

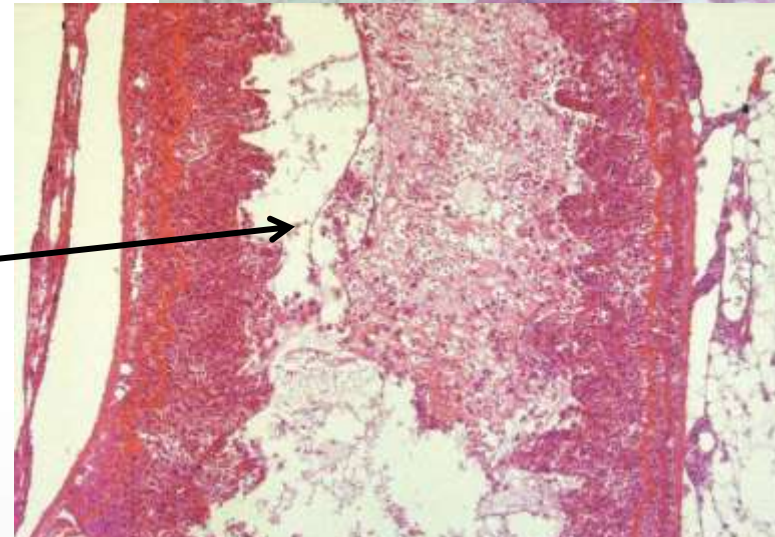
Ceratonova shasta infection and disease in Feather and Sacramento River juvenile Chinook

J.Scott Foott, Jennifer Jacobs, Kim True, Ron Stone, Ken Nichols, Scott Freund, Ann Voss, Scott Voss
and Alana Imrie (DWR)



Ceratonova (Ceratomyxa) shasta (Cs)

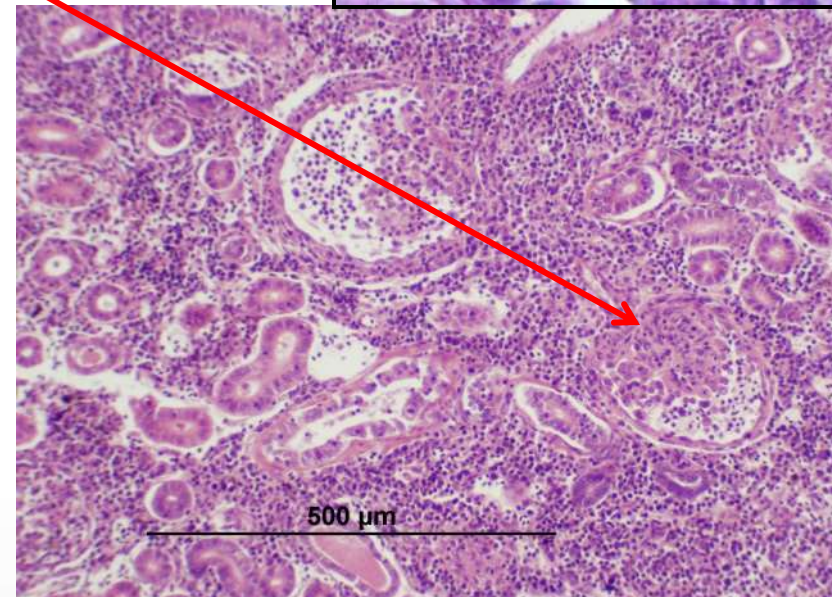
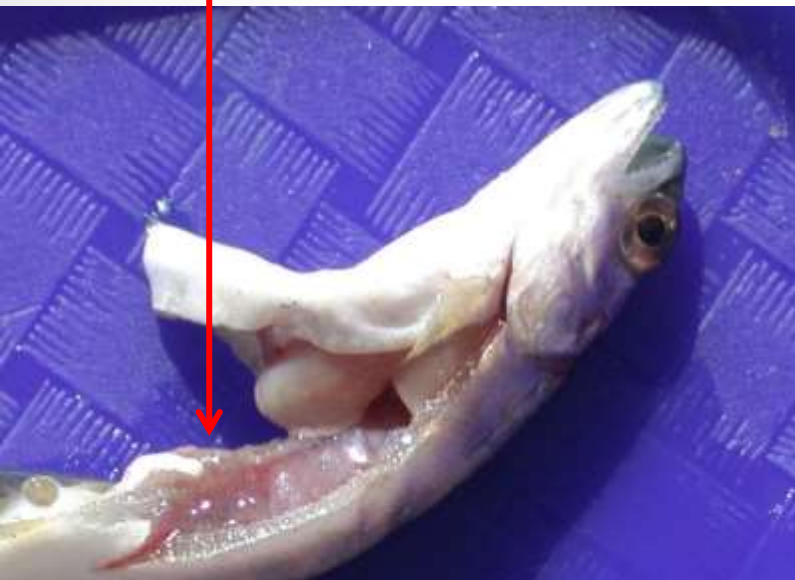
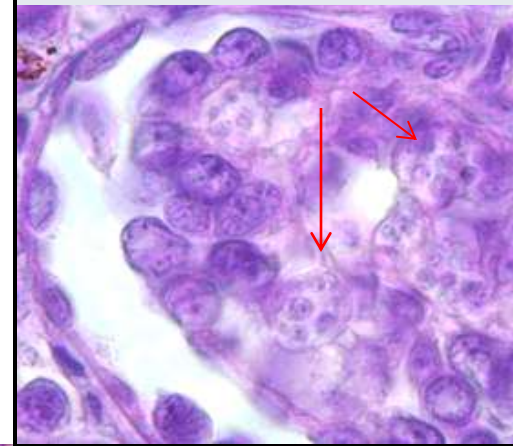
- Myxozoan parasite of PNW salmonids
- Endemic to Central Valley and Klamath drainages
- Enteronecrosis with hemorrhage and anemia
- Progressive disease a function of:
 - challenge “dose”,
 - ITS1 Host specific Genotype, &
 - temperature



Parvicapsula minibicornis (Pm)

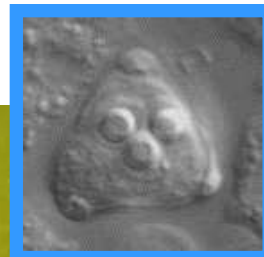
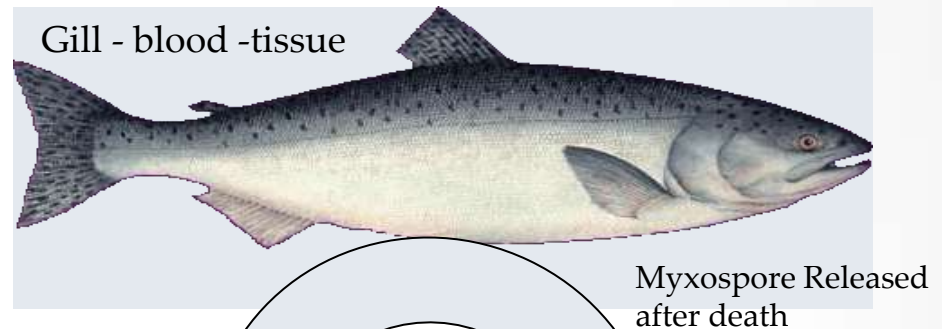
- Myxozoan parasite of PNW salmonids
 - Endemic to Central Valley and Klamath drainages
- Co-infection with *C.shasta* (higher POI)
 - Glomerulonephritis –plasma imbalance
 - Grossly swollen kidney
 - Not as virulent as *C.shasta*

Trophozoite in glomerulus

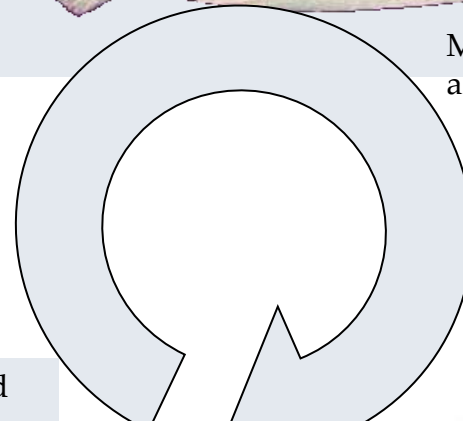


Life cycle

- Alternate host (**Cs & Pm**)= *Manayunkia speciosa*
 - (1-5mm)
- Tube building filter feeder in velocity protected habitats



Actinospore released from polychaete



M. speciosa

Polychaete tubes Klamath River J. Alexander, OSU



- Actinospore concentration and exposure duration = “challenge dose”
 - influences disease response “5-10 spore/Lx 3day”
- Common detection in Sacramento Chinook Adults
 - WCS – LFS – FCS (1995 – present) >50% CS& Pm

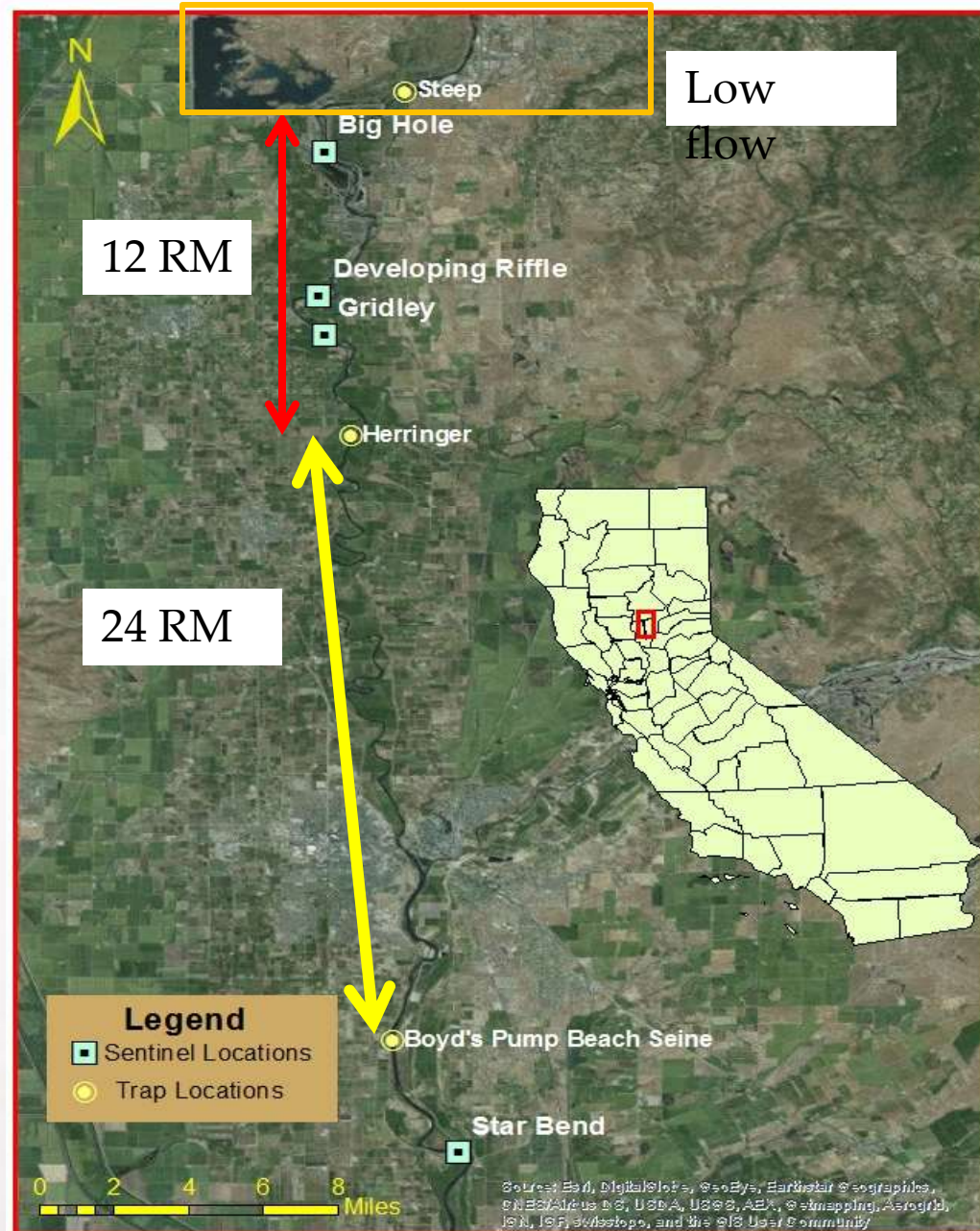
Actinospores present most of the year in Sacramento river

Survey Techniques

- Wild fish (histology and QPCR)
- Sentinel fish (infect “white mice” with standard challenge)
- eDNA filter water (spore/liter)
- Adult carcass survey for intestinal myxospores

Feather R.

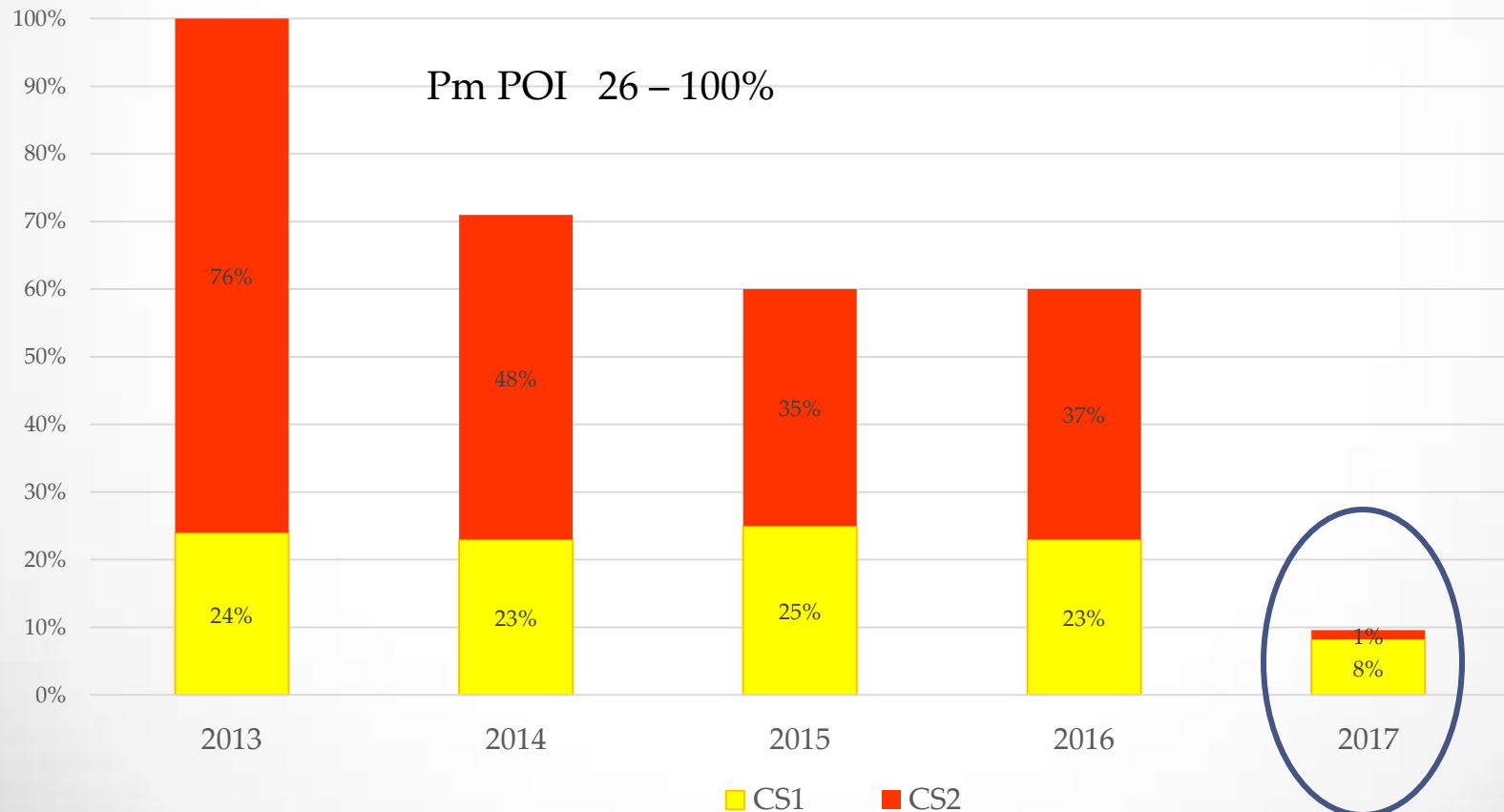
- 2013-present
- high& low flow
- Infectious Zone
 - Top of High flow ~12mi



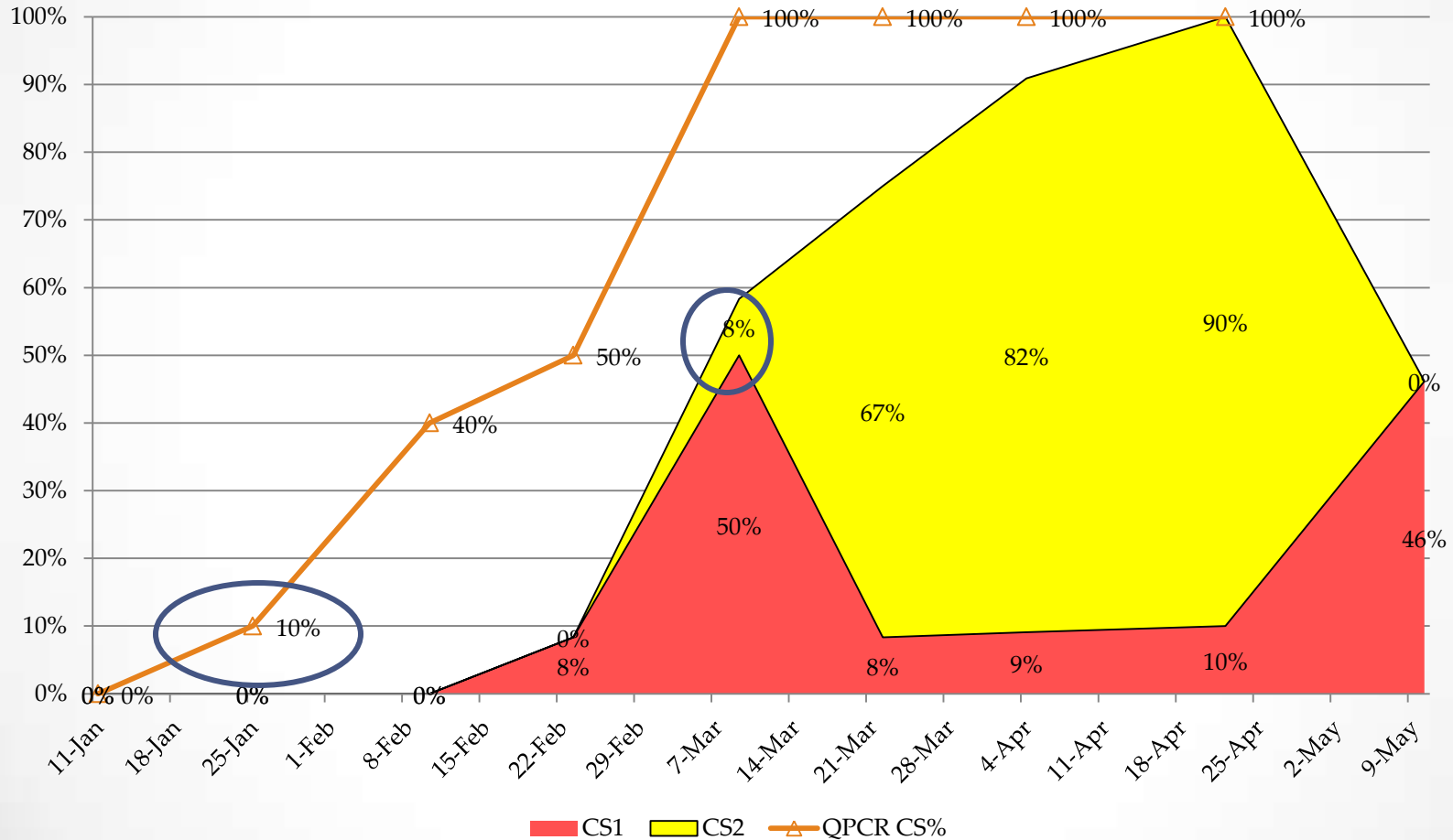
Feather R. High flow Natural FCS

Cs POI (Jan-May)

- Cs Histology POI 10 – 100% (2013-2017)
- Cs QPCR POI 48 – 80% (2014-2017)
- Actinospores detected beginning in **January (~11C)**
 - Earlier than Klamath R.



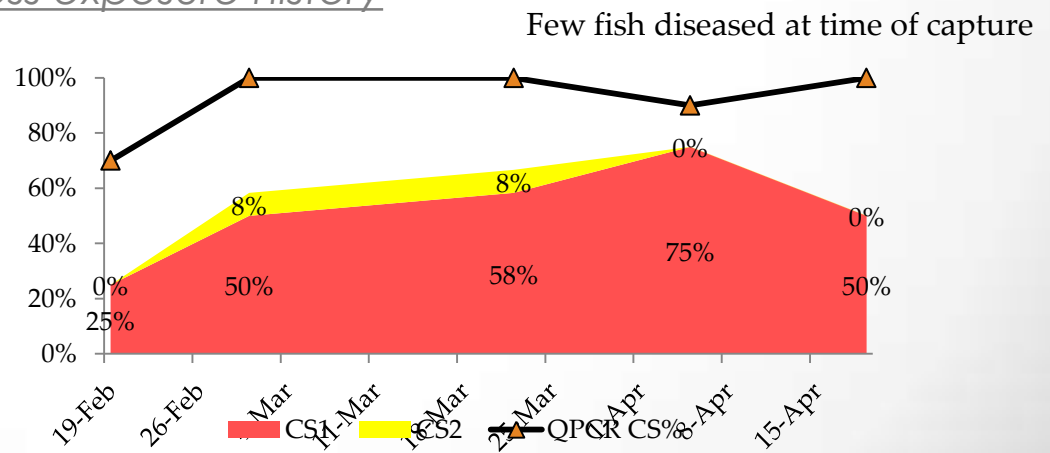
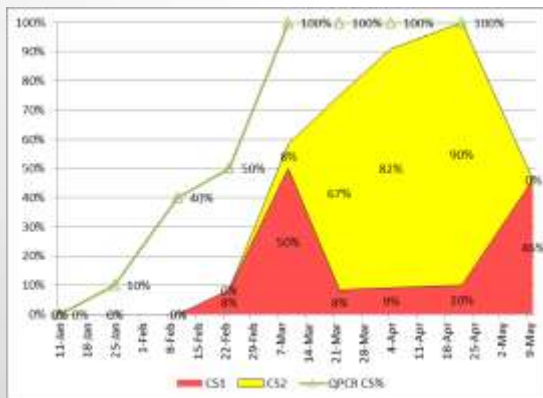
Feather R. Infectious Zone 2016



By mid March majority salmon with clinical infections

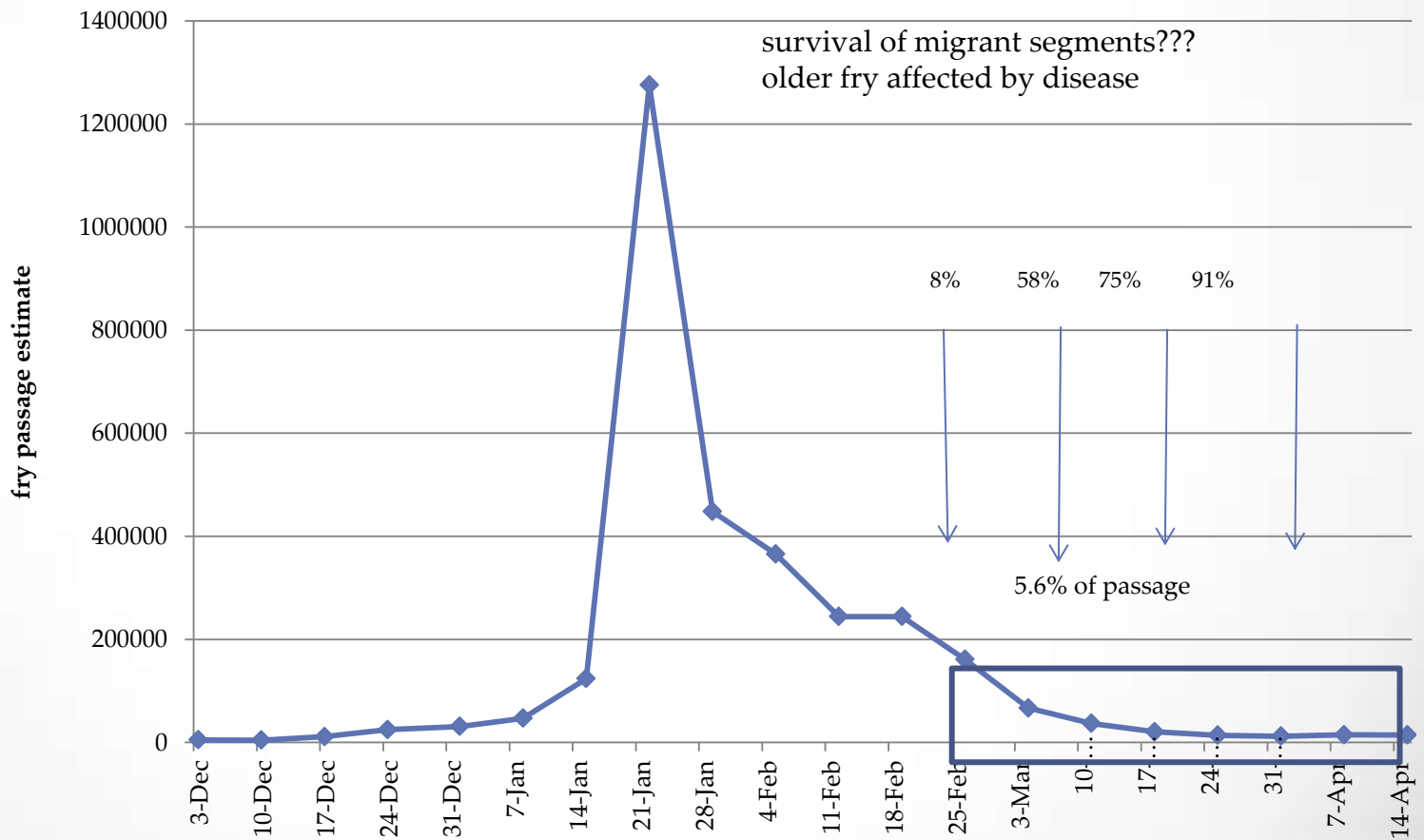
Infectious Zone

- Infectious zone = Start of High flow past Gridley (>12rm)
 - Cs POI in **low flow** = 0-13% all asymptomatic infections
- CsPOI 24rm below infectious zone (below Yuba R.)
 - Variable CsPOI week to week
 - CS2 POI less than Herring (drop out)
 - Unknown contribution of Yuba R. salmon
 - Further downriver = less exposure history

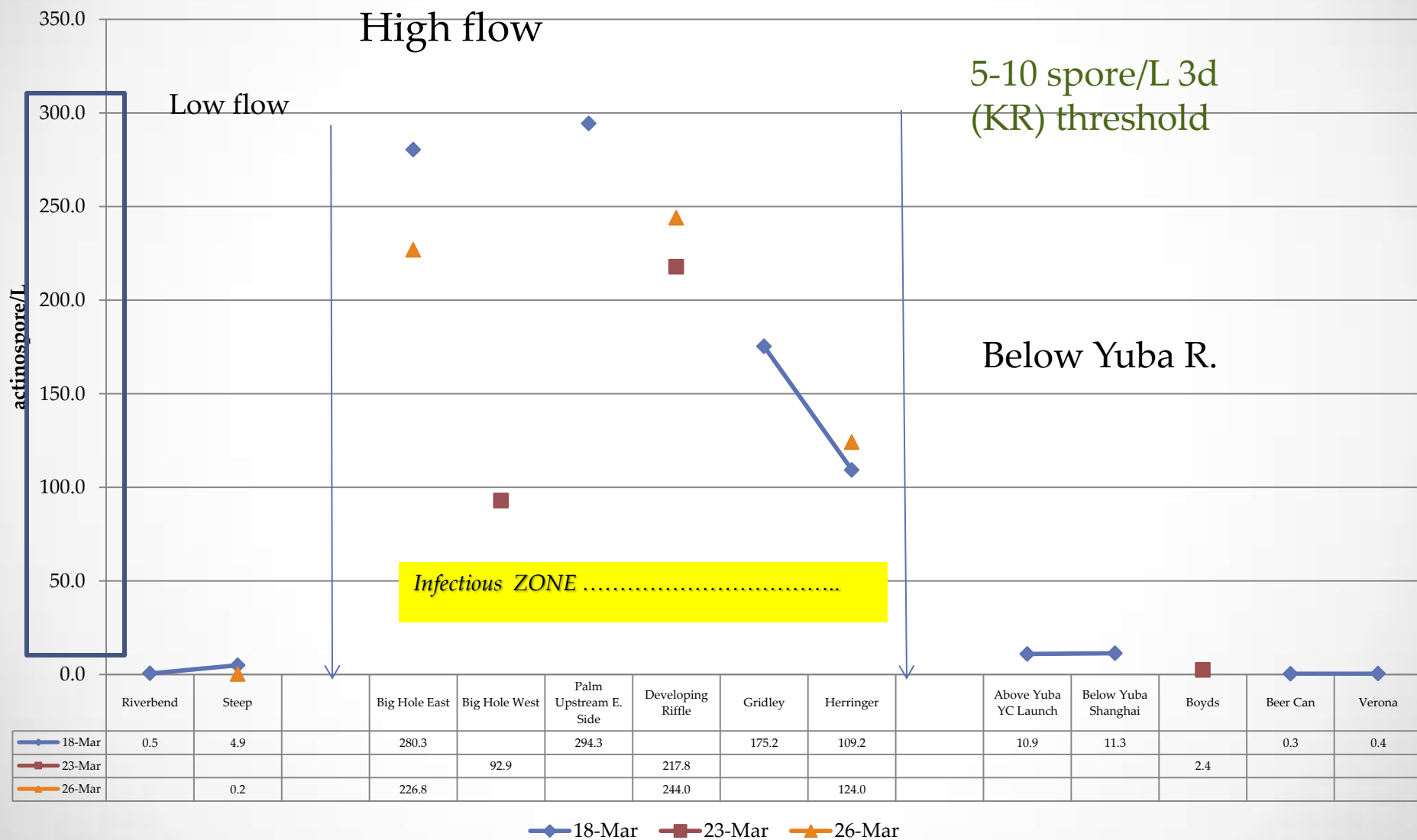


IMPACT??

2016 fry passage from Infect. Zone (rm45)

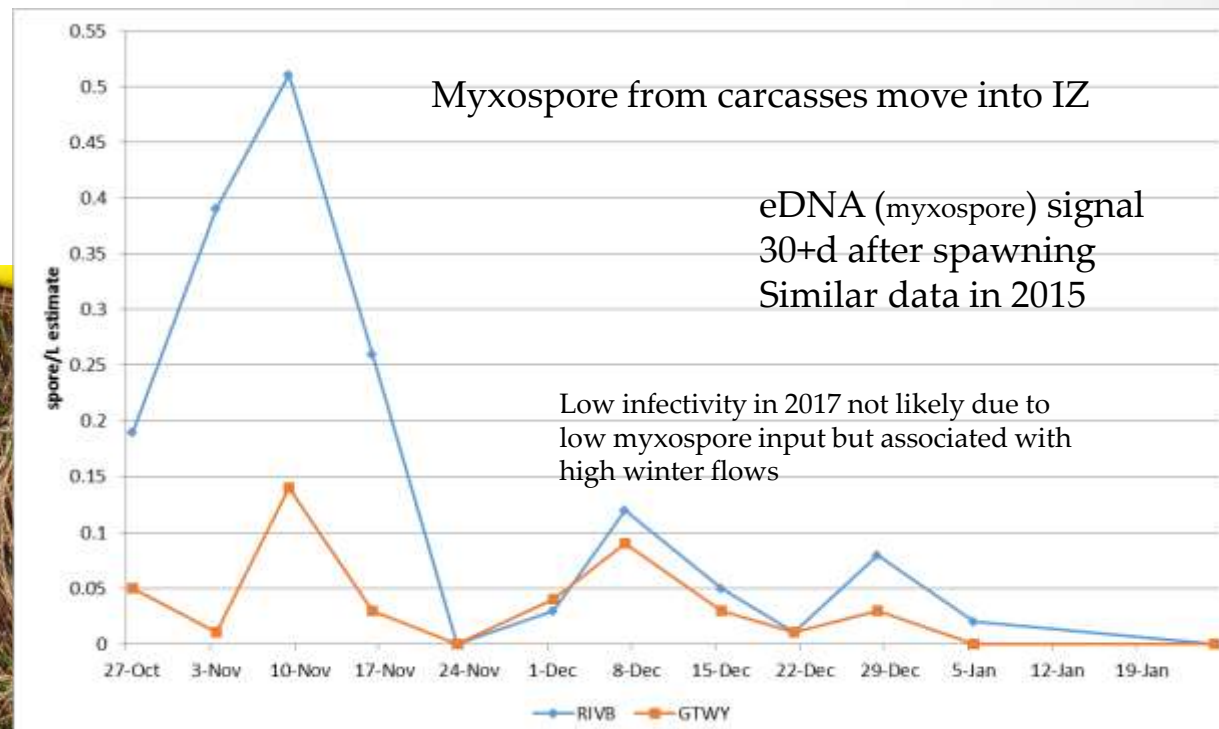
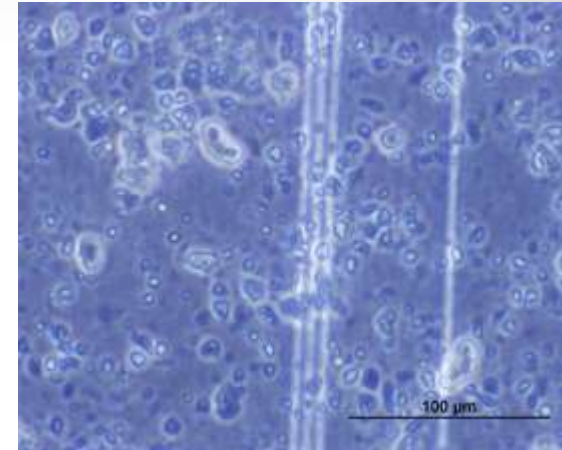


Cs eDNA March 23 2015 *Extremely high concentrations*



Carcass myxospores in Low flow

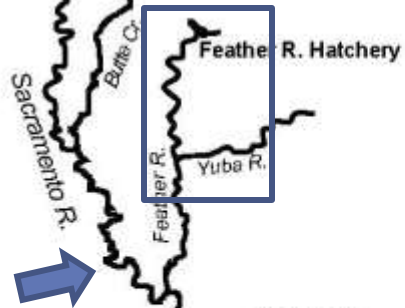
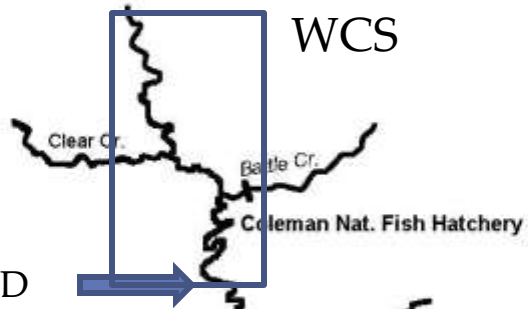
- 2014 **47% and 60%**
 - 875 – 4.7million/scraping
 - 22% >500k
 - *Intact myxospores* 86 and 52%
- 2015 **Falls = 84%, Spring= 78%**
 - 52% of all >500k spores
 - 1000 – 49million/scraping
- Billions of myxospore seeding HF each year



keswick

WCS

RBDD



L.Sac
Tisdale &
Knight's RST



Sacramento R. Natural Fall-run Chinook Juveniles

- April 2013 RB-KL. n=53
 - CS1=27%, Pm=61% Early stage infections
 - “Drought” March – April 2014 Tisdale n = 110 from 4 groups
 - Held at wetlab 9 – 14d for prognosis of infection
 - 18 – 69% cum. mortality, 91% associated with Cs infection
 - 63-77% Cs-POI in 2 week survivors
 - No samples in 2015 due to low catches
 - El Nino “Normal winter” Feb -March 2016, n= 51
 - CS1 = 33% all early infection (Pm1=54%) similar to 2013
- Ceratomyxosis is a progressive disease
 - 2-4wks– “unseen effect in wild juvenile populations”
 - Drought conditions associated with lethal infections (similar to FR)
 - higher polychaete numbers and greater actinospore concentrations in river?
 - = **population impact in some years**

Sept – Nov 2015 (2nd yr drought)

- Sentinel CNFH LFS exposed 5d Sep21-25 at Balls Ferry (rm275) and RBDD (rm243) – held for 22dpe
 - Balls Ferry **Cs 94%** Pm 69%
 - RBDD **Cs 86%** Pm 50%
 - enteronecrosis by 22 dpe, mortality likely if held longer
 - WCS fry RBDD Oct15- Nov29, n=80 ([RBFWO- Jsmith/B Poytress](#))
 - 34-80 mm - *many had reared for a period of time*
- CS 15% early state** , Pm 81% **Ich infections late Oct**
movement through infectious zone - reduced challenge?

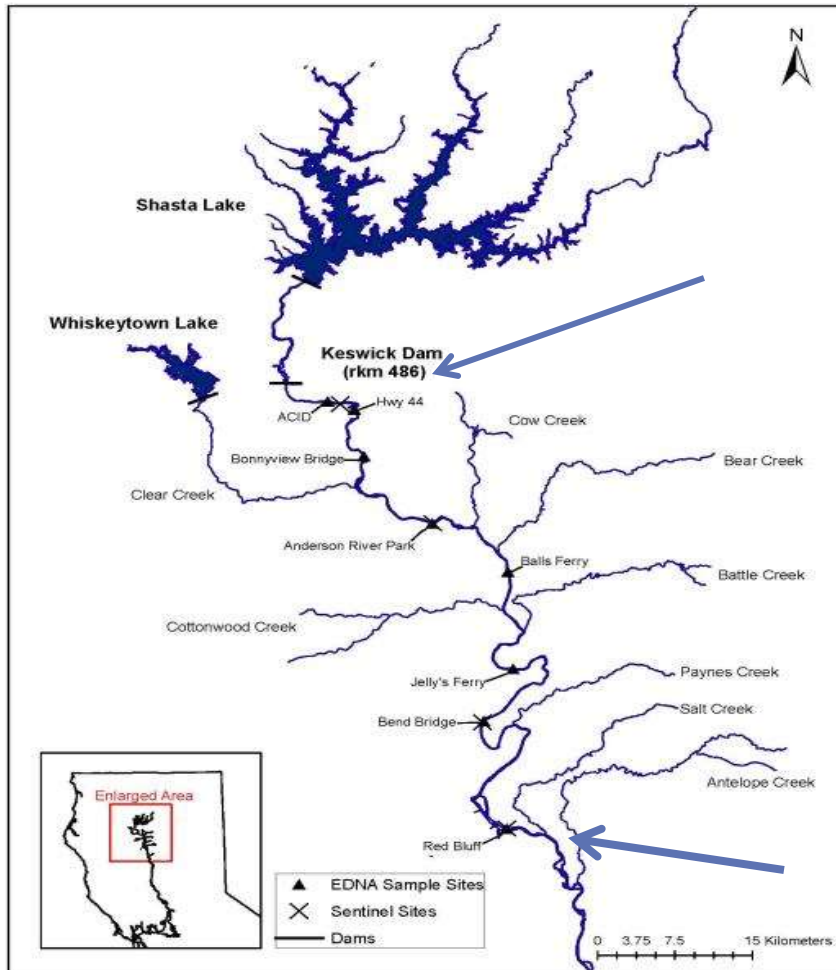


Not likely cause of low egg – fry observations
Can still effect migrants due to progressive nature
Prompted 2016 survey

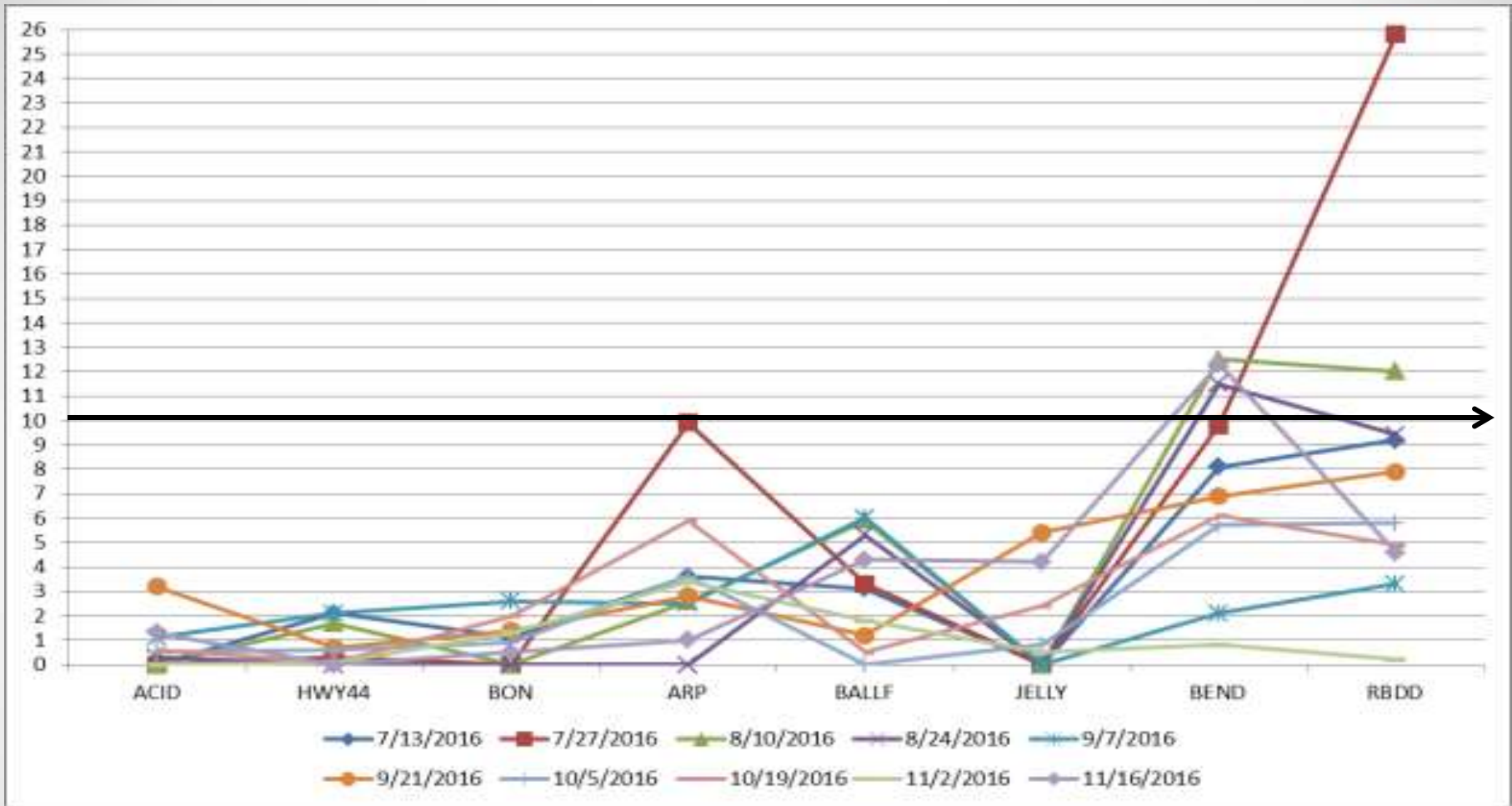


Ceratonova shasta and *Parvicapsula minibicornis* (Phylum Cnidaria: Myxosporea)
infectivity for juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the Upper
Sacramento River: July – November 2016

J. Scott Foott^{1*}, Ron Stone¹, Scott Voss², and Ken Nichols¹



- Five sentinel exposures at 4 locations between July 25 and Oct 11, 5d exposures/21d rear
- Water eDNA 8 locations July 13–Nov 16 (OSU Bartholomew lab)
- Naturally-produced WCS fry (n=80) Sep 9 – Nov 3

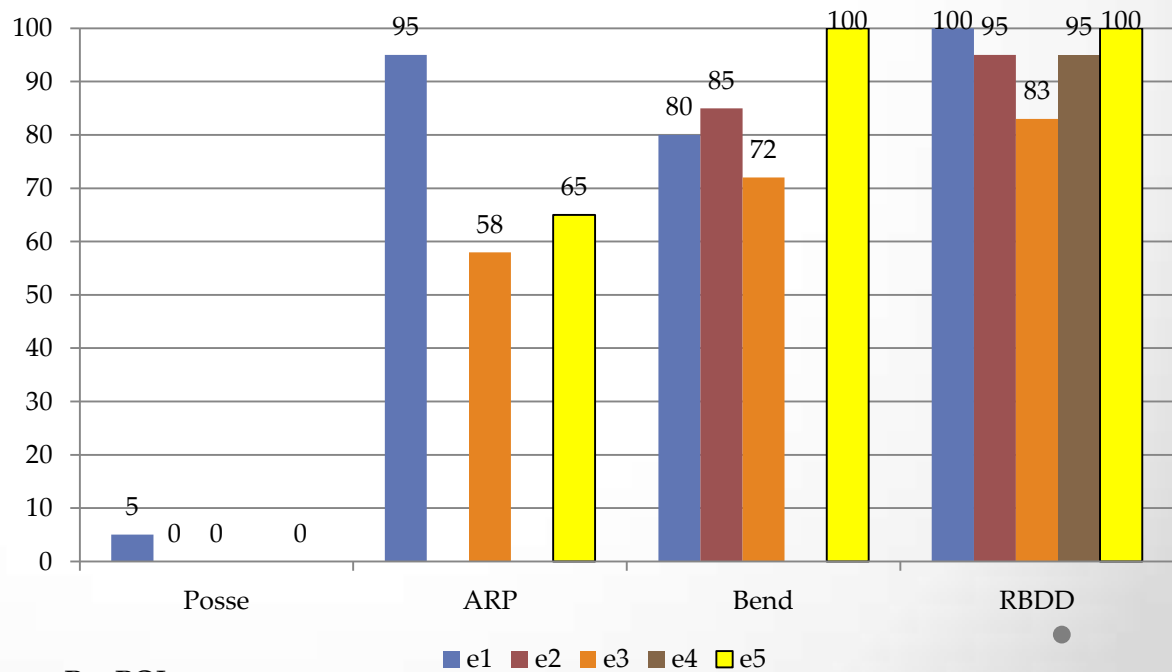
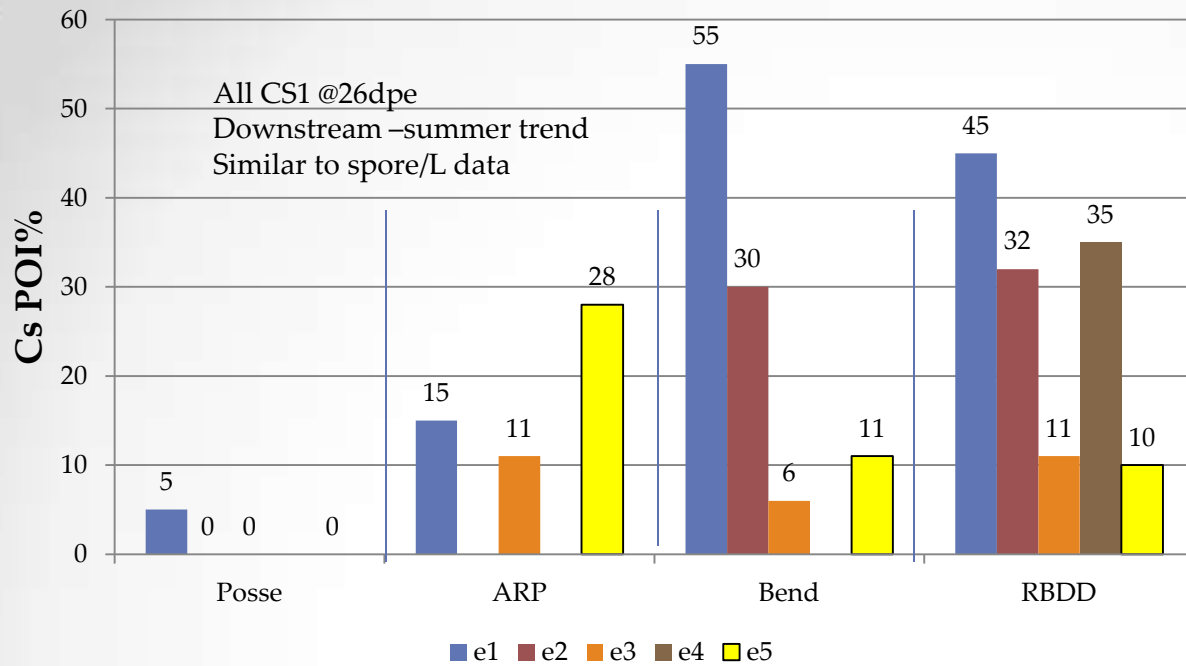


- Actinospore concentration trends :

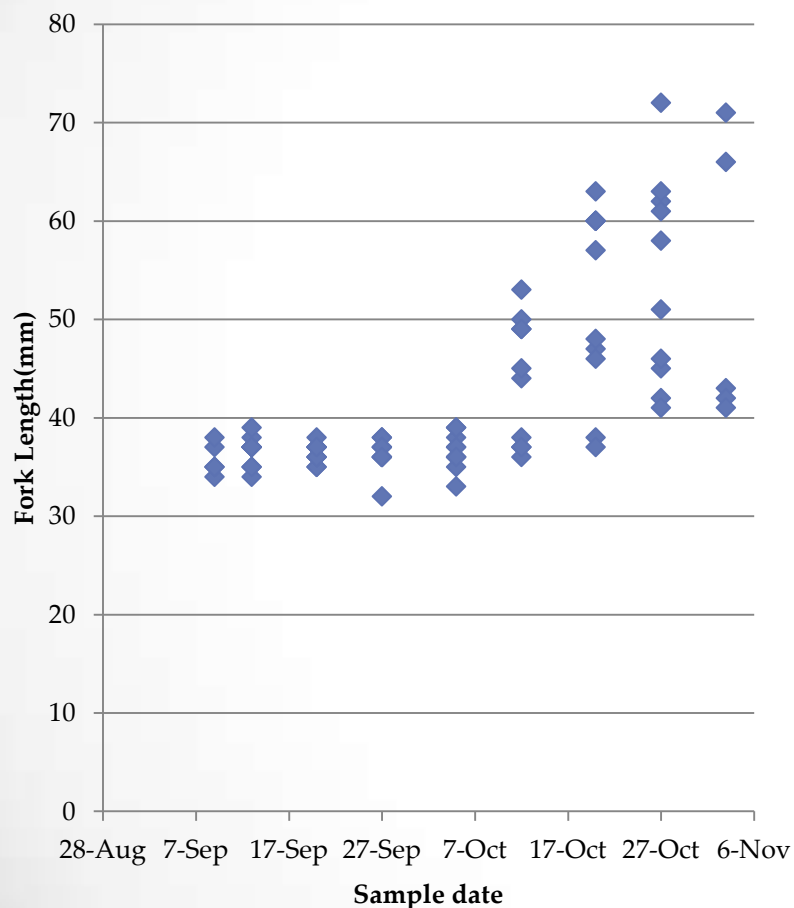
- Low level in study period most < 10 sp/L
- Increases in downstream fashion

max temp=15C

" IZ ~ ARP downriver"



Naturally produced WCS fry (RBDD capture)



- POI
 - CS1 = 5/79 (6%)
 - **CS2 = 1/79 (1%)**
 - PM1 = 6/62 (10%)
- All 3 methods indicate low *Cshasta* infectivity & “impact” to WCS fry during 2016 study period within the upper Sacramento R. reach

Summary

- Ceratomyxosis is a progress disease
 - clinical disease in 2-3 weeks post exposure
 - Difficult to monitor in a large complex system (CV)
- Myxospores from adults likely source for annual infectivity cycle
- Survey benefit from using 3 sources of data
 - eDNA, wild fish, and sentinel exposures
 - Polychaete monitoring difficult (dive surveys)
- Water year affects both in-season and future infectivity
 - Low flow, warmer temperatures favor polychaete population stability, parasite infectivity and rapid development in host
 - Disease may assert population impacts in drought years

Acknowledgements

- CDFW CDWR fishery biologists
- USFWS Red Bluff FWO – Lodi FWO
- OSU S Hallett, S Atkinson