The impact of ground water on the circulation within Great South Bay: A preliminary model study

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Coastal lagoons such as those found along much of the east coast of the U.S. from Cape Cod to Florida are under increasing environmental pressure from development. These water bodies often have a special sensitivity to submarine freshwater discharge because of the relatively small amounts of surface runoff such that the ground waters often represent a significant fraction of the fresh water supply to these estuarine environments. Because of the generally saline conditions within the lagoons, the distributed fresh submarine ground water supply can have a significant impact on the internal density distribution within the lagoons and hence the circulation, depending upon the geometry and tidal exchange with the open ocean. Of particular import for the ecology of the lagoonal systems is that nutrient concentrations of the ground water flow are often substantially higher and in a more immediately useable form than that contained in surface waters. The circulation and mixing within the lagoons control the distribution and residence times of the dissolved constituents and nutrients and thus are critical to the overall ecology of these environmentally critical regions.

Ultimately, the concept is to produce a series of linked models of the ground water fluxes, submarine freshwater discharge and lagoon circulation so as to produce a complete and robust description of conditions within the lagoon. However in this talk, the emphasis is on the circulation within the lagoons themselves showing what effects that submarine freshwater discharge might generate. To illustrate, we start with a very simple geometry. More realistic simulations using a portion of the Great South Bay will be presented at the meeting.

We let the lagoon geometry be represented as an ellipse with a scale similar to that of Great South Bay, 40km x 6km, but limited to a single central opening to the coastal ocean. The bathymetry is also elliptical with a maximum depth of 3.5m, shallower along the shore and at either end with minimum depths of 1m around the boundary so that issues of wetting and drying can be neglected. The model runs begin at rest with uniform salinities of 35 psu. An unrealistically large bottom inflow from a single point ramps up over a period of 12 hours. Figure 1 shows the surface velocities and salinities after 62 hours where the impact of the freshwater discharge is localized along the north shore with an asymmetry imposed by the earth's rotation. To the east, the plume of fresh water gradually spreads out at the surface while to the west the plume forms into a deeper coastal jet.

These east-west differences show up clearly in the cross-lagoon sections shown in Figure 2. If a slightly more realistically distributed although still too large a freshwater discharge is used wherein the discharge of fresh water amounts to 2 cm/day along the north shore, decreasing to 1 cm/day along the south shore, the resulting salinity distribution after two weeks, is given in Figure 3. This time the low salinity plumes encroach on the lagoon from the shallow ends with some of the properties observed before, particularly the generation of coastal jets of low salinity water propagating with the coast to the right. There is flow in and out of the inlet with saline water entering along the east side which results in the saline eddy. The east-west asymmetry is enhanced by the north-south gradient in freshwater discharge and a tendency for a counter-clockwise propagation of the low salinity plume.

In Figure 4 we have introduced tidal forcing through the inlet and have let the simulation proceed for about 25 days to near equilibrium conditions. The tidal forcing increases the friction and vertical mixing considerably but the asymmetries in the salinity distribution persist including the counter-clockwise propagation of the plumes.

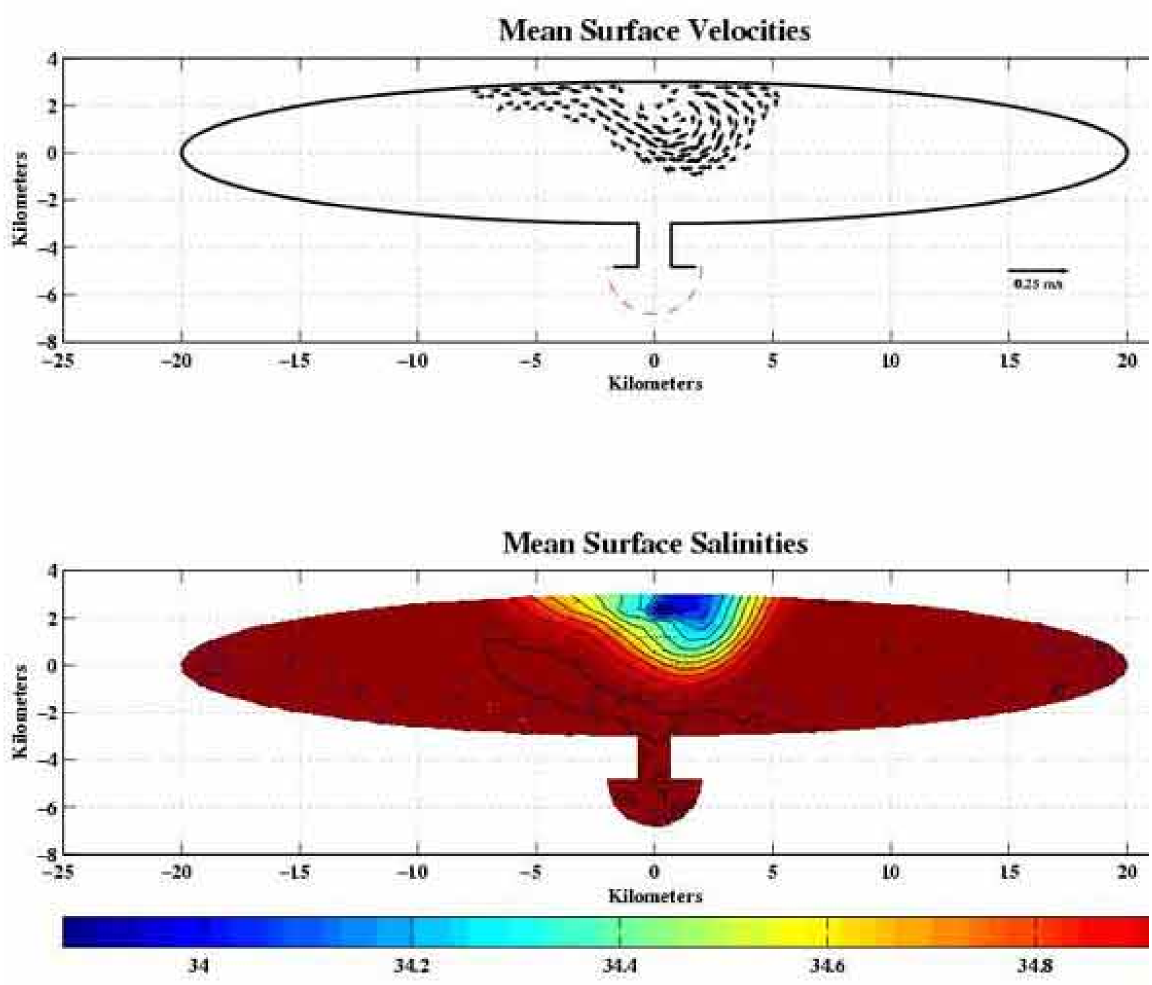

Figure 1. Surface velocities and salinities from a developing plume of low salinity water from a single area of submerged freshwater discharge.