First steps in monitoring cetacean response to an operational power-kite

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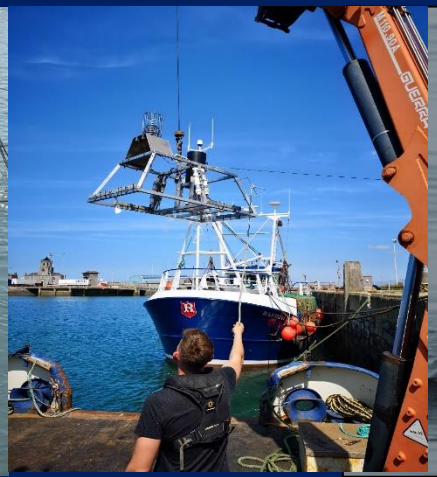
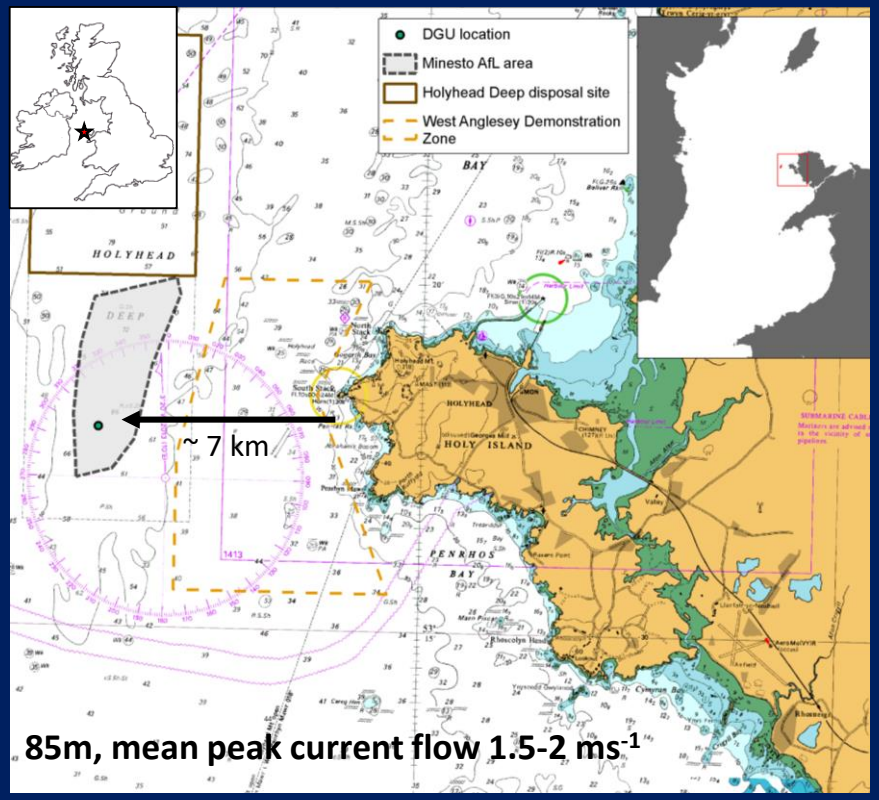


Holyhead Deep – Technology verification at a commercial scale



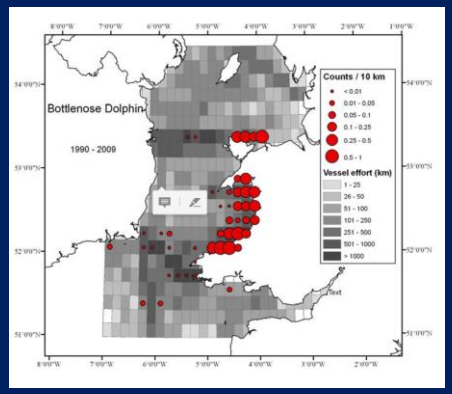
DG500 – the first utility-scale power kite

Successful offshore commissioning and test programme 2018-2019

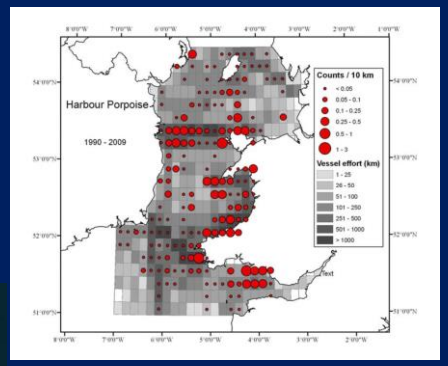
- €14.9m ERDF grant awarded May 2019 for next phase of development:
  - Installation and operation of an additional, uprated system
  - Strengthened manufacturing and assembling capability
  - Permits and consents for expansion towards a commercial 80 MW tidal energy farm

Cetaceans


G. Veneruso




P. Anderwald



Baines & Evans (2012)

Bottlenose dolphin *Tursiops truncatus:*

- Semi-resident population. Known home-range Cardigan Bay – Isle of Man
- Celtic & Irish Sea SCANS II abundance estimate 235 (CV=0.75) (Hammond et al. 2012)
- Cardigan Bay estimate 289 (CV=0.23) (Lohrengel et al. 2016)
- Connectivity between Cardigan Bay SACs and Anglesey (Veneruso & Evans 2012)
- Potential for population-level effect (Booth et al. 2015)

Harbour porpoise *Phocoena phocoena:*

- Most common species.
- Celtic & Irish Sea SCANS II abundance estimate 15,230 (CV=0.35) (Hammond et al. 2012).
- West Anglesey density 1.0 km^{-1} (Veneruso et al. in prep.)

No site- specific encounter rates in Holyhead Deep


P.G.H. Evans

Common dolphin, *Delphinus delphis*


G.Veneruso

Risso's dolphin, Grampus griseus


P.G.H. Evans

Minke whale Balaenoptera acutorostrata

Project Incentives

- DG500 Marine License condition to monitor potential collision risk between cetaceans and the DG500 during operation

- Limited knowledge of collision risk with tidal-stream technology.

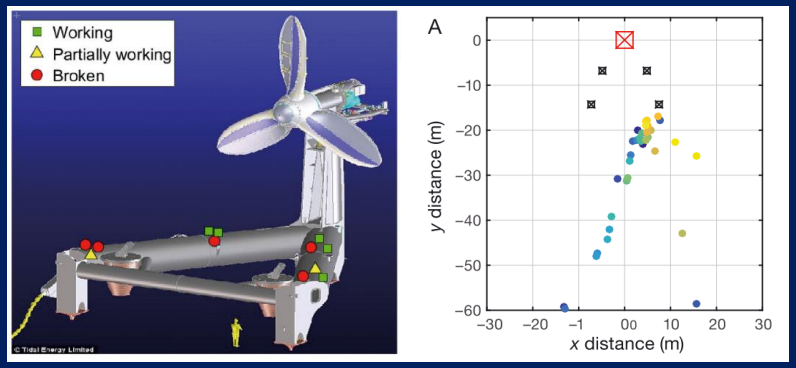
- No knowledge of cetacean underwater behaviour around tidal kites.

- No established system to monitor a tidal kite.

- No published studies of dolphin response around tidal technology.

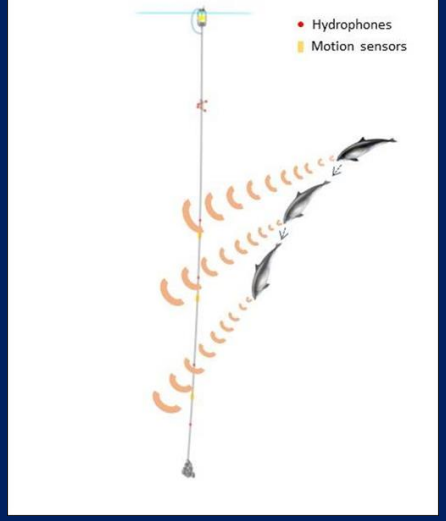
Project objectives

Acoustic tracking around turbines (Malinka *et al.* 2018, Gillespie *et al.* 2020 (in review))



Malinka *et al.* 2018

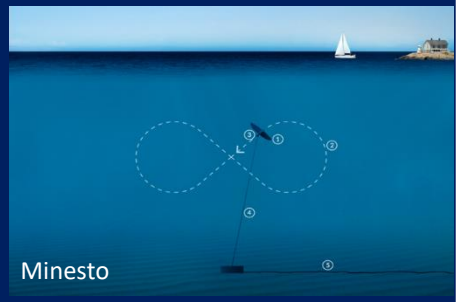
Time of arrival difference (TOAD)

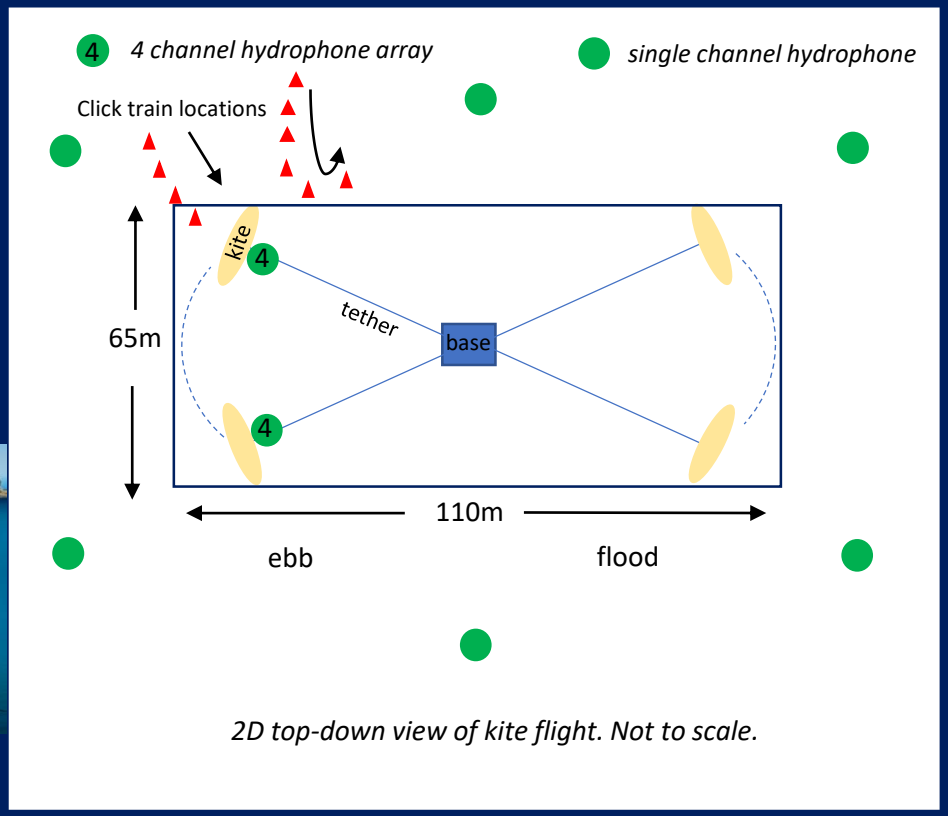


1) Develop a customised passive acoustic array that will localise cetacean vocalizations around an operating power kite.

2) Investigate dolphin and harbour porpoise movement around the operating DG500 to assess potential collision risk.

Project design





2D top-down view of kite flight. Not to scale.

Trade-offs:

Self-powered – rely on batteries
No real-time feed – Data storage limited

→

High turnover of deployments
- Small vessel, small moorings,

Instrumentation

Multi-channel array:

Sonar Point recorders SP300-8 (Desert Star Systems)

- 56-71d endurance
- Poly-lithium quad battery pack, 4TB SD storage
- Continuous sampling @ 312kHz
- GPS clock
- Produces wav files

Customisations:

- UTI-HF hydrophone external to recorder in 15cm tetrahedral array
- Harness cables connecting 4 recorders
- One recorder configured as ‘Master’- sends recording instructions to others. Provides the clock for all connected recorders

Single channel array:

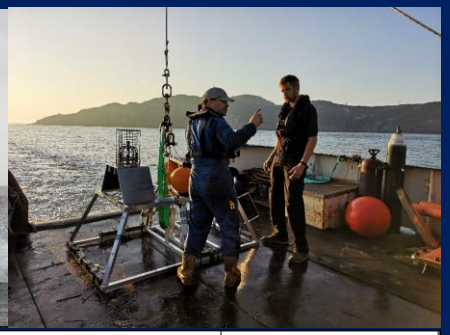
SoundTrap ST300HF (Ocean Instruments)

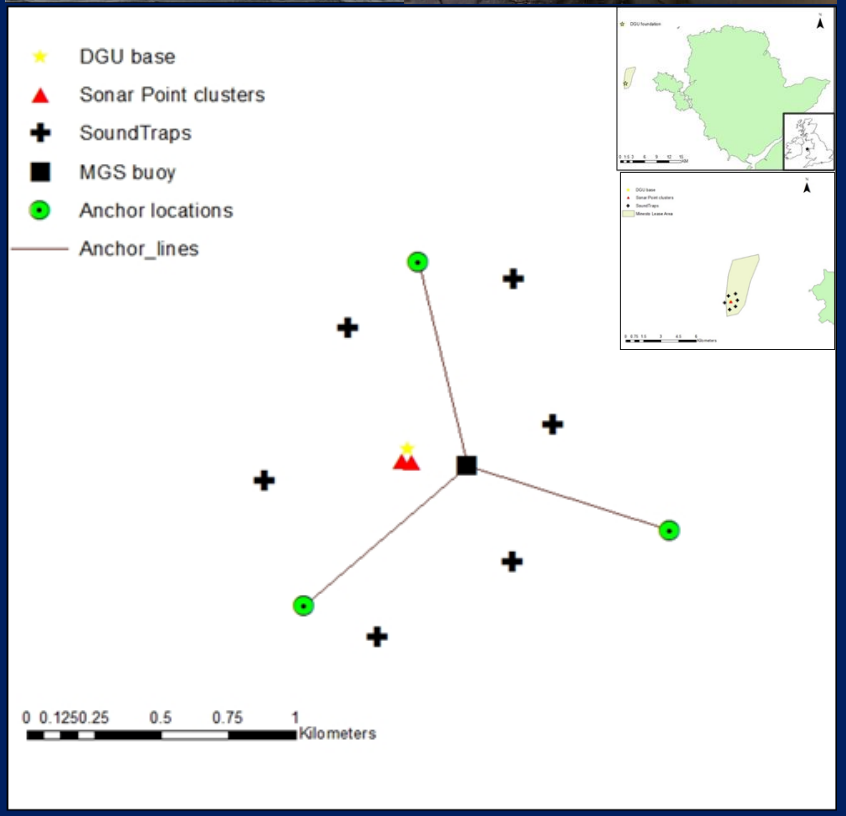
- 50% duty cycle (bar 1 device with larger storage, continuous recording) @ 96kHz & HF click detector
- External battery pack

Field plan

- Sea trial
- Deploy clusters prior to kite installation
- Monthly deployment/recoveries using local boat charter
- Spare batteries and SD cards to swap out at sea; 1-2 day turnover
- SoundTraps deployed 500-800m from DG500

- Seiont IV – 13m r sel
- Marine crane
- 25m^2 deck space
- Gravity-weighted o lower frame to se
- Single-point moo



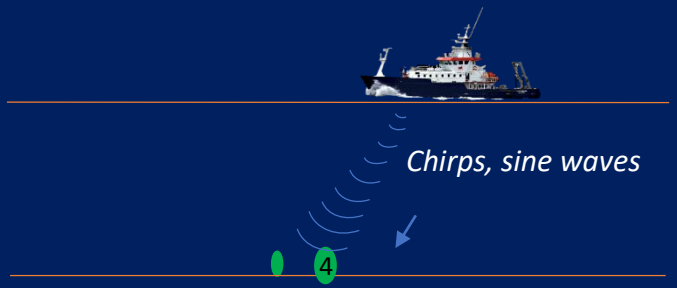


Deployment locations of PAM arrays & Minesto installations in the Holyhead Deep, Wales.

Localising array position

Knowing precise locations of each hydrophone position from the seabed is crucial for accurate localisation

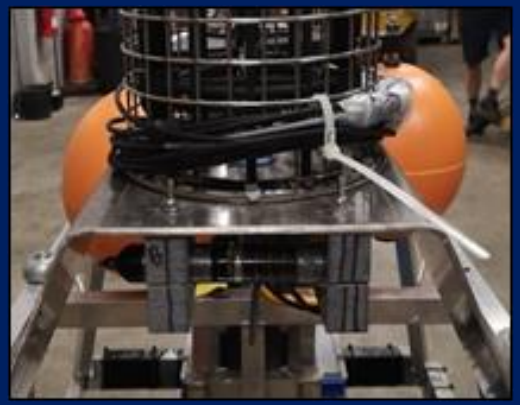
1. Pinger trials to determine location, pitch, roll and yaw & assess bearing accuracy (e.g. Wiggins et al. 2012)



2. Sea Tag (Desert Star), determine orientation and detect movement of mooring frames

Magnetometer

Accelerometer



Sea Mammal Research Unit

Preliminary results

Date	Activity
02/08/2019	Sea trial of single cluster
09/08/2019	Deployment of multi-channel array
11/08/2019	Kite installation
25/08/2019	Pinger trial
27/08/2019	SoundTrap deployments
08/09/2019	Attempted recovery of multi-channel array
21/09/2019	Recovery of multi-channel array
02/12/2019	SoundTrap recovery

Localisation of cetaceans not possible:

- Frame movement on large spring tide
- Within-cluster sync issues
- Water ingress in some cluster 2 recorders (connector corrosion).

Data- lots of it!

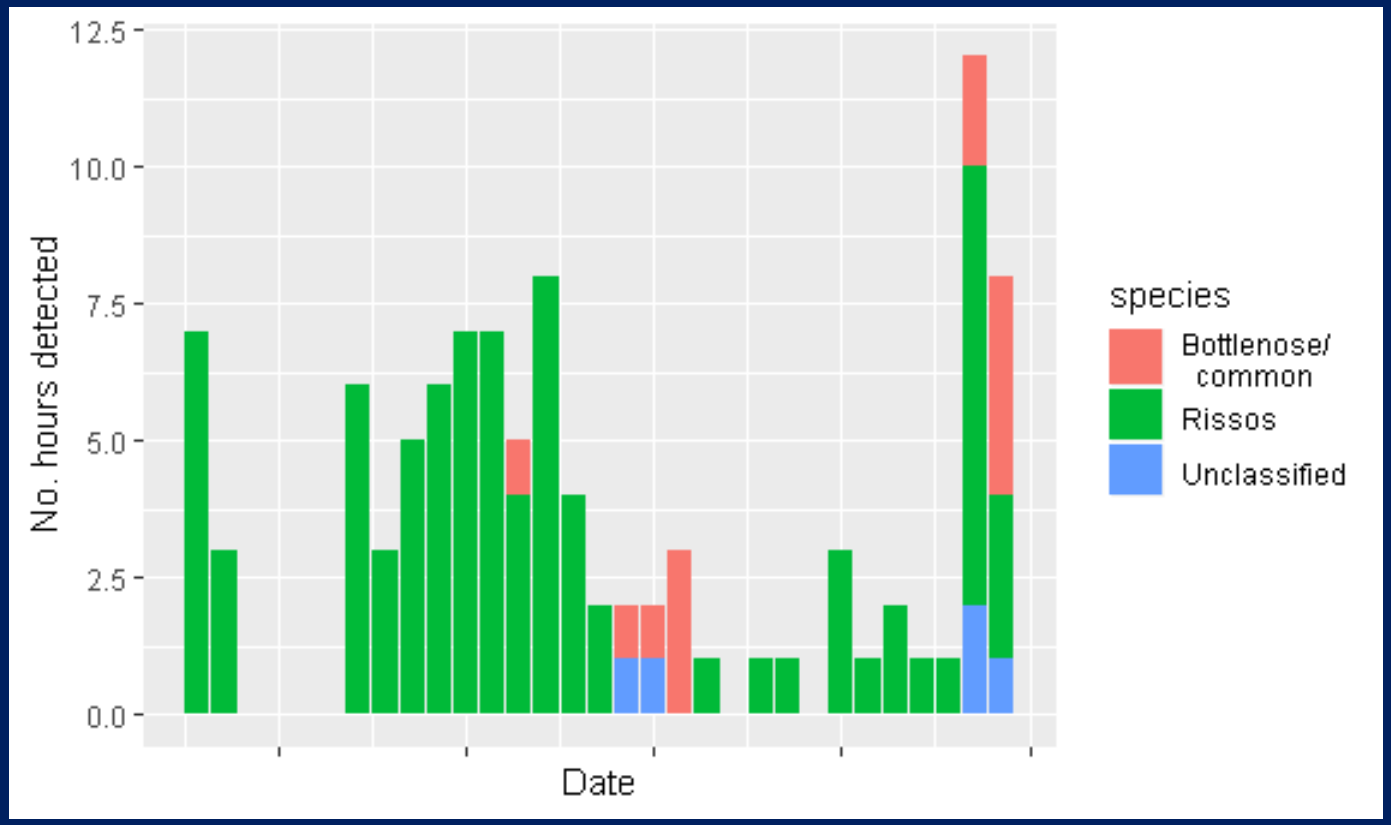
- 31 days (200d total) of data – 11 TB

(not including SoundTraps- to be analysed).

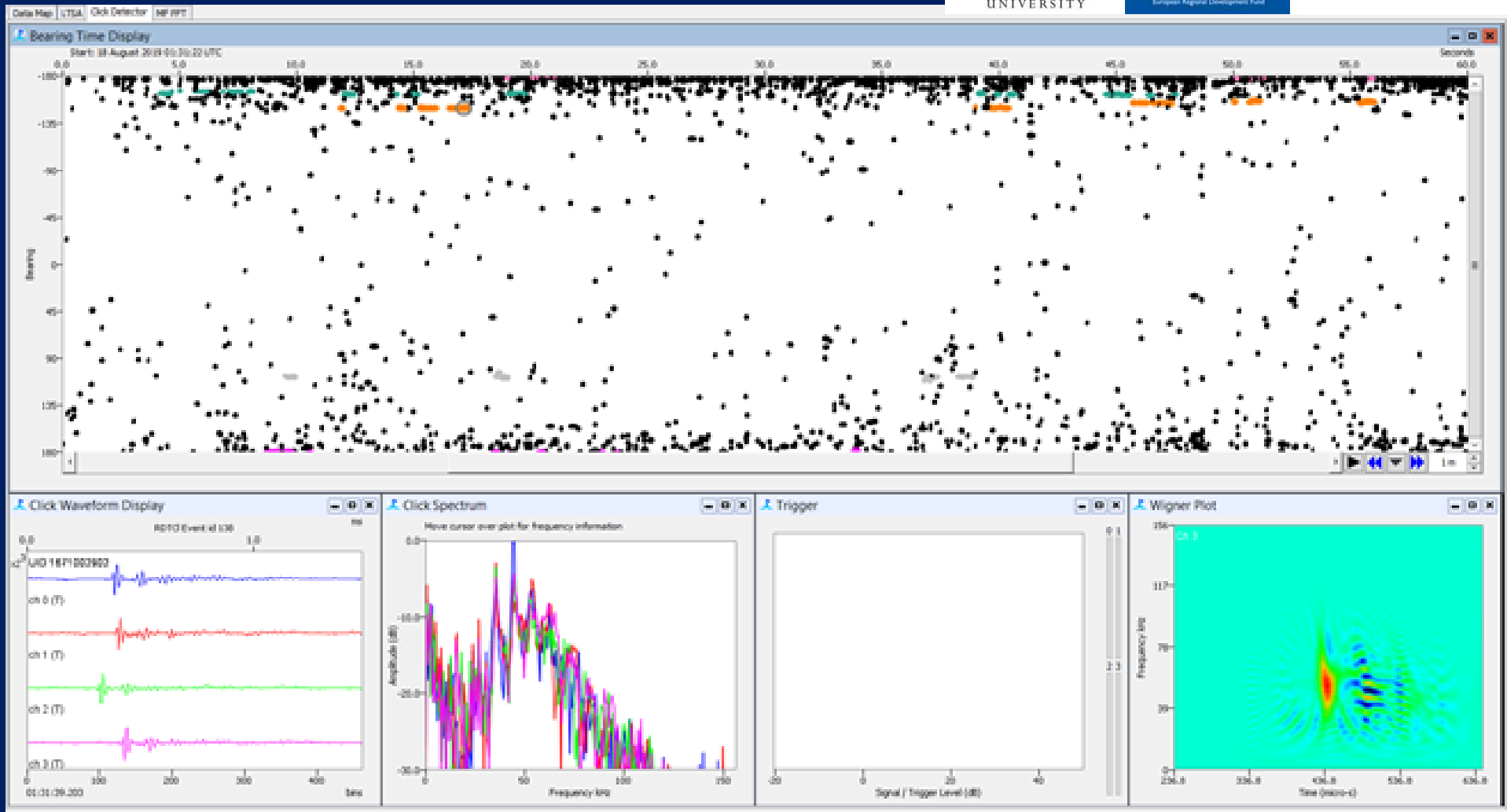
- IT support.
- Partners hold one hard copy each & on cloud.
- Lots of hard drives.
- High processor PC dedicated to this data only.

Preliminary results: multi-channel array

- Raw data channels required crop & merge. Custom software built by Desert Star.
- Processing in PAMGuard (Gillespie 2008). Approx. 12X speed ~ 2 days to run each cluster.
- Data processed with click detector, whistle & moan detector and long-term spectral average.
- Processed data ~ 100 GB for one cluster.

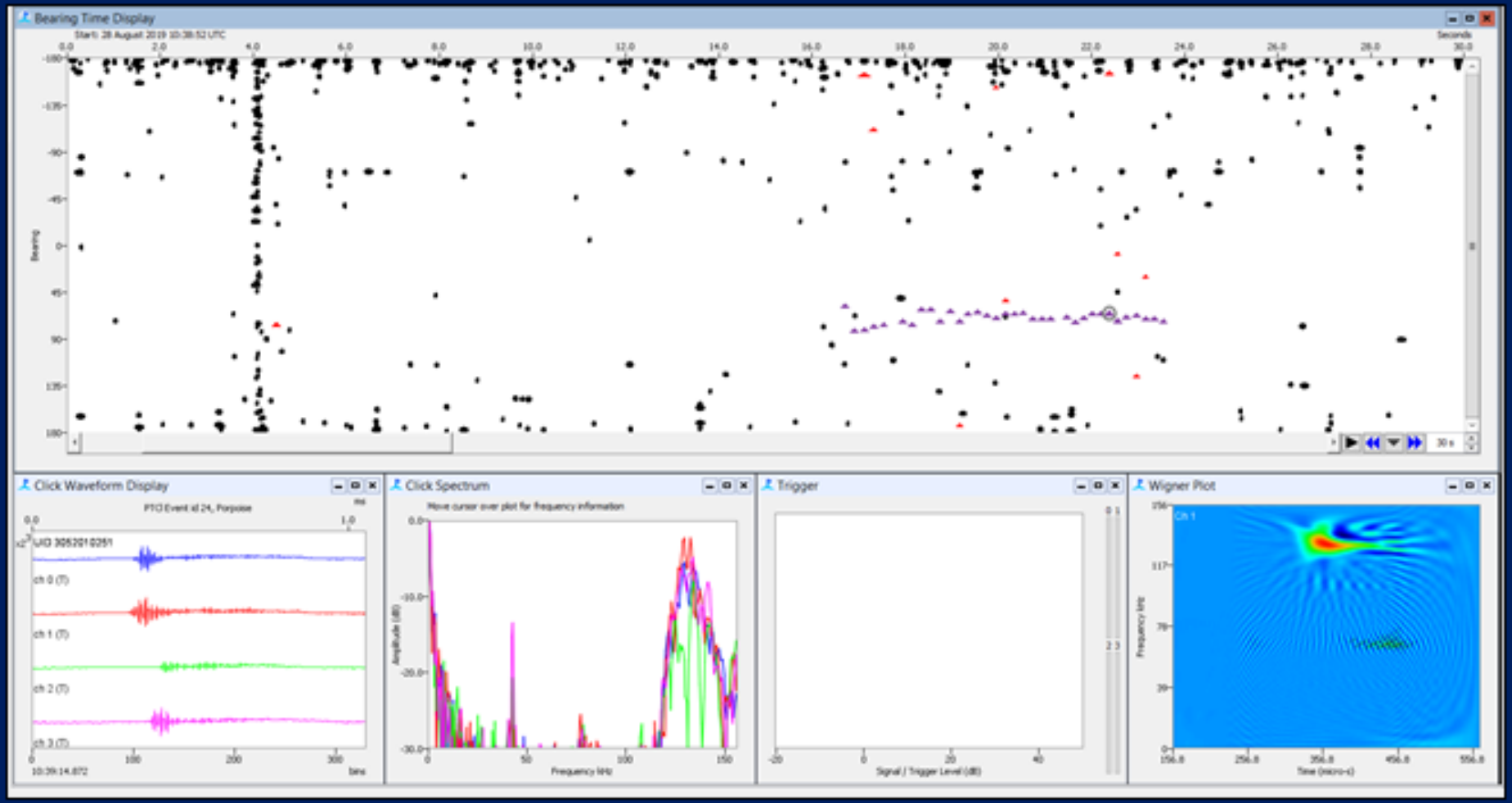


Preliminary results



PAMGuard software showing five Risso's dolphin click trains marked manually in the top bearing-time display each in different colours. The click waveform display shows a click waveform detected on all four channels. The click spectrum and Wigner plot aids species classification.

Preliminary results



PAMGuard software showing a single harbour porpoise click train marked manually in the top bearing-time display shown by purple triangles. The click waveform display shows a click waveform detected on all four channels. The click spectrum and Wigner plot aids species classification.

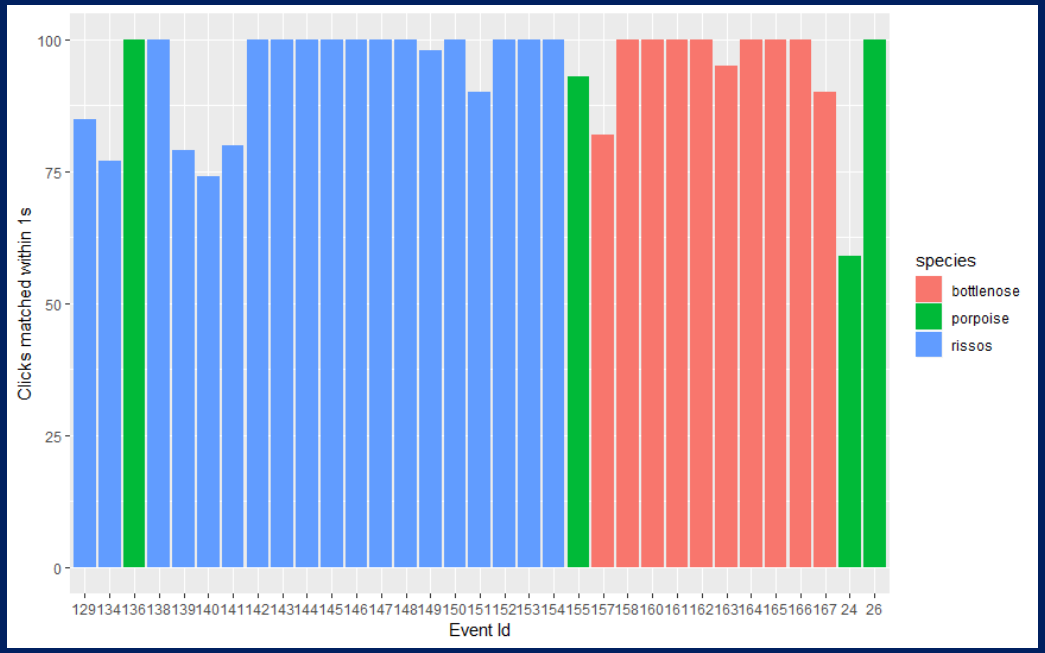
Preliminary results

Click matches between clusters:

- Lots of click matches and minimal clock drift between clusters is critical for successful localisation.

Recapture rates of a random sample of click trains marked on cluster 1 vs. cluster 2

Species	Mean click match within 1s (%)
Risso's dolphin	93.8
Bottlenose/common dolphin	96.7
Harbour porpoise	88.0
All species	94.0



Potential for localisation when all channels functioning is high

Conclusions and next steps

- A compact passive acoustic monitoring (PAM) system and methodology developed to monitor cetaceans around a utility-scale tidal kite.
- Teething problems, but assessment suggests the system fit for purpose.
- Multi-channel system has been updated and will be redeployed summer 2020 with mooring modifications.
- Moderate dolphin encounter rates (porpoises detected, encounter rates TBC); opportunity to study dolphin response and potential collision risk.

Acknowledgements

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