Sound Level Analysis for an Offshore Oil and Gas Drilling Activity

*Guillermo Jiménez *[1], David Hedgeland[2], Stephen Cook[1], Nikhil Banda[1], Phil Johnston[3], Ed Oliver[3]*
[1]Seiche Ltd., BP[2], AutoNaut Ltd.[3]

- Source level prediction for MODU facilities commonly use historical data (from vessels and old-gen MODU).
- Available acoustic data are often limited by the number of sample locations and distances from a facility (kms to 10's kms).
- A survey was carried out to characterise the acoustic output of a 'modern' 6th generation MODU.

A sound field mapping survey was carried out by Seiche Ltd., on behalf of BP, during normal operations of a 6th generation Mobile Offshore Drilling Unit (MODU) using five drift buoys and a USV. The poster briefly describes the operational aspects of the survey, to then present the analysis of sound level dependence with various factors.

MODU

- **6th generation** MODU
- Deep water area (~2.3 km) with significant vessel activity.
- **8 azimuthal thrusters** dynamic positioning.
- Intermittent **periods of drilling** during DP.

Figure 1 The MODU (John Regan, MarineTraffic.com).

Drift Buoys

- **Collection method**: drift by swell and currents.
- **Parts**: mast (strobe and radar reflector), metal housing (battery and tracking system), *e-tube*, wet leg, and hydrophone array.
- **Hydrophone array**: 2 pairs of hydrophones at 30 and 60 m.

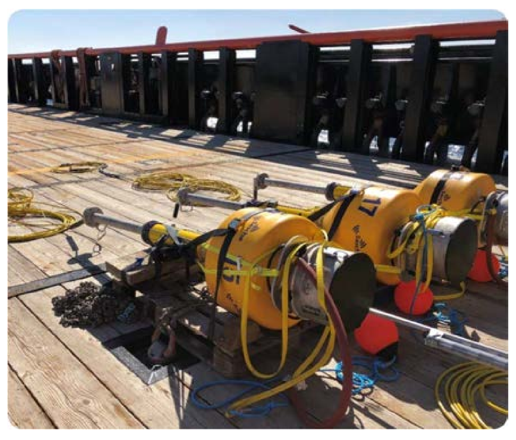

Figure 2 Drift buoys on board the survey vessel, before deployment.

AutoNaut

- **Collection method**: remote control and waypoint navigation.
- **Parts**: communications system, hull-mounted PAM unit and 25 m towed hydrophone cable.
- **Endurance**: energy harvesting and wave foil propulsion (quiet).

Figure 3 5m USV designed by AutoNaut.

Survey Area and Data Collection

- **Acoustically and operationally busy area:** tackled with sound mapping strategy and communication protocol (SIMOPS).
- **500 m safety exclusion zone**: vessel movements restricted inside this area.
- **Drift buoy effort:** 41 h, 1-5 km from MODU
- **USV Towed PAM effort:** 75 h, 5.5 km from MODU. Primary effort within 500 m exclusion zone (daylight, CPA ≈ 140 m). Survey vessel outside exclusion zone.
- **Outcome**: 140 m – 5.5 km coverage, three receiver depths (25, 30, 60 m), 117 hours of continuous valid data.

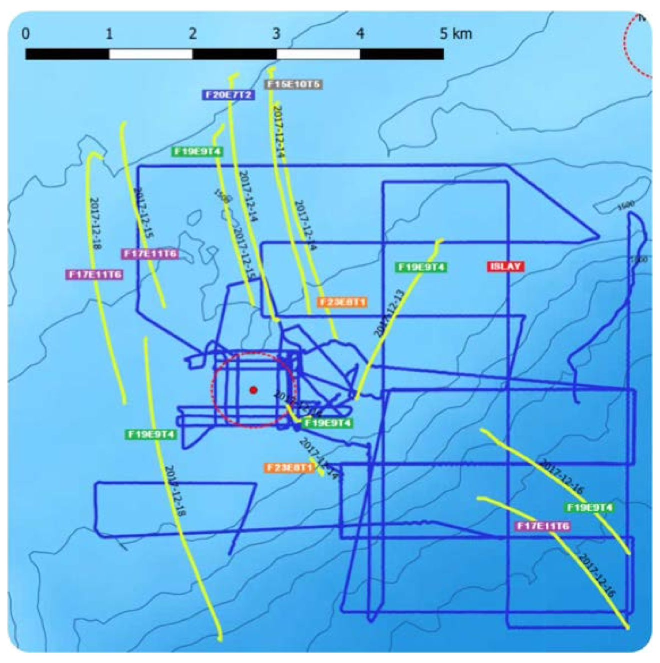

Figure 4 Navigation tracks of *Islay* (blue) and drift buoys (yellow).

The Dataset

- **Dataset content:** audio (.wav, 250 ks/s), GPS (buoys and USV), AIS
- **Identified acoustic sources**
  - ❑ *MODU:* continuous LF sound, HF tones
  - ❑ *Seismic source pulses:* transient broadband with energy < 250 Hz
  - ❑ *Close passes of vessels:* continuous broadband noise with LF tones
  - ❑ *'Chirps':* sequence short frequency sweeps, 25 kHz central frequency
  - ❑ *'Pings':* transitory 38 kHz tones
  - ❑ *Self-noise of USV recording system:* continuous 5.5 kHz tone.

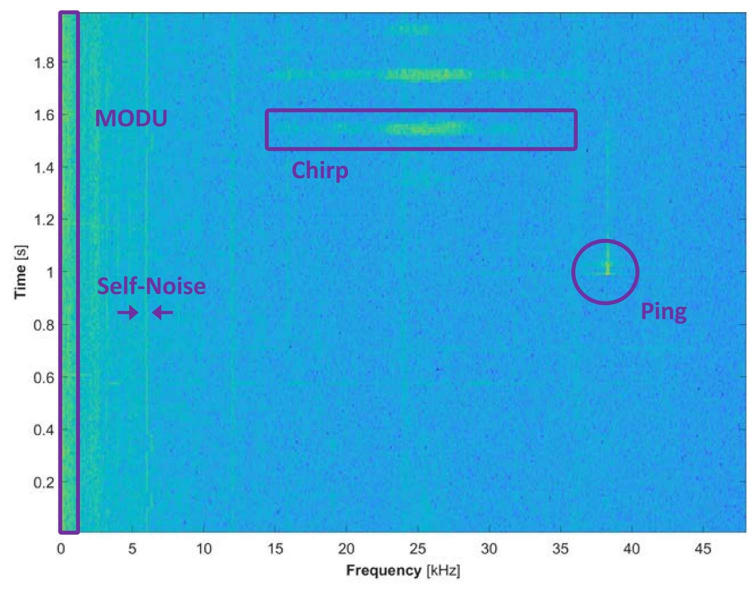

Figure 5 Spectrogram with 4 of the 6 most characteristic sounds in the survey. Close passes of vessels and seismic energy were successfully excluded from the analysis.

Data Analysis. Sound Level variation with time, range, frequency and azimuth

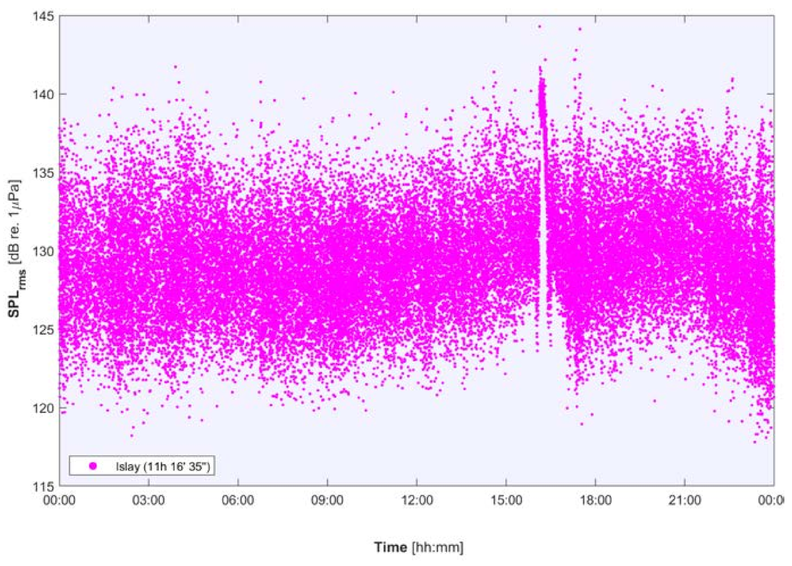

Figure 6 Sound level rms with time (scatter).

- Sound levels **120-140 dB**$_{rms}$.
- **Large short-term variability:** 10-15 dB within 1' segments.
- **No evident increase in sound level** due to nearby vessels (r > 200 m).

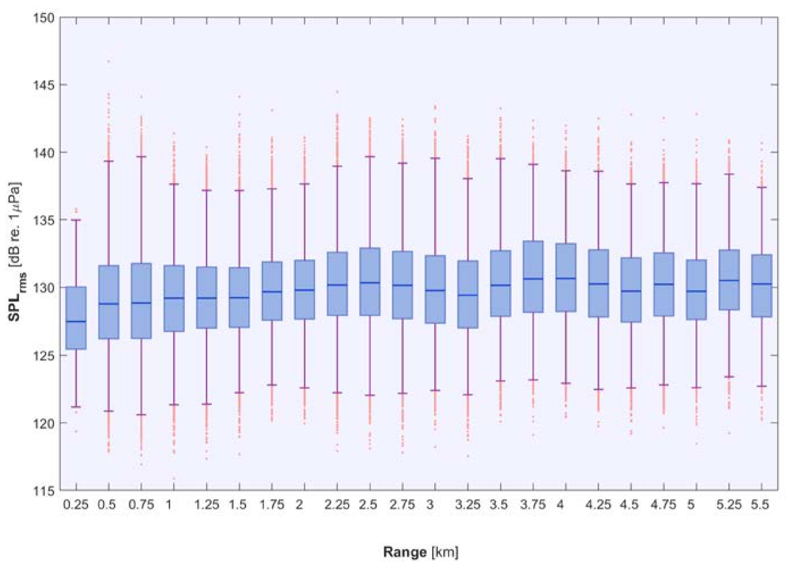

Figure 7 Sound level rms with range (box & whisker)

- **No evident attenuation of sound levels with range** (140 – 5,500 m).
- **Flat SPL(r)?** Caused by multipath reflections, which dominate at ranges greater than 1 km for f < 250 Hz (confirmed by simulations).

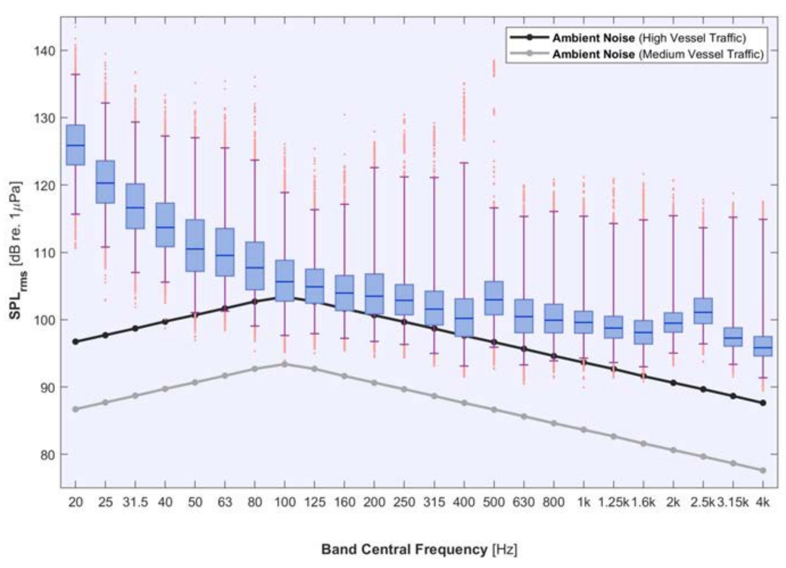

Figure 8 Sound level spectrum (box & whisker)

- Measured sound is **predominantly low-frequency** (99% energy < 100 Hz).
- Measured sound levels comparable to ambient noise levels at **100-500 Hz** for high vessel traffic.
- **Tonal components** close to MODU.

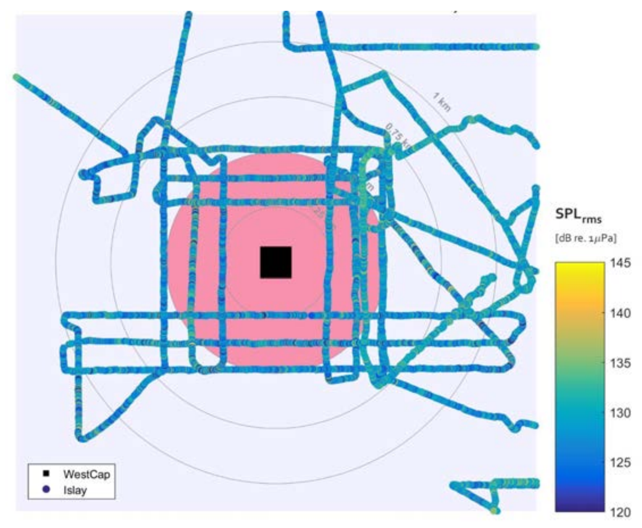

Figure 9 Sound level rms (2D map)

- **No directionality** observed.
- **Low-frequency**: omnidirectional response < 150 Hz (~100 m spacing between thrusters).
- **High-Frequency**: fluctuations from thruster load and depth.

Discussion

- **Back-propagation**: the sound level map of a source can be used to calculate its *Source Level* spectrum (SL) by fitting the simulated *Transmission Loss* (TL) to the measured *Received Level* (RL) for each frequency band.
- **Forward-Model**: simulated RL at any location is the difference between SL and TL.

$$RL(i,r) = SL(i) - TL(i,r)$$

- **Point source** assumption in the propagation model results in **overestimated sound levels** in the near field of the MODU.
- Received Level simulations are **only valid in the far field of the source**.

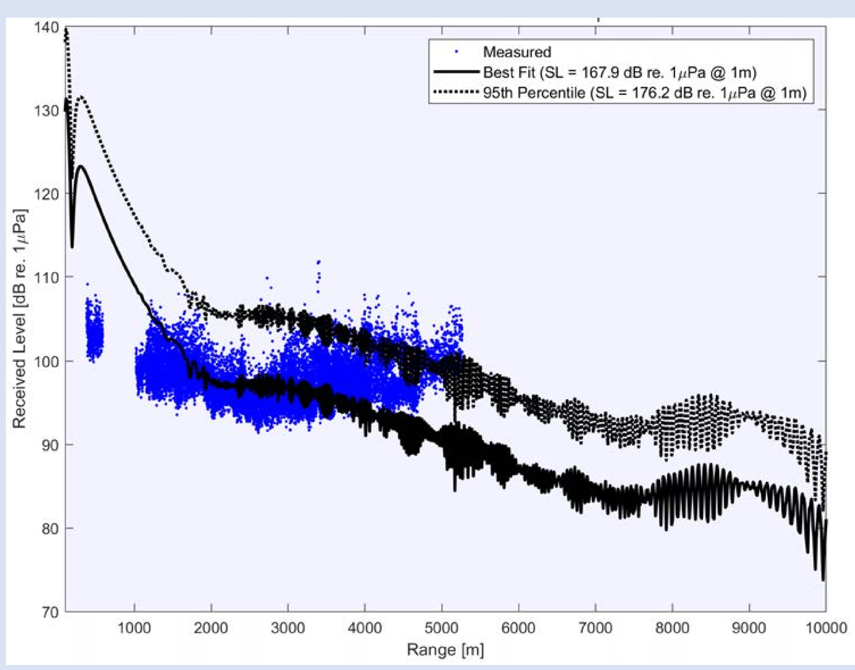

Figure 10 Source level estimation at 250 Hz. Fitting of simulated transmission loss to measured received levels.

Conclusions

- High confidence that processed sounds are associated with MODU
  - ❑ Seismic pulses and vessel close passes excluded from analysis
  - ❑ Chirps, pings and self-noise removed by downsampling
  - ❑ Minimal contribution of ambient noise and seismic reverberation
- Acoustic variability
  - ❑ Complex dependence of sound levels with time, range, azimuth
  - ❑ Causes: propagation path, thruster depth and load, receiver depth
- Characteristics of measured sound
  - ❑ Predominantly low-frequency (99% energy < 100 Hz)
  - ❑ Tonal components close to the MODU attenuate with range
- Source Level Spectrum of MODU
  - ❑ Measured sound levels lower than simulations in near field
  - ❑ Source level only applicable for far-field propagation modelling