

HYDROACOUSTIC ASSESSMENT OF PELAGIC FISH AROUND  
BIDONG ISLAND, TERENGGANU, MALAYSIA

MUJIB CAHORE HASSAN

MASTER OF SCIENCE  
UNIVERSITI PUTRA MALAYSIA

1999





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**DEDICATION**

**By**

*THIS WORK IS DEDICATED TO MY PARENTS, BROTHERS AND SISTERS  
AND ALSO TO SOMALI PEOPLE IN PARTICULAR THOSE WHO ARE  
SUFFERING DUE TO HARDSHIPS AND DIFFICULTIES.*

**MUSSE GABOBE HASSAN**

**Thesis Submitted in Fulfillment of the Requirements for the Degree of Master of  
Science in the Faculty of Applied Science and Technology,  
Universiti Putra Malaysia**

**FEBRUARY 1999**

0128220001

## ACKNOWLEDGEMENT

IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST  
MERCIFUL

Bless be to Allah (S.W.T) the Almighty who had created me and then gave me such an opportunity to conduct a research and to complete its report as my master degree programme.

Numerous people are thanked for making this thesis becomes completed. In short, the following particulars have to be mentioned for their regular motivation through my tenure of study period.

### DEDICATION

First and foremost, ever lasting gratitude goes to the chairman of the supervisory committee, Dr. Khalid Bin Hj. Samo whose constant supervision, value

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Similar thanks are due to my deepest gratitude and completely wholehearted acknowledgements to the members of the committee, namely Dr. Hj. Mohd. Azim Bin Abdullah and Dr. Hj. Mohd. Azim Bin Abdullah whose advice and comments during my study period. Similar thanks are due to Mr. Mohd. Zaidi Bin Zakaria.

***AND ALSO TO SOMALI PEOPLE IN PARTICULAR THOSE WHO ARE  
SUFFERING DUE TO HARDSHIPS AND DIFFICULTIES.***

Great acknowledgements and gratitude go to Assoc. Prof. Dr. Hj. Mohd. Zaki Bin Mohd. Said, the Deputy Rector of Universiti Putra Malaysia, Assoc. Prof. Dr. Noor Azhar Mohd. Shazili, the Dean of Graduate School of Universiti Putra Malaysia, Assoc. Prof. Dr. Fairah Shahrarom, Assoc. Prof. Dr. Hassan Daud, Mr. Atizam Zainal Abidin and Mr. Essa Daim who have helped and guided me one way or an other. I am also grateful to Mr. David Harrison for editing this thesis.

Likewise, I would like to show my appreciation to Mr. Razarudin Bin Ibrahim for translating the abstract into Malay language.

I would also like to acknowledge to Universiti Putra Malaysia for the Research Assistantship under IRPA, which I was temporarily employed during my candidature as a Master of Science student. Special acknowledgements are to the staffs of the Faculty of Applied Science and Technology for their assistance.

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I wish to express my appreciation to Mr. Manaf, Mr. Yakop, Mr. Ayub and the crewmembers of UPERTAMA III who have helped me during my data collection.

In addition, my moral satisfaction and appreciation go to Dr. T. Sasakura (Furuno Co.), Mr. Ismail Taupik, Mr. Raja Bidin R. Hassan and Mr. Fujiwara of the Department of Fisheries Kuala Terengganu and SEAFDEC Kuala Terengganu for their contribution to this thesis.

Last but not least, I wish to express my ultimate gratitude to all postgraduate members for their assistance and sympathy during my study period which I can not express a piece of writings.

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## GLOSSARY

- Absorption Coefficient**: The coefficient  $\alpha$ , stating the power loss due to absorption (symbol  $\alpha$ )
- Absorption Loss**: A temperature and frequency dependent power loss due to acoustic wave, linear with distance (symbol  $\alpha r$ ; unit dB)
- Acoustic Axis**: Region of maximum response, normally perpendicular to the face of the transducer.
- Acoustic Calibration**: Measuring the performance of an acoustic system to a specified standard (unit dB).
- Acoustic Intensity**: Amount of acoustic power through unit area. Reference is plane wave intensity having a rms pressure equal to  $1\mu\text{Pa}$  (one micro Pascal) (symbol I; unit dB/ $1\mu\text{Pa}$ ).
- Acoustics**: The theory of acoustic waves and propagation.
- Amplifier**: The device, which increases signal size.
- Amplitude**: Size of a signal.
- Attenuation**: Reduction of acoustic power due to spherical spreading and absorption of the wave (unit dB/km).
- Back scattering**: Amount of acoustic power scattered by a target into the direction of the transmitting transducer.
- Beam angle**: Full included angle between the half-power points (symbol  $\theta$ ; unit degrees).
- Beam pattern**: Two-dimensional pattern showing the relative response of beam.
- Calibration**: Measuring or adjusting the performance of a system to a specified standard.
- Decibel**: Logarithmic ratio used to express relative levels of acoustic or electrical signals (unit: dB).
- Digital**: Having the circuit state off or on.
- Directivity index**: Concentrating power of a transducer related to dimensions and acoustic wavelength, expressed in logarithmic form (symbol DI; unit dB).

Directivity pattern	: Diagram of the concentrating power of transducer in terms of beam angle and relative amplitude of the lobes.
Echo level	: An acoustic intensity at the receiving transducer (symbol: EL ; unit dB).
Echo sounder	: System comprising acoustic transmitter, echo receiver and display.
Echo trace	: Mark on a record caused by an echo.
Echo	: An acoustic wave reflected from a target.
Echogram	: Record of a sequence of echoes.
Fish abundance	: The amount of fish in a population.
Fish detection	: Location of fish by acoustic means.
Fish target Strength	: Ratio of the acoustic intensity $I_r$ reflected from a fish and measured 1 m away, to the incident acoustic intensity $I_i$ , $10 \log I_r / I_i$ dB (symbol: TS; unit dB).
Frequency	: Number of complete cycles of an electrical or acoustic wave to pass a given point in one second (symbol: f; unit Hz).
Gain	: Amount by which the amplitude (size) of a signal is increased (unit dB).
Incident intensity	: Acoustic intensity falling on a target.
Insonify	: To illuminate by means of acoustic waves.
Interface	: The matching unit between one instrument and another.
Interference	: An unwanted signals or malfunctions
Near field	: The distance within which transducer measurements should not be made.
Noise level	: Number of decibel by which noise is above or below a given reference.
Oscilloscope	: An instrument for viewing and measuring oscillations or signals.
Ping	: A name for the transmitted acoustic pulse.
Pre-amplifier	: Boosts signals before the main amplifier.



Pulse duration	: The time for which a pulse continues (symbol: $\tau$ ; unit ms).
Pulse length	: The distance a pulse extends (unit meters).
Pulse rate	: Number of pulses in a given time.
Range	: Distance to a target (symbol: r; unit m)
Receiving voltage response	: Number of dB relative to 1 Volt for a given acoustic pressure at the transducer face (symbol: VR; unit dB/V).
Reverberation	: The sum of all scattered acoustic energy.
Root mean square	: The square root of the average sum of all squared values of a waveform (symbol: rms).
Sensitivity	: Degree of response of an acoustic or electrical signal.
Sonar equation	: The equalities from which the performance of an acoustic system can be calculated (unit in dB).
Source level	: Ratio of acoustic intensity on the axis of a source at 1m, to a plane wave of rms pressure $1\mu\text{Pa}$ (symbol: SL ; unit dB/ $1\mu\text{Pa}/\text{m}$ ).
Standard target	: A target processing known target strength, used for the calculation of an acoustic system (unit dB).
Target strength	: Ratio of the echo intensity at 1 m from a target to the incident intensity (symbol: TS; unit dB).
Transducer	: Device for conversion of acoustic energy into electrical energy and vice-verse.
Transmission loss	: Sum of absorption loss and geometric loss (symbol: TL ; unit dB).
Transmitter	: Unit, which produces electrical power at the required frequency.
Wave length	: Distance between the crest or troughs of a sinewave (symbol: $\lambda$ ; unit m).

Abstract of Thesis Submitted to the Senate of Universiti Putra Malaysia in  
Fulfillment of the Requirement of the Degree Master of Science

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**By**

**MUSSE GABOBE HASSAN**

**FEBRUARY 1999**

**Chairman : Khalid Bin Samo, Ph.D**

**Faculty : Faculty of Applied Science and Technology**

The first phase of this study investigates the average dorsal aspect (side) target strength of three commercially important fish species, namely *Rastrelliger kanagurta*, *Atule mate* and *Thunnus tonggol*, which are mostly captured by commercial fishermen in waters around Bidong Island. Target strength experiments were carried out in a controlled tank at Universiti Putra Malaysia Terengganu by using a digital transducer split beam echo sounder at 200 kHz.

Fish size for this experiment varied from 13.6 to 24.5 cm total length (avg. 18.8 cm) for *Rastrelliger kanagurta*, 13.8 to 27.5 cm (avg. 20.0 cm) for *Atule mate* and 28.5 to 52.0 cm (avg. 39.6 cm) for *Thunnus tonggol*. Significant differences ( $\alpha = 0.05$ ) were observed between fish total length and weight of all species tested.

The average dorsal aspect target strength results of *Rastrelliger kanagurta* of 18.8 cm (92.5 g.), *Atule mate* of 20.0 cm (109 g.) and *Thunnus tonggol* of 39.6 cm (981 g.) were found to be - 42.0 dB, - 42.0 dB and - 37.0 dB respectively.

The average dorsal aspect target strengths for *Rastrelliger kanagurta*, *Atule mate* and *Thunnus tonggol* showed linear relationship with length. Determination coefficients, ( $r^2$ ) for target strength and total length of these species were observed to be 0.88, 0.78 and 0.80 respectively. The significant differences ( $\alpha = 0.05$ ) were observed between fish target strength and total length.

The general target strength and length equations for *Rastrelliger kanagurta*, *Atule mate* and *Thunnus tonggol* are presented as follows:

<i>Rastrelliger kanagurta</i>	(Avg. TL = 18.8cm): TS (dB) = 20 log TL - 67.5
<i>Atule mate</i>	(Avg. TL = 20.0cm): TS (dB) = 24 log TL - 72.4
<i>Thunnus tonggol</i>	(Avg. TL = 39.6cm): TS (dB) = 20 log TL - 68.9

The second phase, by using the results obtained from the controlled tank as a scaling factor, attempts to estimate the fish population in small area near Bidong Island were performed. The surveys were carried out in July and August in 1997 using the same equipments but were fitted on board UNIPERTAMA III.

The survey area was subdivided into 22 Elementary Statistical Sampling Rectangle (ESSR) along the acoustic track. A total of 790 independent single fish images were extracted along the track. Calculations were performed using the average *in situ* target strength of the individual fish detected along the survey

track. The total fish population in the study area was estimated to be 380 tones with an average density of 6.3 tones/km<sup>2</sup>. The average *in situ* target strength determined during the acoustic surveys was -43.9 dB where the average volume back scattering strength observed was -64.1 dB. The results of *in situ* target strength of individual fish match well with the target strength measurements made in tank conditions. This thesis critically discusses the concept and implications of fish target strength and its application in acoustic stock assessment for fisheries management.

MUSSE GABORE HASSAN

FEBRUARY 1999

Pengerusi : Khalid Bin Samo, Ph.D

Fakulti : Fakulti Sains Gunaan dan Teknologi

Fasa pertama dalam kajian ini adalah untuk mengkaji purata keupayaan memantul aspek dorsa (bahagian dorsal) bagi 3 spesies ikan komersial yang penting iaitu *Rastrelliger kanagurta*, *Atila mate* dan *Thunnus tonggol* di mana-lanya merupakan spesies yang biasa ditangkap oleh nelayan di sekitar perairan Pulau Bidong. Eksperimen keupayaan memantul telah dijalankan di dalam tangki kawalan di Universiti Putra Malaysia Terengganu dengan menggunakan echo-sounder pada halaju gelombang 200 kHz.

Saiz ikan yang digunakan dalam eksperimen ini berukuran di antara 13.5 hingga 24.5 cm panjang (purata 18.5 cm) bagi *Rastrelliger kanagurta*, 13.8 hingga 27.5 cm (purata 20.0 cm) bagi *Atila mate* dan 28.5 hingga 52.0 cm (purata 39.6