A tool to predict the impact of anthropogenic noise on fish

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NATURAL ENVIRONMENT RESEARCH COUNCIL

Knowledge Transfer Partnerships

HR Wallingford
Working with water

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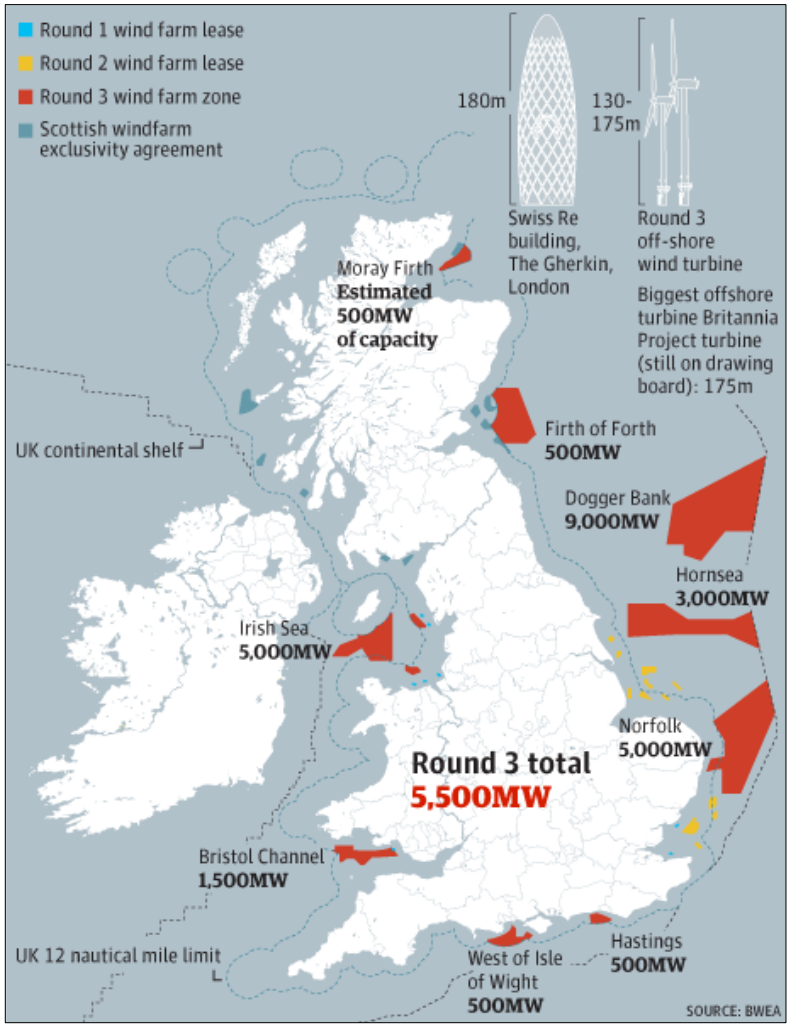
Background



Need for a solid base

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Impact of noise on fish

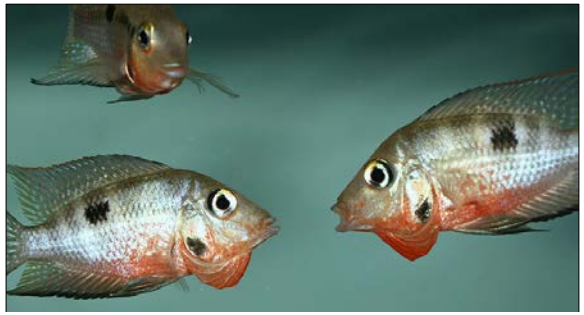
Stress

(Wysocki et al. 2006)

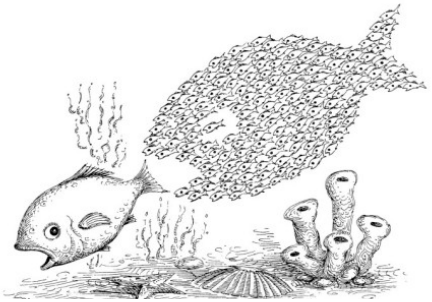
Damage hearing

(Smith et al. 2004)

Group aggression



(Bruintjes & Radford 2013)



Impair com-munication

(Vasconelos et al. 2007)

Knowledge Gap

- Accurate assessment of the impact of underwater noise missing!
  - Underpinned by scientific research

- Impacts of noise on marine environment included in national and international legislation (e.g. MSFD 2008)

  → *important for industry*

- HR Wallingford produced a modelling tool which predicts movement of marine organisms to noise

Aim: improve and validate this tool ecologically and use scientificly obtained data as parameters

Modelling tool - HAMMER

HAMMER: Hydro-Acoustical Model for Mitigation of Ecological Response

1. *Underwater acoustic propagation model*
2. *Hydrodynamic model*
3. *Ecological response model*

- Focus on the ecological response

Rossington et al. 2013. Marine Pollution Bulletin

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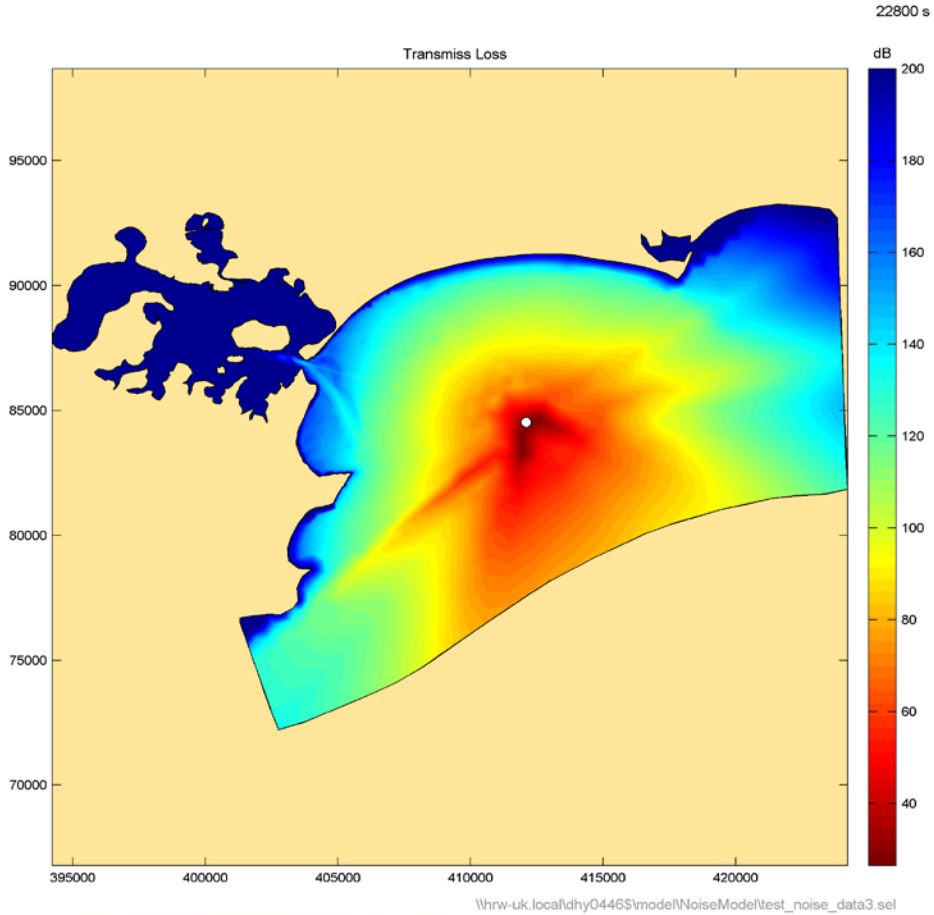
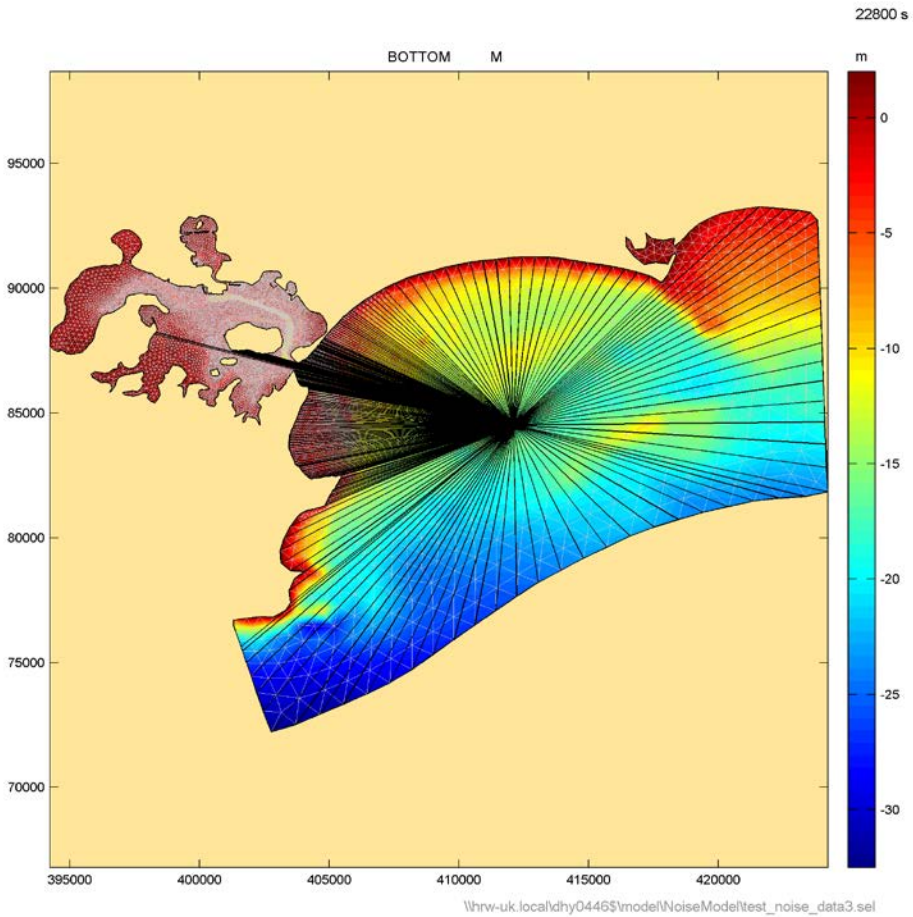
Modelling tool - HAMMER

Noise model uses a parabolic equation based on RAM

- An established numerical model for noise propagation
- Predicts the transmission loss from a point source
  - Throughout the water column
  - 360º around the source
- Takes into account both bathymetry and sediment type of the seabed
  - Both can alter the transmission loss of noise underwater
    - Soft sediments will absorb noise, hard ones will reflect it
    - Deep water allows noise to propagate further, shallow water causes it to attenuate (i.e. disappear) more quickly
- Uses a hydrodynamic model grid (from TELEMAC), to produce sound maps

Noise modelling





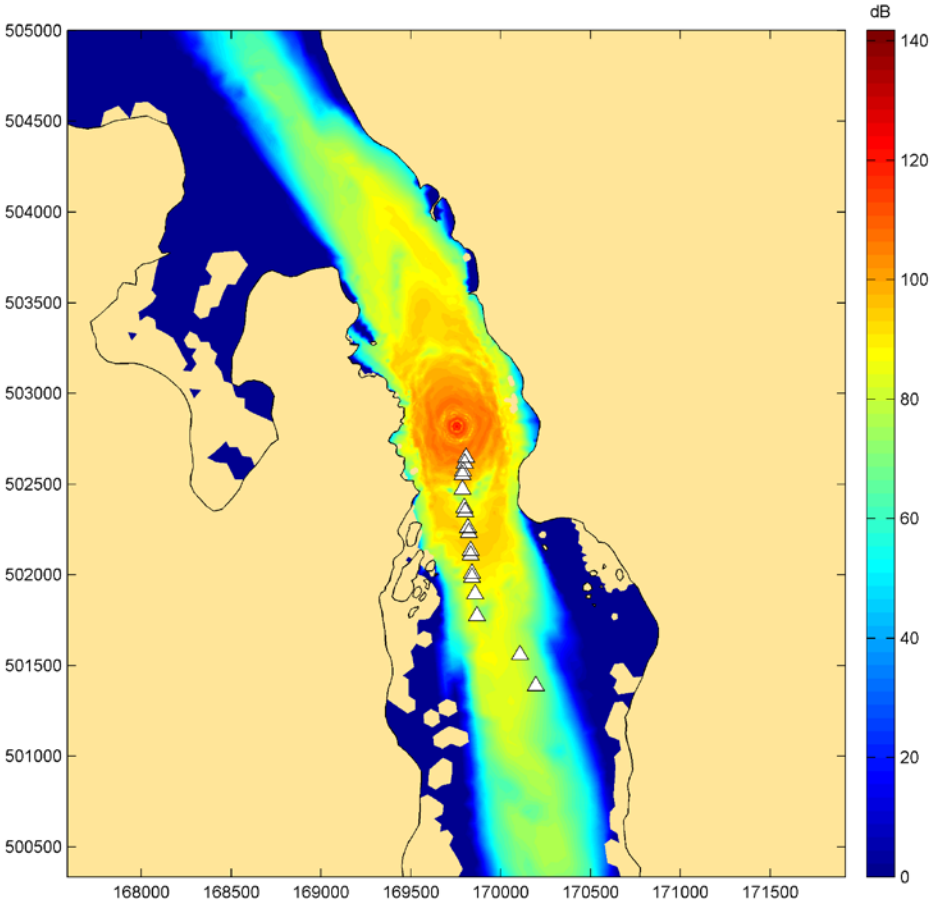
Transmission loss of underwater acoustics from a single source (white dot)

Output of combined acoustic and hydrodynamic model (depth averaged)

Noise model - validation

Validated using pin piling data during construction of SeaGen tidal turbine in Strangford Lough

- Both discrete frequencies and broadband sound, i.e. several frequencies together, were compared to predicted data
- Model showed a high degree of accuracy with the collected data



Transmission loss of underwater noise from pin piling at 250Hz in Strangford Narrows. Triangles represent data collection points.

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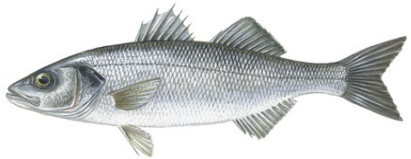
Physiology & behaviour

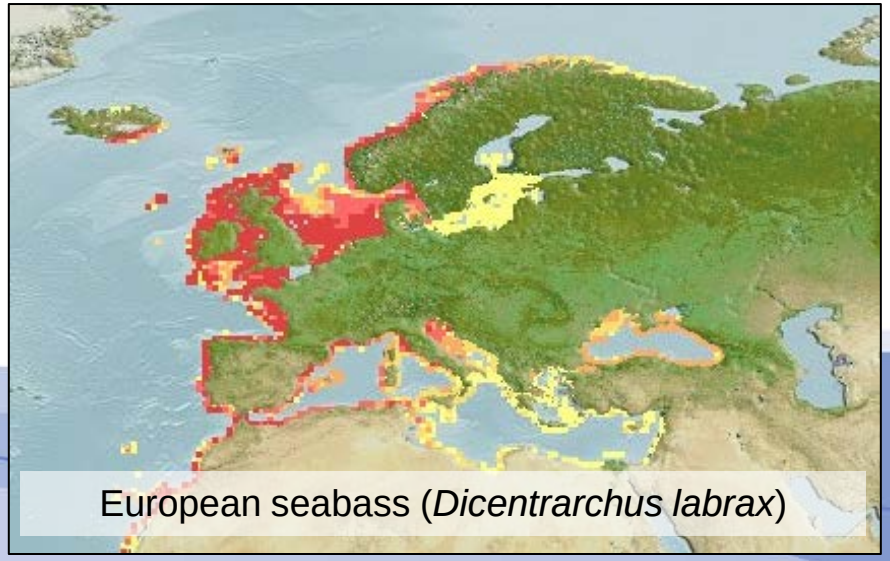


Impact of pile driving and ship noise on:

- ventilation
- O_2 consumption

Impact of pile driving on feeding:

- fish number feeding
- food amount consumed
- attacks on food items



European seabass (*Dicentrarchus labrax*)

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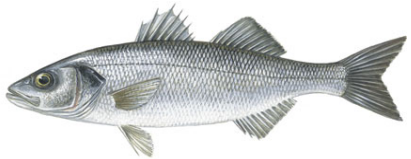
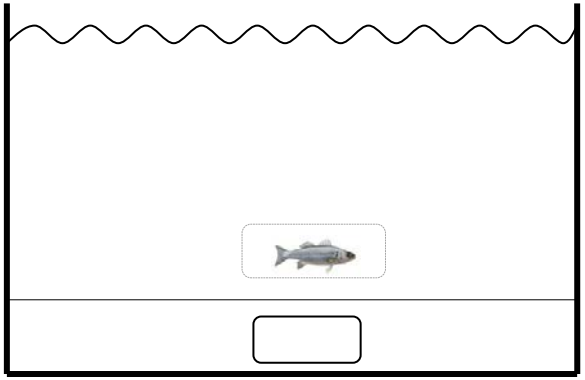
Ventilation



Impact of pile driving and ship noise on ventilation rate?

30 min habituation in plastic container

- Ambient: Amb (2 min) - Amb (10 min)
- Pile: Amb (2 min) - Pile (10 min)
- Ship: Amb (2 min) - Ship (10 min)



Count opercular beat rates / 15 seconds

n=60 (20 fish per treatment)

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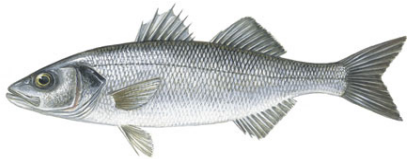
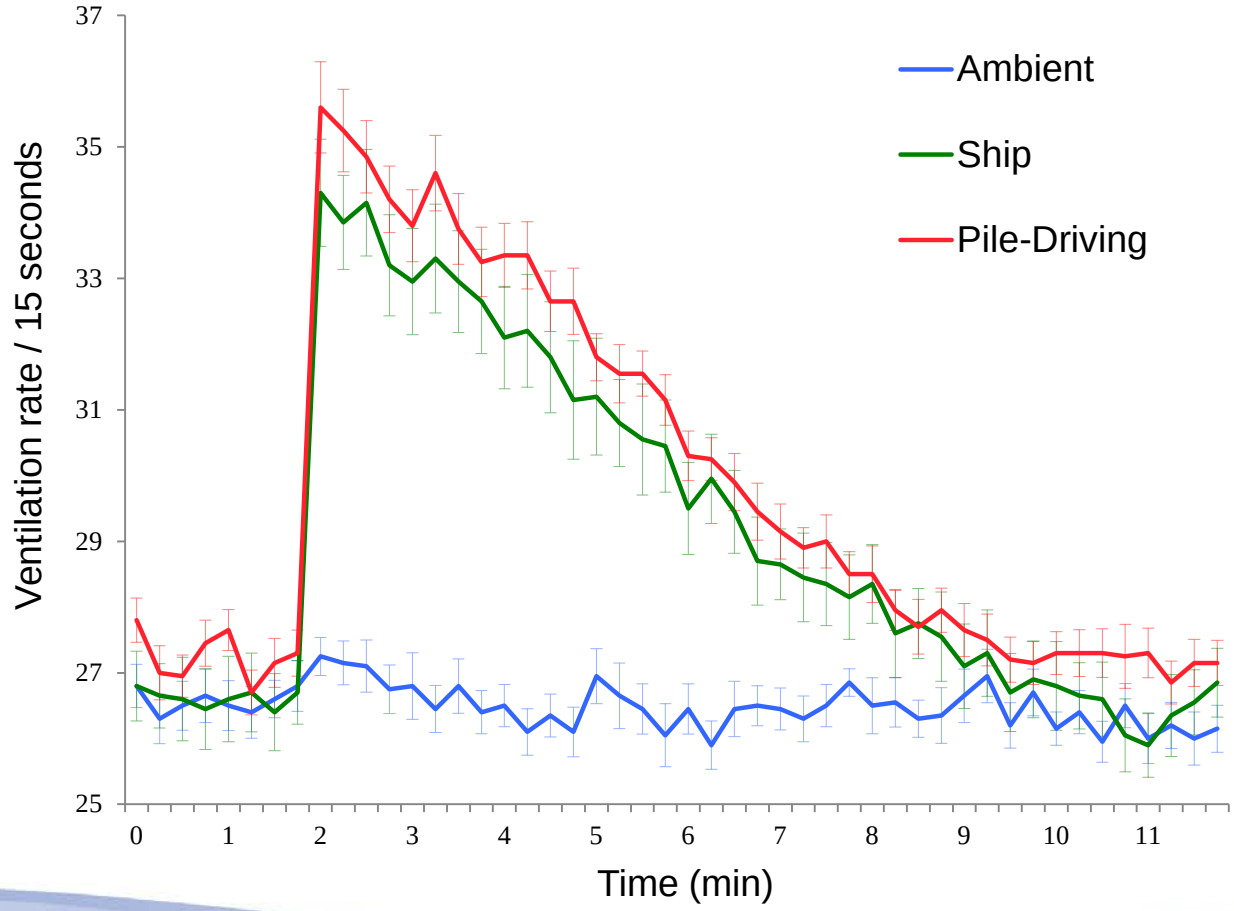
Ventilation





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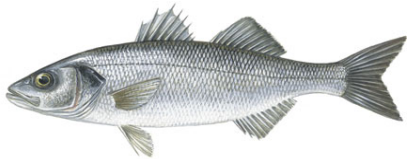
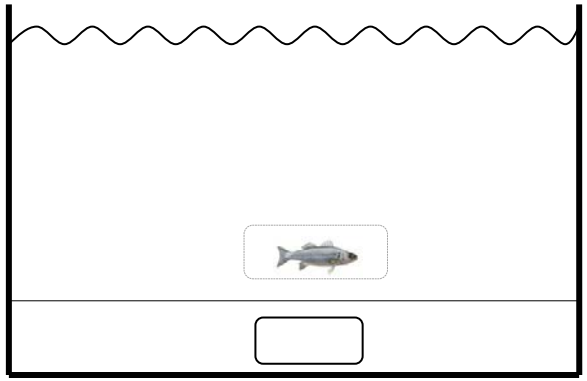
O_2 consumption



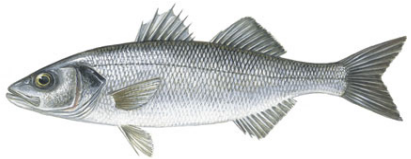
Impact of pile driving and ship noise on O2 consumption?

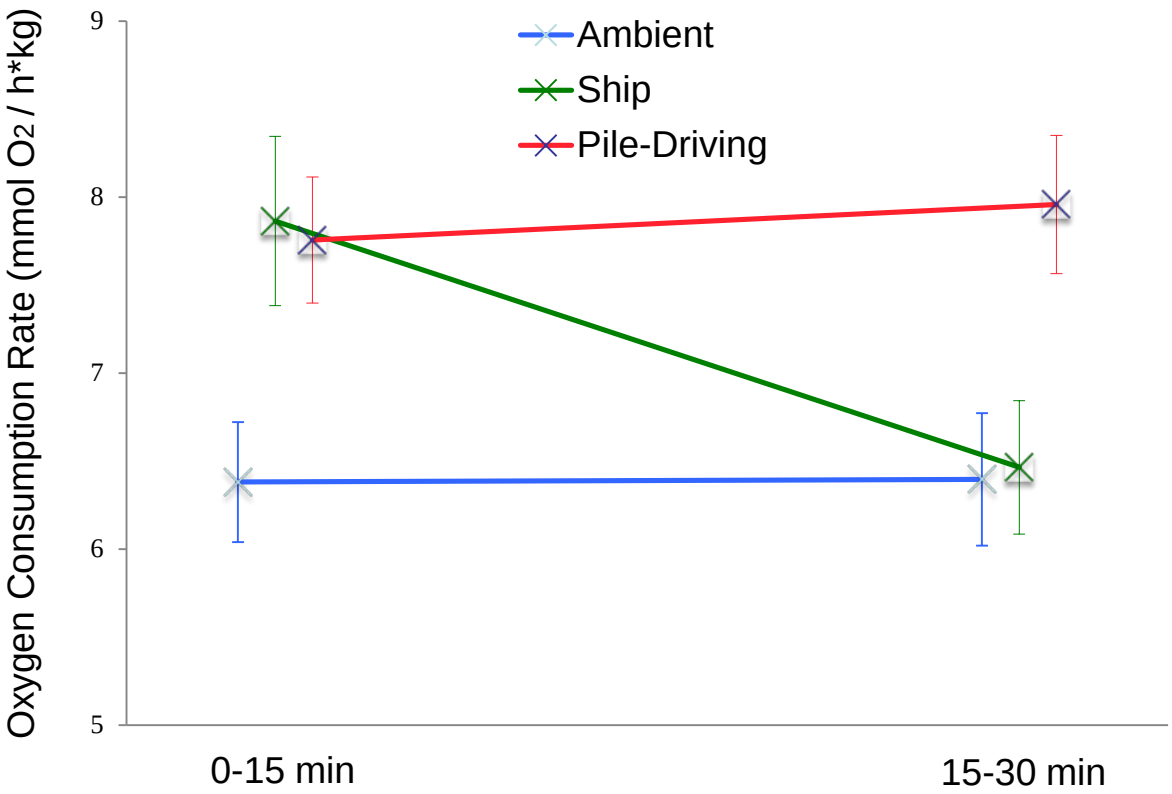
30 min habituation in plastic container (fully oxygen-saturated) – Ambient noise

- Ambient, pile driving, ship noise (30 min)
- Water samples (0, 15 and 30 min)
- Weighed & measured
- Analysed water samples with oxygen meter (n=72)

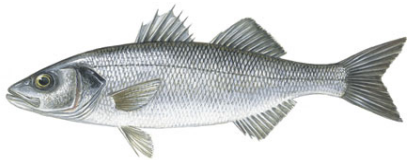


O_2 consumption





Feeding



- Impact of pile driving on feeding?

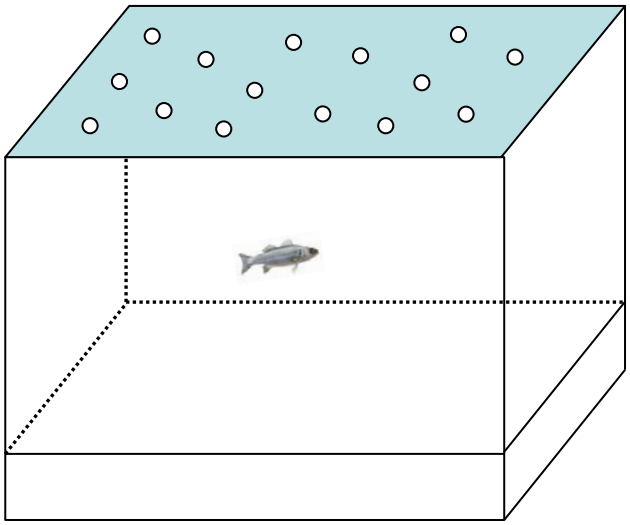
habituation in plastic container (30 min)

Transferred to test tank (4 min habituation, ambient noise)

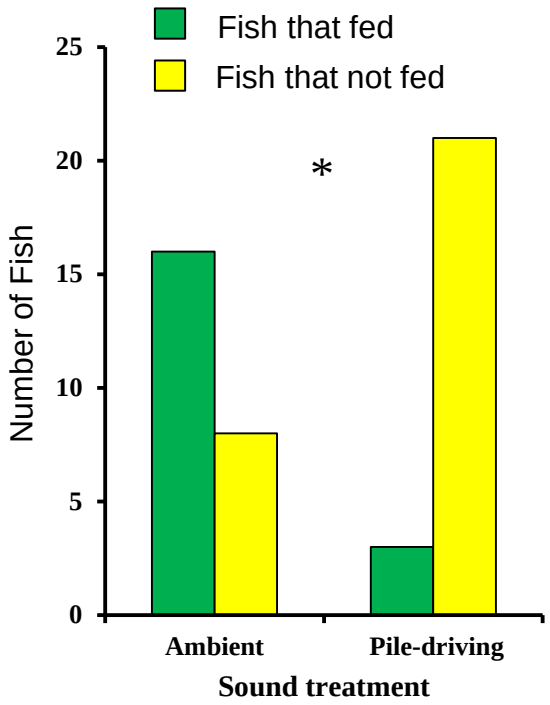
- Ambient noise (5 min 20 sec)
- Pile driving noise (5 min 20 sec)

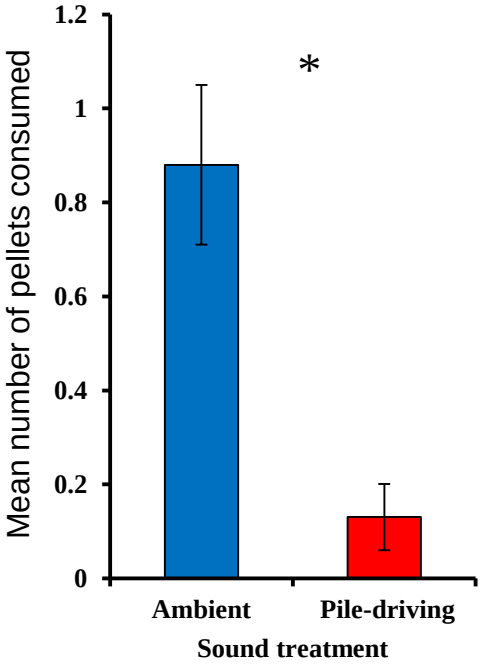
- Every 20 sec a food item was dropped

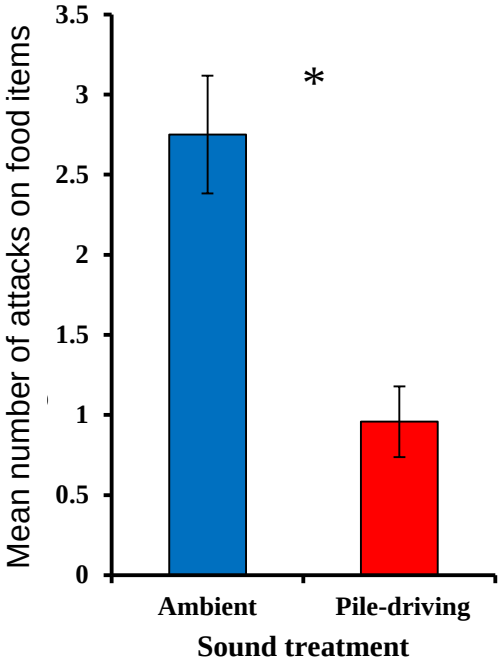
- Recorded strikes and items consumed



Feeding







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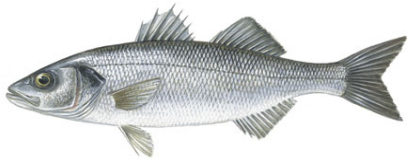
Test case

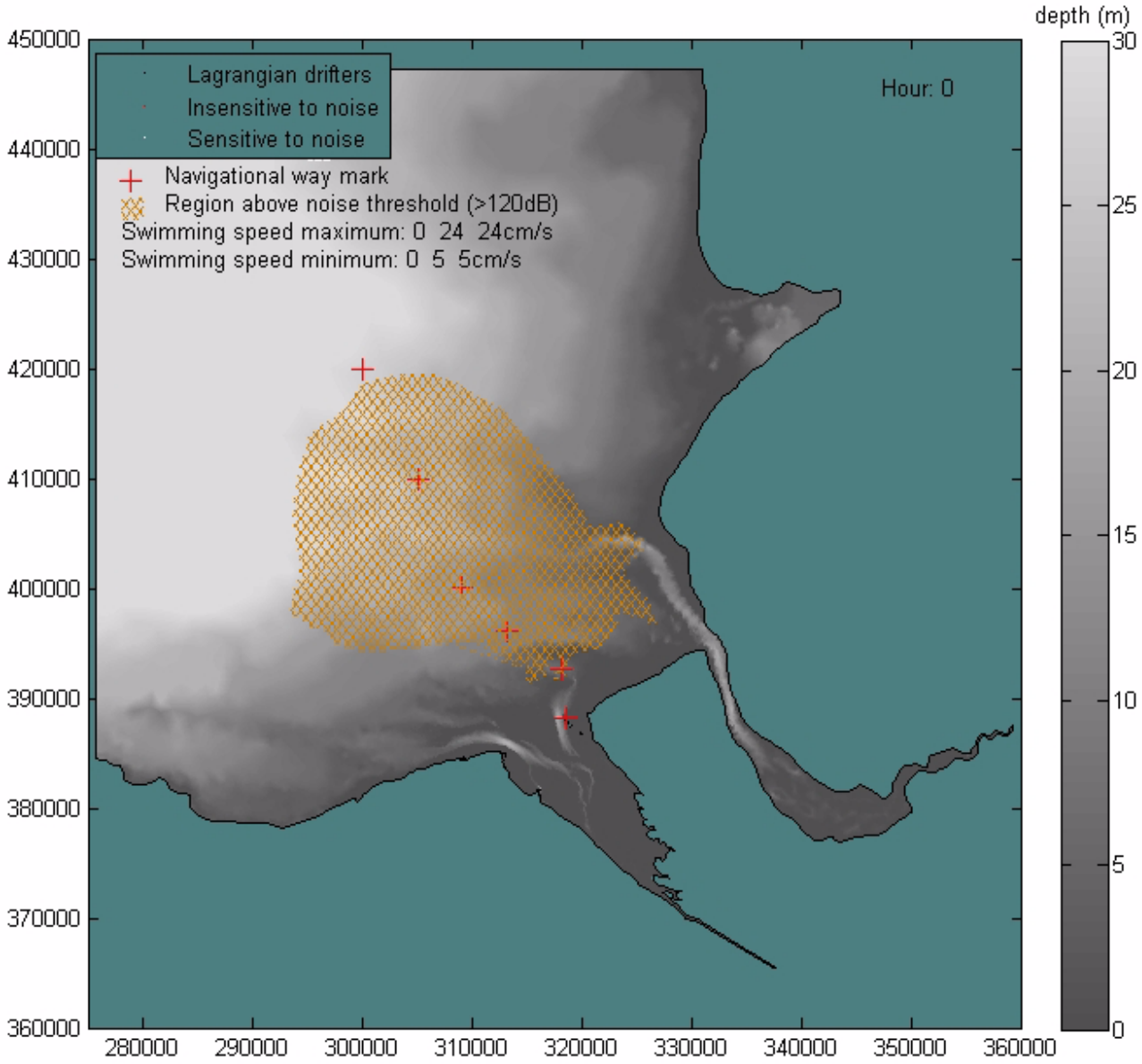


Parameters concerning physiology and behaviour during noise

Liverpool bay (known bathymetry data, currents, etc.)

Noise modelling for pile driving (on from 8-12h and from 14-18h/day)

Fish travel from the north of the bay towards the river Dee.


Lagrangian drifters
Insensitive to noise
Sensitive to noise
Navigational way mark
Region above noise threshold (>120dB)
Swimming speed maximum: 0 24 24cm/s
Swimming speed minimum: 0 5 5cm/s
Hour: 0
depth (m)
450000
440000
430000
420000
410000
400000
390000
380000
370000
360000
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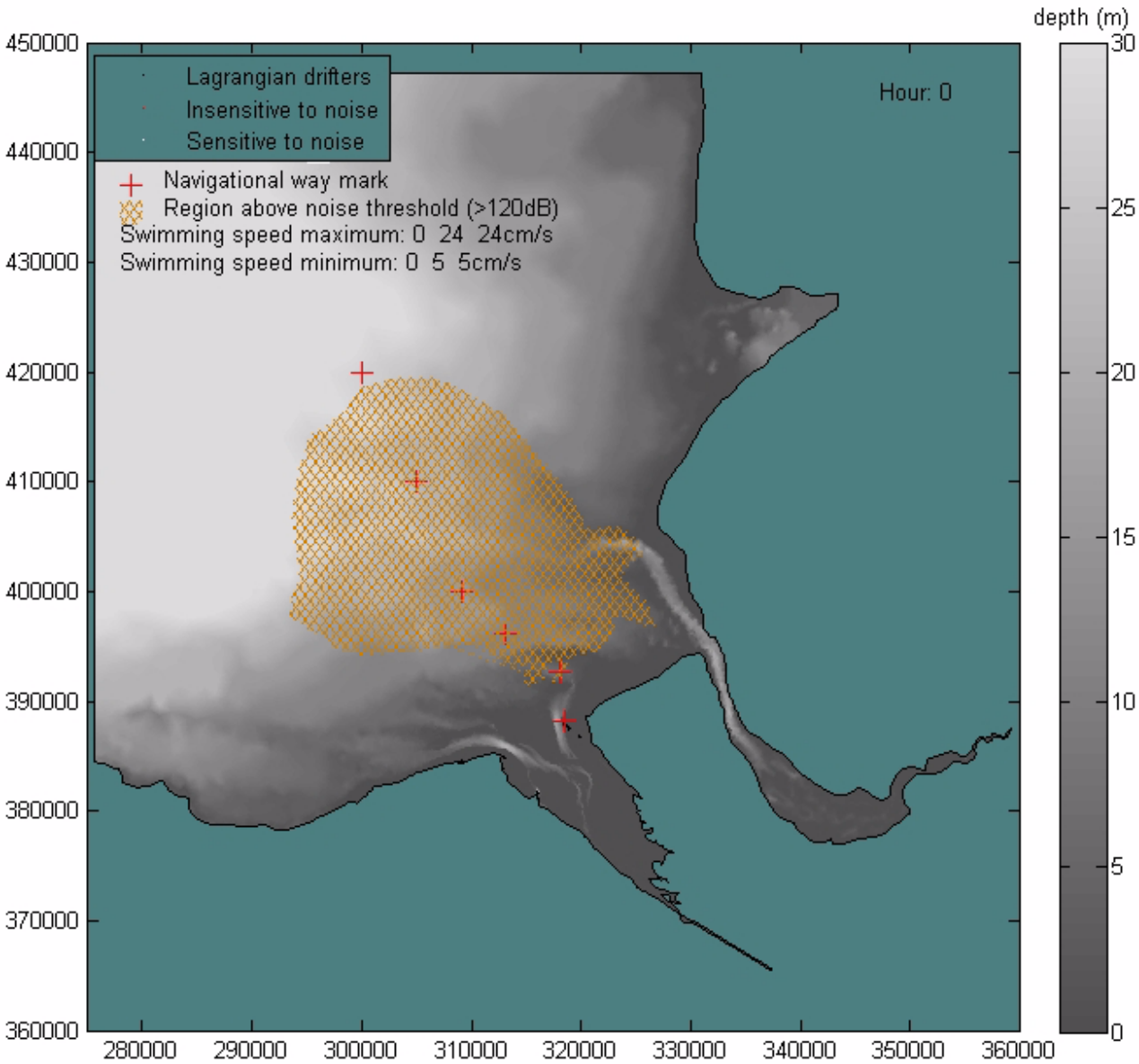
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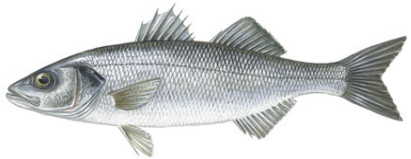
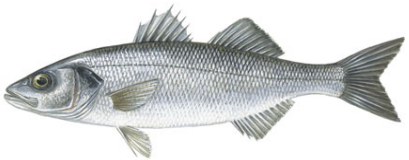
Take home message



- Predictive modelling together with emperical data of physiology and behaviour can help to predict animal behaviour in complex environments.

Future



- Obtain movement data from the field
- Perform field experiments to validate the physiological and behavioural results found in the lab
- Further improve the noise modelling (reflexions)

Thank you for listening

Any questions?

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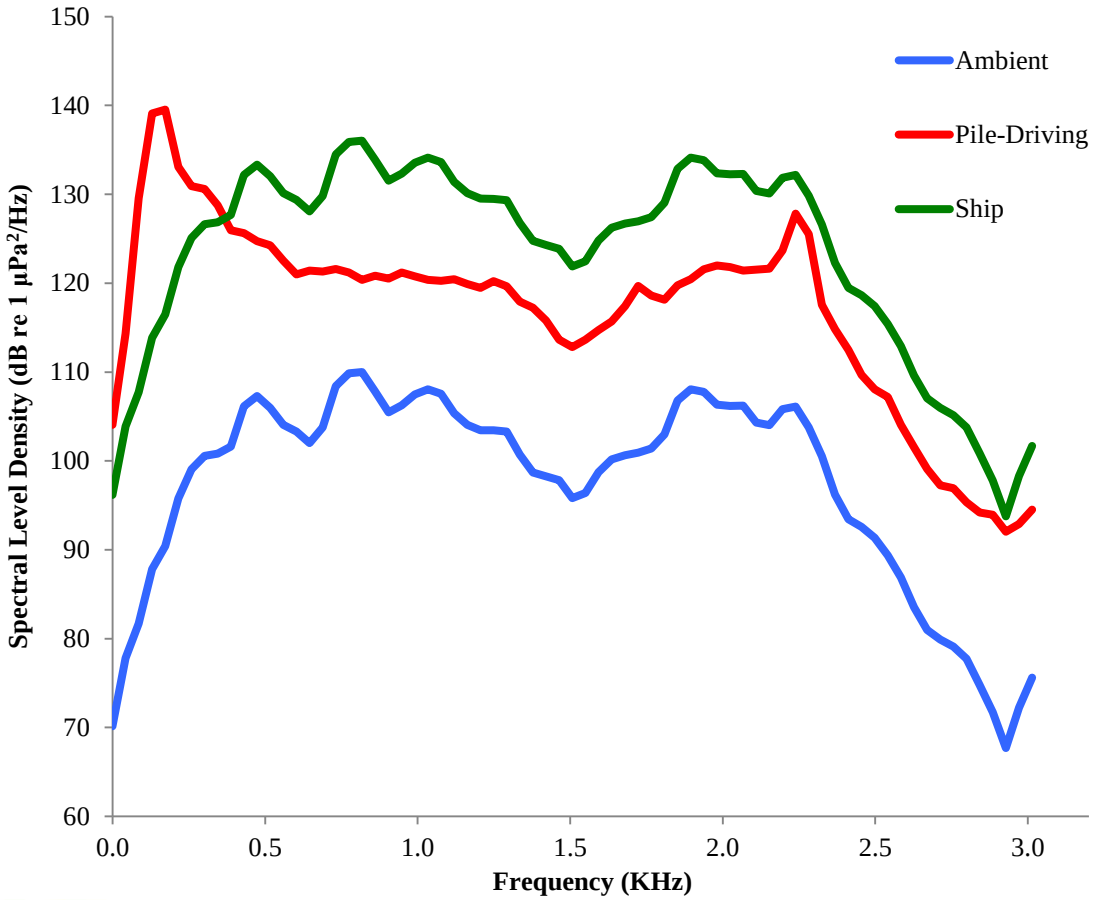
Spectogram



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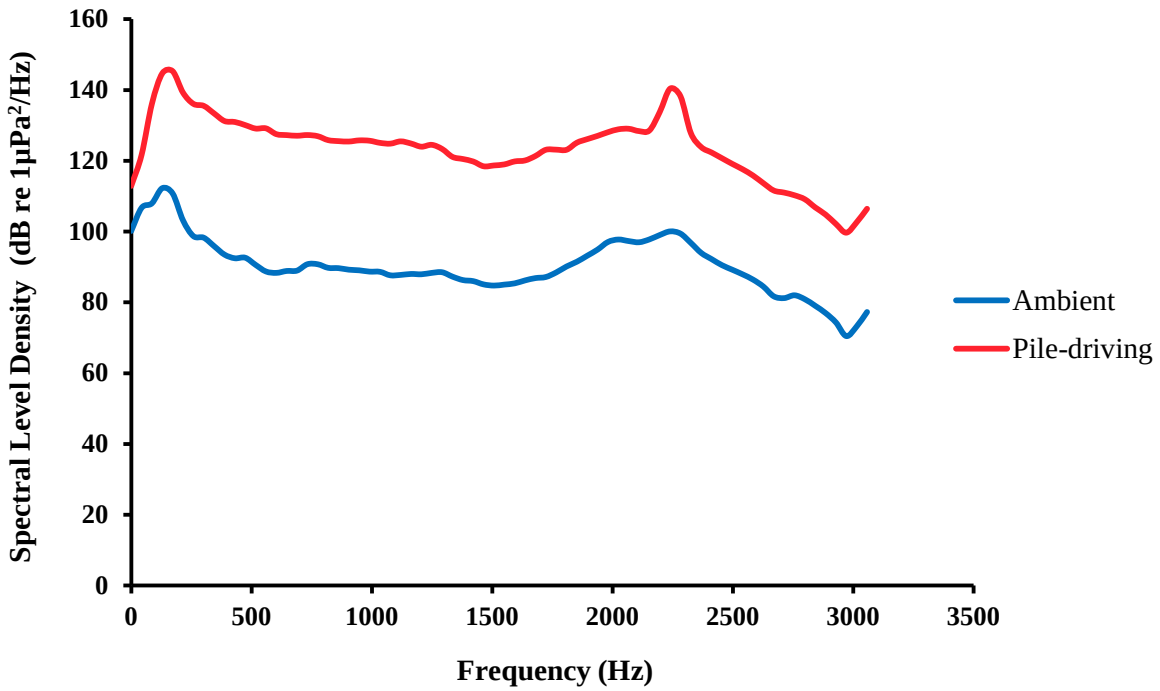
Spectogram



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