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Understanding steady-state Deep Submarine Groundwater Discharge: a case study in Northern Israel

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Deep Submarine Groundwater Discharge (DSGD) is a ubiquitous and highly significant phenomenon, yet it remains poorly understood. Here we use numerical modeling (FEFLOW) to investigate a case study of DSGD offshore northern Israel, aiming to unravel the main features and mechanics of steady-state DSGD: the hydrology that enables its formation, the controls on rates and salinity of seepage, and the residence time of fluid underground. In addition, we investigate the geometry of the fresh-salt water interface within the seeping offshore aquifer. The first part of this work constructs a large scale (70 km) geologic cross-section of our case-study region. The mapping suggests outcropping of confined aquifer strata (Upper Cenomanian Judea Group) on the continental shelf break, 5-15 km offshore. The second part consists of hydrological simulations of DSGD from a confined aquifer similar to the case-study aquifer. The main findings are thus: steady-state DSGD from a confined aquifer occurs far offshore even under moderate heads. It is accompanied by a circulation cell that forms around an intrinsic freshwater-seawater interface. Circulation consists of seawater entering the confined aquifer at the exposed section offshore, mixing with terrestrial groundwater within the aquifer, and seeping saline water out the upper part of the exposed section. In addition, the simulated confined aquifer displays a very flat fresh-salt water interface extending far offshore, as observed in natural offshore aquifers. Preliminary results of a hydrographic survey in the area of study suggest a low-salinity anomaly close to the seafloor, implying seepage of brines in that area, as expected from the model. These new insights have potentially important implications for coastal hydrology, seawater chemistry, biogeochemistry, and submarine slope instability.