

Title

Reducing the Environmental Impact of Seismic Surveys: A Review of Impulsive Source Technologies and Monitoring Solutions

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Abstract

Active seismic surveys are a crucial tool for the oil and gas industry, although they can have significant environmental impact, particularly on marine mammals. The development of new technologies, especially seismic sources, aims to reduce the environmental impact of seismic surveys without compromising data quality. This review article provides an overview of two lower impact seismic sources, called Bluepulse and TPS. We also present equipment and methods that allow detection, identification, and location of cetaceans, to mitigate the risk of harassment to marine life.

Introduction

Seismic surveys are used to explore and characterize subsurface geological structures. They play a critical role in the oil and gas industry. However, seismic surveys can also have significant environmental impact, particularly on marine mammals. The high levels of noise produced by seismic surveys can disrupt the behavior, communication, and habitat use of marine mammals, and can even cause physical harm (Southall et al., 2007). In response to these concerns, the development of new technologies, such as Bluepulse and TPS, aims to reduce the environmental impact of seismic surveys while maintaining or improving data quality.

Bluepulse Technology

Bluepulse is a new generation of seismic source technology that is designed to minimize high-frequency noise. The Bluepulse system uses a proprietary source design that produces a more efficient and directed seismic signal, resulting in reduced noise levels and improved data quality. Field trials and testing have shown that Bluepulse can significantly reduce the environmental impact of seismic surveys. For example, a study conducted in the Atlantic Ocean found that Bluepulse reduced the noise levels and may divide by 3 the Exclusion Zone compared to traditional airgun sources (Tellier et al., 2022), (figure 1).

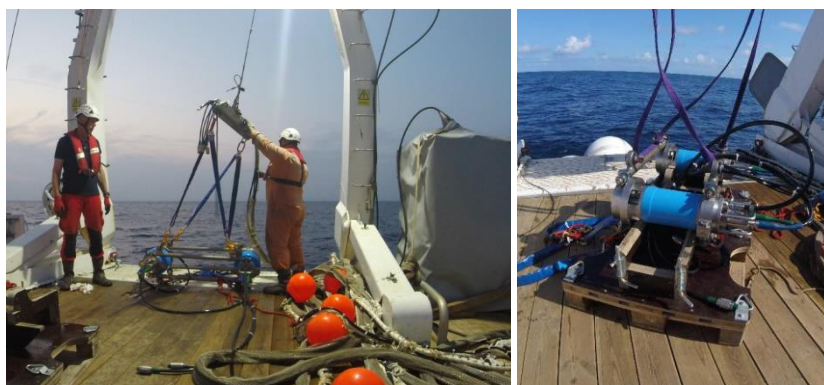


Figure 1, Bluepulse acoustic calibration survey in Atlantic Ocean in 2021

Tuned Pulse Source (TPS) Technology

TPS, shown in figure 2, is a low-frequency seismic source technology that is designed to produce high-quality broadband seismic data with reduced environmental impact. The TPS system uses a large volume source that produces a low-frequency signal, resulting in reduced noise levels and improved data quality (Ronen et al., 2017). Field trials and testing have shown that TPS can significantly reduce the environmental impact of seismic surveys, particularly in deep water environments (Merritt et al., 2024). For example, a study conducted in the US Gulf found that TPS reduced the noise levels and may at least a 3-fold reduction in exposure distance and 9-fold decrease in exposure area for LF mammals. For the HF and VHF mammals, the distances are reduced by a factor of 25 and the area by a factor of 625 when compared to traditional airgun sources (Martin et al., 2023; Southall et al., 2024).

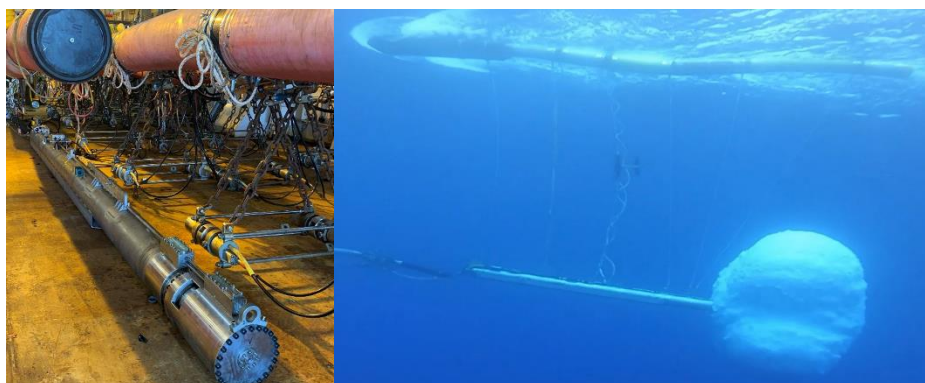


Figure 2, Tuned Pulse Source (TPS) on the backdeck of Fulmar Explorer in 2023 (left) and underwater view of the Tuned Pulse Source (TPS) during firing on Laconia I & II in 2024.

Environmental Benefits

The Bluepulse and TPS technologies offer several environmental benefits, including reduced noise levels, improved data quality, and increased efficiency. The reduced noise levels produced by these technologies can help to minimize the disruption of marine mammal behavior, communication, and habitat use. According to the National Oceanic and Atmospheric Administration (NOAA), anthropogenic noise from human activities such as seismic surveys can have significant impacts on marine mammals, including changes in behavior, physiology, and even physical harm (Southall et al., 2007).

In the context of offshore exploration in Brazil, the use of Bluepulse and TPS technologies can help to reduce the environmental impact of seismic surveys. The Brazilian coast is home to a diverse range of marine mammals, including whales, dolphins, and sea lions, which can be affected by the noise generated by seismic surveys. By reducing the noise levels produced by seismic surveys, the Bluepulse and TPS technologies can help to minimize the disruption of these marine mammals and their habitats. The use of TPS technology can also help to reduce the carbon footprint of seismic surveys (figure 3). This can have a positive impact on the environment, as it can reduce greenhouse gas emissions and help to mitigate climate change. Additionally, the improved data quality produced by this technology can help to reduce the need for repeat surveys, which can further reduce the environmental impact of seismic surveys (Merritt et al., 2024).

In Brazil, the use of Bluepulse and TPS technologies can also help to support the country's commitment to reducing its environmental impact. The Brazilian government has set ambitious targets for reducing greenhouse gas emissions and promoting sustainable development, and the use of Bluepulse and TPS technologies can help to support these efforts.

A recent study by the California Ocean Alliance, in collaboration with industry partners, identified several noise reduction pilot projects that can be implemented in the US Gulf (Southall et al., 2022). The study recommended several options for reducing noise pollution from seismic surveys, including the use of Bluepulse and TPS technologies. The study found that these technologies can reduce noise levels significantly compared to traditional airgun sources, which can have a significant impact on marine mammal behavior and physiology.

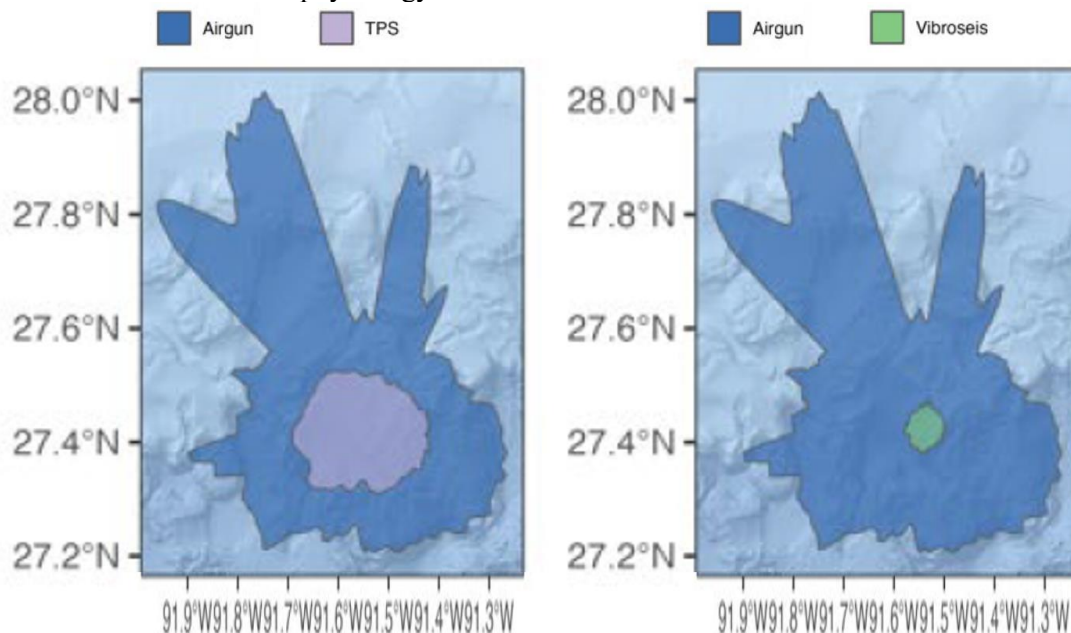


Figure 3. From Southall et al (2024). Modeled noise footprints at 125 Hz for low frequency cetaceans. TPS and Vibroseis are shown relative to conventional seismic airgun. for reference.

Now a days, several case studies have demonstrated the effectiveness of Bluepulse and TPS technologies in reducing the environmental impact of seismic surveys.

State of the art of acoustic monitoring solutions

In order to provide a controlled and safe solution for the environmental noise impact, Sercel has developed a complete an innovative noise monitoring and mammal detection system, this solution is QuietSea™.

This solution consists in an automatic detection and alert of presence of marine mammals, covering the three main categories : LF (baleen whales), MF (Toothed whales), and VHF (harbour porpoise). This can also provide a noise monitoring monitoring and alerting system to be able to evaluate in real time the acoustic impact of the seismic sources.

In the context of a seismic survey, QuietSea™ technology (figure 4) can be divided into two complementary equipment. A good example of this deployment is the planned Viridien seismic survey REGIA in the south of Australia in the Otway basin in 20206/2027 :

- QuietSea™ streamer set-up integrated into Sercel seismic streamers, used as the main Passive Acoustic Monitoring system as close as possible from the seismic source
- QuietSea™ buoys, a fully autonomous and connected real time alerting system, deployed around the critical areas with known whales presence, also used as reference noise measurement points for the seismic source on site.

This set up is currently in test phase in the Otway basin area to evaluate the efficiency of the solution. It aims to provide a complete acoustic monitoring and alerting solution that can be deployed in a constrained environment with significant populations of sensitive species.

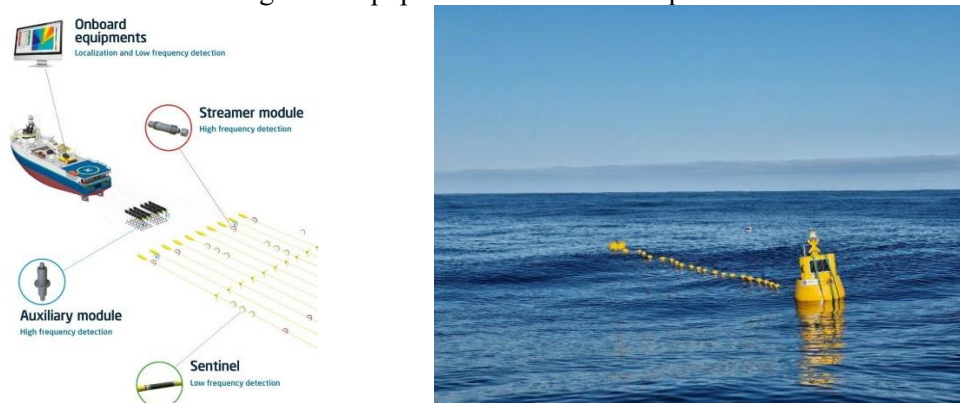


Figure 4, Quietsea™ streamer system deployed on a seismic vessel (Left) and Quietsea™ Buoy deployed in the Otway Basin (2025) in Australia

Conclusion

The development of Bluepulse and TPS technologies is an important step towards reducing the environmental impact of seismic surveys. These technologies have the potential to significantly reduce the noise levels and environmental impacts associated with seismic surveys, while maintaining or improving data quality. The case studies and field trials have demonstrated the effectiveness of these technologies in reducing the environmental impact of seismic surveys. Further research and development are needed to improve the performance and efficiency of these technologies, but the current state of research and development is promising. As the oil and gas industry continues to evolve and adapt to changing environmental regulations and societal expectations, the development of new technologies, such as Bluepulse, TPS and QuietSea, will play a critical role in reducing the environmental impact of seismic surveys.

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