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Exploring underwater noise issues: a study of decentralized approach

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DISSERTATION

EXPLORING UNDERWATER NOISE ISSUES

A STUDY OF DECENTRALIZED APPROACH

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): ....

(Date): ....

Supervised by: **Dr. Tafsir Matin Johansson**

Supervisor's affiliation: **World Maritime University**

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Abstract

Title of Dissertation: A critical redux of the nexus between sources and impacts of underwater noise – Effects and side effects of mitigation measures-

Degree: **Master of Science**

The dissertation is a study of underwater noise science and governance, reviewing existing literature and IMO meeting documents to understand several mitigation measures and their weaknesses.

A brief look is taken at the recent focus on underwater noise mitigation solutions. Underwater noise-related issues are becoming one of the new global-level threads in the ocean ecosystem while international governance frameworks are relatively premature. The difficulties of controlling this new pollution which is not caused by substantial material are found in its complexity depending on geographical or biological characteristics and also the trade-off relationship between greenhouse gas (GHG) emission. Furthermore, engineering solutions which can change the situation have not yet been found.

The issue, becoming increasingly serious as it affects populations of species across an extensively wide range of oceans while also showing regionality is indeed a challenging problem from a governance perspective. However, by introducing monopolistic competition and actively acknowledging the differences in regional approaches, it is found that there is a possibility to improve the overall outcomes concerning this complex issue.

KEYWORDS: Underwater noise, Regionality, Natural ambient noise, GHG

Table of Contents

List of Figures

List of Abbreviations

ABS	American Bureau of Shipping
ANSI	American National Standards Institute
AQUO	Achieve Quieter Oceans
BIAS	Baltic Sea Information on the Acoustic Soundscape
BIMCO	Baltic and International Maritime Council
CBD	Convention on Biological Diversity
CG	Correspondence Group
CHIRP	Compressed High-Intensity Radiated Pulse
CLIA	Cruise Lines International Association
CMS	Convention on the Conservation of Migratory Species
CPP	Controllable Pitch propellers
CSC	Clean Shipping Coalition
DE	sub-committee on ship Design and Equipment
EC	European Commission
ECA	Emission Control Area
EEDI	Energy Efficiency Design Index
FOEI	Friends of the Earth International
FPP	Fixed Pitch Propeller
GHG	Green House Gas
HELCOM	Helsinki Commission
ICC	Inuit Circumpolar Council
ICOMIA	International Council of Marine Industry Associations
ICS	International Shipping Committee
IFAW	International Fund for Animal Welfare
IMarEST	The Institute of Marine Engineering, Science and Technology
IMO	International Maritime Organization
INTERTANKO	International Association of Independent Tanker Owners
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization

IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee
MFSD	Marine Strategy Framework Directive
NFMT	Noise Footprint and Mapping Tool
NOAA	National Oceanic and Atmospheric Administration
LDA	Latent Dirichlet Allocation
OSPAR	Oslo and Paris Conventions
PPR	Pollution Prevention and Response
PSSA	Particularly Sensitive Sea Areas
SONIC	Suppression Of underwater Noise Induced by Cavitation
SPL	Sound Pressure Level
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea, 1982
UNEP	UN Environment Programme
URN	Underwater Radiated Noise
WG	Working Group
WWF	World Wide Fund for Nature

Introduction

1.1. Defining Underwater Noise

Underwater noise is a generic name for phenomena that is causing many problems in oceans by acoustic energy radiation from anthropogenic activities. The problems relating to underwater biodiversity are receiving global attention in various areas, and subsequently, studied scientifically and legally in recent decades.

The impact of human activities on the natural environment has been increasing as the human population is expanding. The effects are well documented in tandem with issues concerning climate change, food security, resource depletion, and other various types of pollution (Intergovernmental Panel on Climate Change (IPCC), 2019). Patently, there are a number of significant issues that have been defined even only in the marine-area, such as sea-surface temperature, sea-level rise, ocean acidification, salinity, ocean circulation, storms and other extreme weather events, fish stock distribution, eutrophication problems, and many other (United Nations (UN), 2016). As such, underwater noise is one of those problems which is attracting attention recently because of the development of observation technologies (Wiggins & Hildebrand, 2007).

Underwater noise as a physical phenomenon can be understood as any kind of noise emanating from anthropogenic activities, such as shipping, although not confined to that example. Consequently, underwater noise is described by Carpenter et al. (2021) as "sound that travels through water and can be heard by marine animals. Underwater noise can be natural (such as waves, storms, earthquakes) or human-made (such as ships, sonar, oil exploration). Underwater noise can affect marine animals in various ways, such as masking communication, altering behavior, causing stress, or injuring hearing". It is noteworthy that, the Convention on Biological Diversity (CBD) describes other noise sources as ship shock trials, air-guns array, military sonar, pile driving, echo sounders, dredging, drilling, and wind turbine (UNEP-CBD, 2012) for examples.

Consequently, the most compelling case is the massive fatalities of cetaceans by mass stranding, a tragic story of the most charismatic marine animal, dolphins or whales, that evoked the consequences of military sonar activities (Scott, 2004). Following this event, researchers have revealed that anthropogenic noises are likewise exacerbating other marine lives and sonar is not only a noise source (National Oceanic and Atmospheric Administration (NOAA) Fisheries, 2022). For examples, there is a type of noise other than sonar origin which destroys squid hearing organs (André et al., 2011). Likewise, McCauley et al. (2017) reported that certain type of noise has a detrimental impact on planktons.

1.2. Sound vs. Noise

Marine animals have adapted their lives in accordance with the underwater natural environment, including sounds of other lives, wind, waves and every sound played in nature. In addition to this, underwater species have evolved through time, and have gained the capacity to acquire underwater sound-based communication and spatial perception, not only cetaceans but also other underwater lives depending on acoustic-based abilities. Further, sound is used for navigating, breeding, maintaining social structures, avoiding predators, and finding food purposes, thus sound is essential for them (NOAA Fisheries, 2022).

On the other hand, anthropogenic sounds, as it exceeds a certain decibel, are considered to negatively impact the natural ecosystem as noises (UN, 2016). The noise might affect the well-being of underwater lives by causing loss of hearing, stress responses, loss of favorable habitat or migration path, and disrupting feeding, breeding, and communications (NOAA Fisheries, 2022).

Moreover, the United Nations Convention on the Law of the Sea (UNCLOS) Article 1 Part 1, describes energy which results or is likely to result in harm to marine life as pollution (UNCLOS, 1982).

To briefly summarize, sound is the energy that vibrates and propagates through the environment which the various organisms in the aquatic system have adapted themselves to in the course of their evolution, and noise is what impairs traditional practice. This new definition of pollution is a bit more advanced than the conventional ones that focus on materials (e.g., oil pollution, waste, and exhaust gases). Thus, the new pollution has a character that is difficult to define in a simple scope, which looks like making it difficult to solve issues.

1.3. Contemporarily noise reduction measures

Disruption of communication, physical harm, behavioral changes, ecological impacts, to name a few, are negative effects on marine lives that appear to be caused by underwater noise. Similarly, according to International Maritime Organization (IMO), one of the central sources of this noise are generated from shipping activities, whose magnitude has been increased and the possibility of its reduction is engineeringly feasible (IMO, n.d.). In this regard, various preventive mechanisms are currently under consideration. However, it still remains difficult to evaluate the comprehensive cumulative effect of underwater noise radiating from these various activities.

Relevantly, human-induced marine activities widely vary in terms of their noise features. The effect, observably, is not only limited to physical trauma. Likewise, it is found that all anthropogenic noises affect marine lives whereby noise also induces behavioral changes in many marine animals (Duarte et al., 2021).

In response to this situation, international societies have been developing governance frameworks. This new pollution is defined in the Marine Strategy Framework Directive (MFSD) (European Union (EU), 2008) within the EU and several distinguished programs were carried out. CBD has been proactively working on the problems (UNEP-CBD, 1992) and the IMO also adopted a guideline in 2014 (IMO, 2014a).

There are also several regional-based efforts and measures that had been taken. Many of the findings from Study AQUO-SONIC (Achieve Quieter Oceans-Suppression Of underwater Noise Induced by Cavitation) (European Commission (EC), 2022a; EC, 2022b) under the MFSD are very informative and have been referred to several times in recent IMO discussions, which tend to focus on the technical aspects of Underwater Radiated Noise (URN) reduction in particular. In addition, there are some other notable activities, namely: Oslo and Paris Conventions (OSPAR); Helsinki Commission (HELCOM); and Baltic Sea Information on the Acoustic Soundscape (BIAS) (BIAS, n.d.; HELCOM, n.d.; OSPAR, n.d.). Another example can be found in the study of Vancouver port. Here, noise reduction measures have been presented to vessels actually navigating in specific water areas, and the extent of noise reduction obtained and the following behavioral changes of specific organisms have been evaluated (Port of Vancouver, n.d.). Some of these area-focused activities have had some success.

However, underwater noise level is expected to be doubled by 2030 mainly because of shipping growth (Kaplan & Solomon, 2016). Given this critical situation, international organizations, including IMO, are trying to explore pathways towards mitigation through the reduction of noise emissions from shipping by "quieting ships" (IMO, 2008a).

1.4. Difficulties Posed by Underwater Noise

As the human population increases and marine activities spread to many areas so does the by-product of energy entering the oceans, which, inter alia, is noise. The concerns for ecological damage have risen and international organizations have started addressing them accordingly. Underwater noise has been actively studied, among others, by naval architects and marine biologists for the last decades. However, the ultimate goal is the sustainable coexistence of underwater life wellbeing and human economic activity. In order to achieve this, it is necessary to comprehend correctly and comprehensively how and to what extent human activities (noise) affect the natural ecosystem with a view to controlling the main control stressors and corresponding levels.

As mentioned earlier, the underwater world is getting increasingly strident. Some researchers linked the current state of the oceans to a "noisy spring" patterning after "the silent spring" that is a metaphor describing the endangered underwater environment (Slabbekoorn et al., 2010). Underwater noise source and impact relationships of each species are gradually uncovered as a result of the diligent efforts made by biologists (Akamatsu et al., 2003), same as the cases with squid and plankton, which are aforementioned.

There are also biologists and naval engineers' collaborative works resulting in regulatory movements which mainly aim to reduce ship cavitation noise (EU, 2016). Nevertheless, to quote the International Fund for Animal Welfare (IFAW): "We do not yet know what the cumulative effects of all the sources of ocean noise pollution are having or are likely to have on marine animals." (IFAW, 2008).

In conclusion, marine biologists have revealed anthropogenic underwater noise impacts marine lives and in cooperation with naval engineers found the major source in shipping. However, IMO and other international organizations are proceeding to mitigate impacts by regulating shipping since the natural ecosystem is being clearly damaged. The expected next step to achieve the ultimate goal is evaluating how quieting ships will make the relationship with marine lives sustainable. A quieting ship is a way to pursue sustainable eco-friendly shipping which must be in tandem with taking account into the side of the fact that this pollution is, again, a by-product of rapidly increasing economic activities and the scope to define the pollution is yet simplified.

1.5. Aims and objectives

The aim of this research is to provide a comprehensive overview of the relationship between the major sources and impacts of underwater noise through the prism of analytical review, and simultaneously project underlying governance challenges for the future. To achieve the aforementioned aims, the research takes into account the following study objectives:

1. To understand the global sources and corresponding impacts of underwater noise;

2. To identify contemporary measures for reducing its impacts; and

3. To analyze future governance challenges for underwater noise that should be addressed for eco-friendly sustainable shipping and other ocean activities.

1.6. Research questions

To reach the aforementioned objectives, this study seeks to answer and address the following research questions:

Research Objectives	Research Questions
1. To understand the global sources and corresponding impacts of underwater noise	1. What are the major global sources and corresponding impacts of underwater noise?
2. To identify contemporary measures for reducing its impacts	2. What are the methods and processes through which adverse impacts could be reduced?
3. To analyze future governance challenges for underwater noise that should be addressed for eco-friendly sustainable shipping and other ocean activities	3. What are the future governance challenges for underwater noise that should be addressed for environmentally sustainable shipping?

1.7. Methodology research design and methods

This research primarily employed a qualitative research methodology, incorporating a literature review that includes IMO conference documents and mainly secondary data sources. Specifically, with regard to IMO conference documents, accessible documents from IMO are reviewed. Moreover, this research, by literature review, is limited to scientific journal and books, policy or legal documents on internet.

Subsequently, it cannot deny that the discussions lack of considering practical domain knowledges owned by expertise in coastal professionals (e.g., fisherman).

While the literature review is primarily used to analyze the content of discussions, the Latent Dirichlet Allocation[1] (LDA) is utilized to ascertain the implications of the reviews as objectively as possible. This involved conducting an analysis of 80 relevant documents from 2008 to July 2023 retrieved from IMO docs[2]. In this research, LDA analysis was carried out based on the Gensim library (Gensim [computer software], 2023), which runs in Python on Google Colab accessible from the WMU account.

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[1] LDA is a text mining technique widely used in various fields to extract topics within documents from textual data. In this text mining process, statistical methods are used to analyze the frequency of words and their associations in the text data, which allows it to generate sets of words (topics). Therefore, the topic model itself does not comprehend the concepts of words or sentences, but it is believed that the results analyzed by well-trained LDA produce sets of words (topics) of which humans can understand the meaning (Jelodar et al., 2019).

[2] Listed in Appendix 1

Chapter 2: Reviewing related science

2.1. What is underwater sound?

Following the previous chapter, which explains the general overview of the underwater noise situation, “What is the sound in water?” is discussed to deal with it more concretely. To begin with, the definition of “sound” can be found as physical waves that are caused by vibrating objects acting on the surrounding elastic body (Southall, 2005; NOAA Fisheries, 2022).

This is a quotidian phenomenon in the under-surface world, filled with seawater which is a relatively high-density fluid body, compared to the over-surface world filled with atmosphere. This makes underwater world character filled with a range of sounds emitted by organisms and environmental clutter to that emitted by anthropogenic activities. The sound, which propagates relatively quickly and far, is very useful in the world more than lights and is utilized by various creatures for various purposes such as detecting enemies and communicating with companies. Excluding the sounds which have positive features, defined as a signal, from sounds leaves noise that obstructs signals (Southall, 2005; NOAA Fisheries, 2022).

The underwater sound turns to be a problem when this vibration energy interferes with the signals and has various adverse impacts on life in the underwater world, and there are many combinations of sources and impacts. In this Chapter, the noise problems in the underwater world are reviewed along with the following sections:

- Types of sound;
- Underwater noise sources (anthropogenic and non-anthropogenic);
- Regionality of the noises;
- Lives and their signals intervene by the noises; and
- Mitigation measures.

2.1.1 Types of sound

As it is described in previous sections, anthropogenic underwater noise negatively affects the underwater world, and the combinations of causes and impacts are enormous. The consequences of the negative impacts are very diverse from displacements of habitat to abrupt critical traumas. Not only those material features of its impacts but also the concerns about perceptions of time span have been increased (UN, 2018). To discuss underwater noise problems the types of noise are focused on in this section.

The classification of underwater noise is reviewed in order to have a set of common definitions which is fundamental for later sections. Underwater noise seems to be understood in four categories, as the United Nations (UN) example cited below illustrates (UN, 2018). The first two are from a perspective of intensity, namely, impulse noise and continuous noise, and the second two are from a perspective of radiating time length, namely, short-duration and long-lasting.

2.1.1.1. Impulse noise

Impulsive noises have a short duration, high sound intensity, and significant fluctuation in amplitude over a brief period of time. They may occur only once or repeatedly. Low-frequency impulsive noises may "smear" and cease to be impulsive at a greater distance from the source due to numerous propagation phenomena. Impulsive sounds are more likely to harm the body physically, especially the hearing.

Percussive pile driving for onshore and offshore construction (wind farms), seismic surveys (airguns to check undersea oil and gas resources), explosions, some sonar sources, and ship propeller cavitation are examples. Although, when impulsive sounds disperse, they may lose hazardous characteristics and become non-impulsive at some distance from the source (Hastie et al., 2019).

2.1.1.2. Continuous noise

In general, continuous/non-impulsive/ambient noises have a lower intensity. Ship propellers, industrial processes (drilling and dredging), renewable energy operations.

2.1.1.3. Short-duration noise

Typical examples of noises that negatively affect aquatic organisms are those caused by sonar, pile driving, air guns, and shipping. Many studies have found that marine life can avoid noisy times or areas, but it has also been shown that once the noisy duration is over, those organisms which took avoiding behaviors tend to return to their original area (Castellote et al., 2012; Dähne et al., 2013; Russell et al., 2016).

2.1.1.4. Long-lasting noise

As it is indicated in the previous section, an effect of the noise character, relatively short duration, is becoming clearer. In addition to the finding, it should be understood that longer-lasting noise may have bigger effect (Leunissen et al., 2019). As Leunissen et al. (2019) found, the duration of pile driving is linked to the level of impact, however, the impacts more than temporally are yet clear. Some researchers are concluding that there are long-term or cumulative impacts in abundance and population that are not well understood because of lack of baseline of monitoring bias (Bailey et al., 2014; Hatch et al., 2012; Jensen et al., 2009). The difficulties imply that the long-term or cumulative effects cannot be explored easily, and Slabbekoorn et al. (2010) conclude that noise affects a wide range of marine organisms rather than a specific species.

2.1.2. Underwater noise sources

Sometimes, the underwater world is seen that it was a quiet place before anthropogenic activities but it is not really true. There are various types of sound. There are many different types of ocean noise sources, each with a unique intensity (measured in decibels), duration (from fractions of a second to infinity), and pitch or tone (measured in hertz). It is just like the tones of a piano correspond to various frequencies. The frequencies used by the majority of large whale species, as well as a sizable number of fish species, are extremely low on the bottom keys (NOAA, 2016).

Another type of underwater sound source, which is anthropogenic noise, can be divided in to different types. The UN categorized the noise into 7 sources with each description in the report of the Secretary-General which is about Oceans and the law of the sea (UN, 2018).

2.1.2.1. Underwater explosions

Underwater, explosives are employed for a variety of objectives, including structure removal, building, ship shock trial, military conflict, and to catch fish, repel marine animals, or mining coal. These are among the most powerful sources of anthropogenic sound. Explosion noises spread evenly in all directions and are observable on a regional scale, yet in certain circumstances, a single shot has been recorded over multiple ocean basins.

2.1.2.2. Seismic profiling

Air guns, boomers, and compressed high-intensity radiated pulse (CHIRP) sonar are possible sound sources. Seismic profiling is the primary technique used in oil and gas exploration to image the earth's crust using high-intensity sound. Air gun arrays are the primary sound-producing devices utilized in oil exploration, and their strength has usually increased over the previous decades as oil and gas research has gone into deeper waters. It could be possible that sound from air guns at the continental margins propagates into the deep ocean and contributes significantly to low-frequency noise. Upper-frequency sound is also produced by CHIRP sonars.

2.1.2.3. Sonars

Sonar systems generate sound energy on purpose in order to acquire information about matters in the water column, on the seafloor, or in the sediment. Most sonars work at a single frequency of sound but create unwanted frequencies that may have broader effects than the primary frequency, especially at low frequencies that travel further below. Military sonars have a wider frequency range and higher sound levels than civilian sonars, which typically use mid and high frequencies. Because training takes up more time than battle, this may be the principal scenario in which marine animals are exposed. Commercial sonars are primarily intended for depth sounding, fish detection, and sub-bottom profiling. These sonars typically produce sound at lower source levels than military sonars, but they may be more prevalent because of a large number of commercial vessels outfitted with sonar.

2.1.2.4. Vessels

It is generally believed that shipping is one of the main sources of underwater noise along with offshore oil and gas exploration industries. The propeller (both cavitating and non-cavitating propeller), machinery (e.g., main and auxiliary engines), and the movement of the hull through the water are the major sources of underwater noise from ships. In many marine areas around the world, large boats dominate low-frequency background noise. Those noises can have an impact on marine organisms, particularly mammals. Other than near ships, ship-radiated noise is predominantly low frequency (1,000 Hz), and aggregate noise can dominate low-frequency bands even well beyond shipping lanes (European Maritime Safety Agency (EMSA), 2021; Southall et al., 2017). Smaller vessels (e.g., recreation boats, jet skis, speed boats, and operational work boats) emit sound that is normally strongest in the mid-frequency band and at modest source levels, however, this varies depending on speed. Because of their higher acoustic frequency and proximity to shore, noise from smaller vessels does not travel far from the source[3].

2.1.2.4.1. Non-cavitation noise

At low ship speeds, machinery noise predominates and is generally low in frequency, but major gearboxes and gas turbines may produce tones in the 1-4 kHz range.

[3] Underwater sound waves are physically more likely to propagate at low frequencies than at high frequencies over greater distances in deep water than in shallow water (Erbe et al., 2022).

Flow noise around the hull is normally minor in comparison to propeller cavitation and equipment noise, but it becomes more important at low frequencies as vessel speed increases (Southall, 2005).

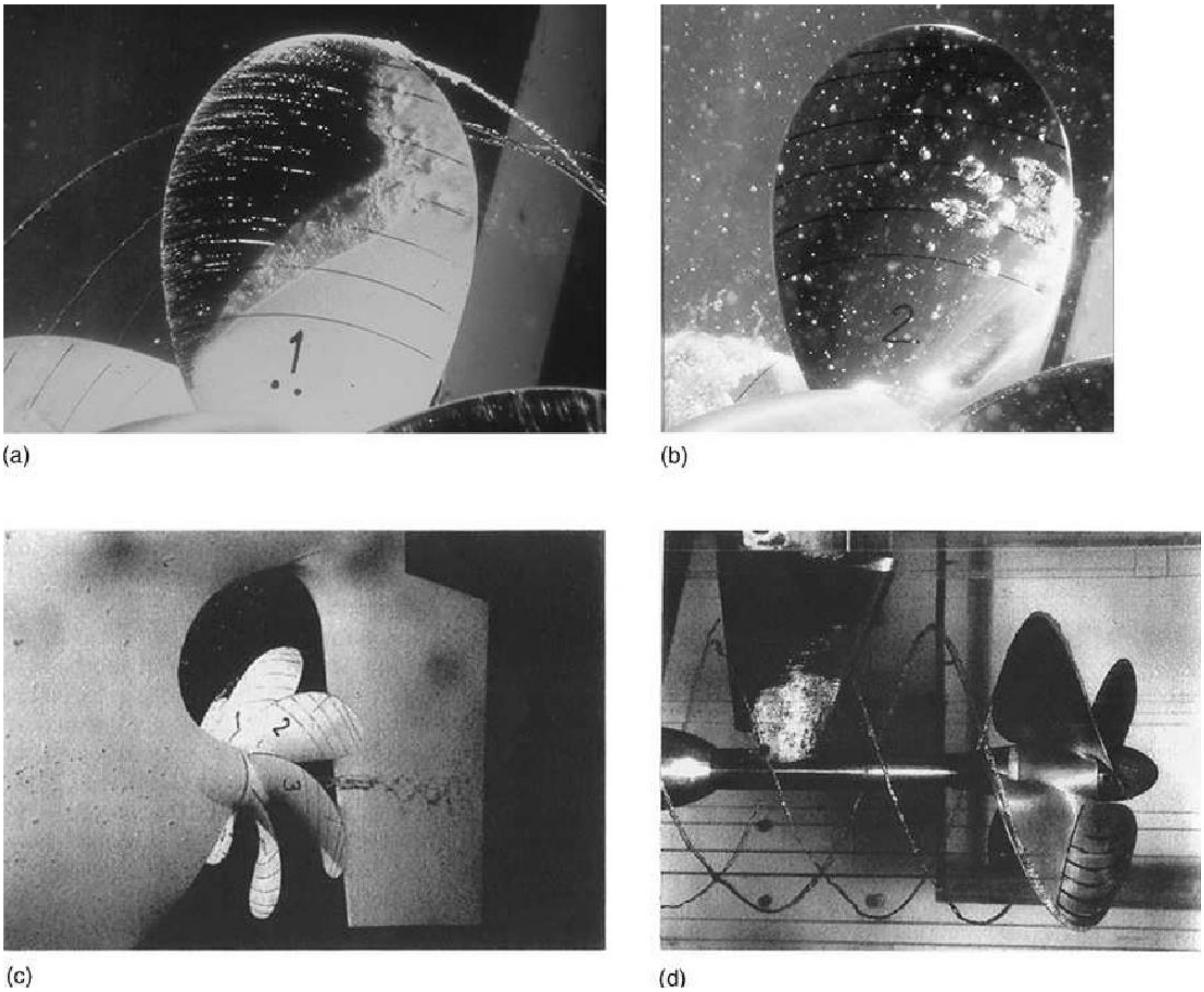
2.1.2.4.2. Cavitation noise

The majority of the acoustic field surrounding big vessels is caused by propeller cavitation and the maximum noise capacity could increase up to 1.9 by 2030, based on three segments of the global commercial shipping fleet is assumingly going to continuously expand in the number of ships, the quantity of goods carried, and the distances traveled (Southall, 2005; Kaplan & Solomon, 2016).

Cavitation is the formation and collapse of vapor bubbles within a liquid due to pressure changes. It is a common phenomenon in marine propulsion systems, where it can cause damage to propeller blades and decrease efficiency. The formation of cavitation bubbles is initiated by a reduction in pressure at the surface of the propeller blades, which causes the liquid to reach its vapor pressure, creating vapor bubbles. The collapse of the bubbles generates high-pressure shock waves that can cause damage to the propeller blade surfaces, leading to erosion, and noise. The cavitation patterns which occur on marine propellers are usually referred to as comprising one or more of the following types: sheet, bubble, cloud, tip vortex, or hub vortex cavitation, which is illustrated in Figure 1 (Carlton, 2018).

It is important to note that a propeller is a propulsion device that generates propulsive force by creating a pressure difference between its front and rear surfaces. In other words, an efficient propeller is one that can create a large pressure difference per unit area, potentially causing cavitation. In other words, propeller design is about how to avoid harmful cavitation (which causes abnormal vibration and erosion) while improving propulsive efficiency as much as possible. From now on, "causing noise" will be added to the definition of harmful.

Figure 1 *Types of cavitation on propellers*



Note. (a) sheet and cloud cavitation together with a tip vortex;(b) mid-chord bubble cavitation together with a tip vortex and some leading edge streak cavitation; (c) hub vortex cavitation with traces of LE and tip vortex in top of propeller disc and (d) tip vortex cavitation source. From *"Marine propellers and propulsion,"* by Carlton, J., 2018, 214

2.1.2.5. Industrial activities

Pile driving, drilling, dredging, coastal power plants, wind farm building, tunnel boring, cable laying, and canal operations are examples of industrial activity. These activities typically generate sound at low frequencies (below 1 kHz). During operations, dredging and near-shore mining create continuous wideband sound, typically in the lower frequencies. Noise levels have been observed to be moderate while drilling on natural or man-made islands, slightly lower when drilling from fixed drilling platforms, and greatest when drilling from drill ships. Because of the usage of drill ships and floating production facilities, deep-water drilling, and production have the potential to radiate more noise than shallow-water production. The sound levels of pile driving, which is utilized for harbor works, bridge construction, oil and gas platform installations, and offshore wind farm foundation construction, might vary based on the diameter of the pile and the manner of pile driving. Construction of offshore wind farms using impact pile driving generates low-frequency noise at comparatively high source levels, while operation radiates much lower source levels.

2.1.2.6. Acoustic deterrent and harassment devices.

The purpose of acoustic deterrent devices is to reduce by-catch or displace fish from potentially hazardous areas, such as guiding fish away from power plant water intakes. Depending on the species of fish being pursued, the frequency range of various devices varies considerably. To prevent seals and sea lions from getting close to aquaculture farms or fishing equipment, acoustic harassment devices emanate tone pulses or pulsing frequency sweeps at high source levels. Some fishing enterprises use explosives such as "seal bombs" to deter seals and sea lions from competing for fish or to frighten dolphins. Seal explosives are also utilized to discourage pinnipeds from endangered salmon species, inhabiting recreational boats, dock areas, and public swimming areas.

2.1.2.7. Other sources

Other sources of sound include the acoustic energy emitted by scientists, which may generate mid to high-frequency, high-level sound. In addition, acoustic telemetry is utilized for underwater wireless communications, remote vehicle command and control, diver communications, underwater monitoring and data recording, trawl net monitoring, and other research applications and industrial. Using 7–45 kHz frequencies at high source levels, over distances of up to 10 kilometers can be operated by long-range systems.

2.2. Regionality of the noise

Underwater noise can be a problem in oceans around the world, but its distribution is not always homogeneous. Coastal regions with higher levels of human activity, such as busy shipping lanes, are the locations most impacted by anthropogenic underwater noise. Some loud underwater noise sources, such as air guns, can be detected over distances of up to a few thousand kilometers. Thus, effects could happen a long way from the source. The Arctic, once a very calm region, is projected to see an increase in anthropogenic noise in the future due to the disappearance of Arctic Sea ice and the consequences of rising activities (UN, 2018).

In conjunction with the noise sources discussed in section 2.1.2, noises are basically intense in coastal areas where shipping, the major source, tends to be concentrated, but it is necessary to pay attention to the sites of high-intensive activities such as air guns and long-range propagation characteristics of low-frequency noise radiated from shipping.

A project entitled SONIC has been organized by the EU which focused on that point and resulted in significant progress contributing to identifying ship noise distribution. The Noise Footprint and Mapping Tool (NFMT) allows the creation of sound maps, which are geographical representations of the Sound Pressure Level (SPL) due to a set of ships in a specified physical scenario. This level is the result of a weighted average over depth and frequency intervals, averaged or integrated over a specified time period. An individual vessel's sound map "footprint" can be produced in a simplified and idealized environment (Prins et al., 2016).

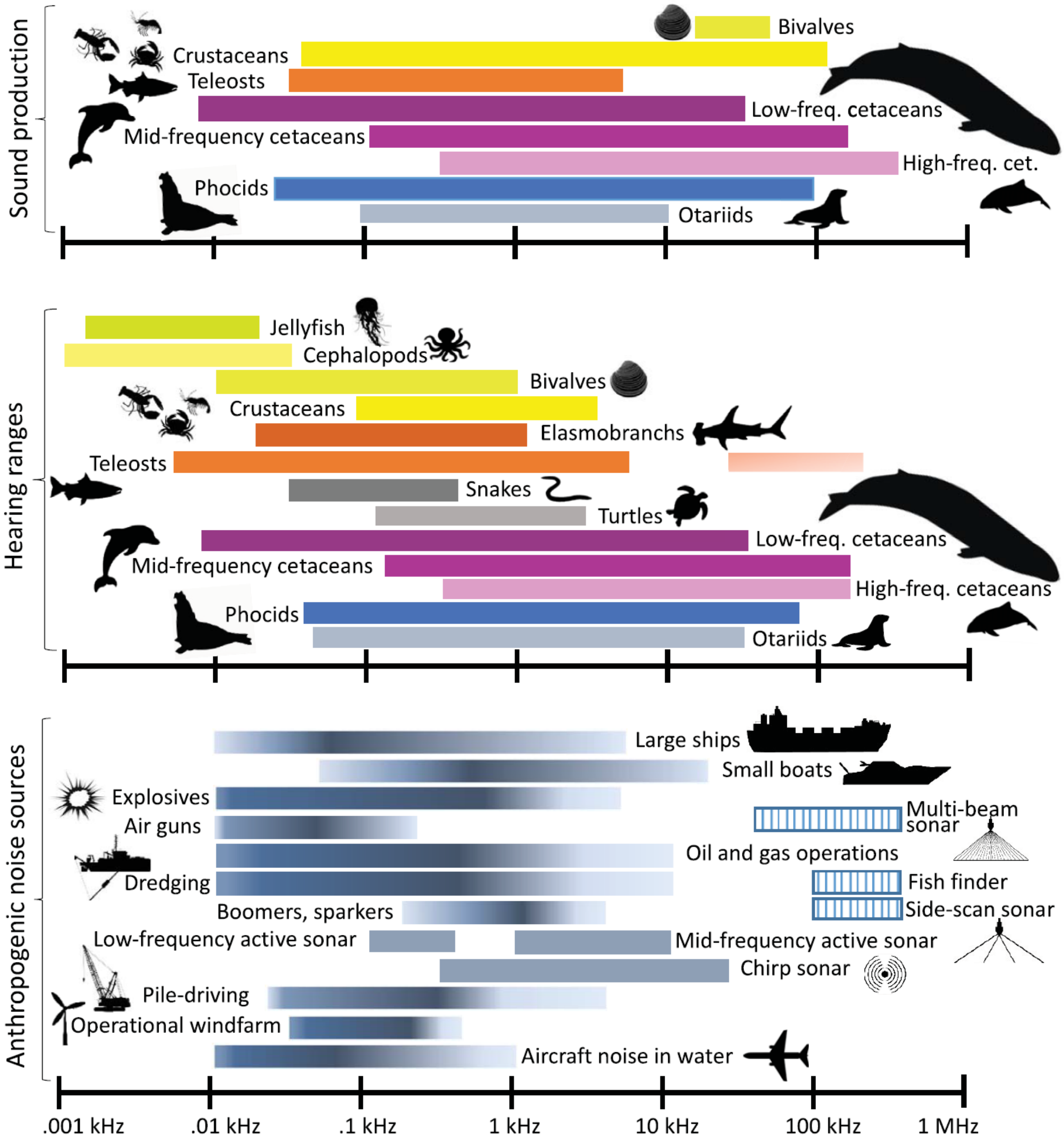
2.3. Lives and their signals intervene through noises

One of the most significant international events in which noise pollution of the marine environment from underwater or anthropogenic noise received increased attention was the stranding of whales on the Greek coast in 1996 (Luttenberger et al., 2022). Since then, the relationships between marine organisms, especially marine mammals, and noises have been studied. Some research has been carried out that are examples of a straightforward cause-and-effect relationship, such as the relationship between sea lion breeding activities and noise from aircraft overflight or animals stranding and intense, discrete noise. Other studies have looked into more subtle, though probably more pervasive, effects that may arise from an increase in overall ambient noise levels, such as the connections to obstructing range of sound communication among breeding marine mammals, predator/prey interference, or, in extreme cases, habitat avoidance (Southall, 2005).

In 2005, Southall (2005) described the situation as “The relative contribution of sounds from various vessel types to overall ambient noise and their possible impacts on marine life remain largely unknown.” Moreover, in the report about Oceans and the law of the sea, UN (2018) explained that “research on the impacts of anthropogenic underwater sound on marine species is still in its infancy”.

To be more specific, as shown by Duarte et al. (2021) in Figure 2, the research has become extensive that it is capable of showing the relationship between sound types and organisms to some extent comprehensively. On the other hand, research on the effects of individual species, especially fish, sharks, crustaceans, and cephalopods, on the ecology and morphology of individual species is also slowly but gradually progressing (André et al., 2011; De Vincenzi et al., 2021; Duarte et al., 2021; Murchy et al., 2019).

Figure 2 *Sources and animal receivers of sound in the ocean soundscape*



Note. This shows how much sound/noise and marine life interactions are complex and also difficulties to generalize the cause-and-effect relation. From *"The soundscape of the Anthropocene ocean,"* by Duarte et al., 2021, American Association for the Advancement of Science 371

2.4. Mitigation measures

As it has been found in this chapter, the impact of underwear noise cannot be ignored especially those vessels' source noise, namely cavitation and machinery, are especially impacting coastal regions. To address this problem, Prins et al. (2016), proposed a set of mitigation solutions as outlined below.

- Propeller cavitation
  - Air injection techniques
  - Silent propeller designs
  - Wake-equalizing devices
  - Propulsion-improvement devices
  - Comparison of Controllable Pitch Propellers (CPP) to Fixed Pitch Propellers (FPP)
  - Pitch/RPM control strategies for CPP
- Machinery noise
  - Lowering engine speeds
  - Design of resilient mounting systems
  - Design of acoustically optimized machinery foundation and hull structures.

Propeller cavitation noise can be stabilized through the use of wake-equalizing devices and vortex generators. In the cavitation tunnel, air injection techniques have a significant effect on the emitted noise level, even at modest flow rates. Utilizing a variable RPM control schedule as opposed to a constant RPM control schedule is a highly effective method for reducing the radiated noise from controllable pitch propellers operating at reduced power. Additionally, this can have significant benefits for reducing fuel consumption. As a result of the sensitivity of engine vibrations and radiated noise to a vessel's design, engine noise reduction measures vary by vessel. Specific measures have been studied in SONIC and it has been determined that engine speed reduces combustion noise and that a more rigid mount and a more rigid and widely spaced base have a positive influence on reducing radiated noise. These mitigation measures are constrained by the required propeller rotation rate, the swell regulations for the installations, and the foundation strength requirement.

2.5. Chapter summary

Since scientists attempted to measure the velocity of underwater sound at a Swiss lake in the beginning of 19th century, this area of study has been explored for sonars especially in years around World War II and its post period (Urick, 1983). And now, the science is expanding its interest to another topic in order to protect marine life. A brief review of the basic knowledge in regard to marine life, science has of underwater noise that has been reviewed in this chapter is summarized here.

First of all, it is undeniable that various human economic activities have introduced a variety of sounds into the sea, which, as noise, have an unprecedented, and most likely undesirable, impact on a wide range of marine life. However, research on the specific negative effects of noise on aquatic organisms, focusing on each specie, which are taking habitat and noise distribution into consideration, has only just begun.

The current focus on the characteristics and frequency components of shipping-induced noise, especially cavitation noise from commercial vessels in general, is relatively new[4]. Furthermore, it becomes apparent the noise originates especially in commercial vessels. More specifically, cavitation is the main cause of underwater noise while focusing on noise sources. For example, Gillespie (2016) emphasized that "Commercial shipping is responsible for more than 75% of the world's ocean noise". However, it does not actually mean that shipping is responsible for 75% of the types or extent of adverse impacts caused by various types of noise. It simply quantifies a 75% increase in measured levels (dB) of underwater noise (in comparison to a certain point in the past) and attributes this increase to shipping (Ritts, 2017). That is to say, even though, shipping is indeed a major source of underwater noise considering that the magnitude and effects of its impact are depending on various factors explained in

[4] A recent report by EMSA (2021) highlights the following studies that focus on this point: AQUO project, 2012-2015; SONIC project, 2012-2015; LIFE-PIAQUO project, 2019-2022; Vard Marine Inc., 2019. The same is true for those studies on the noise regarding dredging, and impact of offshore wind turbine installation and running on nearby organisms.

this Chapter (e.g., characters of sound, distribution of sound and marine life), this fact alone does not necessarily imply that shipping should be the highest priority.

When focusing on the underwater noise generated by shipping and its impact on ecosystems, it becomes apparent that recent studies are pointing out various adverse effects on a range of species (Williams et al., 2015). However, this expression "various adverse effects on a range of species", similar descriptions are found often, sounds somewhat ambiguous. While it is undeniable that noise is causing various forms of harm to a broad spectrum of species, but getting into the specific details can be a bit challenging, as mentioned earlier. To elaborate further, it is oftenly lack crucial information that is about which species are specifically affected by noise-induced communication masking in what hearing range, how marine life activities are affected, and how these effects can accumulate over time (e.g., population reduction) (Erbe et al., 2014; Williams et al., 2015). That kind specific information is crucial for mitigation solutions or their assessment. Nevertheless, there is a growing knowledge of what activities are the sources of noise, and research are proceeding on what possible countermeasures can be taken on them.

From the perspective of marine environmental governance, it is far from easy to handle such pollution which is even difficult to define the contents. It does not only pertain to simple material discharge, and even the cause-and-effect relation is not clear. Generalizing various adverse effects and addressing them on an international level is definitely a challenging task (Luttenberger et al., 2022). In the following chapter, the IMO discussions regarding underwater noise are examined.

Chapter 3: Reviewing IMO governance activities

In this Chapter, international underwater noise mitigation initiatives, particularly the regulatory discussions taking place at the IMO, are reviewed to identify the issues pertaining to the current management of underwater noise.

3.1. Discussions at International Society/IMO so far

The development of the IMO guidelines on underwater noise and related key events are reviewed in chronological order in this section.

MSFD 2008/56/EC:

EU established a new Marine Strategy Framework Directive requiring European Member States to develop marine strategies to achieve or maintain "good environmental status" of EU marine waters by 2020. The Directive explicitly defines good environmental status including underwater noise matter as policy, ahead of other regions (European Union, 2008).

Marine Environment Protection Committee (MEPC) 58 Oct 2008 (MEPC 58/INF.19.)**:**

USA took the initiative to start the discussion about "quiet shipping" for the purpose of marine life protection, mariner stress and fatigue, and shipboard energy efficiency. The target completion date has been set at the third or fourth session from MEPC 59. The establishment of the Correspondence Group (CG). Australia supported the U.S. initiative and raise the key idea, which is regionalities of underwater noise (IMO, 2008a).

MEPC 59 July 2009:

The first CG report (MEPC 59/19) submission. The committee recall the terms of reference of the CG that is working on the underwater noise emitted from commercial shipping in order to reduce the potential adverse impact on marine life. The CG was participated by the following countries and International Non-Governmental Organizations:

Argentina, Italy, Singapore, Australia, Japan, Sweden, Bahamas, Liberia, The Netherlands, Canada, Marshall Islands, United Kingdom, China, Panama, United States, Germany, Republic of Korea, Cruise Lines International Association (CLIA), IFAW, IWC, UN Environment Programme / Convention on the Conservation of Migratory Species (UNEP/CMS), The Institute of Marine Engineering, Science and Technology (IMarEST), World Wide Fund for Nature (WWF), FOEI, International Association of Independent Tanker Owners (INTERTANKO), International Council of Marine Industry Associations (ICOMIA), International Organization for Standardization (ISO), International Shipping Committee (ICS), and International Union for Conservation of Nature (IUCN).

The report categorizes the various noise sources from ships into three broad categories: propellers, machinery, and appendages and lists potential solutions: various cavitation measurements, potential of twin screw, and advantages of diesel-electrics propulsion system. That provides basics of underwater noise situations and leads to the direction to consider related technologies in detail rather than noise impacts from a biological perspective. It also emphasized the importance of cost-effectiveness. In other words, the direction has been recognized that the complexity and need for further study in connections between marine life and noise but it is practical to focus on technological and operational scope due to the time and science limitations (IMO, 2009a).

MEPC 60 April 2010:

The second CG report (MEPC 60/18) submission. The Committee agrees on its direction that the CG focuses on the development of non-mandatory technical guidelines for ship-quieting technologies and potential navigation and operational practices. The connection between GHG emission started to get attention that is one of the major elements for discussions until now.[5]It has been recognized that standard

[5] A simple resource on this issue to understand is ABS's material regarding its notation scheme for Underwater noise. The document describes what the propellor designs are and how it has been

definitions and methods are needed to monitor, measure, and evaluate URN, and their development of standards by ISO and American National Standards Institute (ANSI) were introduced (IMO, 2009b)

MEPC 61 Oct 2010:

The third CG report (MEPC 61/19) submission. Reached the consensus of the recognition that radiated underwater noise from shipping is mainly from propeller cavitation and agreed to concentrate efforts on the major element. It also highlighted that propeller loading condition is important regarding cavitation source noise. The potential of research that focuses on shipping routes may help identify both the loudest ship types and the noisiest individual ships. Around this time, it begins to be referred to that the major noise from merchant ships is cavitation, which depends on speed/propeller load of a ship, and further, not all ships are equally noisy, and also some very noisy ships may be responsible for a major portion of the noise (IMO, 2010).

MEPC 63 March 2012:

With the U.S. initiative, discussions regarding URN issues started in the Design and Equipment (DE) Subcommittee in order to develop non-mandatory guidelines regarding technical elements (propulsion, hull, onboard machinery, and operational modifications) that is applicable for both new and existing ship (IMO, 2011a; IMO, 2011b).

MEPC 66 Mar 2014:

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focusing and developing energy efficiency. Subsequently, it shows that technologies expected to reduce underwater noise/ cavitation are the same technologies that have been developed for energy efficiency purposes and meaning of modifying propeller design which is already optimized for energy efficiency purposes. Surprisingly, in the conclusion it is mentioned that the underwater radiated noise mitigation should not bring adverse impact on energy efficiency (ABS, 2021).

The recent Japanese proposal document attempts to provide a more technical perspective. Specifically, it focuses on blade area, which is one of the most important factors in controlling cavitation in propeller design, and explains how a propeller design which reduces URN will adversely affect energy efficiency (Japan, Nov 9, 2021).

The adoption of the guidelines (MEPC.1/Circ.833). The guidelines were developed as originally intended, to protect marine life; however, it is noted that further research is needed to investigate noise impacts on marine life because the understandings are yet sufficient (IMO, 2014a; IMO, 2014b).

MEPC 76 Jul 2021:

Agreed to include in the agenda to review of the 2014 guideline and identify next steps in the SDC (heir of DE) Sub-Committee for 2022-2023 (IMO, 2021a).

SDC 8 Feb 2022:

Agreed to place the CG in order to amend the guideline. Once again, the CG and Working Group (WG) are established. Furthermore, the difficulty in setting numerical thresholds for URN due to the lack of understanding of the impacts on marine life, the importance of recognizing differences in ambient sounds that differed from region to region and marine organisms have different hearing characteristics are noted. In addition to those the sound characteristic differences in types of ships are suggested as a possible threshold solution. That is to say, the remained issues that have been seen as "premature" are taken up as agendas to revise the 2014 guideline (IMO, 2022a; IMO, 2021b).

SDC 9 Mar 2023:

The draft of revised guideline is established. The Particularly Sensitive Sea Areas (PSSA) is noted as an idea to address the URN regionality. It is noted that there is a need for collaboration between SDC and Pollution Prevention and Response (PPR) subcommittee to achieve the most appropriate technical and operational measures where energy efficiency improvements and URN reduction co-benefit (IMO, 2023a; IMO, 2022b).

MEPC 80 Jul 2023:

Finally, the new revised guideline (MEPC.1/Circ.906) is adopted. However, even the revised new guideline could not achieve substantial threshold (e.g., noise level, locating sensitive area or mandatory equipment) is not defined yet (IMO, 2023b). A brief summary of the above timeline with respect to those two guidelines would be as follows.

Discussions on URN at the IMO were led by the United States and aimed at developing a non-mandatory guideline to minimize the introduction of incidental noise from commercial shipping operations to protect marine life by the time of major replacement of vessels in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL) regulations. From the beginning, discussions on reducing URN from commercial shipping operations overall were prioritized rather than addressing the issue from a biological perspective, eventually leading to the adoption of the first guideline (MEPC.1/Circ.833). However, with the development of subsequent research, it was recognized, once again, that the relationship between marine life and URN is very complex, and at the same time, the need for further discussion on how to reduce adverse impacts was pointed out while several characters of underwater noise regionalities, operational measures and trade of relationship between GHG emission are mentioned. Subsequently, in order to reflect the findings of relatively new studies, international cooperation, balance with GHG emissions, and consider the regionality of URN the revised guideline (MEPC.1/Circ.906) was adopted.

3.2. The topics of the discussion

This section explores by reviewing documents that can be found in the IMO docs what the current issues and topics are, based on the general development of the discussions to date at the IMO in the previous section.

First and foremost, it is imperative to address the factor of natural ambient noise when considering the introduction of a substantial threshold even in the new revised guideline. This is due to the variability of the natural ambient noise depending on time and region, which poses a challenge in implementing a generalized numerical threshold (e.g., allowable vessel radiating noise (dB)) across broad water areas. The scientific understanding of this exceedingly complex situation is still often deemed insufficient.

While focusing on the topic, it becomes apparent that is brought by Australia in the IMO discussion already at very beginning. The State presented information referring to regional differences in underwater noise character caused by anthropogenic and natural factors and also referred substantial regional differences in ambient noise that are caused by different climates (wind waves), biological noise (generated by marine life), and shipping lanes (IMO, 2008b). The intricate nature of the link between ocean noise and temporal and spatial factors is described. Characteristics of ambient noise are very different in region to region and also shipping source noises vary depending on regions (IMO, 2008a).

The second noticeable topic can be found as the trade-off relationship between URN and GHG emission. The relationship between energy efficiency and URN reduction is clearly mentioned in the drafted guideline and also collaboration between SDC and PPR is ongoing. The fundamental challenge of this issue is that it is a question of the best balance between GHG emission and URN that is asking our perception of managing different pollution in different areas (IMO, 2022c; IMO, 2022e; IMO, 2008a).

Major classification societies established their notation processes and recognized in the IMO discussion. American Bureau of Shipping (ABS) has prepared a notation scheme for quieter ships (ABS, 2021), and especially the recent collaboration research by MAERSK and Scripps Institution provided valuable insight into the way of URN reduction. Det Norske Veritas (DNV) also prepared a scheme for quiet ship notation (DNV, 2023; Andreassen, 2019). Although these notations are a unique step in terms of recognizing the potential of individual ship-based noise limitation, nothing is mentioned about innovative propeller design or wake design. As mentioned earlier[6],

[6] **MEPC 60 April 2010 in section 3.1 and footnote 4**

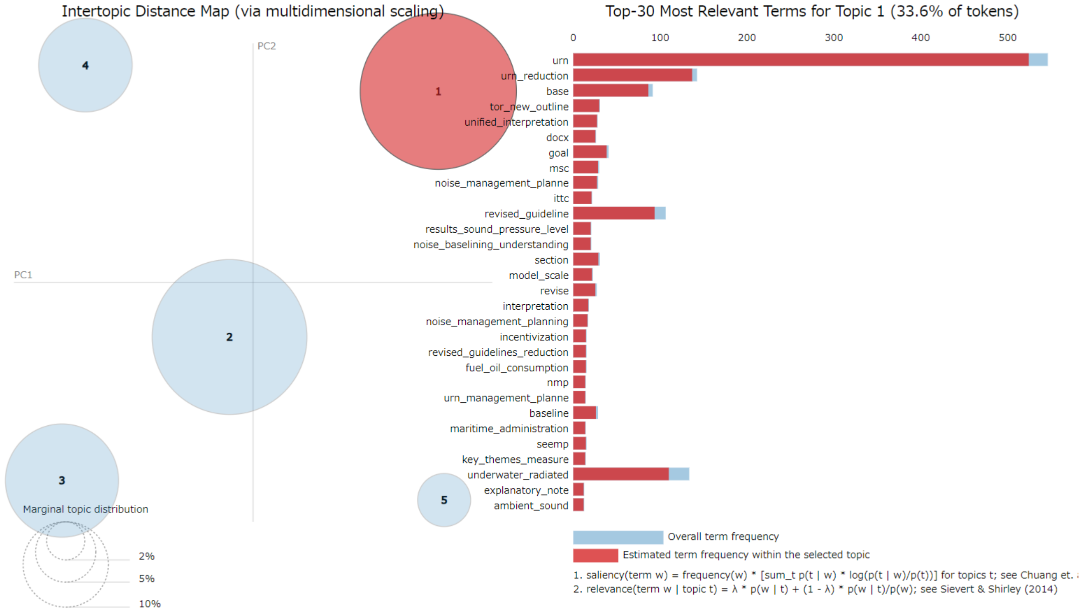
noise reduction in this context seems to be seen as a side benefit of propeller design and wake design aimed at improving fuel efficiency.

Another topic shall be mentioned is several regional-based efforts. The studies mentioned in section 1.3, AQUO-SONIC, Vancouver port case, OSPAR, HELCOM, and BIAS are significantly contributing to the IMO discussions and there are some achievements in regional bases.

Here, for reference, the LDA is applied to check the topics/terms within the IMO discussion regarding URN. Figures 3-7 below show the results of extracting five topics from the relevant documents downloaded from the IMO docs analyzed using the LDA model. The left-hand side of each figure shows the relative relationship between the five topics, while the right-hand side shows the relevant terms within the topics and the share of each within each topic.

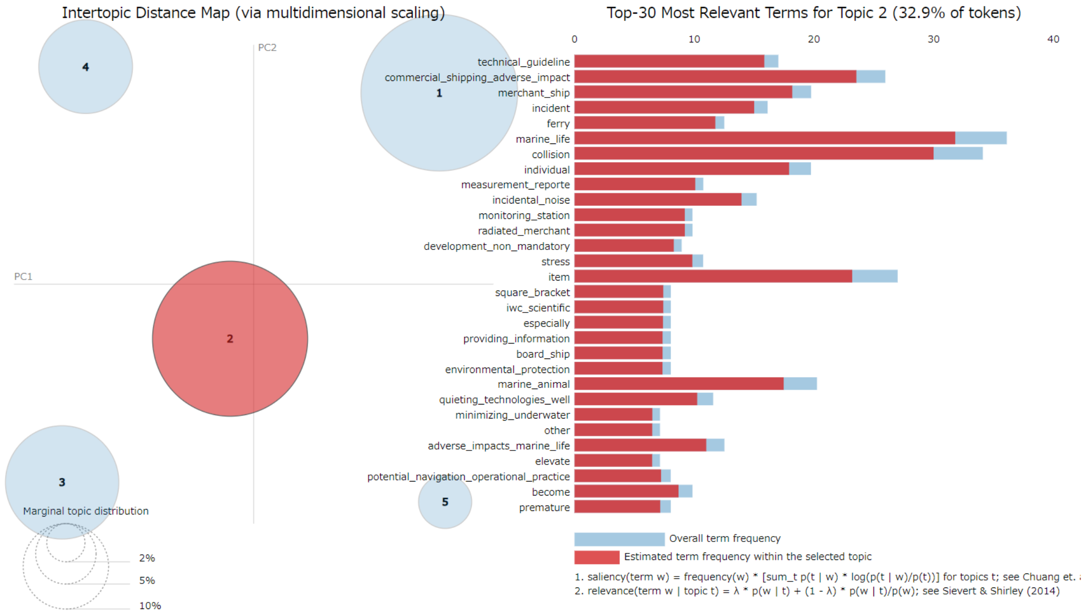
In analyses using LDA, one cannot directly answer whether “topic A” is included within the text or what each topic specifically represents. However, terms like 'noise_baselining_understanding' in Topic 1 (Figure 3) and 'monitoring_station' in topic 2 (Figure 4) are clearly related to natural ambient noise. As for the trade-off relation with GHG, terms related to 'fuel_oil_consumption' in Topic 1 (Figure 3) and terms related to propeller, tank-test, and ship speed in topic 4 (Figure 6) are relevant. Topic 3 (Figure 5) looks relevant to processes of IMO. Topic 5 (Figure 7) appears to discuss dredging and piled driving also. Additionally, terms related to incentivization for URN reduction, noise management planning, collision against cetaceans, navigation operational mesure, and onboard noise sources can be observed.

Figure 3 *Topic 1*



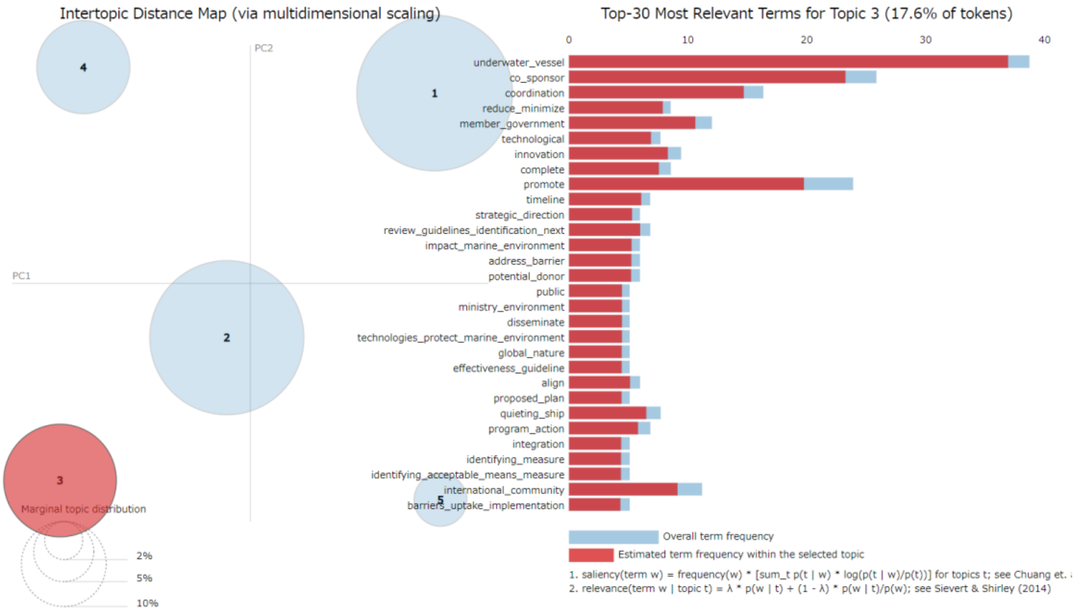
Note. This shows the result of LDA analysation.

Figure 4 *Topic 2*



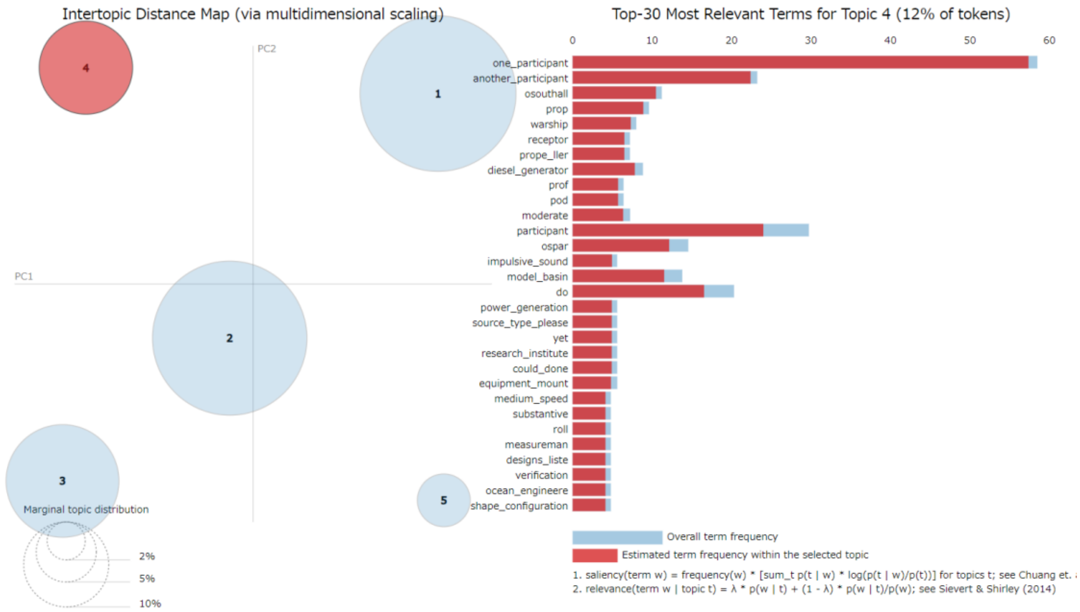
Note. This shows the result of LDA analysation.

Figure 5 *Topic 3*



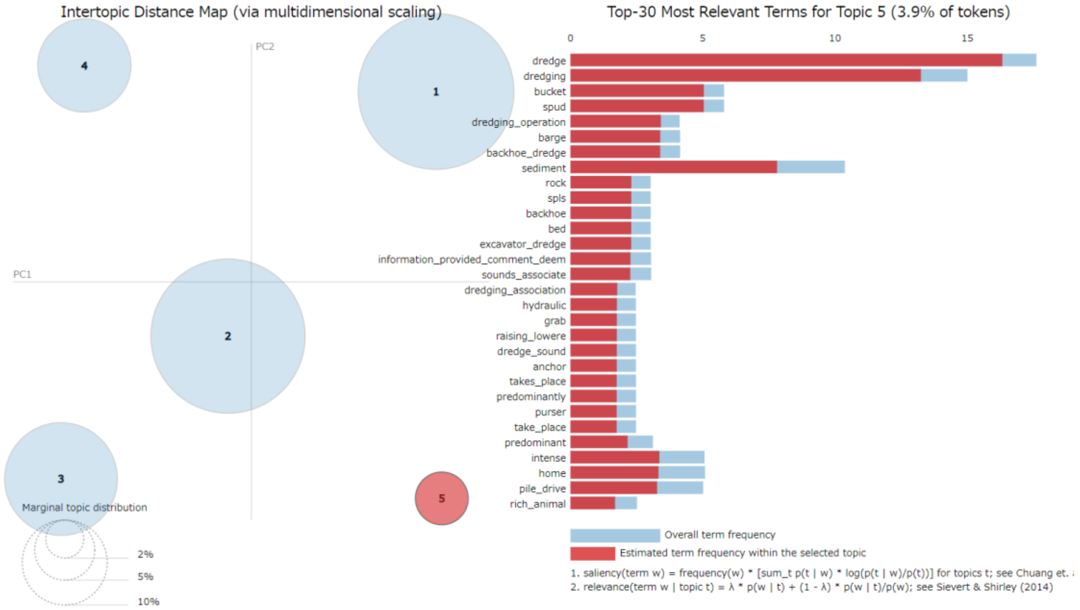
Note. This shows the result of LDA analysation for topic3.

Figure 6 *Topic 4*



Note. This shows the result of LDA analysation for topic4.

Figure 7 *Topic 5*



Note. This shows the result of LDA analysation for topic5.

As is seen, many issues are related to regionality. Natural ambient noise, PSSA, and biological characteristics are problematic exactly because of their nature of regionality. However, it is also true that those regionalities were not taking major part of the discussions in IMO as a result of trying to find a solution to reduce the adverse effects on marine life by pursuing a standard that can be applied universally to all commercial vessels around the world (e.g., conventions or guidelines).

However, interestingly, some States have suggested the potential for a standard for each type of ship (e.g., noise management plan which can be found in Figure 3). The magnitude of the noise may be different for different types of vessels and affects differently depending on species. If the purpose of the discussion is about the adverse impact of URN, it seems only natural that the discussion should refer the local area and its inhabitants so the regulation does.

Chapter 4 The Regionalities

The recent focus on regionality at IMO discussions on URNs is easily confirmed by comparing the 2014 Guidelines with the proposed revisions to the Guidelines in SDC 9/5 Annex. The former guidelines do not include the word "region" and only mention that sensitive marine areas should be avoided in the section on rerouting and operational decisions. In contrast, the new draft frequently refers to "Region," as well as new items in Chapter 7, “URN Goals setting”, part of which is an attempt to reflect various local characteristics; Chapter 8, “URN prediction”, especially section "Soundscape modeling" is a new section that is strongly linked to regionality, which was not included in the old guidelines. In response to this, especially in SDC 8 and 9, each state mentioned the necessity and difficulties pertaining to regionality in the context of PSSA, sensitive marine area, sensitive spices, regional characteristics, regional authority, etc. in discussions related to the Threshold or the monitoring required for it (IMO, 2022e; IMO, 2014; IMO, 2022d).

In the following sections, the regionality and GHG-related trade-off which became apparent as the obstacles to regulatory framework are analysed in 3 categories and a section in conjunction with the relevant knowledge found in Chapter 2.

4.1. Regionality in terms of biological aspects

The series of discussions at IMO on underwater noise was initiated out of concern for the adverse impact on marine life. However, due to the nature of the IMO, discussions from biological perspectives are very limited. We still do not have the capacity to discuss which frequencies should be lowered and by how much in order to reduce the adverse effects of ship noise on which organisms and where they live.

As mentioned at the beginning of Section 3.1 and in Section 3.2, discussions on underwater noise at the IMO began at MEPC 58 in 2008 with the aim of reducing the negative impact on marine life and the burden on seafarers. As declared in the first CG report on this subject “Noise from Commercial Shipping and its Adverse Impacts on

Marine Life" submitted to MEPC 59, from the beginning, the discussion has focused on how to make commercial shipping less noisy through ship-quieting technology and operational practices which can be adopted by the shipbuilding and shipping industries as soon as possible, as proposed by the United States (IMO, 2009a; IMO, 2008a). This pragmatic policy of minimizing environmental impact through measures that can be taken with currently available means is very positive. However, since MEPC66 in 2014, which stated "more research was needed, in particular on the measurement and reporting of underwater sound radiating from ships", the most recent SDC9 in 2023, specific numerical regulations have not been introduced (IMO, 2022e; IMO, 2014b). One of the main reasons why the regulations have not been introduced is that the scientific understanding of underwater noise impacts regionalities on marine life, which has been averted, is not deep enough to propose solutions.

From a biological viewpoint, regionality can manifest in three distinct forms. These encompass: 1) variations in the susceptibility of diverse species to sound; 2) discrepancies in shipping-related noise emission attributed to uneven sea lane distribution; and 3) disparities in naturally existing ambient noise inherent to specific regions. What ensues is an exploration of the scientific insights concerning these divergences.

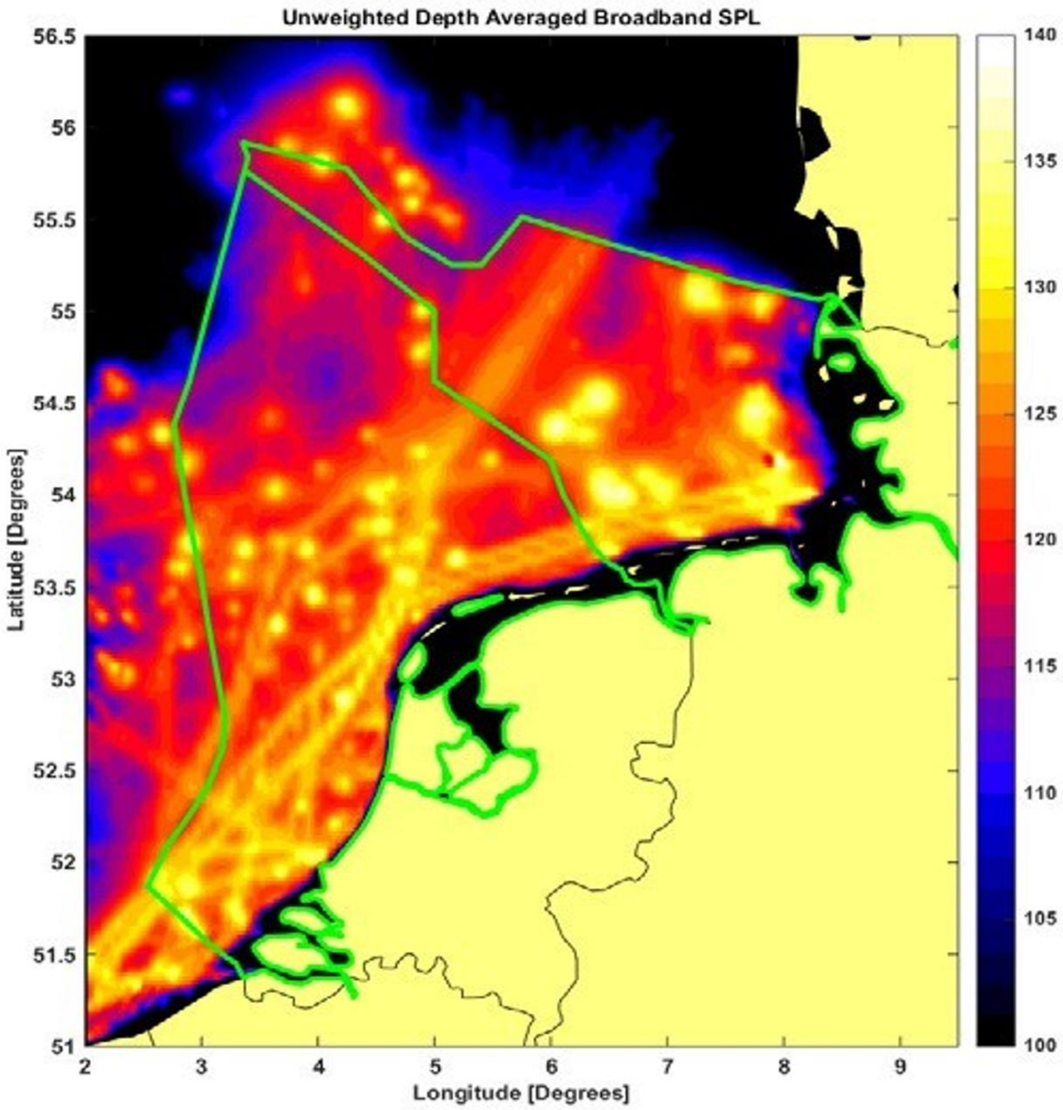
4.1.1. The differences in biological sensitivity to sound in different species

The discussions at IMO describe the situation as follows, even at a very early stage: "it was also acknowledged that how noise can impact marine life is highly dependent on the context of exposure and the species in question" (IMO, 2009a). As shown in the Duarte et al. (2021) study in Section 2.3 (Figure 2 in Chapter 2), the hearing range of each marine life is different, and the frequencies that are sensitive in the range, the sound pressure that affects behavior, and the behavior induced by the sound differ among species (Andersson et al., 2015). In other words, no marine life would complain about reducing shipping-borne anthropogenic noise (in the sense of getting closer to a natural ambient noise environment), but they would disagree on which frequencies and to what degree reduction makes sense for each species.

4.1.2. The differences in the level of noise emitted by shipping due to the maldistribution of sea lanes

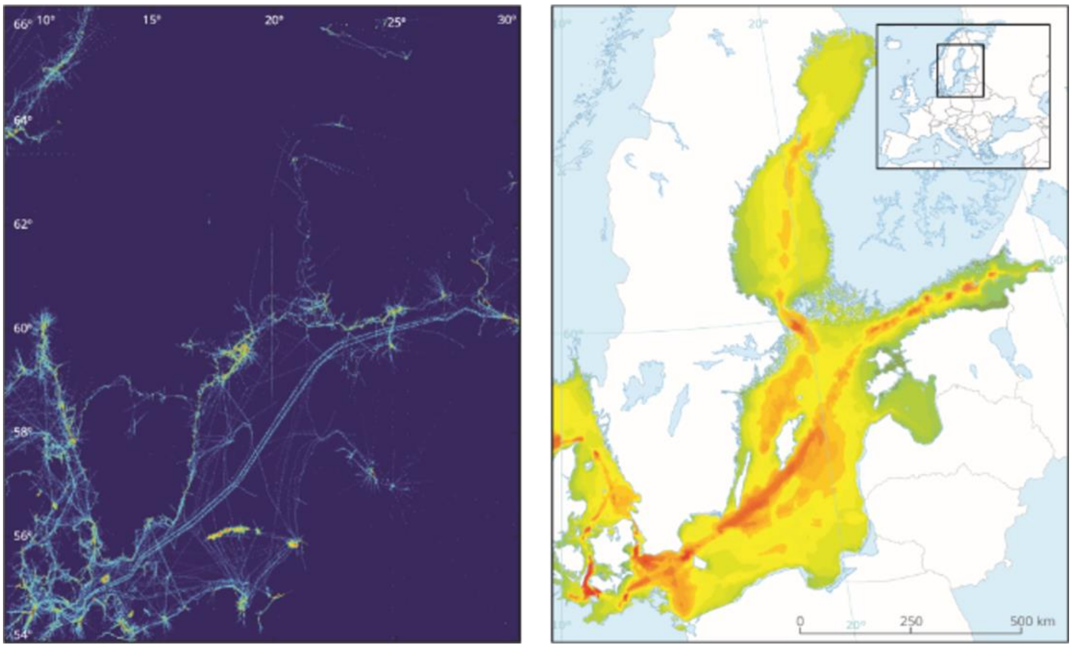
Recent vigorous efforts in this regard have resulted in the establishment of a monitoring standard in ISO (ISO, 2016), which Australia has previously pointed out, regionalities of URN (IMO, 2008b) have become concrete. As mentioned in Section 2.2, the SONIC and BIAS projects are notable examples of studies that have visualized the uneven distribution of noise emitted by shipping, especially its concentration in coastal areas (see Figure 8 and Figure 9) (EMSA, 2021; Prins et al., 2016). As these studies show, URN emitted by shipping is concentrated along major shipping routes, especially in coastal areas, and the level of URN emitted by shipping is certainly superior to the ambient background noise in the vicinity of shipping routes.

Figure 8 *An example of shipping origin noise distribution map*



Note. This is a visualization of radiated sound from shipping showing noise localization, especially concentrated in coastal area. From "Suppression of underwater noise induced by cavitation: SONIC," by Prins et al., 2016, *Transportation Research Procedia*, *14*, 2668-2677.

Figure 9 *A visual example of the shipping and noise distribution relationship*



Note. This is a visualized research result of the BIAS project showing shipping concentration matches noise concentration. Left: shipping density map for the Baltic Sea region. Right: map of ambient underwater noise, including both natural and anthropogenic components type. From *"European Maritime Transport Environmental Report 2021,"* by EMSA, 2021, 77

4.1.3. The differences in naturally occurring noise native to the region

As mentioned in the previous section, it is important to determine whether anthropogenic noise (here, shipping-borne noise; mainly cavitation) is dominant over the natural background noise of the surrounding ocean. Section 2.2 highlighted that the ocean is filled with sound-transmitting water, which propagates sound faster and farther than in the air, but the nature of the propagation changes in a variety of ways depending on temperature, salinity, and depth. And always, in addition to rain and wind creating sound, the ocean is filled with the emissions of various marine life such as whales, fish, and shrimp living there (Hildebrand, 2009).

It was explained that the nature of natural background noise is influenced by the effects of rain and wind, which vary with the season and weather, as well as the type and behavior of organisms that inhabit the area (Cato & McCauley, 2002; Hildebrand, 2009; Ward et al., 2019). A study by Hildebrand (2009) showed that heavy rain can increase the background noise levels by as much as 20 dB in the mid-frequency range. Thus, the level and characteristics of the natural background noise that a regional native varies considerably from region to region and even from season to season.

4.2. Trade-off relationship between GHG emissions and URN reductions

In the previous section, the regionalities that are essential to understanding and managing URN with biological considerations were reviewed. Before exploring the relationship between regionality and the current governance challenge in the next section, there is one more important factor that must be understood: the relationship between technical measures and energy efficiency improvements related to URN reduction.

This trade-off relationship between energy efficiency and URN is one of the main reasons why the IMO has moved its discussions on URN from the CG organized by MEPC to the SDC (IMO, 2011a), and the fact that subsequent discussions, for example (SDC 9/5), clearly include a section "Energy Efficiency and URN Reduction" shows the importance of this relationship (IMO, 2022e). Furthermore, the draft revision of the Guidelines also clearly includes a chapter entitled "Energy Efficiency and URN reduction", which indicates that the trade-off relationship between these two crucial pollutions received attention in the IMO discussions (IMO, 2023a).

A simple explanation in SDC 8/14/3 very clearly describes the trade-off between Energy Efficiency and URN reduction in the paper submitted by Japan to IMO (IMO, 2021c). As explained in Section 2.1.2.4.2, the function of the propeller as a fluid machinery is to create a pressure differential between its front and rear surfaces. Further, it was also stressed that cavitation occurs when the created negative pressure goes below the saturated vapor pressure of seawater due to various physical conditions, and it is accompanied by noise. Propeller manufacturers have made great efforts to improve propulsion efficiency, especially since the Energy Efficiency Design Index

(EEDI) came into effect, but the extent of improvement is limited to a few percent by any company. In the author's experience, the range of 1-5% is a realistic target[7] as substantiated by Japan Ship Technology Research Association (2009). However, this includes not only measures against cavitation but also measures focusing on rotating flow[8] (Carlton, 2007; JRTT, 2016). In other words, it is realistic to think that there is not much room to make major changes in propeller design to reduce noise and energy lost as noise due to cavitation without reducing propulsion efficiency. Maximum efforts have also been made to improve Wake by designing the aft part of the hull in consideration of the propeller design to improve propulsive efficiency. In other words, propeller propulsion efficiency has already been optimized within the range of available technology, even taking Wake into consideration[9]. Therefore, reducing cavitation noise by changing the propeller design means reducing noise at the expense of propeller propulsion efficiency. As mentioned in Chapter 2, cavitation noise is a major component of URNs, which is why solutions have been difficult to find.

4.3. Regionality and URN measurements currently discussed

In Section 4.1.1, regionality which is essential for monitoring and evaluating URN is discussed. Even if it is described as simply URN, once the phenomena is considered from the perspective with its impact on marine life, which is the key victim of the noise, the sensitivity and response of marine life to sound varies from species to species; the degree of disturbance caused by shipping and the baseline for evaluating the disturbance also vary from region to region, thus it is confirmed that very large

[7] The target for propeller efficiency improvement is set at 3%. Furthermore, this only means that the propeller efficiency in design will be improved by 3% when assuming speed at 75% MCR (insert EEDI formula), which is used for EEDI calculations, and does not mean that the actual propeller efficiency for one entire voyage will improve by 3%, nor is it promising to reduce the amount of energy lost to noise in coastal areas, especially around ports and harbors, in where the condition is deviate from the design point.

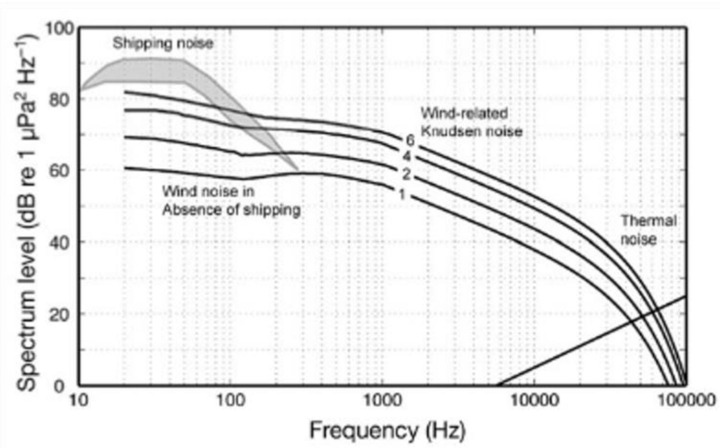
[8]This shows how the energy-saving products, that commonly seen around propellers, are rotation flow-focused, and their effectiveness is not at all satisfactory in terms of noise reduction.

[9] This is probably the reason why nowhere in the previous IMO discussions, old or new guidelines, or documents provided by ship classification (e.g., documents from ABS or DNV previously mentioned) there are specific Wake or innovative design approaches for noise-reduction propellers.

regional variabilities are at the root of the problem. What is to say, as shown in Figure 10, for areas and times when shipping-borne noise dominates over natural-background noise, it is necessary to consider whether there are marine lives in the impacted area that will be adversely affected, and how to reduce the adverse impact/reaction that will be unwanted by them through noise reduction.

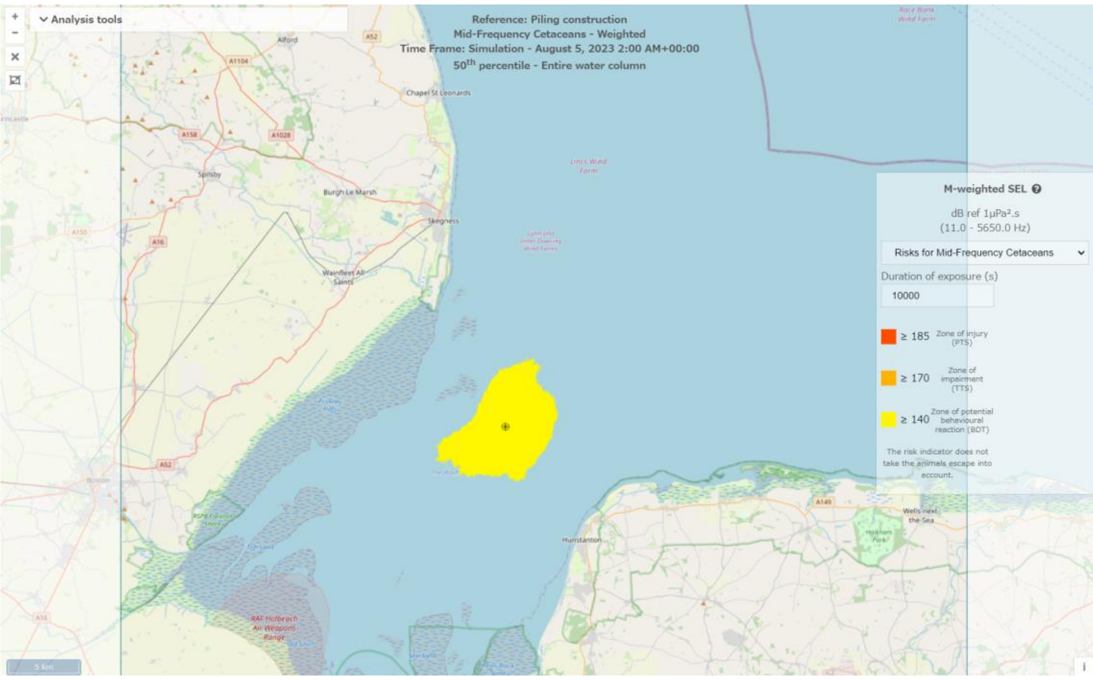
This is a complex assessment activity based on a very wide range of baseline data, and it cannot be said that satisfactory resolution assessments are being carried out in the global ocean. However, Quonops is a very good example. This is a service provided by Quiet-Oceans, which allows the assessment of the impacts of some noise on a few species using a noise propagation model based on underwater noise monitoring data, taking into account temperature, salinity, and surface roughness (Copernicus Marine Service, n.d.). Although it is possible to assess the impact of any given noise source on organisms in a particular area, as shown in Figure 11, the species and areas that can be addressed are currently very limited.

Figure 10 A visualization of shipping noise and natural base noise



Note. This is a visualized ocean ambient noise showing a case of relationship between shipping noise and natural-base noise, which can tell how shipping has to achieve a lower radiation level of underwater noise. However, the extent is debatable since the data is only about a part of natural-base noise and are sampled at 1000m depth meaning the relationship of shipping origin and other noise can be drastically different at other depths or within other environments. From *"Anthropogenic and natural sources of ambient noise in the ocean*," by John A. Hildebrand, 2009.

Figure 11 *An example of on-time assessment of the adverse sound impact on marine life*



Note. This is an example of probably the most sophisticated management level. It is ideal to access and manage comprehensive environmental impacts which also allows us predictions related to our activities. However, it requires enormous base data and infrastructures in an extent that does not allow us to consider the option as realistic to implement it in the global ocean. From Discover the capabilities offered by Quonops Online Services, by Quiet-Oceans SAS, 2023, *Quonops Online Services*, (https://qos.quiet-oceans.com/).

In considering regulations and measurements on underwater noise, it is confirmed earlier that the balance with GHG emission must also be taken into account. In the case of cavitation measures including Wake, which are currently attracting attention as technical measures, consideration of the trade-off relationship between GHG emission and noise reduction is unavoidable, as is the issue of rerouting, which means a diversion to avoid sensitive areas is also vulnerable to the same potential. The discussion has been brought to Pollution Prevention and Response (PPR) in order to put a certain direction on this confusing trade-off relationship. However, the current regulatory framework does not clearly provide line prioritization to minimizing the adverse impact on marine life by reducing URN and minimizing GHG emissions from the consumption of fossil fuels, which is considered as a cause of climate change. Given the circumstances, the statement provided by SDC 9/5 may possibly be a political choice to see this complex and tricky trade-off relationship in a simplified, that is "URN measures should not come at the expense of mandatory IMO requirements on GHG reduction and energy efficiency" (IMO, 2022e).

To effectively address this intricate and challenging issue in a cohesive manner, it is essential to establish a framework that is deliberated upon at the IMO, receives majority consensus among the participating States in the MEPC, and can be universally applied by every Party involved. Universal and static thresholds, which have been most commonly used in environmental regulatory discussions, have been mentioned in the MEPC since the early days of discussions on URN, but are not introduced in either the old or new guidelines. Furthermore, in recent IMO discussions, it has been stated by the International Whaling Commission that some (15%) of the loudest ships are responsible for the majority part of the underwater noise (IMO, 2018b), while others alleged that shipping noise is on the decline (IMO, 2022e) [10]. There are also arguments that seismic surveys are more negatively impacting on the environment (OSPAR Commission, Aug 17, 2018). In addition, the negative effects of dredging (Mcqueen, 2019) have also been highlighted. However, the study by Andersson et al. (2015) contributing to the AQUO project, which is presented in Section 4.1.1.1, shows that there are some negative impacts of ship-borne noise not only on whales and dolphins but also on species of fish that are commonly found in wide areas of the ocean. The presence of regional variations in underwater noise poses challenges in defining effective solutions. Each stakeholder or participant involved in

[10] However, this may be strongly dependent on recent fuel price increases and slow steaming, so it is important to note whether noise will continuously maintain the trend.

addressing this issue holds distinct goals, influenced by their own positions and local contexts such as the complexity demonstrated by the trade-off relationship between underwater noise reduction and GHG emissions. What strategies may be employed to offer incentives in order to effectively tackle this matter? It is exactly like Canada and France that stated: “It was widely acknowledged throughout the workshop that the issue of quieting ships to protect the marine environment is complex” (IMO, 2019)?

Taking a brief departure from the ongoing consensus-building efforts about the universal static noise threshold, it is apparent that various states and regions have independently already undertaken their own initiative to regulate and mitigate the URN. As stated in UN Convention on the Law of the Sea (UNCLOS), section XII Protection and Preservation of the Marine Environment, States have an obligation to protect and preserve the marine environment. A review of the Nineteenth meeting (A/73/124) (United Nations, 2023; United Nations, n.d.) held in 2018 under the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea shows that a great number of regions have their own initiatives in place. This is precisely one of the ways in which cooperation on a global or regional basis is called for in Article 197 of UNCLOS.

Already in the 2021 SDC, nearly 30 countries, including the European Commission, jointly submitted an opinion that a global information platform for sharing knowledge from regional-based initiatives would contribute to research efficiency and noise management (IMO, 2021d). U.S.A., referred to "regionalities" and expressed a positive opinion on the individual ship-based limit while France and Liberia also referred to the appropriateness of localized regulation setting considering local species (IMO, 2022e).

In summary, it was confirmed that URN reduction efforts need to take into account the multifaceted differences that are the regionalities regarding biological impacts and the different priorities of stakeholders that each region has, such as the trade-off relationship with GHG emissions. In response, the recent IMO discussions have focused on localization on a regional basis. The next Chapter will discuss what kind of framework could be used to reach a consensus on this issue where the traditional approach of introducing IMO-defined thresholds for all waters does not offer incentives to bring sufficient participants to an agreement.

Chapter 5 Discussion

This chapter delves into the exploration of feasible governance approaches aimed at addressing the primary obstacle highlighted in the preceding Chapter: the mitigation of underwater noise in relation to its regional dimension. The term "governance" in this context pertains to the resultant effects achievable through the attainment of a consensus on shared advantages between maritime activities, responsible for noise emission, and the specific region or nation aspiring to administer marine conservation strategies that account for ecological impacts. Furthermore, it examines strategies to navigate the predicaments arising from regional disparities and how to proactively involve all concerned parties in minimizing ship-generated noise. What sort of structural framework is essential for effectively tackling this complex challenge?

5.1. Monopolistic competition

Monopolistic competition is an economic theory explaining basic market structure discovered by E.H. Chamberlin through an experiment (Chamberlin, 1948). Briefly, it explains that trading at satisfactory prices negotiated among individual trades (arm’s length transaction), rather than on the basis of a centralized standard price (equilibrium price), increases the number of trades.

In the following sections, it is considered what regulatory frameworks could provide incentives to participate in URN reduction activities whilst focusing on a unique idea, “excess capacity”. To be more specific, what is being discussed in this section is that, when considering the URN reduction market, which exists when the cost of reduction that participants in UNR reduction activities are forced to pay directly or indirectly by regulation is regarded as price, and the reduction in environmental impact that is obtained by the activity is regarded as product, is it a conceivable way to contemplate regulations/ thresholds which can maximize the reduction activities by viewing the market structure as Monopolistically Competitive, thereby identifying the benefits that the market generates, reduction in adverse impact on marine life?

5.1.1. What is the theory of monopolistic competition?

Monopolistic competition is a theory developed by Chamberlin as an additional structure to the three well-known market structures (perfect competition, monopoly, and oligopoly). This theory describes a market structure, monopolistic in that firms are not a price-taker, but competitive in that there can be market equilibrium due to competition among firms supplying similar and different products, as is often the case in real-life markets (Mankiw, 2014). Thus, the theory explains a market structure different from pure monopoly but also different from ideal perfect competition and is one of the basic theories that explain market structures in current economics.

To illustrate the concepts within this theory, let's begin by considering a Chinese restaurant located in a shopping mall's food court. This establishment serves as an apt representation of the market dynamics under discussion. Assuming that this Chinese restaurant is the sole Asian and Chinese cuisine provider among its competitors within the food court, a variety of other fast-food options—such as Caren's Pizza, Ristorante Piccola Italia, Greasy Burger, and Crispy Hot Chicken—offer their menus at approximately 100 SEK. However, the Little Chinese Kitchen adopts a more assertive pricing strategy, with its starting price at 180 SEK for the Fried Rice Combo, a main dish. In this scenario, the Little Chinese Kitchen experiences a partial loss of potential customers due to its lack of price competitiveness. Some customers opt for more economical choices, such as pizza or burgers, over Chinese cuisine. Simultaneously, a segment of mall-goers specifically desire rice or Chinese dishes and are willing to invest a bit more for this preference. Naturally, the reverse is also plausible—certain customers might still select a burger even if the Little Chinese Kitchen lowered its prices. For now, let's concentrate on the situation where the slightly higher-priced Chinese cuisine aligns moderately well with the shopping mall's customer preferences, rendering the business viable.

In this context, the Little Chinese Kitchen does not function as a price-taker, adhering solely to market equilibrium prices. Yet, it also does not exert monopolistic control over the supply of Chinese cuisine, operating with pricing that remains unaffected by competitive forces (Krugman & Wells, 2008).

Defining the aforementioned structure in more economic terms, monopolistic competition is described as a possible market structure when the following three conditions are met. The following is a quoted from “Principles of Microeconomics” by Mankiw (2014);

1. **Many sellers:** There are many firms competing for the same group of customers.
2. **Product differentiation:** Each firm produces a product that is at least slightly different from those of other firms. Thus, rather than being a price taker, each firm faces a downward-sloping demand curve.
3. **Free entry and exit:** Firms can enter or exit the market without restriction. Thus, the number of firms in the market adjusts until economic profits are driven to zero.

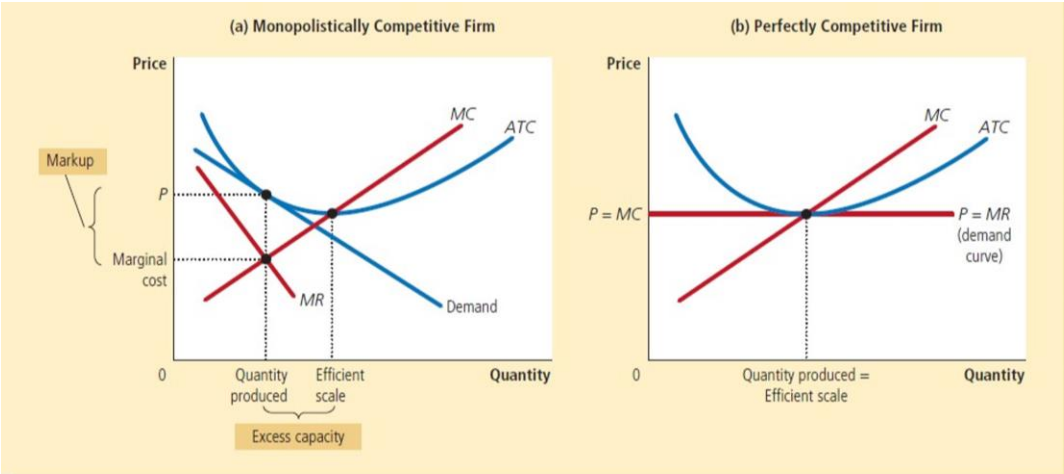
Such a market structure that lies between a sort of monopolistic market and a market of perfect competition is called monopolistic competition.

5.1.2. What is Excess capacity?

The characteristic significantly differentiates monopolistic competition from others is this excess capacity. This concept explains how “a monopolistically competitive firm, unlike a perfectly competitive firm, could increase the quantity it produces and lower the average total cost of production” (Mankiw, 2014).

This is because in an ideal perfectly competitive market the Efficient scale of production is determined by the value at which the average total cost curve shows a minimum, and at the same time there is no incentive to produce, or trade, beyond the quantity produced. In contrast, in monopolistically competitive firms, the amount of production is determined at the point where the average total cost curve and the demand line meet, which creates a difference between the Efficient scale (see Figure 12).

Figure 12 *A visual image of excess capacity found different characters of between perfectly competitive firm and monopolistically competitive firm*



Note. Panel (a) shows the long-run equilibrium in a monopolistically competitive market, and panel (b) shows the long-run equilibrium in a perfectly competitive market. Two differences are notable. (1) The perfectly competitive firm produces at the efficient scale, where average total cost is minimized. By contrast, the monopolistically competitive firm produces at less than the efficient scale. (2) Price equals marginal cost under perfect competition, but price is above marginal cost under monopolistic competition. From *"Principles of Microeconomics,"* by Mankiw, N. G., 2014, p. 335.

Think about what this means using gas station as an example. The monopolistically competitive situation in panel (a) describes, for example, a situation where gas stations are located every three miles but are slightly more expensive (many firms compete for a long enough period of time to reach an equilibrium with Quantity produced and Price P to the left of the Efficient scale). In contrast, in the perfectly competitive situation in Figure (b), you can fill gas at a lower price, but there is a station only every five miles (trading at the efficient point where the market equilibrium is brought about by competition) (Krugman & Wells, 2008).

Monopolistic competition has not been perceived positively, as the out-of-equilibrium price of monopolistic competition leads to economically 'inefficient' outcomes compared to the total surplus obtained by ideal perfect competition (Krugman & Wells, 2008; Mankiw, 2014). However, if we look at the number of trades/participants who can join a trade, rather than the maximum total benefit gained from competition, it appears that this is not all bad. What if this trade-off relationship between market efficiency and the number of trades, which has been viewed negatively, is seen as an advantage that gives more firms the opportunity to participate in the market? For example, in the labor market, it would be preferable to give some priority to provide jobs to as large a proportion of the population as possible, rather than only a few incredibly skilled people getting very well-paid jobs. In other words, a perfectly competitive market maximizes efficiency but minimizes the number of people who can participate, whereas a monopolistically competitive market is less efficient but increases the number of people who can participate (Yosuke, 2021). This feature seems very beneficial when considering the regions that can participate in URNs.

When we hear of markets and competition, we somehow assume that we should strive on a level playing field towards an explicitly defined common set of goals and compete with each other for the best results. Indeed, in a market structure such as a stock market, where there is some kind of centralized environment in which transaction prices are publicly disclosed, the transaction outcome would be closer to a competitive equilibrium, minimizing participants but certainly maximizing the total surplus (Smith, 1962; Yosuke, 2021). However, in consideration of such URN which is characterized by the diversity of regionalities and priorities, it seems more realistic to expect various reduction goals/solutions in each region in monopolistically competitive manner rather than competitive noise reduction activity by setting a universal threshold based on a single numerical value in an ideal perfect competitive manner.

5.2. URN activities regarded as a monopolistic competitive market

The inherently regionally diverse nature of URN issues, coupled with the lack of a definitive technical solution, makes it difficult to have thresholds (reduction targets, mitigation process) that can demonstrate incentives to the majority participants. This was identified in Section 4.1. In this section, the monopolistic competition presented earlier is considered in relation to URN reduction activities.

The first three elements necessary for monopolistic competition, as applied to the current situation in URNs, can be seen as follows;

1. **Many sellers:** Regions that require activities that contribute to reduction are considered as sellers. For URN, it can be said that there are as many sellers who want to enter this market as there are regions with motivations for the reductions since the marine life to be protected from the adverse impacts of noise differs greatly from region to region, thus, the type of noise to be reduced and its extent will also differ according to the need and priority.
2. **Product differentiation:** The content of the solutions required by each of the regions in Item 1 are taken as products. For example, the recommendation of slow steaming, establishment of sensitive areas, and consideration of draft and trim, appear to be realistic. However, there may also be requirements for noise reduction equipment related to propellers that probably depend on specific characteristics and age of the vessels. By carefully selecting and enhancing the different options identified during the review of the discussions at the IMO, it is possible to adapt the product in alignment with the specific needs of individual sellers, as outlined in Item 1 and that will not only enhance the suitability of products for each region but also contribute to the differentiation.
3. **Free entry and exit:** The number of sellers that could realistically be considered in IMO discussions could be basically one firm per state, but the number of sellers that actually supply different products should be considered. For example, the basics of sellers or products in the North Sea may be discussed in the EU, but if the North Sea is further

divided into different regions and there are sellers that can offer different products based on regional characteristics, there will be entry to the market, and if it is too fragmented, exit will occur by encouraging integrated operations in multiple regions that share the same situation. As explained in Item 2: product differentiation, the reduction approach, and thresholds should not be defined in an IMO-centralized way, but in a decentralized way that allows each region to think about its own local way of doing the reduction. Free entry and exit could well occur in the URN reduction activity market.

The question that arises is: in this monopolistically competitive market, can shipping be a customer that enjoys a diversity of products from sellers? The question is whether reduction solutions are products or burdens that no one wants to receive. An example of a gas station was used in Section 4.3.2. No buyer would run out to buy fuel with joy, would they? They receive fuel from gas stations because they need it and pay the price. If shipping was seen as an inherently selfish corporate body, then noise reduction would not be achievable even in the way that introducing a centralized universal threshold and expecting some sort of ideal perfectly competitive market. This is because many countries that enjoy the benefits of shipping that participate in discussions on noise reduction at the IMO will not even agree to acquire thresholds in the first place. In reality, shipping may be motivated to some extent, to be a customer in this market by understanding the need to reduce the environmental impact of their economic activities to the same extent that they understand that fuel is necessary to run a car, that it contributes to noise reduction activities as conveniently as possible.

Let's take a look at what monopolistically competitive URN activities might look like. In this market, each region, as a seller, recognizes the level of noise reduction it expects from shipping within its own waters and provides the necessary solutions. The IMO verifies and authorizes the realistic effectiveness of the solutions provided by each region, and keeps shipping updates on the list of solutions required for entry into each region. Each firm/region will determine what is appropriate for their waters, whether the product they wish to offer is a reduction in URN in their waters through slow steaming, protection of critical habitats by bypassing sensitive areas, or fast and efficient navigation to balance the reduction of GHG emissions in their waters. The IMO is requested to authorize a solution that is scientifically based and contributes to the reduction of adverse impacts on marine life. In this way, the quality of these noise reduction solutions is assured by the IMO checking the scientific evidence provided by each region, to the same extent that food is not served completely differently from the menu or refueling is not contaminated with water.

In this way, it looks possible to create a market for URN reduction activities with decentralized responsibility to the regions and allowing positive recognition of regionalities as well as associated variations in priorities rather than with centralized discussion and authority in the IMO to set traditional universal thresholds to form an ideal perfect competition. There is a potential to provide desired solutions for regions with varying natural ambient sounds, different marine life conservation needs, differing ship noise characteristics, and differing priorities representing the trade-off relationship of GHG emissions.

Apparently, the framework motivates various States to join the framework that wishes to apply slow steaming to their waters for only a few months, which effectively reduces radiated noise in coastal waters where whales are breeding during the winter months while most of the year, priority must be given to ensuring the logistics of ships necessary for port development and economic growth.

In this case, the IMO's role would be to review and approve the validity of region-specific implementations, that could serve as a forum for the global sharing of effective case studies and the knowledge gained, which is the framework attracting attention. The data collected in this manner could potentially lead to the enormous volume base data gathering for analyses such as Figure 11 in the world's oceans.

If URN reduction activities are recognized as a necessary activity by shipping and regions, there may be scope to consider a different regulatory setting in order to maximize the number of participants that can be expected in a monopolistically competitive market structure.

Chapter 6 Conclusion

In this research, especially in the literature review covering up to Chapter 2, it has been observed that various human economic activities are causing adverse effects on a wide range of marine ecosystems through the introduction of noise. These negative impacts can be observed in oceans all around the world, and their severity varies significantly.

To address research question 1, it can be argued that when considering the magnitude of noise as a scale, cavitation originating from shipping scattered across worldwide can be a major source of noise. On the other hand, when considering the intensity of the adverse effects as a scale, it is believed that seismic activity, dredging, and even pile driving associated with the promising field of wind power generation contribute significantly to these effects. Moreover, it cannot be said that these activities have only a minor impact on maritime activities.

One of the factors that make research on the relationship between this new type of pollution, which does not rely on substances introduced into the marine environment, and ecosystems challenging is found its complexity in the relationship between noise and related adverse impacts. Certainly, research on the specific impacts of ship cavitation, pile driving, and dredging on certain species is progressing in regions where these activities are present. Studies related to the avoidance cetaceans in area or duration, and the damage to the hearing cells of squid are good examples. On the other hand, as the location changes, the level of natural ambient noise and the species inhabiting the area also vary, making it difficult to generalize these findings across wide marine areas.

Therefore, to answer research question 2, it can be said that it is in a challenging situation where response measures need to be developed without established target values. Particularly concerning cavitation noise generated by maritime activities, there is a potential for technological noise reduction, but it also introduces a trade-off relationship with GHG emissions. Consequently, the availability of engineering solution options is quite limited[11]. This has led to increasing attention to navigation operational measures.

In essence, these "navigation operational measures" involve responses to reduce this pollution when there are no specific technological solutions readily available. These responses include measures such as slow steaming or diverting around noise-sensitive areas. However, even these measures can lead to an increase in GHG emissions, as altering optimized voyage plans designed for fuel consumption reduction is still a significant consideration.

The pollution itself lacks a tangible substance, and its adverse effects are observed across extensive marine areas that approximate the distribution of shipping. However, at the same time, it exhibits multiple regional characteristics, with the type and extent of adverse effects varying by region. Furthermore, innovative technological solutions have yet to be identified. Introducing a universally applicable and standardized threshold for the global oceans, as has conventionally been employed by MARPOL, and has been emphasized as only way, would likely be challenging in addressing this issue[12](IMO, 2022b; Eric & Holger 2015; Southal et al., 2021).

However, while looking around, it can be found that there are several practices addressing regionally, such as the Port of Vancouver, new regulations in the EU, OSPAR, HELCOM, and BIAS. Also, current frameworks have started to allow regional differences, such as PSSA and Emission Control Area (ECA).

In light of this situation, considering how regions needing noise adverse impact reduction can participate in necessary activities drew inspiration from the theory of monopolistic competition. As a result, to address research question 3, the governance

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[11] For noises that do not propagate over large distances but introduce extraordinal energy into a limited area, there seems to be a solution. Such as air bubble curtains which have been studied in recent years (Würsig et al., 2000).

[12] The three relatively new studies (one of which is a CG report from the IMO) also take a rather negative view of simple governance with a single united threshold.

challenge regarding underwater noise pollution and maintaining ecologically sustainable shipping is recognizing that approaches in other communities can differ significantly from one to one. It necessitates a type competition which allow wider participants while adopting the necessary measures to achieve a quieter marine environment within one's own community. Consequently, IMO may need to explore its role from a new perspective in facilitating this approach.

It is widely considered that centralized governance is required in order to address pollution. The efforts following this approach have been seen in the regulation of pollution, such as regulations to control pollution in air, water, and land resulting from the rapid development of the domestic economy and exhaust emissions due to the widespread use of private vehicles.

However, one of the new types of pollution, underwater noise, seems to advocate for a more decentralized approach[13]. When that ferry comes into the harbor while a man is enjoying fishing, the fishes are disappeared. When that type of ship is coming in and out at the port, it becomes impossible to catch fish. It may be necessary to consider how to incorporate these experiences into regulations in our future interaction with a sustainable ocean[14].

Regarding this issue with its diverse regional implications, it has been demonstrated that a decentralized authority and localized efforts can be effective. Based on the findings of this study, it can be concluded that further research is needed to determine what specific incentives can increase participation in noise mitigation activities in various regional communities, not just the ICC, as more of them consider engaging in such efforts.

[13] At the point that the approach of universally applying a generalized threshold set by the IMO to all the world's oceans is considered unwise, and it rather calls for regionally rooted initiatives.
[14] From this perspective, the arguments put forth by the Inuit Circumpolar Council (ICC) during the revision of these new guidelines are highly valuable. The ICC actively promoted discussions that emphasized the uniqueness of the region, relying less on costly research and results. They advocated for the necessity of including a stand-alone section or annexe related to Inuit Nunaat (Inuit Homeland) within the newly revised guidelines (IMO, 2022f).

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IMO. (2009b). *Noise from commercial shipping and its adverse impacts on marine life.* Report of the Correspondence Group. Submitted by the United States. (MEPC 60/18).

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IMO. (2021c). *Review of the guidelines for the reduction of underwater noise (MEPC.1/CIRC.833) and Identification of next steps. Proposal on approach to the review of the 2014 guidelines for the reduction of underwater noise from* *commercial shipping to address adverse impacts on marine life (MEPC.1/circ.833*). Submitted by Japan. (SDC 8/14/3).

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IMO. (2022a). *Review of the guidelines for the reduction of underwater noise (MEPC.1/CIRC.833) and identification of next steps. Report of the Working Group*. (SDC 8/WP.8).

IMO. (2022b). *Review of the guidelines for the reduction of underwater noise (MEPC.1/circ.833) and identification of next steps. Report of the Correspondence Group.* Submitted by Canada. (SDC 9/5).

IMO. (2022c). Review of the guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (MEPC.1/circ.833) and identification of next steps provisional workplan. Submitted by Canada. (SDC 9/5/1).

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Appendices

Appendix 1 -The list of documents retributed from IMO docs-

Doument ID	**Data**	**Tittle**	**Noted by**
DE 55/22	Apr 15 2011	REPORT TO THE MARITIME SAFETY COMMITTEE	Secretariat
DE 56/2/1	Sep 22 2011	DECISIONS OF OTHER IMO BODIES Outcome of NAV 57, MEPC 62 and FP 55	Secretariat
DE 56/24	Dec 9 2011	PROVISIONS FOR THE REDUCTION OF NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Proposed framework for non-mandatory guidelines	United States
DE 56/25	Feb 28 2012	REPORT TO THE MARITIME SAFETY COMMITTEE	Secretariat
DE 57/17	Dec 14 2012	PROVISIONS FOR REDUCTION OF NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Report of the Correspondence Group	United States
DE 57/25	Apr 5 2013	REPORT TO THE MARITIME SAFETY COMMITTEE AND THE MARINE ENVIRONMENT PROTECTION COMMITTEE	Secretariat
LC/SG 37/8/1	Apr 8 2014	COASTAL MANAGEMENT ISSUES ASSOCIATED WITH ACTIVITIES TO PREVENT MARINE POLLUTION Underwater noise from anthropogenic sources – outcomes of MEPC 66 and the CBD Expert Workshop	Secretariat
LC/SG 37/INF.4	Mar 12 2014	COASTAL MANAGEMENT ISSUES ASSOCIATED WITH ACTIVITIES TO PREVENT MARINE POLLUTION Underwater noise from anthropogenic sources	World Organisation of Dredging Associations
LC/SG 37/INF.23	Apr 11 2014	COASTAL MANAGEMENT ISSUES ASSOCIATED WITH ACTIVITIES TO PREVENT MARINE POLLUTION Assessing Underwater Noise Impacts from Backhoe Dredging	United States
LC/SG 37/INF.28	Apr 25 2014	COASTAL MANAGEMENT ISSUES ASSOCIATED WITH ACTIVITIES TO PREVENT MARINE POLLUTION Underwater noise from anthropogenic sources	International Union for Conservation of Nature

Doument ID	Data	Tittle	Noted by
LC/SG 40/INF.10	Jan 20 2017	COASTAL MANAGEMENT ISSUES ASSOCIATED WITH ACTIVITIES TO PREVENT MARINE POLLUTION Underwater noise levels in United Kingdom waters	United Kingdom
LC/SG 43/8/3	Dec 13 2019	COASTAL MANAGEMENT ISSUES ASSOCIATED WITH ACTIVITIES TO PREVENT MARINE POLLUTION Underwater noise from anthropogenic sources	Chile
MEPC 58/18	Jul 1 2008	DEVELOPMENT OF A GUIDANCE DOCUMENT FOR MINIMIZING THE RISK OF SHIP STRIKES WITH CETACEANS Information for the development of a guidance document for minimizing the risk of ship strikes with cetaceans	United States
MEPC 58/18/1	Aug 1 2008	DEVELOPMENT OF A GUIDANCE DOCUMENT FOR MINIMIZING THE RISK OF SHIP STRIKES WITH CETACEANS The International Whaling Commission (IWC) Ship Strikes Database: Information on the development and progress of a global database of collision incidents between vessels and cetaceans	Australia and Belgium
MEPC 58/19	Jun 25 2008	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Minimizing the introduction of incidental noise from commercial shipping operations into the marine environment to reduce potential adverse impacts on marine life	United States
MEPC 58/23	Oct 16 2008	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS FIFTY-EIGHTH SESSION	Secretariat
MEPC 58/INF.19	Aug 1 2008	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDARY BODIES Information on Noise from Commercial Shipping Operations and Marine Life	Australia
MEPC 59/19	Apr 9 2009	NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Report of the Correspondence Group	United States

Doument ID	Data	Tittle	Noted by
MEPC 59/19/1	May 6 2009	NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Reducing underwater noise pollution from large commercial vessels	International Fund for Animal Welfare and Friends of the Earth International
MEPC 59/24	Jul 27 2009	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS FIFTY-NINTH SESSION	Secretariat
MEPC 60/18	Dec 18 2009	NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Report of the Correspondence Group	United States
MEPC 60/22	Apr 12 2010	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SIXTIETH SESSION	Secretariat
MEPC 61/19	Jul 23 2010	NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Report of the Correspondence Group	United States
MEPC 61/24	Oct 6 2010	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SIXTY-FIRST SESSION	Secretariat
MEPC 62/11/10	May 20 2011	REPORTS OF SUBCOMMITTEES Comments on the outcome of DE 55	United States
MEPC 62/19	May 6 2011	NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACT ON MARINE LIFE Development of an international standard for measurement of underwater noise radiated from merchant ships	International Organization for Standardization
MEPC 62/19/1	May 6 2011	NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Information on the propeller as the main source for ship generated underwater noise	Germany
MEPC 62-INF.22	May 6 2011	NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE Information on Shipping Noise Research and Marine Biodiversity, with a special focus on cetaceans	Spain

Doument ID	**Data**	**Tittle**	**Noted by**
MEPC 63/23	Mar 14 2012	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SIXTY-THIRD SESSION	Secretariat
MEPC 64/23	Oct 11 2012	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SIXTY-FOURTH SESSION	Secretariat
MEPC 65/22	May 24 2013	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SIXTY-FIFTH SESSION	Secretariat
MEPC 66/21	Apr 25 2014	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SIXTY-SIXTH SESSION	Secretariat
MEPC 68/17/3	Feb 6 2015	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Proposal to include new item in the work programme of the Sub-Committee on Pollution Prevention and Response on evaluation of contribution of merchant ships and other sources on underwater noise level	Russian Federation
MEPC 68/INF.26	Mar 6 2015	ANY OTHER BUSINESS New information on impact of underwater noise from ships on fish and invertebrates	International Union for Conservation of Nature
MEPC 71/16/5	Apr 28 2017	ANY OTHER BUSINESS Collaboration to reduce underwater noise from marine shipping	Canada
MEPC 72/16/5	Feb 2 2018	ANY OTHER BUSINESS Reducing underwater noise utilizing ship design and operational measures	Canada
MEPC 72/17	May 3 2018	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SEVENTY-SECOND SESSION	Secretariat
MEPC 72/INF.4	Jan 3 2018	ANY OTHER BUSINESS ITTC Recommended Guideline on Model Scale Cavitation Noise Measurement	ITTC
MEPC 72/INF.9	Jan 19 2018	ANY OTHER BUSINESS Further information related to impacts of underwater noise on marine life	International Whaling Commission

Doument ID	Data	Title	Noted by
MEPC 73/18/4	Aug 17 2018	ANY OTHER BUSINESS Furthering international efforts to reduce the adverse impacts of underwater noise from commercial ships	Canada and New Zealand
MEPC 73/19	Oct 26 2018	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SEVENTY-THIRD SESSION	Secretariat
MEPC 73/INF.23	Aug 17 2018	ANY OTHER BUSINESS Scientific support for underwater noise effects on marine species and the importance of mitigation	Canada
MEPC 73/INF.26	Aug 17 2018	ANY OTHER BUSINESS Information related to OSPAR Commission's work on underwater noise	OSPAR Commission
MEPC 74/17/2	Mar 8 2019	ANY OTHER BUSINESS Advancing international collaboration for quiet ship design and technologies to protect the marine environment	Canada and France
MEPC 75/14	Dec 27 2019	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Proposal for a new output concerning a review of the 2014 Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (MEPC.1/Circ.833) and identification of next steps	Australia, Canada and United States
MEPC 75/14/1	Feb 7 2020	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Comments on document MEPC 75/14 – Proposal for a new output concerning a review of the 2014 Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (MEPC.1/Circ.833) and identification of next steps	FOEI, WWF, IFAW, Pacific Environment and CSC
MEPC 75/14/3	Feb 7 2020	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Comments on document MEPC 75/14 and information on the WMU and Schlüter-Foundation International Symposium on Anthropogenic Underwater Noise	World Maritime University

Doument ID	Data	Title	Noted by
MEPC 76/12/1	Apr 21 2021	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Comments on document MEPC 75/14 – Proposal for a new output on underwater noise	Advisory Committee on Protection of the Sea
MEPC 76/12/2	Apr 21 2021	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Comments on document MEPC 75/14 – Proposal for a new output concerning a review of the 2014 Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (MEPC.1/Circ.833) and identification of next steps	Germany and WWF
MEPC 76/15	Jul 12 2021	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SEVENTY-SIXTH SESSION	Secretariat
MEPC 78/17	Jun 24 2022	REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS SEVENTY-EIGHTH SESSION	Secretariat
SDC 8/14	Oct 1 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Outcome of MEPC 76 on the review of MEPC.1/Circ.833	Secretariat
SDC 8/14/1	Oct 14 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Scoping document on Underwater Noise from Commercial Shipping	Canada, New Zealand, United Kingdom and United States
SDC 8/14/2	Oct 15 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Compendium on Underwater Noise from Commercial Shipping	Canada, New Zealand, United Kingdom and United States

Doument ID	Data	Tittle	Noted by
SDC 8/14/3	Nov 9 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Proposal on approach to the review of the 2014 Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (MEPC.1/Circ.833)	Japan
SDC 8/14/4	Nov 9 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/Circ.833) AND IDENTIFICATION OF NEXT STEPS Provisional Work plan	Canada
SDC 8/14/5	Nov 22 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on SDC 8/14 and SDC 8/14/1	International Whaling Commission
SDC 8/14/6	Nov 23 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on documents SDC 8/14 and SDC 8/14/1	FOEI, WWF, IFAW, Pacific Environment and CSC
SDC 8/14/7	Nov 26 2021	REVIEW OF GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on document SDC 8/14/1	New Zealand
SDC 8/14/8	Nov 26 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on document SDC 8/14/1	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands,

Doument ID	Data	Tiltle	Noted by
			Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and European Commission
SDC 8/14/9	Nov 26 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on SDC 8/14/1 and text proposal for review of the 2014 Guidelines	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and European Commission
SDC 8/14/10	Nov 26 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on documents SDC 8/14/1, SDC 8/14/2 and SDC 8/14/3	ACOPS
SDC 8/18	Feb 4 2022	REPORT TO THE MARITIME SAFETY COMMITTEE	Secretariat
SDC 8/INF.3	Nov 11 2021	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Recent French initiatives on the issue of anthropogenic underwater vessel noise and its impacts on marine life	France

Doument ID	Data	Tittle	Noted by
SDC 8/WP.8	Jan 20 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Report of the Working Group	Secretariat
SDC 9/5	Oct 21 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/Circ.833) AND IDENTIFICATION OF NEXT STEPS Report of the Correspondence Group	Canada
SDC 9/5/1	Nov 17 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE FROM COMMERCIAL SHIPPING TO ADDRESS ADVERSE IMPACTS ON MARINE LIFE (MEPC.1/Circ.833) AND IDENTIFICATION OF NEXT STEPS Provisional Workplan	Canada
SDC 9/5/2	Nov 30 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on document SDC 9/5 – Report of the Correspondence Group on the Review of the Underwater Noise Guidelines	Brazil
SDC 9/5/3	Dec 2 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on document SDC 9/5 – Report of the Correspondence Group on the Review of the Underwater Noise Guidelines	Inuit Circumpolar Council
SDC 9/5/4	Dec 2 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on the concept to manage the underwater radiated noise level of each ship proposed by the Correspondence Group on review of the Guidelines for the Reduction of Underwater Noise (MEPC.1/Circ.833)	Japan

Doument ID	Data	Tiltle	Noted by
SDC 9/5/5	Dec 2 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on the next steps proposed by the Correspondence Group on review of the Guidelines for the Reduction of Underwater Noise (MEPC.1/Circ.833)	Japan, Liberia and CLIA
SDC 9/5/6	Dec 2 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on document SDC 9/5	China
SDC 9/5/7	Dec 2 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments on documents SDC 9/5, SDC 9/INF.2 and SDC 9/5/1	FOEI, WWF, IFAW, Pacific Environment and CSC
SDC 9/16	Mar 13 2023	REPORT TO THE MARITIME SAFETY COMMITTEE	Secretariat
SDC 9/INF.2	Oct 21 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Comments received in the final round of consideration of the Correspondence Group on Review of the Underwater Noise Guidelines	Canada
SDC 9/INF.9	Nov 18 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/Circ.833) AND IDENTIFICATION OF NEXT STEPS Monitoring technology of underwater radiated noise from ships using onboard noise measurement	Republic of Korea
SDC 97INF.10	Nov 22 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Report on underwater sound measurements in Japan and discussion on estimating source levels of underwater radiated noise from a ship	Japan

Doument ID	Data	Tittle	Noted by
SDC 9/INF.11	Nov 18 2022	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/CIRC.833) AND IDENTIFICATION OF NEXT STEPS Study on comparison of operational and design approaches based on the relationship between Underwater Radiated Noise (URN) reduction measures and GHG emission	Japan
SDC 9/WP.3	Jan 26 2023	REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/Circ.833) AND IDENTIFICATION OF NEXT STEPS Report of the Working Group	Secretariat
MEPC 75/14	Dec 27 2019	WORK PROGRAMME OF THE COMMITTEE AND SUBSIDIARY BODIES Proposal for a new output concerning a review of the 2014 Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (MEPC.1/Circ.833) and identification of next steps	Australia, Canada and United States