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

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

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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
Aims & Objectives

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Materials & Methods

Introduction

Results

Conclusions

Future Work
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Group behavioural responses of cyprinids to artificial acoustic stimuli

Upstream of weir: turbine powerhouse

Downstream of weir: increasing water velocities and abiotic factors, e.g. bubbles
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
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)

European minnow (*Phoxinus phoxinus*)

- Strong shoaling behaviour (Partridge, 1980)
- Conservational status differs across Europe (Hesthagen & Sanlund, 2006)
- Local abundance
Global invasive status
(Koehn, 2004)


Source: https://prairierivers.org/
Materials & methods
Plan view

Sound Pressure Level (dB re 1 μPa)

- 175
- 160
- 145
- 130
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Sound Pressure Level (dB re 1 μPa)

175 160 145 130

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
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Sound Pressure Level (dB re 1 μPa)

175  160  145  130

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)

Time effect ($p < 0.001$)
Treatment: time interaction effect ($p < 0.001$)
No differences between treatments

Bonferroni-corrected post hoc analysis

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

Source: documentation.meraki.com/
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
170 Hz pulsed tone @ 130.1 dB (re 1 μPa) under ambient conditions
170 Hz pulsed tone
@ 130.1 dB (re 1 μPa)
under masking noise
@ 110.4 dB (re 1 μPa)

SNR = + 20 dB (RMS)
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

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Thank you

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