Viral Hemorrhagic Septicemia Virus

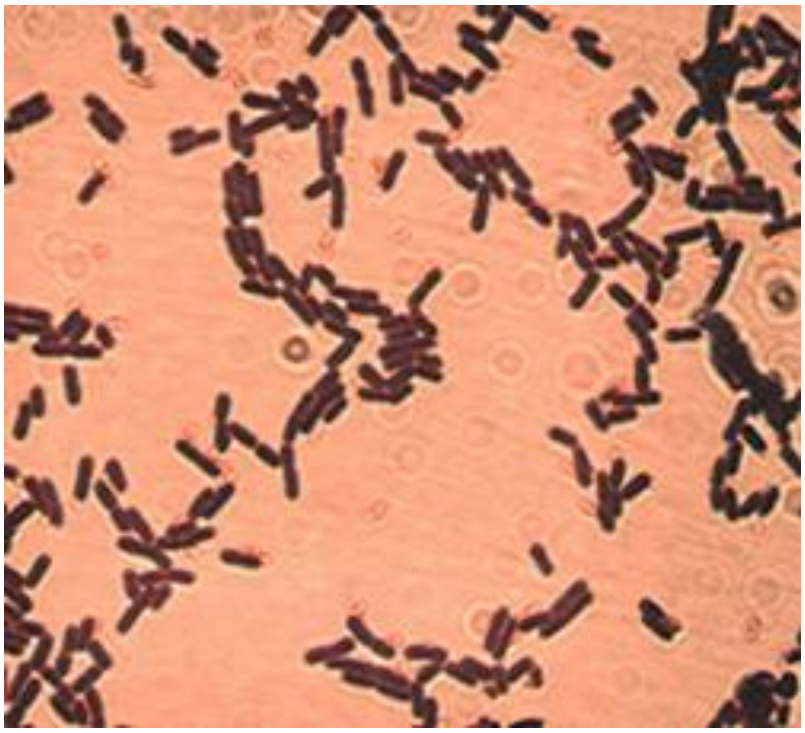

Figure 1 microscopic look at viral hemorrhagic septicemia courtesy of http://cpw.state.co.us/learn/Pages/AAHLEmergingDiseasesIssues.aspx

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Classification

Order: Mononegavirales

Family: Rhabdoviridae

Genus: *Novirhabdovirus*

Species: Undescribed

Known by the common name Viral Hemorrhagic Septicemia Virus, or in Europe Egtved disease, you may find it abbreviated as VHSV, VHSv, or VHS. Viral Hemorrhagic Septicemia is part of the family Rhabdoviridae which also includes the famous rabies virus which can affect humans and other mammals. Not to worry VHS does cannot infect humans, handling or consuming and infected fish will not result in contraction of the virus. The virus is exclusive to fishes. VHS is related to another famous fish killer, the infectious hematopoietic necrosis virus, both are part of the genus *Novirhabdovirus*.

Identification

Much like other rhabdoviruses, viral hemorrhagic septicemia (VHS) contains RNA within a bullet/cylindrical shaped shell made of glycoprotein G, the virus ranges from about 170-180nm long and 60-70nm wide (Elsayad et al. 2006; McAllister 1990; Kipp & Ricciardi 2006).

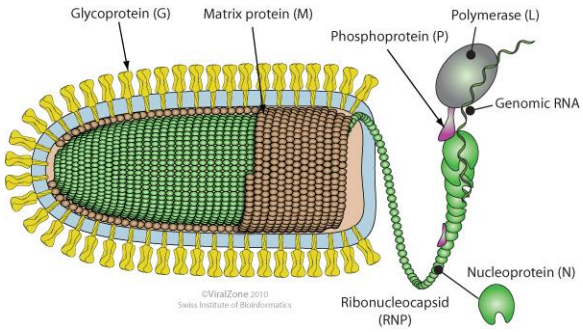

Figure 2 photo illustration of a *Novirhabdovirus* showing the RNA chain and glycoprotein shell. Courtesy of the Swiss Institute of Bioinformatics http://viralzone.expasy.org/all_by_species/76.html

Visual identification can be challenging given the size of VHS, most identification is conducted by examining infected fish. Living specimens will appear either lethargic or over active, making sporadic movements, such as circles or corkscrews. Deceased specimens can appear dark in color, have pale gills, bloated abdomen, fluid filled body cavity, bulging eyes, and most notably external and internal hemorrhaging or bleeding. External hemorrhaging will typically take place around the base of fins, eyes, gills, and the skin. Internal hemorrhaging can be found in the intestines, air bladder, kidneys, liver, heart, and flesh (McAllister, 1990; Marty et al., 1998; Kipp& Ricciardi, 2006; Bartholomew, et al. 2011).

Photo contains gizzard shad infected with viral hemorrhagic septicemia, visual external hemorrhaging. Photo credit to Dr. P. Bowser, Aquatic Animal Health Program, CVM, Cornell University. http://www.cfsph.iastate.edu/DiseaseInfo/disease-images.php?name=viral-hemorrhagic-septicemia&lang=en

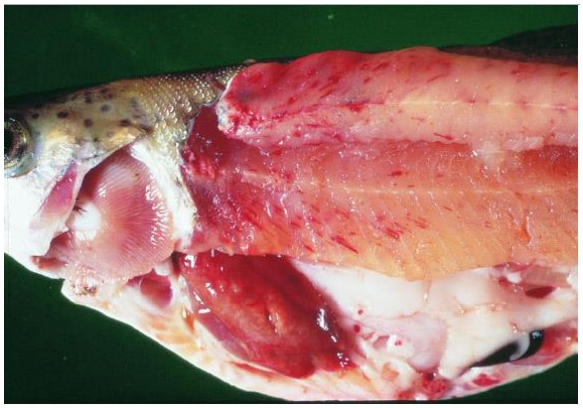

Photo: rainbow trout with internal signs of viral hemorrhagic septicemia, discoloration in the liver, hemorrhaging in the flesh and intestines, and pale gills. Photo by T. Håstein http://www.dfo-mpo.gc.ca/science/enviro/aquaculture/rd2013/rdhealth-eng.html

"Life" history

Viral hemorrhagic septicemia is passed on to other fish through water. Fish that come in contact with infected bodily fluids like excretory waste such as urine or feces, or reproductive fluids such as sperm and ovarian fluid, are likely to become infected. The virus may also be passed on through physical contact with an infected fish touching non infected fish. Predatory fish can also become infected through consumption of infected fish or a carrier of the disease. The virus can enter a fish through the gills, digestive tract, or an open wound (CFSPH 2007)

It is possible for other species to become carriers of the disease. Such as predatory birds, which ingest infected fish and can transport the virus to different locations (CFSPH 2007). Even fresh water turtles such as the red-eared slider, common snapping turtles, and the yellow-bellied slider 10-20 days after consuming infected fish may carry the virus and excrete it into the water; where it has the potential of finding a new host (Goodwin & Merry, 2011).

The most prolific and problematic carrier of the disease are other fish that do not show signs of the disease, do not die, and in turn become lifelong carriers of the disease passing on the virus to their fellow cohorts.

The incubation period for VHS at warm water temperatures is 1-2 weeks, and 3-4 with cold water temperatures. Also mortality has been observed in Pacific Herring 4-6 days after being introduced to the virus (CFSPH, 2007). It was determined by Gary Marty and his associates in 1998 that 10-15% of Pacific herring showed no signs of VHS yet tested positive, they then discovered that the herring only expressed the VHS symptoms when under stress. This is why populations can have the disease yet experience no mass mortality events, and how it can persist in a population and so many individuals can become carriers of the disease.

Life cycle

When VHS comes in contact with a potential host cell the glycoprotein G matches/binds with an entry molecule on the host cellular membrane receptor. The host cell then brings the virus into the cell in a process called endocytosis. Then the virus membrane and vesicle membrane (of the host cell) fuse together. This is when the RNA strands are released into the cytoplasm. The host cell then creates mRNA which is then replicated into RNA. This RNA then binds with other proteins forming a bud which eventually separates thus forming a new virus in search of a new host (SIB, 2011).

Environmental optima and tolerance

The optimum temperatures for replication is 14-15 degrees Celsius, and the optimum pH for replication is 7.4-7.8 (Kipp et al. 2014). It was found that VHS does not replicate effectively at temperatures greater than 18 degrees Celsius (Hendrick et al. 2003). Reproduction is also low at temperatures below 6 degrees Celsius. Reproduction stops and VHS becomes inactive at temperatures above 20 degrees Celsius (De Kinkelin et al., Bernard et al., McAllister, cited by Kipp et al. 2014). Fish mortality as a result of VHS is highest in temperatures ranging from 3-12 degrees Celsius (McAllister, cited by Kipp et al. 2014). It was discovered that VHS can persist in fresh water from anywhere between 28 to 35 days, and up to a year if it is in filtered fresh water. VHS can remain infective even longer if present in ovarian fluid (MDTAA, 2009).

Finding the optimum temperature in which VHS can replicate can help us establish which bodies of water are prone to the establishment of VHS. This would help in prioritizing prevention methods to stop the spread of the virus into favorable habitat. Upper and lower extremes of the VHS replication can also help us rule out potential areas where VHS cannot establish, enabling us to send resources elsewhere. The necessity for cold water is one reason why it is

found in the Northern hemisphere and not in the Southern tropical ocean systems.

Biotic associations

There are over 82 different fish species affected by viral hemorrhagic septicemia. 23 species in the Great Lake region of the United States have witnessed large scale die offs due to viral hemorrhagic septicemia (MDTAA, 2009). On the Pacific Coast of the United States and Canada die offs of Sardines and herring have been recorded (Marty et al. 1998). Fish species affected by this virus can be found in marine or fresh water across the entire globe. Many of these species are extremely valuable either commercially, recreationally, or ecologically.

Family	Common name
Salmonidae (salmonids)	Rainbow trout Steelhead trout
	Chinook salmon
	Coho salmon
	Golden trout*2
	Chum salmon*3
	Sockeye salmon*3
	Atlantic salmon
	Brown trout
	Lake trout*1
	Brook trout*1
	Grayling
	Whitefish
	Whitefish*1
	Lake whitefish
Esocidae	Muskellunge
	Northern pike
Clupeidae	Atlantic herring
	Pacific herring
	European sprat
	South American pilchard
	American gizzard shad
Gadidae	Atlantic cod
	Pacific cod
	Haddock
	Poor cod
	Norway pout
	Blue whiting
Gadidae	Whiting
	Alaska Pollock
	Pacific tomcod
Lotidae (hakes and burbots)	Fourbeard rockling
	Burbot
Merlucciidae	(North) Pacific hake
Anoplopomatidae (sablefish)	Sablefish
Sebastidae (Rockfish, rockcod and thornyheads)	Black rockfish Mebaru (Japanese)
	Schlegel's black rockfish*2
Anguillidae	European eel
Fundulidae	Mummichog
Gasterosteidae	Three-spined stickleback
Aulorhynchidae	Tube-snout
Catostomidae	Silver redhorse
	Shorthead redhorse
Cyprinidae (minnows or carp)	Bluntnose minnow
	Emerald shiner
	Spottail shiner
	Iberian nase
	Zebra danio*2
Percopsidae (trout-perch)	Trout-perch
Petromyzontidae (lamprey)	European river lamprey
Ammodytidae	Pacific sand lance
	Sandeel
	Pacific sandeel
Gobiidae	Sand goby
	Round goby
Embiotocidae	Shiner perch
Centrarchidae (sunfish)	Largemouth bass
	Smallmouth bass
	Bluegill
	Black crappie
	Rock bass
	Pumpkinseed
Sciaenidae	Freshwater drum
Percidae (perches)	Yellow perch
	Walleye
Scombridae	Chub mackerel, Pacific mackerel
Moronidae (temperate basses)	White bass
	Striped bass
	White perch
Sparidae	Gilthead seabream
	Black porgy*2
Moronidae (temperate bass)	European seabass*1
	Black porgy*2
	Red seabream*2
Carangidae	Japanese amberjack*2
Serranidae	Hong Kong grouper*2

Pleuronectidae	Dab
	Flounder
	European plaice
	English sole
	Greenland halibut
	Marbled flounder*2
	Atlantic halibut*1
Scophthalmidae	Turbot
Paralichthyidae	Japanese flounder
Soleidae	Senegalese sole
Ictaluridae (North American freshwater catfish)	Brown bullhead
	Channel catfish
Argentinidae	Lesser argentine
Osmeridae (smelts)	Eulachon
	Surf smelt

Figure 5 lists all of the currently known fish species that have at one time tested positive for VHS. VHS affect 13 orders of both marine and fresh water species. This table is from the Manual of Diagnostic Tests for Aquatic Animals. http://web.oie.int/eng/normes/fmanual/2.3.09.VHS.pdf

Geographic distribution

There are four types of viral hemorrhagic septicemia, based off of geographic location, types 1 and 4 are further broken down into subdivision genotype 1 is broken down into subtype a-e, and type 4 is broken down into a-c. VHS genotype 1a is covers the terrestrial water bodies of Europe, this subtype represents the initial discovery of VHS in the European aquaculture industry. Type 1a likely diverged from a marine source 60 years prior to its discovery (Kim et al. 2014). Genotype 1b is associated with the marine area of the Southwest Baltic Sea and into the North Sea. Genotype 1c is an old lineage of VHS present in some mainland lakes of Germany and Denmark. Genotype 1d is present in rainbow trout reared in fresh or brackish water along Norway and Finland. Genotype 1e is found in parts of the Black Sea (He, 2014). In general VHS 1 is highly virulent in rainbow trout and can have a high mortality rate which can reach up to 100% in trout fry (CFSPH, cited by Kipp et al. 2014).

The geographic range for VHS genotype 2 is the Baltic Sea, found mostly in herring, cod, and sprat. This genotype has not been associated with any disease outbreaks and or die-offs (Emmenegger et al. 2013).

VHS genotype 3 is found in the marine waters of the North Sea and North Atlantic off the coasts of Norway and Great Britain. This strain of VHS only infects marine species such as turbot and rainbow trout raised in marine net pens (Emmenegger et al. 2013).

There are several sub classes of type 4 VHS typically referred to as the North American strain. First, type 4a is found in the Pacific Ocean from Alaska to California and in parts of Japan and Korea. Type 4b is found in the Great Lakes and several other mid-west lakes and rivers. Type 4c is found in the North Atlantic along the Eastern Canadian coast (He et al., 2014). Genotype 4 the North American strain can be highly virulent in herring, sardines, and other fresh water species with a mortality rate anywhere from 20-80%. However it is less virulent in salmonids, compared to the European type 1 (Follett et al., 1997; CFSPH, 2003; Emmenegger et al. 2013; Kipp et al. 2014).

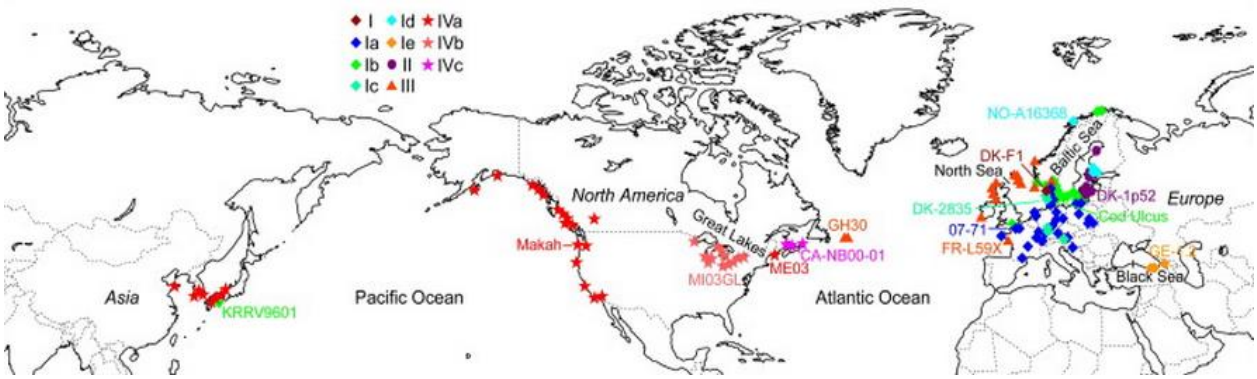

Figure 6: Shows testing locations, in which tissue samples tested positive for geographically distinct types of viral hemorrhagic septicemia. Also shows the global distribution of VHS (He et al., 2014)

History

Viral hemorrhagic septicemia was first discovered in Germany in 1938 (He et al. 2014). It was not until 1962 when VHS type 1a was genetically isolated from tissue samples from an infected rainbow trout in Europe. Then in 1988 type 4 viral hemorrhagic septicemia was discovered in North America off the coast of Neah Bay, Washington in a sample of returning adult Chinook and Coho salmon (Winton et al., Hendrick et al., cited by Pham et al., 2013). By the early 1990's the losses faced by rainbow trout farms in Denmark reached $60 million U.S. dollars annually, the hatcheries had to be cleared out and disinfected (Hill cited by Whelan, 2009).

Through November of 1998 to February of 1999 a mass mortality event occurred in the Queen Charlotte Strait region of Canada. It happened again December 2001-March 2002 this time in Kyuquot sound, Nootka Sound and Spiller Channel, these where the first mass mortality events as a result of VHS type 4a. In the 1998 mortality event 95 of 163 sardines and 26 of 37 herring tested positive for VHS type 4. In the 2001 mortality event 6 of 43 Sardines, 26 of 37 herring, and 1 of 1 shiner perch tested positive for VHS (Hendrick et al. 2003). Hendricks and his associates infer that the dying sardines transmitted the virus to the herring and pile perch.

A separate 1998 study in Prince William Sound conducted by Gary Marty and his associates found that 11 of 233 Pacific herring (4.7 %) tested positive for VHSV. There were reported mortality events in Prince William Sound at the time of the study, however the mortality was attributed to events related to the Exxon Valdez rather than VHS because of the low infected population percentage.

In 2003 VHS type 4b was discovered in the Great Lakes. By 2005 VHS type 4b is thought to have triggered die-offs of fresh water drum in Eastern Lake Ontario, and Muskellunge in Lake St. Clair. Again in 2006 along the St. Lawrence River die-offs of muskellunge due to VHS were observed (Faisal et al., Wren and Lee, cited by Kipp et al., 2014). That same year VHS caused die-offs of muskellunge, northern pike, gizzard shad, walleye, smallmouth bass, and yellow perch in Lakes St. Clair, Erie, and Ontario (USDA & APHIS cited by Kipp et al. 2014). 2006 also saw VHS cause mortality in walleye of Consensus Lake in New York. The following year, 2007 low to moderate fish kills of fresh water drum were observed in the Wisconsin lakes of Butte Des Mortes and Winnebago, addition sun fish die-offs occured in Seneca-Cayuga Canal, New York (Focus on Fish Health cited by Kipp et al., 2014). Lake white fish and walleye have also experienced die-offs in Lake Huron (Kipp et al., 2014). It goes to show the ever expanding range of VHS type 4b in the Midwest United States.

VHS also infects many native species of the Great Lakes and can cause die-offs of their precious species. In Budd Lake, Lake Michigan, Lake St. Clair there have been mild to moderate die-offs of native black crappie and bluegill.

Native white bass in Lake Erie as well as rock bass in Skaneateles Lake in New York have also experienced die-offs as a result of VHS (Whelan, 2009; Kipp et al., 2014).

Polish trout farms experienced 84 VHS outbreaks from 2005-2009 (Reichert, Matras & Skall, 2013). In China in 2005 VHS type 4a was isolated from a tissue sample from an infected flounder (Zhu & Zang cited by He et al. 2014). The first recorded case of VHS in China serves as another example of the rapid and global range expansion of viral hemorrhagic septicemia.

It is unknown where viral hemorrhagic septicemia originated. Generally it is believed that all strains of VHS are derived from one common marine ancestor (Skall et al. cited by Kipp & Ricciardi, 2006). Mei He and others in an August 2014 publication believe that the first division of VHS from a common ancestor may have been around 300 years ago. They later go on to state that it is not possible to determine whether VHS was introduced from Europe to North America or vice versa. However they believe VHS started in the Pacific Northwest and radiated to other parts of the world perhaps aided by human interactions. They admit that there is no way of knowing for sure. Oshima et al in 1993 state that the North American strain 4a is not of European origin and that perhaps the VHS type 4 is endemic to the marine environment of the Pacific Ocean.

Invasion Process

Viral hemorrhagic septicemia is present in an ecosystem either because it occurred naturally there or it has been unintentionally introduced into an area through human activities.

One known vector in which VHS has been locally distributed amongst European lakes and streams is through the aquaculture industry. The infection of Polish trout hatcheries is well recorded by Reichert, Matras and Skall, in 2013 they released their study describing the direct contamination amongst trout hatcheries in Poland. The first example is from a group of hatcheries C,D,E,F, and G that all had rainbow trout test positive for type 1 VHS. It was discovered that the hatcheries shared equipment with one another, and hatcheries C,E,F and G all admitted to borrowing hatchery D's equipment. So there is a direct correlation between the use of stocking materials and the introduction of VHS into a hatchery. A second example looked at two hatcheries on the same stretch of river; hatchery S is directly upstream of hatchery T. Soon after hatchery S experienced an outbreak of VHS, hatchery T soon experienced an outbreak as well. Tissue samples were taken from rainbow trout from both hatcheries; the samples showed an exact genetic match between the VHS strains at hatcheries T and S. This shows that water from a hatchery can travel downstream and infect other hatcheries. The Reichert study also shows the transfer of VHS between Poland and Germany, also due to the exchange of stocking materials and fish fry.

Farmed raised fish in net pens may also contract the disease from wild species, made evident by Kyle Garver and his associates 2013 study. Their study looked at farm raised Atlantic salmon smolts raised in net pens in Clayoquot Sound in British Columbia. When first introduced all Atlantic salmon smolts tested negative for VHS. After a month Pacific sardines around the net pens were showing signs of VHS, as mortality in the sardines went up mortality of salmon smolts inside the net pen also increased. Tissue samples were collected from both sardines and Antlantic salmon smolts, both tested positive for genetically identical VHS strains. Much like the Polish S and T hatcheries that shared the same water source, the shared water between the sardines and salmon smolts enabled the transmission of VHS between species. The same scenario unfolded a year later in the same area except this time involving Pacific herring instead of sardines. Also in 2010 in Barkley Sound Atlantic salmon tested positive for VHS after infected sardines and herring were spotted in the area around the net pens.

If wild stocks of herring and sardines can infect Atlantic salmon raised in net pens, the opposite is surely true. Whenever an infected fish shares water with a healthy fish there is high likelihood that the healthy fish will contract the disease, so long as it is a susceptible species. As made evident in Poland and British Columbia.

It is unknown how VHS got introduced into the Great Lakes. However genetics show a correlation between the VHS type 4b strain in the Great Lakes and that of the VHS type 4c strain. This indicates that the Great Lakes strain of VHS may have originated in the marine environment of the Northeast Coast of Canada and the United States; VHS could have been transported from the North Atlantic Coast of North American into the Great lakes through either ballast water or migratory fish (Elsayad et al. cited by Kipp et al., 2014). VHS could also have been introduced through aquaculture, or recreational fishing via bait bucket release or live well discharge.

Other predatory vertebrates can likely introduce VHS into locations outside its native range such as birds (Kipp et al., 2014) and even aquatic turtles that prey upon infected fish (Goodwin & Marry, 2011). Baitfish that show no signs of VHS but are in fact carriers of the disease which are then released by recreational anglers, is one of the likely ways VHS moved from the Great Lakes to the inland lakes of Wisconsin and New York (Goodwin cited by Kipp et al., 2014).

Factors influencing establishment & spread

The main factor effecting the establishment of VHS in an area is, if there is at least one of the 82 susceptible fish species present in the introduced body of water. The basic need for a host cell for reproduction is the most prominent factor to the establishment of VHS. The next most important factor in establishment is temperature. If temperature is within the optimum reproductive range of 14-15 degrees Celsius VHS is likely to establish, if it is outside that range VHS is less likely to establish (Kipp et al., 2014).

Potential Economic & ecologic impacts

The ecosystems of the Pacific Northwest have already been negatively impacted by the virulent type 4a viral hemorrhagic septicemia, because so many organisms like salmon, seals, sea birds, etc rely on a healthy herring and forage fish population for survival. Viral hemorrhagic septicemia increases mortality in these forage fish populations which in turn harms the productivity of all organisms of higher trophic levels. Three separate populations of herring from Prince William Sound, Alaska were collected and introduced to VHS none of the populations proved to be more resistant to VHS than any other, each population experienced high mortality (Hershberger et al. 2009).

The rainbow trout aquaculture in Denmark was losing $60 million dollars annually in the 1990's because of mortality in juvenile rainbow trout (Hill cited by Whelan, 2009). At times of high mortality in herring populations due to VHS spawning populations can be reduced to 20% of predicted levels, this is a serious blow to a prolific herring fishery in parts of Alaska and Canada; also sardine populations are drastically reduced due to these fish kill events. Many of the sardine catch is shipped to South Australia to feed captive bluefin tuna populations. Less available sardine biomass means less commercial harvest, which means less tuna food, all of these losses take an economic toll on the fishing industry (Hendrick, 2003). I would imagine Australian bluefin growers would also be less likely to buy diseased sardines from Alaska and Canada during outbreaks of VHS.

At a live bait supplier in Winchester Bay, Southern Oregon 60 of 60 dead surf smelt tested positive for VHS. Samples taken from healthy appearing surf smelt showed that 3 of the 17 had VHS. Four weeks later another random sample was conducted on healthy appearing fish this time 3 of 8 tested positive for VHS (Hendrick et al. 2003). The contamination of prominent bait supplying operations by VHS is not only a problem on the West Coast of North America, but in the Great Lakes region as well. The harvest of bait fish for recreational use is a very profitable business throughout the country. Risk of baitfish carrying VHS restricts the transport of bait, this is extremely damaging to these bait fish distributers.

There is also concern that VHS type 4b will travel from the Great Lakes into the Mississippi River where it will slowly expand throughout the Mississippi watershed (Kipp et al., 2014). This would put countless more endemic species at risk and significantly alter the largest fluvial watershed in North America. Efforts must be

made to keep VHS out of the Mississippi drainage.

Management strategies control methods

This brings me into the next subject. How are State and the federal government preventing the introduction of viral hemorrhagic septicemia into other water bodies that have no history of the virus? Gustafson with the help of his peers wrote a 2014 article detailing the management methods that need to be enacted to contain VHS 4b to the eight states surrounding the Great Lakes. They proposed that surveillance should be reduced in regions with either no history or unfavorable reproductive conditions. These surveys are better allocated to areas with a history or high susceptibility to infection. Gustafson et al also include, when importing frozen bait or other fish products from infected regions such as the Great Lake states or Great Lake provinces in Canada, trade officials should be sure to negotiate disease detection thresholds before agreeing to import potentially infected fish which can then infect other areas. Active and passive surveillance methods are critical in evaluating and preventing the spread of VHS to regions with no prior history of the disease.

Whelan in 2009 proposed a series of nine preventive measures that can be put into place in hope of preventing the spread of VHS. 1) Improving disease detection and egg disinfection in hatchery and wild populations especially in cold water species. 2) Placing all Great lake states and the province of Ontario on surveillance programs, where VHS research will remain ongoing. 3) Rigorous biosecurity measures to ensure that fish hatcheries and aquaculture facilities are not vectors, to transport the virus and endanger other water bodies. 4) Either terminating the transfer of fish from infected waters or require mandatory testing of hatchery and wild fish that may have been exposed to the virus; this would ensure that VHS will not be transferred via fisheries management processes. This preventive measure is currently enacted in Great Lake states. However after large push back from the aquaculture industry recent testing has become less stringent. 5) Improve practices within the baitfish supplying industry, by improving testing requirements. This has also been incorporated within baitfish industries with in Great Lake states. 6) Educate angles on the proper ways to dispose of baitfish, emptying live wells and bilge water. In fact require anglers to empty bilges and live wells before leaving the boat ramp and disinfecting it prior to their next launch. 7) Ensure that the commercial fishery does not transfer wild and possibly infected fish species into uninfected bodies of water. 8) Increase public education on the subject of introducing pathogens and potentially invasive species into a body of water and the harm it can cause. Public education methods can include user friendly websites, videos, written material, and public service announcements. 9) Finally increase and maintain funding for research on VHS and other pathogens in the Great Lakes and throughout the United States. At the time this article was released the Great Lakes Fisheries agency received 1 million dollars to research preventive biosecurity measures and determine the susceptibility of different fish species that call the Great Lakes home.

Here is a link to one of the family friendly public service announcements released by the USDA and APHIS, to try and educate the public about preventing the spread of VHS.

https://www.youtube.com/watch?v=_TUNWYB2TFg

To reiterate all of the things that recreational anglers can do to not only reduce their risk of introducing VHS and other aquatic invasive species. Clean off you boat and trailer after use, pressure washing or disinfecting is preferred, then let the boat and trailer dry in the sun for about 4-6 hours. Remember the transportation of living organisms is illegal in many states (Wheland 2009).

It is important to prevent the introduction of VHS strain 1 into the Pacific Northwest because of the high level of virulence in rainbow trout and other salmondis this strain could decimate and already struggling salmon and steelhead population in many Washington, Oregon and California rivers. Hatcheries in the Pacific Northwest provide a substantial portion of the annual commercial salmon harvest and could be

forced to destroy all salmon and trout fry if the introduction of the European strain of VHS were to happen. This is why any importation of VHS susceptible fish from Europe should be heavily tested prior to entering the country.

If a hatchery were to be infected with VHS, the hatchery must undergo a rapid and extensive decontamination process. Destroying all potentially infected individuals, draining the water out of the rearing facility and disinfecting the entire facility, with a 10% chlorine solution commonly used to kill the virus. Thankfully there are ways to prevent the infection of hatcheries. By heating possibly contaminated water above the maximum thermal heat tolerance of the virus, using UV light, or changing the pH to either above 12.2 or below 2.5 these are ways to sterilize the water and prevent VHS contamination (Kipp et al. 2014).

Research is being conducted to find ways of increasing susceptible species resistance to infection or increase their immune response, to hopefully be able to fight off the virus. Research has found that T lymphocytes are important in the immune response of VHS infected rainbow trout; this is evident in the increased levels of T lymphocytes in infected trout compared to the uninfected trout (Castro et al., 2014). It has also been recorded that only 20-40% of rainbow trout exposed to VHS create neutralizing antibodies (Fregeneda-Grandes et al., 2009). This raised the question. What if we could increase the percentage of rainbow trout with neutralizing antibodies? Would this increase survivorship in rainbow trout and other fish species?

A study in 2011 by Hershberger and company sought out to address this question. They found that populations of herring that have been previously exposed to the virus have lower probability of contracting the virus in the future, compared to those with no history with VHS. Plasma was taken from herring that survived prior exposure to VHS, this plasma was then placed into an enclosure containing herring with no prior history with VHS. They called this process “passive immunization”. The passive immunized herring were then introduced to concentrations of the virus. The herring with the passive immunization had a higher survival rate when compared to the experimental control. The survival rates positively correlated to the amount of plasma added, and the amount of time since infection by the donor herring.

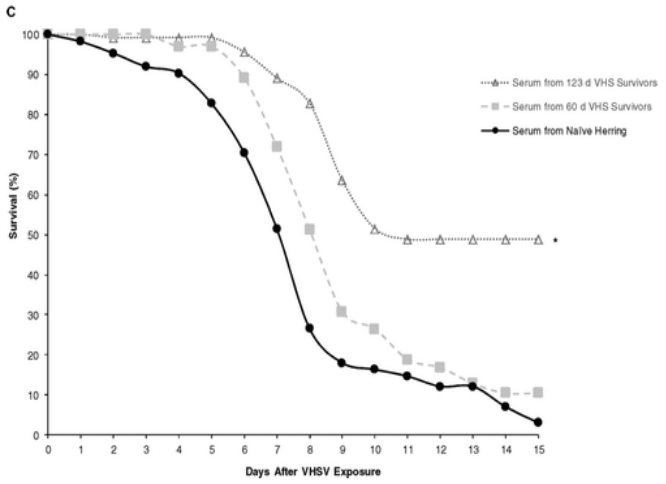

Figure 7 is from the study conducted by Hershberger et al in 2011 the lines show the % survivorship of herring that have undergone passive immunization. The light gray line with triangles represents plasma from herring 123 days after infection. The light gray with squares is plasma from herring 60 days after infection. The black line is the control with naïve herring.

Recent research has provided hope that one day there will be a cure, or a means to reduce the mass mortality events in aquaculture and wild fish species. Perhaps with the help of science we will be able to protect susceptible species from viral hemorrhagic septicemia. In the mean time we must take it upon ourselves to be stewards of our local waterways reporting anything unusual, and making sure to take every precaution to prevent introducing invasive species into local water bodies.

How to report VHS and invasive species in Pacific Northwest.

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Washington Invasive Species Council

http://www.invasivespecies.wa.gov/sighting_form.shtml

Washington Department of Fish and Wildlife invasive species report.

http://wdfw.wa.gov/ais/reporting/

Reporting VHS in the Great Lakes

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Special thanks to Julian Olden and all of the knowledge he has passed down to his students over the course of the quarter. It has been a wonderful class to be a part of. I apologize for this horrible final species report, I tried. I hope no one else will have the misfortune of reading this report.

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