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Taxonomic Distinctness: Measuring the Effects of Nonindigenous Species on the Taxonomic Diversity of Estuarine Assemblages

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Pacific coast estuaries of the United States have been invaded by more than 200 nonindigenous species, primarily from Asia and the Northwest Atlantic (U. S. East coast). Recently, the nature and extent of this invasion in estuarine soft-bottom assemblages has been quantified in two studies. The first study was conducted as part of the U. S. Environmental Protection Agency (EPA)'s 1999 Environmental Monitoring and Assessment Program (EMAP). This study evaluated the regional-scale pattern of invasion in small estuaries (other than Puget Sound, San Francisco, and the main stem of the Columbia River) in California, Oregon, and Washington, using a probabilistic sample design. The second study evaluated the extent of invasion in soft-bottom assemblages within the San Francisco estuary, the "most invaded estuary" in the United States. A relatively high diversity of invaders was observed in both studies: 57 nonindigenous species versus 429 native species in small estuaries on the U. S. Pacific coast and 66 nonindigenous species versus 235 native species in the San Francisco estuary. Alterations to the benthic assemblages in both studies were evaluated by the relative abundance of invaders versus native species and by the invader's overall contribution to species richness at different spatial scales.

A different type of impact not captured by these metrics is alterations to the taxonomic diversity of the entire assemblage, resulting from the introduction of exotic species, commonly representing novel families or orders to the biogeographic region. To evaluate the effects of nonindigenous species on taxonomic composition, we explored two

biodiversity indices that measure taxonomic relatedness. The first index is the average taxonomic distinctness (AvTD), defined as the average length of the taxonomic path between two randomly chosen species within a sample. The second index is the variation in taxonomic distinctness (VarTD or Lambda+), a measure of the evenness of taxonomic structure across taxonomic units. This second index captures the variation in relatedness among species.

Our initial hypothesis was that nonindigenous species would have a lower taxonomic distinctness than native species. However, we observed no difference in AvTD between all the native species relative to all the nonindigenous species among small estuaries of the U. S. Pacific coast or within the San Francisco estuary. We did, however, observe differences among specific taxonomic groups. In particular, nonindigenous polychaetes had a significantly lower AvTD relative to native polychaetes in both the U. S. Pacific coast estuaries and the San Francisco estuary, reflecting the large number of exotic spionid polychaetes observed in both studies. In contrast to AvTD, VarTD was significantly higher for the entire suite of nonindigenous species than for native species in Pacific coast estuaries. VarTD for all nonindigenous species showed the same trend in the San Francisco estuary, although the difference was insignificant. In both studies, nonindigenous polychaetes showed a significantly higher VarTD relative to the native polychaetes, indicating a greater variation in taxonomic path length among nonnative species.

At least in these two studies, the suite of nonindigenous benthic species was not taxonomically impoverished relative to native species, partly reflecting the mixing of invaders from different oceans and biogeographic zones. The observed pattern in polychaetes of decreasing AvTD and increasing VarTD appears to be due to the combined effects of two opposing mechanisms. Adding novel genera/families, which tends to increase both AvTD and VarTD, and overrepresentation of nonindigenous species in a few genera, which tends to decrease AvTD. In contrast to the results observed with nonindigenous species, pollutants have been reported to simplify communities by decreasing the average path length and the variation in path length. Thus, the underlying mechanisms by which pollutants and invasive species alter the taxonomic structure of soft-bottom assemblages differ fundamentally. This difference should be considered when evaluating these and other biodiversity metrics.