EBAO

Optimising Array Form for Energy Extraction and Environmental Benefit

Helen Smith
University of Exeter

Ocean Business: Special Session on Marine Renewable Energy
16th April 2015

NERC SCIENCE OF THE ENVIRONMENT

Department for Environment Food & Rural Affairs

THE UNIVERSITY OF EDINBURGH

UNIVERSITY OF EXETER

Loughborough University

Cefas

Sea Mammal Research Unit

SCOTTISH ASSOCIATION for MARINE SCIENCE

Overview

"EBAO will establish and evaluate a design feedback process which can protect and perhaps enhance the natural environment, while allowing energy extraction to be maximised. Engineers will work with project and device developers to establish appropriate development scenarios which will then be considered using state of the art modelling techniques to assess the levels of ecological impact across a range of key ecological parameters."

EBAO

Overview

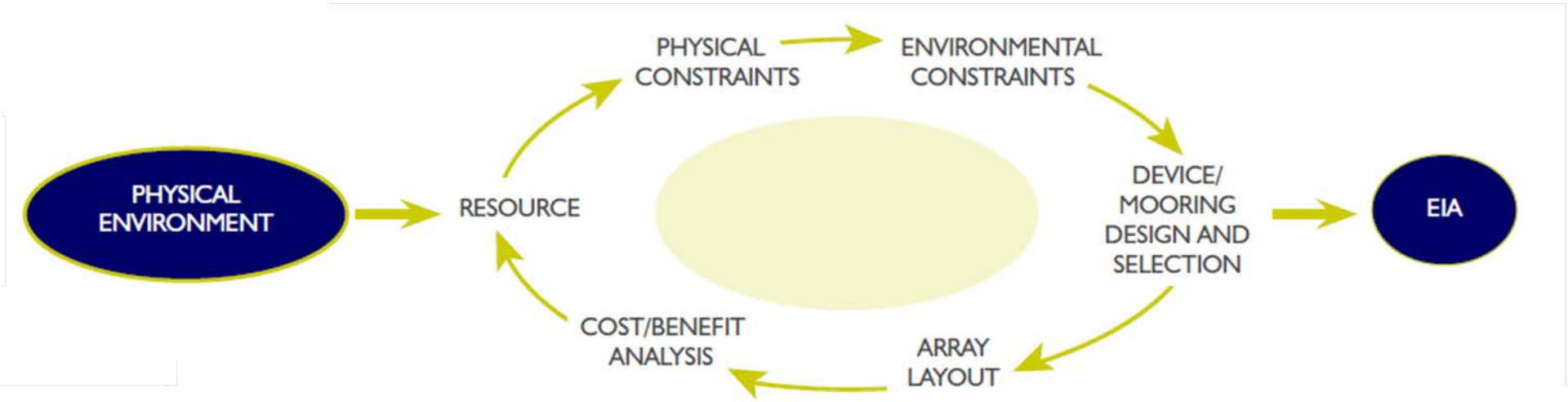
- Primary focus wave and tidal energy, but offshore wind also considered for assessment of large arrays
- Four geographical scenarios addressed:
    - Constrained channel (tidal)
    - Sea area between mainland and island (tidal)
    - Inshore site (wave/tidal)
    - Offshore site (offshore wind)

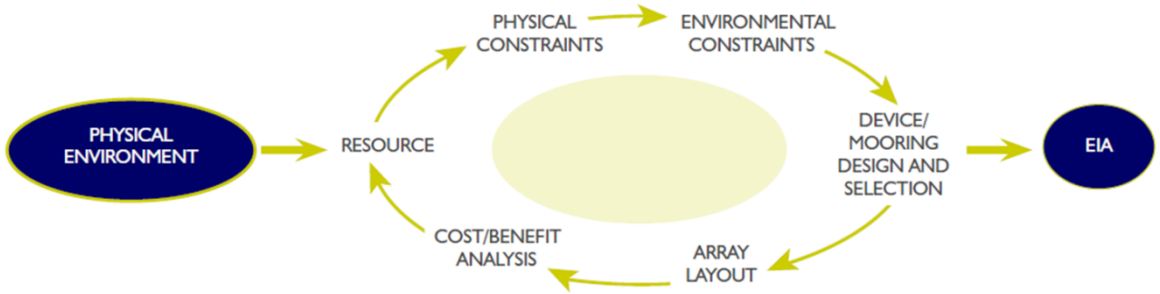
- Project ran from October 2011 to September 2013
- Follow-on work funded by Exeter's NERC Impact Accelerator account

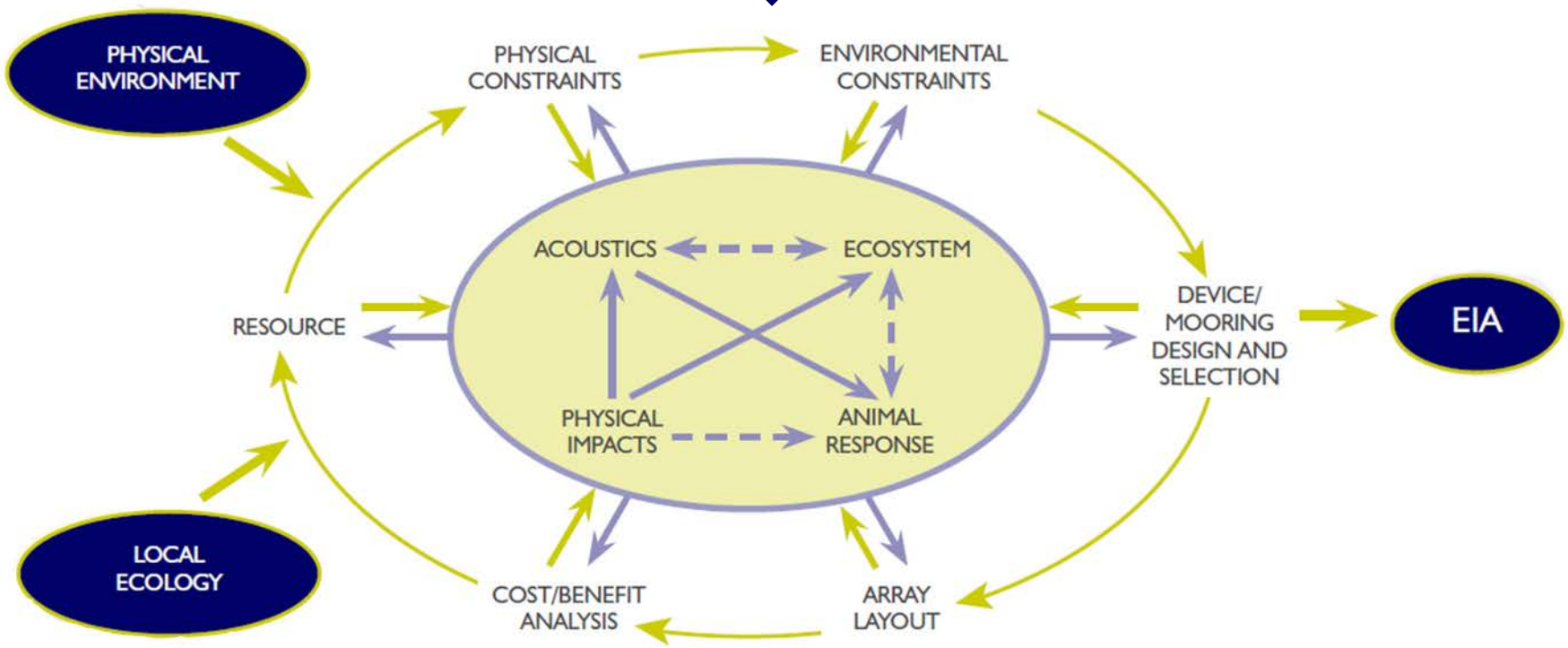
Overview

Aims:

- Identify issues of environmental concern and uncertainty
- Develop new modelling approaches to address these
- Demonstrate how the developed methodologies could be included in an integrated design process



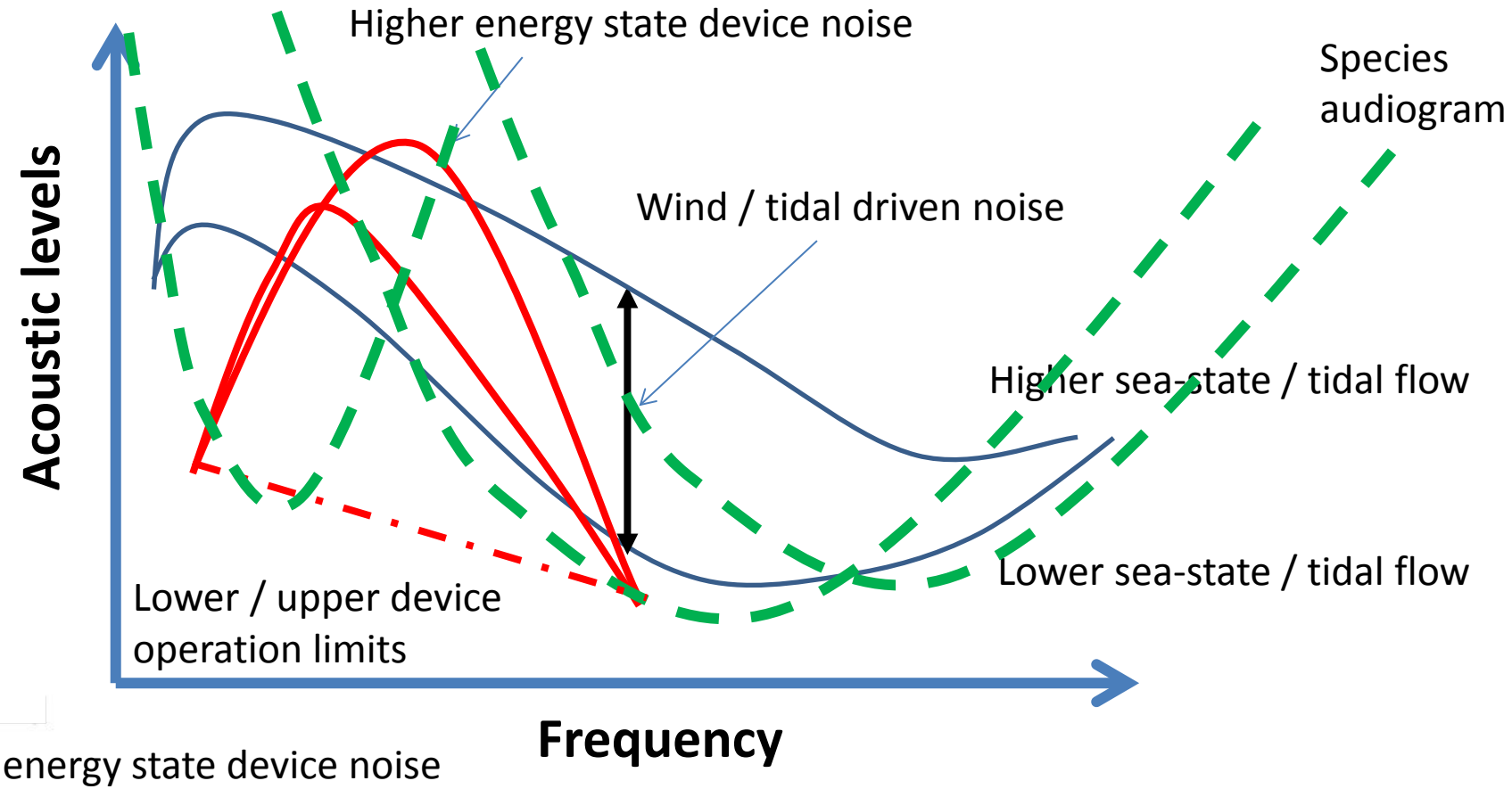

PHYSICAL ENVIRONMENT
RESOURCE
PHYSICAL CONSTRAINTS
ENVIRONMENTAL CONSTRAINTS
DEVICE/ MOORING DESIGN AND SELECTION
EIA
ARRAY LAYOUT
COST/BENEFIT ANALYSIS


PHYSICAL ENVIRONMENT
PHYSICAL CONSTRAINTS
ENVIRONMENTAL CONSTRAINTS
ACOUSTICS
ECOSYSTEM
RESOURCE
DEVICE/ MOORING DESIGN AND SELECTION
EIA
PHYSICAL IMPACTS
ANIMAL RESPONSE
LOCAL ECOLOGY
COST/BENEFIT ANALYSIS
ARRAY LAYOUT

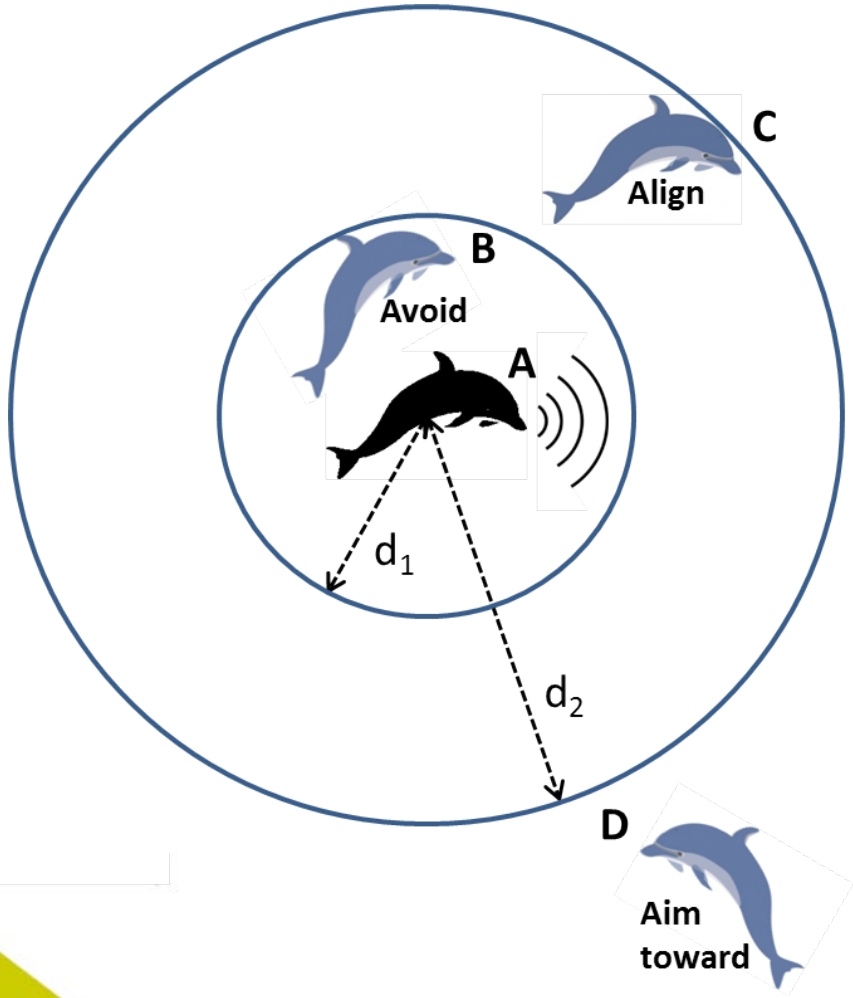
Key issues for consideration

1. Ratio of device to ambient noise
2. Reaction of individual animals to a single device
3. Large-scale acoustic exposure
4. Large-scale physical impacts
5. Large-scale ecosystem impacts

1. Ratio of device to ambient noise



2. Reaction of individual animals to a single device



Whistles between group members used for cohesion:

Close range: avoid

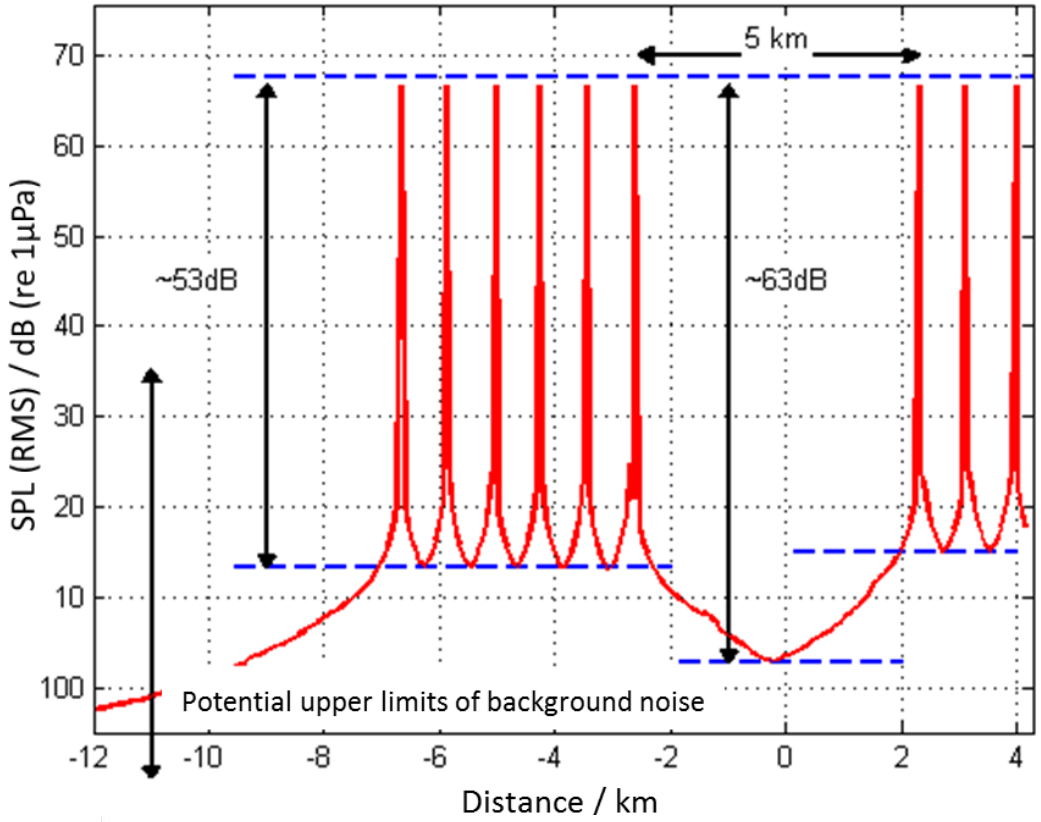
-------- 4m ---------

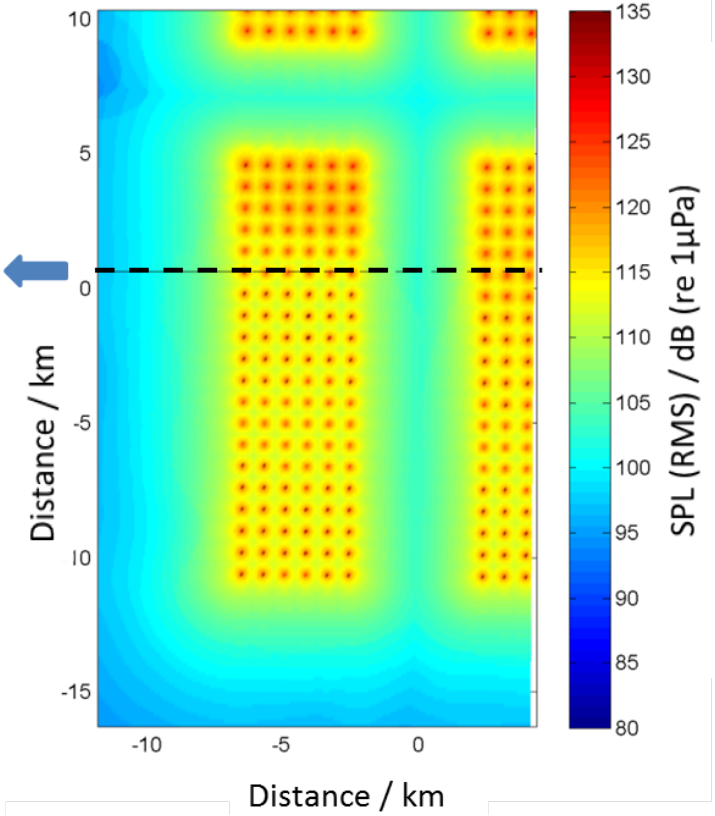
Medium range: align

-------- 10m ---------

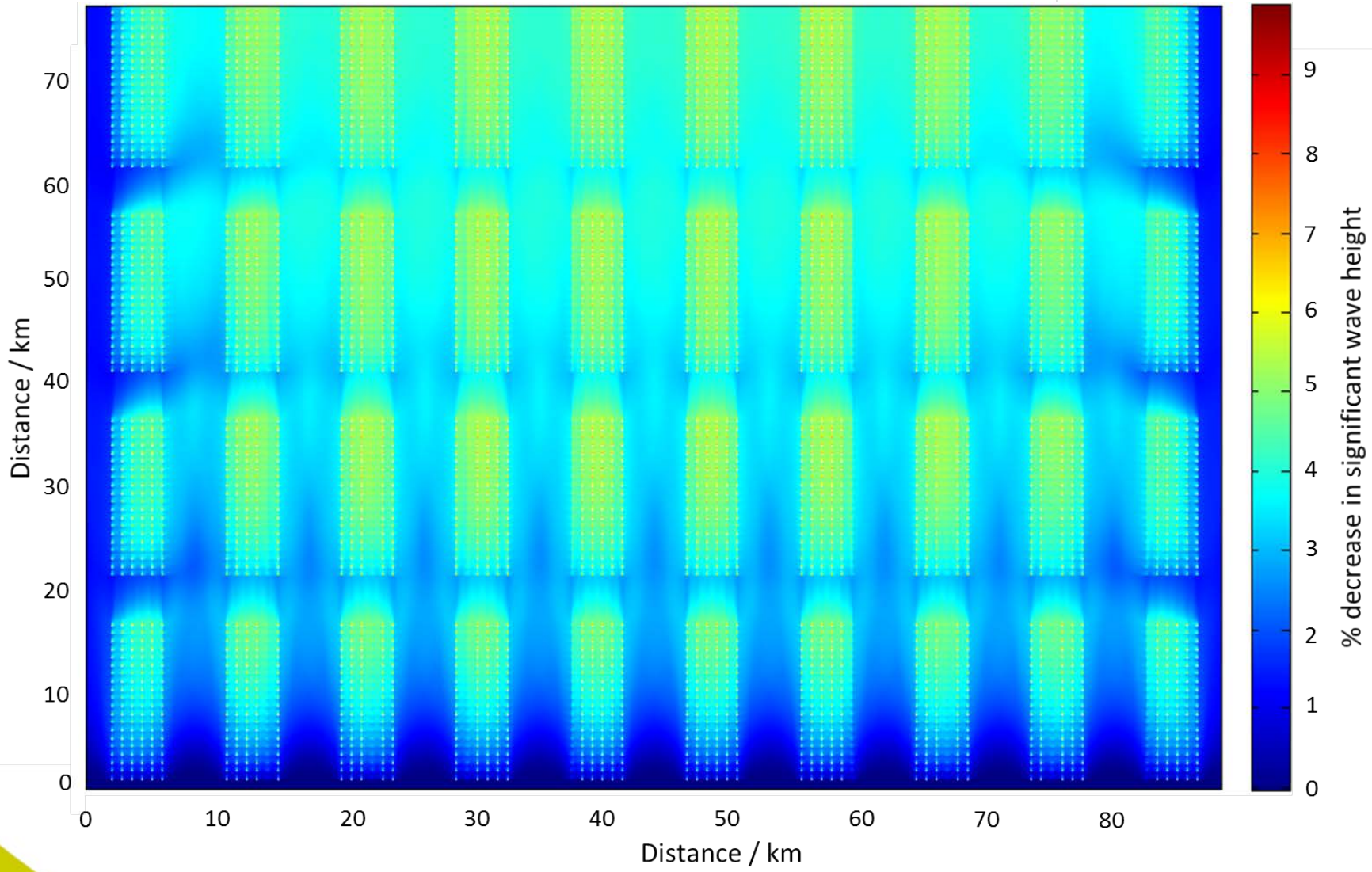
Long range: aim towards

3. Large-scale acoustic exposure

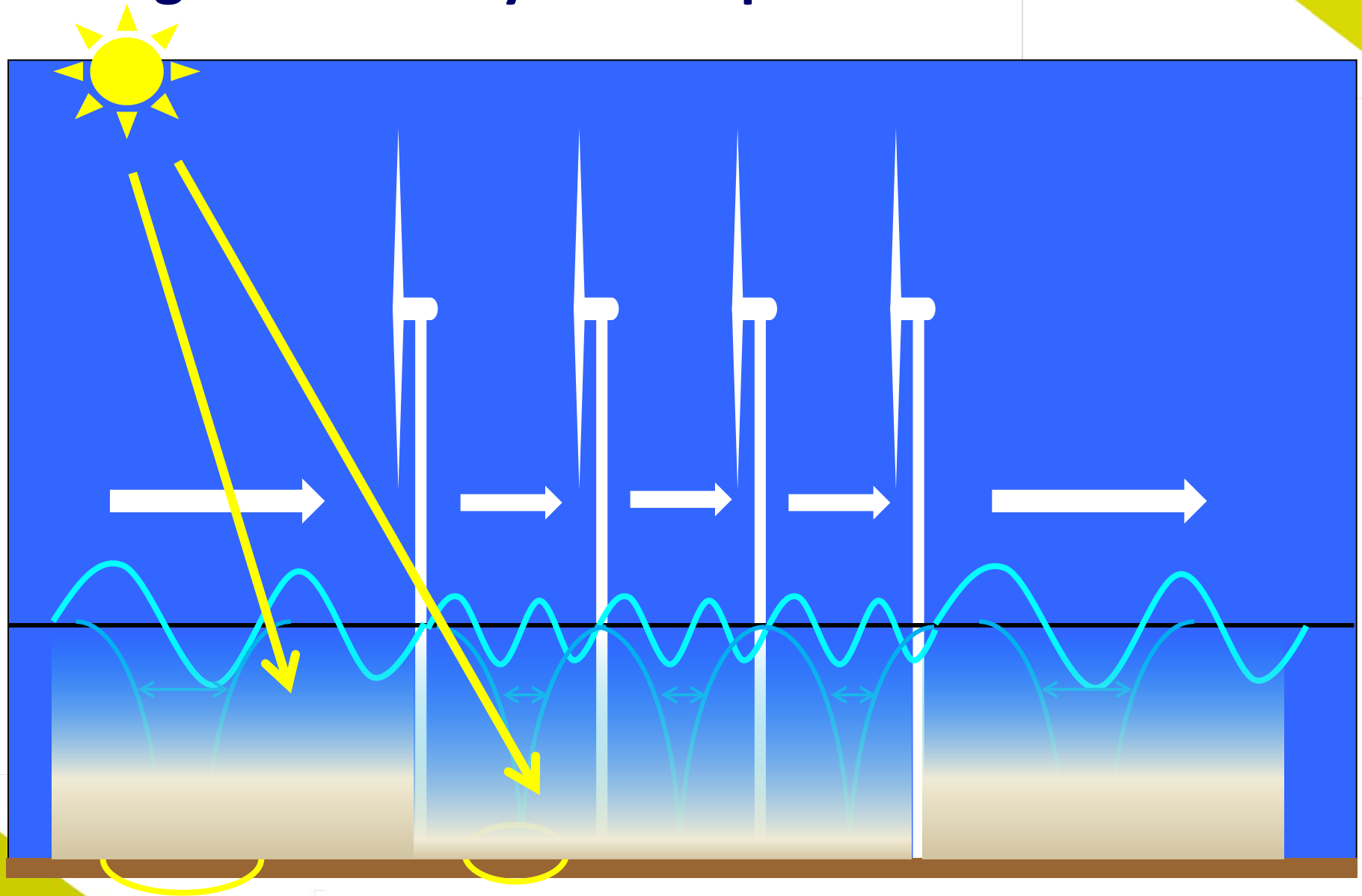




4. Large-scale physical impacts

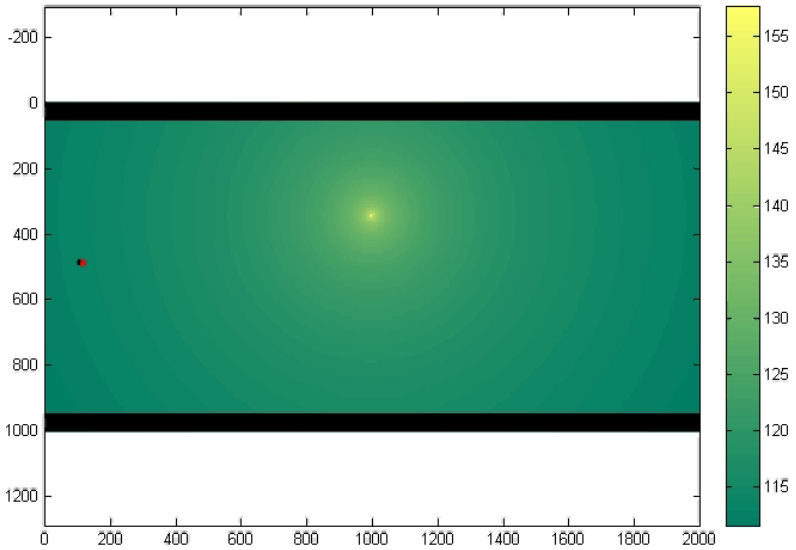


5. Large-scale ecosystem impacts



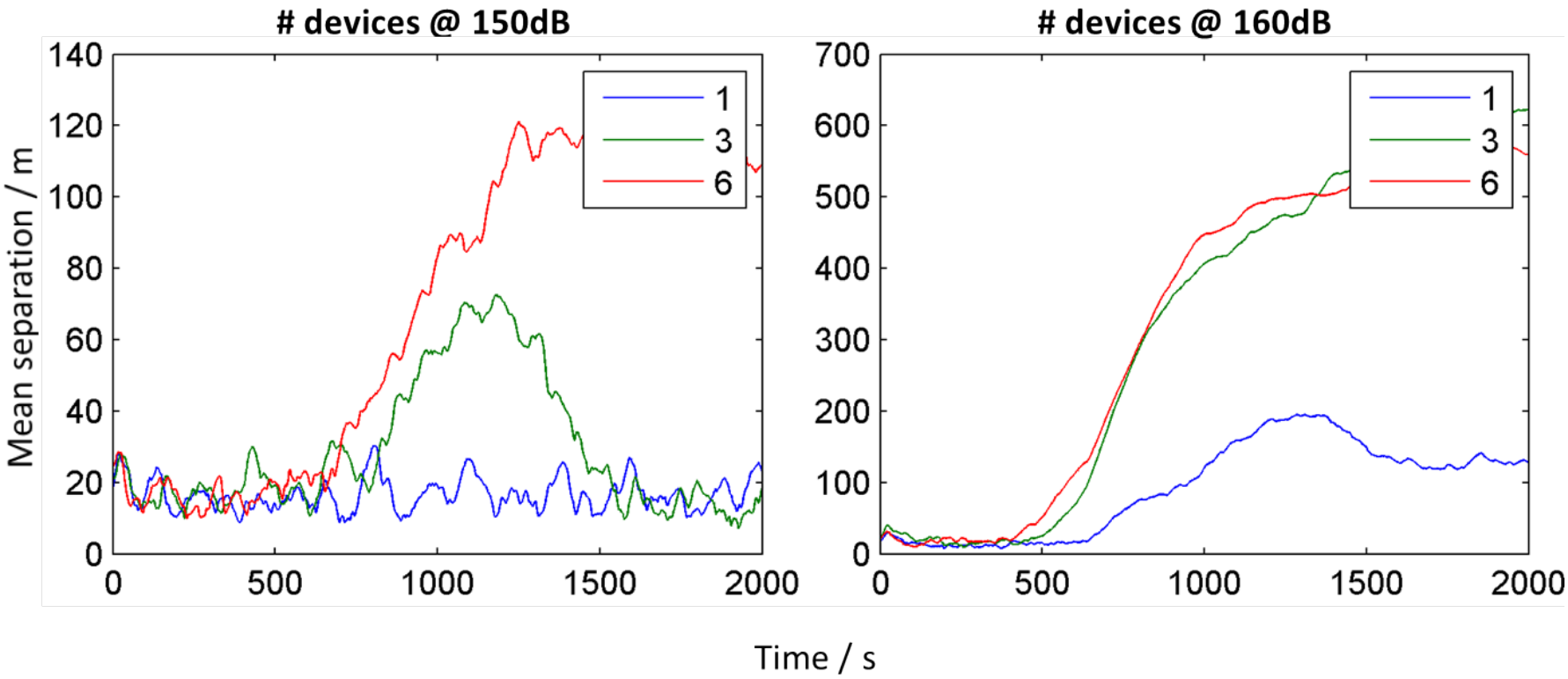
Case Studies

Case study 1: Marine mammal response to underwater noise



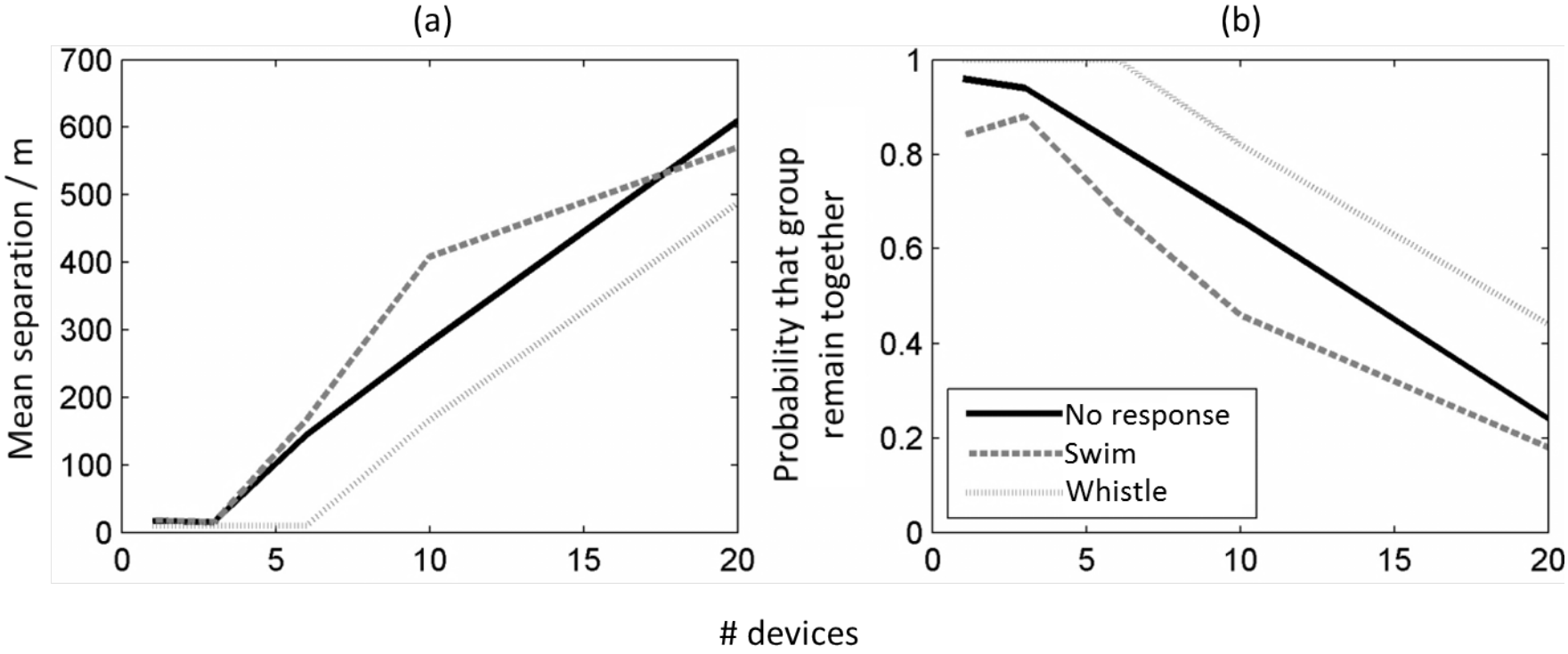
- Model developed to predict impact of device noise on groups of marine mammals
- Two scenarios investigated:
  - Channel containing up to six turbines
  - Area of open water containing up to 400 turbines
- Two group sizes considered:
  - 2 animals (e.g. mother and calf)
  - 10 animals
- Model uses swimming speed, random whistles emitted and probability of animal responding to predict response
- Standard formula for acoustic transmission loss applied

Case study 1: Marine mammal response to underwater noise



Mean separation between mother and calf over time due to device noise from up to six turbines in a tidal channel

Case study 1: Marine mammal response to underwater noise



Impact of altering behaviour for two animals swimming past devices in a channel.
a) Mean separation of animals after 50 simulation runs
b) Proportion of runs in which animals remain together in a tight group

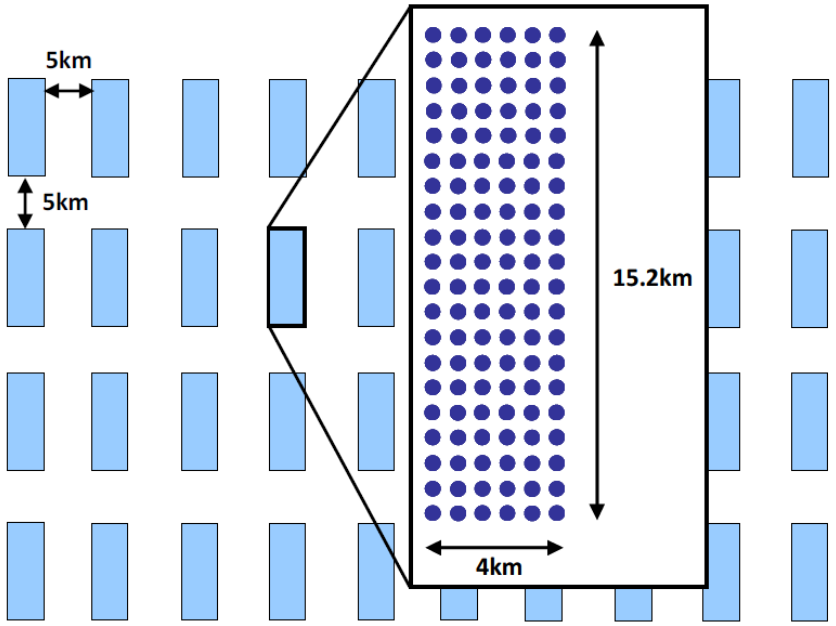
Case study 1: Marine mammal response to underwater noise

In summary:

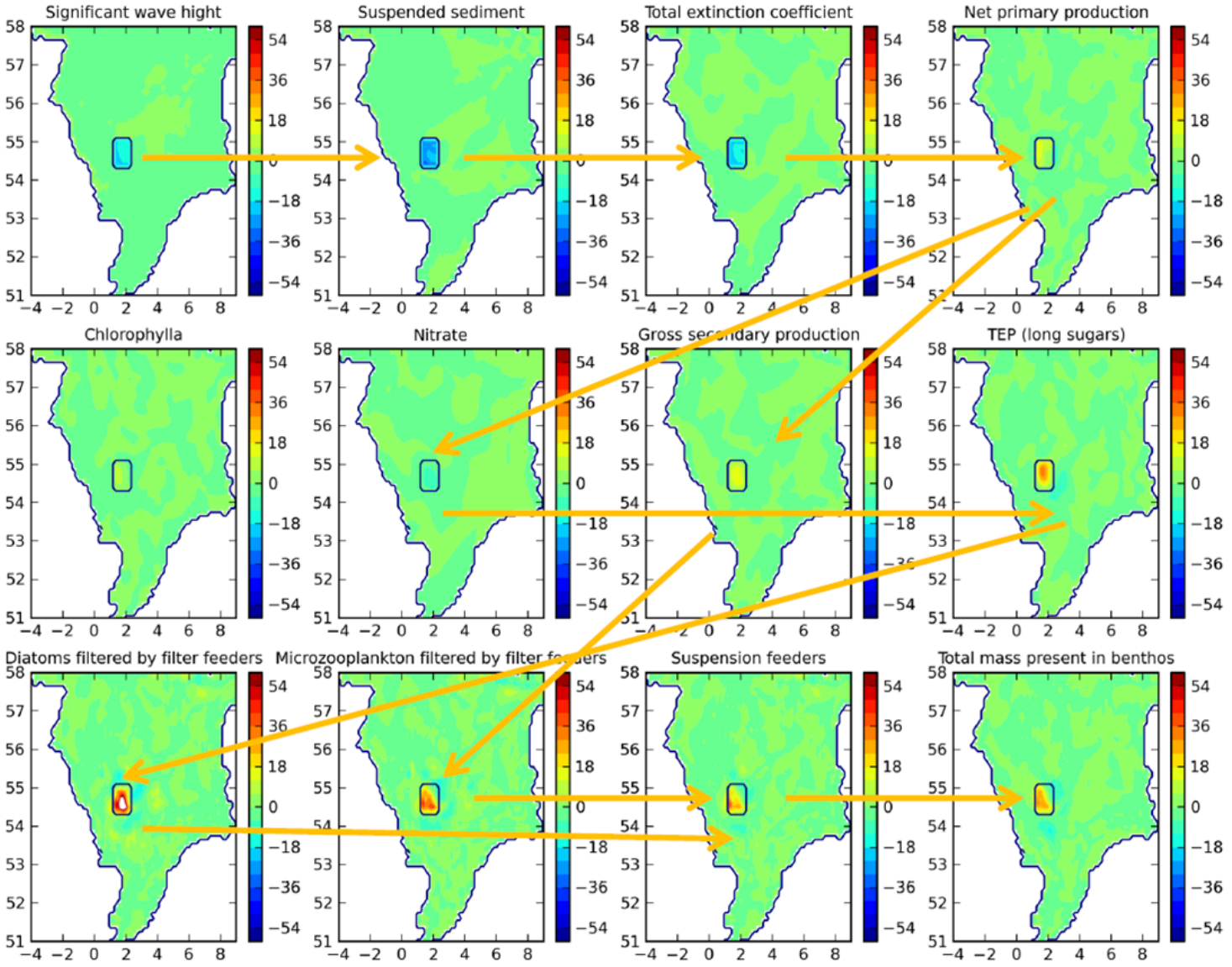
- Arrays of MRE devices have the potential to impact on the movement and group cohesion of marine mammals
- Impact of multiple devices is not simply additive
- Impact occurs across a wider area than the immediate region where the animal vocalisation is masked by device noise
- Device noise has the potential, in extreme cases, to lead to permanent separation between animals
- Range of animal behaviours may mediate impact and allow adaptation to future developments
- Regrouping downstream may be possible, particularly in high current speeds or if whistle levels are elevated

Case study 2: A multi-layered approach to assessing large-scale impacts

- Study based on very large (up to 4800 turbines) hypothetical offshore wind array
- Assumption made that array would be divided into smaller 'farms'
- Variations on farm and turbine spacing investigated
- Coupled physical-biogeochemical model (GETM and ERSEM-BFM) used to explore the potential effects of wind energy extraction across the array
- SWAN wave model used to validate predicted decrease in wave height across the array
- High resolution acoustic modelling study performed for the array, with each turbine modelled as an individual sound source



Case study 2: A multi-layered approach to assessing large-scale impacts



Case study 2: A multi-layered approach to assessing large-scale impacts

In summary:

- Large marine energy arrays have the potential to cause a small increase in food levels within the array
- The array area will experience reduced wave conditions but higher noise levels
- These factors combine to provide an attraction (increased food, calmer seas) offset by a deterrent (noise, obstacles) to marine species
- Combined impact will be highly dependent on array layout and distance from turbines
- A smaller number of more powerful turbines may cause less impact than larger numbers of smaller ones

NERC Impact Accelerator follow-on work

- Funded by University of Exeter's NERC Impact Accelerator Account
- Aim is to increase industry awareness of the project and engagement with the research
- Project includes interviews with industry developers, regulators and consultants
- Main output is a brochure providing a high-level overview of the project and its outcomes
- Feedback welcome!

Final thoughts

- EBAO project has demonstrated the value of a multi-disciplinary modelling approach
- Much of this work is ongoing, and there are many more interactions to explore
- Data sharing is increasingly important
- There is potential environmental value in incorporating such studies into the array design process – improved communication between environmental scientists and project developers is vital.

NERC SCIENCE OF THE ENVIRONMENT

Department for Environment Food & Rural Affairs

Thank you

h.c.m.smith@exeter.ac.uk

THE UNIVERSITY OF EDINBURGH

UNIVERSITY OF EXETER

Loughborough University

SCOTTISH ASSOCIATION for MARINE SCIENCE

Cefas

Sea Mammal Research Unit

EBAO