Sonar signal analysis: Biological consequences of out-of-band acoustic signals from active sonar systems [conference presentation]

This item was submitted to Loughborough University's Institutional Repository by the/an author.

Citation: LEPPER, P.A. and RISCH, D., 2018. Sonar signal analysis: Biological consequences of out-of-band acoustic signals from active sonar systems. Presented at the 176th Meeting of the Acoustical Society of America (ASA), Victoria, Canada, 5-9 November 2018.

Additional Information:

- This is a conference presentation.

Metadata Record: https://dspace.lboro.ac.uk/2134/36016

Version: Accepted for publication

Rights: This work is made available according to the conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) licence. Full details of this licence are available at: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the published version.
Sonar signal analysis: biological consequences of out-of-band acoustic signals from active sonar systems.

Paul Lepper – Loughborough University, UK
Denise Risch – Scottish Association of Marine Sciences (SAMS), UK
One Scientific sonar of interest was the SIMRAD EK60 with operational frequencies at 18 kHz, 38 kHz, 70 kHz, 120 kHz and 200 kHz.
Concerns over the use of active sonars for marine mammal monitoring

Research Questions:

• Characterize full frequency spectrum from EK60 120 kHz and 200 kHz signals.

• Are any sub-harmonic components of EK60 120 and 200 kHz signals audible to harbour seals and porpoises?
EK60 split beam system

EK60 with 120 kHz (ES120-7C) and 200 kHz (ES200-7C) transducers

- 120 kHz center frequency
- 7 deg. Beam width.
- Transmit response 185 dB re μPa/V
- Max. pulsed power 1000W

Data from Simrad ES120-7C data sheet

- 200 kHz center frequency
- 7 deg. Beam width.
- Transmit response 185 dB re μPa/V
- Max. pulsed power 1000W

Data from Simrad ES200-7C data sheet
Measurement set-up

9 m  Marine Scotland's calibration tank (Aberdeen)

3 m deep

5.8 – 6.1 m

Transducers and hydrophone / target at 1.5 m depth

Alignment using a calibrated target sphere / measurements made using direct path
Measurement details

• Calibrated hydrophone (B&K 8105), a band-pass filter (100 Hz - 360 kHz)

• Data was digitized at 1.2 MS/s / 16 bit using a National Instruments 6251 high speed USB DAQ using a custom LabVIEW interface

• Fresh water sound speed was 1447 ms\(^{-1}\) temperature 10\(^{\circ}\) C

• Far-field measurement range of 6.1 m for the 120 kHz transducer and 5.9 m for the 200 kHz transducer

• Free field – far field conditions on direct path

• Measurements made at different signal pulse lengths (64, 128, 256, 512, 1024 µs)

• Power levels
  • 120 kHz: 50, 150, 200, 250, 300, 350, 400, 450, 500 Watt
  • 200 kHz: 30, 60, 90, 120, 180, 210, 240, 270, 300 Watt
In-pulse analysis

120 kHz center frequency / 1024 μs pulse duration at 250 W

pk-pk SPL 208.9 dB re $1\mu$Pa$_{pp}$

1024 point FFT, Hann window, 50% overlap 30 ms integration window – frequency resolution of 1.2 kHz
Full pulse analysis 120 kHz 250W

pk-pk SPL 208.9 dB re 1μPa

Average SPL\textsubscript{RMS} values in range 70-100 kHz 136 dB re 1 μPa for in-signal and 132 dB re 1 μPa for measurements using a 30 ms integration period.

Received Levels at a range of 6.1 m 120 kHz
In pulse analysis 200 kHz 120W

Received Levels at a range of 5.8 m

1024 point FFT, Hann window, 50% overlap 30 ms integration window – frequency resolution of 1.2 kHz
Full pulse analysis 200 kHz 120W

Average SPL\_RMS values in range 90-100 kHz 136 dB re 1 µPa for in-signal and 129 dB re 1 µPa for measurements using a 30 ms integration period.

Received Levels at a range of 6.1 m

~60 dB

1024 point FFT, Hann window, 50% overlap 30 ms integration window – frequency resolution of 1.2 kHz.
Signal level versus pulse length

(a) pk-pk

120 kHz

SPL (dB re 1 μPa)

Duration (ms)

64 128 256 512 1024

(b) pk-pk

120 kHz

SPL_{RMS}

Power (Watt)

50 100 150 200 250 300 350 400 450 500

(a) pk-pk

200 kHz

SPL (dB re 1 μPa)

Duration (ms)

64 128 256 512 1024

(b) pk-pk

200 kHz

SPL_{RMS}

Power (Watt)

30 60 90 120 180 210 240 270 300

Broadband signal strength
Summary

- The primary and lower frequency components of both the 120 kHz and and lower frequency components of the 200 kHz signal (90-100 kHz) are at levels that could potentially be heard by harbour porpoises at relatively short ranges. The actual audibility ranges would depend on the signal properties used, ambient noise, propagation condition, hearing properties of the species of interest (audiogram, critical ratios etc.).

- Harbour seals although significantly less sensitive the range of 70-120 kHz however signal levels in this range for both sonar systems are potentially within their hearing range.

- As with other 200 kHz sonar systems measured by Deng et al. signal levels of these below primary frequency components are unlikely to cause physiological harm however possibilities exist for elicitation of behavioural responses in these species and careful consideration should be made of these components in interpretation of behavioural response data acquired using these systems.
Report

Many thanks to Marine Scotland especially Eric Armstrong and Ian Davies

Thank you

p.a.lepper@lboro.ac.uk