Hudson River at Cornwall Bay, as it enters the Hudson Highlands between Storm King on the right (west) and Breakneck Ridge on the left (east). In summer and fall, the Hudson's salt front (or salt wedge) is often in Cornwall Bay.

That Settles It: Sediment transport in the Hudson River

The historic Hudson River—beautiful in any season—begins at the pristine Lake Tear-of-the-Clouds in the Adirondack Mountains and flows south to its mouth in New York Harbor. Along the way, the river's current transports sediment which may settle at predictable locations based on the size and concentration of particles and the speed and turbulence of the current. Because the Hudson is a tidal estuary, salt water from the ocean mixes with fresh water coming downriver making for a dynamic system of sediment transport.

Some of the sediment in the Hudson contains contaminants that entered the upper river decades ago mainly from the General Electric (GE) manufacturing plant at Fort Edward. These compounds, polychlorinated biphenyls or PCBs, were released before their risks to environmental and public health were known, and still persist in the river sediments. Now many years after the environmental risks were identified, GE has completed the first phase of dredging PCBs from the upper Hudson River in order to decrease the total amount in the sediment. But what is the fate and transport of sediment which contains PCBs? Do particles settle back down into the sediment after being stirred up by currents or dredging? By looking at the behavior of particulates in a tidal estuary, science can give us a better picture of sediment transport.

With NY Sea Grant funding, researchers from Stony Brook University's School of Marine and Atmospheric Sciences (SoMAS) conducted the first-ever modeling of size-resolving sediment tracking in the Hudson River. As published in *Continental Shelf Research*, **Dr. Fanghua Xu** (former Sea Grant Scholar now at Princeton), **Dr. Nicole Riemer** (now at the University of Illinois) and **Drs. Dong-Ping Wang** and **Roger Flood** have come up with a workable model that predicts where along the river contaminated sediments are most likely to have settled. They have also mapped out specific areas of the upper river indicating where the processes of dredging and monitoring for PCBs would yield the most optimal results. In other words, their model could be used to identify those areas of river bottom which would be most likely to have been impacted by releases of contaminated sediments from remedial dredging operations.

Wang summarizes the relationship between particle size and settling this way, "The smaller the particle, the longer it stays suspended in the water column. The bigger the particle, the faster it sinks. Generally, the more concentrated the particles, the more they will collide, form larger particles, then sink to the bottom." Scientists call this aggregation of particles **flocculation**. Adds Xu, "The larger particles tend to capture the smaller ones as they fall through the water column." This settling usually happens during slack tide. The water slows down, large particles are no longer buoyed by the swirling water and the particles settle to the bottom—sometimes in very predictable locations.

Explains Riemer, "Turbulence in the river has several, sometimes opposing effects: it helps mixing the particles in the water column, but as particles grow larger they can also be pulled apart by turbulence." A very strong current may actually lift particles from the river bottom altogether and put them back into suspension. Particle size varies widely, but most are in the range of the width of a human red blood cell to that of a human hair (or about 10 to 100 micrometers).

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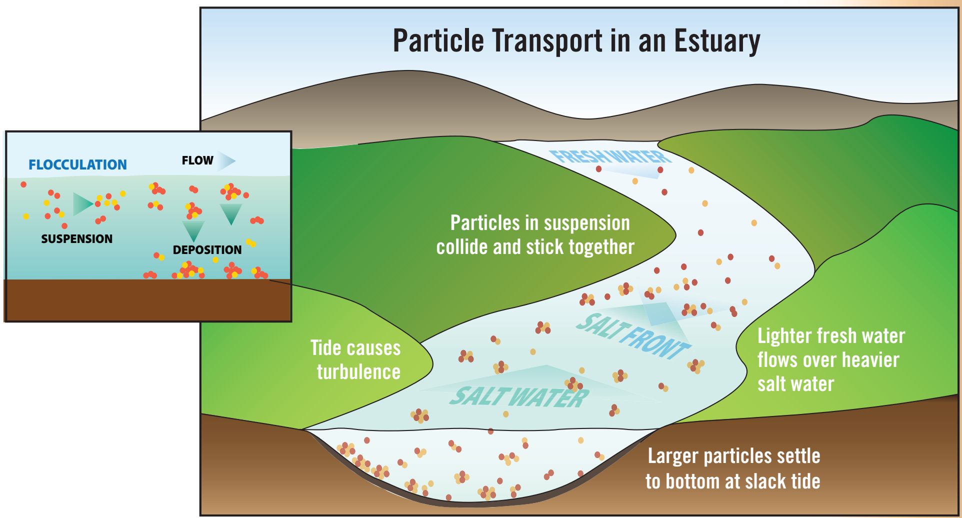

Above the Troy Dam in the upper Hudson, the site of greatest PCB input, the particle size is initially quite small and particles are suspended in the water column. The contaminants adhere to the surface of the particles, thus the greater the number of small particles, the more surface area there is for contaminants. At a part of the river where there is a bend or irregularity in the bottom, there may be a decrease in the turbulence and so many particles collide, coalesce into fewer larger ones, and settle to the bottom.

Below the Troy Dam, the Hudson becomes tidal; at around Poughkeepsie it becomes brackish—a mix of salt and fresh water. Explains Wang, "The area where salt water coming up from the mouth of the river meets fresh water coming down from the mountains is known as the salt front or wedge which moves with the seasons." The spring melt brings more fresh water and pushes the salt front downriver. The heavier salt water pushes upriver with the tidal current and usually flows under the lighter fresh water. Because there is a change in turbulence in the area of the salt front, the model predicts there will be an accumulation of sediment. Adds Riemer, "Only in this model in which flocculation is included, does the predicted accumulation of sediment look like what one is likely to observe."

If the sediment is contaminated, invertebrates, such as copepods and burrowing worms, may feed on contaminated detritus. Then vertebrates like fish and birds may feed on the invertebrates, biomagnifying the PCBs up the food chain. By taking into account model results, managers may be better able to identify representative biological monitoring locations by understanding where there are areas with a greater likelihood of sedimentation impacted by the PCB release in the upper Hudson.

For years, many species of birds and fish along the Hudson have survived despite the persistence of PCBs in the sediment. In a separate project funded by NYSG, a Cornell research team, **Drs. Timothy J. DeVoogd**, **André A. Dhondt**, and graduate student, **Sara DeLeon**, is looking at the *sublethal* effects of PCB contamination on chickadees and other common regional songbirds. The team suggests that the contaminants are not enough to kill the birds, but may affect parts of their brains that control song. Measuring changes in the birds' characteristic song according to their location may indicate areas of higher contamination.

Whether existing on the surface of a microscopic particle carried by the tide, within a stable layer in the sediment, or as part of the dynamic food chain of the estuary, PCBs and the impacts of their dredging and containment are far from "settled." It is hoped that this dynamic model can be used to better focus any sediment sampling efforts by scientists charged with evaluating how the release of contaminants from river dredging impacts fish and other wildlife.

—Barbara A. Branca

NEW YORK Coastlines