Viral Hemorrhagic Septicemia (VHS) Briefing Paper
February 6, 2009

General VHS Information

- *What is VHS?* VHS is viral hemorrhagic septicemia, a viral fish disease that has caused large fish kills in rainbow trout (*Oncorhynchus mykiss* (Walbaum)) and turbot (*Psetta maximus* (L.)) aquaculture operations in Europe (Schlotfeldt, Ahne, Jørgensen and Glende 1991),and in wild Pacific herring (*Clupea pallasii* (Valenciennes)) and pilchard (*Sardinops sagax* (Jenyns)) populations along the Pacific Coast of North America (Skall et al. 2005, and Personal Communication, Dr. James Winton, USGS-Western Fisheries Center, Seattle, Washington). This virus has recently been found in the Great Lakes Basin and has caused fish kills since 2005.

  The disease is caused by a rhabdovirus, Viral Hemorrhagic Septicemia virus (VHSv) and is in *Novirhabdovirus* genus (Walker et al. 2000). Rhadoviruses are a group of viruses that include 8 other fish disease causing agents including the highly virulent Infectious Hematopoietic Necrosis (IHN) that is found in the Pacific Coast salmon populations and Spring Viremia of Carp virus (SVC) found worldwide in carp (*Cyprinus carpio*) populations.

  VHSv has a number of identified isolates (unique genetic types) grouped in four types; three from Europe and one from North America. The European and North American genetic lines likely separated from each other about 500 years ago (Einer-Jensen et al. 2004). Each appears to have unique effects with specific pathogenicity (virulence) on certain species. The isolate recently found in the Great Lakes Basin is nearly identical genetically to the VHS strain previously isolated from the Maritime Region of Canada and has been labeled Type (isolate) IVb (Elsayed et al. 2006 and Gagne et al. 2006).

- *Can VHSv cause illness in humans?* VHSv is **not** a human pathogen as it can not replicate in warm-blooded animals and rapidly dies at human body temperatures (Unpublished data, Dr. James Winton, USGS-Western Fisheries Center, Seattle, Washington). There are no concerns with respect to human health with this pathogen and it can not infect humans if they eat fish with the pathogen.

- *Is VHS a reportable or emergency disease?* VHS is a reportable animal disease that requires notification of Departments of Agriculture, United States Department of Agriculture – Animal and Plant Health Inspection Service (USDA-APHIS), Canadian Food Inspection Agency (CFIA), and the OIE (International Organization for Animal Health). The USDA-APHIS has issued emergency orders that restrict live fish movement over state and national boundaries. The most recent order can be found on their website (http://www.aphis.usda.gov/animal_health/animal_dis_spec/aquaculture/) and the issuance of an interim rule concerning fish movements and VHS is expected in the near future.

The current disease status of VHSv Isolate IVb by the Great Lakes Fishery Commission – Great Lakes Fish Health Committee's (GLFHC) Great Lakes Model Fish Health Program is as an emergency disease which is in the process of being changed to a restricted disease, as it is now endemic to the Great Lakes. Emergency diseases under this program are required to be eradicated from an infected facility and adjacent waters. Restricted diseases require control measures be put into place, which may include infected lot destruction, and infected lots are not to be stocked in Great Lakes waters.

- *Can VHS kill fish?* Yes. VHSv Types I, II, III and IVa are known to cause mortalities in short periods of time, particularly in rainbow trout and turbot (Types I-III) and in marine herring species (Type IVa). Mortalities in rainbow trout and turbot were found in European aquaculture facilities that fed fish feeds made with fish meal from North Sea fish that were positive for VHSv. The losses in rainbow trout farms in Denmark approached $60 million dollars (US) annually in the early 1990s and forced the depopulation and disinfection of these facilities (Hill 1991). Endemic rainbow and brown trout populations in Danish streams that received effluent from these formerly infected fish farms were also positive for VHSv (Jorgensen 1981 and Enzmann and Conrad 1985).

  VHSv Isolate IVa has been documented to kill large numbers of Pacific herring in the Puget Sound (Personal Communication, Dr. James Winton, USGS-Western Fisheries Center); and Pacific hake (*Merluccius productus* (Ayres)) and walleye Pollack (*Theragra chalcogramma* (Pallas)) along with Pacific herring in Alaska (Meyers, Short and Lipson 1999). VHSv Isolate IVb was isolated from mummichogs (*Fundulus heteroclitus*) and sticklebacks (*Gasterosteus aculeatus aculeatus*) after a large fish kill in the Maritime Region of Canada (Gagne et al. 2006). These are the only known widespread wild mortality events outside of the Great Lakes. VHS has been speculated as the cause for the recent decline of Pacific herring in Puget Sound (Personal Communication, Dr. James Winton, USGS-Western Fisheries Center).

- *What temperatures does the virus replicate at?* Typically, VHSv replicates in fish at temperatures from 2-3 C to 15 C with the most activity between 6 to 9 C (Wolf 1988, McAllister 1990, Meyer and Winton 1995, and Personal Communication, Dr. James Winton, Western Science Center, Seattle, Washington). Thus, the virus is more active in colder water (< 15 C) which is why mortalities are often seen in the spring. The isolate of VHSv found in the Great Lakes has been found to cause at least one fish kill at 20-22 C in New York (Personal Communication, Andrew Noyes, New York Department of Environmental Conservation) and has been found to experimentally replicate at temperatures up to 25 C (Personal Communication, Dr. Mohamed Faisal, Michigan State University).

- *How long does the virus take to kill fish?* The time to death is not exactly known for Type IVb and depends on a number of factors including species, water temperature, and overall fish health, in particular stress. Mortalities can occur in days after exposure in optimal conditions to a few weeks. Susceptibility to the virus varies widely among species with muskellunge being the most sensitive in laboratory challenges (death seen in 3-4 days with either injections or water exposure to VHSv) to lake trout being among the least sensitive (Personal Communication, Dr. Mohamed Faisal, Michigan State University). It is important to note that not all fish that are exposed to the virus die and many are capable of fighting off the disease.

- *What does it do to fish?* Clinically infected fish often exhibit hemorrhaging in the skin including large red patches, particularly on the sides and anterior portion of the head. However, infected fish will sometimes exhibit very minor external hemorrhaging (pin-point spots called petichia) or no external signs at all. Internally, all organs are often congested with multiple hemorrhages in the liver, spleen, and intestines. The swim bladders are also often extremely congested with hemorrhages, giving the otherwise transparent membrane a mottled appearance. The ultimate cause of death is usually internal organ failure, often the kidney, or the inability to osmoregulate which is the control and balance of chemical elements in the body versus the water. Sick fish will often appear listless, swim in circles, or hang just below the surface based on staff observations made this past spring. Photos of clinically infected fish can be seen on the DNR – Fisheries Division website (http://www.michigan.gov/documents/dnr/vhs-photos_190459_7.pdf).

- *How is VHSv transmitted between fish?* VHSv can be transmitted by exposure to urine, feces and sexual fluids (ovarian fluids or milt) or by ingesting infected prey fish (Meyers and Winton 1995 and Skall et al. 2005). Reservoirs include clinically ill and carrier fish that do not show signs of the infection. The virus can be found on the surface of the salmonid eggs during spawning of infected female broodstock (sometimes at very high levels) and is capable of persisting for a sufficient time period to result in vertical (actually egg-associated) transmission between generations (adult to progeny). The virus has not been found inside salmon eggs to date which means surface disinfection is effective in controlling this pathogen in fish culture operations. It is also likely to enter the body through the gills or through wounds, although oral transmission is unlikely except by the ingestion of infected prey or food. Recent experiments have showed that blood sucking leeches and other amphipods could potentially transmit the pathogen to fish (Personal Communication, Dr. Mohamed Faisal, Michigan State University).

- *Can VHSv live outside a fish?* Yes. VHSv survival in water depends on the temperature of the water and water other materials are found in it but survival for weeks in cool to cold water temperatures is typical.

At moderate temperatures (15 C) in raw freshwater, the virus can last a few weeks. Hawley and Garver (2008) found that VHSv 99.9% inactivation time in raw freshwater at 15 C was 13 days, but in seawater the virus was inactivated within 4 days. In other studies using seawater at 15 C, the infectivity of the virus was reduced by 50% after 10 hours but could still be recovered after 40 hours (Kocan et al. 2001).

The virus can last a long time in coldwater (1 year at 4 C in filtered freshwater) or if other organic materials are added to water such as ovarian fluids or blood products such as bovine serum (2 weeks to over a month). If ovarian fluid were added at 0.01% or at 1.0%, the virus could still be recovered after 72 hours and 96 hours respectively (Kocan et al. 2001). If other organic materials are added such as bovine serum, 100% of the virus could be recovered after 15 days and 60% of the virus remained after 36 days (Kocan et al. 2001). The virus has been documented to persist in freshwater for 28-35 days at 4 C (Parry and Dixon 1997) and has been found to be infective for 1 year at 4 C in filtered freshwater (Hawley and Garver 2008).

Freezing VHSv infected fish at commercial freezing temperatures then thawing the fish will not completely kill the virus but will reduce infectivity or virus titers by 90% or more (Meyers et al. 1999 and Artkush et al. 2006). Artkush et al. (2006) noted that the remaining live virus remained in the fish tissue and was not lost in the thawed water from the frozen fish.

- *How can VHSv be transmitted between water bodies?* There are a number of likely vectors (or vehicles) to move the virus between waters. The likely effectiveness of these vectors depends on their ability to acquire the virus, move it live to the next water, and making it available to new susceptible fish species in the face of large dilution factors. The most likely vectors to VHSv from one water to another in estimated order of effectiveness are: 1) moving infected fish (baitfish or gamefish) from one water to another; 2) planting infected fish or releasing infected fish or water from an infected fish hatcheries (to date no fish hatcheries have been found to be infected); 3) the natural movement of infected fish from one water to another; 4) moving infected water, fish or fish parts from one water to another in the ballast water of shipping vessels; and 5) moving infected water, fish or fish parts from one water to another in live wells of fishing boats or in bilges of recreational and fishing boats. One factor that is not a likely long distance vector are fish eating birds and mammals since the virus does not live long in the gut of either because of their high internal body temperature. It is also unlikely that the virus will move easily between waters by being associated with water on birds when they take off from infected waters and travel to other waters.

- *What are some of the likely factors that may be responsible for some species being likely infected?* Given the current information on VHS in the Great Lakes, it appears that fish that are in high abundances that congregate or concentrate in specific locations (for spawning, foraging or even in commercial fishing nets), or those species that prey on infected fish are likely species to be infected by the virus. Whether VHSv causes disease in a particular species depends on: 1) the evolutionary history of the species and whether the species has been exposed to a similar virus in its past; 2) the physical condition and stress level of the fish and whether the immune system has been compromised; and 3) the overall immune response of the species to the pathogen.

- *Can fish or fish eggs be treated to reduce VHS transmission?* In the Western United States, salmon eggs are routinely surface disinfected with iodophor (an iodine compound) at or after water hardening to eliminate vertical (parent to egg) VHSv transmission and this chemical has been demonstrated to be effective (Amend and Pietsch 1972, Finley 1978 and Wolf 1988). The reason this topical disinfection is effective is that the virus does not penetrate the egg and stays on the outside. The DNR has for a number of years been routinely using standard iodophor disinfection methods at all of our salmon and steelhead egg take stations. In the fall of 2006, VHSv was detected in Chinook salmon broodstocks at the Swan River weir (Lake Huron near Rogers City, MI). Standard egg disinfection protocols were followed by DNR staff and subsequent repeated testing could not find any evidence of the pathogen.

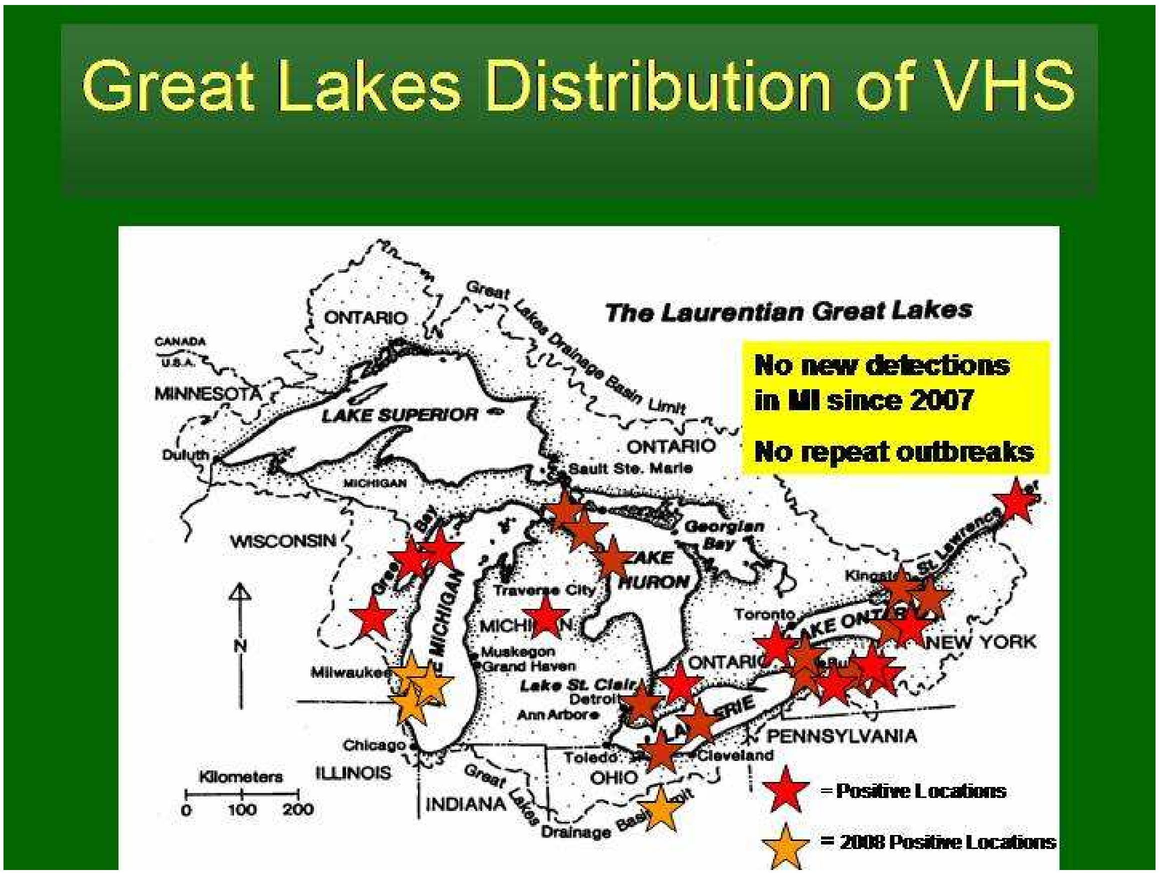
  Less is known about the effectiveness of disinfection methods for coolwater fish (i.e. walleye, northern pike, lake sturgeon, and muskellunge) egg disinfection. It is not known if the virus is able to penetrate the egg but this is considered unlikely at this time (Personal Communication, Dr. James Winton, USGS-Western Fisheries Center, Seattle, Washington). De-clumping agents must be used for coolwater eggs to ensure survival and the effects of these agents on the amount of free iodine in solution appears to be minimal at this time. In 2008, the Great Lakes Fishery Commission - Great Lakes Fish Health Committee (GLFHC) came to consensus on a recommended iodophor treatment protocol that is known to not kill coolwater eggs and based on all of the evidence to date, should be effective in killing VHSv. Experiments are pending on whether the virus is definitively killed by the GLFHC recommended protocol. The DNR has been using this protocol for three years and will continue to do so for coolwater eggs to reduce the transmission risk.

  There are no treatments at this time to stop horizontal (fish to fish) transmission or to treat infected fish. Vaccines for hatchery fish are a possible biosecurity measure to reduce the potential number of candidate fish in populations. Vaccines are currently in development for the European isolates of VHSv.

VHS – Great Lakes Information

- *Where has VHS been found within the Great Lakes basin?* As of this date, the VHSv has been confirmed from the Lake Michigan (Green Bay, Little Sturgeon Bay, Algoma and Milwaukee in WI waters and at Waukegan, IL), Lake Huron (Cheboygan, Rogers City and Alpena), St. Clair River, Lake St. Clair, Lake Erie (all three basins), Niagara River, Lake Ontario (Bay of Quinte - Ontario, Hamilton Harbor - Ontario, Cape Vincent - NY, and Rochester, NY area) and the St. Lawrence River. The pathogen is not widespread in its distribution at this time and appears to be concentrated in specific areas of the Great Lakes Basin.

The virus has also been documented from a few inland waters in NY (Conesus Lake, Skaneateles Lake, Cranberry Pond, Little Salmon River in Mexico, Oswego County, the Seneca - Cayuga Canal, and an isolated farm pond in Ransomville, Niagara County), WI (Lake Winnebago), MI (Budd Lake near Harrison, MI), and OH (Clear Fork Reservoir in the Ohio River drainage).



- *Has VHS Isolate IVb caused mortalities in the Great Lakes?* Yes. In the eastern part of the Great Lakes Basin, a large scale mortality of freshwater drum (approximately 100 tons) occurred in 2005 in the Bay of Quinte, Lake Ontario in Ontario (Lumsden et al 2007). In the spring of 2006, large fish mortalities were observed in Lake St. Clair (Great Lakes muskellunge, gizzard shad and yellow perch), St. Clair River (gizzard shad), Detroit River (Great Lakes muskellunge and gizzard shad), Lake Erie (west basin -freshwater drum and white bass, and central basin-yellow perch), Lake Ontario (round goby) and St. Lawrence River (Great Lakes muskellunge). The mortalities in the spring of 2006 are considered to be one large-scale fish kill event.

Fish kills in Lake Huron - Thunder Bay (lake whitefish and walleye) and Conesus Lake NY (walleye) that occurred in the fall of 2006 were likely related to VHSv. Additional large fish kills were seen in the spring of 2007 in Lake Winnebago WI (freshwater drum), Budd Lake MI (black crappie, bluegills and largemouth bass), Lake Ontario – Hamilton Harbor (common carp), and eastern Lake Erie NY (gizzard shad).

In 2008, fish kills (round goby) were documented in western Lake Michigan in the Milwaukee, WI – Waukegan, IL area.

Repeated fish kills in locations with previous fish kills have not been seen to date in the Great Lakes region.

- *When and how did VHS get here?* The earliest confirmed report is from 2003 in a Great Lakes muskellunge from Lake St. Clair so it is likely to have been introduced here in 2002 or 2003 (Elsayed et al. 2006). The virus was also confirmed from spring 2005 freshwater drum samples from Lake Ontario - Bay of Quinte (Lumsden et al. 2007) and from a lake whitefish from Lake Huron (Cheboygan) from a late fall 2005 sample. At the time of the two Michigan collections, the samples were initially classified have an unknown rhabdovirus which had been subsequently confirmed as VHSv Type IVb, in 2006 for the Lake St. Clair and 2007 for the Lake Huron sample. All of the VHSv Type IVb samples examined to date from the Great Lakes have been very similar in genetic structure to each other and to the VHSv found in the Maritime Region of Canada with only a few base pair difference (Personal Communication, Dr. James Winton, USGS-Western Science Center, Seattle, WA). The lack of significant genetic diverge is an indication that the virus recently arrived in the Great Lakes and is likely from one introduction event.

  It is not known how this virus arrived in the Great Lakes nor is it known precisely how long the virus has been here. Ballast water discharge is considered as the most likely vector given its distribution in the Great Lakes region and the likely origin of the virus, the Maritime Provinces of Canada. None of the other potential vectors (movement of live baitfish, movement of live fish from aquaculture, bilge or live well water) are likely given the potential source location of the virus.

- *Will VHS spread to the other Great Lakes and when?* As noted in the above map, the virus distribution in lakes Michigan and Huron is very spotty at this time indicating that the infections are recent and only slowly moving in each lake. Lakes St. Clair and Erie have the virus broadly distributed throughout them. Lake Superior continues to be negative for VHSv at this time.

  While the exact timing is impossible to determine, it is highly likely that the virus will be found throughout lakes Huron and Michigan in the next 4-6 years. This is based on the large scale fish movements, particularly Chinook salmon, between lakes Michigan and Huron, long distance movement within each lake by Chinook and coho salmon along with walleyes and other prey species, and the rate of spreading of the virus in its current distribution. If fish continues to be the key movement vector, the virus will likely take a very long time to get established in Lake Superior as fish movement through the Soo Locks is limited.

This situation could rapidly change if ballast water exchange becomes the key vector. Duluth Harbor in Western Lake Superior has the second highest ballast exchange rate in the Great Lakes and the Chicago area also has a very high ballast exchange rate. The virus could quickly be spread by this vector if all of the necessary factors to move the virus by this method come together. This would include: picking up sufficient live virus, infected fish or infected fish parts during a disease outbreak; keeping the virus alive to it is discharged; and finally discharging sufficient virus in the face of dilution to infect susceptible species. For all of the factors to line up properly is likely a low probability event but if successful would spread the virus. If anglers and boaters also decide not to comply with the regulations in place in the region and move infected fish or water, the situation and distribution of the virus could also rapidly change. Anglers moving infected bait and/or recreational boaters discharging infected water or fish are the likely mechanism in which VHSv moved into inland waters in the Great Lakes region. It is critical that anglers and recreational boaters not move water or fish (either baitfish or gamefish) from water to water.

- *Which species are affected or infected by VHSv Type IVb in the Great Lakes?* VHSv has been confirmed in 19 coolwater and 5 coldwater species to date.

  VHSv has been implicated as the mortality factor in larger fish kills in: freshwater drum (lakes Ontario and Erie, and Lake Winnebago WI); Great Lakes muskies (lakes St. Clair and Ontario); round gobies (lakes Ontario and Michigan); gizzard shad (Lake St. Clair, St. Clair River and Lake Erie); black crappie (Budd Lake MI); bluegills (Budd Lake MI); white bass (Lake Erie); common carp (Lake Ontario); and yellow perch (lakes Erie and St. Clair).

  VHSv has also been confirmed in smaller mortality events in: lake whitefish (lakes Huron and Michigan); walleye (Lake Huron and Conesus Lake NY); smallmouth bass (Lake St. Clair and Skaneateles Lake NY); rock bass (Skaneateles Lake NY), black crappie (Lake St. Clair), and bluegill (Lake St. Clair).

  A number of other species have been identified as carrying VHSv including: Chinook salmon (Lake Huron); rock bass (Lake St. Clair); silver redhorse (Lake St. Clair); northern pike (Lake St. Clair); rainbow trout – steelhead (Little Salmon River NY); shorthead redhorse (Lake St. Clair); burbot (Lake Ontario); white suckers (Probable unconfirmed report, Lake St. Clair); spottail shiners (Lake St. Clair); channel catfish (NY); lake trout (Skaneateles Lake NY) and emerald shiners (Lake St. Clair, Lake Erie and the Niagara River). Mortalities have not been observed for any of these species in these locations.

- *What are the likely risks to Great Lakes fish populations?* Little is known about this particular isolate of the VHSv virus. The VHSv-European Types 1-3 isolates have caused large-scale mortalities in salmonid and turbot aquaculture facilities in Europe. Large mortalities from VHSv Type IVa have been documented in marine herring populations in and around Puget Sound, WA. Until the recent mortalities in the Great Lakes, the Type IVb isolate was not known to cause large disease scale outbreaks on the East Coast of North America except for a large fish kill that affected mummichogs and sticklebacks from New Brunswick.

  It is known that Great Lakes fish species exhibit a range of sensitivities to VHSv. Muskellunge are very susceptible, dying in a shorter time period and at higher rates in experimental challenge experiments than other species (Dr. Mohamed Faisal, Michigan State University, personal communication). Species such as largemouth bass (*Micropterus salmoides*) are intermediate in their sensitivity and lake trout (*Salvelinus namaycush*) seem less sensitive to the virus (Personal communication, Dr. Mohamed Faisal, Michigan State University).

  It is very unclear what the long-term risk is to our Great Lakes and inland fish stocks from this pathogen as susceptibility and virulence studies are still in progress on this isolate. It can clearly cause large scale mortalities in susceptible fish populations. The potential long-term outcomes range from being a short-term 1-time mortality event to a pathogen that causes annual mortalities that will need to be factored into fisheries management plans. It also appears that there are a wide range of potential carriers for the pathogen which will need to be factored into epidemiological analysis for this virus. There is no doubt that this pathogen will always be an opportunistic disease agent in the Great Lakes region that will cause fish kills in the right conditions when fish populations are stressed.

  Repeated fish mortalities have not yet been documented in locations that had seen earlier VHS related fish kills. It is not known at this time how smaller inland lakes will respond to VHSv. We also do not know whether the virus will skip years and the role of environmental variables such as climate in causing the disease to be expressed is unknown. Information is unavailable at this time concerning the ability of disease survivors to maintain an immune response, and whether this response reduces with time, potentially making these fish susceptible to re-infection.

- *What will be the pathogen management strategy in the Great Lakes?* Since this pathogen can clearly cause large scale mortalities of valuable adult fish and it has a wide range of potential carriers, it is critical to make every attempt to contain the pathogen and not allow a rapid spread of the disease to all Great Lakes and inland waters. It should be noted that once a pathogen gets into a wild fish community, it is impossible to effectively eliminate it and control is highly unlikely.

The Great Lakes Fish Health Committee which operates under the Great Lakes Fishery Commission has developed and implemented through the Great Lakes Fishery Commission – Council of Lake Committees a wide range of management recommendations that focus on key areas of managing this pathogen. The key recommendations and their current status are as follows:

1) Improved disease detection and egg disinfection testing, in particular for coolwater fish such as walleye and muskies - Research studies to answer this need are currently in progress.
2) Greatly enhanced surveillance which determines where the pathogen is present and how it works - All of the Great Lakes states and the Province of Ontario have put into put surveillance programs and epidemiological research is ongoing at this time.
3) Rigorous biosecurity measures in fish culture facilities to ensure hatcheries are not a disease vector - All of the Great Lakes fisheries agencies have put into place enhanced biosecurity measures to reduce the risk in this area.
4) Either terminating fish transfers between waters or requiring the mandatory testing prior to the transfer of wild fish between waters to ensure the disease is not transported by this fisheries management tool - All of the Great Lakes fisheries agencies have put this recommendation into effect.
5) Improving the practices of the bait industry and restricting risky uses of baitfish to reduce this as a potential vector - New baitfish regulations and testing requirements have been put into place by Great Lakes fisheries agencies in locations where the VHSv has been found.
6) Improving the practices of recreational boaters and reducing the possibility of live well and bilge water as a vector - New recreational boating regulations that require the emptying of live wells and bilges upon leaving a boat launch have been put into place by Great Lakes fisheries agencies in locations where the VHSv has been found.
7) Ensuring the commercial fishing industry does not transfer infected wild fish into uninfected waters - The State of Michigan has put regulations into effect that prevent this practice without disease testing and certification.
8) Increasing the amount of information available to the public on the pathogen and how to prevent its spread - All of the Great Lakes fisheries agencies and partner agencies are developing and providing educational materials for the public that include websites, written materials and public service announcements.
9) Encouraging the funding of additional research on transmission and susceptibility of VHSv Isolate IVb - The Great Lakes fisheries agencies have been successful in obtaining over $1 million dollars in research grants to address the effectiveness of biosecurity measures, to determine the susceptibility of Great Lakes fish species to VHSv, and to develop new rapid testing methods.

- *What additional information is needed on VHS Type IVb?* Much is not yet known about this pathogen but a large amount of research is currently in progress to address these information gaps. Some of the key gaps are:

  1) How long this virus can survive in the environment outside of a fish host? This has implications on ballast water as a vector and on methods to disinfect boats and other equipment. Research is ongoing to help address this question.
  2) Can you detect VHSv in the water prior to fish kills? This has implications to the management of ballast water and to fisheries managers in managing around the disease. Research is ongoing to address this question at this time.
  3) What is the effectiveness of standard egg disinfection techniques and will they work on coolwater fish eggs (walleye and muskies are examples)? Coolwater egg fertilization process requires the use of de-clumping agents that may interfere with the disinfection agents. Research is being focused on this question and is in progress at this time.
  4) Which species are susceptible to the virus? This question has implications on how to manage around the pathogen. Ongoing research should address this question this year.
  5) How can we more effectively detect the virus? There is a large need for rapid detection tools and for new tools to track the disease course within a fish population. Currently, it takes 28 days to certify fish are VHSv free which greatly handicaps management efforts. This information is vital to managing wild egg take operations and hatchery operations. Current research efforts are expected to yield new tools in this area during this calendar year.

  This and other basic pathogen information will take time to develop and will greatly inform management decisions. Until the research information is available, precautionary principles will be employed to attempt contain this pathogen to its current distribution. Additionally, the Great Lakes fisheries agencies are taking every opportunity to collect information on the current distribution of the pathogen.

  VHSv is found in West Coast systems. Management strategies used in those systems are being examined to determine which fish management and culture strategies should be employed in the Great Lakes region to prevent the spread of this pathogen.

- *What can anglers and boaters do to help stop the spread of this pathogen?* All of the recommended ways to prevent the movement of aquatic nuisance species (i.e. zebra mussels) will help prevent the spread of this pathogen. The use of a bleach solution (1/2 cup to 5 gallons) to disinfect and clean boats, bilges and gear is very effective in killing VHSv as is completely drying items in the sunlight for 4-6 hours. Another disinfection option that is coming available soon is Virkon Aquatic in pre-measured packets. This disinfection product is commonly used in large-scale fish culture operations, such as the MI DNR Fish Production system, and is known to be very effective in killing VHSv. Cleaning of larger equipment with bleach or other household disinfectants and power-washing boat hulls then drying the boats and gear in the sun for 4-6 hours is very effective at reducing and eliminating this pathogen. It is also critical not to and is currently illegal to move live fish between waterbodies, in particular baitfish, along with any water so be sure to empty live wells and bilges upon leaving any waterbody. These measures will help control the spread of this pathogen along with many other aquatic nuisance species.

- *What would happen if the disease got into one of our hatcheries?* If this disease gets into a fish production facility or hatchery in Michigan, the facility will have to at least destroy any infected lots and may have destroy all fish, depending on the infected lot's location in the hatchery, under new revisions to the GLFHC's Great Lakes Model Fish Health Program.

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