

GREAT LAKES FISH HEALTH COMMITTEE

2011 Summer Meeting
Sault Ste. Marie, Michigan
August 16-18, 2011

Minutes
(with attachments)

Submitted By:

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Great Lakes Fishery Commission

The data, results, and discussion herein are considered provisional; permission to cite the contents of this report must be requested from the authors or their agency.

GREAT LAKES FISHERY COMMISSION
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Great Lakes Fish Health Committee

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List of Attendees

John Coll	U.S. Fish and Wildlife Service, Pennsylvania
John Dettmers	Great Lakes Fishery Commission
Andy Dwilow	Fisheries and Oceans Canada
Mohamed Faisal	Michigan State University
Christina Haska	Great Lakes Fishery Commission
Dave Insley	Ohio Department of Natural Resources
Sue Marcquenski	Wisconsin Department of Natural Resources
Dave Meuninck	Indiana Department of Natural Resources
Paula Phelps	Minnesota Department of Natural Resources
Ken Phillips	U.S. Fish and Wildlife Service- Wisconsin
Ling Shen	Minnesota Department of Natural Resources
Gary Whelan	Michigan Department of Natural Resources
Greg Wright	Chippewa Ottawa Resource Authority
Coja Yamashita	Pennsylvania Fish and Boat Commission

Great Lakes Fish Health Committee Meeting

August 16-18, 2011

Walker Cisler Student and Conference Center

Lake Superior State University

Sault Ste. Marie, MI

Agenda

Tuesday, August 16

- | | |
|-------------------|--|
| 8:00 am-8:15 am | Welcome (Phillips) |
| 8:15 am-8:30 am | Approval of Meeting Minutes (Phillips) |
| 8:30 am-10:00 am | Risk Assessment: Introduction & Discussion (Phillips/Dettmers) |
| 10:00 am-10:15 am | Break |
| 10:15 am-12:15 pm | Risk Assessment Discussion (Phillips/Dettmers) |
| 12:15 pm-1:15 pm | Lunch (catered in) |
| 1:15 pm-2:30 pm | Agency Updates (10-15 minutes each) (All) |
| 2:30 pm-3:30 pm | Risk Assessment Discussion (Phillips/Dettmers) |
| 3:30 pm-3:45 pm | Break |
| 3:45 pm-5:30 pm | Risk Assessment Scenarios (Phillips/Dettmers) |
| 5:30 pm | Adjourn for the Day |

Wednesday, August 17

- | | |
|-------------------|---|
| 8:00 am-10:00 am | Model Program Review & Discussion (Phillips/Dettmers) |
| 10:00 am-10:15 am | Break |
| 10:15 am-12:15 pm | Model Program Review & Discussion (Phillips/Dettmers) |
| 12:15 pm-1:15 pm | Lunch (catered in) |
| 1:15 pm- 2:45 pm | Tour of LSSU Aquaculture Facilities (LSSU Staff) |

2:45 pm- 3:00 pm Research Priorities (Phillips)
3:00 pm-3:15 pm Break
3:15 pm-5:30 pm Model Program Review & Discussion (Phillips/Dettmers)
5:30 pm Adjourn for the day

Thursday, August 18

8:00 am- 10:00 am MSU Research Update (Faisal and students)
10:00 am-10:15 am Break
10:15 am-10:45 am VHSV Surveillance Model (J. Daily—USGS Leetown Science Center)
10:45 am-11:45 pm APHIS VHSV Update (J. Whaley—USDA APHIS)
11:45 am-12:45 pm Lunch (catered in)
12:45 pm-2:00 pm Agency Updates (10-15 minutes each) (all)
2:00 pm-3:00 pm Risk Assessment Wrap-up/Parking Lot/Action Items (Phillips/Dettmers)
3:00 pm-3:15 pm Break
3:15 pm-3:00 pm Selection of Location for August 2012 meeting (Phillips)
3:15 pm-4:45 pm Model Program Wrap-up/Parking Lot/Action Items (Phillips/Dettmers)
4:45 pm-5:00 pm Meeting Wrap-up/Action Items (Phillips)
5:00 pm Adjourn Meeting

Day 1: 16 August 2011

1. Welcome and Introductions (K. Phillips)

2. Approval of Meeting Minutes (K. Phillips)

The minutes from the February 2011 meeting were approved.

3. Model Program Edits: Risk Assessment (All)

The initial feedback from the updated Risk Assessment (RA) was neutral (Appendix 1). This newer RA follows the framework of the USFWS RA, but the values were determined by the subcommittee at their meeting in May.

It was felt that because the GLFHC now reports to the Council of Lake Committees (CLC), this should be taken into consideration with the RA. The GLFHC will provide recommendations, but the CLC will make the decisions.

It was also suggested that it would be helpful to run through examples to determine if the scores and weights made sense.

4. Agency Updates (All)

USFWS- Pennsylvania (J. Coll): There has been ongoing VHS work to see if broodstocks in Lake Ontario and Lake Erie have the virus, but so far none has been found. Two new projects have been funded so they will be able to increase sampling numbers. Currently evaluating PCR primers to look for *Nucleospora* and EEDv, but there are no major findings yet. Lake trout propagation is going as in previous years, but they are getting the broodstock from Vermont. A future broodstock will be from Massachusetts. The construction at Allegheny is nearly complete. The disinfection had a few setbacks, but the brook trout that are being held there have been stressed and tested, and the results were negative for multiple pathogens.

Ohio DNR (D. Insley): Walleye are being collected from Lake Erie at the Maumee. There have not been any detections of VHS in the parental stock. The surveillance for VHS was cut this year, and they will only be doing fish health testing on hatcheries and broodstock sources. So far, the results are negative. The Castalia hatchery has been out of commission since May for renovations.

Michigan DNR and Michigan State University (G. Whelan and M. Faisal): There was a large carp kill on Kent Lake. It was reported broadly as Spring Viremia but subsequent testing showed there was Koi Herpesvirus. It's unclear what role that virus may have played in the kill. They are continuing surveillance for VHS and Dr. Faisal has received money to support his research on the topic. A new APHIS grant was submitted. The Platt River is having UV systems installed to help stop/prevent whirling disease. All broodstocks were negative for VHS this year, and the regulations are under review. There was an IPN case in a private hatchery, as well as an isolation of VHS from Bud Lake.

USFWS- Wisconsin (K. Phillips): There was a furunculosis outbreak in brook trout in early January, and the fish were treated with injections but the disease returned. A recommendation was made and the fish were destroyed. The areas which had received fingerling lake trout and brown trout had outbreaks and went under prophylactic treatments. In early July, another lot showed clinical signs, and the fish were destroyed. Approximately 4,000+ broodfish were vaccinated in the Iron River. The isolation facility at Genoa is now becoming a quarantine facility. The Jordan River hatchery has completed the construction of buildings over its raceways.

Minnesota DNR (L. Shen): There was a government shutdown for three weeks over the summer, during which time there was a report of smelt dying. The kill lasted about ten days. The fish looked healthy, but samples were taken to undergo testing. Information was sent out to the committee about another small-scale fish kill involving Spring Viremia. Carp were killed, but the disease did not affect other fish. There was a small mortality event at French River hatchery, but no pathogens were detected. A generic medication was used and the mortality decreased. BKD continues to be detected at two hatcheries without any clinical signs or fish dying. The APHIS VHS surveillance work is ongoing. Some policy changes include accepting OIE method testing and changing importation rules of bait.

Indiana DNR (D. Meuninck): APHIS money helped expand VHS surveillance to five waterbodies, including Lake Michigan and brood lakes. All testing came back negative, as well as all routine VHS testing of production fish. There were a variety of carp kills, but suitable fish for sampling were not found. There was a fish kill on the St. Joe's River, and samples came back positive for Koi Herpesvirus, which are awaiting verification. A redhorse species was potentially involved. There was also a largemouth bass die-off near Hamilton Lake, and testing is ongoing. Hatchery testing sometimes came back with high positives using FAT slides, but they did not use positive controls. These could be false positives since there were no clinical signs of disease in the fish.

CORA (G. Wright): The hatchery is still in a growth phase. It is receiving funding and expanding. More manpower is needed to provide support. There have not been any positive testing for VHS, and they are currently culturing walleye.

Wisconsin DNR (S. Marcquenski): There were two isolations of VHS in both gizzard shad and yellow perch. Following the APHIS VHS surveillance, they did not find any positive VHS fish, but did get two unknowns which are being tested in LaCrosse. There was an alewife fish kill in Lake Michigan, but the cause is unknown. The GLFHC meeting and AFS Fish Health Section meeting will both be held in Madison next year.

DFO (A. Dwilow): There were no positive hits for VHS in Winnipeg, but VHS was found in round gobies, pumpkinseed and rock bass in Lake Simcoe. There was an incident last year in Hamilton Harbor involving a pathogen found in round bullheads. He is hoping to retire next August, and so all future requests should be sent to his supervisor.

Pennsylvania FBC (C. Yamashita): IPN has been found in a majority of hatcheries, and it's also been a bad year for furunculosis. They will begin vaccinating fish along with studies of these pathogens. *Nucleospora* has been found in steelhead, and they are monitoring fish leaving the hatchery now. There

was a large carp die-off in a river due to *Calamaris*. Within the agency, there is a bit of reorganization going on and people are retiring. Andy Shiels is being promoted, so his position will be open soon. They are still investigating the smallmouth bass die-offs in Delaware and Allegheny.

Day 2: 17 August 2011

1. Model Program Edits: Reporting (All)

Gary had created a new Fish Health Inspection Report that would coincide with the Model Program's recommendations (Appendix 2). The following issues were clarified throughout the discussion of this new form:

- The 'Hatchery Inspection History and Detail' table could have any information included that may be relevant. The Model Program requires the past three years of classification, but there's room here for five years. A column will be added to easily include previous hatchery classifications.
- The 'Designation' box is however you would identify that group of fish.
- The addition of a Lab Report Number was appreciated.
- A column is needed to report the date a lot of fish was inspected, because they all won't be tested at the same time.
- Under the heading 'Pathogens Inspected For and Results', there needs to be additional columns in case other diseases are tested. To identify which methods were used in the testing, superscript could be used as designation (e.g., ¹= PCR, ²= ELISA, etc).
- Adding a table for coolwater fish would be appropriate.
- An instruction manual would be helpful.
- An agency could customize this form to make it useful in the best way possible for them.

It was also suggested that a generic form be created for the Annual Reports which are submitted to the GLFHC every year. It may be helpful for the members to have an easily-accessible database which could contain all the information. John Dettmers will contact Noreen Nobiesz about a potential home for this on her database.

2. Model Program Action Items (All)

See Appendix 3 for the Model Program draft.

- Reorganize the document according to suggestions by Gary and Sue
- Note that testing will only involve emergency and restricted pathogens (not provisional)
- Remove Lymphosarcoma from restricted, place on provisional list
- Clearly state the Model Program sets high guidelines and is ideal; remove all "agencies are encouraged"
- "Importing Emergency Gametes": all emergency pathogens need to go under testing and quarantine---make this clear

- Include 'OIE reportable' section to Emergency Pathogen Detections
- Review Table 1 using the Risk Assessment to verify pathogens are in the correct category
- Make the Restricted Pathogen Detections section jive with Table 1
- Include 'OIE reportable' disease info to the restricted pathogen detections, as in the Emergency section
- Inspections and Testing: discuss how the annual inspection does not necessarily equate to calendar years
- Include appropriate testing variables for pathogens in the Description section; include citations
- Cite John Plum's Integrated Cool and Warmwater Guide
- Add definition of Annual Inspection
- Re-write Classification section
- Pathogen Acronyms (Table 3): Include Lymphosarcoma; determine appropriate acronym for PKD
- Verify we have right to cite Taylor and Ferreri document- receive permission
- Appendix 2: include Sue's citations for species screened; include Ohio's citation for SVC
- Rewrite Appendix 3 (Nomination Form) according to committee suggestions

3. Model Program: Agency Thoughts on the Classification System (All)

See Appendix 3, pages 66-67 for an alternative classification system.

Minnesota DNR (L. Shen): There is some advantage to the alternative, but there are also some things to like about the original system. A combination of the two may be best. When looking at permits, she doesn't focus on the ABC classification necessarily but rather looks at the history and inspection results. BUT, the ABC classification does provide quick guidance. Not all hatcheries follow it though, because some are only tested for certain pathogens.

Indiana DNR (D. Meuninck): The old classification system is used to grade coldwater hatcheries. It gives the When, Where, and Results of transfers. This works for him.

CORA (G. Wright): He dislikes the ABC classification system because it takes precedence over sometimes doing the right thing for the fisheries. The new system would be preferred, recognizing that no one should bring fish in that might compromise their hatchery.

Michigan DNR (G. Whelan): He's indifferent between the two systems. Classifying a hatchery by water supply is disliked, and it should be kept simple. The grades of A, B, or C are not taken into account when transferring fish.

Wisconsin DNR (S. Marcquenski): The old system is not used, but she knows it because of the GLFHC. The classification of a hatchery is not taken into account when moving fish. Because she doesn't import many fish from other states, other hatcheries' classifications don't need to be taken into account.

DFO (A. Dwilow): Canada does not use this system. Officials use test results, hatchery histories, and techniques to analyze movement of fish.

Pennsylvania FBC (C. Yamashita): He uses the details, inspections, and histories when considering moving of fish. The transfers that came into a hatchery (where the hatchery got fish from) is also

important. The ABC system works for hatcheries that are really proud of their rank and want to keep it or gain a higher ranking.

USFWS- Pennsylvania (J. Coll): Data is needed, not just the classification. Overall, the classification can be handy if you're just trying to get a general impression, and it's good for hatcheries to know what they could be getting. Basically, you just need to know what was there or is there currently.

Ohio DNR (D. Insley): The current ABC system is second nature, and it makes it quicker to know how much scrutiny to have a report. The water source is irrelevant. The classification is important for managers to strive for the best.

USFWS- Wisconsin (K. Phillips): The alternative system is better because it simplifies everything. The ABC system doesn't mean much to people outside the Great Lakes.

Ontario (through written comments): Different nomenclature would be preferred.

Day 3: 18 August 2011

1. Michigan State University Update (M. Faisal, T. Loch, C. Schulz, A. Winters)

See Appendix 4 for the presentation. An overview is presented below.

The largemouth bass virus creates four main signs of illness in a fish within its swim bladder: it becomes opaque, the membrane hemorrhages, blood vessels leak, and blood accumulates. There are five different stages of the virus, and only the first can be seen through PCR.

Walleye tumors are often seasonal and are caused by a retrovirus.

In 2003, a new sublineage of the viral hemorrhagic septicemia virus (VHS) genotype IV was found. Fish were tested from 2005-11, and 42 of the 2,090 samples were positive. Over 20 fish species were affected. A Great Lakes Fishery Trust project was funded to study virus challenges of Great Lakes species, develop new tools for detection and quantification, and strain-type isolates and develop a web-accessible database. Conclusions from this study include: 1) there's a broad range of susceptibility. Many species are highly susceptible, some are intermediate, and others had low or no susceptibility, 2) 16 variations were found within one section of a gene within the virus, and all of these were virulent. There was no correlation between variation and host species or year, but there was some spatial correlation from east-to-west, and 3) databases are now currently online. Organs were tested in muskellunge to see which were best to test for VHS, and the liver was best while the spleen was the worst (liver > heart > skin and muscles > gills > pectoral fin > intestine > kidney > spleen). For acute cases, non-lethal testing had a high correlation with organ sampling, but this correlation got weaker with sub-acute and chronic cases. Some fish can shed the virus in the water, and the virus is capable of multiplying in the water so the concentration gets higher. This happens for the first 15 weeks post-exposure, and after stress, fish

that had stopped shedding the virus and had appeared healthy will begin again. To combat infection, some fish can create VHS antibodies, and this has been found both in the lab and in the wild.

The following are some fish pathogenic bacteria of concern in Michigan:

- *Aeromonas salmonicida*: This pathogen has been recovered from many species and has been historically present throughout many Michigan state fish hatcheries. The last detected outbreak was in 2005, but there was an outbreak of furunculosis in 2011 involving fish that hadn't yet been vaccinated and were exposed to the pathogen. Now, that hatchery uses vaccinations and has improved its biosecurity. The Little Manistee River weir appears to be a place for genetic heterogeneity.
- *Flavobacterium columnare*: This pathogen was recovered from a fish kill in Lake St. Clair and can often be a problem in the wild.
- *Flavobacterium psychrophilum*: This pathogen can produce significant lesions and/or affect the spinal cord, and it is prevalent in spawning salmonid populations in the Great Lakes.
- Emerging flavobacteria: Recovered isolates from the wild indicate a wide variety of type strains exist.
- *Carnobacterium maltaromaticum*: This is the causative agent of pseudo-kidney disease, and outbreaks have primarily been reported in captive adult rainbow trout. It is widespread in feral Michigan *Oncorhynchus* spawning stocks. There can be significant differences in infection prevalence according to the host species/strain, gender, and year of collection. Disease signs include external ulcerations, pseudo-membrane formation, and nephrocalcosis.

Bacterial kidney disease (BKD) prevalence has declined in *Oncorhynchus* spp. from 2001-10. There is no discernable difference between sexes shedding the virus, and overall there has been an increase in fish not shedding it. BKD is also present in lake whitefish. Management techniques are working, and although the bacteria are still present in waterbodies, it is being controlled in *Oncorhynchus*.

A study is in press about bacterial infections of Chinook salmon returning to gamete-collecting weirs in Michigan. It examined 480 salmon in 2005 and studied the effects of location, early v. late spawners, and gender on infection prevalence. Fish were found to be co-infected with both *Renibacterium* and *Aeromonas* species. The period of gamete collection can be really important when considering if you will get infected eggs.

Parasites are also common, especially:

1. *Triaenophorus nodulosus*: A cestode that was found in yellow perch in Lake Emily that had large cysts in the livers.
2. *Bothriocephalus cuspidatus*: A walleye tapeworm.
3. *Cystidicola farionis*: A swim bladder nematode in whitefish.
4. Fish leeches that target skin, gills, fins, and the oral cavity of fishes. Hemorrhaging occurs at the attachment and feeding sites, resulting in necrotic tissue.
5. *Myzobdella lugubris*: A leech that can transfer diseases.
6. *Myxobolus cerebralis*: The agent of whirling disease.

Fungi can play a role in fish health, including *Glugea anomale*, *Heterosporis*, and *Phoma herbarum*.

Beneficial relationships should also be recognized in fish health. A study was done on zebra mussels and their interactions with the bacterial communities in the water column. Zebra mussels have novel genes which allow for adhesion and defense mechanisms. The byssus (aka "foot") is controlled by many genes and is responsible for its ability to adhere, while the mussel can also create molecules to protect itself from being degenerated. The bacteria from a mussel was cloned to see the overall community, and 715 sequences were found. Correlations exist with certain organs, so these bacteria could be protective.

Finally, an overview of the decline of *Diporeia* species and its potential causes was given. Terminal RFLP, histopathology, and virology was used and detected VHS for the first time in this species. Preserved samples from Lake Michigan will be analyzed to detect if a historical pathological trend exists.

2. VHSv Surveillance Model (J. Daily)

Jonathan Daily could not attend this meeting, but he sent a handout describing the model. See Appendix 5.

3. APHIS Proposed Rule Status Update (J. Whaley)

APHIS changes are currently on hold while public comment periods and economic analyses are underway. The policy statement includes specifics and can be updated without extensive processes, including interstate movement, split-state status, and importation. The aquaculture program for 2012 and beyond involves a national aquatic animal lab network, training for veterinarians, and a national aquatic animal health surveillance system. New Canadian import regulations will come into effect in December 2011 that will control over 400 species of aquatic animals, both live and dead.

Input from the GLFHC about VHS regulations would be appreciated. Specifically, what do the committee members recommend? How would the Great Lakes states manage VHS in the wild without APHIS? How would the plan prevent VHS from leaving the Great Lakes watershed?

The GLFHC will review its VHS Recommendation document (Appendix 6) and give input as it's available.

4. GLFHC Research Priorities (All)

The document (Appendix 7) was reviewed and members were asked to consider changes they would like to see and have these ready for the Winter 2012 meeting.

5. Meeting Locations (All)

The Winter 2012 meeting will be held the week of February 6th in Sandusky, Toledo, or Cleveland (ODNR will host).

The Summer 2012 meeting will be in Madison or LaCrosse in conjunction with the AFS Fish Health meeting. Dates TBD.

6. Model Program Classification (All)

After much discussion regarding the classification system in the Model Program, the following key ingredients need to remain:

1. Maintain the 3 annual inspections,
2. Distinguish between facilities with pathogens and those with none,
3. The dates of detections needs to be clear, as well as any additional details for the reason behind the classification (transfers, etc.),
4. If the inspection does not look for everything within a family of pathogens, the hatchery will be classified as a 'C' for coolwater fish, and
5. Details on how to obtain a different classification need to be given.

The reporting form should include information on the water source, the influent and effluent treatment, which pathogens were tested for, and a place for additional notes.

If the writing subcommittee chooses to use a different classification (e.g., SPF), they need to make sure it meshes with what other fish health committees use to reduce confusion.

7. Parking Lot Items for the Model Program (All)

1. Clarify that gametes with potential Emergency pathogens need to go to a quarantine facility.
2. Have the Risk Assessment be an appendix to the Model Program rather than a stand-alone document.
3. Determine what an intermediate risk is in the Risk Assessment.

8. Adjourn

Risk Assessment for the Introduction or Transfer of Fish and Associated Pathogens into the Great Lakes Basin

Summary

There is a growing concern in the Great Lakes basin regarding the introduction of serious pathogens along with the importation or transfer of fish from other areas. For this reason, the Great Lakes Fishery Commission- Fish Health Committee (FHC) developed a process to assess the risks associated with importations and transfers and their potential impacts on resident fauna. This Risk Assessment (RA) is to be conducted prior to the importation or transfer of fish and is meant to be used in conjunction with other management considerations. Based on the information provided, the FHC will review and evaluate the proposed introduction or transfer for any potential health risks to the receiving facility or waterbody. This publication describes each component of the RA which will aid in determining management decisions.

Background & Historical Perspectives:

Movement of fish and their gametes continues to be the cornerstone of many conservation and restoration fishery programs in the Laurentian Great Lakes. Parallel to species movements, pathogens have invaded new geographic ranges, leading to exposure to native species that have often generated catastrophic consequences. Control of fish stocking and importation in the Great Lakes basin is the responsibility of those agencies that manage the fishery resources.

To coordinate efforts, the Great Lakes Fishery Commission (GLFC) established the Fish Health Committee (FHC) in 1973 to recommend measures and coordinate efforts aimed at protecting the health of fish of the Great Lakes basin. Like other GLFC bodies, the FHC is comprised of representatives from Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, Ontario, the governments of Canada and the USA, and Native American tribal authorities. Among the FHC charges is the development of a comprehensive fish health plan and policies regarding disease control, fish transfer within the basin, and fish importation. Final recommendations are made by a consensus of the membership. In 1985, the Committee developed a Model Program for controlling fish diseases in the basin. This Model Program was subsequently adopted as a policy of the GLFC, and has been updated twice. The Model Program provides guidelines for health certification and fish stocking in the Great Lakes basin.

With the increasing interest in importation of fishes for conservation and restoration purposes, fisheries management, and aquaculture, the Model Program has periodically failed to provide clear directions over isolated introductions and emergences of serious diseases. For this reason, the FHC developed a protocol to assess and minimize the risk of introducing emerging disease agents with the importation of salmonid fishes from enzootic areas (Horner and Eshenroder 1993). This protocol was adopted by member agencies. Unfortunately, past outbreaks of emerging diseases in

wild and propagated fishes within the basin (such *Heterosporis* sp., Largemouth Bass Virus, *Piscirickettsia* sp., *Nucleospora salmonis*, and Viral Hemorrhagic Septicemia Virus) created a situation that required the adoption of more stringent procedures to follow when proposing the introduction or transfer of fish by the FHC.

National and international agencies have developed a standard, science-based process to accurately assess pathogen introduction risks associated with fish movement, collectively called Import Risk Analysis (IRA)(Perera 2004, Hine 2004, Amos 2004, Bondad-Reantaso 2004, Kanchanakhan and Chinabut 2004, Olivier 2004). Guided by this widely accepted process of IRA in fish movements¹, the FHC proposes to adopt an RA process that is accepted by its member agencies. Specifically, the FHC seeks to:

- Develop a standard procedure for the application process for the introduction or transfer of a fish or shellfish species into the Great Lakes Basin or between individual Great Lakes.
- Develop a general risk assessment (RA) framework that the FHC will follow to reach its recommendations regarding introductions or transfers for which no standard procedures are established, or which fall outside of or in conflict with the Model Program.
- Archive each new risk assessment for periodical review and evaluation of similar cases that may arise in the future.

It is important to emphasize that the proposed FHC RA:

- Does not address the benefits of the proposed introduction or transfer. The final product of the RA is restricted to determining the likelihood of pathogen introductions into the Great Lakes basin.
- Focuses on risks associated with pathogen introduction and not the potential ecological or genetic impacts caused by the introduced fish or shellfish itself.
- Is designed to access the appropriate biological information available at the time of the assessment.

Member agencies are encouraged to implement the proposed RA when considering the movement of fish or shellfish within its jurisdiction, particularly in cases where the movements may spread pathogens into a new watershed or drainage. The proposed RA may be used not only for finfish, mollusks, and crustaceans, but also for other aquatic animals.

¹ Documents used to create this RA include the World Animal Health Organization Aquatic Code (OIE, 2009), the International Council for the Exploration of the Sea Code (ICES 2003), and views adopted by the Food and Agriculture Organization of the United Nations (Bartley et al., 2006).

Risk Assessment for the Introduction to and Transfer of Fish into the Great Lakes Basin:

The RA objectives are to:

- a) Identify pathogen(s) that may be introduced or transferred into the basin along with the fish and shellfish,
- b) Assess the disease risks associated with the transfer or introduction of fish and shellfish, and
- c) Provide a management recommendation as to whether or not to stock this fish of concern.

RA Process:

The following sections of this document describe each step of the RA process. The forms can be found in Appendices I and II.

I. Process Initiation and Required Information

If the request for introduction or transfer of a fish species has the potential to negatively affect a shared resource within the Great Lakes basin, then the FHC chair should initiate the process of risk assessment in coordination with the requesting agency. Depending upon the circumstances of the importation or transfer (i.e., whether the fish are being imported into or out of a facility or waterbody), different information regarding the fish species will be taken into account to adequately address the risk taken by this action. These data include:

1. General information on the proposed introduction.
2. Information regarding the introduced or transfer of fish or shellfish.
3. Information on the fish health history and pathogens of the proposed fish species.
4. Information on the receiving environment or contiguous watershed.

II. Risk Assessment

Some of the inputs that may need to be considered in the risk assessment include:

- the ability of pathogens to be vertically transmitted
- incidence or prevalence of the pathogen in the release waterbody
- incidence/prevalence of the same pathogen in adjoining lakes and/or watersheds
- susceptible species and age of fish
- ease of agent contamination
- effect of diagnostic testing
- effect of prophylactic and therapeutic treatment
- migratory behaviours of the introduced animal
- the presence of potential vectors
- the nature and properties of the pathogen
- routes of exposure, modes of transmission and routes of entry

- geographic and environmental characteristics
- presence of susceptible species in receiving waters
- transmission of infection to other aquatic animals
- subclinical production losses caused by the transmitted infection
- spread of infection or disease, and potential for an epizootic
- fish losses from death or disease
- losses from trade embargo, losses in fish marketability
- costs incurred from control and eradication, monitoring, laboratory testing, disinfecting, treatment, and vaccination
- adverse consequences to the natural ecosystems

III. Estimation of the Pathogen Risk Potential

This process results in a risk estimation, in which the overall risk is assigned a single value. Risk estimation consists of integrating the results from the assessment to consider the risks to naturally occurring populations of native species, important fisheries or aquaculture resources, and biological communities and habitats which may be impacted by a proposed introduction.

IV. Risk Assessment Summary Information

The Risk Assessment Summary Information (Appendix III) draws on the data provided in the RA form and the findings resulting from the Risk Assessment. This report will focus and summarize only the most critical information that was used in the decision making process. The information in this report will be the basis for determining the overall risk associated with the proposed introduction and make recommendations regarding the introduction. That is, the Risk Assessment Summary Information will recommend:

- the introduction proceed as requested
- the introduction proceeds only under certain criteria
- the introduction should not be made.

The report will document what criteria were used in the decision making process and describe why the recommendation was made.

Risk Management

The risk management decision on stocking should be based on the probability of adverse health effects on fisheries resources; that is, the health-associated output of the risk assessment. Elements of risk management include:

- Interpreting, comparing, judging the significance of, and deciding the tolerability of the risk estimated;
- Identifying and evaluating the efficacy and feasibility of mitigation measures, in addition to those that may have been considered in the initial risk assessment, in order to reduce the risk associated with an importation or introduction. The efficacy is the degree to which an option reduces the

likelihood and magnitude of adverse biological and economic consequences.

Low risk request

A stocking request for which the hazards identified pertain only to diseases not capable of inflicting severe losses in fish stocks, or capable of inflicting severe losses in fish stocks but which are already widely distributed in the Great Lakes basin, including the region of concern, may be classified as of low risk.

High risk request

An introduction request for which hazards related to reportable diseases not presently detected in the Great Lakes basin or the receiving states/province have been identified, should be classified as high risk. Diseases or pathogens listed in the Emergency Fish Diseases of the Model Program can have serious deleterious impacts on fish stocks and must be kept out of the Great Lakes Basin. Reportable diseases, such as those listed by the United States Department of Agriculture and the Canadian Department of Fisheries and Oceans, must be prevented from spreading to new areas because of the serious negative impacts they can have on fish stocks and should be considered of high risk.

Other significant diseases of concern that should be evaluated as high risk include diseases that are of current or potential international significance but that have not been included in the diseases previously addressed. While the primary concern is the protection of health of fisheries resources, disease-related hazards that could impact other aquatic organisms should be taken into account as well. Adverse effects involving a wide range of species, a large number of individuals or target species (i.e., of special status) would be judged to have greater consequences/impacts than those that do not, and should be classified as high risk.

Risk Communication

Risk communication represents the interactive exchange of information on risk among risk assessors, risk managers, and other interested parties. It begins when a risk analysis is requested and continues after the implementation of the decision on the acceptance or refusal of the stocking request.

The main principles involved with risk communication include:

- The communication of risk should be open, interactive, and involve transparent exchange of information that may continue after the stocking decision.
- A peer review should represent a component of risk communication in order to obtain scientific and analytic critiques and to ensure the validity of the scientific data, methods, and assumptions.
- The uncertainty in the model, model inputs, and the risk estimates of the risk assessment should be communicated.

Recommendations to Decision-Makers

There are five possible final outcomes that can result following a risk assessment request:

1. Hazard identification fails to identify potential hazards associated with the introduction. Thus, the request is recommended for approval and the import risk assessment process is terminated.
2. The request is returned to the requesting agency prior or during consideration in order to obtain additional information required to assess the level of risk associated with the proposed introduction.
3. The request is recommended for approval with no conditions.
4. The request is recommended for approval with the condition that specific preventive or mitigating measures are followed before the proposed stocking takes place.
5. The request is not recommended for approval if the level of risk estimated is deemed unacceptable.

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Model Program updated by whom and when

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Appendices

Instructions for completion of Appendices I and II.

The Risk Assessment forms found in Appendix I and Appendix II should be completed as follows:

- 1) For each condition, choose the appropriate response and mark that response's number value in the small box to the right of that option.
- 2) Multiply that value by the weight in parentheses in the condition statement itself and place this value in the larger box on the right.
- 3) Total all large box scores and mark this value in the **Total Risk Score** box at the bottom of the worksheet.

Example for Appendix I.

In an instance where the prevalence of a pathogen in the source population is Medium, and its pathogen transmission is vertical, the first part of Appendix I would be filled in as follows:

Prevalence of pathogen in the source population (5)		
High (67-100) – 5		15
Medium (33-66) – 3	3	
Low (1-32) – 1		
None – 0		
Pathogen transmission (10)		
Vertical – 5	5	50
Horizontal – 1		
Unknown – 5		

Total Risk Calculation

The Total Risk Score will be used to determine the level of risk of a proposed introduction.

For Appendix I: Risk assessment for pathogen movements into a facility:

- A score 219 or below is considered LOW RISK.
- A score between 220 and 369 is considered INTERMEDIATE RISK.
- A score 370 or above is HIGH RISK.

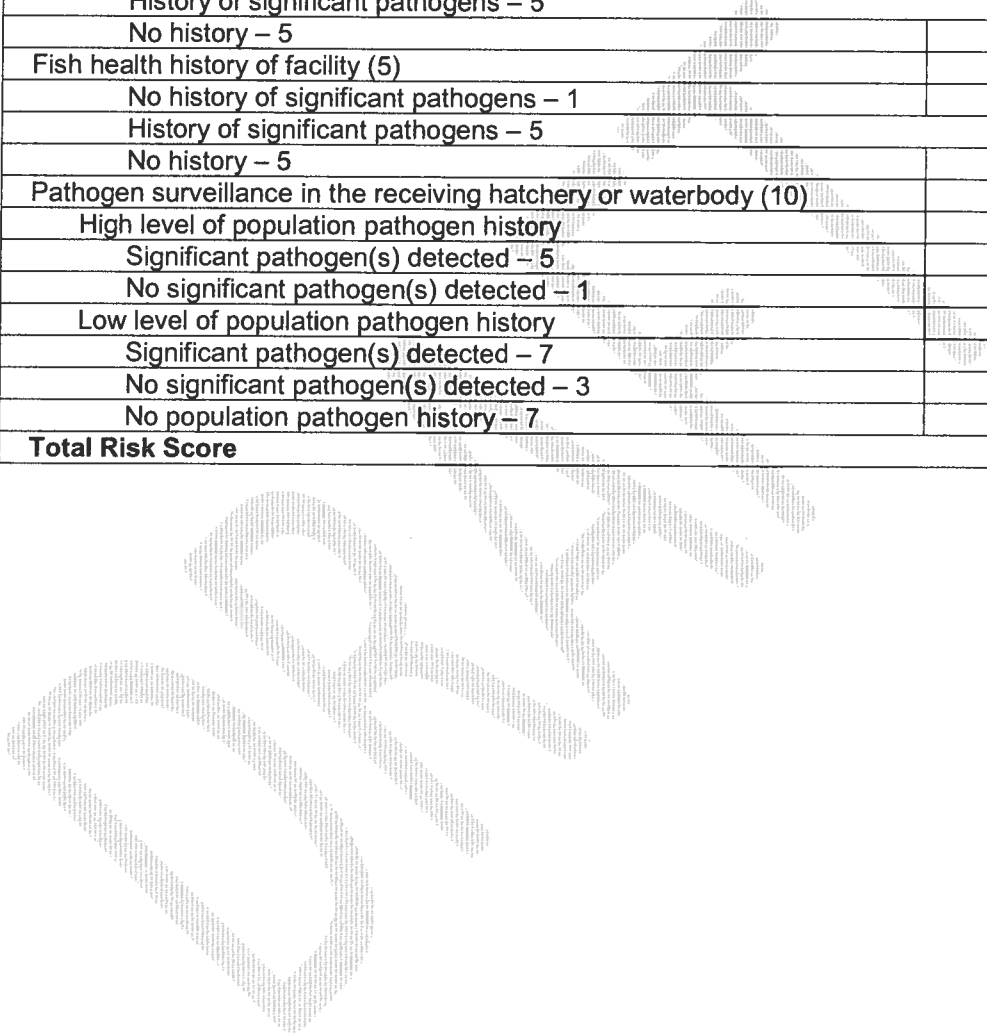
For Appendix II: Risk assessment for pathogen movements out of a facility:

- A score 369 or below is considered LOW RISK.
- A score between 370 and 569 is considered INTERMEDIATE RISK.
- A score 570 or above is HIGH RISK.

Appendix 1. Risk Assessment for pathogen movements into a facility.		
Prevalence of pathogen in the source population (5)		
High (67-100) – 5		
Medium (33-66) – 3		
Low (1-32) – 1		
None – 0		
Pathogen transmission (10)		
Vertical – 5		
Horizontal – 1		
Unknown – 5		
Prevalence of the pathogen in the receiving facility (5)		
High – 1		
Medium – 3		
Low – 5		
Prevalence of the pathogen in the receiving waters' effluent (10)		
High – 1		
Medium – 3		
Low – 5		
Describe the biases or uncertainty of diagnostic testing (15)		
High – 5		
Medium – 3		
Low – 1		
Describe the potential for disease to other animals or species (10)		
No other species affected – 0		
1-2 species affected – 1		
3-4 species affected – 3		
5+ species affected – 5		
How effective are treatments to control infection with the pathogen? (10)		
Egg disinfection – 1		
Vaccinations – 3		
Other – 5		
None available – 10		
Describe the potential for an epidemic in cultured and wild stocks (15)		
Known to cause elsewhere – 5		
Does not cause epidemics – 1		
Unknown – 5		
Knowledge of the fish species and its culture requirements (5)		
Optimal – 1		
Adequate – 3		
Inadequate/Unknown – 5		
Fish health history (10)		
Parental history with no significant pathogens – 1		
Parental history with significant pathogens – 5		
No parental history – 5		
Source location (5)		
Within same Great Lakes basin – 1		
Between Great Lakes basins – 3		
Outside of the Great Lakes basin – 5		

Appendix II. Risk assessment for pathogen movements out of a facility.		
Prevalence of pathogen in the hatchery (10)		
High (67-100) – 5		
Medium (33-66) – 3		
Low (1-32) – 1		
None – 0		
Pathogen transmission (10)		
Vertical – 5		
Horizontal – 1		
Unknown – 5		
Prevalence of the pathogen in the receiving water (5)		
High – 1		
Medium – 3		
Low – 5		
None – 10		
Current geographic distribution (10)		
Presence – 1		
Absence – 3		
Describe the current distribution and prevalence of the intermediate host(s) in the Great Lakes basin and waters to be stocked, if applicable (10)		
High – 5		
Medium – 3		
Low – 1		
Indicate which vectors are accessible for the pathogen (10) Eg. Ballast, bait (preserved, frozen, live), fish stocking (state, federal, certified private hatchery, uncertified private hatchery), fish-eating birds and mammals, bilge and live wellwater in recreational boats, commercial fishing, weed harvesting, etc		
0-1 vectors – 1		
2-4 vectors – 3		
5-7 vectors – 5		
8+ vectors – 7		
Is the activity of introducing these fish likely to increase a pathogen's prevalence/intensity? (5)		
Yes – 5		
Maybe – 3		
No – 0		
Is the activity of introducing these fish like to increase a pathogen's geographic range? (10)		
Yes – 5		
Maybe – 3		
No – 0		
Describe the potential for disease to other animals or species (10)		
No other species affected – 0		
1-2 species affected – 1		
3-4 species affected – 3		
5+ species affected – 5		
Describe the potential for an epidemic in wild stocks (20)		
Known to cause epidemics elsewhere – 5		
Does not cause epidemics – 1		
Unknown – 10		

Confidence in the pathogen surveillance in the hatchery (5)		
Standard methods – 1		
Non-traditional (non-representative) methods – 3		
No surveillance – 7		
Fish health history of lot (5)		
No history of significant pathogens – 1		
History of significant pathogens – 5		
No history – 5		
Fish health history of broodstock (5)		
No history of significant pathogens – 1		
History of significant pathogens – 5		
No history – 5		
Fish health history of facility (5)		
No history of significant pathogens – 1		
History of significant pathogens – 5		
No history – 5		
Pathogen surveillance in the receiving hatchery or waterbody (10)		
High level of population pathogen history		
Significant pathogen(s) detected – 5		
No significant pathogen(s) detected – 1		
Low level of population pathogen history		
Significant pathogen(s) detected – 7		
No significant pathogen(s) detected – 3		
No population pathogen history – 7		
Total Risk Score		



APPENDIX III. RISK ASSESSMENT SUMMARY INFORMATION

Hazard Identification

Viruses:

Bacteria:

Fungi:

Parasites:

Other:

Comments:

Summary of the Request:

Summary of the Risk Assessment:

Statement on Overall Risk:

Signature of GLFHC Chair

Date

FISH HEALTH INSPECTION REPORT

Agency Name
Fish Health Inspection Report

This report is not evidence of future disease status. To determine current status, contact Fish Health Official below.

Name and Location of Facility or Waterbody:	Owner/Manager/Contact:	Inspection Date(s):
This: Prior:		Type of Water Supply: Well/Spring
Classification:		Origin of Fish Examined: Hatchery
		Type of Fish Examined: Salmonid

Species ¹	Designation	Lab Report #	Number in Lot	Obtained as Eggs (E) or Fish (F) From:	Pathogens Inspected for and Results				Signature of Contracted Fish Health Official						
					A _s	I _r	R _s	VHSV		IHNV	IPNV	MC			
Remarks/Recommendations:					Address/Phone of Contracted Fish Health Official				Signature of Contracted Fish Health Official						

¹For juv. hatchery fish give age in months; for feral and adult hatchery fish use symbols e=eggs or fry, f=fingerlings; y=yearlings; b=older fish.
²See list of pathogen and spp. abbreviations (pg 2).
 cc: Gary Whelan

Species Abbreviations							
ATS	Atlantic Salmon	BKT	Brook Trout	BNT	Brown Trout	WAE	Walleye
COS	Coho Salmon	RBT	Rainbow Trout	LAT	Lake Trout	NOP	Northern Pike
CHS	Chinook Salmon	STT	Steelhead	SPL	Splake (Brook x Lake)	STN	Sturgeon
OSA	Other Salmonids	Mixed	Mixed Species	Mixed	Mixed species	MUS	Muskellunge

¹For juv. hatchery fish give age in months; for feral and adult hatchery fish use symbols e=eggs or fry; f=fingerlings; y=yearlings; b=older fish.

²See list of pathogen and spp. abbreviations (pg 2).

cc: Gary Whelan

1 Introduction

2
3 Fish disease management in the Great Lakes basin is a responsibility of those agencies
4 that manage the fisheries resources. The Great Lakes Fish Health Committee, GLFHC, of
5 the Great Lakes Fishery Commission (GLFC) developed a Model Program in 1980¹ to
6 unify and coordinate the fish disease management efforts of the GLFC member agencies.
7 The purpose of the Model Program is to assist efforts aimed at preventing introductions
8 and spread of serious fish pathogens, classifying disease status at fish hatcheries, and
9 establishing protocols for importation and risk assessments associated with fish
10 pathogens. The Model Program is based on information known at the time of writing and
11 will be revised as needed as new information becomes available and new pathogens are
12 detected in the Great Lakes basin.

13
14 Each member agency is expected to work toward the management of fish diseases in the
15 Great Lakes basin by:

- 16 - developing legislative authority and regulations to enable fish disease management
17 and possible eradication of fish pathogens;
- 18 - minimizing the rearing and release of infected fish;
- 19 - preventing the release of clinically diseased fish;
- 20 - preventing the importation of fish infected with emergency pathogens into the
21 Great Lakes basin;
- 22 - limiting the transfer within the Great Lakes basin of fish infected with restricted
23 pathogens; and
- 24 - developing response plans, as needed and appropriate.

25
26 At the time of this most recent revision of the Model Program, both the Canadian and
27 U.S. federal governments began to implement their respective NAAHPs: the National
28 Aquatic Animal Health Program in Canada and the National Aquatic Animal Health Plan
29 in the United States. The objective of the Canadian NAAHP is to protect the Canadian

¹ In 1980 the committee was then called the Great Lakes Fish Disease Control Committee. It was renamed in 1994 to the Great Lakes Fish Health Committee.

30 fish/seafood industries and activities that rely on aquatic resources against the
31 introduction and spread of serious infectious fish diseases. The U.S. National Aquatic
32 Animal Health Plan is being developed and will provide a framework for federal agencies
33 to work together to protect aquatic resources. The Model Program does not replace or
34 duplicate the components or obligations of member agencies to these federal NAAHPs,
35 but rather should be viewed as a complimentary program directed specifically at the
36 activities of member agencies such as the collection, rearing, release and transfers of
37 hatchery and wild fish in the Great Lakes basin. Nothing in the Model Program shall
38 derogate from the right of the member agencies to apply additional measures of
39 inspection, quarantine, depopulation and pathogen eradication in efforts to prevent fish
40 disease outbreaks.

41

42 All member agencies should anticipate that they could have detections of undesirable fish
43 pathogens and appropriate response plans should be developed for timely and effective
44 management actions to contain and, if possible, eliminate the detected pathogen.

45 Response plans should include provisions on biosecurity, personnel needs, testing needs,
46 necessary legislative authority for depopulation and disinfection if necessary,
47 depopulation and disposal procedures, disinfection protocols, and communication needs
48 for a coordinated response that may require state, provincial and federal governments,
49 universities and/or private industry. The GLFHC may recommend steps to eradicate the
50 pathogen from a hatchery and adjacent waters following the best science available in
51 association with information provided in the Model Program.

52

53 **Application**

54

55 The recommendations of this Model Program apply to fish species that have the potential
56 to harbor pathogens that could be transmitted to fish in the Great Lakes basin (Appendix
57 1). In particular, this Model Program discusses movements of wild or hatchery-raised fish
58 within/into the Great Lakes basin that are or could be infected with emergency or
59 restricted pathogens.

60

61 Provided that all necessary biological containment measures are taken to avoid any
62 dissemination of fish pathogens, the recommendations of this Model Program shall **not**
63 apply to:

- 64 a) Fish and water in transit through the Great Lakes basin that are not released from
65 original shipping containers, and
- 66 b) Specimens of fish for purposes of diagnostic services and related laboratory tests.

67

68 Under this Model Program, member agencies signatory to *A Joint Strategic Plan for*
69 *Management of Great Lakes Fisheries* are:

- 70 Chippewa Ottawa Resource Authority
- 71 Fisheries and Oceans Canada
- 72 Great Lakes Indian Fish and Wildlife Commission
- 73 Illinois Department of Natural Resources
- 74 Indiana Department of Natural Resources
- 75 Michigan Department of Natural Resources
- 76 Minnesota Department of Natural Resources
- 77 New York State Department of Environmental Conservation
- 78 Ohio Department of Natural Resources
- 79 Ontario Ministry of Natural Resources
- 80 Pennsylvania Fish and Boat Commission
- 81 U.S. Fish and Wildlife Service
- 82 Wisconsin Department of Natural Resources

83

84 **Pathogen Detection**

85

86 The most recent editions of the following three documents provide the basis for fish
87 hatchery inspections and standard testing methods:

- 88 1) Suggested Procedures for the Detection and Identification of Certain Fish and
89 Shellfish Pathogens, developed by the Fish Health Section (FHS) of the

- 90 American Fisheries Society (Blue Book)²,
91 2) Fish Health Protection Regulations Manual of Compliance (Miscellaneous
92 Special Publication 31, Revised) of Fisheries and Oceans Canada³, and
93 3) The World Organisation for Animal Health (OIE) Manual of Diagnostic Tests
94 for Aquatic Animals⁴.

95

96 More sensitive or definitive procedures may be used, but any departures from the basic
97 procedures set forth by these manuals or updated versions of these manuals must be noted
98 on reports. Efforts are encouraged to employ the most currently accepted methods for
99 detection of pathogens not included in the manuals listed above.

100

101 **Risk Assessment**

102

103 The following risk assessment document may be referenced as appropriate to estimate the
104 risks of introducing a pathogen into the Great Lakes basin:

105

CITATION WILL BE PROVIDED AFTER RA COMPLETION

106 This document provides information regarding risk communication, assessment, and
107 management, as well as hazard identification. This step-by-step guide also offers
108 recommendations for consideration by the decision-makers.

109

110

111 **Amendment**

112

113 Model Program amendments may be proposed by the Council of Lake Committees
114 (CLC) or by the GLFHC member agencies. Any proposed amendment shall be submitted
115 to the GLFHC Chairperson in writing with a short explanation documenting the rationale
116 for the request. The GLFHC Chairperson will seek consensus from member agencies; if
117 the GLFHC endorses the amendment, the proposed amendment will be presented to the

² Available from American Fisheries Society www.fisheries.org

³ Available from www.dfo-mpo.gc.ca

⁴ Available from www.oie.int

118 CLC for consideration, approval, and adoption.

119

120 The Model Program will be reviewed on an annual basis by the GLFHC.

121

122 **Definitions**

123

124 Definitions for some of the terms used in this document:

125 **Clinical sign:** visually apparent abnormalities in the body, organ, or behavior.

126 **Disease:** a condition that impairs normal functioning of the fish and may be manifested
127 by distinct clinical signs.

128 **Emergency fish pathogen:** a fish pathogen that has not been confirmed to be present in
129 the Great Lakes basin but is known to be able to cause epizootic events.

130 **Enzootic:** present at a locality over an extended period of time.

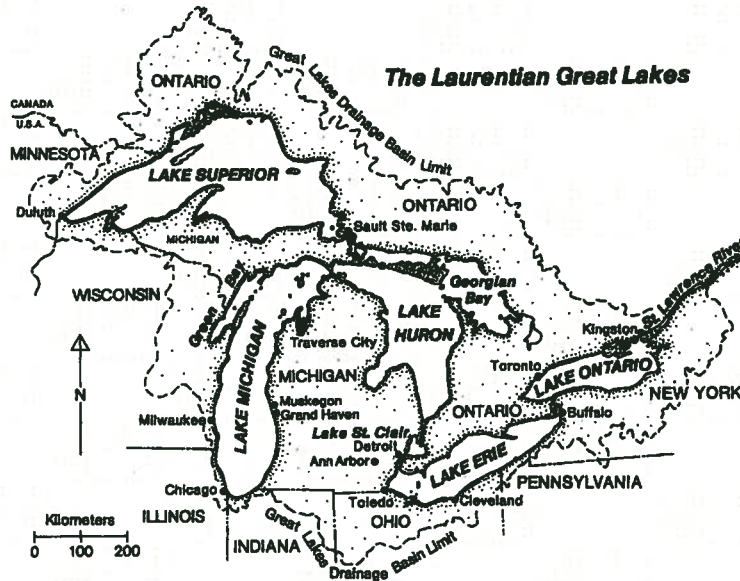
131 **Epizootic event:** an occurrence of disease affecting many fish of one or more species at
132 the same time.

133 **Fish:** all life stages of fish, dead or alive.

134 **Fish Health Inspection:** testing of all fish on site in a hatchery within a calendar year.

135 **Gametes:** all sexual products of fish including sperm, unfertilized eggs and fertilized
136 eggs.

137 **Great Lakes Basin:** the geographical area encompassing lakes Ontario (including the St.
138 Lawrence River from Lake Ontario to the 45th parallel of latitude), Erie, Huron, St.
139 Clair, Michigan, and Superior including their connected watersheds (Figure 1).



140

141 **Figure 1.** Great Lakes basin map from Taylor and Ferreri (1999).

142

143 **Hatchery:** any source facility that holds and rears fish.144 **Infection:** occurrence of a pathogen in a fish.145 **Intensity:** estimation of the pathogen load.146 **Isolation facility:** a facility that maintains a group of fish without any contact with other

147 fish, in order to undergo observation for a specified length of time and, if

148 appropriate, testing and treatment

149 **Lot:** fish of the same species, of the same age, that have always shared the same water

150 supply, and that originated from a discrete spawning population.

151 **Member agency:** federal, provincial, tribal or state government fishery management or152 conservation agency that is signatory to *A Joint Strategic Plan for Management of*153 *Great Lakes Fisheries*⁵.154 **Non-secure water supply:** water source that may contain fish or fish pathogens such as

155 streams, lakes and unenclosed springs.

156 **Pathogen:** a micro- or macro-organism that is capable of causing a disease.157 **Prevalence:** percent of infected individuals within a population at a given time.

⁵ For a list of member agencies see Application Section

158 **Provisional fish pathogen:** a fish pathogen with uncertain geographic distribution, with
 159 limited information on life history strategy, and whose ability to cause disease and
 160 epizootic events within the Great Lakes basin may be unknown.

161 **Quarantine facility:** a facility that maintains a group of fish in isolation with no direct or
 162 indirect contact with other fish, in order to undergo observation for a specified
 163 length of time and, if appropriate, testing and treatment, including proper treatment
 164 of the effluent waters⁶.

165 **Rearing unit:** any hatchery container that is used to hold or raise fish, including a
 166 raceway, pond, or tank.

167 **Restricted fish pathogen:** a fish pathogen that exists in one or more locations in the
 168 Great Lakes basin and is known to cause epizootic events, and for which the GLFC
 169 member agencies intend to restrict their spread, prevalence, and impacts.

170 **Secure water supply:** a water supply that is free of fish and fish pathogens (or treated to
 171 remove pathogens) such as enclosed springs and wells.

172 **Source:** any point or place of origin of fish or gametes including a fish hatchery or free
 173 ranging population.

174 **Transfer:** the movement of fish from one location to another; the location may include a
 175 hatchery, lake or other waterbody.

176 **Vertical transmission:** transfer of a pathogen from broodstock to offspring through
 177 gametes.

178 **Wild broodstock population:** free ranging adult fish of one species or strain generally
 179 from one spawning location from which gametes may be collected.

180

181 **Emergency Fish Pathogens**

182

183 Emergency pathogens are as follows:

184 *Ceratomyxa shasta* (causes ceratomyxosis)

185 infectious hematopoietic necrosis virus

186 infectious salmon anemia virus

187 *Tetracapsuloides bryosalmonae* (causes proliferative kidney disease)

⁶ OIE definition

188 viral hemorrhagic septicemia virus (all strains EXCEPT IVB)

189 white sturgeon herpesvirus

190 white sturgeon iridovirus

191

192 **Restricted Fish Pathogens**

193

194 Restricted pathogens are as follows:

195 *Aeromonas salmonicida salmonicida* (causes furunculosis)

196 *Heterosporis* sp.

197 infectious pancreatic necrosis virus

198 koi herpesvirus

199 largemouth bass virus

200 Lymphosarcoma

201 *Myxobolus cerebralis* (causes whirling disease)

202 *Renibacterium salmoninarum* (causes bacterial kidney disease)

203 spring viremia of carp virus

204 viral hemorrhagic septicemia IVb

205 *Yersinia ruckeri* (causes enteric redmouth)

206

207 **Provisional Fish Pathogens**

208

209 Provisional pathogens are as follows:

210 Asian tapeworm

211 *Nucleospora*

212 EEDv

213 *Piscirickettsia*-like organism

214

215

216 **Importation and Testing Requirements**

217 Before importation of fish or gametes, appropriate testing for all Emergency and
218 Restricted pathogens is required. Specific guidance is offered in the following sections,
219 and the susceptibility of fish species to Emergency and Restricted pathogens are listed in
220 Appendix 2.

221

222 **Emergency Fish Disease/Pathogen Management**

223

224 Emergency fish pathogens are those which have not been isolated from fish in the Great
225 Lakes Basin, are known to cause epizootic events, and agencies would eradicate infected
226 fish in hatcheries and develop programs to minimize spread of those pathogens in the
227 wild.

228

229 **Importing Fish**

230

231 If a member agency seeks to import fish from outside the Great Lakes basin but NOT
232 from an area enzootic for an emergency pathogen, testing for emergency pathogens is not
233 required. The determination of whether an area is enzootic for an emergency pathogen
234 will be based on collective knowledge, a literature review, *and* contact with the exporter.

235

236 If a member agency seeks to import fish from outside the Great Lakes basin and from
237 within an area enzootic for an emergency pathogen or from a hatchery that has imported
238 fish from an enzootic area:

- 239 • The source must be tested a minimum of 5 consecutive years without a
240 positive detection for an emergency pathogen, sampling at the 5%
241 prevalence level in the population with 95% confidence level; OR
- 242 • The source must be tested a minimum of 3 times in 2 years with at least 4
243 months between tests without a positive detection for an emergency
244 pathogen, testing at the 2% prevalence level in the population with 95%
245 confidence level.

246 OR

- 247 • Fish imported from adult broodstock populations or hatcheries with an
- 248 incomplete testing history should be placed into a quarantine facility for 12
- 249 months; AND
- 250 • Testing should be done on these fish for appropriate emergency pathogens
- 251 such that three negative inspections are recorded, with consecutive
- 252 inspections separated by at least four months before release from the
- 253 quarantine facility occurs. Sampling at the 2% prevalence level of the
- 254 population with 95% confidence level. Stress testing is recommended⁷.

255

256 **Importing Gametes**

257

258 If a member agency seeks to import gametes from outside the Great Lakes basin and
 259 from an area enzootic for an emergency pathogen, and the emergency pathogen IS NOT
 260 vertically transmitted (i.e., *Ceratomyxa shasta*, *Tetracapsuloides bryosalmonae*, and all
 261 genotypes of viral hemorrhagic septicemia virus for salmonid eggs only), properly
 262 disinfected fertilized eggs may be imported.

263

264 If the emergency pathogen IS vertically transmitted, properly disinfected gametes may be
 265 imported only if the adult broodstock population is tested according to the following:

- 266 • The source must be tested a minimum of 5 consecutive years without a positive
- 267 detection for an emergency pathogen, sampling at the 5% prevalence level in the
- 268 population with 95% confidence level;

269 OR

- 270 • The source must be tested a minimum of 3 times in 2 years with at least 4 months
- 271 between tests without a positive detection for an emergency pathogen, sampling at
- 272 the 2% prevalence level in the population with 95% confidence level.

273

274 Properly disinfected gametes and their subsequent offspring imported from an adult
 275 broodstock population with an incomplete testing history should be placed into a

⁷ See Minimum protocol for stressing fish section.

276 quarantine facility for 12 months after fish reach testable size. Prior to release from the
277 quarantine facility, testing should be done 3 times without a positive detection for an
278 emergency pathogen with consecutive tests separated by at least four months.

279

280 **Emergency Pathogen Detections**

281 If an emergency pathogen is detected at a hatchery, immediate steps should be initiated to
282 eradicate the pathogen from the facility and adjacent water:

- 283 • Refer to chapter 14 in the Great Lakes Fishery Commission Special Publication
284 83-2 for disinfection procedures,
- 285 • Isolate all susceptible species from the infected fish as much as possible,
- 286 • If the pathogen IS NOT reportable to the World Organisation for Animal Health
287 (OIE), confirm the detection by another laboratory following standard procedures,
- 288 • Eradicate the pathogen from source water and effluent water supplies if possible,
- 289 • Notify the Great Lakes Fish Health Committee Chairperson, who in turn will
290 advise the Great Lakes Fish Health Committee and the Council of Lake
291 Committees,
- 292 • Update the hatchery classification to reflect the new detection, and
- 293 • Notify all transfer sources or recipients of the fish or gametes that an emergency
294 pathogen has been detected.

295

296 To show freedom of the pathogen, the facility must:

- 297 • Test **all lots** of susceptible species 3 times with at least 4 months between tests,
298 sampling at the 2% prevalence level in the population with 95% confidence level
299 per lot,
- 300 • Destroy all fish in infected lots,
- 301 • Disinfect all gear used and all rearing units that contained the infected lots.

302 OR

- 303 • If appropriate biosecurity measure have been taken to isolate **rearing units**, test 3
304 times a minimum of 4 months apart with 2% prevalence level in the population at
305 95% confidence level,
- 306 • Destroy all fish in the infected rearing units,

- 307 • Disinfect all gear used and all rearing units that contained the infected fish.

308

309 If a negative test result indicates the pathogen has been eradicated, the agency may
310 consider stocking the fish as needed.

311

312 **Detections in the wild**

313

314 If an emergency pathogen is detected in the wild:

- 315 • Notify the Great Lakes Fish Health Committee Chairperson, who will in
316 turn advise the Great Lakes Fish Health Committee and the Council of
317 Lake Committees and take appropriate steps to amend information in this
318 Model Program,
- 319 • If the pathogen IS NOT reportable to the World Organisation for Animal
320 Health (OIE), confirm the detection by another laboratory following
321 standard procedures,
- 322 • Notify the competent authority if it IS OIE reportable,
- 323 • Employ all necessary/reasonable means to contain the spread of the
324 pathogen, including limiting movement of fish and/or gametes from the
325 affected location,
- 326 • Determine the geographic distribution of the pathogen and species
327 susceptible to it, if possible, and
- 328 • Eradicate the pathogen, if possible.

329

330 **Pathogen Classification Changes**

331

332 To move an Emergency pathogen to the Restricted pathogen list, it has to be found to be
333 enzootic somewhere in the Great Lakes basin in addition to requiring management
334 actions to restrict its spread or reduce its virulence.

335

336

337 **Restricted Fish Disease/Pathogen Management**

338

339 Whenever possible, importations and/or stocking should be conducted using pathogen-
 340 free sources of fish or gametes to the greatest extent possible. If this cannot occur, the
 341 following measures should be implemented.

342

343 Restricted fish pathogens have been isolated in the Great Lakes Basin, yet response plans
 344 vary depending on the pathogen (Table 1). In all cases, agencies should strive to
 345 minimize the threat of disease transmission with careful management. Certain restricted
 346 pathogens (Level 1) pose minimal threat and may be introduced to fish populations where
 347 the pathogen already exists and the impact on that population is minimal. In these cases,
 348 the risk management protocol should be used to determine if a proposed location is
 349 suitable for transfer or stocking. However, other pathogens are untreatable (Level 2),
 350 difficult to manage, and disease transmission continues throughout the life of infected
 351 fish. Therefore, depopulation of infected stocks is suggested.

352

353 Table 1. Restricted pathogens and suggested action plan for fish infected for those
 354 pathogens.

Level 1	<i>Aeromonas salmonicida salmonicida</i> Largemouth bass virus Lymphosarcoma <i>Renibacterium salmoninarum</i> <i>Yersinia ruckeri</i>	<ul style="list-style-type: none"> • Seek pathogen-free sources, if possible. • Use methods to reduce disease transmission and stock to locations where impact is minimal. • Using the Risk Assessment is strongly suggested.
Level 2	<i>Heterosporis</i> sp. Infectious pancreatic necrosis virus Koi herpesvirus <i>Myxobolus cerebralis</i> Spring viremia of carp virus Viral hemorrhagic septicemia IVb	<ul style="list-style-type: none"> • Avoid sources of infected fish. • Eradicate infected hatchery lots and do not stock.

355

356

357

358 **Importing/Transferring Fish between hatcheries**

359

360 If a member agency seeks to import or transfer fish from a source with a Level 1
361 restricted pathogen, the pathogen should already be present at the receiving hatchery and
362 the import or transfer should be accompanied with a health certificate, hatchery
363 classification, or wild broodstock population classification.

364

365 If the pathogen is not already present at the receiving hatchery and there is not a source of
366 pathogen-free fish and it is critical to management actions to import the fish, the new
367 pathogen will be added to the classification of the receiving hatchery. The hatchery
368 classification must be updated to reflect this change (refer to the Hatchery Classification
369 section).

370

371 *For coldwater fish:*

372 Fish from unknown sources that are enzootic for a restricted pathogen should undergo
373 standard laboratory tests without detection of a restricted pathogen before fish are
374 gathered for import to a hatchery. If the broodstock does not test positive for the
375 pathogen, the fish may be brought into a quarantine facility and re-tested. If applicable,
376 the fish may be stressed according to protocols for that particular pathogen. Once the fish
377 health history is completed, and no signs of the pathogen are present, the fish may be
378 transferred to the hatchery. If the fish are found to carry the restricted pathogen, the
379 hatchery classification should be adjusted to reflect this. . The exact quarantine plan will
380 be developed by each member agency.

381

382 *For warm and coolwater fish:*

383 Fish from unknown sources that are enzootic for a restricted pathogen should undergo
384 standard and appropriate laboratory tests without detection of a restricted pathogen before
385 fish are gathered for import to a hatchery. If the fish are negative for the pathogen, they
386 may be imported into the hatchery. If the fish are then found to carry the restricted
387 pathogen, the hatchery classification should be adjusted to reflect this.

388

389 **Importing/Transferring Gametes**

390

391 If a member agency seeks to import or transfer gametes from a source with a restricted
392 pathogen, and the restricted pathogen IS NOT vertically transmitted, properly disinfected
393 fertilized eggs may be imported or transferred (refer to disinfection protocol on the
394 website).

395

396 If a member agency seeks to import or transfer gametes from a source with a restricted
397 pathogen, and the restricted pathogen IS vertically transmitted, properly disinfected
398 fertilized eggs may be imported or transferred *if the restricted pathogen is already*
399 *present in the receiving hatchery.*

400

401 If the vertically-transmitted restricted pathogen is not present in the receiving hatchery,
402 gametes from non-tested sources should be placed in a quarantine facility until
403 appropriate testing can be done.

404

405 **Releasing Fish**

406

407 Release of fish infected with Level 1 restricted pathogens without clinical signs should
408 take place only when required by fisheries management and only into locations where the
409 pathogen has been detected, or in areas which have received infected fish, within the last
410 five years.

411

412 Release of fish into the Great Lakes basin should not be conducted if any of the following
413 situations exist:

- 414 • Fish exhibit clinical signs of any disease,
- 415 • The mortality rates of fish in one rearing unit deviate from normal hatchery
416 background levels (e.g., no fish should be stocked if losses in that rearing unit
417 in the month preceding stocking exceeded 10%). It is advisable to test these
418 fish to determine if a pathogen is present, OR
- 419 • Fish are infected with a pathogen that is resistant to multiple antibiotics. The
420 fish should only be released into a lake without any inlets or outlets.

421

422 Restricted Pathogen Detections

423

424 If a restricted pathogen is detected at a hatchery:

- 425 • Improve biosecurity measures as needed to limit the spread of the pathogen
- 426 to other rearing units within the hatchery or to other hatcheries,
- 427 • Optimize rearing conditions,
- 428 • Treat infected rearing units to reduce the number of infected fish, if
- 429 appropriate, AND
- 430 • If it is a new detection, determine the origin of the pathogen, if possible,
- 431 and take action to prevent further spread as appropriate.

432

433 If a restricted pathogen is detected in the wild:

- 434 • Limit the collection of fish and gametes from the location, if possible,
- 435 • Employ reasonable means to prevent the spread of the pathogen to new
- 436 locations where it previously has not been detected, AND
- 437 • Determine the geographic distribution of the pathogen, if possible.

438

439 When the guidance provided in this document concerning restricted pathogens is
440 superseded by additional information about the pathogen, the member agency should
441 contact the Great Lakes Fish Health Committee Chairperson. The Chairperson will use
442 the most expedient way to provide appropriate recommendations to the member agency.
443 In the interim, the affected fish shall not be released or transferred and efforts should be
444 made to contain the pathogen.

445

446 Provisional Pathogen Management

447

448 A provisional fish pathogen is a pathogen which may or may not be found in the Great
449 Lakes but is a concern to at least one of the member agencies, primarily because the life
450 history strategies and potential impacts of the pathogen are unknown. A provisional
451 pathogen may be added to the Model Program if it is of previously unknown etiology, has

452 the potential to seriously impact aquatic animal health, and meets the following three
453 criteria⁸:

454

- 455 1. The disease has been demonstrated to cause significant production losses due
456 to morbidity or mortality. Mortality at or above 0.5 percent per day for any 3
457 consecutive days during disease episode is considered significant; OR, the
458 disease has been demonstrated, or there is strong scientific evidence which
459 suggests, that it negatively affects wild aquatic populations;
- 460 2. Infectious etiology has been proven, or an infectious agent is strongly
461 associated with disease but etiology is not yet known, and there is a potential for
462 spread via live animals or their products; and
- 463 3. Consensus is reached among GLFHC members for listing the provisional
464 pathogen/disease.

465

466 GLFHC members should complete the Pathogen Nomination Form (Appendix 3) when
467 requesting a provisional pathogen be added to the Model Program. This document
468 requires information on the pathogen, why it is a concern, and the rationale for defining it
469 as a Provisional Pathogen. The completed form should be submitted to the Chair of the
470 GLFHC, who in turn will present it to the committee to determine if the pathogen belongs
471 on the Provisional list.

472

473 Because of the lack of knowledge on the pathogen, the appropriate management actions
474 may be uncertain. Possible considerations include:

- 475 • Determining if appropriate diagnostic tools are available:
 - 476 ○ If yes, then request member agencies begin surveillance,
 - 477 ○ If no, develop a detection method,
- 478 • Identify the research needs and information gaps, and
- 479 • Identify vectors and hosts in the Great Lakes basin under the regulatory control of
480 member agencies.

⁸ Adapted from the United States National Aquatic Animal Health Plan (2009)

481 If a provisional pathogen is found within a hatchery, the risk assessment should be used
482 to provide guidance on whether or not to import or transfer the fish stock in question. In
483 addition, the agency should identify its threats, determine from where it came, determine
484 if it was transferred to another region/hatchery, and minimize the damage.

485

486 If a provisional pathogen is found in the wild, member agencies can use the risk
487 assessment to provide guidance on whether or not to use the impacted fish as a donor
488 broodstock.

489

490 To move a provisional pathogen to the Restricted pathogen list, the following criteria
491 should be met:

- 492 • It is enzootic somewhere in the Great lakes basin,
- 493 • It can cause epizootic events or reduction of fitness,
- 494 • There is a need for active management against it (prevalence, spread, etc),
- 495 • Reliable testing is available, AND
- 496 • Sufficient life history and biosecurity information is available to determine
497 appropriate mgmt actions.

498

499 To move a provisional pathogen to the Emergency pathogen list, the following criteria
500 should be met:

- 501 • It is NOT enzootic anywhere in the Great Lakes basin,
- 502 • It causes significant epizootic events or reduction of fitness, AND
- 503 • There is a requirement for active management against it (generally, depopulation).

504

505 To remove a pathogen from the Provisional pathogen list without moving it to
506 Emergency or the Restricted lists, the following criteria should be met:

- 507 • It is found to not cause epizootic events or reduction of fitness,
- 508 • Reliable testing is available, AND
- 509 • Sufficient life history and biosecurity information is available to determine
510 management actions are not necessary.

511

512

513 **Inspections and Testing**

514

515 Testing and inspection results should be used to develop classifications and inform
 516 decisions on collection, import, stocking, transfer, etc. Testing for all emergency and
 517 restricted pathogens is encouraged before the release of fish (Appendix 1). Sample
 518 collection staff will be designated by the member agency, and collection and testing will
 519 be done using approved methods.

520

521 The method of collecting subsamples and the number of samples (suggested samples
 522 sizes given in Table 2) collected from rearing units to obtain a representative sample⁹ is
 523 left to the discretion of the member agency. Sampling of wild broodstock populations
 524 and hatchery fish should be conducted throughout the year. Moribund fish and fish with
 525 clinical signs of disease should be included in samples collected during routine testing
 526 and inspections wherever possible.

527

528 Table 2. Minimum suggested sample sizes for populations or lots with 50 to greater than
 529 100,000 fish within a hatchery. Sample sizes are based on upon stratified
 530 random sampling that assumes a binomial distribution and provides 95%
 531 confidence of detecting a pathogen with an assumed minimum incidence of
 532 detectable infection, depending upon conditions, of 2%-5%.

533

Population or Lot Size	Sample Size Assumed Incidence	
	2%	5%
50	50	30
100	75	45
250	110	50
500	130	55
1,000	140	55

⁹ Refer to the three documents listed in the Pathogen Detection section for proper representative sampling.

1,500	140	55
2,000	145	60
4,000	145	60
10,000	145	60
100,000 or greater	150	60

534

535 **Classification of Hatcheries and Wild Broodstock Populations**

536

537 The classification system is designed to facilitate an awareness of fish disease status of
538 fish hatcheries and wild broodstock populations by compiling the results of testing in a
539 simple, easy to follow format. It is recommended that all member agencies maintain up to
540 date classifications (annual updates at a minimum) for each hatchery and wild broodstock
541 population, use this classification system when moving fish and gametes, and provide the
542 classification information to other agencies/hatcheries when transferring fish and
543 gametes.

544

545 By using this classification system, the risk of acquiring a pathogen listed in the Model
546 Program¹⁰ will be better understood. It is recommended that importations and transfers
547 not knowingly move pathogens. Classifications should be dated and include contact
548 information for a person who may be called to provide additional information should it be
549 required.

550

551 Each hatchery and wild broodstock population will obtain a letter-number classification.

552 The letter identifies the presence/absence of one or more restricted pathogen:

553 **Class-A:** no history within the last 2 years of any of the listed emergency or
554 restricted pathogens

555 **Class-B:** a detection of one or more emergency or restricted pathogens

556 **Class-C:** pathogen history unknown (i.e., incomplete testing for a period of 2
557 years)

558

¹⁰Other pathogens not listed in the Model Program may be present.

559 AND

560

561 the number identifies the water supply used at the hatchery:

562 **Class-1:** the water supply is secure

563 **Class-2:** the water supply is non-secure

564

565 Wild broodstock populations will always be class 2 because the water in which they live
566 is non-secure.

567

568 **To obtain an A-1 classification,** the hatchery would have:

- 569 • No detections of a restricted pathogen within 3 calendar years with ongoing
- 570 annual inspections/testing, AND
- 571 • A secure water supply.

572

573 **To maintain an A-1 classification,** hatcheries must:

- 574 a) Undergo a minimum of one annual inspection/testing period, AND
- 575 b) Have no detections of restricted pathogens, AND
- 576 c) Ensure that all fish are obtained from hatcheries classified as A-1 or its
577 equivalent, AND
- 578 d) Ensure that all gametes are properly disinfected after being obtained from
579 hatcheries classified as A-1 or its equivalent.

580

581 **To obtain an A-2 classification,** the hatchery or wild broodstock population would have:

- 582 • No detections of a restricted pathogen within 3 calendar years, with at least two
- 583 inspections/testing periods separated by a minimum of 4 months, AND
- 584 • A non-secure water supply.

585

586 **To maintain an A-2 classification** hatcheries must:

- 587 a) Undergo a minimum of one annual inspection/testing period, AND
- 588 b) Have no detections of restricted pathogens, AND

- 589 c) Ensure that all fish are obtained from hatcheries classified as A-1, A-2 or the
590 equivalent, AND
- 591 d) Ensure that all gametes are properly disinfected after being obtained either from
592 hatcheries classified as A-1, A-2 or the equivalent, or from wild broodstock
593 populations classified as A-2¹¹.

594

595 **To obtain a B-1 classification**, the hatchery would have:

- 596 • A detection of one or more restricted pathogens within the last 3 calendar years,
597 with at least two inspections/testing periods separated by a minimum of 4
598 months, AND
- 599 • A secure water supply.

600

601 **To maintain a B-1 classification**, hatcheries must:

- 602 a) Undergo a minimum of one annual inspection/testing period, AND
- 603 b) Have a detection of one or more restricted pathogens, AND
- 604 c) Ensure that all fish are obtained from hatcheries classified as A-1, A-2, B-1, or
605 their equivalent, AND
- 606 d) Ensure that all gametes are properly disinfected after being obtained from
607 hatcheries classified as A-1, A-2, B-1⁶, or their equivalent.

608

609 **To obtain a B-2 classification**, the hatchery and wild broodstock population would have:

- 610 • A detection of one or more restricted pathogens within the last 3 calendar years,
611 with at least two inspections/testing periods separated by a minimum of 4
612 months, AND
- 613 • A non-secure water supply.

614

615 **To maintain a B-2 classification**, hatcheries and wild broodstock populations must:

- 616 a) Undergo a minimum of one annual inspection/testing period, AND
- 617 b) Have a detection of one or more restricted pathogens, AND

¹¹ See Exceptions for Gametes section for additional information

618 c) Ensure that all fish are obtained from hatcheries classified as A-1, A-2, B-1, B-2,
619 or their equivalent, AND

620 d) Ensure that all gametes are properly disinfected after being obtained either from
621 hatcheries classified as A-1, A-2, B-1, B-2, or their equivalent, or from wild
622 broodstock populations classified as A-2 or B-2⁶.

623

624 **To obtain a C-1 classification**, the hatchery would have:

- 625 • Testing within the last 3 calendar years that does not meet standards of Class A
626 or B classifications, AND
- 627 • A secure water supply.

628

629 **To obtain a C-2 classification**, the hatchery and wild broodstock population would have:

- 630 • Testing within the last 3 calendar years that does not meet standards of Class A
631 or B classifications, AND
- 632 • A non-secure water supply.

633

634 For hatcheries and wild broodstock populations with the B classification the restricted
635 pathogen(s) detected must be identified using a pathogen acronym (see Table 3).

636

637 Table 3. Acronyms for pathogens listed in the Model Program to be used in hatchery and
638 wild broodstock population classifications.

639

Pathogen (Disease)	Code
<i>Aeromonas salmonicida salmonicida</i> (causes furunculosis)	AS
<i>Ceratomyxa shasta</i> (causes ceratomyxosis)	CS
Epizootic epitheliotropic disease virus	EEDV
<i>Heterosporis</i> sp.	HSP
Infectious hematopoietic necrosis virus	IHNV
Infectious pancreatic necrosis virus	IPNV
Infectious salmon anemia virus	ISAV
Koi herpesvirus	KHV
Largemouth bass virus	LMBV
<i>Myxobolus cerebralis</i> (causes whirling disease)	MC
<i>Nucleospora salmonis</i>	NS
<i>Piscirickettsia cf salmonis</i> (muskie pox)	PSP

<i>Renibacterium salmoninarum</i> (causes bacterial kidney disease)	RS
Spring viremia of carp virus	SV
<i>Tetracapsuloides bryosalmonae</i> (causes proliferative kidney disease)	PKX
Viral hemorrhagic septicemia virus	VHSV
White sturgeon herpesvirus	WSHV
White sturgeon iridovirus	WSIV
<i>Yersinia ruckeri</i> (enteric redmouth)	YR

640 *Would designate appropriate strain

641

642

643 **Changing Classifications**

644

645 As test results become available, classification records will be updated to include any
 646 restricted pathogens detected in the preceding 24 month period and to include the date of
 647 the classification. Classifications may change as new test results become available or
 648 when fish or gametes are brought into a hatchery. Refer to the Classification of
 649 Hatcheries and Broodstocks section for guidelines on how to obtain and maintain
 650 individual classifications.

651

652 **Exceptions for Gametes**

653

654 If fertilized eggs originate from a hatchery or wild broodstock population positive for the
 655 pathogens listed below AND the fertilized eggs are properly disinfected, the hatchery
 656 classification will not change because the following pathogens are not vertically
 657 transmitted and can be eliminated with proper disinfection:

- 658 • *Aeromonas salmonicida salmonicida*
- 659 • *Ceratomyxa shasta*
- 660 • *Tetracapsuloides bryosalmonae*
- 661 • *Yersinia ruckeri*
- 662 • Viral hemorrhagic septicemia virus (all genotypes)
- 663 • *Whirling disease*

664

665 **Exceptions for Antibiotic Resistant Bacteria**

666

667 **If** an antibiotic-resistant bacterium is isolated from a hatchery, the detection should be
668 noted on inspection reports, classifications, and in annual reports.

669

670 **Hatchery Depopulation and Disinfection**

671

672 A hatchery that was depopulated and disinfected to eliminate a pathogen will initially
673 become Class B following the disinfection. The hatchery must go through the required 3
674 calendar year inspection/testing period, during which time it will be considered suspect
675 for the previously detected pathogen(s). The hatchery classification will include the
676 acronym for the suspect pathogen and the disinfection date will be noted. Following the
677 inspection/testing period without a detection of the suspect pathogen, the hatchery will be
678 reclassified without the acronym for the suspect pathogen and the disinfection date will
679 no longer be required.

680

681 **Reporting**

682

683 Each member agency shall provide to the GLFHC Chairperson an annual report, covering
684 the calendar year January to December, describing the status of fish health within the area
685 managed by the member agency. Member agency annual reports will be shared with the
686 GLFHC. The annual report shall include summaries of the following:

687

- 688 • The classification of agency hatcheries and wild broodstock populations,
- 689 • A list of known importations into the Great Lakes basin of fish and gametes from
690 outside the Great Lakes basin,
- 691 • Any measures adopted for pathogen management,
- 692 • Any detections of emergency or restricted pathogens within the member agency
693 jurisdiction including information pertinent to fish sample collection, testing
694 method(s), dates, and locations (including lat/long), etc,
- 695 • Any cases of high mortality in fish hatcheries or in wild populations, including
696 information on the causative pathogen(s), if detected, and

- 697 • A summary of any fish disease issues for which the member agency requested input
698 from the GLFHC members, including final decisions made following GLFHC
699 input.

700

701 **Pathogen descriptions**

702

703 *Aeromonas salmonicida salmonicida*

704 *Aeromonas salmonicida salmonicida* infects numerous freshwater fish species. In
705 salmonids this bacterium causes the disease furunculosis, and the bacterium can cause
706 disease in other fish species. This bacterium is distributed worldwide, is enzootic
707 throughout the Great Lakes basin. Clinical signs include boil-like lesions (furuncles) on
708 the skin and in the muscle tissue, exophthalmia, bloody discharge from vent, and
709 multifocal hemorrhages in the viscera and muscle.

710

711 *Ceratomyxa shasta*

712 *Ceratomyxa shasta* is a myxosporidian parasite that infects anadromous salmonids in the
713 Pacific northwest of the United States and Canada causing the disease Ceratomyxosis. *C.*
714 *shasta* initially infects the intestine but the infection generally becomes systemic over
715 time. Ultimately, the spores displace functional tissue in the organs and the fish die.
716 Clinical signs of disease include emaciation, lethargy, darkening of skin, ascites, and
717 exophthalmia. The parasite requires an intermediate polychaete host (*Manayunkia*
718 *speciosa*) (Willson et al. 2010) which has been reported from the Great Lakes basin
719 (Hiltunen, 1965; Rolan, 1974; Spencer, 1976).

720

721 **Epizootic Epitheliotropic Disease Virus**

722 Epizootic epitheliotropic disease virus (EEDv) infects numerous salmonids, particularly
723 lake trout in North America. This virus has been detected in Lake Superior and in
724 hatcheries in California, Michigan, Pennsylvania, Wisconsin, and Wyoming. Clinical
725 signs have only been reported in juvenile lake trout and include lethargy, riding high in
726 the water, hemorrhages of the eye and gray-white mucoid blotches on the skin and fins.

727

728 ***Heterosporis* sp.**

729 *Heterosporis* sp. is a microsporidan parasite that infects the muscle of yellow perch
730 walleye, northern pike, ciscoe, rock bass and pumpkinseed. This parasite is known to
731 occur in a limited number of Wisconsin, Michigan, and Minnesota lakes, the Canadian
732 waters of lakes Ontario and Erie and the U.S. (Minnesota) waters of Lake Superior. It has
733 not been reported from fish hatcheries. The parasite causes disease to infected host fish in
734 the form of infected flesh has patches of white, opaque muscle with the appearance of
735 “freezer-burn” that is unpalatable to the public. Mortality has been induced in the
736 laboratory but natural mortality has not been observed.

737

738 **Infectious Hematopoietic Necrosis Virus**

739 Infectious hematopoietic necrosis virus (IHNV) infects salmonids in fresh and salt water,
740 in the wild and in hatcheries. This virus is a pathogen of international concern. IHNV is
741 present in salmon and steelhead along the west coast of Canada and the United States.
742 Clinical signs of disease include exophthalmia, darkening of skin, petechiae on the skin,
743 in the mouth, pale gills, ascites, pale viscera with/without petechiae (including the swim
744 bladder, body wall and mesenteries). The virus is most likely vertically transmitted.

745

746 **Infectious Pancreatic Necrosis Virus**

747 Infectious Pancreatic Necrosis virus (IPNV) has been isolated from wide range of fish
748 species including salmonids, cyprinids and marine species. The pathogen has a wide
749 geographic distribution, occurring in North and South America, Europe, Asia, and South
750 Africa. In the Great Lakes basin IPNV has been found in Pennsylvania, Michigan and
751 Wisconsin. Clinical signs include darkened body coloration, exophthalmia, petechiae on
752 the skin, cessation of feeding and in the later stages show a loss of balance progressing to
753 a corkscrew swimming motion.

754

755 **Infectious Salmon Anemia Virus**

756 Infectious salmon anemia virus (ISAV) infects primarily Atlantic salmon in wild and
757 farmed fish in the North Atlantic waters of Canada, the United States, Norway, the Faroe
758 Islands and the United Kingdom. This virus is a pathogen of international concern.

759 Clinical signs of disease include anemia, ascites, petechiae in the body wall and eye. This
760 virus is suspected to be vertically transmitted.

761

762

763 **Koi Herpesvirus**

764 Koi Herpesvirus (KHVv) infects carp, koi and goldfish causing the disease koi
765 herpesvirus (KHV) in carp and koi. The virus has been found worldwide and in the Great
766 Lakes basin in Michigan, New York State, Ontario. It is a pathogen of international
767 concern. Clinical signs include skin discoloration, increased respiratory frequency, skin
768 lesions, appetite loss, erratic swimming, sunken eyes, notch on the nose, and swollen,
769 pale, rotting gills.

770

771 **Largemouth Bass Virus**

772 Largemouth bass virus (LMBv) infects centrarchids east of the Rocky Mountains in the
773 United States. In the Great Lakes basin, LMBv has been found in Lake St. Clair, western
774 portion of Lake Erie. The virus also has been found in Illinois and Wisconsin hatcheries.
775 Most fish with LMBv are carriers with no clinical signs. The mortality has only been
776 found in largemouth bass. Clinical signs include difficulty swimming, bloated abdomen,
777 loss of buoyancy regulation, hemorrhaging and discoloration of the swim bladder.

778

779 **Lymphosarcoma**

780 Lymphosarcoma is a malignancy of esocids in North America, the United Kingdom and
781 Europe and is believed to be caused by a retrovirus (Wolf 1988). It may take up to a year
782 for infected fish to show external signs of disease. Fish with lymphosarcoma do survive
783 but the sores and growths associated with severe infections are unpalatable to the public.

784

785 ***Myxobolus cerebralis***

786 *Myxobolus cerebralis* is a myxosporidean parasite of salmonids that causes whirling
787 disease. It is found in Europe, North America, and South Africa. *M. cerebralis* has been
788 found in Great Lakes tributary waters and in fish hatcheries in Michigan and inland
789 waters in Pennsylvania, New York, and Michigan. *M. cerebralis* requires a tubificid

790 oligochaete to complete its life cycle. Clinical signs include darkened tails, skeletal
791 deformities, and “whirling” behavior in young fish.

792

793 ***Nucleospora salmonis***

794 *Nucleospora salmonis* is an intracellular microsporidian parasite reported from salmonid
795 species in Europe, South and North America. In the Great Lakes basin *N. salmonis* has
796 been reported in National Fish Hatcheries in Michigan. *N. salmonis* infects blood
797 leukocytes, hematopoietic tissues in the kidney and spleen, and tubular and glomerular
798 epithelium in kidneys. Clinical signs include anemia and leukemia and can be associated
799 with mortality.

800

801 ***Piscirickettsia* – like organism**

802 A *Piscirickettsia*-like bacterium was isolated from adult muskellunge in Lake St. Clair
803 during the 2003 spawning period and is a likely contributing factor in epizootic events.
804 Clinical signs include quarter-sized rash-like skin lesions.

805

806 ***Renibacterium salmoninarum***

807 *Renibacterium salmoninarium* infects salmonids, especially rainbow trout, brown trout,
808 brook trout and coho salmon, Chinook salmon. This bacterium causes bacterial kidney
809 disease (BKD). It occurs in virtually all areas where salmonids occur, except Australia,
810 New Zealand and Russia. It is a serious problem in the northeast Pacific and Japan. *R.*
811 *salmoninarum* is enzootic and broadly distributed within the Great Lakes basin. Clinical
812 signs include dark coloration, exophthalmia, pale gills, ascites, skin lesions, white
813 nodular masses in the kidney, abdominal distension or hemorrhages at the vent or base of
814 the fins. This bacterium is vertically transmitted.

815

816 **Spring Viremia of Carp Virus**

817 Spring viremia of carp virus (SVCv) primarily affects carp and other species in the
818 Cyprinidae family, but has also been found in a few species of other fish families such
819 as Centrarchidae and Percidae. This virus causes the disease spring viremia of carp
820 (SVC). It has been reported from Europe, Asia, North and South America. It is a disease

821 of international concern. In the Great Lakes basin it has been found in healthy common
 822 carp from the Hamilton Harbor region of Lake Ontario and has been associated with die-
 823 offs in several inland waters in Illinois, Ohio, New York and Wisconsin. Clinical signs
 824 include darkened body coloration, pale gills, abdominal distension, exophthalmia,
 825 inflammation of the vent, petechial hemorrhages of skin, gills and eyes.

826

827 ***Tetracapsuloides bryosalmonae***

828 *Tetracapsuloides bryosalmonae* is a myxosporidean parasite that infects salmonids in
 829 North America and Europe causing Proliferative Kidney Disease (PKD). The parasite
 830 infects the interstitial cells of the kidney and penetrates the lumen of the tubules. Clinical
 831 signs include distended abdomen, enlargement of the kidney, exophthalmia and anemia.
 832 This parasite is not vertically transmitted in eggs.

833

834 ***Viral Hemorrhagic Septicemia (all genotypes except IVb)***

835 The viral hemorrhagic septicemia virus (VHSv) infects wild and farmed freshwater and
 836 marine species of fish causing the disease viral hemorrhagic septicemia (VHS). There
 837 are four genotypes of VHSv: VHS genotypes I, II, and III occur in Europe, genotype IVa
 838 occurs in marine fish species in Japan and on the west coast of North America¹². This
 839 virus is a pathogen of international concern. Clinical signs of disease include petechiae on
 840 the skin, in muscle, in and on the surface of the viscera, ascites, exophthalmia.

841

842 ***Viral Hemorrhagic Septicemia Virus (Genotype IVb)***

843 Viral hemorrhagic septicemia virus genotype IVb (VHSv-IVb) infects a wide range of
 844 freshwater fish species including several species of Centrarchidae, Esocidae, Percidae,
 845 Salmonidae, Coregonidae, Cyprinidae, Sciaenidae. Some species, such as muskellunge
 846 are quite susceptible to disease and mortality however signs of disease have not been
 847 reported from other species such as emerald shiner. VHS-IVb is enzootic and has now
 848 been found in all Great Lakes. It has been detected inland in Michigan, New York, and
 849 Wisconsin and in the Ohio River basin in Ohio. It is a pathogen of international

¹² VHS genotype IVb is present in the Great Lakes basin and therefore is listed as a restricted fish pathogen.

850 concern¹³. Clinical signs of disease include ascites, exophthalmia, enlarged spleen, and
851 petechiae in skin, muscle, and viscera.

852

853 **White Sturgeon Herpesvirus**

854 Two strains of white sturgeon herpesvirus, WSHv-1 and WSHv-2, occur in white
855 sturgeon in west coast of the United States. Both viruses cause moderate to high mortality
856 in cultured fish. No specific external clinical signs of disease. Fish continue to feed until
857 death. Internally, stomach and intestine filled with fluid, but other organs appear normal.
858 Affected wild white sturgeon become listless and appeared to have stopped eating. Other
859 species of sturgeon, including shovelnose and pallid sturgeon, are also susceptible to
860 WSHv.

861

862 **White Sturgeon Iridovirus**

863 White sturgeon iridovirus (WSIV) is known to be pathogenic to the genus *Acipenser* in
864 the Pacific northwestern United States and to both cultured and wild white sturgeon and
865 has been detected in Russian sturgeon. The virus is also known to be mildly pathogenic
866 to lake sturgeon.

867

868 ***Yersinia ruckeri***

869 *Yersinia ruckeri* (serotype I and II) infects marine and freshwater fish in North America,
870 Australia, Africa and Europe. Rainbow trout are especially susceptible. This bacterium
871 causes the disease enteric redmouth (ERM) and is broadly distributed in the Great Lakes
872 basin. Clinical signs include redness of the mouth, exophthalmia, pale liver, hemorrhages
873 in the gills, skin and fins, swollen kidney and spleen. Chronic cases may demonstrate
874 partial or total blindness, exophthalmia, distended abdomen, emaciation.

875

876

877

878

¹³ VHS genotypes I, II, III, and IVa have not been detected in the Great Lakes basin and therefore are listed as emergency fish pathogens.

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Appendix 1. Common and species names of fish included in the Model Program.

Common Name	Species Name
Atlantic salmon	<i>Salmo salar</i>
Black crappie	<i>Pomoxis nigromaculatus</i>
Bluegill	<i>Lepomis macrochirus</i>
Brook trout	<i>Salvelinus fontinalis</i>
Brown trout	<i>Salmo trutta</i>
Burbot	<i>Lota lota</i>
Channel catfish	<i>Ictalurus punctatus</i>
Chinook salmon	<i>Oncorhynchus nerka</i>
Coho salmon	<i>Oncorhynchus kisutch</i>
Common carp	<i>Cyprinus carpio</i>
Cutthroat trout	<i>Oncorhynchus clarki</i>
Freshwater drum	<i>Aplodinotus grunniens</i>
Lake herring	<i>Coregonus artedi</i>
Lake sturgeon	<i>Acipenser fulvescens</i>
Lake trout	<i>Salvelinus namaycush</i>
Lake whitefish	<i>Coregonus clupeaformis</i>
Largemouth bass	<i>Micropterus salmoides</i>
Muskellunge	<i>Esox masquinongy</i>
Northern pike	<i>Esox lucius</i>
Pumpkinseed	<i>Lepomis gibbosus</i>
Rainbow trout	<i>Oncorhynchus mykiss</i>
Rock bass	<i>Ambloplites rupestris</i>
Round goby	<i>Neogobius melanostomus</i>
Smallmouth bass	<i>Micropterus dolomieu</i>
Tubenose goby	<i>Proterorhinus</i>
Walleye	<i>Stizostedion vitreum</i>
White bass	<i>Morone chrysops</i>
Yellow perch	<i>Perca flavescens</i>

Appendix 2. Pathogens listed in the Model Program, the disease they cause, classification in the Model Program, and fish species recommended for screening. Modified from the AFS Bluebook (citation).

Organism	Common Name of Disease	Pathogen Classification	Species to be Screened
Bacterial Pathogens			
<i>Aeromonas salmonicida</i>	Furunculosis	Restricted	Any freshwater fish
<i>Piscirickettsia cf salmonis</i>	Musky pox	Provisional	Esocids
<i>Renibacterium salmoninarum</i>	Bacterial kidney disease	Restricted	Salmonids
<i>Yersinia ruckeri</i>	Enteric red mouth (ERM)	Restricted	Any freshwater fish
Parasitic pathogens			
<i>Bothriocephalus acheilognathi</i>	Asian tapeworm	Provisional	Cyprinids
<i>Ceratomyxa shasta</i>	Ceratomyxosis	Emergency	Salmonids
<i>Heterosporis</i> sp		Provisional	Percids, Esocids, Centrarchids
<i>Myxobolus cerebralis</i>	Whirling disease	Restricted	Salmonids
<i>Nucleospora salmonis</i>	Salmonid Intranuclear Microsporidiosis	Provisional	Salmonids
<i>Tetracapsula bryosalmonae</i>	Proliferative kidney disease (PKD)	Emergency	Salmonids
Viral Pathogens			
Epizootic Epitheliotropic Disease Virus	EED	Provisional	Salmonids
Infectious Hematopoietic Necrosis Virus	IHN	Emergency	Salmonids
Infectious Pancreatic Necrosis Virus	IPN	Restricted	Any freshwater fish
Infectious Salmon Anemia Virus	ISA	Emergency	Salmonids/Atlantic herring
Koi Herpesvirus	KHV	Restricted	Cyprinidae
Largemouth Bass Virus	LMBV	Restricted	Centrarchids/Esocids
Spring Viremia of Carp Virus	SVCV	Restricted	Cyprinids
Viral Hemorrhagic Septicemia (IVb strain)	VHSV	Restricted	Any freshwater fish
Viral Hemorrhagic Septicemia (remaining strains)	VHSV	Emergency	Salmonids
White Sturgeon Herpesvirus	WSHV-1, WSHV-2	Emergency	Acipenseridae
White Sturgeon Iridovirus	WSIV	Emergency	Acipenseridae

Appendix 3. Pathogen nomination form.

<p>Great Lakes Fish Health Committee members should complete this form when requesting a pathogen be added to the Model Program. Upon completion, the form should be submitted to the Chair of the GLFHC.</p>
Pathogen name/disease name (include synonyms):
Suggested classification (Emergency, Restricted, Provisional):
Known geographic range:
Known host species:
Known intermediate/alternate host species (parasites only):
Relevance to the Great Lakes, including estimated pathogenicity:
Clinical disease signs:
Methods for pathogen detection and disease diagnosis:
Relevant literature:
Other:

Classification of Hatcheries and Wild Broodstock Populations

The classification system is designed to designate pathogen status of a fish hatchery or wild broodstock population by compiling the results of testing in a simple, easy to follow format. It is recommended that all member agencies maintain up to date classifications (annual updates at a minimum) for each hatchery and wild broodstock population, use this classification system when moving fish and gametes, and provide the classification information to other affected agencies/hatcheries when transferring fish and gametes.

By using this classification system, the risk of acquiring a pathogen listed in the Model Program¹ will be better understood. It is recommended that importations and transfers not knowingly move pathogens. Classifications should be dated and include contact information for a person who may be called to provide additional information should it be required.

Hatcheries or wild broodstock populations shall be designated as one of the following: specific-pathogen free (SPF), positive, suspect, or other.

Specific-Pathogen Free (SPF) Facilities. Hatcheries or wild broodstock populations where pathogens specified in the Model Program have not been detected during three (3) consecutive annual inspections shall be designated as specific-pathogen free (SPF).

Positive Facilities. If one or more pathogens specified in the Model Program are detected at a hatchery or in a wild broodstock population, that hatchery or wild broodstock population shall be considered positive for that pathogen(s). The appropriate pathogen code(s), as listed in Table 3, shall appear on the fish health inspection report, along with the date of the inspection. A facility shall be considered positive for a pathogen until the next fish health inspection in which the pathogen is not detected.

¹Other pathogens not listed in the Model Program may be present.

Example: Hatchery XYZ tested positive for *Aeromonas salmonicida* during an annual fish health inspection that was conducted on October 10, 2009. The classification for this hatchery would now be:

AS (10/10/2009)

Suspect Facilities. A hatchery or wild broodstock will be considered suspect for a pathogen in any of the following situations:

- (1) The first negative fish health inspection after the detection of a pathogen(s) at the hatchery or wild broodstock population.
- (2) If a hatchery has received properly disinfected eggs from a hatchery or wild broodstock population that has tested positive for a pathogen that is known to be vertically transmitted.

Or,

- (3) If a hatchery has received fish from a hatchery or wild broodstock population that tested positive for one or more pathogens following the transfer.

The suspect classification shall be designated on the fish health inspection report and hatchery classification report by placing a lowercase “s” in front of the appropriate pathogen code (Table XX). The suspect classification shall remain until the completion of a two (2) additional negative fish health inspections after receiving the suspect designation.

Example: Hatchery XYZ tested positive for *Aeromonas salmonicida* during an annual fish health inspection that was conducted on October 10, 2009. *Aeromonas salmonicida* is not detected during the next annual fish health inspection on October 9, 2010. The classification for this hatchery would now be:

s-AS (10/09/2010)

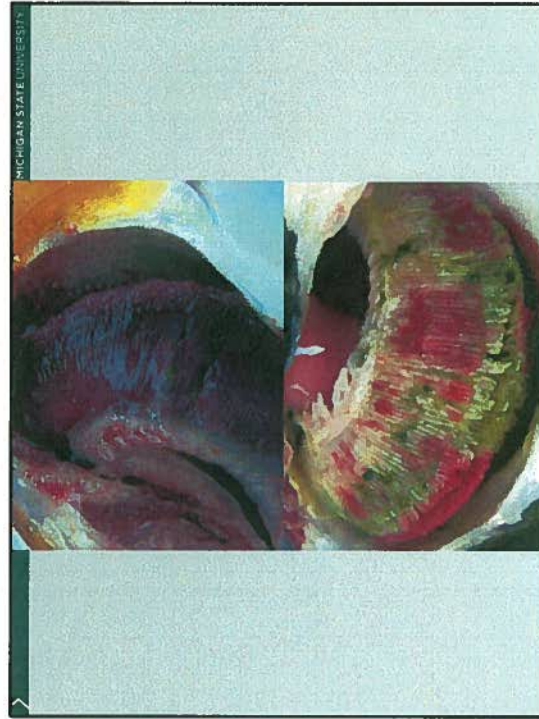
Other Facilities. Hatcheries or wild broodstock populations that do not have a minimum of three (3) annual fish health inspections should designate the hatchery or wild broodstock classification as NA (not applicable).

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Viral Infections




- Koi Herpes Virus (Herpes)
- LMBV (Irido)
- Dermal Sarcome (Retrovirus)
- Discrete & diffuse hyperplasia (Herpesvirus)
- Lymphocystis Virus (Irido)
- Largemouth bass virus (Irido)
- IPNV (Birna)
- VHSV (Rhabdo)




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Thomas Loch Carolyn Schulz Andrew Winters

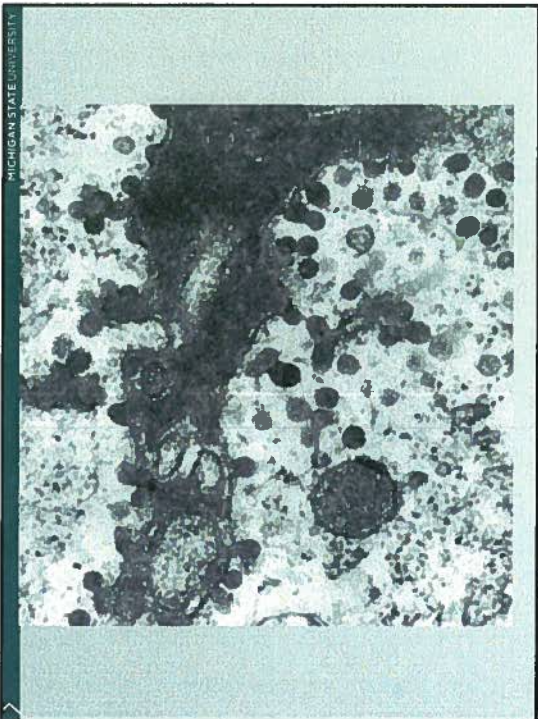
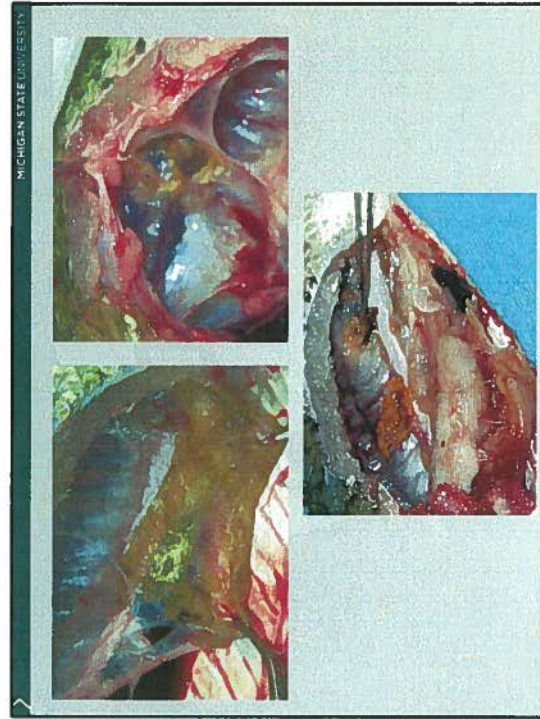
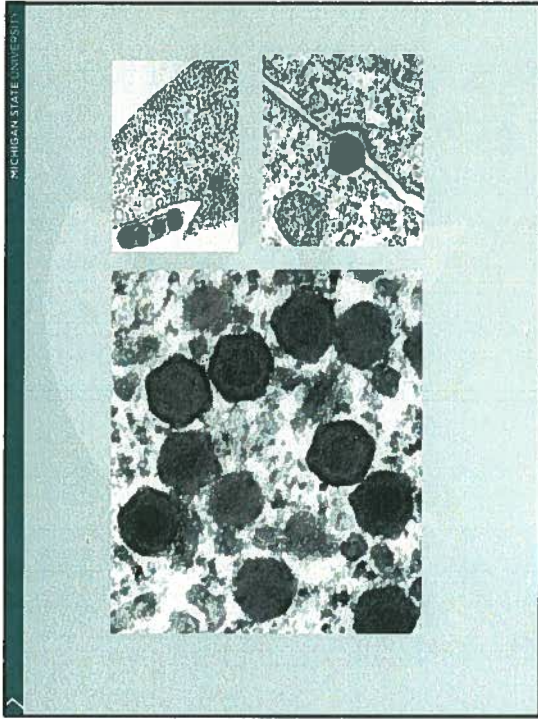


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Clinical Signs of Illness

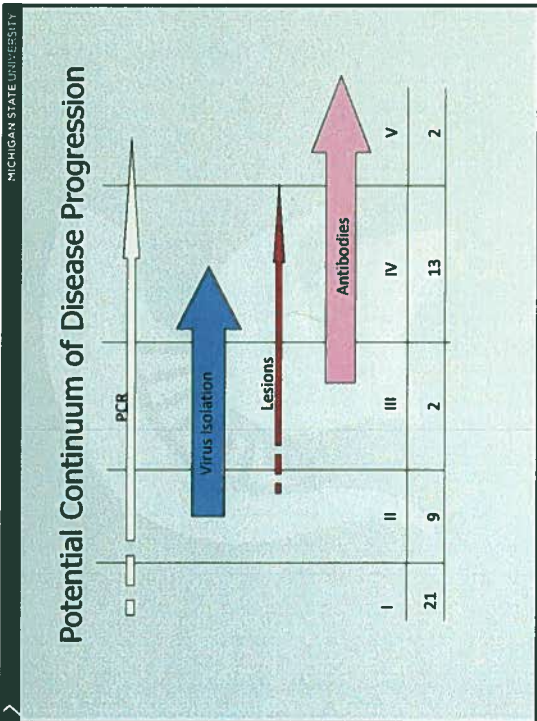
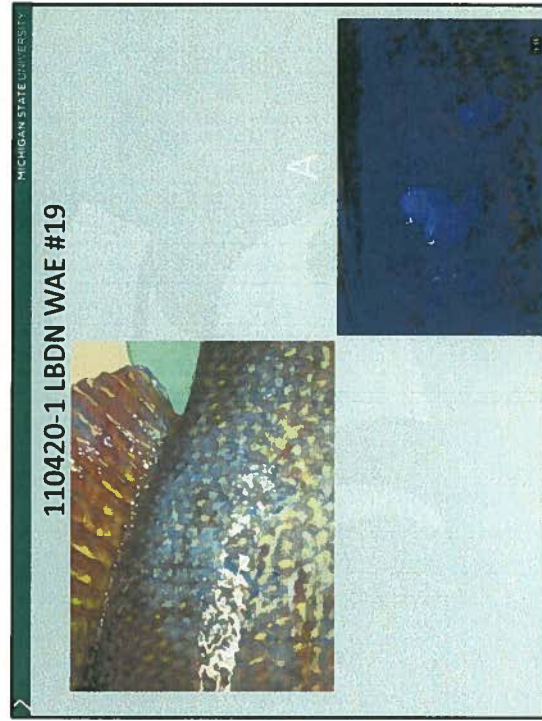
I. Opaque swim bladder (SB)

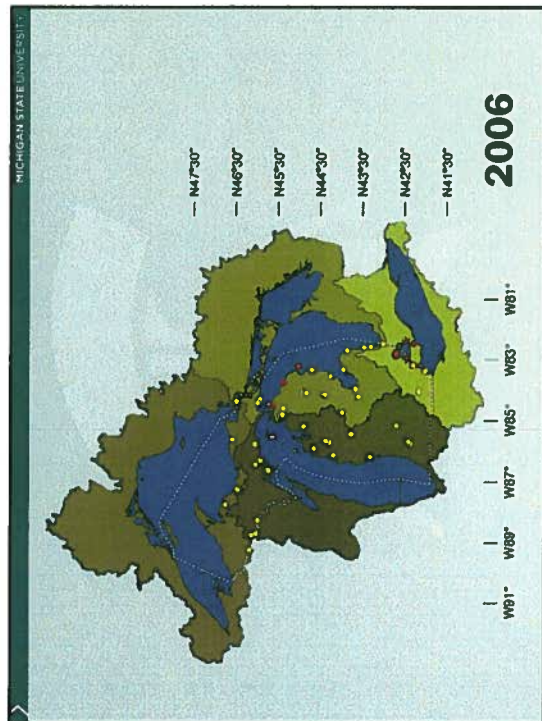
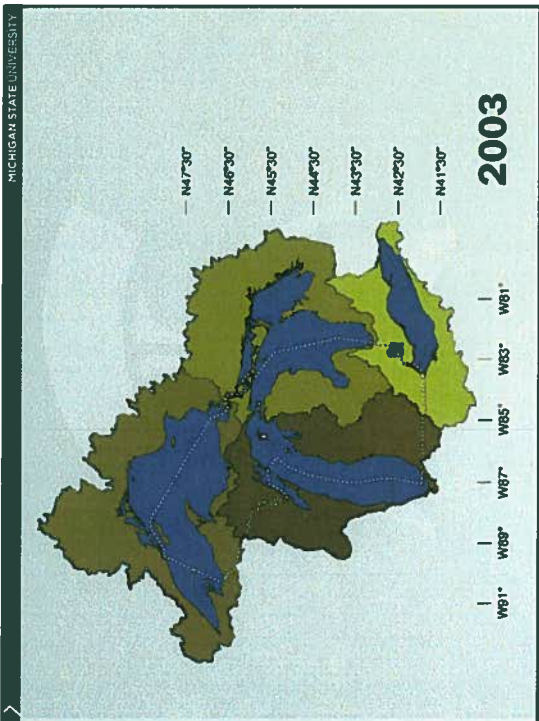
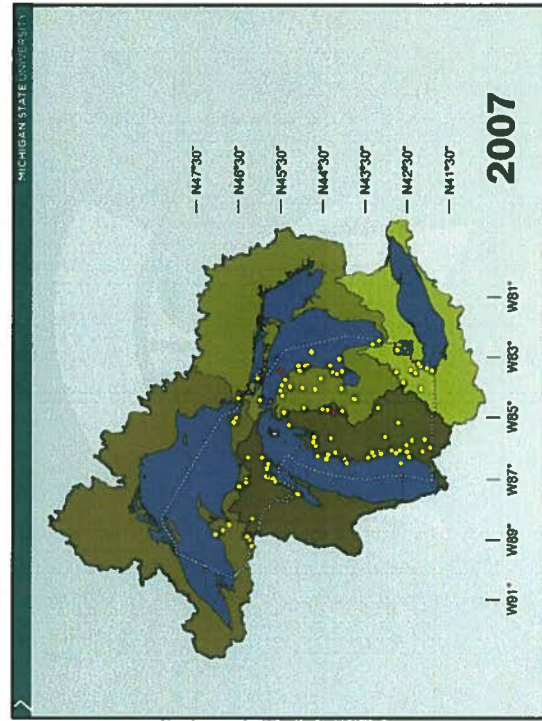
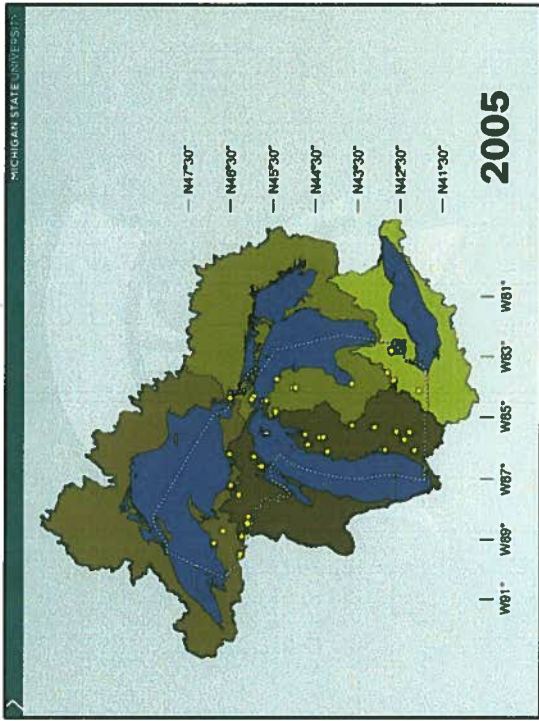
II. Hemorrhaged SB membrane

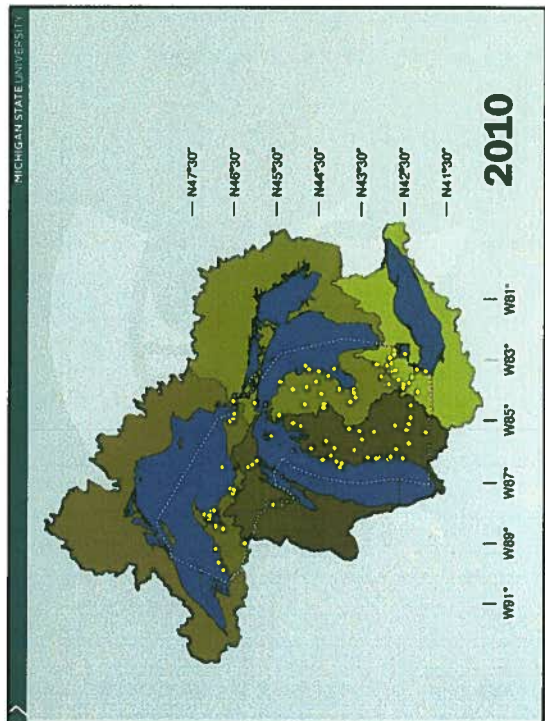
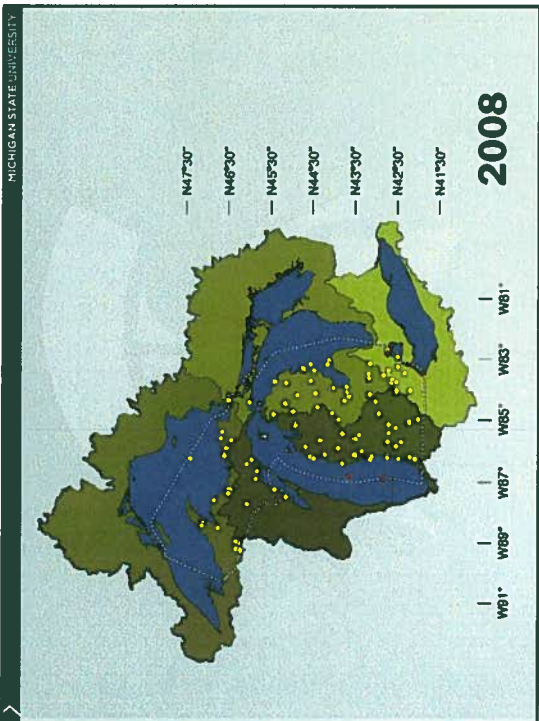
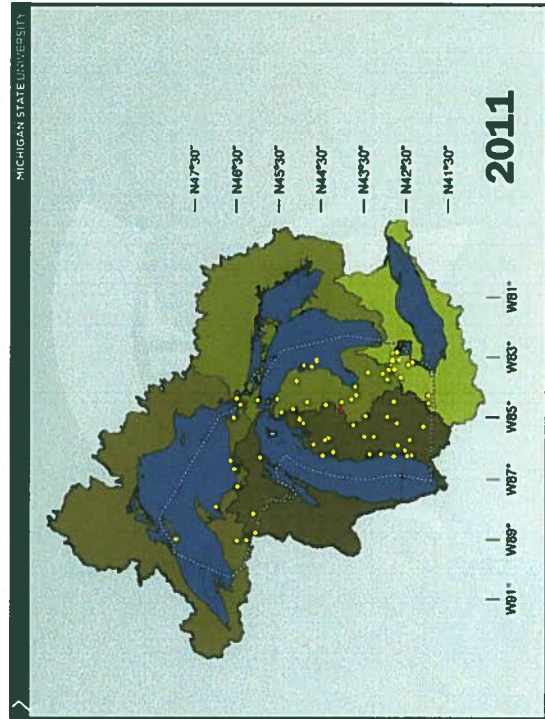
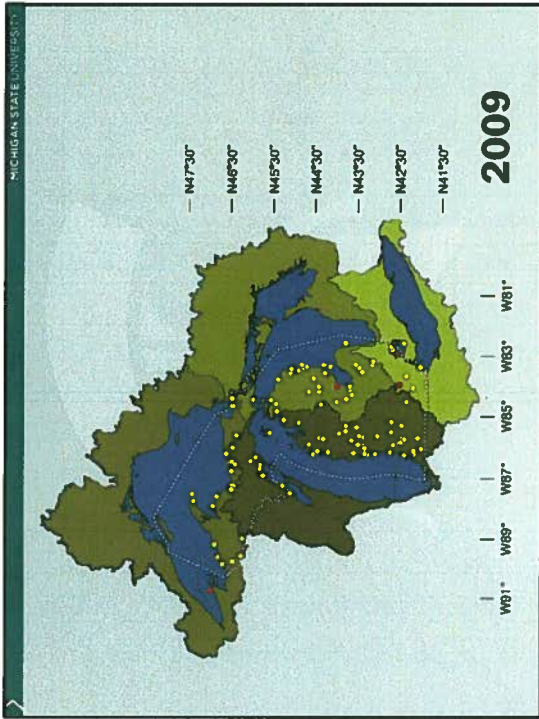
III. Leaking blood vessels in SB

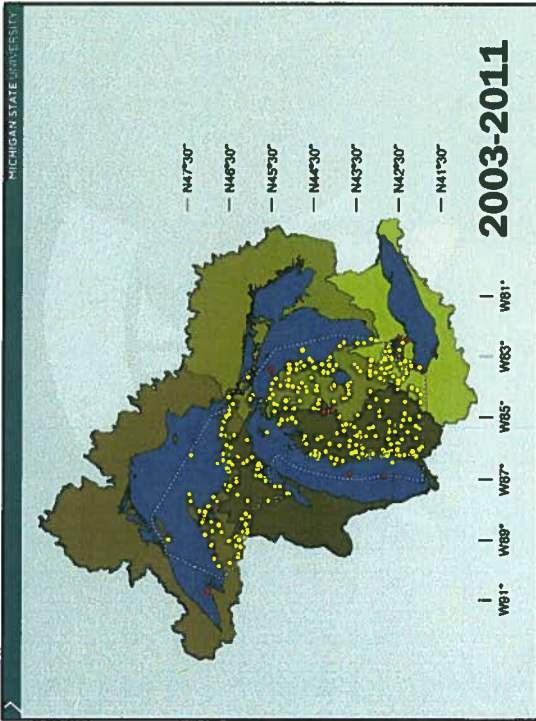
IV. Blood accumulation in SB

The four images illustrate the following signs: I. A swim bladder that is opaque and enlarged. II. A swim bladder membrane that is dark and hemorrhaged. III. A swim bladder with visible leaking blood vessels. IV. A swim bladder with a large accumulation of dark blood.









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VHSV testing

Year	# Cases (# pos/# tested)	Total # Species tested	Total # Fish/inverts tested
2005	0/231	30	11,274
2006	22/205	33	9,587
2007	5/310	43	14,144
2008	6/362	53	16,778
2009	5/378	53	21,816
2010	0/360	52	23,643
2011	4/244	44	9,897
2005-Pre	42/2090	93	107,139

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Fish species in Michigan from which VHSV-1vb was isolated

- Chinook Salmon (*Oncorhynchus tshawytscha*) Salmonidae
- Lake Herring (*Coregonus artedii*) Salmonidae
- Lake Whitefish (*Coregonus clupeaformis*) Salmonidae
- Largemouth Bass (*Micropterus salmoides*) Centrarchidae
- Smallmouth Bass (*Micropterus dolomieu*) Centrarchidae
- Black Crappie (*Pomoxis nigromaculatus*) Centrarchidae
- Bluegill (*Lepomis macrochirus*) Centrarchidae
- Pumpkinseed (*Lepomis gibbosus*) Centrarchidae
- Rock Bass (*Ambloplites rupestris*) Centrarchidae
- Muskeellunge (*Esox masquinongy*) Esocidae
- Northern Pike (*Esox lucius*) Esocidae
- Walleye (*Stenodus vitreus*) Esocidae
- Yellow Perch (*Perca flavescens*) Percidae
- Brown Bullhead (*Ameiurus nebulosus*) Ictaluridae
- Emerald Shiner (*Notropis atherinoides*) Cyprinidae
- Spottail Shiner (*Notropis hudsonius*) Cyprinidae
- Freshwater Drum (*Aplodinotus grunniens*) Sciaenidae
- Gizzard Shad (*Dorosoma cepedianum*) Clupeidae
- Shorthead Redhorse (*Moxostoma macrolepidotum*) Catostomidae
- Silver Redhorse (*Moxostoma anisurum*) Catostomidae

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USGS *Science for a Changing World*

Cornell University

GK: Viral Hemorrhagic Septicemia Virus (VHSV) in the Great Lakes: Final Project Report for the GLFHC

Great Lakes Fishery Trust project 2007-883
April 15, 2008 – June 30, 2011

Jim Winton & Gael Kurath
USGS WFRC
Seattle, WA

Paul Bowser & Jim Casey
Cornell University
Ithaca, NY

Mohamed Faisal
Michigan State University, MI

* presented by Mohamed Faisal

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Objective 1. Virus challenge studies of high visibility Great Lakes species.

Objective 2: New tools for detection and quantification of VHS virus in tissue and water samples, and VHSV-specific antibodies in fish sera

Objective 3. Strain typing of Great Lakes VHSV isolates and development of a web-accessible Great Lakes VHSV database

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Conclude: Wide Range of susceptibility to VHSV DVb

Highest

Intermediate

Very low

Lowest or none

Lake herring
Muskeellunge

Largemouth bass
Fathead minnow
Tiger muskeellunge

Golden shiner
Brook trout

Lake trout,
Lake sturgeon

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VHSV field isolate analysis :134 isolates

Temporal Range: 2003 – 2011

Geographic Range: Great Lakes watershed, including US and Canada, designated as 12 geographic sub-regions

Host Range: 29 species of finfish and 2 invertebrate species



Bill Batts



Tarrin Thompson

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Genetic Typing of 108 Isolates through 2009 shows extremely low genetic diversity

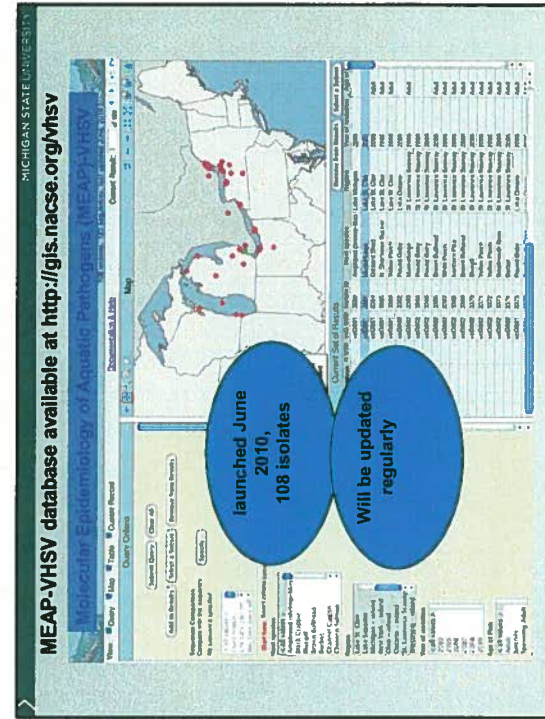
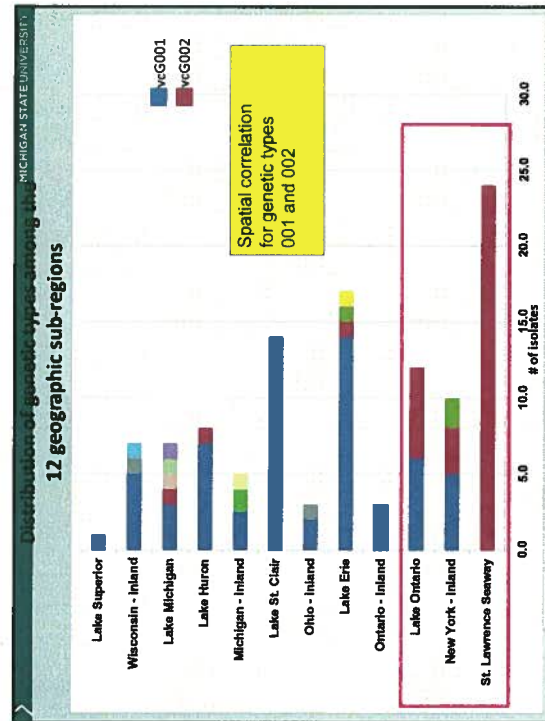
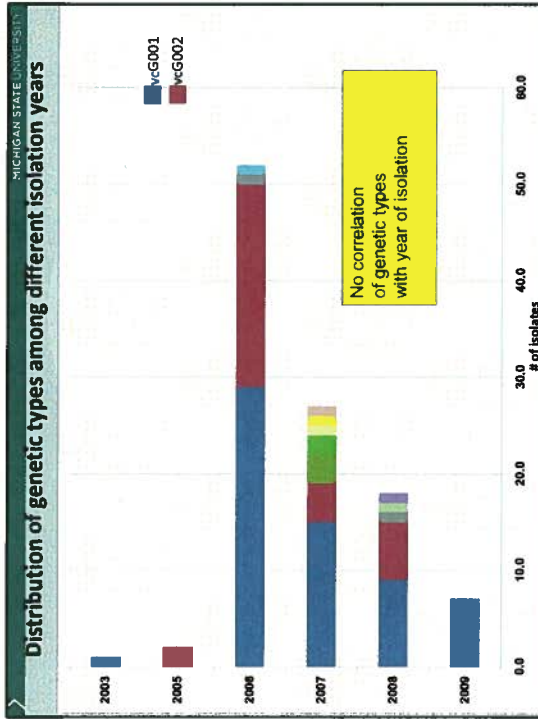
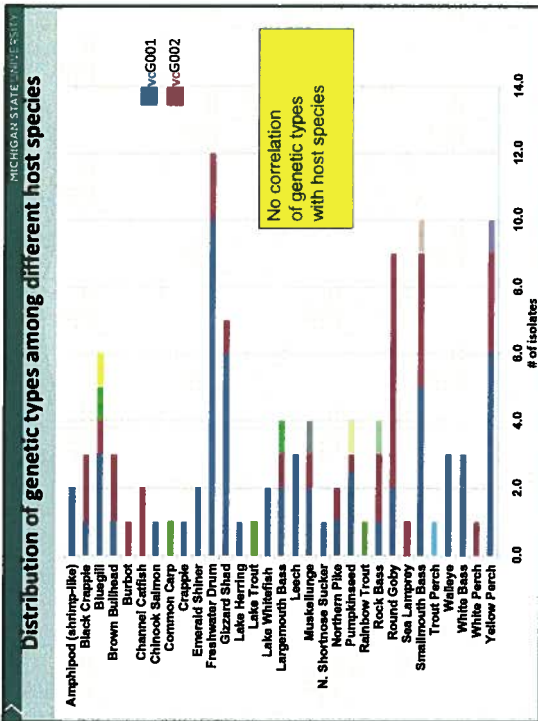
-There are 11 sequence types, cvG001-cvG011

- Sequence type vcG001 is most common and contains the original 2003 Lake St. Clair muskeellunge isolate

Types vcG001 and vcG002 are dominant, accounting for 97/108 isolates

Sequence Type	# of isolates
vcG001	61
vcG002	36
vcG003	3
vcG004	2
vcG005	2
vcG006	1
vcG007	1
vcG008	1
vcG009	1
vcG010	1
vcG011	1

Thompson et al., in press



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MSU Differential Susceptibility Study

Muskellunge
Largemouth bass
Lake Herring
Bluegill

Lake, Brook, & Brown Trout

Rainbow Trout

Atlantic Salmon

Chinook & Coho Salmon

Lake Sturgeon

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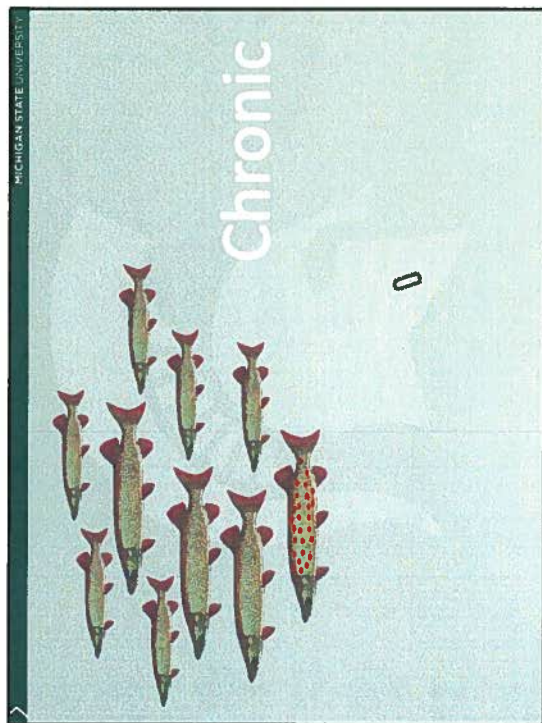
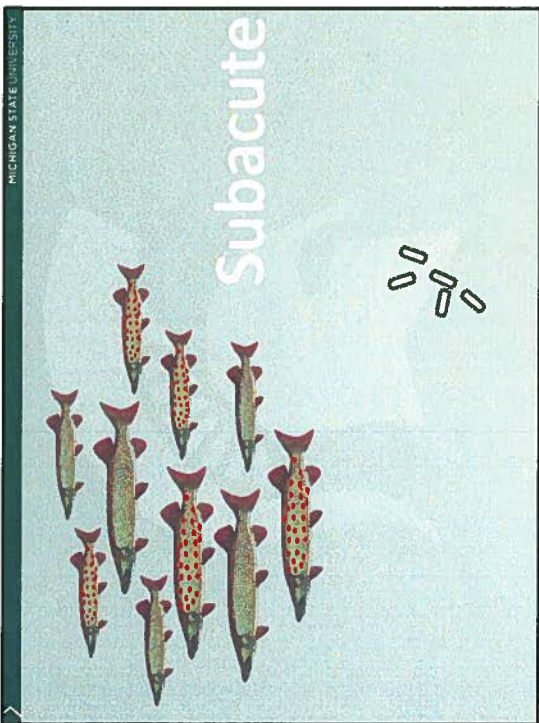
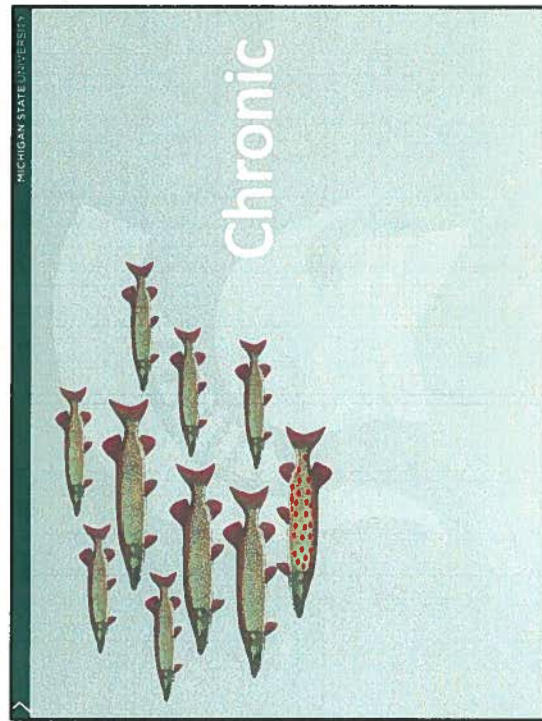
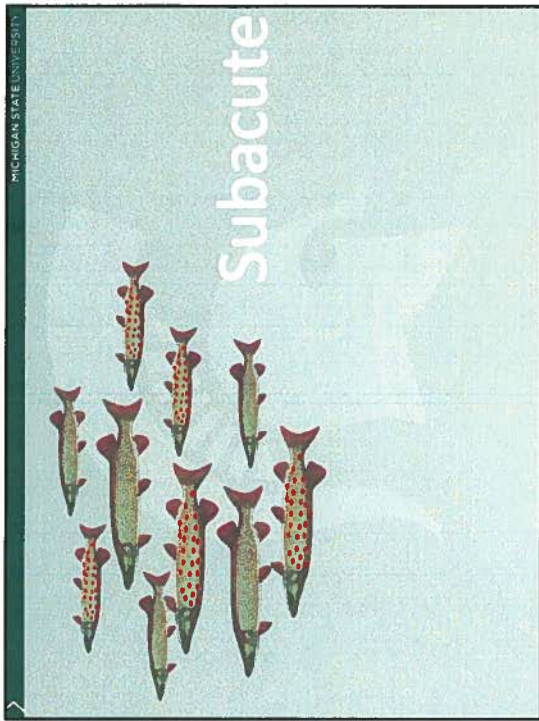
Acute

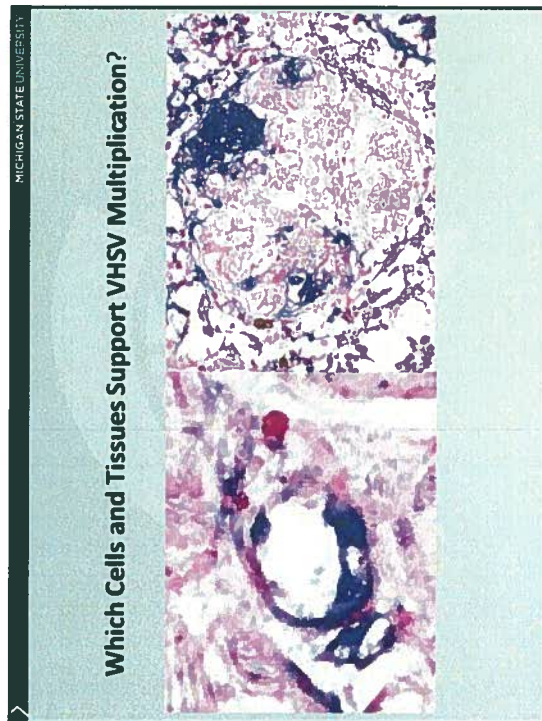
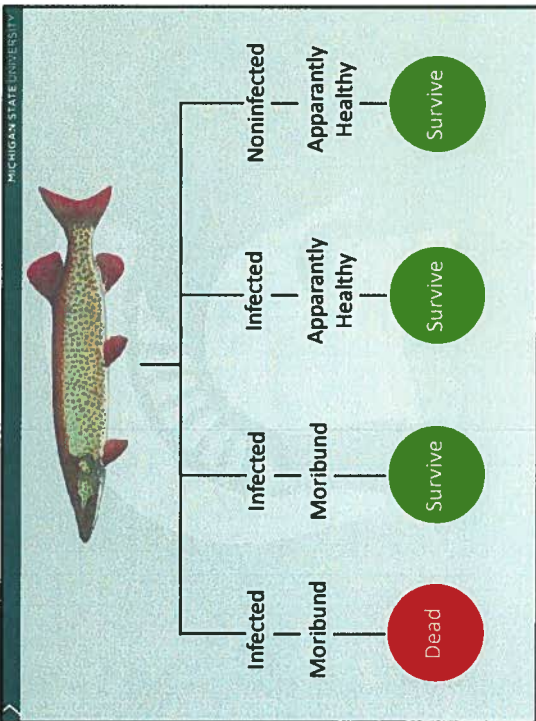
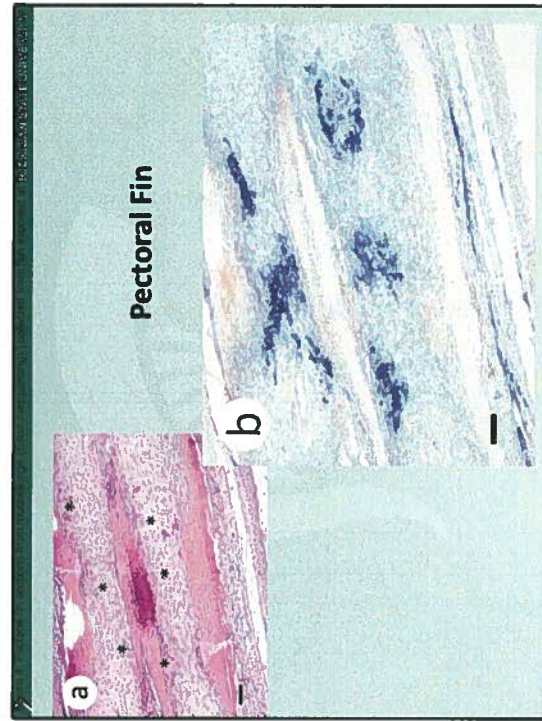
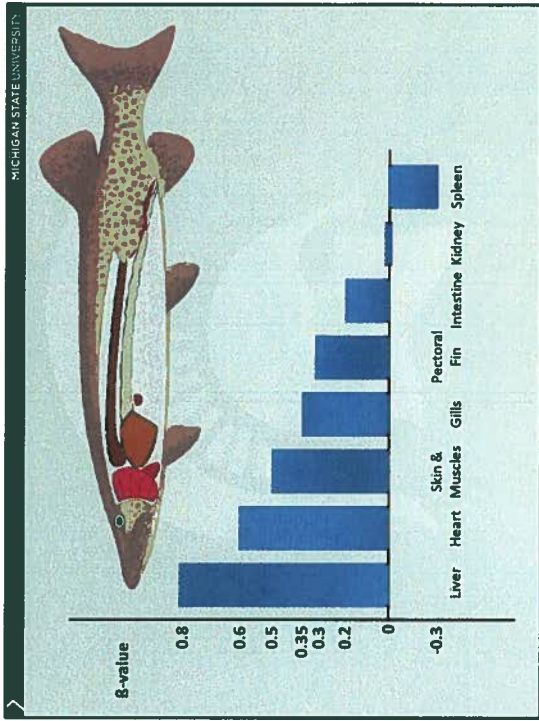
Additional product:
Aquatic Pathogen X Database

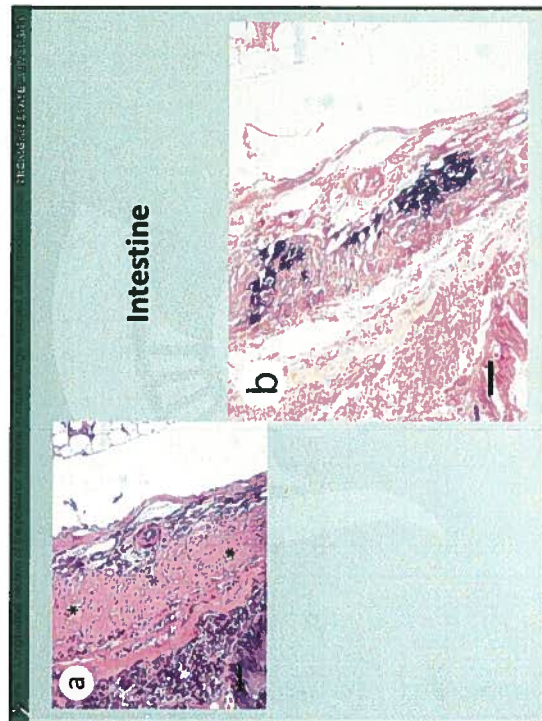
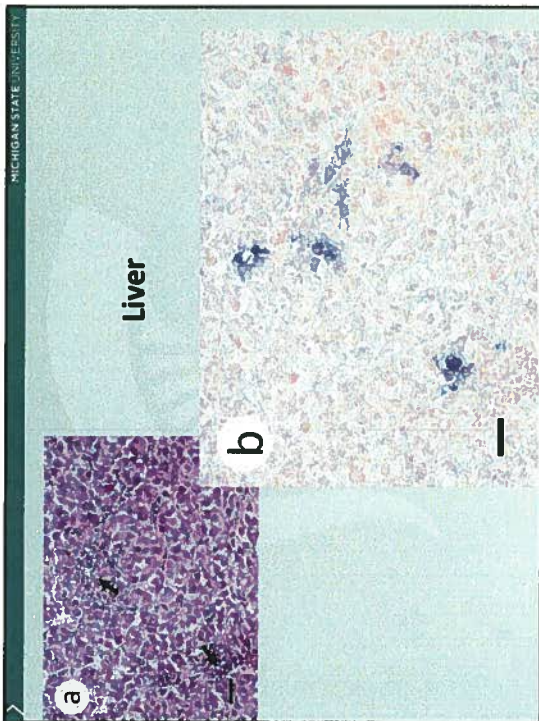
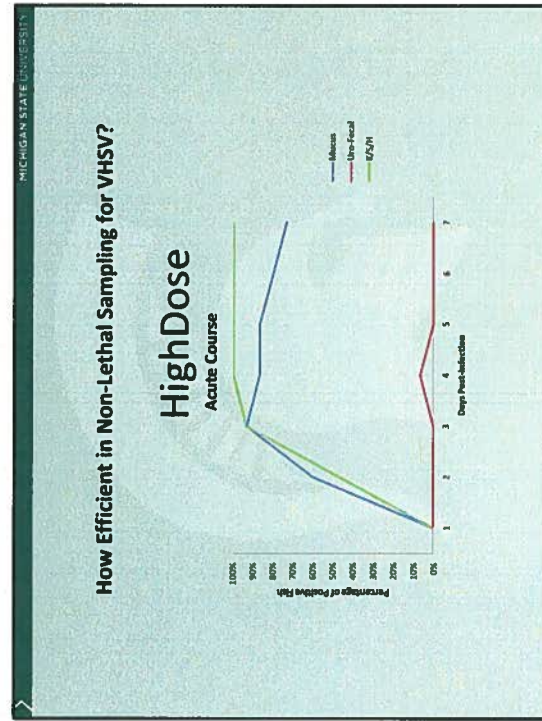
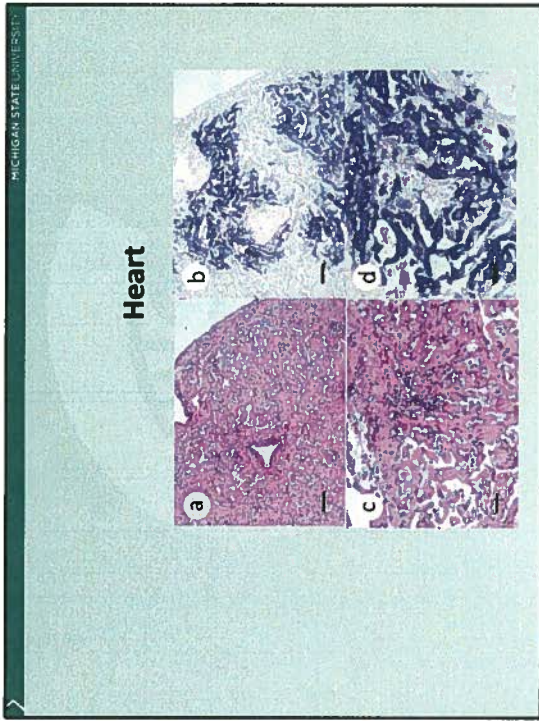
Blank template for general use with any aquatic pathogen.
Filemaker Pro software program.
Available to any interested user as a free download at
http://wfrc.usgs.gov/aquaPath_template.html

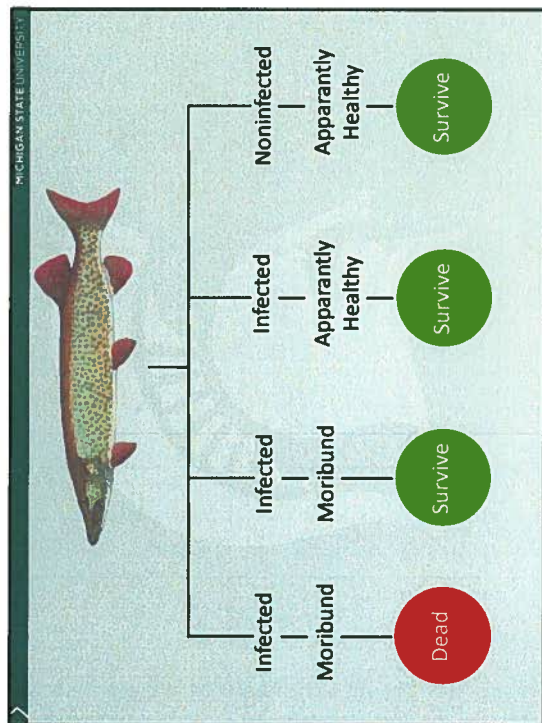
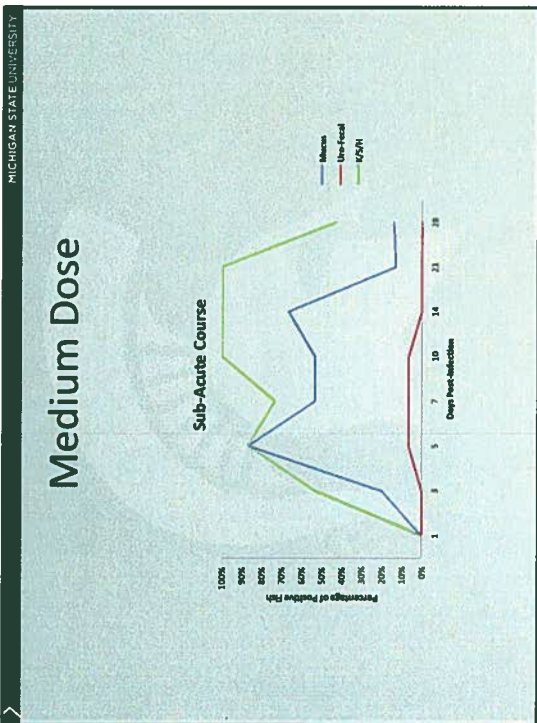
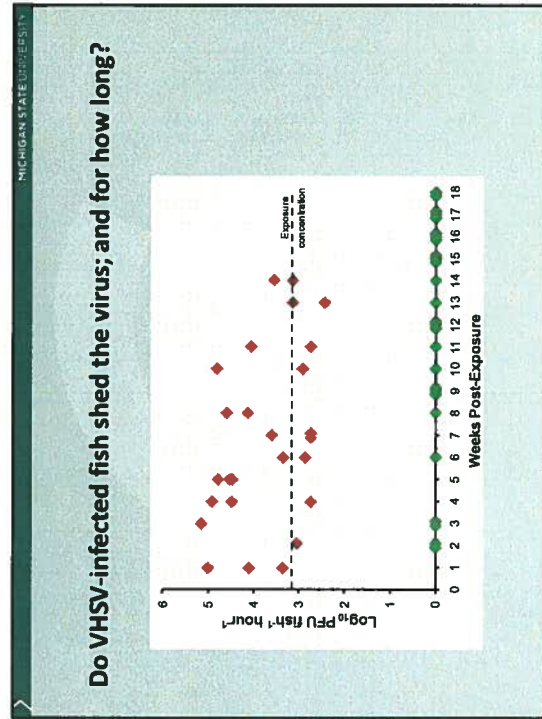
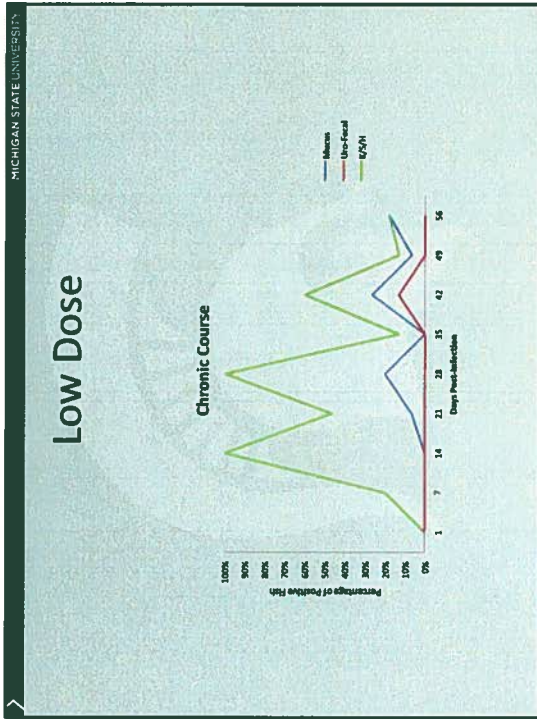
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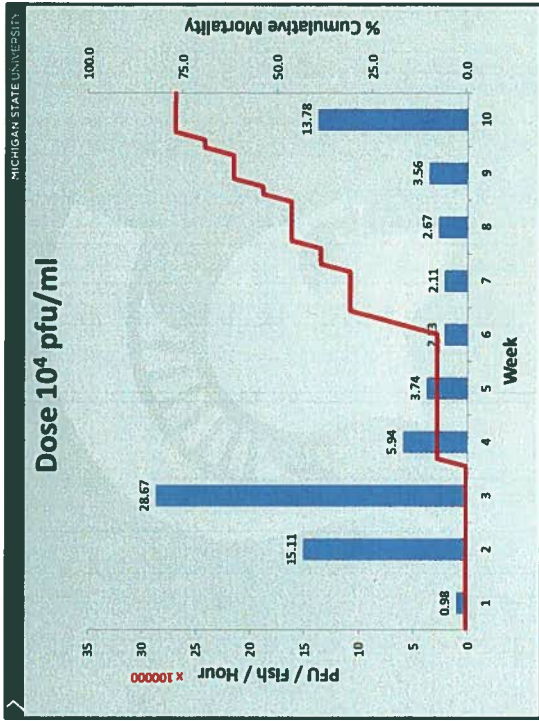
Acute







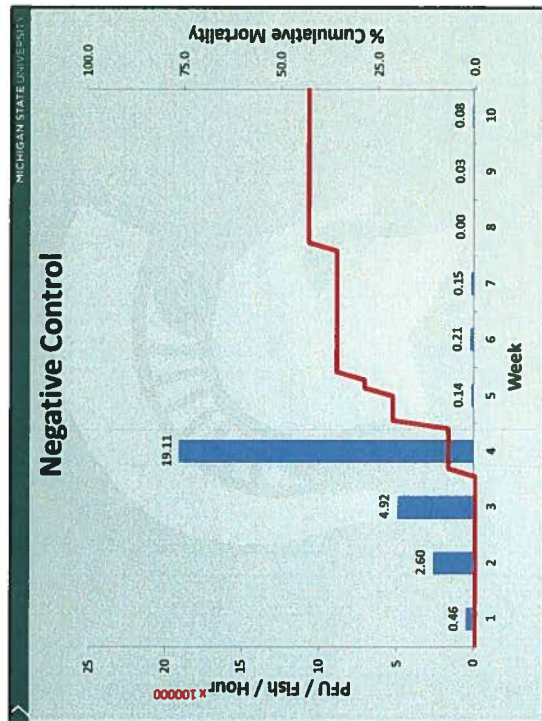
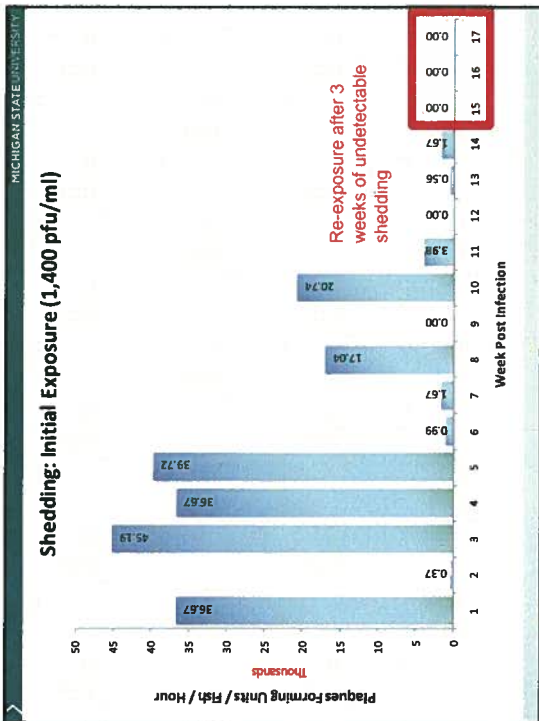


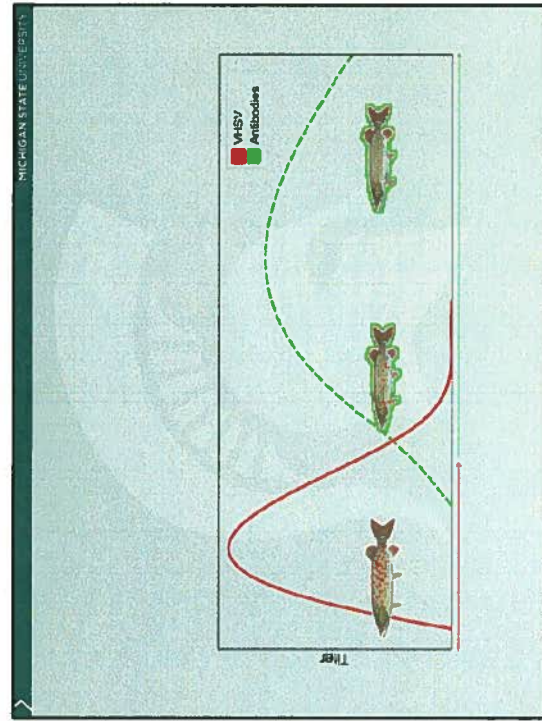
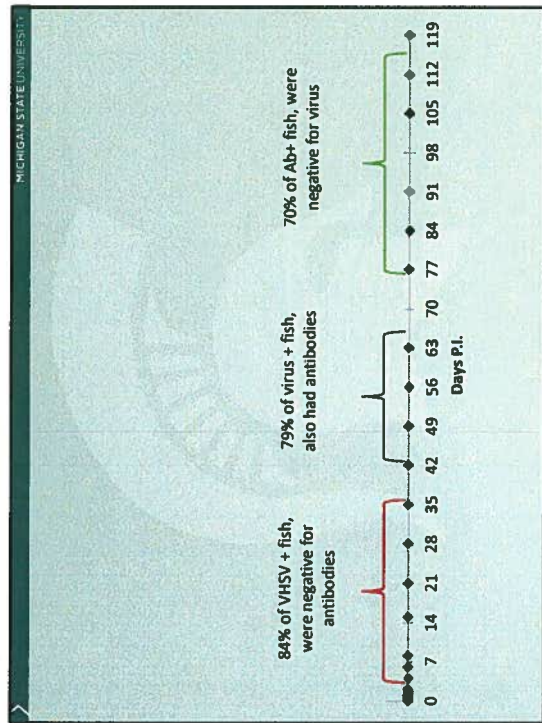
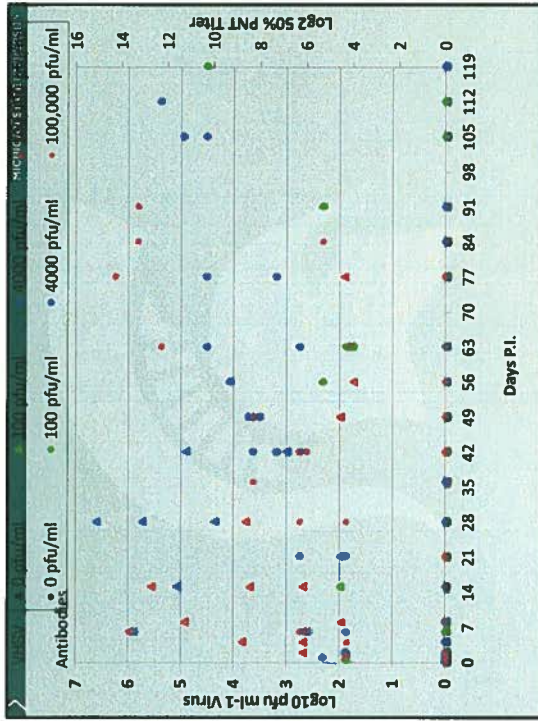
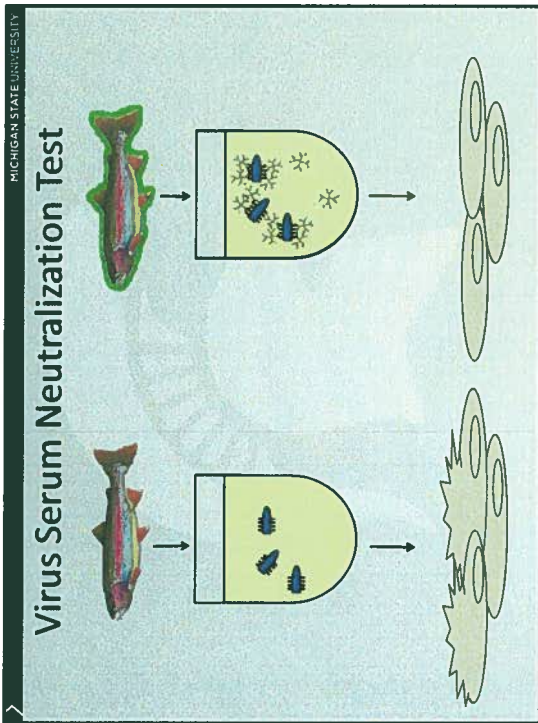


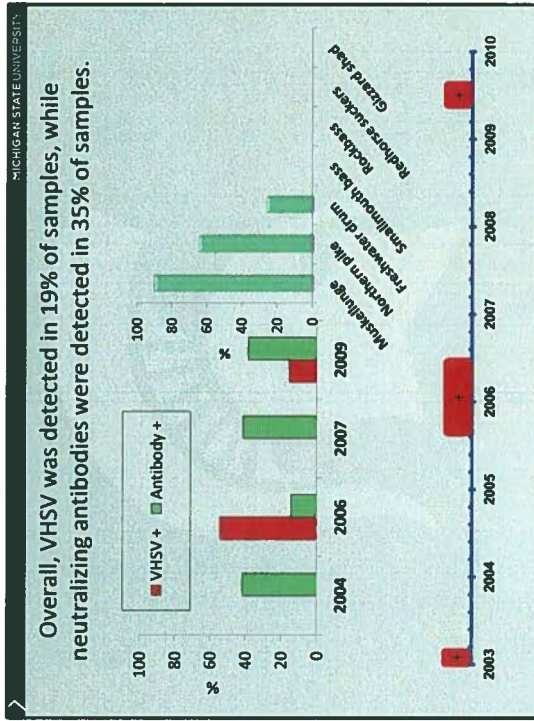
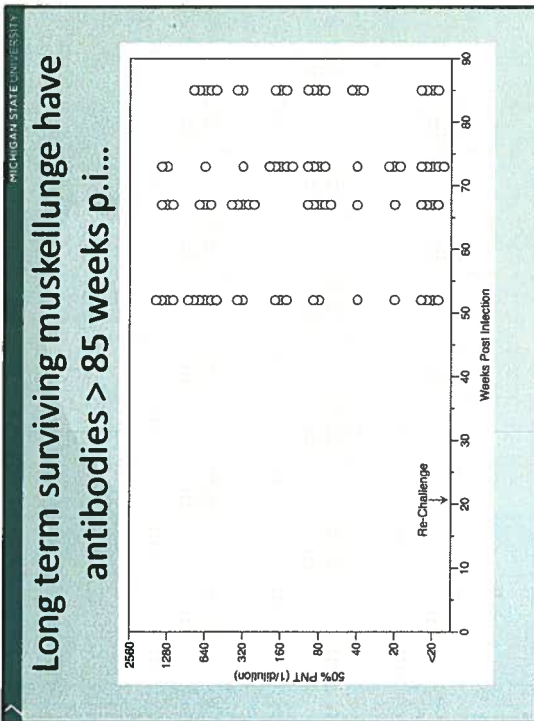
- Apparently healthy may act as carriers

Leeches may act as vectors

Amphipods may act as reservoirs





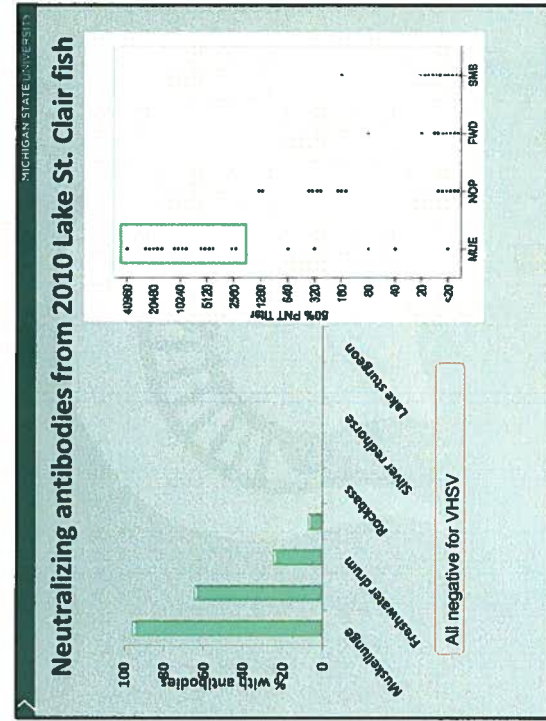


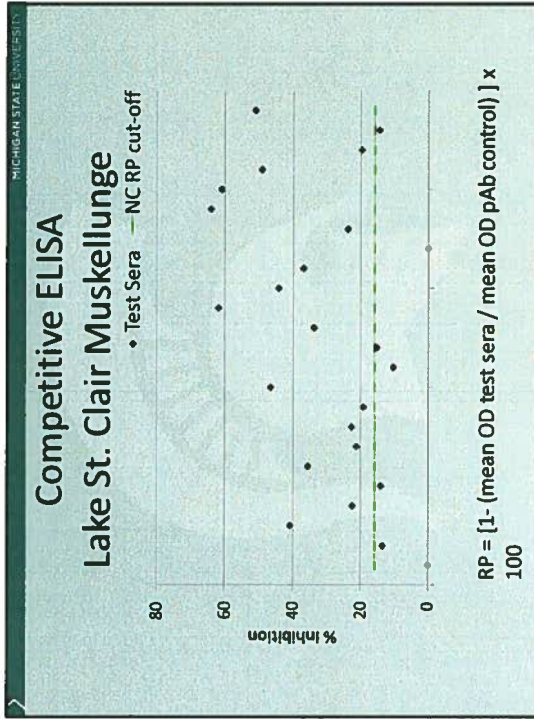
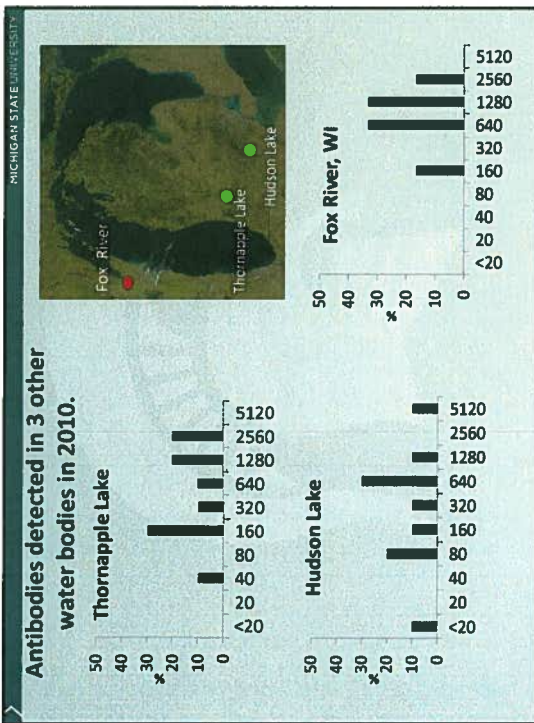
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May 2010

Species	2004	2006	2007	2009	2010
Muskellunge		3	20	10	21
Northern pike	10	4	10		16
Smallmouth bass				16	15
Rock bass		3			15
Freshwater drum		11	40		10
Silver redhorse sucker	2	7			10
Shorthead redhorse sucker					6
Gizzard shad		7			
Channel catfish					25
Lake sturgeon					15

133 samples





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Fish Pathogenic Bacteria of Michigan

- Enzootic
 - A. salmonicida*
 - R. salmoninarum*
 - F. columnare*
 - F. psychrophilum*
- Emerging bacterial pathogens

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A. salmonicida subsp. *salmonicida* in MI

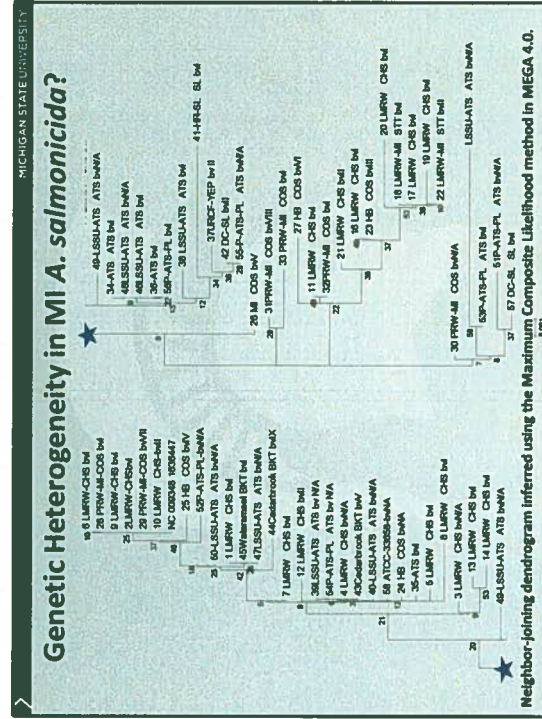
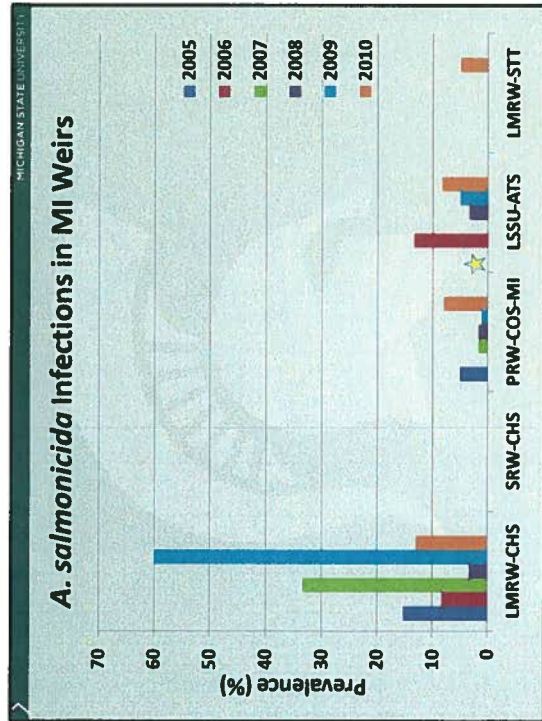
- Recently recovered from:
 - Chinook salmon
 - Atlantic salmon
 - Coho salmon
 - Steelhead trout
 - Sea lamprey
 - Lake whitefish
 - Brook trout
 - Yellow perch
 - Bluegill

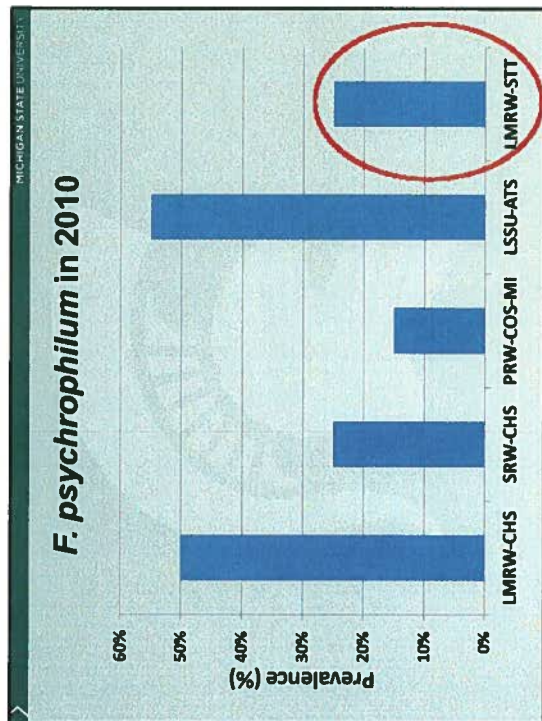
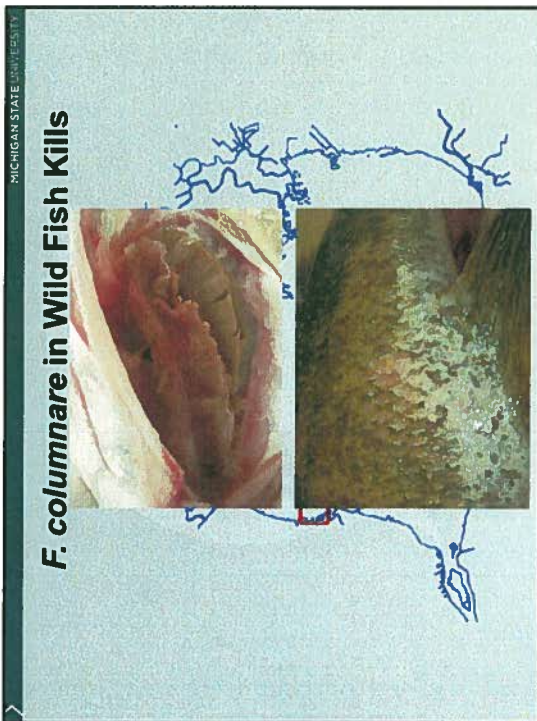
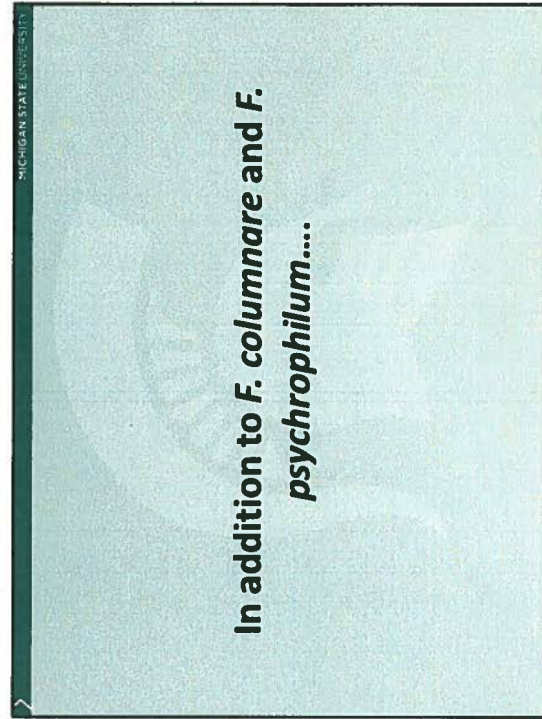
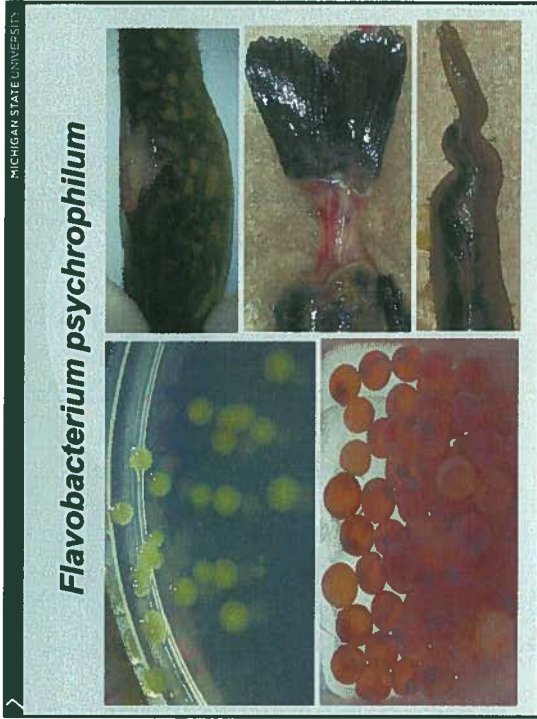


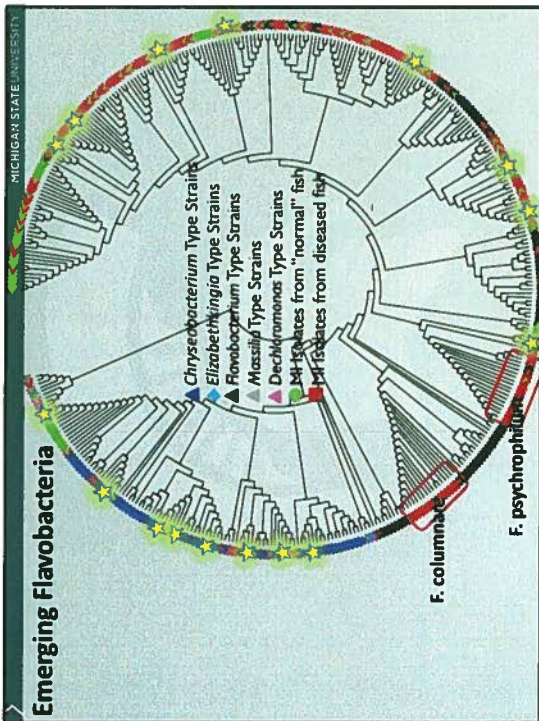
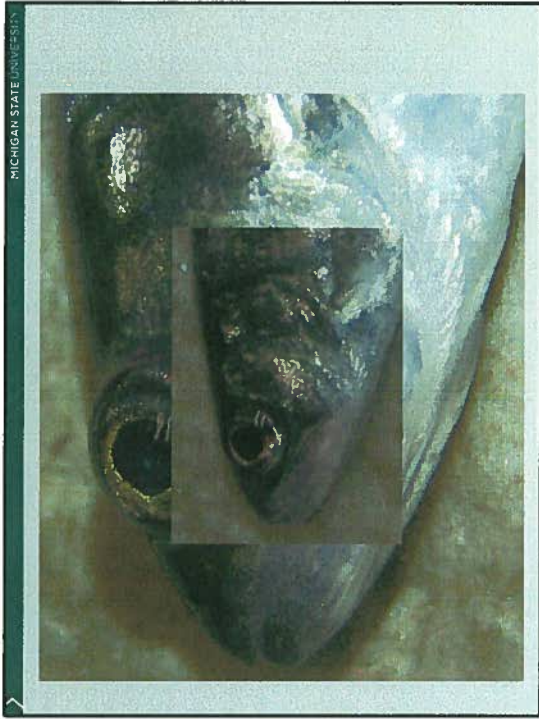
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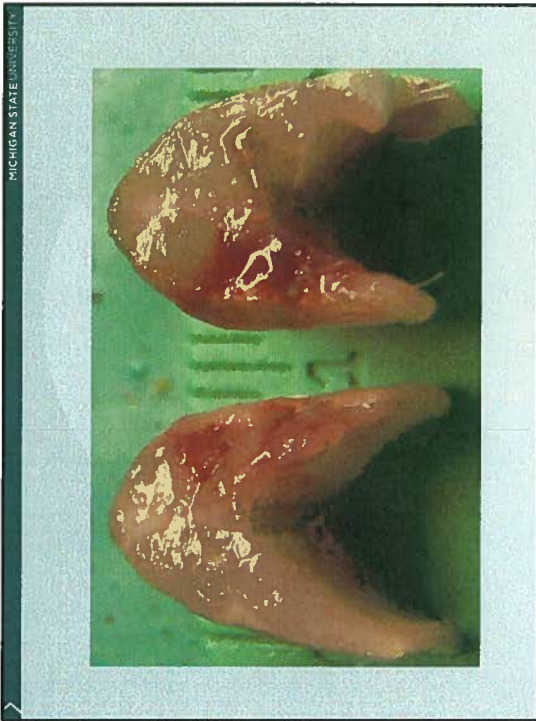
A. salmonicida in MI State Fish Hatcheries

- Historically present throughout MI State Fish Hatcheries (Beyerle & Hnath 2002)
- Last detected outbreaks were in 2005.....
- Vaccinations & improved biosecurity
- Outbreak of furunculosis in 2011







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Carnobacterium maltaromaticum

- Causative agent of pseudo-kidney disease.
- Outbreaks primarily reported in captive adult rainbow trout

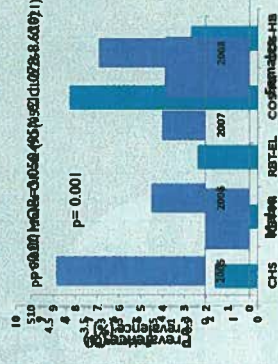




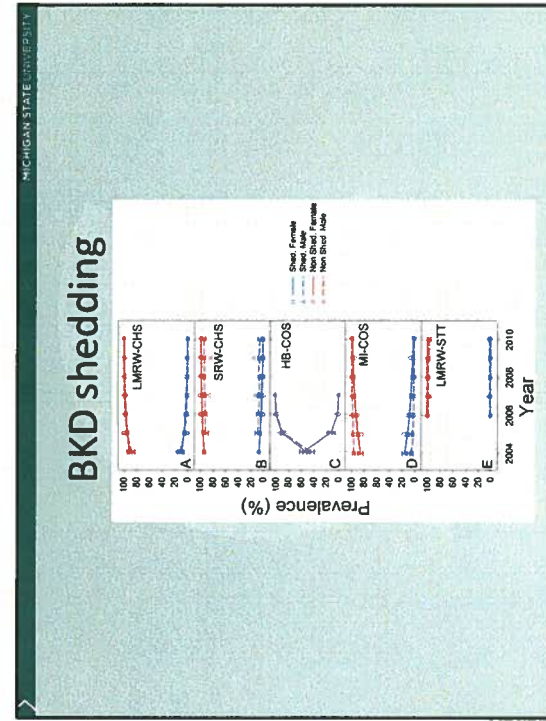
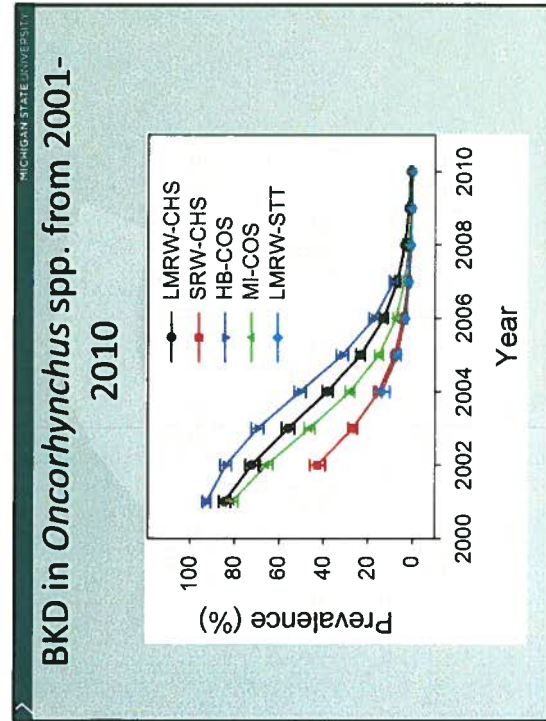
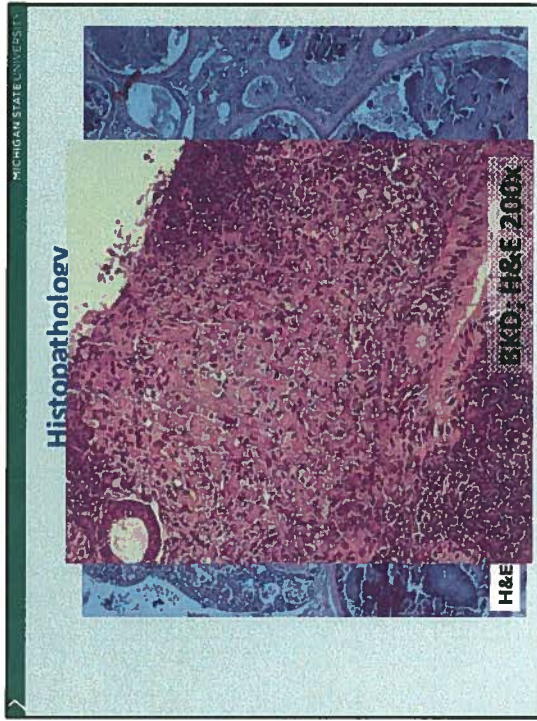
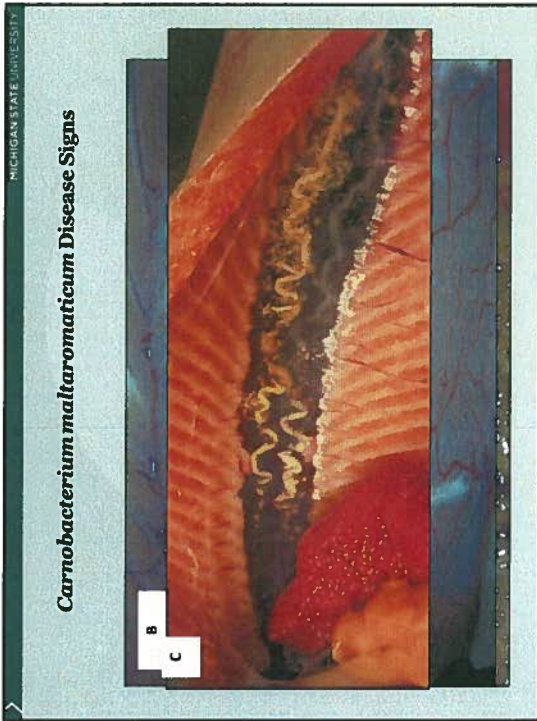

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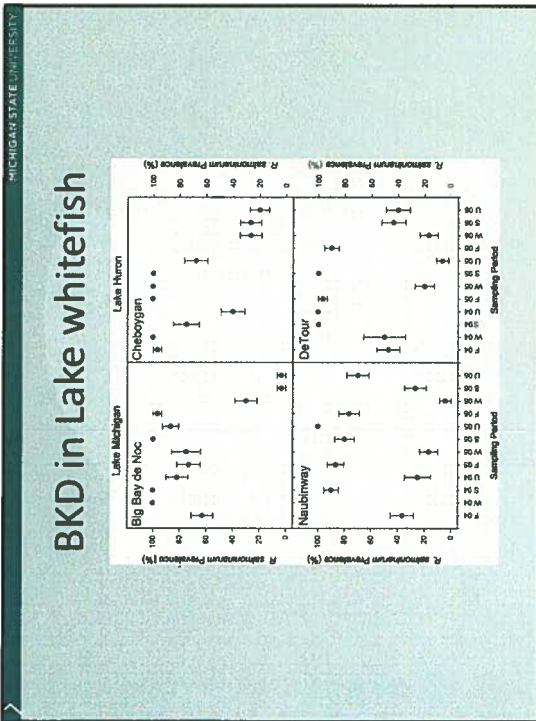
Carnobacterium maltaromaticum infections in propagated and feral *Oncorhynchus* spp. in MI

- Widespread in feral MI *Oncorhynchus* spawning stocks
- Significant differences in infection prevalence according to:
 - Host species/strain
 - Gender
 - Year of collection



Loch TP, Kumar R, Xu W, Faisal M, in press, Journal of Microbiology





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Bacterial Infections of Chinook Salmon Returning to Gamete-Collecting Weirs in Michigan

- Examined 480 CHS in 2005
 - 114 from MCW
 - 366 from LMRW
- Effects of the following on infection prevalence:
 - Location
 - Early spawners vs. late spawners
 - Gender
- Associations between multiple bacterial infections?

Loeb TP, Scribner K, Tempelman R, Wheaden G, Fernald M. In Press, Journal of Fish Diseases

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Detected Bacterial Infections

Likelihood ratio chi-square 4.25, 1 df, p= 0.039

- Renibacterium salmoninarum*
- Aeromonas salmonicida*
- Motile *Aeromonas* spp.
- Carnobacterium* sp.
- Serratia* sp.
- Proteus* sp.
- Pseudomonas* sp.
- Hafnia* sp.
- Salmonella* sp.
- Shewanella* sp.
- Morganella* sp.


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R. salmoninarum & *A. salmonicida* Infection Prevalence

- A. salmonicida* prevalence of 15%
- R. salmoninarum* prevalence of >25%
- Both infections varied significantly according to location/time of collection & gender
 - R. salmoninarum*:
 - Infections in early CHS vs. late CHS ($P < 0.0001$, OR=0.338)
 - Infections in female CHS vs. male CHS ($P = 0.0023$, OR=2.455)
- Period of gamete collection important

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Common lab parasites . . .



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Lake Emily




Trienophora nodulosis

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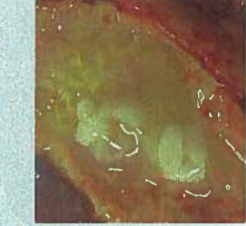
Trienophorus nodulosus



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Walleye tapeworm

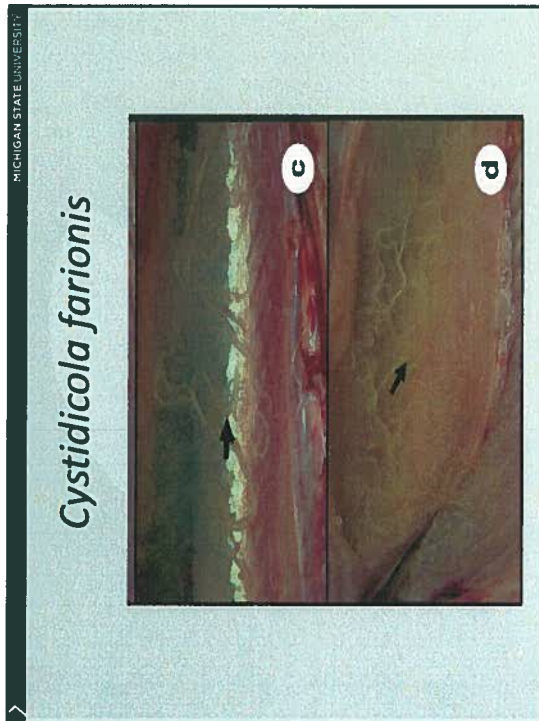
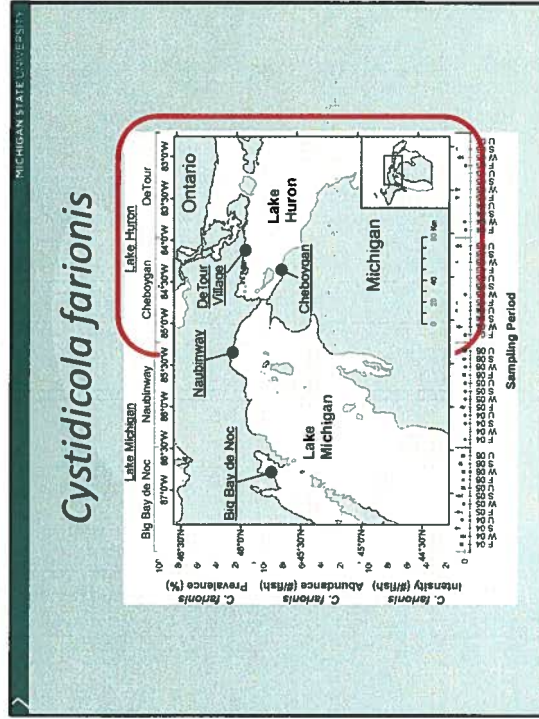
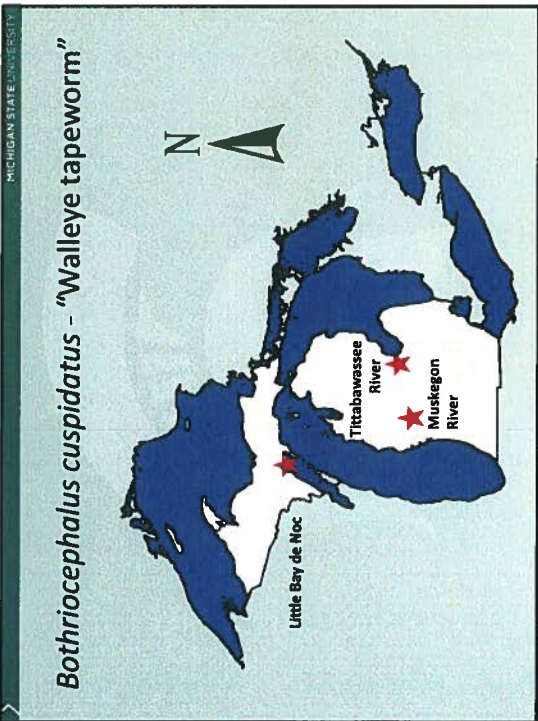


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Bothriocephalus cuspidatus - "Walleye tapeworm"

	Little Bay de Noc	Muskegon River	Tittabawassee River	TOTAL
2007	35.0% (21/60)	0% (0/60)	33.3% (20/60)	22.8% (41/180)
2008	23.3% (14/60)	25% (15/60)	80% (48/60)	42.8% (77/180)
2009	0% (0/60)	64.4% (38/59)	61.7% (37/60)	50.8% (93/183)
2010	0% (0/60)	1.7% (1/60)	20% (12/60)	7.2% (13/180)
TOTAL	21.7% (53/244)	22.6% (54/239)	48.8% (117/240)	31% (224/723)



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Fish leeches



- Target skin, gills, fins, oral cavity
- Hemorrhaging surrounding attaching and feeding sites, necrotic tissue, and nodular swelling of tissue
- Can cause anemia and acts as a vector for viruses, bacteria, and blood parasites

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Myxobdella lugubris



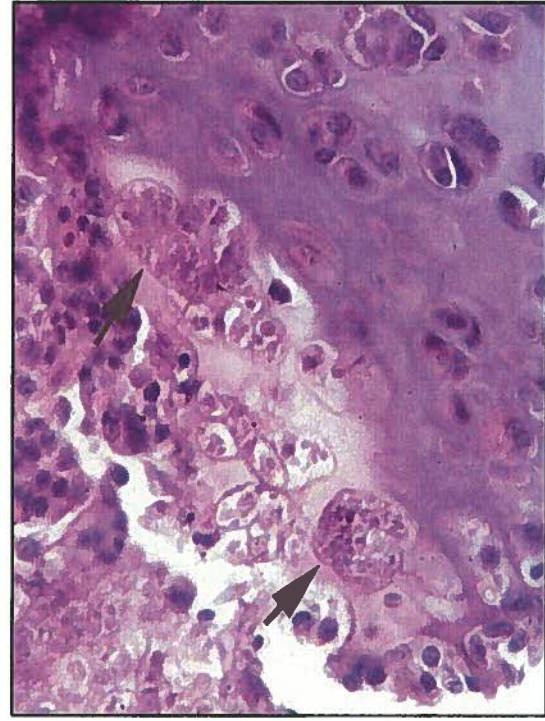
- Pathogenic bacteria
 - *Flavobacterium psychrophilum*
- Viruses
 - Viral Hemorrhagic Septicemia

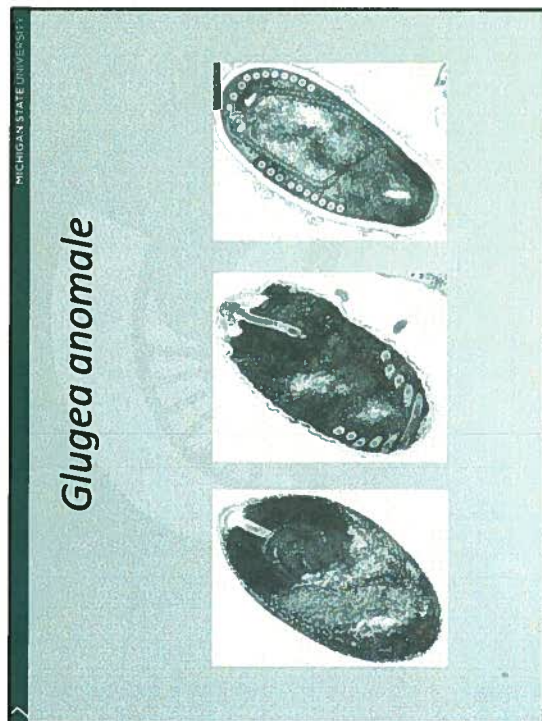
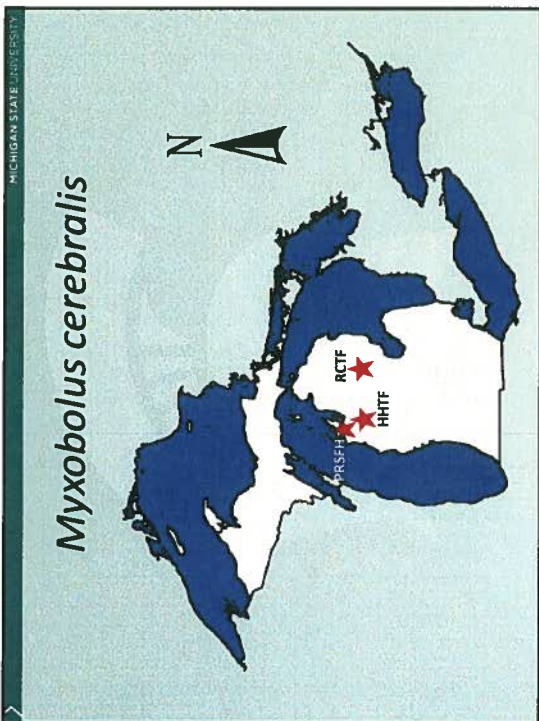
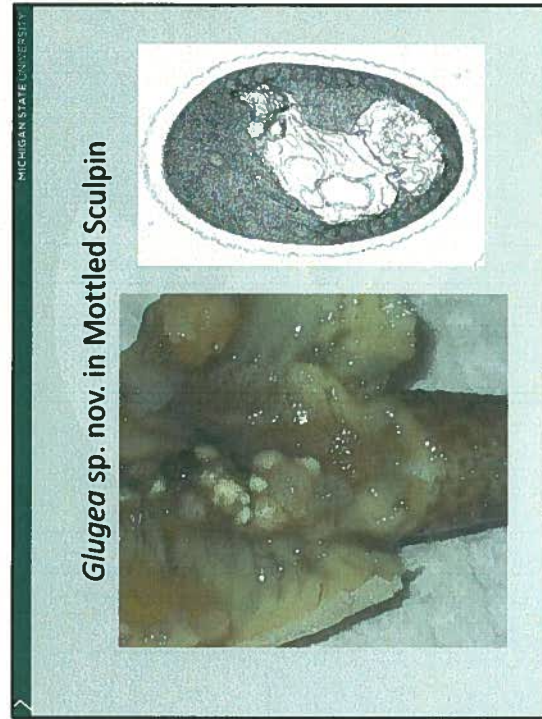
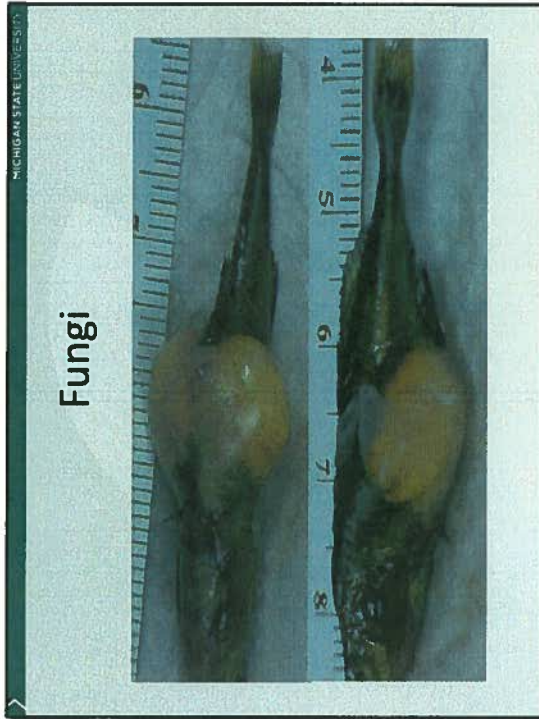
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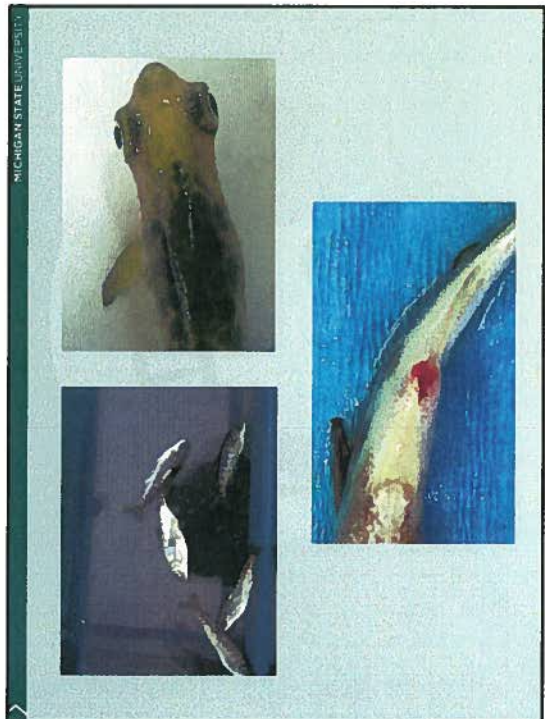
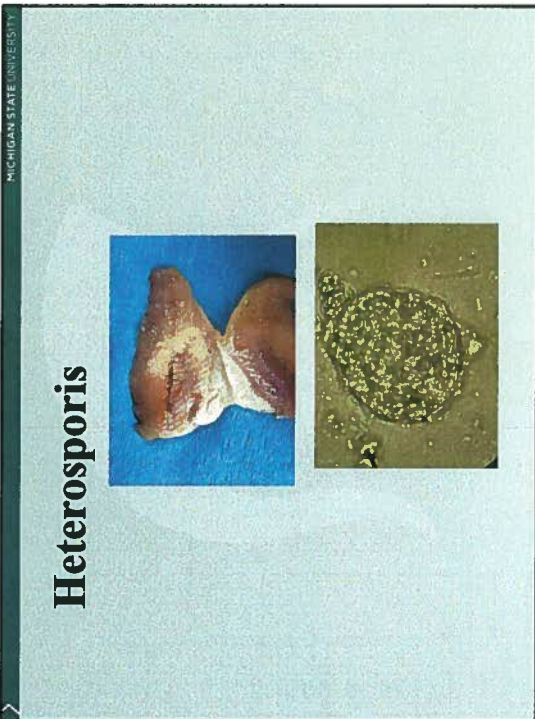
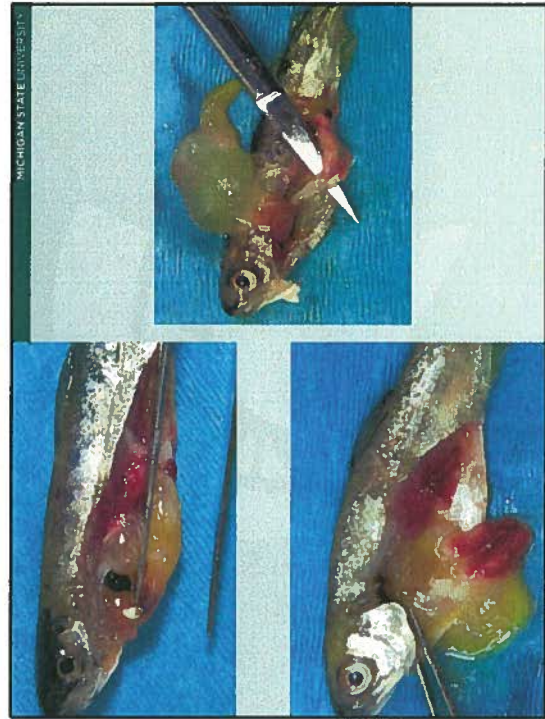
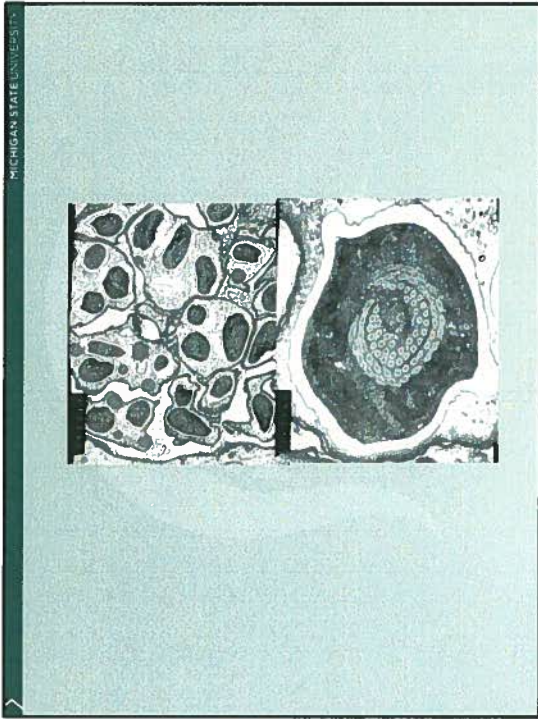
Myxobolus cerebralis




- Whirling disease







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Phoma herbarum

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Overview

- I. Identification of Novel Genes Involved in Zebra Mussel (*Dreissena polymorpha*) Underwater Adhesion and Defense Mechanisms
- II. Molecular Characterization of Bacterial Communities Associated with Zebra Mussels
- III. Epidemiological Analysis to Determine the Potential Causes of the Decline of *Diporeia* spp. (Pontoporeiidae, Amphipoda)



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College of **VETERINARY MEDICINE**
Michigan State University

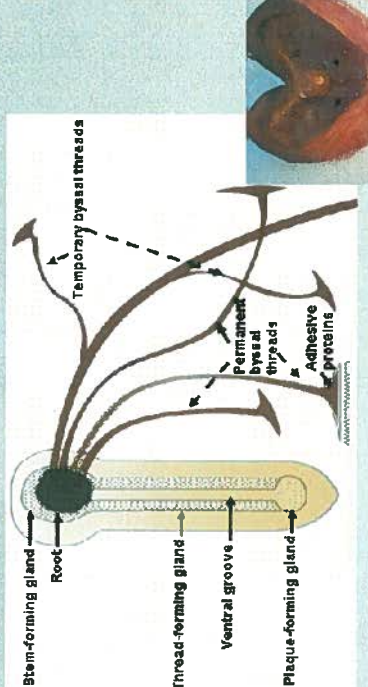
Identification of Novel Genes Involved in Zebra Mussel (*Dreissena polymorpha*) Underwater Adhesion and Defense Mechanisms

Wei Xu, Ph.D.




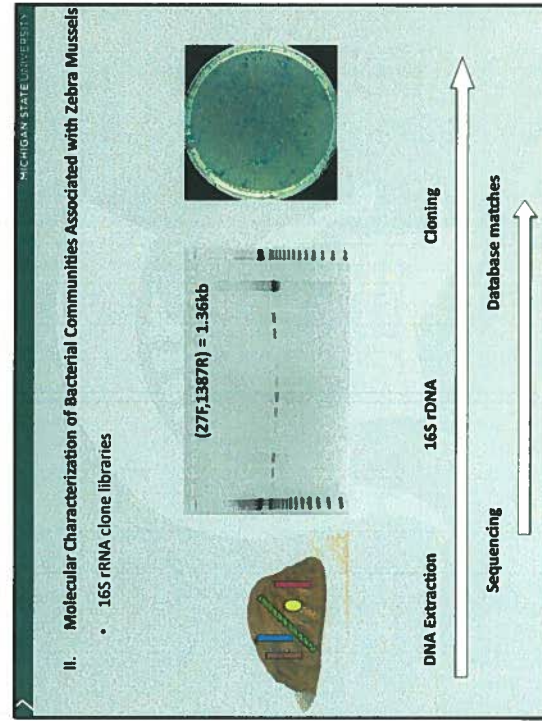
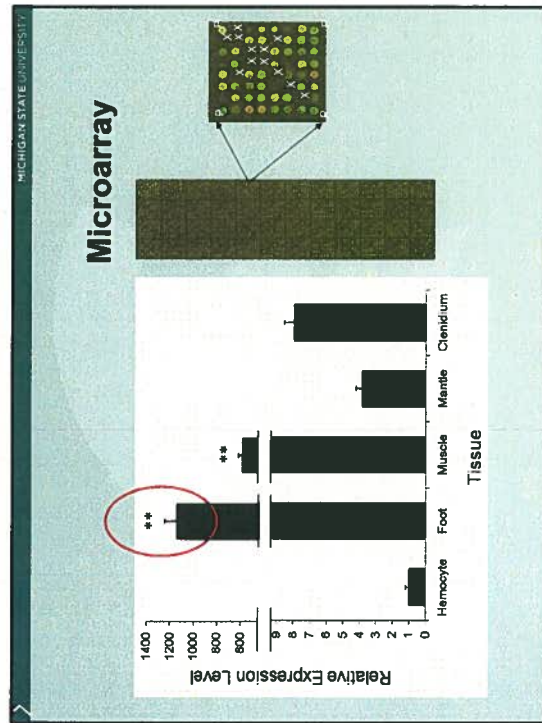
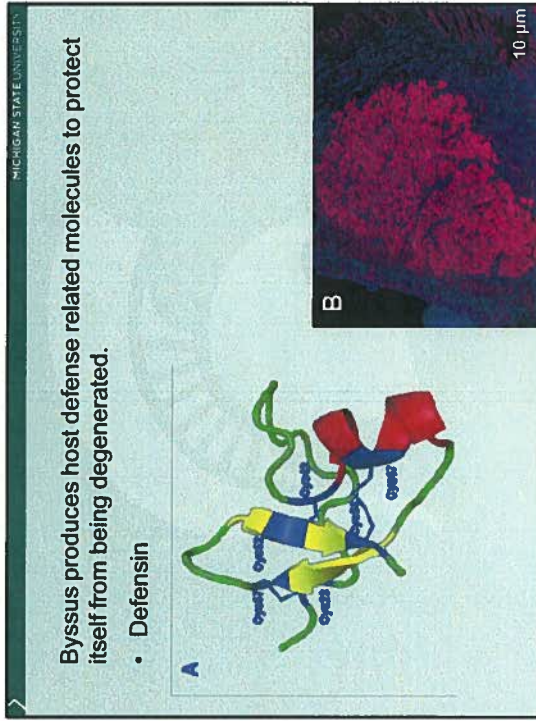
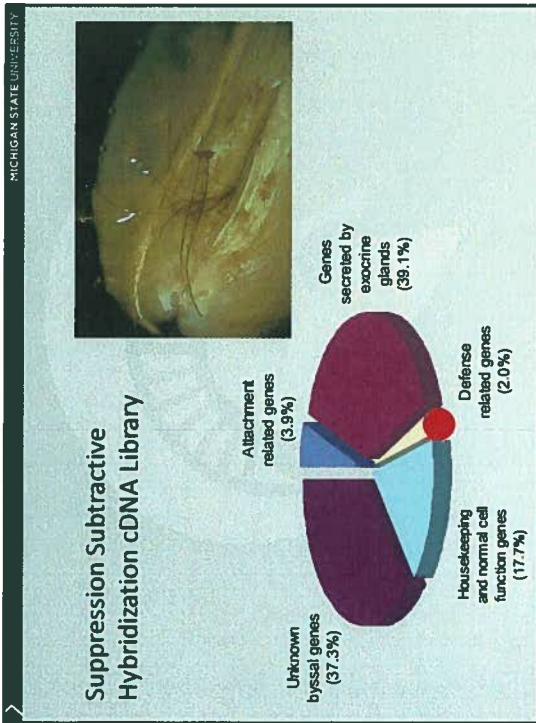

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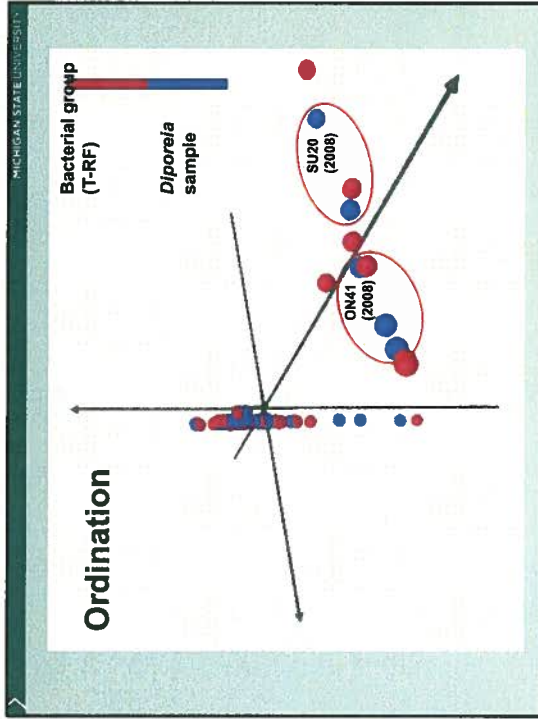
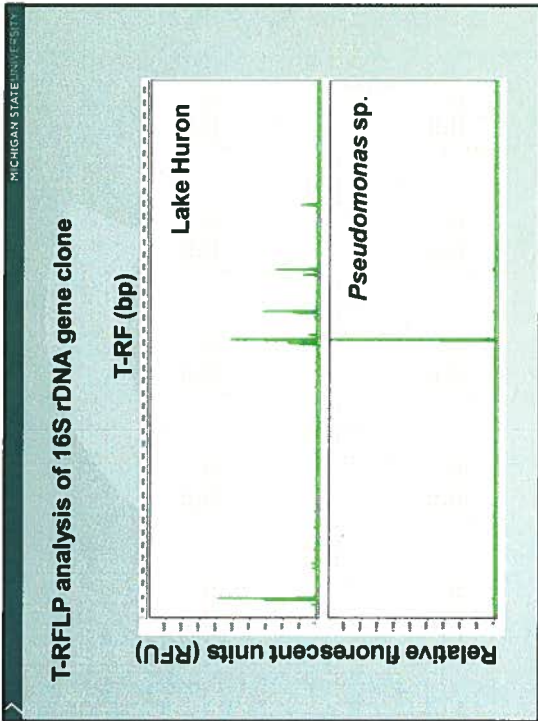
Zebra Mussel Bypass



Stem-forming gland
Root
Thread-forming gland
Ventral groove
Plaque-forming gland
Temporary byssal threads
Permanent byssal threads
Adhesive proteins







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III. Epidemiological Analysis to Determine the Potential Causes of the Decline of *Diporeia* spp. (Pontoporeiidae, Amphipoda)

2. Histopathology

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III. Epidemiological Analysis to Determine the Potential Causes of the Decline of *Diporeia* spp. (Pontoporeiidae, Amphipoda)

3. Virology (cell culture)

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Detection of Viral Hemorrhagic Septicemia Virus (VHSV) from Diporeia

- 103-190m deep
- first incidence of a fish-pathogenic rhabdovirus being isolated from *Diporeia* or any other crustacean
- underscores the role macroinvertebrates may play in VHSV ecology.

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Current research

Historical pathological trends in preserved *Diporeia* samples from Lake Michigan:

- Identify pathogens
- Establish trends
- Predict future declines
- Management strategies

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Thank you

- Gary Whelan
- Previous and current AAHL members
- MDNR Management Team, Biologists, Techs
- MDNR
- USDA: APHIS & CSRS
- EPA-GLNPO
- NOAA
- NIH
- GLFT
- GLFC
- US-FWS

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Power analysis and sample size for VHS surveillance monitoring

Jonathan Daily (jdaily@usgs.gov), Than Hitt, Dave Smith, and Luke Iwanowicz

USGS – Leetown Science Center, Kearneysville, WV

We have developed software to estimate the sample size required to detect the presence of VHS with a given degree of confidence or the power to detect VHS given a sample effort. The software simulates a sampling design similar to pelagic surveys currently implemented in the Great Lakes and implements a hierarchical framework to integrate error rates from field and laboratory methods. Detection rates can be examined for a range of sample sizes as well as a difference between estimated and actual prevalence. Associated costs can be compared. The software is written in R with a graphic user interface (GUI) to facilitate use and operation. Advanced options are in development, but not finalized. In this summary, we briefly describe the software inputs and outputs, and provide an example from Lake Ontario data.

The software takes user specified input or uses defaults. The following information is required:

- Species-specific VHS prevalence
- Species-specific mean and variance of catch per tow
- Prevalence rate or a range of rates to examine
- Number of simulations
- Desired power, sample effort, or maximum cost to detect presence of VHS

76 VHS Occurrence Sampling

File Edit Help About

Environment

Location: [Dropdown] Species: [Dropdown]

Mean Catch/Tow: 0 SD Catch/Tow: 0

Single Prevalence Value: 0.1

Single True Prevalence From/To/By: 0.01 0.12 0.01

Laboratory Method: [Dropdown]

Save Load

Simulation

Tows/location: 1 Simulation Replicates: 1000

Target: Power Sample Size Max Cost

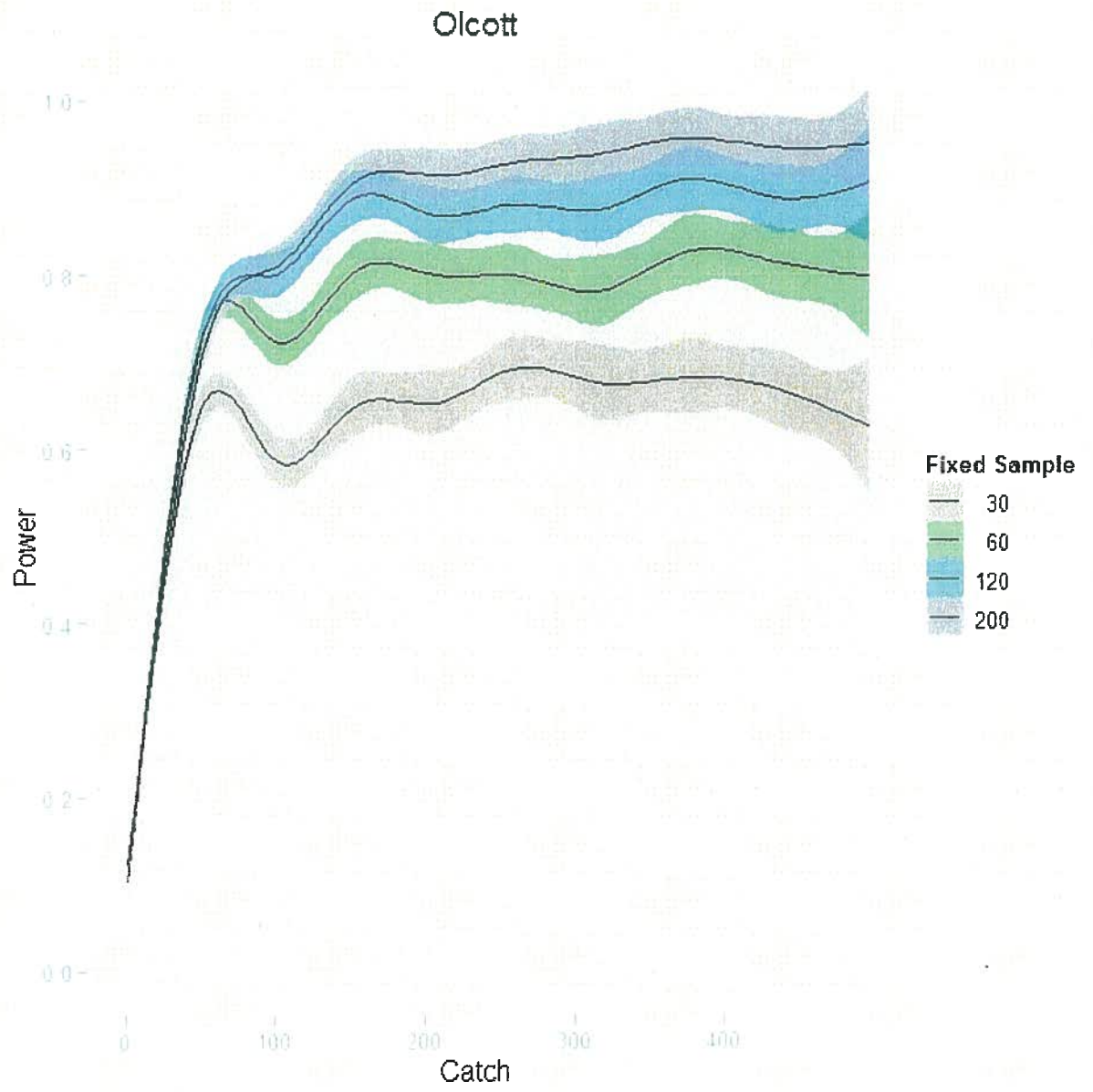
Power: 0.8 Sample Size: 60 Max Cost: 0

The software outputs tables and graphs:

- Simulation results
- Power curves

The screenshot shows a spreadsheet titled 'example.csv - LibreOffice Calc'. The data table has the following structure:

	A	B	C	D	E	F	G	H	I	J		
	catch	samp	sick	obs_prev	prev	occ	meth	cost	Tows	Species	Transect	
1												
2	2	2	0		0	0.01	FALSE	qPCR	60	1 Round	goby	Olcott
3	2	2	0		0	0.03	FALSE	qPCR	60	1 Round	goby	Olcott
4	2	2	0		0	0.06	FALSE	qPCR	60	1 Round	goby	Olcott
5	2	2	0		0	0.12	FALSE	qPCR	60	1 Round	goby	Olcott
6	25	25	0		0	0.01	FALSE	qPCR	300	1 Round	goby	Olcott
7	25	25	1	0.0396	0.03	TRUE	qPCR	300	1 Round	goby	Olcott	
8	25	25	1	0.0396	0.06	TRUE	qPCR	300	1 Round	goby	Olcott	
9	25	25	1	0.0396	0.12	TRUE	qPCR	300	1 Round	goby	Olcott	
10	743	60	1	0.0165	0.01	TRUE	qPCR	720	1 Round	goby	Olcott	
11	743	60	2	0.033	0.03	TRUE	qPCR	720	1 Round	goby	Olcott	
12	743	60	3	0.0495	0.06	TRUE	qPCR	720	1 Round	goby	Olcott	
13	743	60	6	0.099	0.12	TRUE	qPCR	720	1 Round	goby	Olcott	
14	135	60	0	0	0.01	FALSE	qPCR	720	1 Round	goby	Olcott	
15	135	60	2	0.033	0.03	TRUE	qPCR	720	1 Round	goby	Olcott	
16	135	60	2	0.033	0.06	TRUE	qPCR	720	1 Round	goby	Olcott	
17	135	60	10	0.165	0.12	TRUE	qPCR	720	1 Round	goby	Olcott	
18	11	11	0	0	0.01	FALSE	qPCR	180	1 Round	goby	Olcott	
19	11	11	0	0	0.03	FALSE	qPCR	180	1 Round	goby	Olcott	
20	11	11	1	0.09	0.06	TRUE	qPCR	180	1 Round	goby	Olcott	
21	11	11	0	0	0.12	FALSE	qPCR	180	1 Round	goby	Olcott	
22	33	33	2	0.06	0.01	TRUE	qPCR	420	1 Round	goby	Olcott	
23	33	33	0	0	0.03	FALSE	qPCR	420	1 Round	goby	Olcott	
24	33	33	5	0.15	0.06	TRUE	qPCR	420	1 Round	goby	Olcott	
25	33	33	1	0.03	0.12	TRUE	qPCR	420	1 Round	goby	Olcott	
26	15	15	0	0	0.01	FALSE	qPCR	180	1 Round	goby	Olcott	
27	15	15	0	0	0.03	FALSE	qPCR	180	1 Round	goby	Olcott	



In anticipation of CLC member agency needs for guidance in managing this new pathogen, the Great Lakes Fish Health Committee (GLFHC) has developed a set of management recommendations that we request be considered for adoption by all member agencies. The adoption of these recommendations will slow the spread of this pathogen, providing additional time for new options to be developed to more effectively contain this pathogen.

Most of the recommendations had full consensus by all GLFHC and these are requested to be immediately adopted by all CLC member agencies. GLFHC could not reach consensus on a few recommendations because of: differences in management approaches; likely inability of the member agency to be able to effectively implement the recommendations; or other large scale priorities that must be considered such as sea lamprey control. With respect to these recommendations where consensus could not be reached, we recommend that the adoption of the recommendation is up to the discretion of the individual management agencies as they are more protective actions that enhance the recommended actions with consensus.

There are a large number of information needs on this virus and the GLFHC has developed a list of the most important needs for consideration by the Great Lakes Fishery Commission in their research programs along with those of member agencies.

GLFHC Consensus Recommendations

Fish Health Testing

1. GLFHC member agencies should use the most sensitive cell lines in all samples processed for VHS virus.
2. GLFHC member agencies should request that all laboratories used by the agencies conducting VHS virus sample analysis undertake cell line susceptibility analysis, determine best performing cells, clone them, and distribute among all Great Lakes laboratories for sample analysis.
3. GLFHC member agencies should require that periodically all laboratories testing for VHS virus will share cell lines with at least one other laboratory to allow for quality control and assurance analysis to be conducted on the cell lines.

Hatchery Operations – Coolwater Culture

1. GLFHC members should refrain from taking non-salmonid eggs and sperm from any waters that are positive for the VHS virus until more is known about the success of disinfection methods with these species and the VHS virus.
 - a. If there are no feasible alternatives to using wild broodstock from waters that are positive for VHS virus and the fish are absolutely necessary for fish management purposes, production fish beginning with egg and sperm from waters positive for VHS virus can be stocked back into those waters already determined to be positive for VHS virus.

2. All non-salmonid eggs from Great Lakes wild fish sources would be surface treated with iodophor during water hardening in using a known effective concentration and duration.
3. All non-salmonid broodstock lots should be tested annually using standard fish health inspection protocols for VHS virus prior to the stocking of their production lots, where possible, and production fish from positive broodstock lots should be tested for VHS virus.
4. All production lots should be at minimum annually tested for VHS virus using standard fish health sampling protocols and those production lots found to be positive for VHS virus should not be stocked at this time.
5. All fish in a given hatchery will carry the same hatchery fish health designation to ensure full disclosure of potential fish health concerns.
6. GLFHC member agencies should strongly consider the development of protected Great Lakes non-salmonid broodstock lines using isolation or quarantine facilities and holding them in either captive situations or in isolated inland lakes.

Hatchery Operations - Salmonid Culture

1. All GLFHC members should disinfect all salmonid eggs during water hardening from Great Lakes waters using iodophor compounds using a known effective concentration and duration.
2. All adult salmonid broodstock lots should be sampled annually using standard fish health inspection protocols during egg take operations and tested for VHS virus.
3. All production lots with fish larger than fry size should be tested for VHS virus prior to stocking. Those production lots found to be positive for VHS virus should not be stocked.
4. All fish in a given hatchery will carry the same hatchery fish health designation to ensure full disclosure of potential fish health concerns.
5. All GLFHC member agencies consider the development of protected Great Lakes salmonid broodstock lines using isolation or quarantine facilities and holding them in either captive situations or in isolated inland lakes.

General Hatchery Guidance

1. GLFHC member agencies should destroy all fish at hatchery facilities that are found to be infected with VHS virus based on a management plan developed after consultation with GLFHC member agencies.
2. All eggs moved between GLFHC member agency facilities must be surface disinfected using an iodophor compound prior to transfer.
3. GLFHC member agency hatchery equipment and trucks should be fully disinfected after each use and between uses between hatcheries.
4. GLFHC member agencies should not allow the use of untreated water for moving fish from Great Lakes Basin waters testing positive for VHS virus.

Fish Management Activities – Fish Transfers

1. GLFHC members should test all species targeted for transfer from all potential donor waters before fish transfers occur.

Fish Management Activities – Others

1. All GLFHC member agencies should clean and disinfect all sampling gear, personal protective clothing and boots, boats and vehicles after sampling VHS virus positive waters.
2. All investigators under GLFHC member agency control that are sampling VHS positive waters under some type of sampling or collectors (investigators or harvesters) permit should be required to clean and disinfect all sampling gear, personal protective clothing and boots, boats and vehicles after sampling as a condition of any such permit.

Commercial Fishing Activities

1. GLFHC member agencies should periodically test all species of fish used in the live commercial fish trade for the presence of VHS virus.
2. GLFHC member agencies should prohibit the transfer of live fish species that are known to be from fish populations infected with VHS virus and are moving from Great Lakes commercial fishing operations to either live markets or fee-fishing lakes.
 - a. Alternatively, GLFHC members should appropriately test individual shipments from waters positive for VHS virus and prohibit the transfer of shipments that test positive for VHS virus from commercial fishing operations.
3. GLFHC member agencies should require that all live fish shipments from commercial fishing operations being imported for use in public waters be tested for and be certified free of VHS virus.
4. GLFHC members should ensure that all waste products from processed fish collected by commercial fisheries from waters positive for VHS be properly disposed of in either sanitary sewer systems or in licensed landfills.

Bait Industry

1. GLFHC member agencies should at minimum annually test, using standard fish health inspection protocols and proper timing, all wild Great Lakes Basin baitfish sources for VHS virus to determine which locations are positive for the pathogen.
2. GLFHC member agencies should test, or require testing of all imported baitfish sources in the Great Lakes Basin, prior to importation, for VHS virus to determine which vendors' facilities and sources are infected using standard fish health inspection protocols and proper timing to best detect the pathogen.
3. GLFHC member agencies should prohibit the importation of bait that is found to be infected by VHS virus.

4. Any baitfish source testing positive for VHS virus should not be allowed to be sold in any GLFHC member agency jurisdiction.

Non-member Agency Aquaculture Operations

1. All fish tested for VHS virus by non-member agency aquaculture operations for stocking in Great Lakes Basin public waters should use the most sensitive cell line for VHS virus.
2. GLFHC member agencies should recommend or ensure the destruction of all fish at non-member hatchery facilities that are found to be infected with VHS virus based on a management plan developed after consultation with GLFHC member agencies.
3. GLFHC member agencies should ensure or recommend that non-member hatchery equipment and trucks should be fully disinfected after each use and between uses between hatcheries.

Public Information

1. All GLFHC member agencies should jointly develop information sheets, boat launch information, and a website on VHS virus and other pathogens to highlight how the public can prevent their spread.
2. GLFHC member agencies should take every opportunity to inform the public about VHS virus and its potential affects in press interviews, press releases and popular articles.
3. GLFHC member agencies or the GLFC should sponsor a 1-800 number and a website on fish pathogens, their potential affects, and current distribution.
4. The GLFC should assist the GLFHC in using the existing internal website for the posting of information to allow for the rapid dissemination of public information materials among member agencies.
5. The GLFHC strongly encourages the development of a North American website for the posting of current and emerging fish pathogen information that is jointly managed by state, provincial, tribal and federal fisheries agencies.

Other Preventive Measures

1. GLFHC member agencies should undertake all possible measures to prevent the discharge of untreated ballast water within Great Lakes waters.
2. GLFHC member agencies should use the U.S. Coast Guard abilities to prohibit ballast water exchange in areas of high pathogen density and in areas of active mortality events.
3. GLFHC member agencies strongly encourage all possible measures to prevent the use of untreated water for any purpose from Great Lakes Basin waters positive for VHS virus that maybe possibly discharged into waters not yet exposed to VHS virus.

GLFHC Recommendations – Without Full Consensus

Fish Management Activities – Fish Transfers

1. GLFHC members should not move fish from waters positive for VHS virus.
2. GLFHC members can move fish that test negative for VHS virus from waters with other positive VHS virus detections in fish to other waters that have tested positive for VHS virus in fish.
3. GLFHC members can move fish lots that test negatively for VHS virus from waters with positive VHS virus detections in other fish to any water.

Bait Industry

1. GLFHC member agencies can allow the use of bait collected from waters testing positive for VHS virus in fish in other waters testing positive for VHS virus in fish.

Key Information and Management Needs

1. Systematic wild fish surveys to determine the location of VHS virus in the Great Lakes Basin.
2. Improved understanding of host-pathogen-disease relationship for key management species with a high priority on sea lampreys.
3. The length of time VHS virus is viable in the environment.
4. Geographic distribution of VHS virus for all affected fishes in the Great Lakes.
5. The effectiveness of iodophor disinfection of non-salmonid eggs.
 - a. Appropriate safe levels of disinfection need to be determined for each non-salmonid species and that physical manipulation at this stage will not kill the newly fertilized non-salmonid embryos.
6. Determination of which non-salmonid species are susceptible, infectious and carrier species.
7. Improvements in the detection tests for VHS virus
 - a. Evaluation of all available cell lines to determine the most sensitive.
 - i. Most sensitive should be cloned and provided to all fish health labs in the Great Lakes region
 - b. Full development of rapid field and laboratory virus detection tools to include rPCR tests.
 - c. General methodology improvements are needed to include which is the best tissue to test and what is the best way to ship and store samples.
8. Develop a full understanding of the extent of the live fish market for commercially caught fish along with distribution network for these fish to greatly improve trace-back options.
9. Develop a full set of options to use Aquatic Nuisance Species and Department of Homeland Security funds to combat fish health problems that could affect commercially important species.

10. Understand how the baitfish industry operates, the effects of the above recommendations on bait availability for anglers, and extent of bait importation into and movement around the Great Lakes.
11. Understand the seasonal variability of infection in key baitfish species, in particular lake emerald shiners and golden shiners.
12. A systematic survey of VHSV and other pathogens carried in Great Lakes ballast water.
13. An analysis of the movement of fish, pathogens and ballast materials through the Great Lakes should be conducted to examine if any relationships exist among these factors that could inform management decisions.

<p>FISHERY RESEARCH PRIORITIES: GREAT LAKES FISH HEALTH COMMITTEE Great Lakes Fishery Commission</p>

Version October 31, 2009

This listing was compiled based on input from discussions within the Council of Lake Committees (for more information go to <http://www.glfcc.org/lakecom.php>) and the Great Lakes Fish Health Committee (<http://www.glfcc.org/boardcomm/fhealth/fhealth.php>). Order of listing does **not** imply relative ranking of priorities for the Fishery Research Program funding.

Research Priorities

- *What non-lethal field sampling techniques and tissue/fluid samples are equivalent to lethal field sampling methods to determine fish disease status?*
- *What is the ecology of important fish pathogens and diseases?*
- *Examples of GLFHC important disease and pathogens include VHSV Genotype IVb, Heterosporis sp. among other emerging diseases.*
- *What is the effectiveness of the GLFHC disinfection protocols in eliminating VHSV and Nucleospora from fish eggs? There is a need for a reliable disinfection methodology to prevent VHSV and Nucleospora transmission via eggs.*

Additional Research Interests

- i) Development and validation of new methods for detecting emerging fish pathogens or pathogens of concern in the Great Lakes Basin.
 - (a) What factors that affect sample integrity during shipment and storage
- ii) Disease Ecology and Epidemiology
 - (a) What is the susceptibility to of Great Lakes fish species to emerging fish pathogens in the Great Lakes?
 - (b) Identification of reservoirs and vectors for fish pathogens in the Great Lakes Basin
 - (c) What factors affect the virulence of fish pathogens?
 - (d) What are the effects of synthetic estrogen or other hormones on gonad development in Great Lakes fish?
 - (e) What is the effect of population size on disease expression?
 - (f) What are the effects of multiple pathogens or combination of pathogens and nutritional deficiency and/or contaminant exposure on disease expression?
- iii) Nutritional Aspects of Fish Health in the Great Lakes
 - (a) What is the role of lipids or other nutrients in determining and predicting health status?
 - (b) What is the role of thiaminase-producing organisms in Great Lakes ecosystems?

- (c) What affect do invasive species have on nutrient stores in the Great Lakes and what are the associated affects on fish health.
 - (d) What is the effect of nutrition on reproductive success?
 - (e) What is the relationship between genetics and thiamine deficiency complex?
 - (f) Does protein substitution in hatchery feeding formulations or extrusion manufacturing methods have a negative impact on survivorship, migratory behavior and reproductive success of hatchery-reared salmonids?
- iv) Fish Pathogen and Disease Management
- (a) What are the affects of fish stocking and other management decisions on the manifestation of fish disease in the Great Lakes Basin.
 - (b) What effects does culling brood stock for *Renibacterium salmoninarum* have on the genetics of production fish.
 - (c) When should salmonids not be moved past barriers (from a disease perspective)?
 - (d) Development of an emergency response plan for disease outbreaks in the Great Lakes Basin, including (but not limited to) training of field personnel and pre-planning.
 - (e) What is the effectiveness of immunostimulants against BKD in hatcheries?
 - (f) What is the affect of vaccination of hatchery fish on pathogen virulence?