Supplemental Finding for
the Devils Hole Pupfish (*Cyprinodon diabolis*), within the Recovery Plan for
the Endangered and Threatened Species of Ash Meadows, Nevada

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BACKGROUND INFORMATION

Section 4(f)(1)(B)(ii) of the Endangered Species Act (Act) requires that each recovery plan shall incorporate, to the maximum extent practicable, "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list." It is possible that for some species, however, delisting cannot be foreseen at the time a recovery plan is written. In some rare cases, the best available information is so seriously limited that it is truly not possible to identify delisting criteria. This would be an unusual case, such as one in which the species' threats are not understood well enough to identify priorities and appropriate mitigation. For example, the natural habitat may have been so reduced for an endangered species that captive propagation and active management is necessary for the life of a reasonable recovery plan. In another example, the population of a long-lived, slow growing species may be so depleted that possible recovery may be beyond the life of a reasonable recovery plan.

A 2006 Government Accountability Office (GAO) audit of the National Marine Fisheries Service's (NMFS) and U.S. Fish and Wildlife Service's (FWS) endangered species recovery programs recommended that the Secretaries of the Department of Commerce and the Interior direct their staff to ensure that all new and revised recovery plans have either recovery criteria evidencing consideration of all five delisting factors or a statement regarding why it is impracticable to do so (GAO 2006). Since the 2006 GAO audit, we have updated our recovery planning and implementation guidance (NMFS and FWS 2010), and new plans have included determinations regarding the feasibility or possibility of incorporating delisting criteria related to each of the five factors, as recommended by the GAO. Active recovery plans remain, however, that lack delisting criteria and contain either an incomplete determination regarding the practicability of incorporating delisting criteria, or are silent about the absence of delisting criteria in the recovery plan. In this document, we clarify why it remains impracticable to incorporate delisting criteria for Devils Hole Pupfish in the Recovery Plan for the Threatened and Endangered Species of Ash Meadows, Nevada.

METHODOLOGY USED TO COMPLETE THE FINDING

This finding is provided by the FWS, and is based on a review of the best scientific data available relevant to recovery planning for the Devils Hole Pupfish (*Cyprinodon diabolis*), including but not limited to the 1980 Devils Hole Pupfish Recovery Plan, and the 1990 Recovery Plan for the Endangered and Threatened Species of Ash Meadows, Nevada (FWS 1980, 1990). More recent information relied upon since the recovery plans of 1980 and 1990 include the 2017 Devils Hole Strategic Plan Phase 1 (Hauser 2017) and ongoing research and monitoring reports from the state and federal agencies that actively co-manage the Devils Hole pupfish. Co-management responsibilities for the species includes representatives from the U.S. Fish and Wildlife Service (FWS), National Park Service, and the Nevada Department of Wildlife (hereafter, Devils Hole Incident Command Team, or "ICT)."

BACKGROUND

Habitat. The Devils Hole pupfish (DHP) exists precariously as a relict species of biological diversity from pluvial (rainy) periods in geologic time. With arguably the smallest extent of habitat of any vertebrate species, the DHP survives in the submerged limestone cavern of Devils Hole (2.5-meters (m) x 20-m) in Nye County, Nevada. Devils Hole supports the only naturally-occurring population of the Devils Hole pupfish (Wales 1930). In addition to this population,

there is a research-focused refuge tank at a nearby location (Ash Meadows Fish Conservation Facility) operated by the FWS to 1) investigate the spawning biology of DHP, and 2) provide a refugium (second location) if conditions become unsuitable at Devils Hole. Approximately 75 fish are maintained at this location currently (ICT 2019). DHP feed and spawn on a shallow rock shelf that extends part-way across the upper water column at Devils Hole. The limited habitat and small population size, together with the threats from habitat loss due to water development and other anthropogenic stressors, resulted in the immediate listing as endangered under the Endangered Species Preservation Act of 1966.

The environment of Devils Hole is characterized by habitat extremes including high temperature, low dissolved oxygen, fluctuating food resources, and catastrophic events (such as earthquakes). In addition to those inhospitable environmental conditions, anthropogenic habitat modification has likely negatively influenced the abundance of the DHP historically (Brown 2017), and continues to pose a significant threat into the future (Hausner 2017). The small population of DHP is perennially stressed and demographically endangered as evidenced on several occasions (e.g., in 2006 and 2013) when standardized population surveys suggested as few as 35 total animals remained.

Demographic resiliency. The exact size of the population of DHP in Devils Hole is unknown although standardized population surveys (hereafter, counts) conducted annually since 1972 provide the best index of actual abundance. A variety of microhabitats (e.g., rocky crevices, dense algae mats, rock ledges) confounds deriving a true population count (census). Despite the difficulties in estimating true population size, our count estimates have shown that relative abundance fluctuates over short time periods, correlated with seasonal changes in habitat conditions. Considering the entire period of record (1972 – present), seasonal counts have ranged from a high of 553 to a low of 35 fish and, for most of that reporting period, fall counts have been higher than spring counts conducted in the same year (Figure 1). The highest counts for the period of record occurred prior to 1996; counts in recent years have been considerably lower and typically fluctuate around 100 fish. While the reasons for this apparent decline are unknown, several hypotheses are supported by a hierarchy of evidence. These include (in no particular order) changes in the environment affecting water quality (e.g., temperature, dissolved oxygen), physical habitat availability, ecological productivity, food availability, and the loss of genetic variation through bottlenecks in population size. Hypotheses are not mutually exclusive and in some cases may be interdependent. The number of hypotheses, their complexity, and the potential of synergistic effects make biological interpretation of DHP population dynamics a significant challenge.

The unique biological and ecological conditions of this system make standard fish conservation approaches impractical in many respects. Comparisons to historic data suggest that the current population size is suboptimal. The mean value for the fall count was 444 during years 1980-1999, a period when the population was generally believed ‘healthy’, compared to a mean of 147 from 2000-2018 (mean values for the spring count were 218 and 101 for the same periods, respectively). The management agencies consider the 3-fold reduction from historic population sizes to likely reflect human-induced changes to habitat quality and quantity, although specific drivers and their relative influences remain unclear.

Management agencies have not identified an ideal (stable) population size for the DHP in Devils Hole but recognize that there is an inverse relationship between population size and risk of extinction. Increasing the population size of the DHP is particularly important to ensure the persistence of the species due to natural stochastic events such as flooding, earthquakes, and changes in carbon sources that can further reduce population size and genetic variation. A number of management actions have been implemented to increase population size in recent years. Supplemental feeding, which began in December 2006, as an attempt to mitigate the impacts of low productivity and limited food supply shows some evidence that it has contributed to small increases in numbers. Managers have also attempted to address deficiencies in cover and organic matter by introducing discrete packets of woody debris on the shallow shelf. These "cover packets" are used by fish, particularly smaller individuals, and biologists have documented that they provide pockets of cooler water and serve as substrates for biofilm. However, the explicit effects on population size are unknown. Supplemental feeding and cover augmentation are believed to address secondary impacts of broader ecosystem changes and are considered temporary measures until those underlying changes are identified and mitigated. An additional management action may addresses the direct impact of sediment deposition on the shallow shelf from inflowing storm runoff by removing fine sediment from the shelf. Deposited sediments bury or remove algae, reduce habitable space in the water column over the shelf, degrade the substrate for egg incubation and larval rearing, and may increase susceptibility to high air temperatures during the summer. The scale and scope of sediment removal have been based on post-event habitat assessments and are thought to reduce, but not eliminate, the impacts on the DHP.

Historic and current status. During the late 1970s, the population increased from a perilously low number (300) subsequent to a Supreme Court decision to ensure adequate water levels in Devils Hole, increasing to approximately 500 individuals when the water was restored. A fall count estimate of ~500 fish continued throughout the 1980s and early 1990s, until the population entered into a precipitous decline beginning around 1995 (Figure 1). Throughout the 2000s the population has continued to be characterized by extremely low population size averaging around 100 fish counted. In two instances, the spring counts reached all-time lows of 39 and 35 fish observed, in 2006 and 2013, respectively (ICT data). The current (fall 2019) index of population size is 170 fish (ICT data 2019).

FINDING

We have reviewed best available information for the purposes of evaluating the feasibility of developing delisting criteria for the Devils Hole pupfish at present. We relied most heavily on the past and current annual monitoring data, as well as the weekly interagency recovery discussions used to manage this species. The FWS concludes that the development of delisting criteria remains impracticable. In fact, both delisting and downlisting criteria have shown to be problematic or infeasible to adequately define. The 1990 recovery plan failed to identify any objectives for delisting the Devils Hole pupfish, and here, we similarly find that lack of information prevents the development of delisting criteria. This is due to the following reasons:

1) Managers don't know how many pupfish existed before anthropogenic impacts reduced the population size, or how many pupfish might provide a measure of demographic resiliency. Managers in the 1980 recovery plan recommended as a recovery goal a population in Devils

Hole that fluctuates from 300 in winter to 700-900 in late summer, but such an estimate has proven entirely insufficient for delisting or even downlisting considering the population crashed to <40 fish in 2006 and 2013. Because the habitat is very small in scale, any local variation in environmental effects (such as flooding and earthquakes) influence the entire habitat, and paired with the short lifespan of an essentially annual species, results in natural variation in population size that is nearly impossible to predict.

2) The natural variation in population size mentioned above is compounded by anthropogenic stressors. Humans have modified the habitat by groundwater pumping, biological community interactions, resource availability, climate change, and other factors, and have affected Devils Hole in unknown and complicated ways. At present, the ICT is uncertain of which limiting factors, and how the relative influence of each, are affecting the population size of this species. Recent surveys (ICT data 2019) show the population at present is likely less than 200 fish, a population size undoubtedly on the brink of extinction. Despite the ICT's best efforts, it is still unclear why the population crashed from 500 animals post-1995 to fewer than 200 fish at present, or the demographic stressors leading to the exceptionally low estimates of 35 and 39 fish in years 2006 and 2013.

At present, it is not possible to determine what measures are needed to indicate that the species is no longer threatened or endangered. As such, the ICT cannot quantify or otherwise define recovery or how to achieve it mechanistically. The immediate need for the Devils Hole pupfish is to continue research at the Ash Meadows Fish Conservation Facility and in the wild at Devils Hole. Understanding the combination of threats, how they interact, or potentially change seasonally, are high priorities for the recovery team. Given the longstanding and extreme peril that characterizes the DHP, most previous studies are indirect or have used surrogate species. The results of these studies have unfortunately been of only moderate utility as the unique cave habitat of high temperatures, low resources and phylogenetic distinctness make the DHP very different from other pupfishes.

However, the ICT has potentially three major developments in the coming year 2020 that may inform threatened and endangered criteria with respect to this species. The first involves new developments in the propagation of DHP eggs from the FWS refuge tank. Eggs have now hatched under propagation techniques from fish derived from the refuge tank (ICT data 2019). The ability to use propagation tools to conduct future research opens the door for better understanding this species and mitigating the stressors responsible for low survival. A related consumptive action not available prior to successful egg propagation, is for the sacrifice of captively-reared fish to sequence the DHP genome. Understanding how DHP differ genetically from other pupfish might provide reasons why survival is unusually low relative to other pupfishes. This information would provide useful context to assess hypothesized inbreeding effects, and whether the population is likely to be restored, with or without genetic rescue, and inform a future recovery plan. The third development for next year is the development of a strategic plan to mitigate loss of individuals by identifying population trends and providing agreed upon management actions acceptable to the three managing agencies. This document was completed in draft form during fall 2019, and is currently under review. By utilizing the available mitigation techniques in this plan, the ICT could more closely evaluate effects of threats on the population in the foreseeable future, and therefore inform future delisting criteria.

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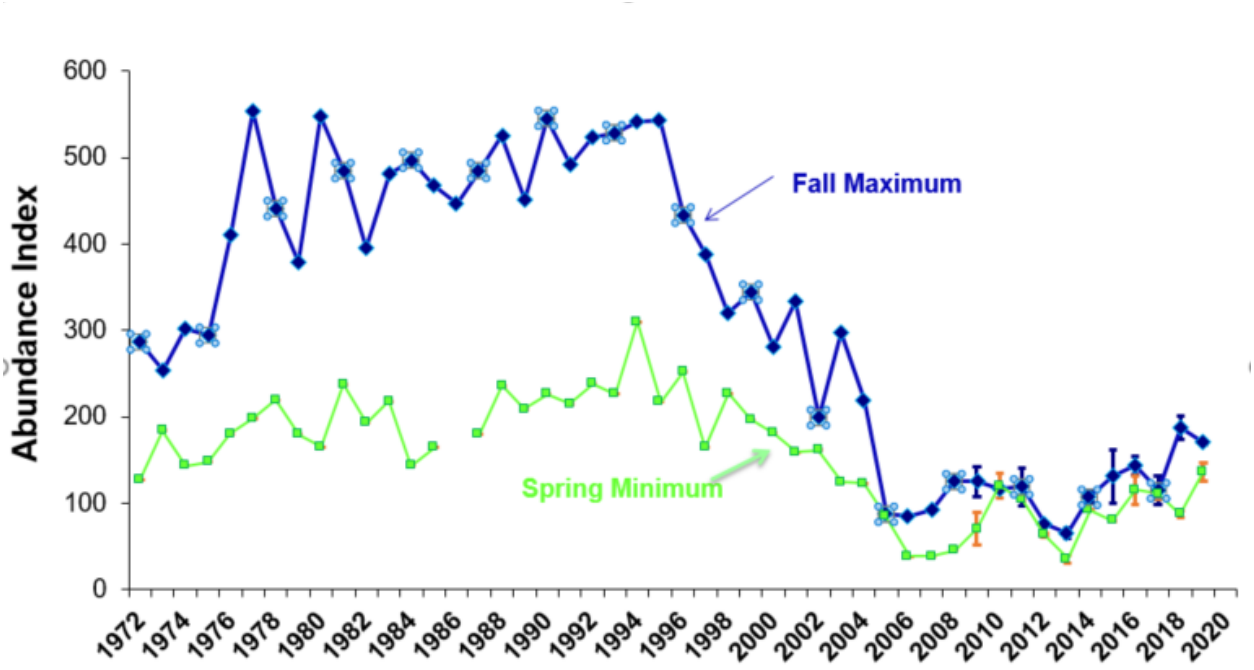

Figure 1. Fall and spring estimates of population size for the Devils Hole Pupfish from 1972 to 2019. Data compiled from biannual surveys conducted by the Devils Hole Incident Command Team (ICT [2019]).