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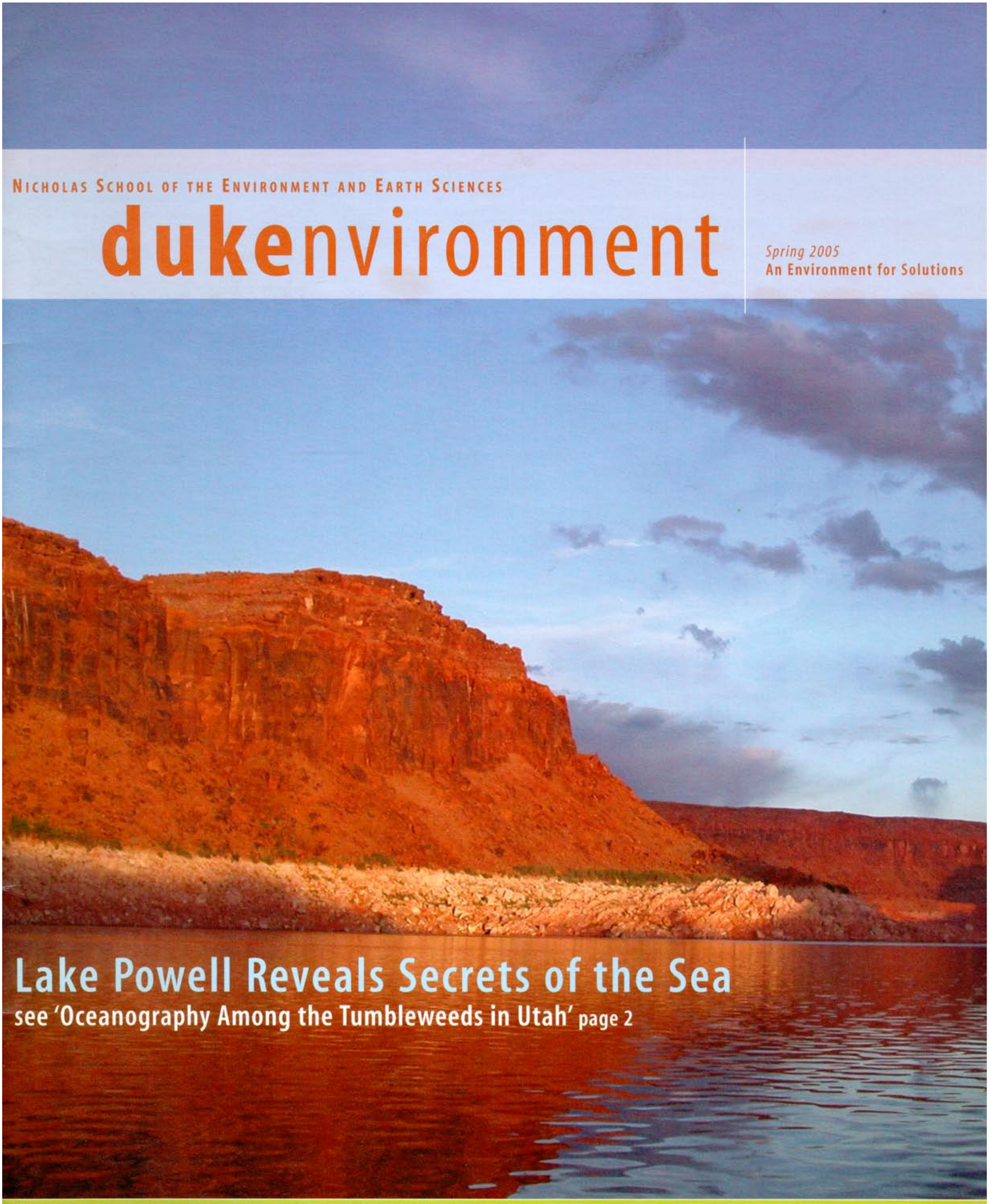

Lake Powell Reveals Secrets of the Sea

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The Nicholas Institute for Environmental Policy Solutions names Timothy Profeta new director. see page 6 for details >

OCEANOGRAPHY AMONG THE TUMBLWEEDS IN UTAH

LINCOLN PRATSON LOOKS TO THE DESERT'S LAKE POWELL TO SHED LIGHT ON ONE OF THE DEEP SEA'S MURKIEST PROCESSES

by Tim Lucas

A landlocked reservoir in Utah's southern desert may seem an unlikely place for oceanography research. But here, amid sagebrush and tumbleweeds, Lincoln Pratson is working to shed new light on one of the deep sea's murkiest processes.

Pratson is associate professor of sedimentary geology in the Nicholas School's Division of Earth and Ocean Sciences.

This May, he'll return to the arid environment of Utah's Glen Canyon National Recreation Area for his third research expedition in five years to map the floor of Lake Powell, a beautiful but incongruous 186-mile stretch of blue-green water amid the region's sun-bleached sands and red rock canyons.

His study of sediment buildup on the manmade lake's bottom is adding new insights to scientists' understanding of similar forces shaping the ocean's floor in the murky depths beneath 3,000 meters, and it may aid oil companies' search for new hydrocarbon deposits located there.

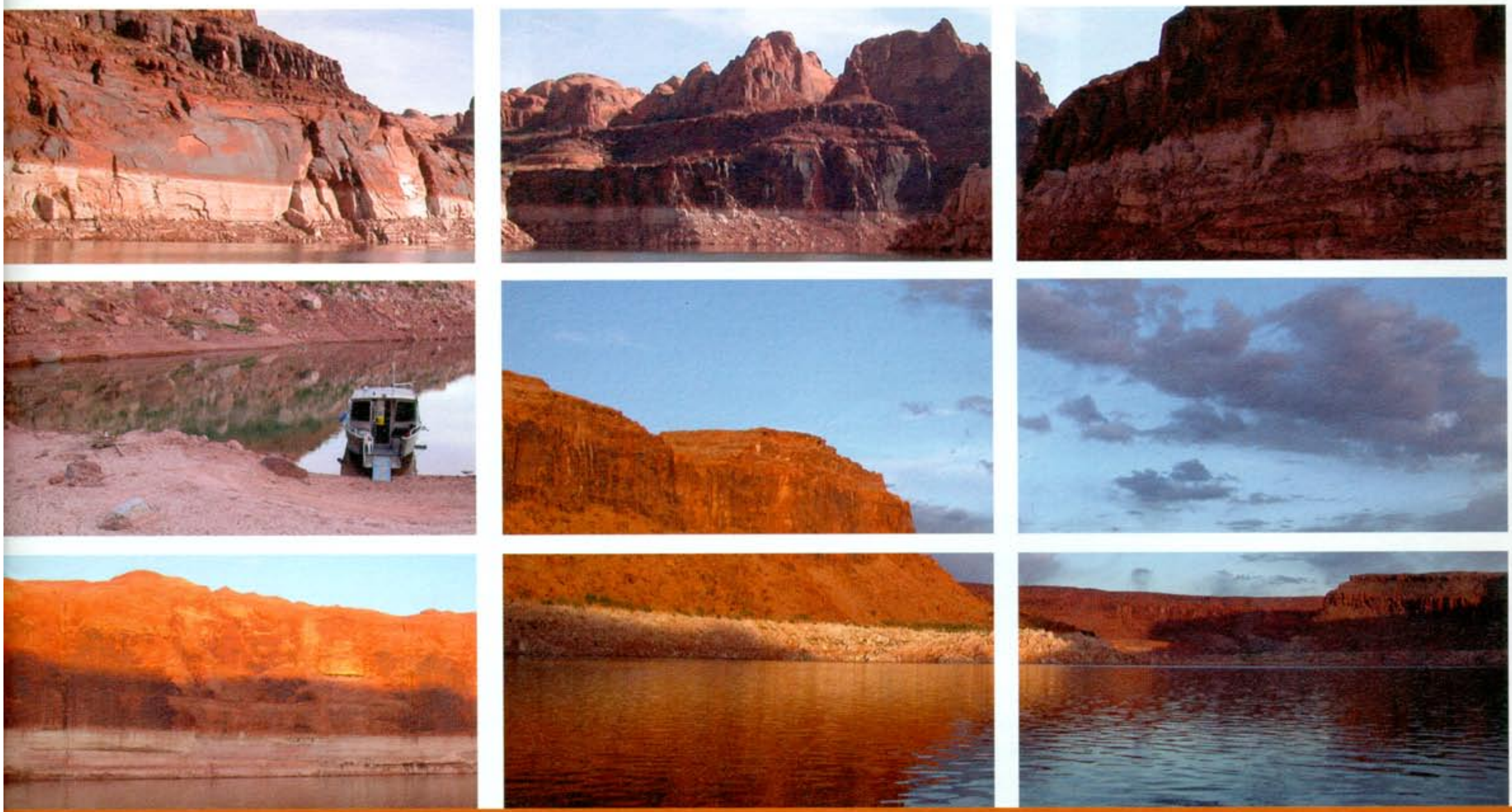
His work has implications here on land, too. Preliminary results from Pratson's surveys of Lake Powell suggest it is now filling with sediment more quickly than in the past. This finding could add new fuel to the debate about development in the drought-prone Southwest—where a rapidly growing population is largely dependent on the holding capacity of reservoirs like Lake Powell for its water supply.

"An oceanographer in the desert is about as incongruous as Lake Powell itself," he says with a grin, as he shows a visitor a photo of his research team untangling waterlogged tumbleweeds from their sonar device. "But sometimes, answers are found in unexpected places."

Pratson, a calm, affable man with a love of the outdoors, has spent the past 20 years searching for them.

He received his PhD in geology from Columbia University in 1993, and continued his research in marine geology at Columbia's Lamont-Doherty Earth Observatory before moving in 1996 to the University of Colorado. Two years later he joined the Nicholas School faculty. Since 2004, he also has served as head of the School's certificate program in Energy and Environment.

His study of the dynamics of marine sedimentation—how mud, sand and other sediment are transported and formed into strata on the ocean's floor—has taken him to far-flung conferences and research sites, from the Mediterranean to Minnesota, and from northern California to the southern oceans off New Zealand.



All photos above are scenes from Lake Powell

In recent years, he's become especially interested in the role turbidity currents play in the sediment transport process.

Turbidity currents—so called because of their turbid and turbulent nature—are underwater avalanches that can occur without warning in nearly all parts of the world's oceans and many inland waterways.

At the large end of their scale, they can move across the sea floor at speeds exceeding 20 miles per hour and push thousands, or even millions, of tons of mud, sand and gravel off the continental shelf and down the continental slope into the deep abyss, more than 3,000 meters beneath the ocean surface.

Sudden, violent events like earthquakes, volcanic activity and coastal landslides have all been known to trigger turbidity currents. But the currents also can have less dramatic causes, like the gradual buildup of excess sediment at the edge of the continental shelf.

Scientists believe these powerful currents have been one of the most important forces shaping and reshaping the seafloor.

Studying them in the ocean environment, however, can be tricky.

"Turbidity currents are very hard to observe," Pratson says, "because they're episodic in nature."

Despite years of research, scientists still can't predict with certainty where or when a turbidity current will occur, except in the relatively rare case when scientists know that a flooding river carries a concentration of suspended sediment that exceeds the concentration of sediment suspended in the basin into which it flows. Nor can scientists yet predict how big a current will be, how fast it will move, or where it will eventually deposit its sediment. Unless a research vessel or moored instrument happens to be in the right place at the right time, the best researchers can do is collect sediment samples from the seafloor after the event has occurred.

These samples provide a snapshot of what's happened at the site, but their usefulness is limited by variables beyond researchers' control, Pratson says.

"It's difficult to discern how much of the sediment you've collected from the ocean floor comes from turbidity currents and how much comes from other events in the marine environment," he explains.

To reduce variables, scientists can simulate small-scale turbidity currents in the controlled environment of the laboratory using a special tank of water called a flume tank. But the clearest picture, Pratson says, comes from observing and tracking natural-scale turbidity currents and the sediment strata they form in the field.

And that's what brings him to Lake Powell.

The lake, a ribbon of flat, blue water woven through a moonlike landscape of eroded mesas and jagged rock spires, was created in 1964 when the controversial Glen Canyon Dam was constructed on the Colorado River, just south of the Utah-Arizona state line.

Located about 15 miles upstream from Glen Canyon's more famous neighbor, the Grand Canyon, the new dam was built to provide a fixed supply of water to towns and

farms downstream, and to regulate the flow of the erratic Colorado, whose raging spring flow often slowed to a barely ankle-high trickle by summer.

Fed by the upper Colorado and the San Juan rivers, Lake Powell gradually submerged the entire length of Glen Canyon north of the dam, as well as more than 50 side canyons.

With a mean depth of 132 feet and a maximum depth of 560 feet, the lake at full capacity could hold more than 21.5 million acre-feet of water, experts estimate, enough to meet the water needs of the rain-starved region for about three years.

Over time, however, sediment from the muddy waters of the Colorado and San Juan began to fill in the bottom of the lake.

Both rivers, Pratson says, carry unusually high volumes of suspended sediment. Near where the San Juan enters Lake Powell, he's collected samples showing it contains more than 10 percent sediment by volume. By comparison, he says, wet concrete is only about 30 percent sediment.

"The mud and sand that used to flow downriver into the Grand Canyon, where it renourished beaches and sandbars on the canyon floor, is getting trapped in Lake Powell," Pratson says. "The water flowing into the lake is brown. The water being discharged out of it is clear and cold."

These conditions, coupled with the lack of marine events and phenomena to muddy the issue, make Lake Powell an ideal setting for studying the dynamics of turbidity currents.

"When the Colorado and San Juan rivers enter the lake, the density of their water is many times greater than that of the lake water, so it plunges and creates a turbidity current down the bottom slope," Pratson says. "It's a manmade but natural-scale laboratory where complications can be minimized and conditions like water level and sediment input are well known. I can make observations here that I can't do in a flume tank or the ocean."

To document changes on the lake bottom caused by turbidity currents, Pratson spent five days last May mapping the lake floor, assisted by Nicholas School doctoral student Thomas Gerber and National Park Service aquatic ecologist Mark Anderson.

They mapped the lake by day, doing their best to steer clear of the lake's two chief dangers: submerged rocks and tourists' houseboats. Lake Powell attracts more than two million visitors a year, many of whom tour the lake aboard rented houseboats.

"Since it was May, we didn't see as many houseboats, jet skis and speedboats as we would have seen in summer," Pratson says. "It could get busy at times, but we had some parts of the lake virtually to ourselves."

At night, they would beach their boat and set up camp on the lake's desolate shore, dwarfed by the eroded rock formations and towering canyon walls that ring Lake Powell. "It's so remote there—at night you don't hear a sound, you don't see a light," he recalls. "It's just you and the stars. The feeling of solitude is incredible."

A 32-foot metal-hulled National Park Service boat served as their research platform. Its shallow draft allowed them to enter twisting side canyons and other waters where boats with deeper drafts would have been grounded—an important practical consideration following six years of drought that has dropped the lake's water level 117 feet.

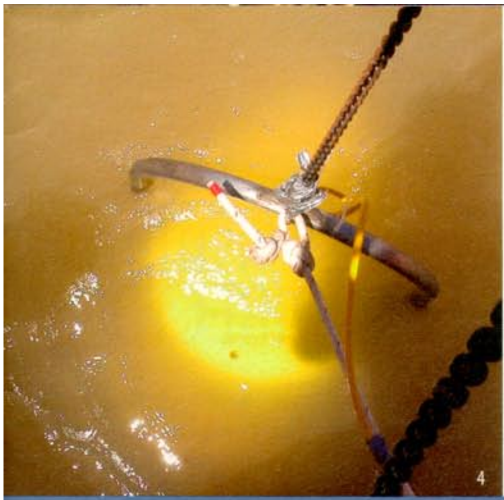
"On the canyon walls you can see a clearly delineated white line about 117 feet high, marking where the water level used to be. It's like a giant bathtub ring," Pratson says. "When a houseboat passes by and you see how small it looks compared to the height of the watermark, you realize the scope of the drought's impact."

To map the lake's floor and analyze its sediment strata, the team used a newly acquired chirp acoustic sonar profiler, purchased with support from the U.S. Office of Naval Research, the National Science Foundation and the Nicholas School.

Housed in a four-foot-long, 400-pound yellow plastic body, the $500,000 piece of high-tech hardware was lowered in and out of the water "very carefully" using a chain winch, Pratson says.

"We were a little nervous at first that it would hit the side of the boat or smack a submerged rock and be damaged its first time out," he says. "But the only run-ins it had were with waterlogged tumbleweeds that kept getting tangled in it. That's one of the unusual aspects of using oceanographic equipment in a desert environment."

Freed of its tumbleweeds and towed behind the boat at a depth of about 10 feet, the profiler performed perfectly. It collected two types of data: sidescan sonar images that could be pieced together to map the lake bottom, and sub-bottom reflection profiles that provided acoustically derived cross-sections of the stacking patterns of sediment strata found there. These cross-sections allowed the scientists to determine the type of sediment and its thickness.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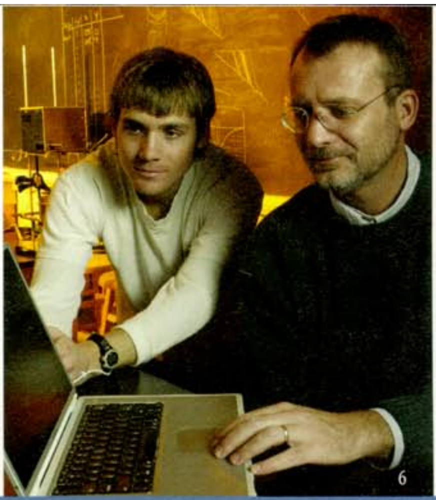
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#6 Jim Wallace photo

Pratson and Gerber are now analyzing data from their survey and comparing it to data from past geological surveys made before the Glen Canyon Dam was constructed and about once a decade following its completion. (Pratson himself conducted one of these surveys—covering the lake's Colorado River arm, or about half its total area—in 2001.)

By comparing the data, they can document changes that have occurred over the years on the lake bottom as a result of turbidity currents, and get a better idea of the rate at which Lake Powell is filling in.

"The rate of infill determines the reservoir's useful lifespan," Pratson explains. With the drought lowering the lake's water level at the same time sediment is filling in the lake floor, "Lake Powell is being squeezed from both top and bottom," he says.

A 1986 survey, headed by scientists from the Bureau of Reclamation, estimated the reservoir had 100 years of useful life left if the rate of infill remained the same.

Preliminary findings from Pratson's team's May 2004 survey, however, suggest that the rapidly dropping water levels caused by the drought may be exacerbating erosion in the lake's deltas and causing more sediment than in past years to be carried into the lake.

The bottom slopes of the eroded deltas have grown so steep that turbidity currents can now quickly build up the speed, volume and velocity they need to carry sediment, and any contaminants the sediment may contain, farther and farther into the lake.

"There are contaminants that have been introduced into the Colorado arm of the lake and we're watching to see if sediment transfer carries them farther downstream, where they could more broadly affect the lake's ecosystem," Pratson notes.

He can't yet pinpoint how far down the lake turbidity currents have reached, in part because the underwater canyon walls are so steep in places that they interfere with accurate sonar measurements. But data from the 2004 survey is providing some interesting insights.

"Near the Rincon area of the lake, about midway down its length, we found evidence that some turbidity currents were still so strong they could climb up and over a pile of rockslide debris 25 meters high. That," Pratson says excitedly, "was very unexpected."

This May, Pratson and Gerber will return to the lake to pick up where they left off. They hope to publish their findings in the near future.

Dave Twichell, an oceanographer with the U.S. Geological Survey at Woods Hole, predicts they'll find an eager audience for their publications.

"Many deep-sea hydrocarbon reservoirs originated as thick sand deposits from turbidity currents, so learning how they form is of great interest to the oil industry," Twichell says. "Because of the work Lincoln and his students are doing mapping Lake Powell's floor, we have the opportunity to understand the link between the processes of turbidity current sedimentation and the deposits that result from these flows."

Pratson knows his data from Lake Powell will likely also generate interest outside the scientific community, among conservationists, urban planners and policy makers throughout the Southwest.

"It's possible there's been a fundamental shift in where sediment's been accumulating in the lake. If it's being distributed over a longer distance, that could have implications for communities and industries across the region," he says. "The usability of the lake for recreation, the hydroelectric generating capacity of its dam, and the lake's useful lifespan as a 'water bank' for the region could ultimately be affected, though to what degree presently remains unclear."

Tim Lucas is the Nicholas School's national media relations and marketing specialist.

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web sites to note

Lincoln Pratson's Bio:
www.nicholas.duke.edu/people/faculty/pratson.html

Energy and Environment Certificate Program:
www.nicholas.duke.edu/programs/professional/energycert.html

Glen Canyon National Recreation Area:
www.nps.gov/glca/index.htm

1. Graduate student Tommy Gerber and National Park Service aquatic ecologist Mark Anderson aboard the Pratson team's 32-foot research vessel **2.** Camping for the night on the banks of Lake Powell **3.** Canyon walls of Lake Powell. The white line is the high-water mark before the recent drought. **4.** Lowering the chirp sonar device into the lake. **5.** Research team members disentangle waterlogged tumbleweed from the chirp sonar device **6.** Gerber and Pratson in their Nicholas School lab.

Lake Powell photos by Lincoln Pratson