Viral Hemorrhagic Septicemia Virus (VHSV)
Risk Assessment for Oregon 2010

Identity

Name: Egtved Virus, Viral Hemorrhagic Septicemia Virus
Taxonomic Position: Ordrer Mononegavirales, Family Rhabdoviridae, Genus Novirhadovirus, Species Viral Hemorrhagic Septicemia Virus

Photo courtesy of Dr. Mohamed Faisal

Risk Rating Summary

Relative Risk Rating: **MODERATE**
Numerical Score: 6 on a 1-9 scale)

Uncertainty: **MODERATE**
A moderate level of uncertainty in this risk assessment is attributed to the presence of a genotype of VHSV already established in the Pacific Northwest and its detection in Oregon. Genotype IVa has been known to exist in this region since 1988 and though it has caused significant mortality in some marine species, it remains relatively avirulent to Pacific salmonids. As a pathogen of marine species, it is unlikely to spread to freshwater ecosystems. Uncertainty associated with the introduction of the IVb genotype, (a freshwater species pathogen), is moderated by resource management differences, the occurrence and abundance of affected species, and geographical conditions present in the Midwest that do not occur in our region. These factors would hinder a rapid dissemination of this form of the virus in Oregon. The exception to this would be the Columbia River basin.

Recommendation

VHSV genotype IVa has an endemic range along the west coast of the United States from Alaska to central California and has been responsible for significant mortality in some populations of baitfish in Alaska, British Columbia, and Puget Sound. It has the ability to remain viable in frozen tissue and thus may be spread through the transfer of frozen baitfish used for angling or as feed used in aquatic culture endeavors. It is important that current regulations regarding the examination of fish before transfer be enforced, and routine surveillance for the virus be continued. Federal regulations regarding the movement of fish from areas endemic to VHSV genotype IVb provides some protection against its dissemination, however, state regulations involving the import of susceptible fish species (in particular, non-native species) need to be rigorous and actively enforced. While the potential for introduction and establishment of this genotype of VHSV is considered moderate overall, the Columbia River basin is the area most at risk and could potentially suffer the largest impact should this form of VHSV be introduced.

Risk Rating Details

Establishment Potential is **LOW**

Justification: Worldwide, there are presently 5 different genotypes of Viral Hemorrhagic Septicemia Virus (VHSV). Genotype I occurs in cultured freshwater species in Europe and Japan, while genotypes II-III are of marine fish origin in Europe and Japan. These three genotypes have yet to be isolated in the United States.

VHSV genotype IVa was first isolated in the U.S. from asymptomatic spawning adult salmon in the Pacific Northwest in 1988 and 1989, (Winton et. al. 1991) and was thought to be of European origin. It was suspected that the virus was inadvertently introduced through ballast water or infected fish contained in ballast water taken on ship in Europe, and then spilled into U.S. waters. Examination of the viral genome however, confirmed that the U.S. isolate was different than the European genotypes. Subsequent new isolations from fish in Pacific Northwest waters suggested a marine reservoir for the virus; several species of ocean fish as well as other salmonids were found to carry the IVa genotype. This genotype is now known to occur in North America, Korea and Japan. In North America, the endemic range spans the west coast from northern Alaska to southern California.

VHSV genogroup IVb was isolated in the Lake St. Claire area of the Great Lakes region of the United States in 2005. The significance of this isolation resides in the fact that the virus was enzootic in a freshwater environment. Up until this time, VHSV was primarily associated with marine fish (but also affected cultured rainbow trout in Europe and Japan, likely a result of using untreated ocean fish byproducts as feed). Examination of archived fish tissues from a massive mortality event in muskellunge, *Esox masquinongy* from Lake St. Claire in 2003 (Elsayed et. al. 2006) proved to be caused by VHSV IVb, indicating that the virus was present for at least two years before detection. Subsequent wide spread sampling of fish species throughout the Great Lakes region, and investigations into recent large-scale fish die-off events found that the virus was capable of infecting approximately 28 species of freshwater fish, and was implicated as the cause of epizootic losses in several of those species. Genotype IVb is now endemic to all the Great Lakes, continues to cause massive mortality in some species, and has been found as far west as Wisconsin and Illinois.

Susceptible fish contract the virus by close proximity to other infected individuals (horizontal transmission), or perhaps by ingesting infected material by predation or cannibalism. Affected fish shed virus into the surrounding environment through urine, sperm and ovarian fluid, thus exposing other fish, or when spawning, may contaminate ova. Depending on water temperature and other factors, VHSV can remain viable in water for several days.(Arkush, et.al, 2006, Kocan, et.al, 2001,

and CFSPH, 2007) Once infected, the fish may begin to show clinical signs in about 7 days, and mortality usually follows shortly after as a result of the breakdown of the epithelium lining the blood vessels (causing the pathognomonic hemorrhaging) and systemic organ necrosis caused by viral septicemia. Survivors of viral infection are thought to be life long carriers and shed virus particles throughout their lives, however, some may undergo a quiescent phase where the virus becomes protected in deep tissue and is no longer shed. External stressors which can compromise the immune system such as elevated temperatures, water quality changes, survival pressure, or infection with another pathogen may allow the quiescent virus to reactivate, overwhelm the fish's immune system and develop into clinical infection.


Photo courtesy of Dr. Mohamed Faisal

VHSV genotype IVa has been isolated from two locations in Oregon (Hedrick et. al. 2003). In 2001 it was isolated from Pacific Eulachon (*Thaleichthys pacificus*) in the Sandy River, a tributary in the Columbia River basin. The virus was isolated from sexually mature fish that migrated up the Columbia River and into the Sandy River to spawn. No clinical infection was evident. The second isolation occurred in surf smelt (*Hypomesus pretiosus*) originating from Winchester Bay on the mid coast, also in 2001. Surf smelt were obtained from a bait supplier in Winchester Bay and transferred to the Hatfield Marine Science Center, Newport, Oregon to be used as feeder fish. A few days after the smelt arrived in Newport, the fish began to show signs of clinical infection and elevated mortality was evident. Examination of several dead fish resulted in the isolation of VHSV. Since 2001, VHSV has not been isolated again from fish in or off the coast of Oregon.

In Pacific Northwest waters, there are approximately 50 species of fish found to be susceptible to the virus. Species such as Pacific Herring and Pilchard (Meyers et. al. 1999, and Traxler & Kieser 1999) have suffered epizootic loss due to the virus in Alaska, British Columbia, and Puget Sound. It has been speculated that significant decline in the populations of herring in Alaska, which have closed or severely reduced the commercial take of these fish in several years of the past decade, has been caused by VHSV epizootics. Commercial fishing for herring along the Oregon coast has been depressed for much of the last decade and may also be influenced by the presence of VHSV. Numbers of eulachon returning to the Columbia River have been at historic lows for the past decade and may well be affected in some way by VHSV.

The IVa genotype of VHSV is well established in the marine environment of the Pacific Northwest, but as yet has not been documented to cause mortality in

salmonids, particularly the Pacific salmon that inhabit the region. Experimental investigation at the USGS at Sand Point, Seattle, Washington has shown the IVa genotype to be mildly virulent to salmonids (Winton et. al. 1991) and there have been no isolations of the virus from a fish loss event in fresh water. It appears at this time, the virus has little impact on salmonid populations in the Pacific Northwest, both naturally produced, and cultured.

The establishment of the Great Lakes IVb genotype in Oregon is considered to be low for several reasons. The current endemic region for this form of VHSV has many aspects to it which were quite advantageous for the virus to spread quickly: large populations of susceptible species concentrated in small areas, multiple susceptible species present throughout the region, the ability for anglers to catch live bait from anywhere in the waterway and transport it for use elsewhere, and, most all of the waterways endemic to the virus are directly connected, allowing infected fish to carry and spread the virus throughout the system. These conditions do not occur in Oregon, or are present to a much less degree. The endemic region of the virus is geographically removed from Oregon such that it would be virtually impossible for this form of the virus to be introduced into the state by any other event but receiving infected fish. It is improbable that the virus could be brought in inadvertently on boats or fishing gear, as extended transport times and conditions would likely not be conducive to viability. Federal regulations presently in effect make it illegal to import fish from the IVb endemic region without health certification, and state regulations make it illegal it import fish from anywhere outside of the state without proper health inspection. The exception to this is aquarium fish. Aquarium trade species susceptible to the virus could be exposed in some manner and make their way into Oregon as pets, ultimately to end up in state waters. However, this scenario makes assumptions that have no current basis, and therefore is given a very low probability of occurrence. Another more probable but still unlikely event would be for exposed or infected fish to be transported into the state illegally. Live fish could be brought in without proper authority for private use, or infected frozen fish might be purchased elsewhere for use as bait and harbor viable virus (Meyers et. al. 1994 and Goodwin et. al. 2004) Both of these scenarios are considered to have a low probability of occurrence.

One additional way in which a virulent form of VHSV could infect Oregon's freshwater fisheries resource is by mutation or acclimation of the present IVa genotype to a new environment. While it is unknown how the Great Lakes strain of virus was introduced in that region, it is theorized that its origin might be from the marine form of the virus which evolved the ability to 'jump' from ocean fish to freshwater hosts (Dixon, P.F. 1999). RNA viruses, such as the rhabdoviruses, are known to have a relatively high rate of mutation and have been known to acclimate to new host species (Kurath et. al. 2003). The necessary processes

and potential of this type of mutation is unknown, but at this time is considered to be low.

Spread Potential is **MODERATE** to **HIGH**
Justification: A number of fish species affected by the virus in the Great Lakes region are also present in Oregon and the Pacific Northwest. However, populations of these fish are spread around the state in much smaller populations, and many are geographically cut off from each other. The potential for the virus being introduced to and spread from a hatchery facility is considered low as routine health monitoring includes surveillance that greatly reduces the chance of acquisition or dissemination. The occurrence of the virus in a lake population may result in high mortality to the species in residence there, but would likely be contained by the boundaries of the water body. The use of live bait in Oregon is not permitted, so dissemination of the virus out of such contained areas would be associated with the movement of recreational users, anglers, birds, and mammals. The conditions necessary for the virus to survive the transport process are not stringent, but neither do they allow simple transfer. The virus is inactivated by drying, increased temperature, sunlight, and after a period of time, lack of a suitable host. Birds and mammals may be able to spread the virus by moving infected material from one location to another, but it is highly implausible that the virus would survive being passed through the animal's digestive system, so movement over large distances is not likely. The use of dead fish for bait, whether frozen or fresh, would pose a larger potential for the virus to spread to new areas but the bait would need to be obtained from an infected source and kept at optimal condition for the virus to survive for long periods of transport. Once transported, viable virus introduced into a new location would need to find a suitable host relatively quickly. It is possible for all of these conditions to be met, but the probability is considered to be moderate.

Of much greater concern would be an introduction of the virus into the Columbia River basin. The area this basin encompasses, the numbers and diversity of the susceptible species present throughout the basin, affected species that migrate over the drainage region, and the commercial use of the waterways would provide an extremely advantageous environment for the virus to spread rapidly over a huge area. Once introduced into the Columbia River basin, containment of the virus would be impossible and efforts to limit its spread would be restricted to fish species that are under management, such as aquaculture and hatchery programs. While the potential for spread in certain river basins in Oregon is high, the overall potential for the virus to disseminate widely throughout the state is considered moderate.

Environment Impact Potential is **MODERATE** to **HIGH**
Justification: The virus affects fish and therefore has no direct impact on physical environmental concerns such as habitat degradation or water quality. The impact

on susceptible fish species could range anywhere from slight to devastating depending on many factors. Epizootic loss events similar to those occurring in the Great Lakes would in all probability be less severe due to our smaller, more spread out populations of susceptible fish. Large scale mortality events due to a similar pathogen, IHN virus are not common, but do occur. The Great Lakes strain of VHSV affects a wider range of hosts however, and large die offs of wild non-salmonid fish in lakes, reservoirs and rivers could very well take place. Significant loss of any fish species in the nutrient/food web will eventually affect other aquatic organisms, as well as the birds and mammals that utilize these fish as a food source, but how and to what extent is unknown. It is, however, logical to assume the greater the loss, the greater the affect on peripheral organisms. Significant losses of aquatic vegetative foragers could indirectly impact water quality in some of the smaller lakes and water bodies by a rapidity of eutrophication. Major losses of prey species in an ecosystem would affect the quality and numbers of salmonids and other predator species, some of which are threatened or endangered.

The environmental impact of the establishment of this virus in the Columbia River basin would be of much greater consequence because it would have the potential to affect larger numbers of fish and a wider diversity of species. Experimental evidence thus far shows the Great Lakes strain IVb virus to be low to moderately virulent to salmonids (unpublished data 2009) yet other species throughout the basin may be dramatically affected. This could conceivably affect the success of salmon populations in regions where the virus has the greatest impact, in particular, threatened or endangered populations. The virus would also have the opportunity to disseminate throughout a huge water basin, allowing it exposure to suitable hosts virtually anywhere in the system.

Ecomonic Impact Potential is **MODERATE** to **HIGH**
Justification: State managed cultured fish programs could suffer heavy economic impacts initially, but once it has been established where the virus occurs and which species are most at risk, protocols to minimize the spread and manage around the pathogen would reduce future impact. This scenario occurred with the first detection of the IVa strain of VHSV in 1988 in Washington state, and the same types of management protocols are currently in use for other viral pathogens endemic to the Pacific Northwest.

The greatest impact due to this virus would be to the recreational fishery throughout the state. Loss of angling opportunities in lakes and reservoirs for non-salmonid game fish could be severely reduced depending on species present and the climatic factors of the affected water bodies. Public monies would be diverted to programs to contain, minimize the spread, or eradicate the pathogen instead of using those funds for the fisheries resource itself. Loss of angler opportunities can result in a decrease in angler dollars received to support

fisheries programs. Depending on many factors such as severity of losses, location of affected water bodies, and the potential for wide spread dissemination through a river basin, significant amounts of state dollars would need to be used just to contend with the consequences of its presence in the state.

It is difficult to estimate the monetary impact of the virus. However, we may be able to draw inferences by comparing fish loss and potential angler opportunity lost due to a similar rhabdovirus that affects Oregon's fisheries. Infectious Hematopoietic Necrosis Virus (IHNV) affects salmonids statewide and has been known to exist in Oregon since 1958. In 2006, this virus was responsible for the loss of approximately 1.6 million fish, primarily juvenile rainbow and steelhead trout destined for recreational fisheries use. Losses per year in the past decade have averaged around 500,000 fish and have been as low as less than 1,000. The Great Lakes strain of VHSV has a much broader range of susceptible species than IHNV and therefore has the potential to cause greater losses. At this time, it is not known how virulent the Great Lakes strain of VHSV is to rainbow trout but this would likely be the species of greatest economic impact in the state. Private growers would also be impacted, by the limitations placed on them as to where their fish could be sold and transported. Surrounding states where VHSV does not occur but import fish from Oregon suppliers would no doubt require extensive fish health examinations, at the grower's expense, before allowing potentially exposed fish into their state.

Human Heath Impact Potential is **NO RISK**
Justification: Viral Hemorrhagic Septicemia Virus is a fish pathogen and does not affect humans. It is not known to affect other organisms.

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Author of Assessment

John Kaufman, Fish Health Specialist/Virologist
Oregon Department of Fish and Wildlife
Fish Health Section
220 Nash Hall, Department of Microbiology
Oregon State University
Corvallis, Oregon 97331-3804
Ph: 541-737-1853
Fax: 541-737-0496
kaufmanj@onid.orst.edu

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