



New Little Belt Bridge, Middelfart, Denmark.

MIDDELFART LISTENING STATION

**A Static Acoustic Monitoring Solution for Monitoring
Harbour Porpoise & Ship Traffic in a Marine Protected Area**

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The harbour porpoise (*Phocoena phocoena*) is one of the world's smallest marine mammals. The species has a widespread distribution in coastal waters across the northern hemisphere, but are increasingly vulnerable to human activities, including fishing, shipping, dredging, oil and gas exploitation, and industrial pile-driving for the construction of offshore wind farms. In Europe, an estimate from 2016 found approximately 42,000 harbour porpoises inhabiting the waters from the Kattegat through the Danish straits to the Western Baltic. These animals constitute the "Belt Sea" population, and they are genetically and movement-wise distinguished from neighbouring populations of the North Sea and the Baltic.

Denmark's Little Belt or Lillebælt is the strait that separates the Jutland mainland from the Island of Fyn. The Lillebælt Naturepark is a marine area based on a network of local authorities, fishermen, industries, and land owners to protect the marine fjord and adjacent coastal areas stretching from Trelde Næs to Hejlsminde. The area is of particular interest because it is home to what is perhaps the world's highest density of harbour porpoise, with up to 3,000 individuals present in the park year-round.

The town of Middelfart is located at the narrowest point of the Little Belt and harbour porpoise can be seen close to shore. The town has an important historical association with the porpoise, which was hunted by whaling communities from at least the 16th century to World War II. In recent times, the harbour porpoise has become a cherished symbol of the town's cultural identity, is endeared by the local people, and attracts visitors through porpoise watching tours and a maritime museum.

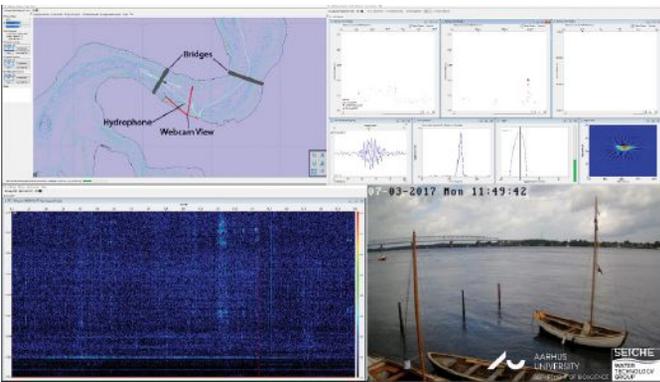
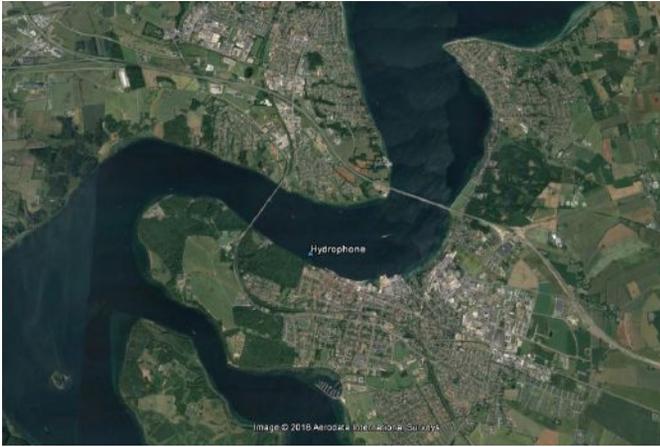
In April 2017, a new collaborative project between Aarhus University in Denmark, Lillebælt Nature Park, the Middelfart Municipality, and Seiche Ltd was launched. The aim of the project has been to install a long-term listening station in order to monitor the sounds of harbour porpoises and boat traffic in the area. Access to underwater sound is provided in real-time and

is made available to the public through educational displays on site and to everyone else through Internet streaming on YouTube.

Harbour porpoise produce distinctive narrow-band, high-frequency echolocation clicks to sense their environment and to detect and locate the small fish on which they prey. The listening station is positioned on the edge of an artificial reef and has two hydrophones mounted to a pyramidal frame that is secured to the seabed. The array connects to an old boat house on shore that provides power and access to the acoustic signals. The upper hydrophone of the array is used for porpoise detection and is sensitive to frequencies from 2 to 200 kHz. The lower hydrophone has a frequency response of 0.2 to 24 kHz and is used for listening to and monitoring the noise levels of background sounds and ship traffic. Both hydrophones are constructed from piezoelectric ceramic spheres and are mounted adjacent to low-noise preamplifiers that provide 40 dB of gain.

An Automatic Identification System (AIS) receiver is included in the system to track the movements of larger vessels





Above: Hydrophone location in the channel. Below: The Middelbart Listening Station display shows location, porpoise clicks, scrolling spectrogram, and webcam view.

in the channel. The passage of these vessels is logged to a database so that their range and bearing from the hydrophones can be related to the received sound levels. The marine mammal detection, classification, and localisation software PAMGuard is used to monitor the digital output of the listening station, and harbour porpoise echolocation click trains are displayed using an automatic click detector.

PAMguard includes a map display that shows the movements of vessels relative to the position of the hydrophone array, and a scrolling spectrogram that enables us to visualise ambient sounds while listening to a live audio stream. Harbour porpoise echolocation signals are far higher in pitch than we are able to hear, but Pamguard lowers their frequency to within our audible range. Porpoise clicks are thereby added to the background sounds of boats, fish, and mooring chains. Many small boats in the area do not carry an AIS system, so a webcam was added to the system to have a visual cue of the type of boat passing the hydrophone.

The system is largely autonomous. It is controlled remotely and monitored over a data-link from a 4G sim-router. The PAMguard displays and real-time audio is streamed over the web to a You Tube channel, and to an app developed by the Middelbart Municipality.

A public educational display has been setup adjacent to the boat house, within the refurbished remains of an old fishing boat, and live sound is transmitted here from the listening station. The display officially opened 29 April 2017 following traditional ceremonial customs and received national news coverage in Denmark. The launch was also an integrated part of the annual conference of the European Cetacean Society, which was hosted in Middelbart at Hindsgavl Castle, by Aarhus University.

Data collected in just the first two weeks following installation of the hydrophones at Middelbart provided fascinating results. The sound recordings showed that porpoises occupy this area daily, but that their acoustic activity is far higher at night. Detection rates at night are very high, with porpoises present near the hydrophones for long periods.

Based on frequent feeding buzz sounds, it is believed that porpoises move close inshore at night to feed around the artificial reef next to the hydrophone. At twilight during the installation itself, several porpoises were seen and heard blowing very close to the boat house jetty. One area of research will now focus on the automatic detection of feeding buzzes to enable scientists to estimate the intensity and the success of night-time foraging.

The project plans to expand to a network of listening stations providing publicly accessible underwater sound and a powerful tool for the long-term monitoring of marine mammals and the ambient soundscape. It is planned to install oceanographic sensors and a weather station, and these will help researchers to understand the factors that affect porpoise behaviour at Middelbart. For example, current and salinity measurements will enable scientists to track the movement of water masses through the Little Belt. The hydrophone array itself may be expanded so that harbour porpoise and perhaps one of their main prey, herring, can be followed in the vicinity of the artificial reef and throughout the water column.

The Middelbart Listening Station demonstrates how a relatively simple Static Acoustic Monitoring solution can be installed to monitoring the spatial and temporal activity of harbour porpoise in a marine protected area. This system benefits from a continuous power and data cable to shore, which enables acoustic monitoring to be carried out in real-time, 24 hours a day. Underwater sound is accessible for multi-purpose scientific and educational use and is already producing exciting results.

Most importantly, the listening station represents an important and powerful tool for passive acoustic monitoring in the longer term and will provide invaluable information to help us to protect some of the most important habitats of the harbour porpoise. To listen to underwater sounds recorded on hydrophones installed on the seabed at Middelbart, Denmark, visit www.youtube.com/watch?v=ZNUMit6PXmQ. To learn more about Seiche, visit seiche.com.