The Palaeoceanographic history of the Celtic Sea since the last glaciation and its potential for carbon storage

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Introduction: Up to 80% of organic carbon in the world's oceans is stored in shelf seas (Sharples et al., 2019). Shelf seas are therefore crucial components of the global carbon cycle and climate, though their history is poorly understood due to the often erosive nature of these shallow marine environments. This project focuses on the history of the Celtic Sea, situated on the NW European continental shelf between France and Ireland, aiming to improve our understanding of how carbon storage in this area has changed throughout the Holocene.

The oceanography and biological productivity of the modern Celtic Sea is influenced by seasonal stratification of the water column, when the influence of insolation during the summer months overcomes tidal mixing effects and triggers the development of a relatively warm and stable surface layer (figure 2). Stratified waters provide favourable conditions for photosynthetic organisms, enhancing the drawdown of atmospheric carbon, ultimately removing it from the atmospheric system (Holt et al., 2009). Questions remain concerning the timing of the onset and evolution of seasonal stratification in the Celtic Sea, and the precise influence this process has had on the storage of carbon.

In 2018, a 7.5 m long sediment core of Holocene age, JC106-052PC, was recovered from the Celtic Sea at a depth of 116 m. Through investigating multiple proxy records preserved in this archive, this project seeks to resolve outstanding questions concerning carbon storage within the Celtic Sea and other shelf seas globally.

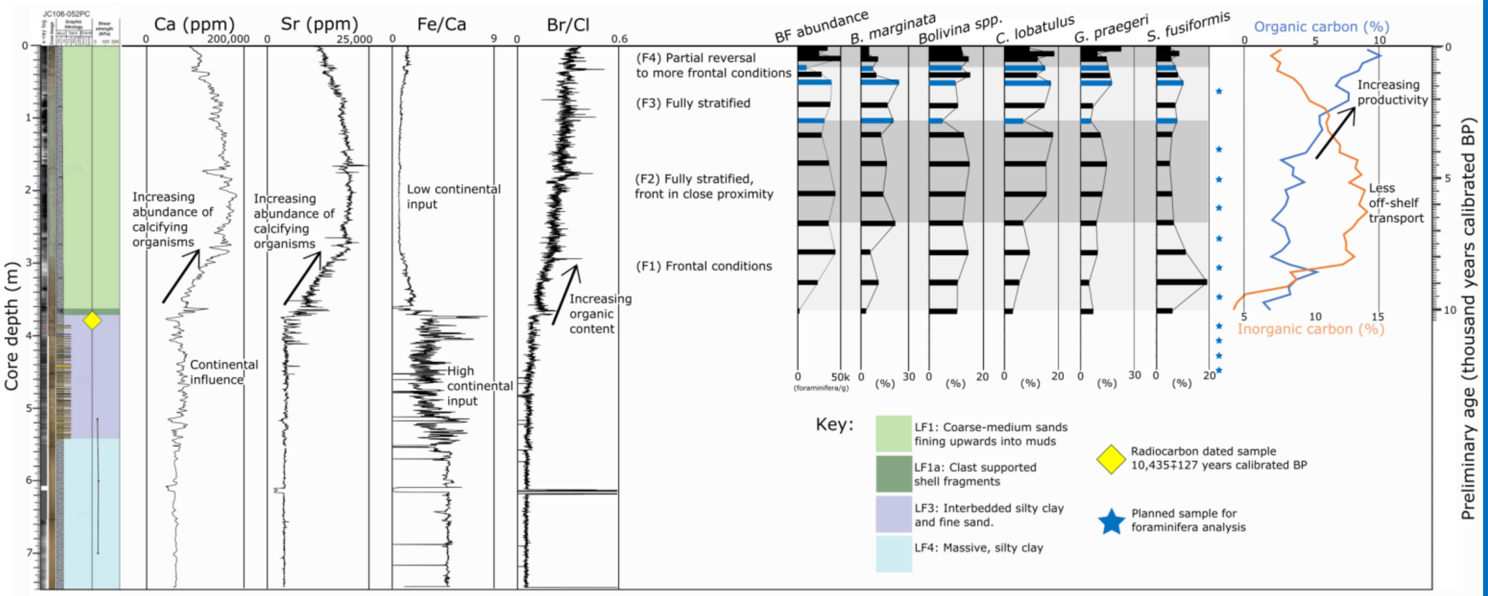

Figure 3. Preliminary results of JC106-052PC. Core radiographs, images, and x-ray fluorescence data for eighteen separate elemental intensities was attained from the ITRAX core scanner at BOSCORF. Foraminifera specimens were identified using transmitted light and scanning electron microscopes; blue bars indicate results which require verification. Carbon content records were produced using the loss-of-ignition method. An intact shell sample of Mactra/Spisula sp. taken at a depth of 389-390 cm was radiocarbon dated, providing an age of 10,435 ±127 years calibrated BP.

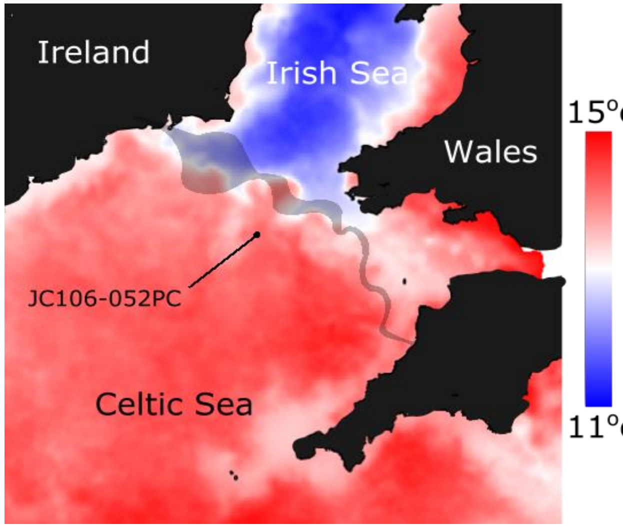

Figure 1. Temperature map of the Celtic and Irish Seas. The boundary between mixed (blue) and stratified (red) waters is termed the front. Shaded area marks mean summer position of the modern front (Scourse et al., 2002). Position of sediment core JC106-052PC marked. Temperature data courtesy of the NERC Earth Observation Data Acquisition and Analysis Service.

Results: Preliminary results (figure 3) are generally in agreement regarding a rapid transition around LF1a, at 3.6 m (ca 10 ky calibrated BP, pending an improved radiocarbon-based chronology). XRF data suggest low productivity, high continental input conditions below 3.6 m (perhaps indicative of deglacial conditions), followed by high productivity and low continental input. Foraminifera stratigraphy can be divided into four main assemblages: F4, characterized by *Cibicidoides lobatulus, Gavelinopsis praegeri, and Bulimina marginata*; F3, *B. marginata*; F2, *B. marginata, C. lobatulus, G. praegeri,* and the *Bolivina* group; and F1, *Stainforthia fusiformis.* The carbon-content record depicts a prominent increase in organic carbon and coeval decrease in inorganic carbon at around 1.6 m (ca 4ky calibrated BP); this is suggestive of increasing productivity, although XRF data for Ca and Sr (also proxies of productivity) show decreasing trends at this time.

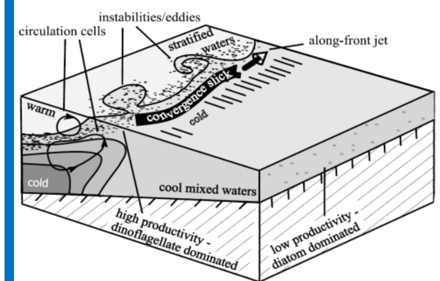

Figure 2. Cross-frontal transfer is driven by cyclonic eddies and periodically introduces nutrient-rich water to the warm, stable thermocline. Thus, conditions conducive to intense biological activity are focused around fronts. Scourse and Austin (2002).

Discussion: XRF and lithological data appear to suggest mixed water conditions below 3.6 m, placing the onset of stratification at roughly 10 ky calibrated BP, slightly earlier than the conclusions of neighbouring studies (e.g. Scourse et al., 2002) who recognize the onset at around 9 ky calibrated BP. F1, the oldest assemblage currently recognized, is characterised by species know to be associated with the nutrient-rich areas around the front, such as *S. fusiformis* (Scott et al., 2003). F4 is therefore interpreted as the front existing in the immediate vicinity of JC106-052PC. XRF and carbon-content data suggest that productivity increases above 3.6 m but stabilizes at around 2.7 m, perhaps reflecting the front's migration away from the core site and subsequent persistence of stratified conditions; the dominance of species which prefer stratified conditions, such as *B. marginata,* in zones F2 and F3 support this interpretation, as do the conclusions of Scourse et al. (2002). At 1.6 m, Ca and Sr values decrease; this perhaps reflects an increase in carbonate dissolution rather than decrease in productivity, as Br/Cl ratios and organic carbon content continue to increase. *B. marginata* abundance also decreases at around 0.4 m, so perhaps this change is also related to a hydrographic change such as the partial reversal of the front's migration.

Preliminary results suggest fully stratified conditions to be favourable to the storage of organic carbon in the Celtic Sea, though apparently at the expense of inorganic carbon. Future work shall focus on extending proxy records below 3.6 m in order to provide comparison with mixed water conditions.

References: Holt et al. Geophysical Research Letters. 2009 Jul;36(14). Scourse et al. Marine Geology. 2002 Nov 30;191(3-4):119-45. Scourse and Austin. Marine Geology. 2002 Nov; 191(3–4): 87-94. Scott et al. The Journal of Foraminiferal Research. 2003 Jan 1;33(1):32-61. Sharples et al. Progress in Oceanography. 2019 Oct; 177:102182.