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The effect of ship noise on the behaviour and physiology of *Carcinus maenas*

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Acknowledgements

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Why Anthropogenic Noise

- Pervasive pollutant in the marine environment coming from many different sources, such as seismic surveys, mining activity, sonar, wind farms, pile driving, shipping and acoustic deterrent and harassment devices
- Ambient noise levels increased 10- to 100-fold in the 20-200 Hz range
- Increasing evidence it can cause behavioural and physiological changes in marine vertebrates

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Why Crabs

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- Very little known about impacts of anthropogenic noise on marine invertebrates
- Invertebrates are key to understanding the larger ecological scale effects of anthropogenic noise
- Decapods able to perceive sound in the environment

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What We Wanted To Know

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- Is the Shore Crab *Carcinus maenas* affected by single exposure to ship noise?
  - Foraging and antipredator behaviour
  - Oxygen consumption
- Does repeated exposure to ship noise change the response?
  - Oxygen consumption

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General Methods

- All experiments performed in tanks to allow tight control and detailed data collection
- Playbacks made from recordings of the passing of single ships and the same harbours without nearby ships
- Playback levels of 140 – 150 dB re 1 µPa RMS for ship noise, 107 – 111 dB re 1 µPa RMS for ambient noise

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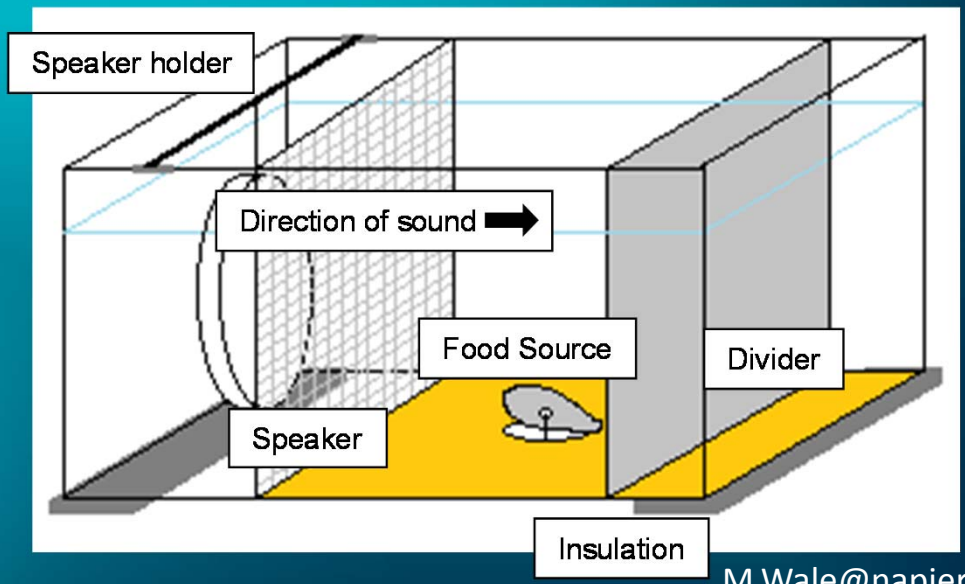
Foraging Behaviour

- Placed in the experimental arena and allowed to find food source
- Crabs exposed to playback
- Any evidence that the animal stopped feeding was recorded



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Sound treatment had a significant effect on the behaviour of feeding crabs

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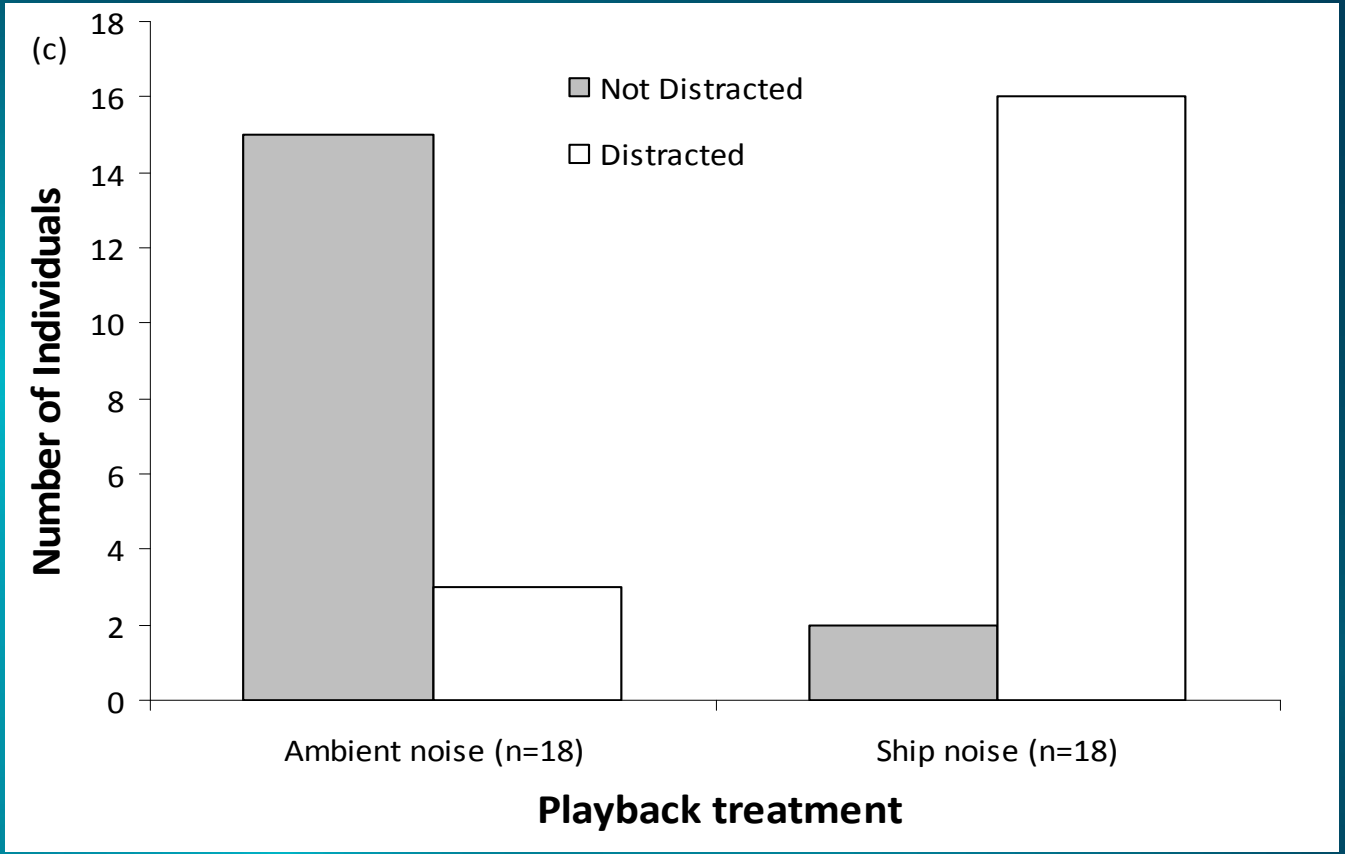

- Individuals exposed to ship-noise playback were more likely to suspend feeding than were those experiencing ambient-noise playback

Wale, M. A., Simpson, S. D., & Radford, A. N. (2013).. *Animal Behaviour*, *86*(1), 111-118.

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Predator Response

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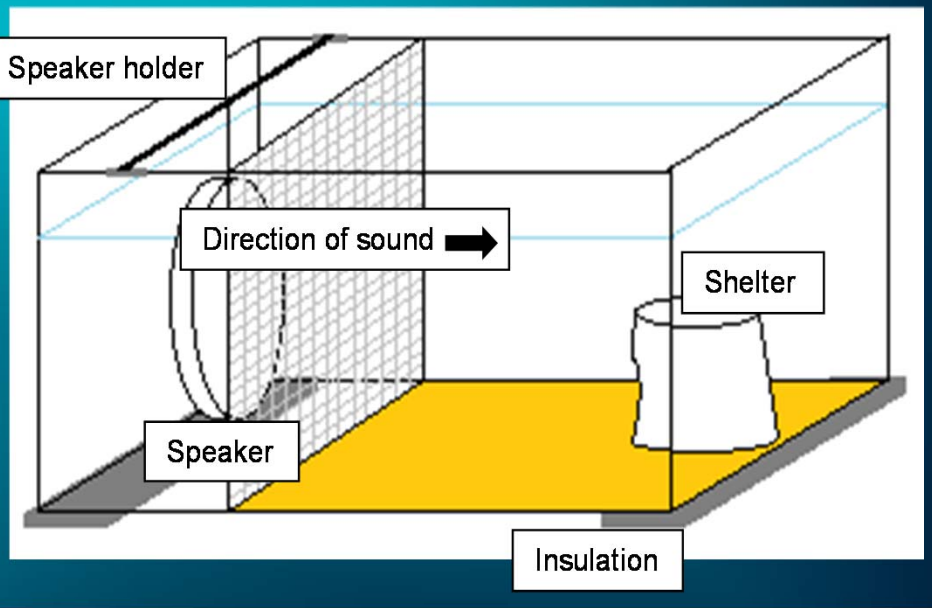
- Placed in shelter in the experimental arena
- Exposed to playback once the crab had left the shelter
- Dowel was driven into tank to simulate predation
- Reaction to predator recorded
- Time to return to shelter recorded



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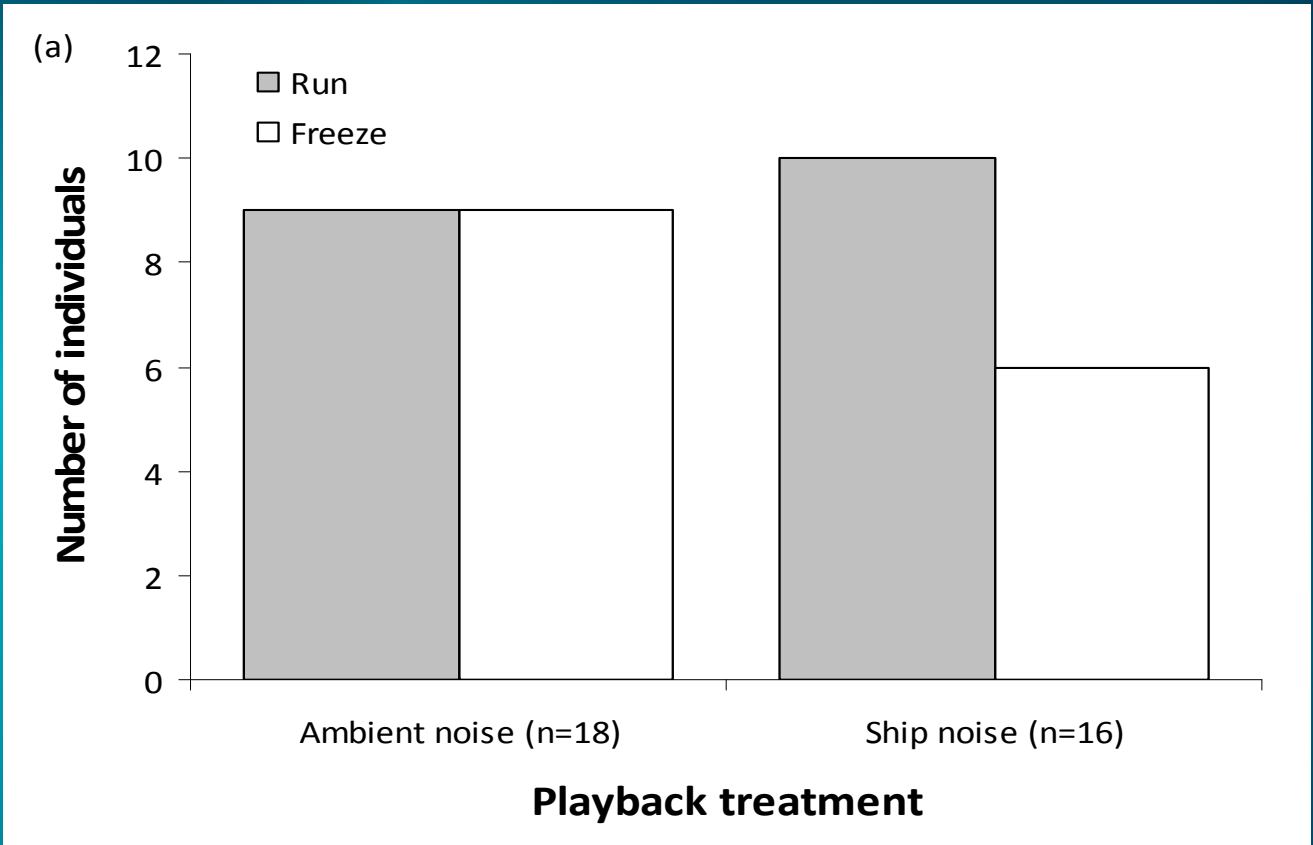
No significant difference in the initial reaction to the predator stimulus



- Individuals exposed to ship-noise playback showed no difference in reaction to a predator stimulus compared to those experiencing ambient-noise playback

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Wale, M. A., Simpson, S. D., & Radford, A. N. (2013).. *Animal Behaviour*, *86*(1), 111-118.

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Sound treatment had a significant effect on the time to return to shelter

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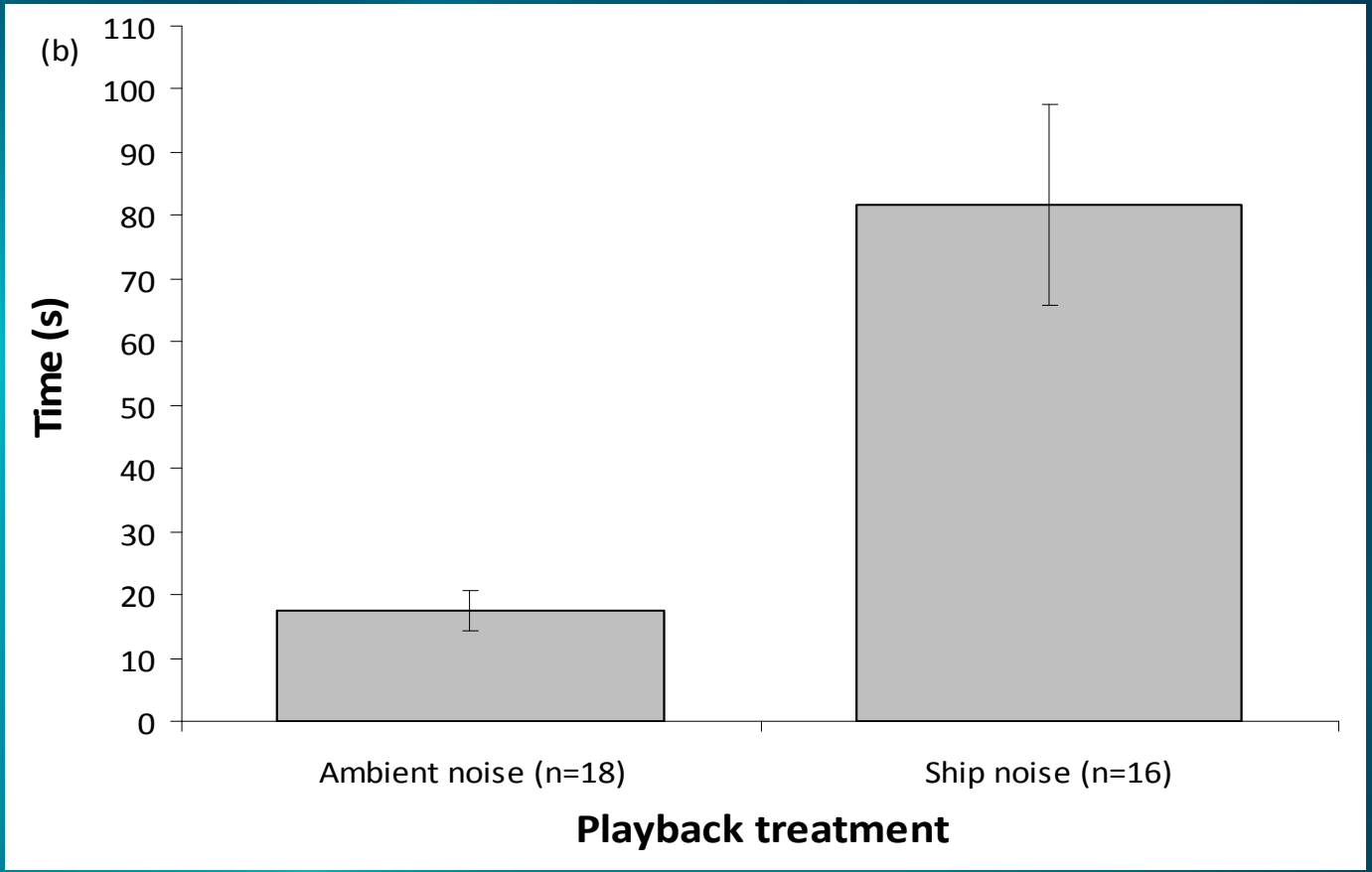

- Individuals exposed to ship-noise playback took longer to return to shelter than those experiencing ambient-noise playback

Wale, M. A., Simpson, S. D., & Radford, A. N. (2013).. *Animal Behaviour*, *86*(1), 111-118.

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Oxygen Consumption

- Crabs were placed in airtight containers
- Exposed to noise playback for 15 minutes
- Dissolved oxygen was measured

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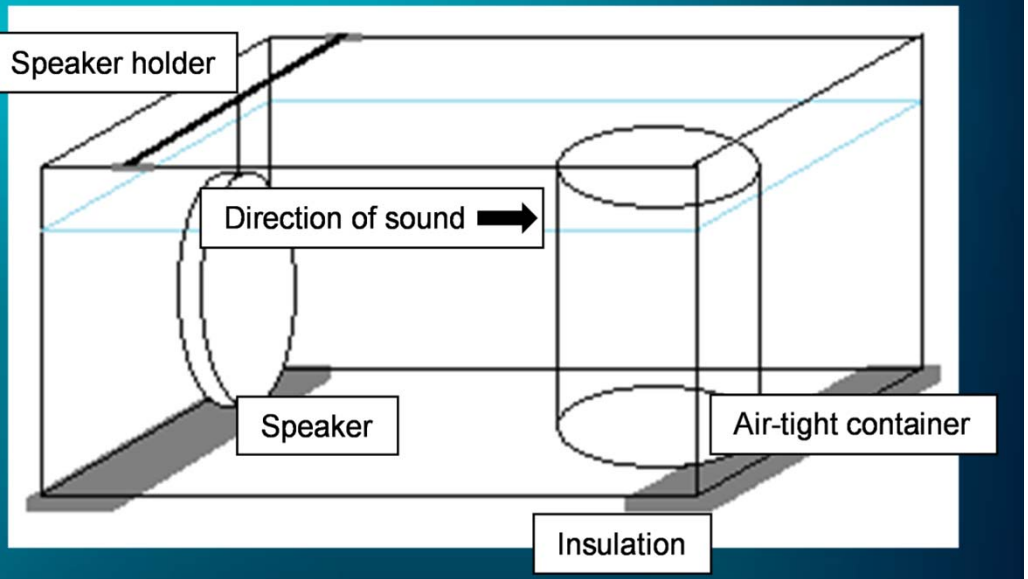

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Oxygen consumption significantly affected by the interaction between weight and sound treatment

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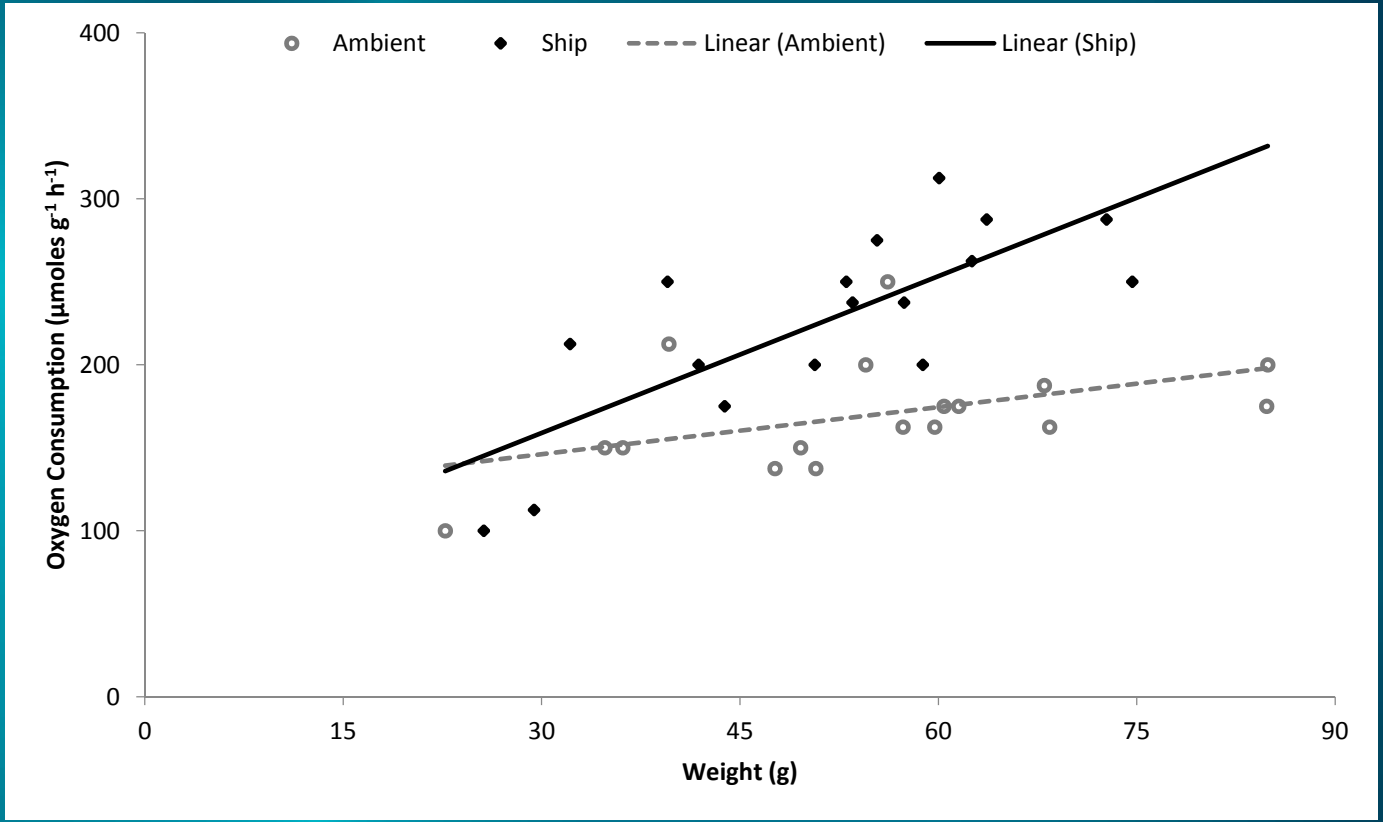

- Crabs experiencing ship noise consumed, on average, 67% more oxygen than those subjected to ambient noise

Wale, M. A., Simpson, S. D., & Radford, A. N. (2013). *Biology letters*, *9*(2), 20121194.

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Oxygen Consumption

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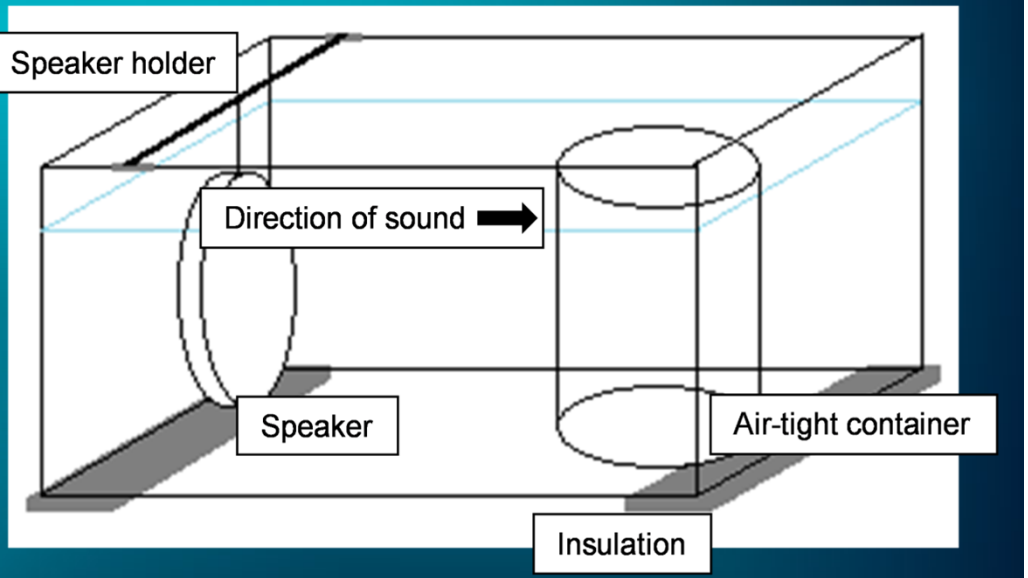
- Used the same method as the single exposure experiment
- Repeated every 48 hours
- Each individual received the same playback every run of the experiment



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Oxygen consumption significantly affected by the interaction between day in the sequence and sound treatment

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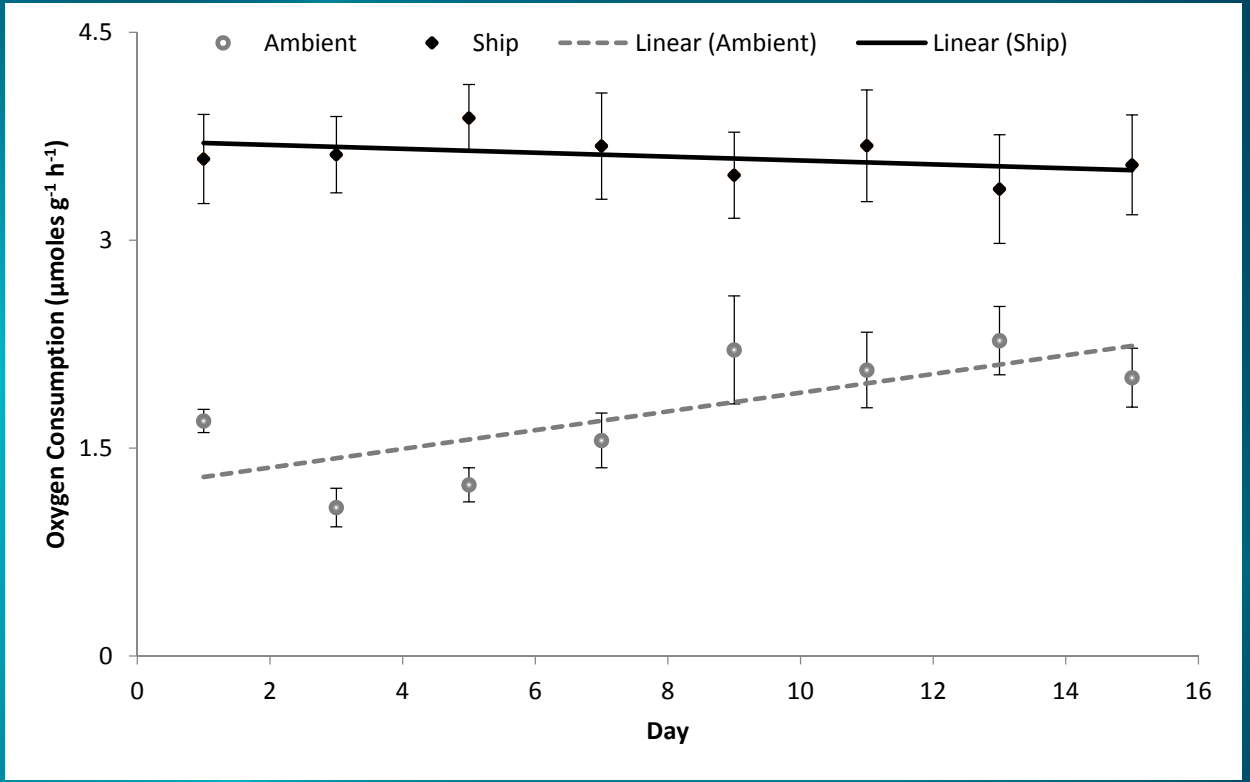

- Crabs exposed to ambient noise showed an increase in oxygen consumption across time, with no significant change in those crabs repeatedly exposed to ship noise

Wale, M. A., Simpson, S. D., & Radford, A. N. (2013). *Biology letters*, *9*(2), 20121194.

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Conclusions

- Crabs had increased distraction from foraging when experiencing ship-noise playback
- Lost food would increase the amount of foraging time required to satisfy energetic needs, at the cost to other essential behaviours
- Crabs took longer to return to shelter following predation
- Extra time spent in exposed conditions before reaching safety further increases the chances of predation

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Conclusions

- Crabs exposed to ship-noise playback consumed more oxygen than those experiencing playback of ambient harbour noise
- The increased oxygen consumption was maintained across repeated exposures to ship noise
- Higher metabolic rate can indicate increased cardiovascular activity and can ultimately reduce fitness through detrimental effects on reproductive success and growth

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Where to go from here

The effect of underwater noise on marine invertebrates: an integrative approach

- **Matt Wale**, Rob Briers, Mark G. Darlison, Karen Diele

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Where to go from here

- PhD at Edinburgh Napier University looking at the effect of underwater noise on marine invertebrates
- Using native species of commercial or ecological importance
- Taking a mechanistic, integrative approach to our experiments
- Addressing the issue of particle motion as the sound component of interest
- Scaling up from smaller aquaria to larger tanks and eventually the field

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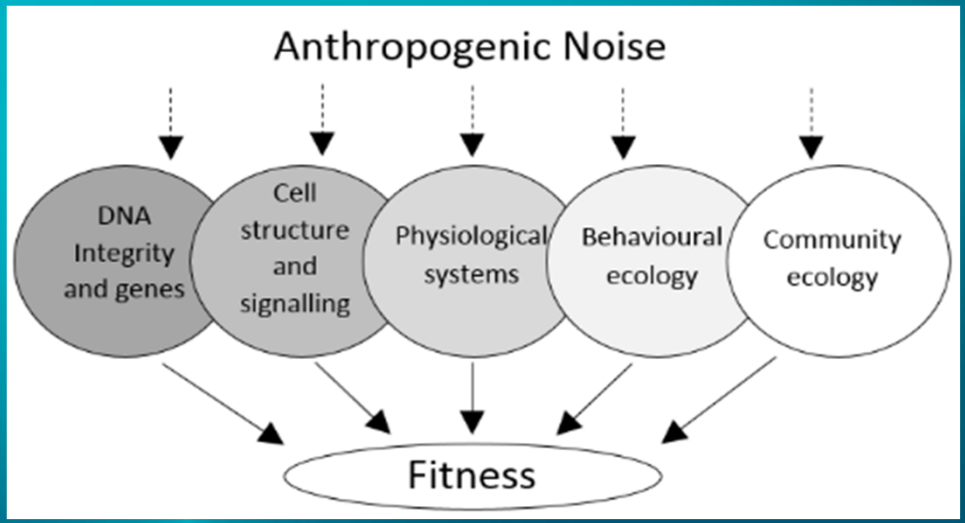
Animals and response parameters

- Benthic and sessile organisms and their reaction to noise in the environment
- Taking a mechanistic, integrative approach, considering behavioural responses, and also their physiological and genetic bases



Response parameters for noise research, adapted after Kight and Swaddle (2011)

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Noise exposures

- Measuring both the pressure and particle motion produced in the experiments
- Mapping the sound field
- Using playbacks from a variety of sound sources; from white noise to marine renewables
- Variable exposure lengths; single, repeated and chronic

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From the lab to the field

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- Aqualab at ENU

- St Abbs Marine Station, using their large tanks and mesocosm

- These techniques can then be taken into the field

RSPB

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