Study of the environmental impacts of no
vibrations and electromagnetic emission
marine renewables - RTD-K3-2012-MRE

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SCOTTISH ASSOCIATION for MARINE SCIENCE

museum

UPC

Cranfield UNIVERSITY

FOI

DEWI

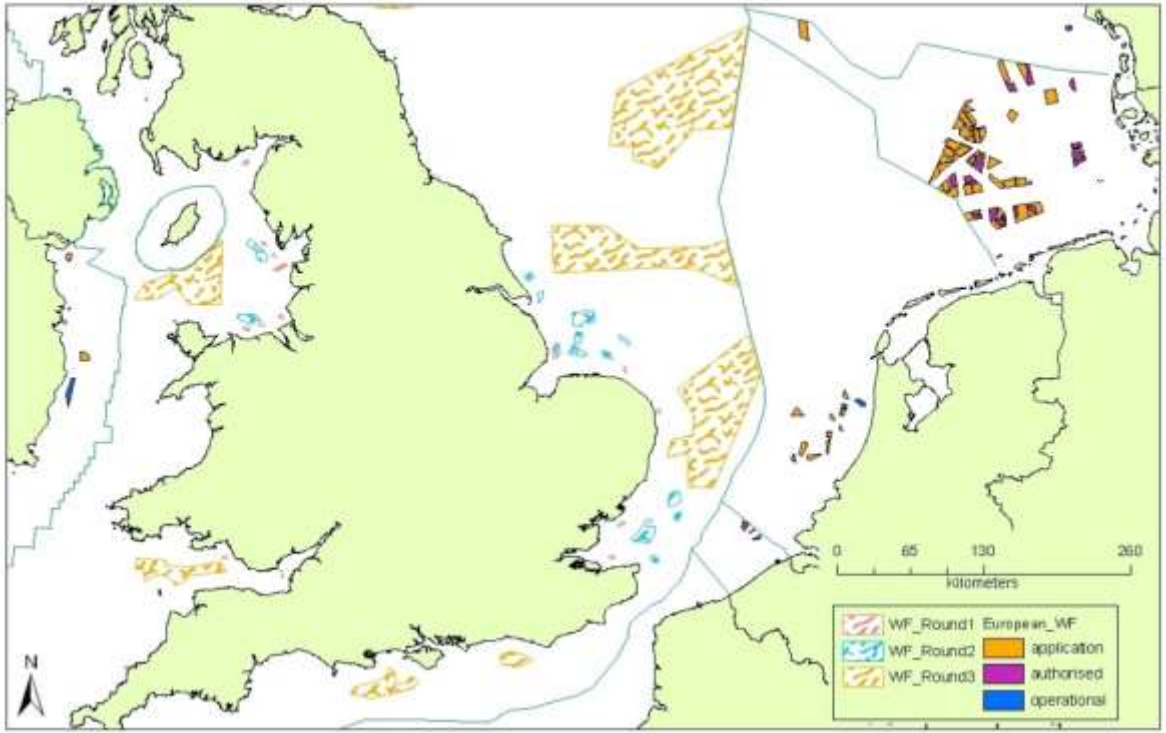
Quiet oceans
Technology for Sustainable Oceans

Cefas

DHI

Marine renewables in Europe

Wind farm locations around the UK and neighbouring areas.

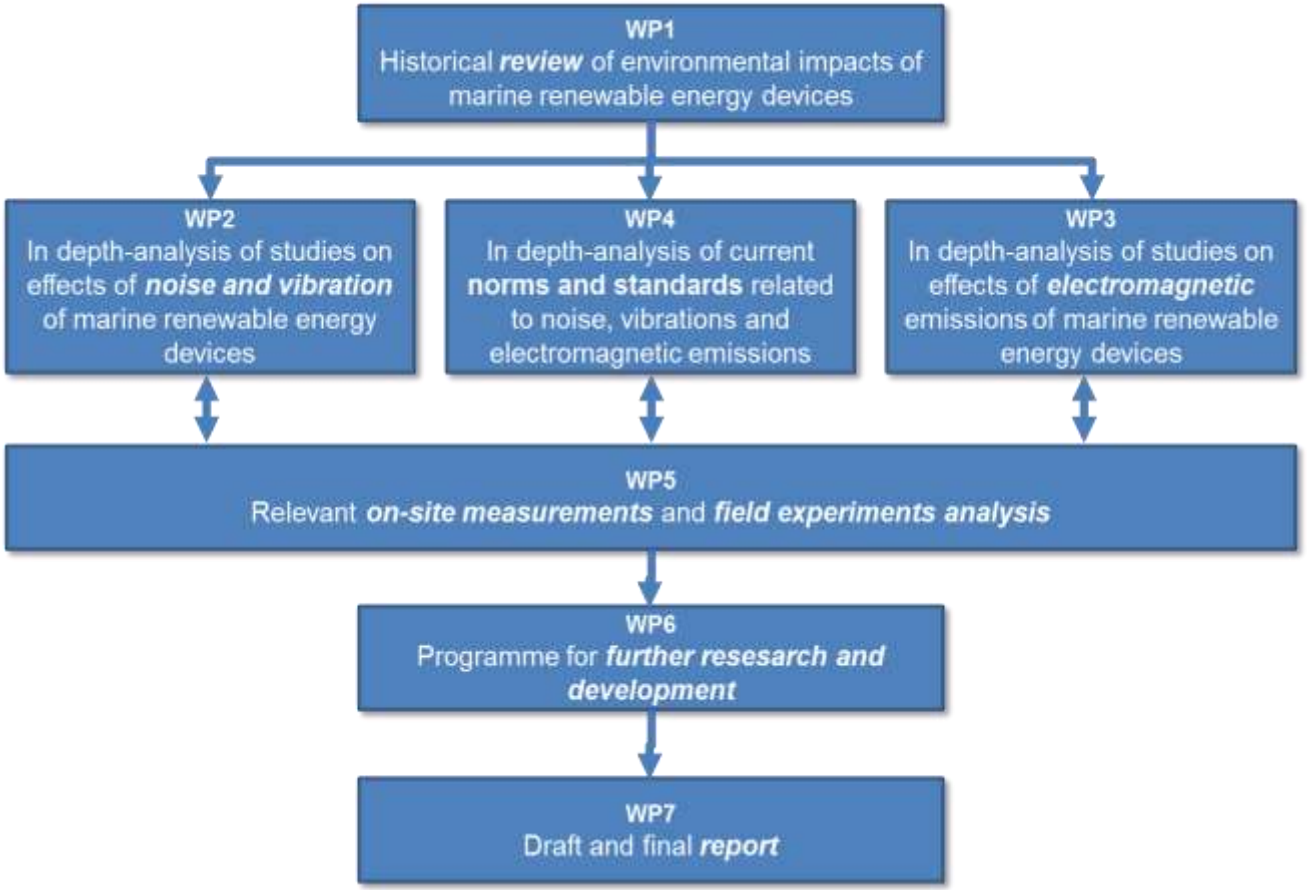


MaRVEN Main objectives (2014-2015)

Marine Renewables Vibrations, Electromagnetic emissions and Noise

- Study of the environmental impacts of noise, vibrations and electromagnetic emissions from marine renewables (i.e. wind, wave and tidal energy systems).
- Critically review the available scientific evidences and significance of those impacts
- Perform field measurements to fill gaps in knowledge
- Make recommendations on solutions to mitigate or cancel any identified negative impacts.

Work packages

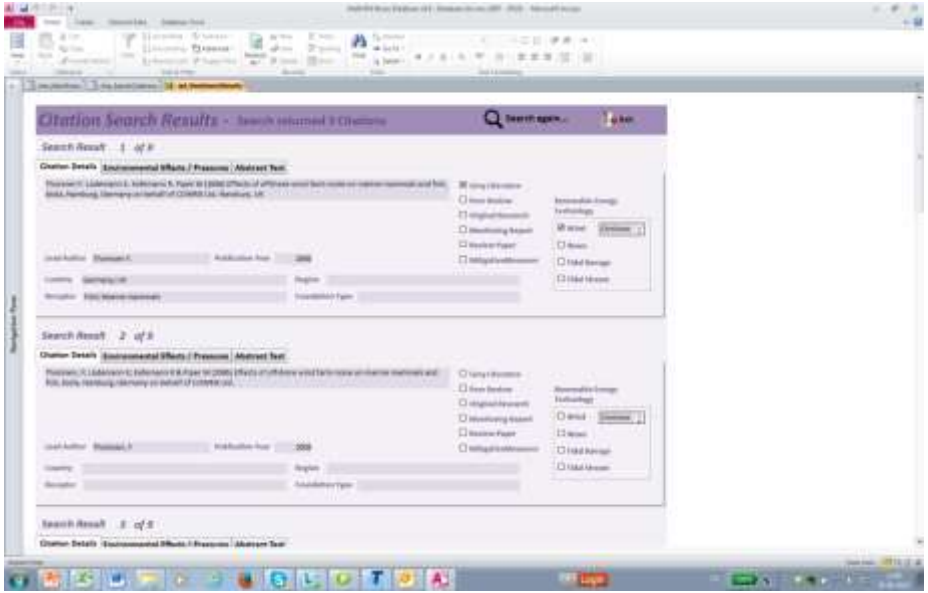


WP1 Historical review of the publications related to environmental impacts of marine renewable energy devices (Lead: Cefas)

1. Database for the literature on MRED impacts on marine life

Main search criteria:

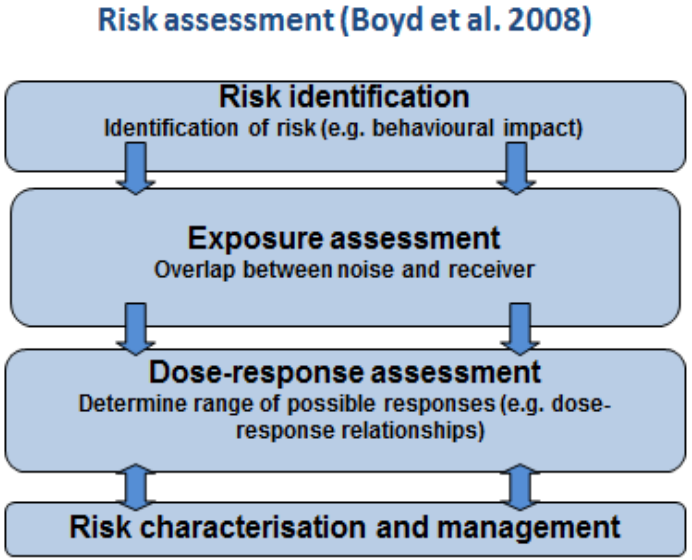
- key words
- author
- environmental effect/pressure
- receptor
- country



2. Summary of the available literature on environmental effects of MRED

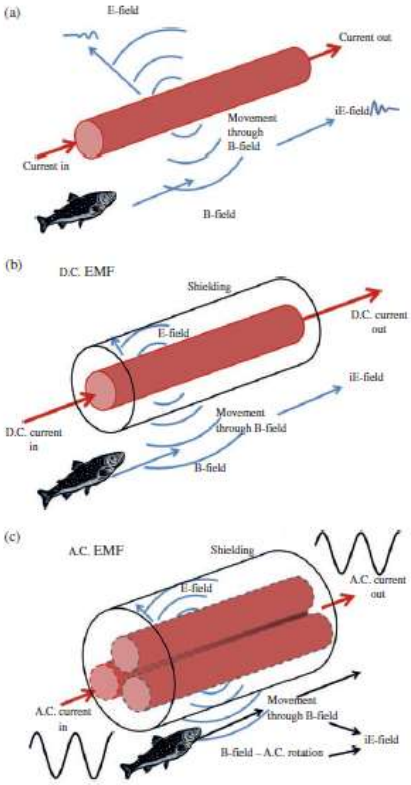
Will be available on SETIS web site https://setis.ec.europa.eu/

- Review of findings on noise impacts on marine life
- Identifying knowledge gaps
- Input to WP5 field work
- Vibration paper prepared by Institute for Sound and Vibration Research, University of Southampton, UK



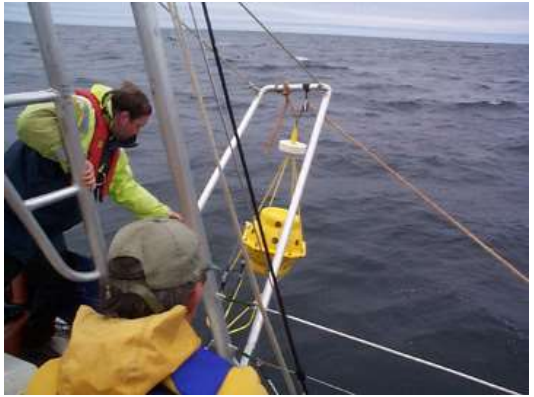
- Exposure assessment – progress in sound source calculations and modelling techniques in recent years
- Dose – response assessment - behavioural response tested only in a few species; effects on other species and taxa are very sparse
- Risk management – progress with regards to risk mitigation especially for impact pile driving

- Exposure assessment – poor knowledge base of MRED EMF studies and little coverage within EIA's in Europe
- Dose – response assessment – little information on MRED EMF effects on marine receptors sensitive to EMF
- No guidelines and standards for measurement methodology EMFs



WP4 In-depth analysis of the current norms and standards related to noise, vibrations and EMF for marine renewable energy systems (Lead: DEWI)

- Standards for noise developed in Germany (BSH), the Netherlands (TNO) and the UK (NPL) – comparison shows many similarities and some differences – ISO on its way
- The standardisation process has to be continued and should lead to united standards and validated measurement methods delivering comparable results



AIM

- On-site measurements
  - Fill priority knowledge gaps
  - Build on the knowledge base from WP1-3

- Priorities
  - **Particle motion** during operation at an offshore wind farm & wave device site
  - **EMF** during operation at an offshore wind farm and a tidal turbine site
  - **Particle motion** during construction, in particular pile driving

WP - 5 Field sites

Operation

- **Wind** – Belgian offshore wind farms (Jacket, monopile + substation) (EMF, SP, PM)

- **Tidal** – Strangford Lough, Northern Ireland
  - Isle of Wight - PLAT-O (SP)
  - Dutch tidal test centre

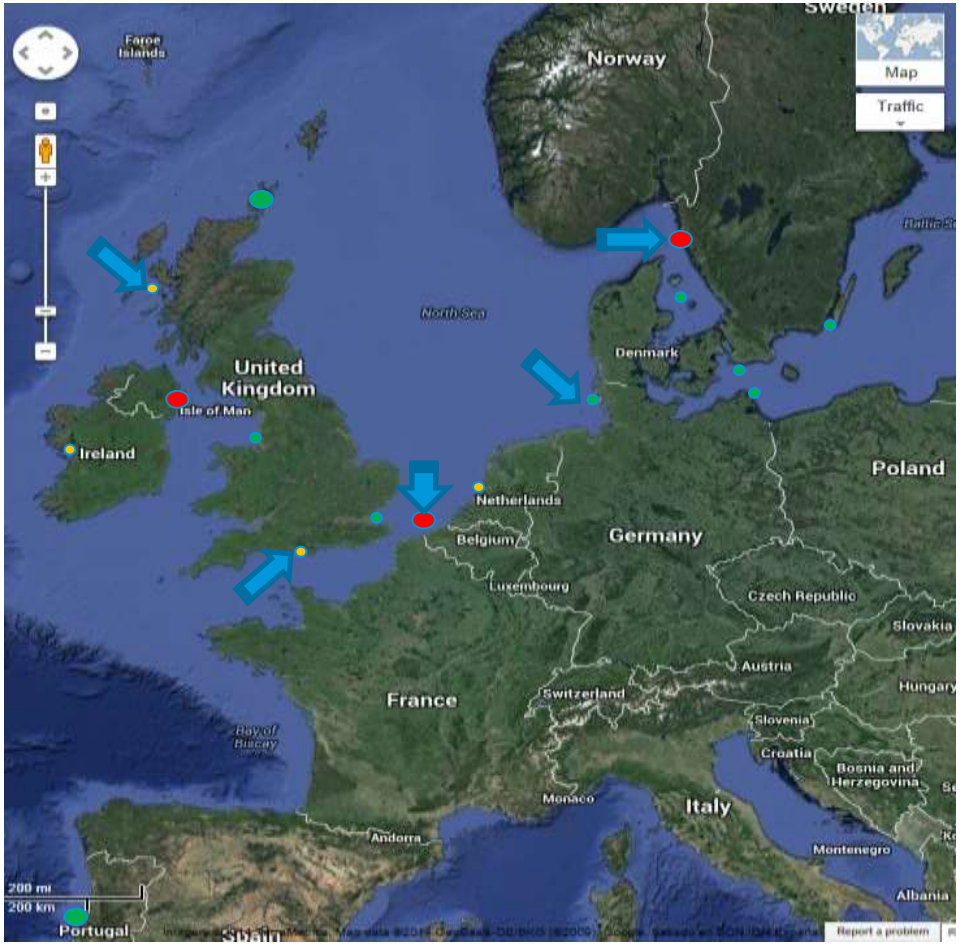
- **Wave** – Lyseskil wave device, Sweden (SP, PM)
  - Kishorn, Scotland – Albatern (SP)

- ***Tidal + Wave*** – EMEC, Orkney, Scotland

- ***Wave + wind*** - Wavec – Portugal

Construction

- German north sea pile-driving (PM)



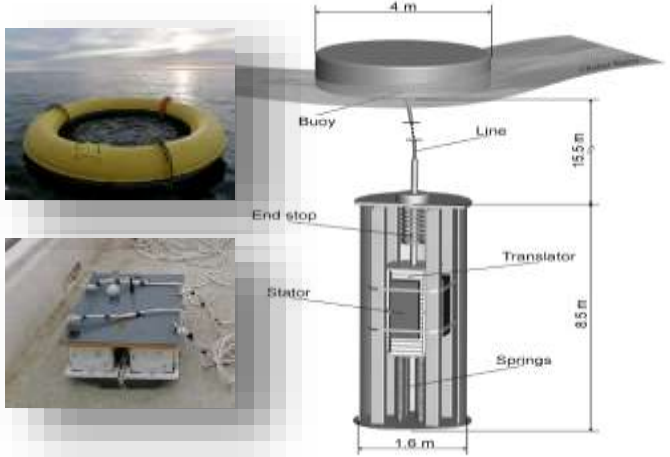
WP - 5 Belgian wind farms

- Trial and test success – (proof of concept)
- - **measuring particle motion and EMF** - biologically relevant levels
- Simultaneous particle motion, sound pressure and EMF - drifting
  - (monopile + jacket, incl. substations)
  - Limits to PM sensor frequency range - interference <500Hz
- EMF export cable
  - onshore - beach
  - offshore - sledge mounted sensor
- Controlled acoustic signals for calibrating acoustic propagation model

WP - 5 Wave devices

Sweden

- Particle motion + sound pressure success – (proof of concept) – static, FOI
- Levels of particle motion were low but detectable at 23 m for fish for wave heights up to 2 m.
- Levels of sound pressure were below hearing threshold at 23 m for fish for wave heights up to 2 m.



Scotland

- Sound pressure @400m, SAMS
- Static hydrophone - no device detected in a variety of sea states
- Ambient sounds dominated and were consistent with weather related events, local shipping noise, as well as the continuous contribution of ADDs deployed on several fish farm cages

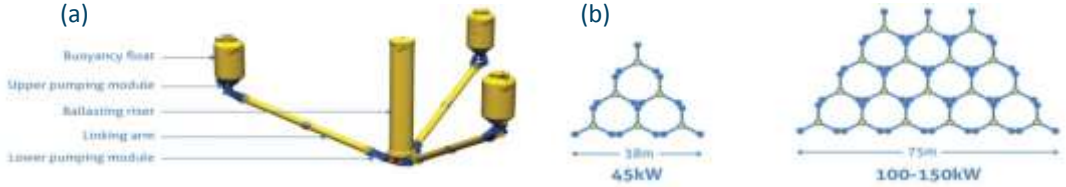


Figure 1 Schematic drawing of the Albatern WaveNET (a) Single SQUID device (b) extended WaveNET array with approximate dimensions and expected power generation. (www.albatern.co.uk/wavenet)

WP - 5 Tidal device

S. England

- Hydrophone Drifters, SAMS
- Measuring sound pressure in noisy environment
- Turbine tonal signal 1 - 2.5 kHz
- 10-15 dB @ 280m above ambient
- Ambient highly variable

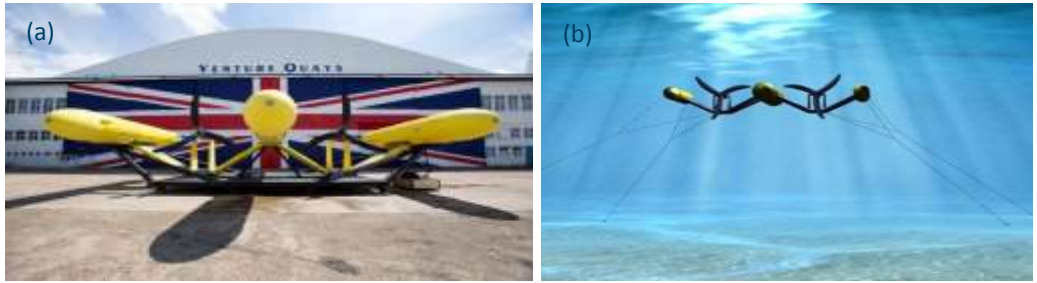
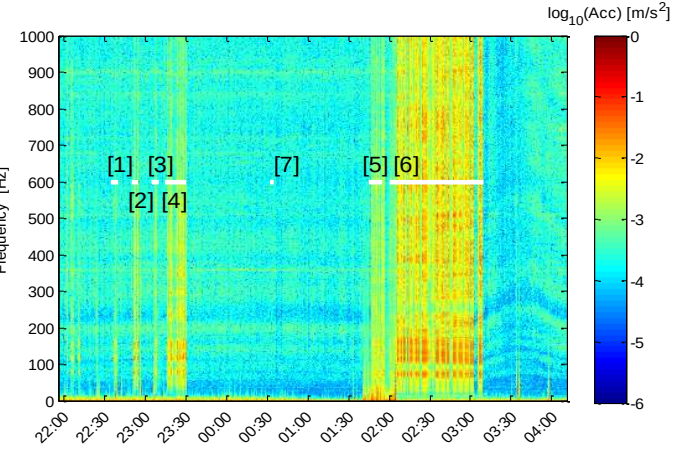


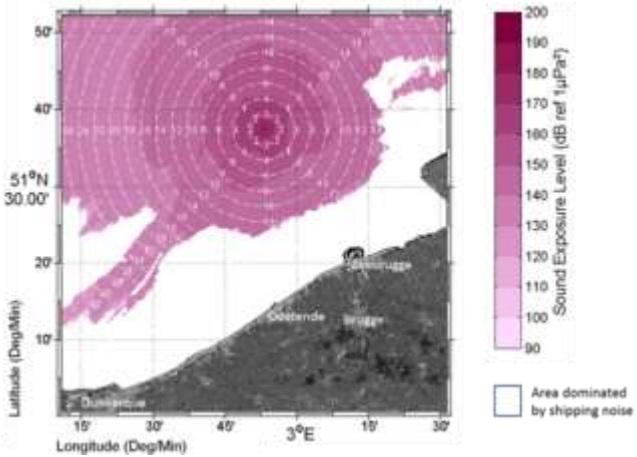
Figure 1 (a) PLAT-O device demonstration device as deployed and measured for this report (b) artistic representation of PLAT-O deployed and anchored to the seabed. (www.sustainablemarine.com)

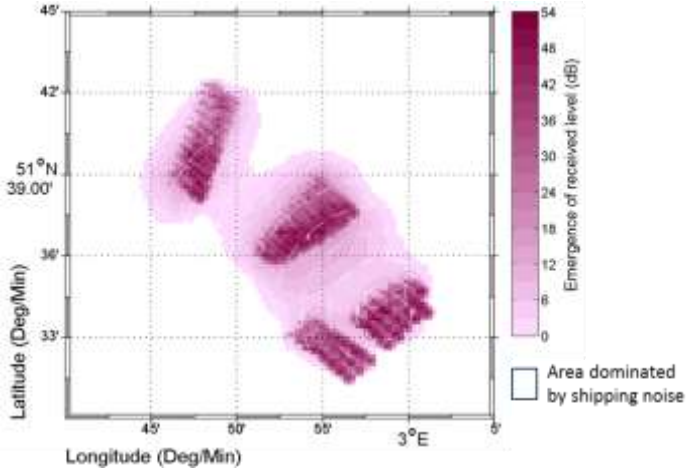
WP5 particle motion and pile driving



- Pioneering measurements in Southern North Sea site in spring 2015
- Particle motion levels with and without mitigation
  - NMS – steel with internal bubble curtain
  - BBC – single bubble curtain
  - Low frequencies not mitigated
- High levels of Particle motion significantly mitigated
  - potentially detectable by fish at 750 m from pile-driving

WP5 Risk assessment for construction and operation





- Construction: Modelling of ‘acoustic footprint’ for pile driving
- Construction: Risk assessment for 3 sediment types and different pile diameters
- Operation: Cumulative footprint rom 3 wind farms during operation showing very limited impact

MaRVEN – Key draft research priorities

Noise and Vibration

- *Dose-response:* Pile driving effects on fish and invertebrate species of commercial or conservation importance and/or key to ecosystem function and investigation of whether effects translate to population level consequences (e.g. displacement or altered movement patterns).

  - *To ensure the risk assessment undertaken on pile driving is appropriate it is fundamental that an aspect of the studies should take relevant dose-response outputs and use them to investigate population level consequences.*

- *Dose-response*: Pile driving noise effect on baleen whales

  - There is some overlap between specific areas planned for MREDs, particularly wind farms, and ranges of mysticete cetaceans (e.g. minke whales on the Dogger bank). Pile driving sounds carry far from the source and could potentially affect the behaviour of protected baleen whales such as minke whales.

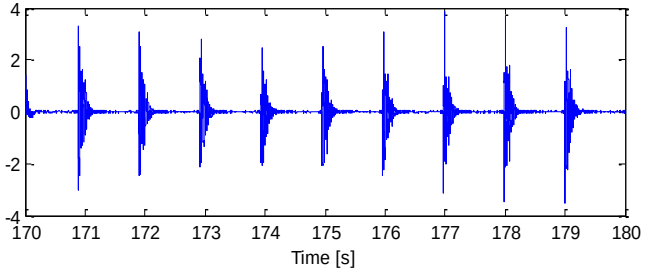
MaRVEN – Key draft research priorities

- *Exposure assessment*: Sediment vibration due to construction of MRED

  - A significant portion of the acoustic energy from pile driving are transported from the pile to the sediment and then subsequently released back into the water column. This could lead to complex sound fields at distance and in-sediment effects that need to be understood better to complete the risk assessment

- *Dose-response*: Cumulative exposure- effect of repetitive noise over the long term

-There is an agreement among scientist that physiological effects such as injury or temporary hearing loss are related to the dose of exposure, which involves the duration of impacts. One important question here is whether multiple pile driving impulses have larger scale effects in comparison to single strikes



MaRVEN – Key draft research priorities

Electromagnetic fields (EMF)

- *Dose response assessment:* Establish the response/effect on key marine species at their most sensitive stages of life to exposure to a range of EMFs (sources, intensities predicted from MREDs).

  - Information from such studies would provide a valuable first database to assess potential risks due to EMF. It could help to assess emergent properties that would be associated with impact at the biologically relevant unit of the species population.

- *Dose response assessment:* Field experiments (e.g. tracking studies) on the potential for cumulative impacts from multiple cables in relation to movement/migratory behavior of EMF receptor species.

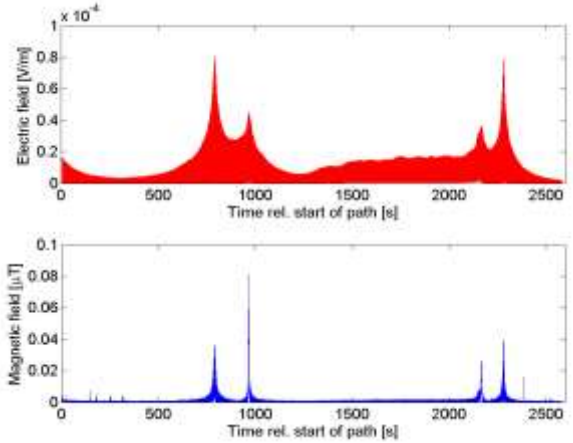
  - Such studies should take relevant dose-response outputs and apply population based approaches (e.g. ecological modelling) to determine significance.

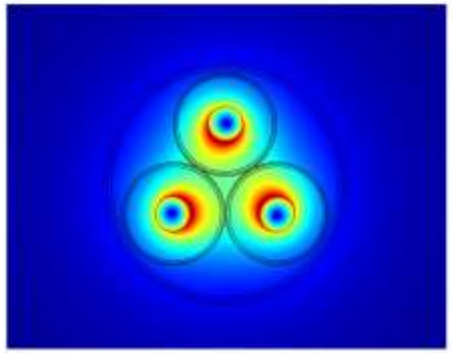
European eel (*Anguilla anguilla*) equipped with an acoustic tag

MaRVEN – Key draft research priorities

- *Exposure assessment: Develop further affordable techniques for measuring electromagnetic fields so as to validate EMF predictions within models.*
  - So far, only a custom made EMF sensor (FOI), have been used in measuring EMFs. In order to facilitate a better comparison of measurements, further development of detectors is necessary.

The Swedish Electromagnetic Low-noise Apparatus (SEMLA)





The observed EMF crossing the Northwind and CPower export cables, The first peak from the left is the Northwind and the second the C-Power. The third is the C-Power and the fourth the Northwind. The upper panel shows the electric field and the lower the magnetic field.

MaRVEN – The team says hello!!!!!

Look out for the final report on the SETIS web site:
www.setis.ec.europa.eu

And the MaRVEN web site:
http://marven.dhigroup.com/