

FISH DISEASE IN THE GILA RIVER BASIN  
A LITERATURE REVIEW

Carol A. Hart  
Biological Consultant

U. S. Fish & Wildlife Service  
Pinetop Fish Health Center  
Pinetop, AZ

August 23, 1999

# FISH DISEASE IN THE GILA RIVER BASIN

## LITERATURE REVIEW

### Introduction

There is scant published and non-published information on fish health in the Gila River Basin (Arizona and New Mexico, USA) and there is no such literature on the Central Arizona Project (CAP), an aqueduct which supplies water to this watershed. Central Arizona Project water introduces non-native fish species and along with them, - non-native fish pathogens, that can cause greater mortality rates in new host species (Hoffman 1970, Amin and Minckley, 1996). The purposes of this literature review are to establish a database for fish pathogens, to assess the impact of pathogens on extant threatened and endangered fish species, and to suggest management strategies when pathogens are present in the Gila River Basin (GRB). Fish health of native species in this watershed, including but not limited to Colorado squawfish (*Ptychocheilus lucius*), Gila topminnow (*Poeciliopsis occidentalis*), loach minnow (*Tiaroga cobitis*), razorback sucker (*Xyrauchen texanus*), and spikedace (*Meda fulgida*), is of paramount importance to species recovery. Fish pathogens as well as other stressors such as increased predation and competition for habitat by non-native fish jeopardize these species.

### Methods

This literature review was conducted by searching for published literature in all pertinent databases and indexes at Northern Arizona University's Cline library as well as Arizona State University's on-line library. Databases searched include Biological and Agricultural indexes, Life Sciences database, and Zoological Record. Three Internet

search engines were used to search for CAP fish health information. Finally, some pertinent references were found in literature cited sections of fish health papers in unpublished bibliographies from fishery professionals.

The following agencies and individuals were contacted for literature and non-published fish health data not found in standard library searches: Arizona Game & Fish Department (Phil Hines); Arizona State University (Paul Marsh); Bureau of Reclamation (Rob Clarkson); Institute of Parasitic Diseases (Omar Amin); New Mexico Game & Fish Department (Dave Propst); U.S. Fish & Wildlife Service (USFWS) Pinetop Fish Health Center (John Thoesen, Jerry Landye); USFWS Ecological Services, Phoenix Office (Sally Steffurud); and U.S. Forest Service (John Rinne).

### **Field sites**

All data (Table 1) from 1960 to 1998 are obtained from references covering eighteen different sites in the Gila River Basin including: Apache Lake, Aravaipa Creek, Big Bonita Creek, Canyon Creek, Gila River, Hurricane Creek, McKnight Creek, Mogollon Creek, Oak Creek, Paradise Creek, Roosevelt Lake, Salt River, San Carlos Reservoir, Spruce Creek, Sycamore Creek, Verde River, Whiskey Creek, and White River. Notably absent from this list is the CAP. All sites are located in Arizona with the exception of McKnight Creek, Mogollon Creek, Spruce Creek, and Whiskey Creek, which are in New Mexico.

Table 1 is comprised of positive data; negative data (pathogens not found) are not listed. All Gila River Basin fish health reports and papers present positive data for at least one pathogen. Restated, the reader can assume that if a field site is excluded from this report then no fish health literature exists for that location. For example, CAP is not listed

in Table 1 because no fish health reports were found for the aqueduct. All fish health studies reported in the Gila River Basin are designed to look only for eukaryotic parasites with the exception of Robinson et al., Arizona Game & Fish Fish Health Reports, and U.S. Fish & Wildlife Fish Health Reports. The later reports present fish examinations for a wider spectrum of pathogens including bacteria (prokaryotes) and viruses. Only in these exception cases may the reader assume that if a bacterial or viral pathogen is not listed that it is absent.

### **Fish species**

Twenty one species of fish are included in the reviewed fish health studies (Table 1), including: *Agosia chrysogaster* (longfin dace); *Catostomus clarki* (desert sucker); *Catostomus insignis* (Sonora sucker); *Cyprinella lutrensis* (red shiner); *Cyprinus carpio* (common carp); *Gila robusta* (roundtail chub); *Ictalurus punctatus* (channel catfish); *Ictiobus bubalus* (smallmouth buffalofish); *I. cyprinellus* (bigmouth buffalofish); *I. niger* (black buffalofish); *Meda fulgida* (spikedace); *Micropterus dolomieu* (smallmouth bass); *Micropterus salmoides* (largemouth bass); *Pomoxis nigromaculatus* (black crappie); *Ptychocheilus lucius* (Colorado squawfish); *Pylodictis olivaris* (flathead catfish); *Rhynchithys osculus* (speckled dace); *Salmo apache* (Apache trout); *S. gilae* (Gila trout); *S. trutta* (brown trout); and *Xyrauchen texanus* (razorback sucker).

### **Pathogens**

Eight different groups of pathogens are observed (Table 1): (1) one acanthocephalan species (spiny headed worm); (2) three annelida species (segmented worms); (3) nine cestode species (tapeworms); (4) one copepod species (crustaceans); (5)

three nematode species (round worms); (6) seventeen protozoa species (single celled eukaryotes); (7) eighteen trematode species (flukes); (8) sixteen bacterial species; and zero viral species. Of all pathogens listed, four are primary fish pathogens: *Costia*, *Ichthyophthirius multifiliis*, *Henneguya*, and *Renibacterium salmoninarum*. Other pathogens listed are secondary agents; they have the potential to cause fish mortality but require other factor(s) to initiate disease. The absence of *Myxobolus cerebralis* (protozoan, causative agent of Whirling Disease) is notable as it can cause mortality and deformity in young salmonids and because fishery biologists are trying to prevent its spread into Arizona and New Mexico from other western states.

## Discussion

Of these four primary pathogens, only *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD), has fishery management implications. *R. salmoninarum* is a highly virulent fish pathogen that can cause devastating fish loss in salmonid populations. When this pathogen is detected in kidney samples from free-ranging fish, it is imperative that the investigating laboratory immediately re-test the sample with another diagnostic procedure. For example, if *R. salmoninarum* is detected using a highly sensitive test such as polymerase chain reaction (PCR) or enzyme-linked-immunosorbent-assay (ELISA), a fluorescent antibody test (FAT) must be performed. If FAT is negative, fishery managers should discuss the possibility that *R. salmoninarum* antigens, but not clinical disease are present in that fish population. In this case, it is advisable to isolate the fish population in question with the use of fish barriers if possible and monitor for disease. In addition, if applicable, the originating hatchery should be contacted to examine fish disease records. If FAT is positive, immediate action must be

taken. At minimum, the fish population should be isolated using fish barriers. If the population in question is large enough to be sampled more extensively, kidney samples should be taken to ascertain the extent of disease. If clinical disease is present and the moribund fish are not threatened nor endangered species, managers should consider removal and destruction of fish from that watershed to prevent spread of BKD.

*In situ* treatment of free-ranging fish with BKD is not practical. If infected fish populations originated from hatchery stock, hatchery managers should be alerted and fish health records should be examined. In the positive *R. salmoninarum* case listed in Table 1 (U.S. Fish & Wildlife Service, 1998), fish health personnel are further investigating the watershed (Whiskey Creek, Gila Wilderness, NM) to determine the extent of pathogen and disease. They will complete surveys before making management decisions regarding this genetically pure Gila trout population.

Secondary pathogens listed in this report, such as *Lernaea*, do not require immediate action, but precautionary measures can be taken to save additional fish from infection. In the case of *Lernaea*, *in situ* treatment is not practical and rarely effective. However, if time permits during fish surveys, salt dip treatments can be performed (3% pure salt solution) on fish before release. These treatments are safe for fish, the environment, and mildly effective at removing most external parasites, but will not eliminate all *Lernaea* organisms.

A more effective management strategy for *Lernaea* and other secondary pathogens is to alert the originating hatchery to the problem, if applicable, and determine if infected fish were stocked. Hatchery managers may then opt to desiccate ponds and raceways to eliminate the pathogen. This technique was used successfully at Bubbling Ponds State Fish Hatchery (Arizona Game & Fish Department, 1994-1995) to eliminate *Lernaea* from

razorback suckers and Colorado squawfish. In this case, hatchery personnel transferred infected fish from ponds to another holding facility, removed fish from the pond water supply source, and allowed the ponds to dry for fifteen days. Ponds were then refilled and infected fish were treated in a salt bath and replaced in the ponds. By using these procedures, losses due in part to *Lernaea* were reduced at Bubbling Ponds State Fish Hatchery.

As mentioned previously, *Myxobolus cerebralis*, causative agent of Whirling Disease, was not detected in fish health surveys listed in this report. The absence of *M. cerebralis* is encouraging as its detection has resulted in destruction of fish populations in other western states to prevent its spread. Preventative management strategies against *M. cerebralis* (and other pathogens) include only importing disease-free fish that have been inspected specifically for the pathogen, and public education. For example, recreationists should be notified of the importance of cleaning boat hulls and bilges before launch into subsequent waters. Anglers should be asked to contact fishery biologists when gross pathology is observed. In the case of Whirling Disease, mis-shapen heads and spines can indicate disease in a fish population.

*Bothriocephalus*, or Asian Tapeworm, was detected in one survey listed here. Fishery biologists have determined that the exotic fish cestode which can cause fish loss will never be completely eliminated from U.S. waters. Endangered fish species may be treated against Asian Tapeworm with Dronset, an effective drug which should be used before fish are transported to new watersheds. U.S. Fish & Wildlife Service efforts are currently underway to prevent spread of this pathogen.

In summary, all pathogens listed in Table 1, with the exception of *R. salmoninarum*, require no immediate action when detected in free-ranging fish. However,

since secondary and primary pathogens are involved in fish losses, fish surveyors and fish health biologists in the field can take some positive actions. When time and resources permit, salt dips on moribund fish with external parasites can be performed in the field. These treatments are safe for the fish as well as the environment and are mildly effective at minimizing stress by reducing parasite load. When exotic fish species are found harboring pathogens that are more harmful to native fish species (e.g., channel catfish with *Lernaea*, co-located with Colorado squawfish), and fishery management plans allow, eradication of infected exotic fish species reduces stress placed on native fish species. Finally, when fish eradication is not advisable as in the case of endangered and threatened species, isolation of infected fish is advisable with the use of fish barriers. Dams will reduce and in some cases eliminate pathogen spread to non-infected fish populations. When all actions are taken and parasites continue to spread throughout fish populations, it is advisable to examine fish in adjoining streams and rivers for a source of infection. For example, CAP fish have yet to be assayed for pathogens that may spread to fish in adjoining bodies of water.

Most Gila River Basin field studies to date have focused on detecting eukaryotic pathogens. Fish surveys *must* include increased emphasis on bacterial and viral pathogens to thoroughly assay health in Gila River Basin threatened and endangered species because all known primary fish pathogens fall into these two categories. Hence, the strongest recommendation made in this report is to incorporate bacterial and viral assays in all fish health surveys performed in the Gila River Basin.

Finally, infectious agents are not always the primary cause of decreased fish health. Environmental factors such as pollutants, altered water flow regimes, and elevated water temperatures may play an important role in fish mortality (Amin 1968). Complete fish

health monitoring should also incorporate histological examination (tissue fixation, micron-thick slicing, and microscopic examination of fish tissues) to include detection of non-infectious disease agents such as elevated pesticide levels.

Table 1. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                                     | fish species                                                                                                                           | date      | location                            | reference                   |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------------------------------|-----------------------------|
| <b>Acanthocephala</b>                        |                                                                                                                                        |           |                                     |                             |
| <i>Neoechinorhynchus</i> sp.                 | <i>Catostomus insignis</i>                                                                                                             | 1966      | Verde and Salt Rivers               | Amin, 1968                  |
| <i>Neoechinorhynchus</i> sp.                 | <i>Catostomus insignis</i>                                                                                                             | 1980-1981 | Salt River                          | Mpoame and Rinne, 1983      |
| <b>Annelida</b>                              |                                                                                                                                        |           |                                     |                             |
| <i>Illinobdella moorei</i> Meyer             | <i>Catostomus insignis</i>                                                                                                             | 1966      | Verde and Salt Rivers               | Amin, 1968                  |
| <i>Myzobdella lugubris</i>                   | <i>Catostomus insignis</i>                                                                                                             | 1997      | San Carlos Reservoir                | Bureau of Reclamation, 1998 |
| <i>Piscicolidae</i>                          | <i>Catostomus clarki</i> ,<br><i>C. insignis</i> ,<br><i>Xyruachen texanus</i>                                                         | 1996      | Verde River                         | Robinson et al., 1998       |
| <b>Cestodes</b>                              |                                                                                                                                        |           |                                     |                             |
| <i>Bothriocephalus</i>                       | <i>Cyprinella lutrensis</i>                                                                                                            | 1998      | Gila River                          | AZ Game & Fish, 1998        |
| <i>Glaridacris confusus</i>                  | <i>Ictiobus cyprinellus</i> , <i>I. bubalus</i> , <i>I. niger</i>                                                                      | 1968      | Apache and Roosevelt Lakes          | Amin, 1968                  |
| <i>Isoglaridacris hexacotyle</i>             | <i>Catostomus clarki</i> ,<br><i>C. insignis</i>                                                                                       | 1966      | Verde and Salt Rivers               | Amin, 1968                  |
| <i>Isoglaridacris hexacotyle</i>             | <i>Catostomus clarki</i> ,<br><i>C. insignis</i>                                                                                       | 1996      | Verde River                         | Robinson et al., 1998       |
| <i>Ligula intestinalis</i>                   | <i>Rhynchithys osculus</i> ,<br><i>Catostomus insignis</i>                                                                             | 1980-1981 | Hurricane Creek, Salt River         | Mpoame and Rinne, 1983      |
| <i>Proteocephalus ambloplitis</i>            | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i> | 1997      | San Carlos Reservoir                | Bureau of Reclamation, 1998 |
| <i>Proteocephalus</i> sp.                    | <i>Salmo apache</i>                                                                                                                    | 1980-1981 | White River                         | Mpoame and Rinne, 1983      |
| <i>Rhabdochona decaturensis</i><br>Gustafson | <i>Agosia chrysogaster</i> , <i>Gila robusta</i> , <i>Meda fulgida</i> ,<br><i>Catostomus insignis</i> ,<br><i>Catostomus clarki</i>   | 1980-1981 | Aravaipa Creek                      | Mpoame and Rinne, 1983      |
| <i>Rhabdochona</i> sp.                       | <i>Agosia chrysogaster</i> , <i>Gila robusta</i> resp.                                                                                 | 1980-1981 | Sycamore Creek, Canyon Creek, resp. | Mpoame and Rinne, 1983      |

Table 1, cont. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                                     | fish species                                                                                                                                                                                                | date      | location                                                                               | reference                   |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------|-----------------------------|
| <b>Copepods</b>                              |                                                                                                                                                                                                             |           |                                                                                        |                             |
| <i>Lernaea cyprinacea</i>                    | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                                                                      | 1997      | San Carlos Reservoir                                                                   | Bureau of Reclamation, 1998 |
| <i>Lernaea cyprinacea</i>                    | <i>Catostomus clarki</i> ,<br><i>Catostomus insignis</i> , <i>Gila robusta</i> ,<br><i>Ptychocheilus lucius</i> , <i>Xyruachen texanus</i> ,<br><i>Micropterus dolomieu</i> , and<br><i>Cyprinus carpio</i> | 1996      | Verde River                                                                            | Robinson et al., 1998       |
| <i>Lernaea cyprinacea</i>                    | <i>Ptychocheilus lucius</i> , <i>Xyruachen texanus</i>                                                                                                                                                      | 1991-1992 | Verde River                                                                            | Creel and Clarkson, 1993    |
| <i>Lernaea cyprinacea</i>                    | <i>Ptychocheilus lucius</i> , <i>Xyruachen texanus</i> and <i>Gila robusta</i>                                                                                                                              | 1986-1990 | Salt River, Verde River resp.                                                          | Hendrickson, 1993           |
| <i>Lernaea cyprinacea</i>                    | <i>Catostomus clarki</i> ,<br><i>Catostomus insignis</i> , <i>Gila robusta</i>                                                                                                                              | 1960-1967 | Salt and Verde Rivers                                                                  | James, 1968                 |
| <i>Lernaea cyprinacea</i><br><i>Linnaeus</i> | <i>Agosia chrysogaster</i>                                                                                                                                                                                  | 1980-1981 | Aravaipa Creek                                                                         | Mpoame and Rinne, 1983      |
| <b>Nematodes</b>                             |                                                                                                                                                                                                             |           |                                                                                        |                             |
| <i>Contracaecum spiculigerum</i>             | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                                                                      | 1997      | San Carlos Reservoir                                                                   | Bureau of Reclamation, 1998 |
| <i>Dacnitioides sp.</i>                      | <i>Gila robusta</i>                                                                                                                                                                                         | 1980-1981 | Aravaipa Creek,<br>Aravaipa Creek<br>and Sycamore<br>Creek ( <i>P. clarki</i><br>only) | Mpoame and Rinne, 1983      |
| <i>Metabronema salvelina</i>                 | <i>Salmo apache</i> , <i>S. gilae</i>                                                                                                                                                                       | 1980-1981 | White River,<br>McKnight Creek                                                         | Mpoame and Rinne, 1983      |
| <i>Metabronema salvelina</i>                 | <i>Salmo trutta</i>                                                                                                                                                                                         | 1981      | Big Bonita Ck.                                                                         | Mpoame and Rinne, 1984      |

Table 1, cont. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                            | fish species                                                                                                                                       | date | location             | reference                        |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------|----------------------------------|
| <b>Protozoa</b>                     |                                                                                                                                                    |      |                      |                                  |
| <i>Ambiphyra ameiuri</i>            | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>             | 1997 | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <i>Ambiphyra</i>                    | <i>Salmo gillae</i>                                                                                                                                | 1995 | McKnight Creek       | US Fish & Wildlife Service, 1995 |
| <i>Apiosoma</i> sp.                 | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>             | 1997 | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <i>Apiosoma</i>                     | <i>Catostomus clarki</i>                                                                                                                           | 1998 | Gila River           | AZ Game & Fish, 1998             |
| <i>Chilodenella</i> sp.             | <i>Catostomus clarki</i> ,<br><i>Cyprinus carpio</i>                                                                                               | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Costia</i>                       | <i>Salmo gillae</i>                                                                                                                                | 1995 | McKnight Creek       | US Fish & Wildlife Service, 1995 |
| <i>Cryptobia</i>                    | <i>Catostomus insignis</i>                                                                                                                         | 1998 | Gila River           | AZ Game & Fish, 1998             |
| <i>Epistylis</i> sp.                | <i>Catostomus insignis</i> , <i>Gila robusta</i> ,<br><i>Ptychocheilus lucius</i> ,<br><i>Micropterus dolomieu</i> , and<br><i>Cyprinus carpio</i> | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Henneguya exilis</i>             | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>             | 1997 | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <i>Ichthyobodo</i> sp.              | <i>Catostomus insignis</i>                                                                                                                         | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Ichthyophthirius multifiliis</i> | <i>Catostomus clarki</i> ,<br><i>Catostomus insignis</i>                                                                                           | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Ichthyophthirius multifiliis</i> | <i>Agosia chrysogaster</i>                                                                                                                         | 1998 | Gila River           | AZ Game & Fish, 1998             |

Table 1, cont. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                               | fish species                                                                                                                                                                                                | date      | location             | reference                        |
|----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------------------|----------------------------------|
| <b>Protozoa, cont.</b>                 |                                                                                                                                                                                                             |           |                      |                                  |
| <i>Ichthyophthirius multifiliis</i>    | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                                                                      | 1997      | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <i>Myxobolus macrocapsularis</i> Reuss | <i>Agosia chrysogaster</i>                                                                                                                                                                                  | 1980-1981 | Aravaipa Creek       | Mpoame and Rinne, 1983           |
| <i>Myxobolus catostomi</i> Fantham     | <i>Catostomus insignis</i>                                                                                                                                                                                  | 1980-1981 | Aravaipa Creek       | Mpoame and Rinne, 1983           |
| <i>Myxobolus discrepans</i> Kudo       | <i>Catostomus insignis</i>                                                                                                                                                                                  | 1980-1981 | Aravaipa Creek       | Mpoame and Rinne, 1983           |
| <i>Myxobolus nodularis</i>             | <i>Catostomus insignis</i>                                                                                                                                                                                  | 1980-1981 | Aravaipa Creek       | Mpoame and Rinne, 1983           |
| <i>Myxobolus</i>                       | <i>Oncorhynchus mykiss</i>                                                                                                                                                                                  | 1995      | Mogollon Creek       | US Fish & Wildlife Service, 1995 |
| <i>Myxobolus oblongus</i> Gurley       | <i>Catostomus clarki</i>                                                                                                                                                                                    | 1980-1981 | Aravaipa Creek       | Mpoame and Rinne, 1983           |
| <i>Trichodina</i>                      | <i>Catostomus clarki</i> ,<br><i>Catostomus insignis</i> , <i>Gila robusta</i> ,<br><i>Ptychocheilus lucius</i> , <i>Xyrauchen texanus</i> ,<br><i>Micropterus dolomieu</i> , and<br><i>Cyprinus carpio</i> | 1996      | Verde River          | Robinson et al., 1998            |
| <i>Trichodina</i>                      | <i>Catostomus insignis</i>                                                                                                                                                                                  | 1998      | Gila River           | AZ Game & Fish, 1998             |
| <i>Trichodina</i> sp.                  | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                                                                      | 1997      | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <b>Trematodes</b>                      |                                                                                                                                                                                                             |           |                      |                                  |
| <i>Atractolytocestus</i> sp.           | <i>Cyprinus carpio</i>                                                                                                                                                                                      | 1996      | Verde River          | Robinson et al., 1998            |
| <i>Cleidodiscus</i> sp.                | <i>Cyprinus carpio</i> ,<br><i>Micropterus dolomieu</i>                                                                                                                                                     | 1996      | Verde River          | Robinson et al., 1998            |

Table 1, cont. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                                     | fish species                                                                                                                                    | date      | location                                            | reference                                        |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------------------------------|--------------------------------------------------|
| <b>Trematodes, cont.</b>                     |                                                                                                                                                 |           |                                                     |                                                  |
| <i>Clinostomum marginatum</i>                | <i>Catostomus insignis</i>                                                                                                                      | 1966      | Salt River                                          | Amin, 1968                                       |
| <i>Clinostomum marginatum</i> Rud            | <i>Gila robusta</i> ,<br><i>Catostomus insignis</i> ,<br><i>Catostomus clarki</i>                                                               | 1980-1981 | Oak Creek                                           | Mpoame and Rinne, 1983                           |
| <i>Crepidostomum</i>                         | <i>Oncorhynchus mykiss</i>                                                                                                                      | 1995      | Mogollon Creek                                      | US Fish & Wildlife Service, 1995                 |
| <i>Crepidostomum cooperi</i> Hopkins         | <i>Salmo gila</i>                                                                                                                               | 1980-1981 | McKnight Creek                                      | Mpoame and Rinne, 1983                           |
| <i>Crepidostomum farionis</i>                | <i>Salmo apache</i>                                                                                                                             | 1980-1981 | White River (E. Fork,) Big Bonita Ck., Paradise Ck. | Mpoame and Rinne, 1983<br>Mpoame and Rinne, 1984 |
| <i>Crepidostomum farionis</i>                | <i>Salmo trutta</i>                                                                                                                             | 1981      | Paradise Ck.                                        | Mpoame and Rinne, 1984                           |
| <i>Dactylogyrus</i> sp.                      | <i>Cyprinus carpio</i>                                                                                                                          | 1996      | Verde River                                         | Robinson et al, 1998                             |
| <i>Gyrodactylus</i>                          | <i>Catostomus clarki</i> ,<br><i>Catostomus insignis</i> , <i>Gila robusta</i> ,<br><i>Ptychocheilus lucius</i> , and<br><i>Cyprinus carpio</i> | 1996      | Verde River                                         | Robinson et al., 1998                            |
| <i>Gyrodactylus</i>                          | <i>Catostomus clarki</i> ,<br>(desert sucker),<br><i>Agosia chrysogaster</i>                                                                    | 1998      | Gila River                                          | AZ Game & Fish, 1998                             |
| <i>Gyrodactylus</i>                          | <i>Salmo gila</i>                                                                                                                               | 1995      | McKnight Creek                                      | US Fish & Wildlife Service, 1995                 |
| <i>Isoglaridacris bulbocirrus</i> Mackiewicz | <i>Gila robusta</i> ,<br><i>Catostomus insignis</i> ,<br><i>Catostomus clarki</i>                                                               | 1980-1981 | Aravaipa Creek                                      | Mpoame and Rinne, 1983                           |
| <i>Ligictaluridus</i>                        | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>          | 1997      | San Carlos Reservoir                                | Bureau of Reclamation, 1998                      |

Table 1, cont. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                                                     | fish species                                                                                                                                                                                                | date      | location                                                              | reference                   |
|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------|-----------------------------|
| <b>Trematodes, cont.</b>                                     |                                                                                                                                                                                                             |           |                                                                       |                             |
| <i>Neascus</i> sp.                                           | <i>Catostomus clarki</i> ,<br><i>Catostomus insignis</i> , <i>Gila robusta</i> ,<br><i>Ptychocheilus lucius</i> , <i>Xyrauchen texanus</i> ,<br><i>Micropterus dolomieu</i> , and<br><i>Cyprinus carpio</i> | 1996      | Verde River                                                           | Robinson et al., 1998       |
| <i>Nematobothrium texomensis</i><br><i>McIntosh and Self</i> | <i>Ictiobus cyprinellus</i> , <i>I. bubalus</i> , <i>I. niger</i>                                                                                                                                           | 1968      | Apache and Roosevelt Lakes                                            | Amin, 1968                  |
| <i>Onchocleidus</i>                                          | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                                                                      | 1997      | San Carlos Reservoir                                                  | Bureau of Reclamation, 1998 |
| <i>Ornithodiplostomum ptychocheilus</i><br><i>Dubois</i>     | <i>Gila robusta</i> ,<br><i>Meda fulgida</i> ,<br><i>Rhinichthys osculus</i> ,<br><i>Catostomus insignis</i> ,<br><i>Catostomus clarki</i> ,<br><i>resp.</i>                                                | 1980-1981 | Oak Creek, Verde River, Aravaipa Creek, Oak Creek, Verde River, resp. | Mpoame and Rinne, 1983      |
| <i>Ornithodiplostomum ptychocheilus</i><br><i>Faust</i>      | <i>Catostomus insignis</i>                                                                                                                                                                                  | 1966      | Verde and Salt Rivers                                                 | Amin, 1968                  |
| <i>Plagioporus</i> sp.                                       | <i>Gila robusta</i>                                                                                                                                                                                         | 1980-1981 | Oak Creek                                                             | Mpoame and Rinne, 1983      |
| <i>Posthodiplostomum minimum centrarchi</i>                  | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                                                                      | 1997      | San Carlos Reservoir                                                  | Bureau of Reclamation, 1998 |
| <i>Tetraonchus</i> sp.                                       | <i>Salmo apache</i>                                                                                                                                                                                         | 1980-1981 | White River                                                           | Mpoame and Rinne, 1983      |
| <b>Bacteria</b>                                              |                                                                                                                                                                                                             |           |                                                                       |                             |
| <i>Acinetobacter lwoffii</i>                                 | <i>Xyrauchen texanus</i>                                                                                                                                                                                    | 1996      | Verde River                                                           | Robinson et al., 1998       |

Table 1, cont. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                           | fish species                                                                                                                                          | date | location             | reference                        |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------|----------------------------------|
| <b>Bacteria, cont.</b>             |                                                                                                                                                       |      |                      |                                  |
| <i>Aeromonas hydrophila</i>        | <i>Xyrauchen texanus</i> ,<br><i>Catostomus clarki</i> ,<br><i>Cyprinus carpio</i> ,<br><i>Micropterus dolomieu</i>                                   | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Aeromonas hydrophila</i>        | <i>Catostomus insignis</i>                                                                                                                            | 1998 | Gila River           | AZ Game & Fish, 1998             |
| <i>Aeromonas</i> sp.               | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                | 1997 | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <i>Aeromonas</i> sp.               | <i>Ptychocheilus lucius</i> , <i>Xyrauchen texanus</i>                                                                                                | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Aeromonas</i> sp.               | <i>Salmo gillae</i>                                                                                                                                   | 1995 | McKnight Creek       | US Fish & Wildlife Service, 1995 |
| <i>Enterobacteriaceae</i> (4 taxa) | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                | 1997 | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <i>Flexibacter</i> sp.             | <i>Ptychocheilus lucius</i>                                                                                                                           | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Pasteurella haemolytica</i>     | <i>Xyrauchen texanus</i>                                                                                                                              | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Plesiomonas shigelloides</i>    | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i>                | 1997 | San Carlos Reservoir | Bureau of Reclamation, 1998      |
| <i>Plesiomonas shigelloides</i>    | <i>Ptychocheilus lucius</i> , <i>Xyrauchen texanus</i> ,<br><i>Catostomus insignis</i> ,<br><i>Catostomus clarki</i> ,<br><i>Micropterus dolomieu</i> | 1996 | Verde River          | Robinson et al., 1998            |
| <i>Proteus mirabilis</i>           | <i>Ptychocheilus lucius</i>                                                                                                                           | 1996 | Verde River          | Robinson et al., 1998            |

Table 1, cont. Fish Pathogens Reported in the Gila River Basin, 1966-1998

| pathogen                          | fish species                                                                                                                           | date | location                                 | reference                          |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------|------------------------------------|
| <b>Bacteria, cont.</b>            |                                                                                                                                        |      |                                          |                                    |
| <i>Pseudomonas aeruginosa</i>     | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i> | 1997 | San Carlos Reservoir                     | Bureau of Reclamation, 1998        |
| <i>Pseudomonas cepacia</i>        | <i>Xyrauchen texanus</i>                                                                                                               | 1996 | Verde River                              | Robinson et al., 1998              |
| <i>Pseudomonas fluorescens</i>    | <i>Xyrauchen texanus</i> ,<br><i>Catostomus insignis</i> ,<br><i>Catostomus clarki</i> ,<br><i>Cyprinus carpio</i>                     | 1996 | Verde River                              | Robinson et al., 1998              |
| <i>Pseudomonas paucimobilis</i>   | <i>Xyrauchen texanus</i>                                                                                                               | 1996 | Verde River                              | Robinson et al., 1998              |
| <i>Pseudomonas putrefaciens</i>   | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i> | 1997 | San Carlos Reservoir                     | Bureau of Reclamation, 1998        |
| <i>Pseudomonas putrefaciens</i>   | <i>Ptychocheilus lucius</i>                                                                                                            | 1996 | Verde River                              | Robinson et al., 1998              |
| <i>Pseudomonas sp.</i>            | <i>Ptychocheilus lucius</i> , <i>Xyrauchen texanus</i> ,<br><i>Catostomus clarki</i> ,<br><i>Gila robusta</i>                          | 1996 | Verde River                              | Robinson et al., 1998              |
| <i>Pseudomonas sp.</i>            | <i>Micropterus salmoides</i> ,<br><i>Pomoxis nigromaculatus</i> ,<br><i>Ictalurus punctatus</i> , and/or<br><i>Pylodictis olivaris</i> | 1997 | San Carlos Reservoir                     | Bureau of Reclamation, 1998        |
| <i>Renibacterium salmoninarum</i> | <i>Salmo gilae</i>                                                                                                                     | 1998 | Whiskey Creek,<br>Gila Wilderness,<br>NM | U.S. Fish & Wildlife Service, 1998 |
| <i>Vibrio alginolyticus</i>       | <i>Cyprinus carpio</i>                                                                                                                 | 1996 | Verde River                              | Robinson et al., 1998              |

## REFERENCES

- Amin, O. M. 1968. Deformed Individuals of Two Species of Suckers, *Catostomus insignis* and *C. clarkii*, from the Gila River System, Arizona. *Copeia* 4:862-863.
- \_\_\_\_\_. 1969. Helminth Fauna of Suckers (Catostomidae) of the Gila River System, Arizona. I. *Nematobothrium texomensis* McIntosh and Self, 1955 (Trematoda) and *Glaridacris confusus* Hunter, 1929 (cestoda) from Buffalofish. *The American Midland Naturalist* 82:188-196.
- \_\_\_\_\_. 1969. Helminth fauna of Suckers (Catostomidae) of the Gila River system, Arizona. II. Five parasites from *Catostomus spp.* *American Midland Naturalist* 82:429-443.
- \_\_\_\_\_ and W. L. Minckley. 1996. Parasites of Some Fish Introduced into an Arizona Reservoir, with Notes on Introductions. *J. Helminthol. Soc. Wash.* 63(2):193-200.
- Arizona Game and Fish Department. Gila River Fish Disease Testing Results. Fish Health Inspection Report case # 98-37. Unpublished data. November 1998.
- Arizona Game and Fish Department. Fish Health Reports. Unpublished data. Phil Hines, Fish Health Specialist. 1994-1995.
- Creef, E. D. and R. W. Clarkson. 1993. Razorback Sucker (*Xyrauchen texanus*) and Colorado Squawfish (*Ptychocheilus lucius*) Monitoring, Verde and Salt Rivers, Arizona, 1991-1993. Special Report, Nongame and Endangered Wildlife Program, Arizona Game and Fish Department.
- Hendrickson, D. A. 1993. Evaluation of the Razorback Sucker (*Xyrauchen texanus*) and Colorado Squawfish (*Ptychocheilus lucius*) Reintroduction Programs in Central Arizona Based on Surveys of Fish Populations in the Salt and Verde Rivers from 1986 to 1990. Final Report, Nongame and Endangered Wildlife Program, Arizona Game and Fish Department.
- Hoffman, G. L. 1970. Intercontinental and transcontinental dissemination and transfaunaation of fish parasites with emphasis on whirling disease (*Myxosoma cerebralis*.) pages 69-81 in S. F. Snieszko, ed. A symposium on diseases of fishes and shellfishes. Special publication No. 5, American Fisheries Society, Washington, D C.
- James, A. E. 1968. *Lernaea* (Copepod) Infection of Three Native Fishes From the Salt River Basin, Arizona. M. S. Thesis. Arizona State University.
- Mpoame, M., and J. N. Rinne. 1983. Parasites of some fishes native to Arizona and New Mexico. *The Southwestern Naturalist* 28:399-405.

#### REFERENCES, cont.

**Mpoame, M., and J. N. Rinne.** 1984. Helminths of Apache (*Salmo apache*), Gila (*S. gilae*), and brown (*S. trutta*) trouts. The Southwestern Naturalist notes: 29: (4) 505-506

**Robinson, A. T, P.P. Hines, J.A. Sorensen, and S.D. Bryan.** 1998. Parasites and Fish Health in a Desert Stream, and Management Implications for Two Endangered Fishes. North American Journal of Fisheries Management 18:599-608, 1998.

**U.S. Department of the Interior. Bureau of Reclamation.** San Carlos Reservoir Drought Impact Findings Report. Phoenix Area Office. Phoenix, AZ. May 1998.

**U. S. Fish & Wildlife Service, Pinetop Fish Health Center.** Stewardship Accomplishment Report. unpublished data. Ronald Major, Project Leader. September 13, 1995.

**U.S. Fish & Wildlife Service, Pinetop Fish Health Center.** Fish Health Inspection Reports. unpublished data. Cases # 98-60, 46 & 48, and 99-44. John C. Thoesen, Project Leader. June 3, 1998, April 21, 1998, and April 21, 1999.