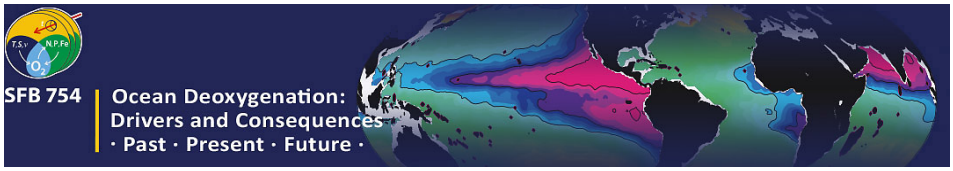

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Deoxygenation effects on fisheries: a mosaic of effects and responses

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Fisheries (harvest) are an ecosystem service that provide employment and nutrition in the global food system. Worldwide production of wild fisheries has leveled off, while demand continues to increase. Over harvesting switches fisheries from an ecosystem service to a stressor. Deoxygenation is anticipated to expand over the next decades, and can affect fisheries through negative effects on growth, survival, and reproduction, and effects on movement that, in turn, affects the availability and location of the harvestable biomass. Quantifying the effects of deoxygenation on fisheries is challenging because of the effects of other stressors (e.g., warming, acidification) that partially covary with oxygen and because the dynamics of oxygen and fisheries are highly site-dependent. We review existing studies on the effects of deoxygenation on fisheries. In statistical (correlation-based) analyses spanning multiple coastal hypoxia ecosystems, stock biomass and landings were positively related to nitrogen loadings but it was difficult to isolate a direct hypoxia effect. However, the analysis suggested that trophic efficiency (landings per unit nitrogen loadings) was low in systems with extensive hypoxia. Eight case studies show the various ways deoxygenation can affect fisheries: Atlantic croaker and shrimp in the Gulf of Mexico, Dungeness crab in Hood Canal (Puget Sound), cod in the Baltic Sea, anchovy and other species in the Peruvian EEZ, Indian Oil Sardine in the southwest coast of India, white grouper in coastal west Africa, and billfishes in the eastern tropical Pacific. Case studies include low oxygen effects on the population itself through reduced recruitment and population abundance, and examples of spatial distribution effects resulting in changes in the dynamics of the fishing vessels. Modeling analyses demonstrate that, in those situations when hypoxia alone may have small to moderate population-level effects, the effects become amplified when hypoxia is combined with other stressors. A prevalent effect of deoxygenation documented in the case studies was changes in fishing locations in response to fine-scale distributional changes of the fish that then affect the catchability and bioeconomics of fishing. Further refining the role of deoxygenation on fisheries will increase the effectiveness of management by enabling proper interpretation of population fluctuations and spatial dynamics, more accurate view of the vulnerability of fish to harvest (e.g., catchabilities), and the derivation of robust population indices used in stock assessments. There is little room for management mis-calculations; too many people depend on effective management of fisheries to ensure sustainable harvests and healthy ecosystems.

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