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# COMMON SOURCES OF UNDER WATER AND AIR BORNE NOISE FROM SHIPS

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## ABSTRACT

The project Silent@Sea, funded by the Swedish Transport Administration, aims to investigate levels of noise radiated from ships into the marine environment as well as on board from diesel engines, from LNG engines and from electric propulsion. The current paper presents results from measurements of on board noise and vibrations, external under water noise and external air borne noise from a hybrid battery/diesel shuttle ferry. On board vibration measurements provided information about sources such as engine mounts and thruster mounts that potentially radiate noise into the water. The most important of these sources were then confirmed by narrow band analysis of corresponding under water noise measurement results. Finally, results from air borne noise measurements were similarly analysed to find sources that contribute to both under and over water marine environment noise exposure. The analyses show that the vessel emit comparatively low levels of noise regardless of propulsion mode, and that when using electric propulsion the noise is further reduced both on board and under as well as over the water.

**Keywords:** *ship, noise, under water, airborne, measurement*

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## 1. INTRODUCTION

Noise from ships is known to affect underwater marine life [1, 2] and may also affect amphibians [3]. In addition, as air borne noise from ships is generally dominated by low frequencies that are generally propagated relatively long distances, there might be dwellings close to the waterfront or close to harbors that can be exposed to increased low frequency noise levels, increasing the risk of negative health effects [4, 5].

Alternative forms of propulsion for ships such as battery operation is slowly being adopted by shipping companies mainly as a measure for reducing green house gas emissions. As an added bonus, battery operation may also reduce noise emissions. In the project Silent@Sea we have performed simultaneous measurements of airborne and underwater noise from (as well as noise and vibrations onboard) the hybrid battery / diesel-electric shuttle ferry Elvy.

## 2. METHOD

The ferry was taken out of operation to an area in the archipelago south west of Gothenburg, Sweden (Fig. 1). The area was reasonably well protected from swell but was to some extent visited by leisure craft during the time of measurements. Since channels of communication were constantly open to the ferry, measurement passes could be held off until potential disturbances were out of range. The weather was ideal with clear skies and very little wind. Elvy performed several passes for each mode of propulsion in both directions along the agreed route that was laid out as a track in the navigation system. Record-

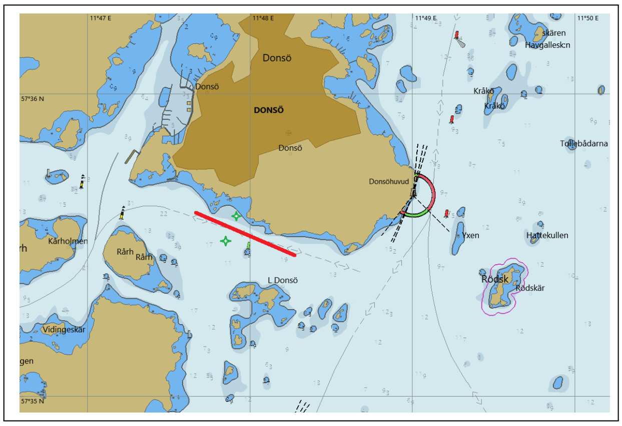


**Figure 1**. The area south of Donsö in the Gothenburg archipelago where measurements were performed. The measurement track is marked in red. The hydrophone array position south of the track and the microphone platform position north of the track are marked in green.

ings of some of the passes had to be scrapped during analysis due to unavoidable disturbances, but several passes for each condition were still useful for analysis.

### 2.1 Under water measurements

Three Soundtrap 300 STD hydrophones sampling at 96kHz were used as a vertical array to measure underwater noise from the passing ferry at different depths. The array was positioned about 80m from closest point of approach (CPA), and measurements were performed in accordance with Bureau Veritas “Underwater Radiated Noise” [6]. The water depth was about 20m at the position of the hydrophone array, and the hydrophones were suspended at roughly 5, 10 and 15m depth.

### 2.2 Air borne measurements

Measurements of air borne noise were carried our in accordance with the method for measuring moored ships suggested in the EU-project NEPTUNES [7], stipulating a distance between the ship and the microphone depending on the ship exhaust funnel height and the microphone height over the water surface. The microphone was positioned about 80m from closest point of approach (CPA). A bespoke floating microphone mount, or raft, was designed specifically for the Silent@Sea project, consisting of a circular aluminium truss base with aluminium tubing serving as supports for a battery platform and a microphone mount (Fig. 2). Two IEPE condenser microphones were mounted at two different heights above the water surface (1.5m and 2.5m), which were connected through two 250m coaxial cables to a measurement interface on a nearby anchored boat used as base of operations. The entire microphone mount was floating on four buoys and was anchored in three directions. The raft was equipped with a Class-B AIS transponder continuously broadcasting it’s position, as well as with an anchor light.

**Figure 2**. The ferry Elvy approaching the floating microphone mount.

### 2.3 On board measurements

A Svantek SVAN957 recording sound level meter was used to measure on board sound. Mesurements were performed on the bridge as well as in the machine room. In addition to sound measurements, self-contained vibration data loggers were placed at key positions on the engine mounts and on the inside of the hull. On board measurements were not performed entirely simultaneous with the airborne and underwater measurements but earlier the same day. Analysis of the on-board measurements is ongoing and will be discussed during the oral presentation at Forum Acusticum in Turin.

### 2.4 Results

Fig. 3 and Fig. 4 show examples of results from Welch analysis of recorded airborne noise and underwater noise respectively. The narrow band analysis allowed for identification of prominent peaks in the spectra corresponding to fundamental or harmonic frequencies related to different sound sources on the ferry. Some of the peaks could be found in both the airborne and in the underwater measurements, whereas others were only visible in e.g. the underwater spectrum.

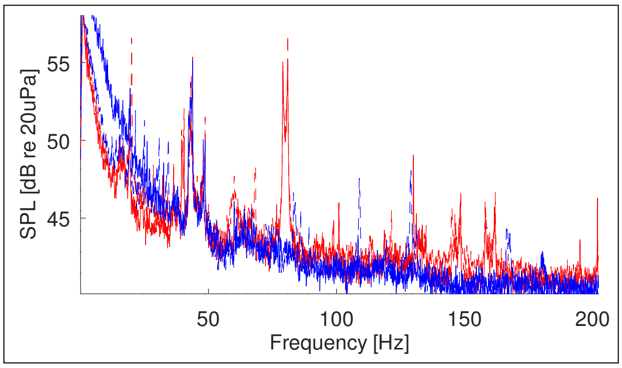


**Figure 3**. Welch spectrum of air borne sound from passes under diesel propulsion (red) and electric propulsion (blue).

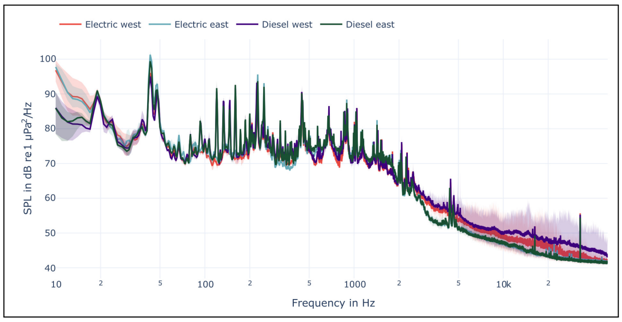


**Figure 4**. Welch spectrum of underwater sound from passes under diesel propulsion and electric propulsion.

Tab. 1 show some of the most prominent peaks found in the airborne and underwater spectra. Interesting to note is that the engine fundamental frequency was not as strong in the underwater spectra as in the airborne spectra. This might be due to well designed engine mounts that isolates much of the vibration energy from the hull. A measurement of some other ship showing prominent peaks in both airborne and underwater spectra for the engine fundamental could be used as indicator that the engine mounts could be better optimised to reduce underwater noise emission, especially for ships intended for sensitive areas such as research vessels. The peaks at 43Hz and 48Hz did not correspond to the propeller blade passing frequency nor to the engine harmonics. Most likely it is a secondary noise source aboard the ferry. This to could be used as an indicator that some secondary machinery could benefit from sound insulation to reduce noise emissions both to the air and under the surface.

## 3. CONCLUSIONS

Underwater and air borne noise from an diesel-battery-electric passenger shuttle ferry was measured simultaneously, allowing for comparison between different operating cases in different modalities. The analysis shows that this kind of simultaneous measurement is valuable in identifying sources of noise from different operating conditions as well as for estimating the overall noise emission to the surrounding environment.

## 4. ACKNOWLEDGMENTS

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[4] WHO Environmental Noise Guidelines for the European Region ISBN 978 92 890 c5356 3, 2018.

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**Table 1**. Table over some of the prominent peaks in the airborne and underwater noise spectra.

| Freq. [Hz] | Air Elec. | Air Diesel | Uw Elec. | Uw Diesel | Comment |
|---|---|---|---|---|---|
| 19 | weak | weak | strong | strong | Likely blade passing frequency |
| 43 | strong | strong | strong | strong | Unrelated to prop or eng |
| 48 | strong | strong | strong | strong | Unrelated to prop or eng |
| 80 | strong | strong | weak | weak | Engine fundamental |
| 160 | weak | weak | strong | strong | Engine harmonic |

[6] Bureau Veritas Underwater radiated noise (URN) NR 614 DT R02 E, 2018.

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