Pathways of oligotrophication – hysteresis, shifting baselines, and legacy effects

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Abstract

Nutrient management plans have been successful in reducing nutrient inputs to many coastal ecosystems, but ecosystem responses have been unanticipatedly weak. This lack of recovery has been attributed to non-linear hysteresis effects, changes in climate and other factors creating a shifting baseline, and delayed responses due to legacy effects of nutrients and organic matter stored in the seabed. This presentation will primarily focus on the potential sediment legacy effect. Sediment pools of carbon (measured as Loss-on-Ignition, LoI), total nitrogen (TN) and total phosphorus (TP) sampled over 25 years in two separate periods (1999-2003 and 2017-2023) across 14 Danish estuaries and coastal ecosystems, following substantial reductions in inputs of nitrogen (>50%) and phosphorus (>80%) from land, the majority of these occurring from 1985 to 1997. Sediment pools were positively correlated with chlorophyll levels at station level, with relatively high accumulation in muddy sediments compared to sand. Consistent declines (5-15%) of LoI, TN and TP were observed for sandy sediments, whereas trends for muddy sediments were more variable, albeit no trends were significant. Variability among sediment cores was high, particularly spatial variability but also temporal variability. Given the relatively large sampling effort (~160 cores), we estimated that it is only possible to detect changes of >20% with sufficient power (probability of at least 80%). The changes in sediment pools are consistent with other studies, when considering the relative reductions in nutrient inputs. Collectively, the trends suggest that the legacy effect of nutrient reductions was small and probably not longer than a few years for sandy sediments. Importantly, the potential legacy effect of the sediments cannot explain increasing hypoxia and chlorophyll levels, which are most likely due to other factors.