

**MODEL PROGRAM FOR FISH HEALTH
MANAGEMENT IN THE GREAT LAKES**



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MODEL PROGRAM FOR FISH HEALTH MANAGEMENT IN THE GREAT LAKES

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ABSTRACT

Fish diseases are known to have exerted unacceptably high natural mortality on some of the most-valuable fish populations in the Great Lakes, and, notwithstanding suppression efforts, their existence continues to present risks to fishery sustainability. To minimize these risks, the Great Lakes Fish Health Committee (formerly the Great Lakes Fish Disease Committee) formalized in 1985 a Great Lakes Fish Disease Control Policy and Model Program for which this document is the first update. This update is intended to further encourage the initiation of basinwide fish health initiatives and to improve their implementation among the agencies signatory to *A Joint Strategic Plan for Management of Great Lakes Fisheries* (GLFC 2007). The specific goals of this update are to prevent the introduction of new pathogens into the Great Lakes basin, to halt the spread within the Great Lakes of established pathogens deemed destructive, and to provide a system for classifying the disease status of fish hatcheries. To accomplish these goals, fish pathogens are classified into one of three groups: emergency pathogens—those that have not been detected previously from fish in the Great Lakes basin, are known to cause epizootic events in their enzootic range, and call for containment and eradication; restricted fish pathogens—those that have been detected in fish from the Great Lakes basin, are known to cause epizootic events in hatcheries or in the wild, and call for containment and minimization of effects; and provisional fish pathogens—those under scrutiny and of concern to at least one member agency of the fish health committee, owing primarily to unknown life-history strategies and possible unwanted effects. To achieve containment of fish pathogens, standards are provided for disease testing, hatchery classification and

certification, importation of fish, and transportation of fish and fish products. Implementation of these measures is expected to reduce the risks of disease outbreaks resulting from importation of new disease agents into the Great Lakes basin or from transfers of infected fish between individual Great Lakes drainages.

INTRODUCTION

The health of fish in the Great Lakes basin is the responsibility of those agencies that manage the fisheries. The Great Lakes Fish Health Committee (GLFHC), formerly the Great Lakes Fish Disease Control Committee, developed a Great Lakes Fish Disease Control Policy and Model Program, which was re-adopted by the Great Lakes Fishery Commission in 1985 (Hnath 1993). Its purpose was to unify and coordinate the fish-disease management efforts of those agencies signatory to *A Joint Strategic Plan for Management of Great Lakes Fisheries* (GLFC 2007). This updated model program supersedes Hnath (1993) and has been expanded to incorporate and update Horner and Eshenroder (1993), which dealt with the importation of emergency disease agents into the basin. The purpose of this model program is to provide fishery managers, fish health professionals, and fisheries policy makers with guidelines for fish-hatchery management, fish health testing, and transportation of fish into and within the Great Lakes basin. The specific goals are to prevent the introduction and spread of fish pathogens in the basin and in fish hatcheries and to provide for classification of the disease status of fish hatcheries. This model program will be revised as new information becomes available or new pathogens emerge in the basin, will be posted on the GLFHC website, and will be updated annually as needed.

AGENCY RESPONSIBILITIES

Each member agency is expected to work toward the control of fish pathogens in the Great Lakes basin by

- Developing legislative authority and regulations to enable the eradication of fish pathogens or minimization of their spread
- Minimizing the rearing and release of infected fish

- Preventing the release of clinically diseased fish
- Preventing the importation of fish infected with specified pathogens
- Limiting the transfer of fish infected with specified pathogens
- Developing response plans as needed and appropriate

At the time of this revision of the original model program, both the Canadian and U.S. governments began to implement their respective policies: the National Aquatic Animal Health Program (Canada) and the National Aquatic Animal Health Plan (U.S.). The objective of the Canadian NAAHP is to protect those Canadian fish/seafood industries and activities that rely on aquatic resources from the introduction and spread of potentially destructive fish pathogens. The U.S. NAAHP provides a framework for federal agencies to work together to protect aquatic resources. This model program does not replace or duplicate the components or obligations of member agencies to the NAAHPs, but rather it should be viewed as a complementary program directed specifically at the activities of member agencies, such as the collection, rearing, release, and transfer of hatchery and wild fish into and within the Great Lakes basin. Nothing in this model program should be interpreted as preventing member agencies from applying additional measures to control fish pathogens through inspection, testing, quarantine, and pathogen depopulation and eradication efforts.

All member agencies should anticipate the presence of undesirable fish pathogens, and appropriate response plans should be developed to ensure timely and effective actions to contain and minimize their impacts and, if possible, eliminate them. Response plans should include provisions on biosecurity (see Illinois Biosecurity Manual, <http://fishdata.siu.edu/secure/bioman.pdf>), staffing requirements, testing needs, necessary legislative authority for depopulation and disinfection, depopulation and disposal procedures, disinfection protocols, and communication needs for a coordinated response, which may involve state,

provincial, and federal governments; universities; and private industry. The GLFHC may recommend additional steps to eradicate a pathogen from a hatchery and adjacent waters following the best science available in association with the guidelines provided here.

APPLICATION AND SCOPE

The recommendations in this model program apply to fish species that have the potential to harbor pathogens transmissible to other fish or aquatic animals in the Great Lakes basin (Appendix A). In particular, it discusses transportation into/within the Great Lakes basin of wild or hatchery-raised fish or their gametes that are or could be infected with designated pathogens.

This model program does not provide guidance to fishery managers regarding disease outbreaks in wild-fish populations. When disease outbreaks are detected in wild populations, member agencies should contact the GLFHC chairperson and/or vice chairperson. The chairperson (or vice chairperson in the absence of the chairperson) will provide appropriate recommendations to the member agency.

Provided that all necessary biological containment measures are taken to avoid any dissemination of fish pathogens, the recommendations in this model program shall not apply to

1. Fish and water in transit (in closed containers) through the Great Lakes basin that are not intended to be released from the original shipping containers while within the basin
2. Fish (alive, dead, or their excised organs and tissues) used for diagnostic services and related laboratory tests, assuming such fish are properly packaged, the chain of custody is documented, and release is not intended

This model program applies to GLFHC member agencies, i.e., those signatory to *A Joint Strategic Plan for Management of Great Lakes Fisheries* (GLFC 2007): Chippewa Ottawa Resource Authority, Fisheries and Oceans Canada, Great Lakes Indian Fish and Wildlife Commission, Illinois Department of Natural Resources (DNR), Indiana DNR, Michigan DNR, Minnesota DNR, New York State Department of Environmental Conservation, Ohio DNR, Ontario Ministry of Natural Resources, Pennsylvania Fish and Boat Commission, U.S. Fish and Wildlife Service (USFWS), and Wisconsin DNR. In practice, the GLFHC operates under the aegis of the Council of Lake Committees (CLC), a body formed to coordinate fishery management among the signatories to the strategic plan.

AMENDMENT

Model program amendments may be proposed by any member of the GLFHC or by the CLC operating as a whole. A proposed amendment should be submitted to the GLFHC chairperson in writing and contain the rationale for the request. The chairperson will seek to form from within the committee a consensus on the scientific merits of the proposed amendment; the results of this effort will be presented in writing to the CLC for its purview. If the proposed amendment is adopted by the CLC, it will become part of the model program.

PATHOGEN DETECTION MANUALS

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

1. *Suggested Procedures for the Detection and Identification of Certain Fish and Shellfish Pathogens* (Blue Book) developed by the American Fisheries Society-Fish Health Section (AFS-FHS)
2. *Fish Health Protection Regulations Manual of Compliance* (Miscellaneous Special Publication 31, Revised) of Fisheries and Oceans Canada
3. *Manual of Diagnostic Tests for Aquatic Animals* of the World Organisation for Animal Health (OIE)

More sensitive or definitive procedures may be used, but any departures from the basic procedures set forth in these manuals or updated versions of these manuals must be noted and explained on hatchery inspection reports. Agencies may employ the most currently accepted methods for detection of pathogens even if they are not included in the above manuals. Appendix B contains information on the pathogens covered in the model program and on the fish species they may infect.

When procedures set forth in the model program appear to be outdated owing to new information concerning testing for a particular pathogen and/or the disease(s) it causes, the member agency should contact the GLFHC chairperson. The chairperson will expediently provide recommendations to the member agency on how to proceed with testing. In the interim, the affected fish should not be released or transferred, and efforts should be made to contain the pathogen to the affected lot(s) or stock(s).

RISK ASSESSMENT

Procedures for risk assessment have been developed independently from this document and can be found on the GLFHC's website (<http://www.glfhc.org/boardcomm/fhealth/fhealth.php>).

PATHOGENS COVERED BY THE MODEL PROGRAM

For pathogens covered by the model program, see Appendix B.

Emergency Fish Pathogens

Emergency fish pathogens are those that have not been detected from fish in the Great Lakes basin and are known to cause epizootic events in their enzootic range. The presence of any of these pathogens in a hatchery calls for the development of a containment and eradication plan that minimizes the risk of transmission to wild fish.

Emergency pathogens (asterisks indicate OIE-listed pathogens at the time of publication) are

- *Ceratomyxa shasta* (causes ceratomyxosis)
- infectious hematopoietic necrosis virus*
- infectious salmon anemia virus*
- *Tetracapsuloides bryosalmonae* (causes proliferative kidney disease)
- viral hemorrhagic septicemia virus (VHSV) (all strains except IVb)*

- white sturgeon herpesvirus
- white sturgeon iridovirus

Restricted Fish Pathogens

Restricted fish pathogens are those that have been detected from fish in the Great Lakes basin and are known to cause epizootic events in hatcheries or in the wild. Response plans to minimize the effects vary depending on the life history of the pathogen (Table 1). Agencies should strive to minimize the threat of pathogen transmission (e.g., fish exhibiting clinical signs of disease should not be transferred to other facilities or released in the Great Lakes basin). Level-1 restricted pathogens pose lesser threats to wild fish than Level-2 restricted pathogens. Fish infected with Level-1 pathogens may be stocked in areas where the pathogen is known to occur in susceptible fish and where its effect on such fish is predicted to be negligible. The GLFHC's risk management protocol should be used to determine if a proposed location is suitable for transfer or stocking. Level-2 restricted pathogens are untreatable, difficult to manage, and transmission continues throughout the life of infected fish; therefore, depopulation of infected stocks is recommended.

Table 1. Restricted pathogens and recommended actions for infected fish. The asterisks indicate OIE-listed pathogens.

Level	Pathogen	Recommended Actions
1	<i>Aeromonas salmonicida</i>	Seek pathogen-free sources, if possible
	<i>salmonicida</i>	Fish exhibiting clinical signs of disease should not be transferred, stocked, or released
	largemouth bass virus	
	<i>Renibacterium salmoninarum</i>	Use biosecurity methods and approved treatments to reduce disease prevalence and transmission risks prior to stocking
	<i>Yersinia ruckeri</i>	Stock fish in locations where potential effect is minimal Fish without clinical signs may be stocked where the pathogen is already established once all member agencies are notified Use of GLFHC's risk assessment is encouraged before stocking begins
2	<i>Heterosporis</i> sp.	Avoid sources of infected fish
	infectious pancreatic necrosis virus	Eradicate infected hatchery lots and do not stock positive lots
	koi herpesvirus*	
	<i>Myxobolus cerebralis</i>	
	spring viremia of carp virus*	
	VHSV IVb*	

Provisional Fish Pathogens

Provisional fish pathogens are those that are not listed as emergency or restricted but are of concern to at least one member agency, primarily because their life-history strategies and potential effects are unknown. Additional information is needed to propose listing them as emergency or restricted pathogens. A pathogen may be classified as provisional if it has an unknown epidemiology and/or etiology, has the potential to negatively affect aquatic animal health, and meets the following criteria (adapted from the National Aquatic Health Plan (2008)):

1. The pathogen/disease has been demonstrated to cause significant hatchery losses due to morbidity or mortality
2. The pathogen/disease has been demonstrated to negatively affect wild populations
3. Evidence strongly suggests a negative effect
4. Infectious etiology has been proven
5. An infectious agent is strongly associated with a disease but its etiology is not known, and a potential exists for its spread via live animals or their products

A GLFHC member should complete the Pathogen Nomination Form (Appendix D) when proposing the addition of a provisional pathogen to the model program. This form requires background information on the pathogen, why it is a concern, and the rationale for classifying it as provisional. The completed form should be submitted to the chairperson (or in the chairperson's absence, the vice-chairperson) of the GLFHC, who will present it to the full committee for the purpose of compiling a technical analysis. This analysis will be submitted to the CLC, which will determine whether or not the pathogen qualifies for a provisional listing.

Because of the lack of knowledge concerning potential provisional pathogens, the appropriate management actions may be uncertain. Important considerations include

- Determine if diagnostic tools are available:
 - if yes, request member agencies begin surveillance
 - if no, recommend as a research priority the development of a reliable detection method, seek funding, and encourage researchers to submit proposals to funding sources
- Identify research needs and information gaps
- Identify vectors and hosts in the Great Lakes basin under the regulatory control of member agencies
- Minimize the spread of such pathogens until sufficient information is known to classify them

Provisional pathogens are

- *Bothriocephalus acheilognathi*
- *Nucleospora salmonis*
- epizootic epitheliotropic disease virus
- *Piscirickettsia*-like organism
- lymphosarcoma virus

Relisting Pathogens

To relist an emergency pathogen as a restricted pathogen, the pathogen must be confirmed enzootic somewhere in the Great Lakes basin. Actions to eradicate/control the pathogen must have been undertaken by a member agency(s) to restrict its spread or reduce its virulence.

To relist a provisional pathogen as a restricted pathogen, all of the following criteria should be met:

- It is enzootic somewhere in the Great Lakes basin
- It can cause epizootic events or reduction of fitness
- Active management against it, such as reducing its prevalence or spread, is needed
- Reliable testing is available
- Sufficient life history and biosecurity information are available to determine appropriate management actions

To relist a provisional pathogen as an emergency pathogen, all of the following criteria should be met

- It is not enzootic anywhere in the Great Lakes basin
- It causes significant epizootic events or reduction of fitness
- Legal or regulatory requirement for active management against it (generally, depopulation) is required

- Active management against it, such as reducing its prevalence or spread, is needed
- Reliable testing is available
- Sufficient life history and biosecurity information are available to determine appropriate management actions

To remove a pathogen from the provisional list without moving it to the emergency or restricted lists, all of the following criteria should be met

- It is not known to cause epizootic events or reduction of fitness
- Reliable testing is available
- Sufficient life history and biosecurity information are available to determine that management actions are not necessary

INSPECTION AND TESTING

Fish health inspections are vital tools that help limit and prevent the spread of deadly fish pathogens and the outbreaks of disease. Inspections allow fish health biologists to make informed decisions regarding transfer and release of fish and provide an opportunity for early detection using the Fish Health Inspection Report (Appendix D). Accordingly, fish health inspections should be conducted annually (at a minimum) at all fish hatcheries operated by member agencies and should include testing for all applicable restricted pathogens (Appendix B). Screening for emergency pathogens should be undertaken during diagnostic testing, while testing for provisional pathogens is encouraged but not required. Detections of provisional pathogen or an antibiotic-resistant bacterium in a hatchery should be noted on inspection reports, hatchery classifications, and annual member reports. Each member

agency should designate individuals responsible for conducting fish health inspections at its facility.

Fish health inspections and all associated laboratory testing should be conducted according to methods described by the most-recent editions of the *Suggested Procedures for the Detection and Identification of Certain Fish and Shellfish Pathogens* (Blue Book) developed by the AFS-FHS; the *Fish Health Protection Regulations Manual of Compliance* (Miscellaneous Special Publication 31, Revised) of Fisheries and Oceans Canada; and the *Manual of Diagnostic Tests for Aquatic Animals* of the OIE. Methods published in peer-reviewed journals may be used only if the previously listed documents do not provide guidance. Recommended sample sizes for lot-based or facility-based inspections are provided in Table 2.

Table 2. Minimum suggested sample sizes for hatchery populations or lots of 50 to >100,000 fish. Sample sizes are based upon stratified random sampling that assumes a binomial distribution and provides 95% confidence of detection at a minimum incidence of 2% or 5%.

Population or Lot Size	Assumed Incidence	
	2%	5%
50	50	30
100	75	45
250	110	50
500	130	55
1,000	140	55
1,500	140	55
2,000	145	60
4,000	145	60
10,000	145	60
>100,000	150	60

When sampling

- Collect moribund fish and fish with signs of disease, if possible, and consider the etiology of the pathogens and collect samples at the optimal conditions for detection (Appendix B)
- Employ non-lethal sampling whenever applicable and especially when working with threatened and endangered species, captive brood stock, or wild populations used as brood stock (a biostatistician or epidemiologist should be consulted prior to initiating sampling of wild populations).

CLASSIFICATION OF HATCHERIES AND WILD BROOD STOCK POPULATIONS

All member agencies should maintain classifications for each of their hatcheries and wild brood-stock populations and provide five years of classification history on a Fish Health Inspection Report (Appendix D). Classifications should be dated and include contact information for a person who can provide additional information. The following guidelines should be used when designating a classification:

- Class A hatcheries or wild brood stock populations where pathogens specified in the model program have not been detected during three consecutive annual inspection cycles shall be designated as SPF (specific-pathogen free) on a Fish Health Inspection Report (Appendix D)
- Class B hatcheries or wild brood stock populations which test positive for one or more emergency or restricted pathogens should identify the detection(s) on a Fish Health Inspection Report (Appendix D) by a pathogen code (Table 3) followed by the date of detection

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 (10/2009) (Table 3); the pathogen code and date will remain part of the hatchery's classification until the facility undergoes three *consecutive annual inspections* without the pathogen being detected

- Class C hatcheries or wild brood-stock populations without a positive detection and that have not completed a minimum of three annual inspections will be designated as Class C (incomplete)

Table 3. Pathogen codes for classifying hatcheries and wild brood stocks.

Pathogen (Disease)	Code
<i>Aeromonas salmonicida</i> salmonicida (causes furunculosis)	AS
<i>Bothriocephalus acheilognathi</i> (Asian tapeworm)	BA
<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
lymphosarcoma	LSV
<i>Myxobolus cerebralis</i> (causes whirling disease)	MC
<i>Nucleospora salmonis</i>	NS
<i>Piscirickettsia</i> -like organism (muskie pox)	PLO
<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 (include strain)	VHSV
white sturgeon herpesvirus	WSHV
white sturgeon iridovirus	WSIV
<i>Yersinia ruckeri</i> (enteric redmouth)	YR

Reclassification

As test results become available, classification records should be updated (with date of reclassification) to include any emergency or restricted pathogens detected in the preceding 36-month period. Classifications may change owing to new test results or to a facility having received fish or gametes from a source classified lower at the time of the transfer or reclassified lower subsequent to the transfer. In any event, the receiving facility cannot have a higher classification than the donor facility, and fish from a source with a Level-1 restricted-pathogen classification should not be transferred to a facility with the same classification unless no other uninfected sources are available.

Exceptions for Gametes

If fertilized eggs originate from a hatchery or wild brood stock positive for the pathogens listed below and the fertilized eggs are properly disinfected (Appendix C), the hatchery classification will not change because the following pathogens are not vertically transmitted and can be eliminated with proper disinfection:

- *Aeromonas salmonicida salmonicida*
- *Ceratomyxa shasta*
- *Tetracapsuloides bryosalmonae*
- *Yersinia ruckeri*
- *Myxobolus cerebralis*

Exceptions for Isolation or Quarantine

Fish, fertilized eggs, or gametes in isolation or quarantine facilities that do not have the required three annual inspections will not affect the classification of an associated rearing station as long as the member agency can demonstrate such fish, fertilized eggs, or gametes had no direct or indirect contact with other fish on the associated station and strict biosecurity measures are in place. Isolation and quarantine facilities are considered independent of their host stations for classification purposes.

Hatchery Depopulation and Disinfection

A hatchery that was depopulated and disinfected to eliminate a pathogen(s) retains a Class B classification following the disinfection. The hatchery must go through the required three annual inspections during which time it will be considered suspect for the previously detected pathogen(s). The hatchery classification will include the code for the pathogen(s) and the date of detection(s). The disinfection date will be noted for five years on the facility's Fish Health Inspection Report.

IMPORTATION AND TRANSFER PROTOCOLS

Before gametes, fertilized eggs, or fish are imported or transferred into any member-agency facility in the Great Lakes basin other than quarantine facilities, testing for emergency and restricted pathogens as established below is required. Susceptibilities of fish to emergency and restricted pathogens are listed in Appendix B. If the testing specified here provides inadequate guidance, the GLFHC's risk assessment provided on its website should be conducted before an importation or transfer is initiated. Where stress tests are called for, the GLFHC recommends that fish health

professionals be consulted to determine the stress test(s) that best induces the disease of concern.

If a member agency seeks to import gametes, fertilized eggs, or fish from a source not located in an area enzootic for an emergency pathogen, testing for emergency pathogens is not required. The determination of whether a source is in an area enzootic for an emergency pathogen should be based on expert knowledge, the opinions of fish health professionals working in the source jurisdiction(s), and a literature review. Importations and transfers should be conducted using pathogen-free sources of gametes, fertilized eggs, or fish to the greatest extent possible. The following measures should be implemented when making an importation or transfer from a source located in an area enzootic for an emergency pathogen.

Importing Gametes and Fertilized Eggs from Sources in Areas Enzootic for Emergency Pathogens

Fertilized eggs may be imported from an area enzootic for an emergency pathogen provided one of the following guidelines applies

- Fertilized eggs must be properly disinfected (Appendix C) and from a source that has been tested a minimum of five consecutive years without a positive detection of an emergency pathogen, sampling at the 5% prevalence level (Table 2)
- Fertilized eggs must be properly disinfected (Appendix C) and be from a source that has been tested a minimum of three times over two years with at least four months between tests without a positive detection for an emergency pathogen, sampling at the 2% prevalence level (Table 2)
- *Ceratomyxa shasta* and/or *Tetracapsuloides bryosalmonae* are the emergency pathogens of concern and the fertilized eggs have been properly disinfected

Gametes and fertilized eggs from a source with an incomplete history or that cannot be properly disinfected may be imported into a quarantine facility. Before release from quarantine, progeny should be tested for the emergency pathogen(s) of concern such that three negative inspections are recorded with consecutive inspections separated by at least four months. Sampling should occur at the 2% prevalence level (Table 2). Progeny should be subjected to an appropriate stress test for the pathogen(s) of concern prior to the final screening.

Importing or Transferring Gametes and Fertilized Eggs from Sources in Areas Endemic for Restricted Pathogens

A member agency may import or transfer gametes or fertilized eggs from a source in an area where a restricted pathogen is endemic if the pathogen is already present in the receiving hatchery. If the pathogen is not in the receiving hatchery, one of the following guidelines should apply

- The source must have been tested a minimum of three consecutive years without a positive detection for the restricted pathogen of concern, sampling at the 5% prevalence level (Table 2)
- The source must have been tested a minimum of three times within two consecutive years with at least four months between tests without a positive detection for the restricted pathogen of concern, sampling at the 2% prevalence level (Table 2)
- *Aeromonas salmonicida salmonicida*, *Yersinia ruckeri*, and/or *Myxobolus cerebralis* (pathogens not vertically transmissible) are the pathogens of concern and fertilized eggs are properly disinfected (Appendix C)

If one of the above criteria cannot be met, the gametes and subsequent progeny should be reared in isolation/quarantine from other fish at the receiving hatchery. Prior to release from isolation, progeny should be tested for the restricted pathogen(s) of concern such that three negative inspections are recorded, with consecutive inspections separated by at least four months before release from quarantine. Sampling should occur at the 2% prevalence level (Table 2). Progeny should be subjected to an appropriate stress test for the pathogen(s) of concern prior to the final screening.

Importing Fish from Sources in Areas Enzoitic for Emergency Pathogens

If a member agency seeks to import fish from a source outside the Great Lakes basin where an emergency pathogen is enzootic or from a member-agency hatchery that has imported fish from such a source, the following guidelines apply

- If the receiving hatchery has a non-secure water supply, importation is NOT recommended
- If the receiving hatchery has a secure water supply, the fish should be held in isolation and one of the following stipulations should be met
 - testing should continue for a minimum of five consecutive years without a positive detection before release from isolation, sampling at the 5% prevalence level (Table 2)
 - testing should continue for a minimum of three times over two consecutive years with at least four months between tests without a positive detection before release from isolation, sampling at the 2% prevalence level (Table 2)

- If a quarantine facility is available and neither of the above criteria regarding a secure water supply can be met
 - quarantine should be maintained for 12 months
 - during quarantine, three negative inspections separated by at least four months are required, with sampling at the 2% prevalence level (Table 2). Stress testing is recommended

Importing or Transferring Fish from Sources in Areas Endemic for Restricted Pathogens

If a member agency seeks to import or transfer fish into a hatchery from a source located in an area endemic for a restricted pathogen, one of the following guidelines applies

- The source must have been tested for a minimum of three consecutive years without a positive detection, sampling at the 5% prevalence level (Table 2)
- The source must have been tested a minimum of three times over two consecutive years with at least four months between tests without a positive detection, sampling at the 2% prevalence level (Table 2)
- The fish are quarantined for 12 months during which time three negative inspections spaced at a minimum of four months are recorded; sampling should be at the 2% prevalence level (Table 2); a sample of the fish should be subjected to an appropriate stress test prior to the final screening

If a member agency seeks to import or transfer fish into a non-quarantine facility from a source with a Level-1 restricted pathogen (Table 1), the receiving facility should have been classified as positive for the pathogen,

and a health certificate should accompany the importation. Fish with Level-2 pathogens (Table 1) should not be imported or transferred between hatcheries.

PATHOGEN DETECTIONS

Emergency Pathogen Detections in a Hatchery

If an emergency pathogen is detected at a hatchery, the following steps should be initiated immediately to eradicate the pathogen from the facility, source, and receiving waters

- Destroy all infected lots
- Isolate as much as possible all susceptible species from infected fish
- Disinfect all potentially contaminated portions of the facility following procedures in Chapter 14 of Great Lakes Fishery Commission Special Publication 83-2
(http://www.glfc.org/pubs/SpecialPubs/sp83_2/index.html)
- Eradicate the pathogen from source and effluent water supplies if possible
- Disinfect all potentially contaminated gear
- Confirm the detection by another laboratory following standard procedures
- Notify the competent authority if it is OIE reportable

- Notify the GLFHC chairperson or, in the chair's absence, the vice-chairperson, who will advise the GLFHC and the CLC
- Notify all transfer sources or recipients of the fish, fertilized eggs, or gametes that an emergency pathogen has been detected
- Update the hatchery classification to reflect the new detection.

To demonstrate the pathogen has been eradicated, the facility should, in addition to the actions stated above, complete one of the following

- Test all lots of susceptible species three times with at least four months between tests, achieving negative results while sampling each lot at the 2% prevalence level (Table 2)
- If appropriate biosecurity measures have been taken to isolate rearing units, test susceptible species within the affected rearing unit three times at intervals at least four months apart, sampling at a 2% prevalence level (Table 2); if the results are negative and if the member agency can demonstrate the fish, fertilized eggs, or gametes in the affected rearing unit had no direct or indirect contact with other fish on station, fish in other rearing units do not need to be in compliance with the guideline immediately above

If the testing described above indicates the pathogen has been eradicated, the agency may stock those fish remaining on station after disinfection. The GLFHC's risk assessment (see the GLFHC website at <http://www.glfhc.org/boardcomm/fhealth/fhealth.php>) should be consulted before stocking proceeds. If the testing described above indicates the pathogen has not been eradicated, the authority should proceed as though the pathogen had just been found, reinitiating the procedure from the beginning. The procedures described above should continue until testing indicates the pathogen has been eradicated.

Emergency Pathogen Detections in the Wild

If an emergency pathogen is detected in the wild

- Notify the GLFHC chairperson, who will advise the GLFHC and CLC and initiate procedures to amend the model program
- Employ all necessary/reasonable means to contain the spread of the pathogen, including limiting transportation of fish, fertilized eggs, and/or gametes from the affected location
- Notify the competent authority if it is OIE reportable
- If the pathogen is not OIE reportable, confirm the detection by another laboratory following standard procedures
- Initiate a surveillance program to determine the geographic distribution of the pathogen and the species susceptible to it, if possible
- Eradicate the pathogen, if possible, and undertake measures to prevent its spread

Restricted Pathogen Detections in a Hatchery

If a restricted pathogen is detected at a hatchery

- Enhance biosecurity measures as needed to limit the spread of the pathogen to other rearing units within the hatchery or to other hatcheries
- Optimize rearing conditions
- Confirm the detection by another laboratory following standard procedures

- Notify the competent authority if it is OIE reportable
- Treat infected rearing units to reduce the number of infected fish if appropriate and test afterwards as necessary

If the detection is new, determine the origin of the pathogen if possible, take action to prevent further spread, and notify the GLFHC chairperson, who in turn will inform the committee of the change in status of the hatchery.

Restricted Pathogen Detections in the Wild

If a restricted pathogen is detected in the wild

- Limit the collection of fish, fertilized eggs, and gametes from the location, if possible
- Employ reasonable means to prevent the spread of the pathogen to locations where it has not been detected previously
- Initiate a surveillance program to determine the geographic distribution of the pathogen, if possible

If the detection is new, inform the GLFHC chairperson, who in turn will inform the committee.

Provisional Pathogen Detections in a Hatchery

If a provisional pathogen is found within a hatchery, a risk assessment (see the GLFHC website at <http://www.glf.org/boardcomm/fhealth/fhealth.php>) should be used to provide guidance regarding whether potentially infected fish can be transferred or stocked. In addition, the agency should assess risks, determine the pathogen's origin, determine if it was transferred to another region/hatchery, and minimize its spread.

Provisional Pathogen Detections in the Wild

If a provisional pathogen is detected in wild fish, member agencies should report the finding to the GLFHC chairperson for surveillance. A risk assessment (see the GLFHC website at <http://www.glfhc.org/boardcomm/fhealth/fhealth.php>) can be used by the agency to address the situation and to provide guidance concerning use of potentially infected fish as brood stock.

RELEASE OF FISH INFECTED WITH PATHOGENS

Emergency Pathogens

Fish from a facility that has tested positive for an emergency pathogen may be released into the wild only if the guidance provided in the Pathogen Detection section is followed.

Restricted Pathogens

Infected fish without clinical signs of Level-1 restricted pathogens may be released in waters where the pathogen has been detected previously or where infected fish have been released within the last five years. Fish infected with Level-1 pathogens that have clinical signs of disease, or those infected with Level-2 pathogens, should not be stocked and all lots should be destroyed.

Fish should not be released into the Great Lakes basin if any of the following exist

- Fish exhibit clinical signs of any disease
- Mortality rates in a given rearing unit deviate from hatchery background levels (such rearing units should be tested for pathogens)
- Prevalence of infection is high
- Fish are infected with a pathogen that is resistant to common antibiotics used for treatment (such fish can be released into a lake without inlets or outlets)

Provisional Pathogens

If a provisional pathogen is found within a hatchery, a risk assessment should be used for guidance concerning release of infected fish. (see the GLFHC website at <http://www.glfhc.org/boardcomm/fhealth/fhealth.php>).

REPORTING

Each member agency should provide to the GLFHC chairperson an annual (calendar year) report that describes the status of fish health within its Great Lakes waters and hatcheries. Annual reports will be distributed within the GLFHC and should include summaries of the following

- Classifications of agency hatcheries and wild brood stock populations
- Records of fish, fertilized eggs, and gametes imported into the Great Lakes basin
- Measures adopted for pathogen management

- Detections of emergency, restricted, or provisional pathogens within the member agency's jurisdiction and associated information pertinent to fish-sample collection, testing method(s), dates, locations (including latitude/longitude), and other information potentially useful for suppression/control
- High mortalities in fish hatcheries or in wild populations, including information on the causative pathogen(s)
- Issues where the member agency requested input from the GLFHC, including its final recommendation

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GLOSSARY

annual inspection	Tests conducted each calendar year on fish in hatcheries and on wild brood stocks under management by a member agency.
biosecurity	Preventive measures intended to reduce the spread of pathogens.
clinical sign	Visually apparent abnormalities in the body, organs, or behavior of a fish that potentially result from infection.
disease	An impairment of the normal functioning of fish that may be manifested by clinical signs.
emergency fish pathogen	A fish pathogen that has not been confirmed present in the Great Lakes basin and is known to cause epizootic events.
enzootic disease	A disease prevailing among or affecting animals in a particular locality.
epizootic	A disease event affecting a large number of animals at the same time within a particular geographic area often resulting in abnormally high mortality.
etiology	Study of the cause of disease.
fertilized eggs	Pertains here to fish eggs from the time of fertilization to hatch.
fish	Refers to species in Appendix A and encompassing their life stages from hatched egg to senescent adult.
gametes	Sperm and unfertilized eggs.
Great Lakes basin	Geographical area encompassing Lakes Ontario (including the St. Lawrence River from Lake Ontario to the 45th parallel of latitude), Erie, Huron, St. Clair, Michigan, and Superior, including their drainages.
hatchery	Facility holding and rearing fish.

importation	Transportation of fish or gametes from a source outside of the Great Lakes basin into the basin for purposes of propagation.
infection	Invasion by and multiplication of pathogenic microorganisms in a bodily organ or tissue.
intensity	The density of pathogens in a particular organism, also called load.
isolation facility	A structure that maintains a group of fish without any contact with other fish or water sources in order to allow observation for a specified length of time and, if appropriate, testing and treatment. The effluent waters are not treated.
lot	Fish of the same species and age that have always shared the same water supply and originated from a discrete spawning population.
member agency	Federal, provincial, tribal, or state government fishery management or conservation agency signatory to <i>A Joint Strategic Plan for Management of Great Lakes Fisheries</i> .
non-secure water supply	Untreated water source that may contain fish or fish pathogens.
pathogen	Any disease-producing agent, especially a virus, bacterium, or other microorganism.
prevalence	The proportion of infected individuals within a population at a given time.
provisional fish pathogen	A fish pathogen with uncertain geographic distribution whose life-history strategy is poorly understood, and whose ability to cause disease and epizootic events within the Great Lakes basin is unknown or uncertain.
quarantine facility	An isolation facility with treated effluent water.
rearing unit	Distinct raceway, pond, or tank used to culture fish at a hatchery.

restricted fish pathogen	A fish pathogen that exists in one or more locations in the Great Lakes basin; is known to cause epizootic events; and undergoes management to restrict its spread, prevalence, and impacts.
secure water supply	A water supply free of fish and fish pathogens (including those disinfected or treated to remove pathogens), such as a well or open or enclosed springs.
source	Any point or place of origin of fish or gametes, such as a fish hatchery or a free-ranging population.
transfer	The transportation of fish or gametes from one source to another source both within the Great Lakes Basin.
vertical transmission	Passage of pathogens from parents to progeny via their gametes.
wild brood stock population	Free-ranging fish population whose adults are captured for gamete collection, often in successive years, and then released unharmed.

APPENDIX A: COMMON FISH SPECIES OF THE MODEL PROGRAM

Commonly cultured fishes covered by the model program (the model program pertains to all fish species).

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 tshawytscha</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>

Common Name	Species Name
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 marmoratus</i>
walleye	<i>Sander vitreus</i>
white bass	<i>Morone chrysops</i>
yellow perch	<i>Perca flavescens</i>

APPENDIX B: SAMPLING GUIDELINES FOR PATHOGENS

Sampling guidelines for pathogens listed in the model program, the disease they cause, their classification in the model program, and fish species recommended for screening should be consulted for current guidance: *Suggested Procedures for the Detection and Identification of Certain Fish and Shellfish Pathogens* (Blue Book) developed by the Fish Health Section of the American Fisheries Society; the *Manual of Diagnostic Tests for Aquatic Animals* of the OIE; and *Fish Health Protection Regulations Manual of Compliance* (Miscellaneous Special Publication 31, Revised) of Fisheries and Oceans Canada.

Organism	Common Name of Disease	Pathogen Classification	Species to be Screened	Temperature for Screening	Miscellaneous Considerations
Bacterial pathogens					
<i>Aeromonas salmonicida</i>	furunculosis	restricted	any freshwater fish		
<i>Piscirickettsia-like organism</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	>10°C	rainbow trout typically affected at ~7.5 cm (3")

Organism	Common Name of Disease	Pathogen Classification	Species to be Screened	Temperature for Screening	Miscellaneous Considerations
Parasitic pathogens					
<i>Bothriocephalus acheilognathi</i>	Asian tapeworm	provisional	cyprinids		
<i>Ceratomyxa shasta</i>	ceratomyxosis	emergency	salmonids	4-10°C	spores are most likely found in the posterior intestine, but also occur in the kidney, liver, gall bladder, and pyloric caeca
<i>Heterosporis</i> sp.		restricted	percids, esocids, centrarchids	ambient	examine fish at least five weeks after the potential exposure
<i>Myxobolus cerebralis</i>	whirling disease	restricted	salmonids		rainbow trout are most sensitive
<i>Nucleospora salmons</i>	salmonid intranuclear microsporidiosis	provisional	salmonids	NA	
<i>Tetracapsula bryosalmonae</i>	proliferative kidney disease (PKD)	emergency	salmonids	any	disease develops after water reaches 12°C and detectible in fish 30 days after exposure

Organism	Common Name of Disease	Pathogen Classification	Species to be Screened	Temperature for Screening	Miscellaneous Considerations
Viral pathogens					
Epizootic epitheliotropic disease virus	EED	provisional	salmonids	6-12°C	test fry to yearling life stages
Infectious hematopoietic necrosis virus	IHN	emergency	any freshwater fish	8-15°C	all age classes susceptible, fry most susceptible
Infectious pancreatic necrosis virus	IPN	restricted	any freshwater fish		
Infectious salmon anemia virus	ISA	emergency	salmonids/ Atlantic herring		
koi herpesvirus	KHV	restricted	Cyprinidae	16-28°C	horizontal transmission typical; vertical transmission possible; young life stages most susceptible
largemouth bass virus	LMBV	restricted	centrarchids /ecocids		
lymphosarcoma		provisional	esocids	unknown	no approved detection method

Organism	Common Name of Disease	Pathogen Classification	Species to be Screened	Temperature for Screening	Miscellaneous Considerations
spring viremia of carp virus	SVCV	restricted	any freshwater fish	10-18°C	horizontal transmission typical but vertical possible; juvenile fish (1 yr or less) most susceptible
viral hemorrhagic septicemia (IVb strain)	VHSv	restricted	any freshwater fish		
viral hemorrhagic septicemia (remaining strains)	VHSv	emergency	any freshwater fish		
white sturgeon herpesvirus	VHSv -1, VHSv -2	emergency	Acipenseridae		
white sturgeon iridovirus	VHSv	emergency	Acipenseridae		

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APPENDIX C: EGG DISINFECTION PROTOCOLS

Background

The recent emergence of VHSV as a fish health concern in the Great Lakes basin has served as a reminder of the need to reduce the risk of transferring pathogens into and between watersheds and hatcheries. The emergence of VHSV has also highlighted the need for a basinwide egg-disinfection methodology that could be supported by the GLFHC. Therefore, the GLFHC developed and is recommending a cool-water-egg disinfection protocol.

These recommendations were developed without complete information on the direct effectiveness of killing VHSV strain IVb associated with cool-water fish eggs and were based on

- The survivorship of cool-water eggs exposed to iodophor solution
- Expert opinion from national authorities on VHSV
- The USFWS Genoa National Fish Hatchery disinfection protocols for cool-water fish eggs
- The USFWS iodophor disinfection protocol for fish eggs
- Detailed literature reviews documenting that for VHSV strain IVa and infectious hematopoietic necrosis virus (a similar virus) the effective concentration of iodophor is 0.08 ppm (Amend et al. 1972; Elliott and Amend 1978; Batts et al. 1991; Yoshimizu et al. 2005)

Thus, the recommendations for Great Lakes cool-water-egg disinfection were based on the best available information and should be considered a minimum disinfection methodology. As new information becomes available, these recommendations will be updated.

Recommended Methodology

The following cool-water-egg disinfection methodology is recommended by the GLFHC for use by all member agencies in the Great Lakes basin

1. The disinfection of fertilized cool-water fish eggs should be conducted during water hardening whenever possible, and, when not possible, surface disinfection should be used after water hardening
2. One of the following procedures should be used for cool-water egg disinfection
 - a. During egg water hardening, a 50 ppm concentration of iodophor solution should be used for 30 minutes to kill pathogens and prevent them from entering the egg; water from a protected source should be used for water hardening, egg rinsing, and egg transport
 - b. If disinfection during water hardening is not possible or if water from a protected source is not used during water hardening, egg rinsing and/or egg transport, a 100 ppm concentration of iodophor solution should be used for 10-15 minutes to kill pathogens adhering to the surface of eggs prior to their being moved into an agency hatchery building
 - c. If eyed eggs are transferred between fish production facilities, a 100 ppm concentration of iodophor solution should be used for 10-15 minutes to kill pathogens adhering to the surface of eggs prior to their being moved into an agency hatchery building
3. When eggs are disinfected, the pH should be buffered to ensure it does not change by more than 0.3 units and remains between 7.0 and 7.5

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APPENDIX D: FORMS

Form MP-1. Pathogen Nomination Form

Downloadable pdf copies of this form can be found on the GLFHC's website <http://www.glfhc.org/boardcomm/fhealth/fhealth.php>.

Date of Nomination:
Requesting Agency:
Pathogen name/disease name (include synonyms):
Suggested classification (Emergency, Restricted, Provisional):
Known geographic range:
Known host species:
Known intermediate/alternate host species (parasites only):
Concern to the Great Lakes or requesting agency, including estimated pathogenicity:
Clinical disease signs:
Methods for pathogen detection and disease diagnosis, including optimal sample testing guidance:
Relevant literature:
Other:

The following should be filled in by the chairperson of the Great Lakes Fish Health Committee.

Decision Date:
Decision Details:
Final Decision:

Form MP-2. Inspection Report

Downloadable pdf copies of this form can be found on the GLFHC's website <http://www.glfhc.org/boardcomm/fhealth/fhealth.php>.

Form MP-2. Inspection Report.

ISH 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:	This Inspection Date(s): This: _____ Prior: _____ Classification: _____	Type of Water Supply: Well/Spring Origin of Fish Examined: Hatchery Type of Fish Examined: Salmonid
Owner/Manager/Contact:		
Remarks/Recommendations:	Address/Phone of Contracted Fish Health Official	Signature of Contracted Fish Health Official

Species	Designation	Lab Report #	Age	Number in Lot	Obtained as Eggs (E) or Fish (F) From:	Pathogens Inspected for and Results								
						A ₁	A ₂	A ₃	VHSV	IBNV	IPNV	MC		

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