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Bubble momentum plume as a mechanism for an early breakdown of the seasonal stratification in the northern North Sea

Janine Nauw (1), Peter Linke (2), Ira Leifer (3,4)

(1) Royal Netherlands Institute for Sea Research, NIOZ, Texel, the Netherlands (janine.nauw@nioz.nl), (2) Helmholtz Centre for Ocean Research, GEOMAR, Kiel, Germany (plinke@geomar.de), (3) University of California, Santa Barbara (ira.s.leifer@gmail.com), (4) Bubbleology Research International (ira.leifer@bubbleology.com)

The presence of a seasonal thermocline likely plays a key role in restraining methane released from a seabed source in the deeper water column, thereby inhibiting exchange to the atmosphere. The bubble plume itself, however, generates an upward motion of fluid, e.g. upwelling and may thereby be partially responsible for an early breakdown of the seasonal thermocline.

Measurements at site 22/4b, located at (57˚55'N, 1˚38'E) in the UK Central North Sea, 200 km east of the Scottish mainland, where gas is still being released since a blow out in 1990, have been used to identify the generation of the seasonal thermocline, the depth of the upper mixed layer and its breakdown in autumn. Data derived from two landers, containing an Acoustic Doppler Current Profiler (ADCP) and a Conductivity Temperature Depth (CTD) sensor, were used to determine the mixed layer depth (MLD) and the breakdown of the thermocline. Mixing of upper layer fluid into the lower layer has been inferred from large amplitude variations in the near-bottom temperature observations.

The ADCPs estimate velocities profiles in four beam directions using Doppler shifted frequency from acoustic pings sent out and received by four different transducers in a specific configuration. Besides that, the intensity of the backscattered sound per transducer is also recorded. Bubbles from the nearby plume contaminate the signal during part of the tidal cycle, but in bubble free periods, the MLD can be estimated using the acoustic backscatter signal as local maxima. Results show that the thermocline broke down between mid-October and early November, several weeks earlier than the breakdown of the thermocline in nearby/comparable areas, likely induced by bubble-induced downwelling at the site. The early breakdown of the thermocline was accompanied by multiple occurrence of a strong jetlike structure, associated with the seasonal tidal mixing front.