Long-term ambient noise monitoring off eastern Scotland, and an exploration of tidal influence on MSFD reporting

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Background

Underwater soundscape: natural, biological and anthropogenic sounds

EU Marine Strategy Framework Directive (MSFD)

- Descriptor 11.2.1. Ambient (continuous) noise
- Threshold levels have not been set yet

Aims

Assess the spatio-temporal variability in ambient noise

- Averaged RMS levels & percentile statistics (for the 1/3 octave band centred at 63 Hz)

Investigation into tidal influence on MSFD reporting

- Average RMS levels
- Exceedance of hypothetical GES threshold

Methodology: Data collection

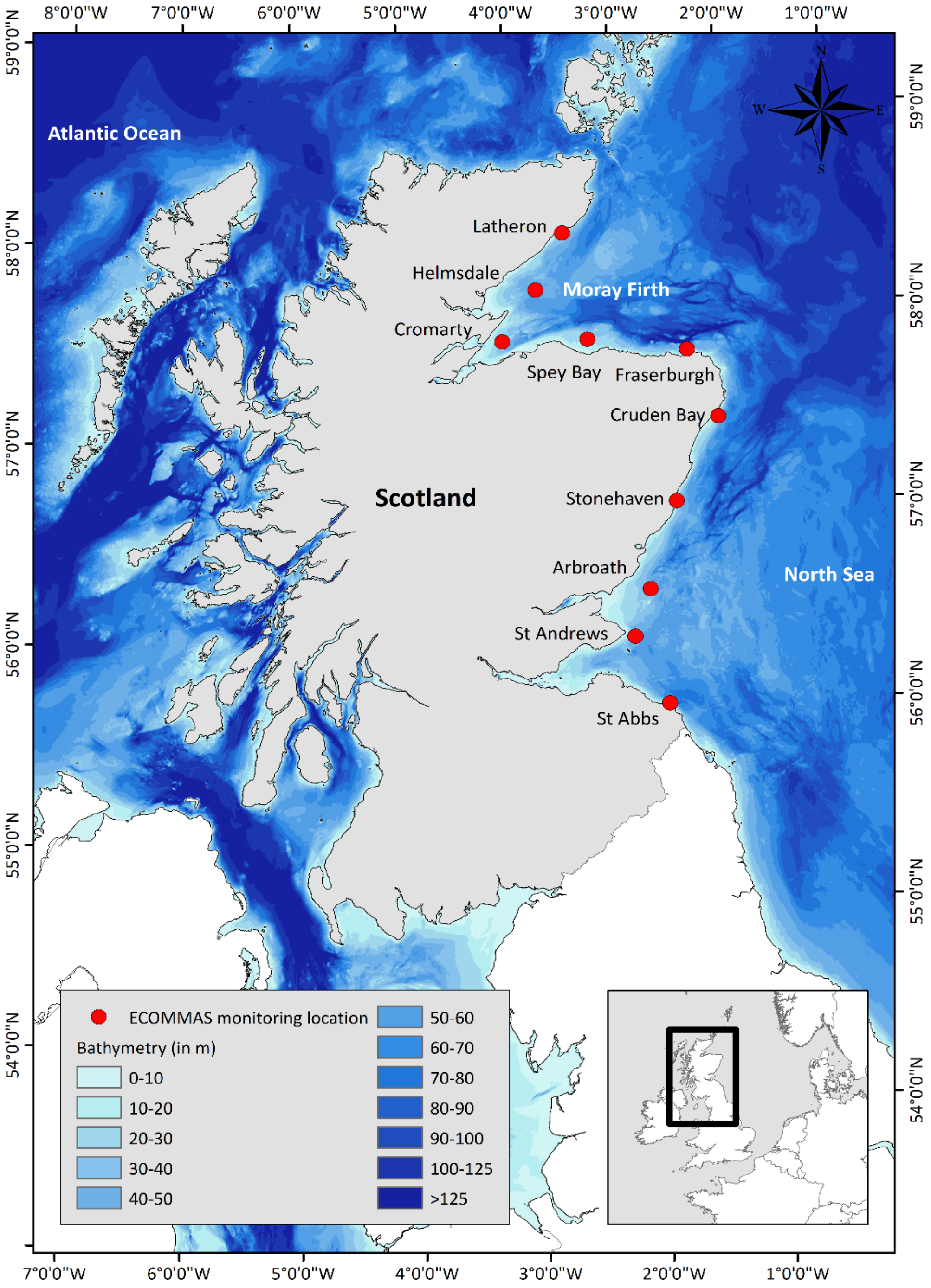
Deployments: **10 coastal sites**

Acoustic broadband recorders: **SM2M/SM3M**

- **96 kHz** sampling rate
- **10/10** and **10/20** min on/off duty cycle

5 years of data: **2013 - 2017**

Increased monitoring effort over the years



Methodology: Data analyses

Ambient noise analysis: Modified version of **PAMGuide**

Tidal influence:

- Tidal **velocity data** obtained from Scottish Shelf Model
- Top 3 tidally-affected sites (Kernell's rank correlation coefficient)
- Exclusion of periods with highest velocity ('tidal-corrected dataset')

RMS levels compared against GES thresholds

Methods in Ecology and Evolution

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Measuring acoustic habitats

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Summary

1. Many organisms depend on sound for communication, predator/prey detection and navigation. The acoustic environment can therefore play an important role in ecosystem dynamics and evolution. A growing number of studies are documenting acoustic habitats and their influences on animal development, behaviour, physiology and spatial ecology, which has led to increasing demand for passive acoustic monitoring (PAM) expertise in the life sciences. However, as yet, there has been no synthesis of data processing methods for acoustic habitat monitoring, which presents an unnecessary obstacle to would-be PAM analysts.

2. Here, we review the signal processing techniques needed to produce calibrated measurements of terrestrial and aquatic acoustic habitats. We include a supplemental tutorial and template computer codes in MATLAB and R, which give detailed guidance on how to produce calibrated spectrograms and statistical analyses of sound levels. Key metrics and terminology for the characterisation of biotic, abiotic and anthropogenic sound are covered, and their application to relevant monitoring scenarios is illustrated through example data sets. To inform study design and hardware selection, we also include an up-to-date overview of terrestrial and aquatic PAM instruments.

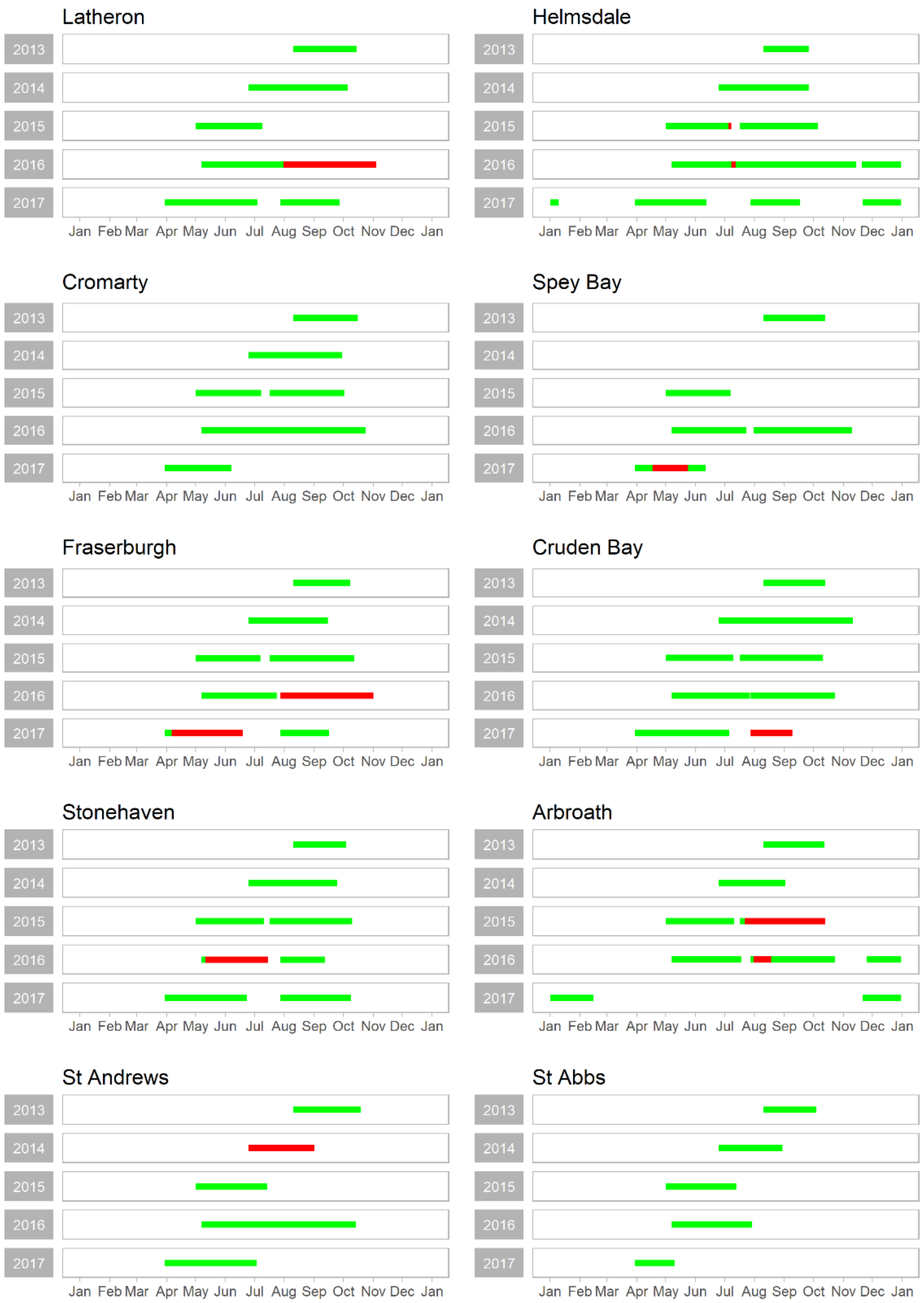
3. Monitoring of acoustic habitats at large spatiotemporal scales is becoming possible through recent advances in PAM technology. This will enhance our understanding of the role of sound in the spatial ecology of acoustically sensitive species and inform spatial planning to mitigate the rising influence of anthropogenic noise in these ecosystems. As we demonstrate in this work, progress in these areas will depend upon the application of consistent and appropriate PAM methodologies.

Results

Effort: 0 – 5191 hrs / site / year

→ Total 112,071 hrs

Annual RMS levels: 86.8 - 111.0 dB re 1 µPa



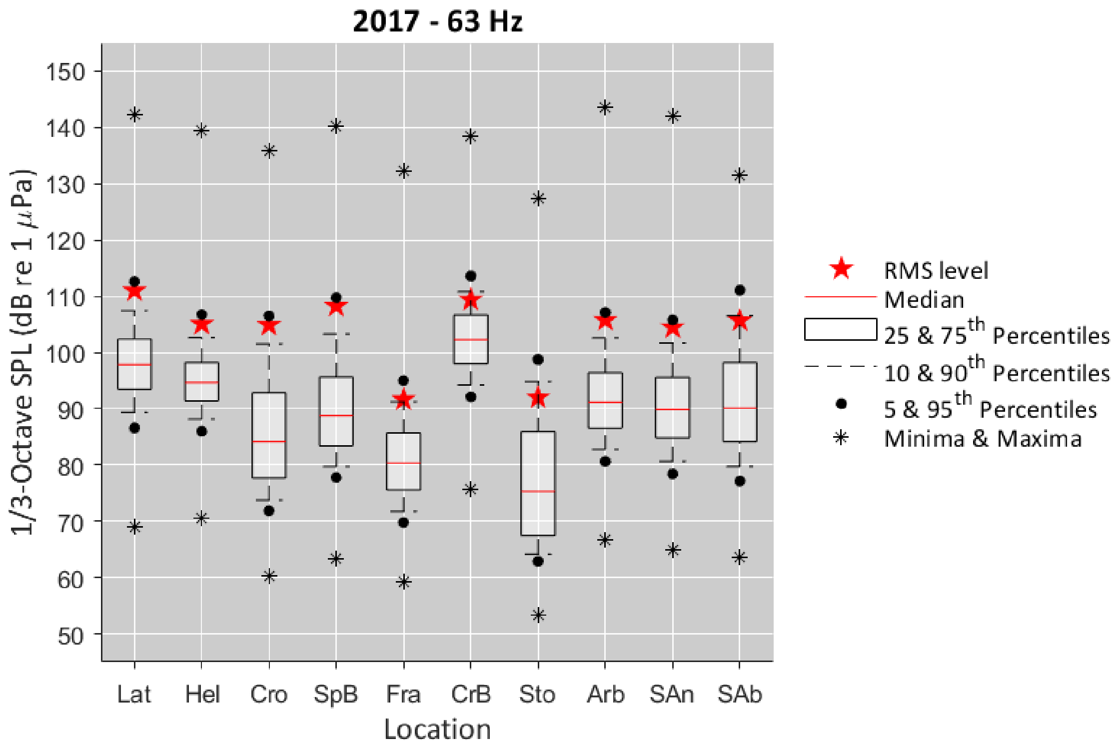
Results

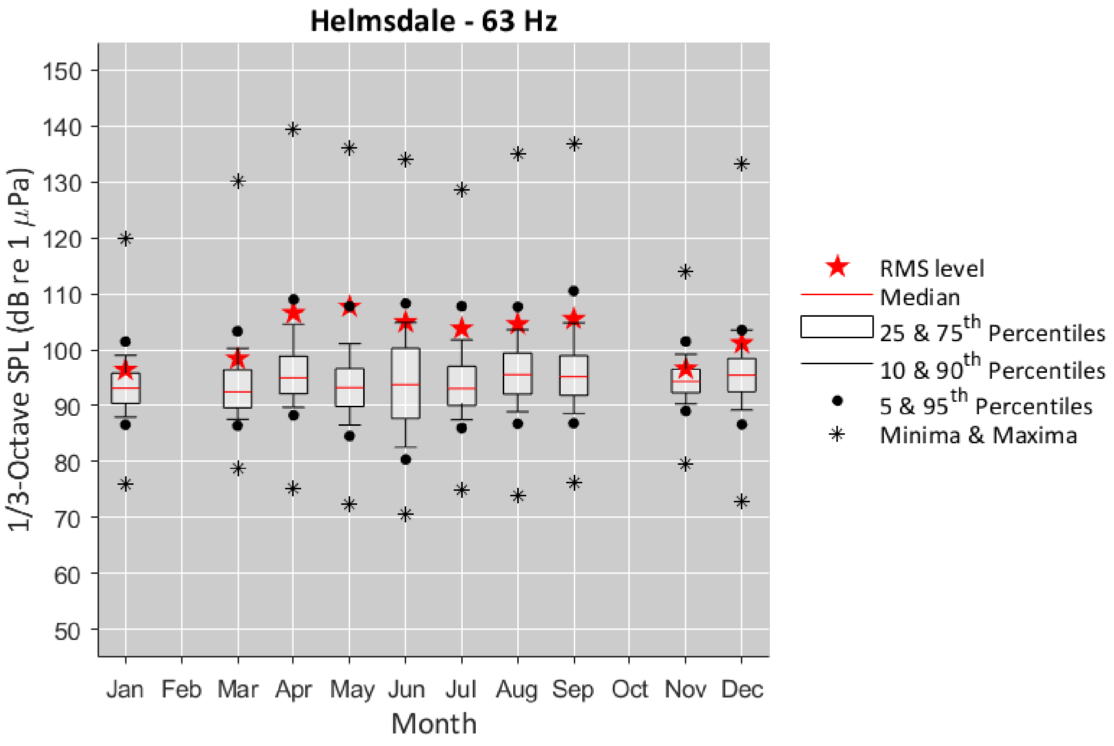
Per year:

- Higher noise levels at Cruden Bay
- Lower RMS levels at Stonehaven and/or Fraserburgh (& Cromarty)

Per month:

- Winter levels appear lower (but limited data: 2017 only, and unequal effort)

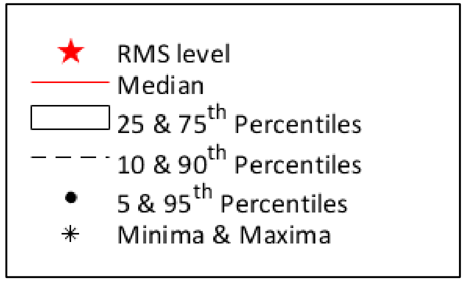


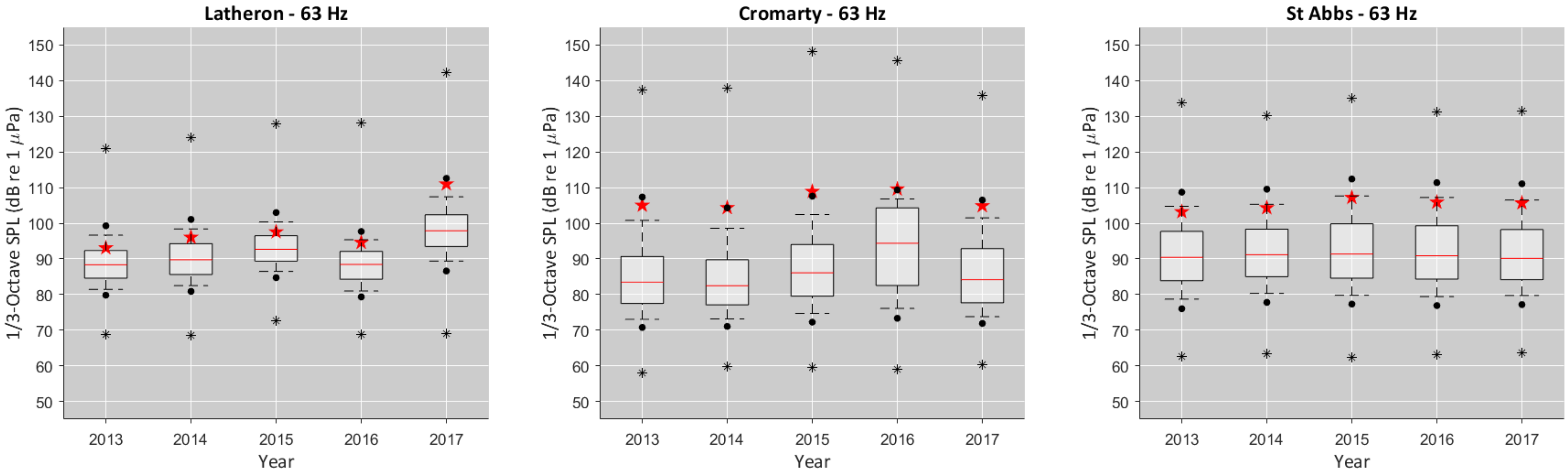


Results

Per site:

- No general pattern





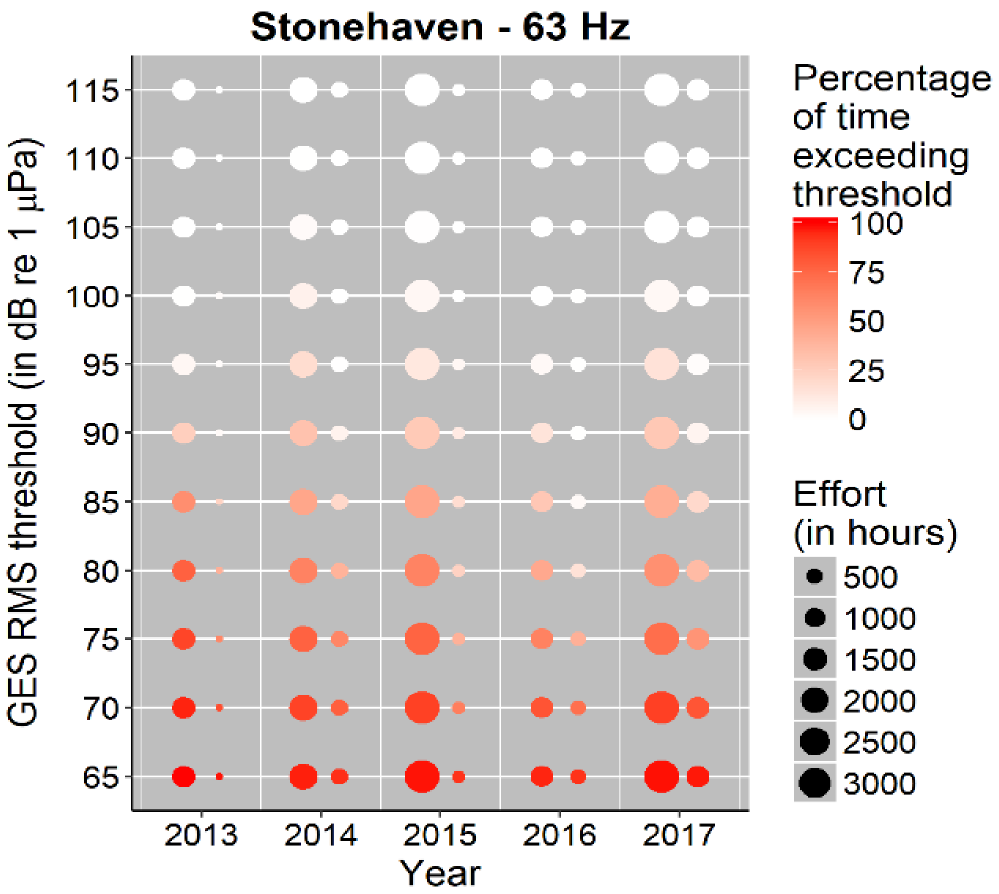
Results

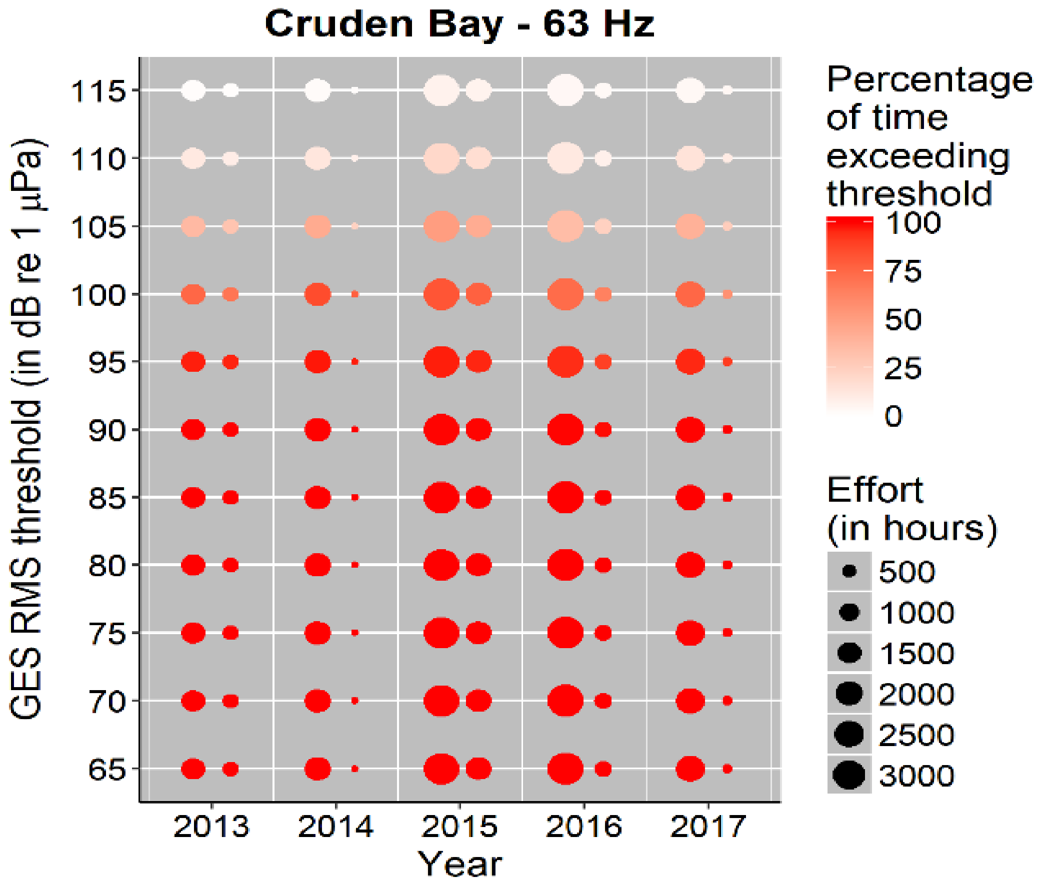
Tidal corrections:

- Substantial exclusion of data
- Varying consequences on RMS levels

	Tidal correction – Data excluded	Change in RMS measurements
Stonehaven	61.0 – 91.8 %	-3.9 to -11.1 dB
Fraserburgh	28.2 – 86.3 %	-6.3 to +2.0 dB
Cruden Bay	51.7 – 85.6 %	-2.1 to 0 dB

Results


Stonehaven - 63 Hz
GES RMS threshold (in dB re 1 μPa)
115
110
105
100
95
90
85
80
75
70
65
2013
2014
2015
2016
2017
Year
Percentage of time exceeding threshold
100
75
50
25
0
Effort (in hours)
500
1000
1500
2000
2500
3000


Cruden Bay - 63 Hz
GES RMS threshold (in dB re 1 μPa)
115
110
105
100
95
90
85
80
75
70
65
2013
2014
2015
2016
2017
Year
Percentage of time exceeding threshold
100
75
50
25
0
Effort (in hours)
500
1000
1500
2000
2500
3000

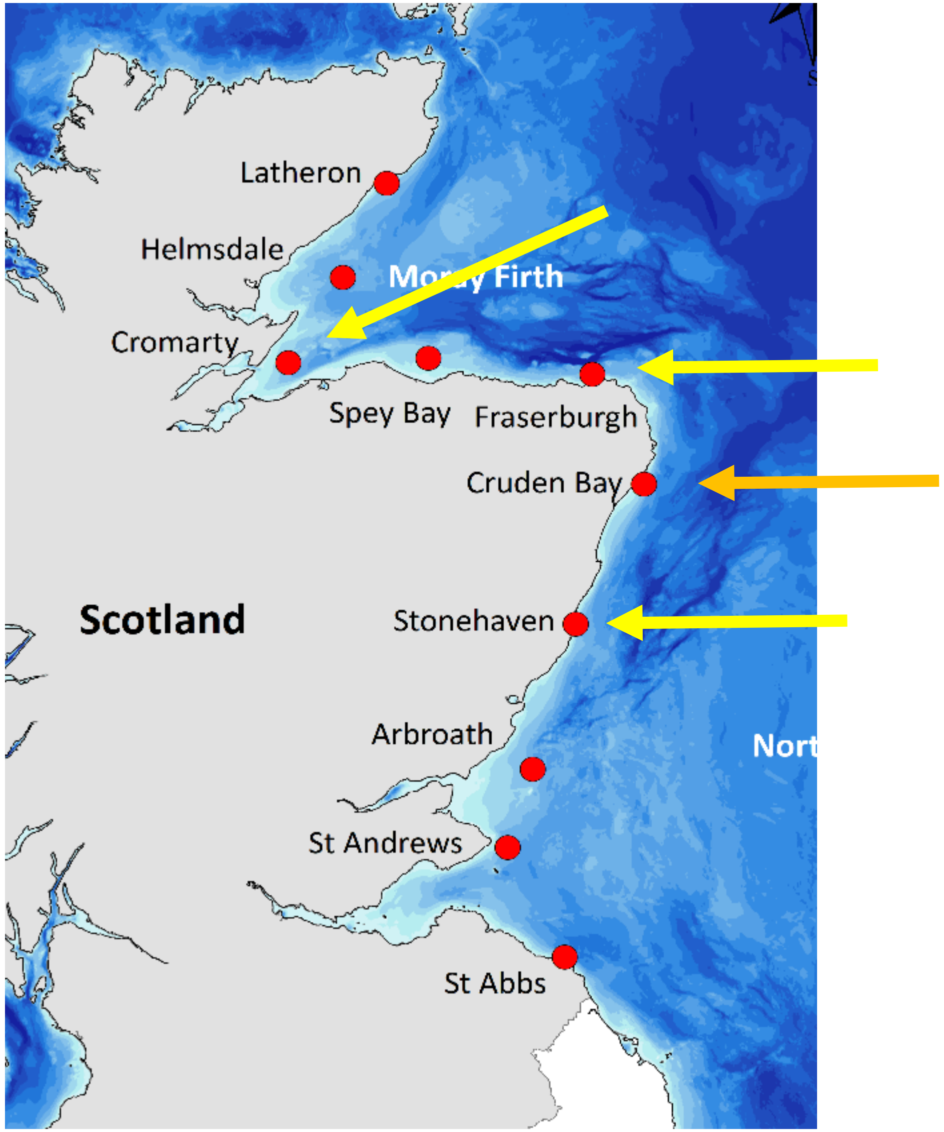
Summary

Annual RMS levels: 86.8 - 111.0 dB re 1 µPa

Consistent noisier and quieter sites identified

Tidal correction (i.e. data sub-setting) possible due to vast amount of annual data

Applied to sites influence by tide → meaningful data for MFSD ambient noise monitoring



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