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Recolonization and succession in soft-sediment infaunal communities: the spatial scale of controlling factors

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Abstract

Succession in marine soft-sediment habitats has been studied extensively and several general models of successional dynamics have been developed. However, few researchers have addressed how successional dynamics may change over different spatial scales. Here we extend a model that focuses on the factors that control recolonization and succession. These factors comprise three levels of a hierarchy which include environmental conditions, life history and population processes and biotic interactions. Using this hierarchical framework, we consider the spatial scales at which different factors operate, and argue that the relative mix and intensity of factors controlling succession change at different spatial scales. As a result, successional dynamics may vary considerably as the spatial scale of disturbance increases. At small scales, factors at each level of the hierarchy are important. The greater potential for biotic interactions at this scale may be particularly critical. At meso- to large scales, population processes and environmental conditions have the most influence on successional dynamics. Due to these differences, responses to small-scale ($\lesssim 1$ m^2) as well as large-scale ($\gtrsim 1$ hectare) disturbances may be quite variable. Within this range ($\gtrsim 1$ m^2 $\lesssim 1$ hectare), short- and long-term responses to disturbance may be relatively more predictable and conform to current models of succession in soft-sediment habitats.

Introduction

Disturbance is recognized as an important factor structuring marine and estuarine soft-sediment communities (Grassle & Sanders, 1973; Johnson, 1973; McCall, 1977; Woodin, 1981; Thistle, 1981). Because of its very nature, the physical fabric of soft-sediment habitats is relatively easily disturbed by a variety of processes over a broad range of spatial and temporal scales (Figure 1). It is not surprising then that recolonization and succession in soft-sediments have been studied fairly extensively (see Rhoads & Boyer, 1982; Probert, 1984; Thrush, 1991; Hall et al., 1994 for reviews, and references therein), and several models have been proposed that attempt to generalize these dynamics (discussed in more detail below). Moreover, this information plays a critical role in documenting impacts and assessing ecological responses to human induced disturbance events.

Over the past several years, many ecologists have turned their attention to elucidating how ecological phenomena vary at different spatial and temporal scales (e.g. Dayton & Tegner, 1984; Schneider & Piatt, 1986; Wiens, 1989; Levin, 1992; Angel, 1994), including the dynamics of benthic communities (e.g. Barry & Dayton, 1991; Thrush, 1991; Dayton, 1994; Hall et al., 1994). In this paper, we focus on the dynamics of recolonization and succession in soft-sediment habitats at different spatial scales. There are several components of spatial scale that can be considered including spatial grain, or patch size, and spatial extent, or the area or distance over which specific phenomena occur. More specifically, we address two questions regarding these components of spatial scale.

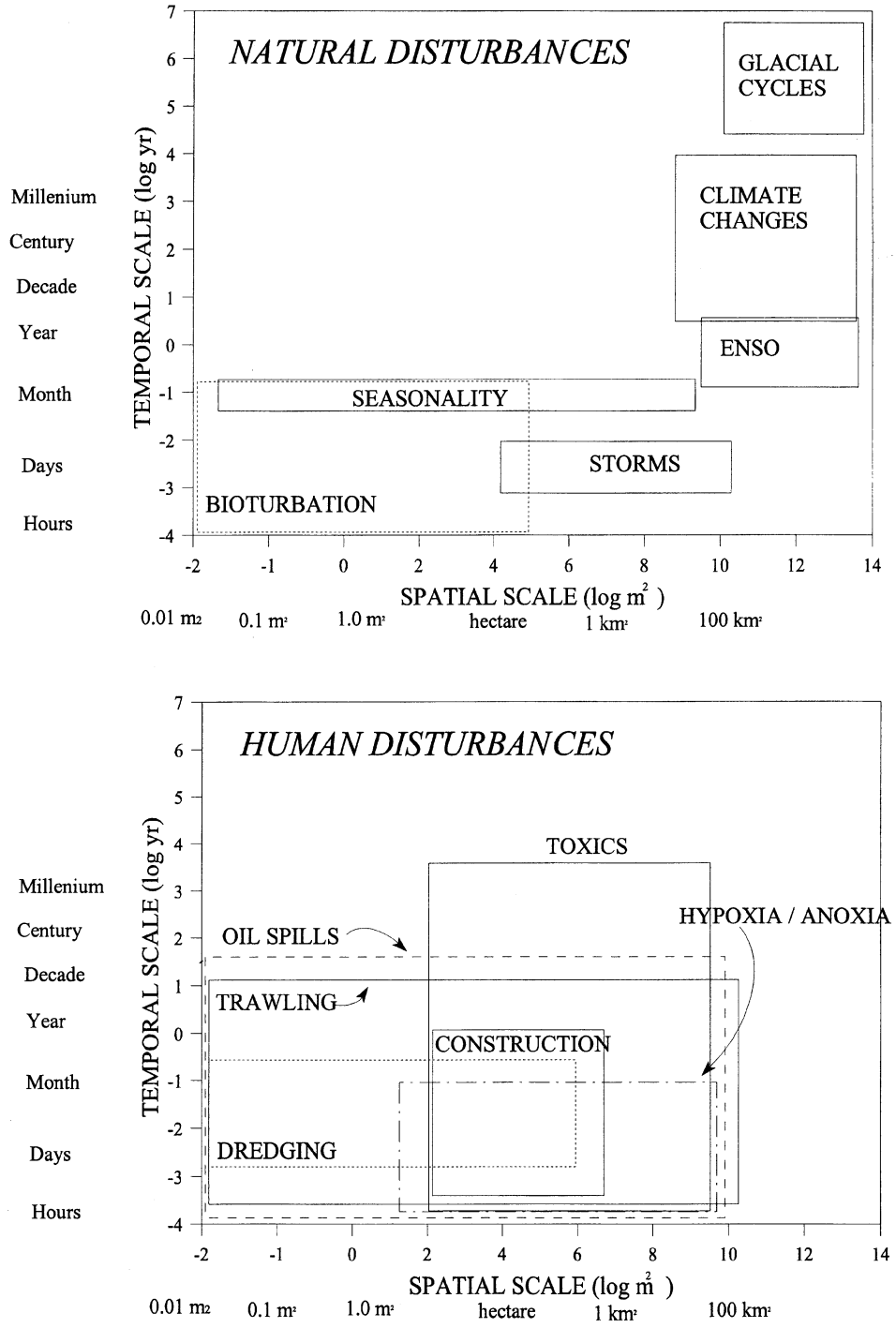

Figure 1. Conceptual depiction of the spatial and temporal scales of different types of natural (top) and human (bottom) disturbances which impact soft-sediment habitats.