# MERIKA

Marine Energy Research Innovation and Knowledge Accelerator

# University of the Highlands and Islands Breakfast Showcase

## SR Marine Conference
## September 2016

merikafp7.eu

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The MERIKA Project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 315925.

University of the Highlands and Islands
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MERIKA

Marine Energy Research Innovation and Knowledge Accelerator

University of the Highlands and Islands
Lews Castle College
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Colaisde a' Chaisteil

# Resource and Risk Mitigation

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HIE
Highlands and Islands Enterprise
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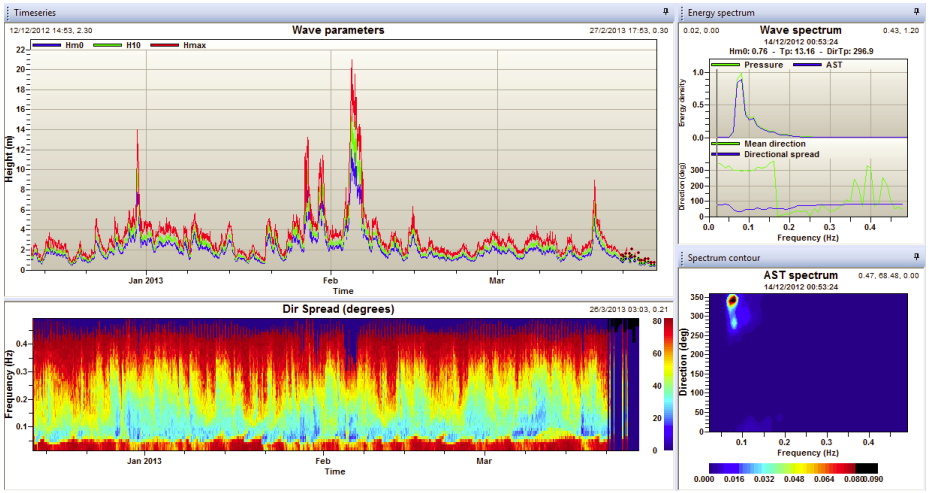
# Introduction/ Background

- Hebridean Marine Energy Futures
  - Wave Data Collection
  - Resource Model
  - Industry Partners



# Location

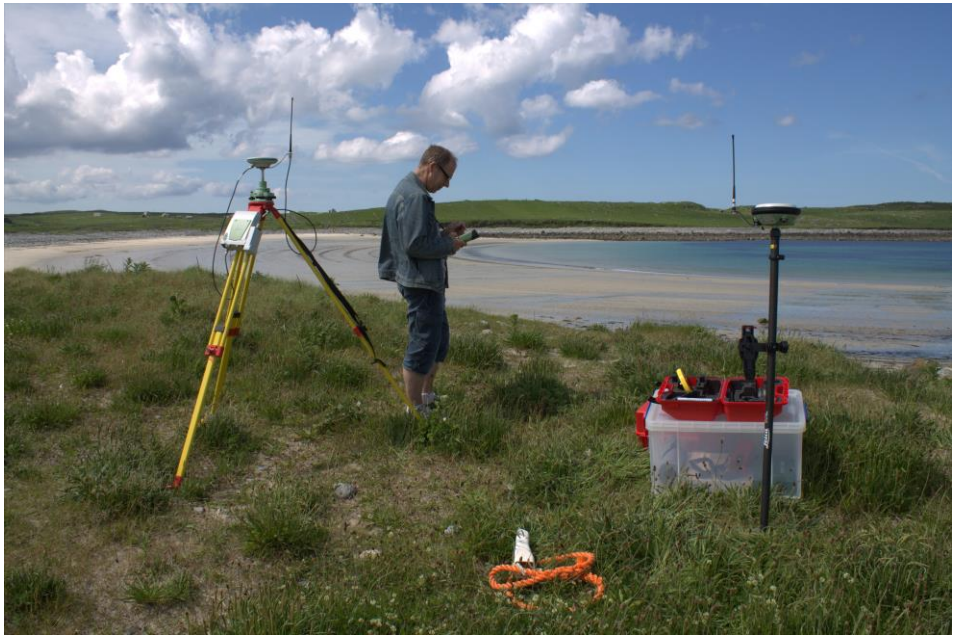
- Large numbers of Wave and tidal sites
  - EMEC
  - West of Hebrides
  - Addition isolated sites

# Surveying

RTK (Real Time Kinematic) GPS

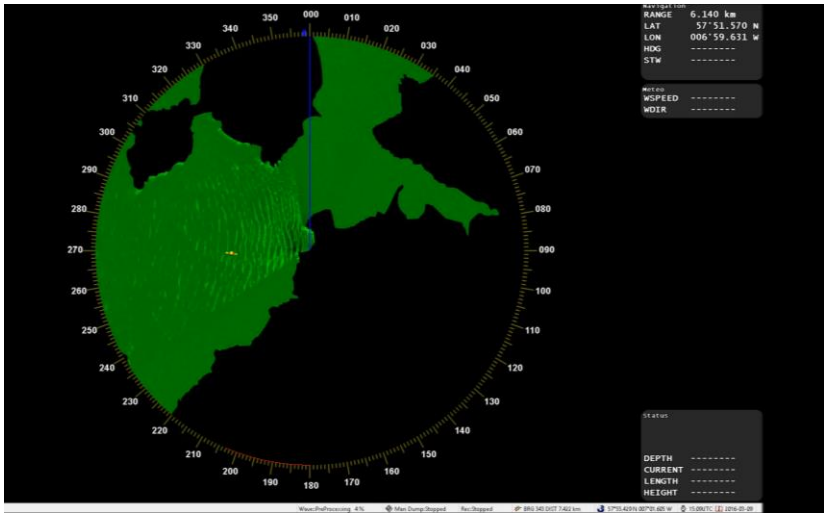
Lica GS15 SmartRover

- Beach morphology

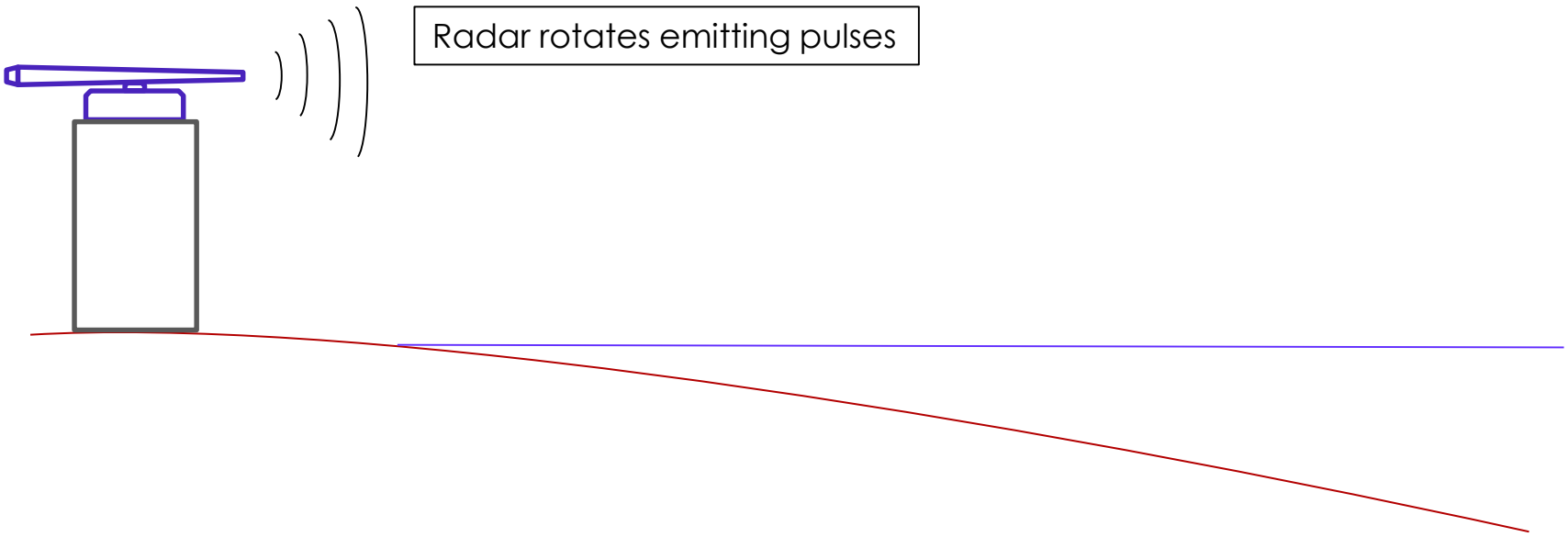


# SeaDarQ X band Radar

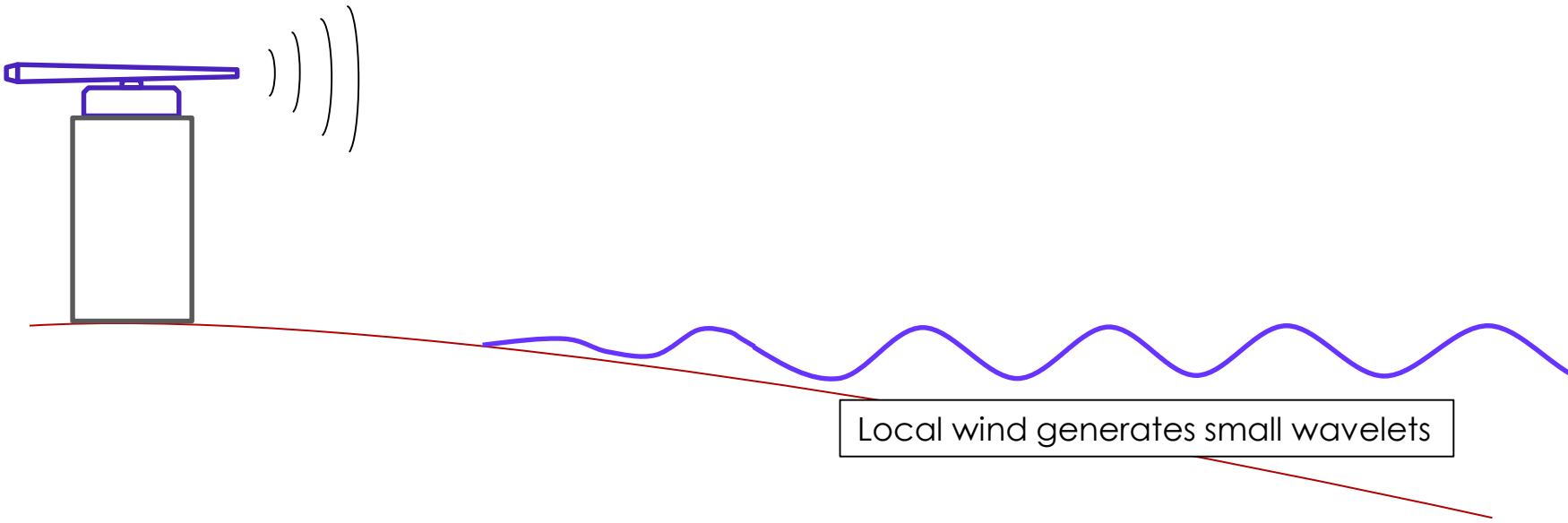
- Range up to 6.5 km
- Sample rate 1.33 seconds
- 5-10 m spatial resolution
- 360°
- PRF 1800 Hz @25kW



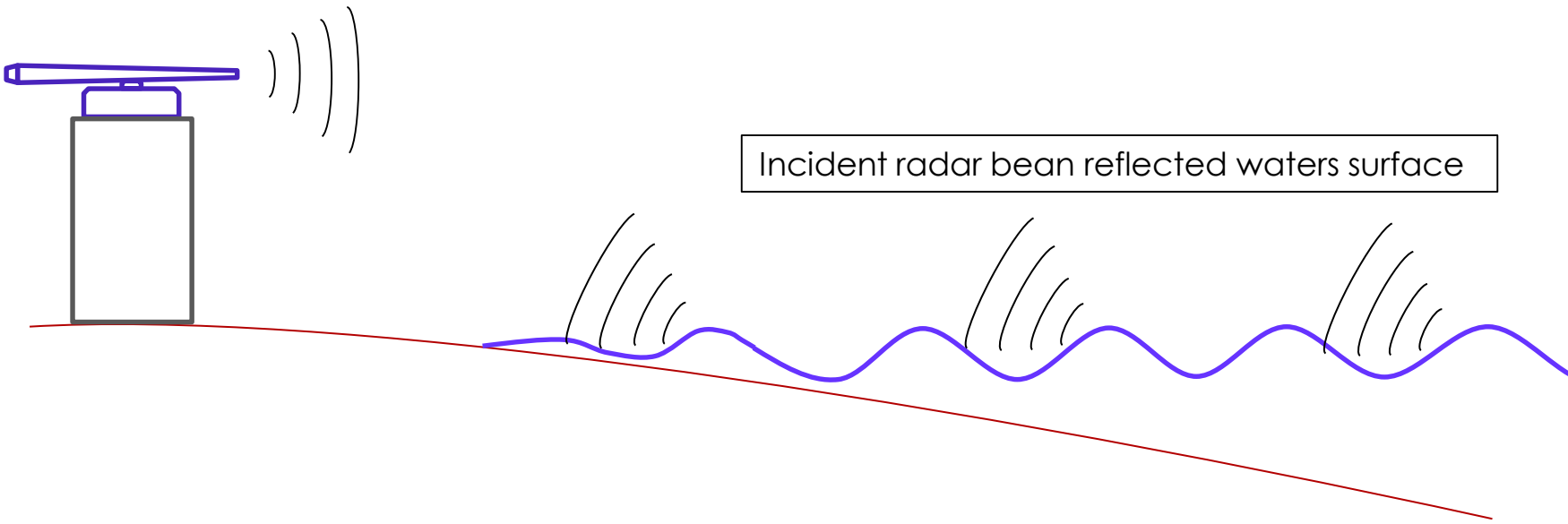
# SeaDarQ X band Radar



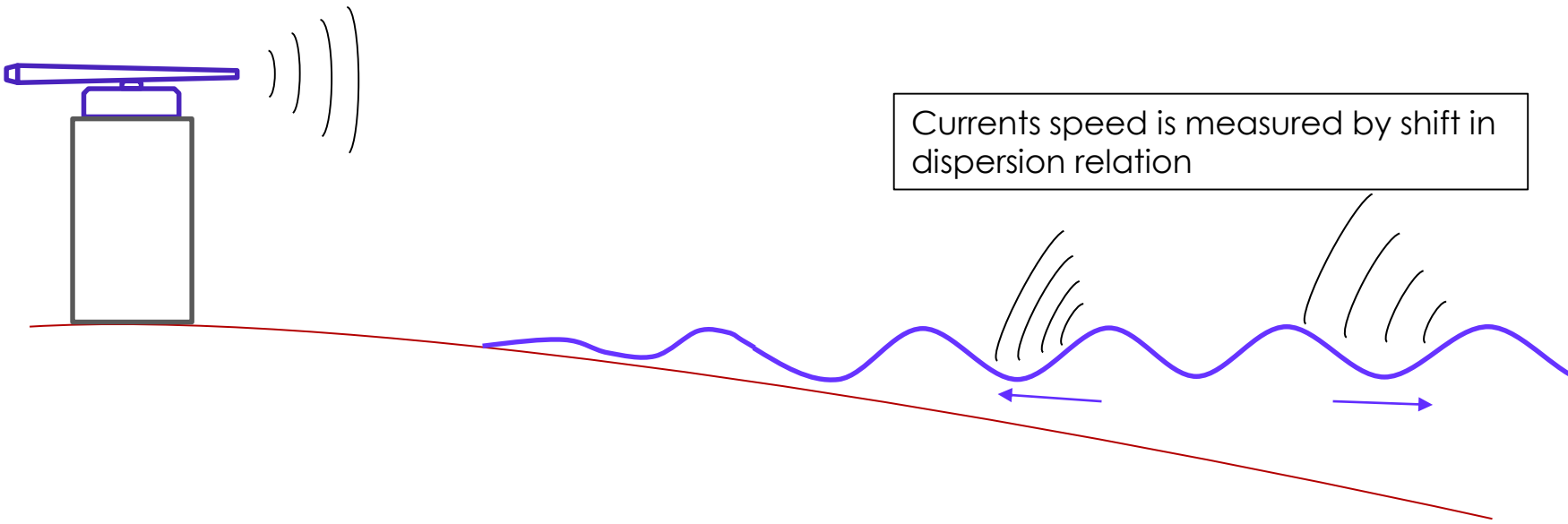
# SeaDarQ X band Radar



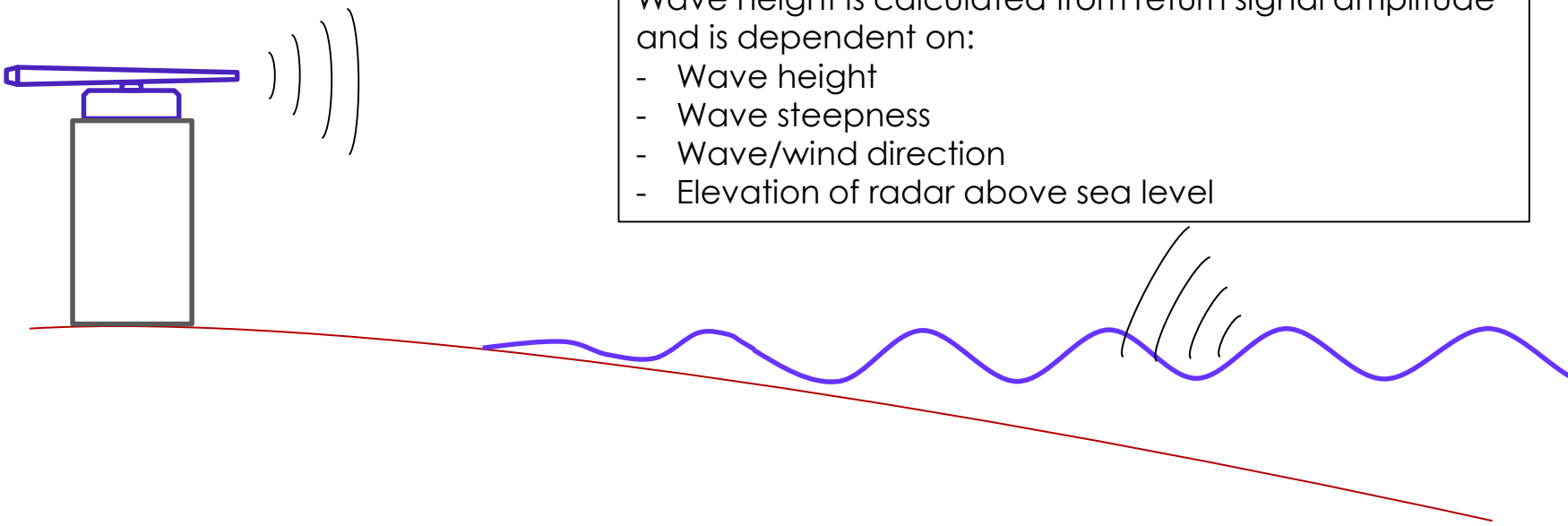
# SeaDarQ X band Radar



# SeaDarQ X band Radar



# SeaDarQ X band Radar



Wave height is calculated from return signal amplitude and is dependent on:

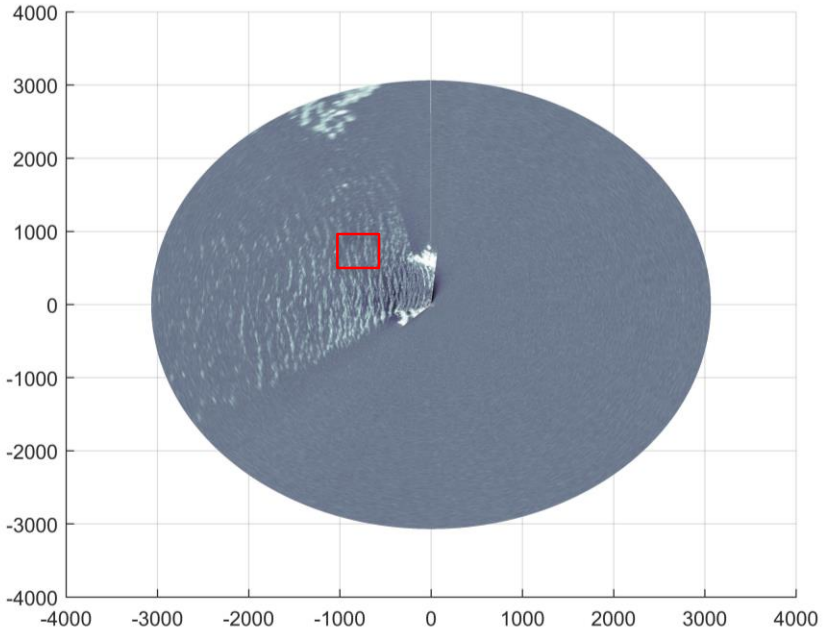
- Wave height
- Wave steepness
- Wave/wind direction
- Elevation of radar above sea level

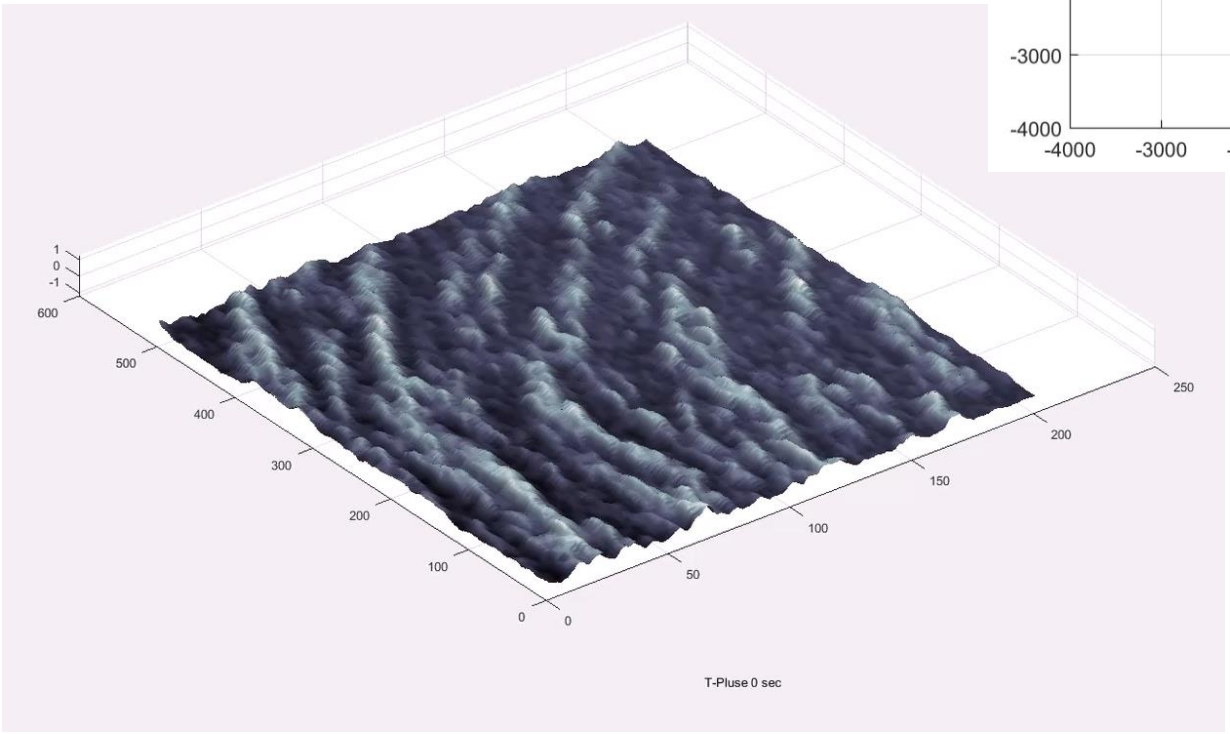
# Deployment 1 - Taransay

- 2-day deployment
- 250Gb
- Range 3 km
- 3 in situ sensors
- Focusing on **wave** measurements

# Deployment 1 - Taransay

Approximation of surface elevation



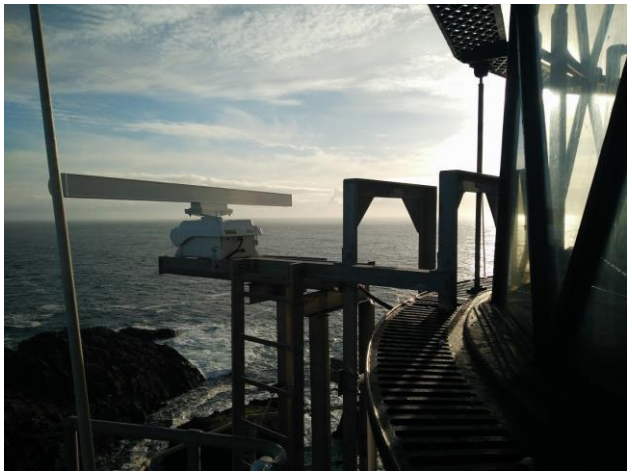



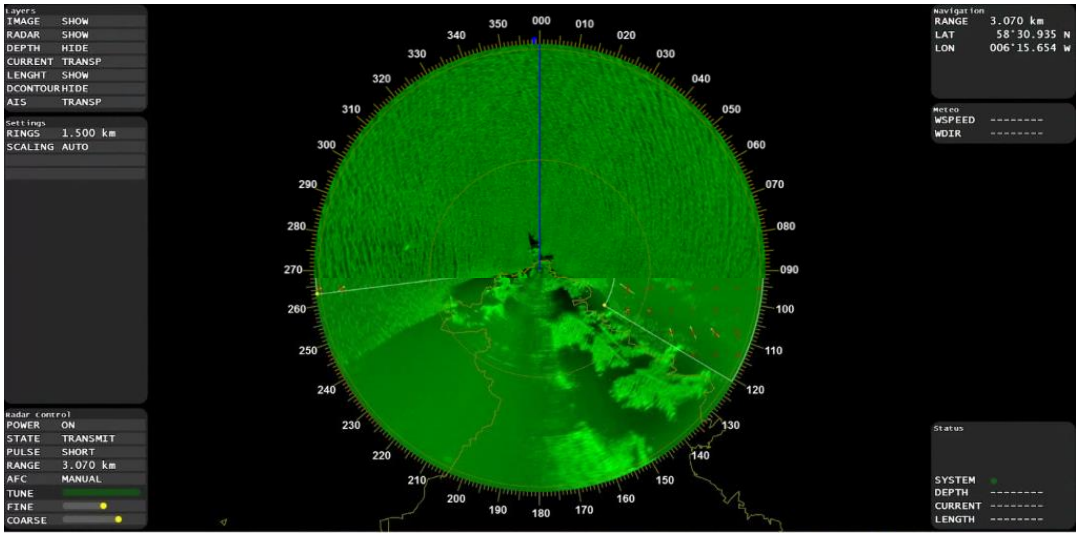
# Deployment 2 – Falls of Warness

- 3-day deployment
- 800Gb
- Range 3 km
- Multiple in situ sensors collaborating with FlowTurb project
- Focusing on current measurements

# Deployment 3 – Butt of Lewis

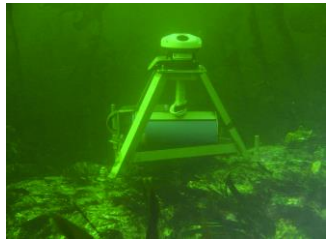
- 1 year
- Estimated 75 Tb
- Range 3 km
- 2 wave buoy
- Both wave and current measurements

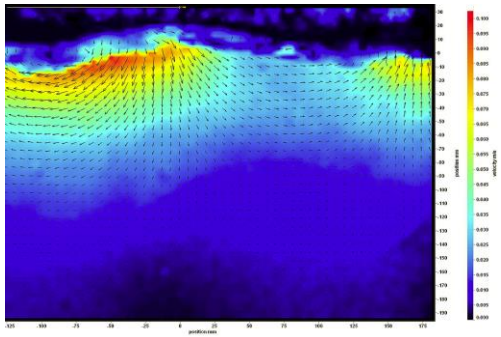




# Deployment 3 – Butt of Lewis

# Other Activities





- Project management and delivery
- Wave and tidal modelling
- Computational fluid dynamics (CFD)
- Resource assessment
- Wave tank testing
- Beach morphology survey
- Side scan sonar
- Magnetometer
- Drop down camera
- Divers
- ADCP AD2CP AWAC Wave Buoys, CPD, RTK

MERIKA

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eri environmental research institute

# The effects of marine renewable energy devices on the environment and ecology

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# Environmental Research Institute

University of the Highlands and Islands

North Highland College

Environmental Research Institute

- Research
- Enterprise
- Teaching Learning
- Outreach

Research:

- Carbon, Water & Climate
- Environmental contamination & ecological health
- Renewable energy & the environment

**Marine energy**
*Resource & risk*
*Physical oceanography*
*Modelling*

**Marine energy**
*Environmental*
*Ecological interactions*

**Renewable energy**
*Socio-economics*

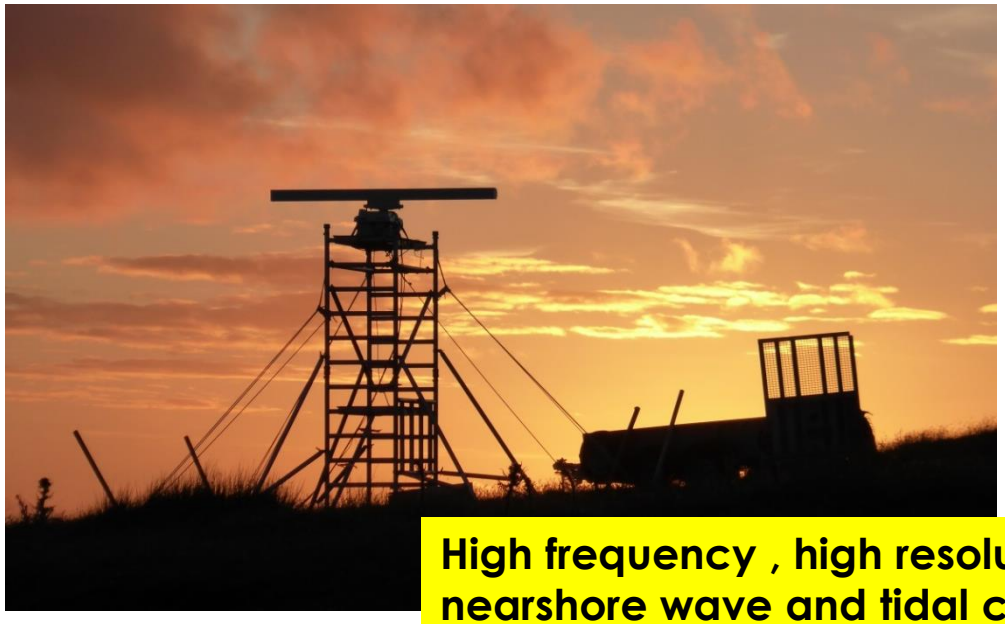
**Bio-energy**

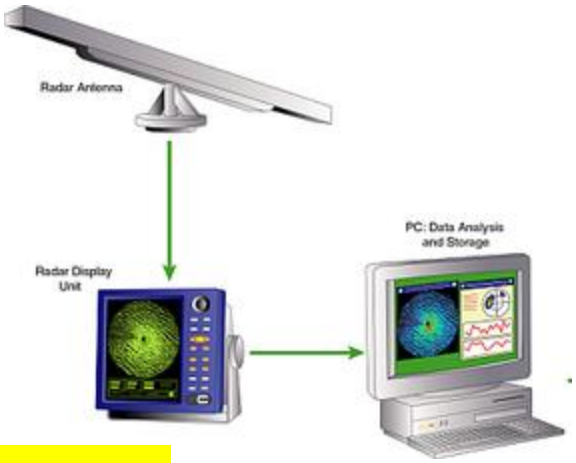

*Courtesy Philippe Gleizon*

# Measuring the wave and tidal environmental with novel technology


**UAV**

- Unmanned Aerial Vehicle (also known as Remotely Piloted Aircraft, RPAs).
- Sensor package of specialist cameras e.g. hyperspectral imagers
- Surveying of coastal areas and inshore wate
  - Turbulence
  - Suspended sediment plumes
  - Coastal morphology






**High frequency , high resolution nearshore wave and tidal current data**

**And .....**

Waverider buoys

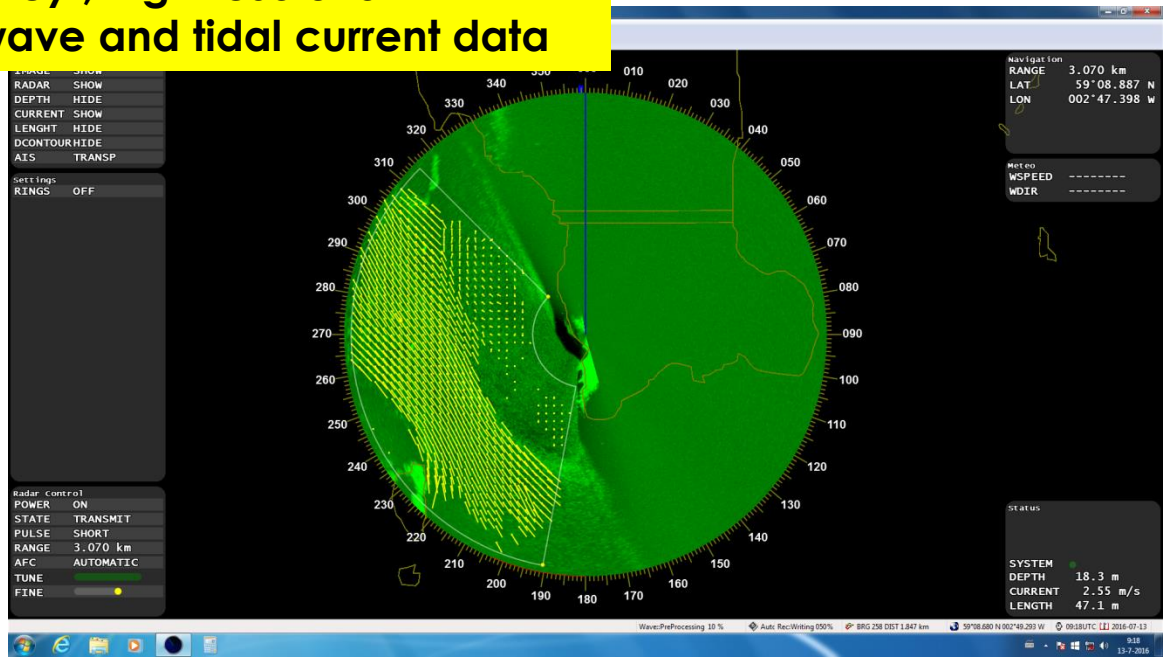
ADCPs, AWAC, current meters

Multi-frequency sidescan sonar

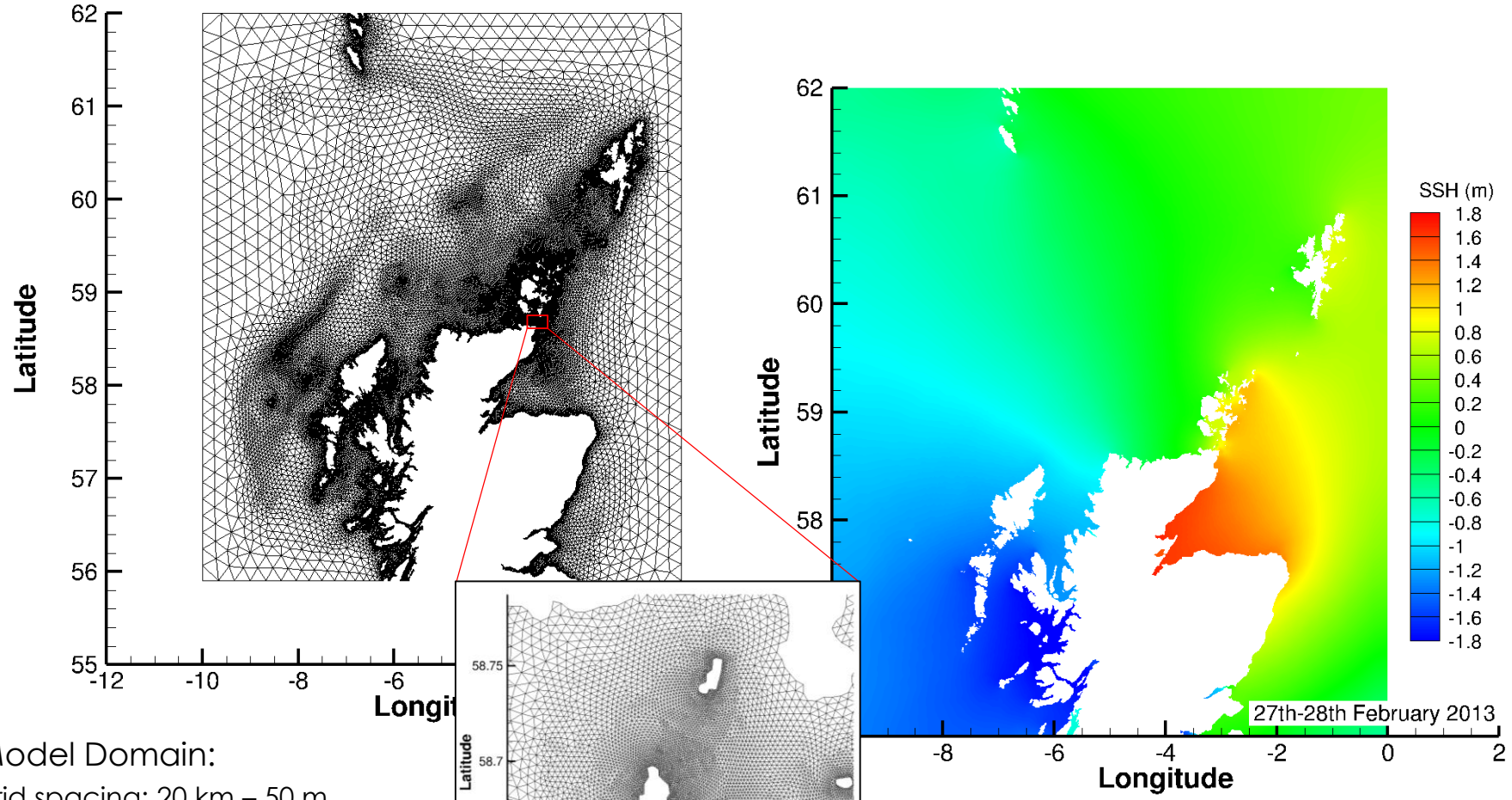
CTD

ROV

etc.



# Hydrodynamic Model Development & Application
# River and Coastal Ocean, unstructured mesh model

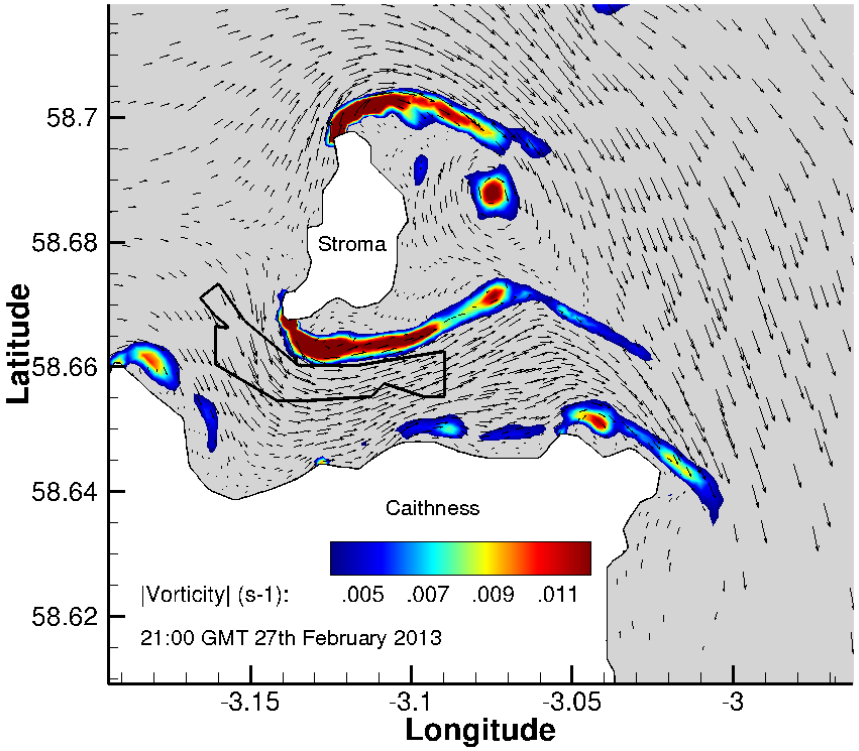



Model Domain:

Grid spacing: 20 km – 50 m
No. Nodes: 167963
No. Elements: 80378
Drag coeff $C_D$ = 0.004
Time step: 36 s
34 days takes: ~ 80 mins (2D)
(8 cores) ~ 6 hrs (3D)

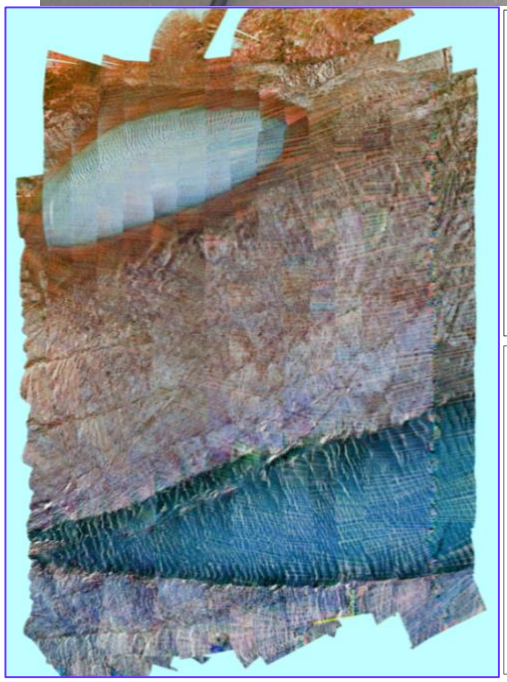
Boundary Forcing:
7 tidal constituents: $M_2$, $S_2$, $N_2$, $O_1$, $K_1$, $Q_1$, $M_4$
Reconstructed sea level along open boundary from OTPS (OSU)

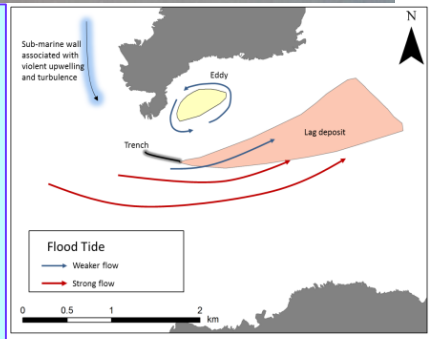
# Tidal currents, eddies and turbulence

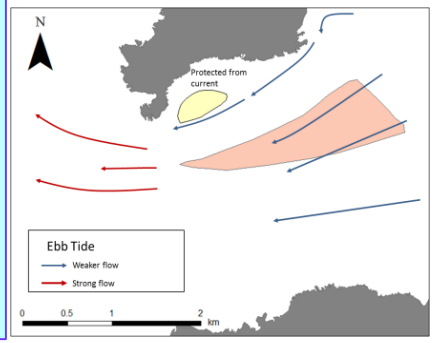



Modelled absolute vorticity through the Inner Sound on 27th – 28th February 2013. Values less than 0.005 $s^{-1}$ are not coloured, to highlight eddies and high shear zones. The Meygen lease area (solid line)

**Multi-frequency Sonar**

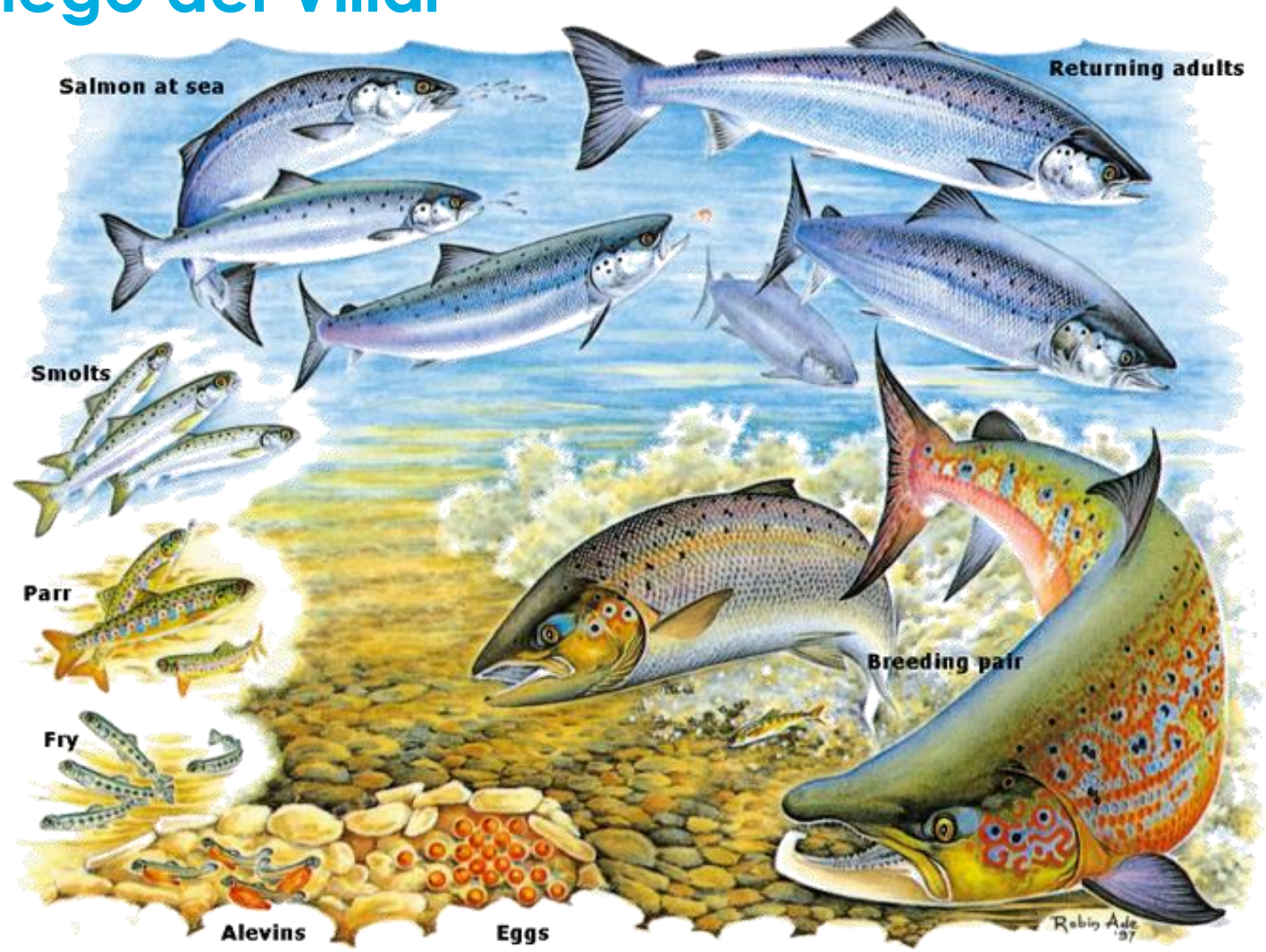




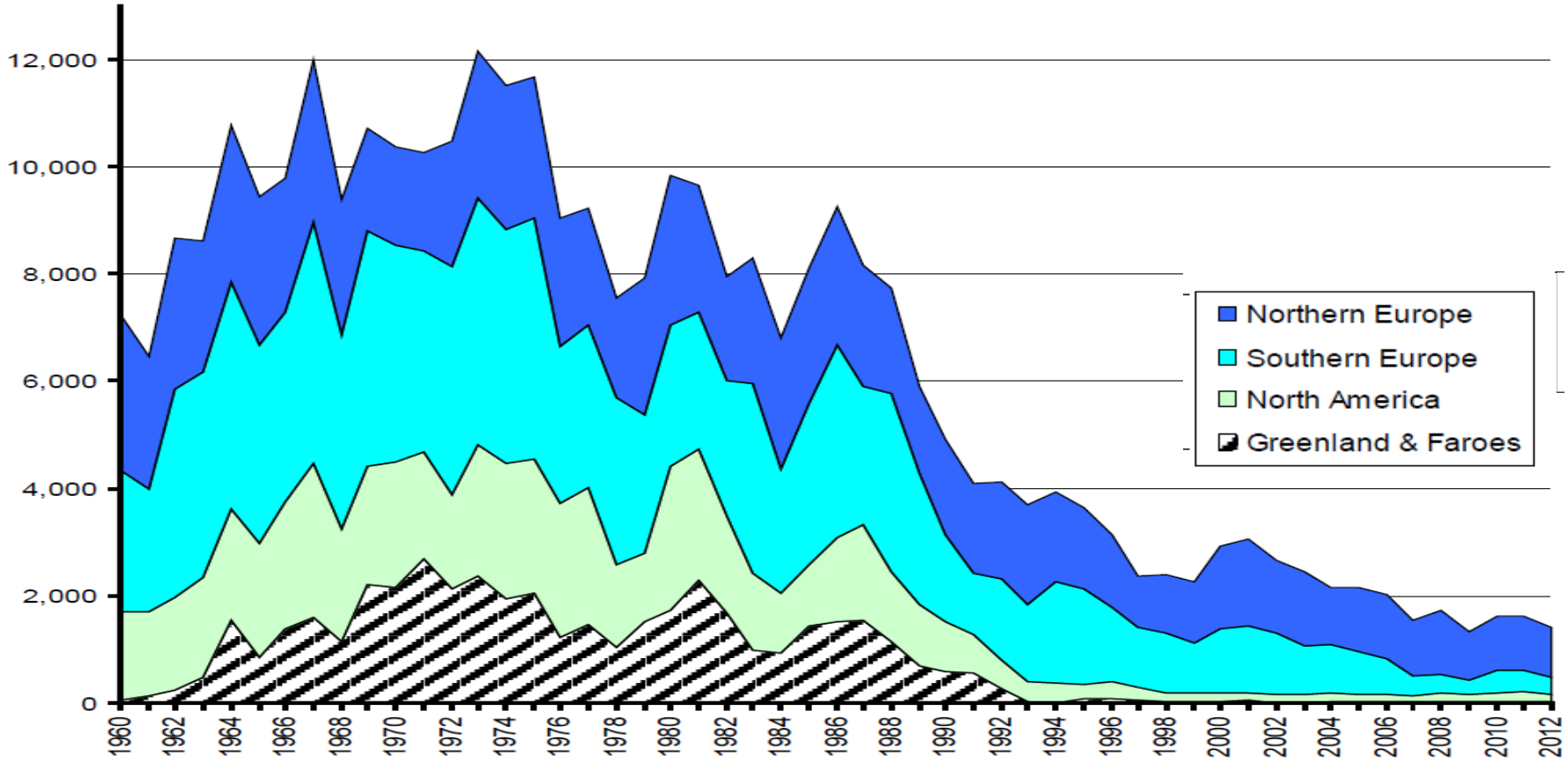




The pattern and strength of tidal current flow within the inner sound has sorted the available sediment into distinct sediment banks (right). A sharply defined sand bank lies beneath the trapped eddy, whereas a bed of shell fragments are found in the higher current area. Sediment dynamics in the area may be inferred from the combined modelling and observations (far right).

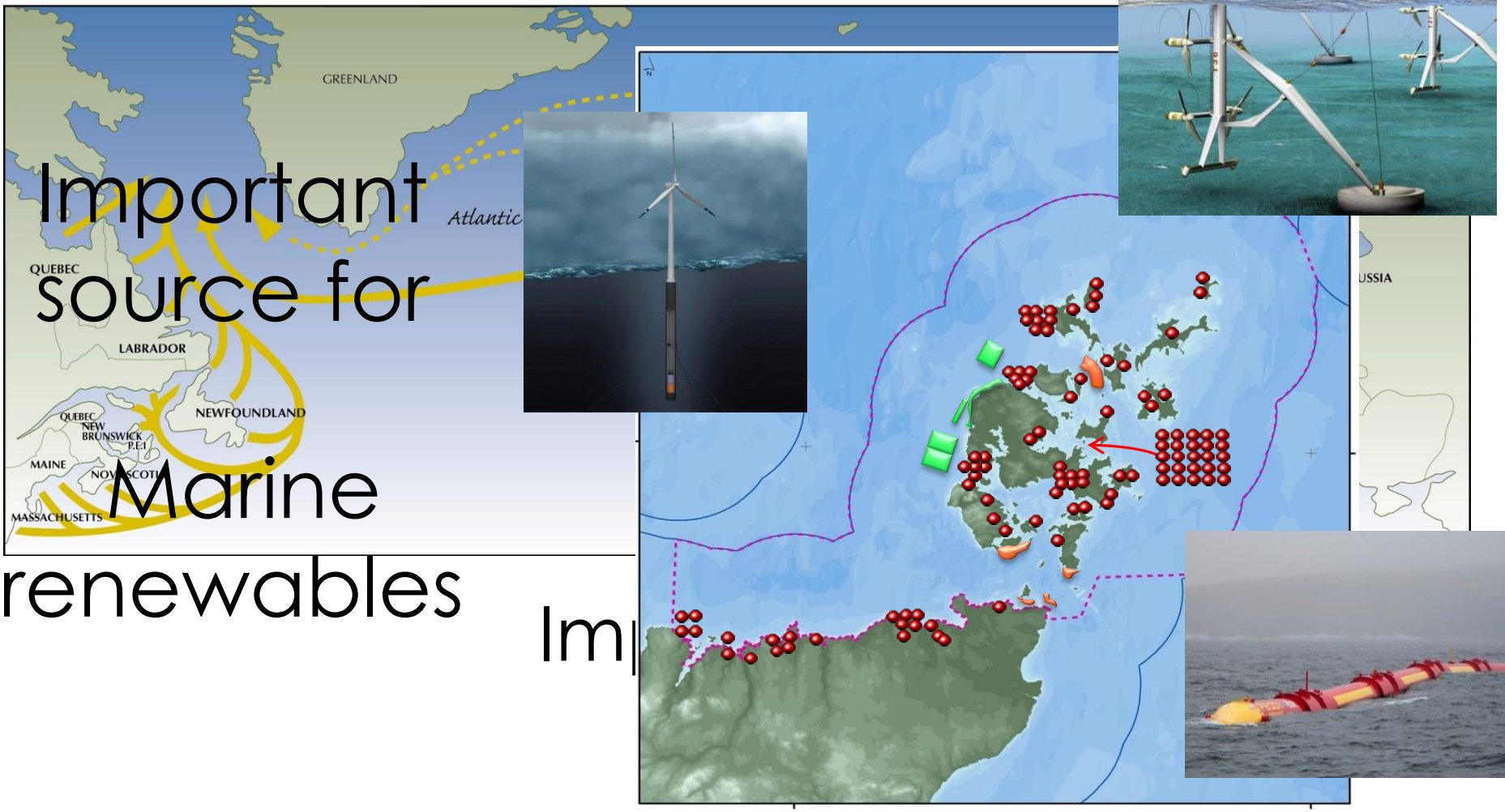
# The Wick Smolt Tracking Project
# Dr Diego del Villar



# Salmon stocks are decreasing



# The Pentland Firth




Important source for Marine renewables

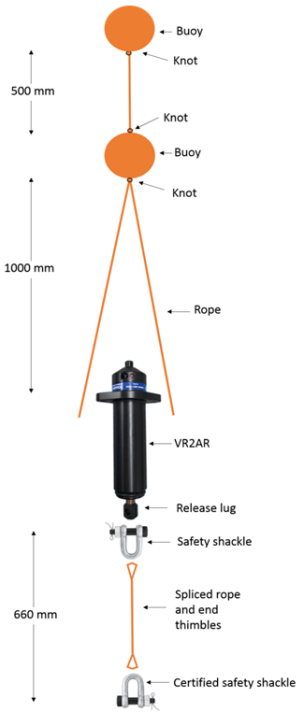
Im

around Europe

# Acoustic tracking

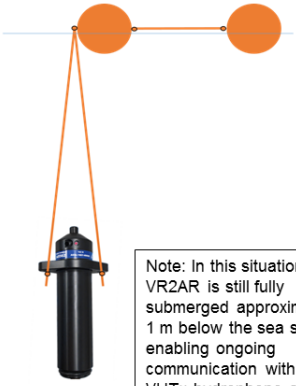


**1- Acoustic receiver. Deployed on the sea bed at 10-20 m depth. All parts of the mooring and floatation system**




**2- The floatation system in operation after acoustic release mechanism is activated. Sea bed anchor (30-35 kg).**

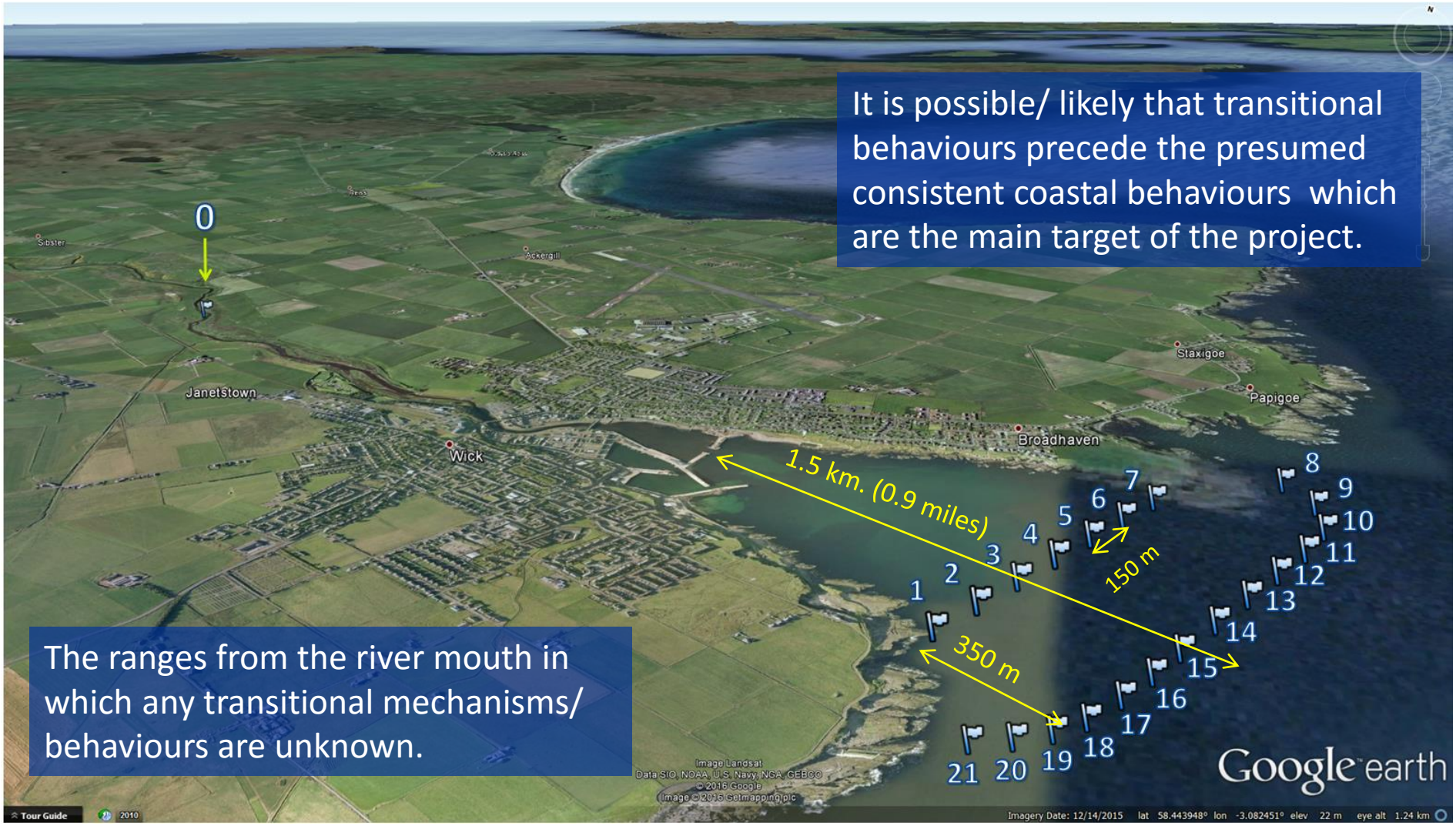

**3- The floatation system at surface awaiting recovery by grappling hook or gaff between the two buoys to insure the VR2AR unit is not damaged by the hook**

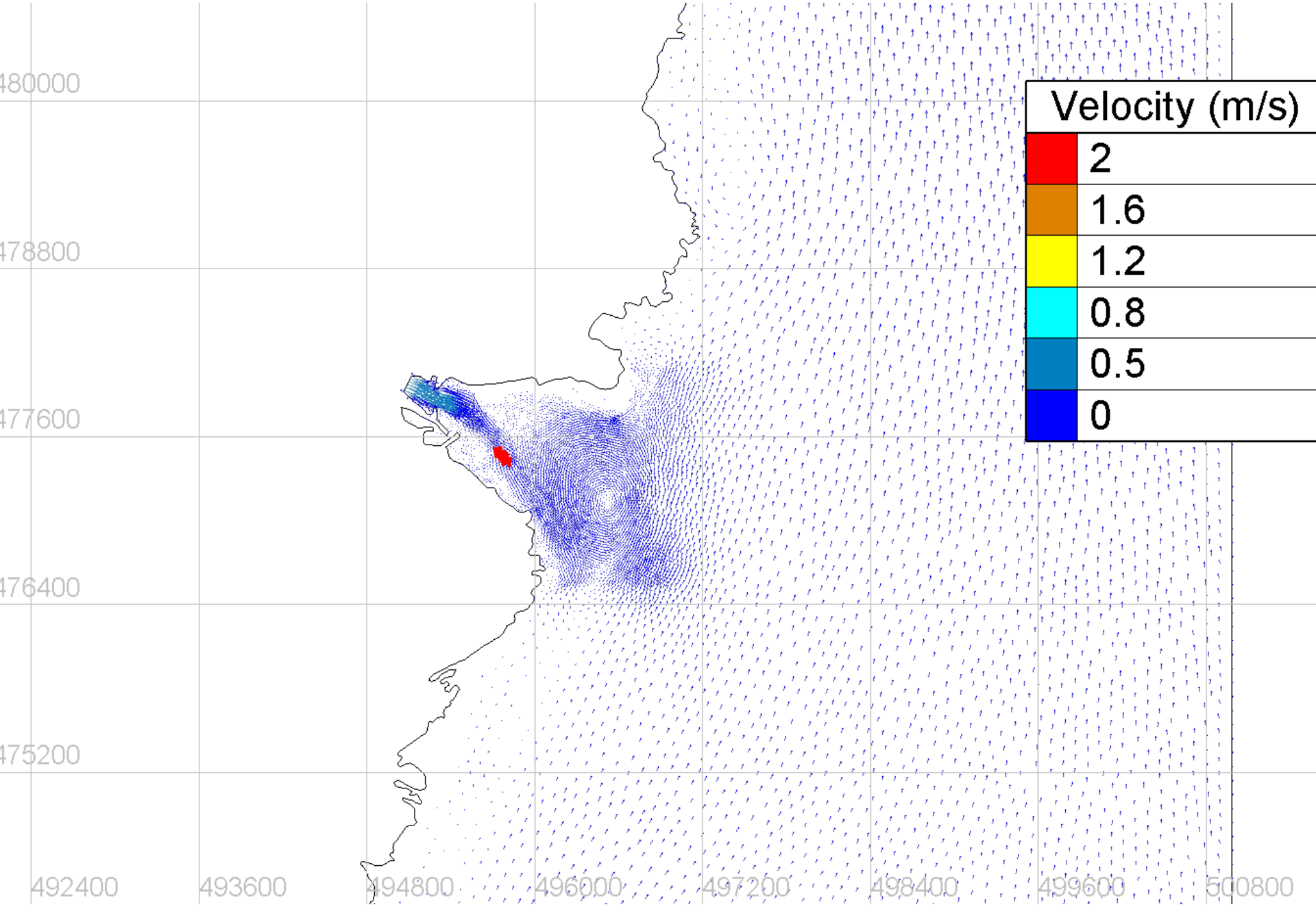


Note: In this situation the VR2AR is still fully submerged approximately 1 m below the sea surface enabling ongoing communication with the VHTx hydrophone and VR100-200 to assist with location and recovery.

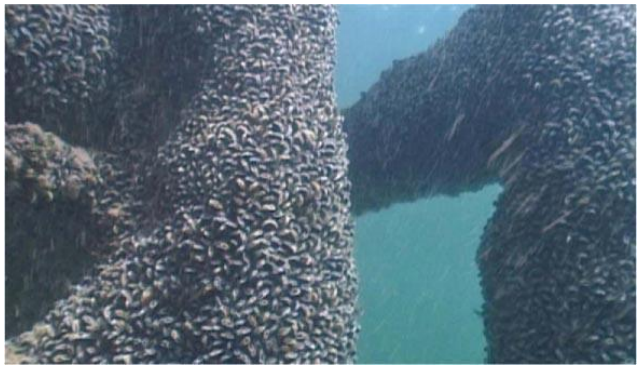
**Vemco VR2W**
**Acoustic receivers**
**used to track fish in open waters**

# “The arc-based design”
# A hypothesis-driven design




Velocity (m/s)
2
1.6
1.2
0.8
0.5
0
480000
478800
477600
476400
475200
492400
493600
494800
496000
497200
498400
499600
500800

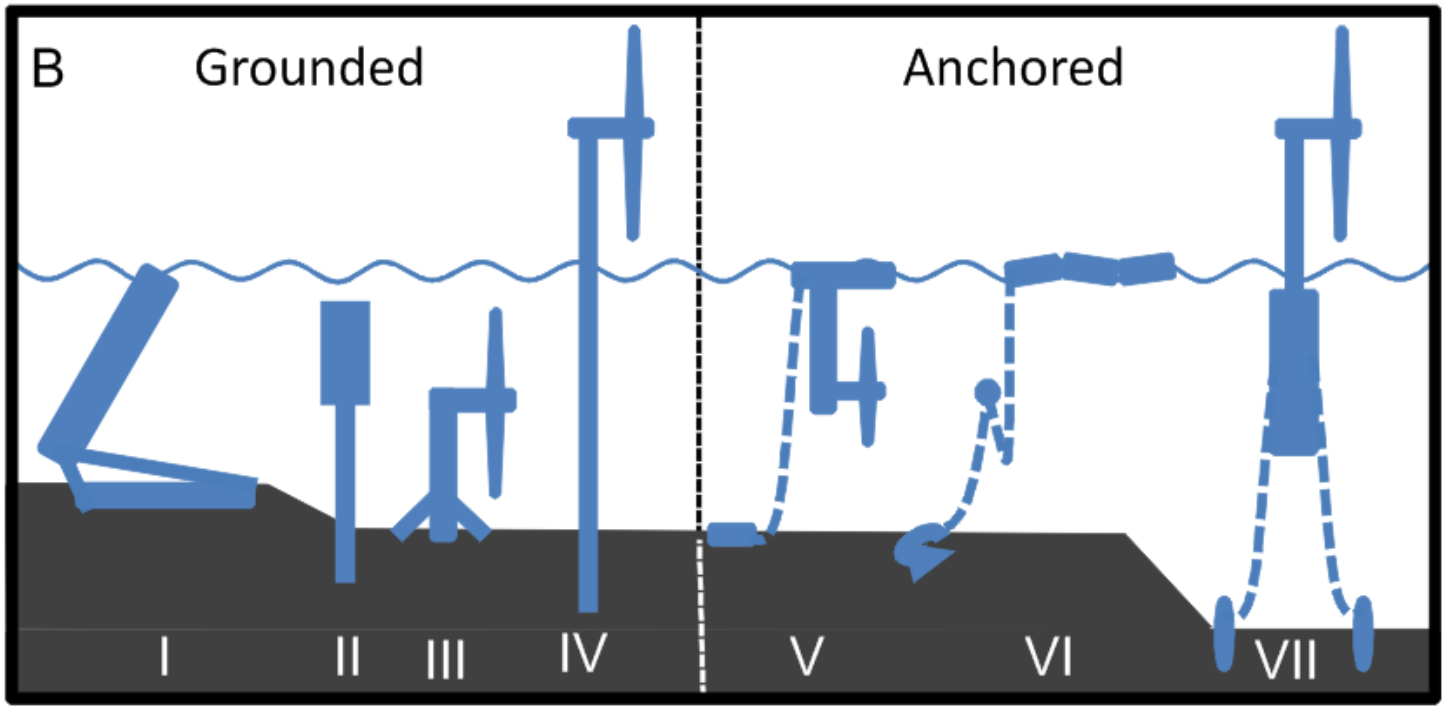
# Biofouling and the Marine Renewable Energy Industry




# What is biofouling?

# Structural influences

- Free moving or static?
- Floating or fixed?
- Splash zone or intertidal zone?




Miller et al. (2013). Frontiers in Ecology and the Environment 11:8, 433-440


- Biofouling happens in all industries
- Particularly relevant in this one – devices are highly tuned to extract optimum energy

# We asked the experts…

SAMS

DNV·GL

PML Plymouth Marine Laboratory

AkzoNobel

CATAPULT Offshore Renewable Energy

marinescotland

University of the Highlands and Islands
Oilthigh na Gàidhealtachd agus nan Eilean

WavEC Offshore Renewables

The University of Edinburgh

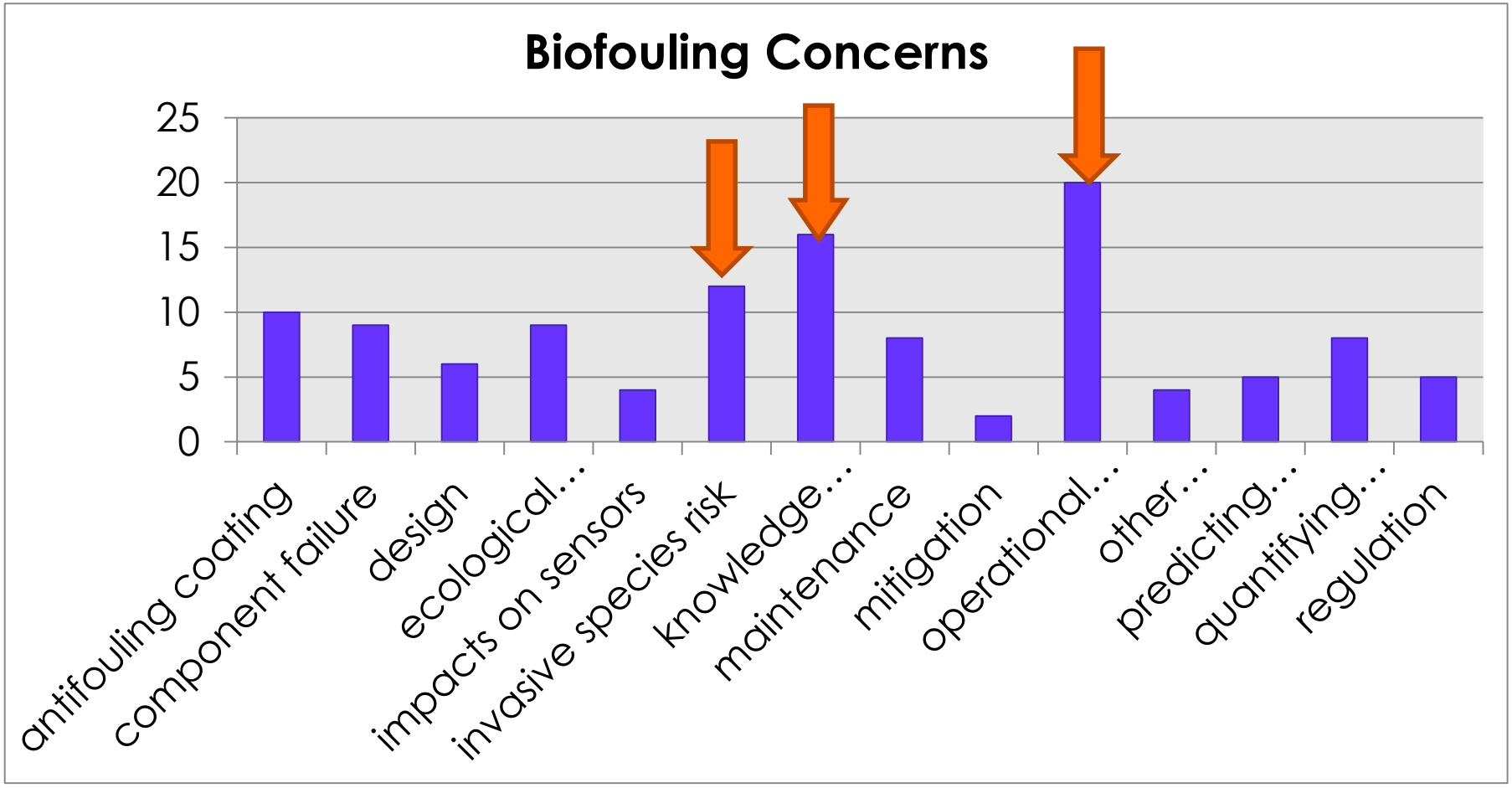
Prifysgol Bangor University

ALBATERN Wave Energy

INNOVATION™ Nova Innovation Ltd

Heriot Watt University

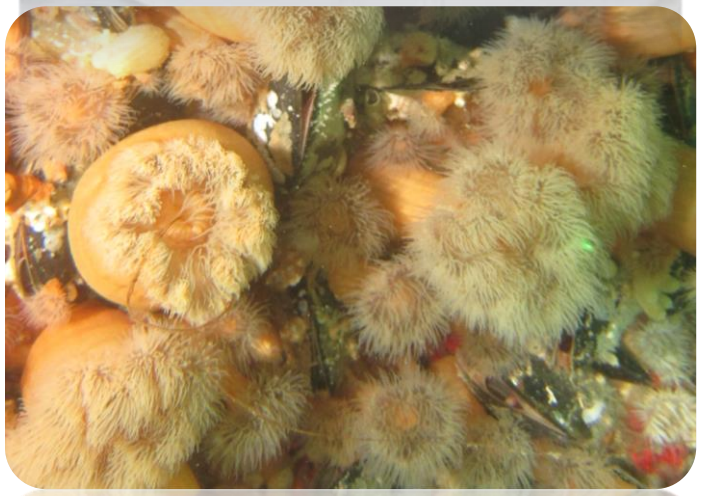
# Identifying issues & drivers



# Positive- artificial reef effects

Aim of many MRE companies

- High biodiversity
- Increases productivity
- Fish aggregation
- Ecosystem services E.g.
  - Filtration
  - Carbon deposition
  - Primary production

# Negative- commercial & environmental implications

Commercial

- Weight
- Density
- Thickness
- Roughness
- Heat transfer coefficients

- Decreased efficiency of energy extraction
- Decreased longevity of materials ( corrosion)
- Increased maintenance costs

# Negative- commercial & environmental implications

<u>Environmental</u>

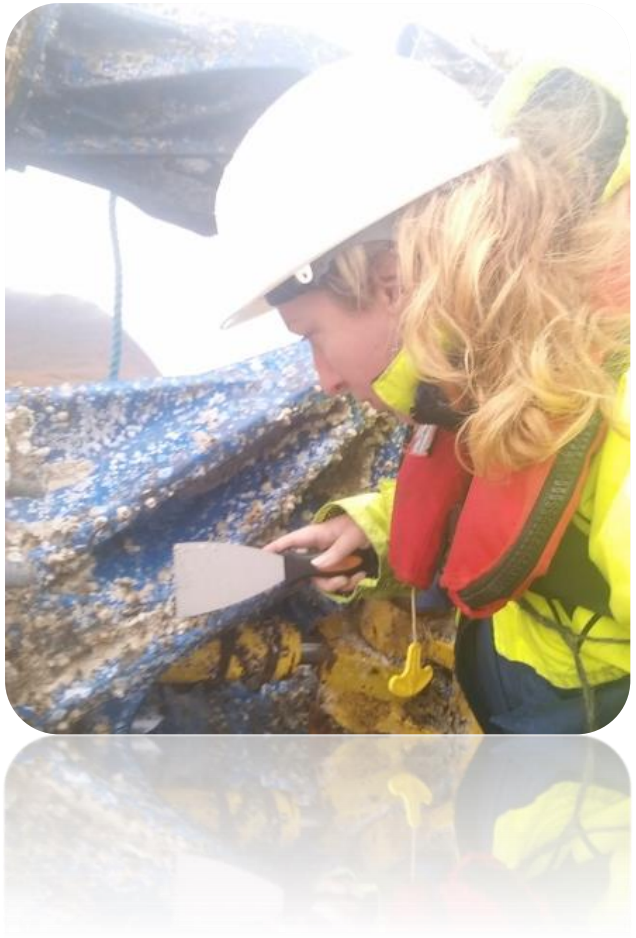
- Fish aggregation may increase risk of predator collision
- May change local benthic community structure
- Risk of non-native invasive species settlement and spread

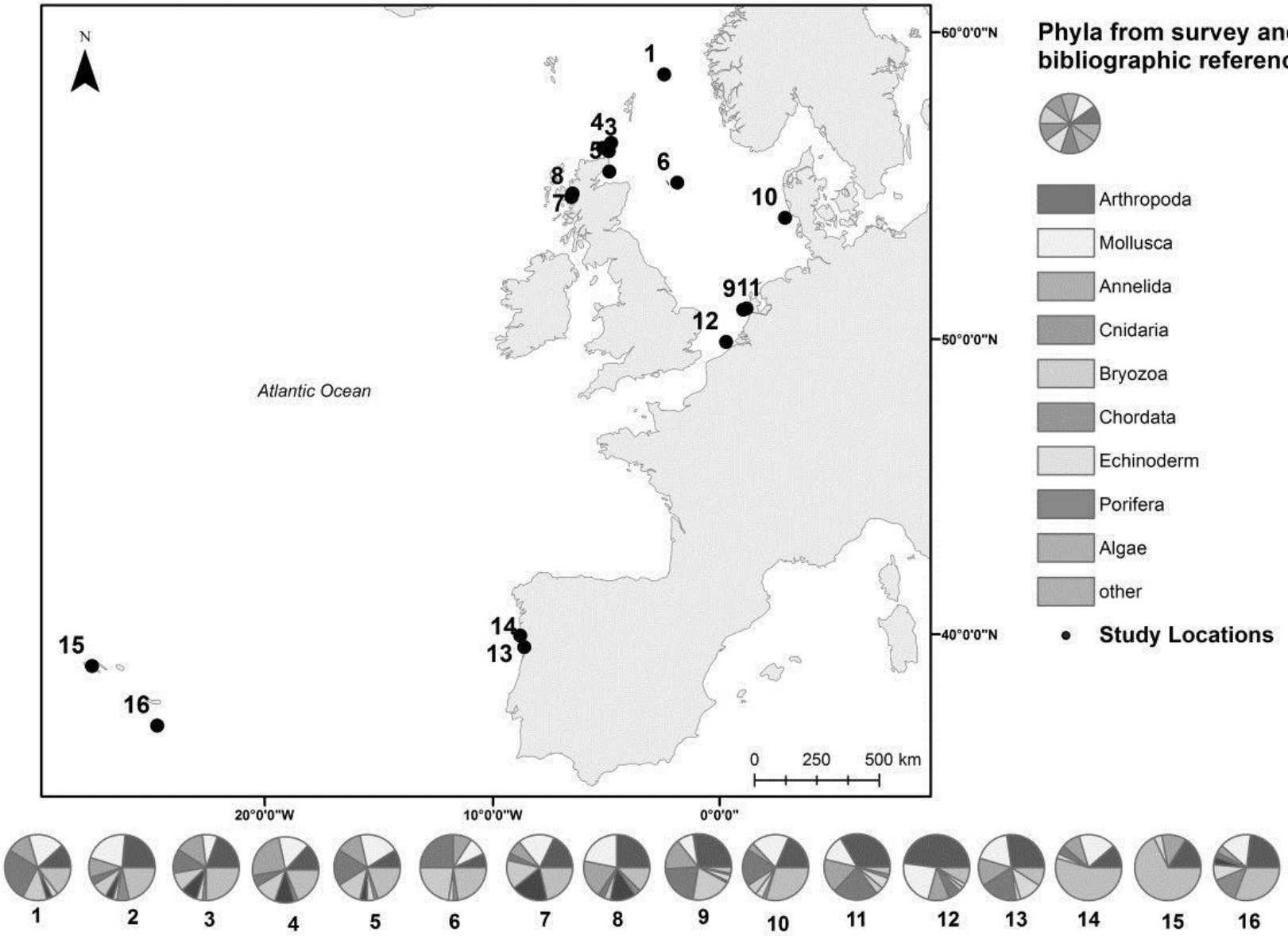
# non-native invasive species (NNIS)

- Can be a licensing consideration
- Risk of "polluter pays" legislation
- Arrays may act as stepping stones into "uncontaminated"areas
- Multiple potential vectors:
  - Wet-towing devices
  - Servicing vessels
  - MRE harbours
  - Nearby industries e.g. Fish farms

# First results from industry

- Biofouling scrape samples were collected for 5 MRE devices.
- Species lists were compared to biofouling data extracted from scientific literature for other marine structures.




N
Atlantic Ocean
60°0'0"N
50°0'0"N
40°0'0"N
20°0'0"W
10°0'0"W
0°0'0"
0 250 500 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Phyla from survey and bibliographic references
Arthropoda
Mollusca
Annelida
Cnidaria
Bryozoa
Chordata
Echinoderm
Porifera
Algae
other
Study Locations

# Summary of preliminary results

- Biofouling of up to 60kg/m2 recorded
- Broadly speaking, location matters. (e.g. Scotland vs Portugal)
- Biofouling in the top ~3m of floating structures is different to biofouling on fixed structures and at greater depths.
- Invasive species were found on all but 1 renewable energy device BUT they have not necessarily been introduced on the device and may already have been widespread in the area.

# Next steps for biofouling research

Peer reviewed publications (Loxton et al. and Machado et al.) – watch this space!

3-year NERC Knowledge Exchange Fellowship – biofouling in the UK  Marine Renewable Energy Industry

Dr Chris Nall: Ongoing experiments to get more refined biofouling data from MRE deployments

# Thanks


Collaborators

Chris Nall
Ines Machado
Raeanne Miller


All developers and test site owners who helped us sample their sites.


## Thank you for listening


Contact information

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www.merikaFP7.eu

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Marine Energy Research Innovation and Knowledge Accelerator

SAMS

# The social, economic and policy dimensions of marine renewable energy

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# MERIKA Staff

**Centre for Society and the Sea**

SAMS

MERIKA
Marine Energy Research Innovation and Knowledge Accelerator

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Denise Risch

Lucy Greenhill

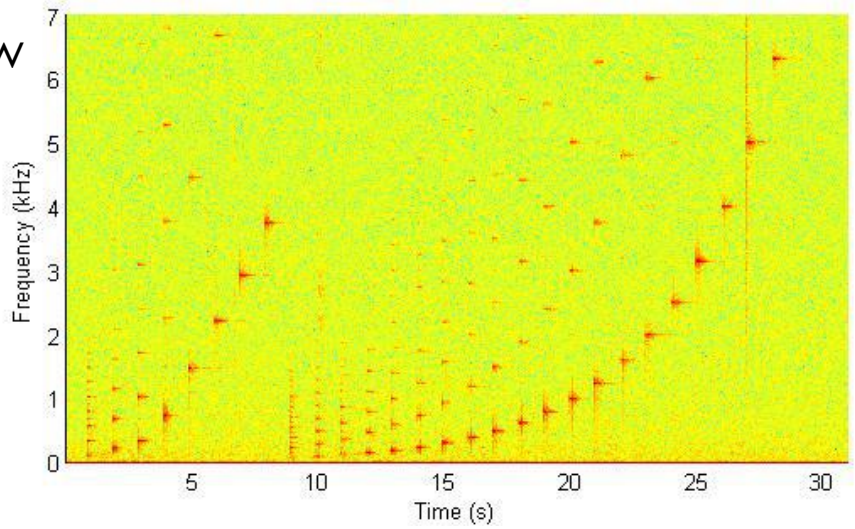
Suzi Billing

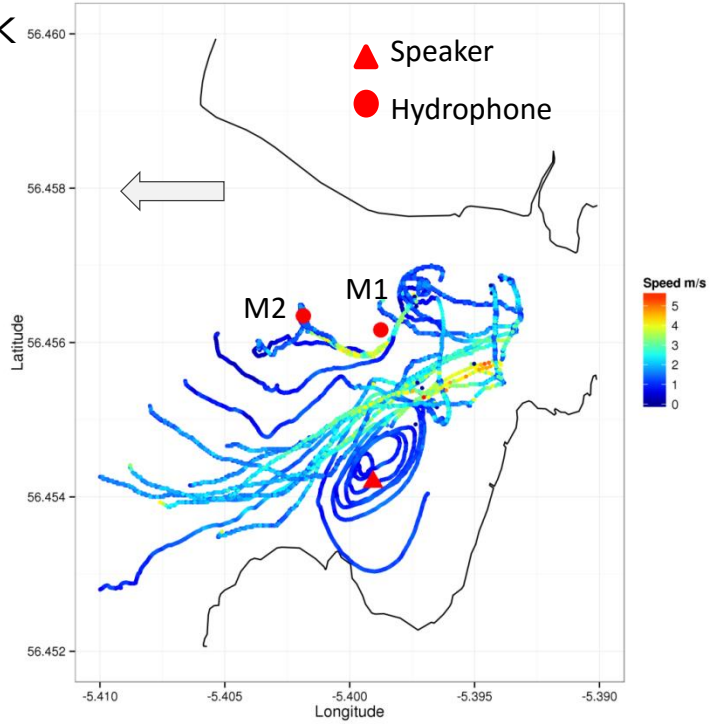
Simone Martino

# How does sound propagate in high tidal flow areas?

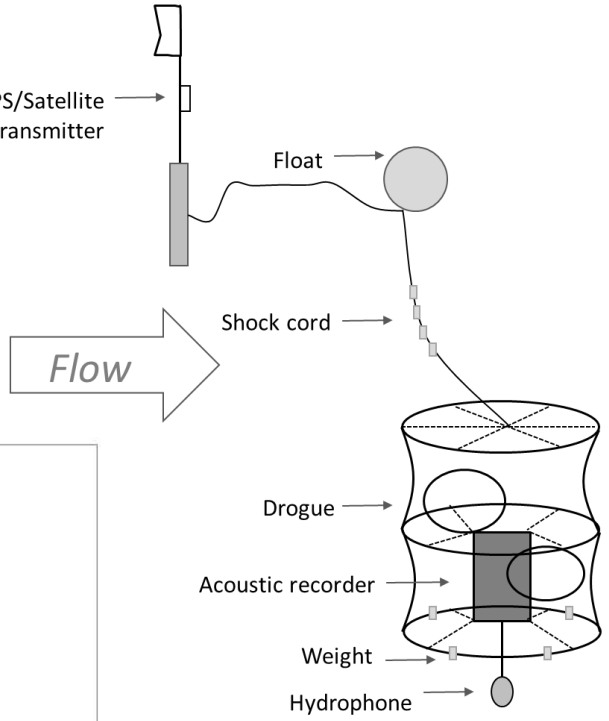
*Dr Denise Risch, Acoustic Ecologist*

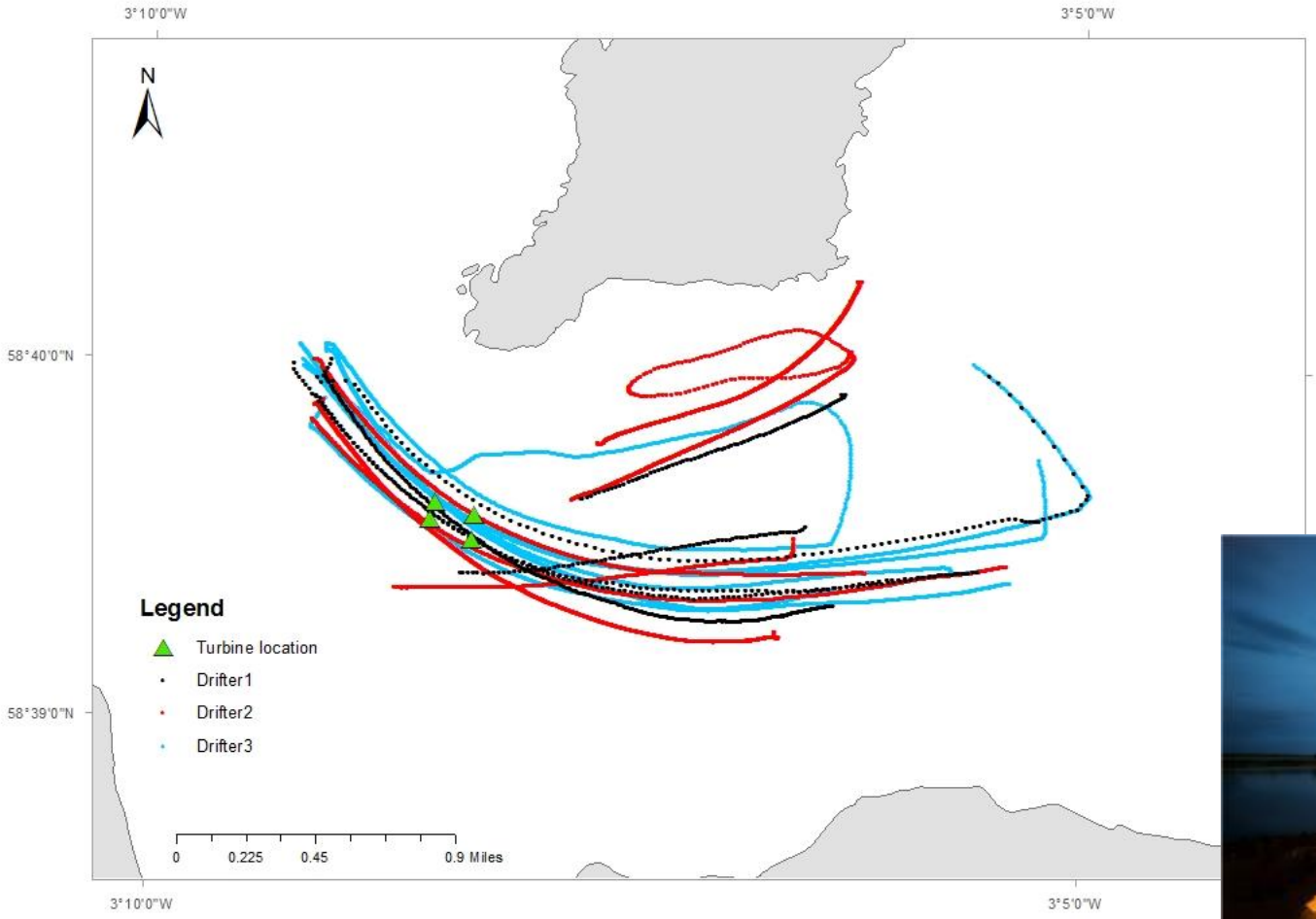
- Higher **ambient noise** levels during high flow periods
- **Propagation** varied by 5-15 dB between high flow and slack periods
  - < 200 Hz: Lower received levels during slack flow
  - > 200 Hz: Lower received levels during high flow



# Ambient Noise Assessment at MeyGen Deployment Site using Drifting Hydrophones




# How do we understand and incorporate 'shared' and 'cultural' values into planning marine activities?

*Dr Jasper Kenter, Ecological Economist*

- Most social impact assessments and cost-benefit analyses take a top-down approach, primarily focussing on economics
- This risks missing out on important shared and cultural values that communities express in relation to the environments in which they live
- These values can be elicited through **shared social processes**

# Firth of Forth Case Study

University of the Highlands and Islands
Oilthigh na Gàidhealtachd agus nan Eilean

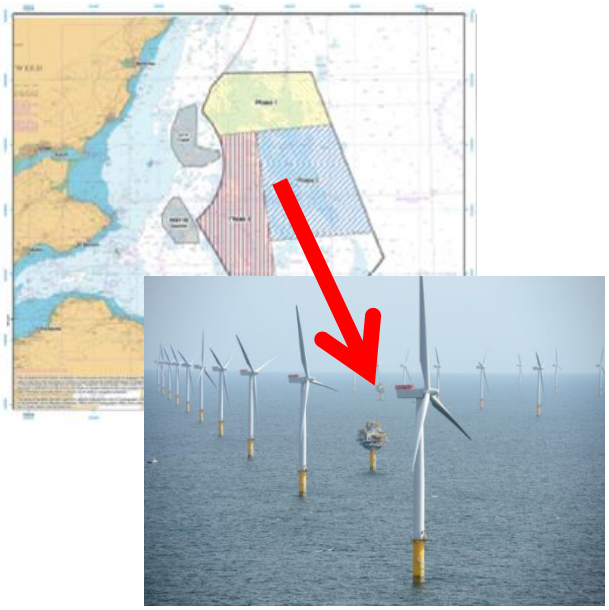
SAMS

1495 UNIVERSITY OF ABERDEEN

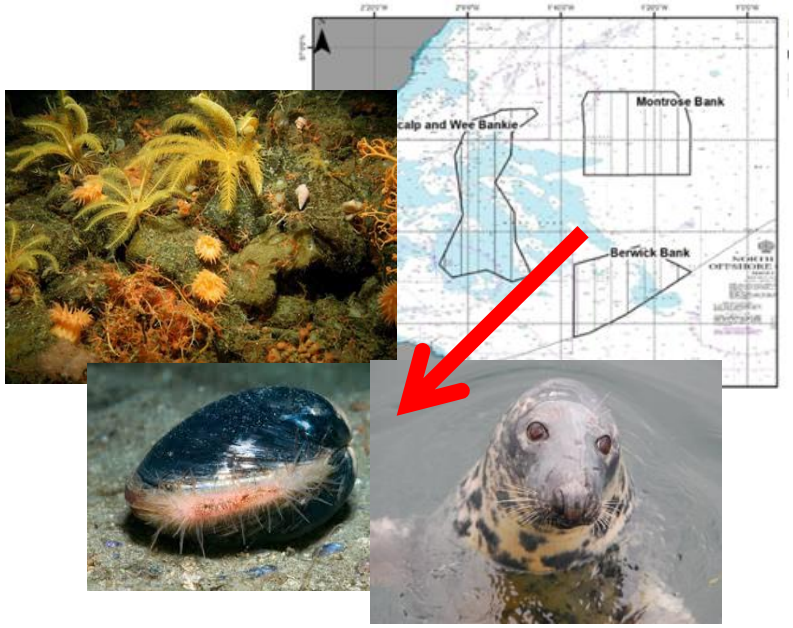
The James Hutton Institute

marinescotland

NERC SCIENCE OF THE ENVIRONMENT



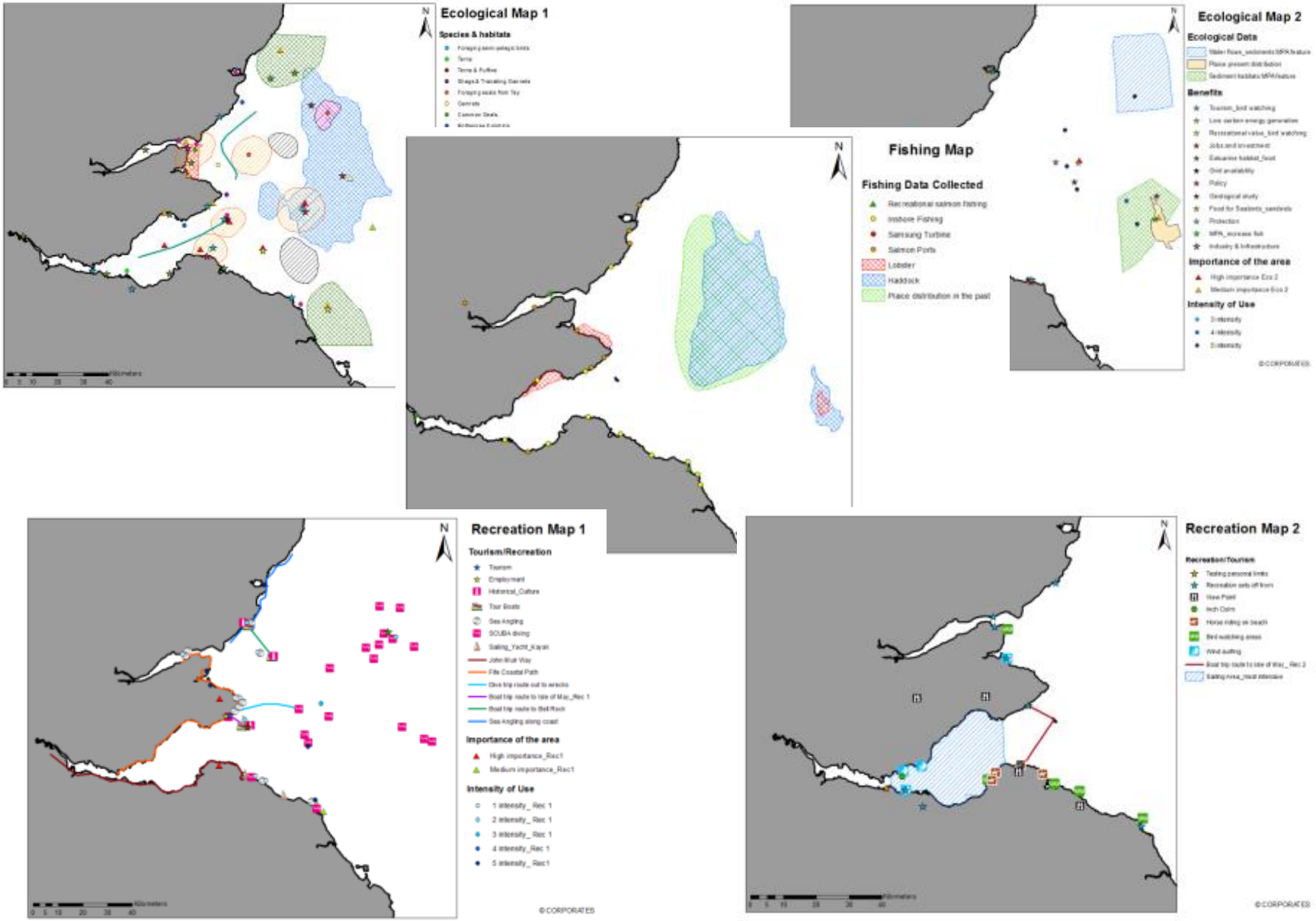
Energy security and climate change => **Offshore Renewables**




Loss of biodiversity and need for resilience under climate change => **Marine Protected Areas (MPAs)**

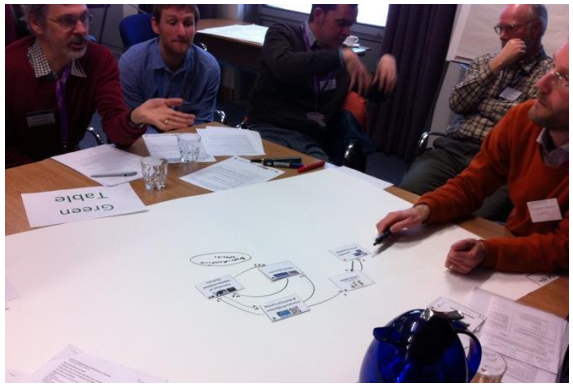
# Workshop 1 – Mapping with wide range of sectors


# Digitised Maps of Spatial Benefits

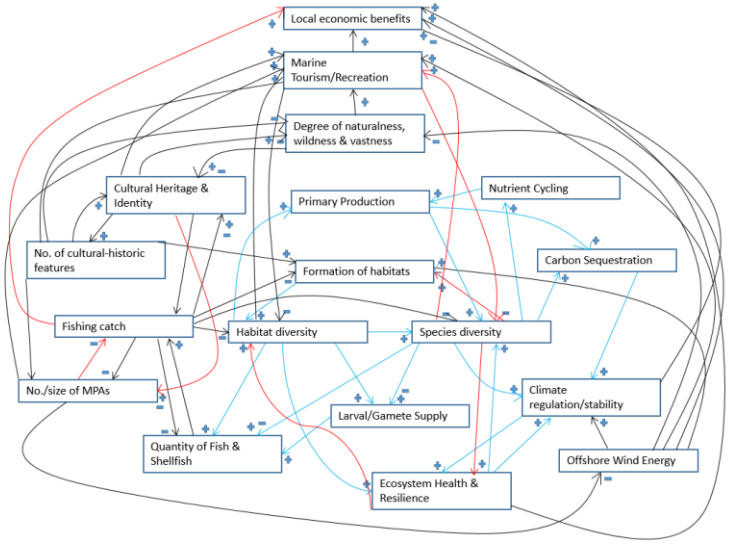


# Conceptual System Model

- Building a conceptual picture of the social-ecological system
- Looking at interactions between ecosystem services, activities, benefits and drivers of change (wind farms, MPAs, fisheries policy)




- Social learning
- It's not about drawing a perfect model, but about the discussion



# Understanding Shared Values: Key factors for successful participation

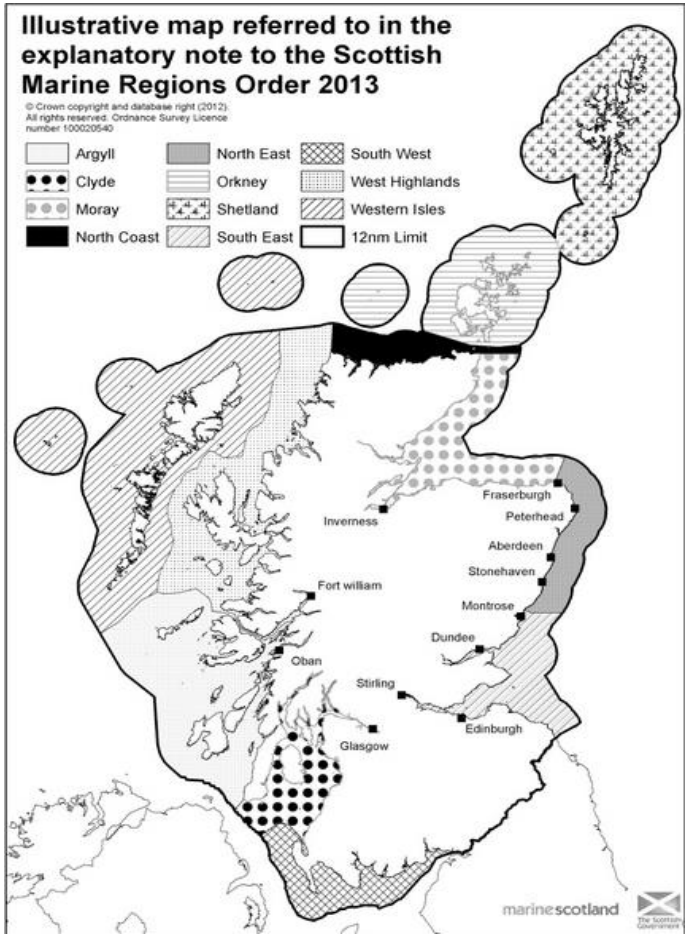
- Establish and communicate what participation is for:
  - What are the objectives?
  - What is the scope for influencing decisions?
- Needs to be timely and ongoing
- All stakeholders adequately represented
- Need for social learning
- Three way knowledge exchange (developers, researchers, stakeholders)
- Careful professional process design and facilitation

Kenter, Fazey & Reed. 2016. The Deliberative Value Formation Model. In press.

# Marine Spatial Planning and Governance

*Lucy Greenhill, Policy and Governance*

- Holistic approach to managing activities in the sea
- Could provide better engagement of local communities
- Could enable us to recognise limits and work within them
- Could facilitate conflict management and co-use to optimise resource use
- Complicated issues around authority, resources, boundaries, cumulative impacts, etc.



# Research Activities

- How does MSP enable adaptive governance in marine activities (to address complexity / uncertainty)?
- How does MSP relate to other concepts (ICZM, EBM, EA, AM) – report with MERIKA partners
- How does marine governance respond to climate change?
- Scenarios / deliberative workshops for negotiating conflicts, sustainability, facilitate multi-use and co-location
- Proposals: ECOREEF (Norwegian Research Council) applying EBM to MRE

# Cost Benefit Analysis and Ecosystem Services

*Dr Simone Martino, Environmental Scientist and Resource Economist*

- Review of costs of deploying different MRE devices and cost of MRE production per GW
- Engaging with MERIKA partners (Nord University) on the implementation of **ecosystem services** approach to address conflicts between aquaculture, mining and energy production
- Exploring the application of **consumer theory** to establish the combination of renewable /non renewable energy production at local scale

# Local scale management and societal interactions of marine activities

*Dr Suzi Billing, Social Scientist*

- Societal perspectives co-location of aquaculture and MRE devices on exchange with Nord University

- Creating case study links in local societal perspectives on renewable energy and aquaculture between Norway and Scotland for potential funding via Norwegian Research Council