Gene Banking Efforts for Endangered Fishes in the United States

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Introduction

A number of fish species have declined in population size or become extinct in the United States, primarily as a result of habitat changes (Ono et al. 1983; Minckley and Deacon 1991; Cloud and Thorgaard 1993; Magnuson et al. 1996). One approach that has been considered in some cases where drastic declines have occurred is the use of gene banking based on sperm cryopreservation to avoid the loss of valuable genotypes. However, such efforts have been relatively limited to date. This paper reviews some of these efforts and identifies some factors that have limited the application of this conservation approach in the United States.

Government in the United States is relatively decentralized compared to that in many other countries. The national (federal) government has responsibility for anadromous and marine fishes and for enforcement of some national regulations (e.g., the U.S. Endangered Species Act). Relevant federal agencies include the U.S. Fish and Wildlife Service, which is primarily concerned with freshwater fishes, and the National Marine Fisheries Service, concerned with marine and anadromous fishes. The 50 States also have authority over fishes within their borders. Examples of State management agencies in the northwestern United States include the Washington Department of Fish and Wildlife and the Idaho

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Department of Fish and Game. Indian tribes within the United States have their own governmental authority and frequently have their own fishery management agencies and biologists. A given fish population may thus be subject to management by several agencies. Management of the salmon of the Columbia River is a prime example of this overlapping responsibility. This rather complex situation does not always contribute to the most efficient management of the populations.

Given the size of the United States and the complexity of the web of agencies managing fishes in this country, we likely may not have identified the full scope of gene banking efforts for fishes in the United States in this review. However, in discussing this issue with people actively engaged in such efforts we believe that we have identified the major focus areas and programs for endangered fishes. The three major foci of gene banking efforts in the United States appear to be (1) Columbia River salmon, (2) Colorado River fishes, and (3) Midwestern and Eastern US sturgeon. We will review each of these foci in order and then discuss some of the overall issues and constraints common to these efforts.

Columbia River Salmon

The Columbia River was historically one of the largest producers of salmon in the world. Unfortunately, primarily due to problems associated with the passage of juveniles around hydroelectric dams which have been built in this drainage, the salmon runs have declined drastically (Magnuson et al. 1996). This has led to the listing of populations of chinook and sockeye salmon in the Snake River, the principal tributary of the Columbia, as endangered under the U.S. Endangered Species Act. In spite of this listing, the populations have continued to decline.

The Nez Perce tribe, with its ancestral homelands in the Snake River basin, has been particularly sensitive to this decline. They have initiated a program to collect sperm from endangered Snake River chinook salmon (Paul Kucera, Nez Perce Tribal Department of Fisheries Resource Management, personal communication). The sperm is collected and stored at the University of Idaho in the laboratory of Joe Cloud and at Washington State University by Paul Wheeler in the laboratory of Gary Thorgaard (Thorgaard et al. 1998). Sperm from a total of 259 individual chinook salmon has been collected and stored from 12 Snake River tributaries. In addition, these universities are storing sperm from 20 other chinook salmon and from 122 Snake River sockeye salmon for the Idaho Department of Fish and Game. Additionally, the Washington Department of Fish and Wildlife is using cryopreservation in its programs in southeastern Washington for Snake River chinook salmon. Together, these efforts represent the most developed gene banking effort at this time for fishes in the United States.

Sperm cryopreservation is also being used in efforts to propagate the endangered winter-run chinook salmon of the Sacramento River (Kristen Arkush, University of California Bodega Marine Laboratory, personal communication). These efforts are primarily focused

around breeding management, although sperm samples have been held for as long as five years and could be used in recovery efforts in the event of future population declines.

Colorado River Fishes

The Colorado River flows through one of the most arid parts of the United States, and there has been considerable development of dams in this basin to allow maximal utilization of the limited available water resources. This impoundment of the river has resulted in dramatic alteration in the habitat of much of the basin and declines in abundance of the native fishes, primarily cyprinids and catostomids (Ono et al. 1983; Minckley and Deacon 1991).

Unlike the salmonids, the technology for cryopreservation of the Colorado River fishes had not been previously developed. Work at Louisiana State University has developed these methods for several Colorado River fish species (e.g., Tiersch et al. 1997; Tiersch et al. 1998). These efforts complement the captive breeding programs which are ongoing for these species at U.S. Fish and Wildlife Service facilities such as the Dexter, New Mexico National Fish Hatchery (Johnson and Jensen 1991).

Although hundreds of sperm samples are being held at Louisiana State University, no comprehensive gene bank has yet been developed for Colorado River fishes. Some biologists in this region have expressed concerns that a gene bank might divert efforts away from habitat protection and enhancement.

Midwestern and Eastern U.S. Sturgeon

A number of sturgeon species have declined in the midwestern and eastern United States, primarily due to habitat changes but also due to overfishing on these long-lived and late-maturing fishes. The technology for sperm cryopreservation is not as well developed for these fishes as it is for the salmonids, cyprinids or catostomids. This may be due to differences in sperm cell structure, including the presence of an acrosome.

Interest in sturgeon sperm cryopreservation comes from both an aquaculture and a conservation standpoint. The efforts by Steve Mims at Kentucky State University and George Brown at Iowa State University have resulted in the improvement of methods for cryopreservation of sperm from paddlefish and shovelnose sturgeon (Steve Mims, Kentucky State University, personal communication). Also in this region, the laboratory of Konrad Dabrowski at Ohio State University is working to develop a Midwest Sperm Bank which is designed to maintain a collection of lake sturgeon (Ciereszko et al. 1996), perch, walleye and muskellunge samples (Konrad Dabrowski, Ohio State University, personal communication). In the Southeast, the U.S. Fish and Wildlife Service's Technology Center at Warm Springs, Georgia, under the directorship of Vincent Mudrak is involved in cryopreservation of sperm from the shortnose sturgeon, as well as the robust redhorse, a

catostomid species (Greg Looney, Warm Springs Technology Center, personal communication) in collaboration with Bill Wayman and Terry Tiersch of Louisiana State University.

Common Issues and Constraints

The complexity of governmental structure in the United States has likely been one of the factors that has limited the development of gene banking efforts for fishes in the country. With several agencies often involved in the management of a specific fish population, the question of who is ultimately responsible for preventing extinction of a given population is sometimes unclear. This has been evident in the Pacific Northwest with salmon, where divided responsibility can lead to confusion and inaction.

The ecological, as opposed to agricultural, background of many fishery biologists may also have contributed to inaction in the gene banking arena. While people with an agricultural background are comfortable with the notion of gene banks, having been exposed to such activities for cattle and seed banks for crop plants, many ecologically trained biologists appear to view such efforts as a distraction and possibly even a threat to efforts to protect the habitat, which they correctly view as their top priority. However, when inexpensive efforts to provide an insurance policy for species approaching extinction are blocked under such circumstances, such good intentions may ultimately and ironically lead to the extinction of the very populations requiring protection.

Perceptions that cryopreservation is complicated and expensive have also hindered the application of cryopreservation to gene banking in fishes. The scientific literature on cryopreservation of fish sperm is distributed across numerous journals and fields with an apparent lack of agreement on suitable procedures for even the well-studied fishes such as salmonids. In reality, cryopreservation is relatively straightforward technically and the use of cryopreserved sperm for production is inexpensive. Recent efforts to convey the simplicity and cost-effectiveness of cryopreservation include special symposia held at the 1997 and 1998 annual meetings of the World Aquaculture Society. In addition, a book on cryopreservation of gametes and embryos of aquatic species is scheduled to be published in 1999 by the World Aquaculture Society with financial support from the U. S. Fish and Wildlife Service, Division of Fish Hatcheries.

In the long term, better coordination among agencies and better explanation of the rationale and cost-effectiveness for gene banking efforts, as well as the success of current programs, may lead to the increased use of gene banks to protect endangered fish populations.

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