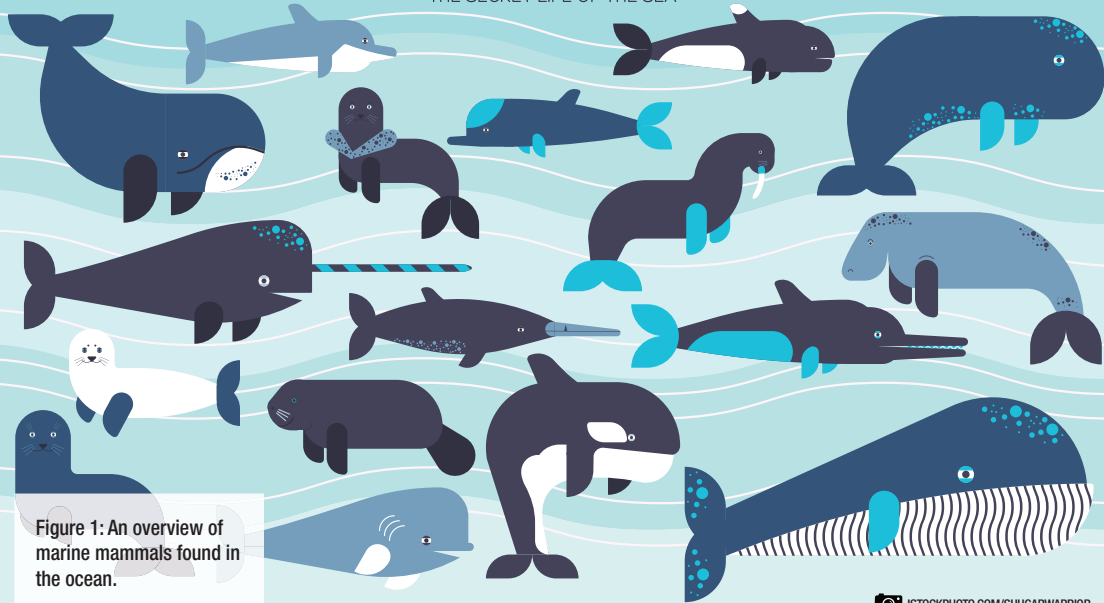


Sounds Generated by Marine Mammals & Impacts of Different Types of Underwater Noise

by Serdar Beji

MARINE MAMMALS

THE SECRET LIFE OF THE SEA



Merriam-Webster Dictionary defines cetaceans as “*completely aquatic, mostly marine mammals consisting of the whales, dolphins, porpoises, and related forms, all having a very large head, a tapering body like a fish and nearly devoid of hair, forelimbs like paddles, no hind limbs, a tail ending in a broad horizontal fin, a large brain, a complex stomach of four or more chambers ...*” To all these, it must be added that cetaceans, or marine mammals, are distinguished not only by being mammals of oceans but also by communicating among their own species through generation and reception of specific sounds. The purpose of this essay is to review in broad terms the sound-related lives of marine mammals (Figure 1).

Sound as Primary Way of Living

Compared to air, sound in water travels much faster and with little loss over considerable distances. More specifically, high incompressibility of water enables the disturbance to propagate relatively quickly, nearly 1,500 m/s, over thousands of kilometres. On the other hand, light, despite travelling incomparably fast, cannot penetrate into water more than a small fraction of a kilometre. It is then easy to understand why

marine mammals have evolved as they have and why they use sound as their primary way of sensing and communication underwater.

Marine mammals produce different types of sounds for various purposes. Since it is quite difficult to categorize these sounds precisely, they are sometimes grouped by phonetically imitating the sound; e.g., “clicks.” Scientifically, these sounds may be classified into three groups based on their spectral features: constant-wave tones, frequency-modulated sounds, and broadband pulses. Baleen whales, for instance, make sounds from all three categories. Pulses emitted as fast pulse trains are usually called “moans.” Blue, fin, and humpback whales can *sing songs* for hours and even days. Toothed whales produce whistles, burst-pulse sounds, and clicks. They also emit clicks to navigate and find prey underwater. This sensory adaptation, called echolocation, works most effectively at high frequencies. Remarkably enough, only bats can compete with toothed whales in their ability to perceive ultrasonic sound higher than 100,000 Hz frequency. The frequency range of sounds produced by marine mammals is quite wide, varying from less than 10 Hz to greater than 200,000 Hz, or 200 kHz.



Figure 2: Some marine mammals produce mechanical sounds by disturbing the surface of the water by breaching or slapping.

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Marine mammal sounds are produced in the larynx while echolocation clicks are generated by nasal air sacs. Also, some marine mammals produce mechanical sounds by disturbing the surface of the water by breaching or slapping (Figure 2). Social interaction, mating, nursing of young, feeding, and many other activities of marine mammals are associated with sound production. Therefore, undisturbed and uninterrupted sound communication is of vital importance to marine mammals. Serious damage to their auditory systems may result in fatal consequences; such problems are addressed in the following sections.

Types of Underwater Sound

Sound generated by surface waves, rain, storms, earthquakes, marine life, etc. in the ocean is essentially of natural origin. On the other hand, sound generated by human activities such as shipping, seabed piling for coastal construction, active use of sonars for research and military activities, underwater explosions, etc. is known as anthropogenic noise (Figure 3). All these contribute to what is called “ambient noise,” which cannot be precisely attributed to a specific source. The total of all noise sources at a given location and time represents the ambient noise level.

Since the ocean is quite an effective medium for sound transmission, low-frequency sound in particular – sound with frequencies less than 1,000 Hz – travels thousands of kilometres. In principle, the lower the frequency of sound, the farther it can travel. Unfortunately, as Figure 4 reveals, much of the anthropogenic noise is less than 1,000 Hz; therefore, it can propagate over long distances. Low-frequency sound causes much concern because it can interfere with the communication and navigation of various marine mammals. Moreover, with increasing sea trade, coastal construction, mineral exploitation, and the active use of sonar, contributions to the anthropogenic noise and consequently the associated threats to marine mammals are on a continuous rise.

Impacts of Disturbing Sound on Marine Mammals

Literature on the behavioural effects and health threats of underwater noise on marine mammals goes as far back as 50 years with studies on the impact of shipping noise on whales. Since then, a considerable body of work has been accumulated on the subject. Among these works, the case of stranding and subsequent deaths of beaked whales following a military operation in the Kyparissiakos Gulf in 1996 stands as a milestone in giving a different impetus to these studies, especially concerning regulatory initiatives.

Frequencies of sounds produced and received by marine mammals are of utmost importance as their susceptibility to a certain noise is dictated primarily by its frequency range. Noise, when produced at certain frequencies, can severely affect and even damage the lives of marine mammals. Such effects are usually examined under four categories: behavioural response, masking, auditory threshold shift, and non-auditory physiological effects.

Behavioural responses of marine mammals to anthropogenic underwater noise are changes in swim direction and speed; changes in natural surfacing, respiration, and dive durations and intervals; and changes in acoustic and circumstantial behaviour such as avoiding favourable areas for feeding, reproduction, and sheltering. The severity of such responses is determined by age, gender, prior exposure, health, etc. of the animal exposed. An important point to note is that over long ranges (≈ 70 km), behavioural responses are observed for noises which are close to the maximum ranges of audibility.

Masking is another consequence of underwater noise; communication among mammals, predator and prey sounds, and echolocation clicks, which are vital for some animals, can be masked, or suppressed, by noise.

Exposure to noise can also cause deterioration of hearing sensitivity, which is termed



Figure 3: Sound is generated by human activities such as shipping, seabed piling for coastal construction, and active use of sonar for research and military activities, underwater explosions, among others.

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threshold shift. The effect is called “temporary threshold shift” if hearing returns to its normal state after some quiet time; otherwise, it is a permanent injury and called “permanent threshold shift.”

While noise essentially affects auditory organs, it may produce non-auditory physiological effects as well. For instance, stress is a physiological response that comprises the adrenalin release, which increases heart rate,

alertness, and blood flow to the brain and muscles. Stress responses improve the survival chances in presence of an immediate threat; however, repetitive or protracted stress can negatively affect health over time, and may even be lethal if it is very severe.

Regulatory Possibilities

Underwater noise can travel long distances across the oceans and into waters under the jurisdiction of different countries; therefore,

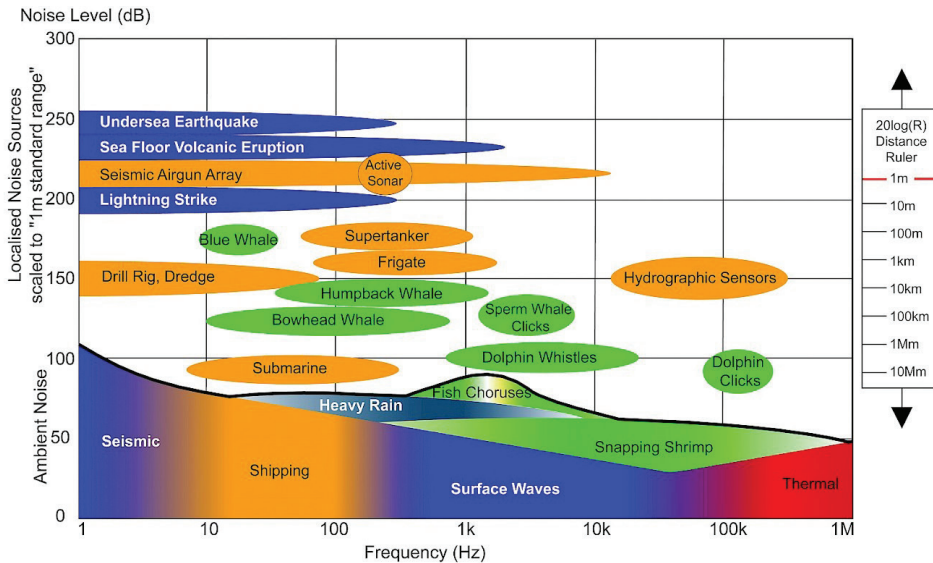


Figure 4: Ambient noise produced by different sources: frequency versus noise level.
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its impacts are essentially international. However, at present, generation and transmission of sound in the ocean are not regulated by any international law. Obviously, there is a need to establish international standards and accepted rules for sound generation and transmission in the world's oceans, especially concerning the problems associated with anthropogenic sound.

Noise, being quite a different type of pollutant, is not a substance but a form of energy and therefore cannot be treated like usual pollutants such as oil spills. When certain regulatory issues are considered, underwater noise should be associated with other types of energy pollutants such as heat and radiation. Therefore, suggested remedies necessarily address protected marine regions, sanctuaries, and multi-lateral regional initiatives in abating underwater noise pollution. At present, ocean management must consider a variety of factors that include technological advancements, limited natural resources, scientific uncertainty, pressures of population increase, and countless other challenges. Ocean noise pollution has taken place among these as one of the newest challenges and must be appropriately addressed.

The wisdom of philosopher Hugo Grotius in his classic study of *Mare Liberum* (Free Sea) entreats us for over 400 years: "No part of the sea can be considered as the territory of any people whatsoever." ~

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Dr. Serdar Beji currently works at Istanbul Technical University, Faculty of Naval Architecture and Ocean Engineering. Theoretical modelling of water waves, rip currents, hydrodynamics of floating and submerged vessels, and underwater acoustics are among his research interests.