Excess nutrients cause environmental deterioration in the Bohai Sea, China

The introduction of excess nutrients (i.e., nitrogen and phosphorus) to coastal areas can have a series of impacts. One of the most common is eutrophication—the enrichment of water with surplus nutrients, which accelerates the growth of algae. In coastal ecosystems, eutrophication can lead to a variety of impacts, including the occurrence of nuisance and toxic algal blooms (e.g., red tides), loss of seagrass beds and benthic creatures, depletion of dissolved oxygen, and fish kills.

The addition of nutrients to coastal waters occurs through natural processes, but in recent decades they have been greatly supplemented by various human activities. These include the application of fertilizer in agricultural practices, release of industrial wastewater and domestic sewage, and burning of fossil fuels. By increasing the natural movement of nutrients from inland watersheds to coastal water bodies, these activities have greatly intensified coastal eutrophication.

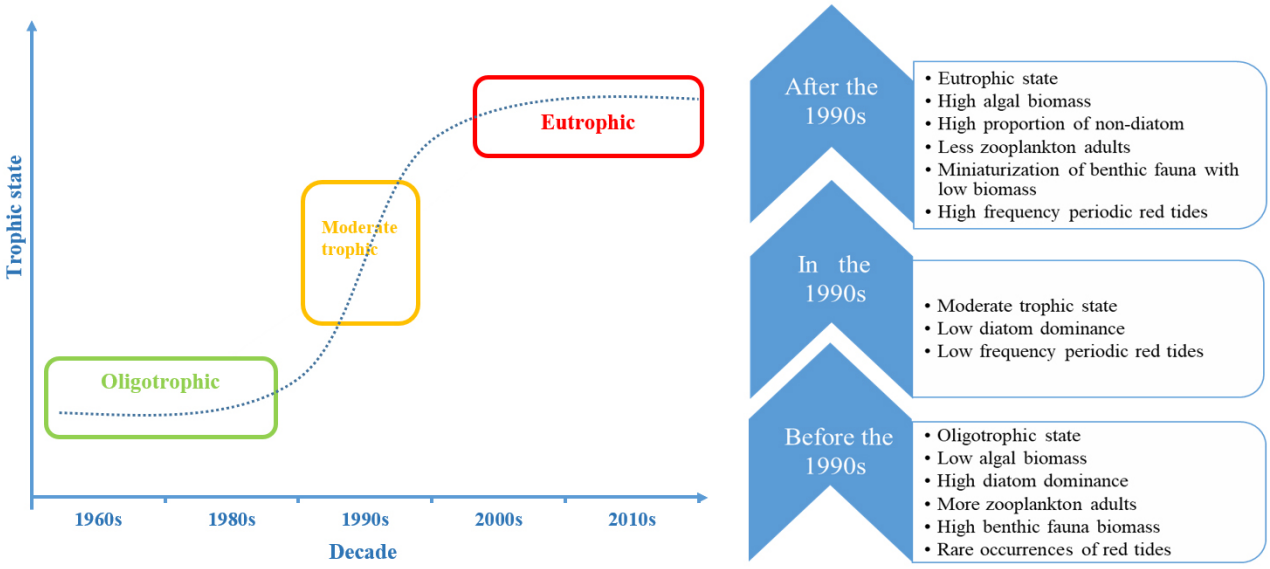

Fig. 1. Shift in trophic state in the Bohai Sea over the last 60 years.

The Bohai Sea is a shallow, semi-closed inland sea with an area of 77,000 km^2 and an average water depth of 18 m. Major rivers flowing into the Bohai Sea are the Yellow (Huanghe), Haihe, and Liaohe Rivers. Over the past few decades, the Bohai Sea, which acts as the critical support system for the Bohai Economic Rim and Yellow River Economic Belt, has come under great environmental pressure owing to rapid social and economic development. Because of human influence, the nutrient levels and ratios in the Bohai Sea have changed significantly in the last 60 years. For

instance, the amount of dissolved inorganic nitrogen (DIN) increased by seven-fold from the end of the 1950s to the mid-2010s, whereas those of dissolved inorganic phosphate (DIP) and dissolved silicate (DSi) decreased from the end of the 1950s to the beginning of the 1990s, and have since increased again. The nonsynchronous changes in the levels of different nutrients resulted in changes in the nutrient ratios. The DIN/DIP ratio increased from 3 at the end of the 1950s to nearly 60 in the mid-2010s, whereas the DSi/DIN ratio decreased dramatically from 10 before the 1990s to less than 2 at present in the Bohai Sea.

Phytoplankton (i.e., microalgae) take up nutrients in specific ratios and levels. In the Bohai Sea, changes in the nutrient levels and ratios have thus had many ecological effects. The amount of phytoplankton increased by six-fold from the 1960s to the mid-2010s, and the species composition changed from diatom dominance (which helps maintain the usual food chain structure) to flagellate dominance (which may alter the regular dynamics of the food chain). Red tides rarely occurred in the Bohai Sea before the 1980s, but they have been seen periodically and frequently since the 1990s and have consistently occurred 10 times a year in the 21st century.

Benthic creatures are more suitable than pelagic species for evaluating coastal eutrophication because of their much longer lifespan. In the Bohai Sea, the dominant benthic creatures changed from large-bodied species before the 1980s to small-bodied species afterwards. The quantity of benthic creatures also decreased. Additionally, the area of low dissolved oxygen in the bottom water is growing in the Bohai Sea, which may make it more difficult for marine life to survive.

In short, the Bohai Sea ecosystem has shifted from a nitrogen-limited, nutrient-poor state before the 1990s to a potentially phosphorus-limited eutrophic state afterwards. What is needed now are policies and management strategies that incorporate resilience approaches to restore the ecological health and services of the Bohai Sea.

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