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PLIGHT OF THE DEVILS HOLE PUFFISH
AT DEATH VALLEY

RARE SEABIRD RECOVERY
AT CHANNEL ISLANDS

REDUCING ANIMAL-VEHICLE CRASHES
IN A CANADIAN NATIONAL PARK

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NEW INFORMATION FOR
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ON THE COVER

Located in Nevada near Death Valley National Park, Devils Hole constitutes the entire aquatic habitat of what may be the world's most isolated fish species: the Devils Hole pupfish. The surface waters are an indication of a vast aquifer that underlies a large part of Nevada. Scientists have recently redoubled their efforts to understand a variety of factors, including dropping water level, water chemistry, and physical processes, that may relate to a recent decline in the population of this unlikely desert fish species. For more of the story, turn to page 26.

COVER PHOTO—NPS/JOHN WULLSCHLEGER

DEVILS HOLE REVISITED

WHY ARE PUFFISH NUMBERS AND WATER LEVEL DROPPING AGAIN?

By John G. Wullschleger
and
William P. Van Liew



Figure 1. The tiny Devils Hole pupfish is less than an inch (2.5 cm) long but has played a big role in native species conservation.

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The diminutive Devils Hole pupfish (*Cyprinodon diabolis*, fig. 1) in Death Valley National Park (California and Nevada) has played an outsized role in the history of native species conservation, including helping to motivate one of the earliest uses of federal reserved water rights to protect habitat

of a species of no recreational or commercial value. However, water levels in Devils Hole are dropping and species numbers are declining (fig. 2). After more than three decades of research and monitoring, managers and researchers still do not have a complete understanding of the ecosystem of Devils Hole.

BACKGROUND

Located 30 miles (48 km) east of Death Valley in the Amargosa Desert of Nevada, Devils Hole is administered as a unit of Death Valley National Park. Geologically, Devils Hole is a surface collapse depression into a fault-controlled open fracture in Paleozoic limestone. Viewed from above, the site appears as a roughly conical depression at the base of a group of low desert hills. From the rim, the opening narrows downward to the surface of a pool, approximately 10 feet (3 m) wide by 60 feet (18 m)

long, and 49 feet (15 m) below the surrounding land surface (fig. 3). A high chain-link fence surrounds the entire opening. Although the surface of the pool appears to indicate the bottom of the hole, nothing could be further from the truth. The

Beyond the edge of the shelf, the bottom drops away into a network of submerged caverns, which no one has fully explored.

southern portion of the pool (16 feet x 10 feet [4.9 m x 3 m]), referred to as the “shallow shelf,” overlies a large boulder; beyond the edge of the shelf, the bottom drops away into a network of submerged caverns, which no one has fully explored. The pool is a surface expression of a vast, regional carbonate-rock aquifer system that underlies a substantial portion of Nevada.

When miners traveling to California’s gold fields in 1849 discovered Devils Hole and paused to bathe in its warm (about 90°F [32°C]), clear waters, they found they

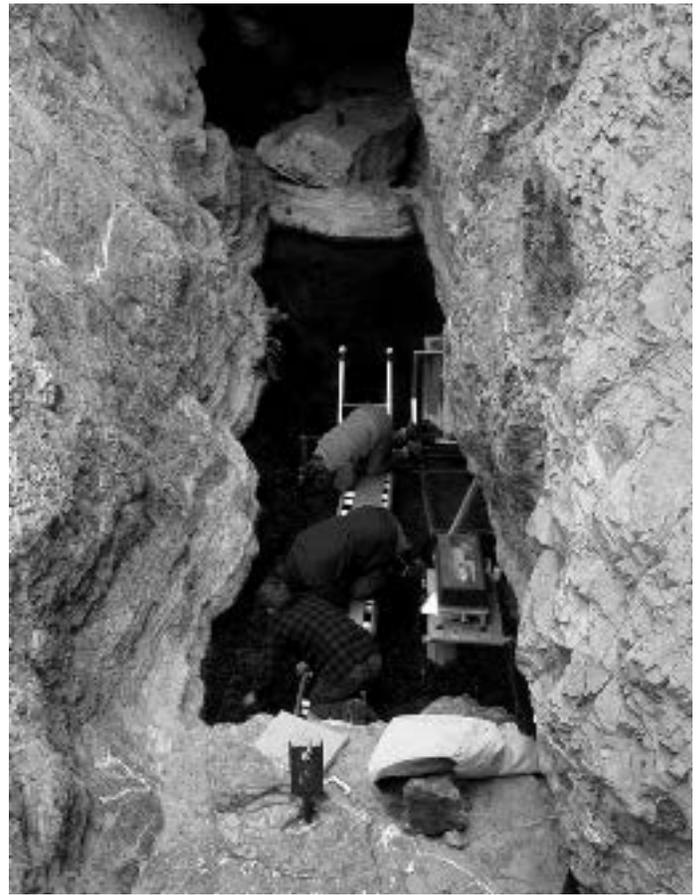


Figure 3. From the rim, the opening to Devils Hole narrows downward to the pool, which is a surface expression of a regional aquifer that underlies a substantial portion of Nevada. Devils Hole may be the smallest habitat in the world occupied by an entire vertebrate species.

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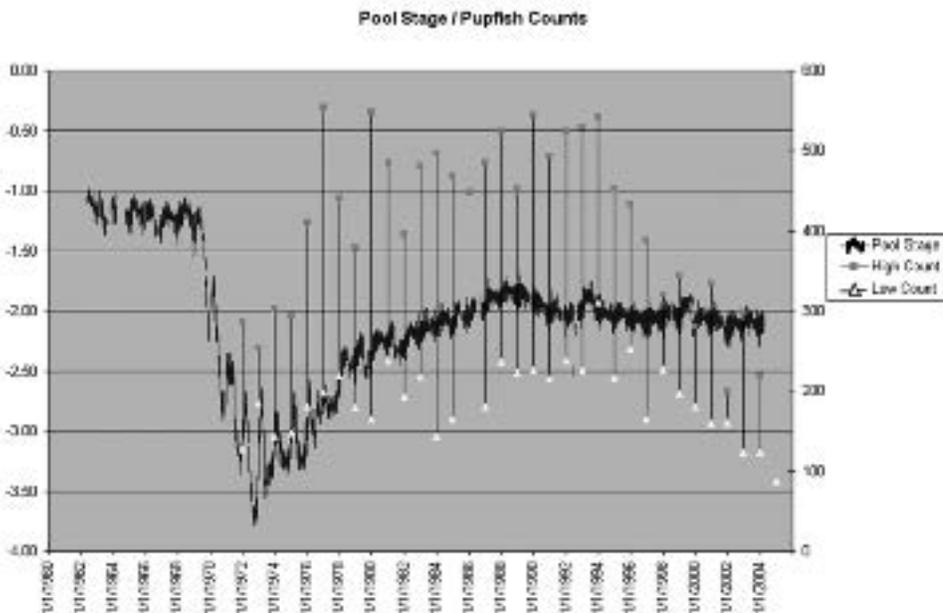


Figure 2. Pupfish numbers fluctuate annually with highs typically occurring in the fall (often October) and lows in the spring (usually April). Investigators have been measuring water levels and pupfish numbers since 1962. The current trend at Devils Hole is that water level is dropping and pupfish numbers are declining. In the graph the left axis represents pool stage measured in feet below a reference point (copper washer); the right axis denotes the number of individual pupfish counted.

DATA SOURCE: NATIONAL PARK SERVICE AND U.S. GEOLOGICAL SURVEY.

were sharing their “tub” with tiny fish, which they misidentified as “minus” [sic]. Actually, the Devils Hole pupfish is a small (adult size <1 inch [2.5 cm] total length) member of Cyprinodontidae, a family known by the common name killifish. Several species that belong to the genus *Cyprinodon* are found exclusively in isolated spring and stream systems of the arid southwestern United States and Mexico. Even by the standards of its congeners, the Devils Hole pupfish is unique in terms of its isolation and limited distribution. Consistent with its name, the Devils Hole pupfish’s native range is limited to the waters of Devils Hole—from the surface to a depth of about 83 feet (25 m), which is the approximate distance that sunlight penetrates the water. Moyle (1976) speculates



that this may be the smallest habitat in the world occupied by an entire vertebrate species. Chances are good that the “49ers” had no idea that the species had subsisted in their makeshift bathtub for thousands of years since the time when its progenitor was stranded there by mechanisms that remain a topic of debate among scientists.

In the late 1960s, the water level in Devils Hole pool began to decline in response to groundwater pumping for irrigation at the nearby Spring Meadows Farm. Concern over the effects on Devils Hole pupfish brought together scientists, resource managers, and interested citizens. This group, which later became the Desert Fishes Council, provided a forum for much of the science that demonstrated the threat of groundwater pumping to the fish. Armed with this information and pressured by broad public support for the pupfish, the U.S. Department of Justice filed for an injunction in federal district court seeking to prevent pumping from those wells that had the greatest effect on water level in Devils Hole. After five years and two appeals, the case reached the U.S. Supreme Court, which in 1976 ruled in favor of the United States, concluding that when the National Park Service (NPS)

Pumping was limited to rates that would not lower water level below a reference point—a copper washer bolted to the wall of the cavern.

acquired Devils Hole it implicitly reserved sufficient water to protect the pupfish and its habitat. Additional legal proceedings followed and pumping was limited to rates that would not lower water level below a reference point—a copper washer bolted to the wall of the cavern.

Following this success, efforts

by The Nature Conservancy and others resulted in the purchase of adjacent lands and the establishment of the Ash Meadows National Wildlife Refuge.

THE STORY CONTINUES

In a simpler world the story of Devils Hole and the pupfish might have ended with these successes. As it stands, however, the outcome has proven to be more complicated and remains subject to uncertainty. Although the initial responses of both water level and pupfish numbers to the restrictions imposed by the court decision were positive, by the late 1980s the pool water level began to drop again. And while pool stage stays above the legally established minimum water level, a slow but steady decrease has continued to the present. A more immediate concern is that the pupfish population has exhibited an overall downward trend from 1996 through the most recent count conducted in January 2005 (fig. 4). That count indicates that the number of pupfish in Devils Hole is lower now than during the period immediately prior to

the Supreme Court decision.

Unlike the situation in the 1970s, reasons for the current declines in water level and pupfish numbers are unclear. Multiple pumping sites in the region and the distances between those sites and Devils Hole make it difficult to discern a relationship between groundwater pumping and

pool-water level, if indeed such a relationship exists. Other factors that could be affecting water level include drought and tectonic activity. In addition, scientists are not certain that the current water level is low enough to adversely affect the pupfish.

In fact, if the information upon which the final court decision was based is correct, the current water level should be adequate to maintain pupfish habitat.

REASONS FOR PUPFISH DECLINE

Scientists who have studied the species over the years have several hypotheses to explain why pupfish numbers appear to be declining; however, none have been adequately tested. Some evidence has caused scientists to speculate that temperatures in Devils Hole may have increased in recent times. Because normal water temperatures in Devils Hole approach thresholds that may be lethal to eggs and early-life stages of the fish, a slight increase could reduce reproductive success (Threlloff and Manning 2003). In addition, people who have worked at Devils Hole for many years believe that substrate on the shallow shelf that underlies the southern section of the pool may contain more fine sediment than it did historically. The shelf is the only area within the pool that is suitable for spawning and is also the location where most primary production occurs (fig. 5). Fine sediments can fill the interstitial spaces of coarser material



Figure 4. Concern about the effects of groundwater pumping on the pupfish habitat at Devils Hole caused scientists, resource managers, and interested citizens to form the Desert Fishes Council. Each year the group conducts population counts of the Devils Hole pupfish.

NPS/JOHN WULLSCHLEGER

Other factors that could be affecting water level include drought and tectonic activity.

Fine sediments can fill the interstitial spaces of coarser material such as gravel and cobble, reducing the movement of water and the concentration of dissolved oxygen.

such as gravel and cobble, reducing the movement of water and the concentration of dissolved oxygen. These conditions, particularly at the warm water

temperatures that occur within Devils Hole, would almost certainly reduce survival rates for eggs and larvae. Moreover, in 2002, blue-green algae proliferated on the surface of the shelf, covering much of the substrate like shrink-wrap. While the causes of this algal bloom remain unknown, biologists suspect that this covering may have prevented pupfish eggs from settling into the gravel, thus exposing them to higher temperatures and increased predation.

REGIONAL PRESSURES

In the region surrounding Devils Hole, groundwater supports agriculture and the rapidly growing urban areas of southern Nevada and California. The NPS Water Resources Division is working to ensure that groundwater withdrawals, which are increasing, do not adversely affect the water level in Devils Hole. Although the underground reservoir from which the water is being withdrawn is vast, annual recharge rates are very low, which is consistent with a desert environment. Thus, recovery of water-level decline from pumping would be very slow, and any damage that might be done to groundwater-dependent resources would likely be long term in nature. While scientists do not know whether the current water level is a factor affecting pupfish, they are clear that if water level continues to decline, the fish ultimately will be adversely affected.

RECENT ACTIVITIES

In response to the observed decline in the number of pupfish, the U.S. Fish and Wildlife Service (USFWS) convened the Ash Meadows Recovery Team. The recovery team held its first meeting in fall 2002 and has been working to ensure the continued survival of the fish. Recent and ongoing activities include development by University of Nevada–Las Vegas researchers of a predictive model that links habitat variables to population dynamics, a

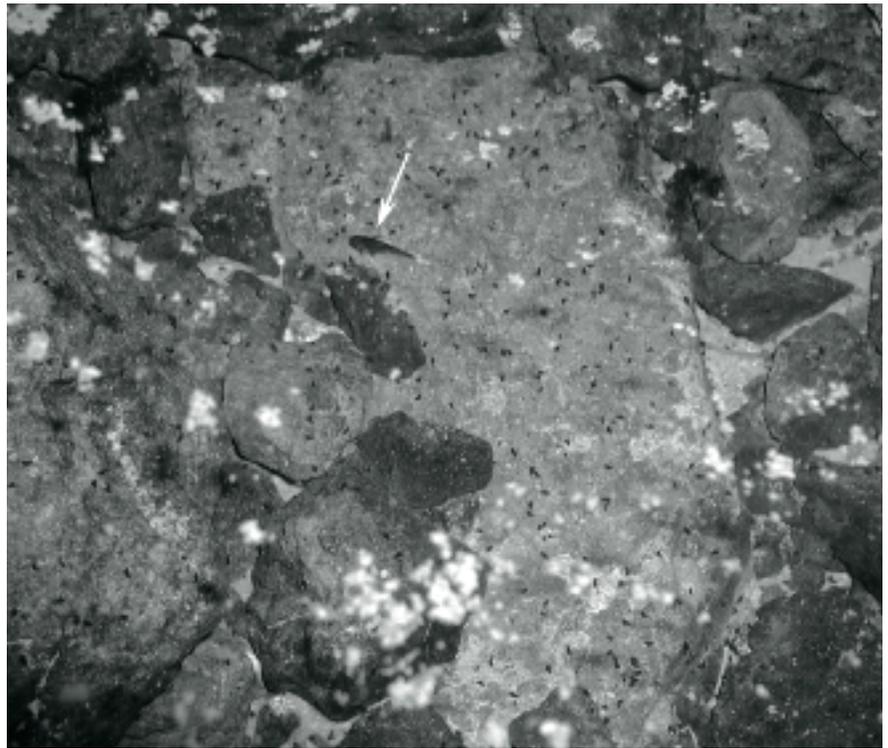


Figure 5. Pupfish forage on the shallow shelf that underlies the southern portion of Devils Hole pool. Conditions on the shelf, which provide a surface for both primary production and spawning, may have deteriorated in recent years because of changes in temperature and increased deposition of fine sediments. A single pupfish appears in the upper center of the photo (arrow). The dark spots on the rocks are mostly a species of snail, one of relatively few invertebrates found in Devils Hole. The white spots are calcium carbonate crystals floating on the surface of the pool. Interestingly these calcium carbonate crystals were the dominant item in pupfish stomachs during food habit studies conducted in the late 1960s and from 1999 to 2000. Because these crystals do not have much food value, investigators believe that they are ingested because of the diatoms on their surface. NPS/JOHN WULLSCHLEGER

Southern Oregon University study of hatching success and larval survival, and an effort to establish a new refuge. Although three refuges exist, pupfish have recently disappeared from one. Conditions in all three refuges have been so different from those in Devils Hole that they subject the fish to different selective pressures, resulting in rapid changes in the appearance and behavior of the fish. The USFWS Ash Meadows National Wildlife Refuge has recently acquired funding under the Southern Nevada Public Lands Management Act (SNPLMA) for the design of a new refuge that will allow closer monitoring by USFWS, NPS, and Nevada Division of Wildlife staffs and will better emulate conditions in Devils Hole. An application for construction funds has been ranked highly in the most recent round of the SNPLMA project selection process. Because of the precarious status of Devils Hole pupfish, establishment of a stable, genetically viable refuge population is critical to the protection of the species.



FUTURE MANAGEMENT

On 11 September 2004 a localized storm deposited an unknown amount of precipitation on Devils Hole and its small but steep watershed. No precipitation occurred at park headquarters or even at the headquarters for Ash Meadows National Wildlife Refuge, a short distance away. As a result, NPS personnel did not visit Devils Hole until several days after the event. Upon arrival they discovered that the security gate and metal frames that were installed for water-level and fish monitoring had interfered with the natural processes of sediment transport and delivery: the gate effectively trapped coarse sediment such as gravels and cobbles; the metal frame, which rests on the shallow shelf, appeared to have interfered with flow across the shelf leading to higher deposition rates of fine sediment. In addition, larval fish sampling equipment, which was temporarily stored inside the gate, was washed into the pool where it resulted in direct mortality of approximately 80 fish.

Actions taken to address the immediate effects of the flood included a February 2005 interagency effort that resulted in the removal of fine sediments and the metal frame that was used to support an access platform. Since then, surveys conducted by Southern Oregon University and the National Park Service have documented the presence of young-of-the-year fish from March through May. Given the absence of successful reproduction following the flood, the presence of these young fish is encouraging. The NPS Water Resources Division has committed funds to a water chemistry study with special reference to DEHP, a plasticizing agent, and the fabrication of a new, less intrusive access platform. DEHP is pervasive in the environment and belongs to a family of chemicals, phthalates, that can reduce reproductive function in aquatic organisms. Recent tests showed elevated levels of this compound compared to tests conducted in 1999.

However, the flood is likely to have more far-reaching effects on the management of Devils Hole: the National Park Service, U.S. Fish and Wildlife Service, and cooperating agencies have become aware of the importance of evaluating the potential adverse effects of actions that are intended to protect the fish and their habitat. Additional actions, which are in various stages of progress, include development of revised protocols for research and management; development of a Devils Hole emergency response plan and contact list; removal or relocation of pool-stage monitoring equipment and development of alternative, less intrusive monitoring methods; installation of transmitters to allow real-time monitoring and more rapid detection of precipitation and seismic events; and relocation of the perimeter fence and security gate to reduce interference with watershed processes.

CONCLUSION

It is humbling for managers and scientists to realize that after more than three decades of research and monitoring, we have been unable to develop a complete understanding of the variables that limit the pupfish in the small and relatively simple aquatic system of Devils Hole. It is equally humbling to recognize that our best efforts to understand and manage Devils Hole have unintended consequences that may themselves prove detrimental. Unfortunately, in light of recent trends and existing and emerging threats, a “hands-off” approach is probably not possible. Providing for the protection of this unique species and its ecosystem is likely to require ongoing research and management programs for the foreseeable future. The challenge for the National Park Service and its partners is to ensure that both research and management are conducted in a manner that minimizes impacts. The still greater challenge that lies ahead is convincing society that preserving Devils Hole and the Devils Hole pupfish are important enough to warrant exercising restraint in the development of groundwater resources in the arid Southwest.

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