A Simple Model of Estuarine Plume Mixing

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Estuaries are the contact zones between the land and the ocean. Typically, light, fresh water flows into a bay and outward above any surrounding salty oceanic water. Both the tides and the differences in velocity between the fresh and salty water create turbulence, causing the two water types to mix within the bay. When a steady state is reached, an estuary generally has fresher surface water flowing out over deeper saltier water that enters from the ocean. Thus, the upper layer of water leaving the estuary is often saltier than the river water that entered; however, it is still lighter than the surrounding oceanic waters. Further mixing can occur outside the estuary, and eventually a coastal current can form and flow away to the right of the estuary.

With support from the Rinehart Coastal Research Fund, I developed a simple, accurate means to predict the turbulent mixing in an estuarine outflow. As the computer model in Figure 1 shows, strong river flow dominates the estuary, so that the water leaving is almost as fresh as river water (dark blue). The flow out of the estuary is initially deflected to the south, and then enters a clockwise, circular flow pattern that terminates in a northward coast-hugging current. The water that flows to the north is almost as salty as the surrounding water. The computer model shows how the salinity increases (color changes from blue toward red) as the water flows around the bulge off the river mouth. This salinity change is due to local turbulent vertical mixing. Specifically, the models reveal the conditions under which turbulent vertical mixing can drive biological activity near a river outflow. These results are useful, for example, in predicting the dispersal of nutrients and organic material away from the river mouth.

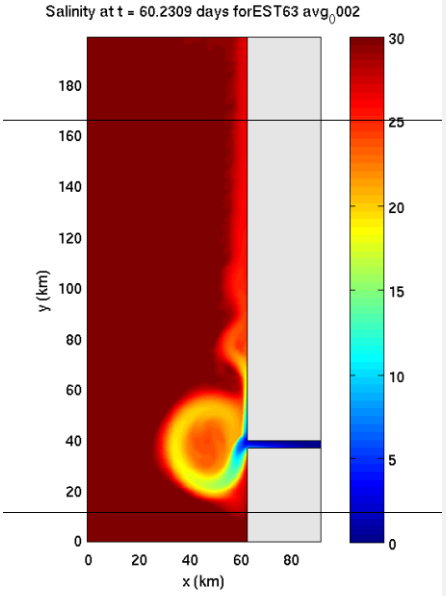

Figure 1: Computer model showing surface salinity. No wind is applied in the system, and the model has been run long enough to reach a steady state. Fresh (blue) water flows into the domain from the right (east). The surrounding oceanic waters appear as red colors. The gray area is land. As water leaves the estuary, it first veers southward, and then flows clockwise in a circular loop, before a portion turns northward, hugging the coast. The change in colors along this path indicates transformation of outflow waters from fresh (blue) to brackish (yellow-red).

The Rinehart Coastal Research Fund has provided a special, and greatly appreciated, source of support for this work.