

People or Pupfish?

New Mexico Adventures in Supercomputing Challenge

Final Report

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Team Members

Eric Willhelm

Taryn Russell

Teacher

Mr. Greg Anderson

Project Mentor

Dan Baggao

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Executive Summary

The Pecos pupfish is a small fish whose habitat lies along the Pecos River. At one time the Pecos pupfish was abundant, occupying the river and its tributaries through close to the whole length of the Pecos River. Sometime in the early 1980s the Sheepshead minnow was introduced into the Pecos River by way of bait buckets. Within a relatively short period of time the two species of fish began to interbreed. After only a decade the population of pure pupfish had decreased by eighty percent. The population of hybrids, however, has since grown rapidly. That in combination with a decrease in habitat continues to threaten the existence of the Pecos pupfish. The Pecos pupfish now resides in only a few places along the Pecos River. The main habitats are Bitter Lakes National Wildlife Refuge and Bottomless Lakes in Roswell, New Mexico, and Salt Creek in Texas. One may ask why we would even be concerned with the size of the Pecos pupfish population. It is not because we are deeply interested in the well being of an obscure fish species. It is simply law. The main purpose of protecting endangered or threatened species is to keep native creatures in their native habitats. The Pecos pupfish has only one native habitat, which is the Pecos River, and unless something is done it will soon lose that. Our project explores the population growth, or decline as the case may be, of each of the three species. By use of mathematic population equations and a computer program to model the results, we have been able to project the population for the next several years. Our findings show that the Pecos pupfish is declining, as is the Sheepshead minnow, while the hybrid population is growing rapidly.

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The Pecos River Valley and the BLM-administered Overflow Wetlands serve as one of the primary habitats for the Pecos Pupfish. This species is currently a federal candidate for listing as Threatened or Endangered by the U.S. Fish and Wildlife Service. One of the greatest sources of concern is the conflict over the water pact with Texas regarding the Pecos River. The small amount of water that flows through the Pecos is supposed to sufficiently support agricultural needs and the demands of the preservation of wildlife while still leaving enough water to send on to Texas. The minimum requirements of the fish must be ascertained in order to find a balance and compromise. We chose this problem because it is one that can help save other endangered species facing similar problems. The Pecos pupfish is a native species to the Pecos River. The populations once spanned most of the length of the river. In the early 1980s, however, the Sheepshead minnow of the Gulf and Atlantic coasts was introduced to the area by bait buckets. Within a little over a decade, the pupfish and Sheepshead minnow had interbred to such an extent that the population of the Pecos pupfish declined by a large percent. (Echelle and Echelle 1978)

We began our project by familiarizing ourselves with the Pecos pupfish as much as possible. We spoke to biologists, read books, and searched the Internet. In the process we found many interesting facts. At first our focus was the habitat and its problems. Although these are both important threats, in the midst of researching that, we found that hybridization with the Sheepshead minnow was by far the greatest threat. (Soussan, 2000) It seemed as though source after source mentioned more and more about the problem of hybridization. It was at this point that we decided to model the potential population growth and decline of the Pecos pupfish. We wanted to see what might happen if hybridization continued at the same rate if the Pecos pupfish and Sheepshead minnow remained together in the same habitat and at the same numbers.

Before starting our program, we looked at the different types of models. Faced with the decision of a definite deterministic model or a stochastic model with the aspect of random chance, we chose the stochastic model. We are dealing with a small population in which random chance has a large effect. When starting the writing of our program, we made a list of specific rules for it. We set the initial populations of all three fish and the carrying capacity of the habitat. (Starfield and Bleloch, 1986) We also estimated the rate at which each fish reproduces, including the rate at which the Pecos pupfish and Sheepshead minnow interbreed. We researched the number and frequency of the different species' production of eggs. We used the equation $dN/dt = rN(K-N/K)$ to calculate the population growth. We used this equation, in a slightly altered format, for each of the three fish populations.

With our first attempt, our results were not as expected. The form in which we used the equations caused the population growth we expected at first, but once the capacity was reached, the numbers remained static. The indication of these results was that once the capacity was met, each population would have a birth rate equal to its death rate and therefore no numbers would change. So we headed back to the Internet. We found another twist on the population growth equation that considered the affect of

competition between two or more populations. We decided this was a good choice because hybridization certainly causes competition between the Pecos pupfish, the Sheepshead minnow, and the hybrids. Unfortunately, we have not yet been able to determine the best way to use the equation in our model.

We have limited results compared to what we hoped we would have. At this point we realize that we need to have real numbers and experience with the Pecos pupfish and its habitat in order to fully understand and complete our project. We have also learned that very few people, even in the science community, know or care about the Pecos pupfish. It seemed strange, then, that there is an effort to protect the Pecos pupfish. There is a more logical reason than we expected. It is simply a law. The government is required to keep native species in their native habitats and ensure they have the best possibility to survive. The Pecos pupfish is in danger of not only becoming endangered or extinct, it is in danger of being forced out of its habitat by a fish that is native to the east coast.

Our results were not as expected. Although we plan to continue working toward an accurate computer model, our recommendation would be to find a new mathematical equation that would realistically model what happens to the populations after capacity is reached. If those results were to come out as we expect, then it would definitely be necessary to remove most, if not all, of the Sheepshead minnows and hybrids from the habitat. We believe that would help the Pecos pupfish to grow at a much higher rate without facing the competition of another species. Our prediction was not based entirely on speculation. It is stated that “the exclusion of the Sheepshead minnow from Bitter Lake National Wildlife Refuge and Bottomless Lakes State Park is essential to preventing the contamination and eventual extinction of the Pecos pupfish in New Mexico.” (Brooks and Wood, 1988)

Many people have helped us along with our project over the last several months. The one person who has guided us the most is our sponsor, Mr. Anderson. He has given us direction for all of our research and programming. Mr. Dan Baggao at the Bureau of Land Management also helped us in the beginning. He gave us the information about the Pecos pupfish that led us to choose it as our topic. We also received a considerable amount of help from two main written sources: Biota Information System Of New Mexico (BISON) and *Building Models for Conservation and Wildlife Management*.

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