InciteShip: A Measurement and Incentive System for Mitigation of Ship Underwater Noise

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Abstract

Shipping is the dominant source of anthropogenic underwater noise in the world's oceans, yet effective tools for linking emissions of underwater radiated noise (URN) from individual vessels to environmental impacts remain underdeveloped. The InciteShip project (2024–2026) addresses this gap by designing, testing, and validating a combined measurement and incentive system for ship URN. The

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system employs autonomous, solar- and battery-powered buoys equipped with hydrophones to measure URN from passing vessels in shallow waters. Measurements are quality assured, transmitted via 4G to land stations, and processed to derive source signatures. An incentive score is calculated by assessing combined ecological impacts on marine mammals, fish, and invertebrates. This score is designed for integration into the Clean Shipping Index, thereby enabling economic incentives for shipowners to reduce URN. Early deployments in Gothenburg and Södertälje fairways demonstrate reliable operation and high-quality data. By linking scientific measurement, ecological assessment, and financial incentives, InciteShip offers a pathway for large-scale uptake of URN mitigation and for inclusion of underwater noise in maritime sustainability frameworks.

Keywords

Underwater radiated noise (URN) · Ship noise · Environmental Index · Shallow-water acoustics · Incentive systems · Sustainable shipping

Introduction

Anthropogenic underwater noise has emerged as a major environmental concern in the marine environment. Ships are today the single largest source of human-generated low-frequency sound in the oceans, contributing to continuous background noise that overlaps with the hearing ranges of many marine species (Duarte et al. 2021). Unlike chemical emissions or greenhouse gases, underwater noise is largely unregulated, and there are no mandatory international regulations requiring reduction of ship noise emissions.

The scientific literature demonstrates that ship noise can affect a wide range of marine organisms (Duarte et al. 2021). For example, harbour porpoises interrupt foraging at distances up to one kilometer from vessels (Wisniewska et al. 2018), cod and haddock experience masking of spawning calls (Stanley et al. 2017), and invertebrates show a range of behavioral and physiological stress responses (Solé et al. 2023).

Despite these well-documented impacts, progress in addressing ship noise has been slow. The International Maritime Organization (IMO) published revised guidelines for the reduction of underwater radiated noise (URN) in 2023, but these remain voluntary (IMO 2023). Some regional frameworks, including HELCOM in the Baltic Sea, have adopted action plans, but implementation mechanisms are not mandatory (HELCOM 2023).

Incentive systems such as the Clean Shipping Index (CSI) (Clean Shipping Index 2025), Environmental Ship Index (Environmental Ship Index 2025), and Vancouver's port fee reductions (Vancouver Fraser Port Authority 2025) demonstrate the potential of market-based approaches. However, none of these systems is currently based on measured underwater noise from individual vessels. They rely on proxies such as vessel notations, documented technical measures, or operator selfassessments. For example, Vancouver offers port fee reductions up to 47% for vessels with “Silent Notation.”

Large-scale URN monitoring has been pioneered by projects such as the ECHO Program in Canada (Malinka et al. 2023), the MARS project in the St. Lawrence estuary (Robin et al. 2022), and the EU LIFE-PIAQUO project (Gaggero et al. 2022). These initiatives established measurement stations that collect vessel noise signatures and link them to incentive schemes or policy frameworks. The InciteShip project develops a novel framework that couples autonomous measurement of URN in shallow waters (< 50 m) with a scientifically based ecological scoring system, enabling financial incentives for shipowners to invest in quieter technologies.

ISO standards define methodologies for URN measurement in deep water (ISO 17208-1 (2016); ISO 17208-2 (2019). However, many European shipping lanes and ports are in shallow waters, where sound propagation is more complex. The ISO 17208-3 (2025) standard addresses shallow-water measurements. InciteShip builds on this framework while adapting it for autonomous, long-term operation.

The InciteShip Project

The overarching aim of InciteShip is to reduce URN from ships by combining autonomous measurement with an incentive model. Objectives include:

1. Developing and validating autonomous shallow-water measurement buoys.
2. Establishing an ecological scoring method linking URN signatures to impacts on fish, mammals, and invertebrates.
3. Creating an incentive system that can be integrated into the Clean Shipping Index incentive system (https://cleanshippingindex.com/).
4. Engaging shipowners, ports, and regulators in uptake and implementation.
5. Disseminating methods and software openly to enable replication. All system designs, software, and methodologies will be shared openly and freely, enabling international uptake and adaptation.

The InciteShip project, which runs from 2024 to 2026, is a collaboration between IVL Swedish Environmental Research Institute, FOI Swedish Defence Research Agency, SMHI, and Clean Shipping Index, with participation from shipowners such as Terntank and Stena Teknik. It is funded by the Swedish Transport Administration (Trafikverket).

The project has built two systems that were deployed for their first testing and measurement period in the summer of 2025: one on the west coast of Sweden (Gothenburg) and one on the east coast (Södertälje). This initial campaign is now nearing completion, and the systems are planned to be deployed again in the summer of 2026 for a more comprehensive measurement period.

Technical Design of the Measurement System

The InciteShip system is designed for cost-effective, autonomous, shallow-water deployment. The system consists of two units: a sea unit and a land unit. The sea unit consists of a surface buoy deployed near a shipping lane, anchored to the seabed, powered by solar panels and batteries, and three bottom-mounted Colmar GP1280 hydrophones connected via cables to the buoy (Fig. 1). The hydrophone cables are up to 500 m long, enabling some freedom in buoy placement. A Conductivity, Temperature & Depth (CTD) probe is located on the cable, at mid-water depth do demonstrate the capability of getting information of the local the sound velocity in real time. The land unit receives data from the sea unit, calculates source level spectra using transmission modelling and stores the spectra along with Automatic Identification System (AIS) and metadata in a database. There is a 4G encrypted communication link between the land and sea units. The system can record and store raw acoustic data, but its default setting is to convert the recordings to hybrid centidecade spectrograms (at most 100 frequency bands per decade) and store and transmit those to shore. This conserves power and reduces data transmission requirements.

Recordings are initiated by collecting and analyzing AIS data from passing vessels. If a ship is within a pre-determined range and is predicted to pass close enough to the hydrophones that the system can make an accurate URN measurement, a recording will be started. The user can select which ships and/or ship categories to record though configuration settings. Configuration settings at the sea unit can be changed by remote login from the land unit.

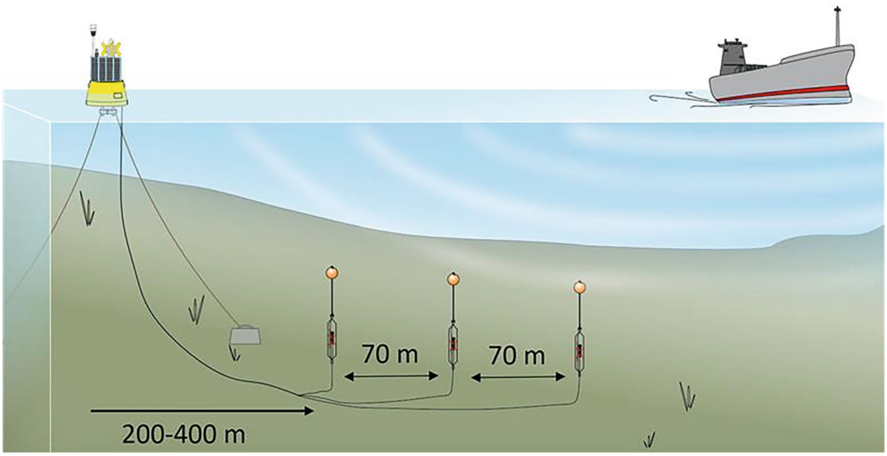

Fig. 1. A schematic drawing of the measurement setup of the InciteShip system at a deployment site near a shipping lane

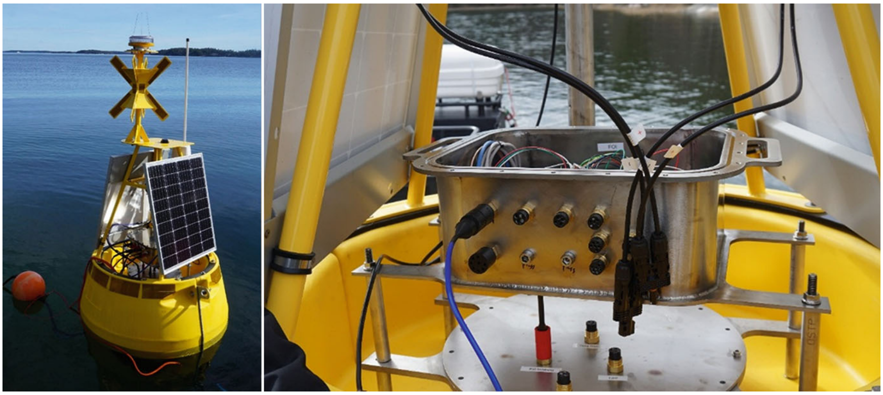

Fig. 2 Photos of the InciteShip system surface buoy (left) and the electronics and battery boxes (right)

Field verification includes repeated passages by collaborating vessels to assess measurement repeatability, and controlled transmissions to validate the employed transmission models. Horizontal measurement ranges depend on depth. At the Gothenburg site, the depth is 25–35 m and the hydrophones are placed 50, 120, and 190 m from the middle of the lane for ships leaving the port. At the Södertälje site, the depth is 40–50 m and the hydrophones are placed 20, 90, and 160 m from the center of the shipping land to and from the harbour.

Figure 2 presents photos of the surface buoy, showing metal containers that house electronics and batteries. The electronics were designed to be power-efficient, so that the solar panels can power the system on a day of average weather in southern Sweden. The batteries serve as buffers for cloudy periods.

The Incentive Model

The InciteShip project develops a framework for a scoring system that translates vessel URN signatures into an incentive score based on environmental risk assessment. Ecologically relevant, documented impacts of URN are first assessed separately for marine mammals, fish, and invertebrates, and then combined to an overall assessment score (Fig. 3). Furthermore, scores are normalized across vessel classes to promote mitigations among all vessel categories. The final incentive score is designed for integration into the Clean Shipping Index, linking financial incentives such as port and fairway fee reductions to actual measured noise performance and risk assessment. The details of the scoring system will be decided and implemented in the first half of 2026, and during the summer of 2026 the system will be fully operational, calculating incentive scores for passing ships.

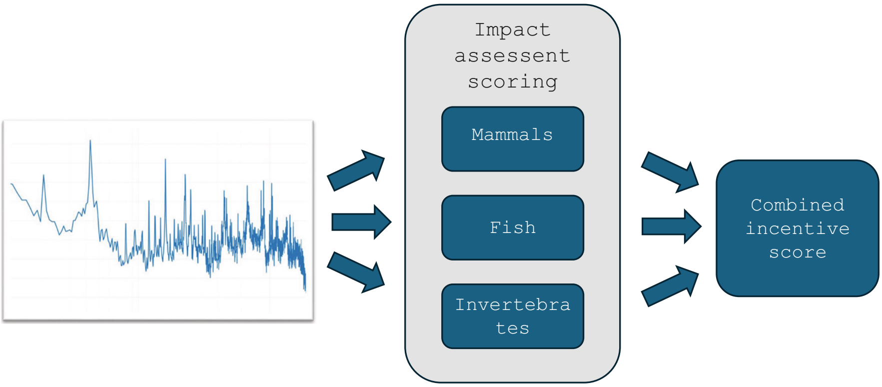

Fig. 3 InciteShip calculates an incentive score from a ship source URN signature based on a combined environmental impact assessment for mammals, fish and invertebrates

Fig. 4 A ship passing an InciteShip buoy system placed near the port of Gothenburg, Sweden

Early Results and Testing

The first deployment phase took place in the summer of 2025, with two buoys deployed near the Swedish coastline. One buoy was deployed near the main channel to the Port of Gothenburg (57°39.071 N, 11°43.703 E) (Fig. 4) and the other south of Södertälje harbour (58°46.144 N, 17°47.323 E). The Gothenburg buoy was deployed on June 12, 2025, and the Södertälje buoy on May 19. The buoys were retrieved in September. Deploying the system requires a crane with capacity of at least 500 kg and takes 2–3 h on site.

The system recorded more than 2700 ship transits in Gothenburg and 1100 ship transits in Södertälje and operated reliably for the duration of the deployments. The

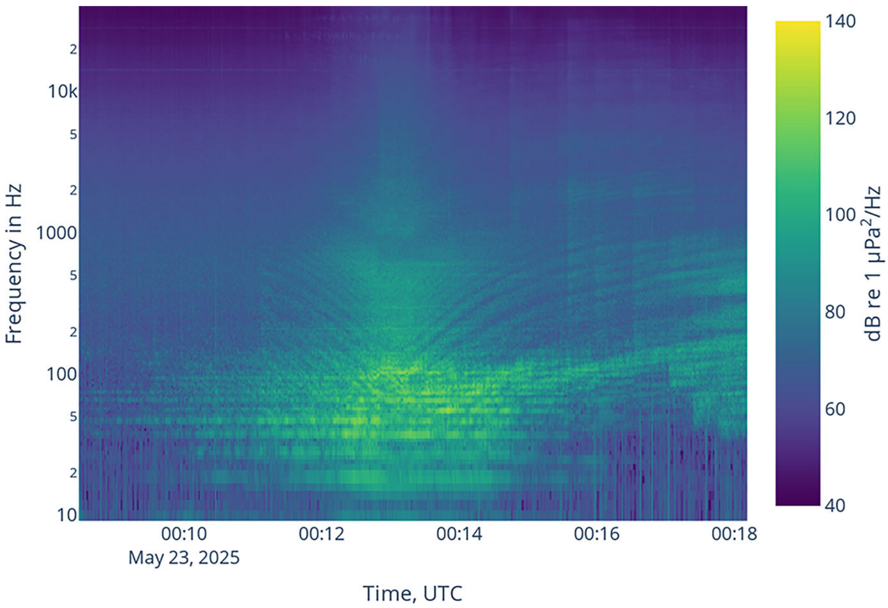

Fig. 5 Spectrogram of data recorded by the InciteShip buoy system during a ship passage

repeatability and accuracy of source signature measurement will be quantified during the summer of 2026 and is thus not yet available. An example of a spectrogram of data recorded by an InciteShip buoy is presented in Fig. 5. During the summer of 2025, the 4G links were always active for easy fault finding and software maintenance. This was not included in the power budget, but both systems still operated continuously on solar power. This shows that there are sufficient margins in the system's power budget.

Conclusions

The InciteShip project demonstrates that autonomous URN measurements and scientifically based scoring of environmental risks of measured URN levels can be combined into an effective incentive system for reducing the environmental impacts of ship URN. Early results show reliable system performance, and validation in 2026 will further confirm robustness. By integrating the scoring system into existing incentive schemes such as the Clean Shipping Index, InciteShip offers a practical pathway for aligning shipping operations with marine environmental protection goals.

Competing Interest Declaration The author(s) has no competing interests to declare that are relevant to the content of this manuscript.

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