International Forum on MRE Environmental R&D

General wave energy monitoring background

23 April 2020
Key wave evidence gaps

• Use of wave energy areas by marine wildlife

• Underwater noise

• Displacement effects

• Consolidation of existing evidence

http://www.orjip.org.uk/documents
Operational noise assessment on Pelamis P2 at Billia Croo, EMEC (Lepper et al., 2012)

- Development of the methodology
- Conclusions:
  - Noise was within hearing range of most marine mammals
  - Detectability of noise dependent on varying background noise
  - Shallow water ‘ambient’ noise is relatively poorly understood

Surface monitoring of **seabird behaviour** at the Pelamis P2 device (Jackson, 2014)

- Automated stills
- Data on tide, wave height and wind speed recorded

**Results:**
- No presence of birds in February-March period
- Regular use of the machine for resting, roosting in May
- Weak negative correlation between presence of birds and wave height
- No correlation between presence of birds and tidal cycle
- Successful, low cost methodology to monitor behaviour of birds around operational WECs

[Link to document](https://tethys.pnnl.gov/publications/riding-waves-use-pelamis-device-seabirds)
Habitat use by seabirds at a marine renewable wave energy test facility (Leesa et al., 2015)

- Kernel density estimates used
  - Baseline seasonal and interannual variation
  - Change as a result of WEC

- **Results:**
  - High variation in baseline distribution
  - Density at the mooring points of the device increased for certain species at certain times of year
  - No avoidance behaviour or significant change in distribution recorded

Wello Penguin Cooling System Noise Study (Beharie & Side, 2012)

- Underwater sound pressure levels measured of two cooling fans and one pump operating continuously

- **Results:**
  - Noise profile successfully measured
  - Ambient background noise expected to be greater than noise profile within 10 m of the device

Assessing the impact of man-made underwater noise from marine renewables in the Outer Hebrides (Ward, 2014)

- Baseline noise data collected
- Construction (drilling) noise recorded during installation of device at EMEC
- Noise propagation model

Results:
- Low levels of noise generated, propagated short distances before falling below background noise level
- No likely fatality or hearing damage (permanent or temporary)
- Disturbance possible depending on background noise
- Overall impact deemed to be negligible
Investigations into Wave Effects

- Effects on benthos
- Noise
- EMF
- Other effects
U.S. Navy Wave Energy Test Site (WETS)

Projects to Date

- NWEI Azura: 6/15 – 12/16
- Modified Azura: 2/18 – 8/18
- Lifesaver w/UW AMP Integration: 10/18 – 3/19

Up Next – Ocean Energy in Hawaii – to WETS in Spring

Projects Ahead
- Oscilla Power
- C Power
- Aquaharmonics
- NWEI Grid Scale

Testing underwater noise, benthic community changes, disturbance of marine mammals
PacWave is an open-coastal wave energy testing facility at Oregon State University, now operated by the College of Earth, Ocean, and Atmospheric Sciences. It consists of two sites, each located within several miles of the deep-water commercial port of Newport, Oregon.

- **Benthic community analyses**
  - Extensive sampling and analysis to set baseline for potential changes due to MRE development
  - EMF and underwater noise measurements from small Azura WEC

- **PacWave North**
  - Established autonomous test site for small-scale, prototype, and maritime market technologies

- **PacWave South**
  - An in-development, state-of-the-art, permitted, accredited, grid-connected wave energy test facility. Developed in partnership with US Department of Energy, the State of Oregon and local community.
Regulatory Thresholds

➢ Marine Mammals
  • NOAA Technical Guidance (2018)

<table>
<thead>
<tr>
<th>Hearing Group</th>
<th>$K$ (dB)</th>
<th>$C$ (dB)</th>
<th>Weighted TTS onset acoustic threshold (SEL$_{cum}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-frequency (LF) cetaceans</td>
<td>179</td>
<td>0.13</td>
<td>179 dB</td>
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<tr>
<td>Mid-frequency (MF) cetaceans</td>
<td>177</td>
<td>1.20</td>
<td>178 dB</td>
</tr>
<tr>
<td>High-frequency (HF) cetaceans</td>
<td>152</td>
<td>1.36</td>
<td>153 dB</td>
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<tr>
<td>Phocid pinnipeds (underwater)</td>
<td>180</td>
<td>0.75</td>
<td>181 dB</td>
</tr>
<tr>
<td>Otariid pinnipeds (underwater)</td>
<td>198</td>
<td>0.64</td>
<td>199 dB</td>
</tr>
</tbody>
</table>

➢ Fish
  • NOAA Fisheries (salmon & bull trout)
Fred. Olsen Lifesaver at WETS

- Hawai‘i Wave Energy Test Site (WETS), Kaneohe, O‘ahu
- Point absorber, floating
- Shallow draft (0.5 m)
- Noise measurements (2016):
  - 3 seabed-mounted hydrophones (3 months)
  - 2 drifting hydrophones (3 drifts)

(Polagye et al. 2017, EWTEC)
Fred. Olsen Lifesaver at WETS

PTO (Standard Operation)

$RL = 116 \text{ dB re } 1\mu\text{Pa}$

50 Hz – 700 Hz

(Polagye et al. 2017, EWTEC)
Fred. Olsen Lifesaver at WETS

\( RL = 124 \text{ dB re } 1\mu\text{Pa} \)

700 Hz – 5 kHz

Mooring
(Mechanical Contact)

(Polagye et al. 2017, EWTEC)
Hearing thresholds for marine animals and underwater noise levels
EMF Fields Studies

EMF-sensitive fish response to EM emissions from subsea electricity cables

- West Scotland, 2007, 10-15m deep, 125 kV AC cable buried 0.5-1m
- Mesocosms with energized and control cables (3 trials)
- No evidence of positive or negative effect on catsharks (dogfish)
- Benthic elasmobranchs (skates) responded to EMF in cable

(Gill et al. 2009)

Sub-sea power cables and the migration behaviour of the European eel

- East Sweden, 2006, unburied 130 kV AC cable
- Used acoustic tags to track small movements of 60 eels across energized cable
- Eels swam more slowly over energized cable
- Effect was small, no evidence of barrier effect

(Westerberg and Lagenfelt 2008)
EMF Fields Studies

Assessment of potential impact of electromagnetic fields (EMF) from undersea cable on migratory fish behavior

- West U.S., 2014, buried 200 kV DC cable
- HVDC cable in San Francisco Bay, parallel or perpendicular to green & white sturgeon, salmon, steelhead smolt migrations
- Tagged fish, magnetometer surveys
- Outcome – such large magnetic signatures from bridges, other infrastructure, could not distinguish cable!
- Fish did not appear to be affected

(Kavet et al., 2016)
EMF Fields Studies

Potential impacts of submarine power cables on crab harvest

- NW U.S. and SW U.S., 2015, 10-13m deep, unburied power cables
- Will rock crab (Santa Barbara channel) and Dungeness crab (Puget Sound) cross a power cable?
- Rock crabs cross an unburied 35 kV AC power cable
- Dungeness crabs cross an unburied 69 kV AC power cable to enter baited commercial traps

(Love et al., 2017)

EXPERIMENTAL SET UP IN BOTH STUDY AREAS

12 units, 3 replicates of each of 4 test conditions, were randomly placed along the cable

- Unit on EAST side of EXPOSED cable
- Unit on WEST side of EXPOSED cable
- Unit on EAST side of BURIED cable
- Unit on WEST side of BURIED cable
Other Potential Wave Effects

• Carnegie (Western Australia)
  ▪ Concerns over entanglement
  ▪ Desalination brine return

• Resolute Marine (Cape Verde Islands)
  ▪ Desalination brine return
References


References


