

Maritime Summary Note n°253 – September 2023

« Noise pollution in the oceans »

The scientific community has been warning for several decades about the introduction of anthropogenic sound sources into the marine environment. Sound travels nearly five times faster in water than in air and can travel tens of kilometers in a few seconds. Cetaceans (whales, dolphins, and porpoises) have particularly sensitive hearing and depend almost entirely on sound. Underwater noise intensifies as maritime uses expand. Commercial shipping is one of the main contributors to anthropogenic underwater noise, alongside the oil and gas industry with its prospecting, research, exploration, exploitation, and decommissioning phases, marine renewable energies, fishing and aquaculture activities, port activities (service vessels, dredging), coastal development works, marine aggregate extraction, submarine cable laying, and recreational, scientific, and research activities. These noises add to a soundscape already rich in physical sounds—such as swell, rain, or tectonic movements—as well as biological sounds (marine mammal communications, sounds generated by crustacean claws, etc.). Noise pollution is now recognized as a threat to the marine environment on par with chemical pollution. Even as maritime transport must make considerable efforts to improve its carbon footprint, other more insidious forms of pollution are slipping under the radar of binding international regulations, though perhaps not for much longer.

Contextual Elements

The effects of anthropogenic noise emissions on marine fauna affect a wide range of species and can be very diverse, ranging from disturbance that may cause flight and habitat abandonment to physiological damage that can indirectly lead to the death of an individual, as well as the masking of communication signals. These effects are therefore likely to impact a species at the scale of an individual or a group of individuals. The perception of noise by marine mammals and the nuisances it causes are complex to determine and depend on numerous factors: salinity, temperature, water depth, ocean floor composition, and type of noise.

International Regulations on Underwater Noise

There is no specific international regulation governing underwater noise emissions at sea. However, underwater noise is incorporated into seven international legal frameworks. The International Whaling Commission has been working on this issue since 2008 and has encouraged member states to implement noise reduction measures since 2018 via a specific resolution. The Convention on Biological Diversity, the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, and the Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution all integrate assessments of the impact of underwater noise generated by human activities. The intergovernmental agreement ACCOBAMS (Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area) encourages parties to reduce their emissions at sea and runs an underwater noise working group with the CMS and ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas). ACCOBAMS organizes training courses for onboard observers and passive acoustic monitoring operators. The consideration of noise pollution is recent. The International Maritime Organization (IMO) recognizes that noise produced by ships can have adverse effects on human health¹ and marine fauna. It was in 2004 that the IMO took up the subject of underwater noise and its impact on

¹ In 2012, noise on board ships was the subject of an amendment to the SOLAS Convention, which establishes strict noise limits within the machinery space, control stations, workshops, accommodation spaces, and alternative spaces on board the vessel. The MLC 2006 concurrently contains explicit mandates regarding noise and structural vibrations.

wildlife. Shipping was then identified as one of the main contributors to anthropogenic underwater noise. Ships produce noise at frequencies ranging from 20 to 100,000 Hertz.

Propeller cavitation and machinery acoustic signatures

The primary sources of underwater noise originate from hull geometry, propeller design, their hydrodynamic interaction, and shipboard machinery configurations. Noise is aggressively emitted when the low-pressure fields generated by the propeller blades trigger the formation of thousands of microscopic vapor bubbles. When these bubbles violently collapse, the resulting acoustic energy operates as the dominant source of underwater vessel noise. Known universally as "cavitation", this physical phenomenon accounts for 80% to 85% of a vessel's total acoustic signature. Concurrently, marine diesel engines represent a substantial secondary noise vector due to structural vibrations radiating directly through the ship's hull plating.

A vessel's noise profile varies depending on the shipping segment, its initial design architecture, its operational speed, and the maintenance quality of both the hull and the propeller. The inherently global character of international shipping mandates a coordinated, worldwide regulatory response. Yet, there is currently no binding international regulation governing underwater noise emissions across the oceans.

To address this vacuum, the IMO published voluntary guidelines in 2014 aimed at commercial shipping to mitigate underwater noise². These recommendations target naval architects, shipbuilders, and shipowners alike. They encompass technical measures to be locked in as early as the initial vessel design phase, alongside operational adjustments during service (such as slow steaming) and strict maintenance protocols (including frequent propeller polishing, hull cleaning, and the application of low-friction smooth coatings). A structural reform of these guidelines is currently underway within the IMO to adapt frameworks to the latest advancements in ship design and eco-technologies. Driven by this regulatory workflow, a standardized international noise management planning framework is destined to emerge.

European frameworks and sovereign state initiatives

At the regional tier, Europe relies on the Marine Strategy Framework Directive (MSFW / DCSMM) enacted in 2008 (Directive 2008/56/EC). This framework targeted achieving a "Good Environmental Status" (GES) for European waters by 2020 and established explicit mandates to reduce noise impacts on marine organisms. Since its inception, the European Commission has formalized specific underwater noise thresholds deemed "acceptable" for marine fauna. Consequently, Member States are authorized to monitor acoustic pressure levels across their Exclusive Economic Zones (EEZs) while launching national initiatives to curtail noise pollution within their territorial waters.

Accordingly, Ireland deployed strict operational protocols as early as 2014, mandating preliminary visual monitoring and a 1,000-meter exclusion zone around acoustic activities. In Germany, the BSH (Bundesamt für Seeschifffahrt und Hydrographie)—the federal agency responsible for approving offshore infrastructure assets—published technical recommendations to be enforced at a minimum during environmental impact assessments for offshore wind farm installations. These guidelines include a standardized underwater noise evaluation protocol. Furthermore, Germany locked in strict statutory acoustic thresholds in 2013 that must not be breached during offshore pile-driving operations—a regulatory mechanism identically deployed by Belgium since 2012.

Alternative European nations, including Denmark and the Netherlands, have similarly issued technical recommendations. Finally, within the United Kingdom, the JNCC (Joint Nature Conservation Committee)—the statutory advisor to the British Government and devolved administrations—drafted several environmental directives designed to minimize underwater noise impacts stemming from offshore pile-driving, underwater explosives usage, and geophysical seismic prospecting.

Polar vulnerabilities and Canadian spatial routing

The Arctic region is warming three times faster than the global average, a rapid cryospheric contraction that could catalyze the opening of greenfield commercial shipping routes, most notably the famous Northwest Passage. Consequently, regional endemic species could soon face identical acoustic hazards to those mapping out alternative oceans. This vulnerability is severely exacerbated by the rapid expansion of expedition cruise ships at the Poles, multiplying anthropogenic pressures across these pristine

² Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life", MEPC.1/Circ.833, 7 April 2014, IMO.

ecosystems. The Arctic Council recently established that vessel-source underwater noise within the High North more than doubled between 2013 and 2019, even skyrocketing tenfold across selected high-density corridors.

To mitigate these pressures, the Government of Canada instituted mandatory seasonal speed restrictions in 2017 across strategic sections of the Gulf of St. Lawrence to prevent lethal collisions between cetaceans and commercial vessels.

Dynamic routing and lane repositioning operate as first-rate solutions to shield vulnerable marine sanctuaries and migration corridors, successfully lowering the adverse impacts of shipping on marine mammals. As early as 2003, the Canadian Government successfully relocated shipping lanes within the Bay of Fundy to reduce collision risks facing endangered North Atlantic right whales. Ultimately, in June 2021, the Federal Department of Transport announced the launch of its Quiet Vessels Initiative, a program focusing on technical retrofits and eco-friendly operational practices backed by a CAN\$26 million funding envelope. The federal government is concurrently drafting a comprehensive ocean noise strategy destined for official announcement during the year.

Selected jurisdictions mandate the continuous presence on board vessels of a certified Marine Mammal Observer (MMO), who ensures through visual and sometimes passive acoustic monitoring that no cetacean species is directly impacted by anthropogenic noise during subsea operations. Aerial surveillance and monitoring grids can alternatively be deployed to verify the presence or absence of marine mammals during naval exercises involving tactical sonar systems (notably across Hawaii, California, and Australia). In the event of marine mammal detection within this critical timeframe, the initiation of all underwater acoustic emissions is legally postponed.

The French regulatory domain and environmental law

Within the French landscape, the European MSFD (DCSMM) is formally transposed into national law under Articles L. 219-7 to L. 219-18 and R. 219-2 to R. 219-10 of the Environmental Code (Code de l'environnement). This framework applies exclusively to metropolitan maritime façades. Furthermore, Article L. 122-1 of the Environmental Code strictly mandates that public and private infrastructure, construction, or spatial planning projects which—by virtue of their nature, scale, or geographic location—are likely to exert notable impacts on the environment or human health must be preceded by a comprehensive Environmental Impact Assessment (EIA — Étude d'impact), which explicitly encompasses a detailed underwater acoustic impact evaluation.

To guide this framework, a national guidebook was published in 2020, analyzing the diverse procedures and technologies available to contract underwater noise footprints on marine wildlife. Addressed to central and decentralized State administrative services, it assists these agencies during the regulatory review and licensing procedures of coastal or offshore infrastructure projects. Centralized summary briefs are also available by industrial activity, spanning the oil and gas sector, Marine Renewable Energies (MRE), fisheries and aquaculture, marine aggregate extraction, and commercial maritime traffic.

While selected sovereign nations have locked in legally binding maximum noise limits at a specific distance during subsea civil engineering works (most notably pile-driving), France does not currently enforce statutory regulatory thresholds regarding maximum underwater noise exposure limits. The Ministerial Decree of September 9, 2019, which details the definition of the "Good Environmental Status" (GES) of marine waters and establishes modern evaluation methodological standards, fixes the baseline criteria to assess the ecological status and pressures weighing on the marine environment across various marine sub-regions.

It does not enforce a binding regulatory threshold to be met during offshore infrastructure projects; nevertheless, technical and legislative workflows aimed at this harmonization are currently underway at both national and European tiers.

Recent research executed within the European Commission under the supervision of the Technical Group on Underwater Noise (TG Noise), in a milestone report entitled "Setting EU Threshold Values for Impulsive Underwater Sound", proposes strict threshold limits beyond which temporary threshold shifts (TTS) or permanent threshold shifts (PTS) in marine mammal hearing can be observed. These specific European thresholds currently constitute the benchmark reference values to be integrated into all underwater acoustic impact assessments, particularly within the compliance monitoring of the MSFD. Conversely, regarding behavioral reaction and disturbance thresholds, no absolute scientific consensus exists today.

What mitigation measures should be taken?

The absolute priority focuses on avoiding and reducing these acoustic impacts, especially since no operational measures exist to compensate for underwater noise pollution. Avoidance measures (*mesures d'évitement*) predominantly consist of downsizing the project footprint and/or adapting the construction schedule and spatial layout to seasons or zones where no sensitive species are present, or deploying alternative technologies that yield zero impact on marine organisms.

Reduction measures (*mesures de réduction*) apply across three distinct operational tiers:

- Temporal planning: scheduling civil engineering works to systematically avoid interfering with a biologically sensitive period (breeding, calving) or a functional ecological zone.
- Acoustic reduction at the source: adopting quieter engineering techniques or deploying physical technologies designed to attenuate noise at the emission source—such as bubble curtains (*rideaux de bulles*), isolation blocks, or cofferdams (*batardeaux*).
- Species displacement: implementing operational measures aimed at monitoring the presence of and safely deterring species away from the active construction zone.

Regarding commercial maritime traffic, the primary levers to contract underwater noise footprints encompass reducing vessel speed, executing frequent hull and propeller maintenance, optimizing naval design architecture, and adapting spatial routing.

The International Fund for Animal Welfare (IFAW) is actively lobbying for a mandatory reduction in vessel speeds across European waters through its flagship "Blue Speeds" initiative. Indeed, according to this NGO, capping vessel speeds by a mere 10% delivers a 50% reduction in whale collision risks, slashes underwater noise pollution by 40%, and contracts shipboard greenhouse gas (GHG) emissions by 13%. It stands as an immediate, simple, and highly efficient operational lever. The adoption of Blue Speeds—which correspond to 75% of a vessel's initial design speed—ultimately implies a marginal slowdown compared to current global average transit speeds.

For offshore dredging, pile-driving, seismic prospecting, or marine drilling operations, specialized best-practice handbooks outline the mandatory enforcement of soft-start and ramp-up protocols.

- The soft-start protocol: consists of progressively elevating the acoustic emission level (such as gradually activating air guns during seismic surveys, or step-by-step accelerating the rotor speed during drilling or the blow energy cadence during pile-driving). The objective targets safely displacing marine species away from the immediate vicinity of the emitting source prior to full power, thereby preventing any risk of physiological trauma or permanent hearing damage.
- The ramp-up protocol: when a progressive acoustic adjustment is technically impossible—as observed during underwater explosives usage or when operating machinery whose intensity cannot be regulated—the ramp-up technique is deployed: acoustic noise is intentionally emitted into the marine environment through an alternative auxiliary device at an increasing level until the target sound pressure is reached. Only once this benchmark level is established will the primary industrial sound source be activated.

Visual surveillance remains the most widespread mitigation method, universally codified across all regulatory guidelines, recommendations, and protocols applied to underwater noise-generating activities. The operational modalities vary extensively, whether regarding the mandatory headcount of onboard observers or the continuous versus fragmented nature of the watch. Although its efficiency remains heavily dependent on observer focus and meteorological visibility conditions, visual surveillance stands as a first-rate, pertinent safeguard. However, visual observation can strictly be executed during daylight hours. Consequently, selected sovereign States mandate that these observers hold formal, accredited certifications to operate within their national waters (notably the United Kingdom, New Zealand, the United States, and Australia).

The integration of thermal or infrared imaging technologies represents a promising path to extend monitoring capabilities into the night. While this technology is currently efficient exclusively for large-bodied marine mammals and restricted to polar or sub-polar zones, it will undoubtedly evolve into a major operational asset in the coming years.

It is strictly recommended to halt all engineering works in the event of an animal intrusion inside the designated safety perimeter. This mandate implies that a clear exclusion zone (*zone d'exclusion*) must be defined *a priori* for the diverse species classified as sensitive to the specific noise spectrum generated. Animal detection is then actively secured through combined visual observations and passive acoustic monitoring (PAM).

Furthermore, targeted acoustic deterrents are available, including pingers (typically emitting frequencies between 2.5 and 100 kHz) and seal scarers (operating between 8 and 17 kHz). While these acoustic repellents have demonstrated clear efficiency across selected construction sites, their generalized deployment cannot be universally recommended. As with alternative acoustic sources, it is critical not to emit sound at power levels exceeding strict operational requirements. Extreme caution is mandatory for species highly sensitive to very high frequencies. Ultimately, executing a rigorous soft-start protocol backed by a meticulous visual and acoustic surveillance of the construction zone remains generally sufficient to safely displace marine animals away from potentially impacted areas.

Incentive frameworks: eco-labels and collaborative projects

Commercial incentives are concurrently emerging through voluntary environmental certification programs tailored for the shipping industry, most notably the "Green Marine" label. This international eco-certification incorporates a diverse matrix of performance indicators spanning atmospheric emissions, eco-friendly ship recycling, invasive species management (ballast water and biofouling), and underwater noise mitigation.

Since 2018, ports and shipowners have been positioned to satisfy specific underwater noise criteria. It is, however, regrettable that Level 1 of this eco-certification merely requires strict compliance with baseline existing regulations (verified through a mandatory annual self-assessment). Succinctly, the diverse performance indicators governing underwater noise mitigation are characterized by:

- Executing regular vessel maintenance protocols, focusing heavily on propeller polishing and hull cleaning.
- Establishing systems for comprehensive underwater noise data collection.
- Implementing verified corrective operational measures.
- Duplicating and scaling up these technical measures to encompass at least 15% of the operator's active fleet.

The acoustic evaluation methodology relies strictly on international measurement standards—namely ANSI/ASA S12.64-2009 or ISO 17208-1:2016—which define the precise field deployment procedures and acoustic quantities required to accurately measure underwater noise generated by vessels, most notably within deepwater configurations. These voluntary, incentive-based initiatives enable shipping lines to project an environmentally conscious corporate image while securing immediate economic benefits, including substantial discounts on port dues (*droits de port*) and fuel savings from enhanced hydrodynamics. It stands as a soft-diplomacy method (*méthode douce*) to successfully rally the global maritime community toward superior environmental best practices.

Collaborative macro-projects and the integration of Artificial Intelligence

Regarding large-scale collaborative frameworks, the Port of Vancouver pioneered the ECHO program (Enhancing Cetacean Habitat and Observation). This landmark initiative aggregates federal government agencies, marine transportation industry stakeholders, indigenous communities (*collectivités autochtones*), environmental NGOs, and academic scientists to better comprehend and mitigate the cumulative impacts of commercial vessel traffic on whale populations. While underwater noise reduction operates as the core focus of the program, its scope concurrently addresses physical vessel-strike disruptions and marine environmental contaminants.

Concurrently, the integration of Artificial Intelligence (AI) forms the core of ongoing research workflows led by academic laboratories and oceanographic scientific institutions. These entities are tackling noise pollution through the engineering of machine-learning algorithms specifically trained for the real-time detection of both anthropogenic noise emissions and marine mammal vocalizations. AI frameworks will ultimately enable the automated detection of subsea acoustic sources in real time while processing these massive, high-density volumes of big data.

Finally, at the regional tier, the European Commission launched a pilot project in late 2022 to build a centralized, open-access European underwater sound library of anthropogenic noises. This digital repository aims to evaluate the ecological health status of marine ecosystems through the acoustic diversity of the soundscape, structured in close partnership with France's Shom (Service hydrographique et océanographique de la Marine). The frontiers of bioacoustic research continue to expand.

Camille VALERO

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