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Reconstruction of Atlantic herring (*Clupea harengus*) recruitment in the North Sea for the past 455 years based on the δ^{13}C from annual shell increments of the ocean quahog (*Arctica islandica*)

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Abstract

Understanding the recruitment variability of the Atlantic herring North Sea stock remains a key objective of stock assessment and management. Although many efforts have been undertaken linking climatic and stock dynamic factors to herring recruitment, no major attempt has been made to estimate recruitment levels before the 20th century. Here, we present a novel annually resolved, absolutely dated herring recruitment reconstruction, derived from stable carbon isotope geochemistry (δ^{13}C), from ocean quahog shells from the Fladen Ground (northern North Sea). Our age model is based on a growth increment chronology obtained from fourteen shells. Ten of these were micromilled at annual resolution for δ^{13}C analysis. Our results indicate that the anthropogenically driven relative depletion of ^{13}C, the oceanic Suess effect (oSE), became evident in the northern North Sea in the 1850s. We calculated a regression line between the oSE-detrended δ^{13}C results (δ^{13}CṠ) and diatom abundance in the North Sea, the regression being mediated by the effect of phytoplankton on the δ^{13}C of the ambient dissolved inorganic carbon. We used this regression to build an equation mediated by a nutritional link to reconstruct herring recruitment using δ^{13}CṠ. The reconstruction suggests that there were five extended episodes of low-recruitment levels before the 20th century. These results are supported by measured recruitment estimates and historical fish catch and export documentation. This work demonstrates that molluscan sclerochronological records can contribute to the investigation of ecological baselines and ecosystem functioning impacted by anthropogenic activity with implications for conservation and stock management.

KEYWORDS
catch per unit effort, ecosystem functioning, herring recruitment, historical documentation, sclerochronology, stable carbon isotope geochemistry