Eutrophication

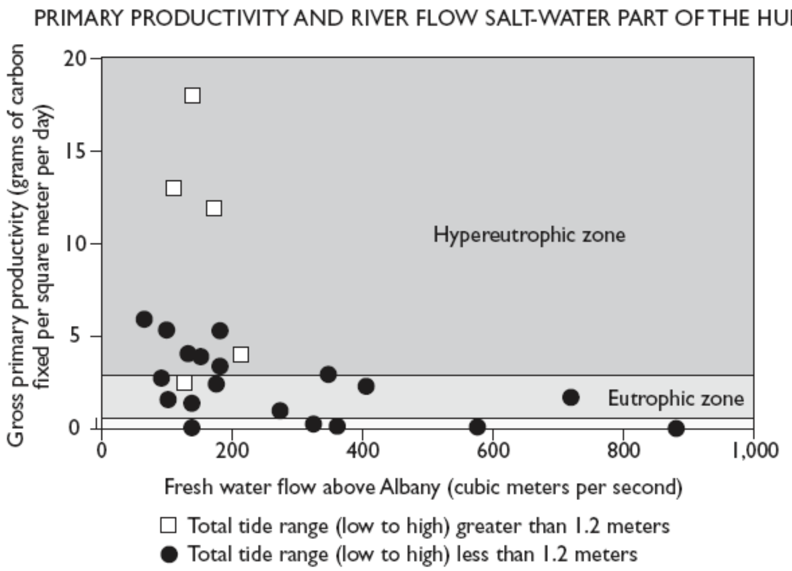
Over time, unless they have continued input from a fresh water source, closed aquatic ecosystems like ponds often become eutrophic. This is a process in which the ecosystem is enriched by nutrients, encouraging excess plant and algal growth. This plant growth often strips the water of necessary oxygen, since microbes use up the oxygen as they decompose the excess plant material. Although eutrophication is a natural form of succession which usually takes hundreds or thousands of years, it can be enhanced through human inputs of nutrients. We call this 'cultural eutrophication'. As the pond becomes covered with surface vegetation, the organic matter settles at the bottom, slowly filling up the pond and causing low dissolved oxygen levels as decomposition takes place.

By increasing the amount of nutrients in an ecosystem, human activity can increase the rate of eutrophication. Fertilizers (including lawn fertilizer), pollution from sewers or septic tanks, agricultural runoff, and runoff from impervious surfaces can increase nutrient loads to the point where a water body becomes toxic. Eutrophication from these excess nutrients (primarily nitrates and phosphates) leads to algal blooms, which leads to a degradation of water quality due to reduced dissolved oxygen levels and a subsequent decrease in biodiversity.

Since the Industrial Revolution, the Hudson River has had problems with pollution, yet the challenges and focus regarding pollution management has changed and evolved. In the last twenty years interest went from reducing toxic substances, such as PCBs and DDT, to controlling nutrient pollution and consequent eutrophication. More than sixty percent of coastal waters in the U.S. are moderately to severely degraded by nutrient pollution, most of which originates in the interior of the U.S.

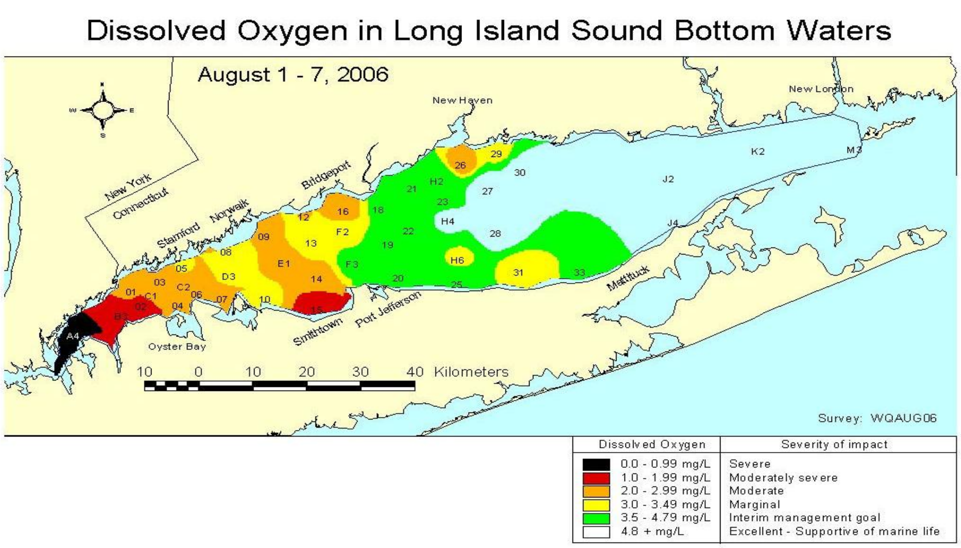
In the Hudson River, primary productivity (a measurement of the amount of photosynthesis by organisms like plants and algae) has increased dramatically since the 1970s. Estuaries are classified as eutrophic when annual production ranges between 200 and 500 g C m^{-2} y^{-1}, and as very eutrophic (sometimes called hypereutrophic) when annual production exceeds 500 g C m^{-2} y^{-1}. If you break this down to a daily rate, the Hudson would be considered very eutrophic anytime daily production goes above 2 to 3 g C m^{-2} d^{-1}. *(Note: when you see a negative exponent after a measurement value, it represents 'per'. That is, 500 g C m^{-2} y^{-1} is the same as 500 grams of carbon per square meter per year.)*

Gross primary productivity, or GPP, is the amount of energy, expressed in carbon, which has been captured or produced by plants through photosynthesis. It is a way for scientists to understand how productive, or how much biomass (and therefore energy) is consumed by plants in an ecosystem.

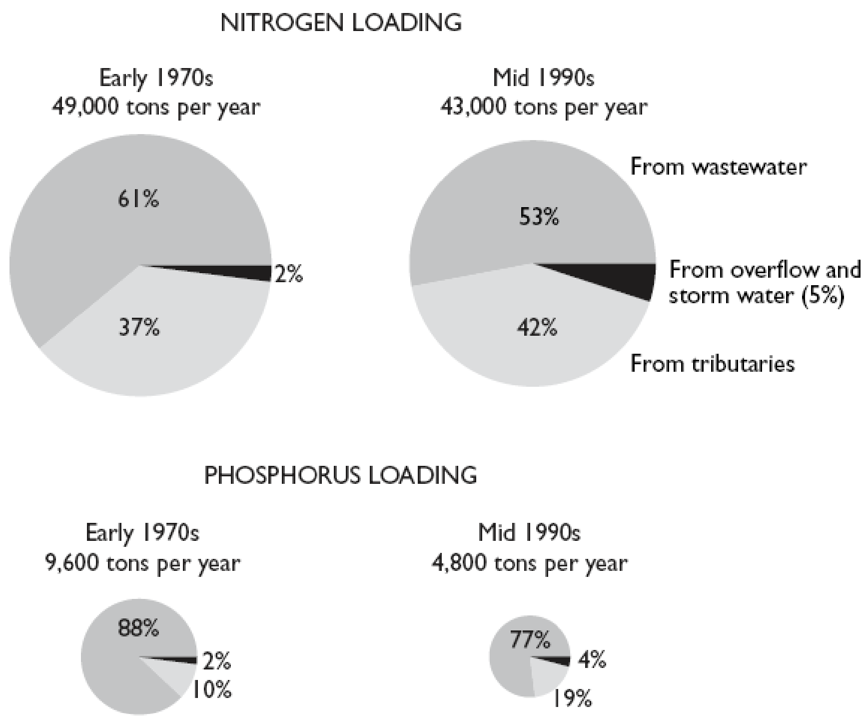


This graph shows the relationship between freshwater flow and GPP in the Hudson River. Data was collected in the spring, summer, and fall of 1994, 1995, and 1997 in the lower Hudson River estuary (where the river is salty). The dotted line represents the approximate value for GPP above which an estuary is considered to be very eutrophic. The open squares represent low tide range (less than 1.15 m), while the dark triangles represent high flow range (greater than 1.15m). Howarth et al, 2000.

The lower parts of the Hudson River estuary flush daily, since there is a lot of freshwater coming down the river from the watershed, and the tides move water around daily. The Chesapeake Bay, on the other hand, flushes only once every 230 days. Consequently, although the Hudson River receives high levels of nutrients, it does not have the severe eutrophication problem of other estuaries. However, nearby Long Island Sound does have problems with low dissolved oxygen levels, as can be seen from this map (darker colors are lower levels of DO).



The quality of the Hudson River has improved over time, especially since the enactment of the Clean Water Act in 1972 and a ban on phosphates in detergent in 1973.



The main source of both nitrogen and phosphorus is wastewater, which, although treated in sewage treatment plants, does not remove most nutrients. Primary wastewater treatment plants in the New York City metropolitan area were built in the 1930s, but secondary treatment plants were not built until after the Clean Water Act required facilities to reduce their Biological Oxygen Demand (a measure of the organic material in the water) levels in 1972. As of the early 1970s, close to 40% of the wastewater discharged into the Hudson River estuary was raw sewage, 15% received primary treatment, and 47% received secondary treatment.

Primary treatment removes materials that can be easily collected from the raw wastewater and disposed of including large particles (rock, sand, & gravel), human waste and floating materials. Secondary treatment is designed to substantially reduce the biological content of the sewage using aerobic biological processes. This is done by allowing bacteria, fungi, and protists to decompose the organic materials, and adding oxygen to allow the microbes to breathe and grow. During this process microbes actually eat and digest potentially harmful waste. The bacteria and solid waste eventually accumulate and settle out in suspension, at which point they are removed from the water, dried, and turned into nutrient loaded 'sludge'. This sludge is sometimes sent to a landfill or incinerator, or it can be processed to become fertilizer. In the 'nutrient removal' process, additional nitrogen and phosphorus are removed by the treatment plant. Most wastewater treatment plants currently do not do nutrient removal, mainly because it is too expensive.