First results on underwater acoustic background in SMO – NEMO Phase II

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Introduction

In recent years the Italian legislation is supporting the conservation of marine ecosystems. The conservation actions require the propaedeutic study and monitoring of the physical and chemical characteristics of the underwater environment that is influenced by the increase of human activities [1].

The European Marine Strategy ([2], [3]) and the Italian legislation establish criteria and methodological standard to identify and analyze the underwater sounds introduced by anthropogenic activities. In particular they define criterions and indicators concerning: *i)* the distribution in time and place of intermittent sounds of high, medium and low frequency (such as airguns, piles, sonars, explosions); *ii)* continuous low frequency sounds (such as vessels).

The Submarine Multidisciplinary Observatory (SMO) - funded by Italian Ministry of Research, University and Education [4] - is an underwater acoustic antenna installed onboard the NEMO-KM3NeT tower (www.km3net.org), that is a prototype of a high-energy neutrino detector deployed at 3500 m water depth, 100 km offshore Capo Passero (Sicily).

We present preliminary results of the analysis of underwater acoustic data recorded by the SMO antenna, operating since 23 March 2013. The data sample reported refers to the first month of operation (April 2013), when the full detector was still under commissioning.

1 The Submarine Multidisciplinary Observatory

The SMO antenna consists of 10 high sensitivity and broadband (10Hz÷70kHz) acoustic sensors (hydrophones) and environmental probes (two Conductivity-Temperature-Depth probes to measure sound velocity at the site and one Doppler Current Sensor) [5-7]. Hydrophone signals are sampled underwater at 192 kHz/24 bit and analyzed in real-time on shore. An unbiased sample of data is recorded every hour for five minutes and stored on a digital library.

The hydrophones were calibrated at different pressures (up to 400 bars) at NATO-URC. Every hydrophone shows isotropic radiation pattern in the whole bandwidth and a relative sensitivity variation with hydrostatic pressure ≤ 1dB. The sensitivity of all the hydrophone + preamplifier assemblies is about -171 dB re 1V/uPa, almost constant in the whole frequency band (see fig. 1). In addition pistophone tests carried out at 250 Hz make us confident in the possibility of extending the hydrophone operational range at lower frequencies.

Fig. 2 shows the architecture of the SMO- KM3NeT NEMO Phase 2 prototype.

Two SMO acoustic sensors are placed, at a distance of about 7 m, on floors #1, #2, #3, #4 and #6.

The analysis presented in this contribution refers to acoustic data recorded by one of two hydrophones placed at floor #6.

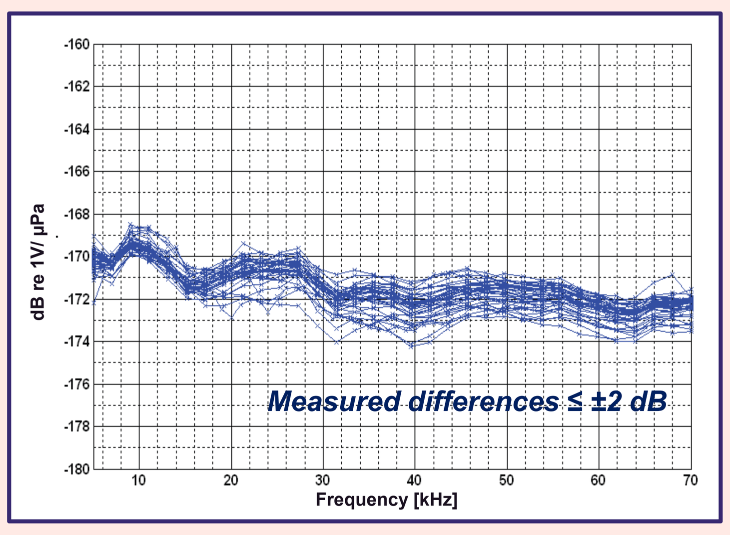


Fig.1 – Hydrophone + preamplifier sensitivity.

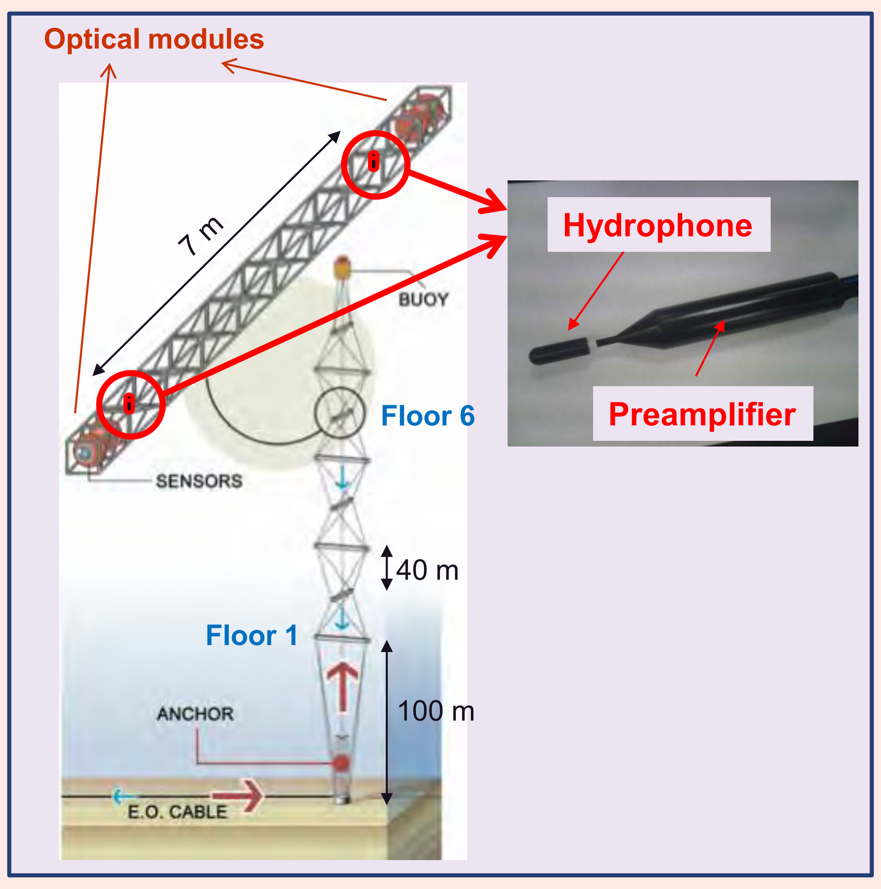


Fig.2 – KM3NeT Nemo Phase-2 Prototype.

2 Data set and analysis procedure

The continuous stream of acoustic data from the hydrophones (6.2 Mbps per hydrophone) is analysed in real time on shore, only the recording of the first five minutes of every hour are stored. The presented data analysis is so referred to the recording of the first five minutes every hour of April 2013. The analysed data set consists of 673 files over 720 recordings scheduled, missing recordings were due to detector commissioning issues.

Fig. 3 displays the power spectral density as function of frequency, of a typical file. The file was divided into slices of 2^{12} samples (21ms), using an overlap of 50% and Hanning windowing, for each slice the periodograms were calculated (NFFT= 2^{12}) as shown by grey area. The figure also shows the mean value of the power spectral density and different percentiles of the distribution. The average PSD of the hydrophone + preamplifier assembly self noise measured in laboratory, is also shown.

Fig. 4 shows the spectrogram of a typical recording using NFFT 2^{16}. The beacon signals, shown in this figure, are emitted by an acoustic emitter used for positioning purposes.

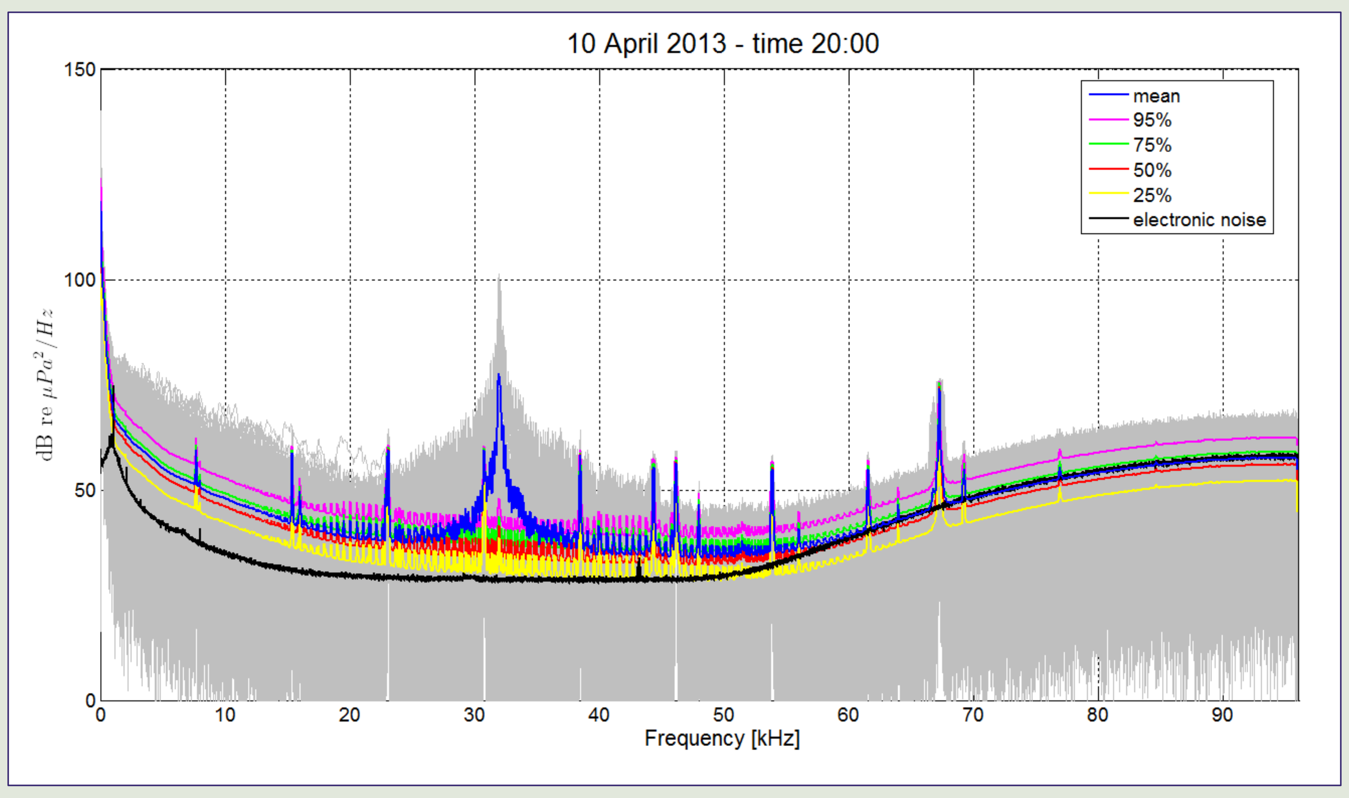
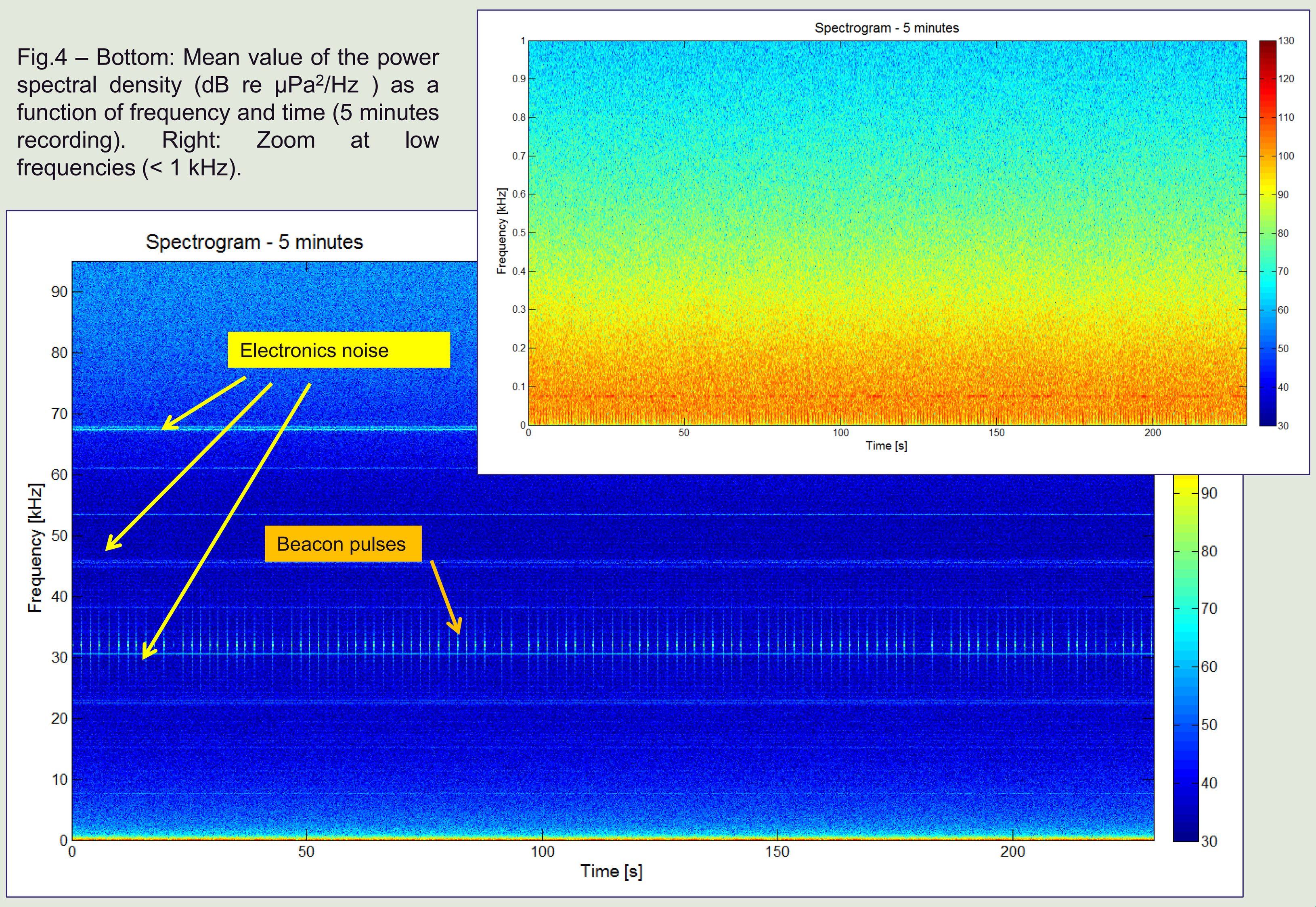


Fig.3 – The grey area represents the Power Spectral Density calculated every 21 ms time-slice of a 5 minutes recording. The Average value and percentiles of the distribution are shown. The average value of the hydrophone + preamplifier assembly is also shown (black line)

Fig.4 – Bottom: Mean value of the power spectral density (dB re µPa²/Hz) as a function of frequency and time (5 minutes recording). Right: Zoom at low frequencies (< 1 kHz).



3 Continuous low frequency sound

The analysis of continuous low frequency sounds have been carried out following the requests of the European Marine Strategy [2,3], that suggests to valuate the trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz central frequencies.

Fig. 5 shows the spectrogram of the average noise level in 1/3 octave bands recorded in April 2013. The strong noise observed below 30 Hz between April 1st and 2nd and after April 20th is due to EMI effect introduced by instrumentation operated during the detector commissioning phase. For this reason, the octave band analysis shown in Fig.6 refers only to the period 13-20 April 2013.

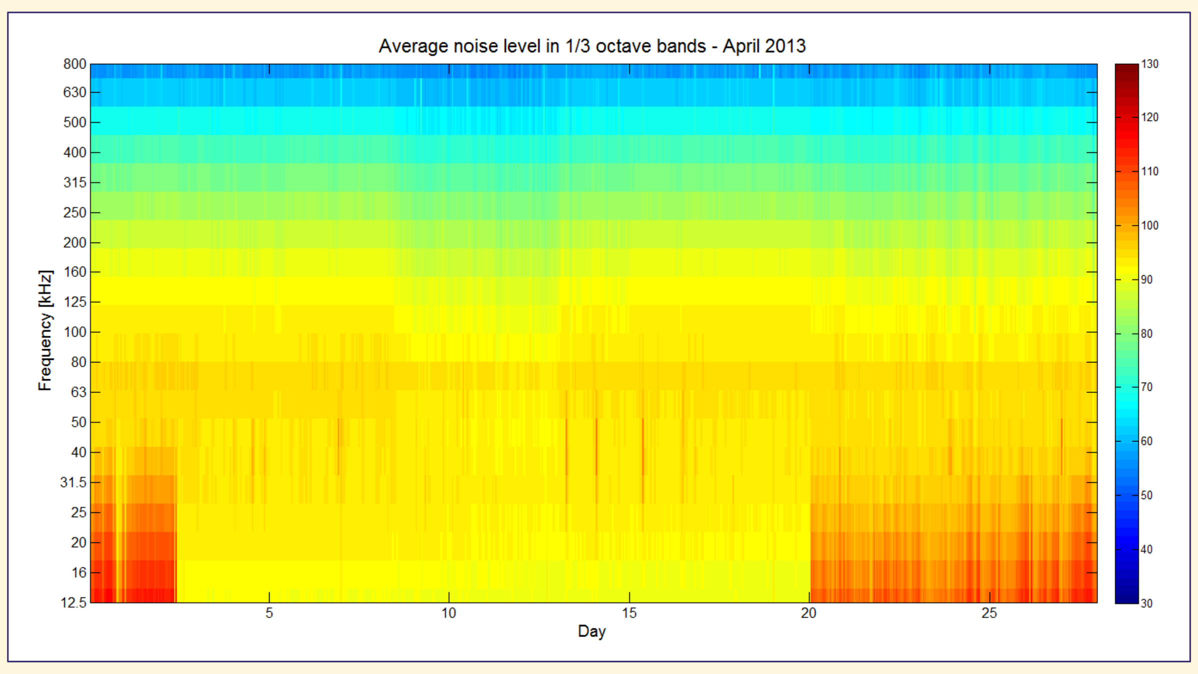
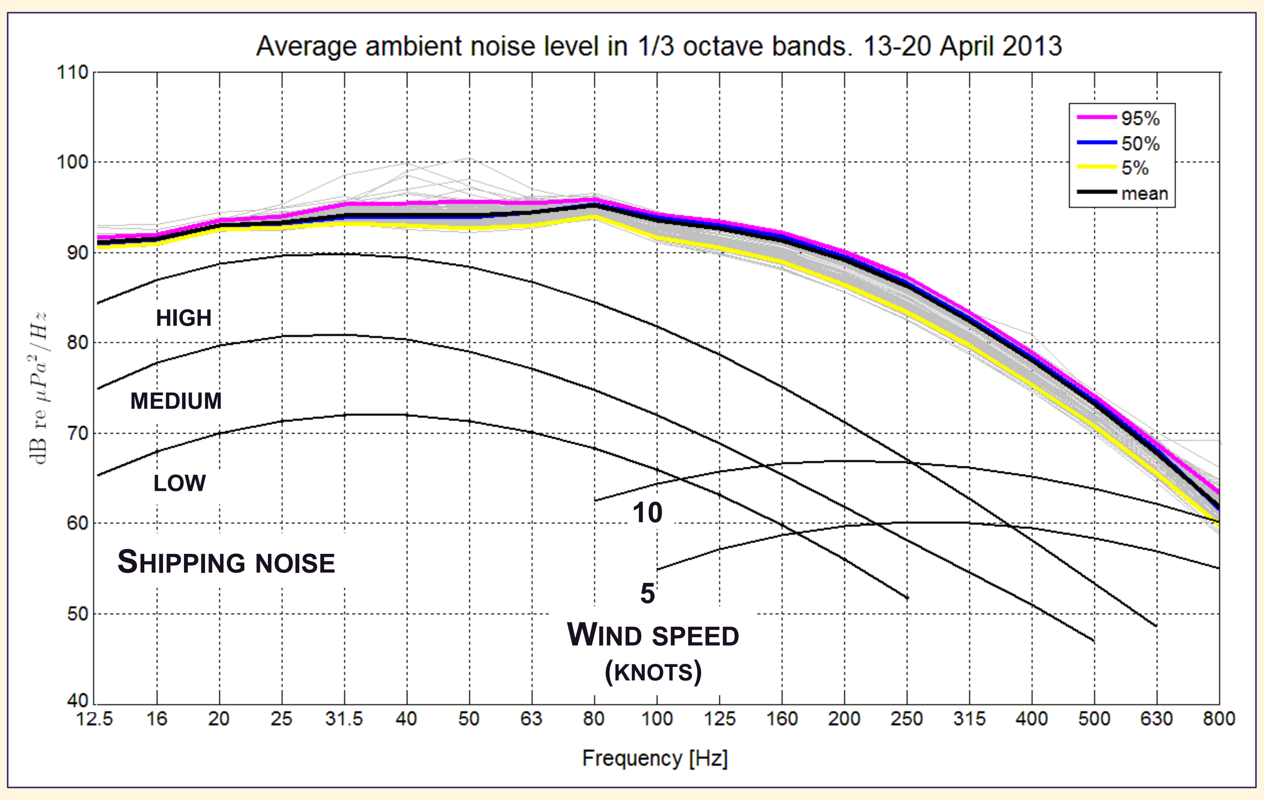


Fig.5 – Spectrogram of the average power spectral density of acoustic noise in 1/3 octave bands, recorded in April 2013 (5 minutes per hour).

Fig.6 – Recordings from 13-20 April 2013 (192 files). Measured noise level in 1/3 octave bands of five minutes recording (light-grey lines), percentiles P5, P50, P95 and mean value (see legend). Shipping noise (high, medium and low) and noise introduced by wind speed (black lines) from Urik [8] is also shown for comparison.



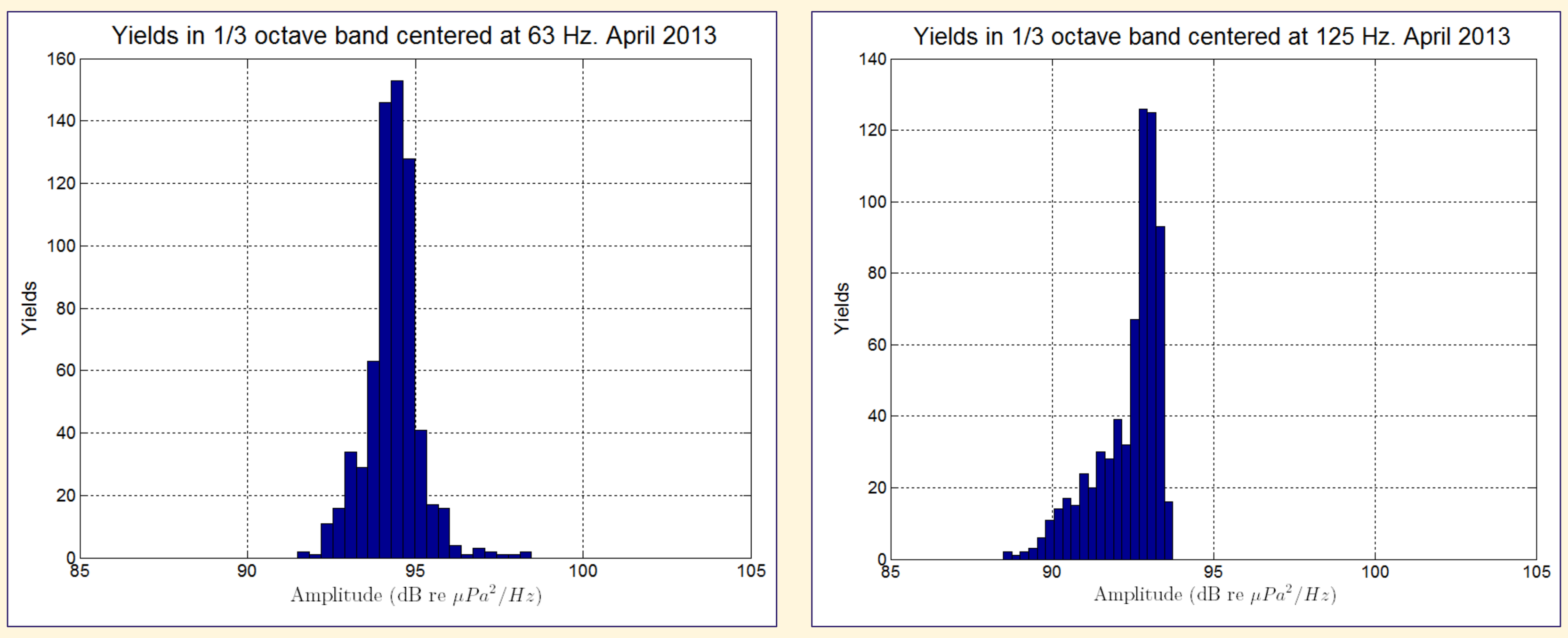


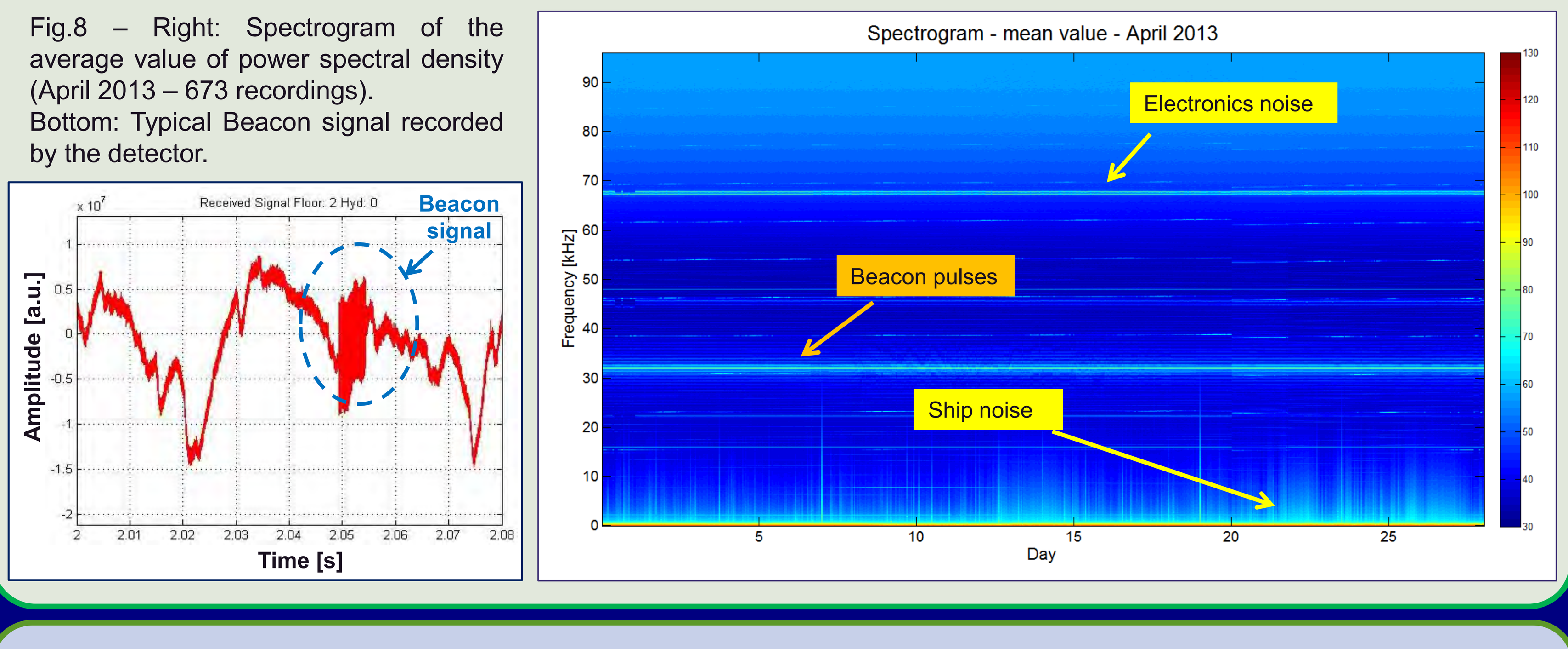
Fig.7 – Average noise level in 1/3 octave bands centered at 63Hz and 125Hz in April 2013.

4 Impulsive sounds

In April 2013 anthropogenic impulsive sounds at high frequency (such as sonar) were not found in the data set. At mid and low frequency (10 Hz – 10kHz) noise produced by ships in transit was detected.

The KM3NeT positioning beacon pulses (frequency of 32 kHz, time duration of 5 ms and power of 180 dB re 1µPa@1m) were identified and they were used as calibration source.

Fig.8 – Right: Spectrogram of the average value of power spectral density (April 2013 – 673 recordings). Bottom: Typical Beacon signal recorded by the detector.



Conclusion

The SMO antenna is operational since March 2013, at 3500 m depth off Capo Passero (Sicily). Data from the 10 hydrophones are continuously sent to shore and analysed in real time. An unbiased sample of data (5 minutes every hour) is stored on hour disk. Preliminary analysis of the data in accordance with the requirements of Italian and European legislation shows the potential impact of the used technique and of the SMO detector.

References

[1] Decreto Legislativo 13 ottobre 2010, n.190 "Attuazione della direttiva 2008/56/CE che istituisce un quadro per l'azione comunitaria nel campo della politica per l'ambiente marino ".
[2] Marine Strategy Framework Directive – Task Group 11 Report – Underwater noise and other forms of energy – April 2010.
[3] European Marine Strategy Framework Directive Good Environmental Status (MSFD-GES) – Report of the technical Subgroup on Underwater Noise and other forms of energy – Final Report – 27 February 2012.
[4] http://web.infn.it/smo
[5] F. Simeone et al. NIM A 662 (2012) S246–S248.
[6] S. Viola et al. NIM A (2013) – in press.
[7] F. Ameli et al NIM A 626-627 (2011) S211-S213.
[8] Knudsen et al, 1948; Wenz, 1962; reviewed in Urik, 1983.