
RTSYS

Offshore wildlife protection: acoustic monitoring and AI detection

Passive Acoustic Monitoring (PAM) technology has been used by offshore wind farms for more than a decade to monitor underwater noise. Underwater environments, despite their apparent inaccessibility, are territories of life, and exceptional scientific wealth. They are full of acoustic events that offer a window on crucial phenomena, such as seismic movements, behaviour of marine species, and anthropogenic activities in the abyssal depths. The precise detection, localization and classification of these underwater acoustic events represent essential challenges for oceanography research, underwater exploration and for the management of marine resources.

The construction and operation of offshore wind farms can pose potential risks to marine life, as certain noise levels can disturb marine mammals, fish, and other aquatic species.

To address these concerns, environmental impact assessments (EIAs) are typically conducted before and during the construction of offshore wind farms. These assessments help to identify potential risks to marine life and inform the development of measures to minimize and mitigate those risks.

Additionally, ongoing monitoring during and after construction helps to ensure that any unforeseen impact is identified and addressed promptly. Regulations and guidelines are in place in many regions around the globe to manage the environmental impact of offshore wind projects, with a single and unique aim: to protect marine ecosystems. The industry is continuously working to develop and implement best practices to minimize its impact on marine life.

A decade of research and development has brought significant advances in the development of a state-of-the-art autonomous acoustic measurement buoy. This is the result of a multi-disciplinary collaboration involving experts in underwater acoustics, electronic engineering and marine sciences PhDs. The buoy is the result of both extensive research and technological innovations, positioning itself as an essential tool for capturing autonomously high-resolution underwater acoustic data.

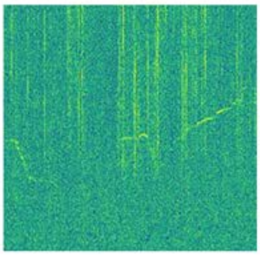
During this development, two primary practices were at odds with each other, resulting in a new problem that needed to be addressed.

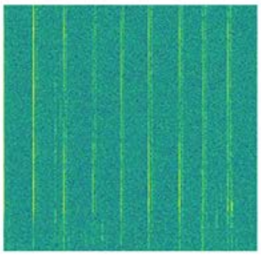
Listening for purposes of characterizing an aquatic environment

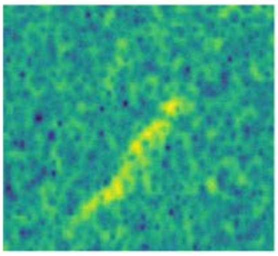
Recording over a long period without transmitting, until the data storage of the recorders is full, or the batteries empty. The endurance of this type of recording can be pushed up to six months non-stop. Post data processing therefore takes a long time and is relatively expensive. However, deploying this type of solution is very easy.

Listening in real time as part of offshore site monitoring during pile driving activities

When buoys communicate via radio signal or wifi, the reception of the signal is carried out on a vessel and the processing of the data is done onboard by a computer and associated software. 24/7 monitoring is necessary to monitor the levels of emissions, as many regulations make real-time characteristics mandatory.


Dolphin whistle


Dolphin clicks


North Atlantic Right Whale upcalls

RUBHY real-time acoustic detection buoy: combining the best of both worlds

The main technological development has sought to combine the best of these two worlds. A system which does not require increased monitoring, but which sends 'real time' alarms, warning the user of potential danger, such as excessive noise level, presence of a mammal, or overall monitoring of vessel traffic.

The RUBHY remote controlled buoy was designed and built by French company RTSYS, PAM experts since 2010.

With a robust design suitable for offshore environments, RUBHY acquires the data of up to 4 wide band hydrophones and simultaneously sends and displays real-time noise information such as SEL, SPL, LE, and 1/3rd octave band levels either by wifi within a 700 m range, over UHF within a 10 km range, or worldwide using 4G or iridium.

The high Sound to Noise Ratio (SNR) and the preamplifier hydrophone inputs of the RUBHY remote controlled buoy allow a high-quality monitoring. Data are recorded on either a SD card or an HDD, typically as 24-bit WAV files. Configuration and monitoring are done through a user-friendly web browser interface. The buoy is supplied with 1 to 4 hydrophones, Kevlar reinforced extension cables, protective cages for the sensors, and GPS along with wifi, UHF and 4G or iridium receiving antennas and modem.

RUBHY technology had been deployed all over the world for more than a decade, from US territories to Taiwan, where it is currently used by offshore contractors including Jan de Nul, Boskalis, Gardline, Van Oord and DEME.

RUBHY^{AI} or the advent of acoustic detection with artificial intelligence

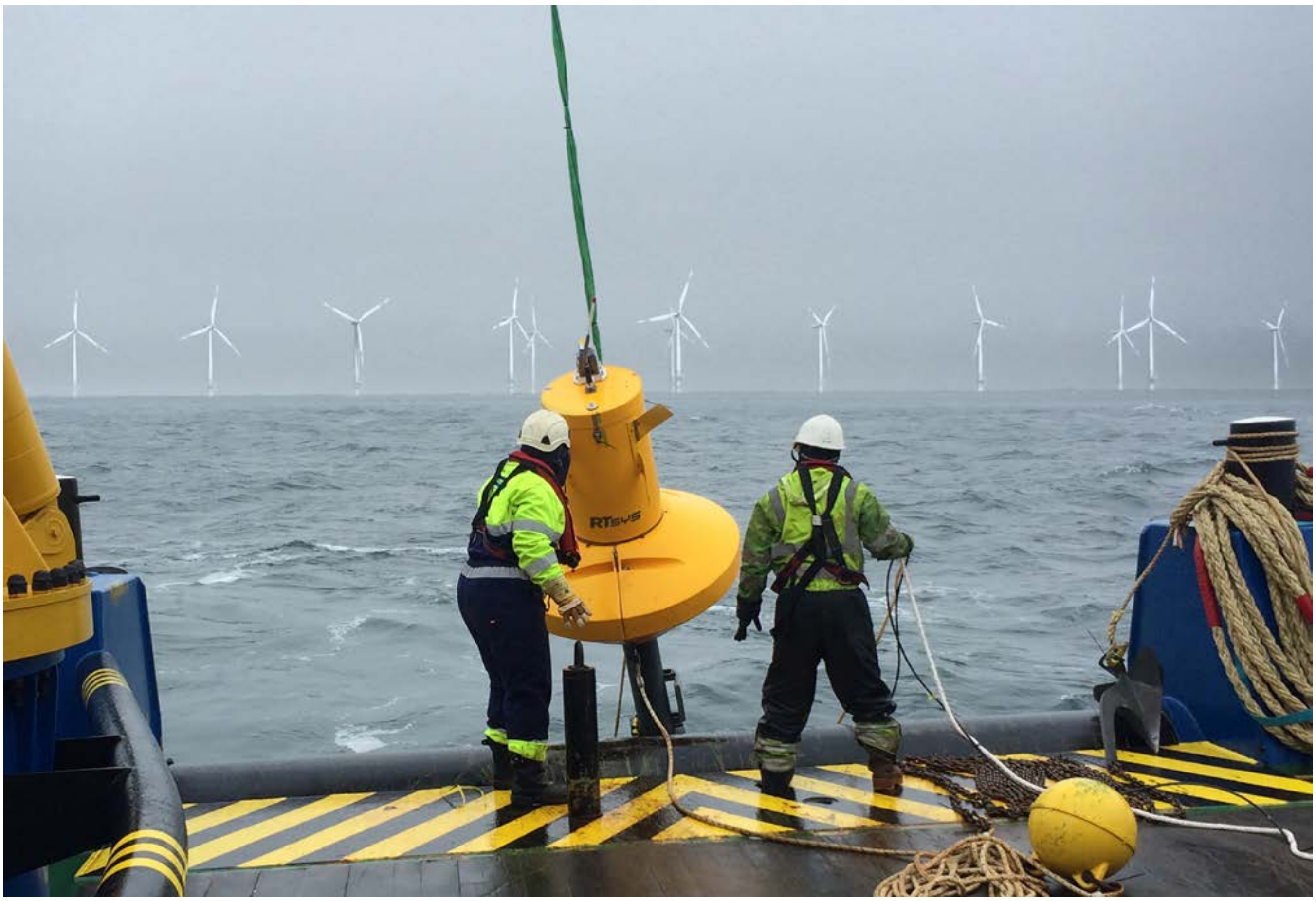
RUBHY is proven to be a powerful tool for monitoring underwater noise. But how can it be enhanced to autonomously detect various sounds from different sources, such as human activity and underwater species, without the need for 24/7 analysis by a PAM operator?

The challenge came in addressing the problem of designing the robust detection algorithms needed to handle diverse and variable acoustic conditions. This led to a close collaboration between RTSYS with specialists in PAM detection by deep neural networks and French company SenseaFR, recognized by the scientific community for its 20 years of sustained R&D activities, more than 30 scientific publications in international peer-reviewed journals, more than 1000 citations, and inventor patent.

A proven algorithm named BioSound, with over 50 years of data processing in more than 15 projects already, has been developed and embedded within RUBHY.

RUBHY^{AI} was born

How does it work? ResNet, an architecture commonly used for image recognition, has been trained to recognize the time-frequency representation of various mammal calls and vocalizations. The network was



trained on several thousand examples recorded at various locations and conditions around the world since 2018.

Used as a detection algorithm based on the machine learning principles, the performance of RUBHYAI improves as more variance is introduced into the database, whereas the opposite trend is observed using a conventional linear discriminant analysis approach. This deep neural architecture also proved with time that the network could be trained to identify very specific species like North Atlantic Right Whales (NARW) upcalls under diverse and variable conditions, with a performance that can remove the human operator from the PAM detection.

The automatic detection by RUBHYAI includes ambient noise study, assessing the noise level in the relevant frequency bands and identifying the sources responsible for the noise, whether that is anthropogenic, meteorological or biological. It also includes the detection, classification and enumeration of animal sounds for cetaceans like odontocetes or mysticetes; and the assessment of the effects of noise on wildlife.

In terms of cetaceans, the algorithm can detect the presence of cetacean sounds in the hydrophone capture radius of ~ 20 km for mysticetes, ~ 1.5 km for delphinid clicks, and ~ 1 km for delphinid whistles. Four detectors can be applied: vocalization, upcall, whistles, and delphinid clicks.

In parallel, RUBHYAI evaluates the detection range. Detectors are based on Artificial Intelligence, neural networks applied to data spectrograms, sent by the buoy for each detected event. For each detector, a methodological note describes the characteristics of the spectrogram, the detection performances such as probability of detection, probability of false alarm, etc., and performances that are illustrated and followed over time.

The annotation of detection is very useful for the classification of biological sounds which can address two specific points of view: the sound functionality in terms of transit, nutrition, socialization, reproduction, etc. and the emitting species.

To date, the artificial intelligence tools applied to cetacean sound detection, which remain the first requirement by regulators on offshore wind farms projects, are in full incrementation, on a database of over 24,000 diverse biological signals and 50,000 diverse noise samples. The level of certainty of detection is:

For vocalizations:

- 93% probability of detection,
- 0.6% probability of false alarm

For clicks:

- 95.6% probability of detection,
- 0.6% probability of false alarm

Since 2022, RUBHYAI has emerged as the premier support tool for offshore wind farm operations globally. It plays an essential role in streamlining operations, boosting efficiency, and safeguarding the marine environment.

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