U.S. Fish & Wildlife Service

Overview of infection and disease problems in juvenile salmon of the Klamath River basin

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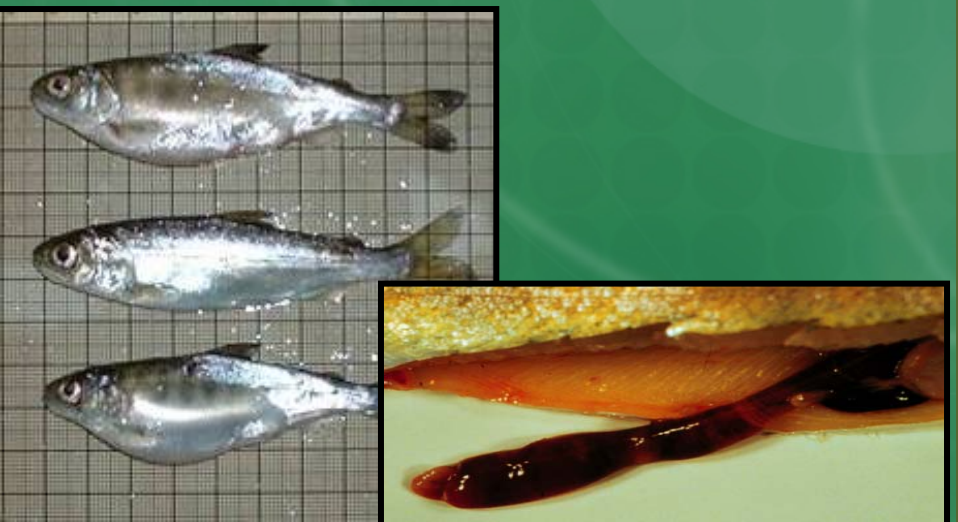
Early Observations

- Surveys in 1990s lead us to focus on 2 myxosporean parasites
  - *Ceratomyxa shasta*
  - *Parvicapsula minibicornis*
- *C. shasta* causes mortality in juvenile and adult salmonids. Less is known about *P. minibicornis*
  - Primarily in mainstem Klamath River (Shasta R. to Seiad Valley = “hot zone”)
  - Low levels in Trinity R.
- Unusual abundance and severity of infections in KR
  - Other river systems report <10% infection levels

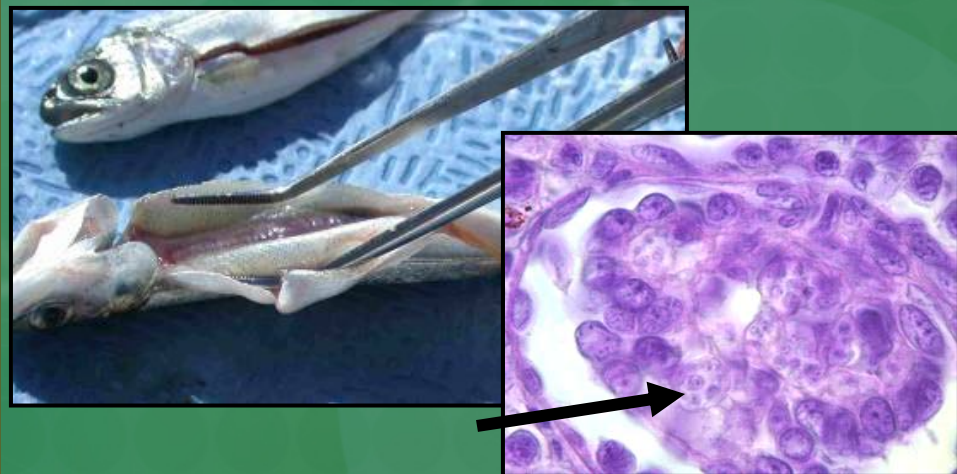
Ceratomyxa shasta

- Vertebrate host: salmon and trout
- Invert host: *Manayunkia speciosa*
- Target organ: intestine
- **Endemic** in many PNW watersheds. Host resistance varies.

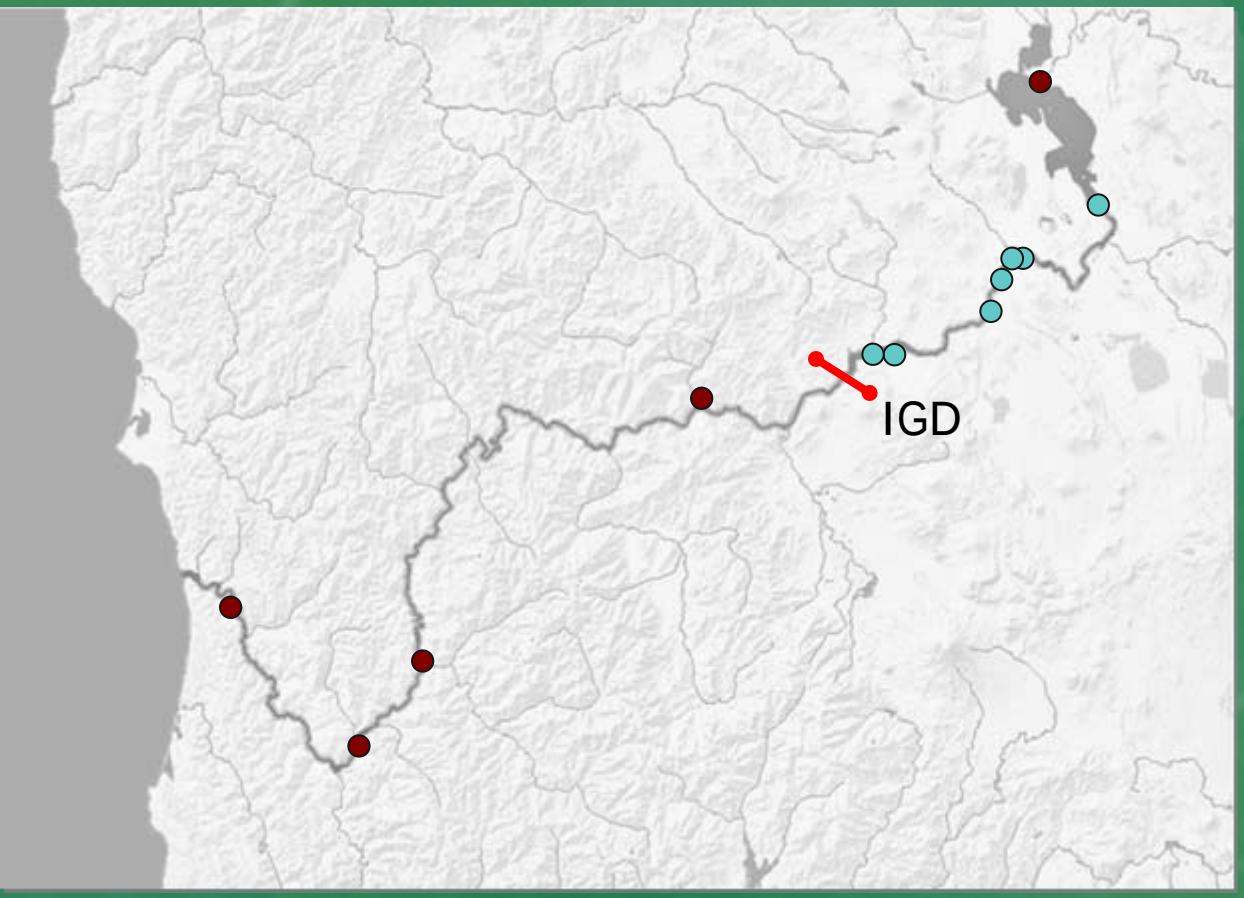


Parvicapsula minibicornis

- Vertebrate host: salmon and trout
- Invert host: *Manayunkia speciosa*
- Target organ: kidney
- Found in similar watersheds as *C. shasta.* Fish can recover from infection



Parasite Distribution

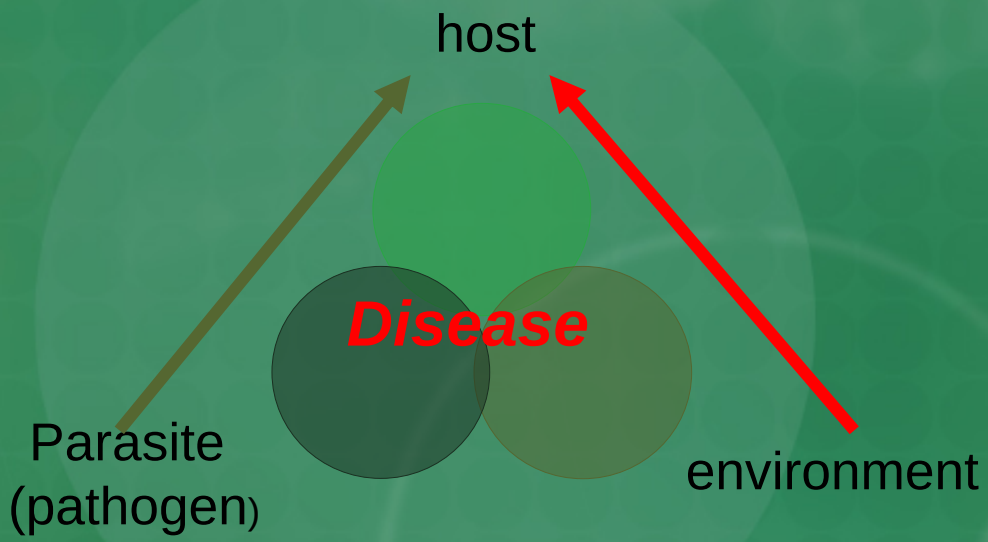


Infection severity high below IGD, low above projects

Fish did not become infected in tributaries, except:

- Williamson (high)
- Trinity River (low)

Host - Parasite - Environment

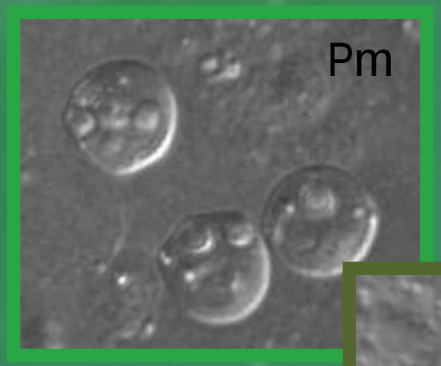


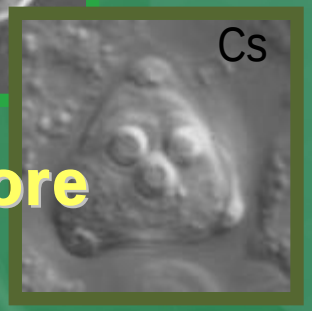
Severity of myxozoan infections below IGD in species that should have high resistance suggests a shift in the host: parasite balance

Chronic exposure to high levels of infectious stage overwhelms salmon resistance

Understanding what causes this shift:
parasite life cycles

Salmonid host





Actinospore stages

Myxospore stages

Polychaete host

BARTHOLOMEW ET AL. J. PARASITOL. 1997
BARTHOLOMEW ET AL. J. PARASITOL. 2006

Why are problems so severe in the river reach between Shasta River and the Seiad Valley?

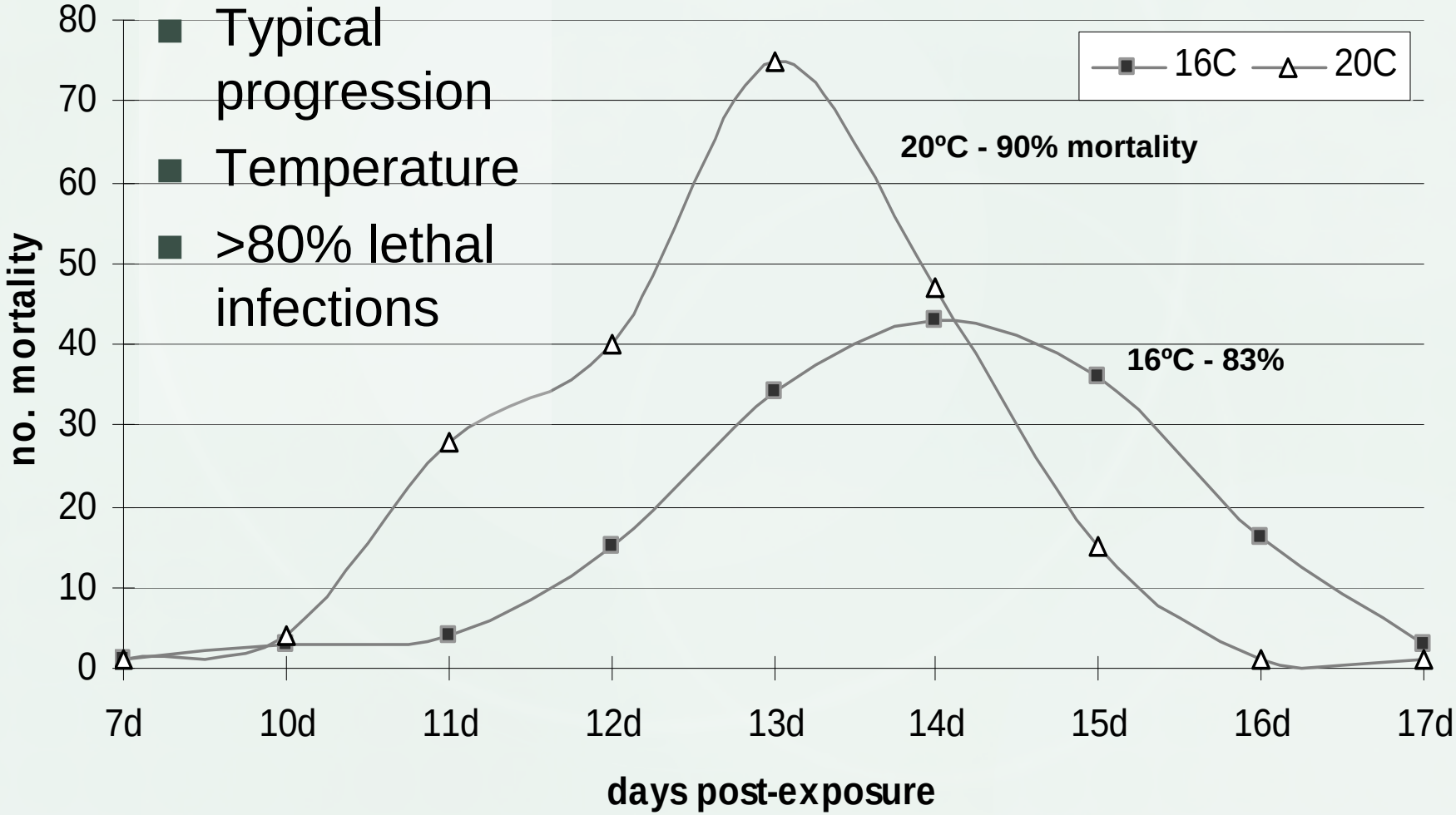
Hypotheses:

- **large numbers of adult salmon contributing myxospores**
- **dense populations of polychaetes**
- **high infection prevalence in polychaete populations**
- **below this reach, tributaries contribute to dilute parasites**

This focus of infection provides an opportunity for targeted actions

Sentinel Studies

What happens to infected fish?



Pathogen Incidence

How did 2008 stack up?

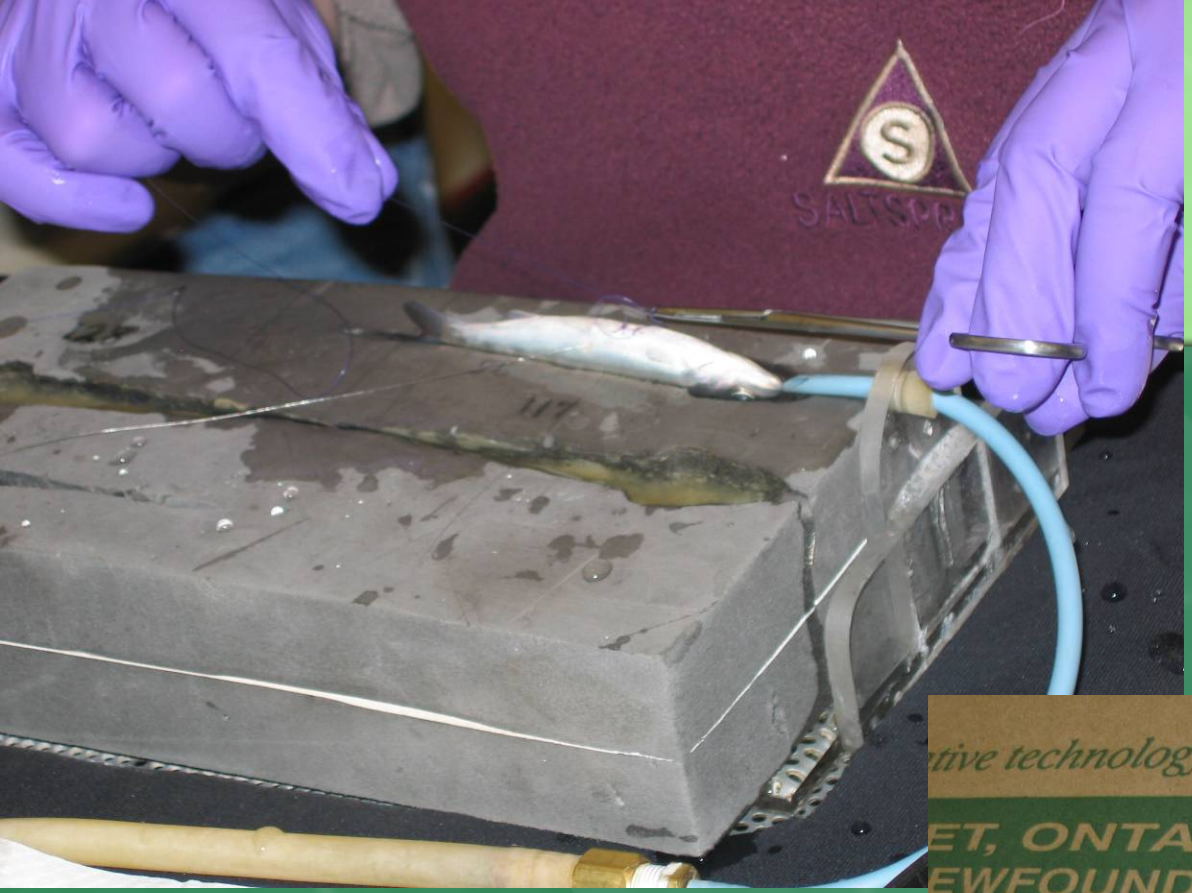
- *C. shasta*
  - 2004 34%
  - 2005 35%
  - 2006 21%
  - 2007 21%
  - 2008 37%
  - Peak typically 50-90% in May
- *P. minibicornis*
  - 58 - 92 %,
  - Typically > 90% by mid May and stays high
- Dual infection *Cs* and *Pm*
  - Cs infection ~ Pm infection

- Index of May-July pathogen prevalence
- 2008 appears high (preliminary)
- Pm more efficient at infecting Chinook
- Population impact highest when peak of infection coincides with peak of migration
- “Synergy”

2008 Preliminary Data
OSU & FWS

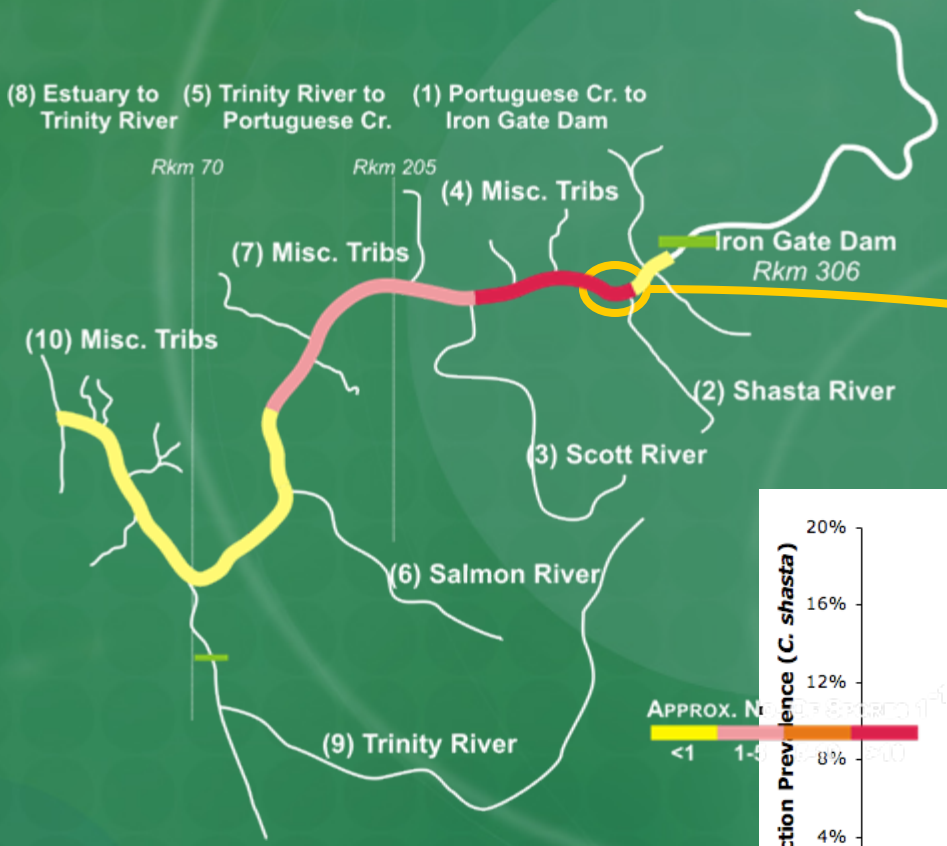
- Mortality due to ceratomyxosis
  - Chinook sentinels = > 92%
  - Coho sentinels = >83%
  - Sentinels held below “hot zone” < 20%
- Cs DNA abundant in water samples
- Radio tag Chinook survival

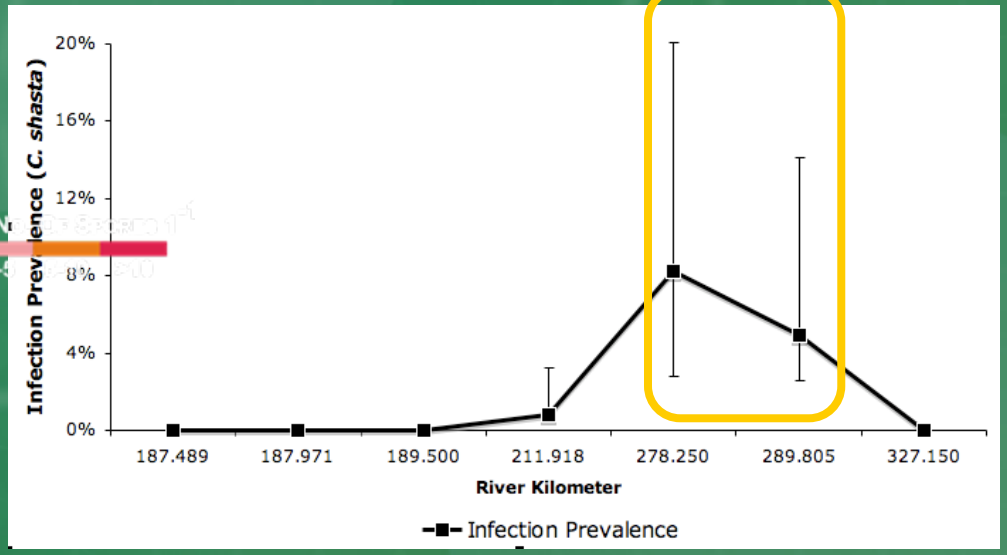
Survival of radio tagged fish



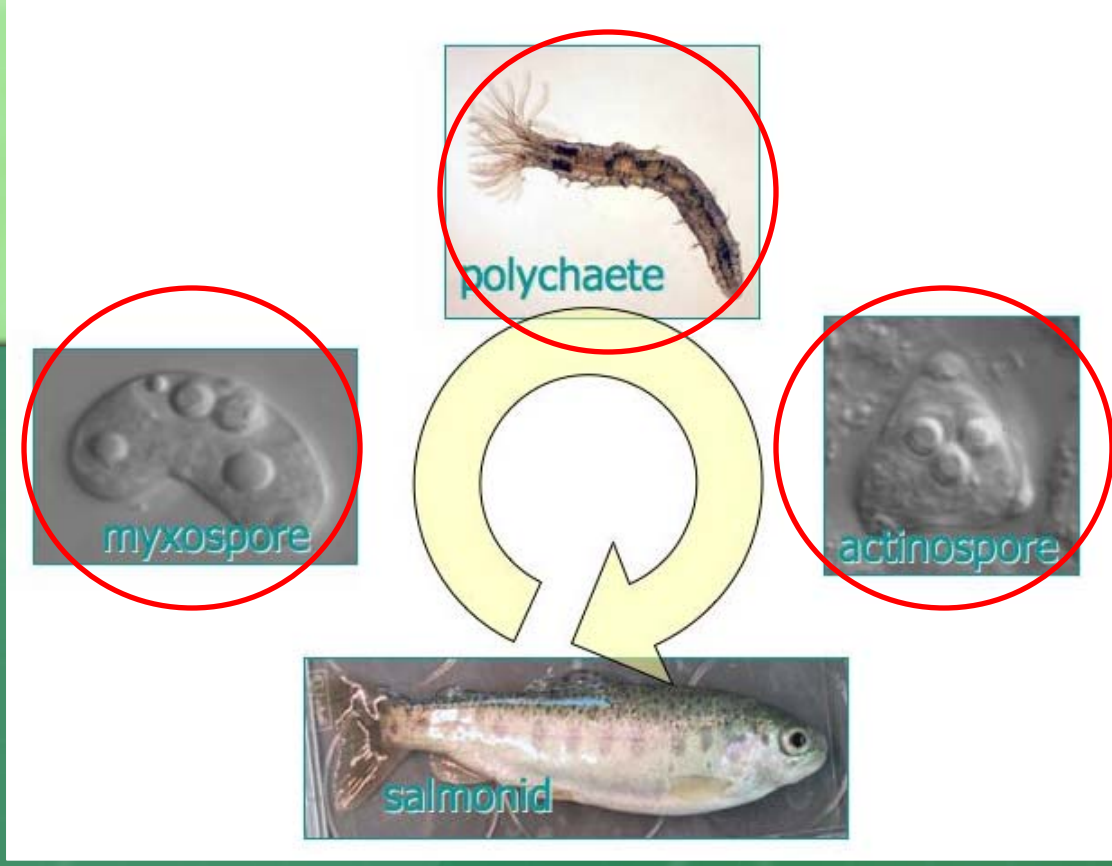
- Radio tag surgically implanted
- 65% “loss” by Trinity R in 10-20d
- Only 8% to estuary

Identifying the infectious zone:
Polychaete Infection





Solutions?

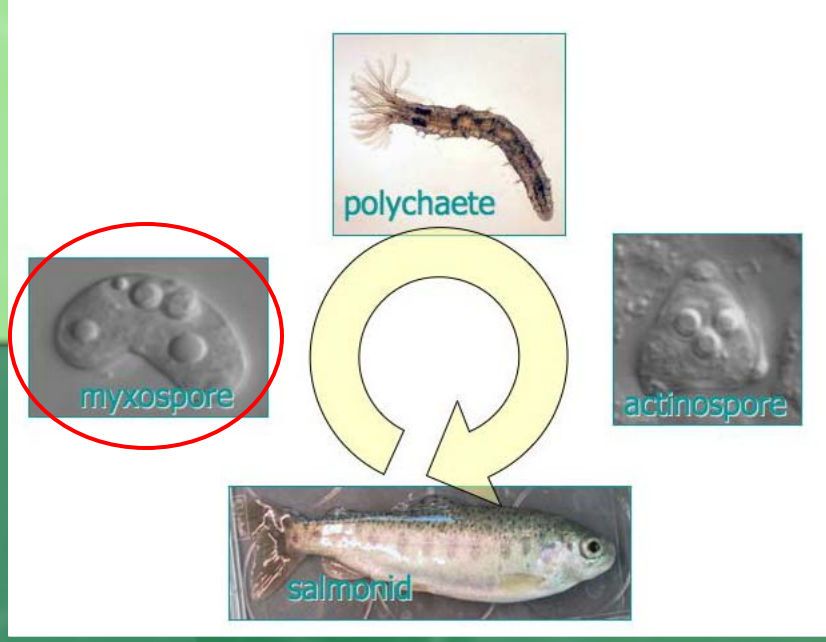


- Actions to decrease disease severity that target the parasite life cycle in that river reach by:
  - Reducing polychaete populations in this reach
  - Reducing fish exposure to actinospores
  - Reducing input of myxospores from adult salmon

Process

- Expert panel met in Aug 2007 and developed a list of management actions that would target the life cycle
- Each action rated by the level of presumed effect on disease.
- Other criteria were:
  - Benefits wild as well as hatchery fish
  - Action must be testable (pilot studies)
  - Must be able to measure a response to the action
  - Doesn’t affect non-target species - ESA concerns
- Critical research tasks were identified for each action

Actions to reduce myxospores



- Selected carcass removal
  - Research tasks:
    - Determine the relative spore contribution of each species/age and whether spores are released during migration or at spawning
    - Determine how long myxospores survive
    - Determine the amount of myxospore reduction necessary (modeling available data)
  - Bogus Cr. carcass project

Summary

- Parasitic disease (Ceratomyxosis) in lower Klamath is reducing smolt survival
- Shift in the host: parasite relationship
- Highly infectious zone (Shasta R. – Seiad)
- Need research into disrupting the lifecycle