URN Management and The Larger Framework

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1. Introduction

Underwater noise levels due to anthropogenic causes have increased rapidly in recent years due to increase in shipping and global sea-borne trade.

As per Schroder-Hinrichs et al, (2018) [1], world sea-borne trade will see an increase of 2.5% in the short term and an increase of 1.4% in the long term. Shipping will play an essential role in this rise leading to increased levels of noise pollution.

Underwater Radiated Noise (URN) is a growing cause of environmental and socio-economic concern (Vakili et al, (2019) [2]), however in sharp contrast to other marine pollutants it is generally intangible. Thus, while the other negative impacts of pollutants such as air or water emissions on oceans due to shipping is regulated or has concrete policies in place, there is a lack of any such framework in case of URN. The primary reason behind this might be the lack of knowledge and research containing scientific data establishing the ill-effects of underwater radiated noise and the uncertainty around the cost effectiveness and efficiency of management techniques. There is also the absence of standardised methods for measurement of underwater radiated noise and lack of noise emission targets for shipping vessels, which hinder the formation of appropriate policy framework. Scientific uncertainties and ways to remedy them must also be considered.

2. Impact of URN and Need for URN Management

Shipping is the primary cause of underwater radiated noise. The underwater noise levels in some areas have nearly doubled every decade (Andrew et al, (2002) [3]) over the past 60 years and this is directly proportional with the Gross Domestic Product (GDP) of the nation. As per G.V. Frisk (2012) [4], the relationship between change in underwater noise levels and amount of shipping is:

$$\Delta NL\,(\mathrm{dB}) = 20\,\mathrm{Log}_{10}\left[\frac{\text{Final Gross Tonnage}}{\text{Initial Gross Tonnage}}\right].$$

A number of researchers have already analysed the adverse impacts of URN of fish, marine mammals, and other invertebrates. Many of these creatures use soundwaves to perceive their surroundings, hunt and communicate. Elevated levels of underwater noise hampers this and leads to 'Acoustic Degradation' of their habitats, and acoustic masking of the signals they use to communicate (Erbe et al, (2019) [5]). As per Weilgart et al, (2018) [6], underwater noise pollution effects over sixty-six species of fish, almost all marine mammals and thirty-six species of invertebrates and can severely hamper intraspecies and interspecies interactions.

As per Southall et al, (2017) [7], majority of the noise from shipping is low frequency. *Fig. 1* shows how the noise from various anthropogenic sources coincides with the hearing of fishes. Marine mammals such as dolphins and whales, on the other hand use high frequency sounds to hunt, navigate and communicate. URN interferes with these sound waves leading to changes in behaviour, reproductive pattern and rate, stunted growth, and reduced immunity (Karsalo et al, (2017) [8]) (Stanley et al, (2017) [9]).

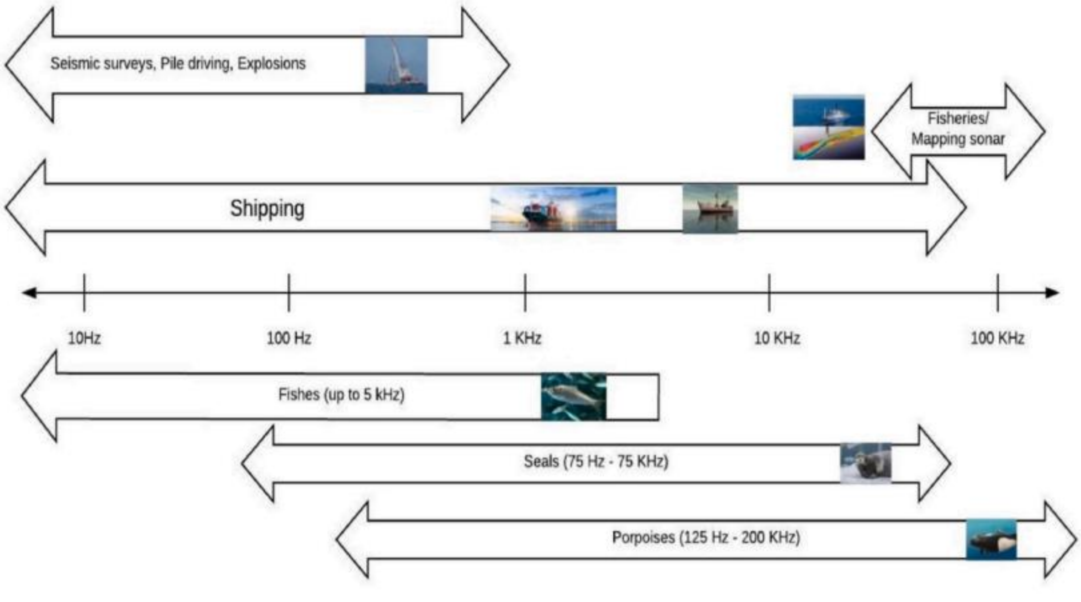

Fig 1: Anthropogenic sound frequencies with auditory range of some marine species

Moreover, as per Vakili et al, (2018) [10], URN also threatens sustainable development and has adverse socio-economic impacts. It can negatively impact fishing and marine tourism industries thus threatening food and job security and hampering economic growth. These negative impacts will become increasingly prevalent as India looks to capitalise more on its marine resources. This socio-economic factor is very crucial and thus policy making towards URN management is of utmost importance.

3. Barriers and Limitations

Shipping systems are very complex where several different stakeholders are involved, with ship owners being the most important stakeholders. One of the primary challenges of a policy framework would be getting all the stakeholders to comply with it. One way of doing it could be establishing regulations, which not only reduce the environmental impact and noise, but also lead to fuel and energy savings, which accounts for approximately 60% of operating costs of ships (Golias et al, (2009) [11]). As a result, ship-owners adopt these readily but show reluctancy for any such regulation which increases the operating costs. Another cause of reluctancy is that underwater noise pollution is still not an integral part of compliance certificates for offshore industries and Pollution Under Control (PUC) certificates of ships and other marine vessels.

Even though many studies show the negative impact of URN on marine ecosystems, the topic still has knowledge gaps. There are also uncertainties about the effectiveness, efficiency, and cost aspects of present technologies. In a country like India, which is increasing focus and utilisation of its oceanic resources, underwater noise pollution is not at the top of the economic priority chart. Thus, in addition to policy formulation and framework establishment, more research is required to ascertain the cost effectiveness and efficiency of URN management technologies. Human Resource capacity and capability building is also another way to achieve this reduction in URN with existing infrastructure. Thus, a holistic approach is required to solve this issue in addition to an effective policy framework.

4. Stakeholders

The main stakeholder in this context is the government and its wings such as the Pollution Control Board and Coastal Authorities, who already have existing laws and regulations in place to control other forms of pollution such as air and water emissions, in which they have been largely successful. Due to the adverse effects of URN on marine wildlife, Wildlife Conservation Authorities also need to play a pivotal role in this.

Noise being a form of energy is in a different class compared to other material pollutants and this needs to be taken into account when establishing policies. Thus, the measurement, monitoring and management of noise requires new policies to be in place.

5. Policy Measures for abatement of URN

3.1. Methods of effective URN Management

It is necessary to take into account the methods and instruments that could aid in reduction of underwater noise from various sources, to develop a suitable policy framework. The methods can be classified into technical, operational, and economic, in addition to human resource skilling and capacity building.

3.1.1. Technical Methods

The sources of noise from commercial ships and vessels can be classified into propeller, machinery, and hull, according to Hildebrand et al, (2009) [12]. The primary way of reducing hull noise is an effective hull design. With a very low increase of roughly 1% in manufacturing cost, a noise reduction of 10 dB is possible, which increases to 20-40 dB with additional 10-15% building cost. Optimizing the design during manufacturing not only reduces the noise output but is also cost-effective and can save further modification costs.

The primary cause of noise from propeller is due to propeller cavitation producing about 80-85% of a ship's radiated noise, which can again be solved by design modifications during the manufacturing stage. Additionally, newer technologies like Air Bubble System and advanced propeller designs like Contracted Load Tip Propeller, high skew propeller, mewis duct and propeller boss cap fin are also effective at reducing underwater noise emissions.

Noise from machinery is mainly prevalent at less than Cavitation Inception Speed (CIS) and has a frequency of less 100 Hz. It can be mitigated by proper choice and design of machinery, acoustic enclosures, dampening tiles and structurally strong mounts.

Newer technological advancements that can be used are hybrid engines along with different types of fuels such as LNG, which are shown to reduce noise. However, cost becomes the main limiting factor in this regard.

3.1.2. Operational Methods

The changes in operational procedures have a significant effect on reduction of noise for both new and existing ships. This is also the sector where upskilling and capability building of the human resource and capacity building comes into play.

Efficient route planning and optimised navigation techniques reduce underwater noise and also aid in fuel savings. The main source of noise from a ship are cavitation and noise from machinery, both of which depend on the load on the engine. The staff can be trained to optimize routes using tides and ocean currents and thus reduce the load on the engine.

Regular maintenance also plays a crucial role in reducing vibrations, efficient fuel consumption and noise mitigation. Fouling of the ship’s propeller leads to increased cavitation and resistance thus increasing fuel consumption, operating cost, and underwater noise.

Moreover, the routes can be adjusted in such a way that they do not pass through sensitive marine habitats and avoid certain regions of the ocean during the mating and breeding season of marine mammals and fishes. Temporary restrictions can be put on shipping routes (e.g., restricting shipping in or near fish spawning grounds during the spawning season).

In terms of management options, speed limits are capable of reducing noise effectively as an operational change, rather than going for design improvements, additional structures, or maintenance. Most ships were shown to reduce their radiated noise by 1dB when they slowed down by just 1 knot. (Veirs et al, 2018 [13]).

3.1.3 Economic methods

Incentive schemes are shown to improve cooperation between regulatory bodies and different stakeholders. This encourages stakeholders to be flexible and come up with innovative ways to abide by a regulation (Peeters et al, (2018) [14]). Since URN management techniques are expensive, introducing various incentive schemes in the form of tax subsidies can encourage ship builders and owners to take steps to reduce underwater radiated noise. Many researchers believe that the polluter pays principle (polluter must pay for his generated footprint) must be considered as an effective way to manage underwater radiated noise. (European Union (2010) [15]).

Policy measures attempting to manage URN can be broadly sub-divided into command-and-control (CAC) regulations and incentive-based measures (IBM), (Perman et al, (2011) [16]).

CAC approaches enforce mandatory regulations on shipping, either through predetermined technologies, limiting the noise level per activity, or limiting the amount of shipping (Cole and Grossman, (1999) [17]).

IBMs, by contrast, offer some economic incentives, which encourage URN management through subsidies or tax reductions linked to emissions. In order be effective, however, taxes and subsidies must provide sufficient economic benefits to influence the behaviour of primary stakeholders such as shipbuilders and ship-owners, and the specific application of IBMs in general, must be carefully analysed for each specific environmental context. For example, even for the same level of noise emission or the same type of vessel, risk factor can be different depending on the location and time of the emission (Chou et al, (2021) [18]).

6. Capacity and Capability Building

In the recent times, substantial research has been done to develop technologies and operational procedures to reducing the emission of underwater noise from ships and other vessels communication, knowledge and data sharing among stakeholders is still underway, especially among the shipowners and yards (Merchant (2018) [19]). To ease this process, a Data Pool of Information can be developed as a way of interaction between key stakeholders to share and synchronize their efforts to develop technologies and undertake measures to manage underwater radiated noise from shipping. This will lead to the creation of a human and technological network that will serve as a medium to exchange, integrate and broadcast information aiding in underwater noise management.

Researchers believe that this will lead to the formation of a state-of-the-art quiet ship design guideline for ship builders, owners, operators, and shipyards to undertake noise management measures, and assist in improving the technological aspect of vessel design. By developing algorithms, software, and underwater radiated noise computational models is for both new and existing ships, stakeholders can ascertain the effectiveness of the proposed technologies and methods (IMO, MEPC (2019) [20]).

After evaluating the efficiency and cost-effectiveness of reduction measures and technological interventions, a Code on management of underwater radiated noise for ships and vessels can be developed. This Code can guide administrators, ship owners and operators on principles of design and operation to effectively manage URN. Its aim is to encourage stakeholders to prevent, control, monitor, and manage underwater radiated noise. This regulatory document can provide a set of ship-based noise limits, which could be phased in and implemented over time. The introduced technologies and policies should be implemented cautiously so that they do not lead to other types of issues. Hence the effectiveness of the technologies and their efficiency would be enhanced, by considering multidimensional measures.

Education and training of operators and associated personnel, both onshore and offshore also plays a crucial role in the management of URN. Provisions can be made to raise awareness and provide appropriate technical and operational training to seafarers, especially masters, officers, engineers, and managers regarding effective management of underwater noise pollution from ships (Vakili et al, (2020) [21]).

7. Research Direction

Due to shipping growth driven by the India's increasing GDP and increased utilisation of India's water resources, Underwater Radiated Noise will increase if appropriate action is not taken at the right time. The main issues here are the lack of research and the absence of a uniform and legally binding control instrument for all the parties. The policy approach to tackle URN pollution at national level must target three dimensions; technical, operational, and economic. In order to tackle URN pollution, it is crucial to address the trade-off between the three pillars of sustainable development (Social, Economic, and Environmental). Single dimensional thinking should be replaced with multi-dimensional thinking.

Furthermore, it is critical to examine and evaluate the socioeconomic effects of higher levels of underwater radiated noise. Since, enhancing energy efficiency is one of the shipping industry's key priorities, it is important to relate underwater radiated noise mitigation efforts to energy efficiency requirements such as the Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP). This method may pique the interest of stakeholders and shipbuilders to address the issue. For any additional action or policy decision making to monitor, analyse and manage underwater radiated noise from shipping, extensive research on the impacts of URN and a multi-disciplinary command and control system along with incentive-based measures and the implementation of the "polluter pays" principle is required.

References

1. J.U. Schroder-Hinrichs, D.W. Song, T. Fonseca, K. Lagdami, X. Shi, K. Loer, Transport 2040: Automation, Technology, Employment-The Future of Work, 2018.

2. S. Vakili, A.I. Olcer, F. Ballini, The trade-off analysis for the mitigation of underwater noise pollution from commercial vessels: case study–Trans Mountain project, Port of Vancouver, Canada, in: Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, 2019.

3. R.K. Andrew, B.M. Howe, J.A. Mercer, M.A. Dzieciuch, Ocean ambient sound: comparing the 1960s with the 1990s for a receiver off the California coast, Acoust Res. Lett. Online 3 (2) (2002) 65–70.

4. Frisk, George. (2012). Noiseonomics: The relationship between ambient noise levels in the sea and global economic trends. Scientific reports. 2. 437.

5. Erbe, C., Marley, S. A., Schoeman, R. P., Smith, J. N., Trigg, L. E., & Embling, C. B. (2019). The effects of ship noise on marine mammals—a review. Frontiers in Marine Science, 6, 606.

6. L.I.N.D.Y. Weilgart, The Impact of Ocean Noise Pollution on Fish and Invertebrates, Report for OceanCare, Switzerland, 2018. https://www.oceancare.org/wp-content/uploads/2017/10/OceanNoise_FishInvertebrates_May2018. pdf.

7. B.L. Southall, A.R. Scholik-Schlomer, L. Hatch, T. Bergmann, M. Jasny, K. Metcalf, A.J. Wright, Underwater noise from large commercial ships—international collaboration for noise reduction, Encyclo. Maritime and Offshore Eng. (2017) 1–9.

8. I. Karasalo, M. Ostberg, € P. Sigray, J.-P. Jalkanen, L. Johansson, M. Liefvendahl, R. Bensow, Estimates of source spectra of 6 (6) ships from long term recordings in the baltic sea, Front. Mar. Sci. 4 (164) (2017)

9. J.A. Stanley, S.M. Van Parijs, L.T. Hatch, Underwater sound from vessel traffic reduces the effective communication range in Atlantic cod and haddock, Sci. Rep. 7 (1) (2017)

10. S. Vakili, Under-water Noise Pollution Sources, Mitigation Measures in Commercial Vessels: The Trade-Off Analysis in the Case of Study for Tran's Mountain Project, 2018. Port of Vancouver, Canada.

11. G.K. Golias, Saharidis, M. Boile, S. Theofanis, M.G. Ierapetritou, The Berth Allocation Problem: Optimizing Vessel Arrival Time Marit Econ Logist, 2009, pp. 358–377.

12. J.A. Hildebrand, Anthropogenic and natural sources of ambient noise in the ocean, Mar. Ecol. Prog. Ser. 395 (2009) 5–20.

13. Veirs, Scott & Veirs, Val & Williams, Rob & Jasny, Michael & Wood, Jason. (2018). A key to quieter seas: half of ship noise comes from 15% of the fleet A key to quieter seas: half of ship noise comes from 15% of the fleet.

14. C. Peeters, R. Pilon, A new relationship between government, industry and knowledge institutes, the case of the maritime sector, in: SHS Web of Conferences, vol. 58, EDP Sciences, 2018, 01023.

15. European Union, Consolidated versions of the treaty on European union and the treaty on the functioning of the European union, Off. J. Eur. Union 53 (2010) 13.

16. Perman, R., Ma, Y., Common, M., Maddison, D., McGilvray, J., 2011. Natural Resource and Environmental Economics, 4th ed. Pearson, UK.

17. Cole, D.H., Grossman, P.Z., 1999. When is command-and-control efficient? institutions, technology, and the comparative efficiency of alternative regulatory regimes for environmental protection. Wis. L. Rev. 5, 887–938.

18. Chou, E., Southall, B. L., Robards, M., & Rosenbaum, H. C. (2021). International policy, recommendations, actions and mitigation efforts of anthropogenic underwater noise. Ocean & Coastal Management, 202, 105427.

19. Merchant, N. D. (2019). Underwater noise abatement: Economic factors and policy options. Environmental science & policy, 92, 116-123.

20. International Maritime Organization (IMO) Maritime Environment Protection Committee (MEPC), Quieting Ships to Protect the Marine Environment Workshop Summary Report Submitted by Canada (MEPC 74/17/2), 2019.

21. S.V. Vakili, A.I. Ölcer, F. Ballini, The development of a policy framework to mitigate underwater noise pollution from commercial vessels, Marine Policy, Volume 118, 2020, 104004, ISSN 0308-597X, https://doi.org/10.1016/j.marpol.2020.104004.

22. Kumar, G. P., Prasad, V. V. S., & Ramesh, U. S. (2021). Underwater noise levels in Indian waters off the coast of Mormugao Port. *Journal of Operational Oceanography*, *14*(1), 48-58.

23. Spence, J. H. (2007). A summary of existing and future potential treatments for reducing underwater sounds from Oil and Gas industry Activities. In OCEANS 2007 (pp. 1-15). IEEE.

24. Das, A. (2019). Underwater radiated noise: A new perspective in the Indian Ocean region. Maritime Affairs: Journal of the National Maritime Foundation of India, 15(1), 65-77.

25. Erbe, C., Reichmuth, C., Cunningham, K., Lucke, K., & Dooling, R. (2016). Communication masking in marine mammals: A review and research strategy. Marine pollution bulletin, 103(1-2), 15-38.

26. J. H. Spence and R. W. Fischer, "Requirements for Reducing Underwater Noise from Ships," in IEEE Journal of Oceanic Engineering, vol. 42, no. 2, pp. 388-398, April 2017.