

Science Notes

Pupfish recovery targets food availability at Devils Hole



Figure 1. A pair of Devils Hole pupfish engages in spawning courtship on 24 September 2007. As of 29 September 2007, 92 adult individuals remained in the wild habitat of Devils Hole, up from 85 in September 2006.

NPS/SARAH FLOOD

THE DEVILS HOLE PUPFISH (*Cyprinodon diabolis*)—a tiny fish with one of the world's smallest known habitats for a vertebrate—was one of the first species listed as endangered in 1966 (fig. 1). Since then, scientists have learned much about the ecology and life history of this species (e.g., Riggs and Deacon 2004). However, a recent population decline beginning in the mid-1990s serves as a reminder of the need for proactive and sustained ecological research and monitoring that guide the development of scientifically credible management strategies. In the absence of this information, the Devils Hole pupfish recovery team has been forced to triage existing hypotheses in order to identify management prescriptions that may stabilize the single wild population, and to buy time to understand the true nature of the observed population decline.

Since 2005, when *Park Science* published the status of the recovery effort for the Devils Hole pupfish (i.e., Wulschleger and Van Liew 2005), two consecutive surveys in spring 2006 and 2007 estimated the population of Devils Hole pupfish at 38 adult individuals. These two counts marked the lowest on record. In the absence of a clear cause of the observed decline in the wild, and therefore a clear solution, response focused on captive propagation

experiments and establishment of refuge populations outside of Devils Hole. These ongoing efforts have proved challenging, however, leading managers to further consider methods to stabilize the single wild population.

Managers and scientists have put forth a multitude of viable hypotheses to explain the current decline (see Wulschleger and Van Liew 2005). One hypothesis that has recently received management attention relates to food availability for the Devils Hole pupfish. Though specific monitoring data from which to assess trends in food availability are unavailable, several associated ecological investigations have collected pertinent information. The morphology and life history of the Devils Hole pupfish suggest food is limited annually, particularly in the late fall and winter when primary production is minimal (Minckley and Deacon 1973; Riggs and Deacon 2004). Moreover, research established a positive correlation between primary production and Devils Hole pupfish population size while documenting increased mortality of 0.6- to 0.7-inch (15 to 19 mm) fish during the late fall, presumably in response to starvation rather than old age (James 1969). If food availability has historically acted to regulate the size of the Devils Hole pupfish population under natural conditions, then small reductions in system productivity would likely result in fewer Devils Hole pupfish.

Though annual food limitations appear to be a major feature of the evolutionary history of the Devils Hole pupfish, several lines of evidence suggest that these limitations have increased in magnitude. Anecdotal observations of fish condition made in December 2006 indicated that adult and juvenile fish were emaciated, were mottled, and had eroded fin margins—all potential indications of malnutrition and all thought to be unusual observations. Comparing Devils Hole pupfish gut contents from before and after the initiation of the recent decline reveals the possibility that shifts in the algal community, from one dominated by the green alga *Spirogyra* to one dominated by cyanobacteria, have occurred (Minckley and Deacon 1975; Wilson et al. 2001). Cyanobacteria are thought to decrease the efficiency of energy

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transfer through the food web, ultimately resulting in reduced biomass at the higher levels of the trophic structure (Stockner and Porter 1988), which in this case are occupied by the Devils Hole pupfish. In a study of energy flow through the Devils Hole ecosystem, researchers did not find the isotopic signature of cyanobacteria in the tissues of Devils Hole pupfish, further suggesting that this energy source was not efficiently transferred (Wilson et al. 2001).

A rigid experimental approach to test the food availability hypothesis was not feasible given the precarious status of the Devils Hole pupfish population. Eventually, however, managers decided to supplement the diet of the wild population in hopes of relaxing the carrying capacity of the system. In January 2007, investigators initiated low-level supplemental feeding using a prepared flake feed developed to nutritionally mimic the diet of the Devils Hole pupfish.

Though supplemental feeding was intended to stabilize the population by potentially compensating for a number of factors that could reduce the carrying capacity of Devils Hole, it also represents a preliminary, if crude, test of one of many viable hypotheses to explain the recent population decline. Initial results from 2007 suggest that larval production has outweighed both 2005 and 2006 levels, and a survey of adult pupfish conducted in late September, which puts the population of adults at 92 individuals, suggests that the population has not continued to decline and that it increased slightly from 2006.

In an attempt to avoid the need to employ crisis management techniques, efforts are under way to implement long-term ecosystem research and monitoring to better understand ecological processes and ecosystem conditions at Devils Hole while specifically targeting individual hypotheses

that may explain the recent decline of the Devils Hole pupfish population.

References

- James, C. D. 1969. Aspects of the ecology of Devils Hole pupfish, *Cyprinodon diabolis* Wales. Thesis. University of Nevada, Las Vegas, USA.
- Minckley, C. O., and J. E. Deacon. 1973. Observations on the reproductive cycle of *Cyprinodon diabolis*. *Copeia* 1973:610–613.
- Minckley C. O., and J. E. Deacon. 1975. Foods of the Devils Hole pupfish, *Cyprinodon diabolis* (Cyprinodontidae). *The Southwestern Naturalist* 20:105–111.
- Riggs, A. C., and J. E. Deacon. 2004. Connectivity in desert aquatic ecosystems: The Devils Hole story. In *Spring-fed wetlands: Important scientific and cultural resources of the intermountain region*, May 7–9, 2002, Las Vegas, Nevada. Conference Proceedings, Desert Research Institute. Available at <http://www.wetlands.dri.edu> (accessed 1 October 2007).
- Stockner, J. G., and K. G. Porter. 1988. Microbial food webs in fresh-water planktonic ecosystems. Pages 69–83 in S. R. Carpenter, editor. *Complex interactions in lake communities*. Springer-Verlag, New York, USA.
- Wilson, K. P., D. W. Blinn, and D. B. Herbst. 2001. Devils Hole energetics/community relationships: Death Valley National Park, California. Two-year progress report to Death Valley National Park. Project 7530. Northern Arizona University, Flagstaff, Arizona, USA.
- Wulschleger, J. G., and W. P. Van Liew. 2005. Devils Hole revisited: Why are pupfish numbers and water level dropping again? *Park Science* 23(2):26–30.

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