NUTRIENTS: SIMPLE CONCEPTUAL MODEL NARRATIVE

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Enrichment of aquatic systems due to excess nutrient concentrations is a common cause of biological impairment. Although aquatic plants and microbes require nitrogen (N) and phosphorus (P) for growth and reproduction, excess nutrient inputs may adversely affect biotic communities. Often these excess inputs of N and P are related to human activities and sources in the watershed, which influence in-stream nutrient concentrations via six dominant pathways: (1) by increasing the delivery of N or P from the watershed; (2) by increasing the amount of N or P in soils transported into streams; (3) by increasing the amount of N or P in surface runoff; (4) by increasing the amount of N or P in subsurface waters; (5) by increasing the amount of N or P in wet or dry deposition; and (6) by increasing the amount of N or P in discharged waters (i.e., point source effluents). For example, many human activities (e.g., agricultural practices, residential and commercial development) lead to land cover alteration, with subsequent increases in surface runoff and watershed erosion; this land cover alteration can increase the mobilization of N and P bound to watershed soils, ultimately increasing nutrient delivery to streams. Other sources (e.g., fertilizers and animal wastes associated with agricultural and residential practices, geology of the landscape) may directly elevate N and P concentrations within the watershed. Increases in watershed N or P loading associated with these sources can eventually reach streams via surface runoff, via subsurface waters (e.g., groundwater inputs), or attached to washed-in particles.

Once in the stream, N or P may occur in dissolved organic, dissolved inorganic, or particulate forms, with transformations occurring among these forms depending on environmental conditions (e.g., dissolved oxygen concentrations). Although N and P may be considered candidate causes, excess nutrients are not proximate stressors. Fish and invertebrates are usually not directly adversely affected by excess nutrient concentrations, but rather are affected by other proximate stressors resulting from nutrient enrichment.

Nutrients can be associated with biological impairment by several pathways. Dissolved N and P can be taken up by primary producers (algae and macrophytes) and microbes, although whether primary producers respond to increased nutrient concentrations is dependent on adequate light levels. Increases in plant and microbial biomass or productivity may negatively impact aquatic fauna in multiple ways. For example, increases in microbial assemblages may lead to greater microbial infection of invertebrates or fish, or altered benthic organic matter processing (e.g., faster processing rates). Increased respiration of microbes and plants often leads to decreases in dissolved oxygen concentrations (see CC.4 Dissolved Oxygen for more detailed information on this pathway), especially during times when photosynthesis is limited (e.g., at night). In addition, increased photosynthesis may lead to increased pH; this increase may be especially important when N is elevated, as unionized ammonia, a toxic form of N, is more prevalent at high pH. Blooms of certain algal taxa also may result in increased production and release of toxins that can affect fish or invertebrates.

Increased plant or algal production may translate to increased food resources, which can benefit herbivorous organisms but may adversely impact other taxa by altering the food resources derived from detritus. Changes in plant assemblage structure also may occur with enrichment, and these changes can affect aquatic fauna by altering habitat structure or by altering the quantity or quality of food resources. Changes in community structure may occur even without overall increases in primary producers, due to alterations of nutrient availability ratios. Increases in suspended organic matter (i.e., phytoplankton or suspended benthic algae) also can negatively affect aquatic biota, for example by increasing turbidity.