

**Are Low-Frequency Acoustic Emissions from Air Gun Seismic Surveys Harmful for Marine Fauna  
and Is the Risk Acceptable?**

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**Abstract:**

With over 70% of the Earth's surface covered in water, the need for human exploration and development into the ocean is imperative. Low-frequency seismic surveying is a primary form of geological exploration in sub-sea environments that can also have critical uses in offshore construction and natural disaster detection. Although these surveys help us to better understand the planet we live on, they also generate controversy with animal welfare groups and members of the fishing industry who believe that these acoustical emissions may have detrimental effects on marine fauna population sizes and survivability. This debate has led to many studies aimed at identifying the risks associated with introducing low-frequency anthropogenic noise to marine animals. Whether it be through particle or pressure detection, all marine fauna studied to date have been shown to possess some form of hearing ability which can make them vulnerable to hearing loss, barotrauma, or changes in social behavior in the presence of seismic surveys. The risk associated with these effects can be high or low depending on the species, and cumulatively create population-level effects on the most vulnerable. Studies that have found low risk for marine fauna claim that effects to an individual's hearing can recover to their normal thresholds hours after the acoustic emissions cease. They also suggest that despite these changes to survivability, there are no noticeable decreases in population size after a survey has been conducted. Contrarily, studies that have found a high risk to marine fauna claim that pressure sensitive species, like invertebrates, can be affected by permanent changes to hearing thresholds, and that these emissions have been shown to evoke changes in the social behavior of marine mammals. In extreme cases, the presence of operating low-frequency seismic surveys has been shown to cause direct mortality in the form of barotrauma and strandings. Therefore, environmental impact assessments and risk mitigation techniques are essential for geological surveyors to employ before conducting low-frequency seismic surveys. Techniques such as temporal restrictions, soft-starts, and passive acoustic monitoring have been shown to reduce the risk involved for frequency-sensitive species and help to ease the controversy surrounding low-frequency seismic operations.