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The development of nutrient criteria for U.S. Estuaries: State of the science

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The U.S. is in the process of developing nutrient criteria for lakes, wetlands and estuaries under the authority of the U.S. Clean Water Act. These criteria provide scientifically defensible limits for States and authorized Tribes to reduce anthropogenic nutrient enrichment of the waterbodies under their jurisdiction. The natural ambient background, or reference condition, is an important element in setting nutrient criteria. It is the historical status against which current conditions can be compared. The challenge in developing nutrient criteria is to describe, and ultimately set quantitative values for water quality parameters below which attainable conditions of biotic integrity or a suite of designated uses for that waterbody can be maintained.

Estuaries are complicated bodies of water, and the task of setting nutrient criteria for them is complex; in fact, far more complex than for lakes or wetlands. Estuarine nutrient complexity arises from the influence of multiple chemical, physical, and biological factors interacting in the delivery of nutrients and their transformations. There are multiple sources of nutrients to estuaries, from land-based point and non-point sources, to atmospheric and groundwater inputs. Each source may vary in the amount of specific nutrients (nitrogen or phosphorus) as well as their proportional ratio to other nutrients in that source. Different sources may also vary in the chemical form of these nutrients. Each of these different forms can affect the biology of the system differently. Systems also vary in their uses, which can alter nutrient processes, for example, the amount of shellfish aquaculture. Estuarine nutrients are also dependent on the physics of the estuary, as residence time determines the amount of time nutrients stay in the system and are available for biological processes. Moreover, ecosystem response to eutrophication is a continual process rather than a static one, and different systems fall on different points along the estuarine continuum making their response to nutrients variable.

One way to establish relationships is to examine variables that are representative of nutrient loading (causal variables) and those that are representative of a biological response (response variables). Causal variables may include nutrient concentrations, nutrient loads, or a proxy for nutrient loads, such as land use. Relationships between causal and response variables will vary depending on the time and space scale under consideration. Another useful approach is to characterize relationships based on estuarine typology, a framework that groups estuaries based on physical characterizations.

Response variables may consider a single measure, such as the amount of chlorophyll a, but more integrated assessments of the biological community may provide an improved understanding of the responses to nutrients. Such integrated assessment, or biocriteria, may include species, populations, or communities of organisms that integrate the aquatic condition and provide information on ecosystem condition, such as algal species composition, or submerged aquatic vegetation. In practice, the establishment of estuarine criteria for each estuary will depend on the availability of current and historical data, the capability for monitoring and the types of parameters that can be assessed, and no single approach can be applied uniformly to all estuaries.