Compilation of information relating to myxozoan disease effects to inform the Klamath Basin Restoration Agreement

JL Bartholomew
Department of microbiology
Oregon State University

JS Foott
USFWS, California Nevada Fish Health

Russell Perry

The findings and conclusions in this presentation have not been formally disseminated by the USFWS and should not be construed to represent any agency determination or policy.

Overview

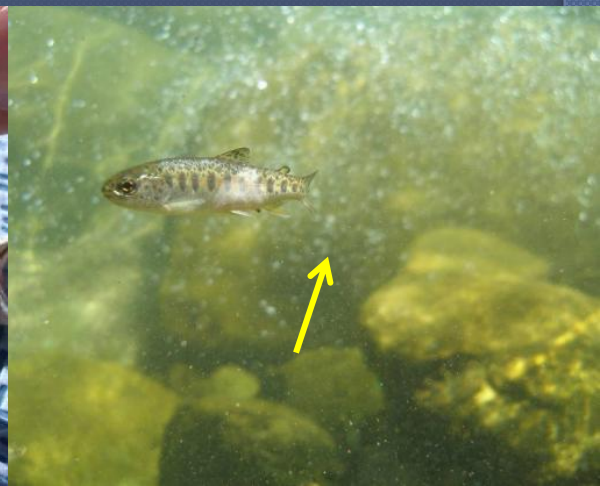
- Myxozoan disease in KRB fish
  - Juvenile and adult salmon
  - Prognosis of infection
  - Factors influencing disease
- Parasite lifecycle
  - Actinospore distribution and abundance
  - Polychaete host
  - Genetics
- Disease model criteria
  - Assumptions / limitations
  - Predictions

JUVENILE SALMON DISEASE MORTALITY

- Juvenile loss is "unseen" unlike adult kills
  - Documented in monitoring
  - Weak = death for smolts
  - >80% at specific times and locations in KR
  - Klamath unlike Trinity and Sacramento

Juvenile disease

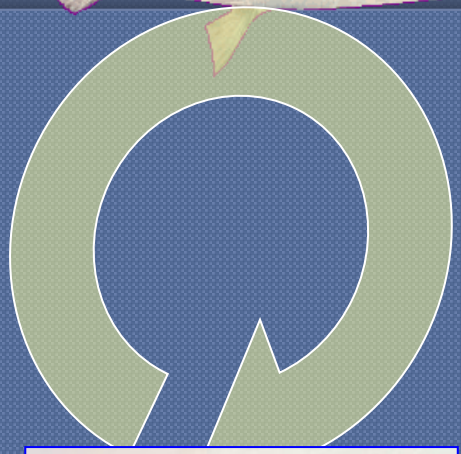
- Surveys since 1991 (bacteria, parasites)
  - Ceratomyxosis *(Ceratomyxa shasta)* during spring and summer in the Klamath River
    - Dual infection with kidney parasite *Parvicapsula minibicornis*
- Columnaris



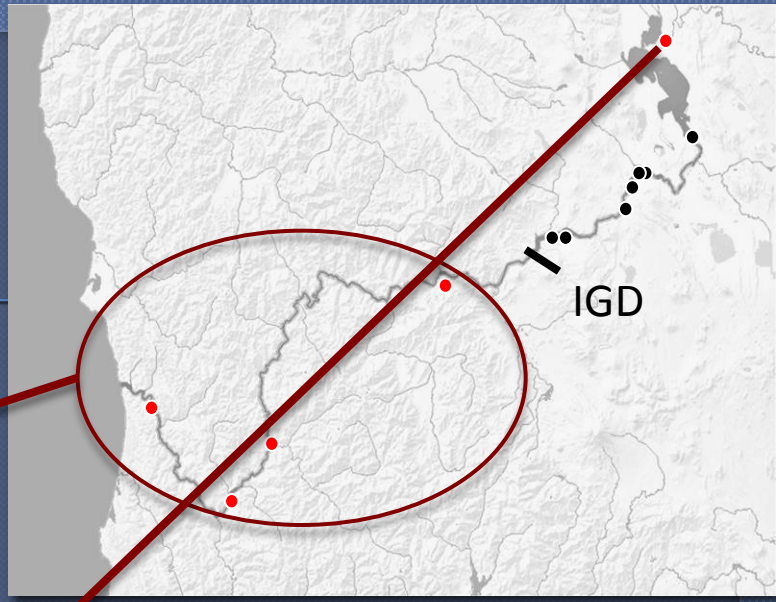
Overview

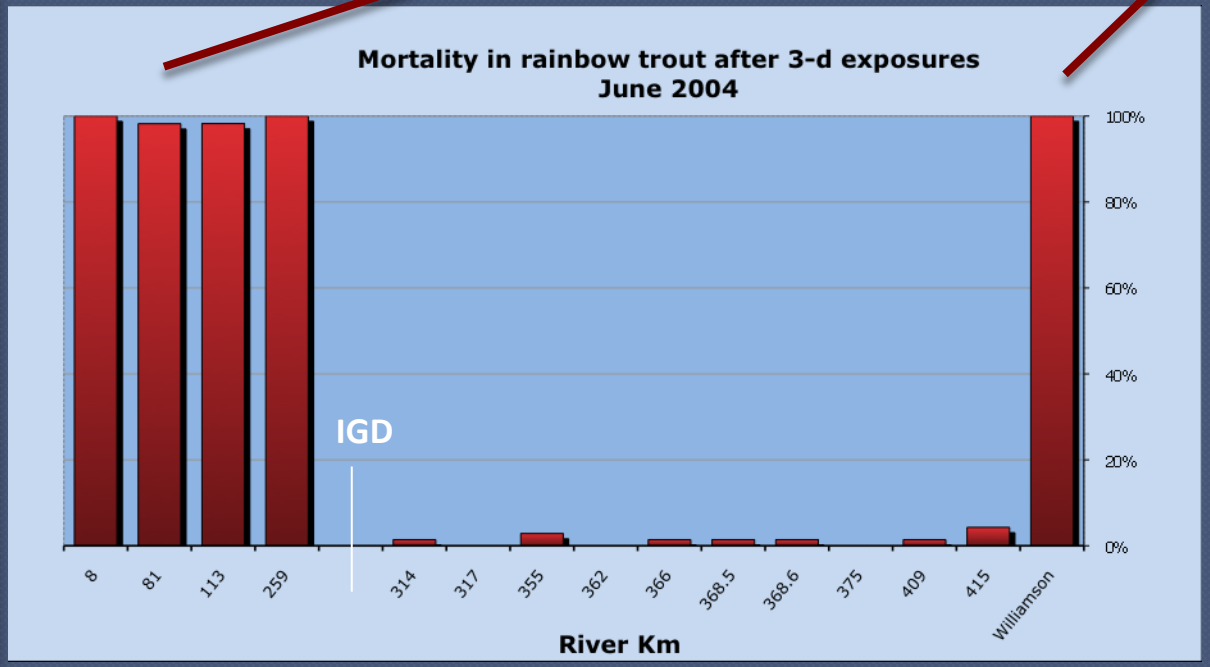
- Parasite lifecycle
  - Infectious zone
  - Parasite genetics
- Factors influencing disease
- Prognosis of infection
- Disease model criteria

Ceratomyxa shasta life cycle



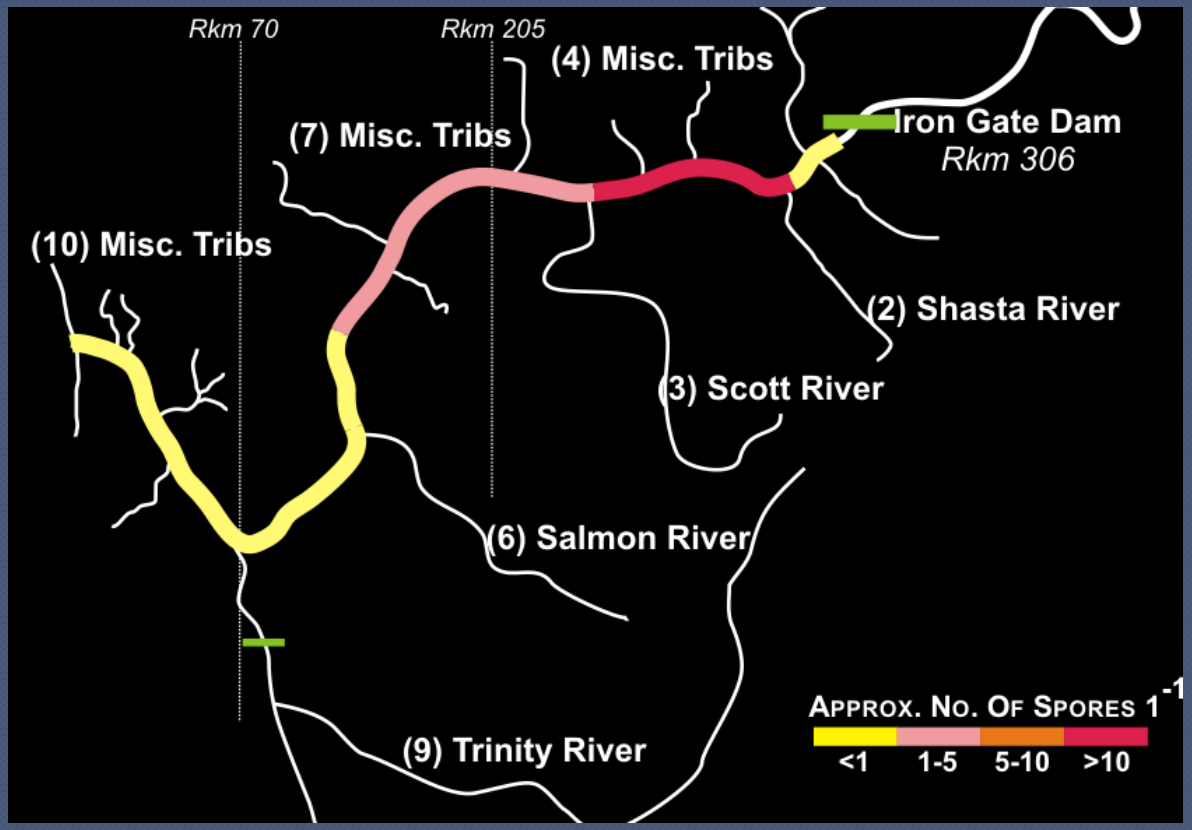
Where do fish become infected?





STOCKING ET AL. JOURNAL OF AQUATIC ANIMAL HEALTH 2006

Current Infectious Zone



C. shasta population structure

	O.tshawytscha		*O.mykiss*		*O.kisutch*
	Water	Chinook	non-native rainbow	native rainbow	coho
Upper	II O	II III	II	O	n/a
Lower	I II	I II III	II III	O & steelhead	II

4 Parasite genotypes

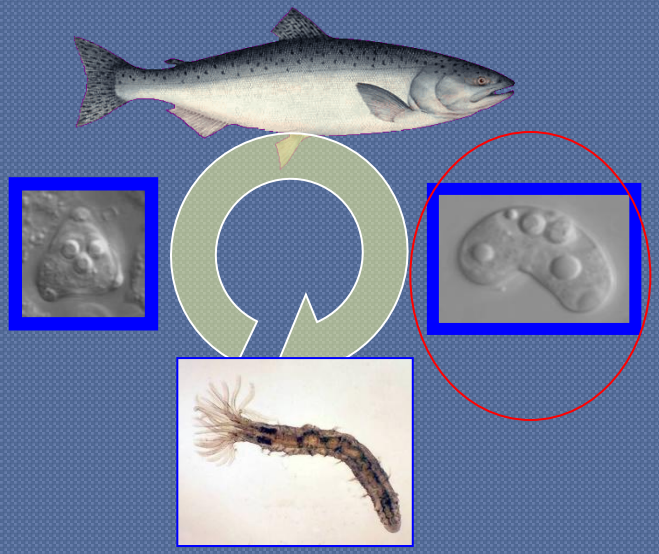
O Redband/Steelhead genotype

I found in CHS lower basin only

II affects coho in lower basin; non-native rainbow

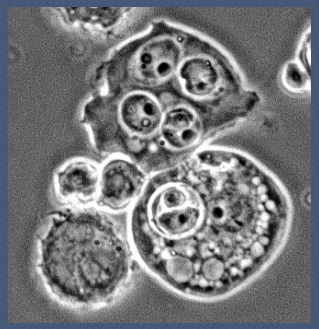
FACTORS INFLUENCING DISEASE

MYXOSPORE INPUTS



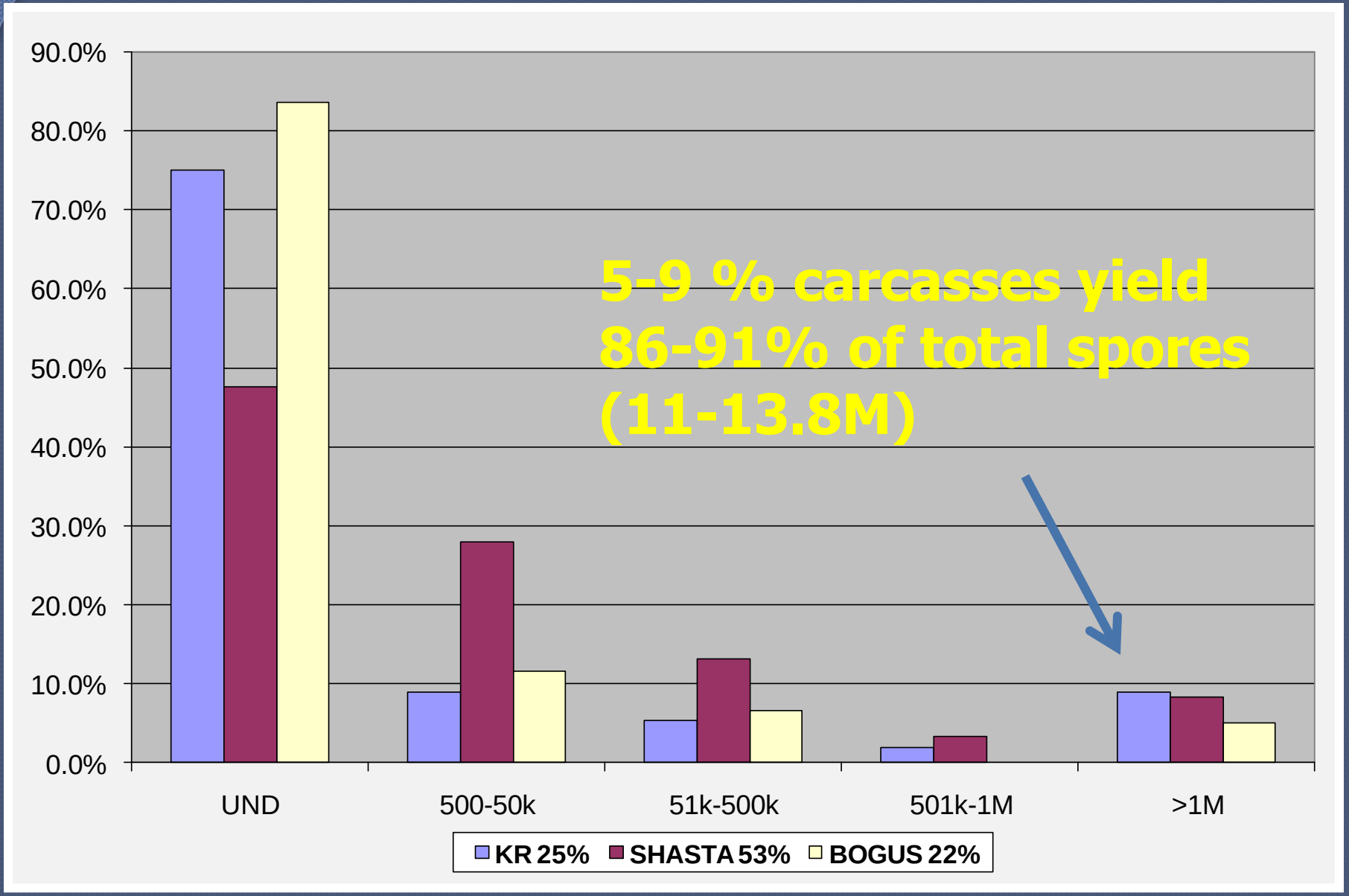
Adult Chinook *C. shasta* data

- Infection starts upon entry into fresh water
  - High incidence trophozoite infection
  - Low incidence myxospore

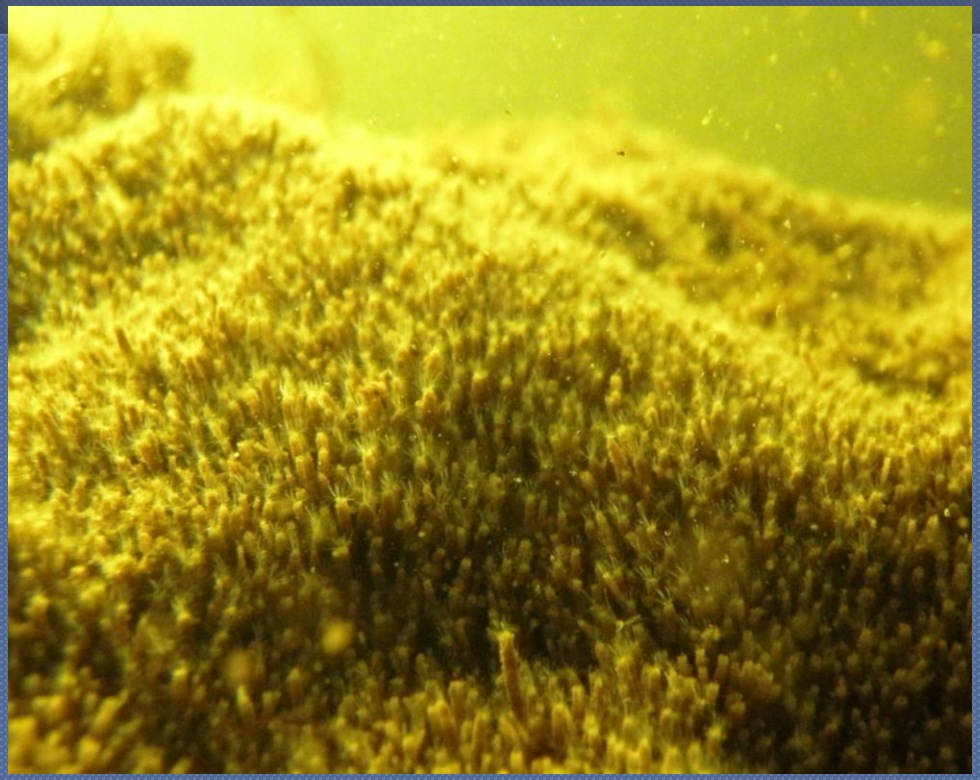


Adult *C. shasta* Myxospore Prevalence

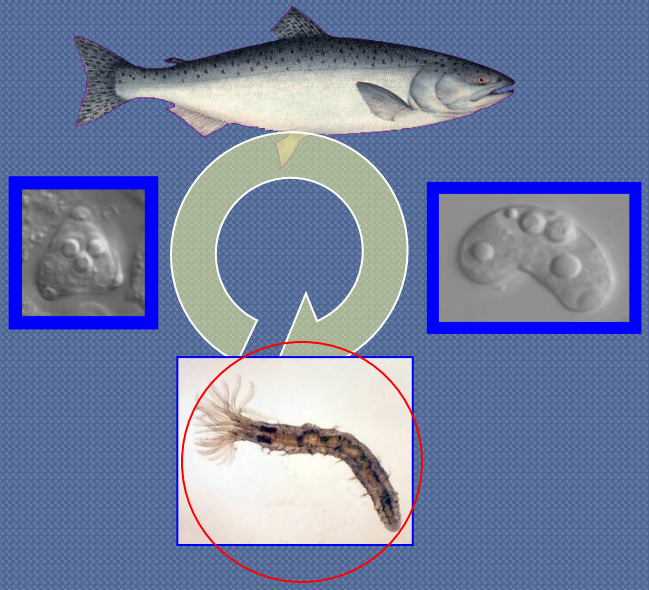
- FCS Carcasses 500 to 1,500,000 spores/gut
  - 2007 KR-B-SR 22 / 64 (34%)
  - 2008 Bogus 30 / 100 (30%)
  - 2009 Bogus 14 /65 (22%)
  - KR 14 / 56 (25%)
  - Shasta 32 / 61 (53%)
  - 2010
  - Juvenile morts Kinsman = 8%
    - Assume these fish die prior to releasing spores or release below the infectious zone


90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
UND
500-50k
51k-500k
501k-1M
>1M
KR 25%
SHASTA 53%
BOGUS 22%
5-9 % carcasses yield
86-91% of total spores
(11-13.8M)

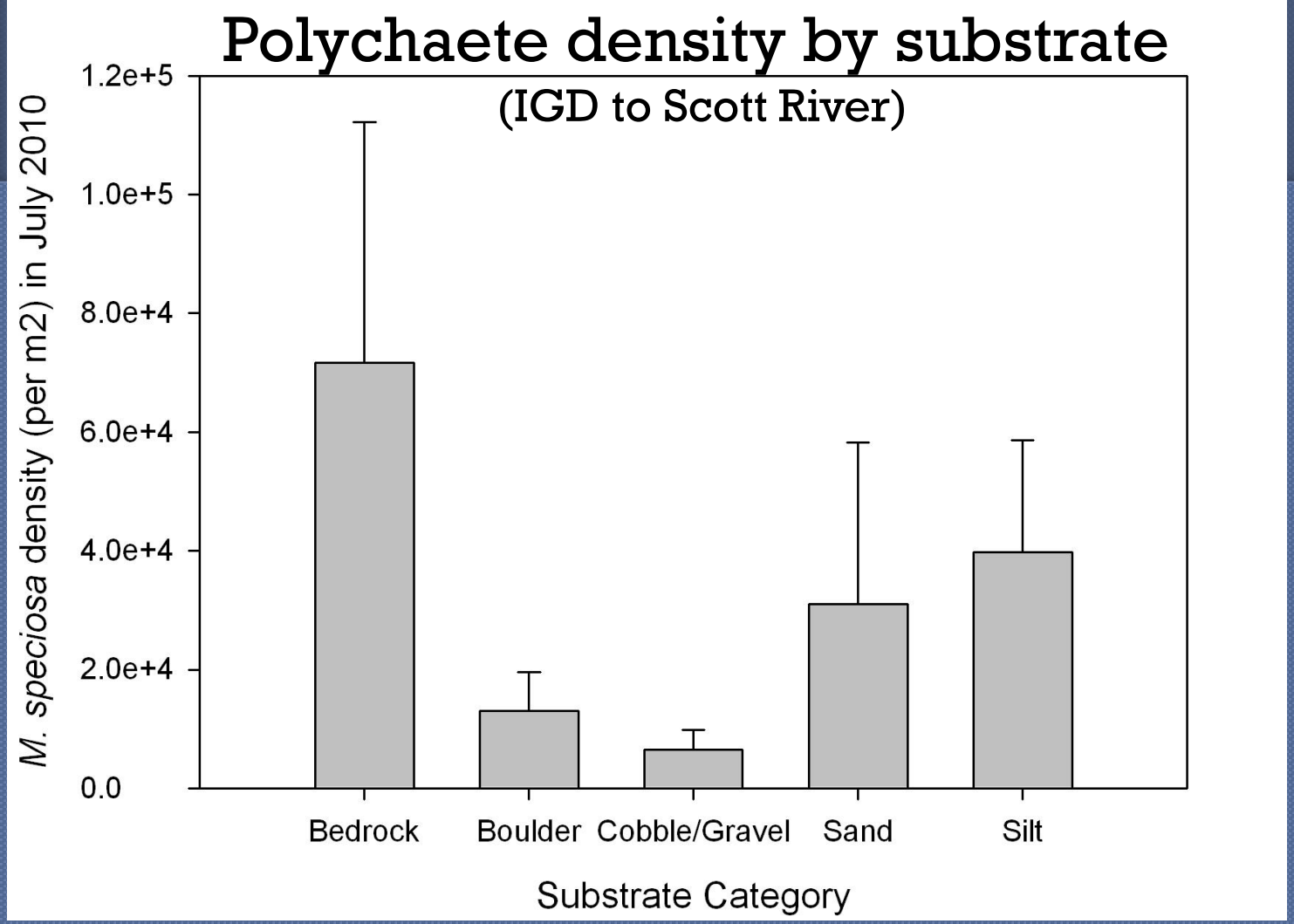
FACTORS INFLUENCING DISEASE



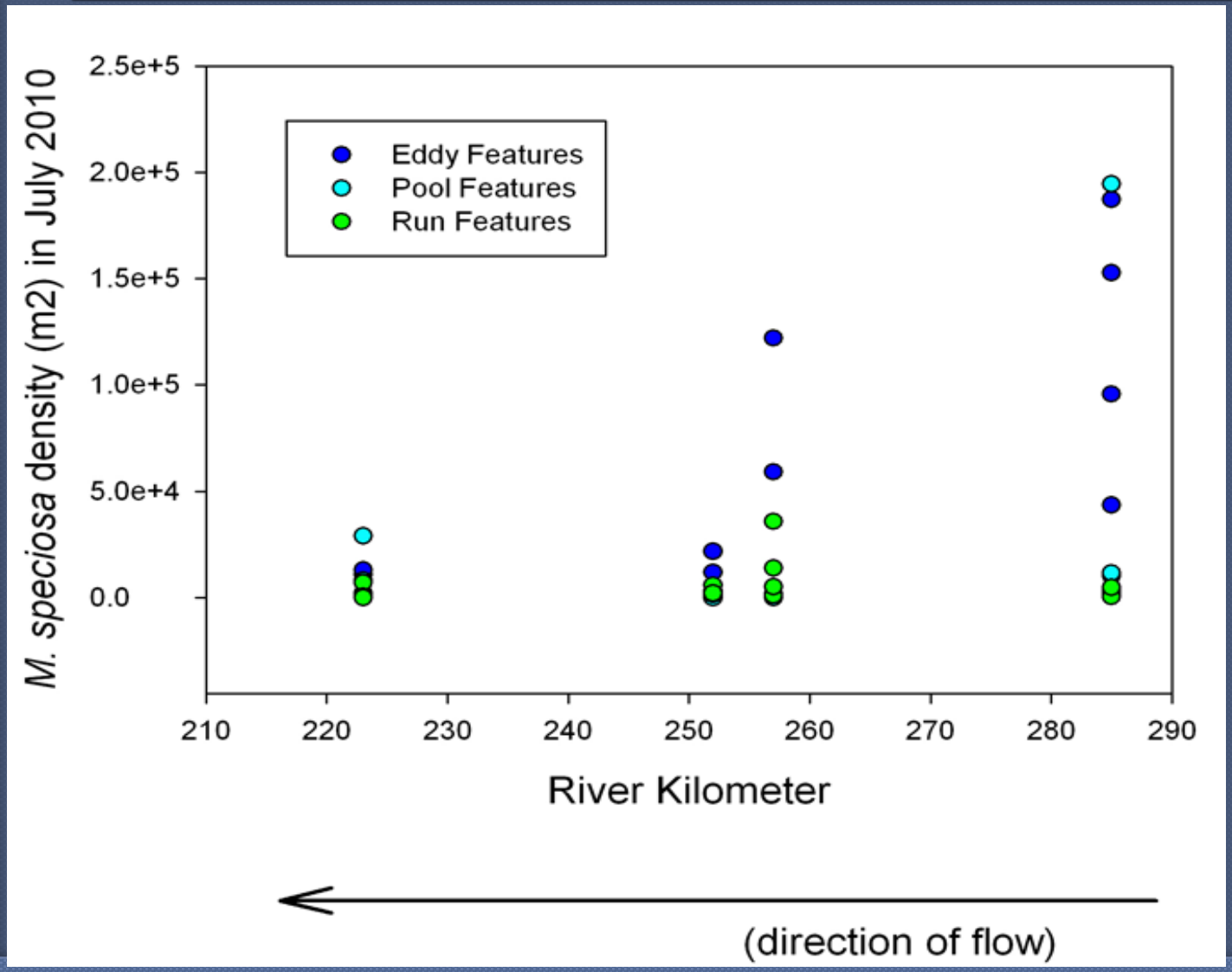
POLYCHAETE DENSITY



POLYCHAETE HABITAT USE



POLYCHAETE DENSITY BY RIVER FEATURE AND RKM

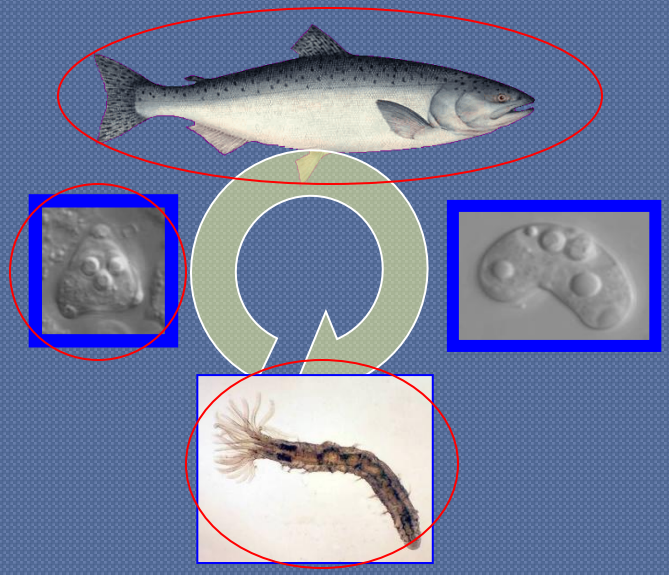


Polychaetes Summary

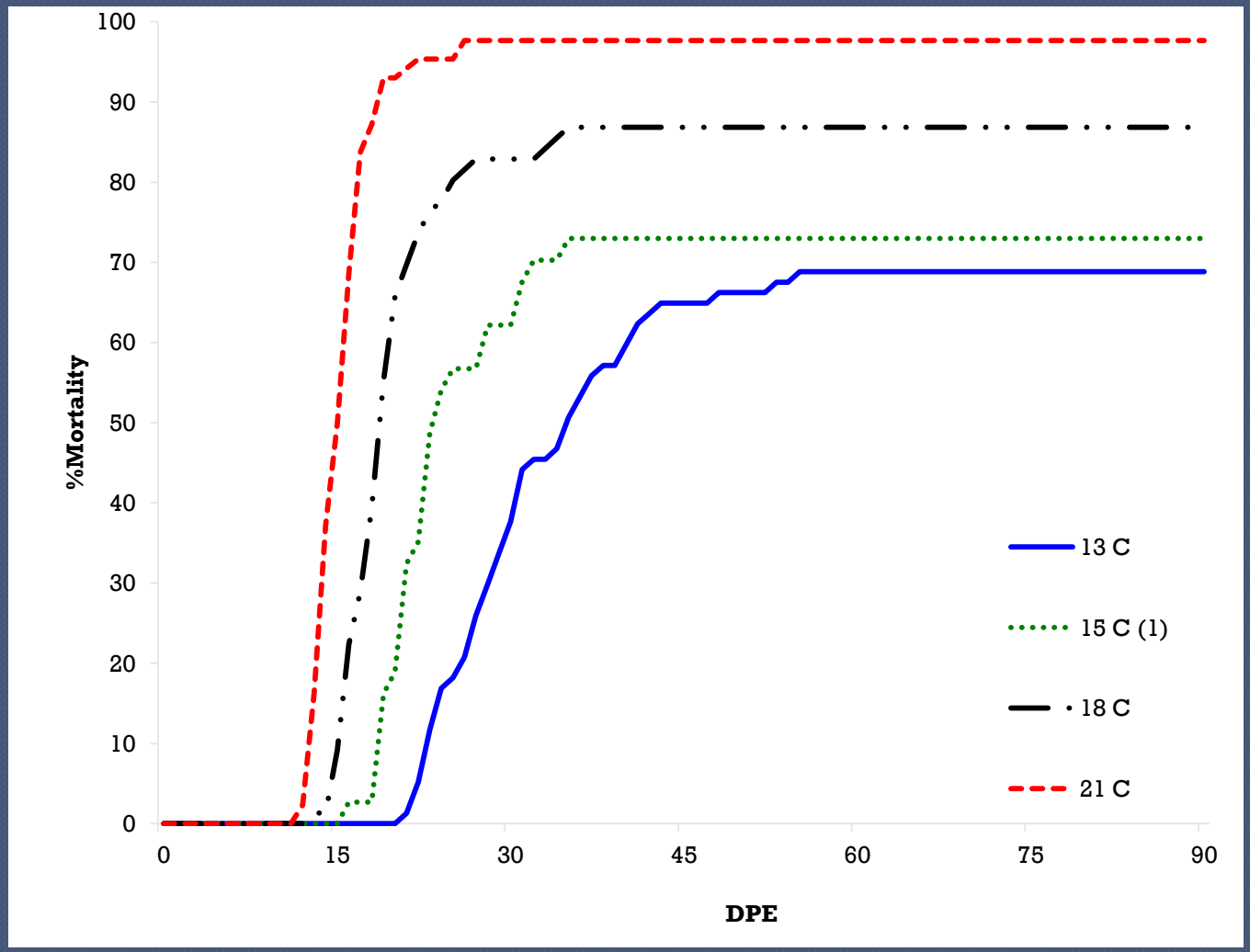
- Polychaetes use 2 primary habitats
  - Fine sand/silt – can be disturbed
  - Bedrock – very stabile
- Polychaete densities decrease with increasing distance downriver
- Polychaetes
  - likely have an annual cycle
  - are able to quickly colonize
  - populations expand in summer

FACTORS INFLUENCING DISEASE

TEMPERATURE

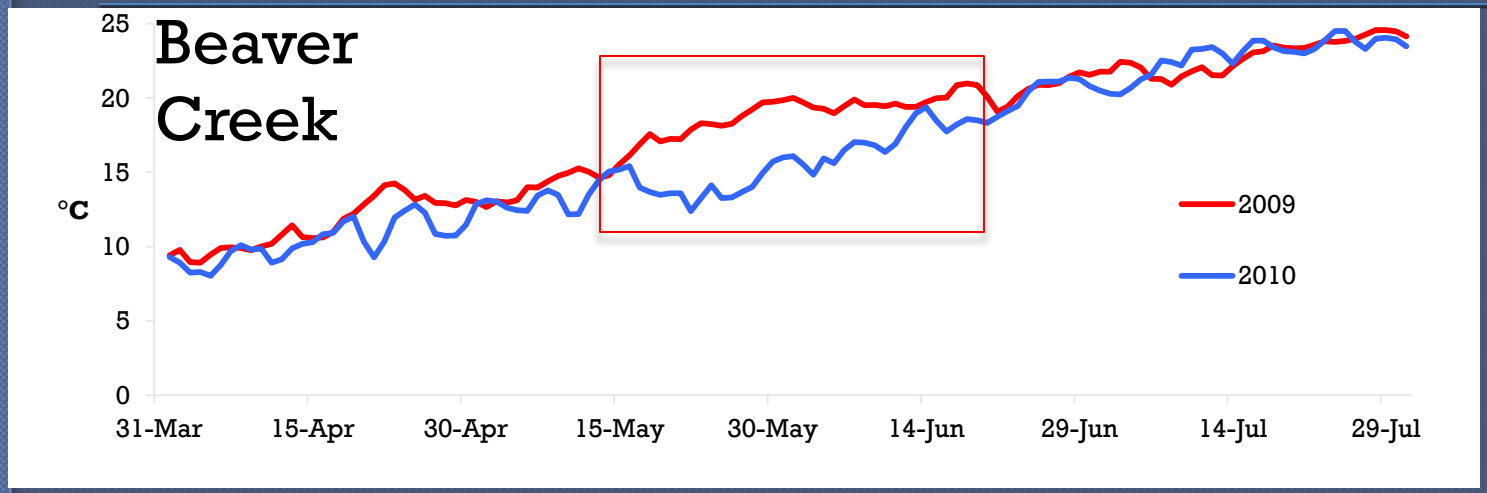


EFFECTS OF TEMPERATURE ON DISEASE IN FISH

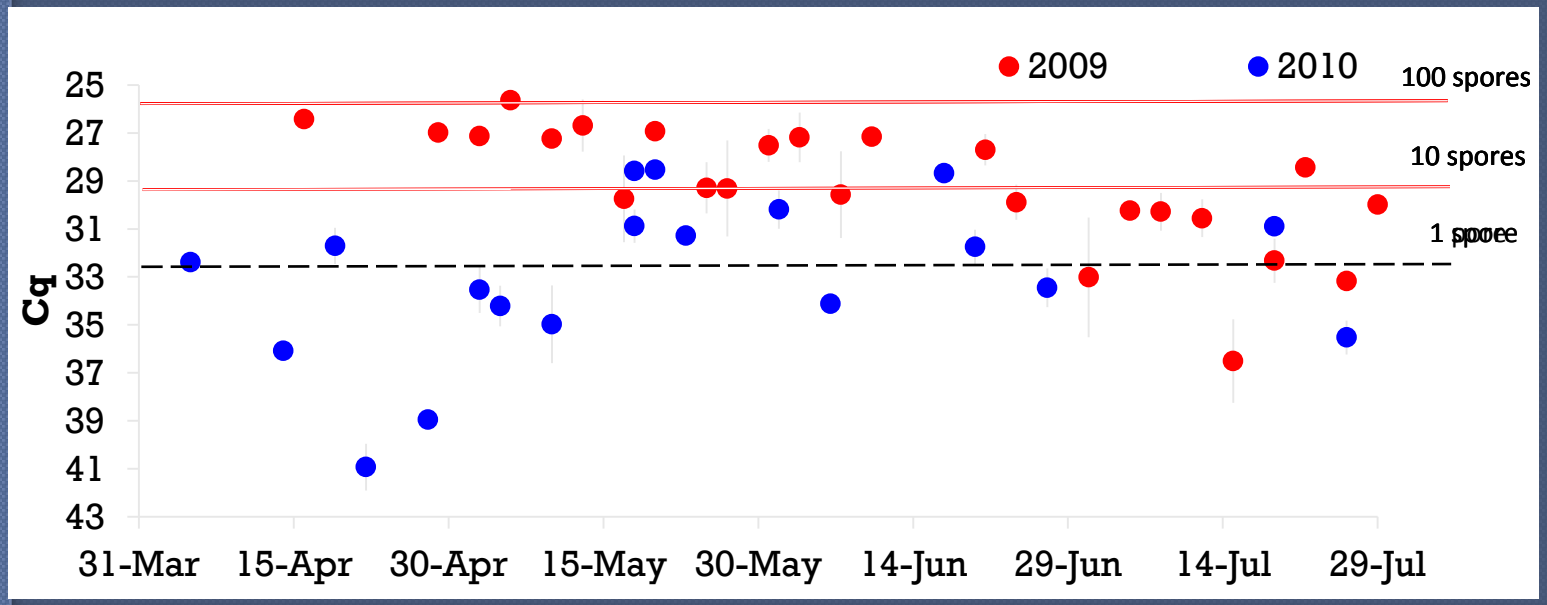


AS TEMPERATURE INCREASES, MORTALITY INCREASES

EFFECTS OF TEMPERATURE ON PARASITE PRODUCTION



Flows similarly low both years



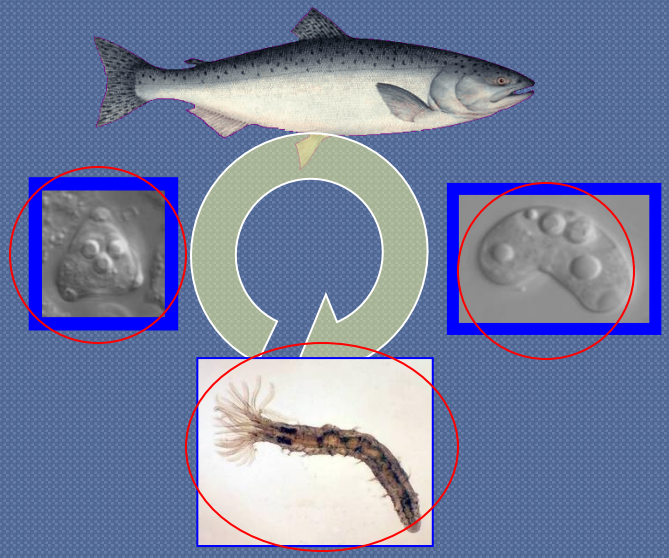
EFFECTS OF TEMPERATURE SUMMARY

- Actinospore release occurs at >10˚C
- Disease progression in the fish increases as temperatures rise above 12˚C
- Maximum threshold for polychaete 23˚C

- Effect — temperature range
  - None — <10C or >23C
  - Low — 10-12C
  - Moderate — 13 – 17C
  - High — >17 </= 23C

FACTORS INFLUENCING DISEASE

FLOW



RELATIONSHIP BETWEEN FLOW AND DISEASE

Disease severity increased in low water years
Subsequent low water years may increase disease

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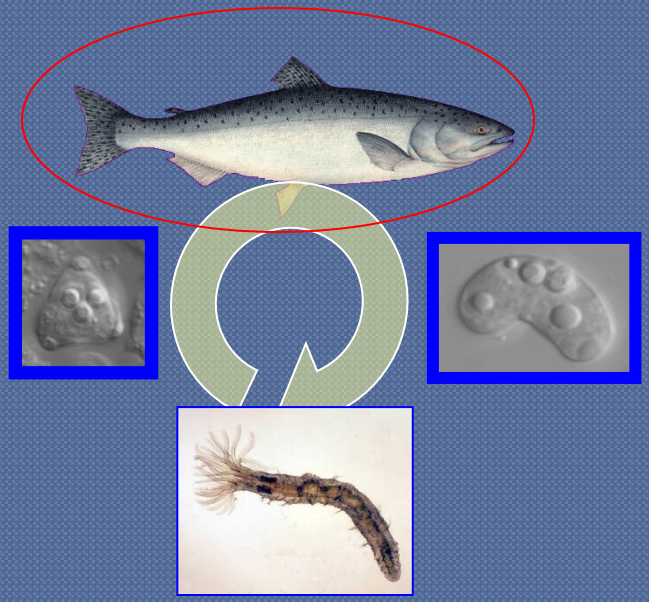
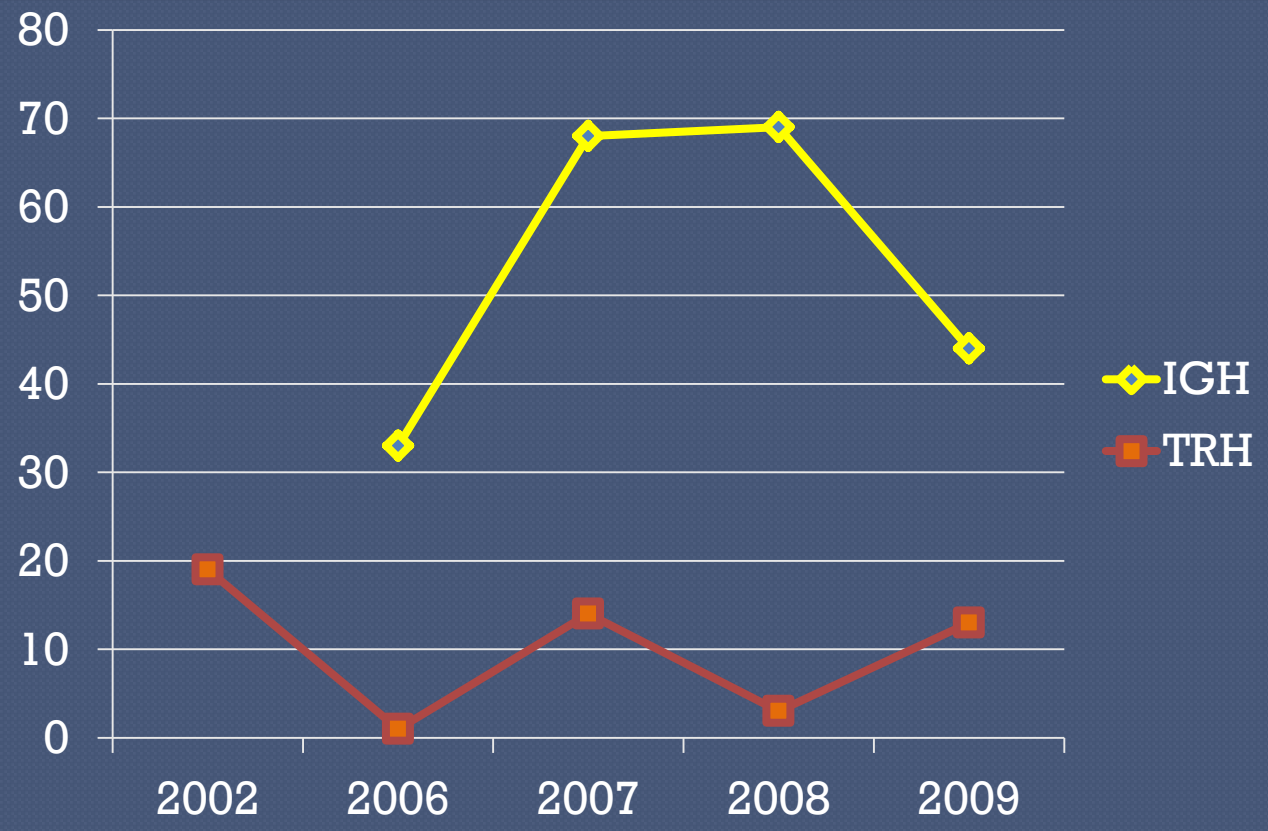
PROGNOSIS OF *C. SHASTA* INFECTION UNDER CURRENT CONDITIONS

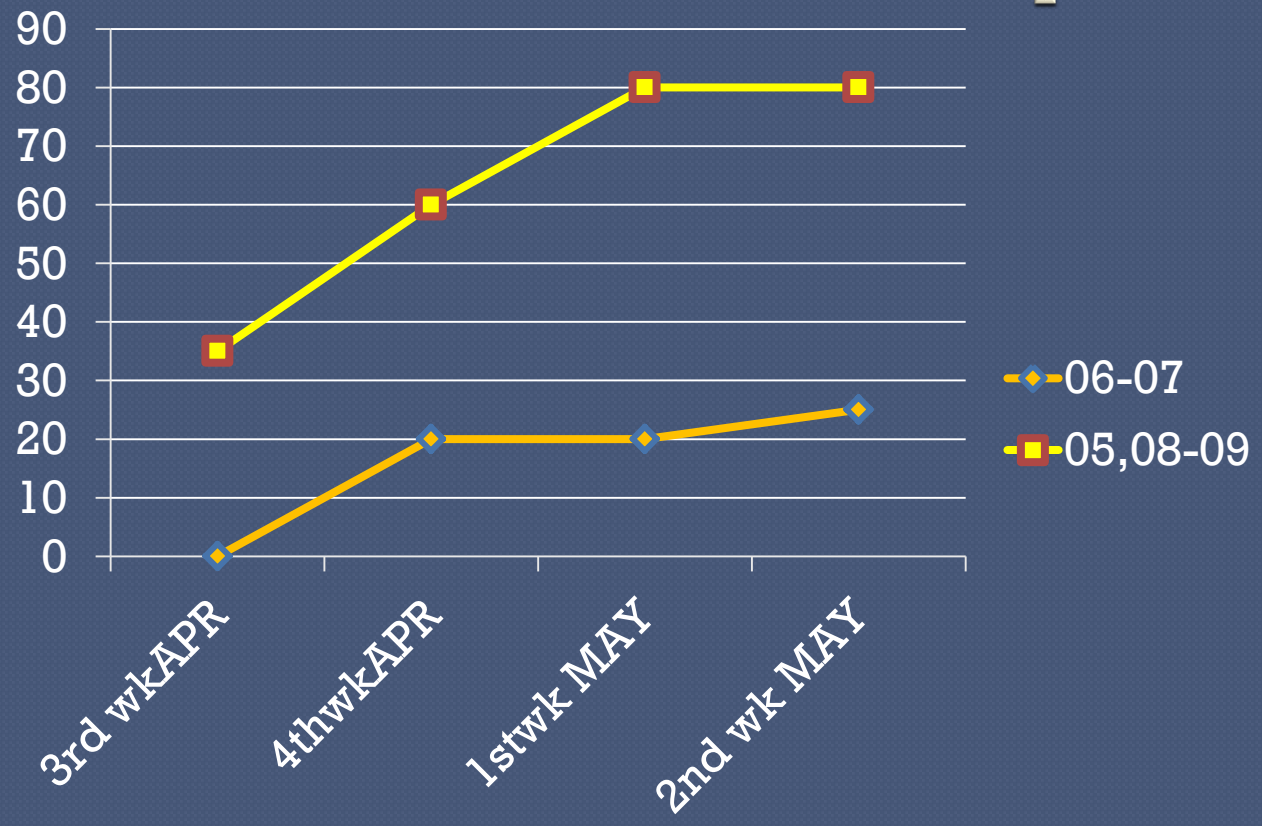


Incidence of *C. shasta* infection CWT salmon IGH & TRH



IGH 33 – 69%, avg = 54% , Shasta R. FCS surrogate
TRH 1 – 19%, avg =10%, entry below Rm 44

Weekly POI Cs Naturals 2006-2007 "low" & 2005,2008 & 09 "high" Kinsman Trap calibration



Low 0.14mort x POI = 0-4% disease mort
High 0.77mort x POI = 27 – 62% disease mort

Prognosis of infection

- Steelhead – rare** to find diseased
- Coho- similar to Chinook
  - 72h Sentinel 2008 - >90% clinical ceratomyxosis
- Chinook :
  - IGH = Shasta R. = Salmon R. ≤ TRH

Prognosis of *C.shasta* infection

- May 2009 Migratory 8h = in situ 8h
  - 3d exposure = 98% mortality
- May & June 2008 = Kinsman capture
  - 5wk mortality Cs = 82 & 95%
- Disease Mortality
  - = 3d sentinel mort (18C) in a given reach and month
  - e.g. 0.80 for June high infectivity zone

Summary of criteria

Ranking	Flow	Flows previous year	Temp.
High	Flows below disturbance threshold for fine sediment		≥ 17C or <23C
Moderate	Flows above disturbance threshold for fine sediment but below that for periphyton	Flows below disturbance threshold for fine sediment (2,400 cfs)	13 – 17C
Low	Flows above disturbance threshold for attached periphyton	Flows above disturbance threshold for attached periphyton	10 – 13C
None			≤ 10 or > 23C

Assume carcass numbers not limiting

Opening of habitat

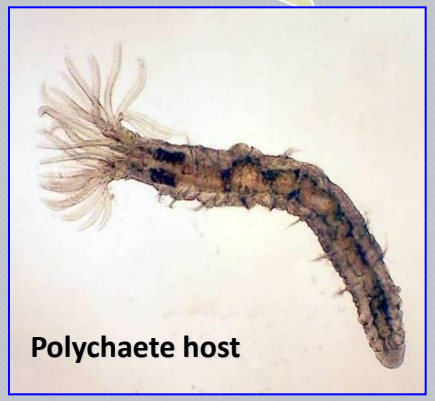
Introduction of salmon into the upper basin

Higher spring temps

Lower fall temps

Ceratomyxa shasta life cycle

Removal of reservoirs



Initial increased suspended sediment

More natural flow regime

QUALITATIVE DISEASE MORTALITY PREDICTIONS

- Williamson R. – moderate
  - High Ms, move Genotype I, outmigration?
- Sprague R. – Low
  - Little data, limited spawn habitat now
- Keno – IGD – moderate
  - Keno low DO, high gradient, Copco-Cottonwood = meander/sediment, freq. of disrupting flows
- IGD- Indian Creek – moderate
  - Freq. of disrupt flow, fewer adults?, low flow years
- Below Indian Creek - low

Disease Scalar