TURTLE HEARING CLASSIFICATION FOR TURTLE EXCLUDER DEVICES DESIGN

ANTON YUDHANA

UNIVERSITI TEKNOLOGI MALAYSIA

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To my beloved mother, father, wife, and children

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ABSTRACT

The process of reducing the accidental capture and subsequent mortalities of sea turtles in regional captured fisheries through the use of Turtle Excluder Device (TED) has been extremely important. The objectives of this study is to determine the hearing ability for Green Turtle (*Chelonia Midas*), identify the green turtle and fish behavior on various sound exposures, and determine the specification of TED using underwater sound technique. Auditory Brainstem Response system is used to identify the hearing threshold of the turtle. The measurements were performed at Turtle and Marine Ecosystem Center (TUMEC) Terengganu, Perak, and Melaka Malaysia. It was conducted at a turtle tank by employing click and tone stimulus. Turtle ages of 2 years, 5 years, 9 years, and 30 years were deployed. The measured data were analyzed in time and frequency domains. It is found that the green turtle has a hearing ability in the range of 50 Hz to 1200 Hz. The results showed that turtle hearing sensitivity is about 300 Hz to 500 Hz. Also, the measurement of ambient noise in the life habitat has been conducted. The measurements were divided into 3 different distances from the sea shore: 200 m, 400 m, and 800 m and within 3 different sea depth: 2 m, 5 m, and 10 m for each point, respectively. The frequency and maximum magnitude of ambient noise are found to increase as the depth increased. Finally, the behavior of the turtle and fish towards the emitted sound has been observed. A group of signals that dispel turtles have been determined. The types of signals are Low and High Frequency Modulation, white noise, and sinusoidal signal. These signals do not give any respond to the fish. Therefore, this information is very useful in the development of TED using sound.

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ABSTRAK

Proses mengurangkan kejadian penyu terperangkap dan kematian penyu dalam industri perikanan dengan menggunakan Turtle Excluder Device (TED) adalah sangat penting. Objektif kajian ini adalah untuk mengenalpasti kelakuan penyu hijau (*Chelonia Midas*) kepada bunyi yang dipancarkan, menentukan kelakuan penyu hijau dan ikan dalam menerima pelbagai bunyi, serta menentukan spesifikasi TED menggunakan teknik bunyi bawah laut. Sistem ABR (Auditori Brainstem Response) digunakan untuk mengenalpasti batas pendengaran penyu. Pengukuran dilakukan di Turtle and Marine Ecosystem Center (TUMEC) Terengganu, Perak, dan Melaka Malaysia. Pengukuran telah dijalankan dalam tangki penyu menggunakan stimulus klik dan tone. Usia penyu yang digunakan adalah 2, 5, 9, dan 30 tahun. Data terukur telah dianalisa dalam domain masa dan frekuensi. Kemampuan pendengaran penyu hijau telah dikenal pasti pada julat frekuensi dari 50 Hz ke 1200 Hz. Hasil menunjukkan bahawa pendengaran penyu paling sensitif adalah pada julat 300 Hz ke 500 Hz. Pengukuran aras hingar di laut telah pun dilakukan. Pengukuran dilakukan pada tiga jarak yang berbeza iatu, 200 m, 400 m, dan 800 m daripada pantai dengan 3 perbezaan kedalaman pada masing-masing titik pengukuran iaitu, 2 m, 5 m, dan 10 m. Frekuensi dan magnitud maksimum daripada aras hingar didapati meningkat dengan peningkatan kedalaman. Akhirnya, perilaku penyu dan ikan terhadap bunyi yang dipancarkan telah pun diperhatikan. Kumpulan bunyi yang boleh menghalau penyu telahpun dikenal pasti. Jenis bunyi tersebut adalah modulasi frekuensi rendah tinggi, noise putih, dan isyarat sinusoidal. Isyarat bunyi ini tidak memberikan sebarang kesan pada ikan. Oleh kerana itu, informasi ini sangat berguna bagi perancangan TED menggunakan bunyi.

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LIST OF ABBREVIATIONS

ABR	-	Auditory Brainstem Response
AEP	-	Auditory evoked potentials
ANSI	-	American National Standard for Institute
ASCII	-	American Standard Code for Information Interchange
ASSR	-	Auditory Steady State Response
AULS	-	Autonomous Underwater Listening Station
CWT	-	Complex Wavelet Transform
dBnHL	-	dB scale relative to normal hearing level
DO	-	Dissolved Oxygen
EEG	-	Electro EnchepaloGraph
EFR	-	envelope following response
EFR	-	envelope following response
FFT	-	Fast Fourier Transform
hh	-	Hour
IHS	-	Intelligent Hearing System
L	-	length
LFM	-	Low Frequency Modulation
mm	-	Minute
MRTF	-	modulation rate transfer function
NMFS	-	National Marine Fisheries Service
NN	-	neural network
NOAA	-	National Oceanic and Atmospheric Administration
NPF	-	Northern Prawn Fishery
PTT	-	push to talk
RMS	-	Root Mean Square

RMSE	-	The Root Mean Squared Error
Sal	-	Salinity
sd	-	Stimulus Duration
SEAFDEC	-	South East Asian Fisheries Development Center
SNR	-	signal to noise ratio
SpCond	-	Sound propagation Conductivity
SPL	-	Sound Pressure Level
ss	-	Second
SSE	-	The Sum of Squares due to Error
Std	-	Standard Deviation
STFT	-	Short Time Fourier Transform
STFT	-	short time Fourier Transform
T	-	tall
TED	-	Turtle Excluder Devices
Temp	-	Temperature
TUMEC	-	Turtle and Marine Ecosystem Center
UTM	-	Universiti Teknologi Malaysia
W	-	width
WN	-	White Noise

LIST OF SYMBOLS

μ	-	micro
W	-	watt
m^2	-	meter square
ms	-	mili second
re	-	relative
Pa	-	Pascal
L	-	liter
mg	-	mili gram
C	-	celcius
d	-	depth
ºC	-	degree celcius
Ω	-	ohm
Vdc	-	volt direct current
(Lx WxT)	-	LenghtxWidthxTall

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Sea turtles are important marine animals, not only under CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) agreement but also traditional living resources in the ASEAN region. Most of the ASEAN member countries have established national programs on the conservation and enhancement of sea turtles. However, information on research, conservation and enhancement of these animals in the region is rather fragmented.

Fisheries (Prohibition of Fishing) Regulations 1990 is released by Fisheries Department Malaysia prohibits unsustainable fishing practices gill net (pukat hanyut) for catching stingray or skates fish (ikan pari) at zone A or coastal marine (5 mile from coast line) of the sea. One reason for this prohibition is the incidental captured of the turtle in the net. Turtle and stingray have the same habitat and when the turtle landed to reproduce and feed into the beach they would died in drawn out caused by catch in the net. The number of landed turtle in Malaysia decrease every year. **(**http://turtlemalaysia.gov.my/ancaman.html). Eckert (1999) reported that green turtle (*Chelonia mydas*) is classified as endangered species, while the hawksbill turtle (*Eretmochelys imbricata*) and the leatherback-turtle (*Dermochelys coriacea*) are classified as critically endangered.

Fisheries Regulation 1990 was aimed to prevent turtle extinction when this regulation had caused stingray fish production got decrease. The stingray fish is quite popular in Malaysia and it is in line with the food industry variety. The demand of this fish is increase in Malaysia. Recreational and sport fishing stingray is also point of interest for tourism industry in Malaysia. The other benefit, its skin had commercial values in exotic leather wear and very rare to found any of the stingray skin wallets in Malaysia.

Meanwhile, the usage of gill net by fisheries had been monitored by local authority because of many fisheries still used it in illegal fishing. The Turtle and Marine Ecosystem Center (TUMEC) has been reported that in 2006 under Fisheries Department they had confiscated more 20 gill nets in the inspection in Terengganu reported by (http://web10.bernama.com/maritime/news). Fishermen still used the gill net in the zone A that has much stingray population there. Plenty of fishes had been collected, but incidentals capture of sea turtles in fishing gear is another major problem. One interesting point to note is that hook and long lines do not seem to be catching turtles within Malaysian territorial waters, although they are known to take turtles in offshore areas. It is clear that prohibition is not really effective.

1.2 Problem Statements

The process of reducing the incidental capture and subsequent mortalities of sea turtles in regional shrimp fisheries through the use of TED (Turtle Excluder Device) has been extremely important. This is the considering to global significance of Southeast Asia’s turtle populations and the importance of shrimp’s fisheries to regional economies and fishing communities. Furthermore, little is known of sea turtles' auditory behavior. Thus, the study on turtle’s hearing especially green turtle is needed.

1.3 Objectives

The main purpose of this research is proposed Turtle Excluder Devices (TED) using Sound technique. The proposed TED designed begin by conducted some basic objectives of research step. The following objectives are:

- To determine the hearing ability for green turtle.
- To identify the green turtle behavior on various sound exposures.
- To determine the specification of TED using underwater sound technique.

1.4 Research Scope

In order to achieve the research objectives, the following scopes will be covered:

- Measurement of turtle hearing threshold using Auditory Brainstem Response (ABR) System.
- Measurement of underwater sound profile.
- Green turtle ABR data analysis.
- Investigation of sound profile in sea water.
- Measurement of the green turtle behavior on specific sound exposures.

1.5 Outline

The thesis is divided into five chapters. Following is an introductory chapter that defines the importance of sea turtles, the aimed of fisheries regulations 1990, and the usage of gill net by fisheries. Then the problem statements, objective, research scope and thesis outline are given.

Chapter 2 begins by discussed on the types of sea turtles with green turtle morphology, evolutionary trends and conservation and green turtle distribution in Malaysia. Then, in the following section are discussed on underwater acoustic units of measurement, the decibel scale in underwater acoustics, turtle auditory system, turtle and fish hearing threshold, TED, long line and gill net, sound classification, Fast Fourier Transform (FFT) algorithm. Finally, FFT application on spectral analysis is discussed.

Chapter 3 presents the research methodology. This chapter begins by discuss design of study, research materials and life specimens, measurements procedures, spectral analysis of the ABR waveforms and sound profile.

Chapter 4 presents the results and discussion. The results consist of turtle auditory brainstem response, seawater profile, sound profile, sound characterization, turtle and fish response, and problem encountered. Finally, the contributions of the research are given.

Chapter 5 presents the conclusion and future works. Simulated and measured results are compared. The experimental verification process is explained with numerical analysis given. The key contributions in this thesis are highlighted. Finally, some recommendations on further work as well as a concluding statement are given.