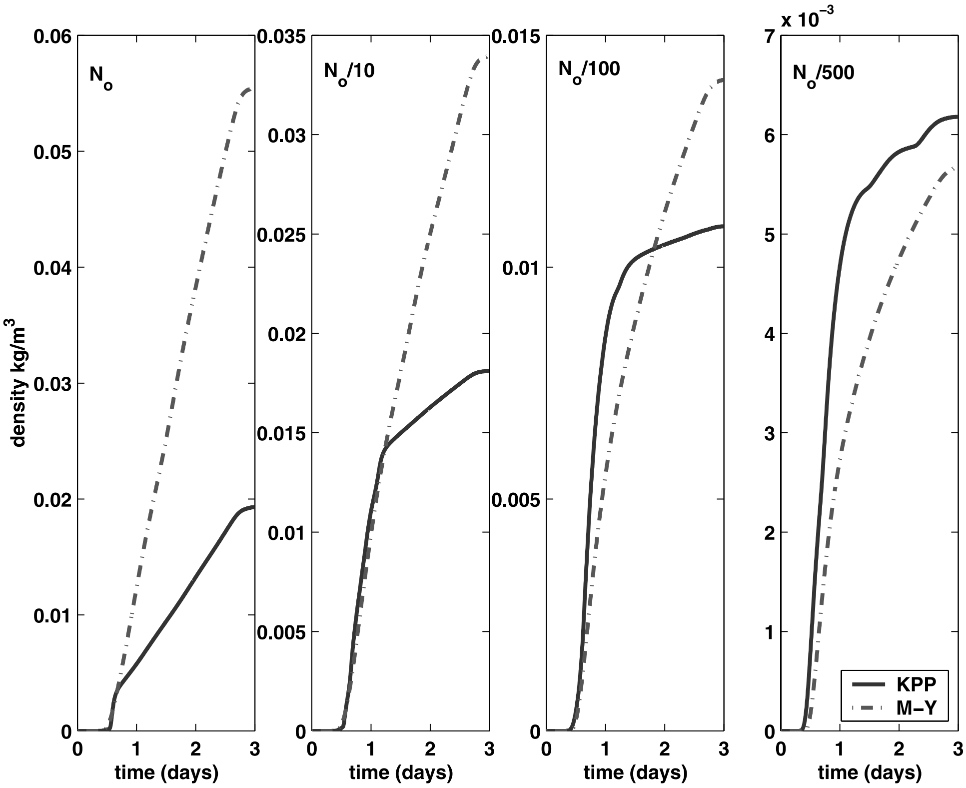

Figure 3. Time series of change in surface density at four different initial stratifications for the two mixing schemes. $N_o^2 = 0.0098\ s^{-1}$.

between the surface and bottom boundary layers that form, the water depth is varied between 15 and 20 m.

3.3. Case 3: Vertical Mixing With Advective Processes, Two-Dimensional Coastal Upwelling

[39] Cases 1 and 2 explore the dynamics of a stratified water column under the influence of vertical mixing alone. In case 3 we explore the interplay of mixing with advective processes in a simple two-dimensional coastal upwelling setting. The domain is set up with a 6-m deep coastal wall at the western boundary and a radiating offshore open boundary 100 km to the east in 106 m of water (bottom slope of 1 m km^{-1}). This represents a broad, shallow continental shelf analogous to that found off the coast of New Jersey. (A comparison of mixing schemes under upwelling and downwelling forcing on a significantly steeper slope, characteristic of the Oregon shelf, has been undertaken by *Wijesekera et al.* [2003].) The shallow bathymetry examined here focuses attention on the upwelling evolution in water less than 25 m where the circulation is likely most sensitive to the vertical mixing processes.

[40] Horizontal resolution is varied from roughly 400 m in the nearshore region to 4 km offshore. Forty vertical levels are utilized. Wind forcing is identical to that in the case 2 experiment and bottom stress is again specified using a quadratic drag law (equation (27)). A free-slip condition is applied at the coastal boundary.

[41] Sensitivity tests were performed with horizontally uniform initial stratification over the full range discussed in the previous 2 cases. The results and discussion below will focus primarily on results from a simulation initialized with a 5 m thick pycnocline at $N_o/10$ stratification located between 7.5 and 12 m depth between well mixed surface and bottom layers.

4. Single Boundary Layer Response: Case 1

[42] Entrainment into the surface boundary layer provides a basic measure of how the two mixing parameterizations perform differently. While the results and discussion below focus on only two idealized forcing conditions the qualitative differences examined here hold in general for wind-forced single-boundary layer simulations.

[43] Figure 3 shows a time series of surface density anomaly for steady wind simulations with four different levels of initial stratification. In these experiments the wind stress sustains a well-mixed surface layer so time series of density anomaly at the top grid level is a fair proxy for the mixing that is occurring at the pycnocline. There are several differences between the schemes worth noting. (1) M-Y tends to entrain more than KPP when there is strong stratification at the boundary layer base, while KPP tends to entrain more at very low stratification. (2) The rate of entrainment near the start of the wind event with KPP is always greater than or equal to that with M-Y. The difference between the two parameterizations increases with decreasing initial stratification. (3) The entrainment rate drops sharply with the KPP scheme within half a day of the onset of wind forcing. No similar response is observed with M-Y.

[44] Clearly over the range of stratification for this simple case, no generalization can be made that one scheme mixes