

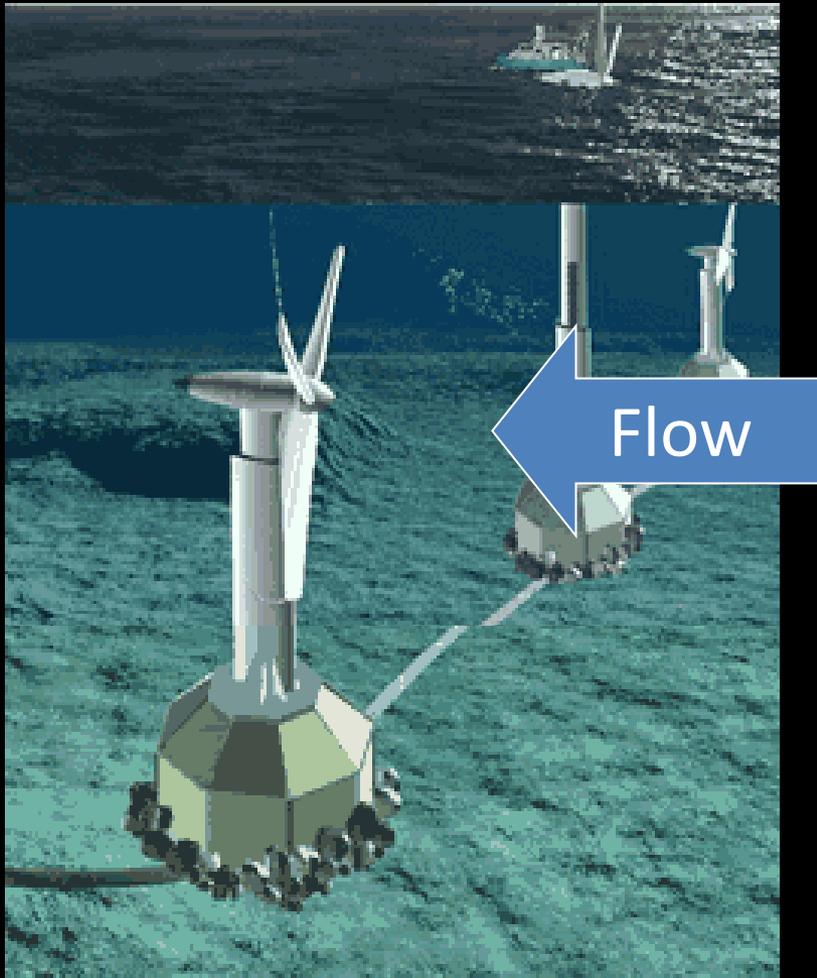
# Marine mammal collision risk: latest science





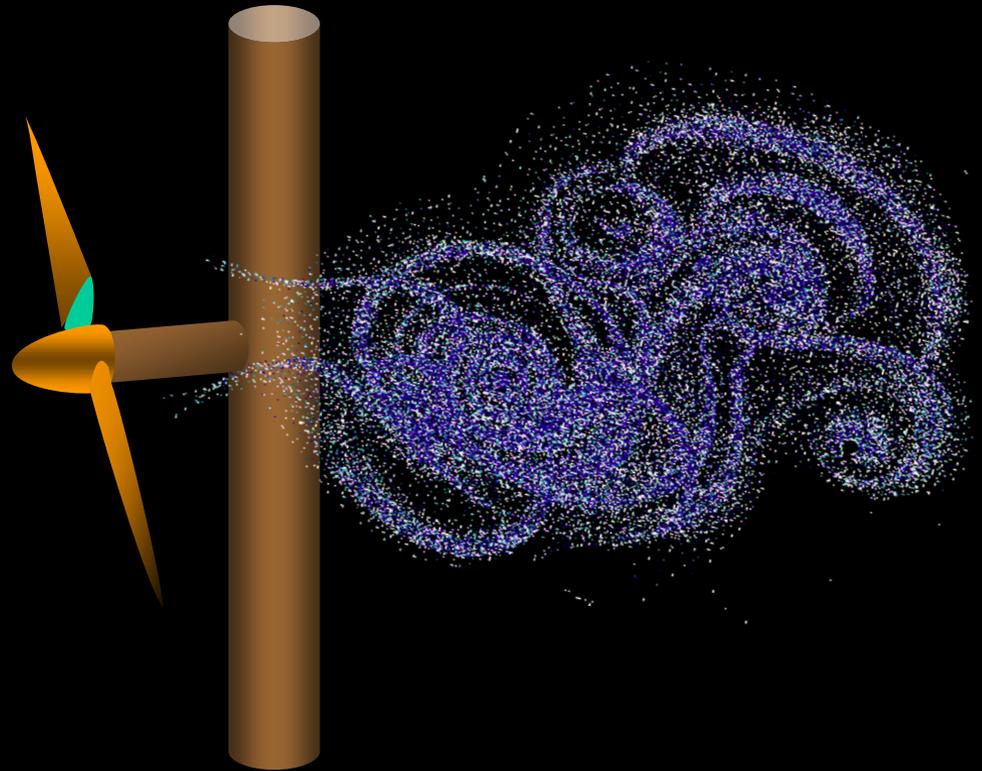
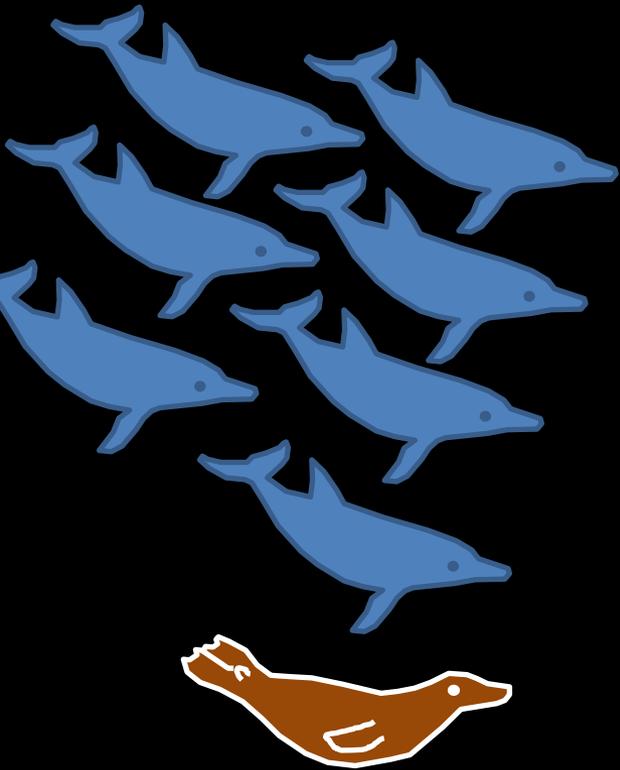
# Are turbine blades a threat?

45 km.h<sup>-1</sup> / 12.5 m.s<sup>-1</sup>

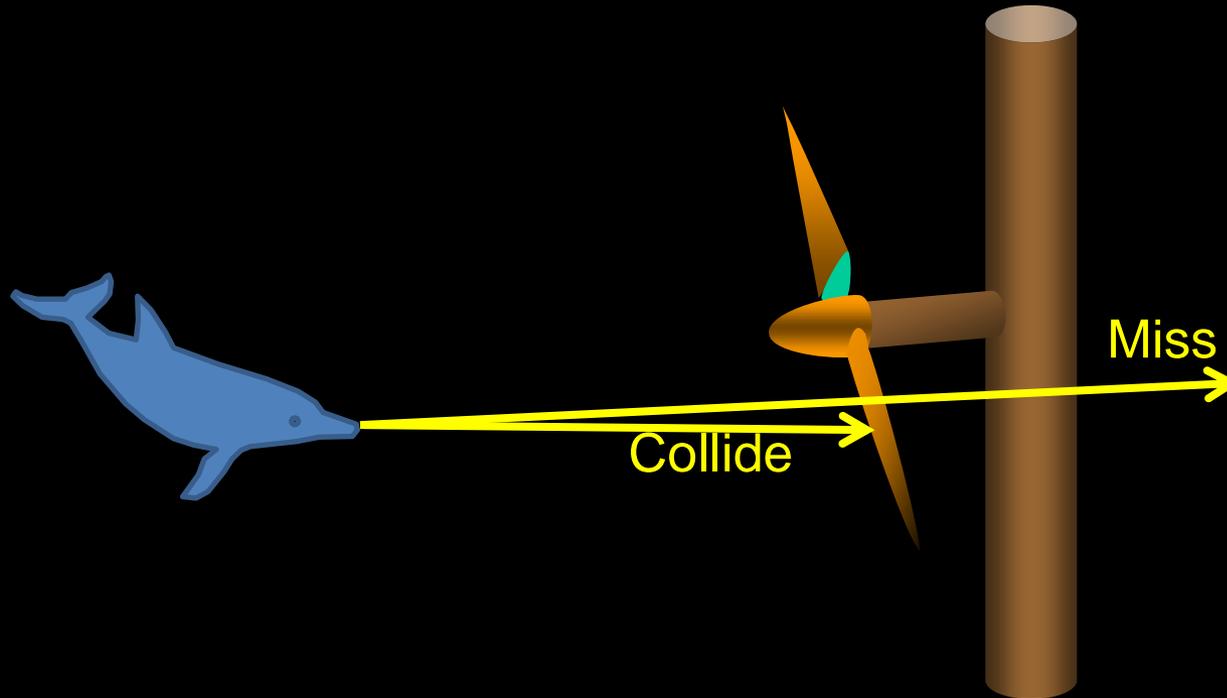




# 1. Which species are at risk (and how many)?



1. Which species are at risk (and how many)?
2. What is the probability of a strike occurring?

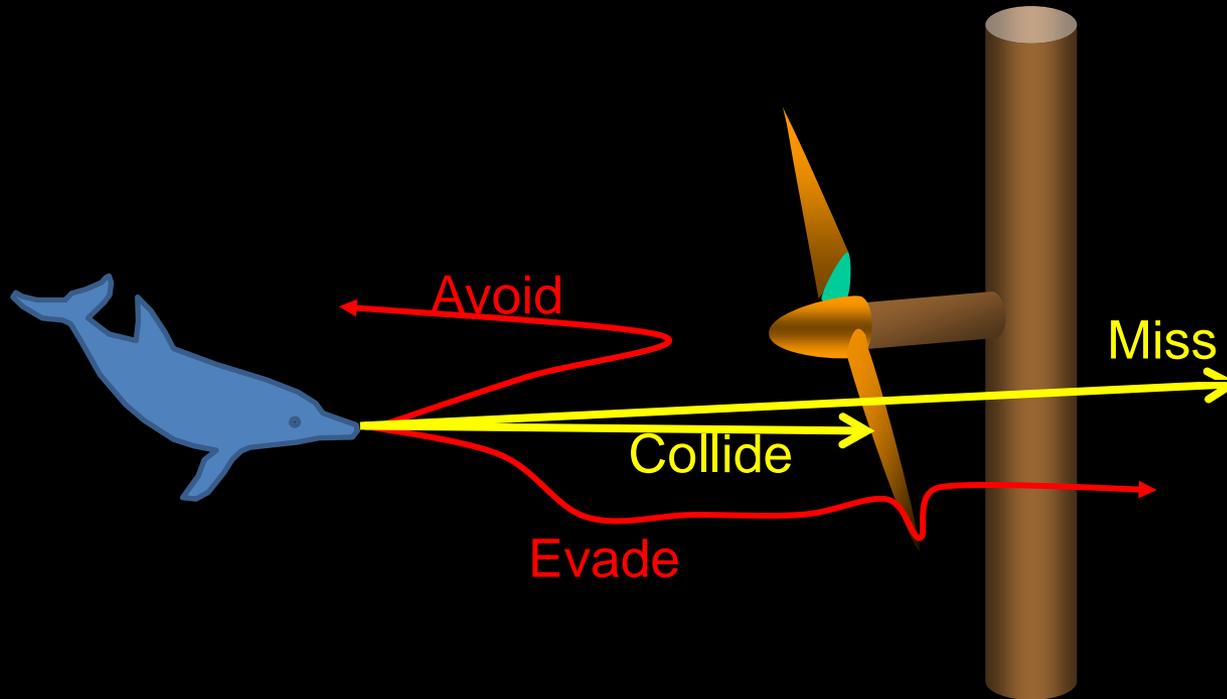


Encounter Rate Modelling (Robert Batty, SRSL)

Collision Risk Modelling (Bill Band)

Exposure time modelling (RPS)

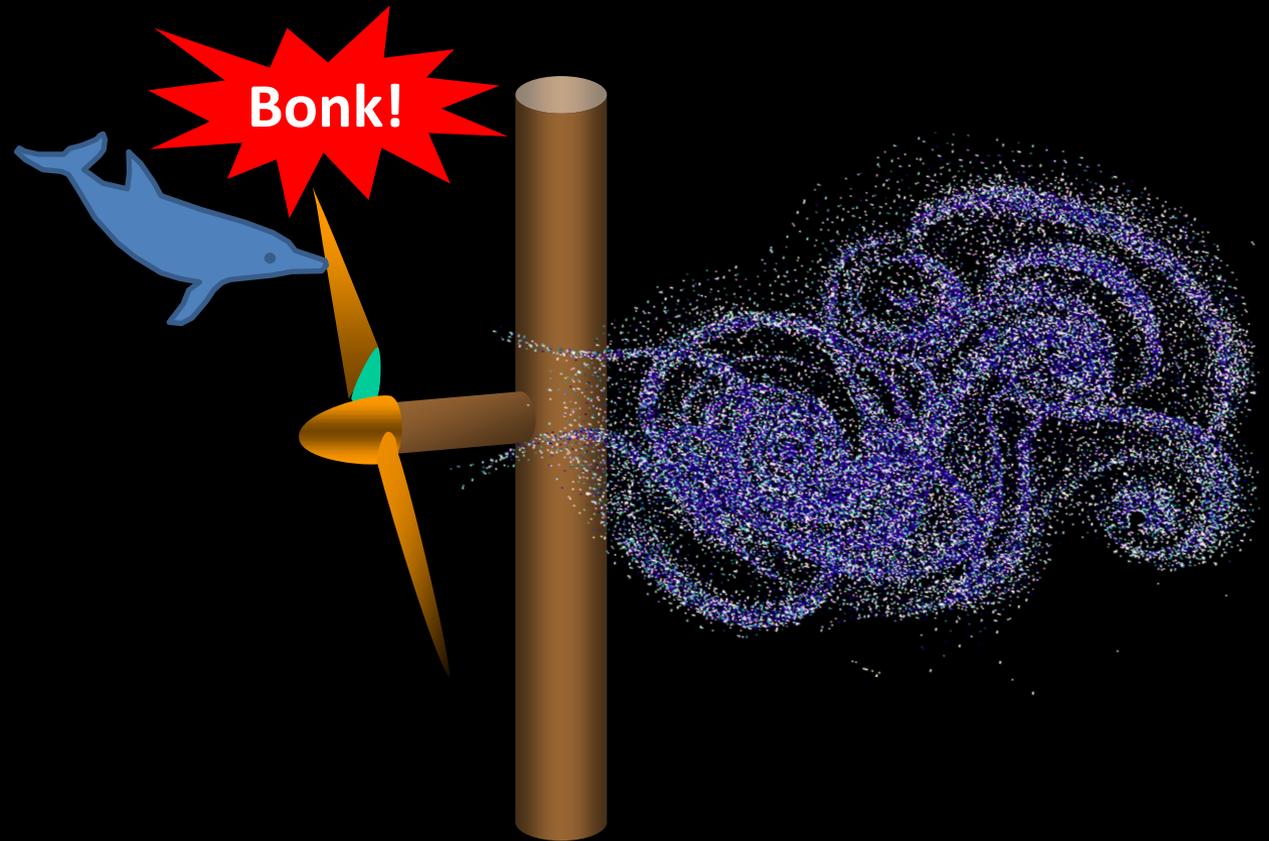
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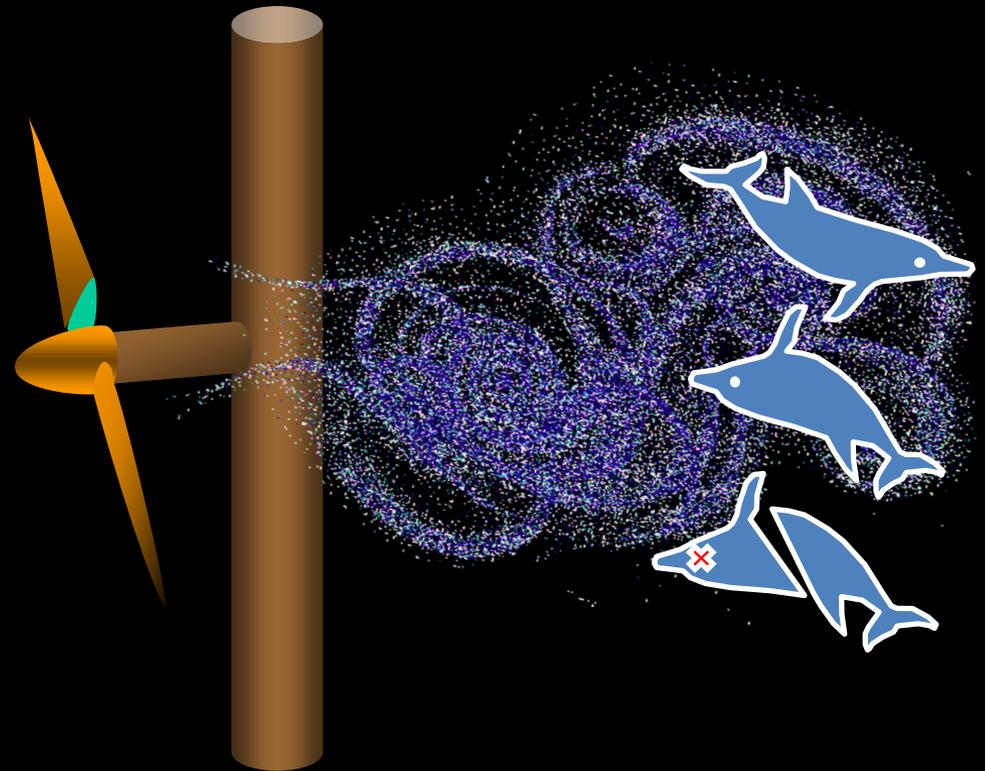
**Ignore turbine**

**Behave relative to turbine**

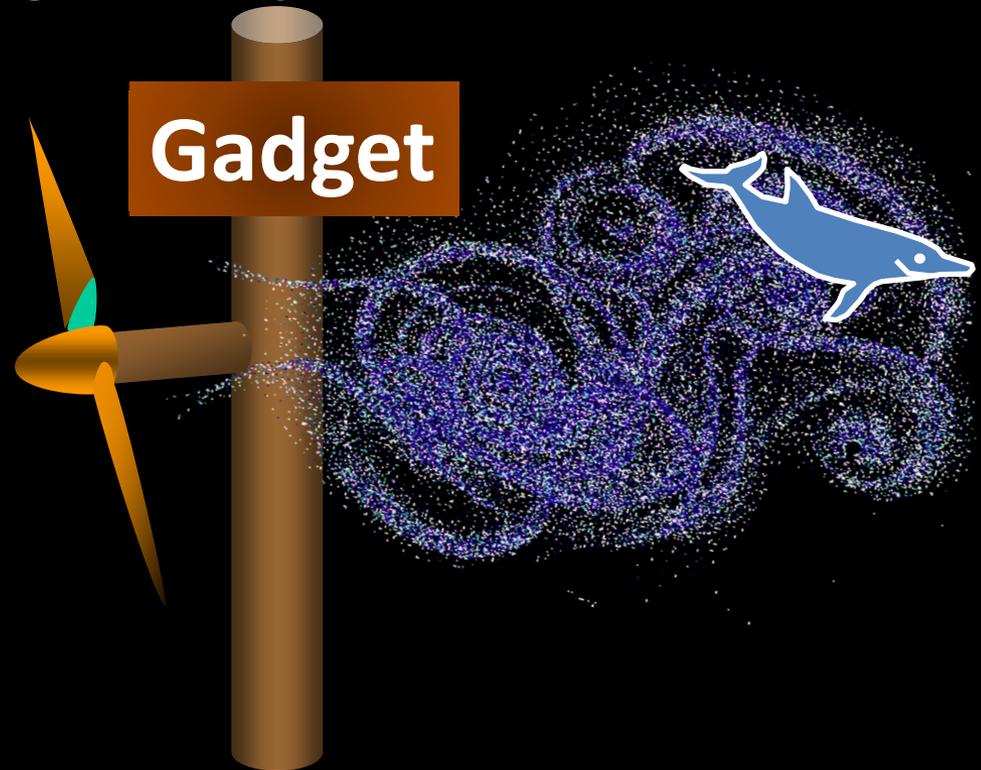
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3. Do collisions actually occur?



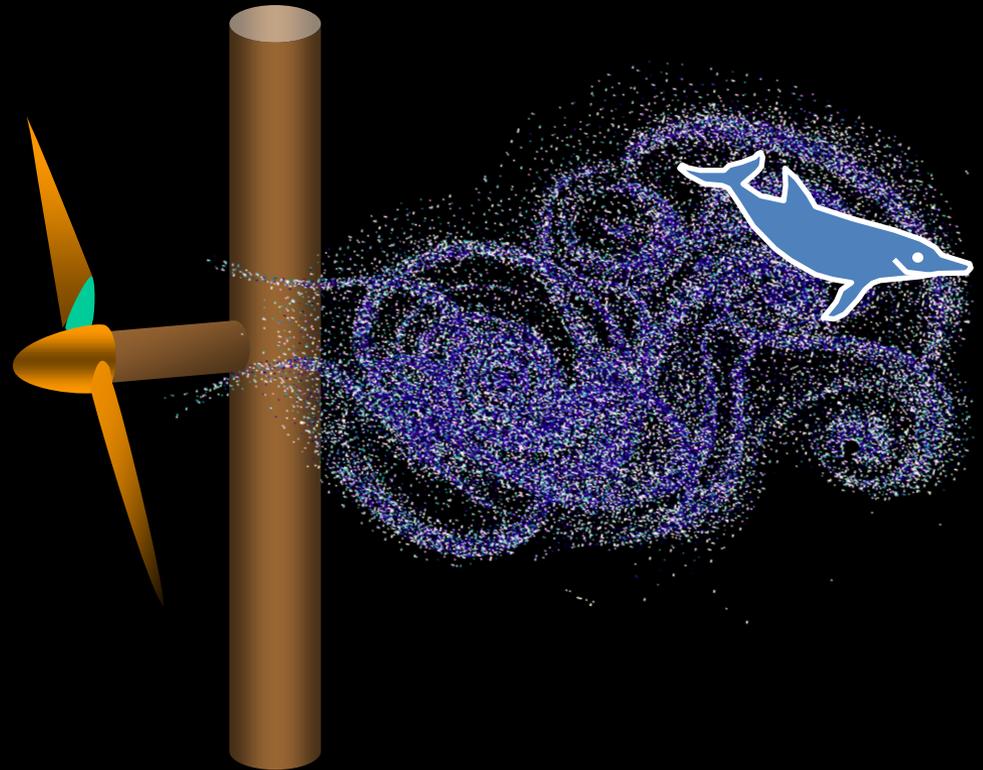
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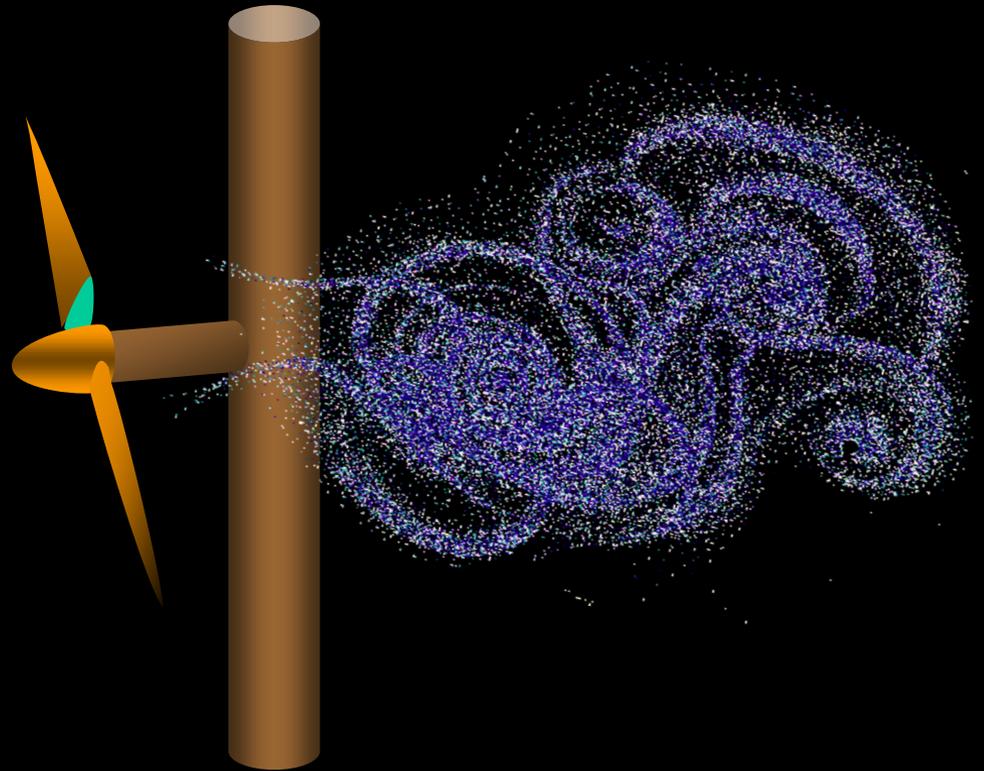
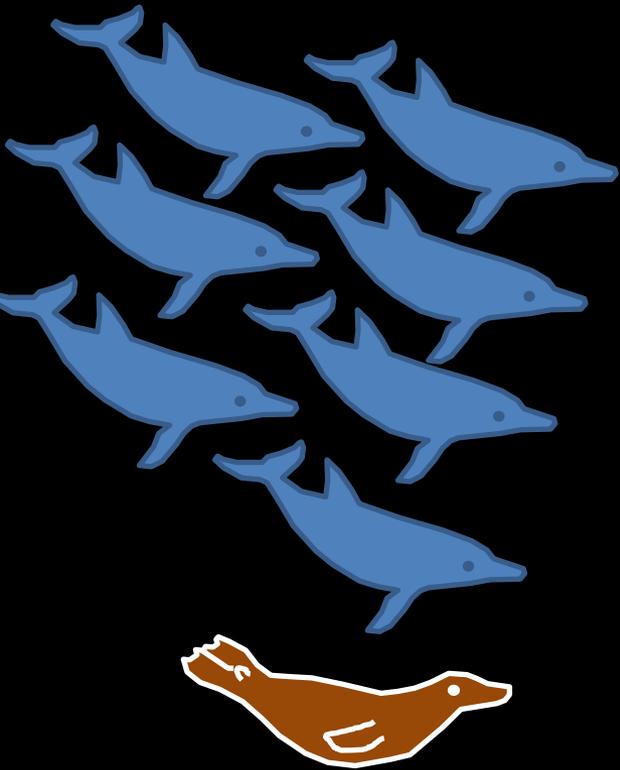
1. Which species are at risk (and how many)?
2. What is the probability of a strike occurring?
3. Do collisions actually occur?
4. What are the consequences of a collision?
5. Are there any mitigation options?



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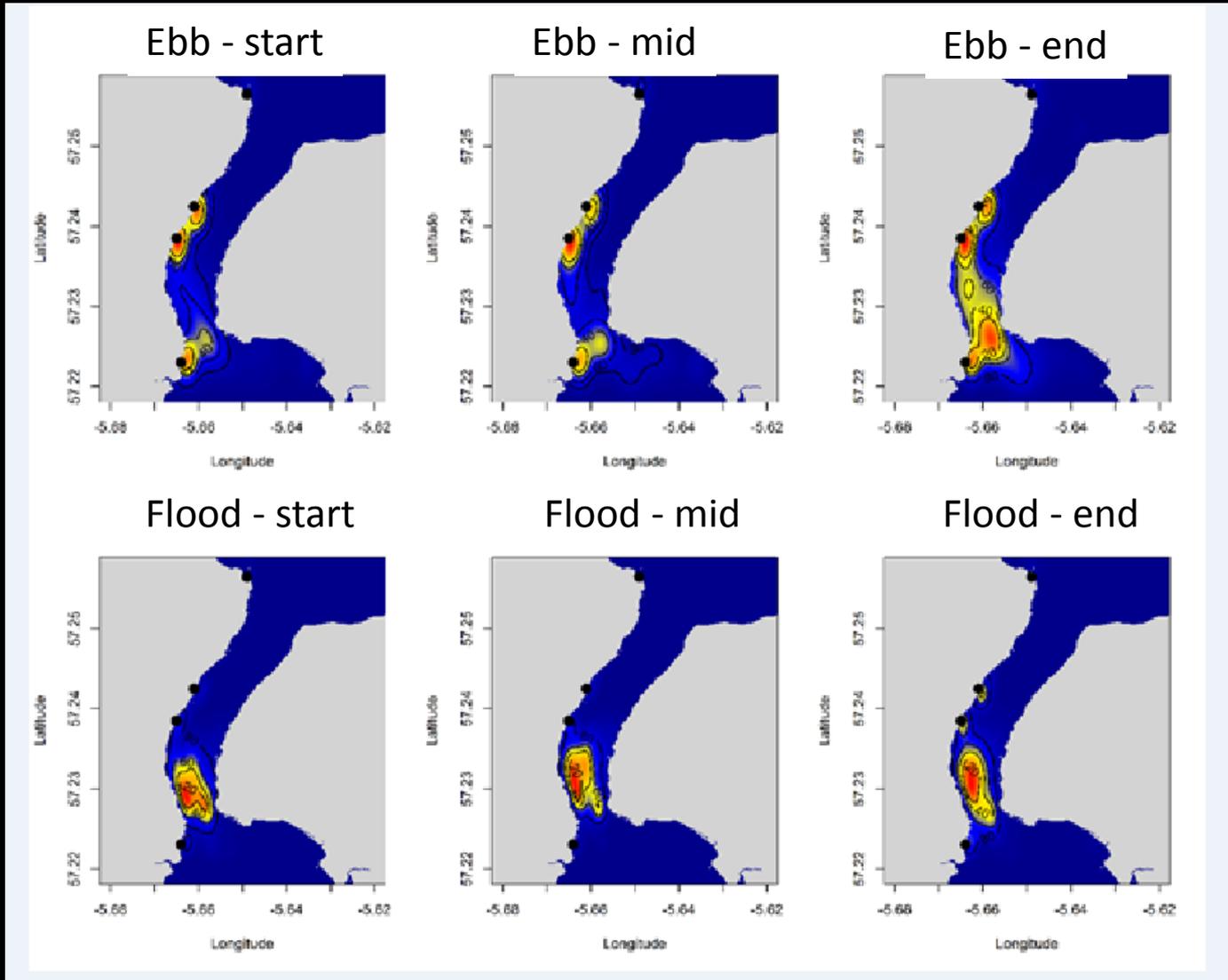


# 1. Which species are at risk (and how many)?



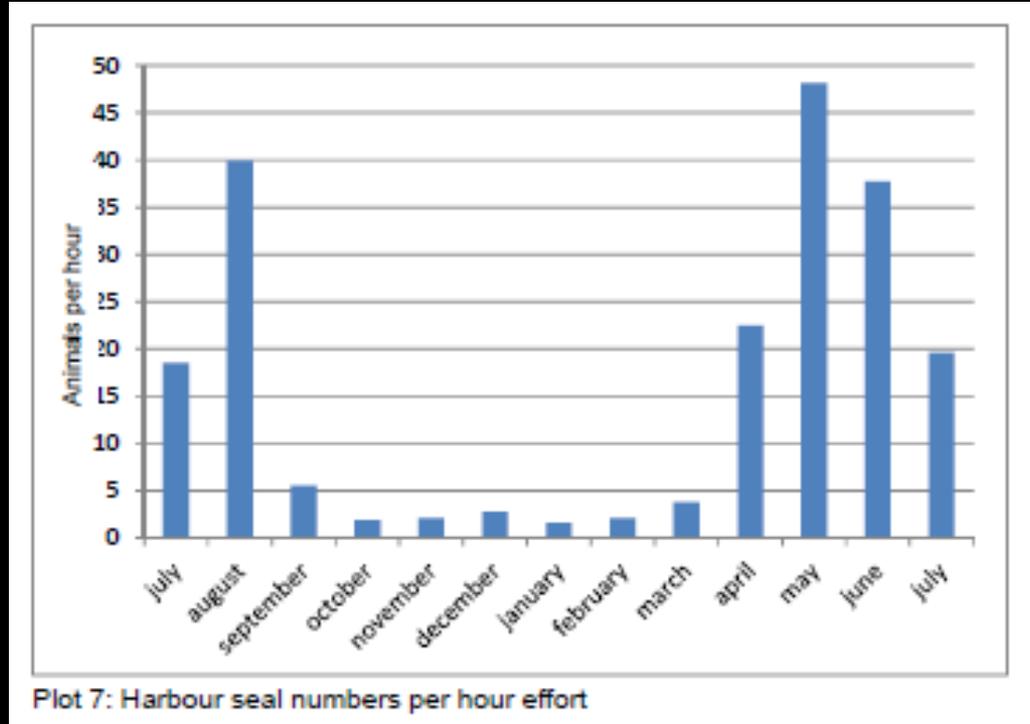
# 1. Which species are at risk (and how many, *and when*)?

e.g. Harbour seal distribution in Kyle Rhea in relation to tide (Hastie et al in review)



# 1. Which species are at risk (and how many, *and when*)?

e.g. Harbour seal distribution in Kyle Rhea in relation to time of year

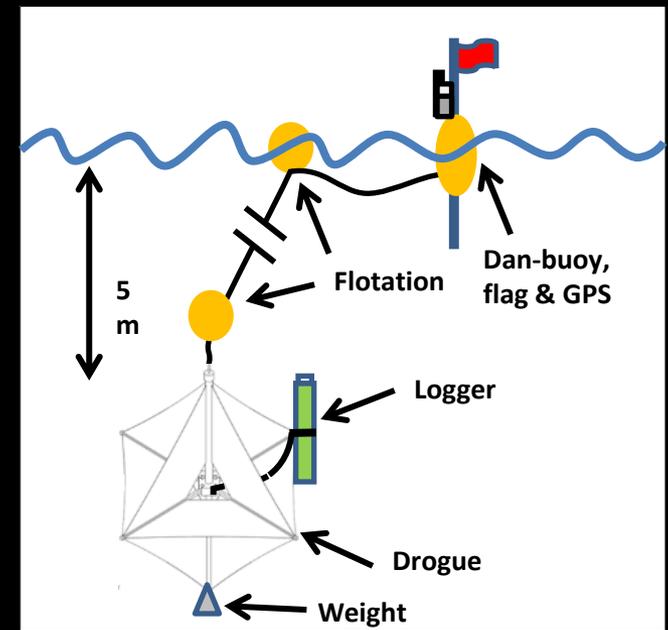
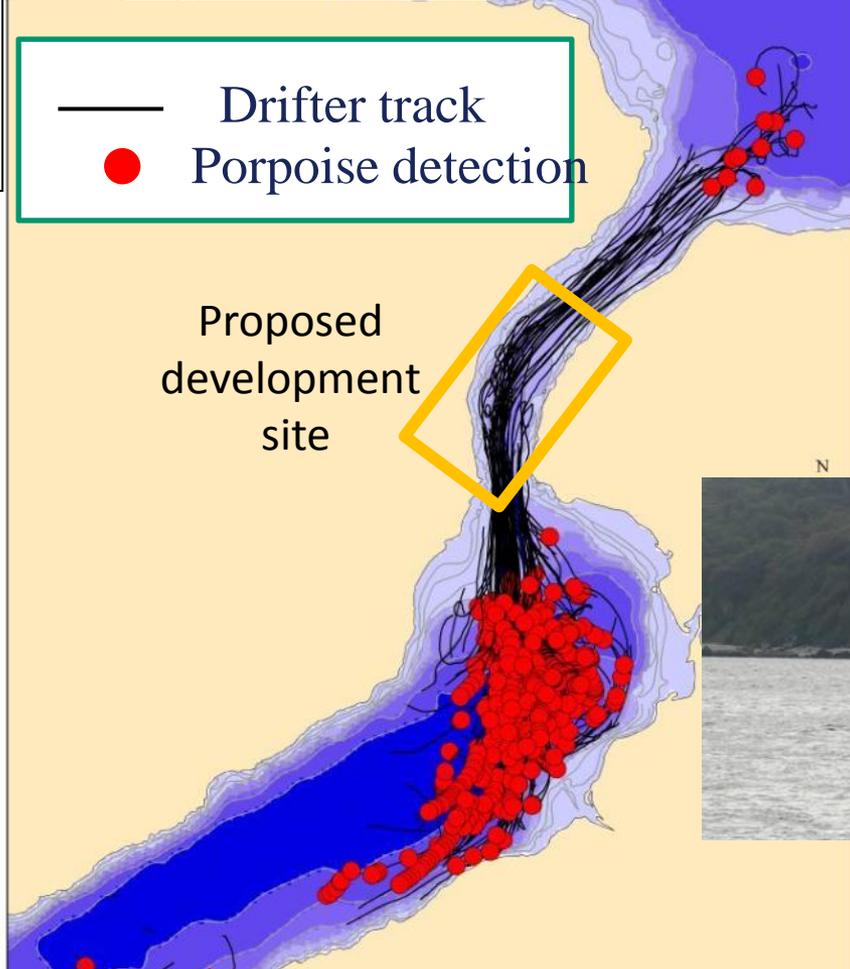




SCOTTISH  
ASSOCIATION  
for MARINE  
SCIENCE



University of the  
Highlands and Islands



Wilson, B., Benjamins, S., & Elliott, J. 2013.  
Using drifting passive echolocation loggers to  
study harbour porpoises in tidal-stream habitats.  
*Endang Spec. Res*, 22, 125-143.

# “Porpoise Localising Array Buoy”

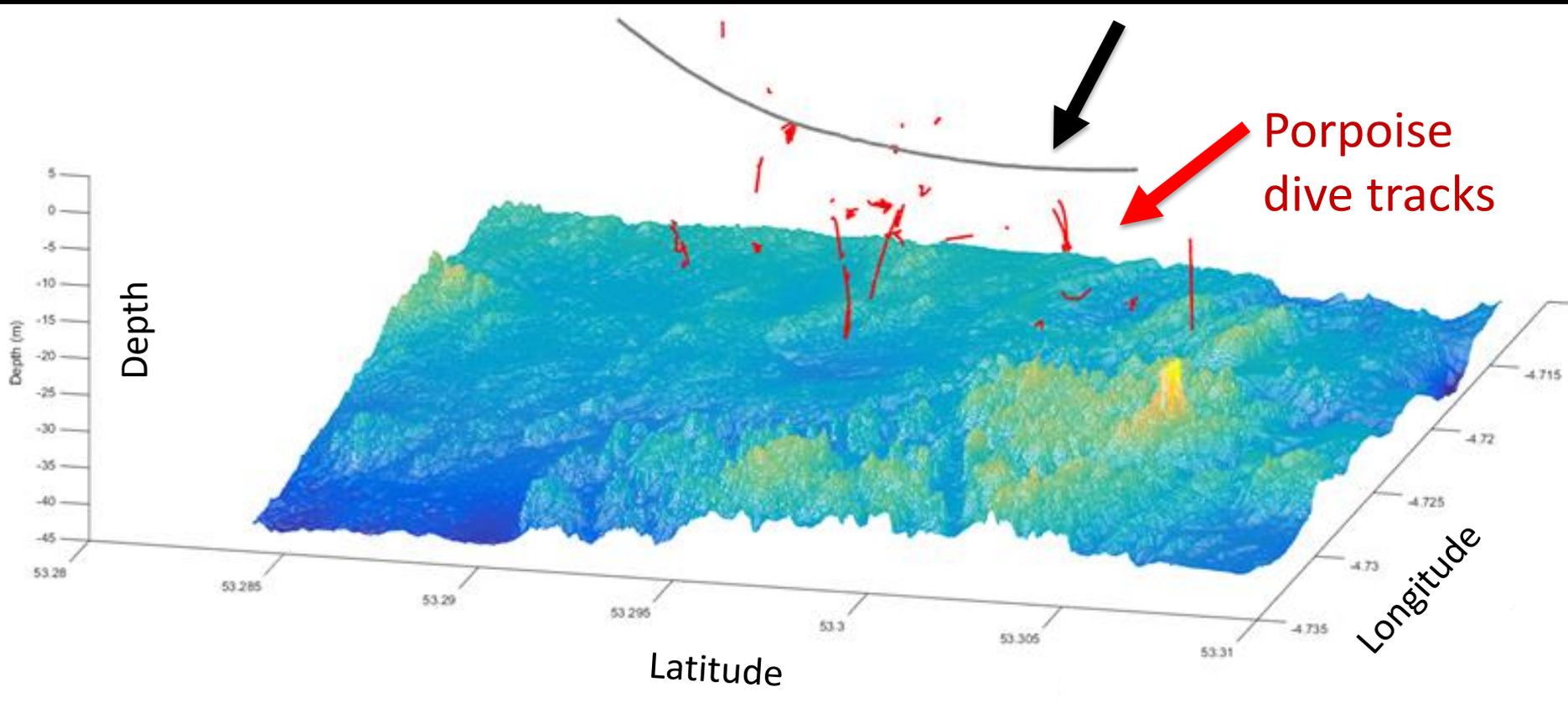


- **Knowledge Exchange** to make industry-friendly version of boat-based vertical array system
- Autonomous, drifting 8-element vertical array
- Provides 3D fine-scale habitat-use information on porpoise movements and dive behaviour



# Example of PLA-Buoy Data

GPS track of PLA-Buoy

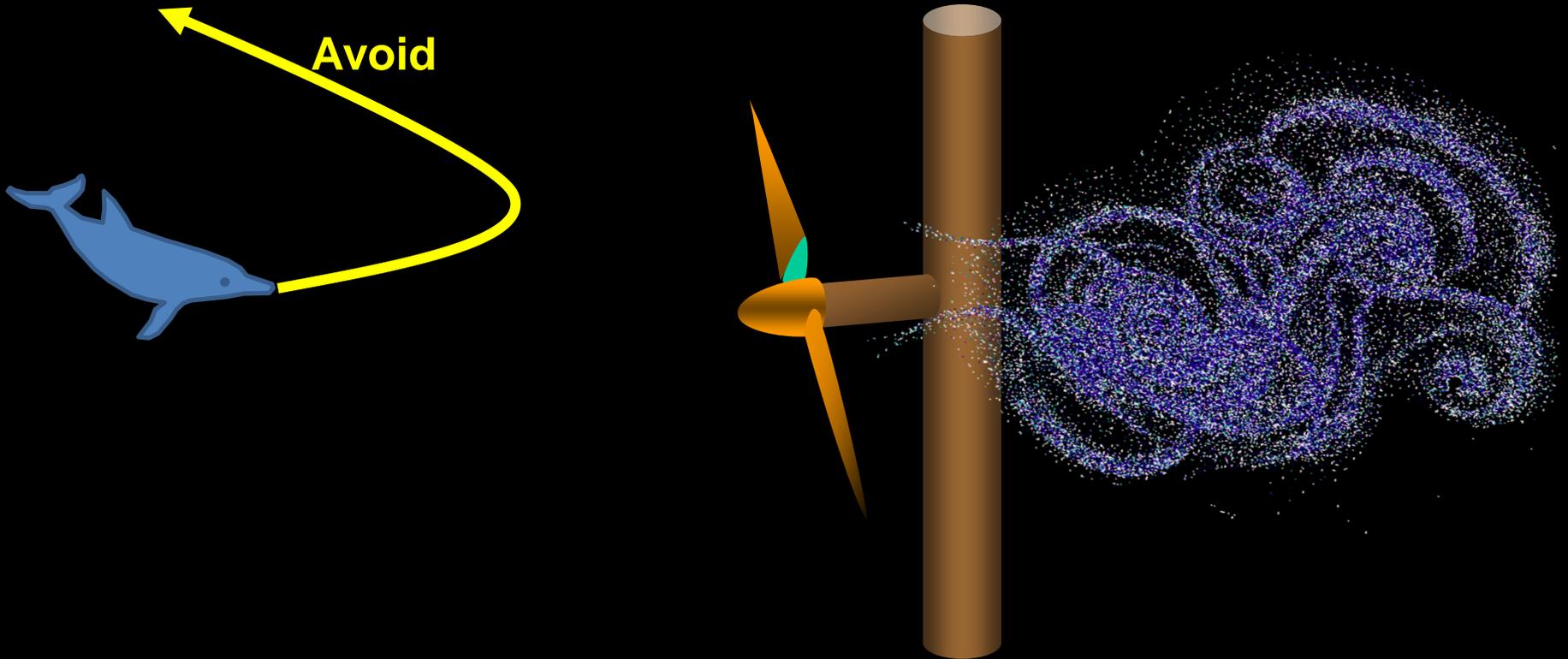


# 1. Which species are at risk (and how many, *and when*)?

TEL PAM detections in relation to the tide

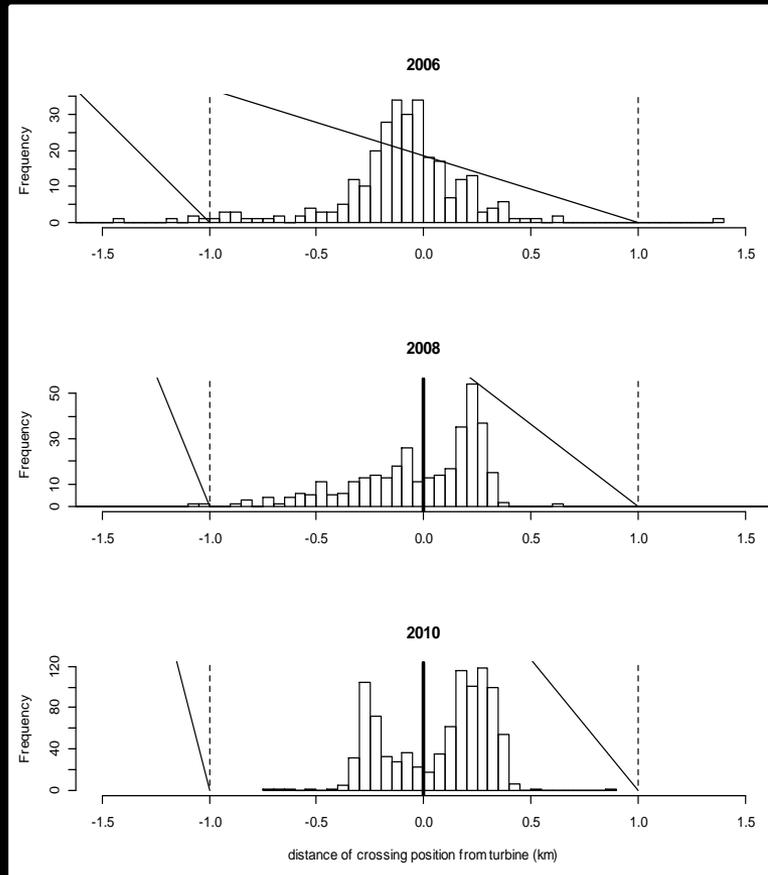
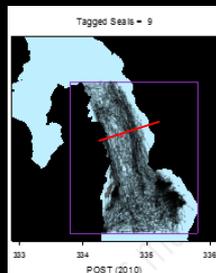
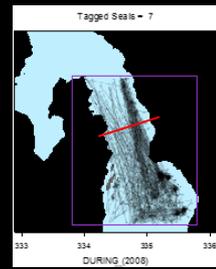
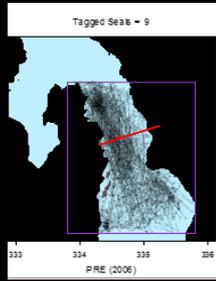


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2. What is the probability of a strike occurring?



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Avoidance?



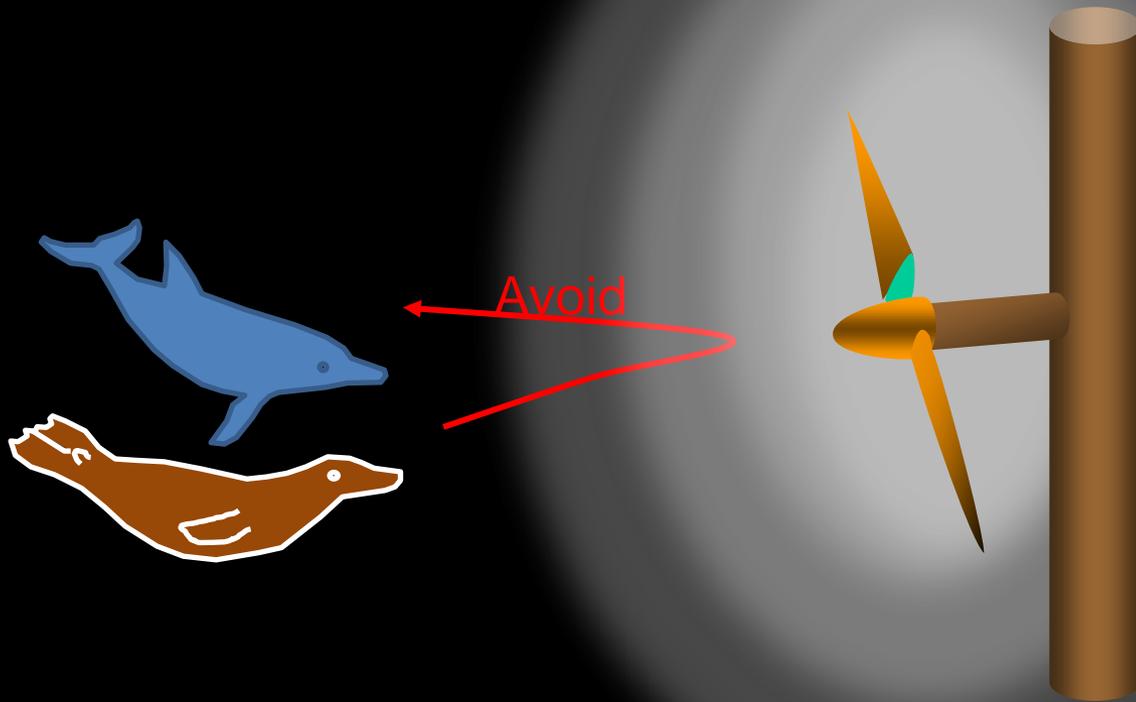
Pre-turbine (2006)

Commissioning (2008)

Full operation (2010)

~60% reduction in the probability of seal tag locations within 200m of the SeaGen location

# Acoustic responses to playbacks



# RESPONSE PROJECT

Responses to playbacks  
of simulated turbine noise

**NERC**  
SCIENCE OF THE  
ENVIRONMENT

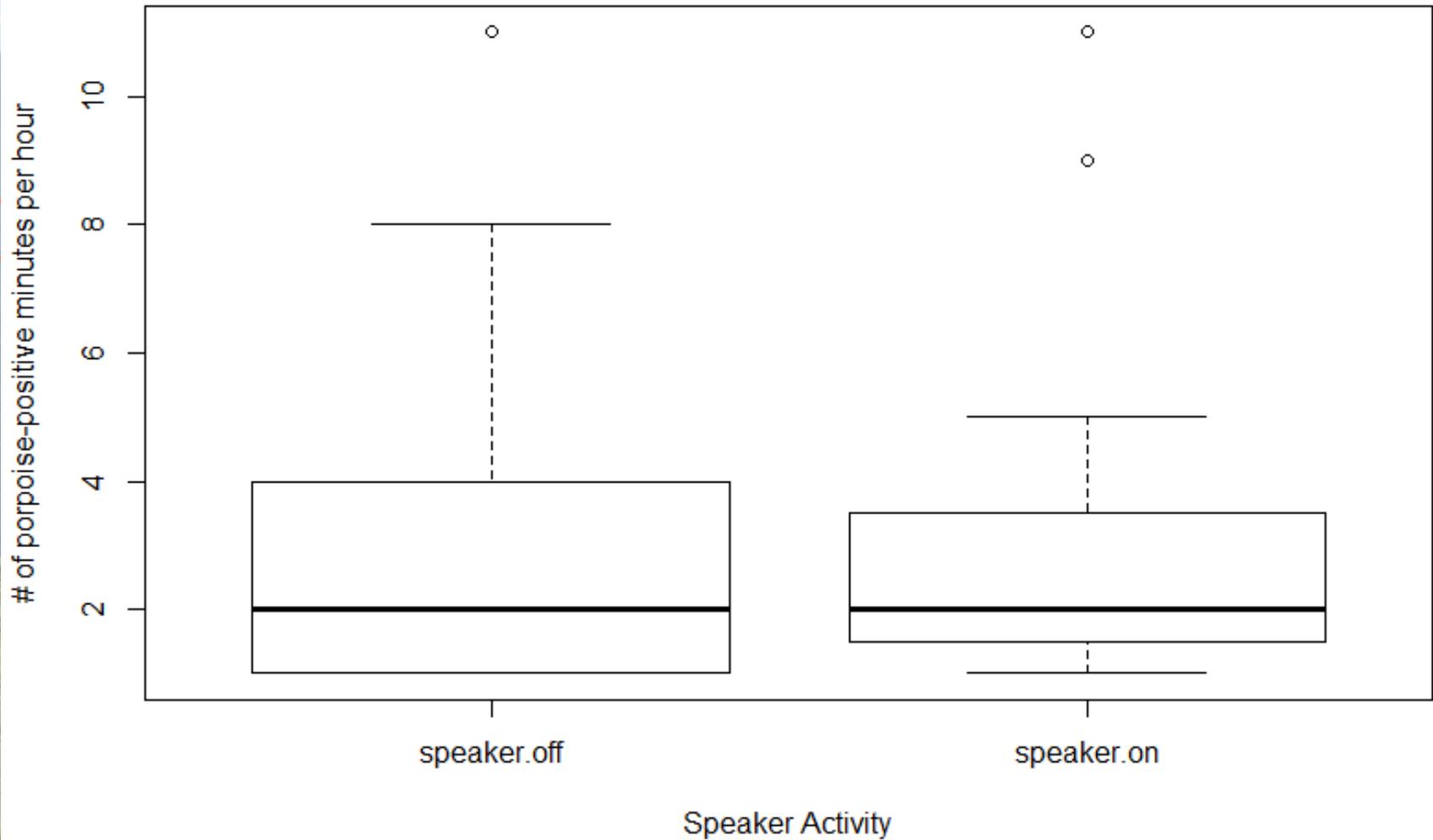
 Loughborough  
University



Underwater speaker



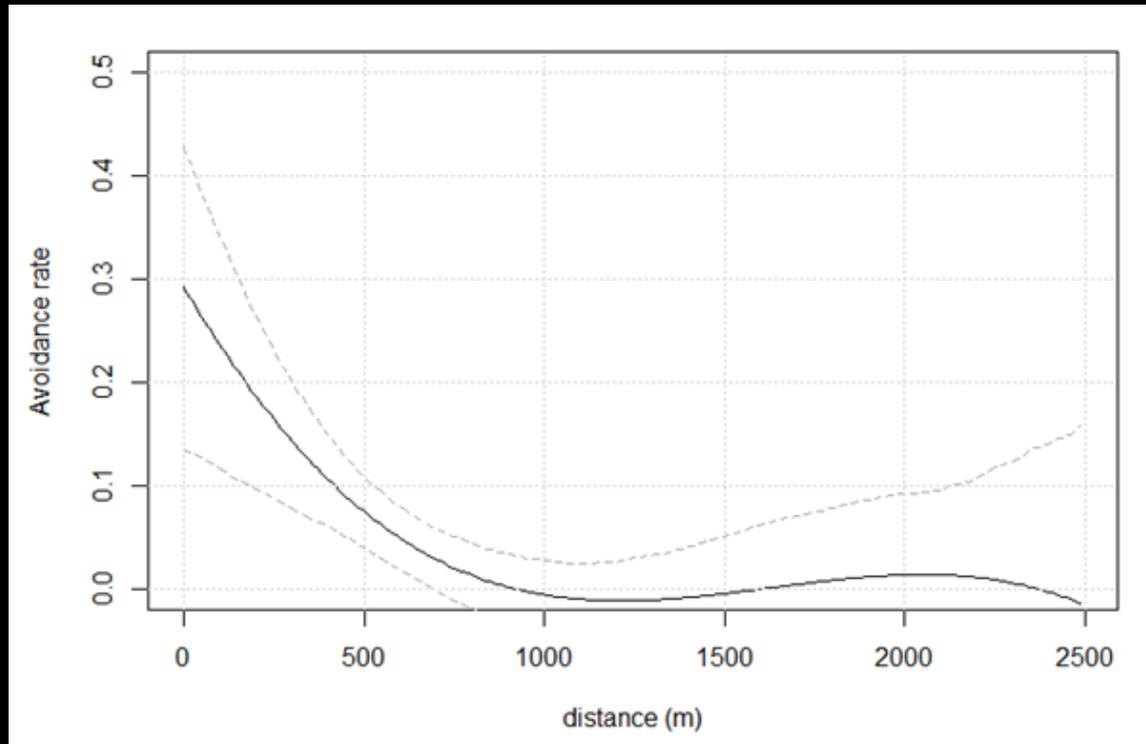
## Playback Period 1



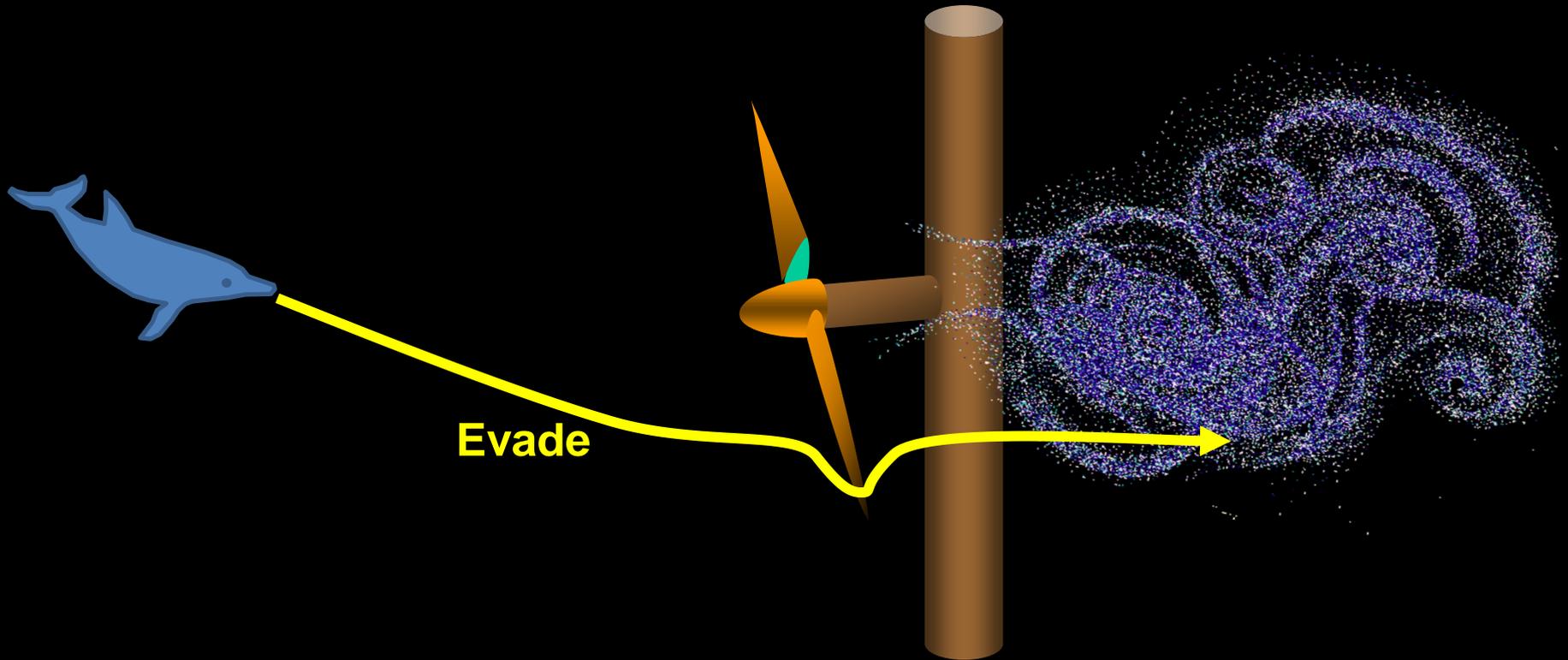
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Avoidance.....

RESPONSE study – Harbour seals in Kyle Rhea, Gordon Hastie et al.



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Close range behaviour.....

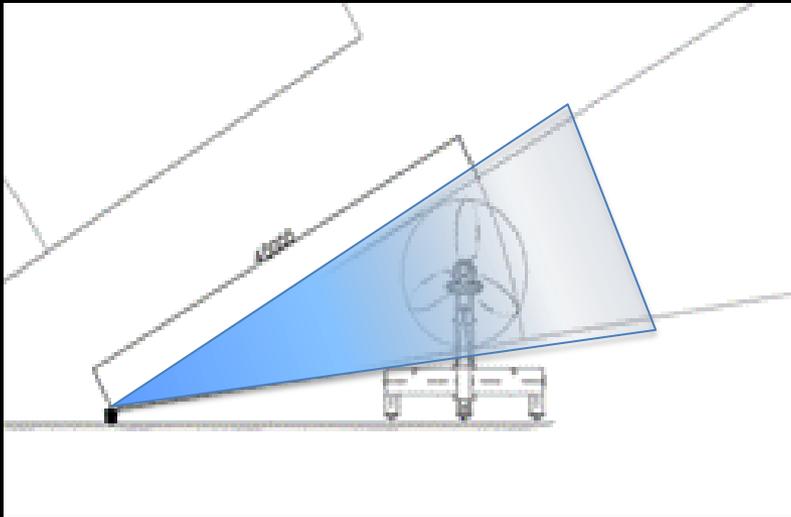
TEL DeltaStream monitoring: Passive Acoustic Monitoring Array



1. Which species are at risk (and how many)?
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Close range behaviour.....

TEL DeltaStream monitoring: Active Acoustic Monitoring, multibeam sonar



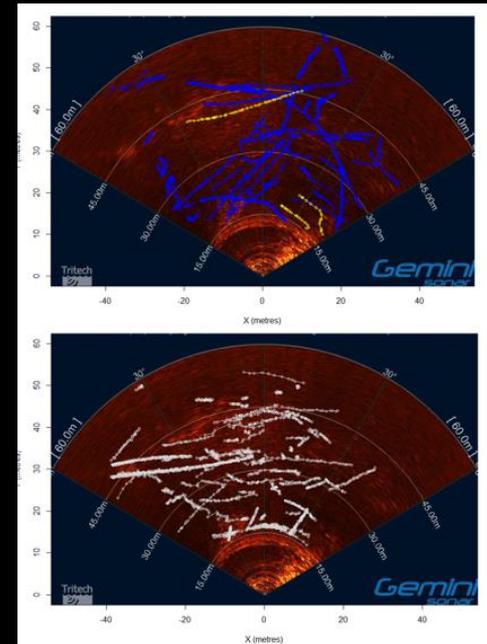
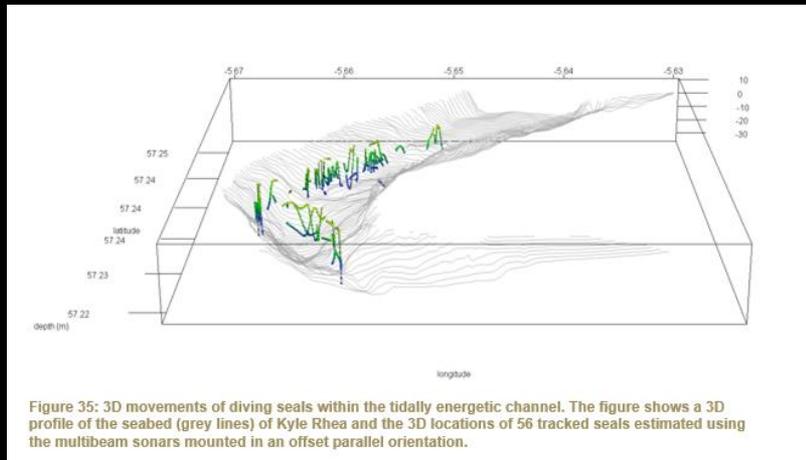
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Close range behaviour.....

Scottish Government Demonstration Strategy: Phase 1:  
Developing and testing methodologies for tracking marine mammals around tidal energy devices

3D tracking using multibeam sonar:

Improved sonar detection and classification algorithms:

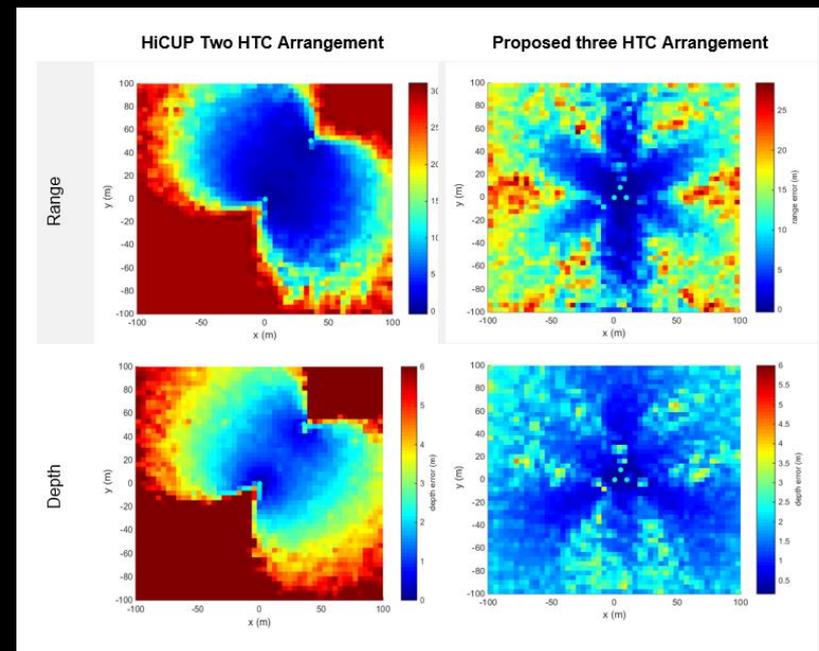


1. Which species are at risk (and how many)?
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Close range behaviour.....

Scottish Government Demonstration Strategy:

Passive Acoustic Monitoring  
Arrays – 3D tracking of  
porpoises (and animals tagged  
with ‘pinger’ tags) around  
devices



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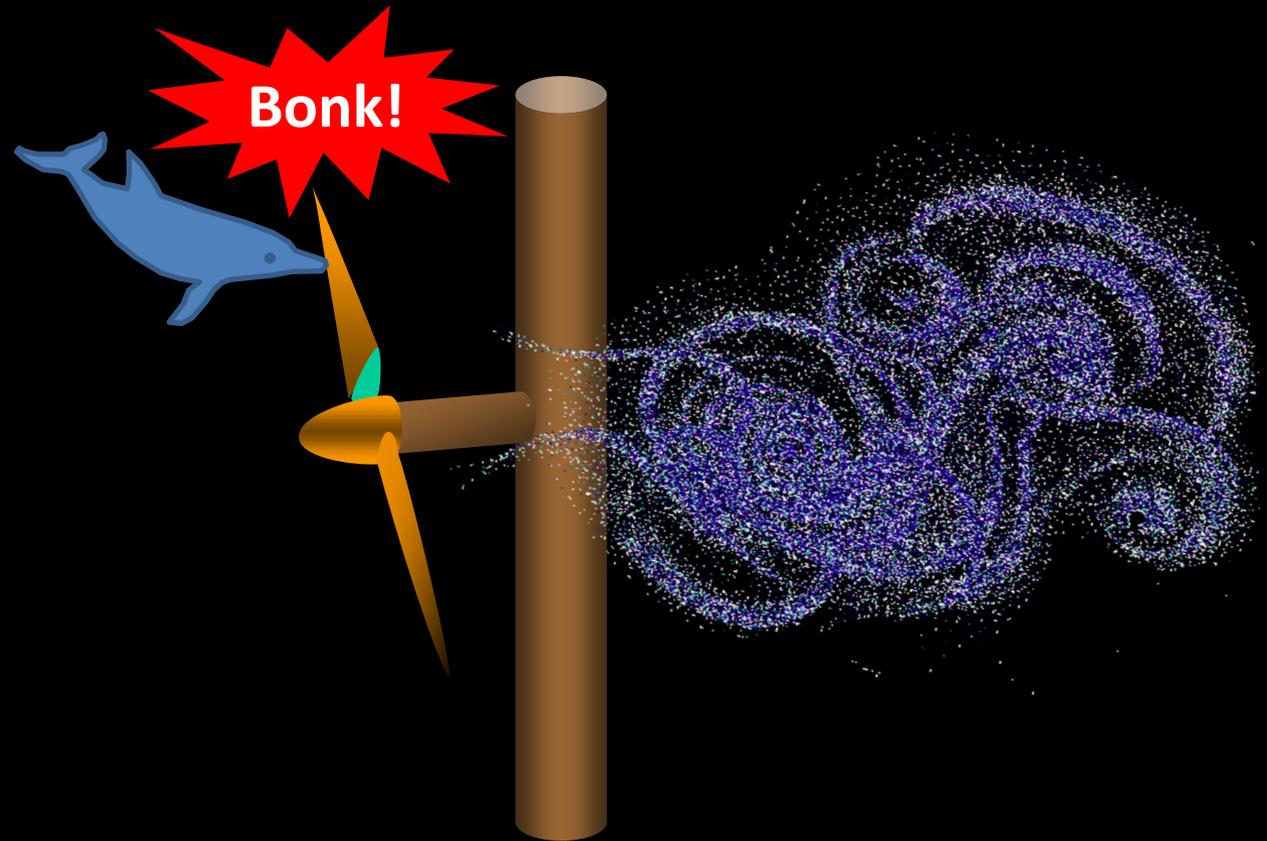
Close range behaviour.....

Scottish Government Demonstration Strategy: Phase 2

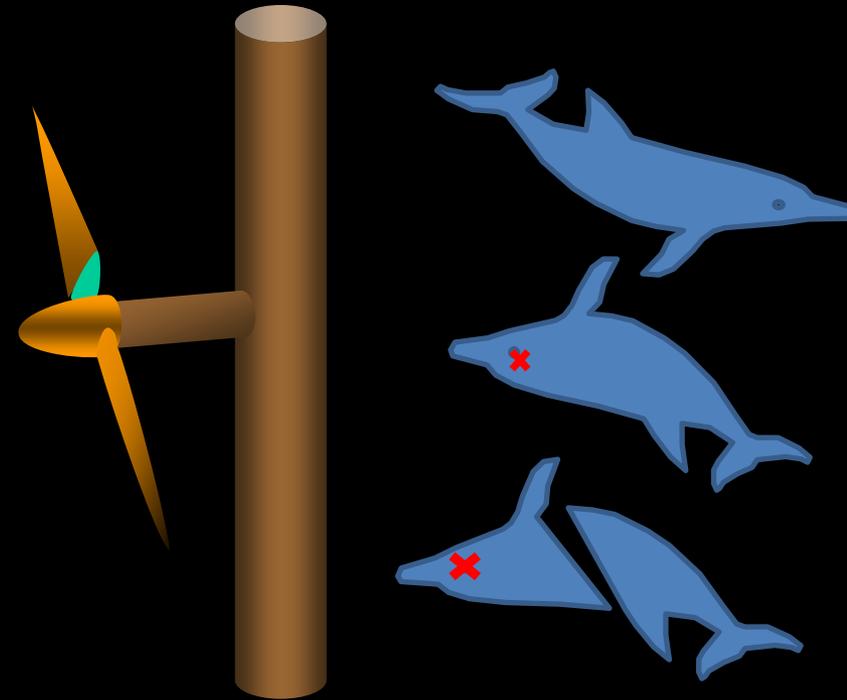
Deployment at MeyGen's Inner Sound project alongside the FLOWBEC platform:



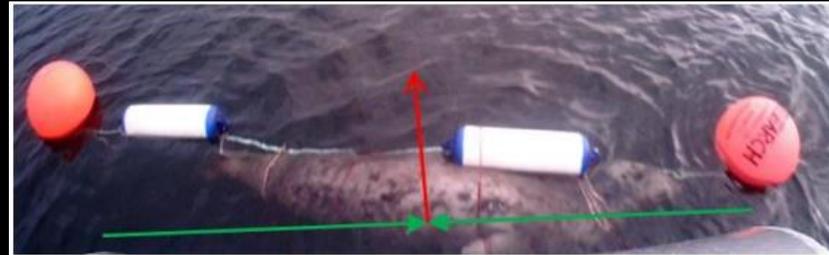
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## 4. What are the consequences of a collision?



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**Figure 5.** View from bow mounted camera indicating direction of movement and line of impact during an abdomen impact trial. The green arrows indicate the centre point of the boat given the position of the nose piece and the red arrow indicates direction of movement. The point at which the green arrows converge indicates the point of impact on the animal.



**Figure 8.** Radiographic images of the head, torso and pelvis of juvenile 1.

No evidence of skeletal or muscle , organ or skin trauma at collisions up to  $5.3\text{ms}^{-1}$

# Predicting stranding sites based on hydrodynamic drift models

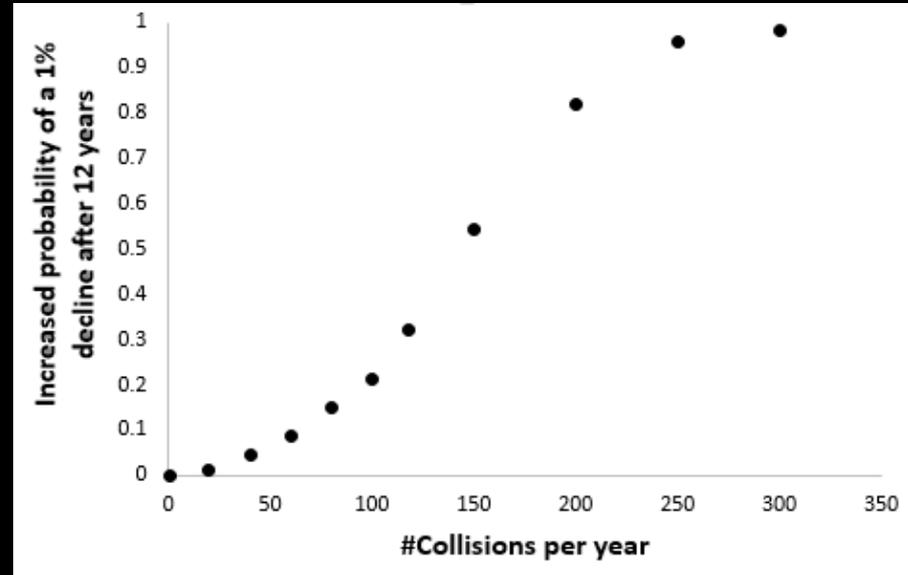
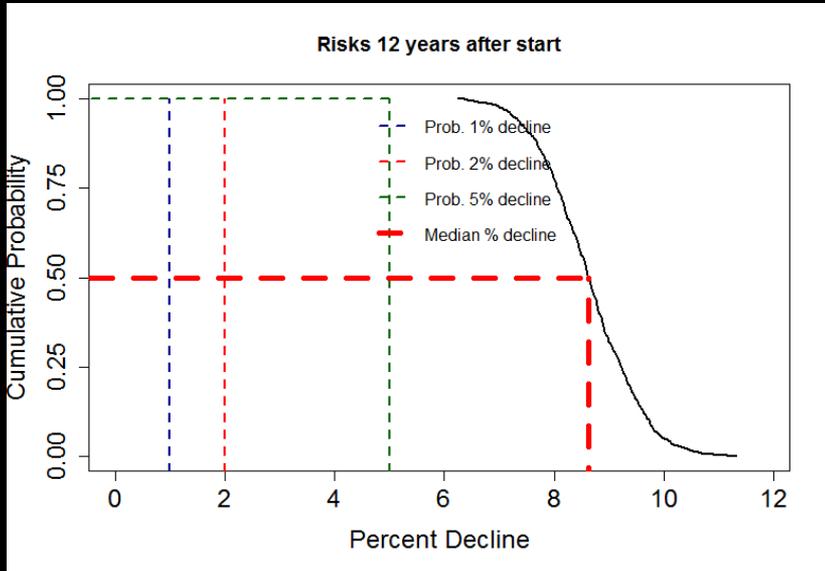
Michael Bedington, Andrew Dale, Ben Wilson

High res. models of currents, wind and waves.  
Lagrangian particle scheme + carcass properties  
(buoyancy/decomposition, size etc)



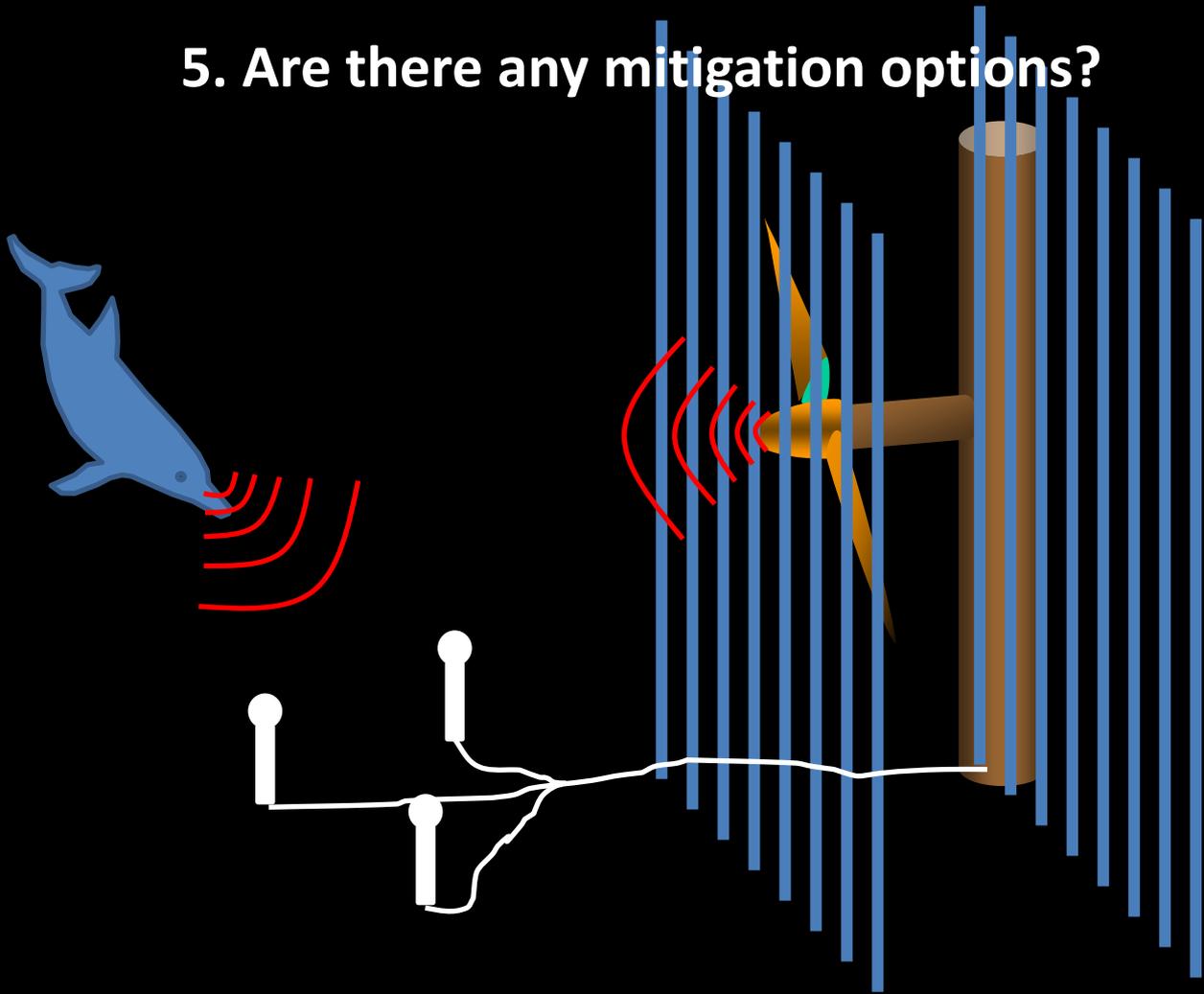
 Start location

# 4. What are the consequences of collisions?



How much is too much?

## 5. Are there any mitigation options?



Avoid bad places !  
Physical barriers **X**

Reduce tip-speed ?  
Detection and stop ?  
Acoustic warning

# Gaps and Future Directions

- Large variations between sites and species in degree and nature of risk – one size won't fit all
- Will we have the statistical power to confidently rule out collisions for scale-up from monitoring at only a few sites?
- Need to know more about consequences of collisions – for individuals (and populations)
- Mitigation solutions - if they are required they will take time to develop and test