Journal of Engineering and Applied Sciences 12 (14): 3747-3751, 2017
ISSN: 1816-949X
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Acoustic Scattering Strength of Sea Turtle and Fish using Echo Sounder

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Abstract: An echo strength measurement of green turtle and fish is proposed in this study using echo sounder. The measurements were conducted in a research tank by employing 200 kHz transmit pulse and reflected echo recorded at 1 MHz sampling rate using high speed analog digital converter. The animals used in the study were green turtle at the age of 1, 3, 12 and 18 years old together with three species of fish which is Indian Mackerel, Indian Scad and Bigeye Scad. The fish echo strength was compared to the turtle echo strength value. The average value shows that echo strength of adult turtles and fish is different. The echo strength of the fish recorded in range of-39.546 to -38.110 dB while the echo strength of the turtle was in range of -37.310 to -34.769 dB. The comparison of echo strength between different ages of turtles shows that the turtle echo strength increases as the ages increases. The results also show significant differences between each angle measurement of the turtle body. The highest average echo strength is from 18 years old turtle at plastron angle which shows-34.769 dB. The acoustic strength value range recorded for all aged of turtle at carapace angle is -36.514 to - 34.871 dB and at plastron angle is-36.371 to -34.769 dB. The comparison of the different ages of turtles demonstrated that the turtle echo strength increases as the age increases. The results also show that there is significant differences echo strength value for each turtle bodies.

Key words: Acoustic strength, green turtle, echo sounder, turtle excluder device, echo signal

INTRODUCTION

Scientists believe that sea turtles are ancient reptiles that have inhabited the world oceans for 175 million years. Sea turtles have large streamlined shell and cannot retract their heads or limbs like tortoise because this would prevent them from swimming or breathing (Yaacob *et al*., 2006). Six species of sea turtles in the world were recorded to nest or inhabit the Southeast Asian water. The species involved are green turtle, leatherback, hawksbill, olive ridley, loggerhead and flatback. All these six species are commonly found in the southeast asian water except flatback turtles which are found in eastern Indonesia (Talib *et al*., 2006). There are four of the seven species of sea turtle are nesting in Malaysia (Chan, 2006). The green species is the most widely distributed in peninsular and East Malaysia. The major nesting sites of green turtle in Peninsular Malaysia are found at Pulau Redang, Paka and Geliga in Terengganu. Meanwhile, Cherating and Chendor are the main green turtle rookery in pahang (Talib *et al*., 2006). In addition, green turtle nesting is also reported on the offshore islands and other remote beaches at Pekan and Rompin. The population at Pantai Segari in Perak constitutes to the only significant nesting aggregation along the west coast of the Peninsular.

Over the last few centuries, sea turtle populations have declined dramatically due to various activities such as tourism development, commercial fishing, marine recreation and pollution. By-catch in commercial fishing has been listed to be a major factor of sea turtle death (McDaniel *et al*., 1999; Arauz, 2000). Now a days we have heard large numbers of turtles were taken in fisheries vessel net.

In Malaysia, there are two regulations applied on turtle protection. The fisheries regulation (Prohibition of Fishing Method) Regulations 1985 has banned large

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meshed gill nets and fisheries regulation (Fisheries zoning) 1991 provides offshore protection to turtles during their nesting period (Hamann *et al*., 2006). The fisheries zoning is enforcement that prohibits any form of trawling within five nautical miles of the shoreline. This can adequately protect marine turtles from trawlers during nesting season (Chan, 2004). Although, much enforcement has been done through the existing laws they still fail to prevent turtles from being caught in the fishing net.

The solution which can be practice to avoid turtle incidental capture in fishing vessel nets is by using Turtle Excluder Device (TED). This additional device was applied in the united states in 1980 which is installed in the shrimp trawl net to guides the turtle swim out through a trap door, avoiding their capture and eventual death (McDaniel *et al*., 1999).

The process of reducing sea turtles caught in fishing nets through the use of TED has become very important in Malaysia. However the use of metal grid TED is seen as not an effective solution because it excludes the larger commercial fish. The study on device effectiveness showed TED with and without accelerator funnels caused shrimp loss rates of 3.6 and 13.6%, respectively (Gallaway *et al*., 2008).

The observation vessel equipped with TED found that the highest reduction in prawn catch occurred during tows in areas with large amounts of star fish, sponges, sea urchins, sea cucumber and benthic debris. Catch loss occurred as a result of starfish blocking the grid or tangling the guiding flap, causing inefficient operation (McGilvray *et al*., 1999). Furthermore, TED which consists of metal trap door in trawling net was seen as not an efficient solution for reducing turtle by-catch because it excluded the larger commercial specimens (Casale *et al*., 2004).

The other technique can be apply to avoid turtle trap in fishing net is using ultrasound technique. The use of sound in improving traditional TED gives alternative way to protect sea turtle trap in fishing net. By using this technique turtle can be alert from approaching fishing net without loss number of catch. Although, using ultrasound can avoid turtles trap in the fishing net but sound must be emitted all the time. This situation will contribute to noise production in the water and could disrupt other marine life. Scientists and conservationists agree that we should avoid increasing anthropogenic sound levels in the ocean (Southwood *et al*., 2008). These sounds have the potential to impact an animal in several ways: trauma to hearing (temporary or permanent) trauma to non-hearing tissue, alteration of behaviour and masking of biologically significant sound (McCarthy, 2004). Previously, the acoustic TED System design focused on repellent sound to avoid sea turtle approaching fishing net where the system only transmit the repellent sound and could not ensure whether the turtles in the fishing nets or swim away from the vessel (Lenhardt, 2002; Yudhana, 2011).

To address this problem, a TED device must be designed detect sea turtle presence earlier and also can monitor the movement of the sea turtle during fishing activities. The best technique that can be applied is using acoustic detection. The sea turtle detection using acoustic is important because it can help identify the acoustic characteristics of sea turtles, especially to distinguish them from other marine species such as fish that share the same habitat.

Acoustic scattering strength of animals: An Acoustic echo sounders have long been used to predict and mapping distributions of marine animals. The devices provide high resolution synoptic information regarding the spatial and temporal variability of the animals. In order to relate quantitatively the acoustic echoes to meaningful biological parameters such as length and numerical density, acoustic scattering models need to be used which describe the efficiency with which the animals scatter sound. Aquatic organisms are complicated, scattered by nature through shape, size, body angle and air body contain. The study on acoustic strength of shelled marine animal is quite difficult because it involves a variety of hard and soft body shapes and biology properties. Based on these conditions, the acoustic characteristics are sometimes inaccurate and very complicated. Generally, the sound reflected from elastic shelled animal is depending on their body properties.

However, reflected sound characteristic also can dependent upon both frequency and angle of orientation (Stanton, 2000; Stanton *et al*., 1998). There are many approaches to model the reflected of sound by underwater objects. The particular approach depends upon the material and shape properties of the body (Stanton *et al*., 1998). An appropriate and accurate model is required to predict the acoustic backscatter of aquatic organisms with complex shapes, morphology and behaviour (Jecha *et al*., 2015). The study on acoustic strength of shelled animal is quite challenging because it involves a variety of body shapes and biology properties which make their acoustic scattering characteristic sometimes very complicated (Stanton *et al*., 1998; Mukai *et al*., 2004). The scattering from elastic shelled animal is characterized by a very strong echo secularly reflected by their hard shell (Stanton and Chu, 2000; Warren *et al*., 2002).

The sea turtle have a complex shape of body and expected have a unique acoustic reverberation scattering. The extensive and intensive survey of literature indicated that very little work has been done on acoustic strength of shell animals. Because of the complexity, development of the models has been a great challenge and has resulted in a number of models of varying accuracy and generality.

Recently researchers hypothesized that the target strength not only depends on size of animal but is also dependent on the natural shape and sea water parameter. The extensive and intensive survey of literature indicated that very little work has been done on target strength of shell animals. Thus, the investigation on sound returned by a scattering of sea turtles is needed in order to enrich knowledge of complicated shape shell animal echo strength in water.

MATERIALS AND METHODS

The research has been conducted at Turtle and Marine Ecosystem Centre (TUMEC) rantau abang, dungun, terengganu, Malaysia. The acoustic data collection and marine life specimen measurement has been conducted in the fibre tank at indoor turtle hatchery. The dimension of the fibre tank is 14 m long, 2.5 m wide and 1.5 m in height is shown in Fig. 1. This tank has been selected because have enough length to observe echo signal of animal at different angle and distance. Moreover, it also has been identified that has no noise effect or other effects that may disturb the result.

Furthermore, the experiments in a tank will facilitate the measurement work and also will help researchers control the behaviour of marine animals which all of this difficult to implement in the original habitat.

The species sample involved in this research is green turtle and three species of fish (Indian scad, Bigeyescad and Indian mackerel) Modified dual frequency echo sounder model V1082 has been used in this research to investigate echo scattering strength from sea turtle in water. The echo signal from the Time Varying Gain (TVG) circuit read directly into laptop computer. The echo characteristic was observed by transmitting the 200 kHz sound signal. The frequency selection is probably well above the hearing range of green turtle (6o-1 kHz). The envelope of the echo was digitized at a sampling rate 1 MHz using High speed analogue to digital converter (measurement computing USB 1208HS) read directly from MATLAB Program. There are five different angles of measurement for green turtle and three different angles of fish involved in this study as shown in Fig. 2.

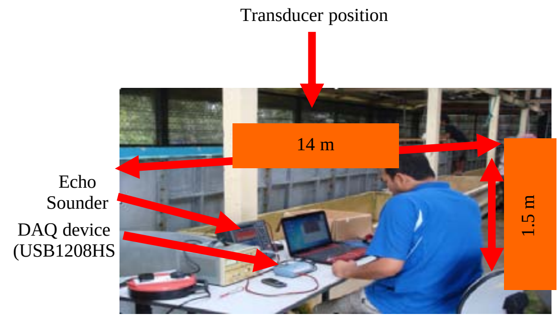

Fig. 1: Indoor turtle hatchery

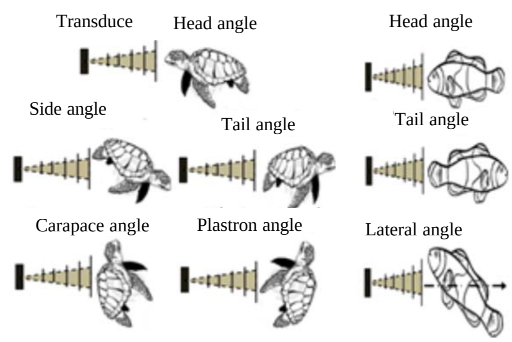

Fig. 2: Green turtle and fish angles measurement

RESULTS AND DISCUSSION

The echo signal obtained from echo sounder TVG was analysed in frequency domain to acquire power spectrum of the signal. The spectrum magnitude comparison of four green turtles has been plotted as shown in Fig 3. The comparison of the different ages of turtles shows that the turtle echo strength increases as the age increases. The results also show significant differences among the turtle bodies. The carapace and plastron are the parts that give the highest values for all turtles. One of the reasons that can be highlighted is that these parts have larger surfaces than the others. The greater the area is covered by the sound, the higher echo intensity is received. In addition, other possibility that could be considered is due to the hard surface of the carapace and plastron.

The echo strength average of the green turtle and fish from 1-5 m have been compared as shown in Fig. 4. The echo strength was calculated using echo power reference method. The scatter graph indicates that there are significant different between turtle aged 3, 12, 18 years old and fish at all angle measurement. The highest average echo strength isfrom 18 years old turtle at plastron angle which shows -34.769 dB. The value

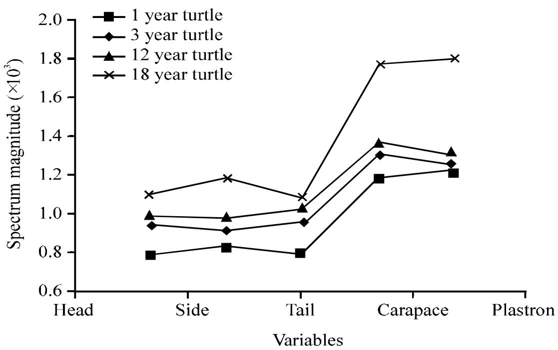

Fig. 3: Spectrum magnitude comparison of various ages of green turtle

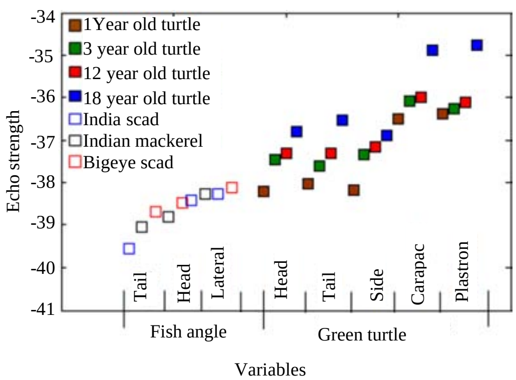

Fig. 4: Target strength value comparison between green turtle and fish

range recorded for all aged of turtle at carapace angle is -36.514 to -34.871 dB and at plastron angle is -36.371 to -34.769 dB.

The echo strength of the fish recorded in range of -39.54 to -38.110 dB while the echo strength of the turtle (12 and 18 years) was in range of -37.310 to -34.769 dB. The result demonstrated that the echo strength value acquired from adult green turtle and fish were different each other and it is proved that this method can be used to distinguish green turtle and fish.

CONCLUSION

Acoustic strength measurement of turtles and fish has been conducted at TUMEC (Turtle and Marine Ecosystem Center) rantau abang, terengganu Malaysia. The comparison between turtles and fish has been investigated based on the echo strength values at the distance 1-5 m. The comparison between 12 and 18 years turtles and fish shows that significant differences at all angles. In addition, the observation of all age turtles shows that the highest echo strength was obtained from the carapace and plastron parts. It reveals that size, surface and body angles play an important role to determining echo strength of the Green Turtles. The finding also showed value increase as the age of green turtle increase. It could be concluded here that acoustic technique can be used as a method to separating fish and green turtle especially adult species come to beach in nesting season. Although, this research shows significant results, further experiment must be conducted for other species of fish in order to avoid overlap values between sea turtles and fish. The experiment of this study conducted in a fibre tank where not consider the sea condition like sea wave and noise in water. Therefore, further research is suggested to conduct at natural habitat and must consider the other effect which can influence the animal echo strength value.

ACKNOWLEDGEMENT

We thank the Electrical Engineering Department Politeknik Sultan Hj Ahmad Shah for providing facilities during the experiments. We thank the TUMEC staff for expert sharing, especially in handling the turtles and providing facilities during the experiments. We also want to thank those who were involved in the experiments, directly or indirectly to ensure the success of this experiment especially polytechnic research and innovation centre for providing financially support and provide a good learning environment and encouraging a culture of research and innovation among staff.

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