Detection and recognition of Atlantic cod grunts

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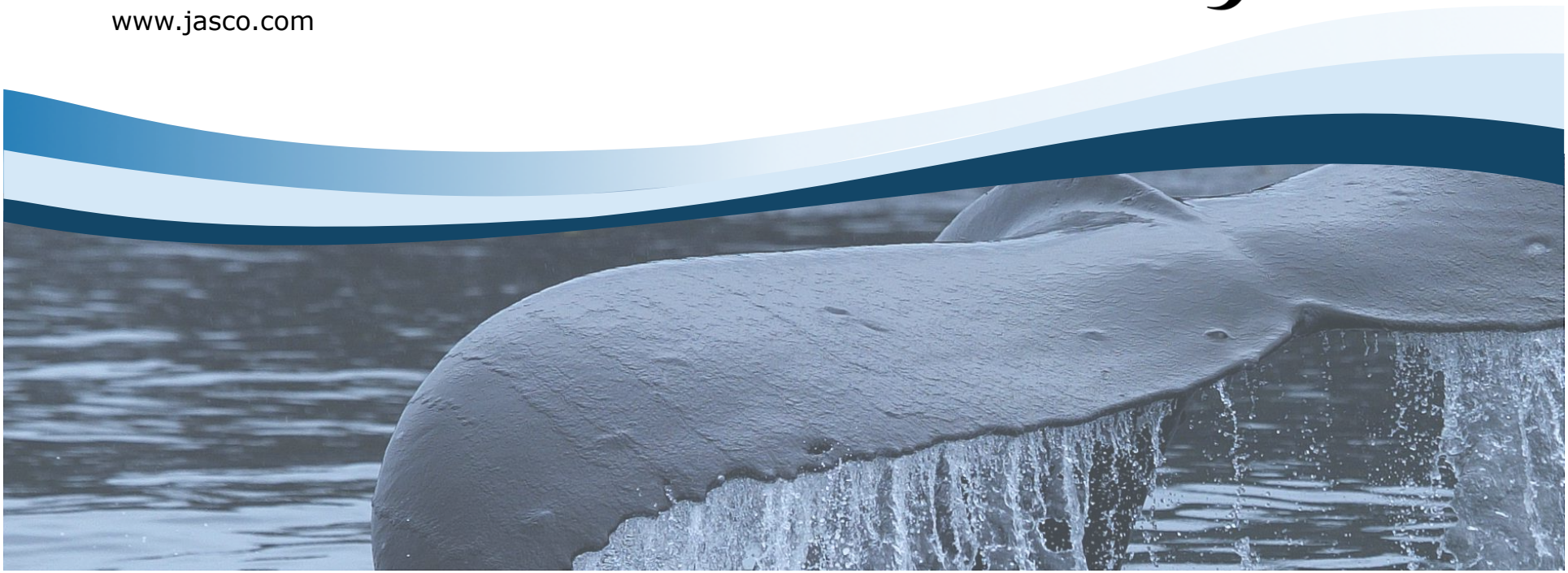
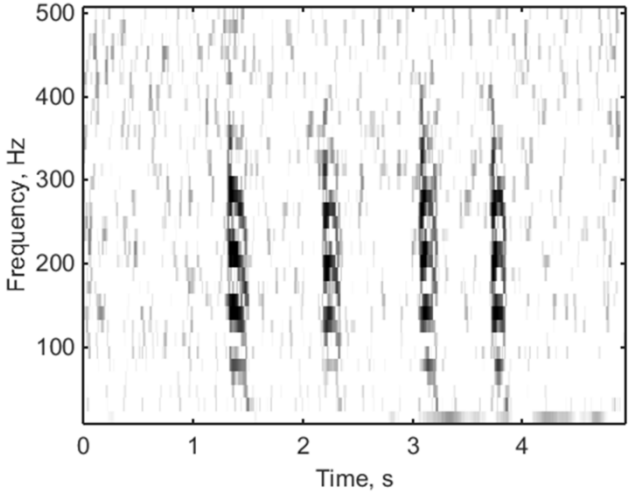


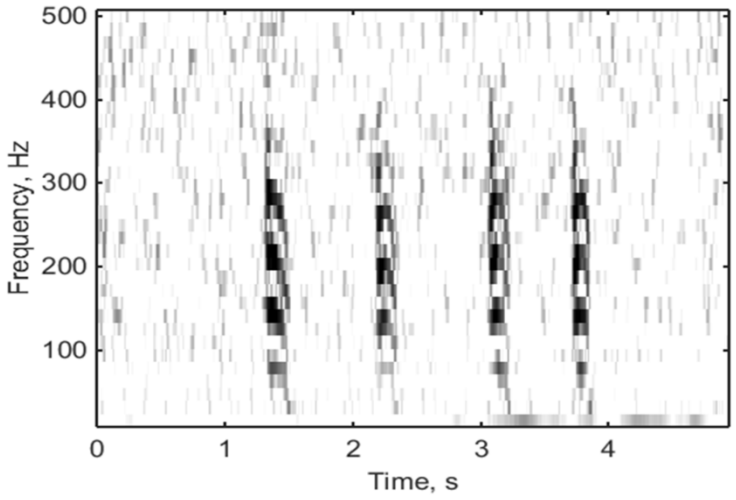
Introduction

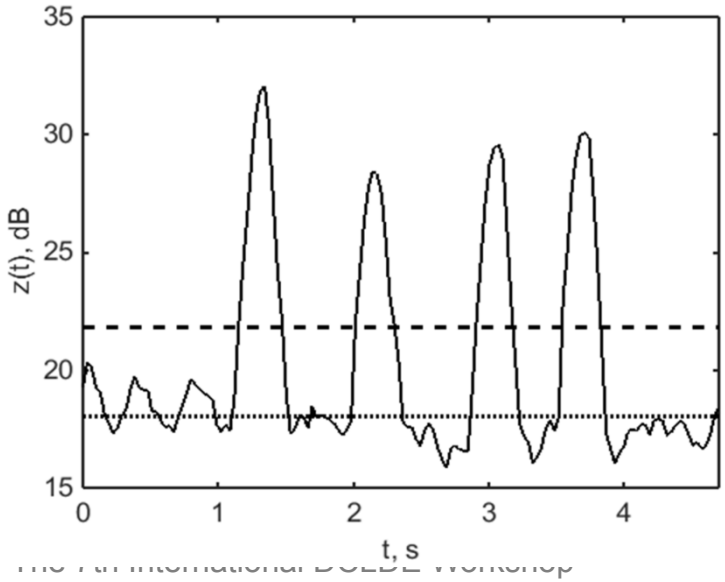


Goal:
To design an automatic grunt detection and recognition algorithm that processes yearlong passive acoustic data.

Method:
Two-step data processing algorithm consisted of signal detection and recognition.

Signal Detection





The detection algorithm computes detection statistic with a bank of 2-D linear filters

$$z(t)=\max_{\tau,p} |u(t,\boldsymbol{\lambda}_p)|^2$$

Signal Recognition

Feature extraction:

The prominent visual features of grunts are the three or more harmonics separated by 50-80 Hz in the frequency domain. We extract these features with two spectrogram transformations. The first is:

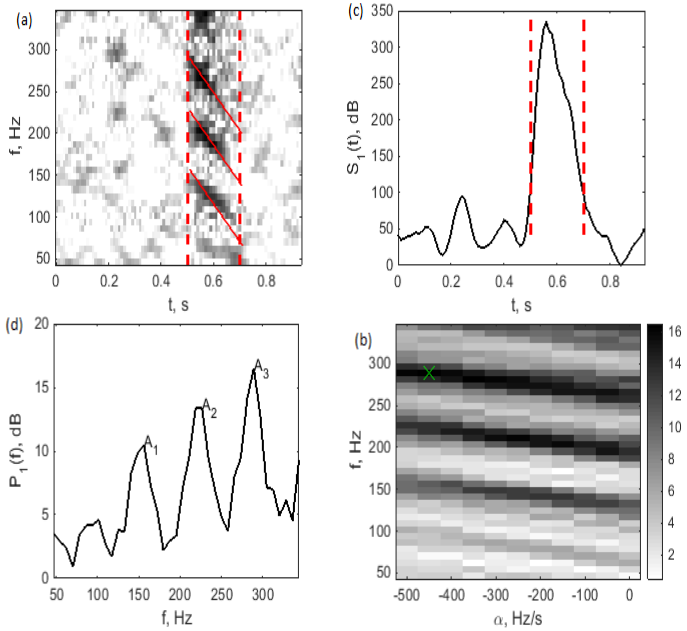
$$S\downarrow 1\ (t)=\sum f=1\uparrow N\downarrow f\ \square X\ (f,t)$$

where $X\ (f,t)$ is the spectrogram in dB.

The second is based on the 2-D function:

$$P(f,\alpha)=\sum \tau=t-0.05\uparrow t+0.05\ \square X\ (f+\tau\alpha,\tau)$$

Signal Recognition



(a) Spectrogram of cod grunt, and functions (b) $P(f,\alpha)$, (c) $S\downarrow 1\ (t)$, (d) $P\downarrow 1\ (f)$

Feature extraction:

We recognize signals with features extracted from $S\downarrow 1\ (t)$ and $P\downarrow 1\ (f)$:

$x\downarrow 1 = T$, (duration)
$x\downarrow 2 = f\downarrow P$, (peak frequency)
$x\downarrow 3 = SNR$, (SNR)
$x\downarrow 4 = \delta\downarrow f$, (inter-harmonic interval)

$x\downarrow 5 = \min\_{m=1..3} r\downarrow m$, (peak-to-min ratio)
$x\downarrow 6 = A\downarrow max / A\downarrow min$, (peak-to-peak ratio)

Signal Recognition

Feature testing:

We tested features using a maximum likelihood algorithm with subjective likelihood functions. We assigned the feature vector $\boldsymbol{x}=[x_1,\ldots,x_6]^T$ to Atlantic cod when

$$W(\boldsymbol{x})=\exp\{-\sum_{n=1}^{6} d_n^2\} \geq C$$

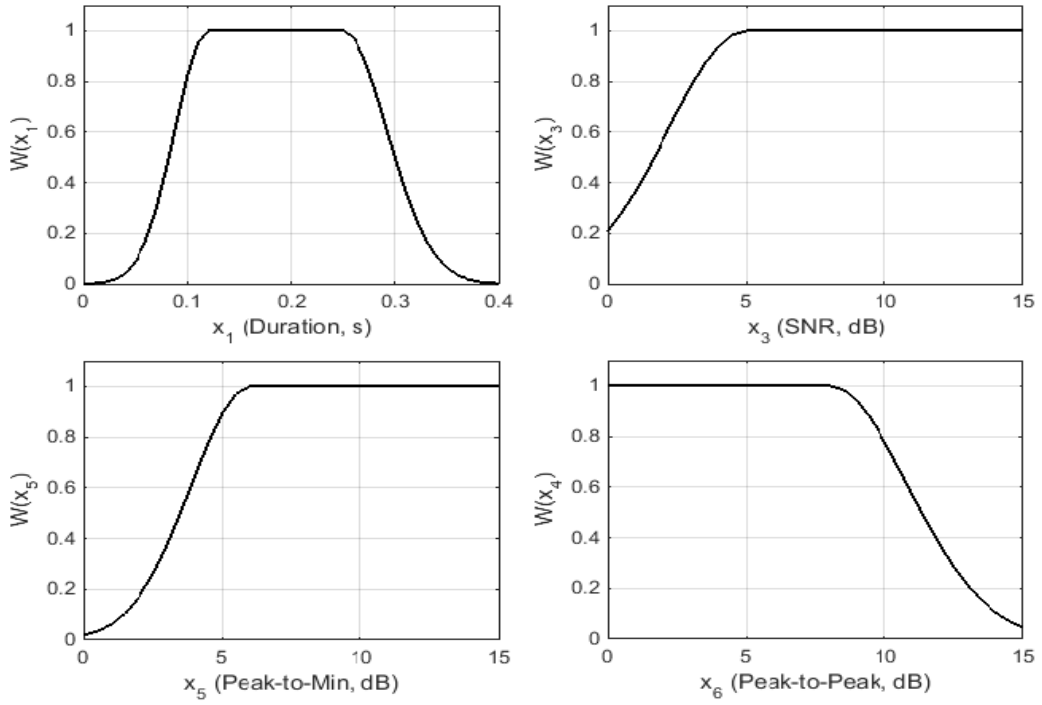
where

$$d_n^2 = \begin{cases} 0, & x_n \in [m_{n1}, m_{n2}] \\ (x_n - m_{n1})^2 / 2\sigma_{n1}^2, & x_n < m_{n1} \\ (x_n - m_{n2})^2 / 2\sigma_{n2}^2, & x_n > m_{n2} \end{cases}$$

is the nth weighting function specifying subjective likelihood function.

Signal Recognition

Feature testing:



Subjective likelihood functions of (a) duration, $x\downarrow 1$, (b) SNR, $x\downarrow 3$, (c) peak-to-min ratio, $x\downarrow 5$, (d) peak-to-peak ratio, $x\downarrow 6$.

Test Results

Performance of the automatic detection and recognition algorithm

Data set	N_{tot}	N_{sig}	N_{noise}	N_d	P_d	N_{fa}	P_{fa}	AUC
MARU 1	9722	7353	2369	5625	0.76	26	0.011	0.96
MARU 2	940	8	932	8	1	17	0.018	0.99
MARU 3	1175	18	1157	18	1	30	0.025	0.99
SNR < 3 dB	15057	905	14152	382	**0.42**	118	**0.008**	0.947
SNR 3...10 dB	15751	5710	10041	4564	**0.8**	874	**0.087**	0.935
SNR > 10 dB	2630	810	1820	751	**0.93**	294	**0.161**	0.955
Total	33438	7425	26013	5697	**0.77**	1286	**0.049**	0.951

Thank you!

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