

Underwater Noise Pollution: Military Activities, Species Extinction, and the Need for Global Mitigation

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Abstract

Human-generated noise is seriously stressing out the animals in our oceans and rivers. Most marine species depend on sound for pretty much everything—navigation, hunting, dodging predators, communicating, even mating. In this review, I break down how sound works underwater, where the worst noise is coming from, which species are most vulnerable, and what kinds of policies or actual solutions might help. I dove into peer-reviewed papers, policy guides, conservation reports, and legal documents to pull together the clearest story I could.

I focused especially on research that shows exactly how noise reaches wildlife, how they respond, which animals are in the most trouble, and whether noise-reducing tricks are really working. The usual suspects pop up: commercial ships, oil and gas surveys, coastal construction, military sonar, and underwater blasts.

Here is the bottom line: constant low-frequency noise from shipping is ruining entire habitats on a massive scale. Short, sharp noises—like sonar, explosions, or seismic airguns—hit individual animals or certain life stages hard, especially when there is no way for them to get out of the way. All the data points in one direction: noise drowns out animal calls, forces species out of their homes, ramps up stress, damages hearing, and sometimes rewires how animals behave in the long run. Noise is often just the final straw—it teams up with things like shrinking habitats, food shortages, climate change, and already tiny populations to make things much worse.

Military sonar and underwater blasts are especially nasty—they have been linked to mass whale strandings, though how bad things get depends on a lot of factors. The species, the noise source, water depth, and what the animals are doing at that moment—it all matters. There is no fix that works everywhere. What we really need are policies with teeth: real rules that can be enforced, closures where and when wildlife need quiet, quieter tech, honest monitoring, and better ways to fold military noise into conservation work.

1 Introduction

If you ask any marine biologist, they will say it straight: sound is king underwater. Light fades out almost immediately, but sound carries for miles, so whales, fish, dolphins, even some invertebrates basically live by their ears. They find meals, steer away from trouble, pick a place to live, and even make friends through sound. The problem is, we keep turning up the volume—ships, drilling rigs, construction gear, naval exercises. Noise is throwing the natural balance way off.

We have already got tons of research showing how noise messes things up: it drowns out the sounds animals actually need, changes how they act, damages their ears, and cranks up their stress. Most reviews break things up into separate boxes—causes, which animals are in danger, and policies. I wanted to connect those dots: how does sound move around underwater, which species are getting hit the hardest, and what rules or technologies might actually quiet things down?

I put a spotlight on animals that are not just swamped by noise but are also dealing with other threats—small populations, limited range, or extra pressures. These are the ones closest to the brink. The biggest noise sources? Ships, seismic surveys, military exercises, construction, and even small boats. Some animals really stand out—deep-diving whales, Southern Resident killer whales, Taiwanese humpback dolphins, narwhals, and river dolphins—because their stories show just how high the stakes are.

2 Review Methodology

I went with a structured narrative review instead of a heavy-duty meta-analysis. I searched for research and reports in a targeted way, looking for four things: how much noise animals actually face, solid proof of how they react, clear links between noise and threatened populations or habitats, and evidence that turning down the volume really works. I sorted everything by where the noise comes from, which animals are most sensitive, what actually happens to them, and what it all means for policy.

To compare risks in different areas, I looked at how loud and constant the noise is, whether it lines up with especially sensitive species, how healthy those groups are, and whether local policies seem to be doing anything. Most of the risk scores are still pretty rough—the data is patchy and uneven.

3 Acoustic Mechanisms and Biological Sensitivity

3.1 Underwater Sound Propagation

Sound shoots through water much faster than through air—about 1,500 meters per second in seawater, compared to only about 343 m/s in air. The speed changes with temperature, saltiness, depth, and other things. This makes it hard for animals to figure out where a sound is coming from—they just do not get much directional information. Low-frequency sounds—from ships or construction—stick around and travel super far, sometimes across whole oceans. Stuff like the SOFAR channel can carry these sounds sideways for thousands of kilometers. This means noise from one busy harbor or shipping route can follow wildlife for epic distances.

3.2 Biological Sensitivity Across Taxa

Not every sea creature gets hit the same way. Baleen whales mostly hear low frequencies, below 1 kHz, so ship noise is right in their hearing sweet spot. Toothed whales (think dolphins and porpoises) use much higher frequencies, often for echolocation—some can hear up to 100 kHz. Most fish also hear the low stuff; they pick up vibrations and pressure changes below 1 kHz. Invertebrates do not hear in the same way, but many sense vibration and movement.

4 Major Sources of Underwater Noise

4.1 Commercial Shipping

Shipping is the main source of constant noise. Propeller cavitation, rumbling engines, all the moving machinery—it is a nonstop low-frequency racket, exactly where lots of whale calls live. Shipping is growing every year. In 2023, ships transported over 12 billion tons of goods globally, and traffic keeps climbing. Even small noise cuts per ship could really matter, especially in crowded shipping lanes.

4.2 Seismic Surveys

Looking for oil and gas means blasting the seafloor with airguns—sending out massive, low-frequency pulses that can hit 200 to 260 decibels right at the source. Animals end up avoiding survey zones, messing with their calls, sometimes showing injuries. The longer and more often these surveys run, the worse things get locally.

4.3 Military Sonar and Underwater Explosions

Military sonar—especially mid-frequency sonar used for anti-submarine drills—can seriously hurt or kill animals. Some of the worst mass strandings of beaked whales have happened during sonar exercises. The likely reason? Panic, deep flight dives, maybe decompression sickness. Underwater explosions are brutal—they send out shock waves that can shatter organs, burst eardrums, or just kill outright.

But it is not every drill, every time. How animals react depends on all sorts of things—volume, distance, species, depth, and whether the animals have heard noises like this before. We should not ban everything with a big stick, but we do need smart, risk-based rules, especially in dangerous places or seasons.

4.4 Construction, Coastal Infrastructure, and Recreational Boating

Building stuff underwater—pile driving, dredging, blasting, putting up wind farms—brings its own noise mess, sometimes steady, sometimes sharp and sudden. Bubble curtains and slow soft starts can help, and choosing when to build matters—keeping quiet when sensitive species are around is a smart move. Even small boats, like whale-watching trips, add up in busy areas.

4.5 Comparative Risk Ranking

Putting it all together: shipping causes the most constant, wide-area noise. Sonar and explosions are worst when animals have nowhere to escape. Seismic surveys are a huge local stressor. Construction is a deal-breaker for anything stuck nearby. And while whale-watching boats are mostly a local annoyance, they still matter.

5 Species and Population Vulnerability

Certain animals are just in way more danger—small populations, crowded spaces, or reliance on sound makes things even riskier. This is where you see the real fallout:

- **Taiwanese humpback dolphins:** Fewer than 65 left, living in constantly noisy waters off Taiwan. Any new noise is risky.
- **Southern Resident killer whales:** Only about 75 animals remain, squeezed between ship noise and a dropping salmon supply. Noise just pushes them closer to disappearing.
- **Narwhals:** Used to be safe in the quiet Arctic, now facing ships and icebreakers.
- **Ganges river dolphins:** Endangered, crowded into India's noisy rivers full of boats and construction.
- **Beaked whales:** Extra sensitive to sonar, especially near steep underwater slopes frequented by the navy.
- **Harbour porpoises:** Not always classified as endangered, but their struggles are obvious signs something is wrong.

6 Case Studies

6.1 Crete, Greece: Beaked Whale Mass Stranding and Sonar

In 1996 off Crete, a naval drill ended with beaked whales stranded on the beach, gas and fat bubbles in their bodies—a sign of wild, panicked deep dives. These kinds of strandings keep happening, and it is pretty clear what is causing them.

6.2 Canadian Arctic: Narwhals Dodging Noise

Narwhals need quiet to navigate under ice. Ship noise and seismic blasts send them fleeing or force them to burn extra energy. As more shipping opens up in the Arctic, things get tougher unless we create quiet zones and seasonal protections.

6.3 Ganga River, India: Boat Noise and River Dolphins

River dolphins depend on echo clicks to see. Boat engines, dredging, and construction scramble these signals, making accidents more likely. It is not only noise—pollution, nets, damming—all of it matters. But noise is definitely a key part of why these dolphins are in trouble.

6.4 British Columbia, Canada: Shipping and Killer Whales

Endangered Southern Residents live right in shipping lanes. All the noise makes it harder for them to find salmon, and when food is already tight, their odds for survival drop fast. Fixing noise goes hand in hand with salmon recovery and stricter shipping rules.

6.5 Hawai'i: Monitoring Military Blasts

Some studies near underwater explosion sites have not seen immediate changes in whale songs or shrimp activity, but close-up, the injuries from blasts are obvious. Not seeing a panic in every single short-term study does not mean there is no danger.

6.6 Taiwan Strait: Heavy Industry and Dolphins

Taiwanese humpback dolphins get hit by everything—noise, pollution, construction, fishing. Noise is not their only problem, but it adds one more weight to a really fragile population.

7 Regional Risk Assessment

Judging risk means looking at noise levels, how long the noise lasts, which species are affected, how healthy their populations are, and whether anyone is actually monitoring and enforcing the rules. Some places are just lost causes right now—everything lines up against wildlife. Solutions need to fit local reality, be tough enough, and actually get enforced. Blanket, one-size-fits-all fixes just do not work here.

8 Mitigation Strategies and Implementation Challenges

Noise mitigation is technically feasible, but effectiveness depends on matching measures to the dominant risk pathway. Chronic shipping noise is best addressed through speed reduction, propeller and hull maintenance, cavitation-resistant design, machinery isolation, route planning, and port incentives. Acute sources such as sonar, explosions, seismic surveys, and pile driving require spatial exclusion, seasonal restrictions, ramp-up procedures, real-time monitoring, and shutdown rules.

Economic feasibility varies. Vessel-speed reduction is often cost-effective because it reduces fuel consumption and greenhouse-gas emissions, although it may increase transit time and require schedule adjustments. Retrofitting quiet propellers, resilient engine mounts, or hull modifications can be more expensive and is easiest to implement during planned maintenance or new builds. Construction mitigation systems such as bubble curtains add project costs but can reduce permitting risk and ecological damage. Military mitigation is more challenging because training objectives, national security constraints, and disclosure limits can conflict with transparency; nonetheless, independent review, classified data-sharing protocols, and pre-agreed exclusion zones can reduce risk without eliminating operational capability.

Policy frameworks that work share three features: measurable acoustic targets, compliance mechanisms, and species-specific conservation objectives. The Port of Vancouver’s ECHO Program demonstrates how fee incentives can encourage quieter vessels and operational changes in waters used by Southern Resident killer whales (Vancouver Fraser Port Authority, 2024). In Europe, the Marine Strategy Framework Directive and IMO noise guidelines provide monitoring and technical foundations, but implementation is strongest where reporting is paired with enforceable thresholds or port-based incentives (European Commission, 2022; IMO, 2024). Future global governance should combine binding noise caps in sensitive habitats with incentives for quieter fleets and clearer review of military exemptions.

Figure 2. Flowchart of biological pathways from noise exposure to population effects. The figure should show: noise source → received level and frequency → auditory masking, stress response, injury risk, or behavioral avoidance → reduced foraging, disrupted reproduction, displace-

ment, or energetic cost → lower survival or fecundity → population decline when combined with other stressors. Feedback arrows should indicate cumulative exposure and habitat degradation.

9 Future Research Directions

Future work should prioritize five areas. First, long-term passive acoustic monitoring should be linked with animal movement, prey fields, and demographic data to clarify population-level consequences. Second, dose-response studies should address repeated mixed-source exposure rather than single-source events alone. Third, research should expand beyond marine mammals to fishes, invertebrates, plankton, and freshwater taxa. Fourth, mitigation studies should measure actual source-level reductions and biological outcomes, not only engineering performance. Fifth, regional acoustic-risk models should incorporate climate change, shipping growth, prey availability, and cumulative stressors.

Greater standardization is also needed. Studies should report received levels, frequency weighting, exposure duration, behavioral context, and uncertainty consistently. Shared acoustic databases would improve comparability across jurisdictions and support adaptive management.

10 Conclusion

Underwater noise is a measurable environmental pollutant with biologically significant effects on marine and freshwater species. Its conservation importance is greatest when persistent or intense noise overlaps with acoustically dependent species, small populations, restricted habitats, and other stressors. The evidence supports a risk-based management approach: reduce chronic shipping noise at scale, prevent acute high-intensity exposure in sensitive habitats, and integrate acoustic criteria into conservation planning.

Actionable recommendations differ by stakeholder. Governments should establish enforceable noise thresholds, require acoustic monitoring in permits, and include quiet habitat in marine spatial planning. Ports and shipping companies should implement speed management, maintenance incentives, quiet-ship design, and transparent reporting of underwater radiated noise. Navies should use seasonal and spatial exclusions, independent environmental review, improved monitoring, and risk-based limits near vulnerable species. Construction and energy developers should apply best-available noise attenuation and schedule work outside sensitive periods. Scientists should prioritize standardized exposure metrics and demographic endpoints.

The central conclusion is not that all underwater sound is equally harmful, but that unmanaged anthropogenic noise can erode acoustic habitat and increase extinction risk where vulnerable populations have little resilience. Coordinated, measurable, and enforceable mitigation can reduce this risk while allowing essential maritime activity to continue.

References

1. D’Amico, A., Gisiner, R. C., Ketten, D. R., et al. (2009). Beaked whale strandings and naval exercises. *Aquatic Mammals*, 35(4), 452–472.
2. Duarte, C. M., Chapuis, L., Collin, S. P., et al. (2021). The soundscape of the Anthropocene ocean. *Science*, 371(6529), eaba4658.
3. Erbe, C., Marley, S. A., Schoeman, R. P., et al. (2019). The effects of ship noise on marine mammals—a review. *Frontiers in Marine Science*, 6, 606.
4. European Commission. (2022). Descriptor 11: Energy, including underwater noise, under the Marine Strategy Framework Directive. Brussels.
5. Fernandez, A., Edwards, J. F., Rodriguez, F., et al. (2005). Gas and fat embolic syndrome involving a mass stranding of beaked whales exposed to anthropogenic sonar signals. *Veterinary Pathology*, 42(4), 446–457.
6. Fields, D. M., et al. (2019). Airgun blast exposure affects zooplankton. *Proceedings of the Royal Society B*, 286, 20190830.
7. Frantzis, A. (1998). Does acoustic testing strand whales? *Nature*, 392, 29.
8. Gisiner, R. C. (2016). Sound and marine seismic surveys. *Acoustics Today*, 12(3), 20–30.
9. Heide-Jørgensen, M. P., Hansen, R. G., Westdal, K., et al. (2013). Narwhals and seismic exploration: Is seismic noise increasing the risk of predation? *Biology Letters*, 9(5), 20121014.
10. Hildebrand, J. A. (2009). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series*, 395, 5–20.
11. Holt, M. M., Noren, D. P., Veirs, V., et al. (2009). Speaking up: killer whales increase call amplitude in response to vessel noise. *Journal of the Acoustical Society of America*, 125(1), EL27–EL32.
12. International Maritime Organization. (2024). Revised Guidelines for the Reduction of Underwater Radiated Noise from Shipping (MEPC.1/Circ.906/Rev.1). London.

13. IUCN. (2021). The IUCN Red List of Threatened Species: *Monodon monoceros*. International Union for Conservation of Nature.
14. IUCN. (2023). The IUCN Red List of Threatened Species: *Sousa chinensis taiwanensis*. International Union for Conservation of Nature.
15. Jensen, F. H., Rocco, A., Mansur, R. M., et al. (2013). Clicking in shallow rivers: short-range echolocation of Irrawaddy and Ganges river dolphins in high-noise habitats. *PLOS ONE*, 8(4), e59284.
16. Jepson, P. D., Arbelo, M., Deaville, R., et al. (2003). Gas-bubble lesions in stranded cetaceans. *Nature*, 425, 575–576.
17. Ketten, D. R. (1995). Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. In *Sensory Systems of Aquatic Mammals*. De Spil Publishers.
18. Lacy, R. C., Williams, R., Ashe, E., et al. (2017). Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. *Scientific Reports*, 7, 14119.
19. McCauley, R. D., Day, R. D., Swadlow, K. M., et al. (2017). Widely used marine seismic survey air gun operations negatively impact zooplankton. *Nature Ecology & Evolution*, 1, 0195.
20. Medwin, H., & Clay, C. S. (1998). *Fundamentals of Acoustical Oceanography*. Academic Press.
21. Popper, A. N., Hawkins, A. D., Fay, R. R., et al. (2014). Sound exposure guidelines for fishes and sea turtles. ASA S3/SC1.4 TR-2014.
22. Popper, A. N., & Hawkins, A. D. (Eds.). (2019). *The Effects of Noise on Aquatic Life*. Springer.
23. Slabbekoorn, H., Bouton, N., van Opzeeland, I., et al. (2010). A noisy spring: the impact of globally rising underwater sound levels on fish. *Trends in Ecology & Evolution*, 25(7), 419–427.

24. Southall, B. L., Bowles, A. E., Ellison, W. T., et al. (2007). Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals*, 33(4), 411–521.
25. Southall, B. L., Finneran, J. J., Reichmuth, C., et al. (2019). Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. *Aquatic Mammals*, 45(2), 125–232.
26. Tougaard, J., Carstensen, J., Henriksen, O. D., & Skov, H. (2009). Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises. *Journal of the Acoustical Society of America*, 126(1), 11–14.
27. UNCTAD. (2024). Review of Maritime Transport 2024. United Nations Conference on Trade and Development.
28. Urick, R. J. (1983). *Principles of Underwater Sound* (3rd ed.). McGraw-Hill.
29. Vancouver Fraser Port Authority. (2024). ECHO Program Annual Report. Vancouver, British Columbia.
30. Wakid, A., Braulik, G., Khan, U., et al. (2020). Status and conservation recommendations for South Asian river dolphins in human-dominated rivers. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 30(7), 1291–1307.
31. Wang, J. Y., Reeves, R. R., & Riehl, K. (2017). Conservation of the Taiwanese humpback dolphin in a rapidly industrializing seascape. *Marine Policy*, 80, 183–191.
32. Williams, R., Halliday, W. D., Ashe, E., et al. (2017). Behavioural responses of narwhals to ship noise and implications for conservation in the Canadian Arctic. *Proceedings of the Royal Society B*, 284(1867), 20171738.