Bay watch

Penn State civil engineers help biologists unlock Glacier Bay's mysteries

It was a chance meeting on kayaks in 2004 that spawned **David Hill**'s research in Glacier Bay, Alaska.

"I overheard some kayakers using some obscure engineering phrases, which caught my ear, so I interrupted and introduced myself," recalls Hill, an associate professor of civil engineering. "It turns out they were U.S. Geological Survey biologists."

Hill explains that the Glacier National Park and Preserve is a rather unique place that's drawn the curiosity of numerous scientists and researchers.

"It possesses one of the highest densities of tidewater glaciers on the planet," he explains. "It's also been a place of remarkable change. The glaciers have retreated more than 50 miles in 200 years. As a result, the terrestrial and marine ecosystems are changing rapidly in response. Interestingly, the amount of water released by this glacier retreat has resulted in a one-centimeter sea level rise around the globe."

The USGS biologists Hill met were trying to understand why they found certain species in some areas of the bay, but not in others.

The biologists suspected that it had something to do with the tidal flows in and out of the bay, but they didn't have a physical scientist on hand to help prove it.

Hill, an expert in coastal engineering and tidal hydrodynamics, arranged to take his sabbatical to help study the issue. The work eventually led to a grant with the National Park Service, which oversees Glacier Bay National Park.

The civil engineer says tide prediction can be extremely useful to biologists studying marine life in the park.

Photo courtesy of David Hill

Faculty member David Hill leads student Suzanne Ciavola as the two embark on some field work in Glacier Bay.

"There's one researcher from the University of Alaska, Southeast, who's very interested in the dispersal of crab larvae. Once they get into the water, they're essentially passive. Their motion is completely dominated by what the water is doing," Hill states. "The biologists have observed very different distributions of larvae in different areas of the park. They would like to know if some larvae are produced in one area, where will they go?"

Another biologist studying adult tanner crabs conducted a population survey of the bay a few years ago by dropping crab pots and plotting the crustacean's distribution. What befuddled the biologist was why the middle of one region showed no tanner crabs at all.

"It was almost as if there was a biological barrier that prevented the crabs from moving back and forth," Hill says.

To find out why, Hill and **Suzanne Ciavola**, a civil engineering senior and Schreyer Scholar, began developing a computer model of the bay.

Starting with a two-dimensional hydrodynamics code originally used for hurricane and storm surge applications, the Penn State team began developing a model of Glacier Bay in early 2006. To complete the model, the team needed data on the bay's tides, meteorological conditions and freshwater inflows.

But, Hill says, "The freshwater inputs aren't known—no one's done any work on it."

Freshwater input not only includes the amount of rain and other precipitation, but also the glacial melt into the bay.

Finding out the amount of freshwater input became Ciavola's task.

"Normally you have people gauge rivers so you know what's going on. In this case, we don't have any gauging," Ciavola, who graduated this summer, explains.

Using a geographic information software system named ArcGIS, the Philadelphia native started with a USGS digital elevation model of the bay and then determined the contributing watersheds and their characteristics. A May 2007 trip to Glacier Bay with Hill allowed her to make some preliminary stream flow measurements with which to test her analysis.

Ciavola's work on the freshwater inflows gave Hill the final piece he needed to complete the model of Glacier Bay's currents.

What the engineers' model showed the USGS biologists was astonishing. It suggested to the scientists one reason why some areas of the bay were completely devoid of tanner crabs.

"With our modeling work, we've been able to strongly correlate the distribution of crabs to tidal speed," Hill states. "We've been able to show that high tidal speed is essentially preventing crabs from being found in that area—the high velocity just scours away the substrate."

For the first time, scientists understood where the bay's water came from and how different areas of the bay interact.

The model also gave biologists a much better idea of how animals interacted with the aquatic environment.

Hill continues, "When we start looking at and correlating the populations of various species with physical quantities, like tidal speed or tidal elevation, you can explore some of those linkages between the physical and the biological."

For the Glacier Bay scientists, Hill and Ciavola's model opens up some new avenues of exploration.

"They're all very curious," he says. "They all seem thirsty for this additional information."

He added that the computational tools and data sets were developed in an open-source way and are available to any interested researcher through the project's website. ■

—Curtis Chan

Dr. Hill can be reached at dfh4@psu.edu or at 814-863-7305. More on the work can be found online at www.engr.psu.edu/ce/hydro/hill/research/glba/default.stm.