Disease Interactions Between Wild and Cultured Salmonids

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PROJECT OBJECTIVES

1. Identify and collect data on the fish health of natural populations of fish in western states with particular reference to the states of Idaho, Montana, Wyoming, Colorado, Utah, Nevada, Arizona, Washington, Oregon and California.
2. Examine and evaluate the database for completeness and extent to determine correlations among historical data using time series analysis. Choose appropriate techniques for analysis.
3. Prepare preliminary maps of the distribution of salmonid pathogens and identify geographic areas to be studied in future surveys.
4. Develop deterministic models of the dynamics of disease/pathogen presence in wild salmonid populations and design risk assessment models for the likelihood of pathogen transmission between wild and cultured fish.

ANTICIPATED BENEFITS

No one has previously compiled the reported historical data on presence of pathogens in populations of free ranging and cultured salmonids across a large geographic scale. Retrieval and summary of these data are important first steps to understanding the dynamics of fish diseases, and the interactions among wild and cultured fish. By examining the strengths and weakness of existing data, we will identify if regions exist that contain data complete enough to conceptually model epidemiology, and begin to estimate the risks of transmission between cultured and free ranging fishes. Through this process we will determine the feasibility of using retrospective data sets to describe epidemiological processes, and determine the additional data needs for research and monitoring of pathogens to better understand the risks that fish diseases and their potential transmission pose to the natural biota and the aquaculture industry. This review and assessment of historic sampling efforts will then be used to propose a more thorough monitoring protocol that would provide better assessment, protection and regulation for the aquaculture industry and the natural community.

PROGRESS & PRINCIPAL ACCOMPLISHMENTS

Responsibilities for collection and analysis of data from the western states were divided into two regions for this project: Idaho, Montana, Wyoming, Utah and Colorado are being summarized and are the responsibility of the University of Idaho (U of I), while Arizona, California, Nevada, Oregon and Washington are the responsibility of Oregon State University (OSU). In June of 1999, all researchers attended the AFS Fish Health Section meeting in Twin Falls, ID and Intelmann and Moffitt presented a poster presentation of preliminary results of *Myxobolus cerebralis* in two drainages in Utah. In February 2000, Intelmann and Moffitt attended the annual Whirling Disease Workshop in Coeur D' Alene, ID and presented a poster presentation addressing the use of GIS and environmental trend data to describe the distribution of *M. cerebralis* at large spatial scales.

Objective 1. Identify and collect data on the fish health of natural populations of fish in western states.

The collection of data (through 1998) was completed at the U of I in the summer of 1999. Student researcher Intelmann met with the Montana Department of Fish, Wildlife, and Parks, the Wyoming Department of Fish and Game, and the USFWS laboratory in Bozeman to obtain spatial information to supplement data collected the previous summer. A follow up visit was also made to the Utah Division of Wildlife to clarify database content. Data were also collected from the USFWS Dworshak fish health laboratory in Ahsahka, ID. A majority of the historical records from Dworshak had been discarded from the laboratory, however, data were obtained for three private hatcheries and three national hatcheries in Idaho from the mid 1980's. Intelmann also met with project industry advisor Peter Walker and spent a week collecting records from the Colorado Division of Wildlife's fish health laboratory in Brush, CO. During the fall of 1999 data collected from Colorado were entered and the databases finalized for the other four states.

Researchers at the Oregon State University completed the collection of data from agencies in 2000. Approximately 50,000 records have been located with information on target fish and target pathogens.

Objective 2. Examine and evaluate the database for completeness and extent.

During the fall of 1999 data collected by U of Idaho from Colorado were entered and the databases finalized for the states of Colorado, Idaho, Montana, Utah and Wyoming. At this time, the pathogen database for these states contains 21,674 pathogen records: 53% of these are from national or state hatcheries; 17% are from private hatcheries; and 30% of these records are from samples of free ranging fishes. Ten target pathogens are included in the database. They include four bacteria - Aeromonas *salmonicida, Yersinia ruckerii, Renibacterium salmoninarum*, and *Flavobacterium psychrophilum*; three viruses - Viral Hemorrhagic Septicemia Virus, Infectious Hematopoietic Necrosis Virus, Infectious Pancreatic Necrosis Virus, and three parasites - Myxobolus *cerebralis, Ceratamyxa shasta*, and the Proliferative Kidney Disease Organism (Table 1). Full data sets include details of fish species tested sample dates, and sample sizes when provided.

Fewer pathogens were noted in the data collected from California, Arizona, Nevada, Oregon and Washington when compared with the intermountain states, except for records of *Ceratomyxa shasta*, which is know to be confined to the Pacific Northwest, and Proliferative Kidney Disease that is predominantly in California. Most data were from public hatchery records.

Objective 3. Prepare preliminary maps of the distribution of salmonid pathogens and identify geographic areas to be studied in future surveys.

We converted the database into geographic format and a GIS point coverage during late 1999. Hydrologic unit code (HUC) coverages were obtained from the U.S. Geological Survey (USGS) and reprojected to match the extent of our pathogen database and then attributed to describe the 2, 4, 6, and 8 digit codes. The pathogen point coverage was intersected with the USGS HUC coverage in GIS allowing query by specific HUC, or by pathogen, species, date, or other classification variables.

In early 2000 we identified regions for free ranging populations that contained the most consistent surveillance and monitoring. Few areas had consistent sampling schemes for any pathogen. The most information was available for *M. cerebralis* and some regions contain records for at least 3-4 consecutive years of surveys. We selected three regions to study further: the Madison hydrologic unit of the Missouri-Headwaters sub-basin of the Missouri basin; the Upper North Platte hydrologic unit of the North Platte sub-basin of the Missouri basin; and the Fremont hydrologic unit of the Upper-Colorado Dirty Devil sub-basin of the Upper Colorado basin (Figure 1). Most regions lacked baseline data, and lacked multiple years of sampling in any given location to provide a good time series. Other difficulties in interpretation included the interbasin transfer of water, and movement and transplanting of infected hatchery fish, pooling of samples, and poor or inconsistent reporting of laboratory analysis.

The Truckee River has been selected as a focus of attention by researchers at OSU for at least three pathogens: *M. cerebralis, A. salmonicida*, and IPNV. Oregon State University researchers have collected data from Nevada Division of Wildlife, California Department of Fish and Game, US Geological Survey, the University of Nevada at Reno and the USFWS Wild Fish Health Survey. The data include pathogen data from 1969 to 1995, and from 1996 on. Five sections of the River have been defined for focused study of *M. cerebralis* (Figure 2).

Objective 4. Develop deterministic models of the dynamics of disease/pathogen presence in wild salmonid populations and design risk assessment models for the likelihood of pathogen transmission between wild and cultured fish.

Researchers at both institutions began collecting environmental data for the regions of interest in 2000 and have found a number of data sets. For Montana, we obtained five years of daily temperature profiles for three sites in the Madison region, but only found monthly temperature readings for the areas of interest in the Fremont region in Utah. Daily temperature data were obtained for one year from Wyoming. Fish population estimates are available for Wyoming. Finding descriptive trend data that corresponds with the same space and time frames of our pathogen monitoring has been difficult.

Considerable environmental data have been collected about the Truckee River. River flow data are available from 1900 to 1999. Fish densities and species composition are available as well as river temperatures and detailed stocking data from 1975–1999. The Verdi State Fish Hatchery had been in operation since the 1920's until 1984, and the hatchery had a history of three diseases and more than 250 stockings from this hatchery have been made into the Truckee River. In addition to the detailed stocking records in Nevada, historical stocking data were obtained from as early as 1877. These data included observations of 15 species of salmonids, including lake trout and Atlantic salmon. For the over one hundred years of records, 24 million trout were distributed into the river. Another hatchery, Gallagher State Fish Hatchery provided many fish used for stocking, and this hatchery harbored a number of pathogens. There is some evidence that *M. cerebralis* has been present in the upper reaches of the Truckee River since the 1950's.

This spring researchers at the U of I we began working with statistical consultants to evaluate ways to express individual prevalence levels and estimate confidence limits from the information provided by pooled samples. Since inconsistent sampling techniques reported some results as individual tests and some as pooled tests, it was necessary to devise a method for comparing the two results on an equal basis. Computer code was written in the S-PLUS language to use a maximum likelihood estimate (MLE) for finding confidence intervals based on the pooled sample sizes. Prevalence estimated from pooled samples using weighted mean proportions will be compared to estimates from pooled data using the MLE method for estimating individual prevalence levels. Our preliminary analysis shows that calculating prevalence levels using the weighted mean proportion method of pooled data tends to overestimate individual prevalence and does not provide as meaningful a confidence limit as the MLE method.

At both Universities, researchers are working on preliminary disease dynamic models. One for the Truckee River includes parameters for the infection of rainbow trout with triactinomyxons as well as the

infection of *Tubifex* with spores of *M. cerebralis*. Data regarding variables in the model have been gleaned from the literature and will be used as starting points for models. This model at the fish level will be integrated into a model of a small section of the river that will contain flow characteristics, depth and fish densities. Idaho researchers have proposed a conceptual model for *M. cerebralis* in previous research projects (Moffitt and Hiner 1999; Hiner and Moffitt 1998). Researchers will confer to determine which approaches will be used with these data. All these will be refined and explored for other areas for which we have data in both geographic regions. The OSU researchers have added Hamdi Ögüt who has extensive expertice in modeling of fish disease from his PhD project on *A. salmonicida* to the research team to replace departing student Tim Miller-Morgan

USEFULNESS OF FINDINGS

These data provide the first ever compilation of the extent of sampling for bacterial, viral, and selected parasites in free-ranging salmonid populations in the western states. This survey provides information for many user groups, from regulatory interests to fishery managers interested in risks to critical stocks. Idaho Power Company has already expressed interest in incorporating our database into a feasibility analysis of reintroducing anadromous fish into the Middle Snake River. .

WORK PLANNED FOR NEXT YEAR

During this final year of this project we will generate a number of models based on the data obtained, in the locations that we have adequate time series data. We will examine the time series of pathogens detected in hatcheries for which we have adequate data, and in natural populations that we have adequate data. Trends in hatcheries will be correlated with hatchery management practices focused on disease prevention. For all populations, we will develop deterministic and stochastic models of pathogen persistence and estimate the potential impact of disease on natural populations of fish. For *M. cerebralis* models, natural population reaches are likely to include the Madison River in Montana, the North Platt River drainage in Wyoming, the Truckee River in Nevada. Other areas for other pathogens will likely be determined. Some regions have had repeated stocking of pathogen positive fish for many years, and other areas that have not been stocked with pathogen positive fish. Environmental variables and fish densities in each area will be important components of the risk assessments.

IMPACTS

This project will result in data bases and GIS coverages that will be useful to several other sectors. We have conferred with Jim Chandler or Idaho Power Company, and after obtaining permission from Dr. Chew, we made the GIS coverage of Idaho available to Idaho Power to use for their hydro relicense of the Hells Canyon Complex of dams. Additional information on pathogen coverages was requested by Dr. Brian Allee of the Columbia Basin Fish and Wildlife Authority to help tribal and government agencies interested in the upper Oywhee River and the risks of introduction of pathogens. The conceptual models and proposed surveillance monitoring programs will provide important information to the aquaculture industry and for regulators so they can begin to understand the risks of transmission to critical stocks of both cultured and free ranging fishes.

REFERENCES

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Moffitt, C. M. and M. Hiner. 1999. Redefining models of epidemiology of Myxobolus cerebralis in Idaho. Pp 89-90 in 5th Annual Whirling Disease Symposium. Whirling Diseases Foundation. Missoula, MT.

SUPPORT (FOR BOTH UNIVERSITIES)

FISCAL YEAR	WRAC-USDA FUNDS	OTHER SUPPORT			TOTAL SUPPORT
		UNIVERSITY PI TIME	INDUSTRY/AGENCY ADVISOR TIME	WRAC	
99	48,438	6,000[a]	L,000[b]	52,438	56,438

[a] Estimated state funds donated to project by PIs;

[b] Estimated funds from Industry advisor Walker.

PUBICATIONS, MANUSCRIPS, AND PAPERS PRESENTED

Intelmann, S.S. and C.M. Moffitt. 1999. Using GIS to visualize epidemiological interactions among hatchery and free ranging salmonids: A preliminary analysis of *Myxobolus cerebralis* in Utah. Poster paper presented at AFS/Fish Health Section Annual Meeting and Western Fish Disease Workshop, Twin Falls, Idaho, June 9-11, 1999.

Intelmann, S.S. and C.M. Moffitt. 2000. Exploring the potential use of environmental trend data and GIS to describe and identify factors affecting the distribution of *Myxobolus cerebralis* at large spatial scales in the Intermountain west. Poster paper presented at the Annual Whirling Disease Symposium, Coeur D'Alene, Idaho, February 3-4, 2000.

C. M. Moffitt, and S. S. Intelmann. 2000. Spatial distribution of pathogens in free ranging populations of salmonids and their potential relationships with anthropogenic influences in the intermountain west. GIS symposium 130th annual meeting of American Fisheries Society, St. Louis MO, 23 August 2000.