Effects and Responses of Ocean Noise to Marine Mammals

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Abstract: Ocean noise pollution poses a significant threat to marine ecosystems, particularly impacting marine mammals such as dolphins and whales. This paper explores the detrimental effects of such pollution and emphasizes the urgent need for comprehensive mitigation strategies to preserve marine biodiversity. The primary sources of disruptive marine noise include shipping activities and oil and gas exploration, which not only interfere with the acoustic environment but also contribute to long-term habitat degradation. The responses of marine mammals to ocean noise are multifaceted, involving alterations in vocalizations, migration patterns, and physiological stress, which can lead to decreased reproductive success and increased mortality rates. This study provides detailed insights into the broader ecological impacts, including changes in species distributions and extensive physiological damage that may lead to ecosystem imbalance. Focusing specifically on the unique challenges faced by dolphins and whales, the paper highlights the importance of oceans and the severe threats they encounter from human-induced noise. It discusses the disruption of critical behaviors such as feeding, mating, and social interactions that are essential for survival. The paper concludes with a strong emphasis on the urgent need for effective mitigation measures to protect marine biodiversity and mitigate the multifaceted threats posed by marine noise pollution. It calls for stricter regulations on noise-producing activities, the development of quieter marine technology, and the establishment of marine protected areas where silence is maintained to allow recovery of affected species.

1 INTRODUCTION

Vast and mysterious, the oceans are of profound significance to life on Earth. The ocean covers more than 70% of the Earth's surface and is known for its biodiversity and various species (Gleick, 1993). Its waters are filled with a variety of animals, plants, and organisms, from the tiniest plankton to majestic whales. However, despite its vast size and ecological importance, the ocean remains besieged by many anthropogenic threats, further damaging its condition more and more severely. Human activities such as overfishing, pollution, industrialization, and relentless development have caused havoc on marine habitats, undermining their resilience and endangering countless species.

Among the many noticeable threats faced by the ocean, one of the most serious is the escalating level of ocean noise, the result of mainly human activities with some natural factors that penetrate all areas of the ocean. Relentless noise from shipping, industrial operations, seismic exploration, and military exercises disrupts the tranquil underwater world and wreaks vital destruction on marine life, especially marine mammals. Year after year, this symphony of ocean noise never stops increasing, showing many profound effects on the inhabitants deeply.

The rising impact of ocean noise affects the entire marine ecosystem, manifesting in a variety of harmful effects. For marine mammals especially, whose lives are deeply associated and intertwined with sound, the impact is particularly dreadful. Whales, dolphins, and other marine mammals rely on complex vocalizations to convey information, coordinate group activities, and establish social bonds.

Continuous noise interferes with important biological functions, errors in communication, navigation, foraging, and reproduction. Marine mammals rely on sound for a variety of basic activities, from locating prey and mates to evading predators and navigating in the enormous oceans (Southall et al., 2019). However, constant man-made noise disrupts these important behaviors and plunges marine mammals into a dangerous struggle for survival.

Navigation errors caused by ocean noise further intensify the condition of marine mammals, as human-generated noise distorts their acoustic landscapes, causing disorientation and confusion.

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Sound tracking being the most important navigational tool for marine mammals, guides them as they move across the vast ocean with unparalleled precision. However, surrounded by the din of human-made noise, this acoustic picture becomes distorted, leading marine mammals astray and even endangering their survival.

Furthermore, the growth in ocean noise increases the risk of deadly accidents between marine mammals and ships, with catastrophic consequences for both the species and the ship. As the use and amount of ships in the world's oceans increase in frequency, the likelihood of accidental collision with marine mammals increases dramatically. The consequences of such collisions are often devastating, resulting in injury or death of marine mammals as well as significant damage to vessels.

Tragically, rapidly increasing ocean noise also threatens the survival of marine mammals, pushing many species to the brink of extinction. As time passes, they are filled with more and more ocean noise, drowning out the natural sound of marine life and the actual way of living. Pushing countless species into endangerment and oblivion yet unaware. Urgent action should be taken to mitigate the impact of ocean noise and preserve the balance of marine life before it's too late.

Regarding the interest in ocean noise and its relationship with marine mammals, this paper focuses on the studies of the appearance and effect of ocean noise and the response of marine mammals, further using the focus to spread notice and awareness.

2 SOURCE OF OCEAN NOISE

Marine environmental noise is a complex mixture of natural and anthropogenic sources, with consideration of different noise frequencies. Human activities generate mainly low-frequency noise, particularly from shipping and underwater operations, in the range of 10 to 500 Hz. With this harming the marine mammals basic hearing system, it further shows the significant impact on marine mammals.Marine mammals frequently get affected by similar ocean noises, forcing them to change their regular sound system, yet shipping alone causing a 12-decibel increase in ocean noise levels in the past years forcingly making marine mammals to adapt to the change (Hildebrand, 2009). In contrast, mid-frequency noise is mainly produced by natural events such as sea surface disturbances and has a frequency range of 500 Hz to 25 kHz. The dominant source of this noise is associated with ocean surface waves brought by wind action on the ocean surface (National Research Council, 2003). Furthermore, smaller vessels and sonar systems may also produce mid-frequency noise. In contrast, high-frequency ocean noise (>25 kHz) is often elusive.

Despite different types of ocean noises, low-frequency ocean noises pose the greatest threat to marine mammals, disrupting their important behaviors and affecting their survival. Therefore, further focusing on two major human causes - shipping and oil and gas production.

2.1 Shipping

The proliferation of shipping activity stands out as a leading contributor to human-induced ocean noise, exerting profound impacts on marine mammals (Figure 1). As the maritime industry flourishes, some negative side effects occur as the reverberations of vessel traffic harm the marine ecosystem, with detrimental consequences to marine species in multiple ways. Four primary deleterious effects of shipping noise: are disruption of habitat, interference with communication and prey detection, induction of physical and physiological stress, and masking of crucial auditory cues (Kraus et al., 2005).

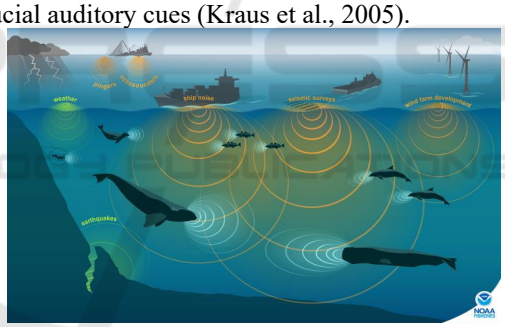

Figure 1: Indicating the range of marine mammals affected by increasing shipping noise (Kraus et al., 2005)

Habitat destruction is the biggest concern, with intensely growing shipping noise eroding specific areas critical to the survival of marine mammals. Many species show loyalty to certain resting sites, but the increasing bustle of maritime traffic has reduced their ability to utilize these habitats. This individually, may cause marine mammals to experience stress and give them less time to locate new habitable environments. In addition, the noise of vessels disrupts important reproductive behaviors, disrupting mating rituals, and hindering the raising of offspring. Additionally, constant low-frequency shipping noise permeates the marine environment, impacting areas important for the delicate balance of marine

ecosystems, thereby threatening the long-term survival of marine mammal populations.

A corollary of transport noise is its potential interference with communication and prey detection which stand a critical place to the survival of marine mammals. Sound is the primary means of communication and navigation for many marine species, facilitating important exchanges between individuals and enabling prey location. However, the increasing intensity of ship noise, characterized by the low-frequency ocean noises, masks these acoustic signals, thereby affecting the ability of marine mammals to effectively communicate and locate important food sources. Such disruptions can have consequences for social dynamics and ecological interactions, therefore worsening the vulnerability of marine mammal populations. Furthermore, prolonged exposure to higher noise levels induces physiological stress responses in marine species, triggering the release of stress hormones that then disrupt immune function, reproductive processes, and metabolic homeostasis. This long-term stress undermines the resilience and health of marine populations, leaving them at risk of disease, reproductive failure, and population decline, also wounding the wholeness of marine ecosystems.

Finally, shipping noise compounds the trouble of marine mammals by masking important sounds, hindering their ability to detect and respond to environmental calls necessary for survival. Noise from ship traffic disrupts signals critical for predator detection, prey location, and social communication, reducing the efficiency of marine mammals' sense organs and undermining their ability to navigate complex ecological landscapes. This important sensory deprivation increases the risk of predation, starvation, and reproductive failure, further showing shipping noises' massive effect on marine mammals.

In summary, due to the increase in maritime shipping, shipping noise therefore also escalating posing a significant threat to the biodiversity of marine ecosystems especially marine mammals, highlighting the urgent need for efforts to mitigate its harmful effects. Marine mammals are deeply affected by the increasing vessels number and noise, showing the importance of maintaining the delicate balance of marine ecosystems and ensuring the long-term survival of marine mammal populations in an increasingly noisy ocean landscape.

2.2 Oil and Gas Production

Ocean noise from oil and gas production demonstrates a significant threat to marine mammals, deepening the challenges they already face in the ocean. Activities associated with oil and gas extraction, including seismic surveys, drilling operations, and the deployment of underwater infrastructure, generate a series of human-made noises throughout marine ecosystems. The effects of this noise pollution on marine mammals are multifaceted. Similarly to shipping noise, oil and gas production noise can have profound consequences for their survival and well-being.

One of the most direct impacts of oil and gas-related ocean noise is its potential to disrupt important behavioral and physiological processes in marine mammals. As the oil exploration moved into deeper water areas, the seismic signals and ocean noise increased (Wenz, 1962). Many marine mammals rely heavily on sound for communication, navigation, foraging, and more. However, intense noise from oil and gas activities can mask these signals needed, interfering with marine mammals' ability to perform essential tasks. This disruption can lead to many negative consequences, including reduced reproductive success, impaired foraging ability, and many more.

Seismic surveys, in particular, are known to produce incredibly loud and low-frequency sounds that can travel great distances through the water column. These surveys involve using airguns to shoot acoustic pulses into the ocean floor to map the geological structures under the ocean floor. Repeated shooting of the airguns can produce intense noise and cause major disturbance to nearby marine mammals. It has also shown that exposure to seismic survey noise can lead to behavioral changes in marine mammals, such as changes in swimming patterns, vocalizations, and feeding behavior.

Beyond disrupting important behaviors, ocean noise from oil and gas production can also cause physiological stress like shipping noises to marine mammals. Exposure to high levels of noise triggers the release of hormones such as cortisol, which can have several negative effects on the health of marine mammals. Chronic stress weakens the immune system, increases susceptibility to disease, and impairs reproductive success, ultimately resulting in the decline of the overall health of affected individuals and populations.

While short-term studies have provided a valuable understanding of the immediate effects of noise pollution on these species, there is growing concern that long-term exposure to high levels of noise may have more problems but equally important effects over time. For instance, long-term exposure to noise pollution may cause desensitization or habituation in

marine mammals, making them progressively less responsive to environmental stress and more vulnerable to other threats. Which overall shows the serious and multifaceted threats posed to marine mammals according to this increasingly noisy ocean environment.

3 EFFECTS AND RESPONSES OF MARINE MAMMALS

As stated before, ocean noise pollution poses a significant threat to marine mammals, especially whales and dolphins, affecting their physical, and psychological behavior, and health. Ocean noise comes from a variety of sources, including shipping, seismic surveys, and offshore construction. These noises interfere with the complex vocalizations frequently used by marine mammals for important activities such as finding mates, finding food, and avoiding predators.

Marine mammal responses to ocean noise vary among species and individuals. It's often that some may change their vocalizations, increase the volume of their calls, or alter their migratory patterns to avoid noisy areas. Yet if the change fails to be made, others may suffer stress, hearing damage, or even become stranded from intense exposure to man-made sounds unsuitable for their hearing range.

3.1 General Harm to Marine Ecosystem

Marine noise pollution adversely affects the entire marine ecosystem in a variety of ways (Jiang, 2021). One major harm is the disruption of communication and behavioral patterns among marine species. From the smallest fish to the largest whales, many marine creatures utilize sound for important living activities. Excessive noise from human activities can interfere with these processes, leading to harm to their health and daily living.

Additionally, ocean noise can alter the distribution and abundance of marine species, potentially changing food webs and ecosystem dynamics as it wasn't supposed to be. For example, noise pollution may cause some species to avoid noisy habitats during mating season or daily, leading to changes in community composition and ecosystem function. Additionally, long-term revelation to loud underwater noise may cause physiological impairments, such as hearing loss or tissue damage, further declining the health and resilience of marine populations. In general, marine noise pollution is seen as a multifaceted threat to marine ecosystems.

3.2 Analysis of Harms to Common Marine Mammals

Ocean noise pollution causes serious harm to a variety of common marine mammals. Pinnipeds for instance, including seals, sea lions, and walruses, are particularly vulnerable to ocean noise. They rely heavily on underwater vocalizations to support their daily living. Excessive noise from sources such as shipping, construction, and industrial activity can obscure these important signals, causing communication disruptions and disrupting the social hierarchy within the colony. Additionally, pinnipeds rely on hearing to detect predators and locate food underwater. Being exposed to human-made noise can cause temporary or permanent damage, impairing their ability to forage effectively and avoid threats.

Likewise, sea otters and manatees are also susceptible to the harmful effects of ocean noise. Similar to pinnipeds, they also use vocalization to support themselves in living. The intensely increased underwater noise levels can disrupt them leading to many downside effects. Moreover, manatees, which are notoriously slow-moving, may be particularly easy to collide with boats in noisy environments, further endangering their populations.

In short, the harm of ocean noise is not limited to a few species but also a variety of common marine mammals.

3.2.1 Dolphins

Dolphins, one of the most iconic and beloved marine mammals, are also not immune to the negative effects of ocean noise pollution. As highly intelligent and social creatures, dolphins show an urgent need for sound for communication, navigation, and locating prey. Yet, the increasing levels of anthropogenic noise in the ocean pose a significant threat to their social structure, daily living, and population dynamics.

Research shows that overexposed to high levels of sound energy can cause hearing loss in dolphins. This overexposure may cause hearing thresholds to increase, effectively reducing their sensitivity to surrounding noise (Mardi, 2008). This damage not only affects individual dolphins but also has knock-on effects on their populations as a whole. Hearing impairment impedes their ability to effectively communicate with each other, food haunting, and

navigate their environment, ultimately affecting their survival and reproduction.

Furthermore, research shows that dolphins change their vocalizations in response to escalating levels of man-made noise. These modifications often involve simplifying their calling, potentially overcoming the masking effects of background noise (Fouda et al., 2018). However, for dolphins categorized as Odontocetes, which includes a variety of species with complex social structures, maintaining diversity and complexity in vocalizations is critical for their social cohesion. Simplifying the sounds caused by ocean noise could disrupt these social structures, leading to a loss of cultural diversity and potentially affecting the overall health of dolphin populations.

The impacts of ocean noise pollution on dolphins extend far beyond direct hearing damage and behavioral changes. This disruption may indirectly affect their social structure and communication patterns, potentially having profound consequences for their long-term survival and ecological role. As apex predators, dolphins play a major role in maintaining the balance of marine ecosystems by regulating prey populations and promoting nutrient cycling. Therefore, protecting the acoustic integrity of dolphin habitats and minimizing anthropogenic noise pollution is critical to ensuring the welfare of dolphins and the health of the entire marine ecosystem.

3.2.2 Whales

Whales, one of the largest marine mammals, are just as affected by human-generated ocean noise as dolphins. Sound plays a crucial role in the lives of whales, the reliance on sound has become an integral and irreplaceable aspect of a whale's existence, underscoring its importance. The effects of this noise pollution range from more predictable hearing impairments and navigation challenges to more hidden effects like significant changes in their migratory patterns and behavior. For example, beaked whales, known for their deep-diving abilities, may show changes in diving and feeding behavior in response to active sonar or other sonar-like sounds (Fisheries, 2022). These active unfamiliar noises disrupt their normal activities, cause stress, and may alter their migration routes and feeding grounds like other mammals. In addition, large amounts of ocean noise generated by human activities can cover up natural sounds and interfere with the acoustic landscape that whales rely on for survival.

Disruption to migratory patterns is especially concerning as it could have profound effects on whale populations and marine ecosystems. Migration is important in the life cycles of many whale species, facilitating reproduction, feeding, and social interaction. Changes in migration routes or timing may disrupt these fundamental processes, leading to a decline in reproductive success, and changes in prey distribution.

In addition, the cumulative effects of long-term exposure to high levels of ocean noise can cause immediate and long-term consequences for whales' health and survival. Stress can slowly increase from ongoing noise pollution weaken immune systems, increase disease susceptibility, and reduce reproductive success, further exacerbating population declines. For instance, sperm whales tend to be dulled under ocean noise next to ships, due to the increased number of ships making them unavoidable. Many sperm whales are found bumping into ships, often causing irreversible harm to the whales. Non-natural sound waves can often cause physical damage to marine mammals. Sperm whales often experience damage to the cells in their ears, causing them to be unable to decode the noise due to the structural disruption in their cells (Rako-Gospić and Picciulin, 2019). This makes them almost incapable of living, as sound is one of the most important senses for their basic survival

4 CONCLUSION

In conclusion, this writing briefly talks about the effect ocean noise has on marine mammals, particularly dolphins and whales.

Ocean noise is a complex mixture of natural and anthropogenic sources, spanning different frequency ranges. The increase in shipping is a major cause of anthropogenic ocean noise, with profound impacts on marine mammals. Additionally, oil and gas production activities, including seismic exploration and drilling operations, generate intense noise, further bringing a negative impact on the rain ecosystem. Despite progress in understanding the immediate impacts of noise pollution, the long-term impacts on marine mammals remain a concern, highlighting the urgent need for mitigation measures to protect marine biodiversity.

Ocean noise pollution poses a significant threat to marine mammals, affecting their physical, mental, and behavioral health. Marine mammals, including whales and dolphins, exhibit a variety of responses to ocean noise, from changing vocalizations and migration patterns to experiencing stress, hearing damage, and even strandings. Furthermore, this

impact is not limited to individual mammals but affects entire marine ecosystems, disrupting communications, altering species distributions, and posing physiological risks. Dolphins and whales are iconic marine mammals that face special challenges. Dolphins change their vocalizations as noise levels increase, while whales may show changes in migration patterns and feeding behavior. In summary, marine noise pollution is considered a multifaceted threat to marine mammals as a whole, with adverse effects on the broader marine ecosystem.

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