CHARACTERIZATION OF SOUND SPEED PROFILE IN MALAYSIAN SEA

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To My Beloved Parents

To all my beloved siblings (Abdurrahman, Maymun, Abdikarim, Mariam, Mohammed, Abdullah and Abdulqadir) and in the hope that they will be encouraged to drive for the best throughout their lifetimes.

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ABSTRACT

The propagation of sound in the sea is dependent on several environmental factors such as the depth and some other ocean properties. The characteristics of sound propagation in the sea are determined by the sound speed profile. The sound speed in the sea is determined and varies with depth, salinity change, temperature, the season as well as the geographic location. In general, the different sea conditions have different characteristics of sound speed profile. This project aimed to analyze the sound speed profile in Malaysian Sea. The data collected from hydrographical measurement during the Matahari'85 expedition in the South China Sea, in Terrengganu coastline together with Mackenzie sound speed equation were used to model the sound speed profile. By comparing the effect of temperature and salinity on sound speed it was observed that temperature has more effect than salinity. Also ray tracing model is used to trace the path of sound which travels through the sea with a sound speed profile given by the depth and corresponding sound speed. In conclusion, by characterizing sound speed profile in the sea, it enables the prediction of the direction and the path that the sound propagates.

ABSTRAK

Perambatan gelombang bunyi di dalam laut bergantung kepada beberapa faktor persekitaran seperti ke dalaman dan ciri-ciri lautan yang lain. Ciri-ciri perambatan gelombang bunyi adalah ditentukan oleh profil kelajuan bunyi. Halaju bunyi di dalam lautan adalah ditentukan dan berubah dengan kedalaman, perubahan kemasinan, suhu, musim dan juga lokasi geografi. Umumnya, keadaan laut yang berbeza-beza, mempunyai ciri-ciri profil kelajuan bunyi yang berbeza. Projek ini mensasarkan penganalisaan profil kelajuan bunyi di lautan Malaysia. Data pengukuran hidrogafi yang dikumpulkan semasa ekspedisi Matahari '85 di Laut China Selatan bersama dengan persamaan kelajuan bunyi Mackenzie digunakan untuk menghasilkan model profil kelajuan bunyi. Dengan membandingkan kesan suhu dengan kemasinan keatas kelajuan bunyi, diperhatikan bahawa suhu mempunyai lebih kesan terhadap profil kelajuan bunyi. Model Pengesan Sinar juga digunakan untuk mengesan laluan bunyi yang merambat di lautan berdasarkan profil kelajuan bunyi yang digunakan bersama kedalaman dan kelajuan bunyi yang berkaitan. Sebagai kesimpulan, dengan mencirikan profil kelajuan bunyi, membolehkan ramalan arah dan laluan perambatan gelombang bunyi.

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LIST OF ABBREVIATIONS

CZ	-	Convergence Zone
DSC	-	Deep Sound Channel
EEZ	-	Exclusive Economic Zone
RAP	-	Reliable Acoustic Path
SCS	-	South China Sea
SONAR	-	Sound Navigation And Ranging
SSP	-	Sound Speed Profile
XBT	-	Expendable Bathythermograph

LIST OF SYMBOLS

D	-	Depth.
dB	-	Decibel
Hz	-	Hertz.
Kg/cm^2	-	Kilogram per centimeter square.
Km^2	-	Kilometer square.
m	-	Meter.
m/s or ms^{-1}	-	Meter per second.
^{o} C	-	Centigrade.
ppt	-	Parts per thousand.
psu	-	Practical salinity units.
S	-	Salinity
T	-	Temperature.
Yd	-	Yard.
θ	-	Latitude.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The science of production, transmission, reception, and utilization of sound in the sea is called ocean acoustics. Research and exploratory activities on underwater life and other resources, communication, sea bottom mapping, and remote control of equipment etc. utilize sound energy. It is essential in military and rescue operations and a number of commercial activities like exploration for minerals and oil, dredging, fisheries, and navigation. Except for a small number of special short-range applications, frequencies of interest in ocean acoustics are less than a few tens of kilohertz. This is because sound absorption by sea water increases so much with frequency that propagation ranges achieved at higher frequencies are very small.

Sonar (originally an acronym for SOund Navigation And Ranging) is one of popular technique that uses acoustic propagation (usually underwater) to navigate, communicate with or detect objects on or under the surface of the water, such as other vessels. Sonar operation is affected by variations in sound speed, particularly in the vertical plane. Sound travels more slowly in fresh water than in sea water, though the difference is small. The speed is determined by the water's bulk modulus and mass density. The bulk modulus is affected by temperature, dissolved impurities (usually salinity), and pressure. The density effect is small.

The largest variation in the speed of sound in water occurs with changes in depth. Obviously the pressure increases with depth causing a uniform increase of 1.7m/s for every 100m. Furthermore, the ambient temperature changes with depth. When we plot the speed of sound as a function of depth in the ocean, it is called sound speed profile. The sound speed profile is a very useful tool for being able to predict the direction of propagation of sound in the ocean.

1.2 Problem Statement

Underwater communications can be established by transmission of acoustic waves. Underwater acoustic communications are a rapidly growing field of research and engineering as the applications, which once were exclusively military, are extending into commercial fields.

Propagation of acoustic waves faces many problems such as attenuation loss, absorption loss and delay in acoustic signal. So the need to study sound propagation and characterize the sound speed profile in seas is very important to underwater communication.

1.3 Project Objectives

The objectives of this work are:

- To investigate the correlation between oceanic variable such as (Temperature, pressure and salinity) and sound speed profile.
- To investigate how sound speed profile effect and control the propagation of sound in the sea.
- To predict the direction and the path of sound waves using the ray tracing model.

1.4 Scope of the Study

The scope of this project is based on a study of underwater acoustic propagation. The first part of the project consists of the basic theory of sound speed profile, literature review and environmental studies of profiles such as temperature profile and salinity profile.

The next part of this project is the simulation of the sound speed profile using sound speed equations and ray tracing model by MATLAB program.

After performing the simulation we will see how sound speed profiles effect and control acoustic propagation for shallow water condition.

1.5 Thesis Organization

This thesis is organized into six chapters:

Chapter 1 focuses on introduction, problem definition, research objective and scope of the work.

Chapter 2 contains the essential background and literature review of the sound in water and its properties, besides the sound propagation in shallow water and propagation models.

Chapter 3 presents sound speed and its equations and the parameters that depend on it such as temperature and salinity; it also contains sound speed profile and the formation of sound channel in the sea.

Chapter 4 describes on project methodology, which provides a full discussion about the flow of this work. It also contains the hydrographical observation in South China Sea (Trengganu coastline) and data of salinity, temperature and depth collected during the expedition of Matahari'85.

Chapter 5 presents the results, result analysis and discussion of the simulation in chapter 4.

Chapter 6 is the conclusion of overall chapters and future works in the related area of sound propagation will be discussed. This includes recommendations for further study.

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