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Quantification of methane loss and transport in dissolved plumes of the Santa Barbara Channel, California

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Methane emitted into the coastal ocean faces two primary fates: escape to the atmosphere or prolonged dissolution that allows sufficient time for oxidation by methanotrophic bacteria. The partitioning of methane between these fates is modulated by physical, chemical and biological factors, including the distribution of methane in the water, temperature, wind speed, water movement, and the biological methane oxidation rate. Because of the underlying complexity, studies rarely quantify all of these factors in unison, thereby leaving gaps in our understanding of methane biogeochemistry in the coastal ocean. In this study we estimated the partitioning of methane between transport, microbial oxidative loss, and sea-air transfer in a defined plume of dissolved methane originating from one of the world's largest seep fields, which is near Coal Oil Point (COP) in the Santa Barbara Channel, California. Depth distributions of methane concentration, biologically mediated oxidation rate, and current velocity were quantified at 12 stations in a 198 km2 area down-current from COP on July 4 – 5, 2007. Six stations were sampled again on July 7, 2007 to evaluate temporal plume variability. The observed methane distribution revealed two distinct methane plumes: a shallow plume centered at $\sim$40 m and a deeper plume centered at $\sim$200 m. The shallow plume originates at COP; the source of the deeper methane plume is not known. Cross sections of both plumes were used to calculate transport and loss terms for dissolved methane. The results indicate that the majority of the dissolved methane is advected and diffuses horizontally by turbulence whereas microbial oxidation, sea-air gas transfer, and vertical turbulent diffusion are less significant. Based on rates estimated in the study area, a model was developed to simulate the fate of the dissolved methane. The model results suggest that 60% of the methane of the sampled plumes will ultimately be microbially oxidized and 40% will be transferred to the atmosphere by sea-air gas exchange under the sampling conditions. These results illustrate the significance of microbial methane oxidation in coastal oceans.