# USING THE FLOWBEC SEABED FRAME TO UNDERSTAND UNDERWATER INTERACTIONS BETWEEN DIVING SEABIRDS, PREY, HYDRODYNAMICS AND TIDAL AND WAVE ENERGY STRUCTURES

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## ABSTRACT

The NERC/Defra collaboration FLOWBEC-4D is investigating the environmental and ecological effects of installing and operating arrays of wave and tidal energy devices. The FLOWBEC seabed platform combines a number of instruments to record information at a range of physical and multi-trophic levels at a resolution of several measurements per second, for a duration of 2 weeks to capture an entire spring-neap tidal cycle. An upward-facing multifrequency echosounder is synchronised with an upward-facing multibeam sonar aligned with the tidal flow. An ADV is used for local current measurements and a fluorometer is used to measure chlorophyll (as a proxy for plankton) and turbidity. The platform is self-contained, facilitating rapid deployment and recovery in high-energy sites. Five 2-week deployments have been completed at wave and tidal energy sites at EMEC in Orkney (UK), both in the presence and absence of renewable energy structures. Using multifrequency target identification and multibeam target tracking, the depth preference and interactions of birds, fish schools and marine mammals with renewable energy structures can be tracked. Seabird and mammal dive profiles, predator-prey interactions and the effect of hydrodynamic processes during foraging events throughout the water column can also be analysed. These datasets offer insights into how fish, seabirds and marine mammals successfully forage within dynamic marine habitats and also whether individuals face collision risks with tidal stream turbines. Measurements from the subsea platform are complemented by 3D hydrodynamic model data, concurrent shore-based marine X-band radar and shore-based seabird observations. This range of concurrent fine-scale information across physical and trophic levels will improve our understanding of how the fine-scale physical influence of currents, waves and turbulence at tidal and wave energy sites affect the behaviour of marine wildlife, and how tidal and wave energy devices might alter the behaviour of such wildlife. These results can be used to guide marine spatial planning, device design, licensing and operation, as these individual devices are scaled up to arrays and new sites are considered.

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## INTRODUCTION

Little is known of the environmental and ecological effects of installing and operating wave and tidal stream marine renewable energy devices (MREDs) [1]. The NERC/Defra collaboration FLOWBEC-4D (*Flow, Water column and Benthic Ecology 4-D*) is investigating the potential effects of MREDs at test sites in Orkney at the European Marine Energy Centre (EMEC). The project aims to understand how currents, waves and turbulence at wave and tidal energy sites may influence the behaviour of marine wildlife, and how MREDs might alter the behaviour of such wildlife as single devices are scaled up to arrays. Mobile predator and prey use of high energy sites is being investigated to identify and quantity which type of habitats (depth of water column, speed of tides, etc.) predators predictably use in these areas for foraging to assess collision risk.

Trends and predator-prey interactions in these sites are known to occur over a variety of temporal and spatial scales [2] requiring data to be captured at a high temporal resolution (several measurements a second) but also for entire spring-neap tidal cycles (2 weeks). Sampling at different positions within these wave and energy sites is also required, to understand the use of habitats by different species and to assess the effect of the presence / absence of MREDs.

Regulators need to know with a high degree of certainty whether tidal and wave devices will affect the population level of marine species, but measuring population level changes is a long term and large spatial range issue. An approach which can rapidly and accurately identify and quantify any changes in individual behaviour, within a species, brought about specifically by renewable development, can allow the quantification of what those impacts will be at the population level [3].

## METHODOLOGY

The FLOWBEC upward-facing sonar platform allows the interaction of fish, diving seabirds and marine mammals with MREDs to be imaged, and the acoustic environment analysed as shown in Figure 1. The FLOWBEC platform combines an Imagenex 837B Delta T multibeam sonar pinging at
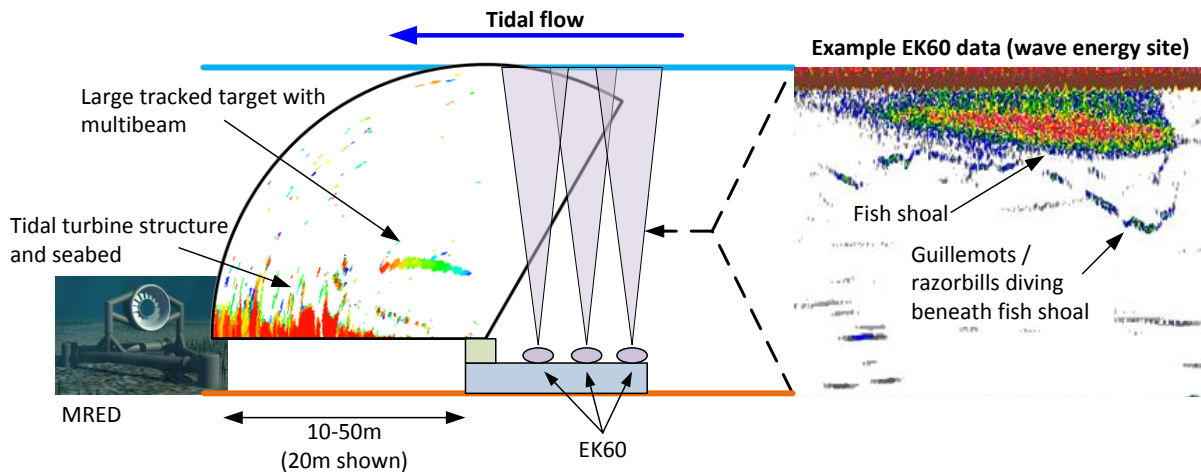
**Figure 1 The multibeam sonar (left) images the water column along the axis of tidal flow for target tracking and monitoring the interactions of targets with tidal turbine structures. The Simrad EK60 multifrequency sounder (right) faces vertically upwards for target identification, abundance estimates and measures of the morphology of turbulence (a 9 minute excerpt at the EMEC wave energy site is shown with diving seabirds (guillemots / razorbills confirmed by shore-based observations) feeding on the fish shoal.**

several frames per second for target tracking, identification and behavioural analysis, synchronised with a Simrad EK60 multifrequency echosounder (38, 120 and 200 kHz) used for target identification, abundance estimates, and measures of plankton and the morphology of turbulence. An ADV provides local current measurements and a fluorometer is used to measure chlorophyll (as a proxy for plankton) and turbidity.

The self-contained seabed platform can be positioned close to the MRED to be investigated allowing the interactions of wildlife to be imaged, but also allowing baseline studies to be conducted under similar conditions in an area free from MREDs. Two-week deployments allow an entire spring-neap tidal cycle to be captured. Data are combined with shore-based bird observations, shore-based marine X-band radar surveys of wave and current data and detailed 3D modelling of the flow and water column.

**RESULTS**

Five 2-week deployments have been completed at wave and tidal energy sites at EMEC in Orkney (UK), both in the presence and absence of renewable energy structures.

Algorithms for noise removal, target detection, and tracking have been written. Figure 2 shows an example fish shoal tracked using the multibeam within a few metres of the Atlantis AK-1000 tidal turbine structure (shaded in green) at the EMEC tidal site. The turbine blades and nacelle were not present during this deployment and their expected radius is outlined with a dashed green line.

Target classification is possible using a variety of methods. The morphology (size, shape, intensity, number of targets per frame, target separation) and behaviour (velocity, velocity relative to water column, directionality, vertical distribution and inter-target interaction) can be observed using the multibeam and classification performed by defining ranges for the various parameters.

Target classification is also possible using multifrequency analysis from the EK60 echosounder data. For fish, the known frequency response of different fish species can be used to identify pelagic and demersal species, and to train software to pick out and track a range of different shoaling / feeding behaviours using the EK60 for identification and the MBES for tracking. The fish shoal in Figure 2 is also shown in the EK60 echogram, with the frequency response closely matching that of a shoal of mackerel [4].

The shore-based wildlife observations are used for ground truthing, particularly for identifying seabird species on the multibeam by their distinctive dive behaviour. A subset of shore-based bird observations can be used to first ground truth acoustic detection of diving seabirds in both sonar instruments, and second to use the known identification of species to 'train' software to pick out different species. The software can then be tested with the remaining shore-based observations.

The outcome of the tracking analysis will allow the environmental effect of MREDs to be explored using the distribution of targets (plankton, fish, birds, marine mammals) and predator-prey interactions with time, tide and space, where space includes vertical use of the water column, and horizontal distribution around the wave and tidal sites, and how all of this changes with the presence and absence of MREDs. The vertical habitat preferences of these ecological groups and collision risks can also be evaluated by looking at spatial overlap with MREDs, and collision risk predicted by looking at the overlap with conditions favoured for MREDs.
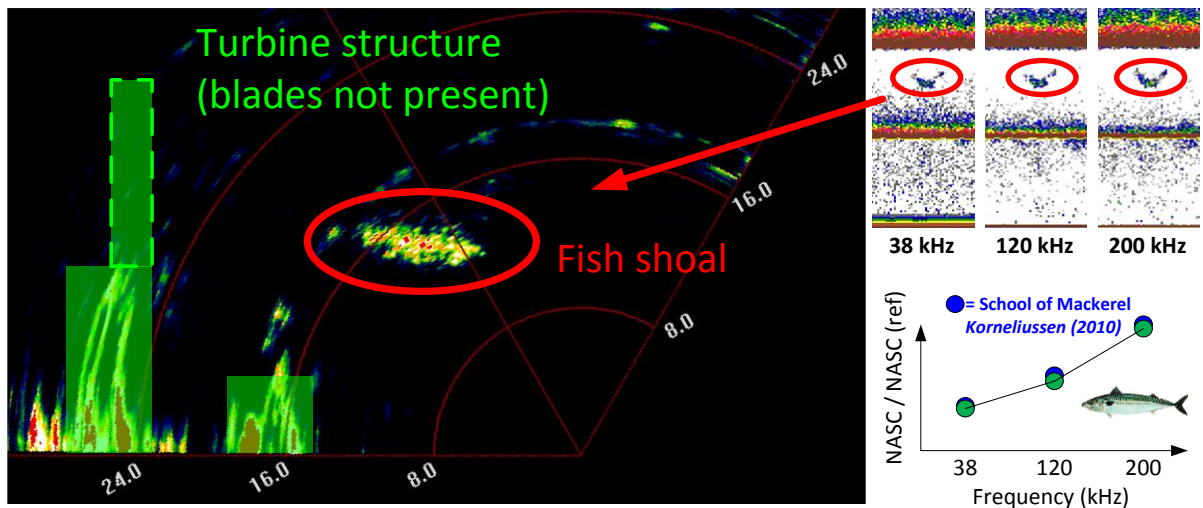
**Figure 2** The multibeam shows an 8 × 2.5 m fish shoal (shoal imaged volume ≈50 m³) moving towards the turbine structure outlined in green. The turbine blades were not fitted but their expected radius is outlined in dashed-green. The same target is detectable in the EK60 second echo, shown in the upper right. The measured frequency response closely matches the published response of a shoal of mackerel [4]

## CONCLUSIONS

The technology and analytical approach developed in FLOWBEC is so far the only subsurface system to continuously capture fine-scale (several measurements a second) data over a wide range of both physical and multi-trophic levels (plankton, zooplankton, fish, seabirds and mammals) over time periods which encompass day and night differences as well as full spring / neap tidal cycles.

The Delta T multibeam provides high resolution information on a variety of targets in the water column around MREDs. The combined use of an EK60 multifrequency echosounder enables fish species identification and has the potential for the identification of seabirds and marine mammals. Fish, marine mammals and diving seabirds can all be tracked during their interactions with MREDs, above water and below water. Acoustic measurements are being analysed as a function of time, tide, waves, modelled data and shore-based wildlife observations and marine X-band radar to understand the hydrodynamic habitat preference of various functional ecological groups (benthos, plankton, fish, birds and marine mammals) and how individual species may use preferred flow conditions.

The techniques for analysis of the raw data and statistical modelling are being tested, such that the combination of the technology and the analysis will ultimately provide an affordable way to measure interactions of marine wildlife in high energy locations and around foundations and active devices. This combination of our current technology and analytical approach can help to de-risk the licensing process by providing a higher level of certainty about the behaviour of a range of mobile marine species in high energy environments.

It is likely that this approach will lead to greater mechanistic understanding of how and why mobile predators use these high energy areas for foraging. If a fuller understanding and quantification can be achieved at single demonstrator scales and these are found to be similar at least at initial smaller array scales, then the predictive power of the outcomes might lead to a wider strategic approach to monitoring and possibly lead to a reduction in the level of monitoring required at each commercial site.

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