What does MaRVEN have to say about n
large-scale study of the environmental in
of noise from marine renewables
DG- Research and Innovation 2014-15

Frank Thomsen, DHI

SCOTTISH ASSOCIATION for MARINE SCIENCE

museum
Operational Directorate Natural Environment
OD Nature I OD Natuur I DO Nature

UPC

Cranfield UNIVERSITY

FOI

DEWI

Quiet oceans
Technology for Sustainable Oceans

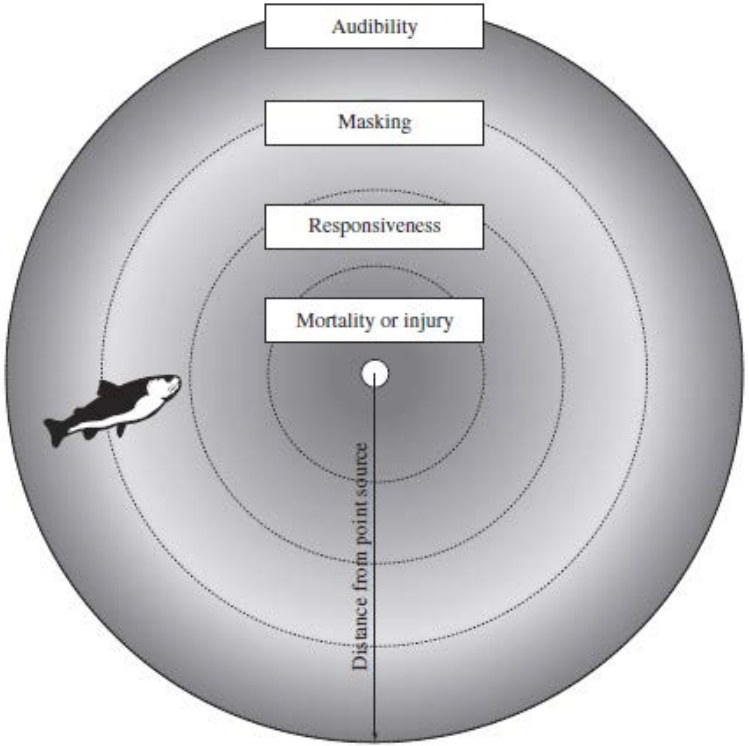
Cefas

DHI

Water is an excellent medium for sound transmisson

Sound is more than four times faster underwater compared to air and there is less attenuation

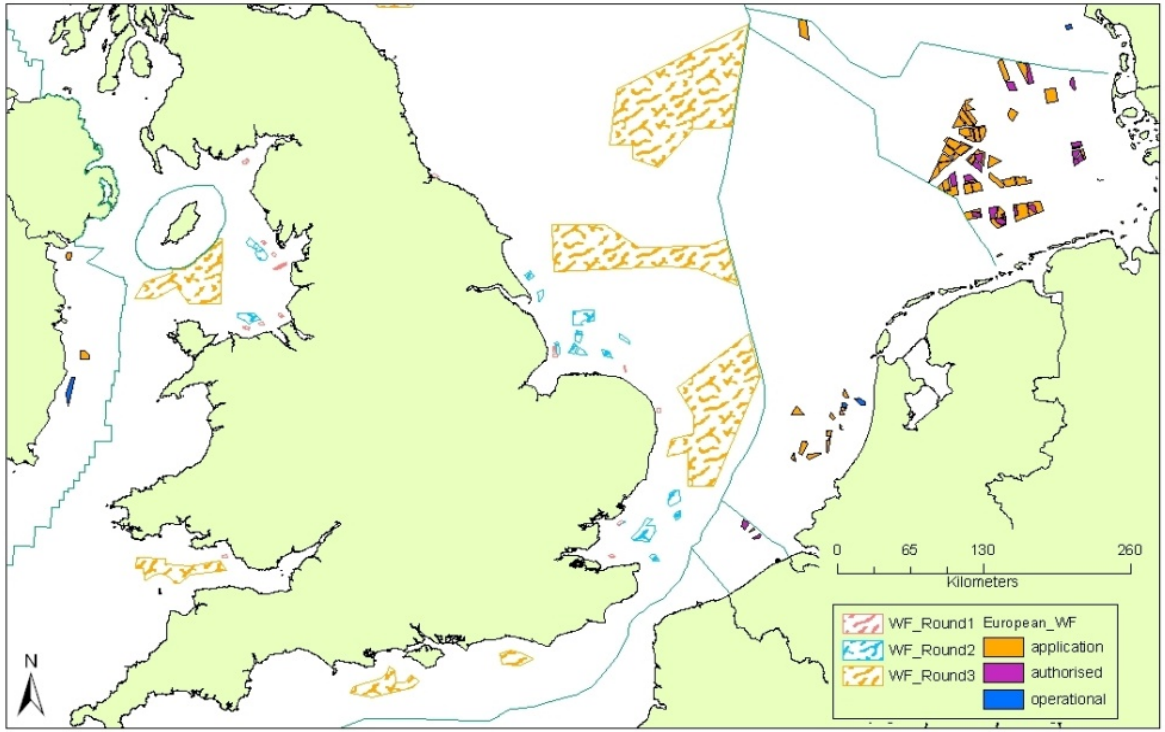
Sound impacts



(Gill, Bartlett & Thomsen 2012)

Marine renewables in Europe

Wind farm locations around the UK and neighbouring areas.



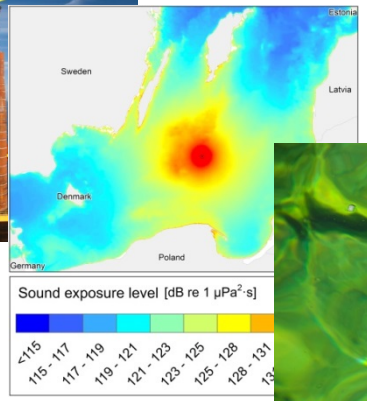
MaRVEN objectives

- Critically review the available scientific evidences and significance of impacts of noise, vibrations and emf
- Perform field measurements to fill gaps in knowledge
- Make recommendations for further research priorities
- Lifetime 18 months
- Budget 1 m EUR

Risk based approach to noise assessment

What is the problem?

How far does the sound spread and how many animals are in range of the sound?



How do they react to the sounds?

How can we mitigate impacts?

Wind farm noise impacts: sound levels

- **Construction:** Impact pile driving with very high peak to peak sound pressure levels (i.e. > 250 dB re 1µPa at 1 metre)

- **Operation:** Much lower levels (i.e. 114 - 130 dB re 1µPa inside owf area)

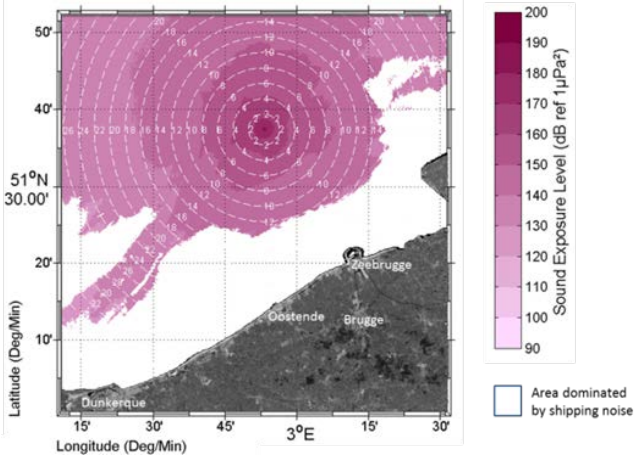
(ITAP 2005; Thomsen et al. 2006; Nedwell et al. 2007; review in OSPAR 2009)

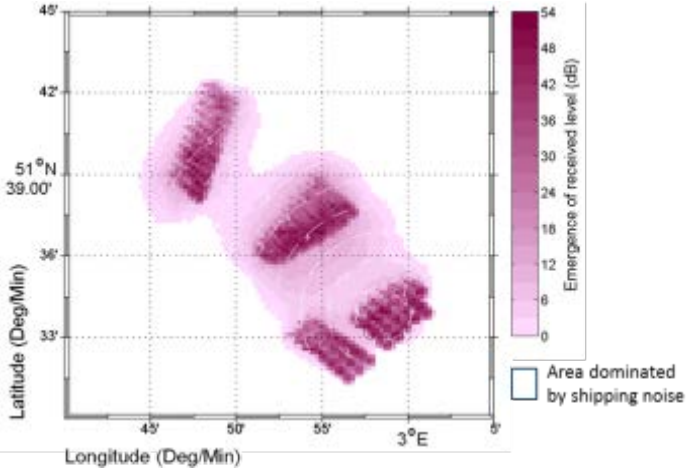
Audibility of construction noise

(Thomsen et al. 2006)

260
200
100
20
dB re 1µPa
1 m
80 km
100
1,000
10,000
100,000
Frequency [Hz]

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 from 3 wind farms during operation showing very limited impact in the context of noise from vessels

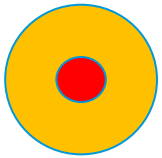
Behavioural response

Construction: Decrease in acoustic activity and indication of avoidance out to 20 km
(6 sites)
Operation: positive (1), negative (1) and no effect documented (3)

Construction: Changes in haul out behaviour; indication of avoidance (1)
Operation: No effect but little studies (1)

(Tougaard et al. 2003, 2005, 2007 Carstensen 2006; Thompson et al. 2010; Brandt et al. 2011 Scheidat et al. 2012; see also IWC 2013)

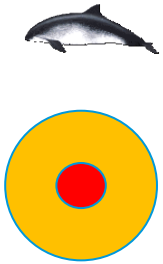
Noise Dose Impacts

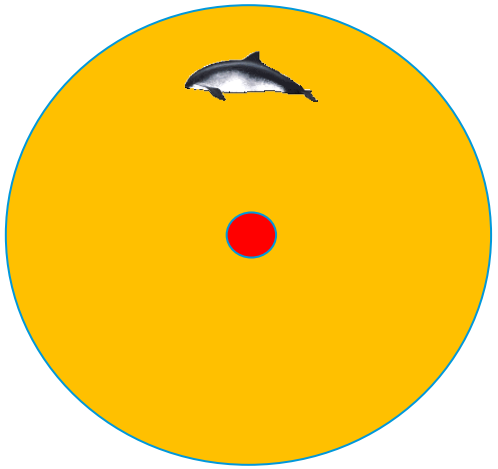


TTS single strike = 700 m

(SL = 207 dB re 1µPa^2 · s, N = 2400 strikes, TL = 15 log (r)

Noise Dose Impacts





TTS single strike = 700 m

TTS 1 h = 12.5 km

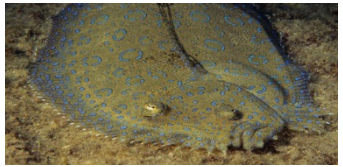
(SL = 207 dB re 1µPa^2 · s, N = 2400 strikes, TL = 15 log (r))

Fish and wind farms

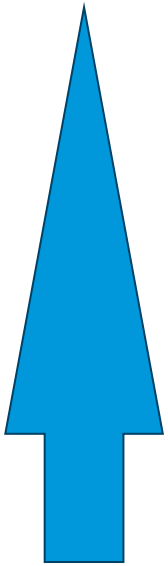
- Many fish species are sensitive to sound
- Offshore wind farm sound can lead to death of fish close to the source and to behavioural reactions far from the construction site

Fish and wind farms

Fish hearing

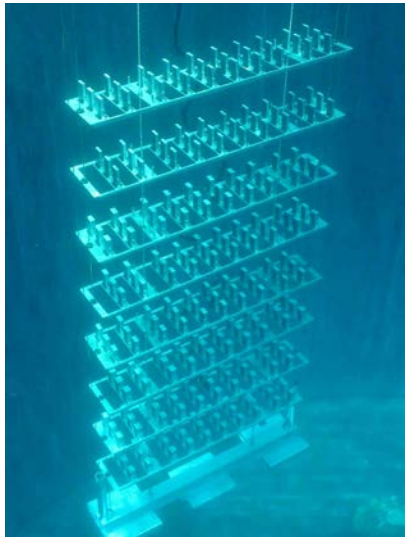


Pressure Detection



Particle Motion Detection

Risk management: new developments



Helmholtz Resonator
(Wochner *et al.* 2015)

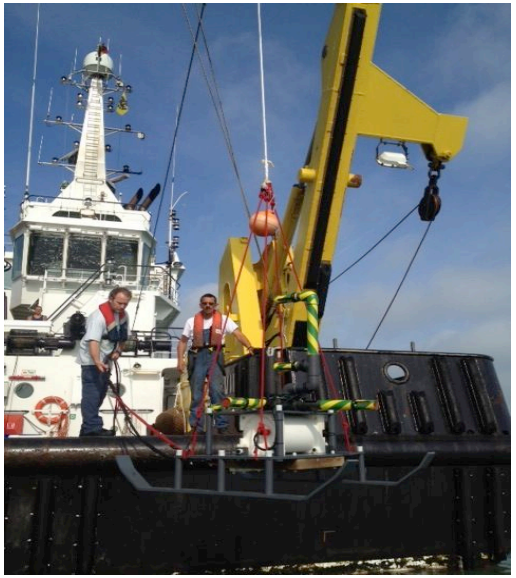
Hydro-sound dampers
(Elmer *et al.* 2015)

IHC NMS
(Schiedek *et al.* 2015)

Field studies

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)

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

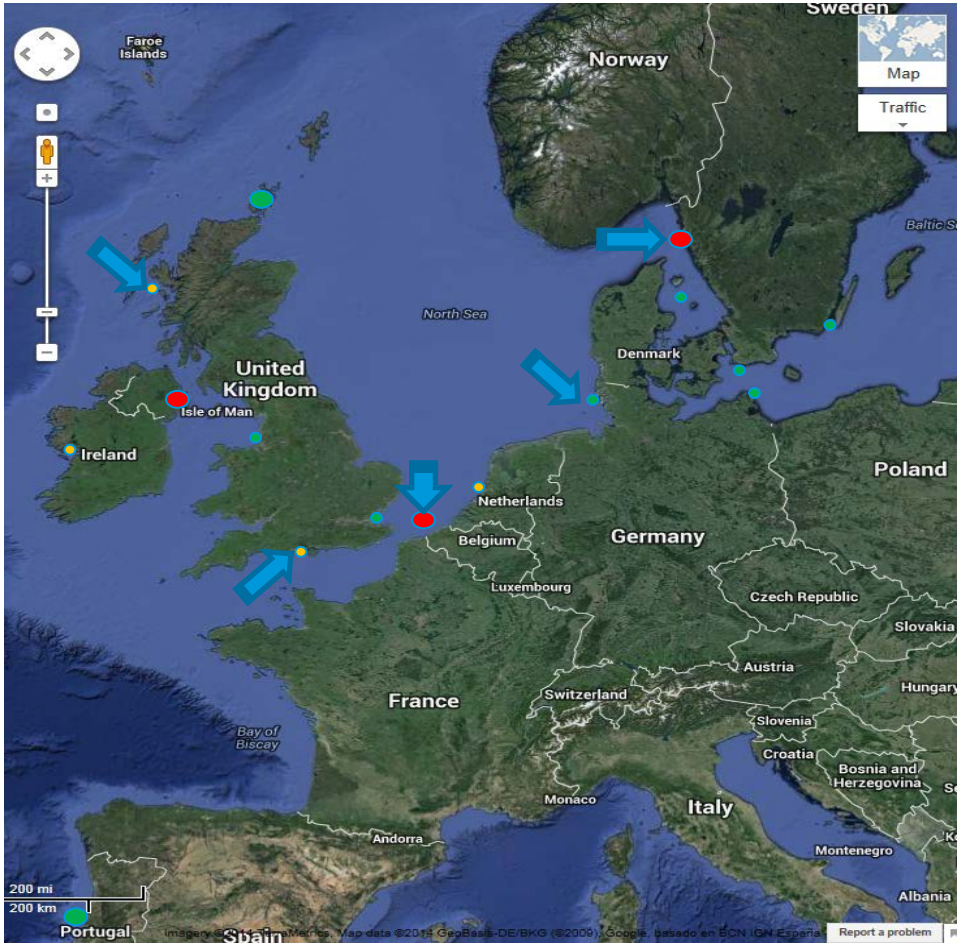
- **Wave** – Lyseskil wave device, Sweden
  - Kishorn, Scotland - Albatern

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

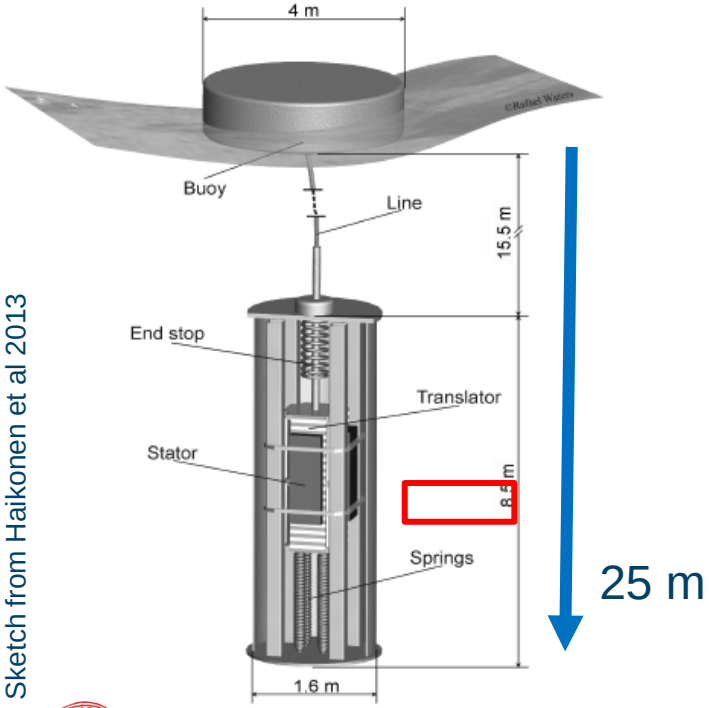
- ***Wave + wind*** - Wavec – Portugal

Construction

- German north sea pile-driving (PM)



Site 2 – WEC Swedish West coast



Sketch from Haikonen et al 2013

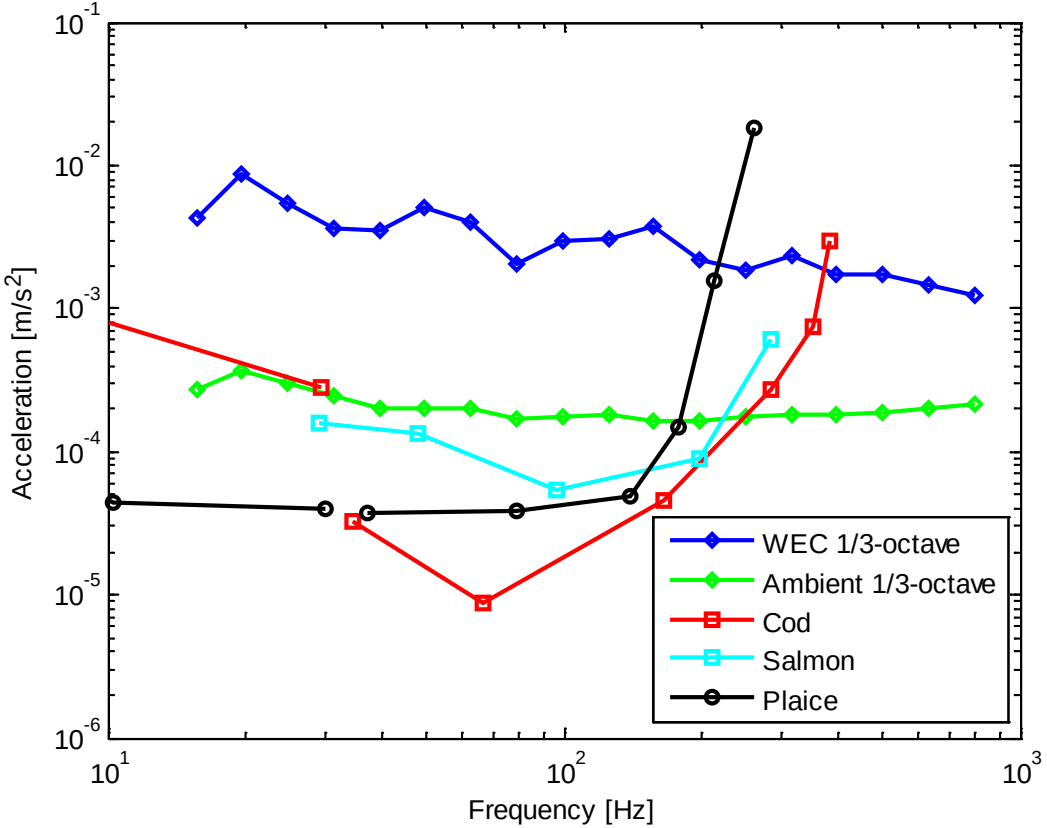
- FOI PM sensor, seafloor 23 m from device
- Hydrophone (-180 dB rel 1V/µPa; frequency range 20 Hz – 50 kHz, located next to the sphere.
- 7 days recording (5 min / hour)

UPPSALA UNIVERSITET

DHI

MA in action

Results – Sweden - particle motion



Particle acceleration RMS March 29th, 07:50:47 WEC, and 07:52:04 at 2 m wave height

- PM from WEC well above ambient levels at 23 m distance
- Levels are above hearing thresholds for cod, salmon and plaice < 300 Hz

Tidal device measurements

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

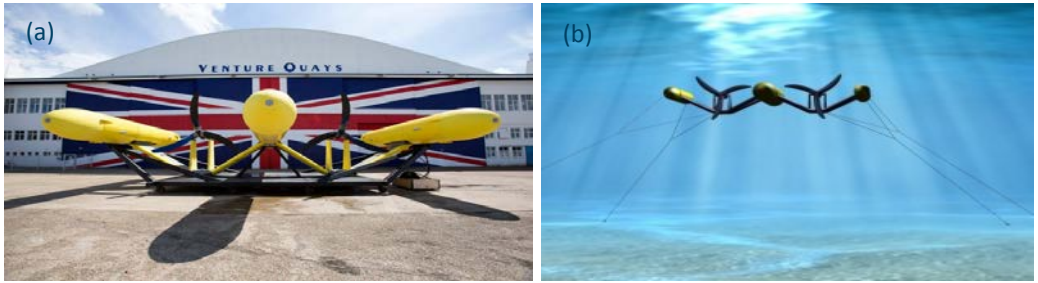
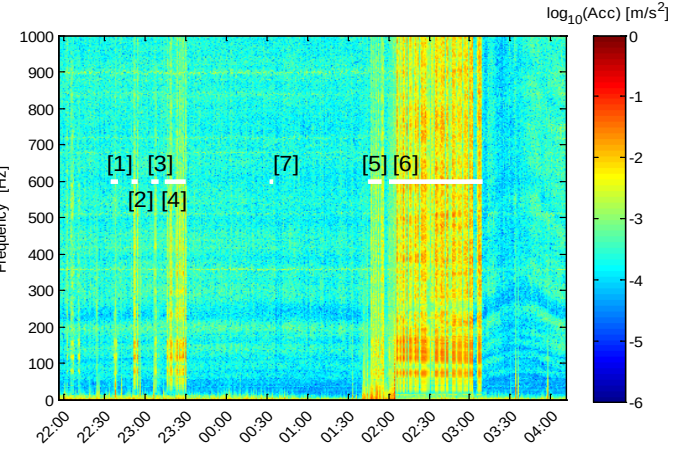


Figure 1 (a) PLAT-O device demonstration device as deployed and measured for this report (b) artistic representation of PLAT-O deployed and anchored to the seabed. (www.sustainablemarine.com)

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

Summary

Review

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

Measurements

- New results on PM and SPL from operating wave and tidal devices
- Groundbreaking results on pm from pile driving

Programme for further R&D with justified priorities

- *Dose-response:* Pile driving effects on fish/invertebrate species of commercial, conservation importance and/or key to ecosystem function (e.g. herring, cod) and investigation of whether effects translate to population level consequences
- *Dose-response:* Pile driving noise effect on baleen whales - but only in areas where wind farms spatially overlap with the distribution range of the taxa.
- *Exposure assessment:* Sediment vibration due to construction of MRED [+ particle motion]

MaRVEN – The team says hello!!!!!