Sticking together:

Movement of marine mammals and response to underwater noise

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Abstract

Marine mammals use vocalisations for a number of purposes: in locating food and underwater obstacles, and to maintain contact with members of their family group. These sounds are loud in comparison with the ambient background, but are subject to masking due to underwater noise sources such as tidal turbines.

We developed a model of animal movement which implements simple behavioural rules to allow group cohesion. We discuss some general features of group behaviour, and approaches to validation of the model using empirical data. Including external sources of noise can lead to loss of contact between group members. However, animals can take various measures to deal with these effects, such as more frequent vocalisation or “panic” swimming in response to sounds.

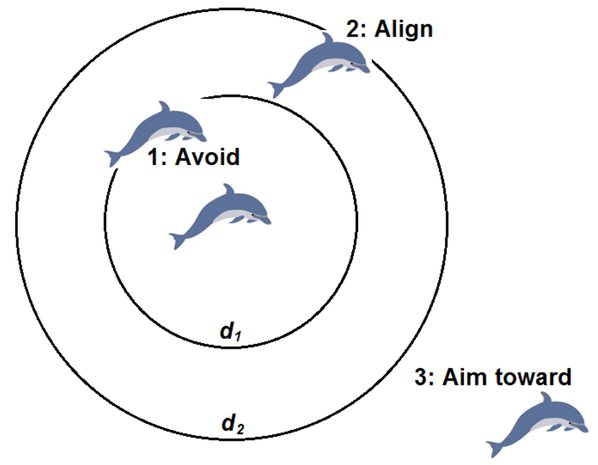
The model

We define individual model animals that:
1. Move at fixed speed;
2. Randomly emit vocalisations at fixed rate, level and frequency;
3. Respond to vocalisations of other animals, according to how distant the sound is.

Underwater noise from model turbines was simulated as a point source, and can mask animal vocalisations.

Two key scenarios containing turbines were investigated:
- Narrow channel;
- Open water.

These scenarios incorporated a range of current velocities, sound levels, and number of sound sources. We simulated the behaviour of groups of 2 and 10 animals, measuring separation distance between them.



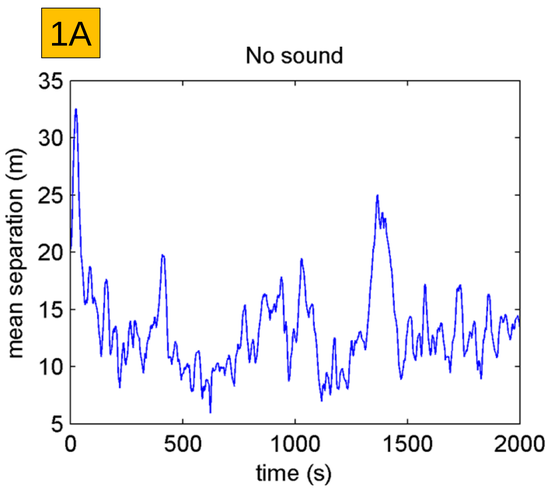
1 General behaviour

Stochastic variation in occurrence of vocalisations means that separation between animals varies over time (Fig 1A). Just as real animals are affected by aspects of their behaviour, particular values of parameters for model animals lead to different behaviours.

Key parameters for model operation are:
- Whistle rate,
- Swim speed,
- Avoidance radius (d_1),
- Align radius (d_2),
- Random turn angle.

Of these, only **whistle rate** and **swim speed** have a significant impact on the average separation of animals (Fig 2A – disc size indicates mean separation).

1A



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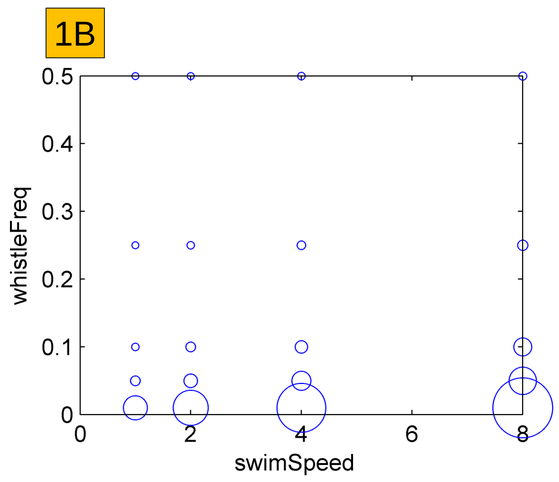
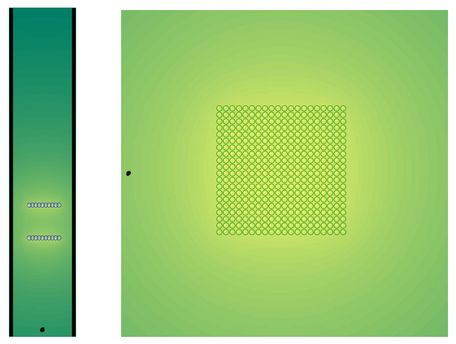
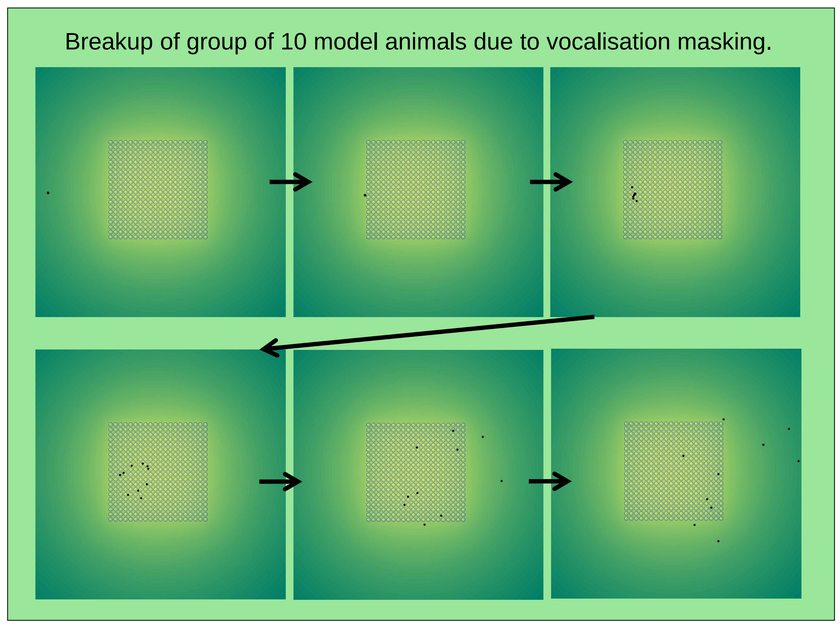


Above: Bottlenose dolphins in the sound of Islay.
Right: Two model sound source scenarios
i) Narrow channel, ii) Open water array.



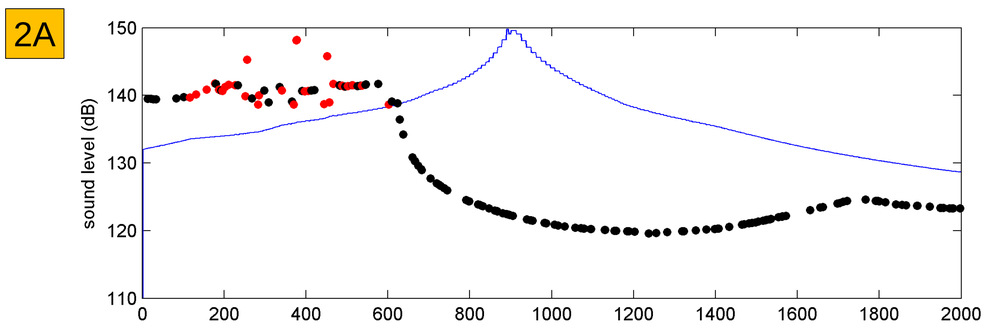


2 Response to noise

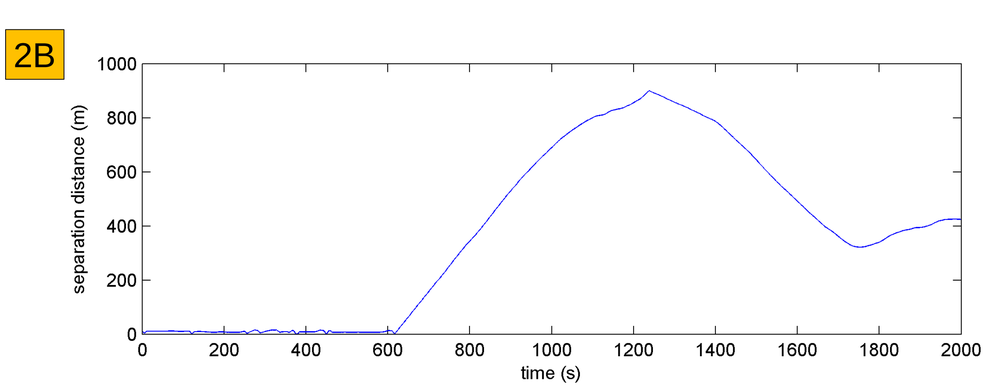
The sound level experienced by an individual model animal changes as it moves in relation to external sources of sound (Fig 2A, blue line). Similarly the experienced level of vocalisation whistles emitted by others in the group alters depending on the separation between them (Fig 2A, dots).

If the background sound level exceeds the level of the whistles, they are masked. This means that animals can no longer maintain contact with one another and become more widely separated (Fig 2B). They may relocate each other by luck, or by moving back into an area where sound levels are lower.

2A



2B



3 Overcoming noise

In areas of high background noise, model animals may reduce their mean separation (and/or reduce their likelihood of becoming isolated) from others by:
- **increasing whistle rate**;
- **swimming quickly** in the presence of loud external sounds;
- moving in **larger groups**.

However, not all situations can be overcome if communication is only vocal; very loud sound from many sources always results in the break up of the group.

Conclusions and discussion

Marine renewable energy devices present a novel and unique source of sound in the marine environment. At present, the exact levels and frequencies emitted are not well studied. Due to difficulties of observation, many aspects of behaviour of odontocete cetaceans are difficult to quantify.

With this in mind, we developed a generic model of animals that maintain group cohesion using vocalisation. Both general dynamics and response to sounds were robust to parameter variation. Model animals were able to mitigate the impacts of noise using certain behaviours, mimicking some of those observed in the wild. These behaviours, and the actual response of animal to underwater noise, represent important avenues for future work on the dynamics of cetacean populations.

References

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