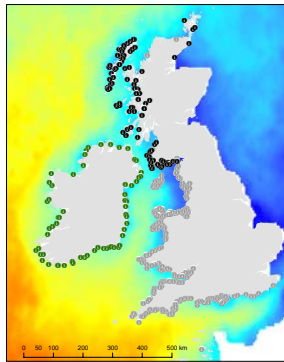


Linking patterns of biodiversity with species interactions and environmental drivers: decomposing spatial variation and establishing scale-dependent associations

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Large-scale variation:
February sea surface temperatures (AVHRR average 2001-2006)

The Issue

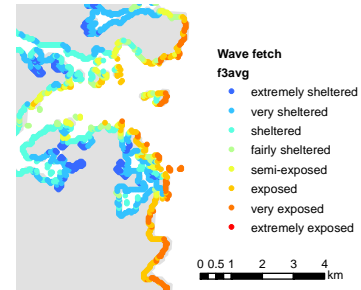
Ecological information from wide geographical areas reveals associations between

•**drivers:** biological and physical characteristics of the ocean: phytoplankton, temperature, and wave exposure

•**biodiversity responses:** species abundance, primary productivity and species diversity

Both responses and drivers can vary on large scales (temperature, left) or over small scales (wave action, right). Characteristic spatial scales of patterns in responses can suggest probable causes: small-scale patterns in responses suggest small-scale causes (see barnacle data below).

Here we extend this approach to determine the strength of associations at different spatial scales by producing **scale-dependent correlations**.



Small-scale variation:
Loch Erisort, Lewis
Wave fetch per 50m coastline modelled from GIS data (Burrows et al 2008)

The Method

Extracting spatial error components

Observations include components of small- and large-scale variation. So,

$$Y = \bar{Y} + \epsilon_{600} + \epsilon_{300} + \epsilon_{150} + \epsilon_{75} + \epsilon_{37} + \epsilon_{site}$$

Site-specific values for errors (e.g. ϵ_{site}) represent components

Residuals are calculated from successively more complex spatial models, thus:

$$Y - (\bar{Y} + \epsilon_{site}) \quad (1), \quad Y - (\bar{Y} + \epsilon_{600} + \epsilon_{300}) \quad (2),$$

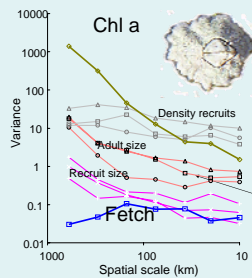
$$\text{so } \epsilon_{300} = (2) - (1)$$

Repeating this process gives the successively smaller terms.

Error degrees of freedom and significance

The number of independent regions separated by each spatial scale gives error degrees of freedom. The MNCR data (right) extended over 2-3 600km regions in the UK, a df of 1.5. Significant ($P < 0.05$) correlations at each scale exceeded the scale-dependent critical r value (shown in red and grey, right).

Scale variance



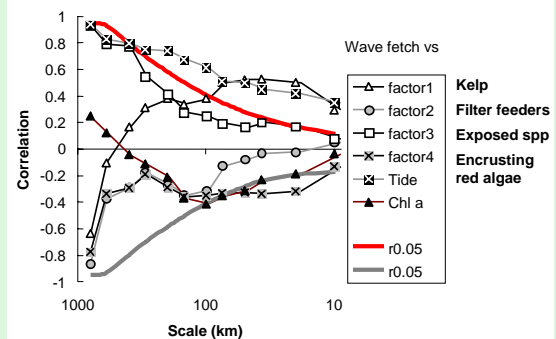
Response variance follows that of the key drivers across scales: chlorophyll – size, wave fetch – density. (Burrows et al 2009, 2010)

An Example: Subtidal communities



The Marine Nature Conservation Review has surveyed shallow water rock communities at over 7000 sites in the UK. Common patterns in abundance for 50+ species were reduced to 4 main trends (PCA factors) aligned with functional groups and compared with wave fetch, temperature and water chlorophyll.

The Result



Correlations among spatial error components at different scales showed the predominant scales where drivers may influence responses. Wave fetch drives kelp (*Laminaria hyperborea*) abundance at small scales but not large scales: regional differences are a result of these small scale processes.

Conclusions

Scale-dependent correlations with site-specific factors (1cm to 100m, including abundance of other species), small-medium scale factors (0.1-50km, habitat-related like wave exposure and tidal flow) and regional factors (>50km scales, oceanographic and climatic variation: temperature, nutrients) point strongly to dominant effects on biodiversity, and repeatedly emphasise the importance of localised and trophically bottom-up control mechanisms in coastal ecosystems.

Acknowledgements

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