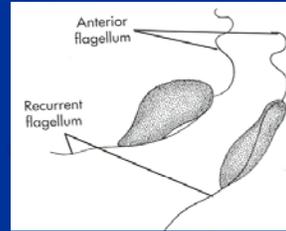


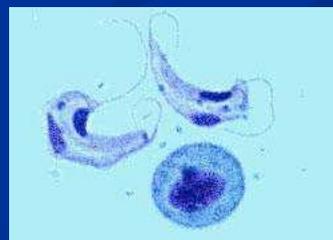
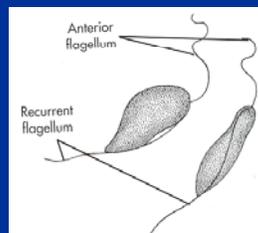
SECTION II: Internal Protozoa

- Includes flagellates and sporozoans (others not covered)
 - Phylum Myxozoa and Phylum Microspora
 - Responsible for the most serious of parasitic diseases
 - Very limited treatments



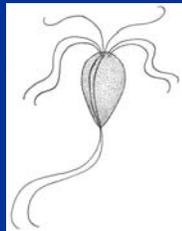
Internal Flagellate-*Cryptobia*

- Causes disease in marine and FW fish, worldwide distribution, similar to *Trypanosoma*.
- 52 spp found in blood or digestive tract (5 spp are ectoparasites)
- *Cryptobia salmositica* found in blood and transmitted indirectly by blood-sucking leeches
- Clinical signs: anorexia, exophthalmia, abdominal distension, and enlarged spleen. Anemia with blood *Cryptobia*. Use wetmounts for diagnosis.



Internal Flagellate-Diplomonads

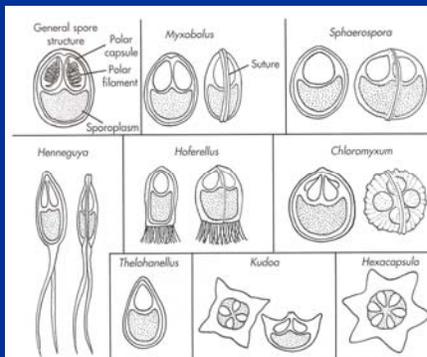
- Includes *Hexamita* and *Spirotrunculus*, most frequently reported from the intestine
- Sometimes associated with morbidity and mortality, although subclinical infections are common. Stress may be a factor.
- Clinical signs can include, anorexia, emaciation, poor growth, whirling, pale gills, abdominal distention, fecal pseudocasts, red vent, dark coloration and popeye



Sporozoans

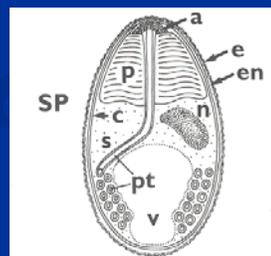
- **Spore producers:**
 - **Myxozoa**—exhibit multicellular spores with nematocyst-like polar capsules. Over 1,000 described species. Causes heavy infections & diseases in cultured fish. Spores are infective to oligochaetes (and other invertebrates). Limited treatments.
 - **Microspora**—simple spores with an elaborate polar tube, not confined in polar capsule. Spores are infective to fish.

Myxozoa



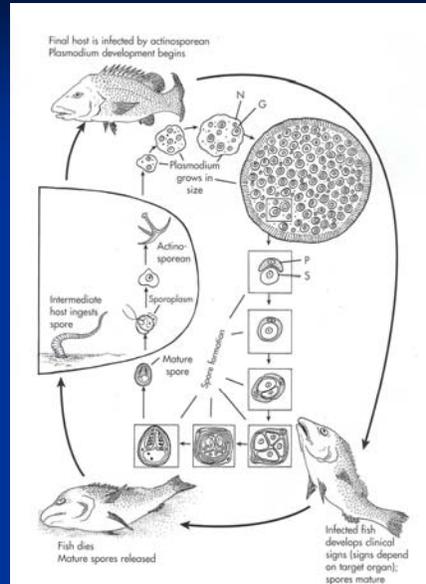
From E. Noga 1996

Microspora



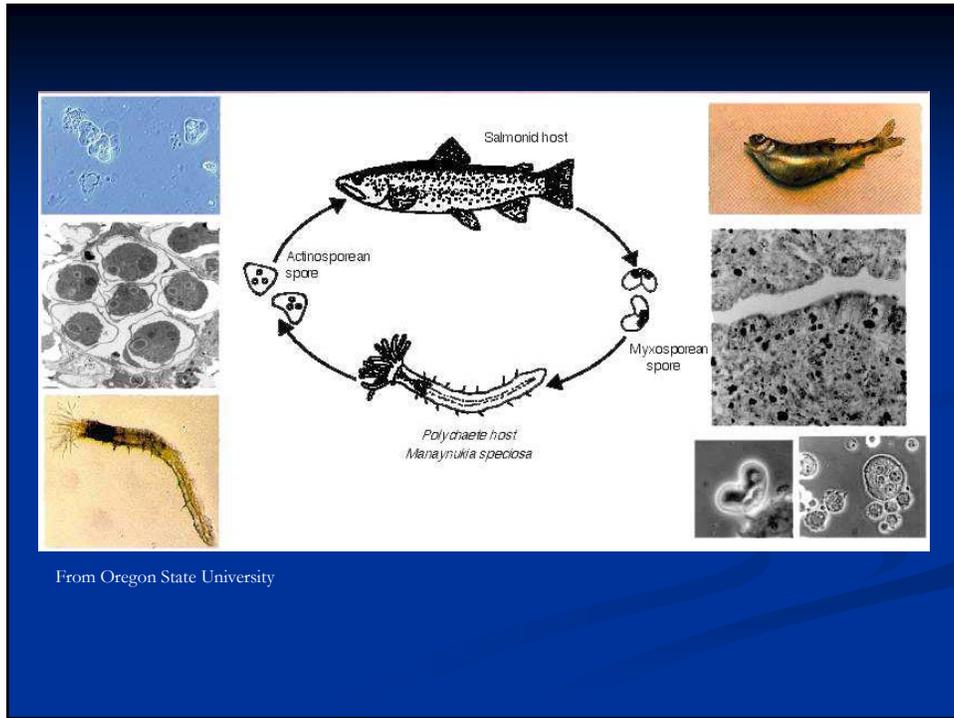
From PTK Woo 1995

Typical Life Cycle Myxozoan



Myxozoa-Ceratomyxa shasta

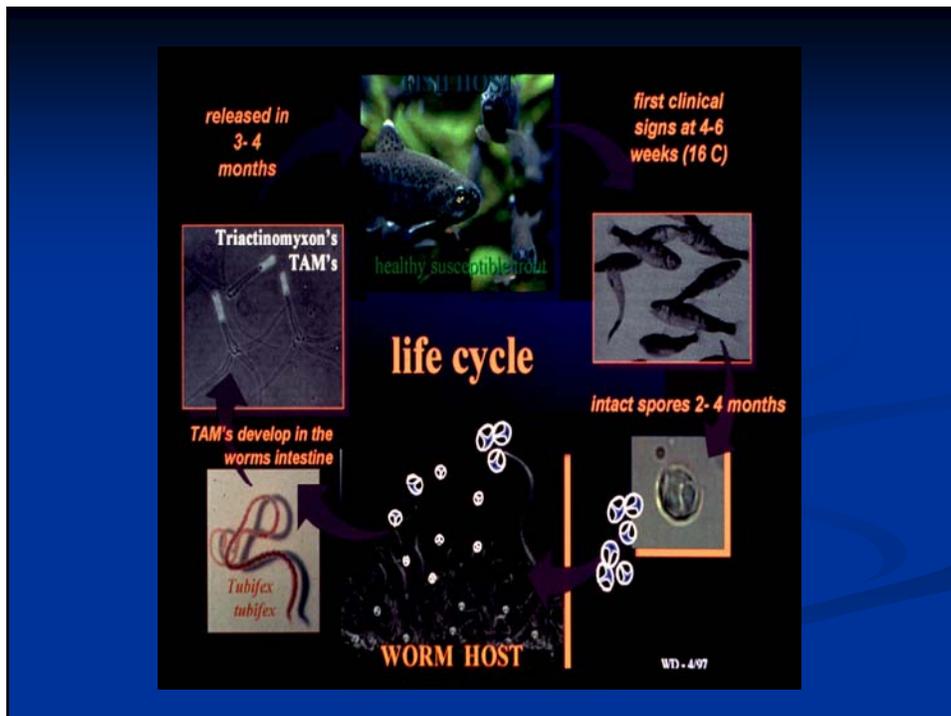
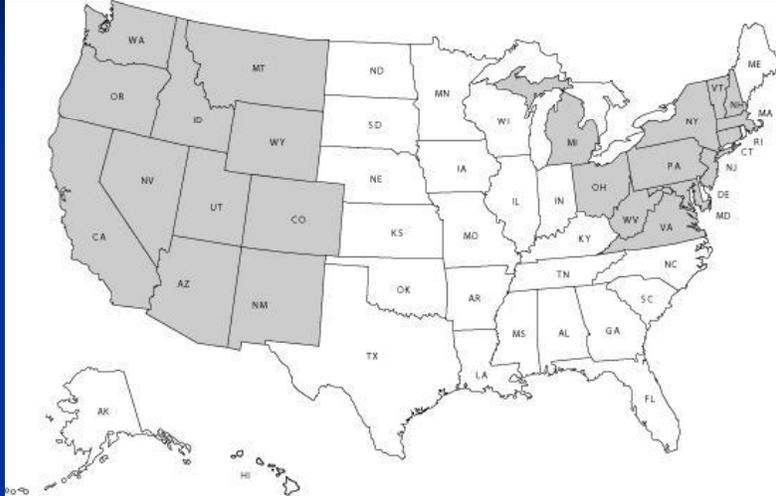
- Causes Ceratomyxosis which affects salmonids (especially rainbow, cutthroat, chinook and chum salmon) primarily in western US & Canada.
- Can cause up to 100% mortality in young fish and pre-spawning mortality in adult fish
- GI is the main target, especially the intestine
- Classic clinical sign is abdomen is distended. Vent may also be swollen.
- Diagnosis is based on identification of typical spores in lesions or scrapings of the intestinal lumen



Whirling Disease-*Myxobolus cerebralis*

- Reported worldwide, including Europe, South and North America, Australia and New Zealand. Most severe intermountain west.
- All salmonids are susceptible to varying degrees, with rainbow trout the most susceptible.
- Younger fish more susceptible, may see 100% mortality in newly hatched fry.
- Parasite attacks cartilage, especially in the head and spine. Clinical signs include scoliosis, axial skeleton deformities and pigment abnormalities (sometimes called black-tail disease. Fish may also “whirl” due to destruction of cartilage around the auditory capsule.
- Some success with Fumagillin treatment – especially with eggs

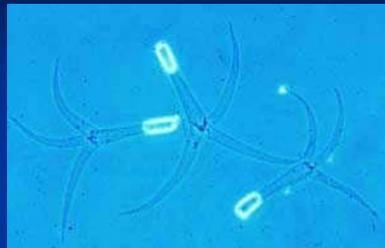
Whirling Disease-*Myxobolus cerebralis* – Distribution



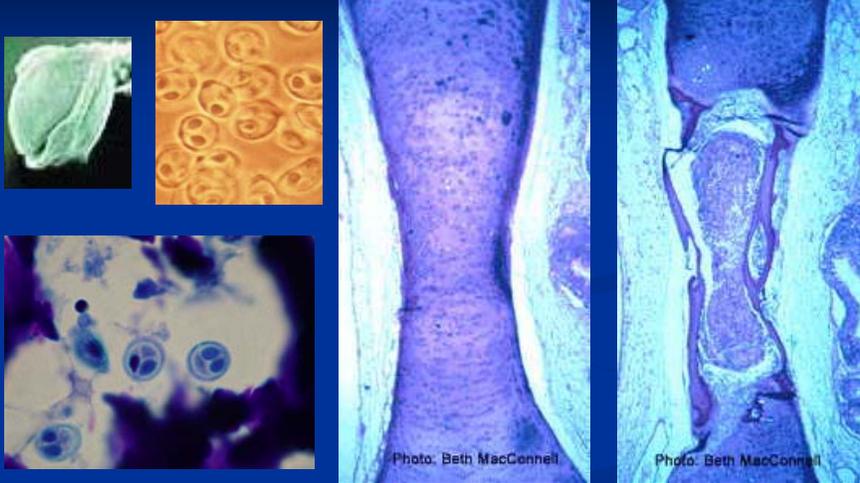
Whirling Disease-*Myxobolus cerebralis*-Clinical signs



Whirling Disease-*Myxobolus cerebralis*-Tubifex host



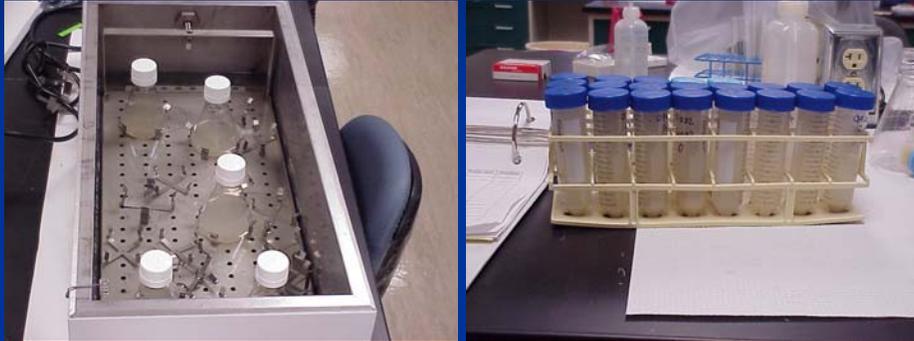
Whirling Disease-*Myxobolus cerebralis*-Diagnostics



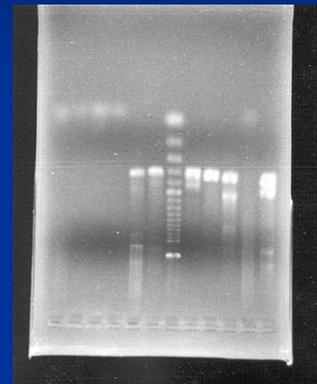
Whirling Disease - PTD Screening



Whirling Disease - PTD Screening



Whirling Disease-*Myxobolus cerebralis* – PCR Confirmation of Screening Tests



Myxozoan Infections-Proliferative Gill Disease

- Affects the gills, early on gills are pale and swollen. Later stages the lamellae are thickened, blunted and bleed easily (aka hamburger gill disease)
- Found in channel catfish throughout SE USA & California
- Low-to-high mortality (up to 95%)
- Occurs most commonly 16-20°C
- A myxozoan infection, “pre”sporogenic stages in the gills and final spore formation in the kidney. Stage in gills causes degeneration and necrosis of gill ray tissue (*Aurantiactinomyxon ictaluri* found in oligochaete worm, *Gero digiatata*)

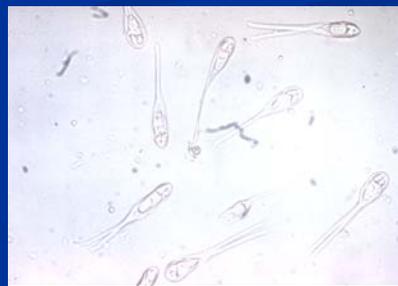
Proliferative Gill Disease



From Noga 1996 (A. Mitchell)

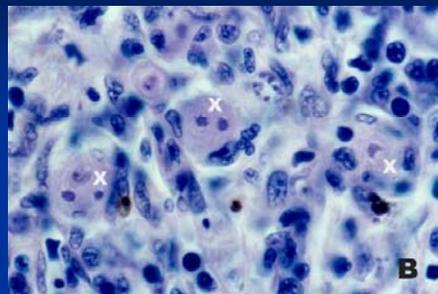
Myxozoan Infections-*Henneguya*

- Approximately 17 different species which can affect a variety of freshwater fish
- Often appears as white cysts in the gills of catfish.
- Can also cause lesions, hemorrhage on the skin
- Distinctive spore: has two caudal appendages



Myxozoan Infections-Proliferative Kidney Disease

- Known as PKD; it is a serious disease of salmonids
- First reported in Europe and now found in Pacific NW.
- Affects the kidney and spleen. Clinical signs: swollen kidney and spleen, bloody fluid in visceral cavity, and pale gills (indicates anemia).
- Causative agent is the PKX parasite which is a prespore stage of *Tetracapsula byrosalmonae*. Instead of an annelid worm, it uses a bryozoan as an invertebrate host.



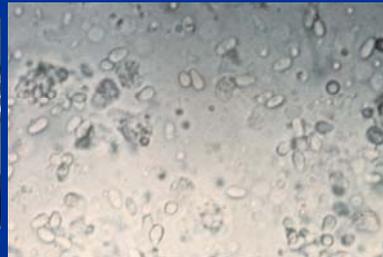
PKX (X) cells are surrounded by inflammatory cells in the kidney interstitium (Photo Oregon State University).

Protozoans-Microsporidia

- Microsporidians are intracellular parasites that require host tissue for reproduction
- Replication within spores (schizogony) causes enlargement of host cells (hypertrophy).
- Infected fish may develop tumor-like masses or cysts (xenomas) in various tissues.
- Clinical signs can vary from no visible lesions to mortalities.
- Diagnosis is by locating spores in affect tissues (in wet mounts or histologic sections)
- There is no treatment. Eliminate infected stocks and disinfect (spores are very resistant and survive for long periods).

Microsporidia-Pleistophora ovariae

- Infects the liver, kidney and ovary of golden shiners and fathead minnows
- In US may have a prevalence of 46% and dramatically affect the baitfish industry
- The parasite can reduce the spawn and growth of the fish



Microsporidia-*Heterosporis*

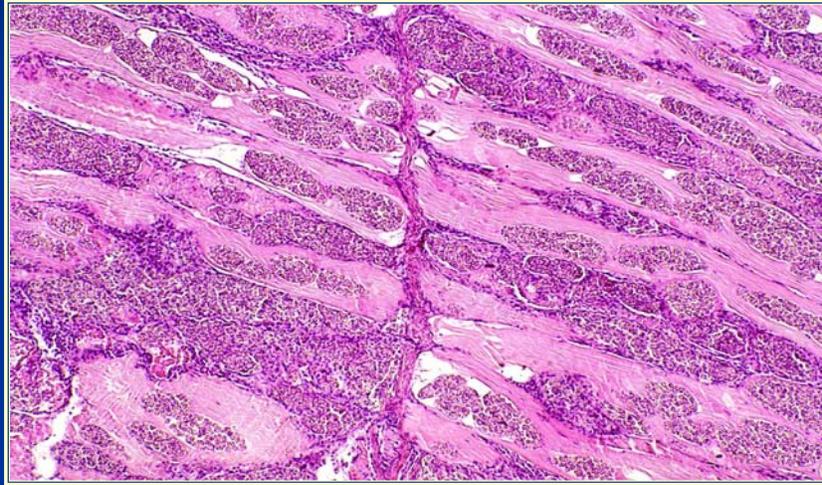
- Recently identified microsporidian of yellow perch, although it has wide host susceptibility



Affected muscle of a yellow perch

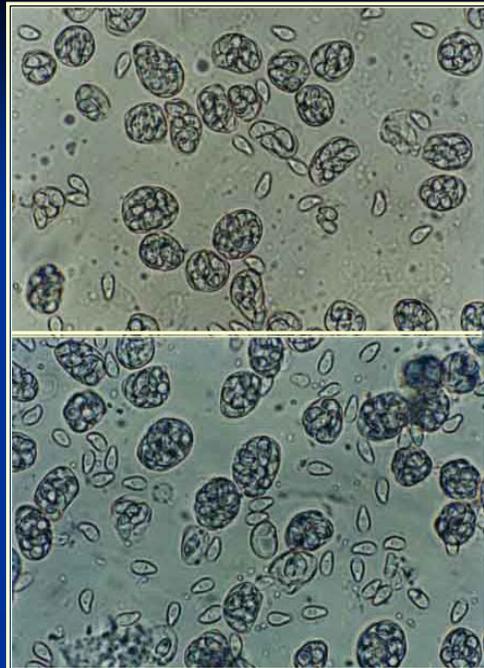


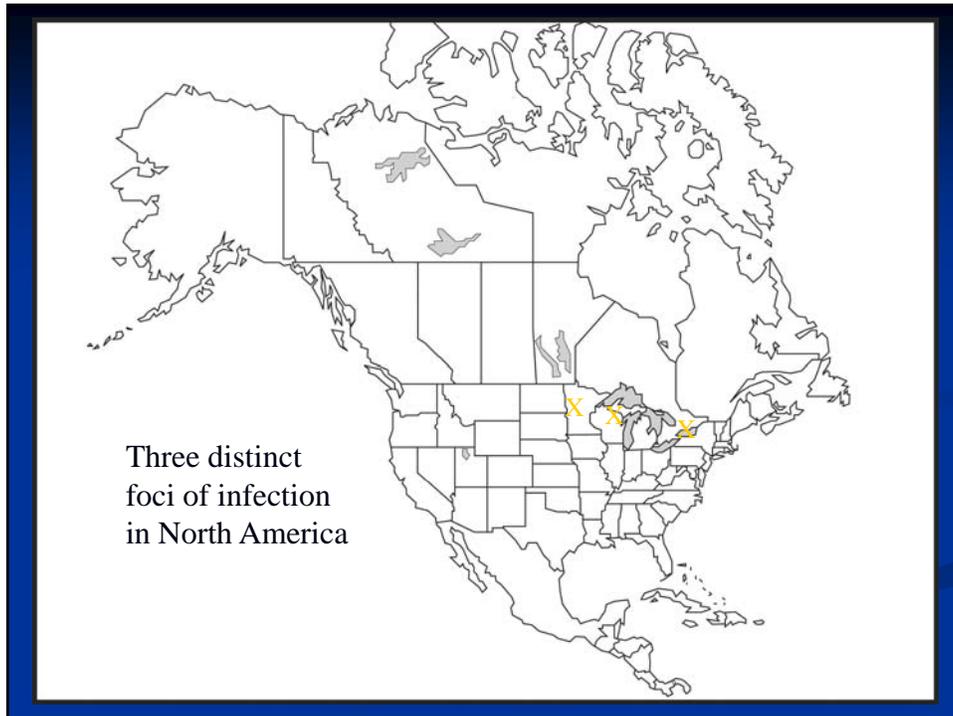
Heavily infected fillets may be mostly parasite



Wetmounts

- SPV's contain 8 or 16 spores
- SPV wall fairly resistant to rupturing





Reports of *Heterosporis* in North America

Yellow perch (*Perca flavescens*)

Chain of Lakes, Vilas Co., WI
 Robinson Lake, Forest Co., WI
 Leech Lake, Cass Co., MN
 Mille Lacs, Isanti Co., MN
 Lake Vermillion, Isanti Co., MN
 Lake Winnibigosh, Isanti Co., MN
 Bear Lake, Itasca Co., MN
 Moose Lake, Itasca Co., MN
 Northern Lake Ontario, Ontario
 Bay of Quinte, Ontario

Walleye (*Stizostedion vitreum*)

Big Sand Lake, Isanti Co., MN
 Chain of Lakes, Vilas Co., WI

Northern Pike (*Esox lucius*)

Clitheral Lake, Ottertail Co., MN

Catfish Lake, Vilas Co., WI

Mottled sculpin (*Cottus bairdi*)

Burbot (*Lota lota*)

Pumpkinseed (*Lepomis gibbosus*)

Rock Bass (*Ambloplites rupestris*)

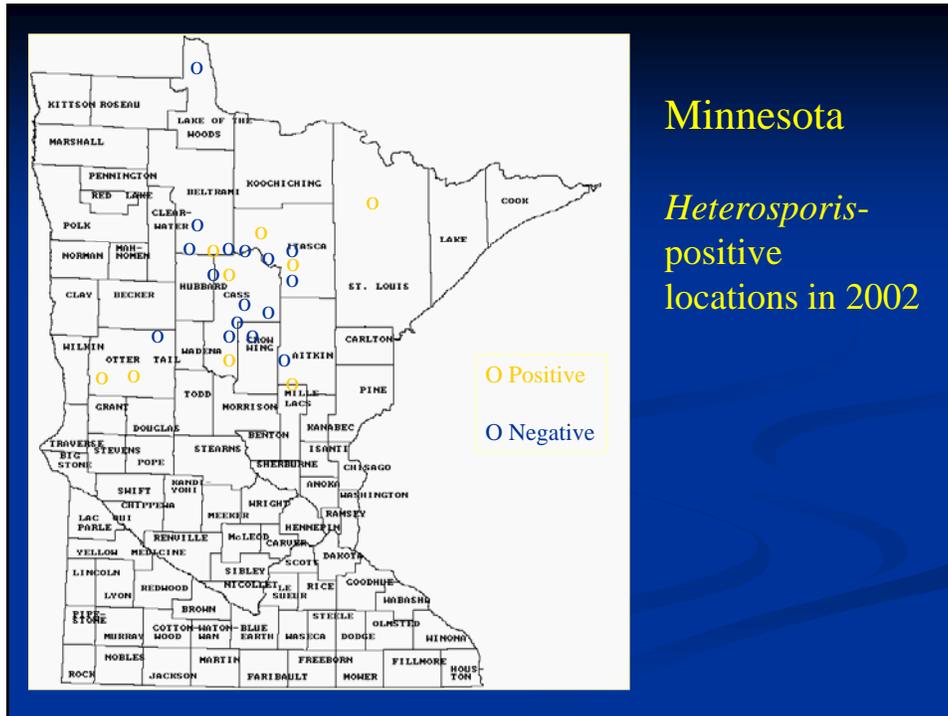
Trout Perch (*Percopsis omiscomaycus*)

Heterosporis-infected burbot (*Lota lota*)
from Catfish Lake, Wisconsin



**Vilas County,
Wisconsin**

**Chain of Lakes:
Headwaters of
Wisconsin River**



Microsporidia-*Glugea*

- Numerous species affected
- *Glugea* can infect multiple organs (attacks connective tissue)
- *Glugea anomala* is the best known species (infects sticklebacks)
- Forms xenomas that appear as white, usually spherical cysts.

