TURTLE HEARING CAPABILITY BASED ON ABR SIGNAL ASSESMENT

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Abstrak

Penyu telah ada di bumi selama jutaan tahun. Telah dilaporkan oleh International Union for Conservation of Nature (IUCN) bahwa Hawksbill Turtle (Eretmochelys imbricata) diklasifikasikan ke dalam penyu yang terancam punah. Penggunaan turtle excluder device (TED) pada nelayan udang diperlukan untuk menjaga kelestarian penyu. TED menggunakan suara merupakan alternatif teknologi yang dapat digunakan dalam teknik penangkapan ikan. Pengetahuan tentang kapasitas pendengaran penyu masih terbatas. Pengamatan terhadap sinyal auditory brainstem response (ABR) adalah metode untuk penentuan pendengaran penyu Hasil penilaian kapasitas pendengaran penyu menjadi dasar bagi perencanaan TED Tujuan dari makalah ini adalah menentukan kapasitas pendengaran penyu dengan analisis spectrum ABR-nya. Subjek dalam penelitian ini adalah penyu Hawksbill berjumlah 2 ekor dengan umur 3 dan 2 tahun.. Pengukuran dilakukan di Pusat Pengurusan Penyu Padang Kemunting Masjid Tanah Melaka Malaysia. Hasil pengukuran telah diperoleh bahwa penyu 3 tahun memberikan respons tertinggi pada frekuensi 50,78, 101,6, 152,3, 304,7, 355,5, 457, dan 507,8 Hz dengan amplitude dalam kisaran 0.03-32.44% spektrum. Penyu 2 tahun memberikan respons tertinggi pada frekuensi 457Hz dengan amplitudo dalam kisaran 0,01-2,5% spektrum.

***Kata kunci**: ABR, kapasitas pendengaran, power spektrum, TED*

Abstract

Sea turtles have existed for millions of years. International Union for Conservation of Nature (IUCN) has reported that the Hawksbill Turtle (Eretmochelys imbricata) is classified as critically endangered. Turtle excluder device (TED) deployment on shrimpnet fisheries is needed for turtle conservation.TED using sound technique is challenge method in fisheries development.The knowledge on turtle hearing capability is limited. The auditory brainstem response (ABR) assessment is method to determine turtle hearing capability. Turtle hearing assessment is basis to design TED. The objective of this paper is to determine turtle hearing cability by analyze its ABR spectral.The subject is Hawksbill turtle with number 2 turtles ie: 3 and 2 years. The measurement was taken at Pusat Pengurusan Penyu (Turtle Management Centre) Padang Kemunting Masjid Tanah Melaka Malaysia. The results shows that turtle 3 years have peak power frequencies 50.78, 101.6, 152.3, 304.7, 355.5, 457, and 507.8Hz respectively whereas the spectral amplitude is ranging 0.03-32.44% spectral. Turtle 2 years has peak power at 457Hz in whole stimulus frequencies while the spectral amplitude is ranging 0.01-2.5% spectral.

***Keywords**: ABR, hearing capability, power spectral, TED*

1. INTRODUCTION

Sea turtles have existed for millions of years. International Union for Conservation of Nature (IUCN) has reported that the hawksbill turtle (Eretmochelys imbricata) is classified as critically endangered in 2004 [1]. Fishermen to catch fish and shrimp in accordance with the rules must be equipped with a TED. TED that is equipped in the nets and trawls will be able to reduce the number of turtle bycatch but the recent TED used is still mechanical [2]. Sound deployment on TED is one of challenge method in fisheries development. The knowledge on turtle hearing capability is limited for previous study so the improvement on turtle hearing measurement is needed as basis on designing TED using sound technique [3].

One method to asses the subject hearing capability is by analysis ABR signal. ABR signals are traditionally occurs during the first 11 ms after the stimulus, followed by a Mid-Latency cortical Response (MLR) which is typically confined to the next 70ms, followed by a slow cortical response which starts at about 80 ms after the stimulus. ABR signals have a waveform morphology which typically exhibits five waves (peaks) in the 1.5 to 6 ms post-stimulus interval [4], [5]. Works described techniques for extracting the human ABR from the EEG by deployed new algorithm of adaptive filtering in the time-frequency domain using a specific Wavelet Transform and compare it to traditional ABR extraction are given in [4].

The ABR signals are acquired from the animals and humans subject in order to asses and determine the cranial auditory nerve function, to asses the viability of cochlear implantation, or the existence of any physical conditions that may prevent successful implantation [6]. The ABR technique is a noninvasive and rapid method to measure the hearing range of animals. It is a method that requires no training of the subject and is used also to asses hearing response in human infants [7]. ABR models classification by generated using time, frequency and cross-correlation measures. Classification employed both artificial neural networks (NNs) and the C5.0 decision tree algorithm [8].

ABR analysis deployed on animals ie: dolphin [9], fishes clupeid species [10], tuna (*Thunnus albacores)*, turle (*C.mydas and L.Kempi*) [11], prawn [12]. The collective knowledge of marine hearing and sound detection capabilities is very limited because limited knowledge of true hearing thresholds of such animals and their sensitivity to various sound levels, frequencies and durations [13].

This research is aimed to identify turtle hearing capability focoused on Hawksbill species by analyze its ABR signal. This study is expected to increase knowledge on marine turtle hearing capability, especially the hawksbill turtle.

2. RESEARCH METHOD

2.1. Subject and Facility

Two Hawksbill Turtles were used in the ABR measurement. The turtle's profile is stated in Table 1.The research was conducted at Pusat Pengurusan Penyu (Turtle Management Centre) Padang Kemunting Masjid Tanah Melaka Malaysia in December 24, 2008. The turtle brought out from the pool and put it into the research box as shown in Figure 1. The turtle dimension measurement was done previously before established ABR recording.

Figure 1. Length Measurement of Karah

Figure 2. Weigth Measurement of Karah

First stage of measurement is dimension measurement. The turtle length divided into 3 categories, ie: total length (TL), length of neck-head (NH), and width. The weight of turtle has been measured. The turtles dimension measurement procedure is shown in Figure 1 and 2.

Table1. Species is used in ABR measurement

No	Age (year)	Sex	TL (cm)	NH (cm)	Width (cm)	Weight (Kg)
1.	3	NA	55	15	34	7,4
2.	2	NA	37	12	33	5,1

Note:
TL : total length
NH : length of neck-head.

Both of length and weight measurement is taken in dried condition. The aimed of this procedure is to get the correlation between the turtle age and its dimension. The second stage was ABR recording. The Measurement used ABR hardware that was supported with the SmartEP software.

2.2. ABR Recording and measurement

ABR system was installed to turtle for one hour as shown in Figure 3. In this measurement click stimulus is used. The frequency of ABR analyzer is ranging between 0 to 5 kHz. During the ABR measurement, turtles were stated in the research box and. Turtles were equipped with ABR system and hold in stable position. The subject becomes relaxed in resting position. During a sound presentation, the turtle was stationed. The measured data is analyzed using SmartEp software and compared with Matlab program. IHS system stimulus was set on parameters as follows:

a. Sweeps = 1000
b. Time = 25.0 us,
c. Intensity = 58 dB nHL
d. Ear = right
e. Rate = 70.00/s
f. Rej. Artefact = 31.00uV
g. Rej. Time = 1.0-10.0 ms

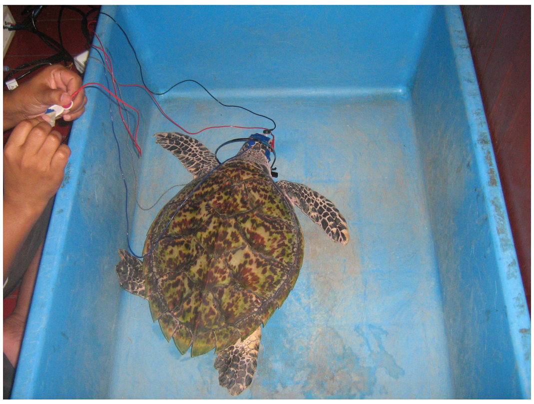

Figure 3. ABR recording in the box

Figure 4. ABR Measurement team

The transducer that produced the stimulus is placed 0.5 m from the box. It is depicted in Figure 3 and Figure 4.The Turtle were equipped with ear electrode (earphones). Earphones are small stimulating transducer that delivers the stimulus to the turtle's ear. Four earphones were used to measured turtle hearing response. The amount of collected data indicated the respond of the turtle.

The click stimulus divided into 15 durations. The durations were set up from 100 μs-1500 μs. The recorded data saved into three modes ie: time domain, ASCII code, and data reported (.rpt).Furthermore, data in time domain were converted in frequency domain using

SmartEP software and Matlab.Both SmartEP dan Matlab deployed Fast Fourier Transform (FFT).

3. RESULTS AND DISCUSSION
3.1. Turtle 3 years

The click stimulus was transmitted started in 100 µs duration time. It was obtained response signal ABR of turtle in the time domain signal. The result of ABR signal for 300µs duration is plotted in Figure 5.

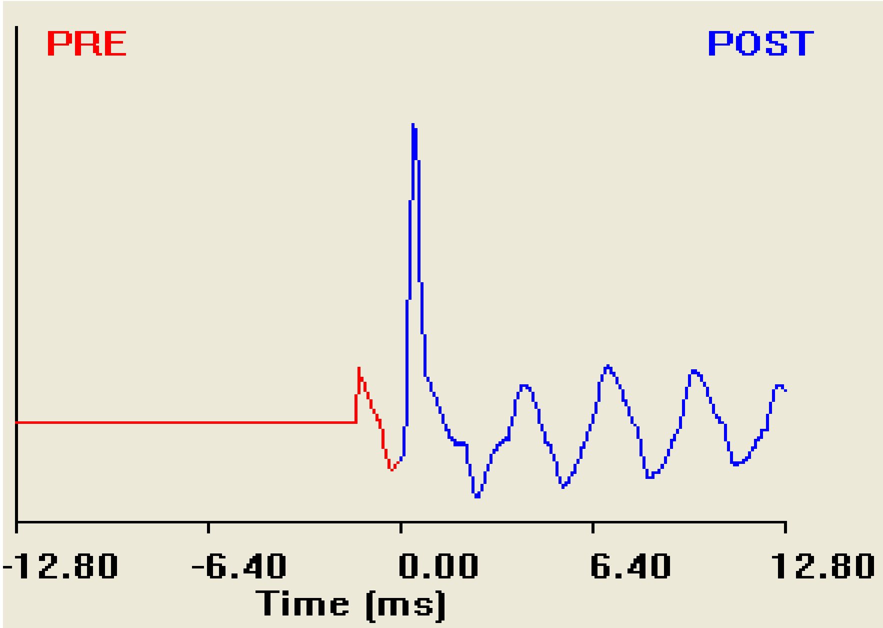

Figure 5. Turtle 3 years ABR signal in time domain, 300µs stimulus duration

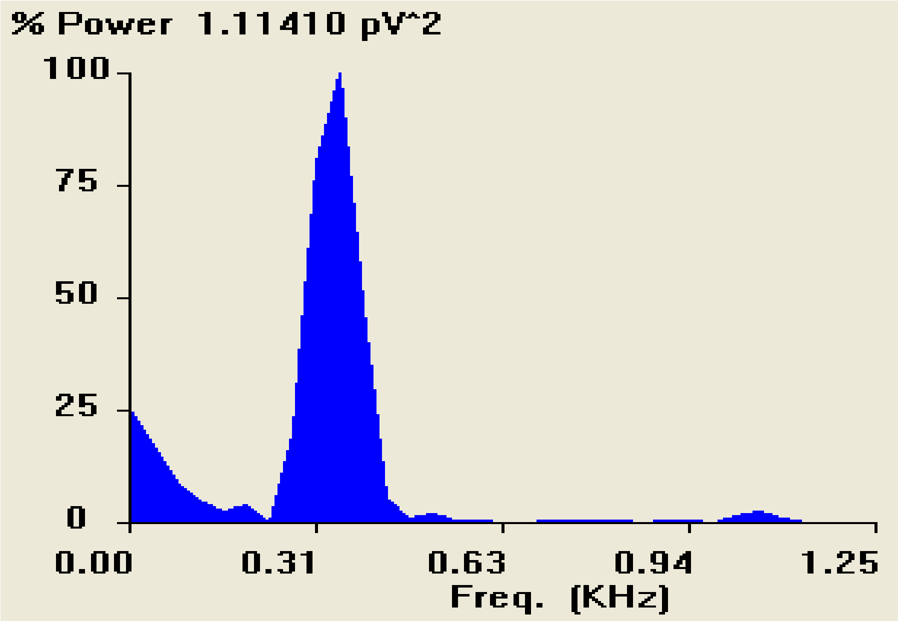

Figure 6. Turtle 3 years ABR spectral, 300µs stimulus duration

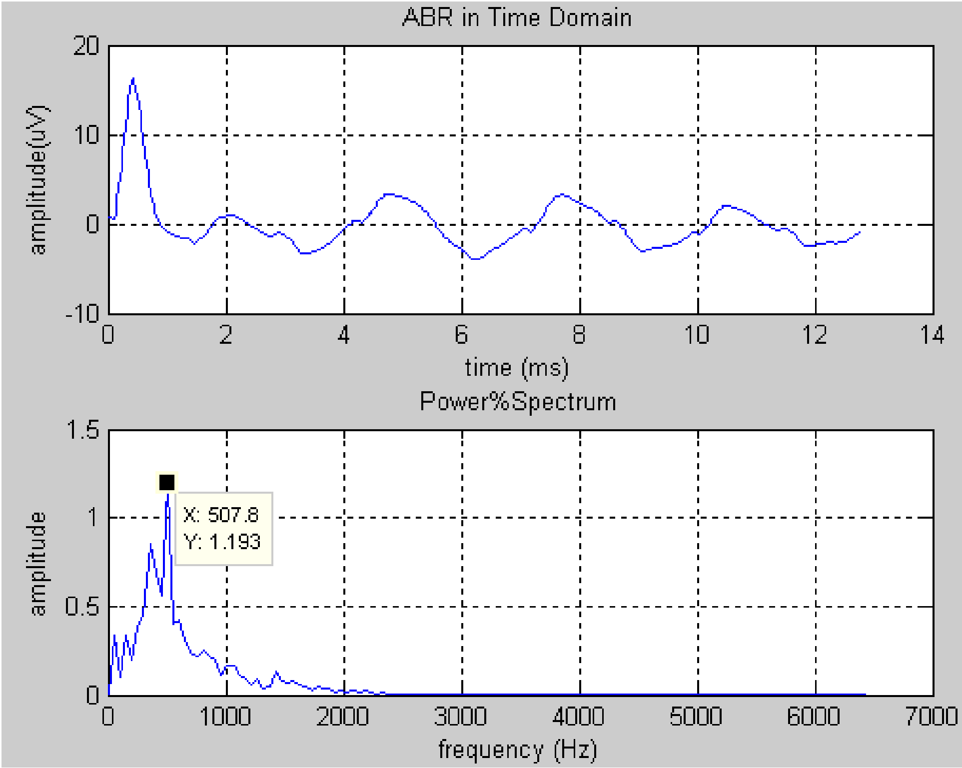

Figure 7. Turtle 3 years ABR signal, stimulus duration 300 µs.

Then the signal in the time domain converted into frequency domain with SmartEp. The resulted signal is called frequency spectral as seen in Figure 6. Figure 6 indicated frequency spectral was obtained with a stimulus duration 300 µs has maximum power at frequency more 300 Hz.The frequency spectral has the harmonisa at a frequency of more 900 Hz.

Table 2. The Response of 3 years turtle

Sample Number	Stimulus Duration (µs)	Peak power in freq Spectral (Hz)	Spectral Amplitude (%)
1.	100	355,5	0,064
2.	200	304,7	0,034
3.	300	507,8	1,193
4.	400	507,8	0,92
5.	500	50,78	4,72
6.	600	152,3	1,27
7.	700	101,6	25,34
8.	800	NA	NA
9.	900	457	32,44
10.	1000	NA	NA
11.	1100	NA	NA
12.	1200	NA	NA
13.	1300	NA	NA
14.	1400	NA	NA
15.	1500	NA	NA

Conversion of ABR signals to its spectral using SmartEP still unclear. To get better results Matlab is deployed as a comparison. To get the ABR signals in time and spectralnya area in Matlab, ASCII data from the ABR processed first in Excel. Artifact information in numeric data is removed. ABR value is selected start from 0 ms-12.8 ms.

Results of ABR signal processing using Matlab is more accurate. Signals have obtained clearly in numerical values of the spectral signal as in Figure 7. The figure shows that ABR signal in time domain selected for 0ms-12.8 ms with the amplitude in µV. Turtles 3 years respond to stimulus at 507.8 Hz and the amplitude 1.193%.

Later in the same manner by increased 100 µs duration time until 1500 µs would be obtained the frequency spectral of 3 years turtle as shown in Table 2. Turtle 3 years response could be analyzed if failed to respond when the stimulus set on 1000µs-1500 µs. While the stimulus 100 µs -700 µs and 900 µs turtle responded obviously. The event of peak power occurs in varying frequencies ie: 50.78 Hz, 101.6 Hz, 152.3 Hz, 304.7 Hz, 355.5 Hz, 457 Hz, and 507.8 Hz. The spectral amplitude is not uniform in some stimulus. The spectral amplitude is ranging 0.03%-32.44% power spectrum.

3.2. Turtle 2 years

The click stimulus was deployed for 2 years turtle. It was transmitted started in 100 µs duration. Measurement has been obtained signal ABR of turtle in the time domain signal that coud be seen in Figure 8. Turtle still not in relaxed yet in stimulus 100 µs as of the ABR signal failed to measure. Futher, stimulus duration was increased to 200 µs. The subject responds to stimulus. Plotted data in the figure is processed in SmartEP.

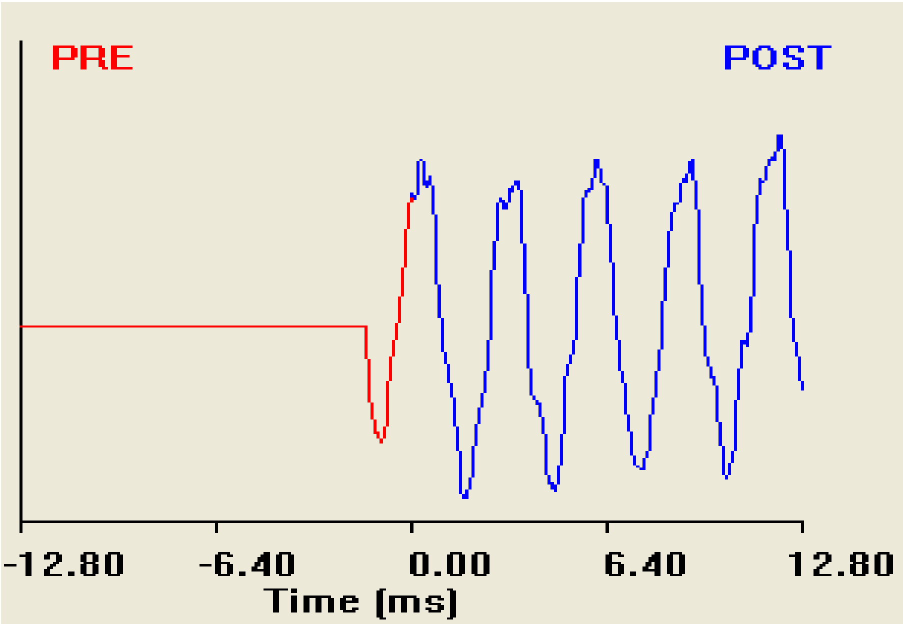

Figure 8. Turtle 2 years ABR signal in time domain, 300µs stimulus duration

ABR signal then converted into spectralnya. Frequency spectral was obtained with a stimulus duration 200 µs has maximum power at frequency more 300 Hz is depicted in Figure 9. The result has the harmonisa at other frequency.

Conversion of ABR signals to its spectral using SmartEP still unclear. The frequency on maximum power not exact yet. Matlab is deployed as a comparison to complement the lack of information. ABR signals in ASCII form is extracted in Excell. Numeric value is easier to analyze in excell form. By reject artifact value ABR signal is selected start from 0-12.8 ms as shown in Figure 10.

The Figure 10 shows that ABR signal in time domain selected for 0-12.8 ms with the amplitude in µV. Turtles 2 years respond to stimulus at 457 Hz and the amplitude is 0.043 %.

Turtle response could be analyzed if failed to respond when the stimulus set on 100 µs. While the stimulus 200-1500 µs turtle responded clearly. The occurance of peak power is at 457 Hz in whole stimulus frequencies. The spectral amplitude is not uniform in some stimulus. The spectral amplitude is ranging 0.01-2.502% power spectrum. Later in the same manner with 3 years turtle the ABR signal of 2 years turtle could be seen in Table 3.

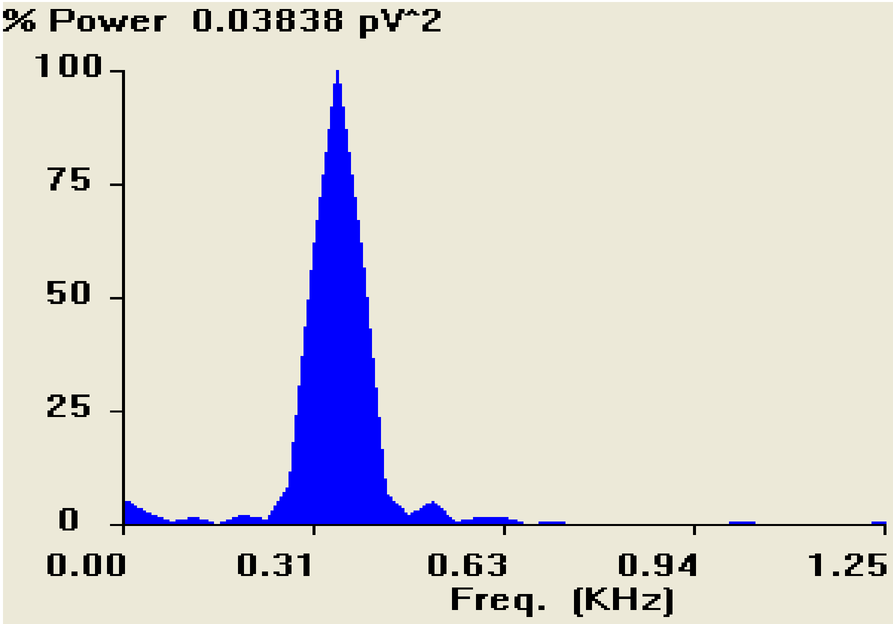

Figure 9. Turtle 2 years ABR spectral, 300(s stimulus duration

Figure 10.Turtle 2 years ABR signal, stimulus duration 300 µs.

Table 3. The Response of 2 years turtle

Sample Number	Stimulus Duration ((s)	Peak power in freq Spectral (Hz)	Spectral Amplitude (%)
1.	100	NA	NA
2.	200	457	0,043
3.	300	457	0,071
4.	400	457	0,011
5.	500	457	0,019
6.	600	457	0,161
7.	700	457	0,203
8.	800	457	1,605
9.	900	457	0,028
10.	1000	457	4,73
11.	1100	457	0,016
12.	1200	457	0,119
13.	1300	457	2,502
14.	1400	457	0,116
15.	1500	457	0,074

4. CONCLUSION

The measurement of Hawksbill Turtle ABR signal has been conducted in the turtle research box. Turtles hearing capability has been determined. ABR signal assesment has been done by converted recorded data into frequency domain by deployed FFT method. The results show that turtle 3 years responds to the transmitted stimulus wider than turtle 2 years in frequency range and amplitude response.

REFERENCES

[1]. Eckert KL, Bjorndal KL, Abreu-Grobois FA, Donnelly M. Research and Management Techniques for the Conservation of Sea Turtles. *Marine Turtle Newsletter*. 2000; 87: 17.
[2]. Putrawidjaja, M. Marine Turtles in Irian Jaya - Indonesia, Marine Turtle Newsletter. 2000; 90: 8-10.
[3]. Yudhana A, Din J, Abdullah S, Sunardi. *An Identification of Turtle Hearing Threshold for Design TED (Turtle Excluder Device) Using Sound Technology*. International Conference on Information and Communication Technology & Systems (ICTS). Surabaya. 2008.
[4]. Elvir AJ, Causevic E, John R, Koyacevix J. *Adaptive Complex Wavelet-Based Filtering of EEG for Extraction of Evoked Potential Responses*. ICASSP IEEE. 2005; 5: 393-396.
[5]. Kuwada S, Anderson JS, Batra R, Fitzpatrick DC, Teissier N, D'Angelo WR. Sources of The Scalp-Recorded Amplitude Modulated Following Response. *J Am Acad Aud*. 2002; 13: 188-204
[6]. User Manual. Intelligent Hearing Systems. 2007
[7]. Hecox K, Galambos R. Brainstem Auditory Evoked Response in Human Infants and Adults. *Arch Oto*. 1974; 99:30-33.
[8]. Davey R, McCullagh P, Lightbody G, McAllister G. Auditory Brainstem Response Classification: A hybrid Model Using Time and Frequency Features. *Artificial Intelligence in Medicine*. 2007; 40(6): 1-14
[9]. Mooney TA, Tachtigall PE, Yuen ML. Temporal resolution of the Risso's Dolphin, Grampus Griseus, Auditory system. *J. Comp Physiol*. 2006
[10]. Popper. http://www.life.umd.edu/biology/popperlab/research/americanshad.htm. Ultrasonic. 2000.
[11]. Ketten DR, Bartol SM. Functional Measures of Sea Turtle Hearing. Final rept. Woods Hole Oceanographic Inst Ma Biology Dept. 2006.
[12]. Lovell JM, Findlaya MM, Moateb RM, Yan HY. The hearing abilities of the prawn Palaemon serratus. *Comparative Biochemistry and Physiology*. 2005; A(140): 89-100.
[13]. Howorth P. Underwater Sound Measurements. http://channelislands.noaa.gov/sac/pdf/acoustic.pdf. 2003: 1-3.