Eddies

Reflections on Fisheries Conservation

Eddies

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On the Cover:
Giant salvinia, an invasive aquatic plant, has taken hold in lakes and bayous in the South. See page 16. USDA photo

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National Park Service

Pythons have invaded the Florida Everglades. Read about one man's snake experience, returning home to Florida in this issue's Meanders, page 30.

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people.

CONSERVING AMERICA'S Fisheries
U.S. Fish & Wildlife Service

Headwaters

Join Us to Make a Difference

By Bryan Arroyo

USFWS

Aquatic invasive species are a clear and present danger to the aquatic biota of our country. It's by boats, boots, and ballast that aquatic invasive species make their way into our waters. Once established, they can spread aggressively and break links in the food chain.

Whether the invasive organisms are plants, bugs, microorganisms, fish, snakes, snails, crabs, mussels, or algae—and the examples are many—the outcome is quite often a short-circuit in an ecosystem's "wiring." Invasive species can change water quality, and they can be the vectors for novel diseases moving into new waters. Invasive fish species can replace or eliminate native fishes entirely, and this is particularly disconcerting when those native species are listed as threatened or endangered.

Then there are the costs. Invasive species can make your wallet thinner. Not only do invasive species tax native fish and plants by disrupting the ecosystem, some devastate private property, damaging your boats, marinas, irrigation systems, or public water works—and the expenses are passed on to consumers. In the end, we all pay. This is why we are aggressively tackling this threat to our native aquatic systems head on with a multi-pronged approach. We are currently examining all existing authorities both within and outside the U.S. Fish and Wildlife Service to harness all of these authorities to better protect our aquatic systems. This approach includes prevention, control, and eradication strategies. The 1990 Nonindigenous Aquatic Nuisance Prevention and Control Act gave us the legislative means to address invasive species. It was through this legislation that we created the Aquatic Nuisance Species Task Force, which I co-chair alongside with the National Oceanic and Atmospheric Administration.

This Task Force, made up of other federal agencies and regional panels whose participants are private enterprises, tribal governments and state governments, steers our work on the water. The Task Force is energized and looking at all avenues to better address invasive species. Legislative authority by itself isn't enough. We are enjoined fully with limited resources, but I fear it's a battle we are currently losing.

These points are illustrated in this issue of *Eddies* in the story by David Britton, titled "Conservation in a Quaggamire." Dr. Britton refers to the quagga and zebra mussel invasions that occurred in the Great Lakes via ballast release, and then spread to points across the country as an "ecological cancer." The metaphor is fitting. In the singular, these tiny mussels are unimpressive. In the aggregate—and they do amass upon one another in a large way—these little organisms are very destructive to native fish fauna, and to public water works.

Writer-biologist Susan Jewell punctuates the point in her story, "Invasive Species in our Waters." Jewell gives us an umbrella look at the issue in the U.S., and strikes a chord, saying "Because water provides such a perfect pathway for pernicious pests, our continent is both blessed and cursed."

The ravages of injurious organisms will not be easily overcome. Witness the story on giant salvinia by retired biologist, Bob Pitman. The Brazilian plant that can spread by boats turns lake coves, bayous, ponds, and duck marshes into fields of the leafy plant in short order. Controlling the plant is no easy matter.

The jury is still out on what "rock snot" may do to our fisheries. Also known as didymo, John Bryan tells how this single-celled diatomaceous algae moves by boots, and grows, and what it may do in the future. It's not much to look at, but what it may do to native ecosystems remains to be seen.

All of the invasive species, terrestrial or aquatic, have one thing in common: you. It's you who can help stop the spread. Through our social marketing efforts, as you will see on the back cover, we are attempting to educate folks throughout industry, through consumers, and through you the reader, that it is they who can make a difference. If there's any message to take home from this issue of *Eddies*, that's the one. *You* can make a difference.

Bryan Arroyo is the Assistant Director for Fisheries and Habitat Conservation in Washington, DC.

Northern pike out, rainbow trout in

California Fish and Game Department

California Department of Fish and Game biologists apply CFT Legumine to kill unwanted, invasive northern pike in Lake Davis.

Where northern pike are not native, they're not wanted. Case in point, Lake Davis, California. Northern pike were illegally introduced in the watershed, and showed up in Lake Davis in 1994. The California Department of Fish and Game (CDFG) eradicated northern pike with the piscicide rotenone three years later. By 1999, CDFG biologists rediscovered northern pike in Lake Davis. Following the controversial use of rotenone and a lawsuit, biologists sought to remove northern pike again, but without rotenone.

Through various means, about 65,000 northern pike were taken from the lake. But pike populations continued to dramatically rebound, and affect several sport fish species. Northern pike also threatened to migrate over the spillway and spread into the Sacramento San Joaquin Delta, potentially damaging a much larger sport fishery. This prompted the CDFG to plan another pike eradication. They used Dingell-Johnson Sport Fish Restoration Act funds to plan, buy materials, test water quality, and conduct fish surveys before and after treatment.

In September 2007, CDFG personnel eradicated northern pike from Lake Davis, and nearby streams using the piscicide, CFT Legumine. When biologists determined several months later that the lake was free of chemicals and pike, CDFG stocked 31,000 Eagle Lake rainbow trout from its American River Hatchery, with a million additional trout stocked in later years.

Removing invasive pike worked. Recent creel surveys show that average catch per angler-hour increased from 0.12 fish to 0.31 fish, turning Lake Davis back into an excellent trout fishery.

Dingell-Johnson Sport Fish Restoration Act funds come from federal manufacturing excise taxes on fishing tackle, trolling motors, and motorboat fuels, distributed to state fish and wildlife agencies. These funds support fishery management that benefits anglers. ✦ Thomas McCoy

Internet provides global connection to fish health survey

Joshua Bradley/USFWS

This online map shows where Largemouth Bass Virus has been detected by U.S. Fish and Wildlife Service biologists at nine Fish Health Centers around the country. The map is delineated by watershed. The virus has been found in watersheds colored pink.

A new website allows anyone to access data from a nationwide survey focused on the health of America's fisheries. Through the National Wild Fish Health Survey, the U.S. Fish and Wildlife Service examines fish for important disease-causing pathogens and parasites in America's lakes and streams. Knowing where pathogens occur is a first-line defense to prevent disease.

Since 1996, nearly 220,000 fish have been examined from some 4,600 distinct sites in 2,560 water bodies. In all, fish health practitioners examined more than 260 fish species. Those fishes were tested at the U.S. Fish and Wildlife Service's nine Fish Health Centers and the results posted on the website. The website allows users to query using a search form and an interactive map, download reports, and create custom maps. Search results may be saved for use in spreadsheet applications or "earth browsers," such as Google Earth®. To find out what's in your watershed, go to www.fws.gov/wildfishsurvey. ✦
Ken Peters

FEATURED FACILITY

Lake Champlain Fish and Wildlife Resources Office

Where: Essex Junction, Vermont
When: Established in 1992

Then: The Lake Champlain Fish and Wildlife Resources Office (LCFWRO) was established for fisheries conservation in the Lake Champlain Special Designation Act of 1990, and the Daniel Patrick Moynihan Lake Champlain Basin Program Act of 2002.

Now: Biologists with the LCFWRO restore populations of lake trout and landlocked Atlantic salmon in Lake Champlain and its Vermont, New York, and Quebec tributaries. Both species were extirpated more than a century ago, yet in cooperation with our partners in Vermont and New York, the LCFWRO has established new populations through stocking. Stocking is only part of the restoration work. Biologists spend more time controlling invasive sea lamprey—a nuisance, an eel-like, parasitic fish that if its population is not suppressed, would decimate the trout and salmon. Through the use of barriers that prevent lamprey spawning, traps that intercept adults, and piscicides that kill larval lampreys, restoration of trout and salmon progresses. Innovative and effective lamprey controls that minimize the environmental impact have paid off. The lamprey population has been more than halved over the past five years, while the size and number of lake trout and Atlantic salmon have increased. ✦ Bradley A. Young, Ph.D.

Wayne Bouffard/USFWS

An adult sea lamprey sucks on the palm of field technician, Patrick McLaughlin, as it does when it parasitizes lake trout and Atlantic salmon, causing stress and wounds that often result in the host's death.

Newts and frogs susceptible to mass die-off

Biologists from the U.S. Fish and Wildlife Service's Fish Health Center in Lamar, Pennsylvania, teamed with Penn State University staff, to test frogs and newts from the Delaware Water Gap National Recreation Area. The intent: find diseases of national concern.

The researchers tested wood frog, gray tree frog, spring peeper, and red-spotted newt—111 amphibians in all—for the deadly Chytrid fungus and viral pathogens. Using leading-edge technology, laboratory analysis revealed that some of the animals had characteristics of an Iridovirus; others had traits characteristic of "frog virus 3" and other potentially serious disorders. Chytrid fungus was not found. Their findings were published in the scientific periodical *Journal of Aquatic Animal Health*, where they noted no die-offs in the field, but what was detected in the laboratory could cause mass amphibian mortality. ✦ Craig Springer

Tom Barnes/University of Kentucky

Red-spotted newts, like this one, were studied by the U.S. Fish and Wildlife Service's Lamar Fish Health Center, in Pennsylvania. Findings were published in the Journal of Aquatic Animal Health.

Asian carp caught above electric barrier

On June 22, 2010, a contract commercial fisher hired by Illinois DNR caught a single, 19.6-pound male bighead carp in Lake Calumet, in the Chicago Area Waterway System (CAWS). Lake Calumet, above T.J. O'Brien Lock and Dam, is about six miles from Lake Michigan.

This is the first Asian carp captured above the U.S. Army Corps of Engineer's electric barrier system, and the second specimen captured in the CAWS since December 2009.

The recent catch occurred during routine sampling by the Asian Carp Regional Coordinating Committee (RCC). RCC member agencies—including Illinois DNR, U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service—began an immediate rapid-response to remove any additional Asian carp from Lake Calumet, if present. The USFWS will continue to work directly with its agency partners to control Asian carp in the CAWS. ✦ Aaron Woldt

Chris Young/State Journal Register

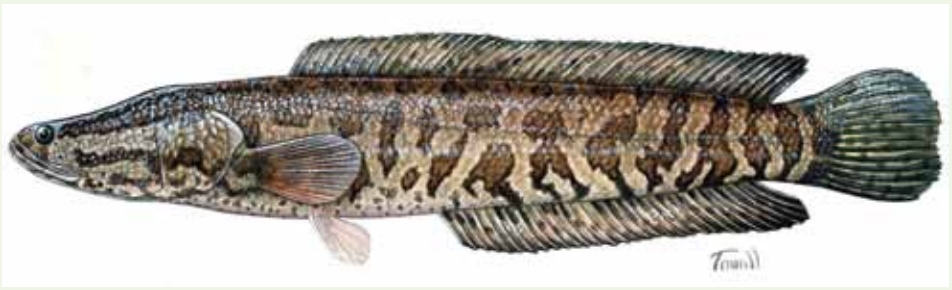
An Asian carp leaps from the wake of a passing boat.

Taiwan satellite to monitor Ohio River waters weeds

Hydrilla. It's an invasive plant from Africa that's made its way into the Ohio River basin, probably hitching a ride on a boat trailer. It has taken root, and so has the Asian-native curly leaf pond weed, both in the backwater bays of the big river, where young native fish live. The unwanted weeds could confound fish management. But now, thanks to a partnership with multiple state and federal agencies under the auspices of the Ohio River Basin Fish Habitat Partnership—and the country of Taiwan—the Carterville Fish and Wildlife Conservation Office, Illinois, will oversee an aquatic weed survey that will save time and money and target control efforts the length of the river. Taiwan's Formosat-2 satellite will provide the means to monitor the underwater weeds. ✦ Richard Christian

Snakehead eradication proving tough in Arkansas

"One man's trash is another man's treasure" holds true for the northern snakehead. In its native range in Korea, the fish with a snake-like appearance is a highly sought food-fish, viewed as a delicacy. Not so, in Arkansas. Here it's an unwanted predator with potential to out-compete and replace native species. It eats fish, almost exclusively.



Susan Trammel/Bugwood.org

Aptly named, the invasive northern snakehead has been found in six states.

The snakehead made national news in 2002, when a specimen was caught in a Maryland pond, and then in 2008, the fish caused a shudder in Arkansas. Like a scene from a bad B-movie, another specimen was found squirming on a country road, left behind with receding flood waters. That led to an intense eradication effort by employees from the U.S. Fish and Wildlife Service's Fisheries Program and the Arkansas Game and Fish Commission in the 4,000-acre Piney Creek basin, in March 2009.

After removing fish with a piscicide, no snakehead were found in the first follow-up. But that didn't last. By October, snakehead had once again appeared in Piney Creek. Snakehead are fruitful, spawning up to five times a year, and adults guard their young a long time.

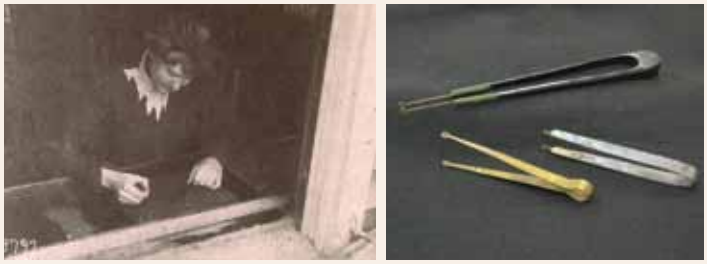
Biologists continue to monitor the snakehead population to better target their eradication in the Arkansas creek. The snakehead has also invaded waters in Florida, New York, California, Pennsylvania, and Massachusetts, proving the worth of prevention over cure. ✦ Ricky Campbell

FROM THE ATTIC

Notes from D.C. Booth Historic National Fish Hatchery and Archives

You had to be "picky" to work in the National Fish Hatchery System back in the old days. The pickier the better, or perhaps better stated, the greater the success at culturing fish. Hatchery workers learned that dead fish eggs, if left among the live eggs, spread fungus and killed more eggs. The dead eggs had to be removed, and without harming the live eggs. The technology of mechanical egg sorters, which are used today, was years away.

A reliable but slow method of egg removal was hand-picking. Need spawned special tongs. These tweezers-like devices had small loop rings at the working ends to pick up an individual egg. With great tedium, one by one, the bad eggs could be removed from the good eggs. Some of the egg tongs were finely crafted, carved of flexible wood with brass loops fastened to the ends, smoothed and finished. At the other end of craftsmanship, but high on the ingenuity scale, are the pair made from a hacksaw blade. Bent in half, rough metal loops are soldered on the ends of the blade. Eggs being delicate, the saw teeth were smoothed off.



Randi Sue Smith/USFWS

Picking dead eggs was a tedious task, often done by wives of hatchery employees, with tools both crude and creative.

Another pair is cut from sheet brass, neatly shaped and bent to form tongs with dished rings at the ends.

At egg-picking time, extra staff hired on, and could be found nearby among the wives and children of the hatchery workers. Many lived on the hatcheries, conveniently close. One photograph housed in the Archives shows young women picking eggs in the better light at the hatchery windows. One suspects that these young ladies knew the photographer was coming, as they wear white lacey collars that seem more suited to afternoon calls than handling trays of fish eggs. Photographers were rare, and the egg pickers would have wanted to look their best. Eventually, automation antiquated hand-picking, but at least seven pairs of egg tongs have survived the years, and live in our collection. ✦ Randi Sue Smith

Pioneers

By Craig Springer

Barton Warren Evermann

Research.calacademy.org

Barton Warren Evermann posed for this portrait in the early 1900s, about the time he led a U.S. Bureau of Fisheries crew to the Sierra Nevadas to learn more about an unknown trout.

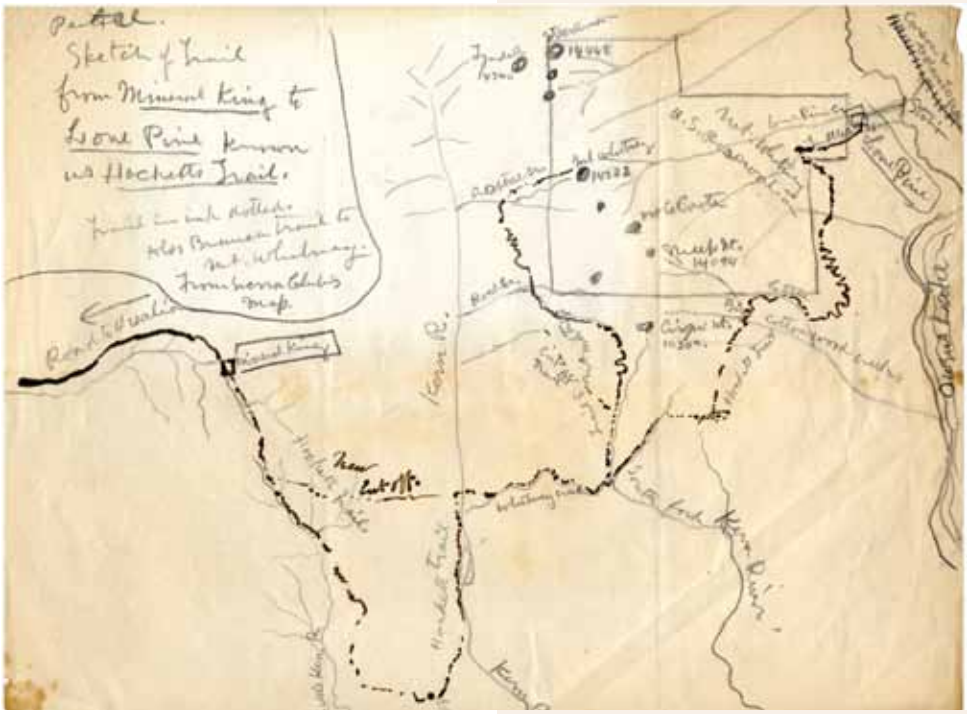
History may not repeat itself, exactly. But it does at least rhyme.

You'll hear a resonance in the mentored relationship Barton Warren Evermann had with his ichthyology professor, David Starr Jordan, a rapport like poet-laureate Robert Frost had with writer Wallace Stegner; Plato to Socrates; Archimedes to Galileo; Obi-Wan Kenobi to Luke Skywalker. The affinity built between Evermann and Jordan yielded a mountain of scientific literature in fisheries conservation well beyond the classroom. Both were full-fledged members of the gilded age of American ichthyology. From it all, Barton Evermann created a greater good, employed by the U.S. Fish and Wildlife Service's ancestral Fisheries Program, starting in 1886.

Barton Evermann was born in Iowa in 1853, and moved at a very young age with his parents to an Indiana farm where he grew up, studied, and married. Despite his world travels and a career that would plant him on the Pacific Coast later in life, Evermann considered Indiana his home. The Evermann farm near Flora, Indiana, is still in the family where Sam, Jane, and son John Evermann Zook still work the land.

Teaching was Evermann's first profession, starting at age 18, and one he practiced intermittently the rest of his life. From 1871 to 1879, he taught in Indiana schools, and then ventured west to California for a two-year teaching stint. He returned to the Hoosier state in 1881, and enrolled at Indiana University to study ichthyology under Jordan. Evermann and Jordan had been acquainted since 1877, when he and his wife took an extended fish-collecting trip with him through Kentucky to Georgia. From 1883 to 1885, Evermann took a break from the university to serve as the superintendent of Carroll County schools. He finished his first degree in 1886, and published one of his first papers, "Fishes observed in the vicinity of Brookville, Franklin County, Indiana" in the *Bulletin of the Brookville Society of Natural History*. A cascade of scientific papers, books and magazine stories on fish, birds and mammals would follow for the next 45 years.

Evermann continued his studies at Indiana University while simultaneously chairing the biology department at Indiana State Normal School, thusly earning a master's and then a doctorate by 1891. The year he earned his Ph.D., and through his connection with Jordan, Evermann the ichthyologist took a job as a research scientist aboard the *Albatross* and steamed to the Bering



Research.calacademy.org

Written in Evermann's hand, this map sketches out the route that he took to find two new species of trout in the Sierra Nevadas in 1904.

Sea. The ship was the world's first vessel built specifically for scientific inquiry, operated by the U.S. Navy for the U.S. Fish Commission, the predecessor of the U.S. Fish and Wildlife Service.

During Evermann's tenure with the Fish Commission (called the Bureau of Fisheries after 1903), he traveled all over the U.S. and the world studying things aquatic. His capabilities as a scientist and administrator led to his rise in the agency. Based in Washington DC, he was the Fish Commission's Ichthyologist from 1891 to 1914. He led the Division of Statistics and Methods of Fisheries in 1902 and 1903. From 1903 to 1910, he was the Chief of Scientific Inquiry, simultaneously serving as Curator of Fish at the U.S. National Museum. From 1910 to 1914, he was the Chief of Alaska Fisheries. All the while, Evermann lectured on fisheries science periodically at Cornell and Yale universities, and somehow found the time to serve as Vice President of the Washington DC, board of education from 1906 to 1910.

During Evermann's tenure with the Fish Commission and the Bureau, he was a prodigious writer, much of what he produced co-written with his former professor. Most any fisheries professional is familiar with "Jordan and Evermann" in the scientific literature. But Evermann also authored scientific papers alone.

"The Golden Trout of the Southern High Sierras," is one such paper, published by the Bureau of Fisheries in 1906. Stuart Edward White's book, *The Mountain* caught President Teddy Roosevelt's attention in 1904, where White penned a concern for a native trout in the Sierras. Roosevelt directed Evermann to investigate.

U.S. Bureau of Fisheries

Barton Evermann named this fish, Roosevelt's trout, in honor of President Theodore Roosevelt following his U.S. Bureau of Fisheries expedition in 1904. Its distinction as a unique species was later revised by other scientists.

In a fashion very much like the capabilities of the current Fisheries Program's 67 Fish and Wildlife Conservation Offices around the country today, Evermann mounted an expedition to learn more about these presumed rare trout. On horseback, Evermann led a Bureau of Fisheries team to the high country to learn more.

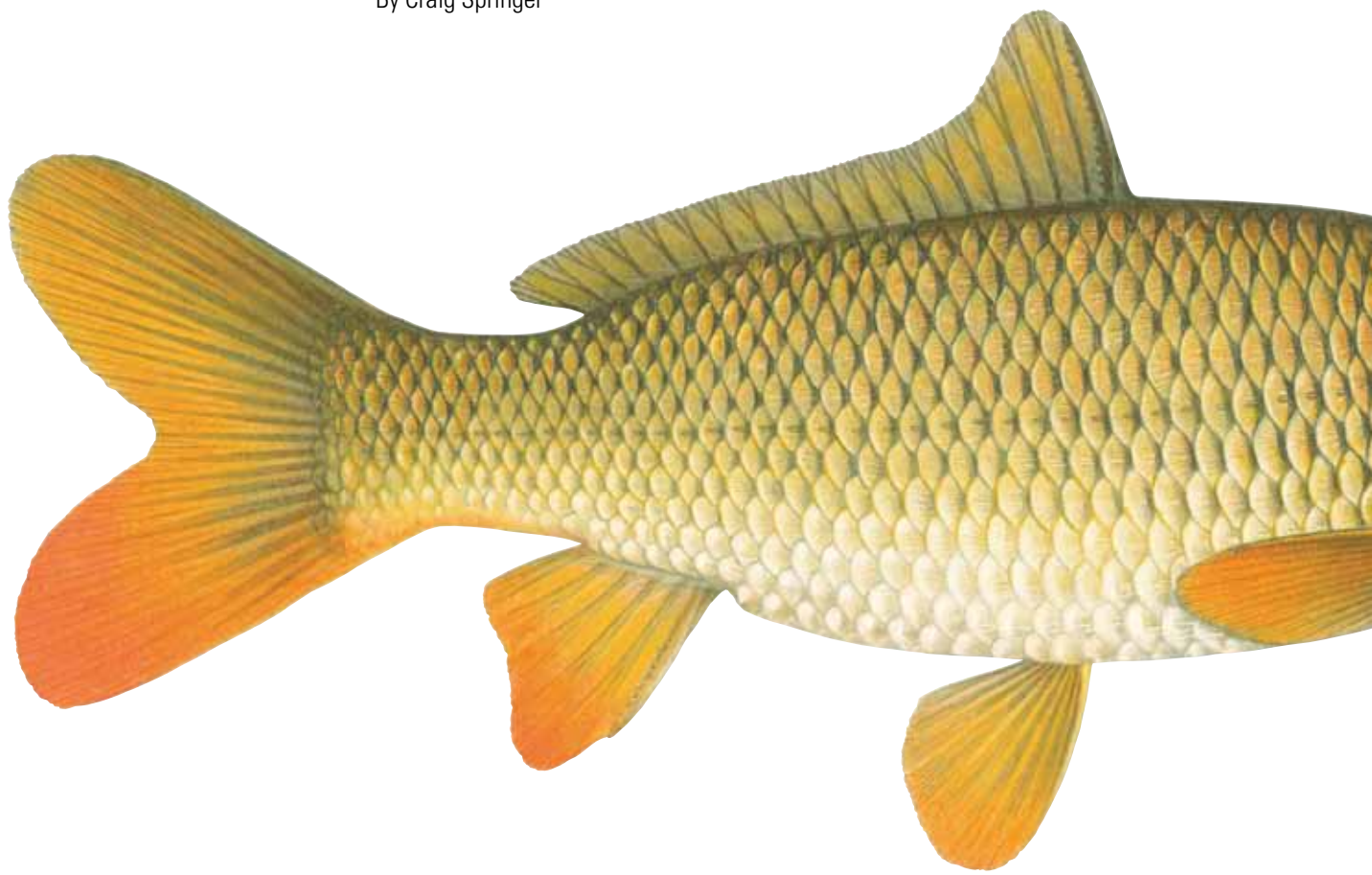
What culminated were two new species of fish: Roosevelt's trout and White's trout. Evermann determined that California's Kern River contained two rare fishes, which he named *Salmo roosevelti* and *S. whitei*, to honor the president and the citizen-conservationist. Evermann's "Golden Trout" paper laid out potential conservation measures for the fish. Other scientists have since revised the species designations, but Evermann's descriptions remain a testament to his capabilities in the field and at a desk.

Evermann left the Bureau of Fisheries in 1914 to direct the California Academy of Science, where he continued to research and publish on fisheries, with and without Jordan. He held that job until his death in 1932, and his remains were interred near his old Indiana farm. All told, he published nearly 400 scientific papers, mostly related to fishes, and many being descriptions of new species.

The Evermann name lives on in organisms named by others in his honor: four fish genera include *Evermanni, Evermanella, Evermanolus,* and *Evermannichthys.* Perhaps the most significant namesake is found on maps, the highest point in the Archipelagos—Mt. Evermann—to go along with the mountain of scientific research that spanned a career. ✦

Common carp

By Craig Springer



Common carp were introduced into the United States in the 19th century, and have become common throughout the country. They live 38 years and grow to nearly 90 pounds.

If the common carp was a vegetable, it would be the Brussels sprout. The dark green plant has been domestically cultivated since the days of ancient Rome. The small ball of leaves appeared in early writings, and took its common name for its popularity on the table in Belgium. There is no discernable reason to eat the vegetable that smells of sulfur, yet the cabbage cultivar made its way to America in the 1800s with French settlers landing in Louisiana.

You either like Brussels sprouts, or you don't. And so it is with the common carp. It is seen as the greatest fish transplant attempt ever taken on, or the worst of government-sponsored ecological disasters. The fish is either a nuisance, or great sport on the end of a line. If you're an angler, you've probably caught one. These things are certain: it's a naturalized American fish, and the common carp is just that—common.

The Swedish medical doctor, Carl Linnaeus, who named you *Homo sapiens*, also penned the scientific name of the common carp. In his 1758 edition of *Systema Naturae* he called it *Cyprinus carpio* to fall in with other members of the minnow family, the *Cyprinidae*. The nomenclature comes from the birthplace of Aphrodite, or Cypris, the goddess of love and beauty, the Island of Cyprus. The common carp is one of hundreds of minnow species worldwide, and among the largest-growing of them all. And it is certainly the most widely distributed of minnows, if not all freshwater fish species, owing to its natural attributes and the works of people. When Linnaeus set a name to the common carp, it had already been transplanted to Europe for food.

The common carp appears in writing in China circa 500 BCE. Fast forward a thousand years to the Common Era and common carp show up in writing in a circular to government officials in the Ostrogothic Kingdom, circa the year 500. Cassidorus, the secretary to King Theodoric of Ostrogoth, ordered high governing officials over present-day southern Europe to advance the supply of common carp for the king's table.

Joe Tomelleri

The big minnow had been domesticated by the time the fish arrived in the U.S. The common carp was probably established in the Hudson River basin by 1850. But the decade of the 1880s has been fixed as the most successful effort, one that tipped the scale in favor of the invasive minnow taking hold in American waters. With Spencer Baird leading the U.S. Fish Commission, common carp flourished. Baird knew that the fish was a delicacy in Germany. He reasoned that the fish would be happily received in the U.S. given that it had been cultivated in the Old World for a good long time. Baird believed that common carp could feed the people—that the fish could be grown for much less cost than bovine or fowl on lands more suited to water than grains.

According to U.S. Fish and Wildlife Service historian Dr. Mark Madison, Baird was not only a consummate scientist, but also an astute politician (see *Eddies* Special Issue 2009). Baird cultured common carp in the capital city, in ponds at the base of the Washington Monument. He made fingerlings available to Congressmen to send to their constituents back home. Railroads veined over the landscape and sent common carp overland in Fish Commission railcars.

The fish may have been suitable for the king's table in a far-off land, at a time far removed from 19th century America. But the populace in this republic resisted. Even recipes published by the Fish Commission couldn't sway sentiment. Common carp never gained favor.

Throughout the country now, common carp swim just about anywhere there is water, be it flowing or flat, clear or polluted, a farm creek in the Midwest, or a reservoir in the South. They live in every state in the continental U.S., that ubiquity due not only to the desires of Baird and the conformity of the early state fish commissions, but to the fish itself.

Warm and muddy waters are what common carp like. If they invade clear water, they will soon turn it off-color. They make a living by rooting and wallowing in the bottoms looking for food, aided by the barbels in the corners of their mouth. And they eat anything, living or dead. What they don't eat gets coated in mud, which makes the fish a nuisance. Fish eggs suffocate in silt and important aquatic insect habitats are ruined. Native fishes that live by sight, like the top predators, can't see so well in the muddied water.

The common carp gains a competitive edge in that a mature female produces about two million eggs. They are spring spawners. Usually by May in the South both sexes gather in the shallows of streams or lakes where they roil en masse in weedy bays or the big river backwaters. Pods of a few males fertilize eggs of one or two females at a time. Their fertilized eggs stick to vegetation and hatch in a week, and the young set about eating microscopic plants and animals. Their diet soon turns to plants and roots, mollusks and bugs, small fish, eggs, and carrion, and they muddy the waters as they go along. Granted, not every egg is fertilized and not every fertile egg grows into a mature fish. But this much is true, young common carp are fast-growing and can out-compete young native minnow and sunfish species for food and space.

Something else to chew on: what would the American palate be without Brussels sprouts? Well, there are those who see no reason to have the vegetable on the plate. What it lacks in taste, though, it makes up for in nutrients. American waters would be vastly different had the swimming nuisance not become so common. But a fish that grows to 90 pounds, lives 38 years, and is surprisingly wary has its adherents of ardent anglers who take the fish by bow, fly, gear, or spear.

In the end, the success of the common carp in American waters is a testament of what not to do. Don't spread fish around. Arguably, though, the common carp has become an American fish. ✦

By Susan Jewell

Invasive Species in Our Waters

The U.S. Fish and Wildlife Service is uniquely authorized to manage unwanted aquatic organisms

Bugwood.org

Purple loosestrife goes by another name, "the purple plague." This invasive plant turns wetlands and shallow fish-nursery waters into dense mats of plant matter.

"It's a tiny little program with incredible people that is trying to stave off a colossal problem." That's how Dr. Stuart Leon describes the U.S. Fish and Wildlife Service's Aquatic Invasive Species (AIS) Program. Leon oversees AIS issues in the Fisheries Program as its Chief of the Division of Fisheries and Aquatic Resources. With an estimated 50,000 or more non-indigenous terrestrial and aquatic species that have invaded the U.S., at a cost of more than $120 billion a year in ecological damages and control costs, it's easy to see that the 23 full-time employees nationwide have a demanding workload.

Invasive species are a growing problem, threatening the very core of our national fisheries resources. Most of them arrive from other continents without the diseases or predators that would keep their populations in check naturally. Plants and animals have been carried across the seas to North America by people for at least five centuries, but only a few became pests early on. Not until the last century—the era of intensified globalization by machine-powered craft—did multitudes more species and pathogens land on our soils and in our waters. Because water provides such a perfect pathway for pernicious pests, our continent is both blessed and cursed. We are blessed with abundant waterways, and therefore cursed with abundant pathways and opportunities for disaster.

Even terrestrial invaders can harm aquatic resources by altering surrounding watersheds, but aquatic invaders often fester unnoticed in underwater realms until they are too established to be eradicated. These

invaders have taken a grave toll on our fisheries resources. Because the Fisheries Program restores and maintains aquatic resources, it is entwined with the problems created by invasive species.

The journey to quash the invaders got an early start. In 1900, Congressman John Lacey recognized the potential crises caused by the "unwise introduction of foreign birds and animals" and spearheaded the passage of the Lacey Act. The Act authorizes the U.S. Fish and Wildlife Service to list invasive vertebrates, mollusks, and crustaceans as injurious wildlife if they are deemed to be "injurious or potentially injurious to the health and welfare of human beings, to the interests of forestry, agriculture, and horticulture, and to the welfare and survival of the wildlife and wildlife resources of the United States." Once a species is listed, its importation and interstate transport is prohibited. The Lacey Act was visionary for its time by allowing the listing of species that had not yet become established—certainly the most effective way to fend off invasive catastrophes. Fruit bats, mongooses, and some birds were listed as injurious in 1900. Injurious aquatic species today include the walking catfish, Chinese mitten crab, snakehead, and three species of Asian carp. The U.S. Fish and Wildlife Service is currently ramping up its use of the Lacey Act as one tool of an integrated plan to prevent the establishment of invasive species.

One of the early aquatic invaders to explode onto the "most unwanted" scene was the sea lamprey, a parasitic fish of the Atlantic Ocean that got a free pass through the Great Lakes in 1829 after the Welland Canal was dug to bypass Niagara Falls. The U.S. Fish and Wildlife Service cut its proverbial teeth by addressing sea lamprey impacts on lake trout in the 1950s under the auspices of the Great Lakes Fishery Commission.

The zebra mussel, which hitchhiked to North America in ballast water on ships from Europe and was discovered in the Great Lakes in 1988, elevated the issue of invasive species to a national level. The diminutive bivalves clog water intake pipes and filter essential nutrients away from native organisms. The phenomenal damage caused by the sheer numbers of zebra mussels led to the passage of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). NANPCA provided a way for government agencies to develop a national program to reduce the risk of unintentional introductions, ensure prompt detection and response, and control established species. NANCPA was subsequently reauthorized and amended in 1996 by the National Invasive Species Act. Congress had added the zebra mussel to the list of injurious wildlife in 1991.

NANCPA established a task force that has grown to 13 federal members and 12 ex-officio members to coordinate governmental efforts with those of the private sector and other North American interests. This Aquatic Nuisance Species Task Force (ANSTF) is co-chaired by the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration. The ANSTF established regional panels that include representatives from states, Indian tribes, non-governmental organizations, commercial interests, and neighboring countries to address invasive species.

Mike Goehle/USFWS

U.S. Fish and Wildlife Service biologists try to thin out mats of invasive water chestnut in New York.

Rolling back the carpet

Before June: six acres of open water in a New York county park. After June: a carpet of water chestnut that grinds all boating, fishing, and recreational use to a halt for the rest of the summer. Isolated rosettes of plants are beginning to pop up several miles outside the park, likely due to hitchhikers on boats, drift of seeds in the current, and perhaps attachment to waterfowl. Biologists are checking for stragglers outside the park and getting a mechanical harvester to eradicate this year's crop. It will be a multi-year response to eradicate this population, as well as the single rosettes we're finding, but our most important goal is to prevent establishment in the Niagara River, Lake Erie, and Lake Ontario. **Mike Goehle, Northeast Region AIS Coordinator**

Mike Goehle/USFWS

No boats can navigate this thick mat of water chestnut in New York.

Many parts of the Fisheries Program play a role to directly or indirectly reduce the threat of invasive species to maintain or restore aquatic ecosystems. Some examples are:

- The National Fish Hatchery System produces native species whose populations were threatened with extinction and others depleted by invasive species. Hatchery staff research techniques to prevent the spread of invasive species when transporting and releasing hatchery-reared species.
- The National Fish Habitat Action Plan, modeled after the North American Waterfowl Management Plan, was adopted by state and federal agencies in 2006 to protect, restore, and enhance priority habitats. Says Tom Busiahn, the Service's coordinator, "Declines of our freshwater fishery resources are largely due to habitat loss and invasive species. But many invasive species also alter habitat, so the effects of these problems are interrelated. The Fisheries Program brings an integrated conservation 'toolbox' to meet the challenges they pose to our aquatic ecosystems."
- The Fish Technology Centers, Fish Health Centers, and Aquatic Animal Drug Approval Partnership provide national scientific and technical leadership to solve fishery and hatchery management problems, including how to deal with invasive species.
- The Injurious Wildlife Program endeavors to prevent the spread of extremely damaging invasive wildlife species by listing them as injurious under the Lacey Act.
- The National Fish Passage Program provides grants and technical assistance to agencies, tribes, and communities to remove barriers to fish passage.

Other coordination efforts exist. The National Invasive Species Council, developed under Executive Order 13112 in 1999, called for a national plan to coordinate federal agency efforts. The Fisheries Program's ANSTF Executive Secretary represents the Service on this council. The ANSTF is the only entity that has statutory standing and is operationally linked to on-the-ground conservation.

How aquatic invaders get a root- or shell-hold in a new land is of paramount importance. The single most significant pathway for invasive species has been in ballast water of large ocean-going ships. However, since these introductions have crept inland from the coasts, finding ways to relate this issue nationally to the public is critical. When zebra mussels subtly spread from the Great Lakes by way of boating and fishing equipment, boaters and anglers became the primary focus of the ANSTF's national public awareness campaign. While this campaign gained traction, a representative of the pet and aquarium industry approached the U.S. Fish and Wildlife Service to develop a similar campaign to curb the release of unwanted aquarium pets and plants into the wild.

Today, both of these campaigns serve as the public face of the ANSTF. Known respectively as *Stop Aquatic Hitchhikers!*®™ and *Habitattitude*™, they are coordinated nationally by the Fisheries Program (see back cover). *Stop Aquatic Hitchhikers!* encourages people to become part of the solution by decontaminating their boats, trailers, and other aquatic gear after leaving a waterway. *Habitattitude* educates pet owners and ornamental pond owners not to release plants, ornamental fish, snails, and other aquatic animals into natural waters by providing alternatives to this environmentally damaging action. Northern snakehead, nonnative catfish, water hyacinth, and hydrilla are examples of aquarium and ornamental pond animals and plants that have drastically reduced the ability of freshwater bodies to sustain native fisheries. A dense carpet of aquatic invasive plants can force a motorboat to a standstill. The campaigns work at the community level and encourage the caring public to be responsible. These campaigns are a springboard for conservation at the local level that have the potential to create jobs and galvanize citizen support to protect our aquatic resources.

The Fisheries Program supports one Aquatic Invasive Species Coordinator in each of its eight administrative regions across the country. That title might conjure up an image of someone trying to train a team of quagga mussels, but these coordinators play a critical role in connecting information and resources with management needs. They both

Exercising those mussels

Fire drills, earthquake drills . . . mussel drills? The Pacific Northwest, home of iconic salmon and steelhead runs, is one of the few remaining places in the U.S. not yet invaded by the insidious zebra and quagga mussels. The U.S. Fish and Wildlife Service and its partners work hard to keep it that way. Though prevention is the priority, they coordinate drills via the Columbia River Basin rapid response plan as a second line of defense. To test and improve the plan, regular response drills work through "what if" scenarios. This translates to a more effective response if a real introduction occurs. A recent exercise in Idaho's Lucky Peak Reservoir trained local law enforcement dive teams in underwater mussel surveys. A drill planned for the fall of 2010 will focus on coordinating a Canada-U.S. response within boundary waters. **Paul Heimowitz, Pacific Region AIS Coordinator**

support and receive support from field biologists and spend much of their time collaborating with private and public partners. On any given day, they may develop budget proposals and review grant project reports, lead a training course, meet with state agencies to develop a monitoring plan, or give a presentation to a youth group. Engaged in prevention, early detection, rapid response, and long-term control projects at local and national scales, the aquatic invasive species biologists wear nearly as many hats as the plethora of invasive species they target.

Much of the invasive species field work is accomplished through coordination with the U.S. Fish and Wildlife Service's 67 Fish and Wildlife Conservation Offices around the country that work with the states agencies and other partners. Their efforts include implementing an integrated pest management approach for sea lamprey control in the Great Lakes and Lake Champlain, tracking snakehead movements in the Potomac River, eradicating water chestnut from the New York State Canal System, managing Chinese mitten crab along the California coast, and serving on the frontline of our fight against many of the highest profile invasive species.

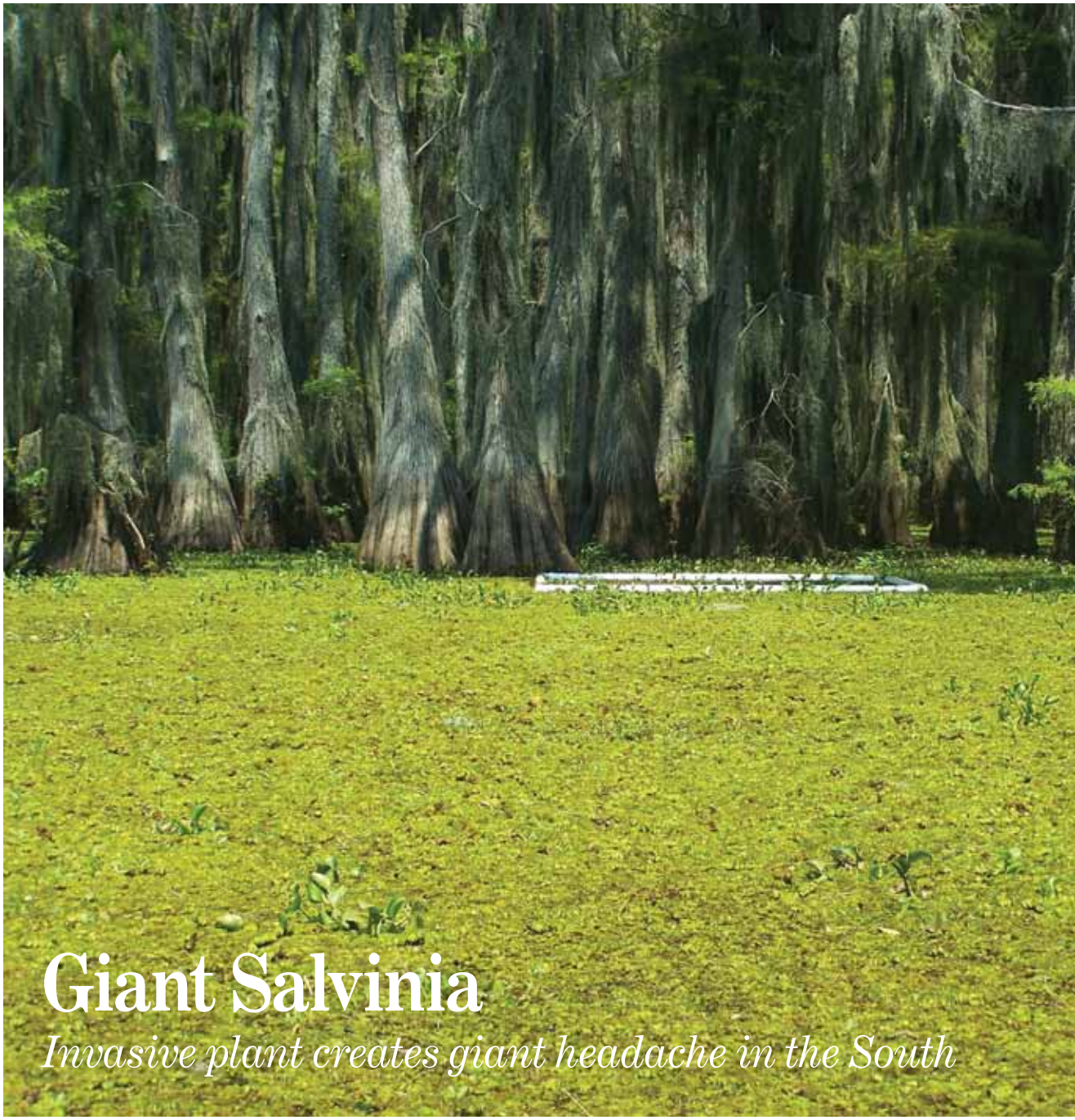
Certainly, invasive species are not the only threat to aquatic ecosystems. But if we could magically end all other threats except for invasive species, we would still ultimately lose the race to save our corner of the planet. The "tiny little program" is swimming against the tide, but it is pooling its talents in a big way. ✦

Susan Jewell is an Injurious Wildlife Listing Coordinator for the U.S. Fish and Wildlife Service, stationed in Arlington, Virginia.

Bugwood.org

Thick mats of hydrilla cover shallow waters, choking fish habitat.

By Bob Pitman



Giant Salvinia

Invasive plant creates giant headache in the South

It is not a field. This east-Texas bayou is covered with the invasive giant salvinia.

Its scientific name couldn't be more appropriate: *Salvinia molesta*. This floating plant has a predilection for being a problem. It's often called "the world's worst aquatic weed" for good reasons. In common terms, it's known as giant salvinia.

Giant salvinia isn't a towering plant, but it grows voluminous. Unchecked, it rages out of control spreading over water surfaces, doubling the area it can cover in as little as five days. It is an invasive floating fern native only to Brazil. It has become a giant problem in Texas and Louisiana where it was unintentionally introduced. The plant threatens all southern-tier states where warmer conditions suit the plant. In the last 70 years it has been

Texas Parks and Wildlife Department

spread by people to Australia, New Zealand, Africa, India, and Papua New Guinea.

You may have seen it by its market name, "koi kandy," where it has been popularly sold to aquarium owners for several decades. The aquarium or aqua-garden trade is probably how the plant made its way into the open waters of Texas in 1998.

Once established in open water, boat movement most likely spread plant fragments to several east-Texas lakes including Toledo Bend, Caddo, Conroe, and Sam Rayburn, as well as to several Louisiana lakes. Anglers and boaters lost open water and fishing opportunities, and related businesses lost some livelihood. Ducks lost habitat, and lake-front property dropped in value.

Here is something else to consider. Giant salvinia is a big financial burden for state fish and game agencies, as they are forced to deal with yet another stressor on natural resources management. Recently, Louisiana managers began partially draining popular Lake Bistineau to improve giant salvinia control. The drawdown may last throughout 2011.

A single plant of giant salvinia consists of a horizontal stem floating just below the surface with two thumb-sized emergent green leaves covered with short hairs that are joined at the tips, resembling an eggbeater. A modified third leaf is brown, highly divided and dangles below the water surface resembling roots. Leaf pairs are produced at each node growing ropes of giant salvinia. The prolific plant reproduces by fragmenting. Pieces grow into entirely new plants. Individual plants or floating fragments are readily dispersed by wind, water currents, or people. The plant easily invades new locations. Giant salvinia is native to Brazil's temperate waters and can survive some winter freezing but will not persist where surface ice forms. With optimum conditions of temperature, sunlight and nutrients, the plant grows at an astonishing rate. A single plant has been known to cover forty square miles of water in three months.

Unchecked, it rages out of control spreading over water surfaces, doubling the area it can cover in as little as five days.

…A single plant has been known to cover forty square miles of water in three months.

Aquarium owners and aqua-gardeners desire giant salvinia because it is persistent, hard to kill, easily shipped with minimal expense and guaranteed to arrive alive to customers. Unfortunately, these are also classic qualities inherent to invasive species. Giant salvinia is a notorious hitchhiker. Suppliers often unintentionally send it, if only fragments, in shipments of other requested aquatic plants.

Australian researcher Dr. David Mitchell scientifically described *Salvinia molesta* in the early 1970s. He appropriately named the species "*molesta*" to emphasize what he had seen this plant do to waters in Australia, Africa and Papua New Guinea. The U.S. Department of Agriculture responded to his warning and listed *Salvinia molesta* as a Noxious Weed to prevent its purposeful importation. However, the loose net of federal and state regulations and authorities used to block invasive species distributions and movements were not sufficient to prevent the inevitable release of giant salvinia. It is now, and probably forever, a permanent challenge to conservation in the southern U.S.

Giant salvinia is a serious invasive species, but it does have some weakness.

Present controls involve spray crews regularly treating giant salvinia mats with herbicides to temporarily reduce coverage. Only in rare circumstances do herbicides provide long-term relief. Mechanical controls are also very costly and temporary. Giant salvinia control may ultimately be achieved by the herbivorous salvinia weevil. The weevil and the plant naturally co-exist in nature in Brazil, the weevil so named since it eats the plant. The weevil has successfully controlled giant salvinia around the world.

Scientists have researched, reared, and released the control weevil in Texas and Louisiana for a decade, but with limited success so far. Giant salvinia spreads quicker than the weevil can eat, or the bug can reproduce. Winter weather sets the weevil back, more than it does giant salvinia. A control strategy it seems, will include weevils, herbicides and mechanical removal.

Giant salvinia is only one among a list of other aquatic invasive plants. One thing they almost all have in common is that invasions of these plants cost much money to control—not eradicate, but control. Federal

Texas Parks and Wildlife Department

The salvinia weevil shows promise in controlling giant salvinia, especially when combined with mechanical and chemical controls.

Texas Parks and Wildlife Department

Cypress trees, up to their knees in giant salvinia, is a sign that fish and waterfowl habitats are compromised. Restoring habitat will be no easy or inexpensive task.

and state agencies, universities and stakeholder groups are increasingly working together to control the plant.

Hydrilla and Eurasian water milfoil are two such examples. Both are native to Asia and Europe. Hydrilla forms extremely dense colonies growing from bottom to surface in water up to 20 feet deep. Water milfoil forms dense colonies from the bottom to the surface, the colonies making boating and angling impossible. Hydrilla has its "Typhoid Mary," tracing its origin in the U.S. to one aquarium dumped in a Florida canal by one person. This irreversible action will have ecological and economic costs that will never go away.

Prevention is cheaper than the cure, to paraphrase the old adage. Just ask home owners near Lakes Bistineau, Caddo, or Conroe, who deal with giant salvinia year after year. Anyone who uses water for work or play should understand the consequences of their actions. Responsible users help protect our water and that which lives in it, on it, or near it. ✦

Bob Pitman retired as a fishery biologist from the U.S. Fish and Wildlife Service in 2010. Pitman exemplified a commitment to conservation, working on invasive species issues for over a decade. He's headed to Montana, where he went to college years ago and minored in fisheries science and majored in flyfishing.

By Jeffry Anderson

Kenai's Most Unwanted

Adrian Baer/ADFG

Samantha Oslund, a biologist with the Alaska Department of Fish and Game, caught this northern pike in Alexander Lake, near Anchorage, where the species was introduced in the 1950s.

Northern pike are revered as the ultimate trophy fish. But where they have been illegally introduced in parts of Alaska, they are reviled for the serious problems they cause for native fishes. Northern pike are native to Alaska, north and west of the Alaska Range where they are an important sport and subsistence fish. They are not native to southcentral Alaska's Kenai Peninsula—and are very much unwanted.

This toothy predator co-evolved with salmon and trout in much of its native range. But several lakes on the Kenai that supported rainbow trout, Dolly Varden, and migratory Pacific salmon, are now dominated by northern pike—the unintended consequence of illegal stocking. It's particularly bad in habitats needed by juvenile trout and salmon—shallow, weedy, slow-moving waters—which happen to be prime northern pike habitat, too.

The Kenai River is a world-class fishery. It's the primary destination for many visitors to Alaska who hope to catch record-sized Chinook salmon and trout. Illegal northern pike introductions on the Kenai Peninsula threaten multi-million dollar sport and commercial fisheries, as well as important subsistence fisheries. These invasive northern pike were illegally introduced into a lake on the Kenai Peninsula in the 1970s, and have since spread to 16 more lakes and two tributaries of the Kenai River.

Northern pike catches on the Kenai Peninsula have increased dramatically in recent years, from only 36 in 1994 to over 2,000 in 2004, according to the Alaska Department of Fish and Game (ADFG) harvest surveys. The ADFG continues to receive reports of sport-caught northern pike, even from the Kenai River. Although the swift-flowing Kenai River provides little northern pike habitat, several tributary streams do. These tributary streams and their associated lake systems also hold important habitat for juvenile salmon and trout, and northern pike threaten those native fisheries.

As is the case with virtually all aquatic invasive species, no easy fix exists once a northern pike population becomes established. However, the ADFG management plan for invasive northern pike outlines ways to control their spread on the Kenai Peninsula.

Rotenone, a natural plant substance that is short-lived in the environment, kills fish by clogging their gills and is one tool used to control northern pike in lakes. But rotenone is controversial, and is used only in landlocked lakes that have been entirely taken over by northern pike.

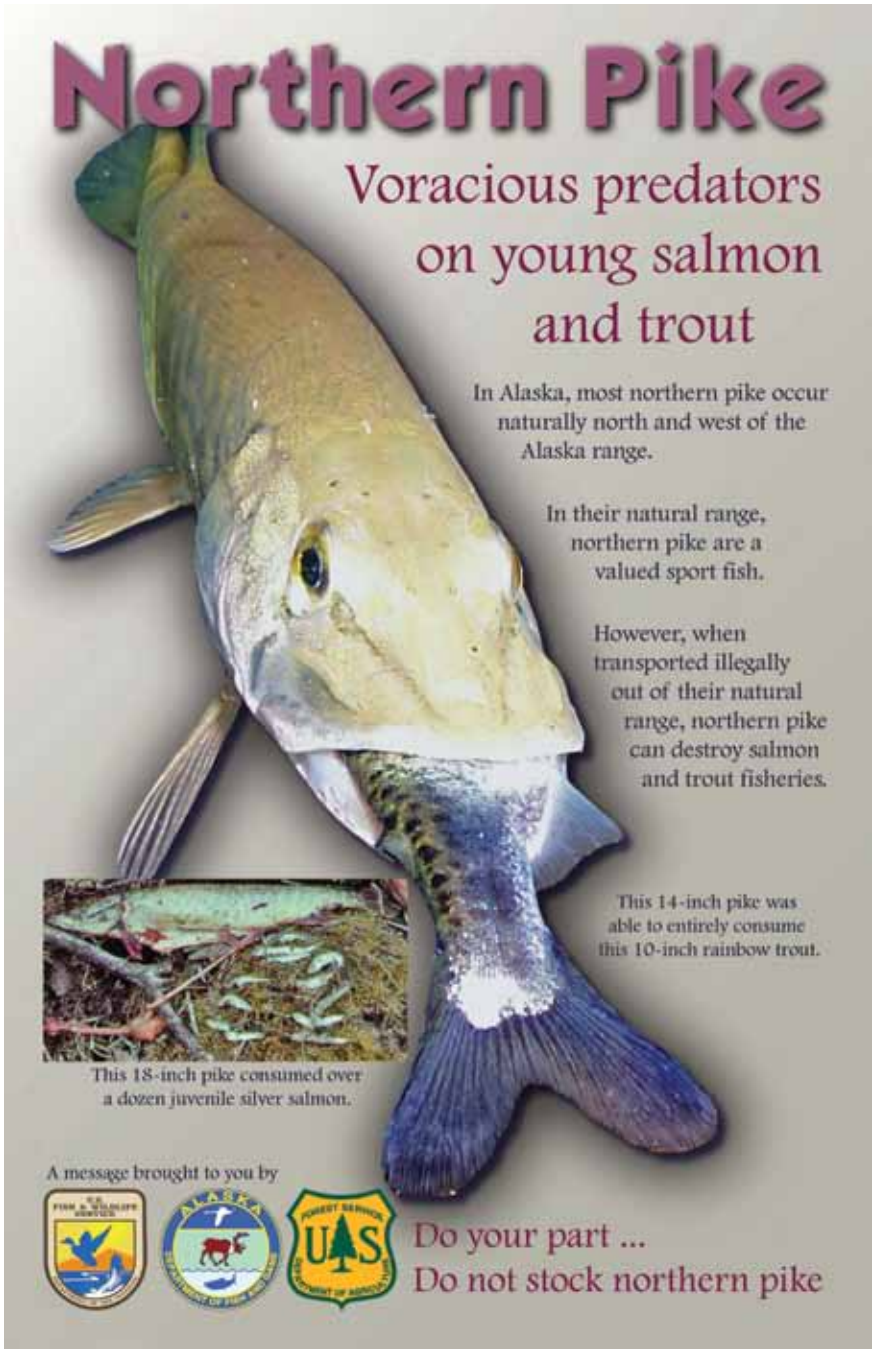
ADFG biologists use netting and control barriers on several lakes. Intensive netting reduces pike numbers over the short term, but catching all of the pike in a water body is nearly impossible.

Water control structures on lake outlets can prohibit pike movements from lakes into connecting streams, but the structures can also inhibit migrations of native fishes. Control barriers are also expensive and can fail during high water flows, not to mention become impractical when lakes are covered with ice.

Controlling pike populations or movements in rivers and streams is an even more daunting challenge. So far, research has not found a single management tool that can rid streams of northern pike.

However, the U.S. Fish and Wildlife Service's Kenai Fish and Wildlife Field Office operates an underwater video system at a weir in the Soldotna Creek watershed, where northern pike were first introduced on the Kenai Peninsula. Underwater video captured two northern pike swimming through the weir since April 2009, about 50 yards upstream from Soldotna Creek's juncture with the Kenai River. Underwater video has become a valuable outreach platform. It's used to help spread the word in the community and with visiting anglers about the dangers of invasive pike on the peninsula, and the threat that they pose to popular Kenai River sport fisheries.

Since controlling invasive northern pike is both difficult and expensive, the ADFG and the Kenai Fish and Wildlife Field Office use public education through newspaper articles, posters, brochures, and public meetings. The ADFG website features a wealth of information, including an informative video clip that shows pike preying upon rainbow trout.



USFWS

Unwanted: Northern pike on the Kenai Peninsula. Northern pike eat fish, and readily ingest young trout and salmon.

Illegal pike introductions on the Kenai were probably done by people who wanted to fish for pike but were ignorant of the consequences of their actions. Biologists hope that an educated public—one that knows that introducing pike is both illegal and detrimental to native fishes—will stave the spread of northern pike on the Kenai Peninsula. What's revered elsewhere is reviled on the Kenai for good reasons. ✦

Jeffry Anderson is a fishery biologist at the Kenai Fish and Wildlife Field Office in Soldotna, Alaska.

By John Bryan

"Rock Snot" Poses Problems for Fisheries Conservation

Mark S. Hoddle/Center of Invasive Species Research UCR

This wet wooly mass is a mat of single-celled diatomaceous algae, called didymo. It fouls fishing, and may create problems for fish habitat.

It's spring 2006 as Dan Genest wades knee-deep into Virginia's Smith River clarity. His 5-weight rod throws a blue-winged olive with a pheasant tail dropper.

"Dirty, wet toilet paper," is how Genest, former president of Fly Fishers of Virginia, now describes what he saw. "It was carpeting the river."

It was *Didymospenia geminate*, aka didymo, aka rock snot—a freshwater diatom, an algae—that can thrive in coldwater shallows. It suddenly began to appear in the middle of the last decade.

In the fall of 2007, Bill Fletcher of the Lamar Fish Technology Center, received word that didymo was in Vermont's White River—next to the White River National Fish Hatchery. This was its first appearance in the Northeast, recalls Fletcher.

Historically uncommon, the single-cell alga now known as didymo recently began blossoming as an apparent invasive species. Its 2004 appearance in New Zealand spawned global attention and communication. There are currently no methods for eradication.

Genest sees trout rising, but his dry fly stops its drift as the dropper snags on the carpet of toilet paper. It easily pulls loose, but Genest has to clean it. After a dozen cast-and-cleans he removes the dropper, and then quickly catches a wild brown on the dry fly.

A one-cell organism, didymo can be present even if it can't be seen—and thus it's currently impossible to know whether new blooms are the result of transferral or of newly ripe conditions. "There's a bit of a smoking gun in that it's showing up at popular international fishing locations," says Dr. Leslie Matthews of the Vermont Agency of Natural Resources.

An angler can wade in a U.S. stream and 17 hours later be wading in one in New Zealand. Didymo can survive two days when dry, and a month when damp.

The carpeting blocks Genest's view of the river bottom as his feet search for rocks and holes. "It would wrap around my feet and I couldn't see rocks," he remembers. "You could hit a big rock and lose your balance." *But the wild browns keep hitting on top.*

Mark S. Hoddle/Center of Invasive Species Research UCR

Called "rock snot" in the vernacular, didymo has the appearance of wet toilet tissue.

The U.S. Fish and Wildlife Service began identifying probable vectors for spread, determining methods for stopping those pathways, and initiating education efforts. "By the time I showed up on the White River there were little yellow warning signs everywhere," says Fletcher. A brainstorming session among New Zealand's communications team produced the term "rock snot." The term made its first public appearance in a quotation that the team attributed to Dr. Christina Vieglais, a frontline leader in New Zealand's scientific response to didymo. "I don't like the word and didn't want to use it," recalls Vieglais, now a biotechnologist

Mark S. Hoddle/Center of Invasive Species Research UCR

The icky algae, didymo, can cover a stream bottom in light layers or in thick masses.

Mark S. Hoddle/Center of Invasive Species Research UCR

Not particularly pleasing to look at, what the full impact the invasive algae may have on fisheries remains to be seen.

with the USDA's Environmental Risk Analysis Programs. "It was misleading." But the term grabbed attention and informed New Zealanders.

Genest pulls a clump of didymo from his boots. It looks slimy but it feels like wet wool. His apprehension about touching it vanishes when it doesn't sting or abrade or prick.

U.S. Fish and Wildlife Service officials identified anglers and boaters as probable transfer agents for the spread of didymo. And they learned that didymo needs moisture to survive. "The general message is CHECK, CLEAN, AND DRY," says Michael Goehle, an Aquatic Invasive Species Coordinator for the U.S. Fish and Wildlife Service in New York. "Remove foreign material from boats, trailers, and equipment." Additional guidance includes washing all equipment—especially felt-soled waders—in a cleaning solution such as two-percent bleach.

Genest's day job is spokesperson for Dominion—a large energy company that puts a priority focus on the environment. "Dominion has looked at its hydropower waterways and has not found didymo," Genest reports. This includes Black Creek—a catch-and-release delayed-harvest stream that runs through Dominion property associated with the Bath County Pump Storage Facility in Virginia.

Didymo could potentially interfere with the water intake systems of Dominion and other organizations, resulting in costly repairs and redesign. Intake problems can also be fatal—such as fouling a jet boat while negotiating hazardous rapids.

Didymo near the White River National Fish Hatchery that raises Atlantic salmon caused the hatchery to have to spend the money to switch from river water to well water. "We distribute salmon fry throughout the Connecticut River basin," says hatchery manager Ken Gillette, "and we don't want to risk seeding didymo."

Genest catches his seventh wild brown—all of them healthy with no signs of ill effects from didymo. Later he will encounter didymo in Tennessee's South Holston River and in Virginia's Jackson River—both with seemingly healthy fish populations.

CHECK, CLEAN, AND DRY," … "Remove foreign material from boats, trailers, and equipment."

In spite of widely held presumptions that didymo "smothers" invertebrate populations and therefore harms fisheries, research has proven the opposite. "That's what the prediction was," says Vieglais, "but our results proved otherwise and the fact that there has been no collapse of the New Zealand trout fishery since didymo arrived bears that out."

An active angler, writer, and environmental volunteer, Genest admits, "It's hard for most anglers to remember to clean their boots , and I've been guilty. It's human nature not to want to spread didymo, but it takes a real conscientious effort."

"I try to deemphasize the idea of knowing whether didymo is present, but promote spread-prevention, period," says Matthews.

Didymo's primary detrimental impacts are focused on two areas: recreation and water intake. Both mean money. New Zealand estimated a potential impact of $57 to $285 million over 8 years. When there is a flushing flow, didymo dislodges and can create a waterway that appears to be full of sewage, uninviting to recreational users, and quite difficult for anglers.

The U.S. Fish and Wildlife Service's focus on education is working, and one evidence is the widespread support for procedures to ban felt-soled waders. "It shows that we've come a long way with our messages to politicians and those who make decisions," says Goehle.

"Let's minimize potential spread until we know more," says Matthews. "It may turn out not to be as much of an ecological problem as we fear—or maybe it will become a huge problem that one day we'll be able to address."

"Easily 100 different trout waters in 10 states," is Genest's angling experience. Education surrounding didymo is convincing him and other recreational users that CHECK, CLEAN, and DRY is—no matter how inconvenient—"just something we do." ✦

John Bryan wrote "Cruising for Atlantic Sturgeon" in *Eddies,* Spring 2010. He lives in Richmond, Virginia.

Mark S. Hoddle/Center of Invasive Species Research UCR

A didymo-covered cobble is also habitat for aquatic insects. Insects are essential food for fishes.

By David Britton, Ph.D.

Conservation in a Quagga-mire

Dealing with zebra and quagga mussel invasions

David Britton/USFWS

This zebra mussel cluster was pulled from Lake Oologah, Oklahoma. The tiny but invasive mussel has steadily spread from the Great Lakes.

An Ecological Cancer

Zebra and quagga mussels are notorious. They invade our waters like an ecological cancer. Incipient populations of zebra and quagga mussels exhibit rapid, uncontrolled growth and tend to invade new, otherwise healthy areas. They permanently damage or destroy these systems. What's worse, zebra and quagga mussels are spread by contact. They are chronically debilitating, with the power to cause permanent, irreparable damage.

Individual zebra and quagga mussels do not appear formidable. They are only about an inch or less long, with alternating dark and light stripes. In large numbers, however, they are unstoppable. When healthy, they attach to hard surfaces and live in dense clusters where they glue themselves to each other and other hard surfaces using sticky threads. In this way they form enormous populations that can cover all hard surfaces. Densities exceed 100,000 mussels per square meter. They attach to rocks, dock pilings, beer cans, bottles, logs, boat hulls and outboards, ropes, anchors, turtles, crustaceans, clams, insects, shopping carts—any hard surface submerged in water.

The History of the Problem

In the 1980s, transatlantic ships supplied goods and grains to Eastern Europe. These ships returned to North America carrying ballast water contaminated with aquatic invaders. Some have argued that zebra and quagga mussels came attached to anchors and chains as well. Zebra and quagga mussels were unintentionally released into the Great Lakes system and discovered in 1988 and 1989 respectively; although no one recognized that these were actually two different species until a year or two later. Zebra mussel populations exploded, reaching a vast distribution in the Great Lakes by 1990. They spread through connected waterways like metastatic cancer, into the Mississippi drainage, reaching St. Louis, Missouri by 1991 and New Orleans, Louisiana by 1993.

How they Spread

Zebra mussels from the Great Lakes spread rapidly downstream. An artificial connection between the Great Lakes and the Mississippi River drainages allowed for rapid range expansion of these insidious invaders without delay after their original introduction. The Chicago Sanitary and Ship Canal, originally designed to move Chicago's sewage waste away from Lake Michigan, provided the same gateway for the Great Lakes' aquatic invaders into the Mississippi system. Downstream spread was inevitable. Mussel larvae are suspended in the water, and travel wherever the flow takes them. The infested Mississippi River then served as a conduit for zebra mussels to reach all areas connected via navigable waterways. Adult zebra mussels spread upstream to other rivers attached to boats and barges. Since the 1980s, zebra mussels have invaded much of the eastern United States, including the Mississippi, Missouri, Tennessee, Ohio, and Arkansas rivers as well as the Great Lakes and the St. Lawrence Seaway.

Quagga mussels initially invaded North America at a slower pace than zebra mussels. They remained restricted mostly within the Great Lakes until 2007, when quagga mussels were discovered in the lower Colorado River at Lake Mead. It is likely that quagga mussels came attached to a houseboat brought from the Great Lakes. From there, they immediately spread following the flow of water. Just as a medical transfusion can spread disease-laden blood from one human body to another, artificial diversions of water from the Colorado River swiftly transferred these virulent invaders to otherwise unreachable water bodies and associated drainages in southern California and Arizona. Meanwhile, trailered boats have spread them, albeit more slowly, into more isolated systems. Quagga mussels have also been detected in unconnected waters in Colorado and Utah.

Impacts

There are economic and ecologic effects from mussel invasions—and both are negative. Anglers and others who use water for recreation can tell you that zebra and quagga mussels are a nuisance. They foul hulls, intakes, props, dock lines, and anything else submerged in water. They are known to clog cooling water intakes in outboards and lower units, which can lead to permanent damage and costly repairs. Crappie and bass anglers in Oklahoma have their monofilament lines regularly cut by sharp mussels. Bait buckets become unrecognizable as such because of a dense mussels encrustation. A floating dock submerged in winter became unable to support the weight of snow on the roof combined with dense zebra mussel encrustation below.

Zebra and quagga mussels are not just a nuisance to those who use our waters for recreation. They are also problematic for industrial facility operations that use raw water to supply utilities for our communities. Zebra and quagga mussels substantially reduce flow in large pipes and clog smaller diameter pipes in cooling and fire suppression systems in power plants. They clog screens and pipes in water treatment facilities. Expensive routine maintenance is needed to keep water flowing. Authorities in the Columbia River basin have estimated that

David Britton/USFWS

Quagga mussels infest this piece of marine equipment, pulled from Lake Mead, Nevada.

costs to install chlorination systems to keep mussels out of pipes could be as high as $2 million for some raw water sources. They estimate that recurring operational costs could equal or exceed $100,000 per year for a single facility. MSNBC reported that the Metropolitan Water District of Southern California expects to spend between $10-$15 million in a single year to control quagga mussels in their systems. In the Great Lakes area, congressional researchers have estimated that the power industry spent over $3 billion to control zebra and quagga mussels between 1993-1999. Of course, such costs are passed on to you in your utility bills. The combined economic impact to industries, businesses, and communities may have exceeded $5 billion during that six-year span.

The economic costs are terrible, but the ecologic costs may be worse. Zebra and quagga mussels filter water for plankton to eat, and they are especially good at it. Clear water doesn't necessarily mean healthy water. Plankton is the base of the aquatic food web and nutrient-rich waters are naturally murky. Water clarity increases dramatically following a mussel invasion. Removing algae can have a cascading effect that impacts the entire food web from zooplankton to large top-predator fishes. Over the last decade, water clarity has increased prominently in Lake Michigan while populations of crustacean species of the genus *Diporeia* have decreased by over 95 percent. These crustaceans are part of the zooplankton that feed on algae. They are, in turn, fed upon by smaller fish, which are fed upon by larger fish. A dramatic reduction in algae has likely driven a cascade leading to the reduced catch seen in commercial and recreational fishing in Lake Michigan in recent years. In the West, this is alarming because western water supports many threatened and endangered fish species like the humpback chub (see *Eddies* Summer 2008) and razorback sucker that might not be able to withstand a zebra or quagga mussel invasion. Following the introduction of zebra and quagga mussels, populations of native freshwater mussels in Lake St. Clair and the western basin of Lake Erie have plummeted. It seems that our native fauna may be unable to compete. It's a simple fact that once zebra or quagga mussels invade a system it will never be the same.

David Britton/USFWS

Any hard surface, including marine equpiment, is potential habitat for invasive mussels. This piece of encrusted gear was pulled from Lake Oolagah, Oklahoma.

QZAP

The Western Regional Panel on Aquatic Nuisance Species created a Quagga-Zebra Mussel Action Plan for Western U.S. Waters, recently approved by the federal Aquatic Nuisance Species Task Force. This plan, affectionately called QZAP, identifies priority actions to thwart the mussels' spread and control existing populations. Specific prevention strategies include mandatory inspection and decontamination at infested waters; continued development of effective watercraft and equipment inspection and decontamination protocols and standards; adoption of protocols and standards in the western states; establishment and implementation of strong, consistent law enforcement programs; and development of a risk-assessment model for water bodies. QZAP also provides strategies for early detection and monitoring, rapid response, containment, and control of existing populations, as well as outreach and education. Many state and federal agencies have already begun implementing QZAP at all jurisdictional levels. The public can help by learning about zebra and quagga mussels (and other aquatic

invaders) and take the simple steps necessary to prevent unintentional spread.

Bureau of Reclamation

Quagga mussels encrust a penstock gate at Davis Dam on Lake Mohave, Arizona.

Stopping the Spread

No cure exists for zebra or quagga mussels. Only two eradication attempts have been successful, one in Virginia and one in Nebraska, both in isolated small ponds where mussels were poisoned. This method is not feasible in larger systems, flowing systems, or in systems used for drinking water. Those of us who use waters that currently have zebra or quagga mussels will have to get used to them. Research has focused on controlling these mussels, to keep water flowing, rather than eradicating them in open waters, which is a more daunting task. Preventing further spread is our best hope at the moment.

Although we are essentially powerless to stop downstream spread, we can prevent overland spread on trailered boats. This mode is much slower and quite preventable. Boaters should know that zebra and quagga mussels could survive several days out of water if conditions are humid and cool. As predicted by laboratory studies, we now know that they can survive long enough in air to travel from one of the Great Lakes to Lake Mead, a distance of approximately 1,800 miles. Boaters should always clean their equipment thoroughly, drain all standing water, and dry everything before moving to other waters. If boats are kept in infested waters, they should be professionally cleaned with 140°F, high-pressure water before transport.

Remember, zebra and quagga mussels are an ecological disease. Most of us understand the importance of personal health and hygiene. We accept the necessity to bathe. We wash our hands, brush our teeth, and maybe even floss on occasion. When it comes to our own bodies we are careful not to let disease find an easy way in. This is common sense. As you go about your business, keep in mind that water bodies, like human bodies, are also vulnerable to invasion. They can be healthy or diseased. And like many nasty human diseases, currently we have no cure for zebra and quagga mussels. ✦

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Meanders

By Jason Goldberg

The River of Life Courses in Unusual Ways

I'm home again in Florida, visiting from my Washington DC office. It's a surprisingly cold January day in the Everglades. Larry Perez, a biologist with Everglades National Park, leads us into the woods to search for African pythons. The terrain is very dense woodland, not really meant for navigation by *Homo sapiens*. As a wetlands ecologist, the thick foliage confounds my attempts to move through it. I wonder, "Where's a good muddy marsh when you need one?" Still, Perez skillfully finds even the narrowest of paths. I crawl on my belly under a fallen tree, wallowing in cold mud and leaves, and fervently hope that I don't encounter a constrictor snake in this precarious position. When my head hits a tree branch for the fourth time, I wonder how I came to be here.

Oh yes, I remember. It's all my parents' fault.

Like most residents, I'm not a native Floridian. We moved from New York when I was six, but with all of its eccentricities, Florida is home. The heat and humidity melded into my blood. My parents supported me and my siblings in whatever endeavors we pursued as we grew up: horseback riding, piano. My girlfriend wishes I'd taken dancing lessons. I suspect my parents secretly wanted me to go into the tech world, but there was no summer camp for such a thing in those days.

But there was Big Pine Key's *SeaCamp*. I was interested in science from an early age, but it was while snorkeling in Looe Key when I was just 11 or 12 that I saw living coral reefs as big as a house and thousands of years old. A seven-foot-long tarpon hovered near me before vanishing in a brilliant silver flash. I skimmed the surface of the shallow Everglades on an airboat, and marveled that there were thousands of tiny animals beneath my bare feet as I walked the beach. I was hooked. From then on, it was always aquatic science for me.

Then, there was a birthday gift. My mother wrote to Marjory Stoneman Douglas about her budding biologist son. Soon after, I received an autographed first edition of her *River of Grass*, the lightning rod for south Florida conservation. Then, in high school, a bus tour of the Everglades and a conversation about environmental outreach with the nice person next to me proved serendipitous. Two years later, she turned out to be on the acceptance committee for the University of Miami, where I studied marine biology.

The river of life courses in unusual ways.

So it was that I found myself, years later, back in Florida with the U.S. Fish and Wildlife Service's Fisheries Program, a biologist in the Branch of Aquatic Invasive Species. The Department of the Interior recently proposed to list large constrictor snakes as "injurious." Constrictors threaten the native species in the Everglades. The importation and interstate transport of these animals are significant, and highly controversial given the way these snakes have made their way into the wild. The Florida Fish and Wildlife Conservation Commission organizes periodic search parties like the one I am on to follow the spread of the snakes. But doing so is not easy. Burmese pythons have existed in the Everglades for some time, but it was unclear whether African pythons also live here. Large constrictors are masters of camouflage; it's possible to be within four feet of one and still not see it. I leapt at the chance to search for them.

The cold January weather works in our favor, as the snakes are more sluggish. The area we search isn't the typical Everglades, with its deep mud and airboats. Instead, we search a site adjacent to development, much of which has been drained and is now drier terrain. As part of the Everglades Cooperative Invasive Species Management Area collaboration, we work with the Miccosukee Tribe of Indians of Florida. They allow the surveys on their land, and they also participate.

We organize into several teams. My first shift was driving a labyrinthine route very slowly to search for snakes along the roads and houses. South

Florida's quirks quickly emerge. Coming so soon after the holidays, we look for snakes wrapped around weary Santa Claus lawn ornaments or hiding under old Christmas trees waiting to be mulched. Ironically, we motor down *Marjory Stoneman Douglas Drive*. We annoy drivers who don't care much for our 10-mph speed. We also annoy a goose anxiously guarding a flock of Muscovy ducks (yet another invasive) in the middle of the road. We stop to talk with landscapers and post office workers, people who work outside and might spot snakes. Our search yields nothing, but the other teams have recovered a few snakes. Even finding four, given their fantastic ability to camouflage, is cause for concern—they have been spreading.

South Florida is a land of nonnative species, and the signs are everywhere that snakes and Muscovy aren't the only problem threatening the landscape. Acres and acres of dead melaleuca (an invasive tree) line the roads, their papery bark still flaking in sheets. It looks like a fire exploded in the area, the result of herbicide spraying to control the melaleuca. Though they look less threatening, invasive plants pose an even bigger problem for the Everglades by changing habitats native species need.

My next tour is with the field crews. Given the small area of our search, it's surprisingly diverse: farmland, forests, streams, old roads, and drainages. Here too, Florida's eccentricities appear. We explore a decayed shack, now home to a massive wasp nest. Half of a truck still hitched to a broken boat sits nearby, and countless beer bottles litter the ground. Cuban revolutionaries used to plot here, rumors say. One of my teammates, who already reminded me of Indiana Jones (sans bullwhip), proves his spirit when he tangles with two constrictors. Each is at least ten feet long and escapes into the ground despite the firm grip he had on their tails. He leaves the encounter unsuccessful, but unharmed.

I can identify and survey with pixel-point accuracy a point in a wetland that corresponds precisely with remotely sensed data. So, I'm concerned about my reputation when I lose my group barely twenty yards from the road. Breaking through a bad patch of thorns and only slightly scarred for the experience, I rejoin my team. One of them, a law enforcement officer, beckons me. A short distance from the road, just inside the stand of trees, is a glass chicken, a totem of a human face composed of seashells, incense, and other objects I can't quite identify. These remains of a religious ceremony were intended to discard bad luck. If only it were as easy to find and eradicate invasive organisms.

We're back in the forest, near a stand of Brazilian pepper (yet another invasive tree), when I finally twist my way free from under the tree. Another of my teammates has made a new discovery. The cold weather affects all reptiles in the area, and she has found a near-comatose nonnative brown basilisk lizard. It hangs upside down in a tree by just one claw, its ginger belly visible. She collects it easily.

I didn't find any snakes during my part of the survey but the team found enough to confirm that constrictors are spreading through the Everglades. It's just one more problem we must address to conserve the "river of grass."

With my teammates, I discover that we had a mutual and ironic admiration for these snakes we were tracking down. You can't help but admire and respect pythons. Aside from the natural beauty and jeweled quality of their bodies, they are marvelously efficient survivalists, singular in mind and purpose.

And this is really ironic: many of the people on the survey owned constrictors, but they recognized that the big snakes don't belong in Florida's *wild* habitats. The trackers came from different backgrounds, but all shared a commitment to conservation. Invasive species are one of the top threats facing ecosystems, costing this country an estimated $120 billion annually in environmental and economic harm. It's difficult and controversial, but I'm confident we can solve problems with invasive species, and restore habitats.

It's in that effort where I take real pride and meaning in my work. Someday, maybe even yesterday, someone just saw a big fish for the first time, or some other spectacle of nature, and decided that they also will make a difference. ✦

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Eddies

Reflections on Fisheries Conservation

U.S. Fish and Wildlife Service– Fisheries
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U.S. Fish and Wildlife Service
http://www.fws.gov/eddies

Summer/Fall 2010

Marketing Social Change

Globalization over the past forty years has changed the world. It has manifested in the invasive species that confound conservation. Moving people and goods around the world has moved unwanted organisms to where they don't belong. Regulations to prevent such spread don't always work. The U.S. Fish and Wildlife Service seeks to encourage voluntary citizen-conservation through social marketing, partnering with business, industry, and conservation groups to empower targeted citizens to adopt conservation-friendly behaviors.

The public faces of these partnerships are the national *Stop Aquatic Hitchhikers!*® and *Habitattitude*™ campaigns.

Stop Aquatic Hitchhikers! targets people who recreate on the water and encourages them to prevent the spread of invasive species by cleaning their equipment every time they leave the water. To date, 930 organizations communicate the message, generating a brand that bespeaks responsible use of fisheries.

Habitattitude targets pet owners and water gardeners, encouraging consumers to prevent the spread of invasive species. It established a cooperative relationship with the pet industry, and substantial financial support from the industry helps to communicate the conservation message. ✦

Joe Starinchak

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