

**Mitigation of Common Ocean Noise Sources  
Incidental Noises**

Noise Source	Function/Purpose/Cause/Objective	Frequency Spectrum	Audible Range	Mitigation/Alternative
<b>Shipping:</b> Propeller noise	Propulsion	1Hz – 1 kHz (Up to 195dB)	Individual vessels up to 10 miles, cumulative fleet noise is globally widespread	Quieter propeller technologies such as “vortex” drives, variable pitch drives and diesel electric and hydraulic “turret drives.”
<b>Shipping:</b> Hull radiated mechanical noise	Hull mounted equipment	2 Hz – 20 kHz (Up to 195dB)	Individual vessels up to 10 miles, cumulative fleet noise is globally widespread	Mounting equipment on resilient and sound attenuating mounting systems.
<b>Shipping:</b> Hull friction	Biological growth on hull. Hydrodynamic forces on the hull and external hull mounted equipment	2 Hz – 5 kHz	Individual vessels up to 10 miles, cumulative fleet noise is globally widespread	Periodic hull cleaning. New hull designs and coatings.
<b>Construction:</b> Pile Driving	Impulse/impact noise	Broadband impulse every 1 – 4 seconds (Up to 240dB)	In shallow harbors and ports up to 5 miles, in coastal areas 10 to 200 miles	Bubble curtains around driving operations. Select “lower acoustical impact” pile material in sensitive areas such as reinforced concretes.
<b>Construction:</b> Materials handling	Impact, friction and fastening noise	1 Hz – 5 kHz	In shallow harbors and ports up to 5 miles, in coastal areas 10 to 200 miles	Bubble curtains around operations. Quieter materials handling procedures.
<b>Industrial Process:</b> Mechanical noise	Machinery, pumps, materials handling, provisioning.	10 Hz to 5 kHz	Depending on the location and size of the operation, up to 20 miles on coastal waters.	Design noise mitigation criteria into new facilities. Retrofit existing facilities as needed. Vibration isolation of mechanical systems.

Alternatives to and mitigation of common ocean noise pollution sources.

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**Intentional Noises**

Noise Source	Function/Purpose/Cause/Objective	Frequency Spectrum	Audible Range	Mitigation/Alternative
<b>Seismic Exploration</b> Airgun blasting	Mapping sub-sea bottom profiles for oil and minerals extraction industries	10Hz – 8kHz, periodic explosions at 5 – 20 seconds (Up to 250dB)	10 – 1500 miles	Multiple receive arrays. Improved sensors and sensor information processing. Refined targeting with electromagnetic (e.g. Remote Resistivity Mapping “R3M”) and aerial thermal mapping.
<b>Navigation:</b> Underwater beacons	Identify underwater objects Locate underwater equipment	1kHz – 30kHz 160dB +	1 – 5 Miles	GPS systems. Improve receivers to sense and resolve quieter signals.
<b>Communication:</b> Mid and high frequency analog signals	Vessel to vessel communication, remote control of equipment and vessels(ROV’s). Unmanned Autonomous Vessels (UAV’s)	1 kHz – 100kHz (Up to 235dB)	5 miles to 20 miles depending on frequency and volume	“Time correlated” analog signals. “Spread Spectrum” analog signals Distributed communication buoys. Bio-acoustic mimicry.
<b>Communication:</b> Digital signals	As with the analog signals, but with faster data rates, clearer resolution.	1 kHz – 100kHz (Up to 235dB)	5 miles to 20 miles depending on frequency and volume	“Time correlated” analog signals. “Spread Spectrum” analog signals Distributed communication buoys. Bio-acoustic mimicry.
<b>Communication:</b> Low frequency acoustic signals	Long distance communication Surreptitious communication to submarines. Long distance surveillance Acoustic Thermometry	2 Hz – 1 kHz (Up to 240dB)	10 miles to 2000 miles depending on frequency, location and volume	Unmanned Undersea Vessels that serve as local communication links between satellites and subs. Distributed communication buoys. Distributed seafloor transponders. Satellite thermal mapping. Bio-acoustic mimicry.

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Noise Source	Function/Purpose/Cause/Objective	Frequency Spectrum	Audible Range	Mitigation/Alternative
<b>Surveillance:</b> Passive sonar	Locate and identify marine vessels	Available sound spectrum	Not audible	Safest surveillance alternative includes: Fixed and stationary hydrophone arrays such as SOSUS, Vertical Line Arrays (VLA) and complimentary towed arrays such as ARCI and TB-29. Integrated Undersea Surveillance System (IUSS). Advance Deployable Sonar (ADS)
<b>Surveillance:</b> Active sonar	Locate and identify marine vessels. Navigation and mapping	2 Hz – 100kHz (Up to 240dB)	Less than 1 mile for HF signals. 5 miles to 20 miles for mid frequency, up to 1500 miles for low frequency.	More sensitive receive sensors, Improve resolving algorithms. Use multi-line arrays or synchronized distributed receive platforms. Distributed seafloor transponders. Satellite magnetic, thermal, radar and laser scanning technologies Bio-acoustic sonar mimicry.
<b>Surveillance:</b> Non-sonar submarine surveillance	Sky space based submarine detection.	Electromagnetic and thermal spectrums, Laser interferometry	N/A	Satellite and aircraft surveillance, Integrated and independent platforms using Magnetic Anomaly Detection (MAD), Synthetic Aperture Radar (SAR.) Infrared detectors. Laser surface scanning. Coordinated sonobuoy arrays.

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