Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(2): 2301 – 2314 (2025)
www.ejabf.journals.ekb.eg

Evaluation of Underwater Noise Levels Caused by Ships Movement in the Kakinada Bay Area

Prasanna Kumar Pammi[1*], Pavan Kumar G.V.V[2], Prasad V.V.S[1]
[1]Andhra University
[2]Indian Maritime University
***Corresponding Author: pammi55@yahoo.com**

ARTICLE INFO
Article History:
Received: Dec. 5, 2024
Accepted: March 24, 2025
Online: April 15, 2025

Keywords:
Shipping traffic,
Underwater noise,
Mitigation means and awareness

ABSTRACT
With the increase in the number of ship operating in the oceans, shipping traffic is identified as a major contributor to the increase in the ocean noise levels. Shipping radiated noise have led to a longer term and broad scale effects with a concentration of sound generation in coastal areas and along wider shipping lanes. The primary noise sources from the ship are the propulsion system, operational machinery and the flow around the hull. This noise, often unintentional and unwanted, can have significant impacts on marine life, affecting communication, navigation, and behavior of marine species. With the current knowledge being limited in some areas, the issue became a major concern with studies focused on understanding the sources of noise, developing measurement techniques and exploring mitigation measures. In the present paper, efforts were exerted to evaluate the underwater noise levels due to various ship types movement within the Kakinada port waters which is also an important location near to coring wildlife sanctuary. The port facilitates various types of vessel operations including large cargo ships, barges and many fishing boats. The background underwater radiated noise (URN) levels measured were around 120-130 dB re 1μPa in the region. The vessel operation increased the URN by over 20-40 dB re 1μPa higher than the background noise levels. Mitigation means need more assessment of their effectiveness due to vast remaining uncertainties. In addition, a better standardization is required aligned with a more effective governance of the activities producing noise. One way is by increasing awareness of the issue by the decision-makers and implementing the underwater noise management plan to assist the authorities.

INTRODUCTION

Ports are gateways to international trade and commerce. Ports offer tremendous potential for development and growth of a wide spectrum of maritime activities such as shipping, ship repairs, fishing, captive ports for specific industries, tourism etc., along the coastline of the country. Andhra Pradesh with a coastline of 974km, the second largest in India, recognized the imperative need for modernized port infrastructure and initiated with 16 ports for development and put few in operation **(Kumar & Chandramohan, 2024)**. To conserve the valuable and fragile environment, Kakinada has undertaken vigorous expansion programs to stay current with changing custom requirements and evolving industry standards. Kakinada has three ports operating such as Kakinada Deep Water Port (KDWP), Kakinada Anchorage Port and Kakinada SEZ Port. Kakinada possesses a good port connectivity with road, rail, air and pipeline.

1.1 Kakinada deep water port (KDWP)

The port came into operation in 1999, with seven berths, year-round channel depth of 14.5m. Kakinada forms the main gateway port for the rich agricultural belt of East Godavari, West Godavari, Krishna districts of Andhra Pradesh and for the entire state of Telangana.

1.2 Kakinada anchorage port

The port has a century old history, set up as a key facility on the eastern seaboard and in an all-weather port naturally protected by 17km length of Hope Island. The cargo handling capacity of the port is about 4MT. The commodities of exports include maize, rice, cement etc. The port limit extends upto 1.5km on all four ends.

1.3 Kakinada SEZ port

SEZ gateway port is about 30km away from KDWP; it was privatized to Kakinada SEZ for development under the PPP mode.

1.4 Initiatives to convert Kakinada port into Green port

There have been lots of efforts in India to set up an environmental framework and to move toward the idea of "GREEN PORTS/ECO FRIENDLY PORTS". While ports and their associated activities drive economic growth, it is important for port authorities and states to actually work on minimizing pollution levels and environmental changes. Some key areas are air quality, water quality, habitat degradation and marine pollution and underwater noise radiated due to shipping traffic in the port region.

Weighing to the environmental perspective for sustained growth and though Kakinada is not a major port, there is an immediate need to put up the idea of "Green Port". The Kakinada sea ports are located in the fragile area where three categories of ecosystems (Marine, Riverine and Estuarine ecosystems) existing in area of influence and the ports located near to the eco-sensitive areas i.e. Coringa Wildlife Sanctuary, Sand pit Hope Island andPport of the Kakinada Bay **(Adari & Surisetti, 2023)**. One such area of interest and very important in the present day is the underwater noise levels of the region and influence due to the port activities mainly shipping movement in the Bay region **(Rajyalakshmi *et al.*, 1986)**.

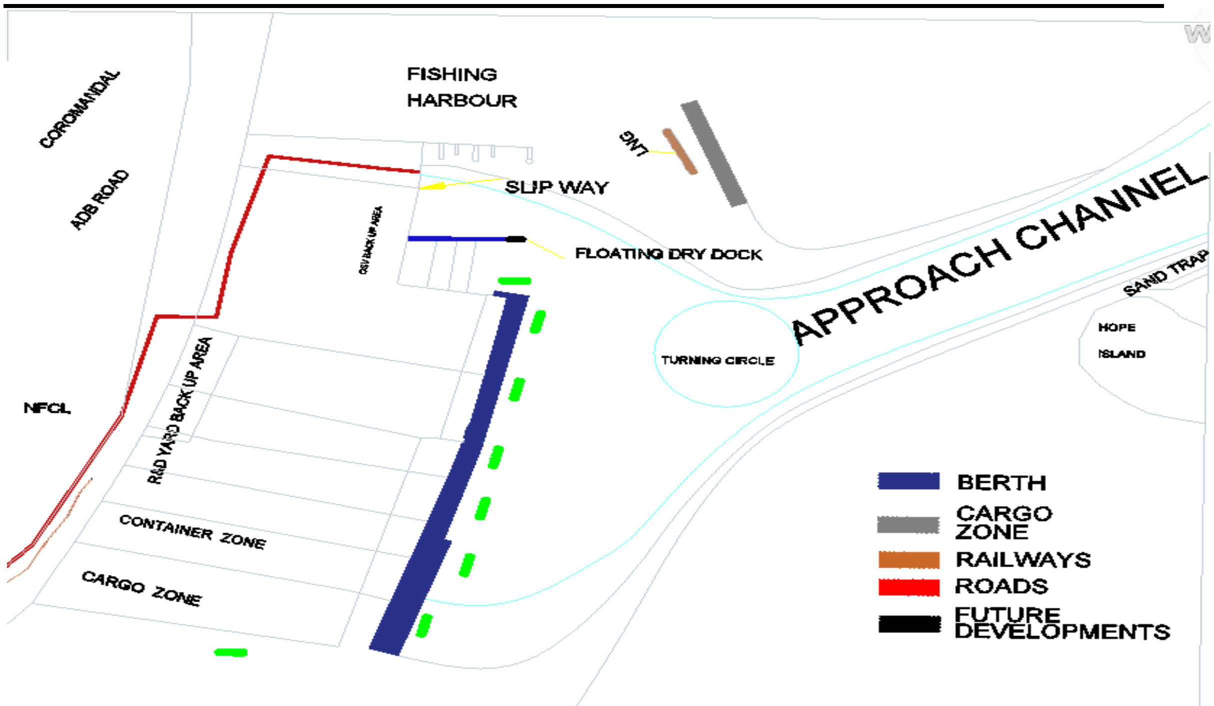

Fig. Error! No text of specified style in document.**.** Kakinada Port limits layout

Increased underwater sound from anthropogenic activities include the vessel movement, trawling gear, dredging, piling, etc. Ship movements are responsible for the continual and steady rise of URN levels at the low frequency (10-100 Hz) in many regions at a rate as high as 3dB/decade **(Erbe *et al.,* 2016)**. The increase in underwater sound is primarily attributed to fishing vessels, recreational boating, and higher volumes of commercial shipping activity **(Erbe *et al.,* 2019)**. International Maritime Organization (IMO) has addressed the adverse impact of ship radiated noise on marine life. The revised guidelines issued by the Marine Environment Protection Committee (MEPC 80) in 2023 **(IMO, 2023)** provide an overview of approaches applicable to designers, shipbuilders, and ship operators for reducing the underwater radiated noise of ships. Additionally, the guidelines aim to support relevant stakeholders in establishing mechanisms and programs to implement noise reduction efforts—such as through the development of an Underwater Noise Management Plan. Underwater noise pollution is not at the top of the economic priority chart of the developing countries. The policy formulation and framework establishment should be efficient and effective toward underwater radiated noise reduction technologies **(Merchant *et al.,* 2012)**. One way to achieve the reduction in emissions of underwater noise from ship is developing data pool of information of shipping traffic in relation to the underwater radiated noise levels on the port regions. Ports are hubs essential for carrying out logistic and industrial activities with global supply chains. Considering the rising port activities and a long term prediction of stable growth of the shipping industry, environmental issues are becoming more significant. The rise in port traffic on a global scale will certainly coincide with an increase in environmental noise emission, especially in the near shore area like port regions. The Automatic Identification System (AIS) data have been used in various noise studies. This will help mostly to identify the vessel information like position, speed, etc. ***(Kumar et al.*, 2020)**. The source modelling efforts shall provide insight on the shipping noise by correlating with the underwater radiated noise measurements. The method to estimate shipping URN of a region has helped identify the high shipping noise regions. Variations in the URN levels that was found by various researchers is primarily related to the density of vessels movement, but the new regulatory measures and technology improvements have paved way to quieten the water in some regions.

Given the increasing trend in ship traffic—both from commercial shipping and fishing vessels—in the Kakinada Bay region, it is likely that underwater radiated noise (URN) will continue to rise, potentially emerging as a significant environmental concern in the future. It is necessary that background studies on the underwater noise emissions from shipping is carried out by field measurements, which wiould help assess the underwater noise levels of the region. Even a wide scale monitoring on routine basis will be of great benefit on the long-term. Vessel underwater radiated noise decreases with vessel speed, which can be suggested as one of the means for noise reduction, fuel consumption and emissions **(Gassmann *et al.*, 2017)**. The aim of the this paper was to provide a view on the current underwater radiated noise levels from ships movement in the Kakinada bay region. Long term measurements shall help to analyze traffic pattern changes and ship type contours contributing to the underwater noise levels. The present study aimed to support future research on the impacts of underwater radiated noise in this ecologically sensitive region. The objectives were focused to raise awareness among stakeholders and assist authorities in planning appropriate regulatory measures for the implementation of relevant guidelines by vessel operators. Potential mitigation strategies may include retrofitting schedules, reduced vessel speeds, management of shipping traffic density, re-routing, and optimized scheduling—practices that have already been adopted in several developed countries through regulatory frameworks.

DATA COLLECTION

The purpose of this study was as follows (a) to classify the underwater noise sources in the port region, (b) to provide an overview of the strategic noise distribution, and (c) to analyze the social and environmental damage generated in the area.

The specific location and, in particular, the geographical configuration of the port contribute to the complexity of underwater noise propagation. It is important to note that the Kakinada Deep-Water Port (KDWP) is bordered by the mainland coastline to the west and Hope Island to the east. This unique setting concentrates major shipping activities within the KDWP and the Anchorage Port, as illustrated in Fig. (1): Kakinada Port Limits Layout. Due to ongoing cargo operations in the anchorage region, there is continuous shipping traffic involving workboats towing barges to larger vessels anchored offshore, as shown in Fig. (2). These activities occur along the designated commercial channel. Additionally, the area serves as a natural hub for fishing, with numerous fishing vessels operating regularly. Larger vessels, with capacities of up to 40,000 DWT, are towed by tugboats to the deep-water port area. The measurement system employed in this study consists of a hydrophone system deployed at various locations, as indicated in Fig. (3): *Kakinada Port Limits & Vessel Locations During Measurements*. The hydrophone was deployed using a survey boat, with the engine turned off during the measurement period to minimize self-noise. The hydrophone is an omnidirectional sensor designed for frequencies below 10 kHz and features a streamlined shape that allows it to be towed behind a boat with minimal flow-induced noise, thereby enhancing underwater acoustic performance. A PCM recorder was used for data acquisition, interfaced with the hydrophone, and the recorded data were later processed using specialized software for post-analysis.

2.1 Underwater noise sources

The URN sources can be primarily categorized as shipping traffic and port activities on the landside. These categories reflect the wide aspects of activities in ports, such as noise generated during operation of handling systems, cargo loading/unloading, and machinery in use of ships at jetty **(Kumar & Chandramohan, 2024)**. In the study region, underwater radiated noise (URN) from shipping traffic primarily originates from propeller activity, onboard machinery, and water flow around the vessel hull. The most frequently operating vessel types include workboats, fishing vessels, and barges. Additional noise sources arise from generators used on ships during cargo operations at both the anchorage and the deep-water port. The collected data provides a comparison with ambient noise levels, highlighting the increase in URN due to intensified shipping activities. Establishing a comprehensive noise database is essential, as it will aid in identifying critical areas for monitoring and management.

2.2 Vessel type operating in the port vicinity

Kakinada port has consistently embraced modern practices, systems, and technologies in port management, positioning itself as a dynamic, multi-product port capable of handling liquid, bulk, and break-bulk cargo, along with various types of vessels and crafts, as summarized in Table (1). The port’s berthing facilities can accommodate vessels up to 295 meters in length, 45 meters in beam, and a draft of up to 14 meters during high tide **(Rajyalakshmi *et al.*, 1986)**.

Anchorage port operations were carried out using steel dumb barges with capacities ranging from 500 to 1,000 tonnes, towed by workboats approximately 12 meters in length and powered by 99 bhp engines. For barges exceeding 550 tonnes, two workboats were typically employed to tow the barge to anchorage vessels, covering a maximum distance of 4 nautical miles at an average towing speed of 1.5 knots.

Additionally, the region supports a large number of fishing boats, typically 5 to 6 meters in length. Most of these were traditional country crafts equipped with outboard motors featuring 10-inch diameter propellers and 20 bhp engines.

Table 1. Different types of crafts/vessels located at Kakinada port area

No.	Vessel type	Location	Size	Ship movement per day
1	Larger vessel upto 40000 DWT	Deep water port	Length 170-230 m around	1
2	Vessels up to DWT	Anchorage port	Length	<1
3	Barges 1000 DWT	Commercial channel;	Length 70-80m	10
4	Workboats	Commercial channel;	Length 12m	15
5	Fishing boats			30

Fig. 1. Barge passing through commercial channel

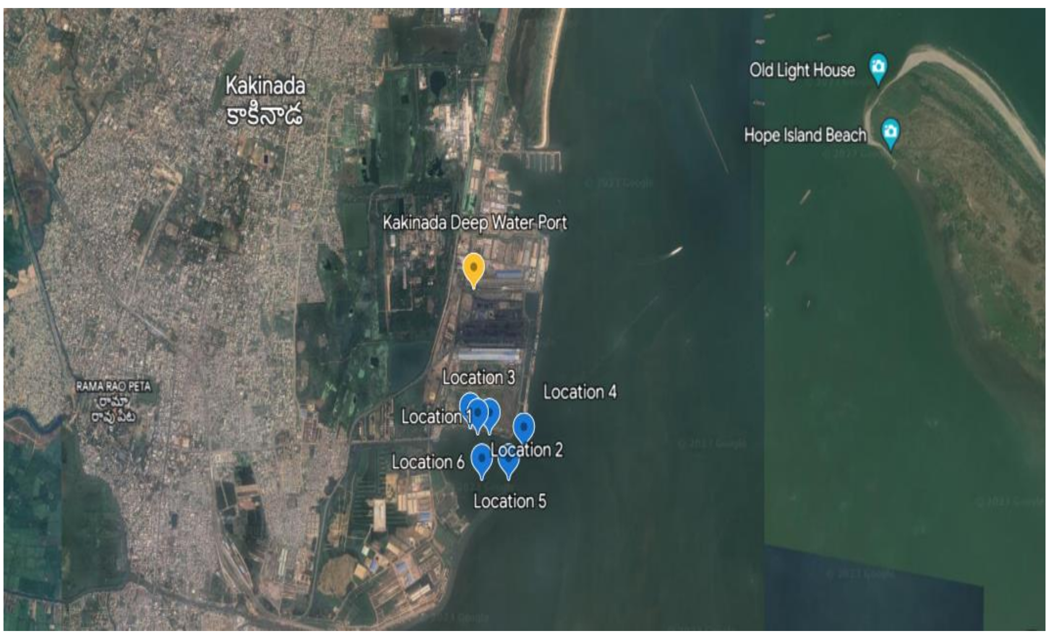

Fig. 3. Kakinada Port limits & location of vessel when readings were taken (hydrophone deployed)

RESULTS AND DISCUSSIONS

The underwater noise recorded during the barge movement across the hydrophone deployment indicated disturbance in the lower frequency zone i.e. < 100Hz, as shown in

Fig. 5. Barge radiated underwater noise spectrogram. It is clear that the barge radiated noise levels are of SPL levels about 140 dB re 1µPa in the lower frequency, as shown in Fig. Error! No text of specified style in **document.**. **Barge radiated underwater noise spectrum**. The other peak observed was at 250Hz with SPL of 115 dB re 1µPa during the vessel movement.

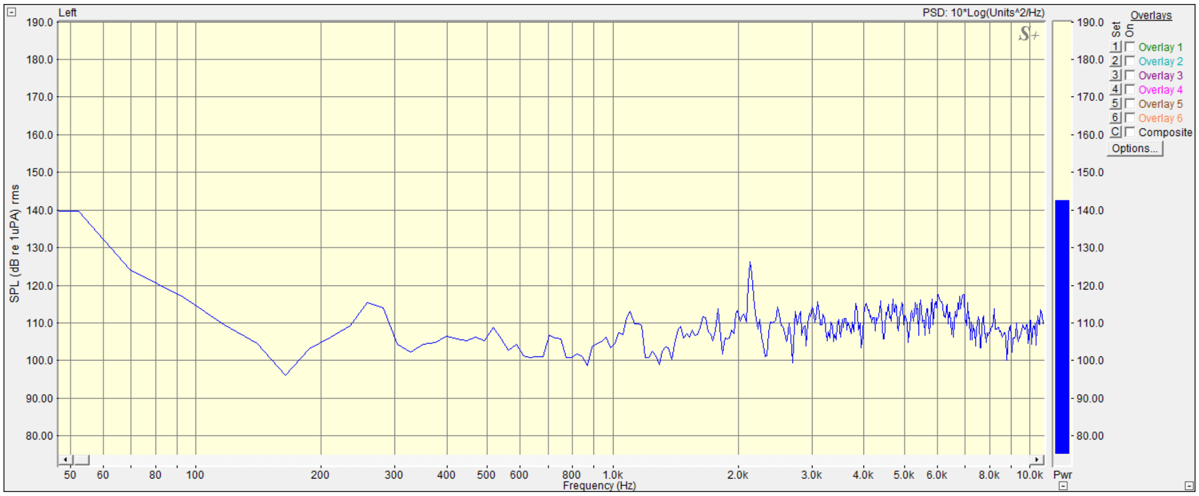

Fig. Error! No text of specified style in document.**.** Barge radiated underwater noise spectrum

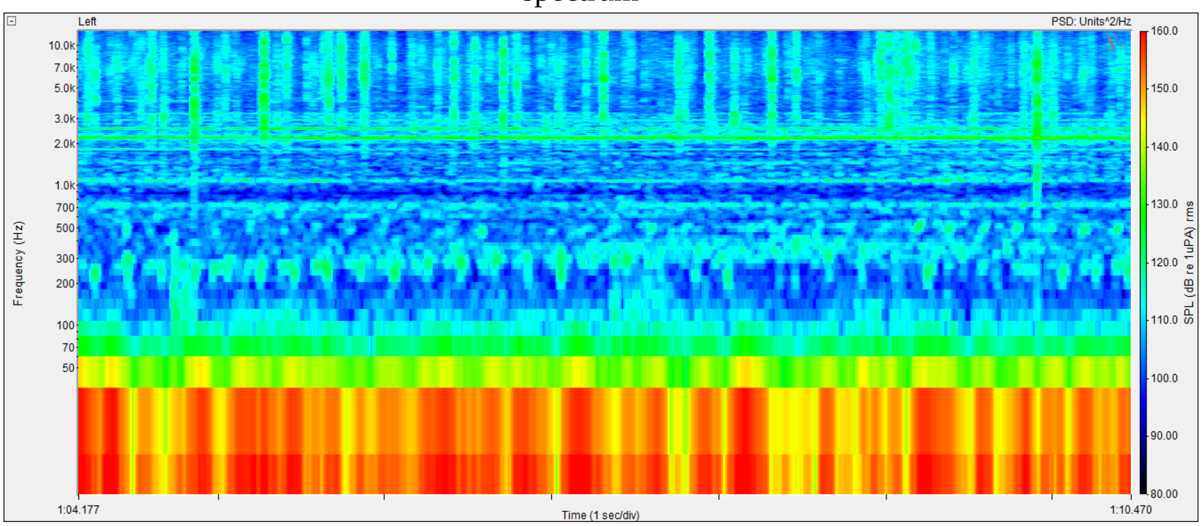

Fig. 5. Barge radiated underwater noise spectrogram

Underwater noise measurements of a 25,000 DWT bulk carrier during jetty conditions—with auxiliary generators in operation—recorded a sound pressure level (SPL) of 120 dB re 1 µPa at a frequency of 180 Hz. The generators used were six-cylinder units operating at approximately 1800 rpm, as illustrated in Fig. (6): Underwater Noise Spectrum of Bulk Carrier Generators in Operation at Jetty Condition. The corresponding underwater noise spectrogram revealed that the peak SPL, radiated primarily by onboard machinery, was concentrated in the lower frequency range below 200 Hz, as shown in Fig. (7): Underwater Noise Spectrogram of Bulk Carrier Generators in Operation at Jetty Condition.

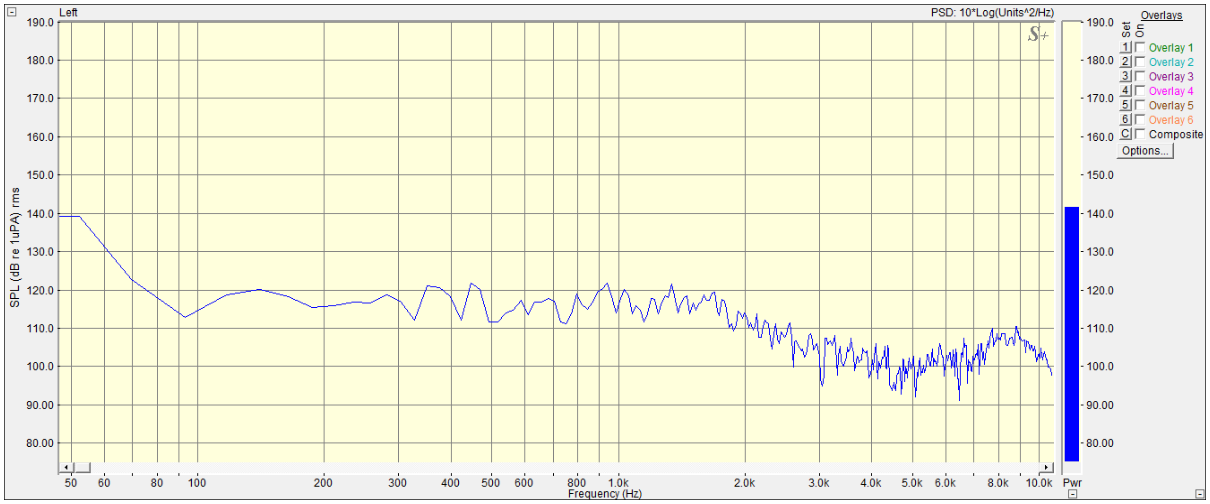

Fig. 6. Underwater noise spectrum of bulk carrier generators in operation at jetty condition

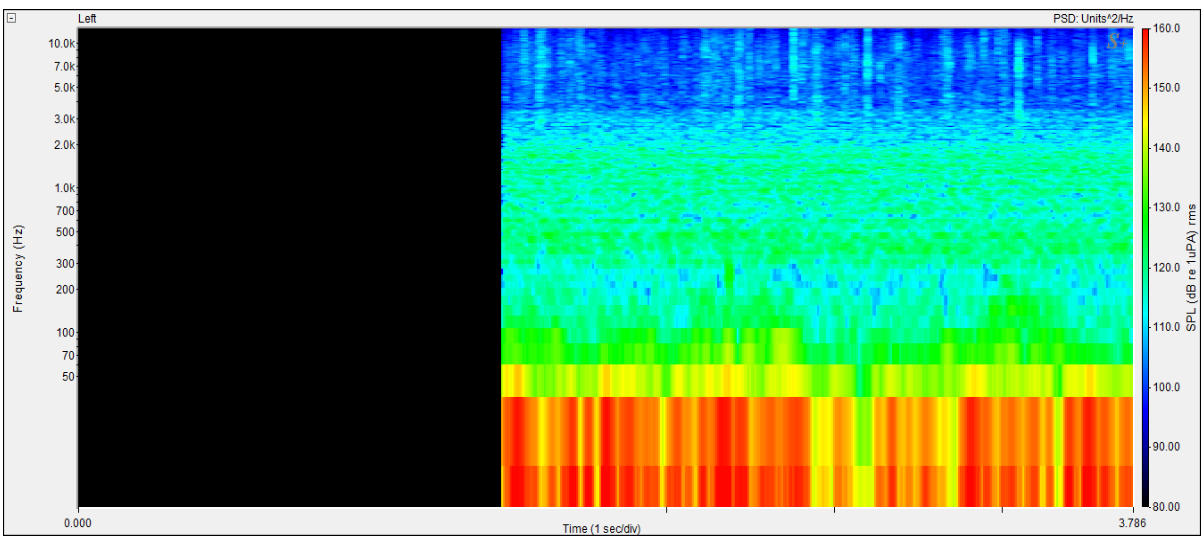

Fig. 7. Underwater noise spectrogram of bulk carrier generators in operation at jetty condition

Underwater noise measurements of an 81,000 DWT bulk carrier during jetty conditions—with auxiliary generators in operation—recorded a sound pressure level

(SPL) of 130 dB re 1 µPa at a frequency of 50 Hz, as shown in Fig. (8): Underwater Noise Spectrogram of Bulk Carrier Generators in Operation at Jetty Condition.

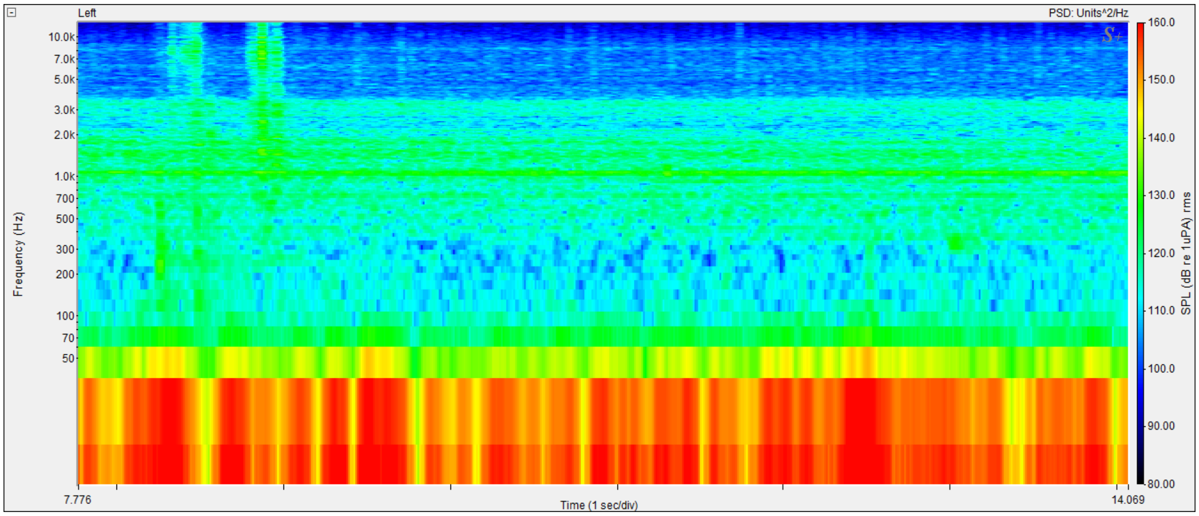

Fig. 8. Underwater noise spectrogram of bulk carrier generators in operation at jetty condition

A high speed craft of 40m length was passing the commercial channel out to the open sea during the measurement. The craft was operating at approx. 10 knots with twin FP propeller at 300rpm and main engine loaded to 30%. The underwater noise spectrum indicated the peak values of the propeller and machinery in the lower frequency range <500 Hz, as shown in Fig. 9. High speed craft spectrogram crossing the channel to open sea. The propeller measured 150-160 dB re 1µPa at 20 Hz and main engine SPL of 100 dB re 1µPa in the frequency range of 300-500 Hz, as shown in Fig. 10. High speed craft spectrum crossing the channel to open sea.

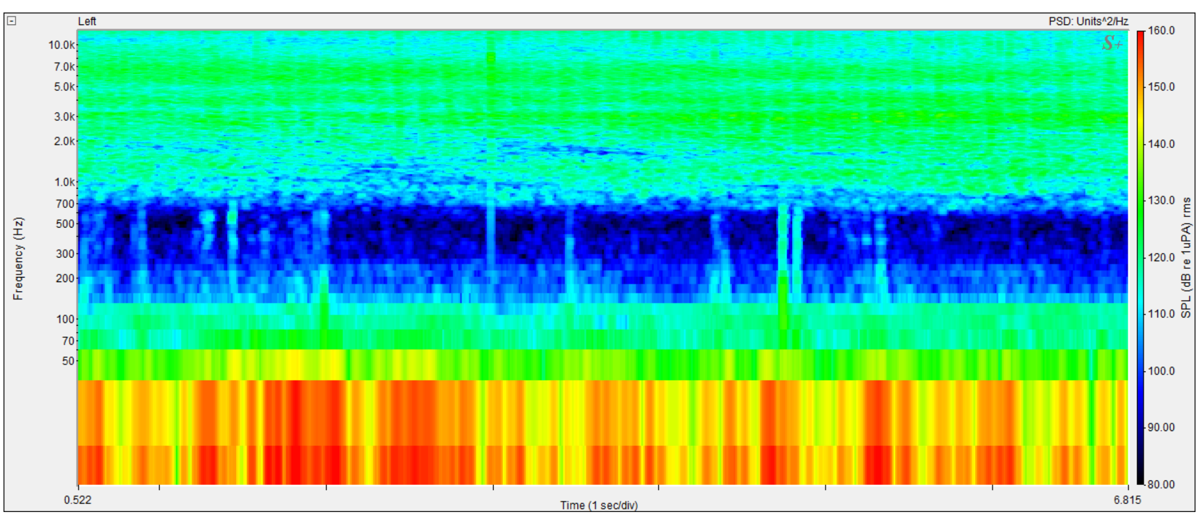

Fig. 9. High speed craft spectrogram crossing the channel to open sea

Fig. 10. High speed craft spectrum crossing the channel to open sea

Small fishing boats operating within the commercial channel—typically around 12 meters in length and powered by 20 bhp outboard engines—were found to produce underwater noise predominantly in the lower frequency range, with a recorded sound pressure level (SPL) of 160 dB re 1 µPa. The time-domain representation of the measured underwater radiated noise (URN) is presented in Fig. (11).

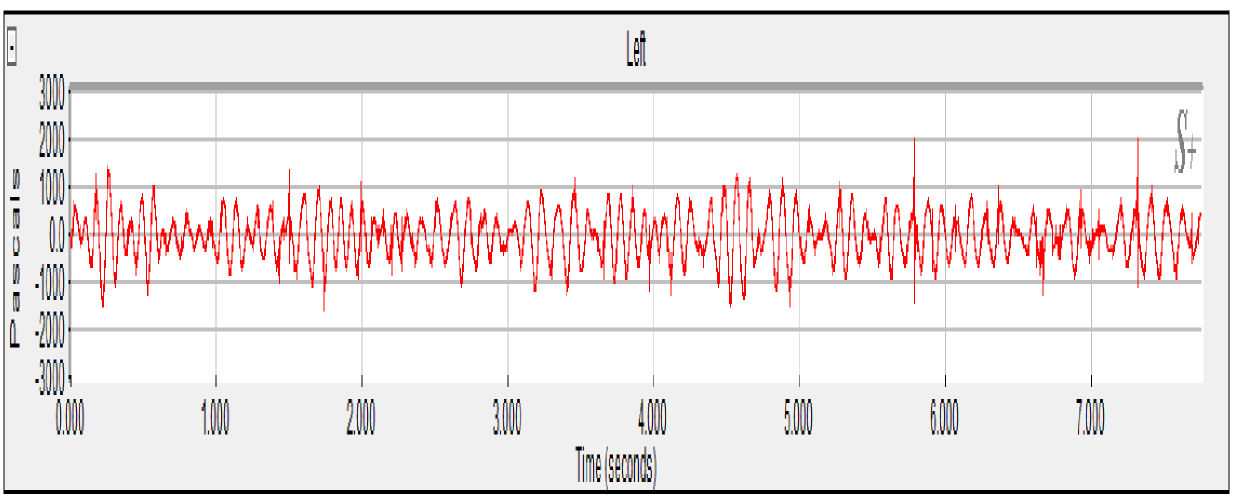

Fig. 11. 10 Small fishing boat spectrum crossing commercial channel

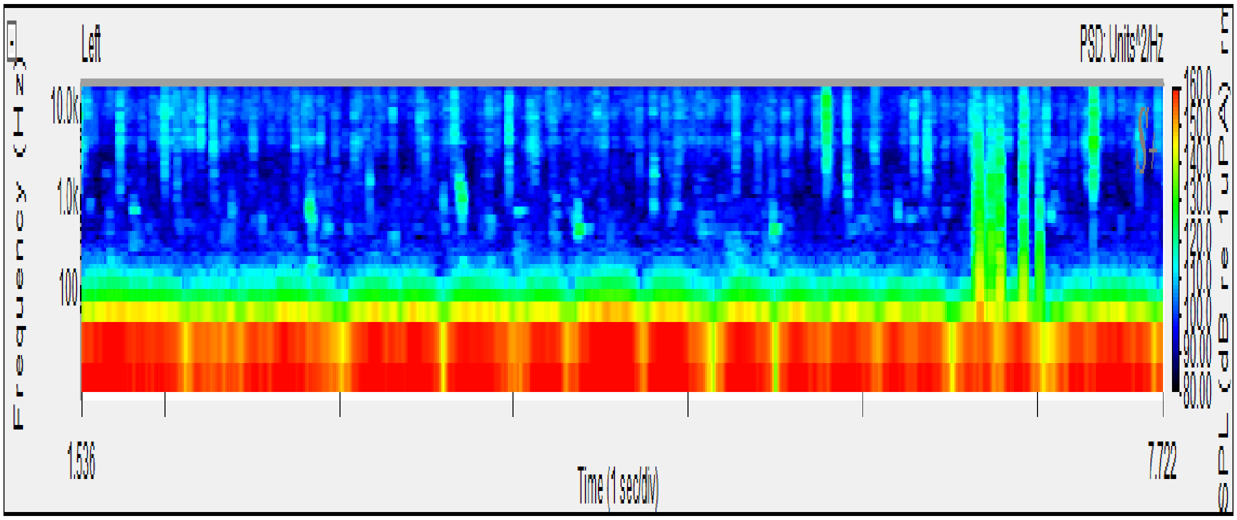

Fig. 12. 10 Small fishing boat spectrogram crossing commercial channel

The Kakinada channel and bay is a busy traffic zone with multi number of vessels operating on continuous basis, and attaining the clam condition was highly impossible. Therefore, the ambient URN levels measured in the channel and bay entrance indicate a SPL 120-130 dB re 1µPa, reflected in the spectrogram, as shown in Fig. (12).

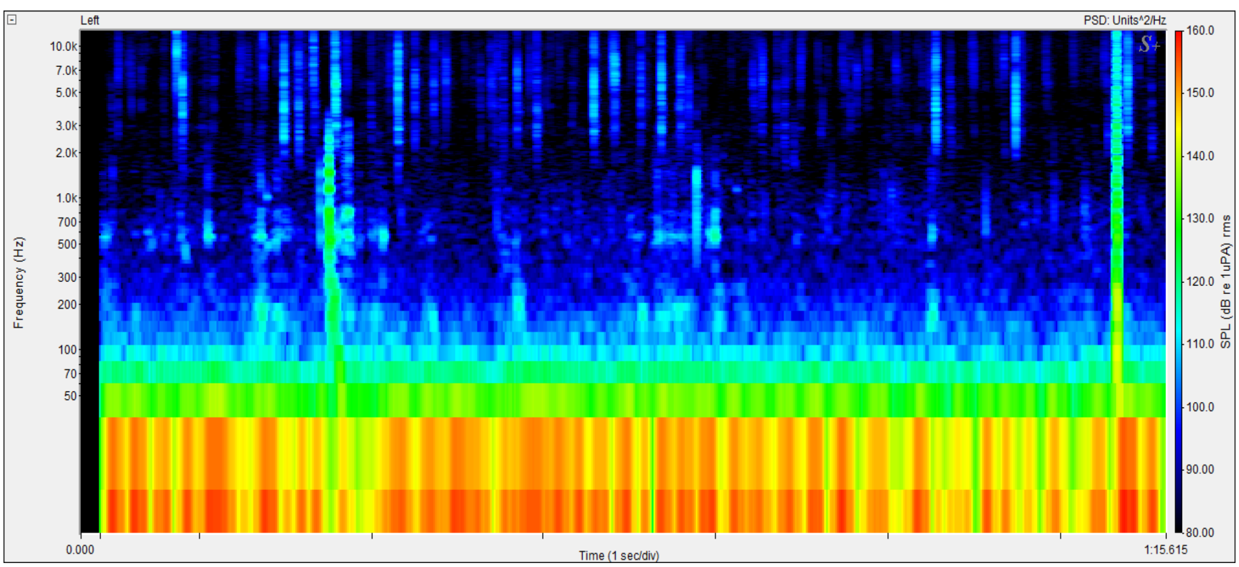

Fig. 13. Spectrogram of ambient under water radiated noise

CONCLUSION

The ambient underwater radiated noise (URN) conditions in the Kakinada port area, as illustrated in Fig. (13), reflect contributions from distant vessel operations and ongoing port handling activities, with sound pressure levels (SPL) ranging between 120 and 130 dB re 1 µPa. The port accommodates a wide range of vessel types and sizes, as listed in Table (2), which are actively engaged in cargo handling and operational movements. Measurements taken during jetty operations—particularly involving auxiliary machinery—show URN levels that closely align with ambient noise conditions, typically around 120–130 dB re 1 µPa.

In the anchorage port area, cargo movement is facilitated through the use of barges, towed by workboats. These operations have been observed to generate underwater noise levels approximately 20 dB re 1 µPa higher than ambient conditions, as seen in Fig. (4). Furthermore, regular vessel traffic in the commercial channel and Kakinada bay—particularly from high-speed craft (HSC) and fishing vessels—results in even greater noise levels, with increases of up to 40 dB re 1 µPa above ambient.

These findings are consistent with global assessments from organizations such as the International Maritime Organization (IMO) and other scientific bodies, which identify ship traffic as a significant contributor to rising background noise in marine environments. The data presented in this study confirm that vessel movement, whether from large ships or small crafts, exerts both localized and broad impacts on underwater acoustic conditions. The potential ecological consequences include acoustic masking, reduced hearing sensitivity, disruption of marine animal communication, and in severe cases, internal injury.

To address these challenges, there is a pressing need to reduce ship-radiated noise through improvements in vessel design, construction, and operational practices, in accordance with the latest IMO guidelines. Measures such as reduced speeds in sensitive areas, regular hull and machinery maintenance, and the use of non-cavitating propellers are practical and effective. In particular, the widespread use of outboard motors by fishing vessels operating near the surface has been identified as a major noise source. The application of a Kort nozzle around propellers could help reduce their URN by approximately 12%.

As Kakinada continues to grow as a major multi-terminal port, URN mitigation should be considered a key element in its pursuit of sustainable and environmentally responsible port management. This study, though limited in duration, underscores the importance of long-term, continuous monitoring. Such an approach would enable port authorities to take informed actions, define regulatory criteria, and position Kakinada as a model for acoustic sustainability—potentially becoming the first "Silent Port" in India.

REFERENCES

Adari, A. A., and Surisetti, R. B. (2023). Ecology and diversity of the mangroves on diverse waterways of Coringa Wildlife Sanctuary, India. *Journal of Aquatic Biology & Fisheries* |, *11*(1), 188–192. http://www.jabf.in/

Erbe, C.; Marley, S. A.; Schoeman, R. P.; Smith, J. N.; Trigg, L. E. and Embling, C. B. (2019). The Effects of Ship Noise on Marine Mammals—A Review. *Frontiers in Marine Science*, *6*(October). https://doi.org/10.3389/fmars.2019.00606

Erbe, C.; Reichmuth, C.; Cunningham, K. Lucke, K. and Dooling, R. (2016). Communication masking in marine mammals: A review and research strategy. *Marine Pollution Bulletin*, *103*(1–2), 15–38. https://doi.org/10.1016/j. marpolbul.2015.12.007

Gassmann, M.; Wiggins, S. M and Hildebrand, J. A. (2017). Deep-water measurements of container ship radiated noise signatures and directionality. *The Journal of the Acoustical Society of America*, *142*(3), 1563–1574. https://doi.org/10.1121/1.5001063

IMO (2023). Revised Guidelines for the Reduction of URN from Shipping to Address Adverse Impacts on Marine Life. *International Maritime Organization*, *MEPC.1/Cir*(October), 1–19. https://wwwcdn.imo.org/localresources/en/OurWork/ PartnershipsProjects/Documents/GloNoise-Library/MEPC.1-Circ.906 - Revised Guidelines For The Reduction Of Underwater Radiated Noise From Shipping to address Adverse Impacts on Marine Life %252822 August 2023.

Kumar, P.P.; G. V. V. P., Kumar and Prasad, V. V. S. (2020). *Assessing Underwater Noise Levels during Various Port Activities at the Visakhapatnam Channel* (Vol. 7, Issue 3, pp. 16–29). http://techjournals.stmjournals.in/index.php/JoOST/ article/ view/1012

Kumar, R. S. and Chandramohan, A. (2024). Construction, operation and maintenance aspects of a deep-water port-A case study on Kakinada port, Andhra Pradesh. *IOP Conference Series: Earth and Environmental Science*, *1326*(1). https://doi.org/ 10.1088/1755-1315/1326/1/012092

Merchant, N. D.; Witt, M. J.; Blondel, P.; Godley, B. J. and Smith, G. H. (2012). Assessing sound exposure from shipping in coastal waters using a single hydrophone and Automatic Identification System (AIS) data. *Marine Pollution Bulletin*, *64*(7), 1320–1329. https://doi.org/10.1016/j.marpolbul.2012.05.004

Rajyalakshmi, T.; Maheswarudu, G.; Reddy, D. M. and Joshi, H. C. (1986) A. approach to environmental impact study in the K. bay. E. B. C. E. pp. 125-140. (n.d.). *An approach to environmental impact study in the Kakinada bay*.