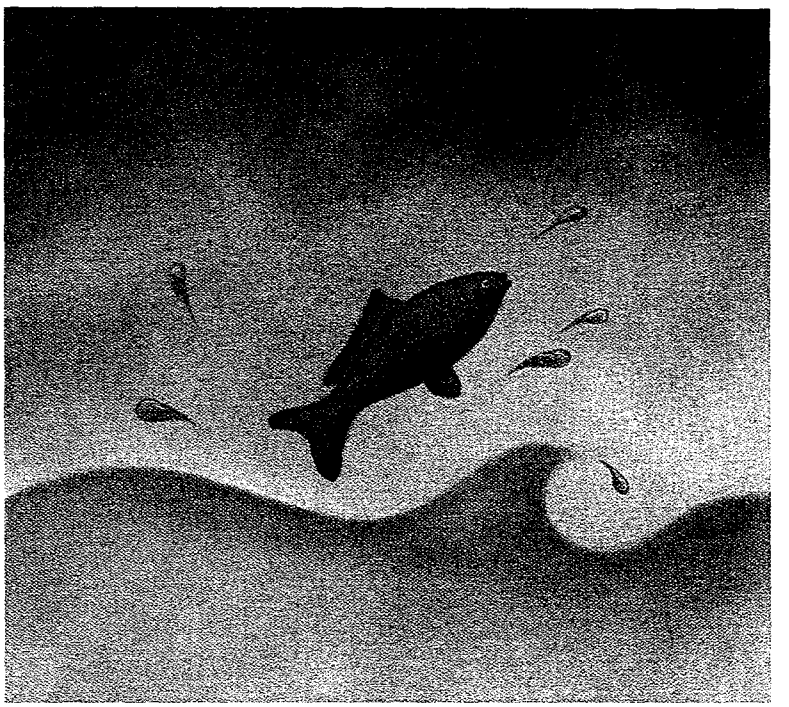


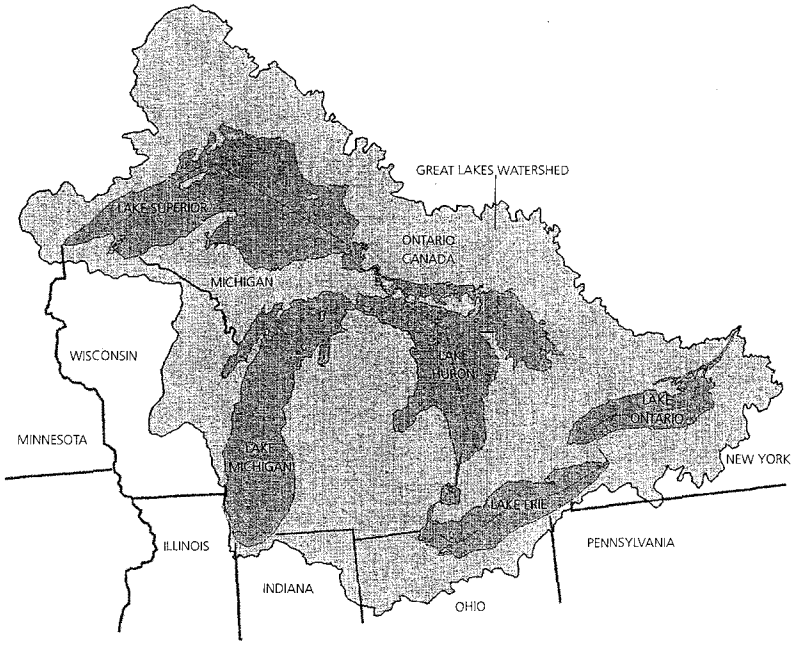
Opening Rivers to TROJAN *Fish*

The Ecological Dilemma of Dam Removal in the Great Lakes

By Ross Freeman
with William Bowerman, Teryl Grubb, Allen Bath, Gary Dawson, Kenneth Ennis, and John Giesy

UNDER CURRENT ECOLOGICAL THINKING, there is no goal nobler than restoring a river's hydrologic connectivity by removing dams. Fish can access upstream spawning grounds, historic habitat is once again available, and the naturally fluctuating flow of nutrients and water is reestablished. But what if those same fish are so laden with toxics that predators such as bald eagles (*Haliaeetus leucocephalus*), mink (*Mustela vison*), and otter (*Lutra canadensis*) stand to suffer upon consuming them? Could it be possible that in certain cases dam removal may in fact cause more harm than good by fostering the introduction of bioaccumulated toxics into relatively untainted ecosystems and permitting aggressive nonnative species to invade virgin territory?

This is the question that Bill Bowerman, an ecotoxicologist at South Carolina's Clemson University, faces in his research on bald eagles in the Great Lakes region of the U.S. and Canada. On the one hand, dam



The Great Lakes of North America

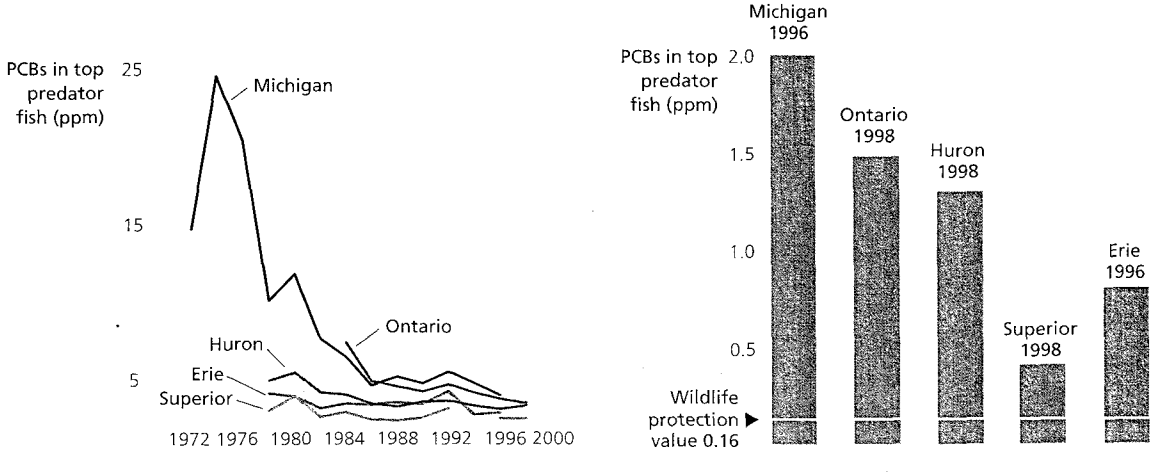
removal offers a multitude of ecological benefits and makes compelling economic sense. For example, in the Pacific Northwest, partially breaching four dams may be the best chance for wild salmon recovery in the Snake River; and in New England, removing the 8-meter tall Edwards Dam cost far less than mandated upgrades and was the only way to meet restoration requirements. On the other hand, in the Great Lakes watershed, Bowerman finds the issues more murky—much like the region's polluted past.

For decades, unregulated industry spewed huge amounts of pollution into the regional rivers and lakes, much of it either absorbed by benthic sediments or resident fish. From the 1930s to 1950s, many small hydropower dams were built on tributaries to the Lakes, effectively isolating upstream eagle habitat from fish downstream. Now, ironically, these dams may serve as barriers, protecting upstream wildlife, such as bald eagles, from bioaccumulated toxics.

How can we stop the eagles that hunt and live along the tributaries from eating these "Trojan" fish that bring with them hidden contami-

Have contaminant levels changed?

Although water quality has dramatically improved over the past 30 years, the pollutants from the 19th and early 20th centuries are still very much at large in the Great Lakes. PCB concentration in the tissues of the Great Lakes' top predator fish (lake trout, walleye in Lake Erie) are still far above the U.S. EPA wildlife protection value.



Data are from the Great Lakes Fish Monitoring Program, a cooperative effort of the U.S. Environmental Protection Agency Great Lakes National Program Office and the U.S. Fish and Wildlife Service (currently USGS Great Lakes Science Center). *http://www.epa.gov/glnpo/glindicators/fishtoxics/topfishb.html*

nants? According to Bowerman, the difficult answer may be to leave some dams in place. This is the dilemma facing the region's conservationists and resource managers, who are keen to restore a more natural hydrograph but wary of broader scale ecosystem impacts.

Bowerman's story, however, is not just about bald eagles and Great Lakes toxicants. It is also about keeping an open mind to unintended consequences of human manipulation. And, it is a reminder of the idiosyncratic nature of ecological systems. One size doesn't fit all—even with a strategy as widely embraced as dam removal.

Cascading Effects

Even though the Great Lakes contain an astonishing 20 percent of the world's surface freshwater, they were altered forever by a simple earthen trench just over one meter deep.

In fact, the five-lake ecosystem has endured a series of human manipulations, with perturbations still resonating throughout the region. By altering just one aspect of this complex aquatic web, the fates of countless other interconnected elements hang in the balance. This legacy of cascading effects—some intended, some accidental—is due ultimately to the Erie Canal. Of course, no one knew that in 1825, the year of its completion.

The 584-kilometer-long canal provided large barges reliable, seagoing access to the Atlantic Ocean from Niagara Falls below Lake Erie via the burgeoning port of New York City. In return, the Ocean provided an unwelcome gift: a 50-centimeter-long, voracious, eel-like parasite called the sea lamprey (*Petromyzon marinus*). The gruesome adult form of this jawless fish—which makes its living by attaching to the flanks of a host and sucking fluids—can eat up to 18 kilograms of fish during its 12- to 20-month lifespan. The lamprey's Lake Erie invasion was officially recorded in 1921 after another connecting canal was built, and it appeared in the three other upper Great Lakes (Huron, Michigan, and Superior) within two decades. As the canal's water flowed east, exotic species flowed west. To date, almost 150 other invasive species have made a similar journey, often as stowaways in ships' ballast water or cargo.

Sea lampreys are particularly fond of consuming the native lake trout (*Salvelinus namaycush*). By 1950, lake trout populations had been decimated, especially in Lakes Michigan, Huron, and eastern Superior. And the cascade of effects continued: as this top predator disappeared, populations of its favored prey—the alewife (*Alosa pseudoharengus*)—skyrocketed, creating a massive nuisance due to its frequent annual spring die off. The alewife also happens to be an exotic anadromous fish species, native to the Atlantic coastline but able to exploit the massive freshwater habitat of the Lakes.

Within a few decades, an intensive chemical control program met with fair success but never achieved complete lamprey eradication. Resource managers also built many low weirs on tributaries to prevent upstream sea lamprey passage. Today, millions of dollars are spent each year to continue these efforts. But still the story continues.

In the 1960s, the State of Michigan decided that the Lakes ecosystem was still out of bal-

At the top of the food chain

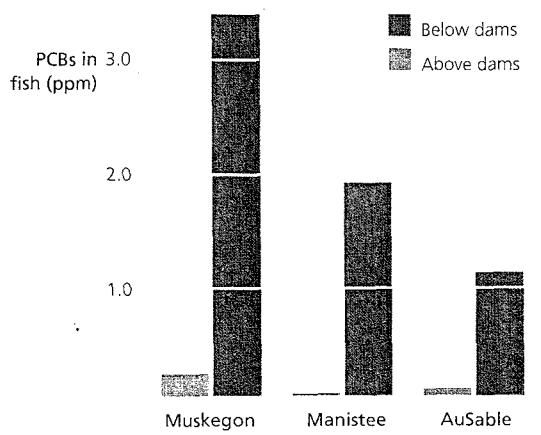
A predator like the bald eagle reflects the health of its customary prey and their habitat. In fact, this led to the eagle's 1976 endangered listing in the first place: a notorious and persistent organic chemical—the pesticide DDT—was decimating the reproductive success of this emblematic species. Since then, nesting pairs outside Alaska have rebounded tenfold to over 4,500 in the 1990s, and the eagle may become one of the few species to be removed from endangered listing. Although DDT is no longer used in the U.S., plenty of other chemicals from our poorly regulated industrial past are still haunting both humans and wildlife, often decades after their use has ceased. These chemicals, such as polychlorinated biphenyls (PCBs) and heavy metals, are highly persistent, patiently waiting to reenter the food chain. Ultimately, the effect is highly magnified in proportion to the number of tainted species consumed—a textbook case of bioaccumulation.

ance: vast numbers of unconsumed forage fish—such as the alewife—needed a vigorous new predator. The nonnative fish selected were coho and chinook salmon (*Oncorhynchus kisutch* and *O. tshawytscha,* respectively). It is no coincidence that these fish also happen to be tremendously popular with recreational anglers willing to pay amply for the thrill of the chase.

These are the Trojan fish that today migrate up the tributaries of the Great Lakes, their strong swimming ability impeded only by natural waterfalls and small hydropower dams with no bypass facilities. Although native sturgeon and trout explore new territory, neither species has distinct migration patterns and an instinct to spawn in small headwater streams. Salmon do. But during their time spent in the Lakes themselves, these anadromous fish ingest the toxics found in water, sediment, and other fish and absorb them permanently into their own body tissues. Thanks to this legacy of sequential human manipulation, indigenous bald eagles have the unprecedented opportunity to eat an exotic meal of nonnative, toxic fish.

Holding back toxins

Mean concentrations of PCBs in a fish-based bald eagle diet above and below the dams for three rivers in Michigan.



Data from Giesy, J.P. et al. 1995. Contaminants of fishes from Great Lakes-influenced sections and above dams of 3 Michigan rivers. III. Implications for health of bald eagles. *Archives of Environmental Contamination and Toxicology* 29:309-321.

Risk Assessment

In 1989, Bowerman (who at the time was a PhD student at Michigan State University under Dr. John Giesy) joined a group of research scientists studying the potential impacts of hydroelectric dams on bald eagles. The findings from this research caused U.S. Fish and Wildlife Service (FWS) managers to make the ultimate decision on fish passage that was so controversial and divisive that many colleagues among the natural resource agencies involved never spoke to each other again.

Michigan's largest electric utility, Consumers Energy, was submitting a routine hydropower dam re-licensing proposal, and the research conducted at Michigan State was to assess likely environmental effects under different management scenarios. An oversight committee of agency biologists from the FWS, U.S. Forest Service, and Michigan Department of Natural Resources was formed after questions arose from Tim Kubiak of the FWS about the safety of passing fish over the dams.

The researchers would look at the operation under the status quo as well as after proposed fish passage installation. Previous researchers had studied the downstream release of toxic-laden sediments from behind a dam; but this research was unique in its examination of the *upstream* toxics migration. Implicit in this task was an evaluation of the watershed-scale ecological benefits of a free-flowing river versus the likely costs to all fish-eating species.

The Federal Energy Regulatory Commission (FERC) is charged with overseeing nonfederal hydroelectric projects across the nation and is not known for its progressive environmental record. Nonetheless, every 30-50 years dam licenses come up for renewal, and FERC must prepare an Environmental Impact Statement[1] to evaluate the ongoing impacts. This used to be a formality—but not this time. The utility and various state and federal agencies de-

[1] Mandated by the U.S. National Environmental Policy Act in 1970, an Environmental Impact Statement requires all federal agencies to consider the various impacts—environmental and other—of any large federal project or proposal.

The percent of eagle territories exposed to the **polluted food chain** would have almost doubled with the proposed fish passage.

signed a study and hired Giesy, Bowerman, and colleagues to do the research for 11 hydroelectric projects on three central Michigan rivers: the AuSable, Manistee, and Muskegon.

They flew the entirety of the three rivers to assess habitat. In addition, they determined eagle food habits during the breeding season, breeding and wintering habitat use by nesting eagles, exposure to environmental toxics, and effects of human disturbance. Using these data, they developed two models. The risk assessment model compared the toxic loading to eagles under a 90-percent fish diet at sites above and below the barrier dams on the three rivers and contrasted the numbers with a diet that would lead to "no effect" levels of bioaccumulation. This assessment was based on a white paper written by Tim Kubiak and Dave Best of the FWS using the data generated by Giesy and Bowerman. The negative effects on breeding success were added to the original assessment and extrapolated to determine potential impacts statewide on the rivers where fish passage was proposed. Fish passage was predicted to increase the percent of eagle territories in the state exposed to the polluted Great Lakes food chain from 35 percent to 66 percent and result in approximately 19 fewer fledgling eagles for the 257 active nests each year (1). Meanwhile, the habitat-use model identified suitable nesting, roosting, and perching habitat for bald eagles and determined availability under a variety of human impacts. The output led to proposed management criteria such as limits on recreational sport fishing, use and placement of boat ramps, and hiking access.

The scientific review was a long and contentious process that polarized the Great Lakes resource management community. Ultimately, the FWS, which had veto power, recommended *against* any form of dam bypass structure and *for* retention of the dams to prevent toxics-laden fish from migrating upstream into prime bald eagle habitat.

Dave Best, a 19-year veteran biologist with the environmental contaminants program of the FWS in Michigan, was involved in the research and supported Giesy and Bowerman's findings. He recalls that against the protests of the State of Michigan—which was eager to expand the reach of the revenue-generating chinook fishery—the FERC determined no fish passage would be allowed until such time as the downstream fish showed lowered levels of toxicity deemed acceptable for eagles. Some toxicologists think this may never happen, but Dave Best thinks that Michigan will never stop fighting. According to Bowerman, toxics levels in fish have not dropped since the early 1990s and are still above background levels—up to 30

Dam removal around the world

Perhaps due to the strength of the environmental movement in the U.S., dam removal is well underway. But there is emerging international interest, too. Denmark has removed several small dams for fish passage purposes (2), and the World Commission on Dams report lists several dozen larger removals in Canada, three in France (two on the Loire River to assist native salmon), and one in Norway. The International River Network also describes vigorous, citizen-led, large-dam decommissioning campaigns in Colombia, Thailand, and the Czech Republic.

times in some cases. Based on current trends in fish contaminant concentrations and the guidance of the Environmental Protection Agency's Great Lakes Initiative, Bowerman doubts that the fish will be clean enough to pass over the dams in his lifetime.

In the U.S., almost 500 small dams have been removed to date and over 60 are scheduled this year alone, according to the national conservation group American Rivers. In her book, *Watershed: The Undamming of America*, author Elizabeth Grossman writes that the rate of demolition now has even exceeded the rate of construction. This has Bowerman worried. Now that we've addressed the past 150 years of cascading ecosystem effects in the Great Lakes, we may be about to unleash a new flood of problems with the surge in dam removal. These removals could once again raise the threat of major impacts on Great Lakes bald eagles. To Bowerman, dam removal is clearly beneficial in many cases, but like other actions it must be assessed in the context of past resource management decisions and future ecosystem goals.

Not everyone grants the same significance to bioaccumulation concerns. Jim Kitchell, aquatic ecologist at the University of Wisconsin's Center for Limnology, thinks that a bigger concern to the overall Great Lakes ecosystem is the potential upstream migration of aggressive exotic species like the sea lamprey. To fully understand and rank the potential impact of upstream toxic salmon migration, Kitchell feels that complete bioenergetic modeling is needed.

Meanwhile, dam removal proponents in the Great Lakes point out that there is no documented case of dam removal leading conclusively to reproductive failure in eagles because of toxic fish. Of course, this may simply reflect the scarcity of studied cases.

One Size Doesn't Fit All

If we've learned anything from past experiences, it's that management decisions with far-reaching implications must be addressed on a case-by-case basis. The complex history of pollution in the Great Lakes drives home the point that we are not dealing with natural systems anymore. We have to keep in mind the cascade of human-induced effects already in play. Those effects may help one species at the expense of others. In altered systems, adds Dave Best, there is no returning to the original condition—rather, an informed choice must be made as to the best way forward.

Such ecological dilemmas aren't limited to the Great Lakes and toxins. On the Cuyahoga River in the state of Ohio, the federal Environmental Protection Agency wants to remove four dams to improve water quality, for both fish needs and human safety, but the lowest dam is blocking invasive and nonnative species such as the zebra mussel (*Dreissena polymorpha*) and the round goby fish (*Neogobius melanostomus*).

Creative compromises are needed. Elizabeth Maclin, who directs the dam removal campaign at American Rivers, suggests that one solution may be to remove the upper dams on a tributary and leave the lower ones in place.

Similarly, Helen Sarakinos, small dams program manager with the nonprofit conservation group River Alliance of Wisconsin, notes that plenty of opportunities exist in the region to remove uncontroversial dams while we learn more about upstream toxics. Better scientific documentation of future dam removals will help clarify the ecological tradeoffs at stake. Until then, informed compromise will surely play a key role in each case. ❧

For More Information

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Ross Freeman, freelance writer based in Seattle, Washington; **William Bowerman**, Clemson University, South Carolina; **Teryl Grubb**, USDA Forest Service, Arizona; **Allen Bath**, Michigan State University, Michigan; **Gary Dawson**, Consumers Energy, Michigan; **Kenneth Ennis**, USDA Forest Service, Michigan; **John Giesy**, Michigan State University, Michigan