U.S. Fish & Wildlife Service

ENDANGERED Species BULLETIN

February 2007 *Vol. XXXII No. 1*

For over a century, the Fish and Wildlife Service has played a vital role in conserving America's fishery resources. In 1871, Congress established what is now known as the National Fish Hatchery System. Its original purpose was to provide domestic food fish to replace declining native fish. Over the past 30 years, in the face of increasing demands on aquatic systems and growing environmental threats to those systems, the mission of the National Fish Hatchery System expanded and diversified. In addition to restoring native fish populations, mitigating for fisheries lost as a result of federal water projects, and providing fish to benefit tribes and national wildlife refuges, the system has a unique responsibility in helping to recover various aquatic species listed under the Endangered Species Act.

U.S. Fish & Wildlife Service

USFWS

WASHINGTON D.C. OFFICE *Washington, D.C. 20240*

H. Dale Hall, *Director*
Bryan Arroyo, *Acting Assistant Director for Endangered Species*

Claire Cassel, *Chief, Division of Partnerships and Outreach* *(703) 358-2390*
Rick Sayers, *Chief, Division of Consultation, HCPs, Recovery, and State Grants* *(703) 358-2106*
Chris L. Nolin, *Chief, Division of Conservation and Classification* *(703) 358-2105*
Martha Balis-Larsen, *Chief, Office of Program Support* *(703) 358-2079*
http://www.fws.gov/endangered

PACIFIC REGION—REGION ONE *Eastside Federal Complex, 911 N.E. 11th Ave, Portland OR 97232*

Hawaii and other Pacific Islands, Idaho, Oregon, Washington,

Renne Lohoefner, *Regional Director* *(503) 231-6118*
http://www.fws.gov/pacific

SOUTHWEST REGION—REGION TWO *P.O. Box 1306, Albuquerque, NM 87103*

Arizona, New Mexico, Oklahoma, and Texas

Benjamin Tuggle, *Regional Director* *(505) 248-6282*
http://www.fws.gov/southwest

MIDWEST REGION—REGION THREE *Federal Bldg., Ft. Snelling, Twin Cities MN 55111*

Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin

Robyn Thorson, *Regional Director* *(612) 715-5301*
http://www.fws.gov/midwest

SOUTHEAST REGION—REGION FOUR *1875 Century Blvd., Suite 200, Atlanta, GA 30345*

Alabama, Arkansas, Louisiana, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Florida, Tennessee, Puerto Rico, and the U.S. Virgin Islands

Sam Hamilton, *Regional Director* *(404) 679-7086*
http://www.fws.gov/southeast

NORTHEAST REGION—REGION FIVE *300 Westgate Center Drive, Hadley, MA 01035*

Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia

Marvin Moriarty, *Regional Director* *(413) 253-8300*
http://www.fws.gov/northeast

MOUNTAIN-PRAIRIE REGION—REGION SIX *P.O. Box 25486, Denver Federal Center, Denver CO 80225*

Colorado, Kansas, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming

Mitch King, *Regional Director* *(303) 236-7920*
http://www.fws.gov/mountain-prairie

ALASKA REGION—REGION SEVEN *1011 E. Tudor Rd., Anchorage, AK 99503*

Alaska

Thomas O. Melius, *Regional Director* *(907) 786-3542*
http://www.fws.gov/alaska

CALIFORNIA/NEVADA OPERATIONS *2800 Cottage Way, Sacramento, CA 95825*

California and Nevada

Steve Thompson, Operations Manager *(916) 414-6464*
http://www.fws.gov/cno

ENDANGERED Species BULLETIN

Telephone: *(703) 358-2390*
Fax: *(703) 358-1735*
E-mail: *esb@fws.gov*

Web site:
www.fws.gov/endangered/bulletin.html

Editor
Michael Bender

Editorial Assistance
Ann Haas

Layout
Dennis & Sackett Design, Inc.

Contributors
Stuart C. Leon
Jeff M. Finley
Craig Springer
Richard Shelton
Wade Fredenberg
Mark Maskill
Yvette Converse
Tom Brandt

On the Cover
Photographed in a clear, shallow stream, this Lahontan cutthroat trout displays its lateral line, which is a sensory organ used to detect movement in the surrounding water.

The Endangered Species Bulletin is now an on-line publication. Three electronic editions are posted each year at www.fws.gov/endangered/bulletin.html, and one print edition of highlights will be published each year. To be notified when a new on-line edition has been posted, you can sign up for our list-serv by clicking on "E-Mail List" on the Bulletin web page.

The Bulletin welcomes manuscripts on a wide range of topics related to endangered species. We are particularly interested in news about recovery, habitat conservation plans, and cooperative ventures. Please contact the Editor before preparing a manuscript. We cannot guarantee publication.

The Bulletin is reprinted by the University of Michigan as part of its own publication, the Endangered Species UPDATE. To subscribe, write the Endangered Species UPDATE, School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI 48109-1115; or call (734) 763-3243.

Please send us your comments and ideas! E-mail them to us at esb@fws.gov.

IN THIS ISSUE

The National Fish Hatchery System

by Stuart C. Leon

USFWS

The Fish and Wildlife Service's Fisheries Program is steeped in the conservation traditions of America. Throughout a history that spans 136 years, the Fisheries Program has endeavored to respond to the ever-changing challenges in resource conservation wrought by constantly evolving societal demands. This remains true today.

From the earliest beginnings of our Fisheries Program, the Service's National Fish Hatchery System has been a principal asset in responding to emerging conservation challenges. Within the National Fish Hatchery System, captive propagation has been, and continues to be, a valuable and irreplaceable tool in the management, restoration, and recovery of fish and other aquatic-dependent species. Used in the right way at the right time, the System employs captive propagation to restore and replenish aquatic animal populations in ways that no other conservation tool can.

Hatcheries complement habitat conservation and restoration programs. Today, the System's 70 National Fish Hatcheries,

Fish hatcheries raise more than fish. Wyoming toads (above) are being propagated at Saratoga National Fish Hatchery in Wyoming, and the Genoa National Fish Hatchery in Wisconsin produces several species of mussels.

USFWS

Andrew Starostka/USFWS

Wells "Geno" Adams with a pallid sturgeon collected in St. Charles, Missouri.

nine Fish Health Centers, seven Fish Technology Centers, and Aquatic Animal Drug Approval Partnership program all play a significant role in conserving our Nation's fish, mussels, aquatic insects and plants, and amphibians. In doing so, we also help provide recreational opportunities to America's 34 million anglers, who spend $36 billion annually in pursuit of America's favorite pastime.

I am honored to be associated with the many outstanding professionals that comprise the Service's Fisheries Program. Our workforce is diverse and among the most technically competent; it includes ecologists, culturists, geneticists, veterinarians, statisticians, disease pathologists, aquaculture drug researchers, and facility maintenance experts. They are vested with the responsibility for recovering species listed under the Endangered Species Act, restoring native aquatic populations, mitigating for fisheries lost as a result of federal water projects, and providing fish to benefit tribes and national wildlife refuges. The National Fish Hatchery System works closely with other Service biologists and with states, tribes, and the private sector to complement habitat restoration and other resource management strategies for maintaining healthy ecosystems that support healthy fisheries.

With this issue of the *Endangered Species Bulletin,* we highlight a few of the valuable contributions the National Fish Hatchery System makes to species recovery. From the saga of the Lahontan cutthroat trout to the less visible but equally dramatic struggle for survival of the Higgins eye pearlymussel, Service fisheries biologists and our partners are working hard to restore aquatic wildlife for the benefit of future generations.

Dr. Leon is Chief of the Division of the National Fish Hatchery System in the Service's Arlington, Virginia, headquarters office.

A Living Fossil Fights for Survival

by Jeff M. Finley and
Craig Springer

Some call the pallid sturgeon (*Scaphirhynchus albus*) a living fossil. This large fish arose in the Cenozoic Era like a dinosaur, then survived the cold crunch of advancing glaciers and lived to thrive in the big, muddy rivers of middle North America. Only recently has the pallid sturgeon experienced changes so extreme as to threaten its survival. In a century's time, habitat destruction, pollution, dams, changes in river flows, over-fishing, the caviar trade, and hybridization in the Missouri River basin drove the pallid sturgeon to the brink of extinction.

The pallid sturgeon's life characteristics—a long life and slow growth—may contribute to its decline. This fish grows to a size of more than five feet (1.5 meters) and 80 pounds (36 kilograms), and it lives beyond 60 years. But maturity comes slow; it takes females a decade to ripen, and even under ideal conditions, spawning is sporadic and infrequent, perhaps every other year.

USFWS

Wyatt Doyle, Branch Chief of the Columbia Fishery Resources Office, holds two stocked fingerling pallid sturgeon after recapture.

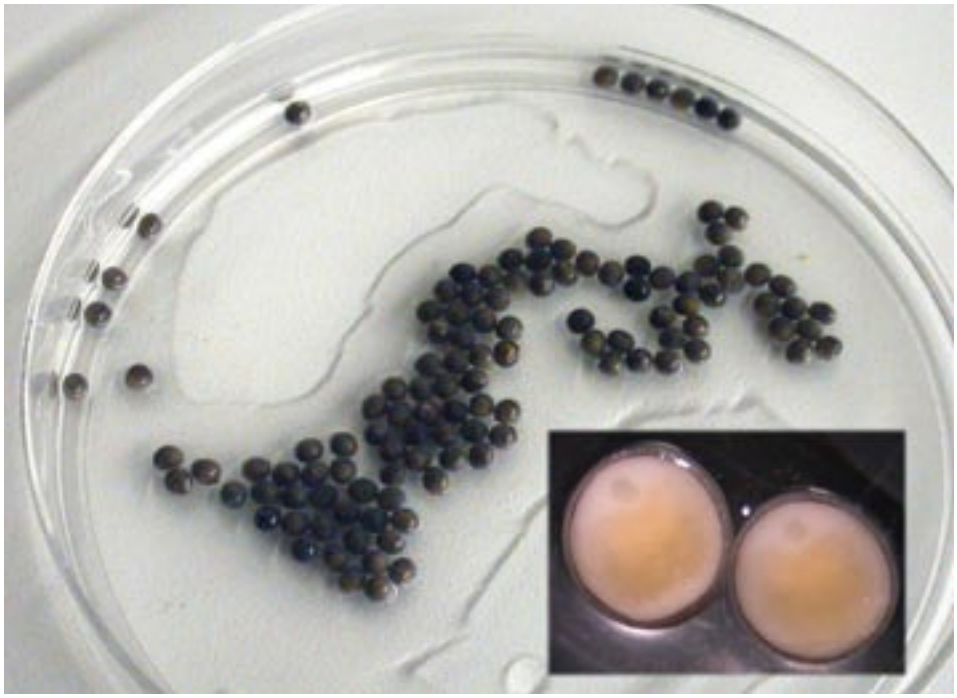
The Fish and Wildlife Service listed the pallid sturgeon as an endangered species in 1990. Since then, natural resource agencies, governments and citizens from Louisiana to Montana have joined forces to recover this ancient fish. The Neosho National Fish Hatchery in Missouri is one of six federal and state hatcheries raising pallid sturgeon for stocking into the Missouri River.

Only in its fifth year of raising pallid sturgeon, Neosho NFH continues to increase its production from wild-caught fish, both by refining culture techniques and increasing the amount of tank space. Like most pallid sturgeon raised at hatcheries, the fish receive either a colored latex tag or coded wire tag along with an individually numbered PIT (passive integrated transponder) tag before stocking. This helps biologists distinguish between wild and hatchery-raised pallid sturgeon, yielding a better understanding of the species in the wild.

"The Middle Basin Workgroup determines how many fish we produce; they set the stocking goal," says Neosho's manager, David Hendrix. "The Service's Columbia Fishery Resources Office in Missouri does the follow-up on survival, and those tags in the fish tell us where they came from. The hatcheries are a management tool to keep the fish from going extinct."

In 2004, Neosho's original sturgeon building was expanded through a partnership with the Army Corps of Engineers. This addition allows the hatchery to spawn and rear an estimated 4,000 pallid sturgeon each year. A building under construction will allow the facility to produce another 10,000 fish per year. The expanded Neosho facility will prove vital in rearing pallid sturgeon, as will the Corps-funded renovation of hatcheries like Miles City State Fish Hatchery in Montana, Gavins Point NFH in South Dakota, and the Blind Pony State Fish Hatchery in Missouri, all of which have expanded to stock pallid sturgeon.

Over 150,000 pallid sturgeon have been stocked since the fish was listed. The efforts to raise pallid sturgeon are the result of cooperation between the Corps and Service to bring the Corps's federal projects into compliance with the Endangered Species Act. "We are committed to protection and recovery of threatened and endangered species like pallid sturgeon," says Brigadier General Gregg Martin, Northwestern Division Commander.



USFWS

Pallid sturgeon eggs were collected in the past for the caviar trade.

At the lower end of the species' natural range, biologists at Natchitoches NFH in Louisiana have spawned pallid sturgeon for release in the Mississippi River. They stocked nearly 12,000 fish in autumn 2004. No pallid sturgeon have been stocked there since 2004 because biologists believe the fish is doing well enough in the lower basin; these fish tend to grow faster due to warmer temperatures, thus reaching maturity sooner. Assistant Hatchery Manager Dr. Jan Dean continues to advance our understanding of the fish by creating a larval identification series, which allows hatchery and field biologists to identify pallid sturgeon in their rapidly changing early-life forms and distinguish them from the more common shovelnose sturgeon (*Scaphirhynchus platorynchus).* Dean is also on the leading edge of research with the Service's Jackson, Mississippi, Ecological Services Field Office to study

USFWS

Biologists with the Service and USGS surgically implant a sonic transmitter into a pallid sturgeon for tracking research.

fish movement in the wild. And move they do; one of the fish recently caught by Dean and Paul Hartfield of the Jackson Office was spawned and tagged at the Blind Pony State Fish Hatchery, more than 300 miles (480 kilometers) away.

Next up the Missouri River from Neosho is Gavins Point NFH in South Dakota. This hatchery also was retooled to handle pallid sturgeon. Hatchery Manager Herb Bollig and crew have been spawning pallid sturgeon since the early 1990s. The facility houses the only pallid sturgeon brood stock in the world: 10 year-classes of 88 families, comprising thousands of fish. They are still immature, and Bollig expects a few more years to pass before they start producing eggs. With so few wild fish left in the Missouri River, this brood stock is critical to the species' survival. Inspections by Service biologists at the Fish Health Center in Bozeman, Montana, lend an extra level of security, ensuring that the brood stock remains robust. A new well coming online should ensure the fish get disease-free water.

Farther upstream, wild adult pallid sturgeon are brought to Garrison Dam NFH in North Dakota, spawned, and returned to the wild. Some of the wild adults get a radio transmitter surgically implanted so management biologists can learn more about habits and habitats. Their offspring are eventually released into the Missouri River as well. Hatchery Manager Rob Holm says the adults in the wild are getting old. Some fish that have been caught over time have lost weight, underscoring the need for maintaining a captive brood stock. But the problem for pallids remains one of habitat. Captive propagation and milt (fish sperm) preservation only buy some time to fix habitat problems, says Holm. "Our milt cryopreservation repository captures the existing genetic makeup of the species," Holm says. "If the necessary habitat changes can be made in the next 50 years to facilitate recovery, we want as genetically a diverse group of sturgeon as possible to release back into the wild, and the National Fish Hatchery System makes this possible."

Yvette Converse, Assistant Director of the Bozeman Fish Technology Center in Montana, agrees on the need to address habitat: "In the long-term, we don't want to be dependent on hatcheries for recovery, but want to have the habitat suitable for fish survival in the wild, and that may take decades. Water management may be the biggest obstacle for pallid sturgeon recovery." In the meantime, the Bozeman Center has expertise to offer. Physiologist Dr. Molly Webb has conducted blood assays, using blood chemistry and hormones to identify an optimal time to spawn fish. Those assays could ultimately mean less stress on an aging and obsolescent population of wild fish, as well as on captive stocks, and a greater yield of offspring. Biologist Kevin Kappenman conducts thermal studies, looking at egg maturation, hatching and larval rearing development with changing temperatures—information useful for better captive propagation.

Hatchery-raised pallid sturgeon released into the Missouri River now have a greater chance to find some of the shallow-water habitats that are critical for their survival. The Corps undertook an aggressive effort in 2004 to create an

estimated 1,200 acres (485 hectares) of new habitat in the lower reaches of the Missouri, where habitat loss in the past has been so great. The Columbia Fishery Resources Office (FRO) monitors some of the newly created habitat to see if it is used by both wild and hatchery-raised pallid sturgeon. This information will help guide the designs of future habitat restorations and determine if a greater diversity of habitat types is necessary.

In addition to the habitat work, the Columbia FRO is responsible for pallid sturgeon recovery in some 300 miles of the Missouri River, stretching from Kansas City to St. Louis. Dr. Tracy Hill, Columbia's Project Leader, chairs the Middle Missouri River Basin Pallid Sturgeon Workgroup, a multi-stakeholder forum for coordinating conservation efforts, and is a member of the Pallid Sturgeon Recovery Team. The recovery team is making great strides in scientific and technological breakthroughs.

Since 1999, Columbia FRO biologists have managed to capture only 123 pallid sturgeon in the lower 200 miles (320 km) of the Missouri River. Seventy-four of those fish were produced by state and federal hatcheries. Forty-two fish had no tags and were thought to be wild fish. Seven others were of unknown origin but were suspected to have been stocked.

An important milestone on the road to recovery occurred in 1999 when biologists from the Columbia FRO discovered a freshly hatched larval pallid sturgeon in the naturally formed Lisbon side chute of the Big Muddy National Fish and Wildlife Refuge. This is the only verified case of natural reproduction within the lower Missouri River in more than 50 years. The Lisbon chute, created during the great flood of 1993, has since been a hot spot for collecting pallids.

Columbia FRO collected 44 pallid sturgeon in 2005. However in 2006, it could collect only 21 fish despite a significant increase in the sampling effort. The 2006 results are vexing and perplexing, and they show there is still much to learn. A myriad of complications face this ancient and extremely rare fish. Success is incremental, on the river or in a hatchery.

Jeff M. Finley is a biologist in the Columbia FRO, and Craig Springer is a biologist in the Division of the National Fish Hatchery System in Albuquerque, New Mexico.

USFWS

Jan Dean, Assistant Manager of the Natchitoches National Fish Hatchery in Louisiana, shows off one of the facility's pallid sturgeon.

The Return of a Lake-dwelling Giant

by Craig Springer

Craig Springer/USFWS

A Lahontan cutthroat trout photographed in a shallow stream. In its lake habitats, Lahontan cutthroat trout can grow to larger than 60 pounds.

Jay Bigelow holds a male Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*), one about three years old and 16 inches (40 centimeters) long, and admires the sunlight reflecting off the black-spotted silvery-white flanks. It's part of a unique brood stock he's developing. Bigelow supervises operations at the Lahontan National Fish Hatchery in Gardnerville, Nevada, on the banks of the Carson River. The hatchery is part of a larger integrated fisheries complex that includes the Nevada Fishery Resources Office and Marble Bluff Fish Passage Facility. These stations coordinate programs to plan and implement the recovery of the threatened Lahontan cutthroat trout.

One of 13 cutthroat trout subspecies in the American West, this fish evolved in ancient Lake Lahontan, which at its maximum size inundated about 8,600 square miles (22,300 sq. kilometers) of northwestern Nevada and parts of surrounding states. As glaciers retreated at the end of the last ice age, an attendant climate change dried the basin, and Lake Lahontan receded to form the few isolated lakes found today. With gradual climate change, the Lahontan cutthroat trout developed into a fish able to withstand environmental extremes that today readily kill other fish species. Two forms of the Lahontan cutthroat arose: one accustomed to life in flowing waters; the other, a lake-dweller.

Pyramid and Walker lakes at the bottom of the present-day basin held native Lahontan cutthroat trout. These are terminal lakes, meaning that water leaves them only by evaporation. As a result, their mineral content is extremely high.

© Michael Graybrook

Craig Springer/USFWS

Hatchery Supervisor Jay Bigelow feeds the facility's Lahontan cutthroat trout.

Lahontan cutthroat trout not only tolerate this condition, they evolved to thrive in it. These lake-form fish had other remarkable adaptations. The numbers of cartilaginous filaments or gill rakers inside their throat are exceedingly high, indicating a habit of feeding on microscopic animals. The fish also has a digestive track for preying on fish. For eons it was atop the food chain, wreaking havoc on fish like the cui-ui (*Chasmistes cujus*) and tui chub (*Gila bicolor*), and most likely cannibalizing its own. In its lake habitats, the Lahontan cutthroat trout grew to phenomenal size. The largest known specimen tipped the scale at 62 pounds (28 kilograms) in 1916.

In 1905, the Bureau of Reclamation's first water development project, the Newlands Project, altered water availability and flow to Lahontan cutthroat trout. Pyramid and Walker lake levels dropped as farmers diverted water to irrigate fields, and fish lost their access from Pyramid Lake to their spawning gravels in the Truckee River. Due to a lack of available spawning habitat, Pyramid Lake was devoid of the trout by 1939. Although reduced numbers of river-dwelling Lahontan cutthroat trout remained, the native strain of lake-dwelling trout that carried the genes for tremendous growth in the face of harsh conditions appeared to be extinct.

At some point in the past, trout were transferred from Pyramid Lake into a small fishless stream, Morrison Creek, on Pilot Peak in Utah, an event that proved priceless for conservation. When and by whom the transfer was made is unknown. Fast forward to the 1970s. As a precaution against extinction, Bryce Nelson of the Utah Department of Natural Resources later transferred some of the Morrison Creek fish to nearby fishless Bettridge Creek on Bureau of Land Management lands. Genetic studies commissioned by Lisa Heki, Project Leader of the integrated Lahontan NFH Complex, and conducted by Dr. Mary Peacock, University of Nevada-Reno, found that the fish surviving in the Utah streams are pure representatives of the original lake-dwelling form of Lahontan cutthroat trout.

Through Heki's 12 years of recovery work, the Lahontan National Fish Hatchery has moved from a focus on a short-term put-and-take sport fishery to a facility centered on the recovery of a native threatened species, but one with even greater sport fishing qualities. Heki is optimistic. "Yes, it can be done, and quicker than people believe—if there is cooperation," she says. "Twenty years down the road, we could have 20- to 30-pound cutthroat trout running the river right through downtown Reno."

Building brood stocks from wild fish takes time. Bigelow and crew carefully manage the brood stock to maintain a robust line and genetic integrity. To "keep the wild in the fish," fertilized eggs from Morrison Creek trout are brought to the hatchery and infused into the brood stock. The hatchery complex has a willing and able partner in Steve Doudy, a conservation-minded citizen who owns the land over which Morrison Creek flows.

In 2001 the hatchery achieved success in its hatching efforts, and in 2004 the hatchery placed 13,197 fish into Pyramid Lake. There they are expected to significantly contribute to the recreational fishery managed by the Paiute Indian tribe.

The hatchery continues to meet rigorous demands for fish health. Some of the fish will be stocked in California's Fallen Leaf Lake and perhaps in Lake Tahoe. The fish culture expertise will be applied as eggs are incubated at the Marble Bluff Fish Passage Facility, located near the terminus of the Truckee River above Pyramid Lake. To imprint the young fish on the river water and get the adults to swim back through the passage into the Truckee to spawn, the eggs will be incubated in Truckee River water. It will be a few years before success can be measured, but now this unique fish has a real chance for recovery.

Hatcheries are for More Than Fish

by Richard Shelton

USFWS

Mussels collected during a stream survey.

Native mussels may be the most endangered aquatic animals. Here in Arkansas, they were once found in great abundance within many streams. But pollution, over-harvest, impoundments, and dredging changed the character of streams and took a toll on many aquatic organisms.

Native Americans found mussels a dependable food source, and they used the shells for tools, art, and jewelry. From the 1800s until the 1940s, mussel shells were used extensively for buttons until the advent of Bakelite plastics. "Mussel shelling" has seen a resurgence in recent years; they have become valuable not only for their own freshwater pearls but for shipment to Asia for use as "seed" for more valuable saltwater oyster pearls. Mussels occupy a valuable ecological niche; they provide a food source for fish and mammals and provide a natural filtering mechanism, which also makes them excellent biological indicators of aquatic health.

Mussels have a complex life cycle. They begin as larvae, or glochidia as they are called. The glochidia must attach to specific host fish species, upon which they transform and grow until dropping onto the stream bottom and maturing into adults. Each species of mussel has a specific fish host that it must find when it is ready to spawn. Some mussels have developed ingenuous adaptations to lure fish close enough for implantation, such as appendages that resemble worms. When pollutants or other processes cause a decline in either the mussel population or the fish host species, the reproductive cycle is broken and entire mussel communities may collapse.

Perhaps the most insidious threat to all freshwater mussels is the invasive zebra

Hatchery biologist Josh Seagraves (left) and Assistant Manager Dewayne French record data from aquatic habitat system used to hold fish for mussel host fish research.

Richard Shelton/USFWS

mussel (*Dreissena polymorpha*). A native of Europe, the zebra mussel was accidentally introduced into the Great Lakes in the 1980s when foreign ships dumped bilge water containing zebra mussel larvae. This thumbnail-sized invader has a propensity to attach in huge masses to any hard object, including the hard shells of other mussels. Zebra mussels can cover and even smother beds of native mussels. They have already spread throughout much of the Mississippi River drainage by attaching to the bottom of boats and barges or entering the cooling system of boat motors. Without natural predators, it is a virtual certainty that this pest will eventually inhabit most North American streams, with predictably devastating effects on native mussel populations.

To address the threats to native mussel species, the Mammoth Spring National Fish Hatchery has dedicated its facilities and expertise to helping endangered mussels for the past decade. Its biologists have teamed with Arkansas State University to learn the basic life history of the animals, learning the techniques needed to grow and spawn them. Part of that effort is to discover the specific host-fish species. These fish are often obscure or rare, and much remains to be learned about them as well.

Due to the threats posed by a zebra mussel invasion of southern waters, Mammoth Spring biologists investigated the utility of holding native mussels in ponds, essentially providing refugia against loss of wild populations. Over two years, about 850 mussels of 25 species from the White River system were held while their growth and survival were monitored. Juveniles were reared for release into native habitats to restore depleted populations. As early as 1995, Mammoth Spring staff propagated native mussels and reared them to the juvenile stage for release into Leading Creek.

During these efforts, important life history traits continue to be discovered. We now know more about propagating the endangered speckled pocketbook (*Lampsilis streckeri*), the threatened Arkansas fatmucket (*Lampsilis powellii*), and the threatened Ouachita creekshell (*Viliosa arkansasensis*) for reintroduction. Mammoth Spring biologists are investigating the life histories of two additional endangered mussels, the pink mucket (*Lampsilis abrupta*) and fat pocketbook (*Potamilus capax*), both of which could be affected by future highway projects in Arkansas. The Arkansas Highway and Transportation Department is an important partner with the Fish and Wildlife Service in conserving these native mussels.

The breadth of projects undertaken and the lessons learned show that fish hatcheries are for more than fish. In an ecological sense, the ties that bind fish and mussel are strong, and conserving mussels benefits fish and other animals.

Richard Shelton/USFWS

Dewayne French studies mussel glochidea.

Dewayne French/USFWS

Dr. Jerry Farris of Arkansas State University (left), Bill Posy of the Arkansas Game and Fish Commission, and diver Josh Seagraves (USFWS) search for endangered mussels in a stream.

Richard Shelton is the manager of Mammoth Spring National Fish Hatchery in Mammoth Spring, Arkansas

Apache Trout: Swimming Towards Recovery

by Craig Springer

© Michael Graybrook

Arizona's iconic image may be a saguaro cactus in a gritty desert, but when you get out of the Sonoran lowlands and into the high country, things change. The cooler, forested mountains of east-central Arizona are home to the Alchesay-Williams Creek National Fish Hatchery Complex on the Fort Apache Indian Reservation of the White Mountain Apache Tribe. Ideal for producing Apache trout *(Oncorhynchus apache),* the facility is essential for the recovery of the species.

In the years after settlers came to Arizona, the Apache trout teetered on the brink of extinction following overharvesting, degradation of its habitat, and hybridization with non-native trout species. Habitat degradation was due to timber harvest, grazing, and road construction, all of which increase siltation during spring runoff. Apache trout are spring-spawning fish, and silt can keep oxygen-rich water from percolating over fish eggs in gravels.

Endangered until 1975, the Apache trout was reclassified to threatened in recognition of its improved status. Now, in partnership with the Tribe, the U.S. Forest Service, and the Arizona Game and Fish Department, the Fish and Wildlife Service's Arizona Fishery Resources Office is expanding the range of the fish and helping it swim toward the final goal of recovery. In fact, planting Apache trout in streams free of introduced species may result in recovery and delisting within the next couple of years. Crossing the recovery goal line will be a truly remarkable event, given that no fish species has been delisted due to recovery.

Just 25 years ago, wildlife managers were stocking waters of the Fort Apache Indian Reservation and Apache-Sitgreaves National Forest with non-native species—rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki* sp.*),* brook trout (*Salvelinus fontinalis),* and brown trout (*Salmo trutta)* for recre-

USFWS

This pond helps to contain and settle effluent from the hatchery.

USFWS

Biologist Sherri White spawns an Apache trout.

ational fishing. In many instances, these fish were planted immediately downstream of protective barriers that sustained native Apache trout in segments designated as essential for recovery.

In 1983, the hatchery complex changed its practice, replacing non-native sport fish with Apache trout and setting about developing a brood stock from wild Apache trout. Learning to acclimate a wild fish to captive conditions was slow going at first.

With an eye toward recovery, hatchery biologists implemented a new brood stock management plan, stocking Apache trout in the Reservation's streams. This action has dramatically lessened the likelihood of hybridization.

Experience breeds success. Last year, the highest percentage ever of the hatchery's Apache trout eggs made the "eye-up" stage—more than 90 percent. The brood stock management plan has increased prospects for maintaining the genetic variability and integrity of Apache trout propagated in captivity. Meanwhile, improvements to the hatchery, such as its ultra-violet disinfection system, have benefited the propagation program.

These achievements are measurable; about 20 percent more fish now reach stocking size. "Not only are we protecting streams on the Reservation from hybridization, we are also preserving a long-standing sport fishery important to the economy of the White Mountain Apache Tribe," says Bob David, manager of the Alchesay-Williams Creek National Fish Hatchery Complex.

The 2005-2006 spawning effort wrapped up early, but not for a want of fish. What normally lasts through March was accomplished this time by the end of January. The early start produced larger fish throughout the summer stocking season, and all of the fish went into the waters on tribal lands. Biologist Sherry White says that she typically sees a few trout ready to spawn each week during the winter months. This year, 675 Apache trout females produced more than 767,000 eggs fertilized by 1,054 males.

Not all of the eggs are reared at the hatchery complex. Since 1995, about a quarter-million eyed-eggs have gone to the Arizona Department of Game and Fish each year for stocking in the Apache-Sitgreaves National Forest. In addition, the Arizona Fishery Resources Office is continuing to expand Apache trout populations through stream-to-stream transfers. In November 2006, fishery biologists planted Apache trout in two streams that had been declared free of non-native fish. Two more streams await, and biologists will clear another one or two streams of introduced species in the autumn of 2007. By that time, the goal of 30 separate stream populations in 485 miles (780 kilometers)—the number needed to delist the Apache trout—will have been achieved.

The Alchesay-Williams Creek National Fish Hatchery Complex also produces rainbow, brook, and brown trout for stocking altered habitats such as artificial lakes on 18 Indian reservations in the American Southwest. Altered habitats are not capable of supporting or sustaining Apache trout populations because of water quality constraints, especially in summer. These lakes do not drain into waters bearing native trout. Apache trout are put in streams; they are a stream fish with no evolutionary experience in flat water.

The Fish and Wildlife Service established the Williams Creek National Fish Hatchery in 1939, and the Alchesay National Fish Hatchery in 1962, both at the behest of the White Mountain Apache Tribe. The complex was completed in 1972. The Arizona Fishery Resources Office is co-located at the Alchesay National Fish Hatchery.

The Texas Blind Salamander

by Craig Springer

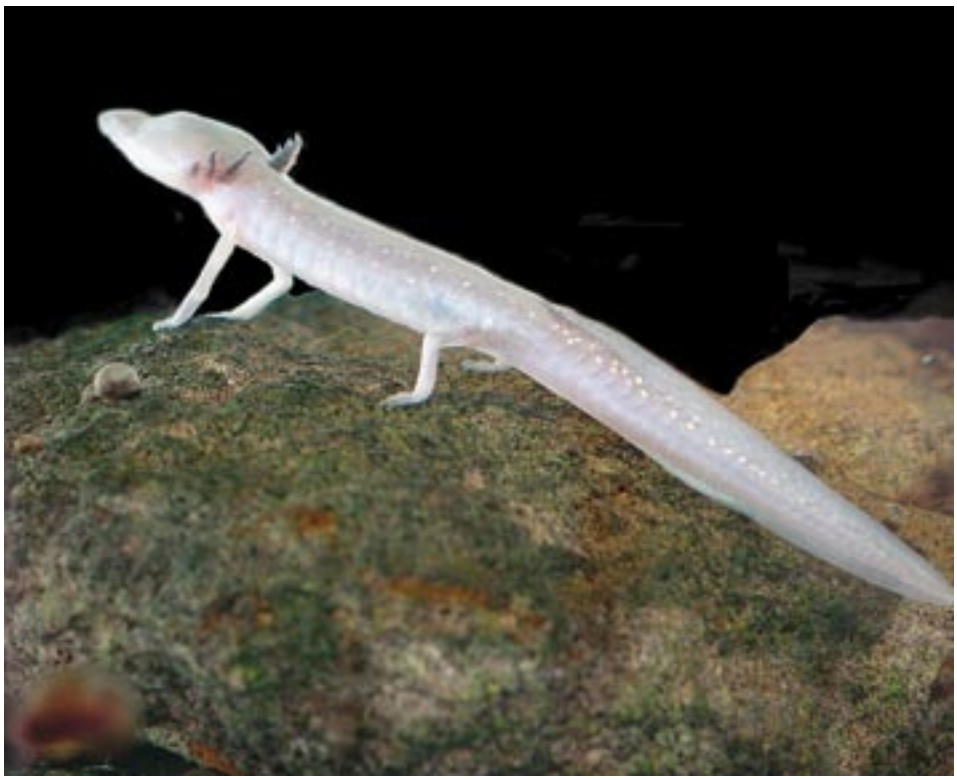
Joe Fries/USFWS

Cannibalism has been noted with Texas blind salamanders.

Pallid and spindly, eyeless and other-worldly, Texas blind salamanders (*Typhlomolge rathbuni*) make their living in the watery labyrinth of the Edwards Aquifer in central Texas. Top predators, they eat crustaceans, snails, and probably each other in the wild. Their entire lives are spent in water and in the darkness of caves. They have no reason to come into daylight, as indicated by the vestiges of eyes (which begin as tiny black dots and quickly disappear early in life) and by the lack of pigment. It was by accident that they were even discovered and by happenstance that the discoverer launched their conservation.

In 1896, specimens of Texas blind salamanders welled up 190 feet (58 meters) into the light of day via a well casing sunk by the U.S. Fish Commission, the precursor to today's U.S. Fish and Wildlife Service. The well serviced the National Fish Hatchery at San Marcos, Texas. The uniqueness of the habitat and

The Texas blind salamander is a cave-dwelling, unpigmented amphibian with reduced, vestigial eyes. Adults reach an average length of about 4.7 inches (12 centimeters).



Joe Fries/USFWS

its good water influenced renowned U.S. Fish Commission ichthyologist Barton Evermann to locate the hatchery there. He wrote, "The river has its rise in a number of springs at the foot of a limestone ledge or hill just above town. All these springs together form a large, deep stream, from the bottom of which, near the upper end, wells up the principal spring." Four years later, Evermann facilitated the collection and description of the eyeless salamanders from the springs that had so impressed him.

The facility, today known as the San Marcos National Fish Hatchery and Technology Center, works with the Service's Austin Ecological Services Field Office to recover the rare amphibians, arguably among the country's rarest and most unusual animals.

Fish biologist Joe Fries guides conservation initiatives for the species at the Technology Center, maintaining tanks and keeping salamanders collected from different sites separate to ensure genetic diversity. Almost anything learned through the work is new information, he says.

"We know they are highly endemic and rare, but just how rare we can't say for sure," says Fries. "They are hard to research because they are so hard to get to; that's why we're looking into their life-history in captivity."

Keeping salamanders at the facility serves a dual purpose. Maintaining captive populations allows biologists to gain important information about the species—its growth rates, eating habits, temperature tolerances, and reproductive ecology. The facility also serves as a refuge. Captive animals are a back-up population in the event of a dramatic loss in the wild. And that speaks to threats; what goes into the Edwards Aquifer goes through Texas blind salamanders.

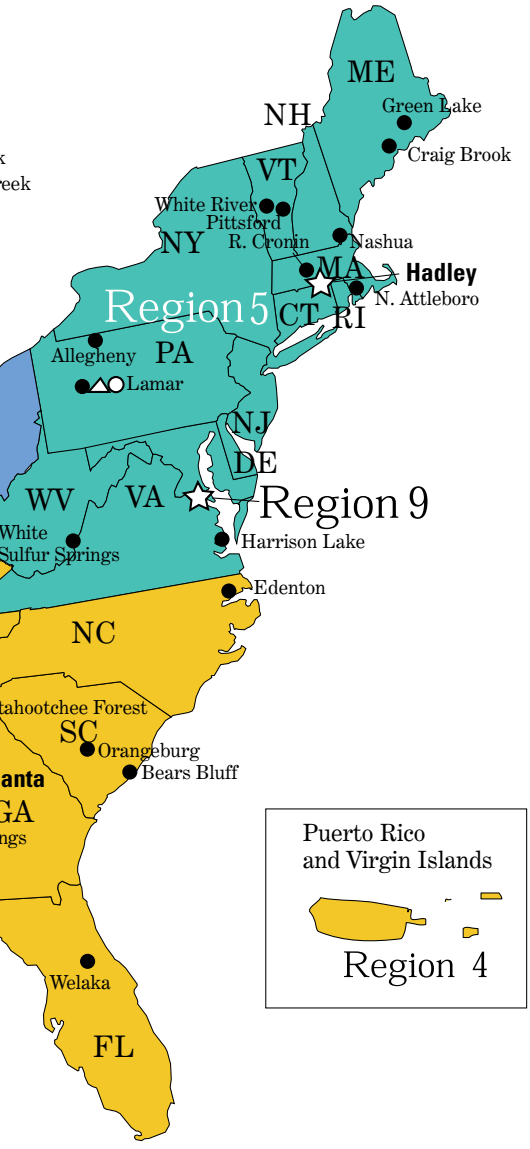
The region is known for its karst topography. Karst is a three-dimensional landscape shaped by the dissolution of soluble carbonate bedrock, such as limestone, that is highly fractured and contains subsurface drainage systems, often including caves. Aquifers formed in karst topography are usually quick to recharge from surface drainage. A diesel spill, or other contaminants such as run-off of agricultural chemicals, within the recharge zone of the Edwards Aquifer could cause serious harm to the water quality, and thus to Texas blind salamanders.

A lifetime naturalist, Barton Evermann served as Chief in Charge of the Division of Scientific Inquiry of the U.S. Bureau of Fisheries from 1891 to 1910 during which time he chose San Marcos, Texas, as the site for a federal fish hatchery. Later Dr. Evermann was Director of the museum at the California Academy of Sciences.

Water quality aside, there is the issue of water *quantity*. As the human population grows, so does its demand for water. Reducing the amount of water in the aquifer could reduce available habitat. The threats of pollution and aquifer overpumping were what led to listing the species in 1967 as endangered.

Although salamanders at the Technology Center have laid eggs and produced offspring, the survivors have yet to reproduce. Eggs from the first-generation of captive salamanders have disappeared and were probably cannibalized. In his studies, Fries is striving to fill in knowledge gaps, closely following the species to bring about its recovery in anticipation of its eventual delisting.

National Fish Hatchery System Facilities



May 2005

National Fish Hatchery System field stations involved with one or more listed Species:

NFHS Field Station	Project Leader	Phone
Abernathy FTC (WA)	Judy Gordon	360-425-6072
Alchesay/Williams Creek NFH Complex (AZ)	Bob David	928-338-4901
Bears Bluff NFH (SC)	Kent Ware	843-559-2315
Bozeman FTC (MT)	Bill Krise	406-587-9265
Carson NFH (WA)	John Hitron	509-427-5905
Coleman NFH (CA)	Scott Hamelberg	530-365-8622
Craig Brook NFH (ME)	Tom King	207-469-6701
Creston NFH (MT)	Mark Maskill	406-758-6868
Dale Hollow NFH (TN)	Andrew Currie	931-243-2443
Dexter NFH & TC (NM)	Manual Ulibarri	505-734-5910
Eagle Creek NFH (OR)	Douglas Dysart	503-630-6270
Entiat NFH (WA)	Julie Collins	509-784-1131
Garrison Dam NFH (ND)	Rob Holm	701-654-7451
Gavins Point NFH (SD)	Herb Bollig	605-665-3352
Genoa NFH (WI)	Doug Aloisi	608-689-2605
Green Lake NFH (ME)	Paul Santavy	207-667-9531
Harrison Lake NFH (VA)	Mike Odem	804-829-2421
Hotchkiss NFH (CO)	Adam Mendoza	970-872-3170
Lahontan NFH (NV)	Jay Bigelow	775-265-2425
Lamar NFH & NE Fishery Center (PA)	Mike Millard	570-726-4247
Leadville NFH (CO)	Ed Stege	719-486-0189
Leavenworth NFH (WA)	Julie Collins	509-548-7641
Little White Salmon NFH (WA)	Speros Doulos	509-538-2755
Livingston Stone NFH (CA)	John Rueth	530-275-0549
Makah NFH (WA)	Al Jensen	360-645-2521
Mammoth Spring NFH (AR)	Richard Shelton	870-625-3912
Mora NFH & TC (NM)	John Seals	505-387-6022
Natchitoches NFH (LA)	Karen Kilpatrick	318-352-5324
Neosho NFH (MO)	David Hendrix	417-451-0554
Orangeburg NFH (SC)	Willie Booker	803-534-4828
Ouray NFH (UT)	Mike Montagne	435-789-4078
Private John Allen (MS)	Ricky Campbell	662-842-1341
Quilcene NFH (WA)	Ron Wong	360-765-3334
San Marcos NFH&TC (TX)	Tom Brandt	512-353-0011
Saratoga NFH (WY)	Lee Bender	307-326-5662
Spring Creek NFH (WA)	Larry Marchant	509-493-1730
Tishomingo NFH (OK)	Kerry Graves	580-384-5463
Uvalde NFH (TX)	Grant Webber	830-278-2419
Valley City NFH (ND)	Ron Zitzow	701-845-3464
Warm Springs FTC (GA)	Vince Mudrak	706-655-3382
Warm Springs NFH (GA)	Carlos Echevarria	706-655-3382
White Sulphur Springs NFH (WV)	Catherine Gatenby	304-536-1361
Willow Beach NFH (AZ)	John Scott	928-767-3456
Winthrop NFH (WA)	Chris Pasley	509-996-2424
Wolf Creek NFH (KY)	James Gray	270-343-3797
9 Fish Health Centers	Robert Bakal	919-513-6851

The "Running of the Bulls" at Creston NFH

by Wade Fredenberg and Mark Maskill

It's named for its size, brute strength, and bullish-looking head. The bull trout (*Salvelinus confluentus*) is really a char, but it is kin enough to brook trout (*Salvelinus fontinalis*) and Dolly Varden (*Salvelinus malma*) that they sometimes interbreed. That and other problems, such as competition with its cousin, the lake trout (*Salvelinus namaycush*), which was introduced into the Columbia River drainage from east of the Continental Divide, led to the bull trout's listing in 1998 as a threatened species.

Seeing the approaching decline, the Creston National Fish Hatchery in Montana initiated bull trout research in 1993. That gave fishery managers options for refining culture techniques and possibly developing brood stock to augment wild populations. The bull trout was designated a priority for conservation to make up for the Flathead Basin fisheries that had been lost to water projects. The former Montana Power Company funded construction of an isolation facility to incubate wild bull trout eggs. Staff at Creston consulted with staff at the Hill Creek Hatchery operated by the British Columbia Ministry of the Environment, a mitigation hatchery near Upper Arrow Lake. The partnership capitalized on the experience of Canadian biologists, who had run a successful bull trout culture program at the facility since the late 1980s, rearing fish from eggs taken from captive wild adults and stocking them in the wild.

In September 1993, Creston NFH biologists collected about 20,000 eggs from seven pairs of wild bull trout in Lion and Holland creeks of the Swan River drainage. Unexpectedly, a high 97 percent of the eggs hatched. The following year, another 12,000 eggs were brought to the hatchery from three more pairs of wild fish.

Creston biologists conducted a number of feeding and growth experiments using various light and temperatures regimes, plowing new ground in the field of bull trout aquaculture. Knowledge of imprinting behavior by evaluating thyroid hormone levels was improved with these experiments. Bull trout growth in captivity was excellent, and the bulls eventually outgrew their pen in the isolation facility. Some were moved to raceways outside and ultimately stocked in Duck Lake on the Blackfeet Indian Reservation in a recreational fishery. Others were transferred to the Fish and Wildlife Service's Bozeman Fish Technology Center for additional studies.

Listing bull trout as a threatened species began a new phase in the Creston

Wade Fredenberg/USFWS

Kurt Fredenberg, son of Service biologist Wade Fredenberg, admires his catch: a 10-pound male bull trout. Take of bull trout is allowed if done in accordance with state laws and regulations.

NFH culture program, which quickly expanded to evaluate captive fish as broodstock to produce eggs and fry for research. Hatchery biologists discovered that brood fish mature about two years sooner in captivity than in the wild due to the high growth rates achieved under controlled conditions. Each year from 1997 to 2003, between 70,000 and 210,000 eggs were collected from the first known captive bull trout brood and incubated in the isolation facility to study development, fecundity, and egg viability.

Year-round water temperatures at Creston NFH are appropriate for bull trout brood development. Brood stock performance is remarkably consistent for ages four through 10, and the rate of egg eye-up—the stage of an egg shortly after fertilization, when the eyes become visible—is consistently near 75 percent, well within acceptable limits for other species. As the bulls age, productivity naturally declines. Progeny of some of the original fish live on at the hatchery and supply bull trout for additional research.

Listing the species underscored the need for a reliable captive population since using wild fish for research programs was curtailed. During the experimental program, bull trout eggs and a few fry were sent to a wide variety of cooperating researchers. Dr. Ronald Hedrick at the University of California-Davis and biologists at Montana Fish, Wildlife and Parks both investigated the fish's susceptibility to whirling disease. Oregon Department of Fish and Wildlife biologists created field identification kits with preserved fish. Staff at the Bozeman Center learned more about the bull trout's thermal tolerance. The Environmental Protection Agency and University of Wyoming studied dioxin and copper toxicities. Dr. Eric Taylor at the University of British Columbia researched hybridization of bull trout with Dolly Varden. Visiting Russian scientists collected some adult specimens from the hatchery to compare skull morphology with that of the bull trout's close kin, the white-spotted char (*Salvelinus leucomaenis*). Scientists at the Service's Abernathy Fish Technology Center in Washington State studied bull trout swimming behavior, susceptibility of fry to loss into diversion structures, and the fish's response to various screen configurations to help prevent unintended capture during water withdrawals in the wild.

USFWS

A bull trout in the experimental brood stock.

Bull trout from Creston NFH reared for experiments in facilities across the country have yielded basic, yet vital life history information on incubation, growth, thyroid hormone levels, physiological changes associated with migration, diet and feeding behavior, thermal tolerance, and predator avoidance.

As we learn more about this wonderful fish, we can help assure that the "running of the bulls" will continue in the Pacific Northwest.

Wade Fredenberg is the Service's Native Fish Coordinator for western Montana. Mark Maskill is the manager of Creston National Fish Hatchery.

Wade Fredenberg/USFWS

Linda Vannest from the Bozeman Fish Health Center collects tissue and disease samples from a bull trout netted in Glacier National Park.

Mora NFH&TC Brings Gila Trout Closer to Recovery

by Craig Springer

The names we pin on places tell a story of human experience. In the Gila region in southern New Mexico and Arizona, the lexicon appearing on road signs and maps speaks of conflict, privations, and chance encounters, adding color to this rugged land. Names like Raw Meat Canyon, Rainy Mesa, Hells Hole, and Turkey Creek embellish the maps.

In the Gila country, creeks course through steep-walled canyons, some so deep that direct rays of the sun never warm the water. With the hardscrabble roughness of this expanse, you can see how the Apache Indians were emboldened to resist the United States government for so long. The word "Gila" itself relates to the shape of the land, corrupted from a Spanish term derived from the Apache word *zhil,* meaning "mountain."

It's also a fitting name for the region's only native trout, the Gila trout (*Oncorhynchus gilae*). This copper-colored fish survives despite overwhelming odds. For more than a century, it has faced habitat loss and competition with introduced fishes for food, space, and mates. By the time the Gila trout was closed to fishing in the 1950s, its numbers and range were so depleted that it was rarely seen by anglers.

The Gila trout was among the first species protected under the Endangered Species Act in 1973. At the time, Gila trout inhabited just 20 miles (32 kilometers) of water in only four streams, compared with the estimated 600 miles (965 km) it occupied in New Mexico as late as the 1890s. By July 2006, after a great deal of work by the game and fish departments of New Mexico and Arizona, the Forest Service, and the Fish

Bill Roston

A Gila trout in Main Diamond Creek, New Mexico.

and Wildlife Service, the Gila trout was reclassified to the less critical category of threatened, with a special provision that allows limited sport fishing for the first time in nearly half a century.

Meanwhile, the Fish and Wildlife Service's fishery resources offices have diligently expanded the range of the trout through stream-to-stream transfers, adding geographic security by widely separating the replicated populations. The arid mountains of the Gila are prone to forest fires, and trout don't do well in ash-laden waters.

Recovery would not be possible without the Mora National Fish Hatchery and Technology Center in northeastern New Mexico. This facility has been a refuge for wild fish faced with the grim prospects of wild fire. Three times, Gila trout have been brought there from the wild in advance of fire and held safely in quarantine.

The Mora facility also has produced Gila trout for supplemental stocking in the wild. The fish at the hatchery are not far removed from wild stock. That is by design since a science-based brood stock management plan guides the fish culture work. Only young Gila trout go from the hatchery out to the wild, and by the time they reach maturity at three years of age, nature will have selected those fish that get to breed.

Science moves forward at Mora with research into fish diets. Feed trials conducted on young Gila trout are beginning to determine an optimal diet for survival and growth. That technology will be transferable to the manufacturers of fish food to help them produce a better product, not just for Gila trout but other species of fish.

The brood stock at Mora have provided a means for scientists with the New Mexico and Arizona game and fish departments to conduct a study of post-hooking mortality of Gila trout during sport fishing. Though only recently completed, the results of the research will help the state agencies responsible for managing the sport fisheries to develop sound fishing regulations.

Craig Springer/USFWS

The control panel and biofilter for the Mora facility, which boasts a Department of Energy award winning recirculating water system.

The progress in Gila trout conservation reflects the dedication of those who have worked to see that this fish swims successfully against the current of extinction.

Mussels Enjoy the Waters of White Sulphur Springs

by Craig Springer

Rivers can be seen as conduits, expressing in their content the character of the land they drain and the ways that land is treated. Land use practices within the watersheds are manifest in the presence or absence of aquatic life forms such as fish, bugs, and mussels. Because mussels are filter feeders, the river literally runs through them, making water quality a vital concern.

Some of the Fish and Wildlife Service's important mussel conservation work is taking place at White Sulphur Springs National Fish Hatchery, a facility tucked away in a small West Virginia town of the same name. The hatchery is on the leading edge of freshwater mussel conservation in the United States, and its work ripples waters well beyond this quaint place.

Northern riffleshell

Craig Springer/USFWS

The White Sulphur Springs facility has enjoyed a consistent and reliable source of water since it was built in 1900. Good water makes for a good place to research and culture imperiled freshwater mussels. The names of these mollusks speak to their looks and their habitats: threeridge, purple wartyback, mucket, and riffleshell. Conservation of these imperiled mussels is important for the services they provide to other animals, and eventually to people.

Freshwater mussels begin their lives as larvae that parasitize specific species of host fish. After they morph into juveniles, the small mussels drop to the river bottom where they continue to grow, spending the rest of their days paying back their hosts by helping to clean the water. Mussels feed by filtering river water and silt, gleaning tiny plankton, fecal matter, and the detritus of biological matter produced within the stream and its watershed. Remarkably, a bed of 10,000 mussels will filter 60,000 gallons (22,500 liters) of water per day, free of charge.

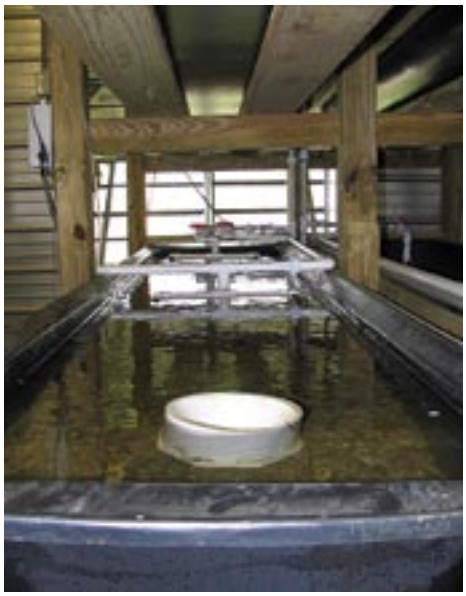
Freshwater mussels function as keystone species in many streams and rivers, benefiting a host of aquatic life. It should be no surprise to find more bugs and fish around mussel beds. But the very way mussels make a living makes them vulnerable to habitat alterations and pollution. Dams have altered stream flow and inhibited the natural dispersal of host fish species. Dredging and channeling activities result in higher levels of suspended sediment and siltation, which can smother mussel beds and degrade water quality faster than the mussels can improve it. Invasive zebra mussels also pose a serious threat to native species by competing for food and living space.

Because of habitat loss associated with a bridge replacement in Pennsylvania, two endangered species, the northern riffleshell (*Epioblasma torulosa rangiana*) and clubshell (*Pleurobema clava*) are being held at the hatchery until the aquatic habitat heals and the mussels can be returned. Meanwhile, biologists at the hatchery are conducting studies on surrogate species to promote mussel recovery. Through work on these common species, hatchery biologists have tested a variety of water types—well water, spring water, and dirt ponds—to develop captive rearing techniques. They've also examined mussel rearing densities to maximize occupied space while keeping the animals in good condition. Juveniles of the common species will be released in advance of the endangered mussels. The strategy is that the beds of common mussels will stabilize the river bottoms and improve the water quality, creating a more hospitable environment for the imperiled species.

Hatchery biologists closely watch the captive endangered mussels, monitoring how much algae they consume over given time periods. The algal feed is produced on-site with a space-age looking device that concentrates the excess into a paste for delivery to other state and federal hatcheries to feed their mussels.

Information gathered on common and endangered mussels at White Sulphur Springs is being parleyed into a controlled propagation plan to direct propagation of federal and state-listed species for release in Virginia and West Virginia waters. But the conservation expertise at White Sulphur Springs extends well beyond the confines of this part of the Blue Ridge.

Craig Springer/USFWS



Craig Springer/USFWS

Mussels are grown at the hatchery in large rearing trays.

Julie Devers pours an algal solution that will be fed to the mussels, which filter their food from the water.

Hatchery Breeds Wyoming's Rarest Toad

by Craig Springer

USFWS

Wyoming toad eggs (above) and toadlets at the Saratoga National Fish Hatchery.

USFWS

Detroit. Toledo. Cincinnati. New York City. Saratoga. They all hold captive populations of an endangered amphibian, the Wyoming toad (*Bufo hemiophrys baxteri*). Small captive populations of the rare toad live in eight city zoos across the country, all participating in the American Zoo and Aquarium Association's Species Survival Plan (SSP), a systematic arrangement to keep the toad from going extinct. But it's near a small Wyoming town where the Saratoga National Fish Hatchery has one of the largest captive populations, which should contribute in large measure to the toad's recovery.

The Wyoming toad's natural range is within roughly a 30-mile (48-kilometer) radius of Laramie. Following a population crash, the toad was listed as endangered, and most of its habitat is now protected as part of the Mortenson Lake National Wildlife Refuge. As is the case with most listed species, the major factor behind the decline was habitat loss. Irrigation out-competed wetlands for water, and matters were made worse by continued drought. Sensitivity to herbicides was a factor, too. Then there's the chytrid fungus (*Batrachochytridium dendrobatidis*). Chytrid infections seem to play a large role in suppressing the animal, says David Paddock, the lead toad biologist at Saratoga NFH.

As part of the recovery program, Wyoming toads were brought to the Saratoga NFH for propagation. Captive breeding began in earnest in 1999. Since that time, an average of 6,863 Wyoming toads have been released each year. Between 1999 and 2003, Saratoga produced an average of 55 percent of the toads released to face the rigors of the wild in the Laramie basin. Just last year, tadpoles from Saratoga were released onto two new private land sites covered under Safe Harbor Agreements, a wonderful arrangement made possible by the Service's Cheyenne Ecological Services Office and the Laramie Rivers Conservation District.

The Saratoga facility also produces trout for restoration into the wild. Paddock is a fish biologist by training and a toad biologist by necessity. But he says animal husbandry is much the same, whether for trout or amphibians. He keeps toads at the hatchery carefully isolated from the fishes in their own environment, and he adheres to strict protocols to prevent the spread of chytrid fungus or other disease-causing pathogens. Toads with chytrid are cared for with antifungal treatments.

He says it's easier to get the toads to breed than one might expect. Of the 150 adult toads kept on station, breed-

Tyler Fox

ing pairs are carefully selected from a studbook—one used by all the participating zoos in the SSP—to maintain genetic integrity. He gets it done, he says jokingly, "with a little wining and dining." Selected adults are paired off in tanks in two inches (five centimeters) of water filled with artificial plants, then injected with hormones to induce production of eggs and sperm. He leaves them to their desires while recorded toad calls play in the background to simulate the competitive breeding that exists in nature. And Wyoming toads are fecund. Three days later, some of the 2,000 eggs start hatching, and in a matter of days to a few short weeks tadpoles and toadlets are forming. They also quickly become crowded, and therein lies part of the reason the Saratoga Hatchery is so important to the toad's recovery. The participating zoos have such limited space that breedings are few—maybe four a year. Because of its space and expertise, Saratoga is able to perform many more breedings each year, 20 or more, and that means more toads released into their native habitat. That expertise, Paddock is quick to note, isn't all in husbandry. The physical plant is irreplaceable. The hatchery is plumbed with a good supply of water, and maintenance man Pat Malone takes care of it all.

Most of the toads are released in the tadpole stage, and about six weeks after eggs are laid they enter the toadlet stage. Toadlets are released in August, giving them a chance to acclimate to the wild and find quarters in small-mammal burrows before the cold Wyoming winter arrives.

Paddock and others at the hatchery continue to improve the toad husbandry techniques. The 2006 breeding season saw a 17.8 percent increase in its hatch rate over previous years. It's probably attributed to how they treated their brood stock toads over the winter. Paddock held select pairs of toads in colder temperatures over winter to more closely simulate the harsh weather they face in the wild. That exposure during hibernation may have cued something physiologically to make the animals more fecund. So, another refrigerated hibernation unit is on the way to the hatchery, and Paddock expects the toads to show even greater reproductive success in 2007.

The Saratoga Hatchery has a long and productive history. Established in 1911, it created the first brood stock of the threatened greenback cutthroat trout (*Oncorhynchus clarki stomias*). Now, Saratoga is the first facility in the National Fish Hatchery System to hatch and raise an endangered toad. It's making its mark; after the hatchery put toads into the wild, there is evidence of natural reproduction on Arapaho National Wildlife Refuge, a vital step on the road to recovery.

USFWS

David Paddock examines a Wyoming toad at the Saratoga National Fish Hatchery.

The Science Behind Fish Nutrition

by Yvette Converse

Did you know that most recovery plans for threatened and endangered fish species identify captive propagation as necessary to achieve recovery? That's really no different than for, say, condors or ferrets. Captive spawning and rearing programs for fishes are necessary to maintain genetic safety nets and allow managers to supplement wild populations until long-term threats like habitat loss can be addressed. Without captive propagation programs, many fish would go extinct in the wild.

But spawning and rearing wild fish in captivity is not as easy as it may sound. It requires scientists to retain in captive fish the attributes and natural adaptive potential of wild stocks. Every aspect of the fish's ecology must be considered to accomplish this, including what and how to feed captive fish to keep them suitable for the wild.

The science behind fish nutrition is complex. Managers must address such factors as the physiological capabilities of each species, nutrient balance and availability of formulated diets, and the feeding ecology and physical mechanics of how a particular species feeds. Feed characteristics also change as fish develop from larvae to adults. Understanding the interaction among these variables and the species requires sophisticated research and knowledge of the science of fish nutrition.

At the Fish and Wildlife Service's Bozeman Fish Technology Center in Montana, researchers have successfully developed specialized diets for several imperiled fish species. A focus

USFWS

An endangered wild June sucker collected from the Provo River, Utah, during the spawning season. Adults are collected annually to provide eggs for the propagation and research programs in Utah and at the Bozeman Fish Technology Center.

USFWS

Recently hatched Snake River cutthroat trout from the Jackson National Fish Hatchery. A cooperative research project is ongoing with several agencies and Service facilities to investigate diet, temperature, and density propagation requirements for three strains of cutthroat trout and Gila trout.

USFWS

Lucas Porter, University of Idaho student, manufactures flake feeds at the Bozeman Fish Technology Center with a drum dryer for endangered Rio Grande silvery minnow propagation. Experimental feeds are provided by U.S.D.A. fish nutritionist Dr. Rick Barrows for use by facilities in New Mexico.

on endangered fish began in the 1990s with a call from the Colorado River Fishes Recovery Program. Fish culturists were experiencing difficulties raising the endangered razorback sucker (*Xyrauchen texanus*). Although the fish spawned successfully, offspring were experiencing up to an 80 percent rate of spinal deformities and poor growth and survival. After a specialized diet was created, spinal deformities in razorback suckers decreased to as low as five percent and survival is greatly improved.

In recent years, biologists at the Service's Dexter National Fish Hatchery and Technology Center in New Mexico and at New Mexico State University observed low survival and uncharacteristic "whirling" behavior in captive stock of the endangered Rio Grande silvery minnow (*Hybognathus amarus*). Their facilities were in a fight against time to establish captive refugia for the small, short-lived species as the wild population neared extinction during extreme drought conditions. The problem turned out to be a deficiency of the vitamin pyridoxine. Within days after a new flake feed was developed, whirling ceased and fish stopped dying. Other species for which specialized diets have or are being developed to prevent deformities include Gila trout (*Oncorhynchus gilae*), pallid sturgeon (*Scaphirhynchus albus*), and June sucker (*Chasmistes liorus*).

Much work remains to be done and nutritional and economical feeds are needed all over the country. The Bozeman Fish Technology Center continues to get calls for help. In June of 2006, it was contacted about an especially rare and vulnerable species, the endangered Devils Hole pupfish (*Cyprinodon diabolis*). Endemic to a single natural spring in Death Valley, California, it is vulnerable to a drop in water levels from local irrigation. After more than 30 years of carefully monitoring the wild population, biologists are scrambling to establish a refugium for this small fish. With a historically low number of individuals remaining, this short-lived species may be nearing extinction. The species has never been successfully raised in captivity and initial attempts have been tenuous. Service biologists at the Bozeman Technology Center are developing and testing diets to improve survival of captive Devils Hole pupfish, and the preliminary results are promising.

The current fish nutrition program at Bozeman works closely with a co-located U.S. Department of Agriculture fish nutrition program. Dr. Rick Barrows, a fish nutritionist with the Agricultural Research Service, coordinates with the Technology Center's senior researcher and fish culturist, Greg Kindschi, to develop species-specific diets and design studies that detect the subtle effects of various ingredients, qualities, or nutrients. Matt Toner, manager of the Bozeman Hatchery, oversees feeding trials and maintains controlled rearing conditions, usually involving several diets so that comparisons can be made. Some studies may involve an evaluation of the physiological or immunological response of fish to different diets. In these situations, Technology Center biochemists Eli Cureton and Mariah Talbott conduct laboratory analyses, bio-assays, and histological preparation. In addition, Dr. Molly Webb, fish reproductive physiologist, Linda Beck, micro-biologist and fish immunologist, and Cal Fraser, water quality specialist—all staff of the Technology Center—work as a team to evaluate spawning, survival, immune conditions, and behavior. The program benefits from a one-of-a-kind Fish Feed Nutrition Laboratory with a variety of equipment capable of producing feeds under commercial conditions or with new experimental processing technologies. No other laboratory in North America has this diversity of scientific and technological capabilities.

With so many fish, mussel, and amphibian species facing conservation challenges, the Service is fortunate to have nutritional research facilities like the Bozeman Fish Technology Center and the salmonid nutrition program at the Abernathy Fish Technology Center in Washington State to assist in recovery.

Yvette Converse is the Assistant Director at the Bozeman Fish Technology Center.

Mussels on Road to Recovery at Genoa NFH

by Craig Springer

USFWS

These tiny mollusks are the first winged mapleleaf mussels ever cultured.

Tony Brady carefully opens an adult Higgins eye pearlymussel to harvest its glochidea.

USFWS

His southern brogue isn't what you would expect to hear in Wisconsin. But then again, his work isn't what you would traditionally expect from a National Fish Hatchery. Tony Brady, a native of North Carolina, headed north armed with degrees from Cumberland College and Tennessee Technological University to become the Fish and Wildlife Service's first mussel propagation biologist, a position focusing on the recovery of listed species.

Brady's experiences prove that chance encounters can change lives and the course of conservation. At Cumberland, he met a biologist with the Kentucky Department of Fish and Wildlife Resources who was helping direct a senior thesis research project. Brady immersed himself into examining population characteristics of largemouth bass (*Micropterus salmoides*) and was captured by the prospects of a career in conservation. His interactions with agency biologists aimed him toward a master's degree at Tennessee Tech studying a new mussel propagation program.

While completing his thesis research, Brady met biologists from the Genoa National Fish Hatchery who were on a fact-finding expedition for mussel recovery. The station would soon be looking for a biologist to help in its mussel restoration efforts. His experience in conducting mussel field surveys could be applied towards the cooperative efforts to stave off the extinction of the Higgins eye pearlymussel (*Lampsilis higginsii*) and the winged mapleleaf mussel (*Quadrula fragosa*).

At one time, the winged maple leaf was thought to be restricted to the St. Croix River in Wisconsin and Minnesota. It has since been found in the Saline and Washita rivers of Arkansas and Missouri, but it is still endangered, confined to the fringes of its former ranges due to dams, habitat loss, and pollution.

The Higgins eye pearlymussel has been listed as endangered since 1976. Its plight became even more critical with the invasion of non-native zebra mussels (*Dreissena polymorpha*) into the Mississippi River basin. At one point, the Higgins eye was one among 27 mussel species found in the east channel of the Mississippi River at Prairie du Chien, Wisconsin. Surveys showed that from 1996 to 2000, the mussel bed became much less diverse; only seven species had survived, and the Higgins eye was not among them.

A mussel coordination team consisting of biologists from the Army Corps of Engineers, Fish and Wildlife Service, U.S. Geological Survey, state conservation agencies of Minnesota, Wisconsin, and Iowa, and academic interests focus on saving the Higgins eye. The team approached the Genoa NFH about the possibility of raising the mussel in captivity. Every spring since 2000, gravid Higgins eye females have been collected in the wild, and about 9,000 walleye (*Sander vitreus vitreus*), largemouth bass, and smallmouth bass (*Micropterus dolomieu*) have been infested with mussel larvae or glochidia, which parasitize the fish until they are ready to survive and grow on their own.

Annually, up to 3,500 of the fish infested with Higgins eye glochidia have been released to face the rigors of the wild in the Wisconsin, Iowa, and Wapsipincon rivers, all tributaries of the Mississippi. It's up to nature as to where the young mussels drop from their host fish. The remaining fish are placed in cages, not so much to retain the fish but to protect the mussels as they fall off and mature. As they get bigger, the mussels are marked and stocked in the wild with the intent of establishing five new populations. Since 2003, over 7,000 adult and sub-adult mussels have been stocked annually into the wild. Approximately 22,000 Higgins eye pearlymussels from the 2005 year-class are set to be stocked out in fall of 2007 from 110 cages.

In fall of 2003, biologists from the Service's LaCrosse Fisheries Resource Office and the U.S. Geological Survey made a breakthrough, discovering the host-fish species for the winged mapleleaf mussel. Genoa NFH was once again called upon to propagate the winged mapleleaf. Each year, divers collect gravid female mussels within a narrow window of time in September. The mussels are then taken to Genoa, where they are held until the glochidia are expelled. The species' natural host, channel catfish (*Ictalurus punctatus),* also play host at the hatchery. In temperature-controlled tanks, the water is cooled in the winter and warmed in the spring to mimic what the fish and growing mussels might face in nature. By October of 2006, the effort yielded 25 winged mapleleaf mussels 0.4 to 0.8 inches (10 to 20 millimeters) in length, marking the first captive propagation of this rare species. Currently, more than 600 channel catfish are infested with approximately 120,000 glochidia being held at the hatchery for spring release.

Brady says that the limited assessments of the released Higgins eye pearlymussels in Iowa have turned up 10 specimens. With a high natural mortality rate in the first year of life, and a large potential habitat, locating them is like "finding a needle in an 80-acre hayfield," according to Brady. But advances in mussel propagation may give this and other species a better chance for eventual recovery.

USFWS

Biologists count cage-harvested Higgins eye pearlymussels.

USFWS

A Higgins eye pearlymussel engraved with a tracking number.

Diet Research for the Shortnose Sturgeon

by Craig Springer

It may fall upon the National Fish Hatchery System to prevent the extinction of the shortnose sturgeon (*Acipenser brevirostrum*). This fish has been listed as an endangered species since 1967. Its recovery plan, published by the National Marine Fisheries Service in 1998, calls for a captive-rearing program since wild populations may need to be augmented with hatchery-raised fish. Since the late 1980s, national fish hatcheries, the National Marine Fisheries Service, and state agencies have investigated fish culture techniques to raise this rare and unusual fish.

The Bears Bluff National Fish Hatchery in South Carolina, a satellite of the Warm Springs Regional Fisheries Center in Warm Springs, Georgia, is studying the early life history of this ancient fish. As part of this effort, it has conducted diet studies in captivity to increase the efficiency of hatchery propagation. Ultimately, that will translate into improved survival of young fish, benefiting their conservation and achieving it at a lower cost.

Adult shortnose sturgeon

USFWS

The shortnose sturgeon has suffered from the typical suite of environmental impacts that have hurt other fishes, says Bears Bluff fish biologist James Henne. For example, shortnose sturgeon naturally made extensive upstream migrations to reproduce, but dams have impeded their access to historic spawning habitat. Changes in river flows from dams have also affected the fish by altering oxygen levels, river flows, and water temperatures. Over-fishing and incidental catches in commercial fisheries operations have had impacts on the shortnose sturgeon as well.

The fish is named for its snout, which sets it apart from all the other sturgeons. It's most similar to the widely distributed lake sturgeon that naturally occurred over much of the inland waters of the South and Midwest and through the Great Lakes. The shortnose sturgeon was naturally confined to the estuaries and major streams tributary to the Atlantic coast from Florida to New Brunswick. Across its range along the coast, it does appear locally abundant in southern rivers like the Santee and Altamaha, but culture programs and intensive protection are still needed to conserve the species as a whole.

Toward that end, the Bears Bluff NFH maintains a refugium population of adult shortnose sturgeon that originated from hatchery stock. Over the last 10 years, hatchery biologists have made impressive progress in learning sturgeon culture techniques.

"Early on, the experience was simply learning to keep fish alive. There's a steep

learning curve when you're trying to culture a fish where the techniques aren't well known," said Henne. "We've gotten better. Though our fish aren't intended for release in the wild, in the event their conservation necessitates that, we have the technology and techniques to do it."

That readiness comes in part with the advances made in early-life diet. Hatchery biologists at Bears Bluff fine-tuned feeding techniques to get through what amounts to a bottleneck: converting larval fish from a natural to a prepared diet. Mortality can be extremely high at that stage of the life cycle. The work can be labor-intensive, requiring manual feeding of brine shrimp about every four hours over the 24-hour period for up to 60 days. Most feeding is done at night, since the animal is naturally most active nocturnally, and that requires much staff time at odd hours.

Hatchery biologists tested six different feeding regimes, including an automated regime using formulated feed mixed with live feed. After a 30-day trial, the automated feed regime proved best. At the end of the trial period, the larval fish fed a mix of natural food and formulated food had an increase in body weight 46 percent higher than larval fish fed the traditional live-feed only. This regime reduces labor costs as well as benefiting the fish.

Not only does this work move things along for shortnose sturgeon, but the findings are probably applicable to other sturgeon elsewhere. Since the findings of this research were published in the American Fisheries Society's *North American Journal of Aquaculture,* Henne has corresponded with researchers from across the United States, Spain, Germany, and Portugal.

The work at Bears Bluff NFH doesn't stop with fish culture. As the larval fish become juveniles, hatchery biologists use them to advance the understanding of what can be done to conserve sturgeon in the wild. Marking fish for release in the wild is important for estimating populations or simply recognizing during future surveys whether a fish is from hatchery stock or a product of natural reproduction. Henne and others have tested implanting PIT (passive integrated transponder) tags in shortnose sturgeon to identify the minimum size at which a young fish can be tagged and the best place on the body to place the tags for the long-term.

Bears Bluff biologists have learned that a suitable place to tag small fish may be under the third cranial scute, a large bony plate. After months of study, survival and growth do not appear to be influenced by tagging. The tags thus far are well retained. In the end, Henne says if the growth and retention rates follow the current trend, the study at Bears Bluff should lend confidence to management biologists monitoring and studying populations in the wild.

Ultimately, conservation of the shortnose sturgeon depends on continued cooperation among the vested partners, not the least of which is the ongoing commitment of biologists at the Bears Bluff National Fish Hatchery.

USFWS

USFWS

Top: A member of the shortnose sturgeon brood stock. Above: Bears Bluff National Fish Hatchery staff collect sturgeon eggs for propagation.

Fountain Darter Parasites and Conservation

by Craig Springer and
Tom Brandt

The Comal River in central Texas begins rather abruptly, gushing forth clear water from fissures at hundreds, if not thousands, of gallons per second. This stream is unique in many ways, but perhaps its most intriguing quality is a rare fish, the fountain darter (*Etheostoma fonticola*).

The historically large volume, steady flow, and warm temperature (74°F or 23°C) of the Comal River created habitat for the fountain darter and, unfortunately, a non-native snail, the red-rimmed melania (*Melanoides tuberculatus*), and its accompanying parasitic trematode or flatworm. The trematode parasitizes the fountain darter, manifesting itself as cysts in the gills. These cysts are not benign. They can do extensive damage to a fish's gills, disrupting respiration. Aquatic biologists at the National Fish Hatchery and Technology Center in San Marcos, Texas, are staying atop the learning curve with respect to the threat this parasite poses for fountain darter conservation.

USFWS

A well-camouflaged fountain darter in its Comal River habitat.

Fountain darters live only in the Comal and San Marcos rivers. At present, only Comal River fish seem to be threatened by the trematode. Luckily, the parasite has occurred at only very low numbers on San Marcos River darters. But what the parasite means for the security of the species is not known yet. It's certainly something that concerns us.

That concern is directed toward scientific inquiries into this very question. A group including graduate students and Dr. David Huffman of Texas State University, Dr. Robin Overstreet of the University of Southern Mississippi, and Andrew Mitchell of the U.S. Department of Agriculture-Harry K. Dupree Stuttgart National Aquaculture Research Center in Stuttgart, Arkansas, is compiling information to better understand the impact of the trematode infestation.

The group is not just interested in what is happening in central Texas. The snail has been found in 15 states. Tropical fish production in Florida was being seriously affected until a Florida group developed methods to control the snail in production ponds. In spring systems of west Texas and Nevada, the snail and the parasite affect numerous native fish species including the largemouth bass (*Micropterus salmoides*), and at least four listed species, including the Devils Hole pupfish (*Cyprinodon diabolis*).

The group associated with the San Marcos Technology Center has been involved in many studies. As a result, the snail's habitat requirements are now better understood. We know the snail prefers spring runs, and that it is sensitive to cold temperatures and temperatures above 90°F (32°C). The snail's range in the U.S. will probably be restricted to the southern and western states because of its thermal tolerance. The snail resists most disinfectants but fishery equipment can be successfully treated with commonly used dimethyl ammonium chloride compounds.

The interaction of the parasite and several fishes has also been studied, revealing that some fish species are much more resistant to the parasite than others. Some young fishes are more sensitive to the parasite than older fishes. Methods for monitoring the parasite level within a stream or river are being developed.

The information compiled during the last couple of years will be used to study potential methods for controlling the

Nature's Images, Inc.

spread of the snail and its parasite and for managing the habitats where they can not be completely removed.

Meanwhile, the Technology Center maintains a standing stock, or refuge population, of fountain darters on site. Should the worst happen in the wild—a chemical spill or drying of the springs that serve as darter habitat—the station holds more than 500 adult fountain darters at any given time for future restocking into the wild.

Holding darters in captivity under the watchful eye of biologists has led to ancillary benefits. These adult fish produced over 10,000 young last year, and they were used for several studies. The longer we have darters on station, the more we learn about their biology. In the end, we're better equipped to deal with threats that may arise with darters in the wild.

USFWS

Outflow of Coral Springs, habitat of the fountain darter.

Some very serious threats challenge the fountain darter, but with the capable help of university, state, and federal biologists, this native fish may someday be removed from the endangered species list.

Dr. Brandt is the director of the National Fish Hatchery and Technology Center in San Marcos.

ENDANGERED
Species
BULLETIN

U.S. Department of the Interior
Fish and Wildlife Service
Washington, D.C. 20240