

Optimising Array Form for Energy Extraction and Environmental Benefit (EBAO)

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The EBAO Principle

- To establish robust methodologies to maximise the economic potential of marine energy developments in harmony with the ecological (and social) environment.
- To ensure these methodologies are widely circulated to the benefit of the new marine energy industry and the ecology

Defined Aims

- To incorporate environmental considerations into Optimal Array design procedures:
 - Identifying and implementing appropriate modelling procedures to predict physical, ecological and social impact
 - Using these to predict the impact from developments
 - Assessing the acceptability of impacts and using these to evolve the array designs for acceptability
 - Incorporation into web based guidelines and protocols

The Team

- The University of Edinburgh
- The University of Exeter
- The University of Loughborough
- Sea Mammal Research Unit (SMRU)
- CEFAS
- Scottish Association for Marine Science (SAMS)

Methodology

- EBAO is identifying procedures for effective, rapid assessment of marine energy projects, which simultaneously optimise economic energy production and ecological benefit.
- This involves identification of these procedures and testing their effectiveness through application to key development scenarios.
- Conducted through a series of parallel work streams:

1: Impact Parameter Identification

- The team is working with stakeholders throughout the project to identify impact parameters which are of most concern and most likely to contribute developmental constraints
- Impact parameters include:
 - physical impact between technology and marine mammals,
 - local energy deficits leading to modifications in nutrient transport,
 - visual intrusions and acoustic pollutions

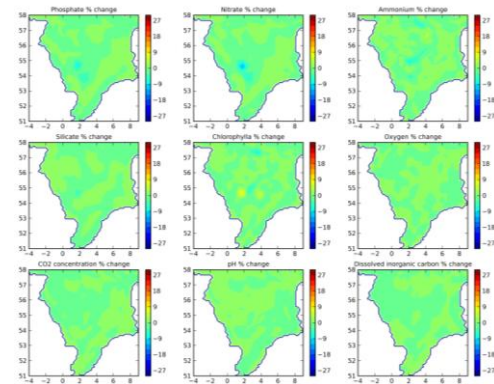
The 1st Brainstorm

see Liverpool workshop

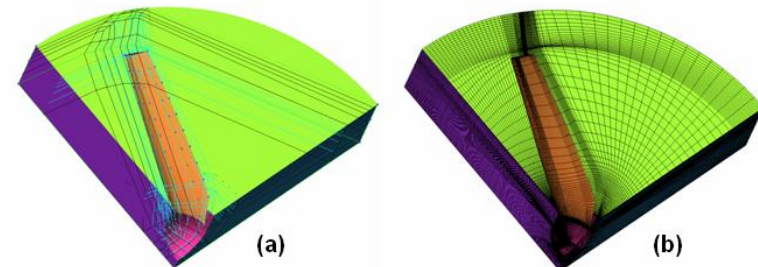
Technology	Physical	Ecological	Social/Economic
<p>Rating (MW) <small>[Kapture Width]</small></p> <p>Footprint (km²) <small>shape & size & orientation</small></p> <p>F.D.C. <small>(surface, subsurface wave/tidal wind noise)</small></p> <p>No of devices</p> <p>materials</p> <p>λ (tsr)</p> <p>installation (jack-up, dpv, cable & connection, maintenance issues)</p>	<p>extremes Ambient noise</p> <p>*black noise</p> <p>Energy Extraction</p> <p>Velocity reduction</p> <p>Shadows</p> <p>turbulence</p> <p>scour & sediment transport (bed morphology)</p> <p>bathymetry</p> <p>sediment type</p> <p>hydrodynamics</p> <p>current profile</p> <p>turbidity</p> <p>stratification</p> <p style="writing-mode: vertical-rl; transform: rotate(180deg);">some properties</p> <p style="writing-mode: vertical-rl; transform: rotate(180deg);">Fronts</p> <p style="writing-mode: vertical-rl; transform: rotate(180deg);">resonance & reflectivity</p>	<p>water quality</p> <p>collisions</p> <p>acoustic disturbance</p> <p>migratory patterns</p> <p>habitat exclusion</p> <p>Contaminants</p> <p>masking</p> <p>artificial reefs</p> <p>spill-over effects</p> <p>defacto MPAs</p> <p>habitat changes</p> <p>distribution</p> <p>electromagnetic enhancement</p> <p>substrates</p>	<p>Export Prospects (stability)</p> <p>Competition with other users <small>ecological</small></p> <p>evolution zones (milling & construction) <small>historical</small></p> <p>noise generation zones</p> <p>Visual amenity</p> <p>marine archaeology <small>heritage</small></p> <p>Leisure users</p> <p>MOD</p> <p>cross boundary effects</p> <p>coastal defence</p> <p>Cumulative impacts</p>

2: Physical and Ecological Model Identification and Development

- Assessing the appropriateness of modelling techniques, taking into account their capability of predicting physical flow responses and consequential ecological impact
- Judgment based on:
 - Robustness
 - Appropriateness
 - Verification

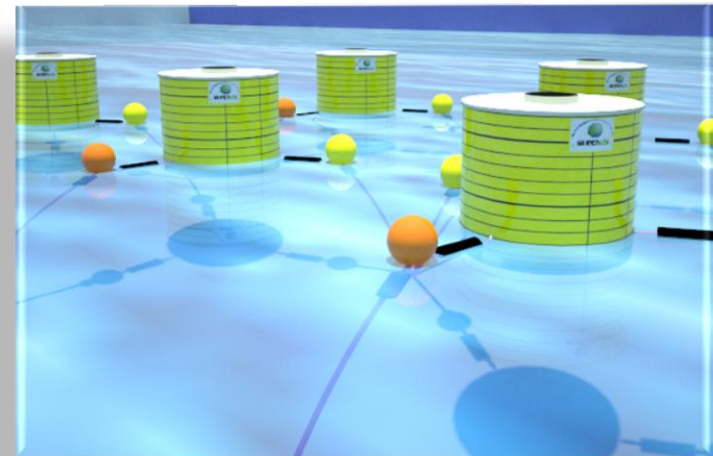
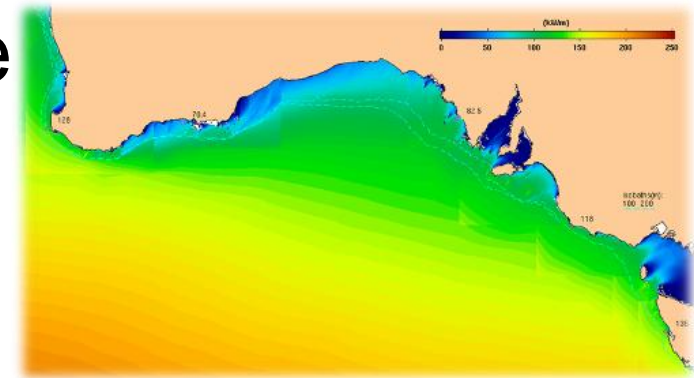


Hexahedral meshing of rotor (a) Block topology (b) Surface mesh



3: Scenario Development and Evolution:

- Development scenarios have been identified
- Ongoing workshops with key developers



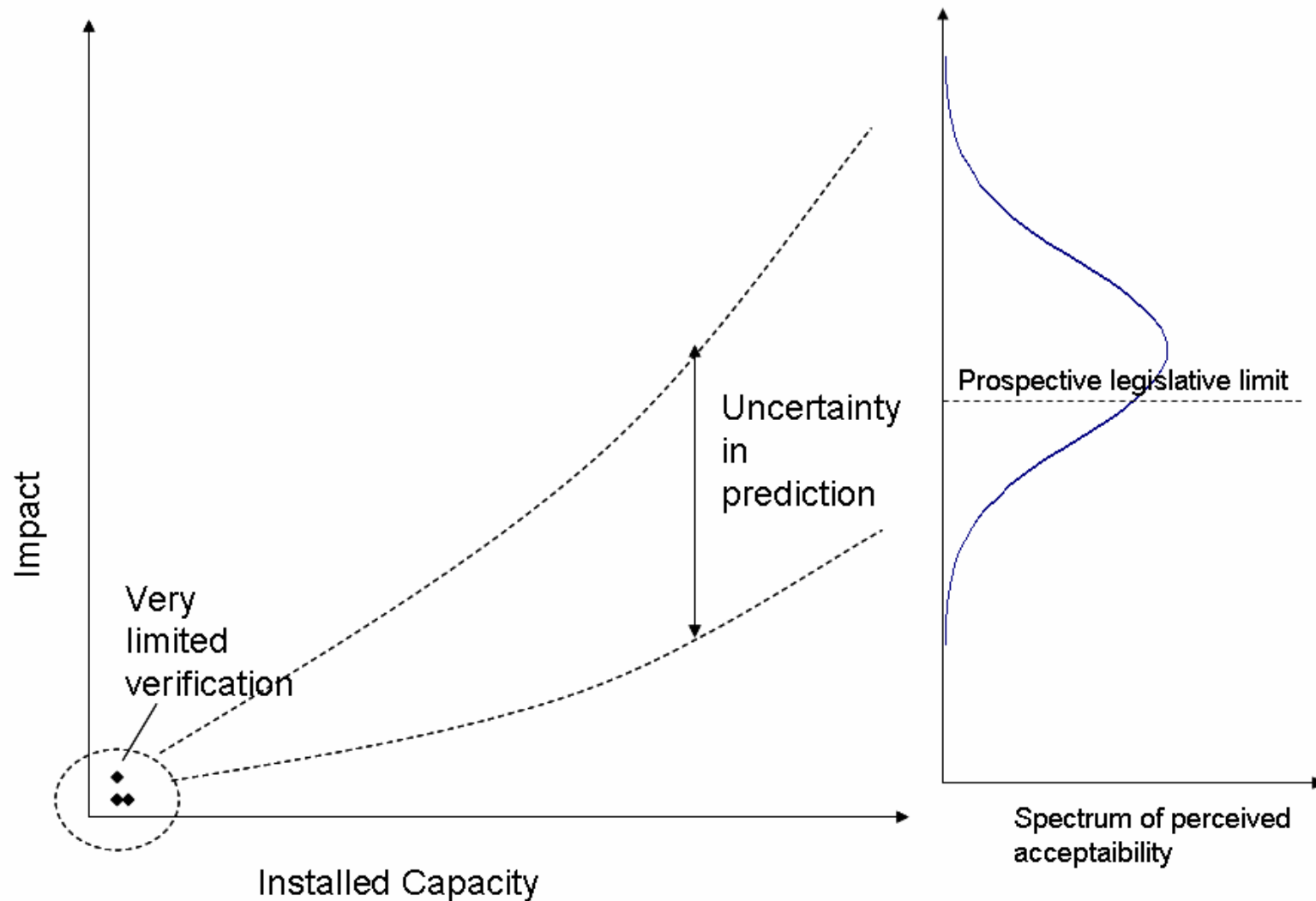
4: Acceptability Assessment

- “Acceptability” workshops to assess acceptable ecological perturbations
 - Impact is not automatically negative and assessment will incorporate potential for ecological improvement through, perhaps, the sheltering of sensitive ecosystems or the introduction of no fishing areas.



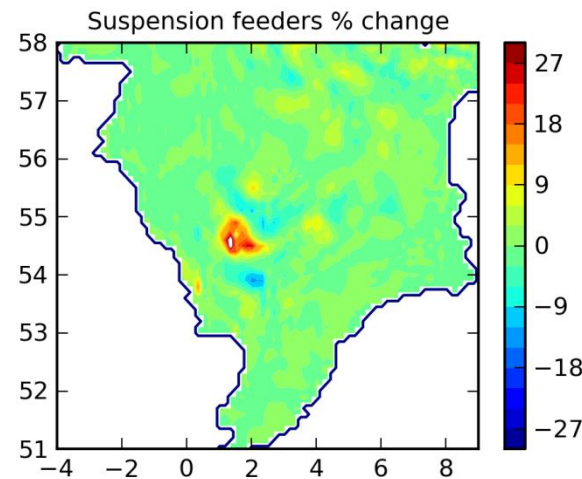
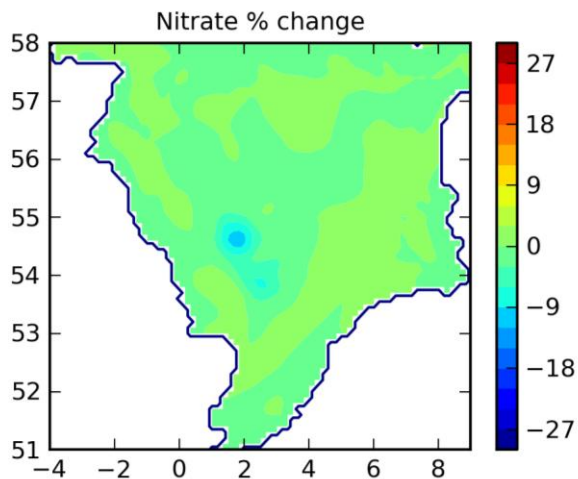
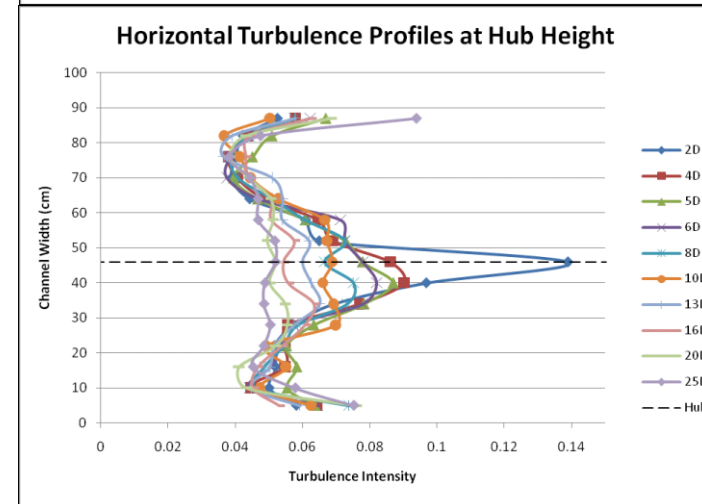
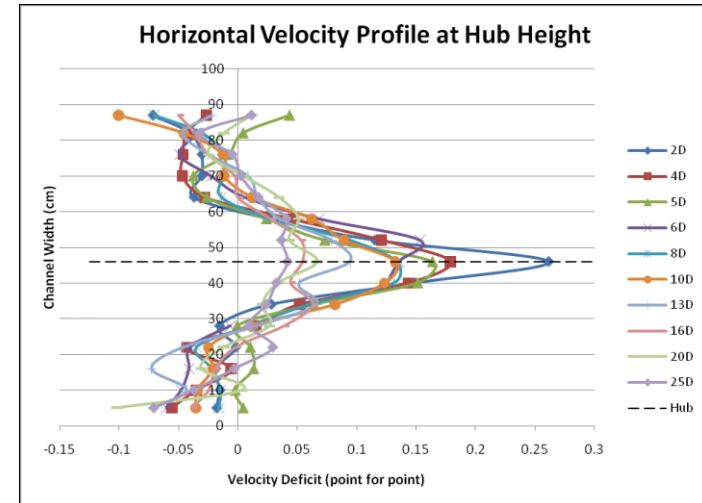
The Spectrum of Acceptability

Impact Prediction and Assessment



5: Ecological Model Application

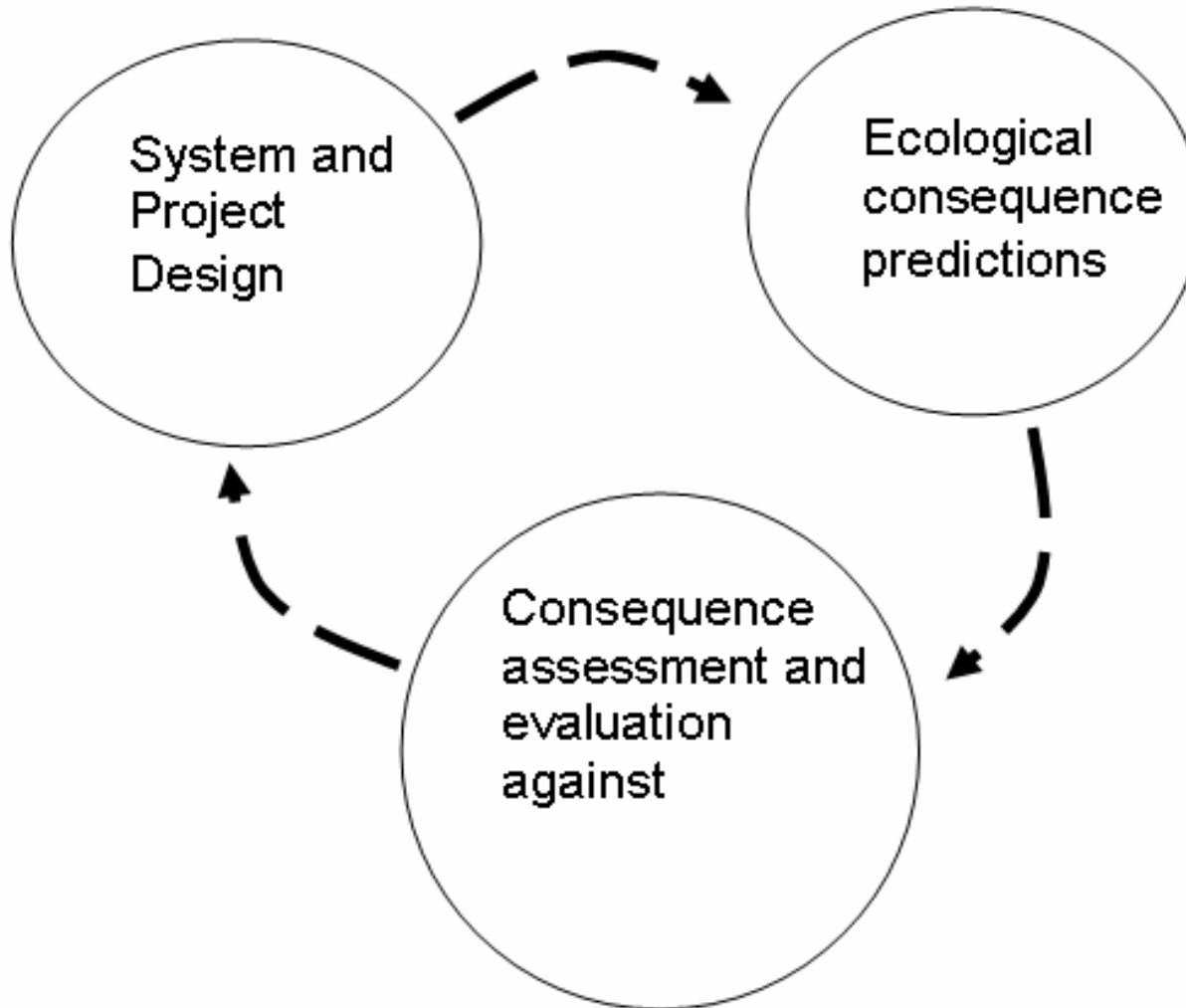
- Impact models applied to the scenarios.
- To determine whether the scenarios are compliant with acceptable change and how the parametric representations of the developments might be changed to improve compliance



6: Feedback into Scenario Development

- The output of the ecological model analysis will be fed back into the scenario development to consider the implications, including;
 - Requirements to make conceptual changes to the scenarios, which might offer more advantageous ecological perturbations.
 - This might include change to the FDCs!

Philosophy of Ecological Design



7: Reporting and Protocol Development:

- Presentation of empirically-based models for optimising the design of large scale arrays.
- EBAO protocols will represent principles established to optimise the ecological and energy conversion performance of marine energy projects.
- They will be adaptive and continually re-evaluated as experience from progressively larger marine energy projects becomes available.