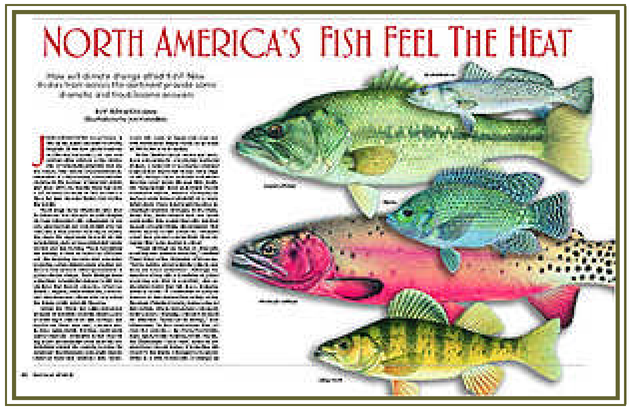
North America's Fish Feel the Heat

By T. Edward Nickens

How will climate change affect fish? New studies from across the continent provide some dramatic and troublesome answers


NORTH AMERICA'S FISH FEEL THE HEAT

JOHN MAGNUSON doesn’t have to fire up the latest computer modeling program to see how global warming is affecting his world—he can look out his office window at the University of Wisconsin–Madison and see the broad, blue sweep of Lake Mendota. Magnuson is a limnologist, a scientist specializing in the ecology of lakes and ponds, and since 1853, he reports, there has been a 25 percent decrease in the amount of time the lake remains frozen over during the winter.

That’s tough on ice fishermen, who flock to Mendota. But it might be even tougher on Lake Mendota’s fish. Magnuson is one of a growing number of scientists who are concerned that global warming is setting the stage for large-scale impacts on fish populations, such as Lake Mendota’s perch, walleye and lake herring. These researchers are turning to data as varied as 150-year-old fur-trapping records and computer modeling of hemispheric-scale weather systems to forecast how fish might respond to global climate change. Their findings reveal a spectrum of potential changes in fish populations that should concern—if not astound—anglers, conservationists, commercial fishermen and others who care about the future of fish in North America. Unlike the visible and often immediate impacts of pollution or urban sprawl, global warming’s effects on fish ecology and habitat are likely long-term, complex and, in some cases, subtle. But they could prove just as dramatic. Scientists believe that rising water temperatures could shift fish distributions around the country, moving the boundary that separates cold-water species (such as trout and walleye) from warm-water fish (such as largemouth bass and even subtropical tilapia) north by as much as 300 miles by mid-century.

As the Earth’s climate warms and large-scale atmospheric circulation patterns change, a network of ecological changes might follow that would impact every stage of fish biology. New patterns of seasonal flooding could scour fish eggs from southern Appalachian trout waters and Pacific Northwest salmon streams. Changing ice regimes could impact whitefish on a population scale. Deep lakes might become increasingly depleted of oxygen. In the Chesapeake Bay, larval striped bass and perch could suffer from waters that offer less food because of earlier spring temperatures. And native species of fish across the continent could face greater competition from invaders from more southerly climes.

“These findings are based on forecasts, modeling and possible scenarios,” cautions Frank Rahel of the University of Wyoming. “We’re talking about potential effects, and there are major unknowns.” Although the specifics of how fish will respond to global warming are still in question, few researchers doubt that fish face a changing thermal world. A consensus of concern formed at last summer’s meeting of the American Fisheries Society, during a special symposium where researchers compared notes about a changing climate’s impacts on fisheries. “What we’re seeing,” says Magnuson, “is that researchers from all over the country—the Gulf, Far North, East, West, North Atlantic, North Pacific, the Chesapeake—now have stories to tell about how climate change is impacting fish or will in the future. I thought we might be living in a little microcosm of change up here on Lake Mendota. But no part of North America escapes.”

The potential impacts range from primary, temperature-related effects to insidious secondary and tertiary possibilities. Consider water temperature. As air temperatures warm, many stream, river and lake temperatures will rise accordingly. For the trout of the Rocky Mountain west, Rahel found, the results could be dramatic. Rahel and his graduate student Christopher Keleher calculated that a 1-degree C increase in the average July air temperature of the region would reduce thermally suitable trout habitat in the Rockies by 17 percent. A 2-degree C increase would wipe out more than a third. Warm the average July climate by 3 degrees C—well within the range of many meteorological models—and half of the Rockies' suitable trout range evaporates before today's first-graders start collecting Social Security.

"These are very substantial losses for cold-water species," Rahel admits. "We were surprised at the high numbers." When the researchers produced maps showing the future potential distribution of cold-water fish given a 3-degree C increase in average July air temperature, the document looked like a piece of tattered lace.

And the nature of the remaining habitat is as much of a concern as the loss of habitat. As native cold-water fish are pushed farther and farther up the sides of the mountains, populations will become increasingly fragmented and isolated. Already conservationists are concerned about imperiled Rocky Mountain trout populations such as the Yellowstone cutthroat, Bonneville cutthroat and federally endangered greenback cutthroat trout. With warming water temperatures, Rahel explains, not only is there a loss of suitable habitat, but "tributaries are left dangling out in the landscape, isolated from other populations that would normally provide a mix of genetic material. And once you have a series of small, isolated populations, they become vulnerable to extinction like lights blinking out on a Christmas tree."

It's easy to understand that waters might get too warm for cold-water fish. Other potential impacts of a warming climate are far less obvious. Across the country from those Rocky Mountain streams is the Chesapeake Bay, one of the largest and most productive estuaries in the world. Each spring a large pulse of fresh water flows from the bay's tributaries, bringing a flush of nutrients that kicks off a series of plankton blooms—first a bloom of minute floating plants, or phytoplankton, and then a flush of tiny animal organisms, or zooplankton, that feed on the microscopic plants. Millions of hungry fish larvae—striped bass, white perch, menhaden, spot and others—depend on certain kinds of zooplankton, but not at the same time, says Robert Wood of the University of Maryland. Spot and Atlantic menhaden, for example, spawn far out on the coastal Atlantic shelf during winter. Their eggs are transported to the bay by wind-driven currents and arrive as hungry larvae at their riverine nursery grounds in March and early April. Striped bass and white perch spawn in April, and don't develop into zooplankton-eating larvae until May and June.

But what if winters get shorter and spring comes earlier, as climate warming models suggest? "That would favor coastal spawning species such as spot and menhaden over striped bass and perch," Wood explains, although he points out that "scientists can't be sure which dominoes will fall, and when. And it's not simply a matter of what happens in the spring, but a matter of the timing of these processes."

And how they relate to other impacts of global warming. Wood lists a series of changes that could befall the bay. Paired to global warming is sea level rise, which will consume the tidal wetlands that serve as nursery areas for fish as varied as mummichog and spotted seatrout. Warming water temperatures could push out cool-water species such as soft clams and striped bass, even though some fisheries might actually benefit from a warmer Chesapeake Bay. Brown and pink shrimp could increase. Blue crabs tend to fare better during warmer winters. "But we don't know enough to predict the particular response of the ecosystem to global climate change in the Chesapeake Bay," says Wood. "It's like a spider's web. Break some of the connections and we're not sure which parts of the ecosystem will degrade. But it's clear that cascading effects could transform the ecosystem in ways that we can't foresee right now."

Changes in some ecosystems already are visible, if you look as hard—and as far—as Wisconsin's John Magnuson has. In 2000, Magnuson led an international research team that uncovered evidence that lakes and rivers in the Northern Hemisphere are freezing an average of nearly nine days later, and thawing ten days earlier, than they did a century and a half ago. This conclusion came from studying records from around the globe, including Hudson's Bay Company shipping logs and freeze dates from ancient Japanese religious sites. In one intriguing case, a Madonna figure had been carried across a lake on the Germany-Switzerland border each year that the lake froze as far back as the ninth century, giving savvy researchers a data set of total ice cover.

"Ice is very responsive to changes in climate, and so are fish," explains Magnuson. But even more importantly, ice records provide a longer record than do conventional fishery statistics. Trends that might not appear in studies that examine year-to-year or even decade-to-decade data can show up when the time scale is broadened to a century or more. "Fishermen see behavioral changes in fish over their lifetimes, so they know that fish are very responsive to climate change and variability," says Magnuson. "But the biggest changes are the long-term shifts, even though they are more difficult to observe."

A changing regime of ice cover of lakes and rivers could affect fish through hidden, second-order impacts in the same way the warming of the Chesapeake Bay might skew fish ecology. In Lake Michigan's Grand Traverse Bay, Magnuson says, whitefish have had poor hatching success in years when there is relatively little ice cover. “No ice, and winter winds roil the water, mixing it up,” he explains. “When the water surface is frozen, the eggs sit safely on the bottom in a very still environment.”

Another potential impact would be a shift in how lake waters stratify. During the summer, warmer water layers the tops of lakes, while cooler water settles towards the bottom. Those cooler waters provide a thermal refuge for many cold-water fish, such as lake trout, whitefish and salmon. If the lakes are covered with ice for shorter periods of time, Magnuson says, the growing season lengthens and isolated deep waters run the risk of running out of oxygen. “The trout, whitefish and salmon that need those cool-water refuges will suffer.”

These effects, researchers say, signal a paradigm shift for fisheries managers. “We’ve always assumed that human fishing activity was the major regulator of fisheries abundance,” explains Magnuson. But these new studies show that climate change and variability affect fish populations in significant ways. How humans manage fish will need to change. In the salmon fisheries of the Pacific Northwest and Canada, harvest rates for certain stocks of salmon have commonly been as high as 60 to 80 percent of the total population.

“We’ve been managing salmon fisheries for 50 years by making decisions based on employing people and producing seafood,” explains Richard Beamish, with Fisheries and Oceans Canada. “People have assumed that fishing harvest rates were so high, and the ocean so vast, that the ocean environment wasn’t even an issue.” Now researchers like Beamish contend that the effects of climate on the ocean are as important as fisheries impacts.

Beamish recently analyzed pink, chum and sockeye salmon harvest rates to see how fish populations respond to broad shifts in Pacific weather patterns. Plotting surface water temperatures, atmospheric circulation of winter winds and changes in the Aleutian Low (the north Pacific’s major winter weather system), Beamish learned that Pacific salmon stocks responded dramatically to four major shifts in these weather indices—in 1947, 1977, 1989 and 1998. In certain instances these “regime shifts,” as Beamish calls them, prompted increases in salmon numbers. In others, fish populations crashed. In 1985 and 1986, the highest total catches in the history of the Canadian salmon fishery were tallied, about 105,600 tons for each of those years. Following the last major climatic shift in the region, in 1998, the total catch was a meager 25,500 tons. Last year it dropped even lower, to 7,500 tons, the lowest in history.

The mechanics of how salmon respond to such changes isn’t yet clearly understood. But recognizing that salmon abundance fluctuates according to the dynamics of the Pacific Ocean’s weather patterns, Beamish says, is a critical first step to bringing scientists and fisheries managers together. “Now we have to learn how to incorporate climate change effects into our strategies for managing fish populations,” Beamish says.

It’s a welcome sea change. For years, scientists concerned about the impacts of climate on fish populations felt like voices crying in far-flung wildernesses. No longer. And if the thought of casting to smallmouth bass in a river that once held Wyoming cutthroat trout is troublesome, at least the acknowledgment of the issue will empower fisheries managers. “The silver lining,” says Robert Wood, “is that we now recognize that climate change can have profound effects on fisheries.”

Writer T. Edward Nickens hopes he never catches a tilapia in his native North Carolina waters. Kansas City artist Joe Tomelleri’s illustrations of fish have appeared in more than 200 publications.