Static Passive Acoustic Monitoring: Pitfalls and Possibilities

PAM: Pitfalls and Possibilities

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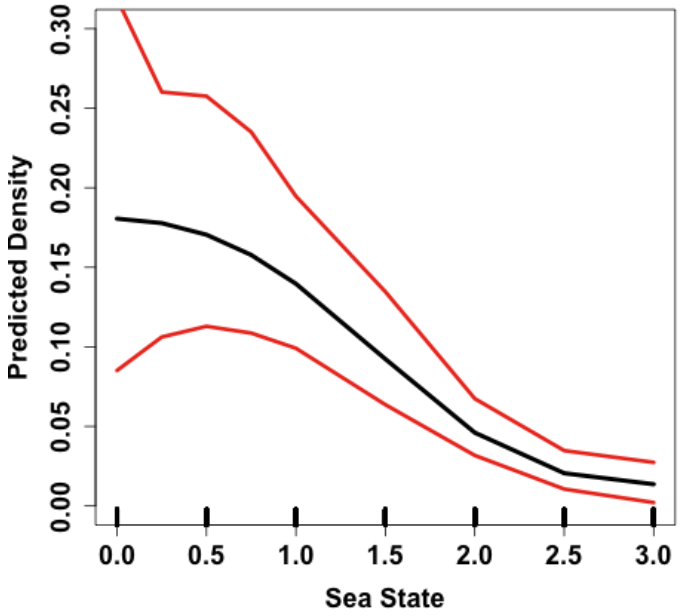
What is Passive Acoustic Monitoring?

* ‘Without active effort’
  * Not using active acoustics
    * ‘listening’
      * Now an area of study aided by quickly developing technology

* Why?
  * **Marine mammals difficult to spot visually at sea**
    * Heavily impacted by weather
    * Heaving impacted by daylight

What is **P**assive **A**coustic **M**onitoring?

* ‘Without active effort’
  * Not using active acoustics
    * ‘listening’



* Why?
  * Marine mammals difficult to spot at sea
    * Heavily impacted by weather
      * Wind
      * Fog
    * **Even more heavily impacted by daylight**
  * Fortunately many species of marine mammal produce sounds
    * Can use these sounds to monitor species

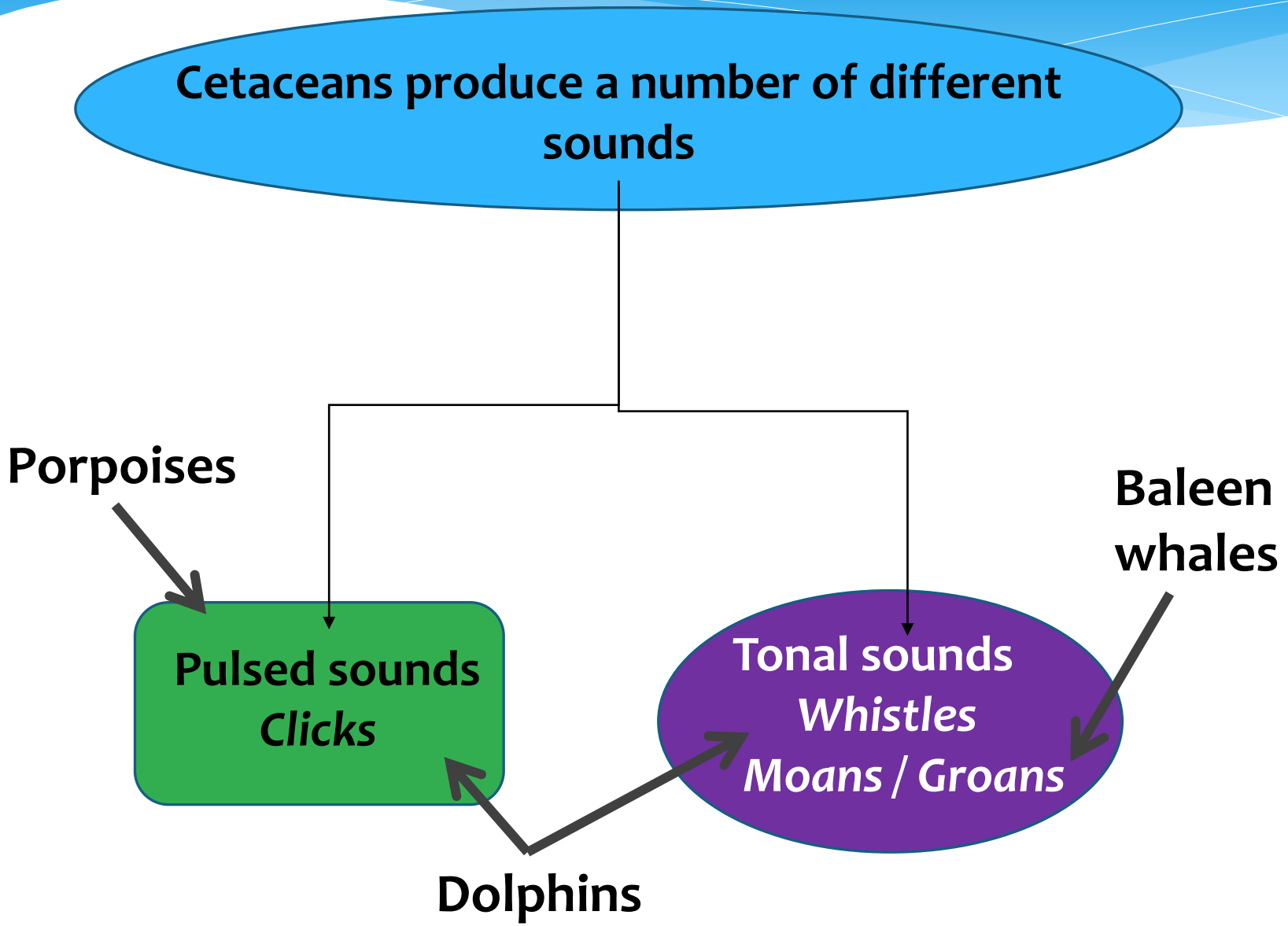
Long term monitoring

* Generate long temporal datasets
  * Deploy units for months
* Difficult to achieve using other methods
  * Requires
    * Vessels
    * Personnel
      * High cost per detection event
  * Detection rates for some species likely to be higher than visual methods
    * Particular for inconspicuous species
  * PAM delivered cost effective solution

What can PAM deliver – key considerations?

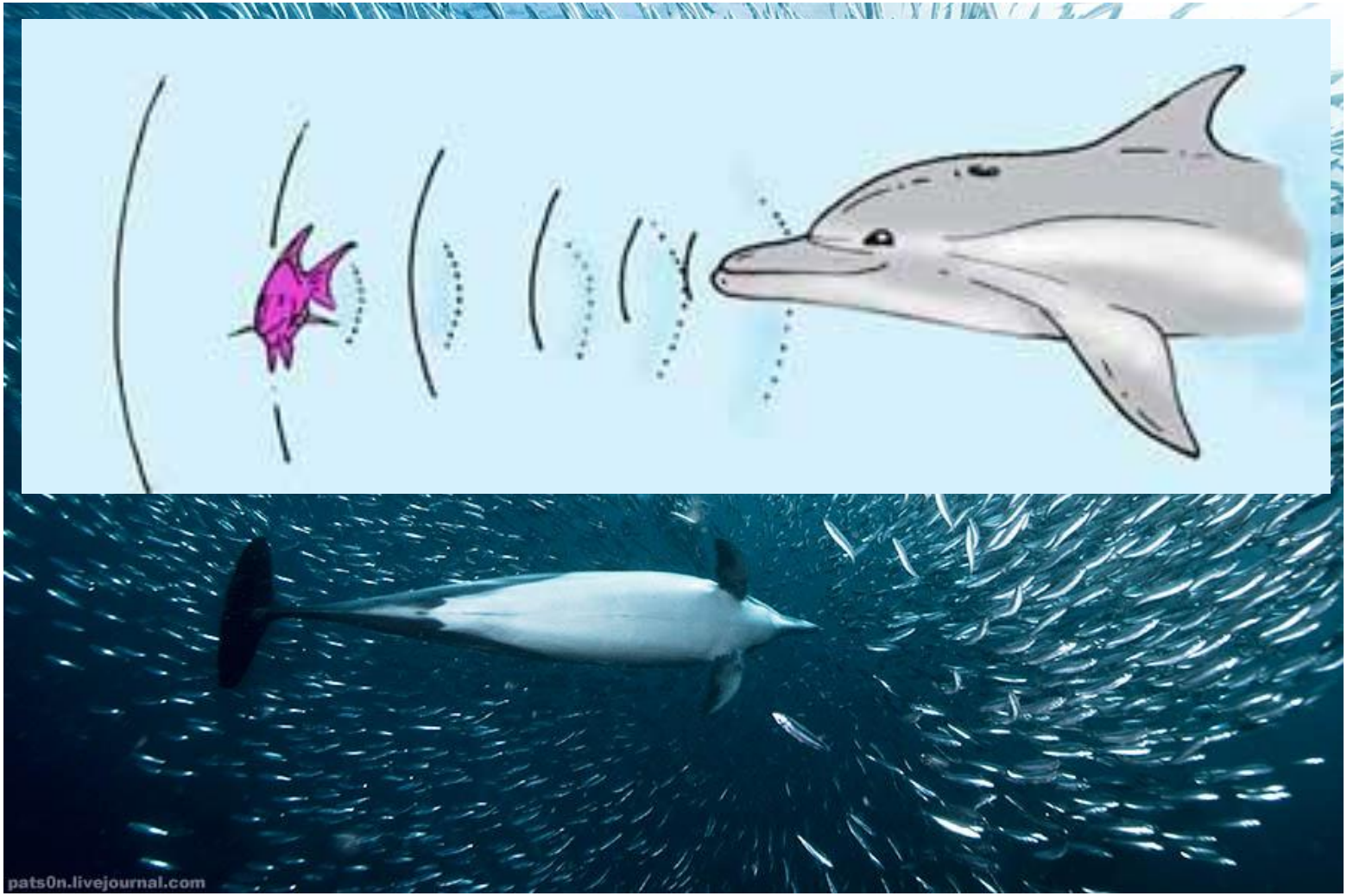
* Why do marine mammals produce sound?
  * What sounds do they produce?
  * When/where do they produce sound?
* What are the pitfalls and possibilities associated with detecting these sounds?
* What information can we infer?
  * Presence?
  * Abundance?
  * Behaviour?

PAM: Cetacean vocalisations



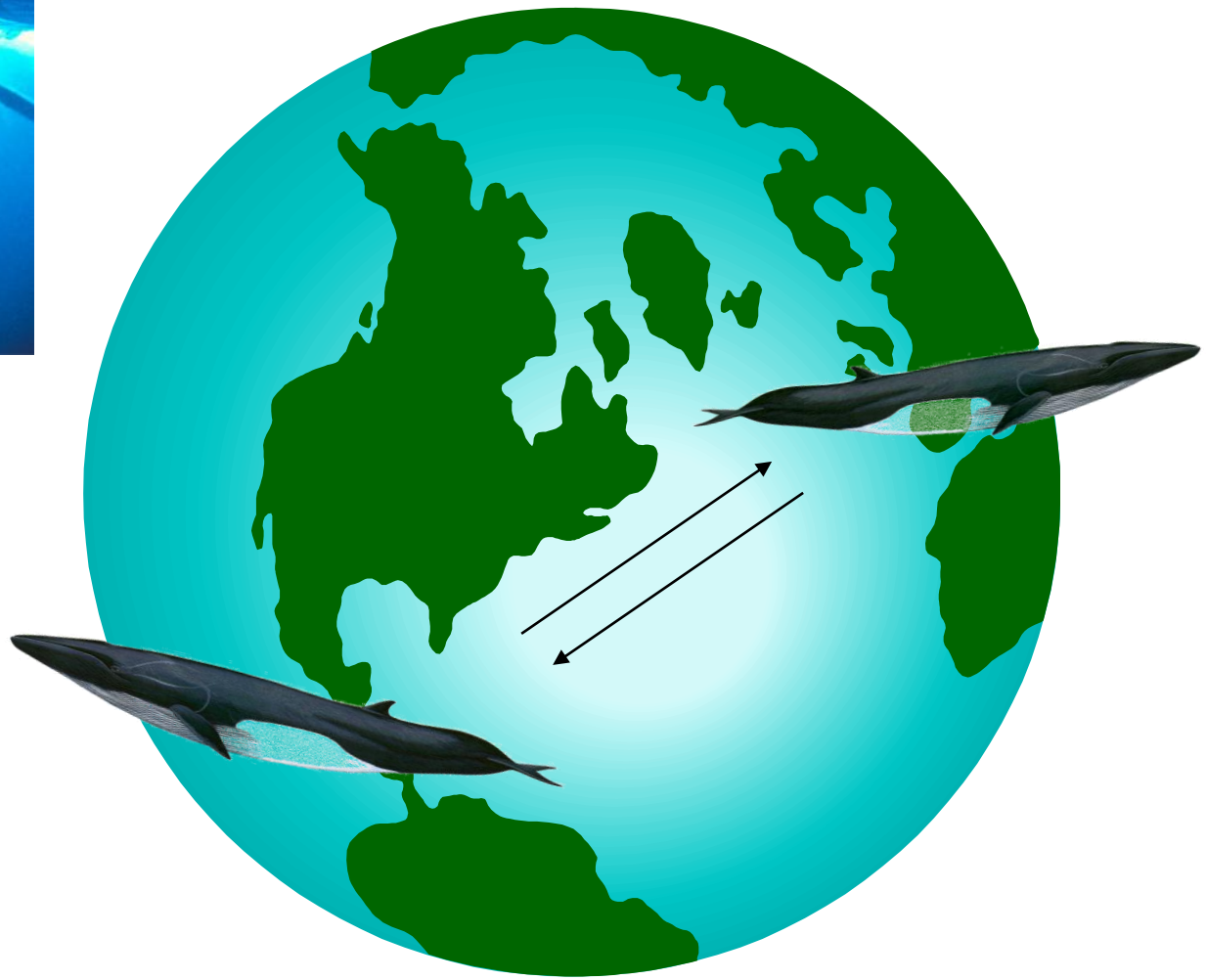
1. Prey detection

- Echolocation



2. Communication

- Mate attraction



fin whale 10x

blue whale 20x

- Social cohesion

dolphin whistles

dolphin brays

2. Communication

- Individual recognition

Sperm Whales May Have Names

By Brandon Keim | March 14, 2011 | 7:00 am | Categories: Animals

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Subtle variations in sperm-whale calls suggest that individuals announce themselves with discrete personal identifier. To put it another way, they might have names.

The findings are preliminary, based on observations of just three whales, so talk of names is still speculation. But "it's very suggestive," said biologist Luke Rendell of Scotland's University of St. Andrews. "They seem to make that coda in a way that's individually distinctive."

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* What are the pitfalls and possibilities associated with detecting these sounds?

* What information can we infer?
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  * Abundance?
  * Behaviour?

Challenges of PAM

1. Can only detect vocalising animals
2. Limited spatial coverage - detection ranges
3. Species Identification
4. Does ↑↓ calls = ↑↓ animals?
5. Monitoring in noisy environments

Detecting cetaceans using PAM

* Detection relies on:
  * **Animal producing a sound;**
    * Temporal (e.g. seasonal) changes in vocal behaviour;
    * Sex differences (e.g. mate attraction) differences in vocal behaviour;
    * Spatial differences (e.g. foraging) in behaviour;
  * Equipment must be capable of detecting the sound – sampling rate/suitable detector;
  * Sound must be 'louder'/at a different frequency than the surrounding environment
* Detection vs. classification
  * If we are interested in determining species; it's not good enough to simply detect;
    * Forming the foundation for much of the work being done now

A word about ‘detection ranges’

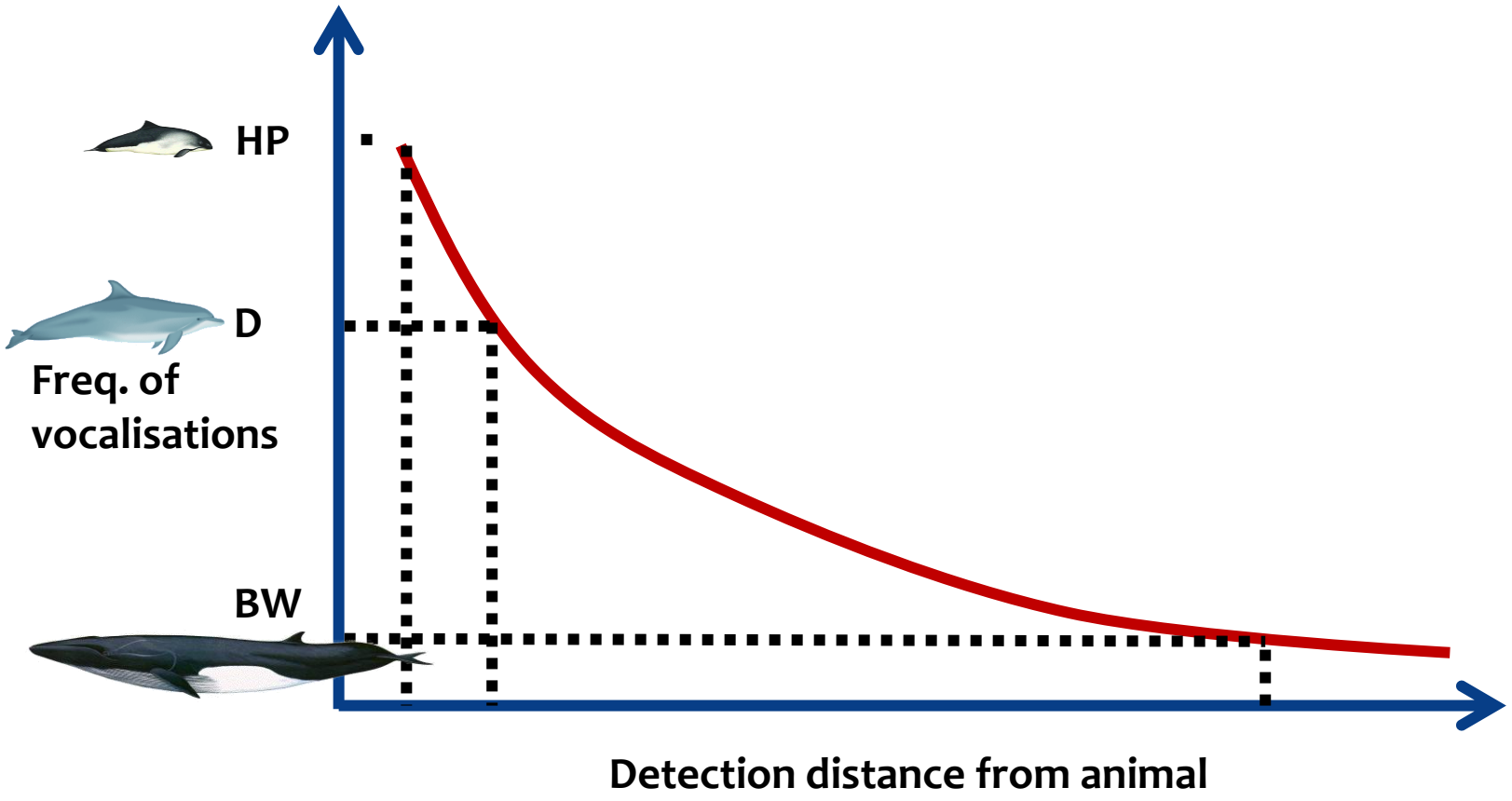
* Sound travels better in water than in air
  * Variations in temperature, sea floor geography, ocean depth and sound frequency can affect how far it travels

* **Low frequency sounds can travel LONG distances**
  * e.g. baleen whale sounds
    * 20-100 Hz – across oceans

* **High frequency sounds travel only very SHORT distances**
  * e.g. harbour porpoise clicks
    * 130-150 **k**Hz – < 1000 m

* **BUT the distances over which these sounds can be detected or classified against a real noise-background is much lower.**
  * **Dolphins = ~1000 m**
  * **Porpoise = <300 m**

A word about ‘detection ranges’



What information can we infer?

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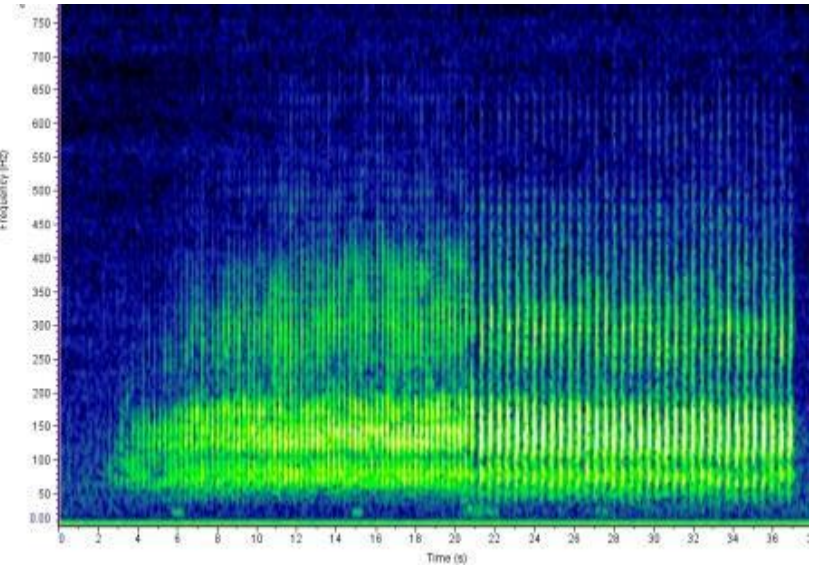
PAM in the Europe: seal species

* Seals do make vocalisations
  * Many species make very distinctive sounds
    * But those species mostly in polar regions

* But species in the UK (grey/common) produce largely seasonal (in water) vocalisations
  * Often associated with breeding
  * Quite low frequency
    * Potential for masking

* PAM is not a great tool for monitoring for seals in UK/Europe

PAM in the Europe: minke whales



* Please see:
* Seal, grey
* Seal, common

* Seasonal vocalisations
* Low frequency (candidate for masking)

* Not yet recorded around the UK, so may eliminate them as a candidate PAM species

* 1950s boing in Pacific – turned out to be a minke whale
* So there is hope…

PAM in the Europe: dolphins

* Generally difficult to distinguish between dolphin whistles or clicks using only vocalisations
  * By ear = largely impossible
  * Initial success building whistle classifiers to distinguish species
  * Focus of a lot of work to distinguish species
  * **e.g. bottlenose dolphins vs The Rest**

PAM in the Europe: harbour porpoises

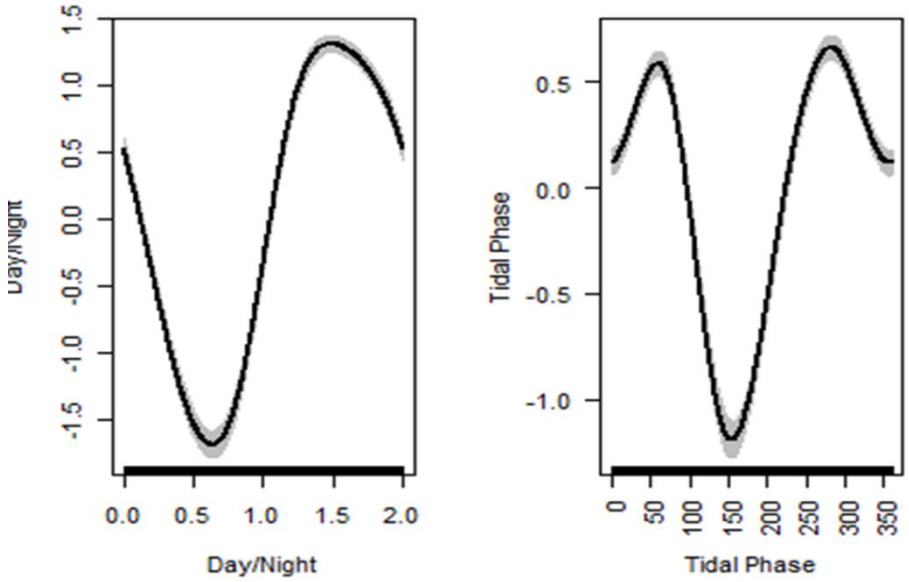
* **Thanks to high sampling rates we can now readily study porpoises using PAM**

* Great study species (for PAM – visual not so much…)
  * High vocalisation rate (near constant)
  * Very distinctive high frequency and narrow band clicks

* **Only issue is confusion with ship echosounders which are a common cause of false positive (if overlooked)**
* **Limitation is the high attenuation in their clicks – i.e. they don't travel very far = ~ 300 m max in real world conditions**

Animal presence?

* Without visual data to support PAM results
  * Usually limited to describing ‘acoustic presence’
  * Does more detections = more animals or simply more vocalisations?



* For some species you might be able to determine this manually

Animal abundance?

* Determining abundance from PAM is possible for some species
  * **But requires a good understanding of:**
    * **Vocalisation behaviour**
    * **Vocalisation rates**

OR

Animal behaviour?

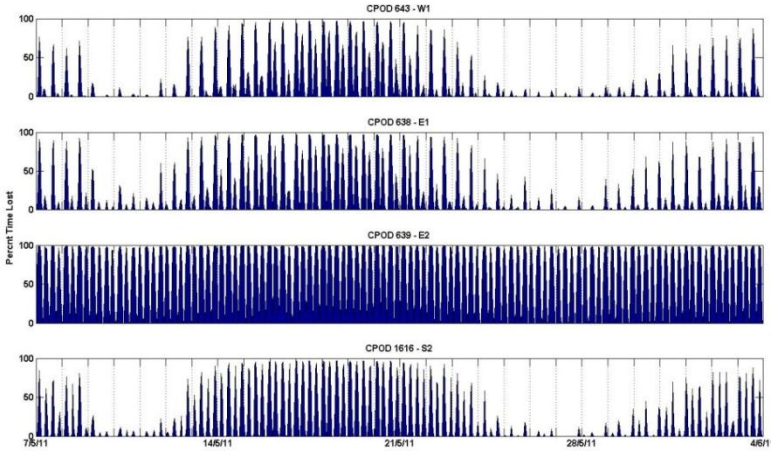
* It is possible to learn about behaviour using PAM methods
  * **However…**
    * Most difficult to determine
    * Usually needs visual data to corroborate
    * **Labour-intensive**

    * Dtags – a lot of success – hydrophone tag deployed on the head/back of the animal

Dynamic environments - challenges

* Noisy environments
  * Tidal/wave energy sites
  * Harbours, regions of high shipping?

  * Sources of noise
    * Flow noise
    * Increased suspended sediment?
    * Vessel echosounders (false det.)



- **High noise can either 'mask' the signals** you are interested in hearing
* Or they can **fill up the memory** of your PAM system meaning the unit has no room left to detect the signals you're interested in.

* **Loss of units?**

Summary: Benefits and Challenges of PAM

Benefits

1. Not limited by conditions (weather, day/night etc.)
2. Inc. detection rates for some inconspicuous species
3. Cost-effective long term monitoring (£/detection)
4. Audit trail of detections/noise events
5. Automated: no observer-fatigue

Limitations

1. Can only detect vocalising animals
2. Limited spatial coverage - detection ranges
3. Species Identification
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Thank you