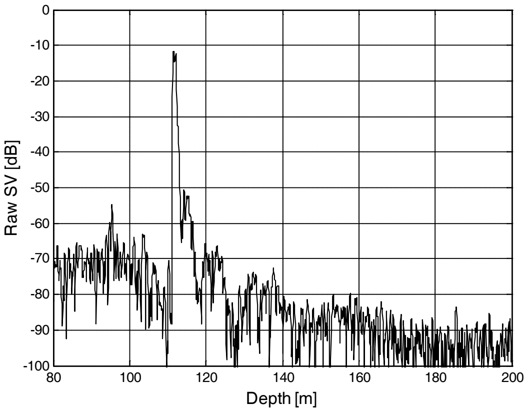

Fig. 7. Echo from water column and seabed

We derived the multiple echo received from target as shown in Figure 8, where the highest reflection shown in highest peak of signal. Figure 9 shows the echogram of seagrass with the TS value range from -46.9 to -48 dB. Finally, the conclusion of this research that the sonar system and its signal processing is reliable tool to observe underwater target detection and classification.

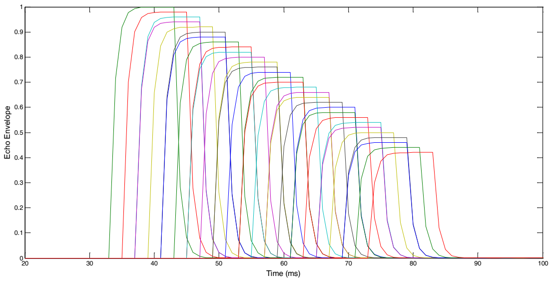

Fig. 8. Multiple signal echo derived from sonar

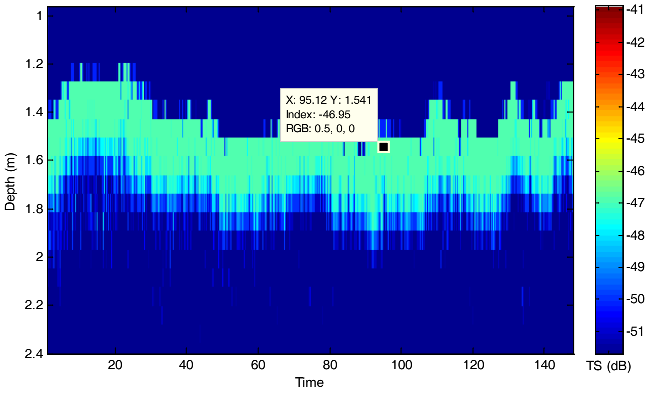

Fig. 9. Sonar images of seabed .

Acknowledgement

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