Introduction

Resource Management efforts can benefit greatly from habitat information and maps regarding the species of interest. For benthic and demersal species, these maps are dependent upon accurate bathymetric data, which historically has been of very low resolution in all but a few select areas. Traditionally, seafloor habitat maps have been produced by visual interpretation of bathymetric and other acoustic (backscatter, subbottom/sidescan) and non-acoustic (sediment grab, cores, in-situ observation) data types. Visual interpretation is time-consuming and requires a skilled expert to perform; thus it is by its very nature subjective and of varying repeatability. It is also subject to human limitations regarding compromises between the scale and the amount of detail possible.

As more high-resolution digital elevation model (DEM) data becomes available for the seafloor, quantitative, computer-aided terrain analysis techniques become an increasingly viable tool for creating data layers that can complement those created by expert visual interpretation. Algorithmic terrain analysis is non-subjective, repeatable, makes use of relatively inexpensive computing power, and is limited only by the scale and resolution of the DEM data available.

Abstract

There is a great need for accurate, comprehensive maps of seafloor habitat for use in fish stock assessment, marine protected area design, and other resource management pursuits. Recent advances in acoustic remote sensing technology have made it possible to obtain high-resolution (meter to sub-meter) digital elevation models (DEMs) of seafloor bathymetry that can rival or surpass those available for the terrestrial environment. This study attempts to use an algorithmic terrain analysis approach to efficiently, non-subjectively classify seafloor habitats according to quantifiable parameters such as slope, rugosity, and topographic position index (TPI). In addition, we explore the effects of original x,y,z and gridded data density on the results of these analyses, in order to provide insight into how inherent depth-dependent decreases in data density may affect this approach, and to assess the appropriateness of using historical, lower density bathymetric data. Finally, issues of scale with regard to rugosity and TPI are explored and their potential biological relevance are discussed.

Rugosity Analysis

Rugosity analysis is a measure of a surface’s roughness or coarseness. Rugosity analysis calculates the ratio of surface area to planar area for each cell in an elevation grid using the elevation of the cell and its 8 neighbors (Fig 2). This algorithm evaluates the surface area for the cell and surrounding eight cells (Fig 2) by comparing the elevation of the cell to the mean elevation of the cell and its neighbors (Fig 2). The result is a number between 0 and 1; higher values indicate rougher surfaces (Fig 2). Values for rugosity range from 0 to 1, with 1 indicating a perfectly flat surface.

Surface Areas and 3-dimensional view of elevation grid

Topographic Position Index (TPI)

Topographic Position Index (TPI) is a measure of where a location is in the overall landscape. That is, in relative terms, the topographic position of a place may be a hilltop, or a valley bottom, or a slope, or an exposed ridge, or a flat plain, or other feature. TPI can be calculated for each cell in a grid by comparing the elevation of the cell to the mean elevation of the surrounding cells in an annulus, or ring, around the cell (Fig. 4). Locations that are higher than their surroundings (at the scale specified) will have positive TPI values, while those that are lower will have negative values. Flat areas, as well as areas of constant slope, result in zero or near-zero TPI values. These two cases can then be distinguished based on TPI class (Fig. 5).

Data Density & Resolution Considerations

This study used high-resolution bathymetric data recently collected by the CSU, Monterey Bay Seafloor Mapping Lab (SFML) using a Reson E111 multibeam echosounder system aboard the RV Eltanin. Among other sites, the SFML has created one-meter (in some areas half-meter) resolution DEMs for the Monterey sub-basin environment from as shallow as 4 or 5m out to a minimum of 50m, and extends from the Del Monte beach area to Point Lobos Marine Reserve. This study primarily makes use of DEM data in the Cannery Row to Point Pinos area of the Monterey peninsula nearshore (Fig 1).

Study Area

This area is notable for its deep and steep coastal shelves and deep canyons. The area has been of great interest to scientists and resource managers due to its diverse benthic habitats and the large number of species that live there. In addition, this area is a popular recreational fishery for anglers and scuba divers.

Study Methodology

This study used high-resolution bathymetric data recently collected by the CSU, Monterey Bay Seafloor Mapping Lab (SFML) using a Reson E111 multibeam echosounder system aboard the RV Eltanin. Among other sites, the SFML has created one-meter (in some areas half-meter) resolution DEMs for the Monterey sub-basin environment from as shallow as 4 or 5m out to a minimum of 50m, and extends from the Del Monte beach area to Point Lobos Marine Reserve. This study primarily makes use of DEM data in the Cannery Row to Point Pinos area of the Monterey peninsula nearshore (Fig 1).

Figure 1: Multibeam bathymetry-derived 1m resolution DEM of study area on coast of Monterey peninsula, CA (a) and close-up area near Pt. Pinos (b). All maps are UTM Zone 16, WGS84 datum.