With an increase of offshore Green developments and Marine Protected Areas, the demand on managing marine space more effectively has never been higher. **Dr Beth Scott** and **Dr Jonathan Sharples** explain how a multi-disciplined approach to defining marine habitat can improve methods

# A pragmatic approach to defining marine habitat

The role of managing our seas is changing rapidly. The traditional approach of single species management has proven inadequate, with many stocks fished at unsustainable levels. This method, by definition, has proved too singular, failing to incorporate wider environmental considerations and lacking direct input from the fishing industry. A more pragmatic approach is clearly required. It is no surprise that improvements to marine management have emerged in those areas where fisheries are open-minded to the knock-on effects of underlying ecosystems and advice from the fishing industry in management decisions. Such an approach requires a more mechanistic understanding of the roles played by ocean physics through to complex sub-surface species interactions. It is also clear that, as more demand is put upon the use of space in our marine systems (ie. offshore renewable developments, Marine Protected Areas and a fishing effort managed increasingly on a spatial premise), a better understanding of the role of marine habitat is essential. One complication in achieving this goal lies in the nature of the habitat itself; unlike those found on land, marine habitat is unique in its ability to move in both space and time. Despite such complications there are evidently basic principles underlying our research; any fisherman will tell you that some locations and times are better than others for good catches. Understanding why is a fundamental challenge.

The key to this challenge seems to lie in understanding what patterns emerge at the primary point of action governing the relationships within these marine habitats. In this instance, the primary point of action is posited when high levels of predator-prey interactions occur. Previous projects based in the North and Celtic Seas have gone some way to suggest why these aggregations occur and it is upon these findings that the current project builds. Our results from the earlier project clearly show a correlation between high levels of sub-surface primary production (the growth of the marine algae that lie at the base of the food chain) in spatially limited areas and disproportionate numbers of seabirds, marine mammals or fishing efforts [Fig.1]. These areas appear to be associated with internal waves caused by large banks on the seabed. The waves occur during high and falling tidal current speeds in areas where the water column is stratified, with a warmer surface layer of water. They cause a large amount of turbulence, mixing nutrients from the deeper water up towards the surface where the algae are. It is the presence of these waves that we believe holds the key to why high predator-prey interactions occur where they do. The sub-surface signature of these areas has meant that they have been overlooked in studies which have identified important surface features alone, such as tidal fronts, known to contain aggregations of many marine species. These areas therefore represent a newly-identified class of spatially important locations in shallow seas.

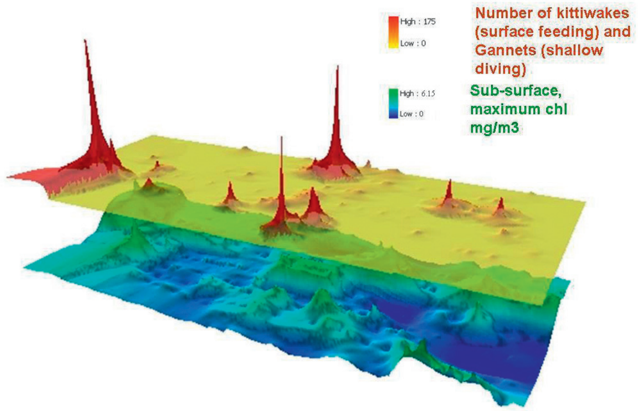


Figure 1. Two layers of continuous information from the survey in the North Sea, with the top red/yellow layer representing the number of surface-foraging, fish-eating birds (Kittiwakes and Gannets). The bottom layer is the maximum values of sub-surface chlorophyll

## The project

Our main objective in undertaking the current project is to determine the role of seabed topography, and more specifically internal waves, in creating high predator-prey aggregation, with two prominent hypotheses emerging:

- complex trophic interactions via 'bottom-up forcing', with more prey available due to higher primary productivity where internal waves have caused vertical mixing of nutrients
- topographical forcing, with prey in those areas simply easier to catch as the internal waves bring them closer to the surface

To test these hypotheses, an innovative new survey framework was piloted. This framework incorporates a broad spectrum of surface and sub-surface features and defines the critical characteristics of the habitat in minute detail. The uniqueness of this study lies in its attention to micro- and macrocosmic concerns. The repeated circular surveys used

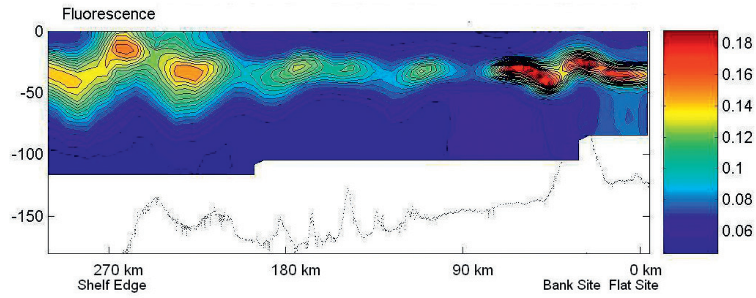


Figure 2 – Scanfish chlorophyll levels on bank (on the right) to shelf edge (on the left)

in this study were first piloted in the North Sea survey and have allowed us to resample the same area of predator-prey interaction at different tidal speeds. In the Celtic Sea upward-facing instruments were added in set locations recording the direction and speed of water all the way through the water column. The seabed instrumentation, circular surveys and new 'on the spot' surveys were conducted in regions of contrasting topography; one site with a steep bank and the other site where the bottom topography was flat. However, the sites were quite close together (<15km), so we did not expect to find large differences in fish species types or water mass characteristics. This experimental design was tested to investigate whether marine animals are using sub-surface turbulence created by tidal friction to aid in capturing prey.

on the composition of chemistry and plankton species. Evidence from both the sub-sea camera and fishing vessels showed that the fish species composition was very different between the bank and just off - bank sites even though there was only a 5 km difference between these locations. However, the increased production of algae is exported to a much larger area [Fig. 2 – Scanfish chlorophyll levels on bank to shelf edge]. These combined results have direct implications about the spatial scale of what constitutes a 'critical habitat' for marine species.

The internal waves were found in only one location on the bank, an area not predicted to produce such turbulence given pre-existing knowledge of the bathymetry of the location prior to this survey. It has

## The most advanced acoustic and oceanographic instruments were used to record changes in both the physical and behavioural aspects, second by second

## Results

The findings of the project are of significant interest. Where circular surveys were deployed in the North Sea, the main prey species, sand-eels, clearly modified their schooling behaviour with changes in the tidal speeds. As the water reaches maximum speed the fish move higher in the water column, grouping themselves together in large shoals. This suggests that increased tidal speeds not only create large prey aggregates, but also increase the probability of aggregate interaction with predators by drawing them towards the surface.

Results from the Celtic Sea surveys, focusing on increases in primary production suggest that higher turbulence through the lower trophic levels had localised effects

taken topographical measurements at scales down to 10s of metres to be able to have detailed models predict the occurrence of internal waves. In contrast, the direct response by foraging gannets, targeting the exact location of the internal waves but not at the exact time of their production, confirms that visible top predators can be used to 'indicate' where the internal wave activity occurs. The results from both surveys indicate that both topographical forcing of tidal currents and sub-surface primary production are playing crucial roles in influencing predator-prey interactions. This type of multi-disciplinary study is allowing a more precise definition of critical marine habitat, as well as improving our ability to pinpoint where they are likely to occur. ★

## At a glance

### Full Project Title

Do oceanographic characteristics and predator-prey behaviours define critical marine habitats? (CMarHab)
**http://cmarhab.blogspot.com**

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Beth Scott obtained a B.Sc. in Marine Biology from Simon Fraser University, a M.Sc. in Fisheries Oceanography from the University of British Columbia and a PhD in ecosystem modelling at the University of Aberdeen.

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