

Disease Risks Posed by Hatchery Salmon

James Winton

**US Geological Survey
Western Fisheries Research Center
Seattle, Washington**

Disease in Populations of Wild Fish

- Disease is a component of natural mortality in all ecosystems
- Features of the host, pathogen and environment determine the ecology of fish disease
- Limited understanding of disease in populations of wild fish
- Most diseases of wild fish are caused by endemic pathogens
- Fish in normal ecosystems are typically in balance with disease
- Severity of disease may increase when conditions change
- Explosive outbreaks may follow first encounter with a new pathogen
- The role of hatcheries in the ecology of disease in natural populations of fish is poorly studied

Potential Disease Risks Associated with Salmon Hatcheries

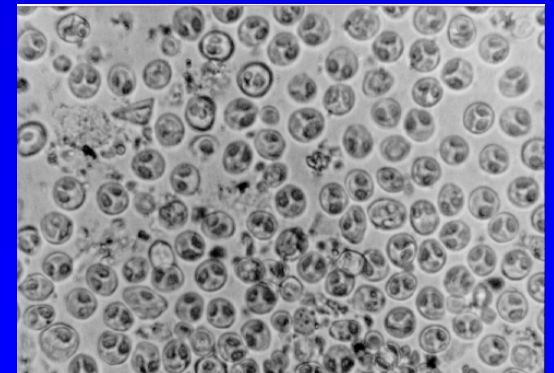
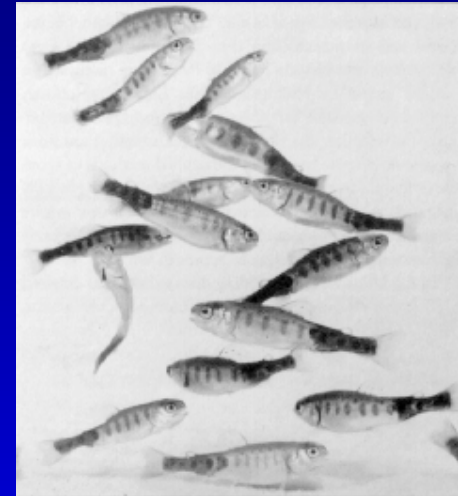
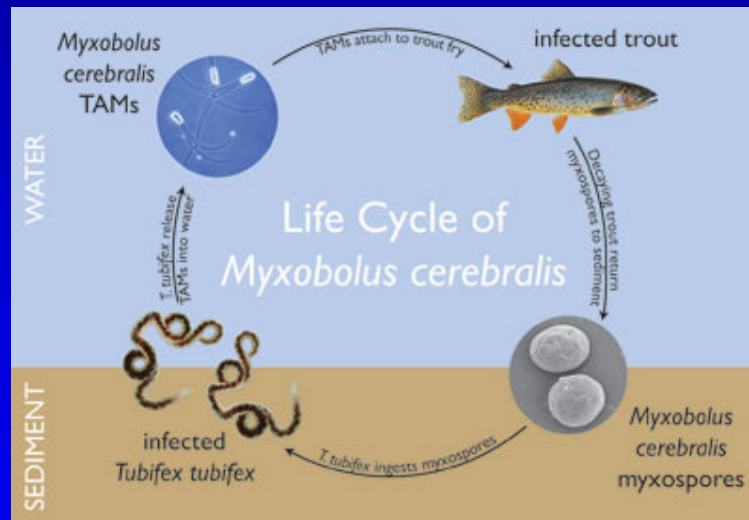
- Introduction of exotic pathogens
- Amplification of endemic pathogens
- Release of infected fish that contact wild stocks
- Provide a source of infection at unnatural times
- Alter frequency of genes associated with resistance
- Release of susceptible fish that amplify disease in wild
- Introduction of pollutants or stressors to ecosystem

From Naish et al. 2008

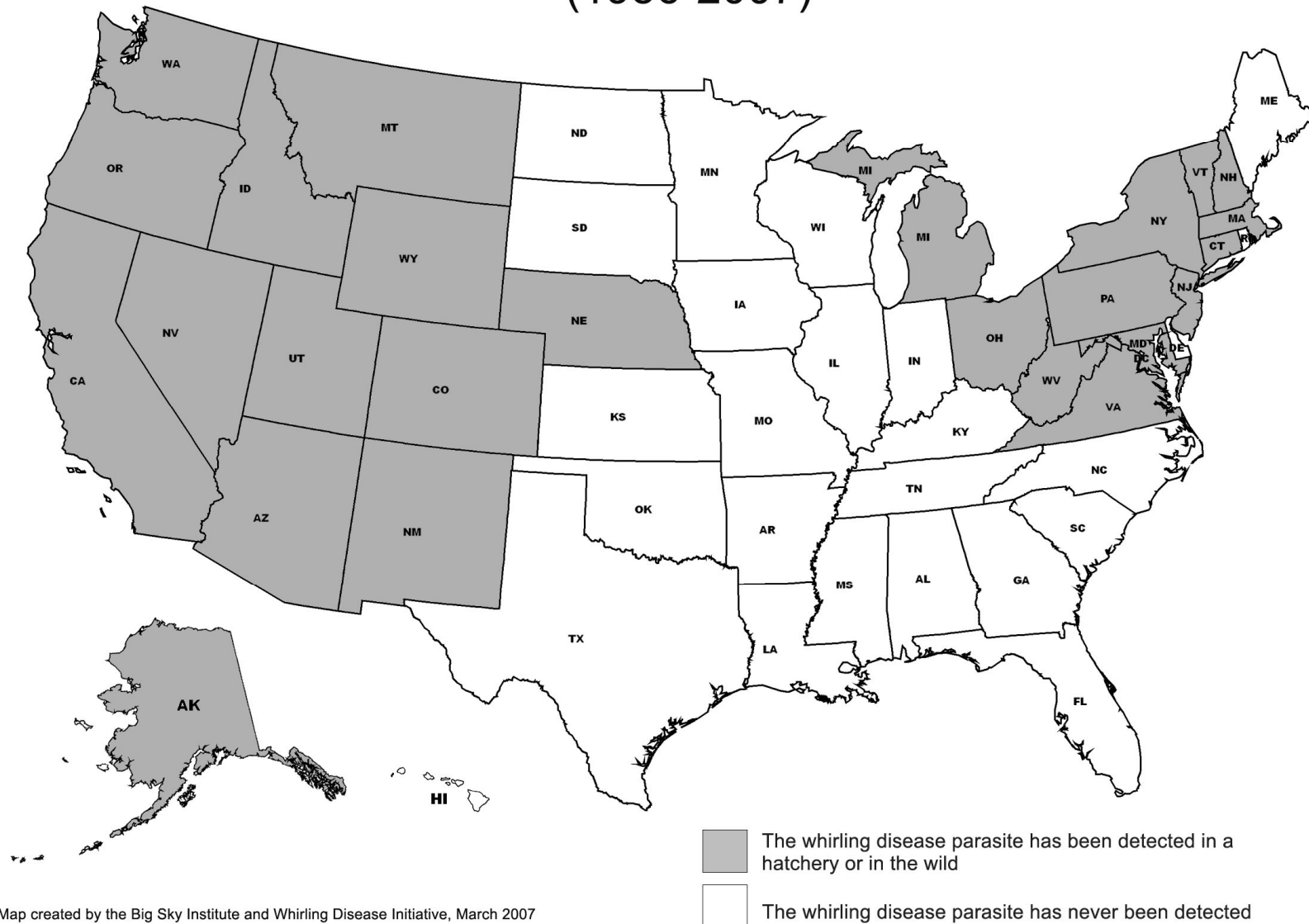
Introduction of Exotic Pathogens

- Greatest threat to native, wild and free-ranging fish
- Often associated with public hatcheries or private aquaculture facilities
 - Movement of live, infected fish or eggs between watersheds
 - Use of raw fish or fish products as food
- Other pathways also important
 - Movement of baitfish by anglers
 - Ballast water
 - Migratory fish
- Whirling disease and gyrodactylus are examples

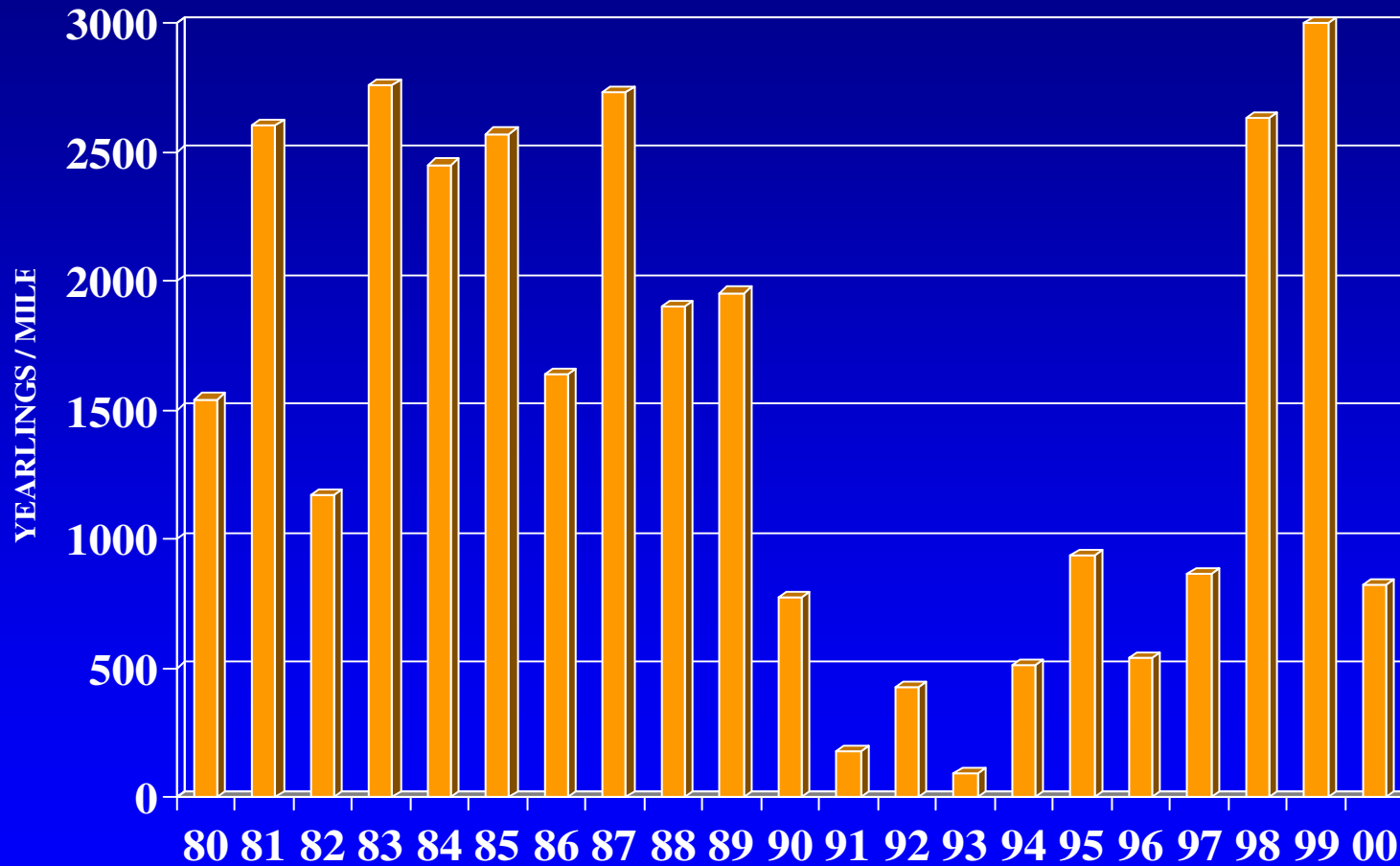
Whirling Disease



Detection of the whirling disease parasite in the United States (1956-2007)



Yearling Class Strength in Madison River (1980-2000)

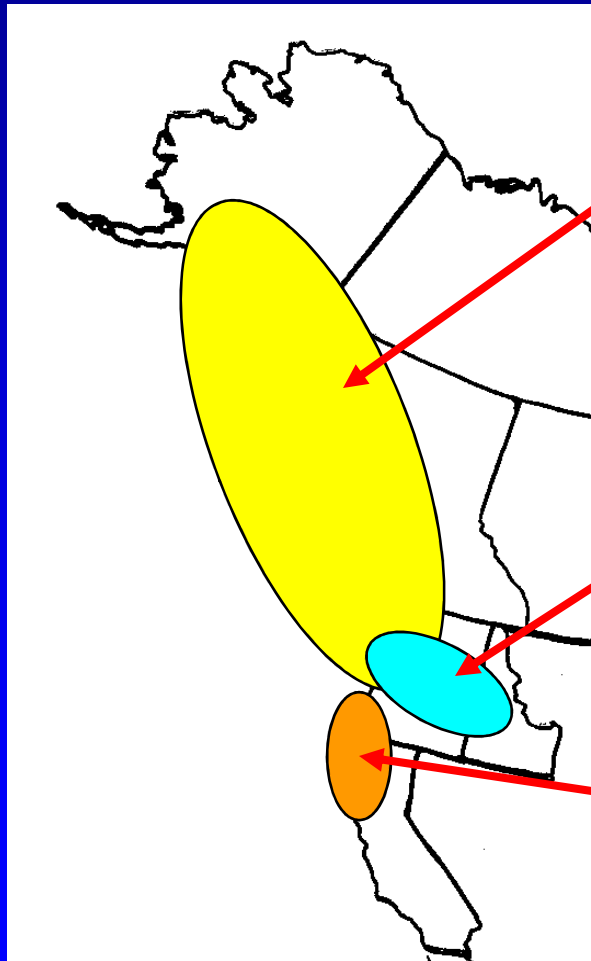
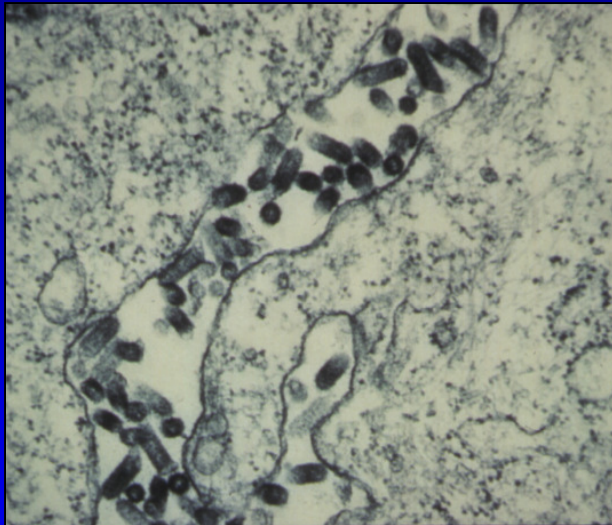


Whirling disease introduced in 1987

Amplification of Endemic Pathogens

- Second greatest threat to native or wild stocks
- Involves pathogens already in system (typically maintained among wild fish)
- Hatcheries can produce very high levels of pathogens
- Hatchery fish can also provide selective pressure on endemic pathogens (e.g. adaptation to new species)
- Stability of pathogen and exposure history of wild stocks are important factors
- Sea lice and infectious hematopoietic necrosis virus are examples

Infectious Hematopoietic Necrosis Virus in Steelhead



U

Upper region - Alaska, British Columbia and Washington.
Mostly sockeye salmon

M

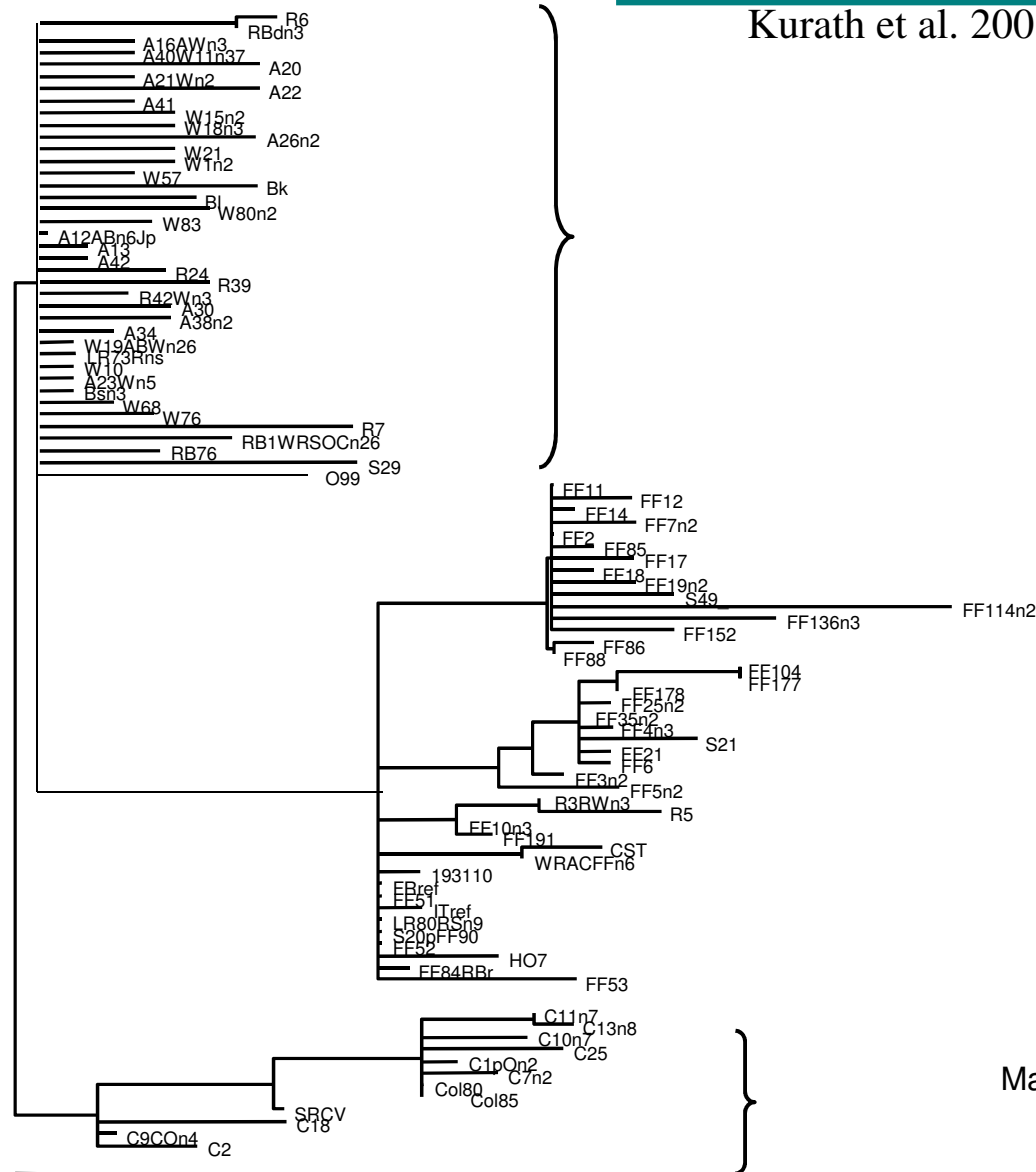
Middle region - Hagerman Valley, Idaho extending into lower Columbia River Basin.
Mostly rainbow and steelhead

L

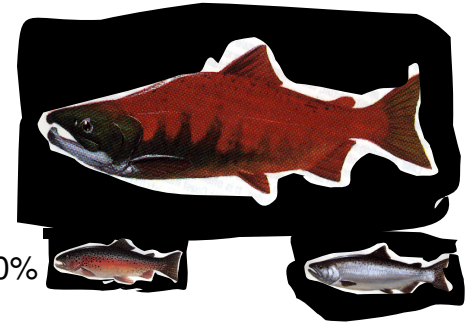
Lower region - Sacramento River Basin, coastal rivers of Northern California and Southern Oregon.
Mostly affects Chinook

IHN Virus Phylogeny

Kurath et al. 2003



U genogroup
Maximum diversity 3.0%



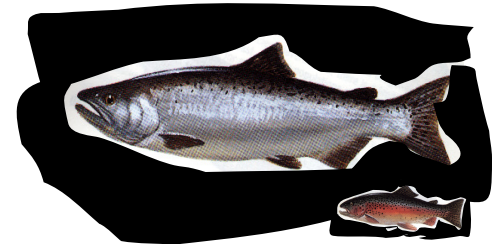
Sockeye,
chinook, steelhead

M genogroup
Maximum diversity 7.6%



Rainbow trout
steelhead

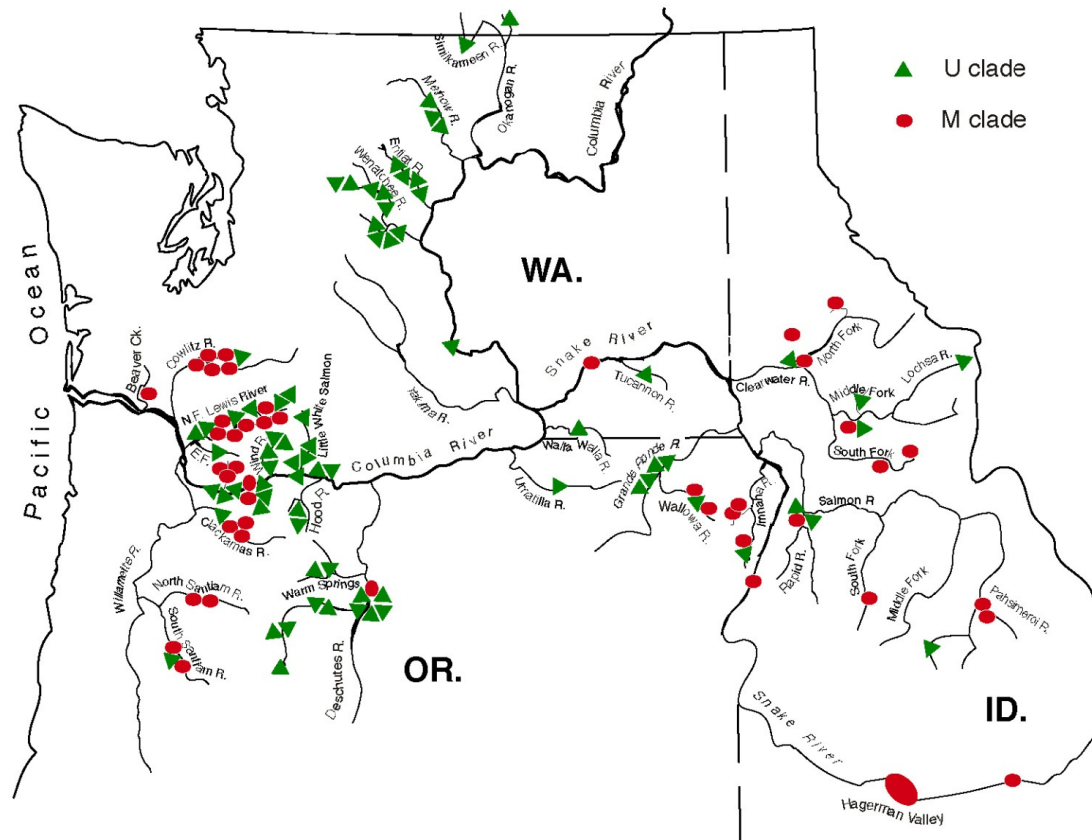
L genogroup
Maximum diversity 3.3%



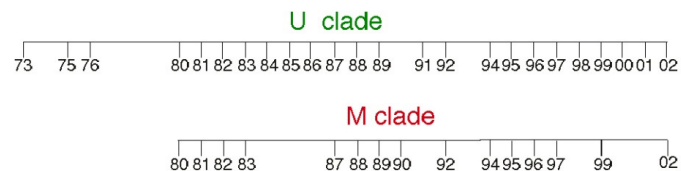
Chinook, steelhead

IHNV in the Columbia River Basin

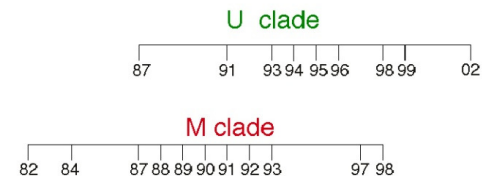
- M group virus
- ▲ U group virus



Lower and Middle Columbia River basin



Snake River and Tributaries



M-type IHNV in Olympic Peninsula Steelhead

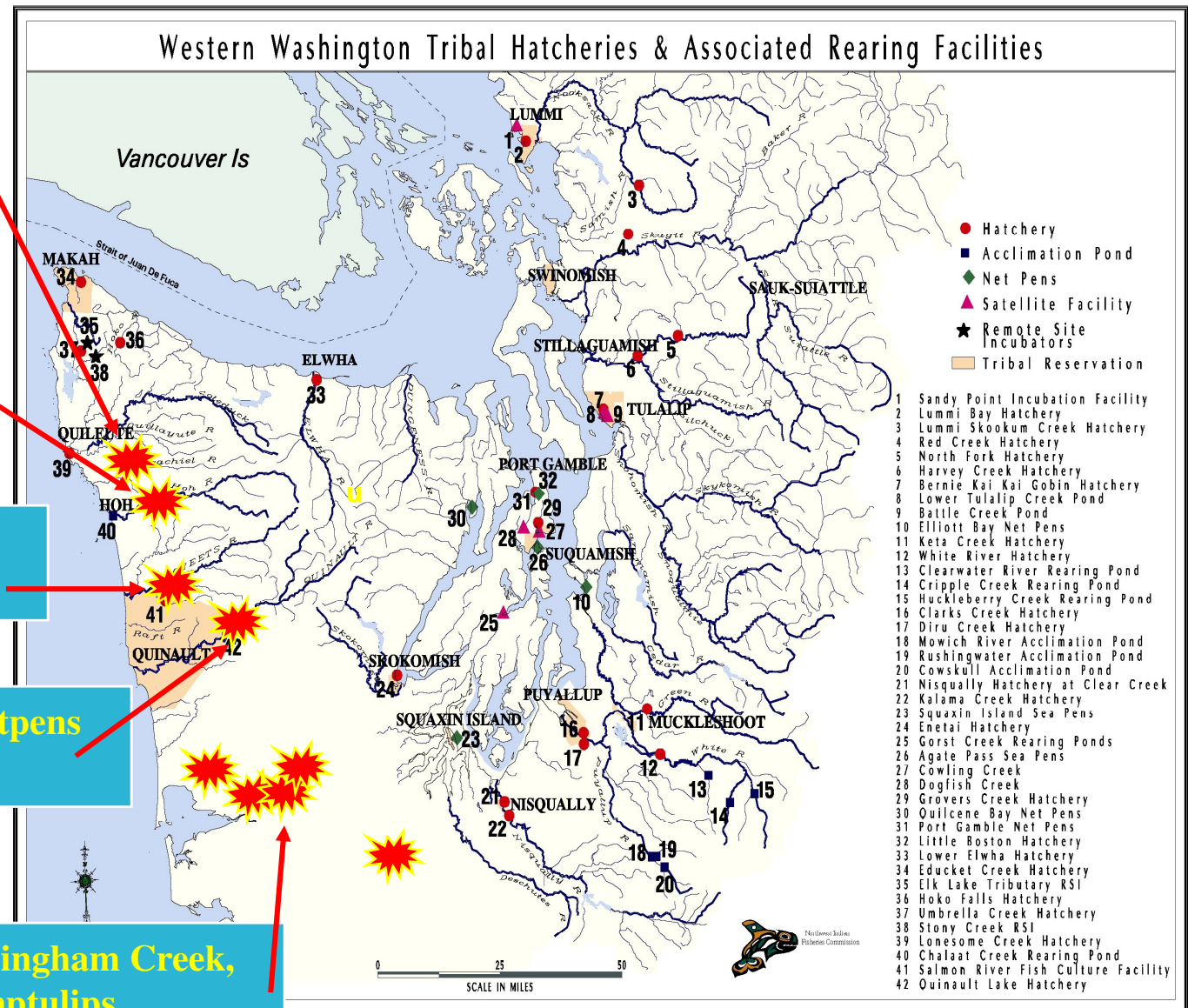
2009 Bogachiel Hatchery
Steelhead adults

2010 Hoh River Wild
Steelhead adults

2007 Salmon River Hatchery
Steelhead juveniles

2008-2009 Lake Quinault Netpens
Steelhead adults, yearlings

2007-2009 Skookumchuck, Bingham Creek,
Satsop, Lake Aberdeen, Humptulips
Steelhead adults, juveniles, yearlings



Release of Infected Fish that Contact Wild Stocks

- Infected animals released by hatcheries can associate with native or wild stocks
- Hatchery fish may have higher intensity or prevalence of infection than native fish
- These animals may provide greater source of infection than typically present in natural systems
- Some activities (e.g. collection facilities at dams or barging) can increase stress and opportunity for contact
- Bacterial kidney disease and infectious hematopoietic necrosis virus are examples



Provide a Source of Infection at Unnatural Times

- Fish in hatcheries can maintain some infections for a prolonged period
- Hatcheries may rear species or developmental stages that are different from the natural system
- Release of such fish or the hatchery effluent may provide source of infection for wild fish at times or life stages not typical of nature
- Infectious hematopoietic necrosis virus may be example

Source of infections at abnormal times or life stages

Box Canyon Facility Clear Springs Foods, Inc



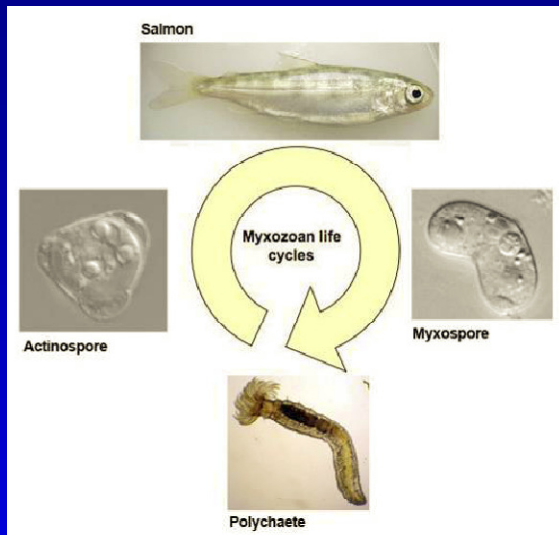
Photo: courtesy of Scott LaPatra

- IHNV is present year-around in the commercial aquaculture hatcheries of the Hagerman Valley of Idaho
- Steelhead reared in the region may acquire IHNV infections before outplanting as smolts

Alter Frequency of Genes Associated with Resistance

- Hatchery programs may use stocks having differences in disease resistance from wild stocks
- Hatcheries can exert (sometimes intense) selection
 - Positive selection from large outbreaks
 - Relaxed selection by disease avoidance
 - Disease resistance may be reciprocal
- Interbreeding with hatchery fish may alter frequency of genes or alleles associated with disease resistance in the wild stock
- *Ceratomyxa shasta* is example

Ceratomyxa shasta



J. Bartholomew



Wikipedia

- Buchanan et al. (1983) reported an Oregon coastal stock of steelhead was highly susceptible to infection compared to three Columbia River tributary stocks where the parasite is endemic.
- Initial use of susceptible stocks of steelhead in Columbia River Basin hatcheries was probably the reason that few, if any, fish survived to return.
- Ibarra et al. (1992) reported crosses between susceptible and resistant stocks of rainbow trout yielded progeny with susceptibilities intermediate between the parental stocks.
- Currens et al. (1997) Showed introgression with susceptible, non-native, hatchery rainbow trout reduced resistance of wild trout in Metolius River of Oregon.

Release Susceptible Fish that Amplify Disease in the Wild

- Hatcheries pathogen-free water supplies may release fish that have not encountered certain diseases
- These naïve fish may acquire infections after release
- Such fish may provide source of infection for wild fish at times or life stages not typical of nature
- *Ceratomyxa shasta* and *Parvicapsula minibicornis* in the Klamath River Basin are partial examples

Disease transmission to naïve hatchery fish

Iron Gate Hatchery



Klamath Basin Tribal Water
Quality Work Group

- A high proportion of marked hatchery salmon released into the Klamath or Trinity Rivers as disease-free smolts were found infected upon recovery downstream
- Origin of infections presumed to be from natural sources
- Significant disease with apparent loss of infected hatchery fish within river
- Transmission or risk to wild fish not demonstrated

Introduce Pollutants or Stressors to Ecosystem

- Effluent from large hatchery may have local effects
 - Release of chemicals (drugs, antibiotics)
 - High loads of nutrients (algae growth, low D.O.)
 - Altered temperature
- Changes may increase stress to wild fish
- Most likely to occur in small watersheds

Lookingglass Hatchery



Acknowledgements

- Western Fisheries Research Center
 - Gael Kurath
- US Fish and Wildlife Service
 - Scott Foott
- Oregon State University
 - Jerri Bartholomew
- University of Washington
 - Kerry Naish
 - Thomas Quinn
 - Ray Hilborn
 - Rachael Life

