Dec 11th, 1:30 PM - 3:10 PM

Group behavioural responses of cyprinids to artificial acoustic stimuli: implications for fisheries management

Helen A.L. Currie
University of Southampton

Timothy G. Leighton
University of Southampton

Paul R. White
University of Southampton

Paul S. Kemp
University of Southampton

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Helen A. L. Currie

Helen.Currie@soton.ac.uk

Academic Supervisors: *Prof. Paul S. Kemp, Prof. Paul R. White & Prof. Timothy G. Leighton*

@HelenALCurrie

Fish Passage 2018: Fish Guidance and Diversion Screening
11th December

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Introduction

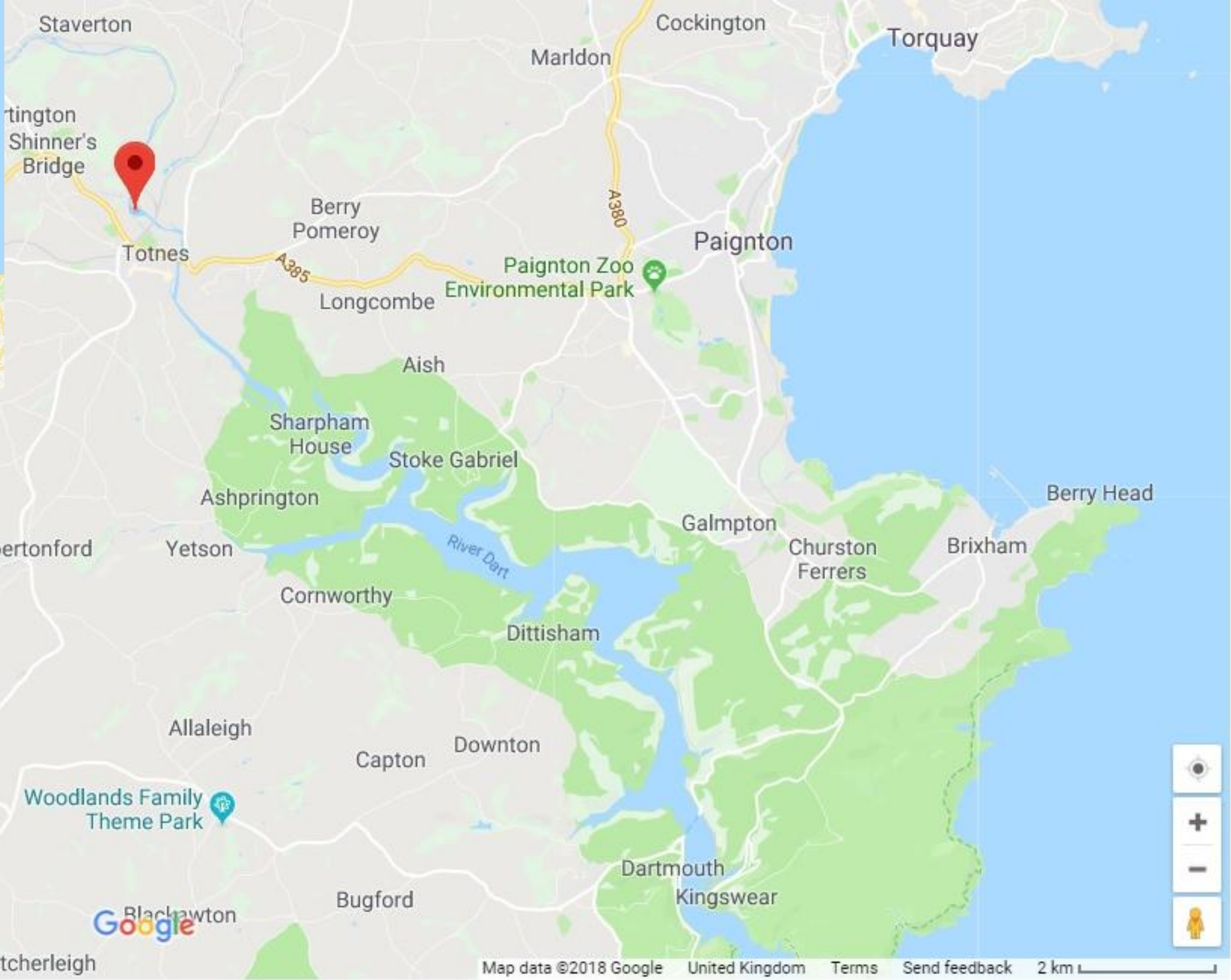
- Common approaches to development of acoustic screens do not provide sufficient information on a desired wild migratory fishes' behavioural response to stimuli (Kemp, *et al*., 2012)

- Lack of focus regarding life strategy response to sound (Budaev & Zworykin, 2002) – *e.g*. group behavioural responses and quantification of behaviour

- Many studies taking place in acoustically "quiet" environments, not taking into consideration propensity of background noise to "mask" signals (Klump, 1996)

- Current studies monitoring the use of such strategies fail to appropriately test such systems in advance of implementation


SCOTLAND
Dundee
Edinburgh
Glasgow
United Kingdom
Isle of Man
Leeds
Manchester
Liverpool
ENGLAND
Cambridge
WALES
Oxford
London
Bristol
Cardiff
Brighton
Southampton
English Channel


Staverton
Cockington
Torquay
Marldon
Shinner's Bridge
Berry Pomeroy
A380
Paignton
Totnes
A385
Paignton Zoo Environmental Park
Longcombe
Aish
Sharpham House
Stoke Gabriel
Ashprington
Berry Head
Galmpton
Yetson
River Dart
Churston Ferrers
Brixham
Cornworthy
Dittisham
Allaleigh
Downton
Capton
Woodlands Family Theme Park
Dartmouth
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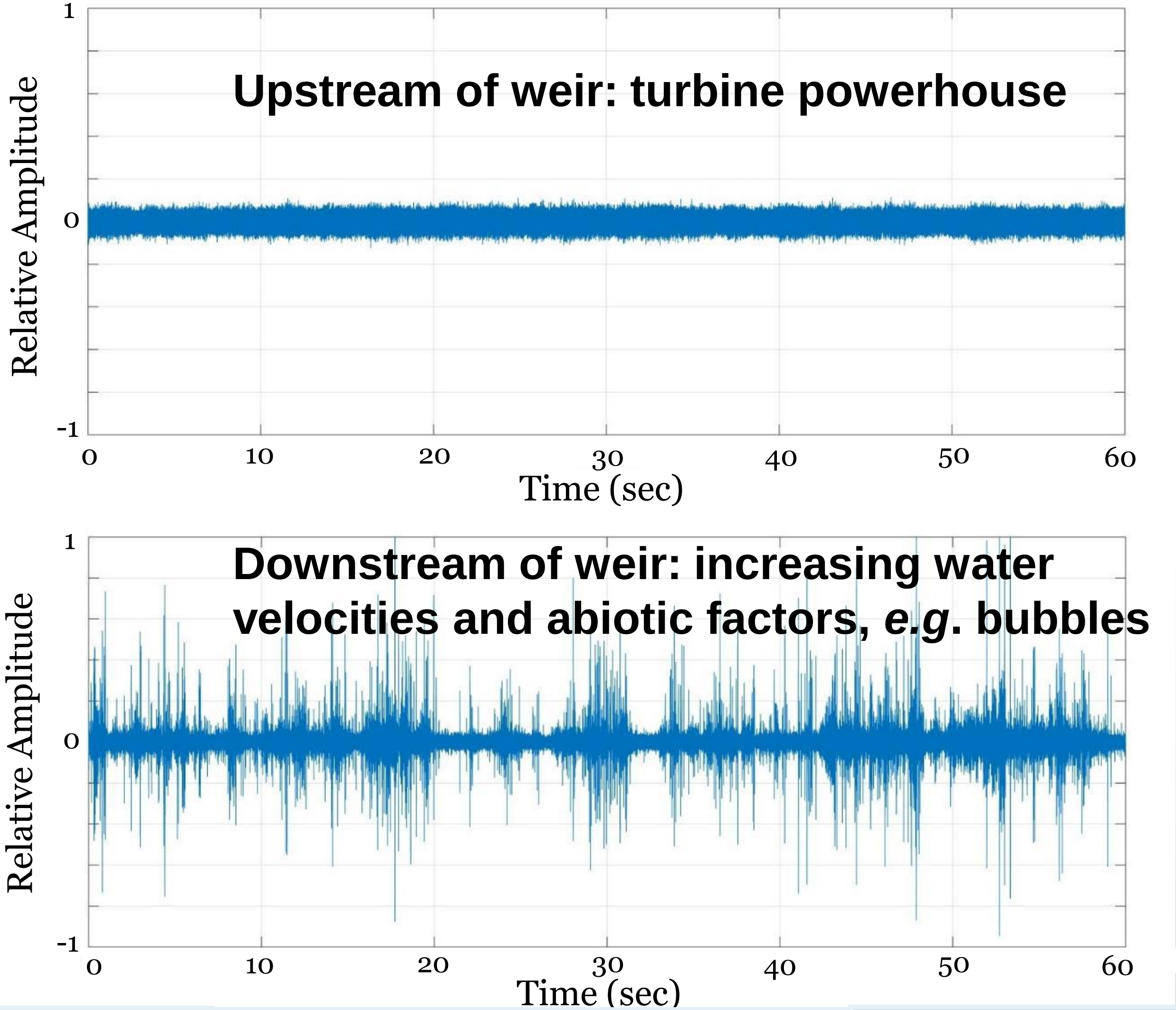

Upstream of weir: turbine powerhouse
Relative Amplitude
1
0
-1
0
10
20
30
40
50
60
Time (sec)
Downstream of weir: increasing water velocities and abiotic factors, e.g. bubbles
Relative Amplitude
1
0
-1
0
10
20
30
40
50
60
Time (sec)

Aims & objectives

- Determine subject species optimum acoustic frequency and appropriate treatment type (tonal vs noise) for trial and/or implementation within the field

- Determine optimum signal-to-noise ratios to elicit behavioural responses to acoustic deterrents

- Better quantify group behavioural responses for development of use within freshwater fisheries management techniques

European minnow (*Phoxinus phoxinus*)

- Strong shoaling behaviour (Partridge, 1980)
- Conservational status differs across Europe (Hesthagen & Sanlund, 2006)
- Local abundance

Common carp (*Cyprinus carpio*)

- Well-studied auditory sensitivity (Takahito, *et al*., 2005)
- Strong aggregation & social shoaling behaviour (Ghosal, *et al*., 2016)
- IUCN “vulnerable” red list (Freyhof & Kottelat, 2008)

Global invasive status

(Koehn, 2004)

Source: *http://www.fishingworld.com.au/news/**carp-the-australian-story***

Source: *https://prairierivers.org/*

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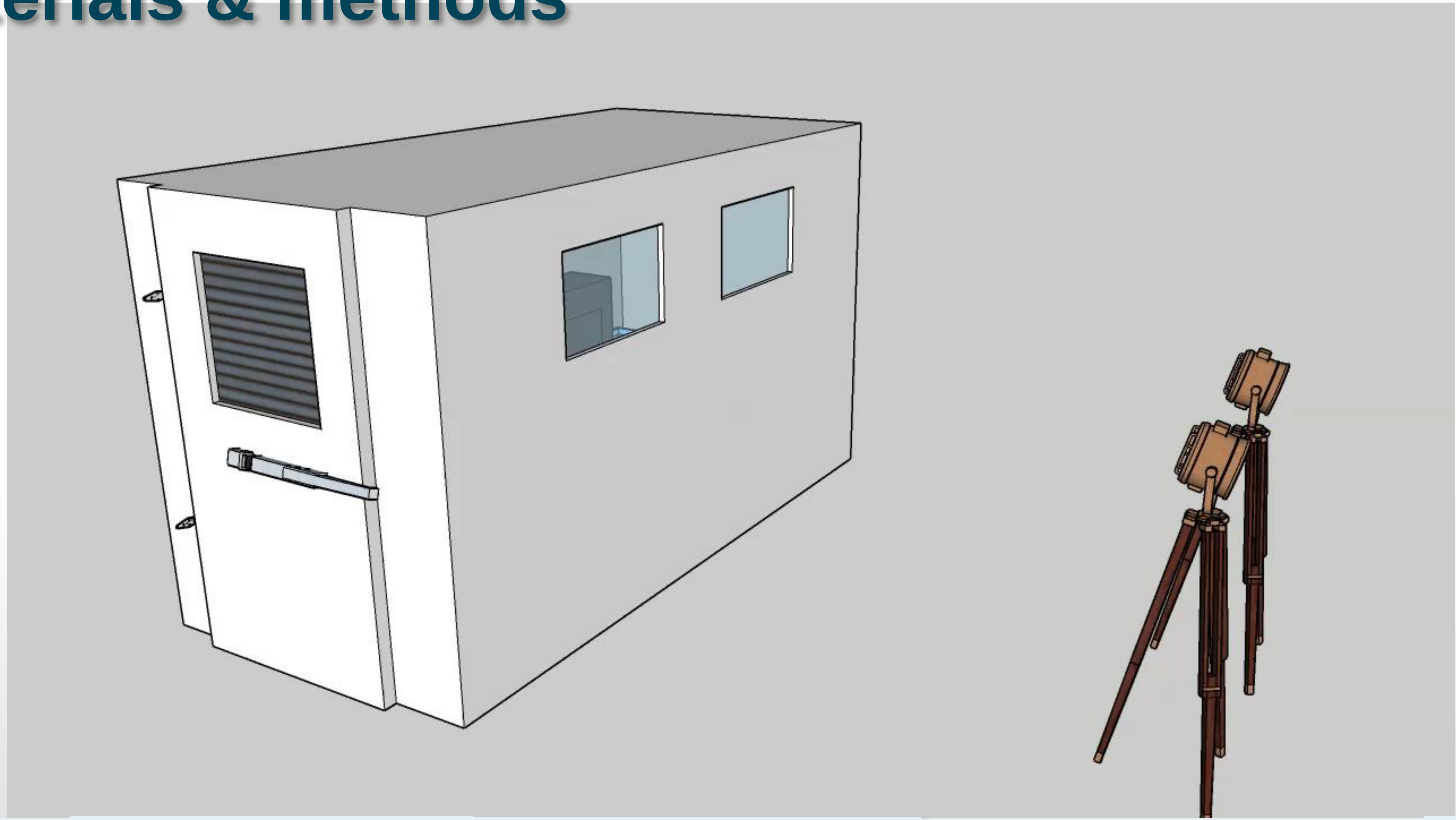
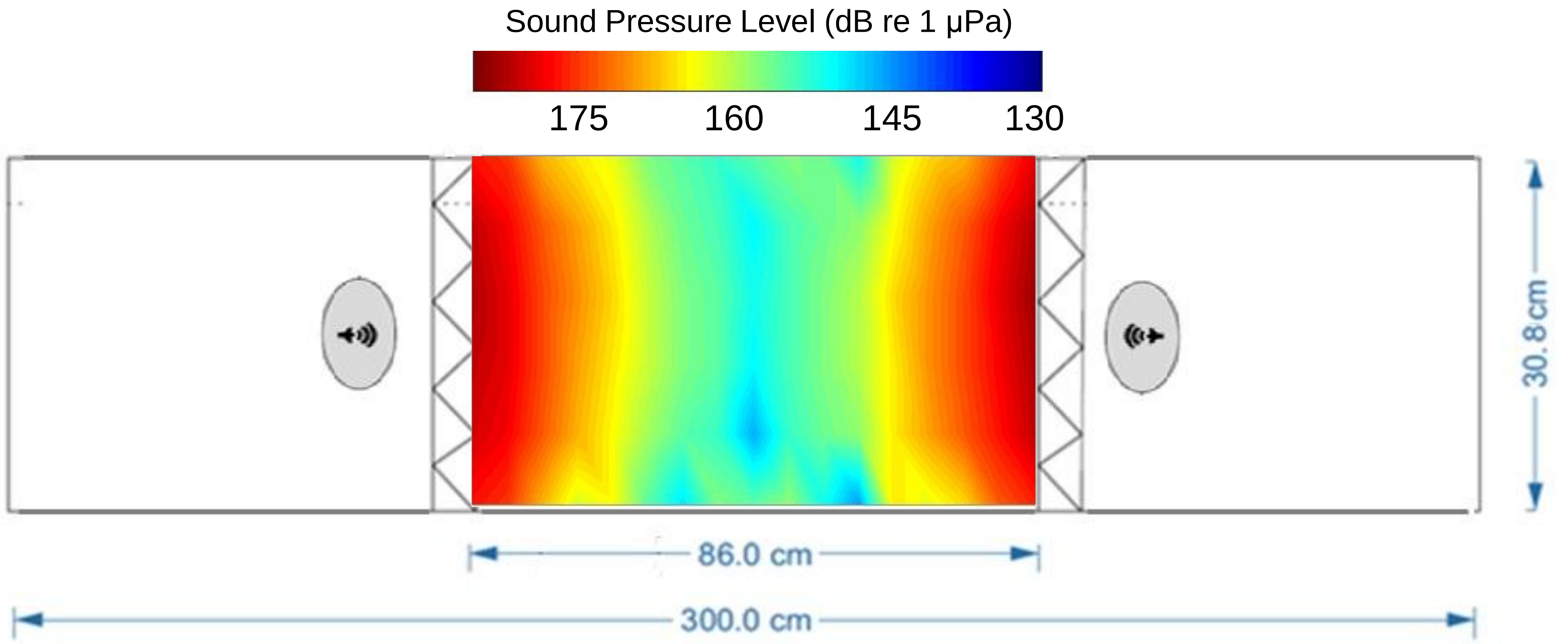
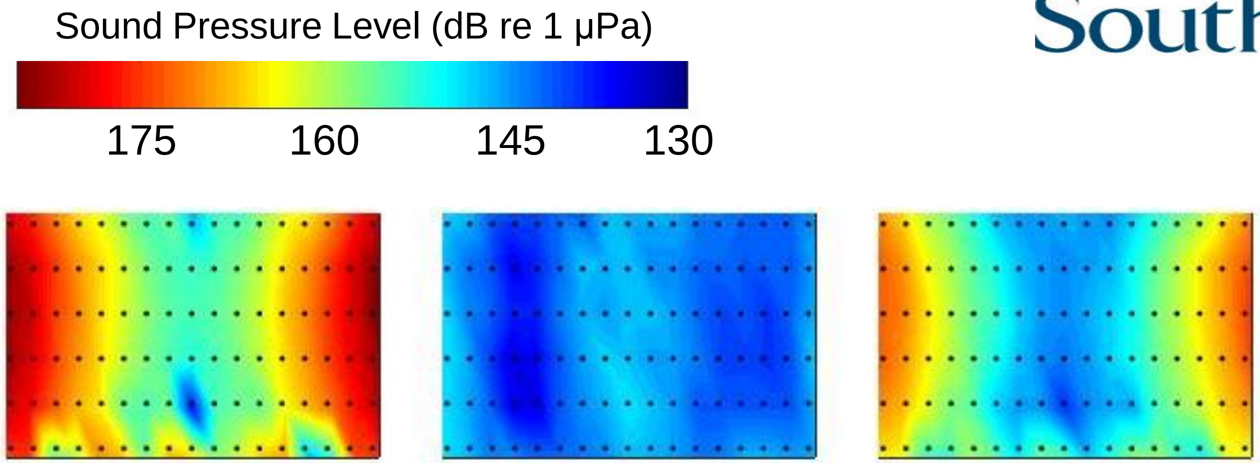
Materials & methods



Plan view


Sound Pressure Level (dB re 1 μPa)
175
160
145
130
30.8cm
86.0 cm
300.0 cm

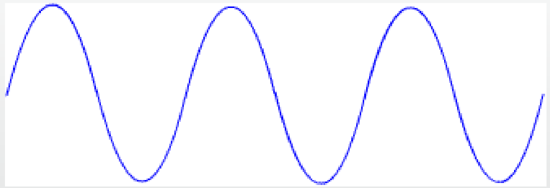


150 Hz (sinewave)

2200 Hz (sinewave)

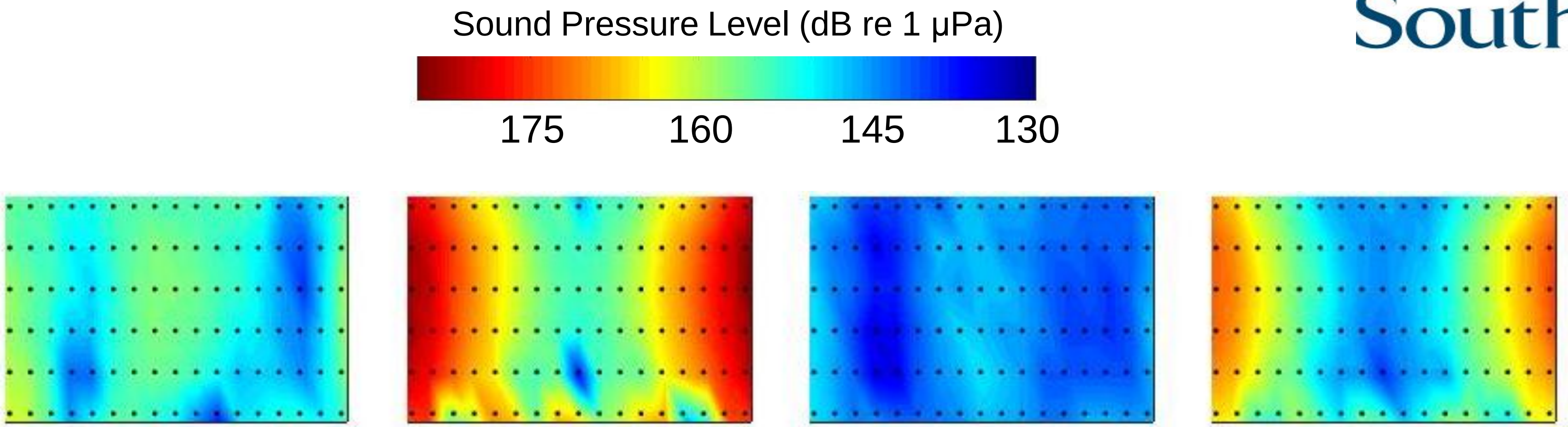
Octave Band Noise (centred at 150 Hz)

Octave Band Noise (centred at 2200 Hz)



2 Tonal Treatments (sinewave)

2 Noise Treatments

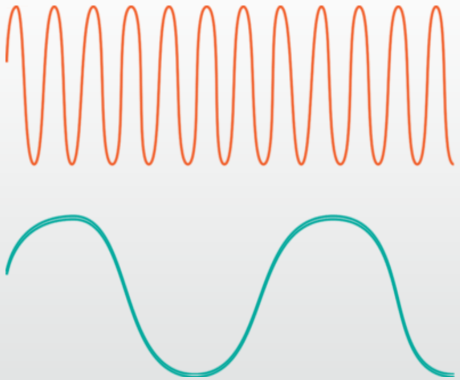


150 Hz (sinewave)

2200 Hz (sinewave)

Octave Band Noise (centred at 150 Hz)

Octave Band Noise (centred at 2200 Hz)



2 Low Frequency Treatments

2 High Frequency Treatments

Group average swimming speed (m/s)

Startle response (yes/no)

Group orientation (˚)

Group cohesion (m)

Spatial distribution (x,y)

Plan view

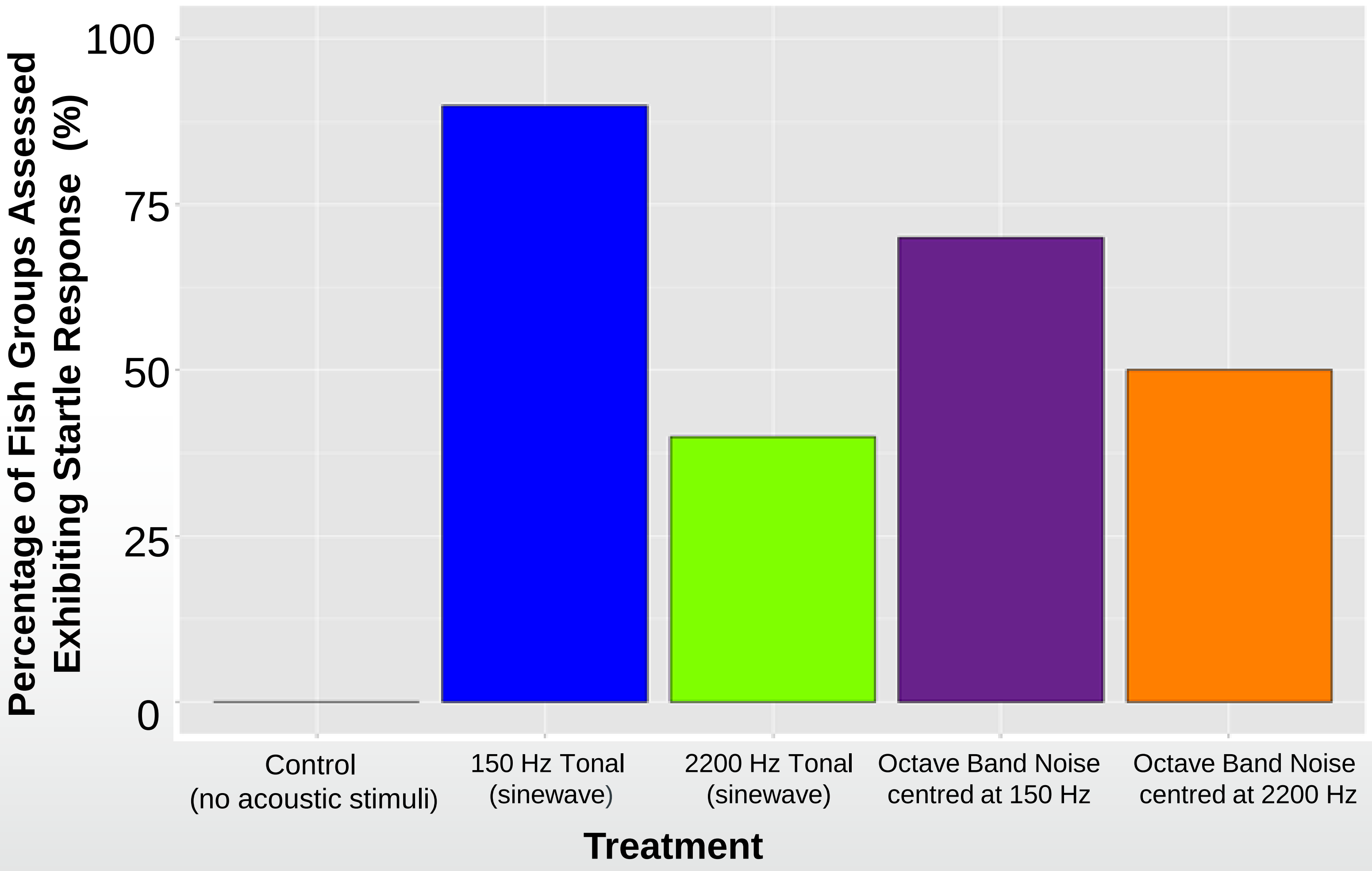
Optimum signal experiment: *Phoxinus phoxinus*

How is group behaviour influenced by tonal (simple) and octave band frequency (complex) noise?

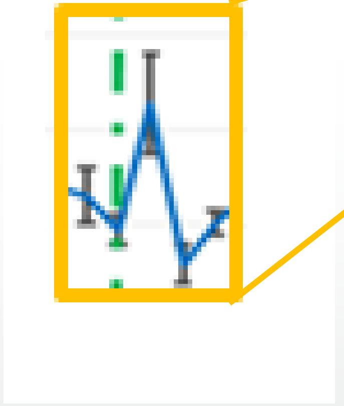
Results

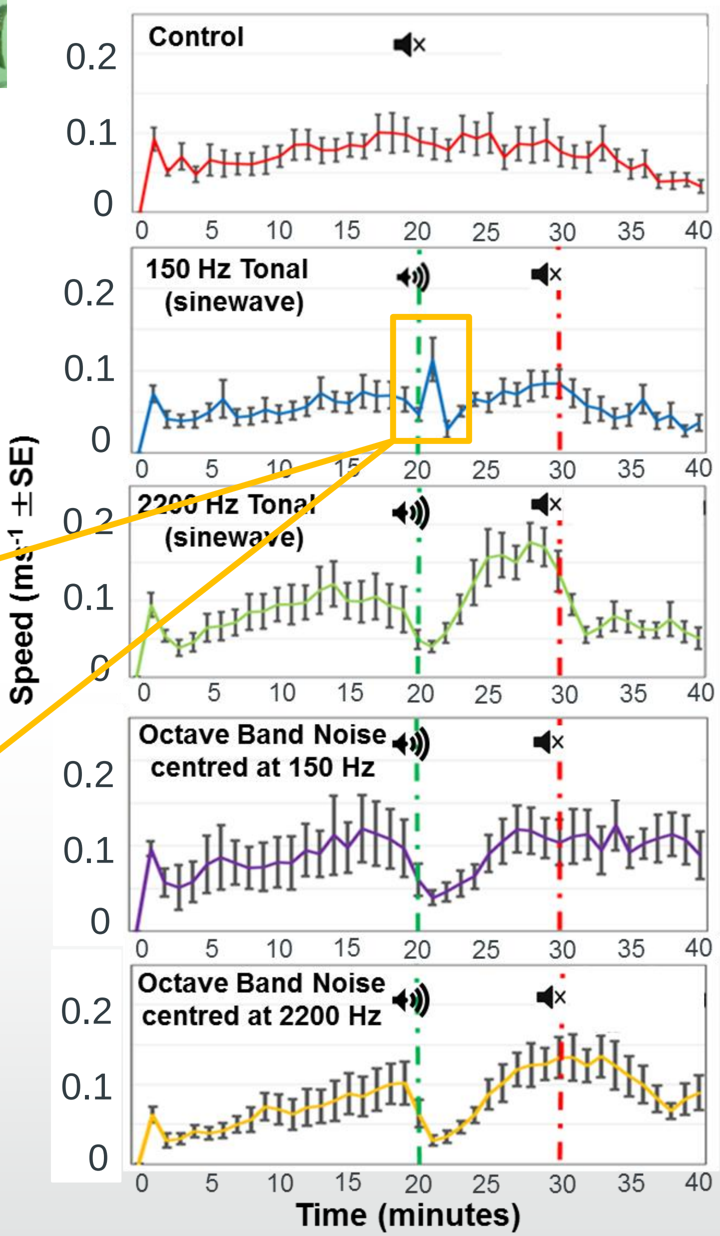
More fish exhibit "c-start" at onset of acoustic stimuli for lower frequency (150 Hz) treatments

p < 0.001

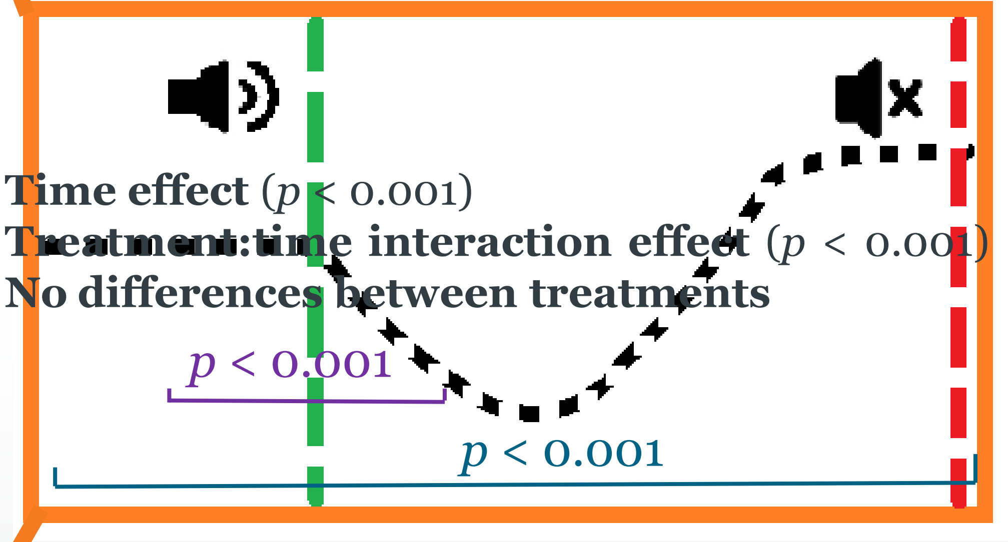


Acoustic stimuli influences group swimming speed (m/s)

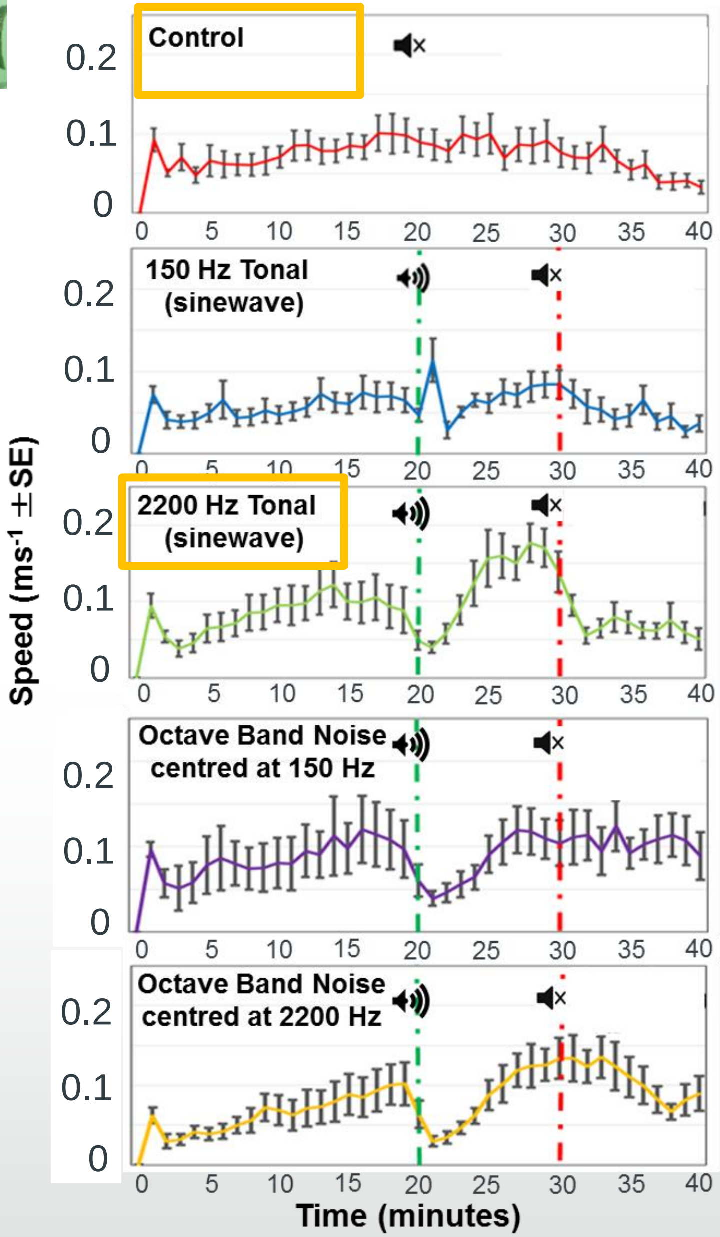




Bonferroni-corrected *post hoc* analysis



Acoustic stimuli influences swimming speed (ms^{-1})



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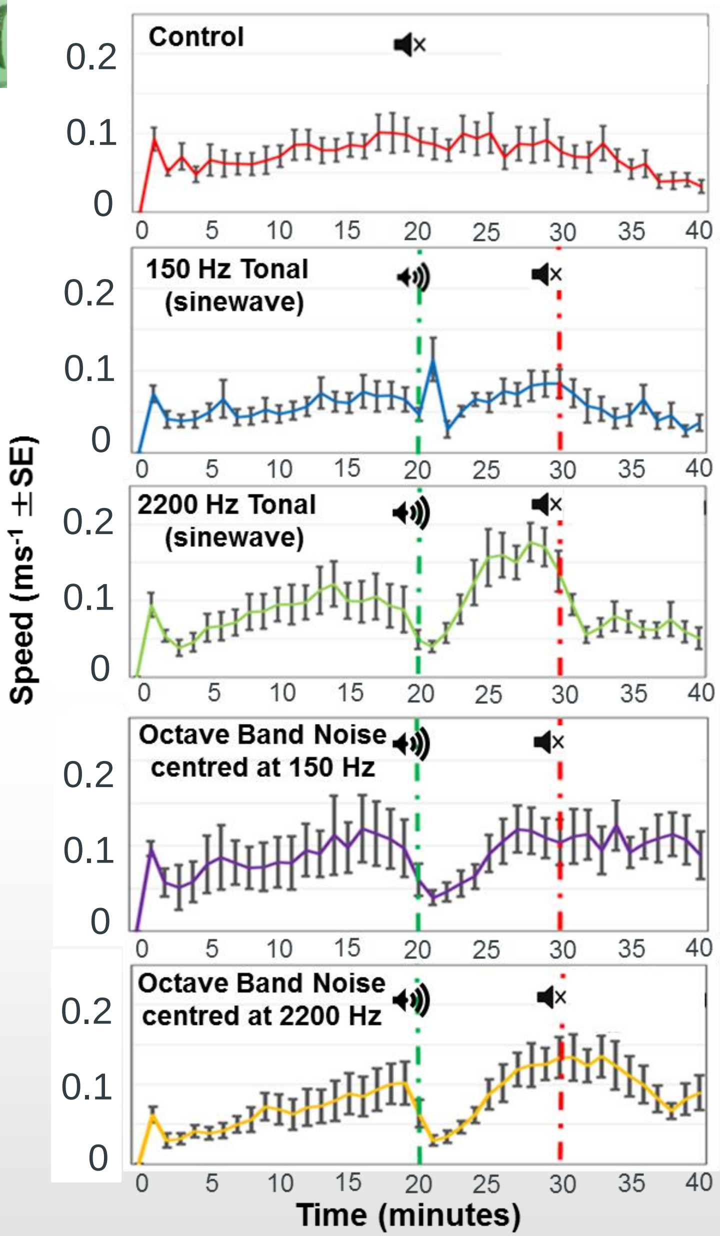
Differences in group orientation between treatments

$p < 0.05$

Bonferroni-corrected *post hoc* analysis:
$p < 0.05$

Acoustic stimuli influences swimming speed (ms^{-1})



Differences in group orientation between control & 2200 Tonal (sinewave)

No significant differences for group cohesion

Introduction | Aims & Objectives | Materials & Methods | **Results** | Conclusions | Future Work

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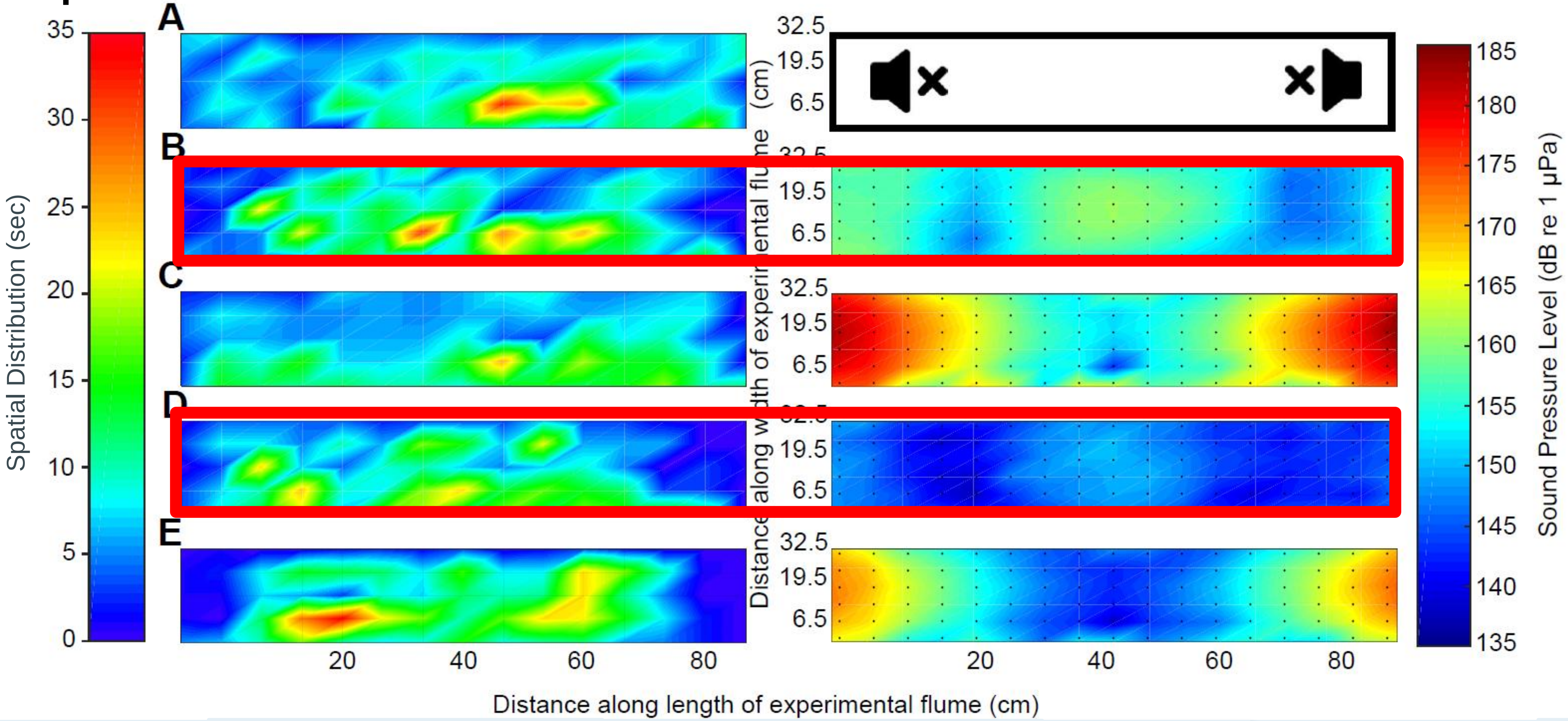
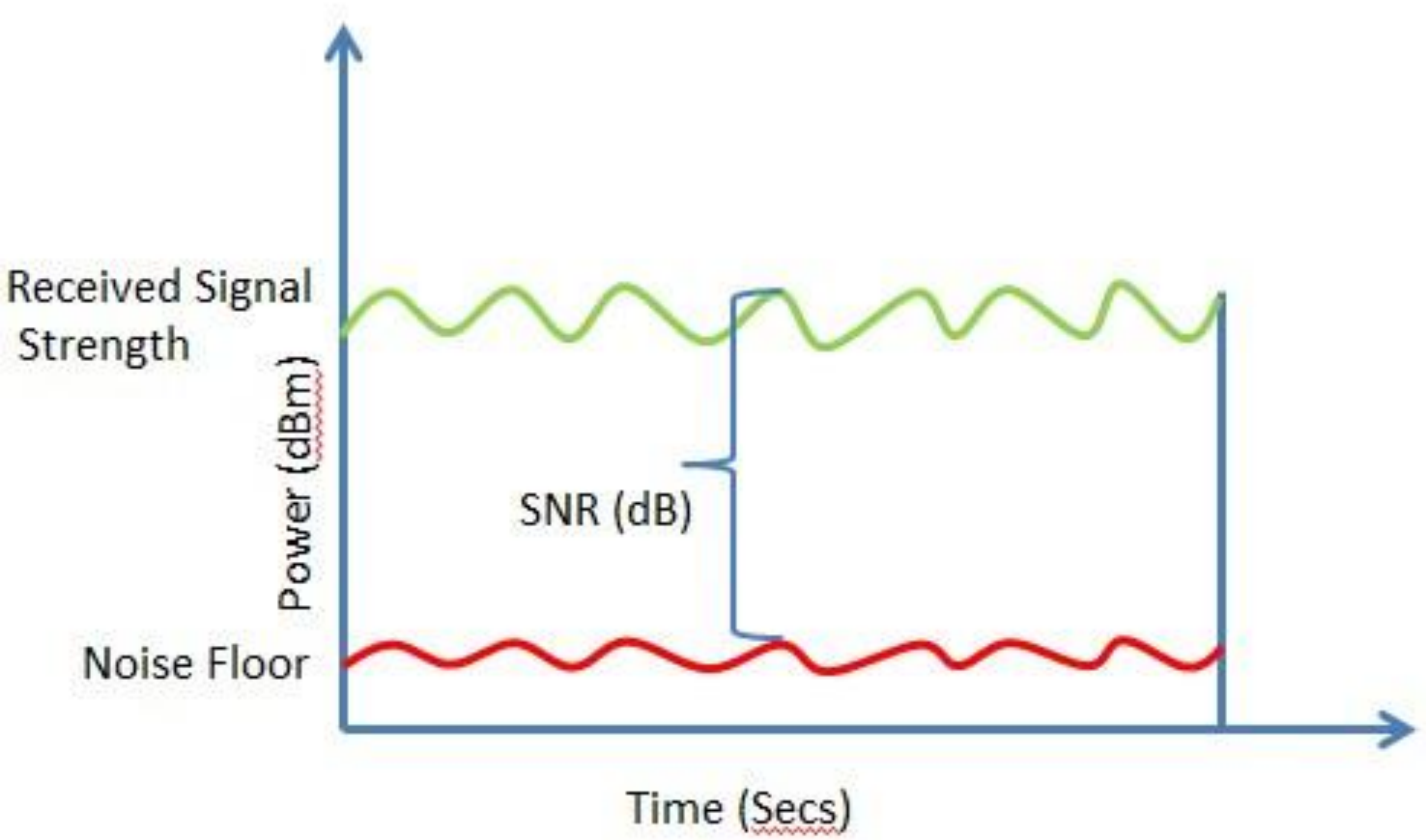
Fish exposed to lower frequency treatments spent less time in areas of higher acoustic intensity and more in areas of lower acoustic intensity in comparison to control fish



All p-values significant for low frequencies

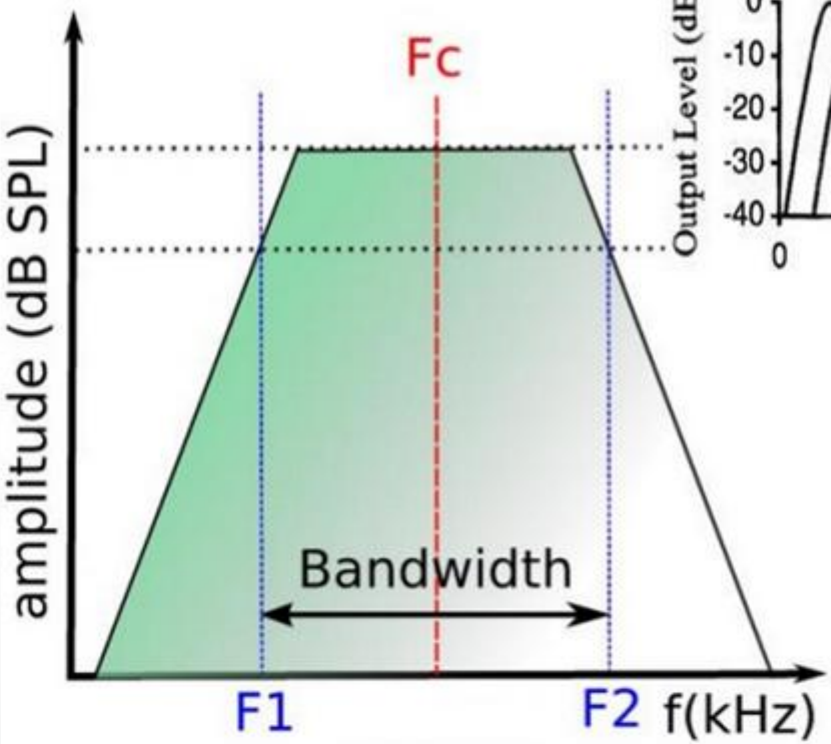
Detection under masking noise experiment: Cyprinus carpio

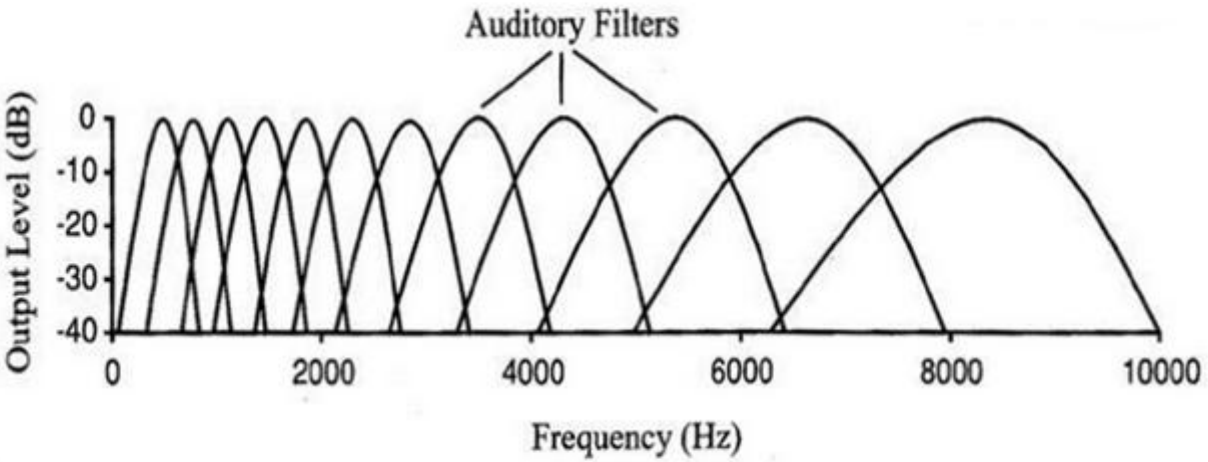
How is group behaviour influenced by tonal frequency pulses in the presence of masking noise?



Source: *documentation.meraki.com/*

Detection and recognition of signals is dependent on the signal-to-noise ratio (SNR) (Klump, 1996)



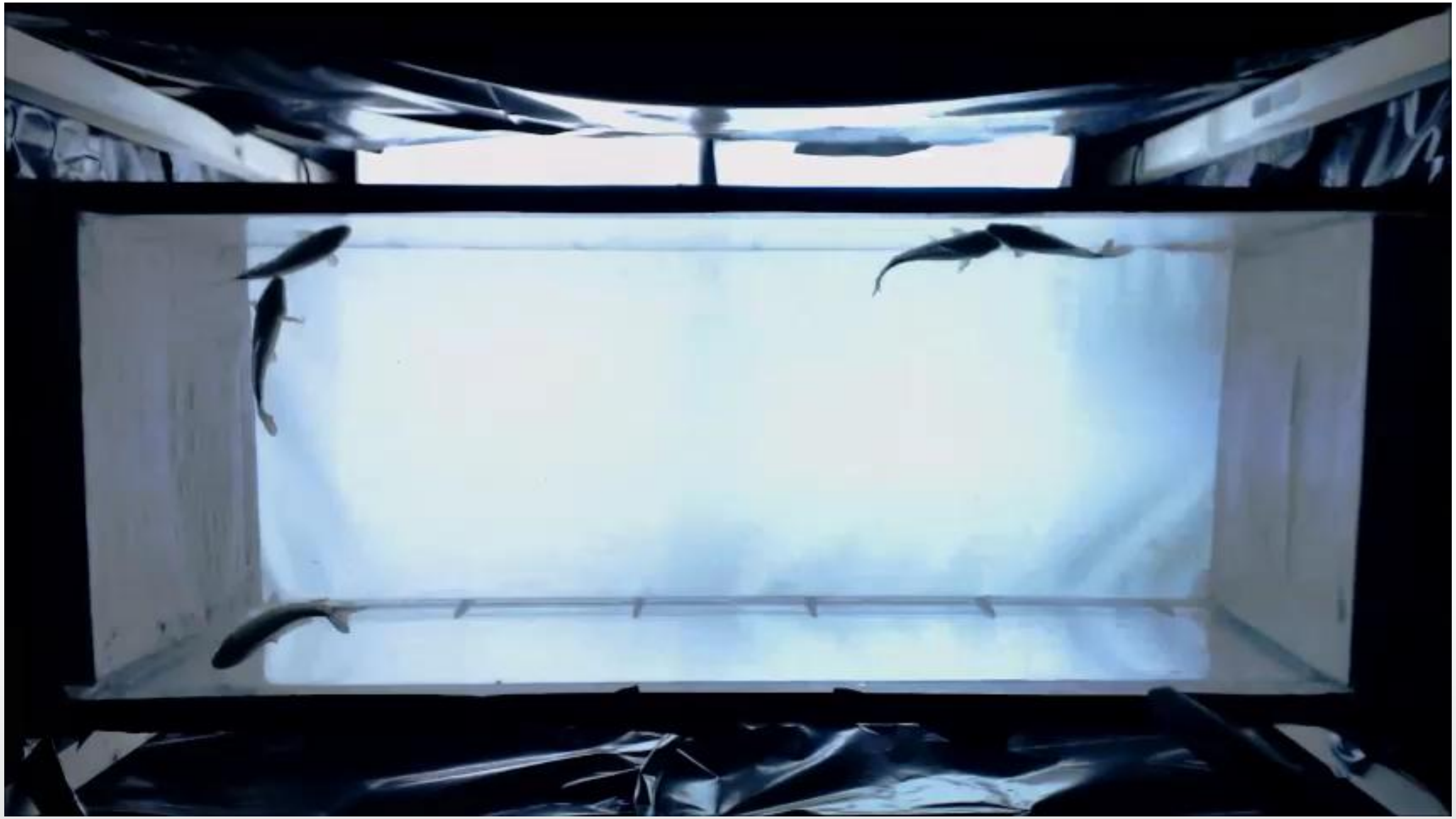


Acoustic masking is also highly frequency selective (critical band) (Fletcher, 1940)

Cyprinids possess frequency-selective auditory filters (Dijkgraaf, 1952; Fay & Popper, 1980)

Source: https://www.slideshare.net/franzonadiman/frequencyplacetransformation-41810312

Results



170 Hz pulsed tone @ 130.1 dB (re 1 μPa) under ambient conditions

Stimuli OFF
Stimuli ON

170 Hz pulsed tone
@ 130.1 dB (re 1 μPa)
under masking noise
@ 110.4 dB (re 1 μPa)

SNR = + 20 dB (RMS)

Stimuli OFF
Stimuli ON

Conclusions

Clear differences exist between stimuli, with lower frequencies found to have the biggest influence across behavioural parameters tested in minnows (startle response, speed and spatial distribution in relation to the sound field).

A SNR of +20 dB is not of a high enough threshold to elicit startle responses in common carp within a background noise floor of 110dB - further quantification of behavioural parameters under these conditions is required.

Potential implications for acoustic deterrents used within fisheries management – sites should be appropriately pre-assessed and some may be inappropriate for use of effectively working systems

Future work & ongoing analyses

How does temporal pulse rate influence the rate of tolerance of groups of fish to acoustic stimuli?

Does seasonal variation influence group behavioural response to artificial acoustic stimuli?

Can fish directionality be manipulated using artificial acoustic stimuli in the presence of masking noise under differing flow conditions?

Acknowledgements

Academic Supervisors: *Prof. Paul Kemp, Prof. Paul White & Prof. Timothy Leighton*

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Helen.Currie@soton.ac.uk

Thank you

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Background photo source: *http://www.etc-hearing.com/oneday.html*