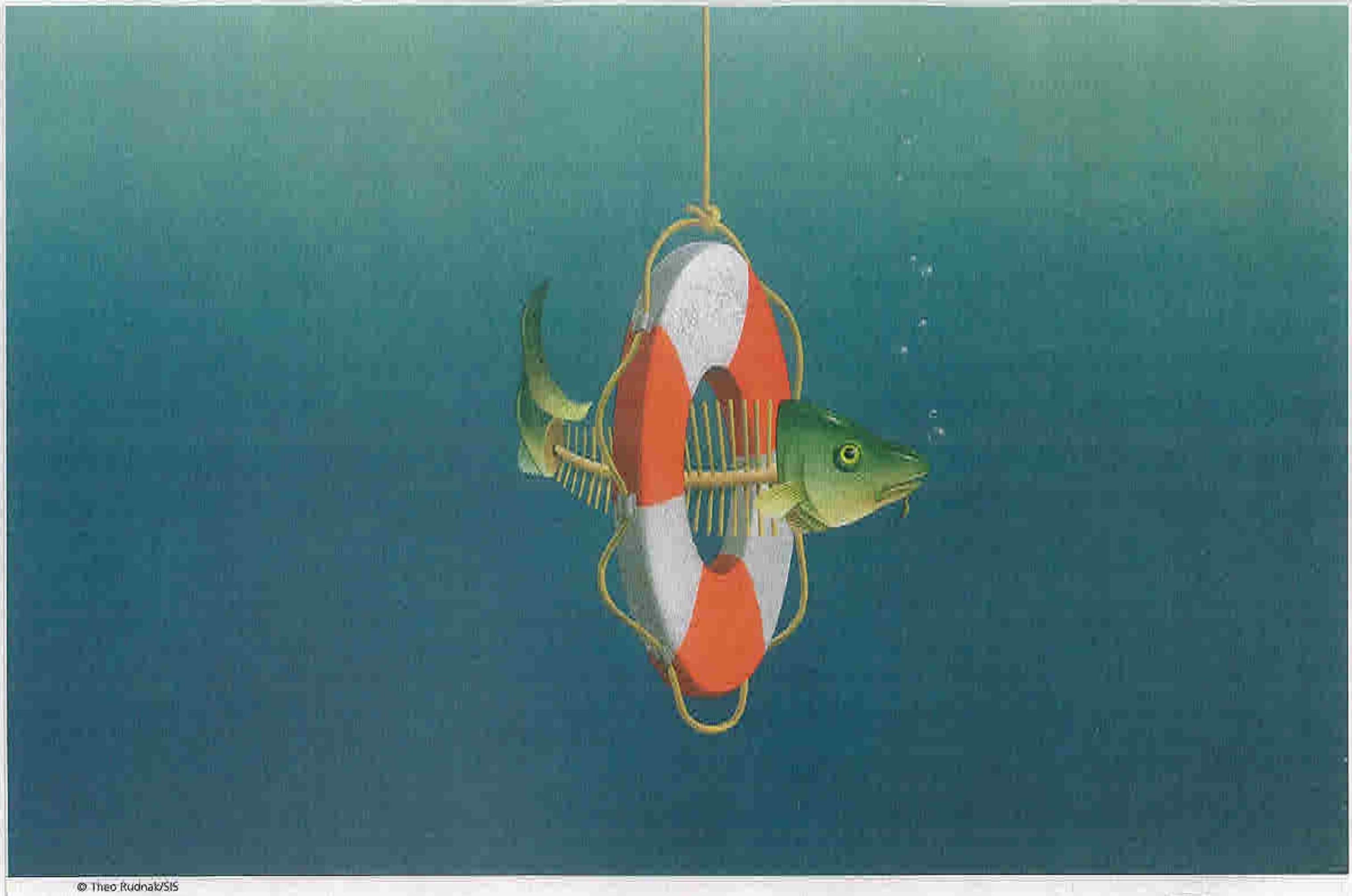

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LOST & FOUND

In Lake Victoria, researchers have rediscovered an "extinct" cichlid. Capitalizing on this serendipitous conservation opportunity, they have found a way to reconcile species recovery and fisheries.

In 1993, a group of Dutch and Tanzanian biologists working on a survey of Lake Victoria's fish

fauna pulled up a small, vermilion-finned fish in a trawl conducted along a transect in the Mwanza Gulf, near the southern shore of the lake. This handsome fish was a specimen of *Haplochromis tanaos*, and the most remarkable thing about it was that no one had thought it would ever be seen alive again.

H. tanaos was one of about 200 species of haplochromine cichlids endemic to Lake Victoria that had been consigned to memory. All 200 were thought to have been driven extinct in large part by the Nile perch (*Lates niloticus*), a voracious predator introduced to the East African lake in the 1950s. The catastrophic demise of the lake's haplochromine cichlids (a large group of small, brightly colored fish found in fresh waters throughout Africa and prone to excessive speciation) had become one of the world's best known conservation tragedies—a cautionary tale of the dangers of releasing exotic species into fragile natural ecosystems.

But the rediscovery of *H. tanaos* is part of a constellation of evidence that began to emerge in the mid-1990s and has now revealed a new twist in this old story. This new twist points to the often serendipitous nature of conservation opportunities and suggests that biodiversity conservation and fisheries production need not always be in conflict. Researchers are now using a combination of computer modeling and ongoing observations of Victoria's often surprising dynamics to pull from the vast lake the points where these two goals may intersect.

DÉJÀ VU ALL OVER AGAIN

Lake Victoria, the world's largest tropical lake and third largest overall, sits on a high plateau between East Africa's two great rift valleys, its

■ BY SARAH DEWEERDT

(right and far right) Experimental midwater trawl from the north end of Lake Victoria—over 99 percent of the mass were juvenile Nile perch, an early indicator of overfishing; (middle left) Fisherman setting net near Jinja, Uganda, in a typical plank canoe; (middle right) A little zooplanktivorous haplochromine belonging to the *tanaos* group, believed extinct until it was rediscovered in 1993, is now very abundant in some places. *Haplochromis tanaos* that used to live over sand now lives over soft organic mud bottoms, and several similar phenotypes occur at rocky islands. Shown here is a form similar to *Haplochromis thereutherion*.

Photo by Daniel Schindler

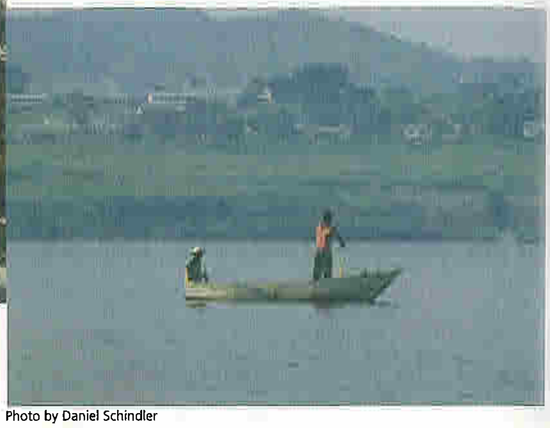

Photo by Daniel Schindler

waters shared by the nations of Tanzania, Uganda, and Kenya. At the beginning of the 20th century, the lake was home to upwards of 600 species of haplochromine cichlids, which were nearly all endemic to the lake and had evolved in only a few hundred thousand years—one of the world's most impressive examples of vertebrate adaptive radiation.

In addition to this evolutionary treasure, Lake Victoria was home to a rich community of native fish species, many of which were caught by subsistence fishers in small canoes near the shores of the lake. With the introduction of modern fishing gear, such as synthetic nets and outboard motors, fishing pressure rapidly intensified, and within a few decades the native species had been severely overfished.

To replace these decimated stocks, in the 1950s and 1960s several species were introduced to the lake, including the Nile perch, which authorities hoped would convert the still-abundant but tiny haplochromines into higher-value, more easily caught fish.

Convert haplochromine biomass the Nile perch did indeed. The species is an efficient piscivore that can reach a length of 2 meters and 100 kilograms in mass. After laying low for about two decades, the perch population exploded during the late 1970s and early 1980s, and at the same time haplochromine populations plummeted. In the course of less than a decade, 40 percent of the lake's then known haplochromine species disappeared altogether in one of the largest and most rapid episodes of vertebrate mass extinction ever witnessed.

Yet as this conservation tragedy unfolded, a valuable export fishery for Nile perch developed, bringing hundreds of thousands of jobs and huge inflows of hard currency to a region that desperately needed both.

But now, in a repeat of the lake's history, it appears that the Nile perch is itself being overfished. Total perch catch is declining, the average size of perch caught has decreased over the last decade, and in recent experimental trawls, 70 percent of the perch catch by mass consisted of immature fish—all classic signs of overfishing.

Along with this decline in perch stock—and as a direct consequence, scientists believe—some of Lake Victoria's cichlids have begun to come back. In addition to *H. tanaos*, several other species of haplochromines that had been thought extinct have been rediscovered, while others that had become very rare have rebounded.

At first, this latest development in Lake Victoria's saga sounds like good news. But on

Photo by Ole Seehausen

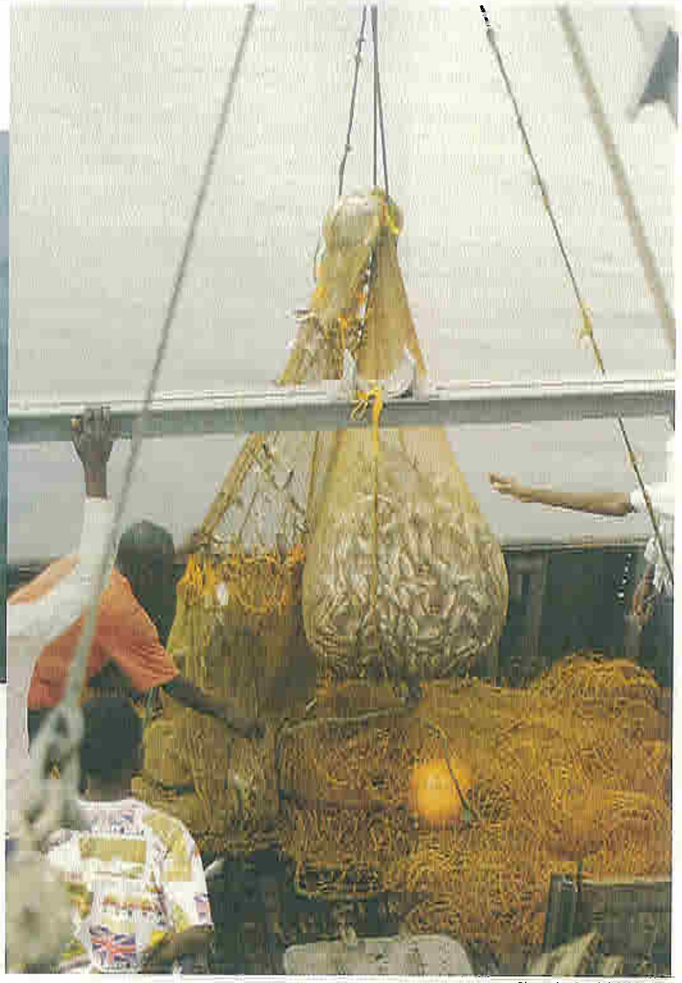

Photo by Daniel Schindler

second thought, it doesn't sound like news at all. A decrease in the population of an introduced species led to a recovery of native species: isn't that the principle behind any effort to eradicate an exotic species?

WHERE TWO WAVES INTERSECT

But no one is trying to eradicate the Nile perch from Lake Victoria—in fact, most people in the region are desperate to preserve the perch fishery, which was valued at US$220 million in 2000. Just getting rid of the major component of the largest freshwater fishery in the world is simply not an option.

Still, many scientists working in the region saw reason for hope. Having watched the populations of perch and haplochromines rise and fall, like two waves in opposite phase, they began to wonder if there might be a point of balance—enough perch for people to catch, and enough haplochromines to ensure the survival of the lake's remaining species. They began to think that building a sustainable fishery and conserving biodiversity might not be mutually exclusive aims after all.

Finding this balance is more than just a pie-in-the-sky conservationist dream. The livelihood of thousands may depend on that balance be-

Having watched the populations of perch and haplochromines rise and fall, like two waves in opposite phase, researchers began to wonder if there might be a point of balance.

A male in nuptial dress of one of the demersal types of haplochromines that were discovered in Tanzanian waters in recent years. They may be hybrids between several previous species.

Photo by Ole Seehausen

Some locations could become "reverse marine protected areas," with the protected area (for cichlids) actually the area that's fished the hardest (for perch).

cause the Nile perch grow fastest when they are eating mostly haplochromine cichlids. "We can only sustain the kind of fishery we're looking for on a haplochromine prey base," says Les Kaufman, a biologist at Boston University and former head of the Lake Victoria Research Team, an international consortium of scientists working on the lake's ecology.

Initially, Nile perch in Lake Victoria fed almost exclusively on haplochromines, producing some of the highest growth rates ever recorded for the species and fueling the rapid expansion of the fishery. As haplochromines disappeared, the perch switched to a diet of tiny prawns (*Caridina nilotica*), minnows (*Rastrineobola argentea*), and juvenile Nile perch. Like humans before it, the Nile perch was "fishing down" the lake, switching to smaller or less desirable prey as preferred species were overexploited.

On this new diet, it seemed, the perch grew more slowly. So as fishing began to deplete Nile perch stocks, haplochromines were released from predation pressure and began to resurge. Just as soon as that happened, the perch turned back to haplochromines, which they seem to prefer above all other prey.

In fact, one of the first clues that the cichlids were coming back was that they began to show up in perch stomachs again. "The predators can sample the cichlids much better than we can," says Daniel Schindler, an ecologist at the University of Washington in Seattle. Back on a diet of haplochromines, the perch should now be growing faster.

That's the prediction of a computer model of Nile perch population dynamics constructed by Kaufman and then graduate student, Jesse Schwartz. The two researchers turned to computer modeling to find the intersection between fishing and biodiversity conservation. Their model predicted that perch yields should be greatest when fishing effort is intermediate—a familiar result perhaps, but for an unusual reason. An intermediate level of fishing also results in lots of haplochromines in the lake. "If you fish too much, there will be lots of haplochromines but no fishery because the perch population will collapse," explains

Kaufman. "But if you fish too little, you'll have too many perch and not enough haplochromines, and the perch growth rate will go down."

In other words, a sustainable perch fishery and cichlid conservation are more than just potentially compatible—they're interdependent. Fishers and fishery managers need haplochromines to feed the Nile perch, and conservationists need fishers to remove Nile perch from the lake to reduce predation pressure on cichlids.

SELECTIVE PREDATION

Practical clues about how to accomplish this intermediate level of fishing come from an earlier computer model constructed by Schindler and his colleagues. Theirs is a classic predator-prey model that treats gill nets, the primary gear type used in the commercial perch fishery, as a size-selective top predator in the lake.

This model predicted that instituting a 5-inch minimum mesh size* throughout the lake would reduce Nile perch predation on haplochromines and other species by 44 percent, while decreasing perch yield by only about 10 percent. Although perch eat cichlids over most of their lives, the larger perch do the most damage. "It turned out that 5 inches was a good mesh size to eliminate a lot of predation but was maybe big enough to let the perch mature as well," Schindler explains.

Schindler argues that this type of fishing regulation has the advantage of being practical. "In my view the mesh-size restriction is viable because it's one of the few things you can do that's enforceable," he says. Nets are mostly imported, so enforcement involves policing a small number of net importers and sellers.

Regardless of the specific regulations that are instituted, the system will need frequent monitoring. That's because the balance managers are aiming for is not a static maximum sustained yield but an ever-shifting interplay between humans, perch, haplochromines, and other species in the ecosystem. Striking that balance requires constant calibration, with haplochromines as well as the perch themselves used as indicator species. According to Kaufman and Schwartz's model, Lake Victoria's fish stocks need to be assessed about every nine months to fine-tune management decisions and avoid over- or undershooting the balance point.

"Fortunately, it's an extremely resilient system," Kaufman says. Nile perch are extremely fecund and grow quite fast, which makes them very responsive to changes in management, suggesting that they could recover from overfishing relatively quickly. "If you back off fishing on perch. . .the little ones will pop out and grow up," he says.

Another key means of modulating the effect of the perch will be to protect the refugia where haplochromines can escape predation by perch. Researchers have identified a number of natural refugia such as swampy wetlands at the lake edge and rock islets within the lake, and they've noticed that local areas where perch have been fished out—such as the Mwanza, Napoleon, and Winam Gulfs—also function as such refugia. "Where there has been intense fishing—in isolated bays and such—is where the cichlid species are coming back," explains Schindler.

Schindler and others have suggested that local fishers could be recruited and paid to continue fishing for perch in these areas. In other words, these locations would become a system of "reverse marine protected areas," with the protected area (for cichlids) actually the area that's fished the *hardest* (for perch).

A NEW VERSION OF COMMON SENSE

The story of Lake Victoria may no longer be an unalloyed conservation tragedy, but it remains bittersweet. The vast logistics of managing fisheries in a lake the size of Switzerland are complicated by international borders and scarce economic resources. The three lakeshore nations have implemented a 5-inch minimum mesh-size restriction for gill nets, but so far this measure has been only a partial success. Up to 20 percent of the gill nets used today are below the legal mesh size. Some scientists are now pinning their hopes on a new slot-size restriction under which lakeshore processing plants would only be able to accept perch between 55 and 85 cm long.

* The nets are constructed and sold in inch rather than centimeter measurements.

Photo by Ole Seehausen

Platytaeniodus degeni is a representative of a morphologically unique genus of Lake Victoria cichlids with peculiar jaw and tooth shape. It almost went extinct but was rediscovered in Tanzania in December 2000 and has since increased in abundance. However, the new population is morphologically and in coloration quite different from the original *P. degeni*.

But the Nile perch is not the cichlids' only problem. The turbidity of the water in the eutrophic lake appears to be wreaking havoc on the cichlids' mating system. Females rely on visual cues from male coloring to select appropriate mates. Scientists are finding a number of haplochromine species that they've never seen before and that may be hybrids, suggesting that the lake has become a kind of singles bar where everyone looks good in the dim light.

"Fishery science is potentially quite powerful, but what we really need is clean water," says Ole Seehausen, who was part of the team that rediscovered *H. tanaos* in 1993 and is now based at Hull University in the U.K. He notes that so far, the cichlid resurgence consists of just a handful of species that have come back in large numbers—not a return to the previous level of diversity. In fact, eutrophication, which occurred about the same time as the Nile perch upsurge in Lake Victoria, may have been a more important factor in the cichlids' original decline than scientists first thought. And reversing it is likely to be key to maximizing cichlid recovery, particularly in terms of species diversity.

Yet already, some lessons of this latest act in the lake's story are clear. "We now have a new version of common sense," says Kaufman. Whereas common sense once dictated that fishing and biodiversity conservation are opposing goals, it now says that the two are compatible and even interdependent.

This interdependence rests on still another unexpected twist in this story of unintended consequences: the most important predator in Lake Victoria is not the Nile perch, it's the human fisher. Of course, the idea that humans are a powerful ecological force is nothing new—that's what overfishing is about. Nor is the idea that humans can be a force for good in ecosystems—that's what restoration is about. But the idea that humans can help foster ecological balance *while* making a living through resource extraction is a novel view.

Daniel Schindler suggests that this way of thinking about humans as predators could be applied to other ecosystems, such as some of the Great Lakes of North America, where exotics are currently the most important species in both a biological and an economic sense. And Les Kaufman goes further, arguing that this philosophy is the underpinning of an ecosystem approach to fishing. Today in Lake Victoria, scientists and fishery managers aren't merely asking "How many fish can we catch sustainably?" but "How does our catching fish affect the balance between all the other parts of the ecosystem?" ❧

Sarah DeWeerdt is a freelance science writer based in Seattle, Washington.

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