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Modeling the physical and biological responses of a fjord to a submerged buoyant discharge

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Due to stratification and summer depletion of nutrients in the surface layer, some fjords are plagued with the growth of toxic algea. Artificial upwelling has therefore been used to improve the environmental conditions for the growth of non-toxic algae. A diffusor plate was mounted above a submerged discharge of freshwater from a hydropower plant to enhance the upwelling of nutrients. Laboratory tests showed that the entrainment of nutrient-rich seawater could be 6 times the freshwater discharge, in agreement with field data. The increased entrainment of seawater to the buoyant plume led to a deeper intrusion of the discharge into the compensation current and a longer residence time in the local fjord arm. The manipulation led to a reduction of the ambient stratification and an increased supply of nutrient-rich seawater to the euphotic zone. An ocean-coastal model based on the primitive equations confirms this. A biological model, containing nutrients and trophic levels up to mussels, was coupled to the hydrodynamic model and used to see how the manipulation affected algae growth and composition. The field of influence from the discharge extended several kilometers into the fjord and gave a significant increase in the primary production of non-toxic diatoms.