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Cold seeps as methane sources in Cook Strait, New Zealand: effects of lateral and vertical processes on regional methane budgets

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Uncertainty in the global marine methane (CH_4) budget is exacerbated by undersampling in the Southwest Pacific Ocean. Methane is formed in the marine environment by anaerobic decay of organic matter in sediments and the water column, and in the form of gas hydrates and at cold water seeps in ocean sediments. Around New Zealand natural sources of marine CH_4 are particularly poorly constrained. Recent exploratory work at the southern end of the convergent Hikurangi subduction margin has identified high concentrations of methane in oceanic waters of the Cook Strait, with elevated concentrations in surface (maximum 500% saturation) and deep waters (>10000%). CH_4 in seep gas plumes is also highly depleted in ^{13}C (-67‰), and so is readily distinguishable from the open ocean surface signature of -45‰. In order to identify the source(s) of surface water methane in Cook Strait, surveys of methane distributions were made across the region, targeting riverine and upwelling sources, with a local cold seep site, the Wairarapa Seep in southeastern Cook Strait, studied over several voyages as a focal point for process studies. Measurements included methane distribution, ^{13}C-methane and particulate isotopes in the water column, and characterisation of the microbial methanotroph community. Gas bubble plume heights at the Wairarapa Seep site at 1050 m water depth rarely exceed 350m, and lateral currents and stratification prevented methane from the seep reaching the sea surface directly at the site. Plume morphology and dynamics, however, were observed to be affected markedly by tidal currents, and the topography and dynamic current system of the Cook Strait offers the potential for lateral transport of seep methane in deeper waters.

For example, lateral advection of seep methane to canyon heads could facilitate transport into surface waters. The depleted ^{13}C-CH_4 at the surface in Cook Strait, however, was primarily associated with low salinity, suggesting a terrestrial or shallow sediment origin. These different methane sources are examined using simple isotope mixing models to determine their relative contributions, and presented in the context of a new marine methane budget for New Zealand waters.