Problems Presented by Emerging Pathogens: 
Potential Threat of Great Lakes VHS Virus in the Western United States

Jerri Bartholomew, Oregon State University

Images and Slides courtesy:
Gael Kurath and Jim Winton
USGS Seattle, WA

Kyle Garver
DFO, Canada

Jill Rolland
USDA-APHIS

Ken Cain
Univ. of Idaho

Laura Kessel
USFWS, Idaho Fish Health Center

Photo M. Faisal
Photo P. Bowser
What is Biosecurity?

Defined as: “the exclusion, eradication or effective management of the risks posed by unwanted organisms from the environment.”

- Disease causing organisms
- Aquatic invasive species

Disease outbreaks
- Can happen rapidly and spread quickly
- Routine Biosecurity measures can reduce risk!
Biosecurity Principles for Aquaculture Facilities

Disease threats (type of operation, species, life stage)

- Primary step - Management Awareness
- Realize that many solutions exist, but there is no “one size fits all” solution
- Develop a Plan (facility specific)
- Create Barriers
- Disinfection
What do you consider when assessing risks posed by new pathogens?
How is the disease transmitted?

- Example of modes of disease transmission in humans
  - Respiratory - influenza
  - Fecal-oral – cholera
  - Direct contact – athlete’s foot
  - Sexual - chlamydia
  - Vertical - syphilis

- Now, think in terms of a fish’s environment and biology
  - Respiratory
  - Fecal-oral
  - Direct contact
  - Sexual
  - Vertical
  - Water env
• Horizontal transmission – pathogen goes directly from one fish host to the next

Most common route of transmission

Controlled by good husbandry
Horizontal Transmission

• Water sources
  – Good medium for transfer of pathogens
  – Movement of contaminated water during transport
  – Aerosol, spray/splashing between tanks
Horizontal Transmission

• Oral
  – Consumption of disease agent
    • contaminated feed
    • cannibalism of dead or dying fish
    • Ingestion of water contaminated with waste products from infected fish
• Vertical transmission – an infected adult fish (usually female) passes the infection to progeny (eggs)

Egg-associated – control by disinfection

Inside egg – difficult to control
• Indirect transmission – usually involves pathogens that have complex life cycles
Disease Transmission

• Fomites (inanimate objects)
  – Can transfer pathogens between rearing areas of production sites
    • Standard equipment
    • Nets, buckets, siphon hoses, footwear, clothing, contaminated vehicles, etc.
Disease Transmission

• Vectors
  – Living creatures that can spread disease agents
    • Fish-eating birds
    • Rodents – can transfer some fish pathogens by contaminating environment or fish feed
    • People – probable most common vector during handling of fish
Does the Pathogen Exist in a Carrier State?

Carrier: individual that is not sick that harbors a pathogen which may cause disease in those to whom it is transmitted

1) Fish become infected, but disease doesn’t develop

2) Disease survivors are immune but may still carry and shed pathogen
Does the Pathogen Persist in the Environment?

Are the Aquaculture Species Susceptible?

Can the Disease be Treated?
Biosecurity Measures

Identify Risk Areas:

1. Fish Movement
2. Water sources
3. Vectors
4. Fish health
5. Equipment & Vehicles
Risk Assessment: Introduction

INTRODUCTION

- Fish Transfer
  - Species
    - Fry
    - Juveniles
    - Adults

- Recreation
  - Boaters, anglers

- Commercial
  - Infected fish products

Natural Dispersal
Risk Assessment: Disease

Pathogen

Disease

Species susceptibility

Size

Age

Virulence

Dose

Fish

Environment

Temperature

DISEASE

Species susceptibility

Size

Age

Virulence

Dose

Fish

Environment

Temperature
Developing a Plan

- Define sanitary units
- Separate/isolate units
- Restrict movement
- Communicate

- Make weekly, monthly, annual checklists.
- Define Cleaning & Disinfection protocols
Create Barriers

External Barriers
Block the spread of unwanted organisms onto and off of a facility

- Fish Movement
  - Stocking healthy fish, Quarantine new arrivals
- Water sources
  - Use pathogen free sources
- Vectors
  - Wild fish/animals, people, etc.
- Vehicles
Create Barriers

Internal Barriers
Block the spread of unwanted organisms around the facility

- Fish Health Records
  - Stress, water quality, nutrition, sick fish
- Equipment & Vehicles
- Vectors
Disinfection is important throughout all seasons and life stages of fish.

- Spawning
- Incubation
- Nursery
- Ponds and Raceways
- Empty ponds and Raceways
Definitions

• **Cleaner/Detergent** - serves to disperse and remove soil and organic matter from surfaces to allow disinfectants to penetrate

• **Sanitizer** - do not destroy all microorganisms

• **Antiseptic** - applied to the surface of living organisms to prevent microorganisms from multiplying and harming them

• **Disinfectant** - applied to surfaces to destroy or inactivate pathogenic microorganisms

• **Sterilization** - the process that destroys or eliminates all forms of life.
What do we know about VHSV that we can use to control its spread?
Where did it come from?

- Great Lakes Genotype IVb is not related to the European Genotype
  - most closely related to Genotype IVa

- It probably originated from marine fish off the Atlantic coast of North America
How did it get into the Great Lakes?

– Movement of infected fish?
  • Sport fishing (bait minnows, “ad hoc fish stocking”)
  • Natural fish movement

– Movement of water containing the pathogen?
  • Ballast water
  • Boating, contaminated live well water
  • Contaminated fishing equipment

– Animal predators (mammals, birds) are a lower risk
  • Virus does not survive long at high body temperature

– Basically – We don’t know how it got here
  • So it is difficult to determine what will facilitate its further spread
How is VHSV Transmitted?

• **Horizontal transmission
  – Through urine, feces, sex fluids
  – By ingesting infected fish
  – Reservoirs include carrier fish

• Vertical transmission has **NOT** been demonstrated for VHSV
  – Virus can be egg-associated

• Possible that blood feeding leeches and amphipods can transmit the virus between fish – not well documented
What do we know about VHSV that we can use to control its spread?

- Not currently found in Great Lakes aquaculture
  - Movements from certified facilities a low risk

- No treatment available

- Cultured salmonids may not suffer high mortality because of their low susceptibility to the virus; however, they may serve as carriers

- Therefore, impacts from introduction may be severe as regulatory agencies will likely require depopulation, disinfection and restrict movement
What do we know about VHSV that we can use to control its spread?

• Can infect a wide variety of fish and survivors may be lifelong carriers
  – Importing any species represents a risk

• Signs of disease can be variable and many fish die with no signs
  – Difficult to detect without culture/PCR

• Transmission is horizontal
  – Importation of properly disinfected eggs a low risk
What do we know about VHSV that we can use to control its spread?

• Virus persists days-weeks in water, longer in sediment
  – Need to disinfect equipment
    • Virkon Aquatic

• Disease is most likely to occur in spring as temperature fluctuate
  – Reduce stress during this period

• Drying and heat are effective in inactivating the virus

• Freezing significantly reduces virus infectivity
  – Live bait represent a higher risk than frozen
  – However, freezing does not eliminate risk
What are the future risks for aquaculture and wild fisheries?

• Long-term risk unclear
  – Are we over the worst outbreaks?
  – Will resistance develop in populations?
  – Is the current decrease in mortality just a factor of moderate temperatures and rainfall?
<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>High Risk</th>
<th>Low Risk</th>
<th>Very Low Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic connectivity</td>
<td>Connected with fish movement</td>
<td>Upstream, no fish movement</td>
<td>No connection</td>
</tr>
<tr>
<td>Linear distance</td>
<td>&lt;100 km</td>
<td>&gt;500 km</td>
<td></td>
</tr>
<tr>
<td>Known susceptible species</td>
<td>Yes, with areas of congregation</td>
<td>Yes, but no congregation areas</td>
<td>No</td>
</tr>
<tr>
<td>Conducive water temperatures</td>
<td>Cool to cold water (8-12C)</td>
<td>Below 8C, above 12C</td>
<td>18C and above</td>
</tr>
<tr>
<td>Fomite exposure</td>
<td>Yes, shared traffic or wastes</td>
<td>Yes, but limited by education or regulation</td>
<td>No</td>
</tr>
<tr>
<td>Live fish transfer, bait, culture, stocking</td>
<td>Yes, without testing</td>
<td>Yes, with testing</td>
<td>No transfers</td>
</tr>
<tr>
<td>Frozen fish transfer</td>
<td>Yes, without testing</td>
<td>Yes, with testing</td>
<td>No transfers</td>
</tr>
<tr>
<td>Regulatory framework</td>
<td>Insufficient</td>
<td>Sufficient</td>
<td></td>
</tr>
</tbody>
</table>

Viral hemorrhagic septicemia virus (VHSV IVb) risk factors and association measures derived by expert panel
Recommendations

– Improve pathogen detection
– Enhance surveillance
– Rigorous biosecurity in culture facilities
– Eliminate fish transfers between waters or require testing
– Improve practices of bait industry and restrict risky uses of baitfish
– Require emptying live wells and bilges when leaving boat launches in positive areas
Current Provisions Under the APHIS Federal Order

• VHS susceptible species are prohibited from moving out of the 8 States and 2 Canadian Provinces bordering the Great Lakes except under certain conditions
  – Movement to slaughter with adequate disinfection
  – Movement to a research or diagnostic lab with adequate disinfection
  – Movement of live fish testing negative for VHS virus by laboratory assays
  – Movement of salmonids from Canada that meet Title 50 requirements
Regulated Aquaculture Species
http://www.aphis.usda.gov/animal_health/animal_dis_spec/aquaculture/

- Black Crappie
- Bluegill
- Bluntnose Minnow
- Brown Bullhead
- Brown Trout
- Burbot
- Channel catfish
- Chinook Salmon
- Emerald Shiner
- Freshwater Drum
- Gizzard Shad
- Lake Whitefish
- Largemouth Bass
- Muskelunge
- Northern Pike
- Pumpkinseed
- Rainbow Trout
- Redhorse Sucker
- Rock Bass
- Round Goby
- Shorthead Redhorse
- Silver Redhorse
- Smallmouth Bass
- Spottail Shiner
- Trout-Perch
- Walleye
- White Bass
- White Perch
- Yellow Perch
Next Steps

• Develop a rule to replace the emergency Federal Order
  – Potential scope of the regulations
    • Affected watersheds?
    • 4 States that currently have had outbreaks?
    • 8 Great Lakes States?
    • All 50 States?
    • All VHS virus strains or IVb?
  – Will provide for specific testing requirements
What happens if VHSV is found on a facility

- VHSV is a reportable disease and requires notification of USDA-APHIS
  - who in turn notifies the World Animal Health Organization (OIE)

- Detection will most likely involve destruction of infected lots and/or all fish at the facility
What additional information is needed?

• Methods for detecting virus in water
• Effectiveness of egg disinfection for non-salmonid eggs
• Additional species susceptibility
  – E.g. sturgeon
• More rapid detection methods
  – Ability to differentiate between type IVa and IVb
Available Outreach Information

http://www.focusonfishhealth.org/outreach-campaign.php
Questions?