WORKING WEEK 2025 AND Locate25 THE NATIONAL GEOSPATIAL CONFERENCE

Geospatial Council of Australia

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Brisbane, Australia 6–10 April

Metric for Assessing The Potential Effects of Echo Sounders on Marine Mammals

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1.0 Introduction

POTENTIAL EFFECT

AUDITORY OF MARINE MAMMALS/CETACEANS

1. BEHAVIOURAL CHANGES
Disturbance/response

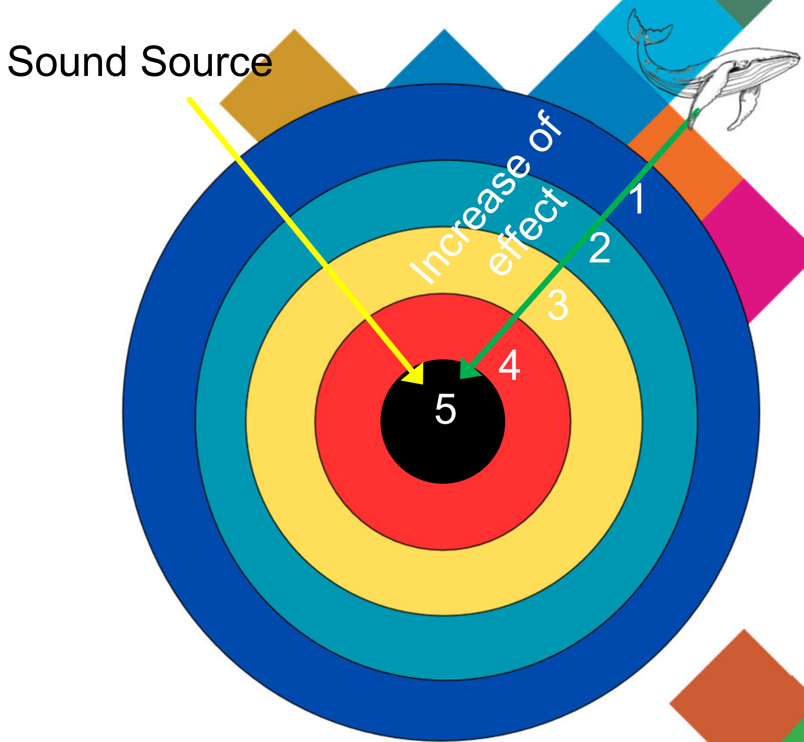
2. Masking
Avoidance, changing of direction and pattern

3. TTS
Temporary Threshold Shift (Temporary lost of hearing ability)

4. PTS
Permanent Threshold Shift (Permanent lost of hearing ability

5. Traumatic Injury
Decompression sickness and mortality

Source:
(Kates Varghese, Miksis-Olds et al. 2020)z



Schematic diagram showing zones of impact around a high energy underwater sound source (at centre) and listing the potential effects upon a receiving animal, assuming spherical spreading.

Aim & Objective

The purpose of this paper is to understand how echo sounder sonar emissions can impact marine mammals.

This is essential for sound management guidelines in hydrographic surveying especially at areas designated as Important Marine Mammal Areas (IMMA)

Important Marine Mammal Areas (IMMMA) and Marine Parks of Malaysia

1 **Satun-Langkawi (Kedah)**
5,493 km2 (13,57,349 acres)

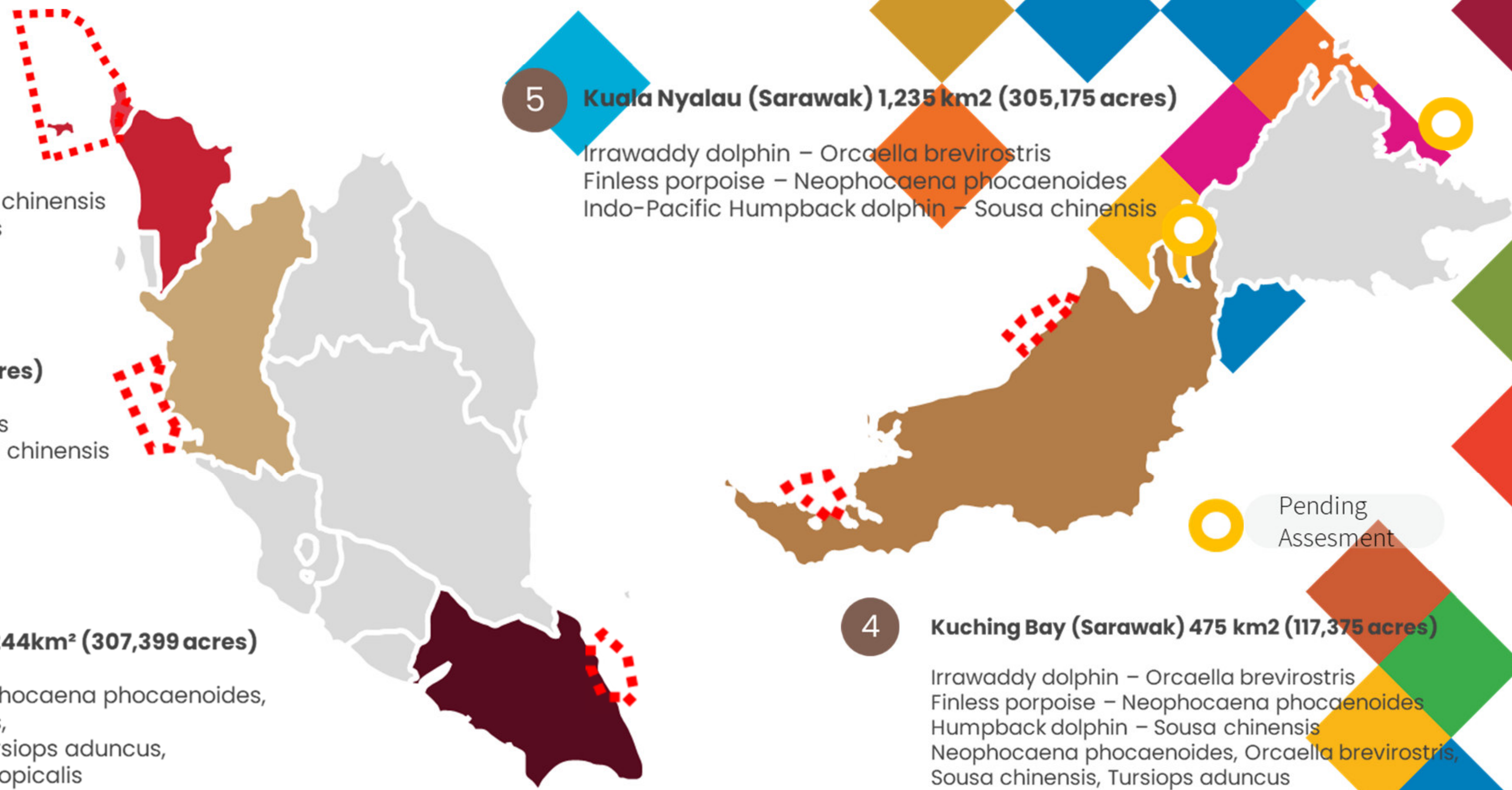
Indo-Pacific finless porpoise
-Neophocaena phocaenoides
Indo-Pacific humpback dolphin-Sousa chinensis
Irrawaddy dolphin-Orcaella brevirostris
Dugong dugon, Stenella longirostris,
Tursiops aduncus, Balaenoptera edeni

2 **Matang (Perak) 2,386 km2 (589,593 acres)**

Irrawaddy dolphin – Orcaella brevirostris
Indo-Pacific humpback dolphin – Sousa chinensis
Indo-Pacific finless porpoise –
Neophocaena phocaenoides
Tursiops aduncus, Stenella longirostris

3 **Mersing (Johor), 1,244km² (307,399 acres)**

Dugong dugon, eophocaena phocaenoides,
Orcaella brevirostris,
Sousa chinensis, Tursiops aduncus,
Delphinus delphis tropicalis



5 **Kuala Nyalau (Sarawak) 1,235 km2 (305,175 acres)**

Irrawaddy dolphin – Orcaella brevirostris
Finless porpoise – Neophocaena phocaenoides
Indo-Pacific Humpback dolphin – Sousa chinensis

4 **Kuching Bay (Sarawak) 475 km2 (117,375 acres)**

Irrawaddy dolphin – Orcaella brevirostris
Finless porpoise – Neophocaena phocaenoides
Humpback dolphin – Sousa chinensis
Neophocaena phocaenoides, Orcaella brevirostris,
Sousa chinensis, Tursiops aduncus

MALAYSIA'S MARINE MAMMALS

An Indo-Pacific finless porpoise in the Similajau-Kuala Nyalau IMMA.
Photo: Sarawak Dolphin Project

Indo-Pacific finless porpoises (top) and an Indo-Pacific humpback dolphin (middle) in the coastal waters of the Langkawi Archipelago, and an Irrawaddy dolphin (bottom) in the coastal waters of Perlis, Malaysia.

Photo: MareCet Research Organization

Indo-Pacific humpback dolphins (top) and Irrawaddy dolphins (bottom) in the coastal waters of Matang, Perak, Malaysia

Photo: MareCet Research Organization

A dugong herd, including the presence of mother-calf pairs, sighted during aerial surveys around Sibu Island, Johor, Malaysia.

Photo: The MareCet Research Organization

An Irrawaddy Dolphin is seen surfacing close to a fishing boat in the Kuching Bay IMMA. Dolphins sometimes occur in close proximity to fishing boats that are hauling their catches in, to feed on fishes discarded by the fisherfolk.

Photo:
Sarawak Dolphin Project

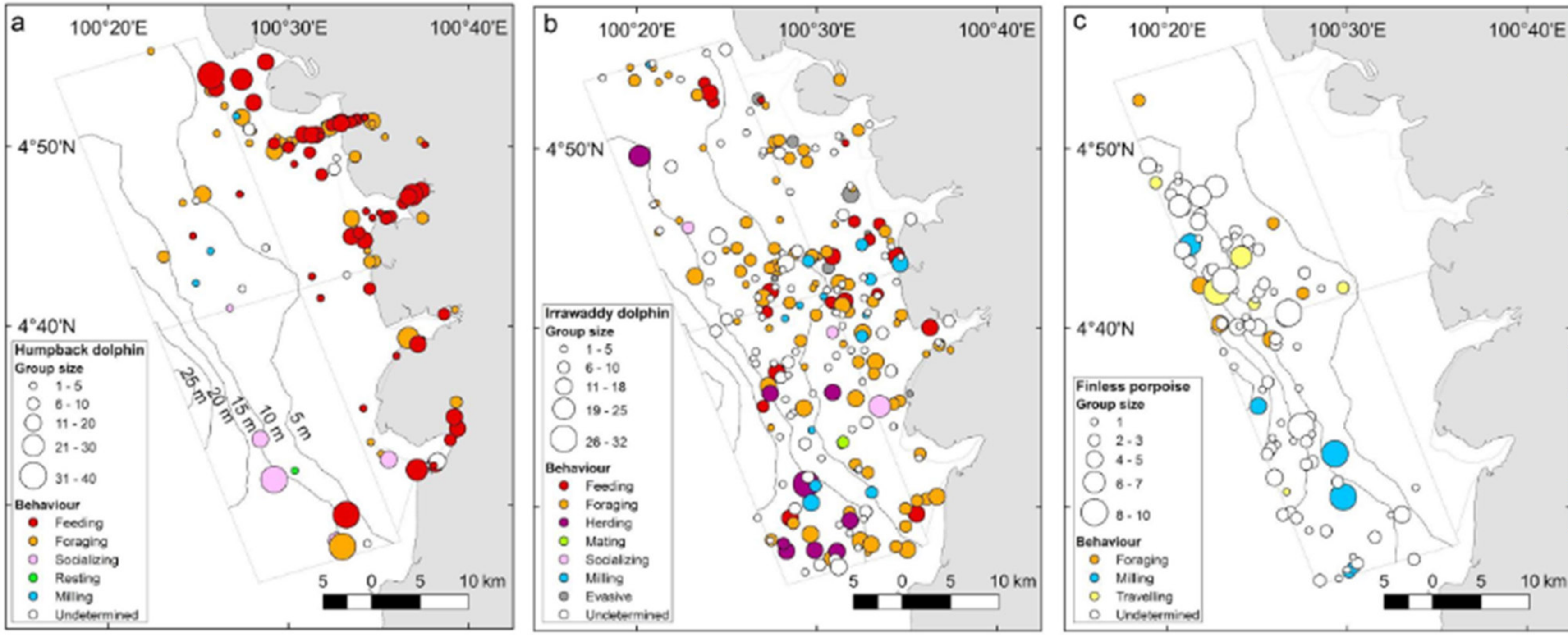


Figure 1: Spatial distribution of group size and behaviour of (a) Indo-Pacific humpback dolphin, (b) Irrawaddy dolphin, and (c) Indo-Pacific finless porpoise sightings in Matang. The size of the circle indicates the group size, and the colour of the circle indicates the predominant behaviour of the group. (Extracted from Kuit et al., 2019 & MMPATF 2020)

Systematic research from 2013 – 2016 in the area within the IMMA measuring 1152 km2 and effort amounting 110 survey days across 11 surveys has found that there were **763 Irrawaddy dolphins**

2.0 Metric Assessment

FUNCTIONAL HEARING GROUP

Functional Hearing Group	Estimated Auditory Bandwidth	General Represented (Number Species/Subspecies)
Low-frequency cetaceans	**7 Hz to 22 kHz**	***Balaena, Caperea, Eschrichtius, Megaptera, Balaenoptera*** **(13 species/subspecies)** ***Dugong dugon***
Mid-frequency cetaceans	**150 Hz to 160 kHz**	***Steno, Sousa, Sotalia, Tursiops, Stenella, Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Orcacella, Physeter, Delphinapterus, Monodon, Ziphius, Berardius, Tasmacetus, Hyperoodon, Mesoplodon*** **(57 species/subspecies)**
High-frequency cetaceans	**200 Hz to 180 kHz**	***Phocoena, Neophocaena, Phocoenoides, Platanista, Inia, Kogia, Lipotes,Pontoporia, Cephalorhynchus*** **(19 species/subspecies)**
Pinnipeds in water	**75 Hz to 75 kHz**	***Arctocephalus, Callorhinus, Zalophus, Eumetopias, Neophoca, Phocarctos,Otaria, Erignathus, Phoca, Pusa, Halichoerus, Histriophoca, Pagophilus, Cystophora, Monachus, Mirounga, Leptonychotes, Ommatophoca, Lobodon, Hydrurga, Odobenus*** **(41 species/subspecies)**
Pinnipeds in air	**75 Hz to 30 kHz**	***Same species as pinnipeds in water (41 species/subspecies)***

Source: Southall et al 2007

2.1 Frequency Range Overlapping

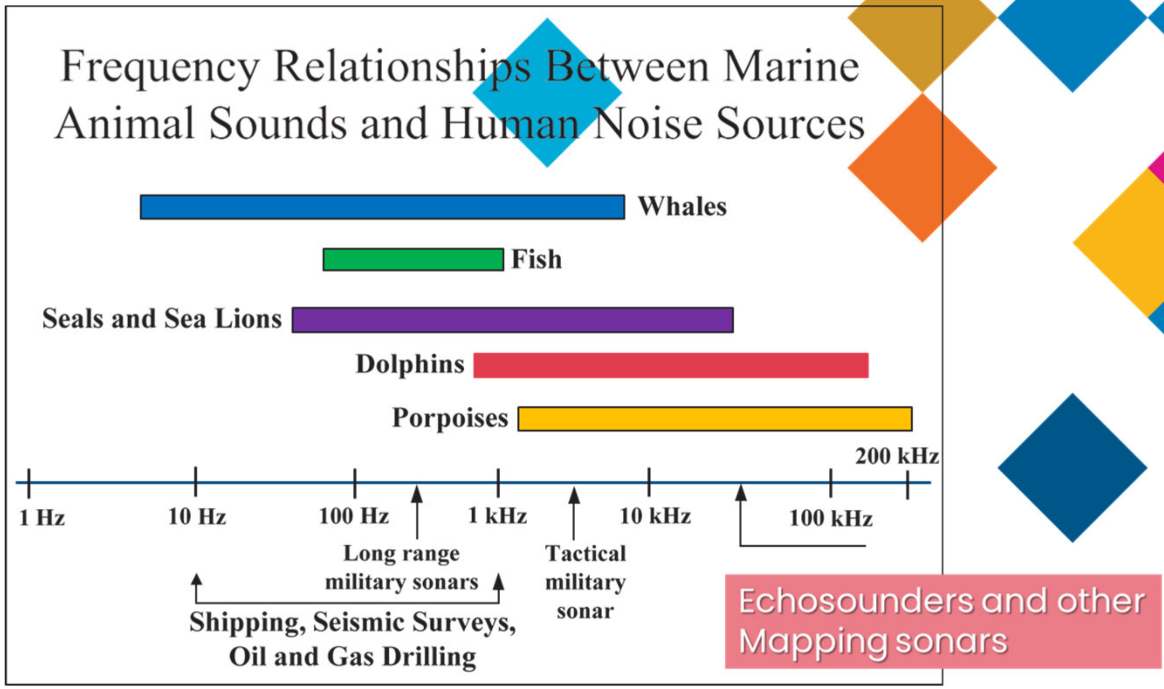


Figure 1. Frequency Range of Sounds Generally Produced by Different Marine Animal Groups Shown Relative to Major Human Noise Sources

UNDERWATER SOUND OF SONAR AND MARINE ANIMALS

2.2 Threshold of Sound Level and Exposure

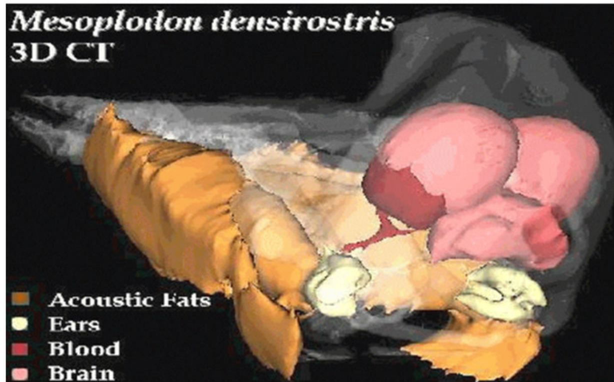
Criteria for Permanent Injury (Estimated Values for PTS-ONSET

Cetaceans			Pinnipeds	Pinnipeds
Low frequency 7 Hz-22 kHz	*Mid-frequency* 150 Hz-160 kHz	*High frequency* 200 Hz-180 kHz	*in Water* 75 Hz-75 kHz	*in air* 75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Single Pulse: 230 dB SPL 198 dB SEL Multiple Pulse: 230 dB SPL 198 dB SEL Non-pulses: 230 dB SPL 215 dB SEL	Single Pulse: 230 dB SPL 198 dB SEL Multiple Pulse: 230 dB SPL 198 dB SEL Non-pulses: 230 dB SPL 215 dB SEL	Single Pulse: 230 dB SPL 198 dB SEL Multiple Pulse: 230 dB SPL 198 dB SEL Non-pulses: 230 dB SPL 215 dB SEL	Single Pulse: 218 dB SPL 186 dB SEL Multiple Pulse: 218 dB SPL 186 dB SEL Non-pulses: 218 dB SPL 203 dB SEL	Single Pulse: 149 dB SPL 144 dB SEL Multiple Pulse: 149 dB SPL 144 dB SEL Non-pulses: 149 dB SPL 144 dB SEL

Units of measurement:
Sound Pressure Level, SPL (in water): measured in dB re: 1 μPa (peak)
Sound Exposure Level, SEL (in water): measured in dB re: 1 μPa2-s

Source: Southall et al 2007

Figure 4 Ziphius cavirostris (BMMS 00-13) Gold Rock beach, Grand Bahama, 19 March 2000. Carcass has been buried and exhumed.



Evidence provided in 2000 at Bahamas when a sonar trial using frequencies between 3–8 kHz and source levels of 223–235 dB led to the stranding of 17 whales
(Balcomb and Claridge 2001)

2.2 Threshold of Sound Level and Exposure

Criteria and values for TTS-onset (single pulses only) and Disturbance/Behavioural Response (multiple pulses and non-pulses)

	Cetaceans		Pinnipeds	Pinnipeds
Low frequency	***Mid-frequency***	***High frequency***	***in Water***	***in Air***
7 Hz-22 kHz	150 Hz-160 kHz	200 Hz-180 kHz	75 Hz-75 kHz	75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Single Pulse: 224 dB SPL 183 dB SEL	Single Pulse: 224 dB SPL 183 dB SEL	Single Pulse: 224 dB SPL 183 dB SEL	Single Pulse: 212 dB SPL 171 dB SEL	Single Pulse: 109 dB SPL 100 dB SEL
Multiple Pulse: 120-180 dB SPL Not applicable	Multiple Pulse: 120-180 dB SPL Not applicable	Multiple Pulse: Data unavailable Not applicable	Multiple Pulse: 150-200 dB SPL Not applicable	Multiple Pulse: 150-200 dB SPL Not applicable
Non-pulses: 120-160 dB SPL Not applicable	Non-pulses: 90-200 dB SPL Not applicable	Non-pulses: 90-170 dB SPL Not applicable	Non-pulses: 100+ dB SPL Not applicable	Non-pulses: 100+ dB SPL Not applicable

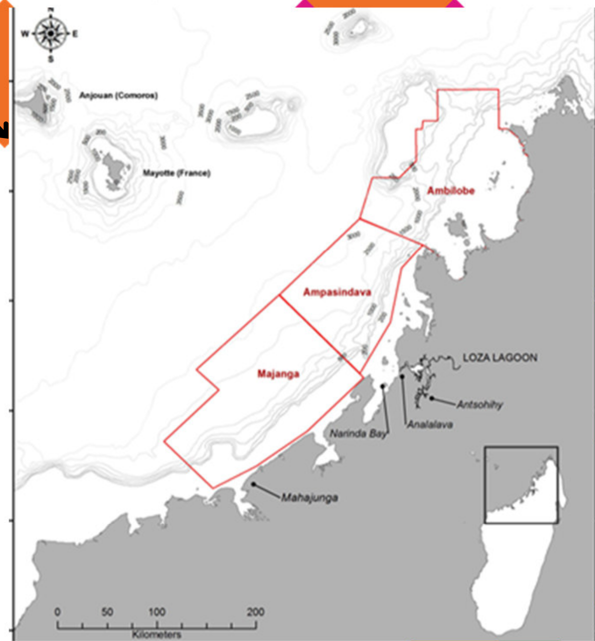
Units of measurement:
Sound Pressure Level, SPL (in water): measured in dB re: 1 µPa (peak) (flat)
Sound Exposure Level, SEL (in water): measured in dB re: 1 µPa2-s

Source: Southall et al 2007

RESEARCH AND EVIDENCE

- In 2008, The Independent Scientific Review Panel (ISRP) determined one of the primary factors behind the mass stranding of 100 melon-headed whales (Peponocephala: 150hz -160kHz) in Madagascar's Loza Lagoon was the result of acoustic signals from a multi-beam echo sounder (12 kHz) used by a survey vessel (Southall 2013). MBES Model: (SIMRAD EM1002, mounted to hull) specified with a sound pressure level of 235 dB re: 1μPa and peak frequency of 12 kHz.
- This findings supported by a study by U.S eastern seaboard on beaked whales that changed their behavior upon detecting sounds from a multi-frequency single beam echo sounder (18-200kHz) (ISC 2023)
- A study in 2020 by University of New Hampshire using MBES 12 kHz on Cuvier's beaked whales (Ziphius: 150hz - 160kHz) found no alterations in foraging behavior (Kates Varghese, Miksis-Olds et al. 2020

Given the ongoing debate, it is advisable to take precautions when addressing this issue



2.2 Threshold of Sound Level and Exposure

RULE OF THUMB

Taking MBES Kongsberg EM 712 (40-100kHz) used by KD Perantau (225-237dB at peak) as an example,

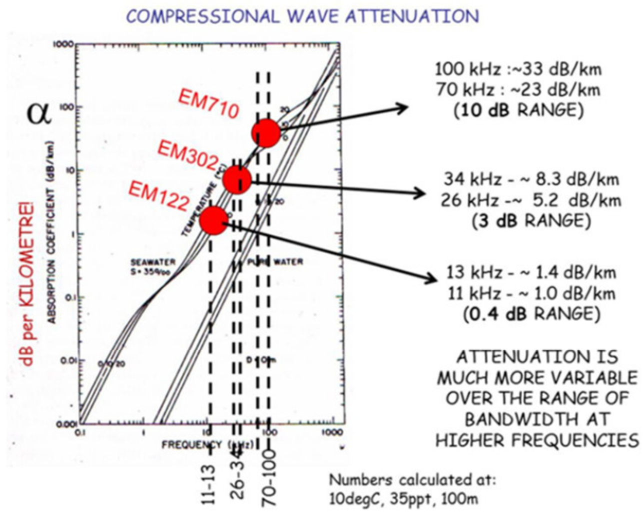
assuming attenuation about 10dB/km and considering of Southall's sound exposure limit "183dB SEL". / sound level "224 dB SPL" that change the behaviour.

Theoretical safe distance for marine mammals directly from the source can be calculated as:

(237dB-183dB) / 10dB = 5.4 km.

(237dB-224dB) / 10dB = 1.3 km.

Internationally, the distance of 1km (sea surface) was adopted by Government of Ireland as code of practice (Department of Environment 2007).



The variation in attenuation coefficient as one moves over the bandwidth of common deep sea and shelf sonars.

Note that for the EM710 (70-100 kHz) attenuation changes by 10 dB/km. For the EM302 (26-34 kHz) the attenuation changes by 3dB/km and for the EM122 (11- 13 kHz) the change is only 0.4 dB/km.

For the higher frequency system, the number of sectors is not increased in deep water, as the benefits of improved attenuation outweighs the benefits of more sectors. For the lower frequency systems, more sectors are added as the pusle bandwidths reduce.

Source: Class Note "Motion Compensation"

ADVISE

BEST PRACTISE OF SOUND MANAGEMENT IN HYDROGRAPHIC SURVEYING OPERATION

1) Hydrographic surveyors **working at IMMA areas need to be aware of the presence of various cetaceans**, such as dolphins and porpoises classified as (150Hz-160kHz) and (200Hz-180kHz) cetaceans, as well as dugongs, which are low frequency cetaceans (1kHz to 18kHz) (Anderson and Robert 1995). Hydrographic surveyors must carefully select appropriate operation frequency when operating within these regions. Surveyor can **use appropriate echo sounder model which outside the cetacean's frequency** such as Kongsberg EM 2040 (200-400kHz).

2) Echo sounders, such as the Kongsberg EM 712 on National Hydrography Centre Survey Vessel (KD Perantau), emit their strongest sonar signals within a meter beneath the transducer (approximately 225-237 dB at their peak). The sound becomes less intense as moves away from the source, making **it safer for marine mammals which are 1km (sea surface) away from the source** (Department of Environment 2007).

3) Before survey commence, it is advised to **use a soft start pinging mode and reducing the sound level by 10 or 20 dB during 140º coverage** (Kongsberg 2019).

4) Survey **line shall start from the coast and move towards deeper waters** and not the opposite to prevent marine mammals from being disturbed and swimming toward the shore (Department of Environment 2007)

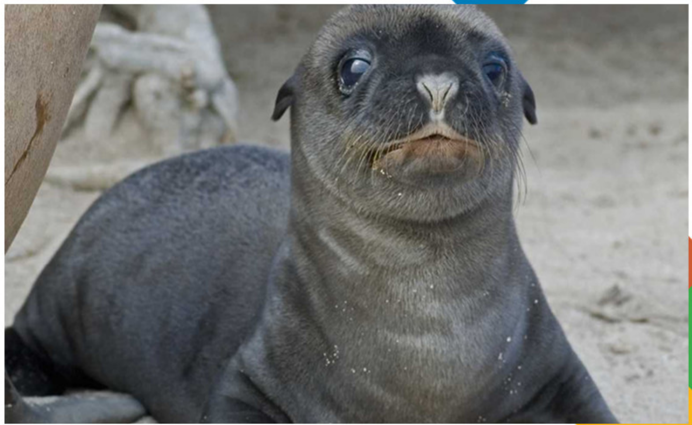
CONCLUSION

"Echo sounder sonar emissions may not potentially harm marine mammals if proper survey practices are followed as suggested in this brief note. This practice can set a new professional guideline for hydrographic surveying especially during the campaign of charting Malaysia's waters using MBES. This ultimately reduce harm to marine mammals which are the remarkable marine life in our country"


Bangkai dugong terdampar di Pulau Tinggi

Nurul Amanina Suhaini - April 21, 2017 @ 10:53am
bhjb@bh.com.my

BANGKAI dugong yang ditemui terdampar di pantai Kampung Tanjung Balang, Pulau Tinggi, Johor, petang semalam. - Foto Ihsan Jabatan Taman Laut Malaysia Johor



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THANK YOU

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15 LIFE ON LAND
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