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RADIOCARBON IN THE MARINE ENVIRONMENT: AN OVERVIEW

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Understanding carbon cycling in the ocean is critical for understanding past ocean dynamics, local impacts of environmental changes, and predicting future changes due to climate change. Radiocarbon plays an important role in deciphering the carbon puzzle and, here, we highlight some of the contributions this isotope has made to oceanography. The field is enormous and distilling it to three short papers was a challenge; we chose to focus on three areas: radiocarbon in the carbonate record, in organic matter, and in the dissolved inorganic carbon (DIC) pool in the ocean.

The carbonate record here focuses on two marine records: shells and corals. Although there are many more carbonate bearing animals and plants in the oceans, the focus lies on these as they also provide valuable information in combination with other disciplines. Readers are introduced to the diverse possibilities these species offer with respect to oceanography but also paleoclimate and archaeology. Shells and corals both show growth patterns like tree rings which makes them a valuable tool for measurements in yearly resolution if necessary. The article starts with an historical overview of the challenges faced when using shells. An important aspect is the determination of the reservoir effects, that are species-specific and may vary over time and location. Examples from current research complete this retrospective on shells. Corals face a long tradition in radiocarbon dating and are very important for the calibration curve data. An historic overview with some description of the challenges faced with various species rounds up this part. A short note is also given on foraminifera. These are important for reconstructing ocean conditions in the present and in the past.

Studying radiocarbon in the many forms of organic matter in the ocean—dissolved, particulate, sinking, suspended—provides a wealth of information about transformations impacting global and molecular processes. The earliest work with dissolved organic carbon (DOC), a challenging analytical accomplishment, demonstrated the parallel but offset age profiles of DOC and DIC, with DOC being significantly older. Much research has been devoted to understanding the old age of the DOC using increasingly sophisticated techniques such as solid-phase extraction (SPE) and ultrafiltration (UF). While its age remains a conundrum, research is starting to unlock the mysteries of this carbon pool. Compound class and compound specific radiocarbon analyses (CCRA and CSRA, respectively) are revealing insights into the origin and fate of organic matter in the ocean. A relatively new technique, ramped pyrolysis oxidation (RPO), allows for the thermal separation of the entire organic carbon pool into discrete fractions that can be analyzed for radiocarbon and will add to our knowledge and understanding of organic matter in the oceans.

DIC is the largest active inorganic carbon reservoir that exchanges with the atmosphere and understanding its role in the ocean is critical for understanding the impacts of global climate

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change. Nuclear weapons tests in the 1950–60s added a spike of radiocarbon to the atmosphere whose transfer to the oceans provided a means of quantifying air-sea gas exchange. The realization of its utility as an ocean tracer has led to its measurement, as $DI^{14}C$, in almost all the global ocean surveys conducted since the 1970s. The tens of thousands of measurements made over the years have contributed enormously to our understanding of ocean circulation, the uptake of anthropogenic CO_2 in the surface ocean, and will be instrumental in studying the transfer of anthropogenic carbon to the deep ocean.

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