



Viral Hemorrhagic Septicemia in the Great Lakes

State of the Ecosystem

Background

Viral hemorrhagic septicemia virus (VHSV) is a fish pathogen reportable to the World Organization for Animal Health (OIE). First reported in as a disease of European rainbow trout (*Oncorhynchus mykiss*) in 1938, it was not until 1963 that a virus (VHSV) was identified as the pathogen responsible. Since that time, three (3) VHSV genotypes have been isolated from fish in Europe, and in 1988, a fourth genotype was isolated from marine fishes in the Pacific Northwest (Meyers and Winton 1995). One of the European genotypes significantly affects freshwater salmonids and pike, whereas the remaining two affect marine fishes (Jim Winton, personal communication). Gagné et al (2007) reported the isolation of VHSV from brown trout (*Salmo trutta*), mummichog (*Fundulus heteroclitus*), striped bass (*Morone saxatilis*), and three-spined stickleback (*Gasterosteus aculeatus*) from New Brunswick and Nova Scotia, Canada. It is unknown how VHSV was introduced into the Great Lakes basin. Suspected vectors for the introduction and spread within the Great Lakes include ballast water, movement of live fish (including baitfish) into the Great Lakes, and the natural migration of fish.

2005 Reports

During the spring of 2005, significant mortality of freshwater drum (*Aplodinotus grunniens*) occurred in the Bay of Quinte, Lake Ontario. The Ontario Ministry of Natural Resources (OMNR) reported the isolation of viral hemorrhagic septicemia virus (VHSV) from the fish (reference). Although this was the first report of VHSV in the Great Lakes, it was not the first isolation of the virus from the Great Lakes. Biologists at Michigan State University had isolated an unknown virus from a muskellunge (*Esox masquinongy*) caught in Lake St. Claire in the Spring of 2003, but did not pursue identification of the virus until learning of the OMNR isolation. Confirmation of the Lake St. Claire isolation as VHSV was made in December 2005 (Elsayed et al. 2006). These two separate reports of VHSV in the Great Lakes placed the virus into emerging pathogen status in the Great Lakes Basin.

2006 Reports

In 2006, VHSV was determined to be the cause of fish kills in Lake Erie, Lake Ontario, Lake St. Claire, St. Lawrence River, and Conesus Lake (NY). Species affected included burbot (*Lota lota*), freshwater drum, gizzard shad (*Dorosoma cepedianum*), muskellunge, round goby (*Neogobius melanostomus*), smallmouth bass (*Micropterus dolomieu*), walleye (*Stizostedion vitreum*), and yellow perch (*Perca flavescens*). Other Great Lakes fish species that were shown to be carriers (no fish kills reported) of VHSV-IVb in 2006 included black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), bluntnose minnow (*Pimephales notatus*), emerald shiner (*Notropis atherinoides*), northern pike (*E. lucius*), redhorse sucker (*Moxostoma* sp.), rainbow smelt (*Osmerus mordax*), trout-perch (*Percopsis omiscomaycus*), white bass (*M. chrysops*), and white perch (*M. americana*).

In a press release dated January 25, 2007, the Michigan Department of Natural Resources (MI DNR) reported that VHSV had been isolated from Chinook salmon (*O. tshawytscha*), lake whitefish (*Coregonus clupeaformis*), and walleye from the Thunder Bay (Alpena, MI) and Rogers City, MI regions of northern Lake Huron during the fall of 2006. Although mortality was not associated with this report, the fish did show clinical signs of VHSV. Additionally, the MI DNR reported that an archived lake whitefish collected near Cheboygan, MI in the fall of 2005 had been obtained from Chippewa Ottawa Resource Agency (CORA), a tribal organization located in the upper peninsula of Michigan. The lake whitefish had shown clinical disease signs and had tested positive for VHSV-IVb.

2007 Reports

Freshwater drum kills were observed in Little Lake Butte des Morts and Lake Winnebago in the spring of 2007, the first reports of VHSV in Wisconsin waters (WI DNR News Release May 18, 2007). Both lakes are part of the Lake Winnebago system and are in the Great Lakes Basin. Additional detections of VHSV were made in smallmouth bass, lake whitefish, and brown trout fish collected from Wisconsin waters of Green Bay and Lake Michigan near the Door County Peninsula (WI DNR News Release May 24, 2007).

A significant fish kill occurred on Budd Lake in Clare County Michigan in the spring of 2007. Fish species affected included black crappie, bluegill, golden shiner (*Notemigonus crysoleucas*), largemouth bass (*M. salmoides*),

muskellunge, pumpkinseed sunfish (*L. gibbosus*), and yellow perch (MI DNR press release May 17, 2007). Budd Lake is land-locked, with virtually no flow in or out, indicating that the source of VHSv to the lake was probably a live-fish introduction such as baitfish (Gary Whelan, personal communication).

The State of New York was the site of numerous fish kills in 2007 that were associated with VHSv. In May, a significant kill of smallmouth bass and rock bass occurred at Skaneateles Lake in New York's Finger Lakes region (NY DEC press release June 19, 2008). A lake trout collected from Skaneateles Lake also tested positive for VHSv. VHSv was also detected in rainbow trout collected from the Little Salmon River (rainbow trout), sunfish collected from the Seneca-Cayuga Canal, and sunfish and koi carp (*Cyprinus carpio*) collected from a farm pond in Ransomville. The farm pond was infected when the owner transferred fish from nearby 12-mile creek as part of a fish rescue operation and infected their own ponds (NY DEC press release July 23, 2007).

2008 Reports

The Wisconsin DNR reported a round goby kill in Lake Michigan waters just south of Milwaukee in May of 2008 (WI DNR press release June 5, 2008). Yellow perch collected nearby as part of surveillance efforts by the DNR also tested positive (WI DNR press release June 13, 2008). Similarly, rock bass (*Ambloplites rupestris*) and round goby collected from Illinois waters of Lake Michigan near Waukegan tested positive for VHSv, but did not show clinical signs of the disease (IL DNR press release July 2, 2008).

Sea lamprey collected from northern Lake Huron tributary streams tested positive for VHSv. The animals were collected from the Cheboygan River, Green Creek, and Ocqueoc River during routine sea lamprey trapping operations in early June and screened for VHSv by the La Crosse Fish Health Center (LFHC) as part of the National Wild Fish Health Survey. Clinical disease signs were not observed in the lamprey screened. The results indicate that sea may serve as a vector for spread of the virus throughout the Great Lakes basin.

The first detection of VHSv outside of the Great Lakes basin was made from muskellunge collected from Clear Fork Reservoir (OH) in April 2008. Clear Fork Reservoir is located in north central Ohio and drains to the Ohio River. Ovarian fluid samples taken as part of routine fish health screening of spawning fish by the Ohio Division of Wildlife tested positive for VHSv-IVb at the LFHC, the first isolation using ovarian fluids. Clinical disease signs were not observed in the muskellunge.

Pressures

Biological Impacts

Canadian assessment of the St. Lawrence River muskellunge population indicates that the muskellunge kills that have occurred on the St. Lawrence River since 2005 have significantly impacted mature fish. Casselman et al (2008) reported that the all of muskellunge carcasses from the St. Lawrence River were larger, mature fish in the age-classes of peak fecundity. Analysis of creel census data from 2003-2007 indicated a 49% reduction in catch of mature individuals (Casselman et al 2008).

Population-level effects due to VHSv-linked fish kills Great Lakes have not been reported at other sites in the Great Lakes basin. The Bay of Quinte in Ontario was the site of a significant freshwater drum kill in 2005, the first kill from VHSv in the Great Lakes. Assessments of the Bay of Quinte freshwater drum population by the Ontario Ministry of Natural Resources have not shown a decline (Christie et al 2008). Michigan DNR assessment data indicate that VHSv-linked fish kills in 2003 and 2006 did not have a significant impact on the adult muskellunge population in Lake St. Claire (Belore et al 2008). Kayle and Wright (2008) reported that yellow perch population in Lake Erie has not been affected by the VHSv-related kills that occurred in the central basin in 2006.

Regulatory Impact

As a response to the significant scale of the VHSv outbreaks in the Great Lakes during the spring and summer of 2006, the USDA Animal and Plant Health Inspection Service (APHIS) issued a Federal Order on October 24, 2006. The initial order prohibited the interstate movement of VHSv-susceptible species from Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, as well as the importation of the same species from Canadian Provinces of Ontario and Quebec. Upon gathering additional information, APHIS amended the Federal Order on November 14, 2006 to allow for interstate movement from the affected states if the fish have tested negative for VHSv according to the USFWS Standard Procedures for Aquatic Animal Health Inspections, AFS-Fish Health Section Bluebook, or the World Organization for Animal Health (OIE) Manual of Diagnostic Tests for

Aquatic Animals. Interstate movement was also allowed for human consumption if the fish were transferred to a state-inspected slaughter facility. Additional amendments have been made for catch and release fishing and to the list of susceptible species list. APHIS' interim rule for VHSv was published in the Federal Register on September 9, 2008 and will go into effect November 10, 2008. The interim rule places more specific testing requirements and guidelines for transporting of fish species listed by APHIS as being susceptible to the Great Lakes strain of VHSv (VHSv-IVb). APHIS will be taking comments until November 10, 2008 before developing a Final Rule for VHSv.

The states of Illinois, Indiana, Michigan, New York, Ohio, Pennsylvania, and Wisconsin, along with the Canadian provinces of Ontario and Quebec have also adopted VHSv rules. Rules vary by state or province, but generally place limits on live fish (including baitfish) movements and require testing for VHSv prior to intra or interstate transfer or release. The state of New York has adapted rules requiring testing for eight additional fish pathogens for intrastate movements importations into the state.

Management Implications

The scale of the VHSv outbreak in 2006, the subsequent Federal Order, and state regulations have had significant impacts on the operations of Federal, State, and Tribal natural resource agencies, as well the private sector. The most significant impact has been, and will continue to be, the movement of warm and cool water fishes. Warm and cool water rearing programs are a major component of state and tribal hatchery programs. Historically, fish health inspections have not been performed on warm and cool water fish species. Often these species are not at the culturing facility long enough for inspection laboratory tests to be completed prior to stocking, or are reared using extensive culture methods, which require additional effort to sample. In these instances, brood stock (which is often from wild stocks) will need to be tested prior to egg take to ensure that the virus is not passed down from parents to progeny. Costs associated with the additional fish health testing have stressed the limited budgets of Federal, State, and Tribal agencies.

State natural resource agencies have also altered their warm and cool water fish rearing programs in response to the VHSv outbreaks that have occurred since 2006. The Michigan Department of Natural Resources suspended its muskellunge and walleye rearing programs in 2007; these programs resumed on a limited basis in 2008 (Gary Whelan, personal communication). Many natural resource agencies have also limited wild gamete collection to sites that have not tested positive for VHSv.

The APHIS rules have not had a significant impact on salmonid fish operations since cold water species have historically received fish health inspections.

Conclusions

Viral hemorrhagic septicemia is a new introduction into the Great Lakes, probably introduced in 2001 or 2002. To date, VHSv has been confirmed to be present in all of the Great Lakes except Lake Superior, and inland lakes and streams in Michigan, New York, Ontario, Ohio, and Wisconsin. The detection of VHSv in Clear Fork Reservoir in Ohio in 2008 was the first isolation of the virus outside of the Great Lakes Basin. The Chicago Waterway links Lake Michigan to the Mississippi River Basin, providing an additional entry point for VHSv to make its way to the Mississippi River. Movement of live fish, including baitfish, will contribute to the spread of the Great Lakes strain of VHSv through the Great Lakes basin and other regions of the United States and Canada.

Significant fish kills are expected to occur as VHSv spreads into these new areas. Additionally, naïve fish populations or year classes in areas where the virus has already occurred will be susceptible to periodic outbreaks of VHS in the future.

Acknowledgments

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Information Sources

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