Multiscale analysis of information content: How much information is lost and which scale should be used?

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Questions of scale are recurring in ecology and pixel size is one of the basic considerations of remote sensing. At too coarse a resolution, important features driving ecological processes might be missed, while at too fine a resolution, stochasticity can make identifying relationships difficult. Although there is no single appropriate scale at which to study a system and each scale can provide information regarding different processes, in many cases, particularly in deeper environments, a single resolution is often chosen arbitrarily due to data acquisition, time or cost limitations without the knowledge of how this choice affects the information acquired. Or in other words, we do not know how much information is lost by acquiring or processing data to a particular resolution.

As part of the CODEMAP project, three areas of Whittard Canyon, NE Atlantic, were mapped at fine resolutions (1m) using an ROV, while the broader canyon was also mapped at lower resolution (50m) using a ship-borne multibeam system. The area had also been mapped as part of the Irish National Seabed Survey (INFOMAR) at a third resolution (100m). Three ROV video transects were further collected to examine spatial patterns in megabenthic invertebrate density and diversity (1/D). Using information theory metrics, we examined how the entropy (the amount of information needed to encode the signal) and mutual information content (MIC, a measure of the information gained on signal *X* after measuring signal *Y*) changed across scale for both geomorphological and biological characteristics. MIC was also used to quantify how much information on the biological signal was acquired by examining the bathymetric (and derived environmental descriptors) signal.

Using both raster grids and triangular irregular networks (TINs), we found that the normalized entropy of the morphological characters such as depth, slope and aspect decreased with increasing pixel size while bathymetric position index (BPI), roughness, terrain ruggedness index (TRI) and all biological characteristics increased. For all environmental and biological descriptors MIC decreased quickly until 20m pixel size, but more gradually thereafter. The bathymetry-derived environmental descriptors from the raster grids influenced biological characteristics over a range of scales, but similar trends were observed for both density and diversity. At the finer scale roughness, TRI and flow direction influenced biological characteristics, while slope and depth had an impact at medium scales and finally BPI had an influence only at the broader scale.

We discuss the implication of these results for the broader study of this canyon and suggest that such an information theory approach based on a fine-scale examination of a small area can provide information upon which broader-scale surveys can be designed as well as help tease out the relative importance of processes occurring over various scales.