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DEPARTMENT OF MARITIME STUDIES

**MSc in Sustainability and Quality in
Marine Industry**

**THE EFFECT OF SHIP NOISE TO MARINE
MAMMALS**

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Dissertation

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ABSTRACT

This thesis is a research and a record of the facts and conclusions drawn from its subject "The effect of ship noise to marine mammals". Its goal is to highlight a very significant problem that of noise pollution, that sea mammals face due to the frequent passage of ships through their environment.

Below will be analyzed terms of shipping and marine mammals, as well as the course of development of shipping over the years. Also, it will be analyzed how marine mammals and their life in the sea are affected by shipping, while at the same time Mr. Alexandros Fratzis from the Pelagos Institute will report important problems, including the sound of ships, which face the mammals of the sea in Greece and by extension throughout the world.

To conclude, recommendations will be given in order to reduce the noise that ships create in the ocean, such as improve ships' design to reduce hydrodynamic noise caused by propellers, reduce ships' speed, route planning and management etc.

Keywords: Noise pollution, marine mammals, shipping

ΠΕΡΙΛΗΨΗ

Η παρούσα διπλωματική εργασία αποτελεί έρευνα και καταγραφή γεγονότων και συμπερασμάτων για το θέμα «Η επίδραση του θορύβου των πλοίων στα θαλάσσια θηλαστικά». Στόχος της είναι να αναδείξει ένα πολύ σημαντικό πρόβλημα, αυτό της ηχορύπανσης, που αντιμετωπίζουν τα θαλάσσια θηλαστικά λόγω της συχνής διέλευσης των πλοίων από το φυσικό τους περιβάλλον.

Παρακάτω θα αναλυθούν οι όροι της ναυτιλίας και των θαλάσσιων θηλαστικών, καθώς και η πορεία εξέλιξης της ναυτιλίας στο πέρασμα των χρόνων. Επίσης, θα αναλυθεί πώς επηρεάζονται τα θαλάσσια θηλαστικά και η ζωή τους στη θάλασσα από τη ναυτιλία, ενώ παράλληλα ο κ. Αλέξανδρος Φρατζής από το Ινστιτούτο Πέλαγος θα αναφέρει σημαντικά προβλήματα, μεταξύ των οποίων ο ήχος των πλοίων, που αντιμετωπίζουν τα θηλαστικά του θάλασσα στην Ελλάδα και κατ' επέκταση σε όλο τον κόσμο.

Κλείνοντας, θα επισυμανθούν προτάσεις για τη μείωση του θορύβου που δημιουργούν τα πλοία στον ωκεανό, όπως η βελτίωση του σχεδιασμού των πλοίων για τη μείωση του υδροδυναμικού θορύβου που προκαλείται από τις έλικες, η μείωση της ταχύτητας των πλοίων, ο σχεδιασμός και η διαχείριση διαδρομής τους κ.λπ.

Λέξεις κλειδιά: Ηχορύπανση, θαλάσσια θηλαστικά, ναυτιλία

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CHAPTER - 1

1.1 INTRODUCTION

Underwater noise pollution, that refers to the excessive and harmful levels of sound generated in aquatic environments due to human activities. This form of pollution has become a growing concern as it can have significant impacts on marine life, ecosystems, and the overall health of the oceans. Shipping can have significant impacts on marine mammals, and these effects can be both direct and indirect.

Various human activities contribute to underwater noise pollution and could be harmful and negatively affect marine mammals. Some of the major sources of underwater noise pollution include the below: Shipping: Commercial vessels, cargo ships, and recreational boats emit low-frequency noise, propeller cavitation, and engine noise, which can travel over long distances in the ocean.

Offshore Energy Exploration and Production: Activities related to offshore drilling, seismic surveys, and underwater construction generate loud noises that can disturb marine life.

Military Sonar: Navy exercises and other military operations use sonar systems that produce intense and frequent underwater sounds, which can disrupt marine animals' behaviors.

Underwater Construction: Construction of offshore structures, such as oil rigs, wind farms, and bridges, can produce significant noise during their installation and operation.

Recreational Activities: Activities like jet skiing, scuba diving, and recreational boating can also contribute to underwater noise pollution.

Collisions: Collision risks refer to the potential for two or more objects, vehicles, or entities to come into physical contact, resulting in an unwanted or unexpected impact. Collisions can occur in various contexts, including traffic accidents, maritime incidents, aviation mishaps, space exploration accidents, and even in the digital world, such as collisions in computer networks or hashing algorithms. In the context of

maritime transportation, ships can collide with each other due to navigational errors, adverse weather conditions, or equipment failures. Collisions at sea can lead to severe consequences, such as oil spills or sinking.

Habitat Disturbance: Shipping lanes and ports can alter the natural habitats of marine mammals. The construction of ports, dredging, and other infrastructure development can lead to habitat destruction, fragmentation, and loss, which can displace marine mammal populations and disrupt their normal behaviors.

Chemical Pollution: Ships release pollutants, such as oil, ballast water, and hazardous chemicals, into the marine environment. These pollutants can contaminate the water and food sources of marine mammals, leading to negative health effects and, in extreme cases, mortality.

Invasive Species Introductions: Ballast water exchange, a common practice in shipping, can introduce non-native species into new areas. Invasive species can disrupt the balance of marine ecosystems, affecting the availability of food for marine mammals and leading to changes in their distribution and abundance.

Climate Change Impacts: Shipping is a significant contributor to greenhouse gas emissions, such as carbon dioxide (CO₂) and black carbon (soot). These emissions contribute to global climate change, which can have cascading effects on marine ecosystems, including altered ocean temperatures, sea level rise, and changes in prey availability for marine mammals.

Entanglement: Fishing gear and other debris from shipping can cause entanglement issues for marine mammals. They may become entangled in fishing nets, ropes, or other materials, leading to injury, impaired movement, and even death.

Disruption of Migration and Breeding: The presence of shipping traffic in certain areas can disrupt the migration routes and breeding patterns of marine mammals. This can lead to avoidance of critical habitats or interference with mating and calving activities.

To address these impacts and reduce the negative effects of shipping on marine mammals, various measures are being implemented, such as the establishment of marine protected areas, speed restrictions in sensitive areas, and the development of quieter ship designs. Additionally, international regulations and conventions, like the

International Maritime Organization (IMO) regulations, aim to mitigate the environmental impacts of shipping. However, continued efforts and awareness are needed to protect marine mammals and their habitats from the ever-growing shipping industry.

2.1 DEFINITION AND MEANING OF SHIPPING

Shipping includes a multitude of meanings such as: shipowner-ship-sailor-yard-sea-marine environment-maritime agent-port-shipper-feeder-charterer-ship exchange-shipping company-shipowner-insurer-ship surveyor-ship finance-Ministry of Merchant Shipping-Port Authority-Naval Defense Fund (N.A.T.) etc. (Mylonopoulos, 2004, page 23)

By saying "shipping", we mean all those activities connected with and supporting the maritime transport of people and goods. Shipping is an integral part of mankind's peaceful international trade. Ships of various types, carry people, dry and liquid cargo, packaged or in bulk, vehicles, animals, etc. This transport takes place from and to all latitudes and longitudes of the earth.

Shipping contributes significantly to the economic development and prosperity of a country both with the movement and exchange of material goods and with the inflow of foreign exchange and the creation of thousands of new jobs. This and tourism are two of the most profitable sectors of a country. Greece is among the few countries in the world that manages to combine, balance and unite these two wealth-producing and foreign exchange-generating sectors to strengthen its economy. These two sectors are the pillars of the Greek economy.

We must recognize that Greece has been a maritime nation since ancient times. The oldest form of employment of the ancient Greeks was proven to be shipping. It is admirable that it manages, after the passage of thousands of years, to remain faithful to this tradition, as it is one of the strongest and most important states in this area. As the English admiral Cunnigan typically said "a battleship is built in two years, a naval tradition takes two hundred". (Mylonopoulos, 2004, page 25)

Apart from the fact that shipping contributes significantly to the economy of a country, it also contributes to the cultural development of people, because the ship and its people are the main factor in spreading ideas and customs, as during a voyage the ship approaches ports of different states and its crew and passengers (passenger-tourist) come into contact with different peoples. (Mylonopoulos, 2004, page 25). As

far as the economy is concerned, it is a key driver for economic progress and development because:

- Serves maritime trade.
- Connects a country or states ports and islands to the mainland.
- Contributes to the increase of national income (fares received in foreign currency for the transportation of cargoes of third countries inflow as maritime foreign exchange).
- Offers jobs to the country's workforce and many times to the country's workforce and many times to the workforce of other countries-employment of foreigners.
- Creates other economic activities - direct and indirect of shipping - such as shipbuilding industry, production of marine equipment, brokerage, insurance, technical inspection companies, etc. (Mylonopoulos, Moira, 2005, page 36)

2.2 THE DEVELOPMENT OF SHIPPING

The development of shipping has undergone significant transformations throughout history, evolving from primitive watercraft to the complex and global industry it is today. A brief overview of its development is as per below:

- **Early Watercraft:** Humans initially used simple rafts and canoes for transportation across water bodies. These early vessels were limited in terms of cargo capacity and navigational capabilities. (Maritime Archaeology Trust, 2023)
- **Ancient Civilizations:** Ancient civilizations like the Egyptians, Greeks, and Romans developed more advanced ships for trade and warfare. They constructed larger vessels with multiple sails and improved navigation techniques. (Mylonopoulos, 2004)
- **Medieval and Renaissance Periods:** During the Middle Ages, ships like the Viking longships and medieval cog ships allowed for better long-distance navigation and trade. The development of the magnetic compass and improved cartography enhanced maritime exploration and trade routes. (Wikipedia, 2023)
- **Age of Exploration:** The 15th to 17th centuries saw a surge in maritime exploration. The development of caravels, galleons, and carracks enabled sailors to venture into uncharted waters, leading to the discovery of new lands and trade routes. (History Crunch, 2023)

- **Industrial Revolution:** The 18th and 19th centuries brought significant advancements in shipbuilding with the use of iron and steel, leading to more durable and larger vessels. The invention of the steam engine revolutionized shipping, allowing ships to travel independently of wind conditions. (Britannica, 2023)
- **Containerization:** One of the most transformative developments in shipping occurred in the mid-20th century with the introduction of containerization. This standardized method of packing goods into containers streamlined loading, unloading, and transportation, significantly reducing costs and increasing efficiency. (Britannica, 2023)
- **Globalization and Technology:** Shipping became an integral part of the global economy in the late 20th century. Innovations like satellite navigation, GPS, and advanced communication systems revolutionized maritime navigation and safety. Larger vessels, known as container ships and bulk carriers, were developed to accommodate the growing demand for international trade. (Sea news, 2018)
- **Automation and Digitalization:** In recent years, automation and digitalization have been making their mark on the shipping industry. Technologies like autonomous ships, remote monitoring, blockchain for supply chain transparency, and data analytics for route optimization are being explored. (DNV, 2023)

Overall, the development of shipping reflects both the progress of human technology and the changing demands of global trade. It's a dynamic industry that has constantly evolved to meet new challenges and opportunities.

2.3 DEFINITION AND MEANING OF MARINE MAMMALS

Before we start analyzing marine mammals, we need to define what marine life actually is. Marine life means any type or species of saltwater fish, shellfish, mollusks, crustaceans, coral, or other marine animals, including any part, product, egg, or offspring thereof; or seaweeds or other marine plants, including any part, product, seed, or root thereof (Marine life definition, Law Insider, 2023).

Several million years ago, various marine animals moved from the sea to dominate the land. Then some global climatic and geographical changes forced some of the land mammals to return to the sea. The laws of evolution pushed these animals into an adaptation to the marine environment. More than 100 different mammals depend on the ocean for all or most of their life needs (Sakellariadou, 2007, page 251-252).

Marine mammals evolved from reptiles about 200 million years ago. They are vertebrates, warm-blooded, carnivorous, have hair and breathe with lungs. Cetaceans are the largest group of marine mammals. Whales, dolphins and porpoises belong here. Cetaceans about 55 million years ago made the complete transition from land to sea life. Cetaceans are divided into two subgroups: the minke whales (infiltrating whales, fin whales & the blue whale) & the toothed cetaceans (dolphins & porpoises) (Theodorou, 2017, page 646). Cetaceans have been extensively hunted for their meat, blubber and oil by commercial operations.

Although the International Whaling Commission has agreed on putting a halt to commercial whaling, whale hunting is still going on, either under IWC quotas to assist the subsistence of Arctic native people or in the name of scientific research, although a large spectrum of non-lethal methods are now available to study marine mammals in the wild. Cetaceans also face severe environmental hazards from underwater noise pollution, entanglement in abandoned ropes and nets, collisions with ships, plastic and heavy metals build-up, to accelerating climate change (Wikipedia, 2023)

3.1 HOW SHIPPING AFFECTS MARINE LIFE

It is true that throughout the years and as the presence of shipping continues to grow, many important agreements have been put into effect with the aim of reducing the impact of shipping activities on the natural environment. The huge presence of shipping makes it difficult to eliminate some of these impacts. More specifically, the increase in shipping traffic is such, that in the last two decades it has increased by 300%. This increase has naturally affected marine flora and fauna to a huge extent. Below are some examples regarding the effects of shipping to marine ecosystem:

Ship strikes: Ship strikes are among the main causes of death for endangered whale populations, according to WWF. Last September, a photo of a 10-meter-long dead whale stuck on the bulbous bow of a tanker circulated around social media when the ship berthed at Mizushima port, in north Japan. According to local media reports, the ship struck the 5-tonnes male Bryde whale at the middle of its body and was dragging it during the rest of its journey through the Pacific without the crew realizing it.

In addition, a shocking photo taken by underwater photographer Francis Pérez and published by the US-based NGO Great Whale Conservancy depicts a sperm whale having its tail cut off by a ship's propeller. The number of whales killed by ships are about 1,000 every year, Michael Fishbach from the NGO the told Business Insider.

As, in most cases, the dead whale ends up to the bottom of the ocean, estimations and proper monitoring of the issue are hard. The International Whaling Commission says that evidence comes only from direct reports from the vessel involved, and examination of dead whales found floating at sea or washed up on the beach. Most reported collisions with ships and boats involve large whales, seals, or sea lions, according to US NOAA. Endangered North Atlantic right whales are especially vulnerable to vessel strikes because their natural habitat is the busy waters off the east coast of the US and Canada. (Safety for sea, 2022)

Underwater noise: Many marine mammals communicate by emitting sounds that pass through water. Such sounds can be received across great distances and can influence the behavior of these undersea creatures. In the past few decades, the oceans

have become increasingly noisy, as underwater sounds from propellers, sonars, and other human activities make it difficult for marine mammals to communicate. Continuous sound sources are mainly from shipping. Sound is referred to as ‘noise’ only when it has the potential to cause negative impacts on marine life. (OSPAR Commission, 2023)

Plastics pollution: Despite the MARPOL ban of discharging plastic litter at sea, the environmental impact of shipping on marine environment still includes discharge of garbage, i.e., from shipbuilding and ship recycling activities or from shipping accidents. Lost containers are also an alarming issue on their own, with Statista figures revealing 391 occurrences of shipping containers lost at sea in 2019 in Europe alone and Bloomberg data showing 1,000 containers lost at sea globally in the first three months of 2021 alone.

The most visible impacts of plastic debris are the ingestion, suffocation and entanglement of marine species that mistake plastic waste for prey; most then die of starvation as their stomachs become filled with plastic. They also suffer from lacerations, infections, reduced ability to swim, and internal injuries. Floating plastics also help transport invasive marine species, thereby threatening marine biodiversity and the food web, according to IUCN. Through the food web, plastics can also affect human health. Regulatory framework led by MARPOL, which bans ships from dumping plastic at sea, as well as the London Convention and the London Protocol are great steps, but plastic pollution is still growing dramatically. (Safety4Sea, 2022)

Oil spills: Oil is an ancient fossil fuel that we use to heat our homes, generate electricity, and power large sectors of our economy. But when oil accidentally spills into the ocean, it can cause big problems. Oil spills can harm sea creatures, ruin a day at the beach, and make seafood unsafe to eat. It takes sound science to clean up the oil, measure the impacts of pollution, and help the ocean recover. Wildlife recovery, cleaning, and rehabilitation is often an important part of oil spill response. However wildlife is difficult to find and catch, oil spills can happen over wide areas, and some animals (like whales) are too big to recover. Unfortunately, it’s unrealistic to rescue all wildlife impacted during oil spills. (NOAA, 2020)

Ballast water: Ballast water is pumped in to maintain safe operating conditions throughout a voyage. This practice reduces stress on the hull, provides transverse

stability, improves propulsion and manoeuvrability, and compensates for weight changes in various cargo load levels and due to fuel and water consumption (IMO, 2023). Even though ballast water provides the vessel with all the above it is also one of the biggest treats to the environment, especially to biodiversity.

Ballast water is water that is taken on board a ship or vessel to stabilize its balance, trim, and draft. The primary purpose of ballast water is to maintain the vessel's stability by adding weight to counterbalance the load of cargo or to adjust the ship's buoyancy when there is no cargo on board. This helps to ensure safe navigation, especially during rough seas and adverse weather conditions.

Ships typically take on ballast water when they are not fully loaded with cargo or when they need to adjust their weight distribution. For instance, a ship may take on ballast water after unloading cargo in one port and before loading new cargo in another port. Additionally, ballast water can be used to compensate for the change in weight distribution as fuel is consumed during the voyage.

While ballast water serves an essential purpose for ship stability, it can also introduce various environmental and ecological issues. When ballast water is taken on in one location and discharged in another, it can inadvertently transport non-native species, including aquatic organisms like plants, animals, and pathogens. These invasive species can pose serious threats to local ecosystems, native species, and even human health. The spread of invasive species through ballast water has been a major concern for environmentalists and maritime authorities worldwide. (Clear Seas, 2022)

To address this issue, various international regulations and conventions have been put in place to control ballast water management. The International Maritime Organization (IMO) adopted the Ballast Water Management Convention in 2004, which requires ships to manage their ballast water to minimize the transfer of harmful aquatic organisms and pathogens. The convention sets standards for ballast water treatment and discharge to reduce the risk of introducing invasive species into new environments. (IMO, 2023)

Shipowners and operators have been implementing ballast water treatment systems to comply with these regulations and minimize the environmental impact of ballast water discharge. The goal is to ensure that ballast water does not contribute to the spread of

invasive species and maintains the delicate balance of marine ecosystems worldwide. (Clear Seas, 2022)

3.2 HOW SHIPPING AFFECTS MARINE MAMMALS

Ship noise can have significant effects on marine mammals, impacting their behavior, communication, and overall well-being. Ship noise greatly affects marine mammals as per below:

- **Acoustic Masking:** Acoustic masking occurs when noise interferes with an animal's ability to perceive a sound. A related study was done in the Adriatic Sea in Italy, investigating the effects of ship noise on three classic vocal fish families with different hearing abilities. The results showed that the noise reduced the auditory sensitivity of these fish families since their hearing thresholds were almost completely masked. (UBC, 2018)
- **Stress and Health Effects:** Chronic stress is particularly worrisome because it can lead to disease, reduced reproduction, and reduced survival. Stress has long been known to affect the health of humans, and it affects the health of other animals, as well. Marine mammals experience stress from natural factors like disease, lack of food, and predation, but also from human-caused factors such as noise, pollution, and injury due to fisheries interactions. Prolonged exposure to high levels of ship noise can lead to chronic stress in marine mammals. Stress responses can negatively impact their immune system, reproductive success, and overall health, making them more susceptible to diseases and other environmental stressors. (NMMF, 2023)
- **Communication Interference:** Marine mammals rely heavily on sound for communication, navigation, and locating prey. They use various vocalizations to communicate with each other over long distances. However, the noise generated by ships can interfere with these vocalizations, making it difficult for marine mammals to hear each other and disrupting their ability to communicate effectively. (Umwelt bundesamt, 2023)
- **Behavioral Changes:** Studies have shown that ship noise can cause behavioral changes in marine mammals. Some species may alter their swimming patterns or avoid certain areas with high levels of noise pollution. These changes can have consequences on their migration routes, foraging grounds, and breeding sites, potentially disrupting their life cycles. (Umwelt bundesamt, 2023)
- **Strandings and Disorientation:** In some cases, marine mammals may become disoriented by loud ship noises, leading to strandings or collisions with vessels. Whales, for instance, may become disoriented by the noise and end up in shallow waters or too close to shore, putting them at risk of beaching. (Frontiers, 2019)

- Population Impacts: Persistent exposure to ship noise and its associated effects on marine mammals can have population-level consequences. Reduced reproductive success and increased mortality due to stress or behavior changes can lead to declines in certain species' populations over time. (Marine in sight, 2022)

Efforts to mitigate the impact of ship noise on marine mammals include implementing speed limits in sensitive areas, modifying ship designs to reduce noise emissions, and creating quieter shipping routes. Additionally, more research is being conducted to better understand the specific impacts of noise pollution on different marine mammal species and develop further strategies to protect them.

4.1 INTERVIEW

A very interesting and fruitful discussion with Mr. Alexandros Frantzis (Scientific Director) from the cetacean research institute “PELAGOS” will be presented below, about the marine mammals of Greece and specifically how they are affected by the ships/shipping. Pelagos Cetacean Research Institute is a scientific non-profit organisation aiming to the study and conservation of cetaceans. Cetaceans include whales, dolphins, porpoises and a few more related species. Using science as a tool, the Institute is constantly expanding the limits of knowledge about cetaceans in the Greek Seas and the Mediterranean. This knowledge is then spread to the society and used as a base start for conservation efforts focused on cetacean species populations.

The main objectives of Pelagos Institute are:

- To conduct scientific research on cetaceans in Greece and the Mediterranean Sea as a whole.
- To spread information and knowledge towards every concerned individual or public body.
- To promote the public awareness.
- To achieve the conservation of cetaceans and of the integrity of marine ecosystems. (Cetacean research institute “PELAGOS”, 2023)

Following our discussion with Mr. Frantzis regarding the Hellenic trench, we have a clearer image of how sound pollution affects marine mammals worldwide. As per Mr. Frantzis, collisions that occur between marine mammals and ships are a big threat to their lives. Sound pollution is closely related to these collisions.

By using Greek Seas that exhibit a remarkable biodiversity in their cetacean fauna, we can understand more about noise pollution in all seas of the world. The importance of this fauna for both the marine environment and the society makes its conservation an immediate priority. However, the threats to the cetacean populations and their environment are manifold (chemical pollution, noise pollution, ship collisions etc.) and keep increasing in number and intensity. As a consequence, some cetacean populations are drastically decreasing the last decades and start facing their extinction.

For example, when Pelagos Insitute first started to study sperm whales, the quantity of them was 200-250 in total and due to their clollisions with ships, the number of them is constantly decreasing. As specifically mentioned by Mr. Franztis, within the next decades sperm whales will disappear as species throughout the eastern Mediterranean.

It is worth noting that marine mammals have different feeding habits, live in different areas, dive to different depths, have different ways of communicating and are likely at risk from different threats. In regard to this, each species needs different treatment. In order to be able to evaluate the noise pollution and how mammals are being affected by it, Pelagos Insitute installed a hydrophone, as an expirement, at Ioanian Pelagos in 1994 when they first started their research. The reason why they decided to install the hydrophone there was because the traffic of ships at this specific area was intense due to the many islands of the area. When the hydrophone was installed, as per Mr. Franztis, there were no vessels visible in the horizon, hence it could assume that the noise pollution at this specific time and date, would not be so strong. To his surprise the noise was defeaning, and it could only be described and compared to the sound of trains passing by. If a human was obliged to listen to this noise 24 hours a day, with no intermission (as these mammals are forced to do due to traffic), then they would be bound to go deaf at some point. Just as loud and constant sounds disturb humans, mammals are also disturbed by the sounds of ships. It is well understood that shipping cannot cease to exist, although ways will have to be found so that the mammals of the sea are not disturbed by shipping. Ways need to be found for us humans not to intervene to the marine mammals' natural habitant and endagare their existence and their quality of life. On the contrary, us humans will need to adapt to their environment, and not the other way around.

Some effects of ship sounds on marine mammals are:

- Decrease of their reproduction
- Hearing problems
- Overall health problems
- Stress caused by all the above

Some solutions to reduce ship sounds & to protect marine mammals are:

- Decrease ship speed. The faster they go the louder the sound. In many areas the speed can and should be reduced. If regulations were to be implemented by International Laws, some areas could be characterized as protected areas.
- Use of technology for the protection of marine mammals. There are specific areas as per scientists that marine mammals gather, so by using this technology we could hypothetically determine how to effectively reduce the loud sounds produced.
- Change of routes. It has been observed that a small change in ships' route, a deviation of about 5 to 10 additional minutes per route, may be an important factor for the presence of marine mammals. Basis rough calculations this deviation will not cause financial harm to Shipping companies and Ship Owners, but could potentially save many marine mammals.
- Enactment of existing laws and implementation of new ones.

As per Mr. Frantzis, a role model country on this matter is Costa Rica (Central American) that has been actively involved in environmental protection for many years.

“As a nation between two shores, the Caribbean and the Pacific, Costa Rica is conscious of the immeasurable benefits that these bring to life on Earth. With this in mind, we are striving to become a plastic-free zone and to expand marine protected areas, along with models of local governance to manage fisheries and tourism in a sustainable manner,” said Luis Guillermo Solís, President of Costa Rica. (UNEP, 2023) In recognition of its decades-long commitment to ambitious policies to combat climate change and protect the planet's natural resources, Costa Rica was awarded the United Nations Environment Programme's Champions of the Earth award for policy leadership on 2019. “Costa Rica has been a pioneer in the protection of peace and nature. With effective policies that involve the state, citizens, scientists and the private sector, the country will achieve its goals and set an example to the region and the world,” said Leo Heileman, the UN Environment Programme's Regional Director in Latin America and the Caribbean. (UNEP, 2020)

Remarkable facts of Costa Rica:

- More than 98 per cent of energy is renewable, forest cover now stands at more than 53 per cent after painstaking work to reverse decades of deforestation and around a quarter of the country's land has been turned into protected parks and reserves. (UNEP, 2020)

- The National Decarbonization Plan, with bold mid- and long-term targets to reform transport, energy, waste, and land use, was launched in February of 2019. The aim is to achieve net zero emissions by 2050, meaning the country will produce no more emissions than it can offset through actions such as maintaining and expanding its forests. (UNEP, 2020)
- The National Plan's targets are ambitious: by 2050 all public buses and taxis will emit zero emissions, and an electric train will provide transport in the capital city, San José. (UNEP, 2020)
- Beyond transport, the Decarbonization Plan also states that by 2050 all of the country will have solutions for the collection, separation, reuse and disposal of waste, and forest cover will be increased to 60 per cent. (UNEP, 2020)
- Costa Rica protects coral reefs, beds of seagrass, a thermal dome, an oceanic trench more than 4,000 meters deep and an underwater mountain range more massive than the Talamanca, Guanacaste and Central Volcanic ranges combined. (Visit Costa Rica, 2023)

President Alvarado has a clear vision of the city of the future. “I imagine a city where mobility is based on clean energy; a city that bets on technology but prioritizes people’s well-being, freedom and right to privacy; a city where you breathe clean air; a city that manages waste sustainably and a city where you are in contact with nature to find peace of mind,” he said.

Costa Rica’s message is that sustainability and growth can—and must—go hand-in-hand. (UNEP, 2020)

The conservation of whales, dolphins and all cetaceans requires serious scientific background and validation, as well as active public support, since occasional emotional manipulation of the public's sympathy for these animals can offer little to their substantial protection. When the decision makers, either due to pressure, or because of self-motivation, will be willing to take measures to protect cetaceans, it won't be sufficient to claim that dolphins or sperm whales are near extinction. We need to have defined the urgent priorities for the different species and their populations, as well as to have concrete, realistic and precise proposals with measures on how to protect them. This proposals need to be substantiated with scientific arguments and data. That is why Pelagos Cetacean Research Institute primarily focuses on the research and the production of the necessary knowledge (otherwise unavailable) using scientific methods and tools, and in parallel contributes in the

information and awareness of the public through participation of ecovolunteers in scientific and training programs. In this systematic and serious way, it strives for the conservation of one of the most important constituents of the natural and cultural heritage of Greece and of all the Mediterranean region. (Cetacean research institute “PELAGOS”, 2023)

4.2 RECOMMENDATIONS

Reducing the noise that ships create in the ocean is essential to mitigate the negative impact on marine life, including marine mammals and fish, as excessive underwater noise can disrupt their communication, navigation, and feeding behaviors. Here are some recommendations to help decrease ship noise in the ocean:

- **Propeller Design and Maintenance:** Improve ship design to reduce hydrodynamic noise caused by propellers. Well-designed and well-maintained propellers produce less noise.
- **Slow Down:** Reducing ship speed can significantly lower noise levels. Slower speeds create less turbulence and noise, benefiting both marine life and fuel efficiency.
- **Advanced Materials:** Use advanced sound-absorbing materials in ship construction to dampen noise emissions.
- **Underwater Coatings:** Apply specialized coatings to the hulls of ships to reduce the noise generated by the interaction between the hull and water.
- **Route Planning and Management:** Implement shipping lanes and route planning that minimize exposure to sensitive marine habitats, especially during critical times like breeding and feeding seasons.
- **Traffic Separation Schemes:** Implement traffic separation schemes to regulate ship traffic and minimize congestion in ecologically sensitive areas.
- **Quiet Ship Technologies:** Promote the development and use of quieter propulsion technologies, such as electric or hybrid systems, which produce less noise compared to traditional diesel engines.
- **Bubble Curtains:** Install bubble curtain systems around noisy equipment, such as pile drivers used in construction, to reduce underwater noise propagation.
- **Regulations and Incentives:** Encourage compliance with noise reduction standards through international and national regulations. Provide incentives for ship operators to adopt quieter technologies.

- **Monitoring and Research:** Continuously monitor underwater noise levels and study its impact on marine ecosystems to inform future policies and technological advancements.
- **Educational Outreach:** Raise awareness among ship crews and the maritime industry about the importance of reducing noise pollution in the ocean and its impact on marine life. Also, raising awareness among the public about the impacts of underwater noise pollution can foster support for conservation efforts.
- **Collaboration:** Encourage collaboration between governments, environmental organizations, and the shipping industry to collectively work towards reducing ship noise.
- **Regulations and Guidelines:** Governments can establish regulations and guidelines to limit noise levels in certain areas, especially those of ecological importance.
- **Technology Improvements:** Industries can develop and implement quieter technologies to reduce noise emissions during offshore activities.
- **Marine Protected Areas:** Designating and effectively managing marine protected areas can provide safe havens for marine life where noise levels are minimized.
- **Time and Area Restrictions:** Implementing time and area restrictions on noisy activities in critical habitats can help protect marine species during sensitive periods.

By recognizing the significance of underwater noise pollution and taking proactive measures to mitigate its effects, we can work towards preserving the health and biodiversity of our oceans and by implementing these recommendations, we can significantly reduce the noise footprint of ships in the ocean and help protect marine ecosystems.

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