U.S. Fish & Wildlife Service

California Nevada Fish Health Center

FY2017 Technical Report:

Prevalence and severity of *Ceratonova shasta* and *Parvicapsula minibicornis* infection in Feather River Juvenile Chinook Salmon (**January – May 2017**).

J. Scott Foott*[1] and Alana Imrie[2]

[1] U.S. Fish and Wildlife Service
California-Nevada Fish Health Center
24411 Coleman Hatchery Road
Anderson, CA 96007

[2] Pacific States Marine Fisheries Commission
California Department of Water Resources
DES Feather River Program
460 Glen Drive, Oroville CA 95966

*direct correspondence

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Summary: The Feather River had exceptionally high flows in the spring of 2017. These conditions limited our ability to obtain fish samples throughout the January to May study period to 153 natural Chinook fry (approximately 30% of our target number). Prevalence of infection in natural fry for *Ceratonova shasta* was 10% by histology and 48% by QPCR (there was a temporal bias in PCR samples for April and May), and 26% for *Parvicapsula minibicornis* by histology. Few of the infected fish were deemed in a disease state. No parasite infections were observed in hatchery spring-run Chinook captured 8 – 24 d post-release. Little to no detection of *C.shasta* DNA occurred in water samples from the historic "infectious zone". This finding supports the low infectivity observed in juvenile salmon.

The correct citation for this report is:

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Introduction:

This progress report is for the third season of the initial 3 year contract study. Previous surveys have documented a highly infectious zone for *Ceratonova shasta* that begins at the top of the high flow reach and extends approximately 14 river miles (rm) (Foott and Imrie 2016). While infection can occur as early as January, peak prevalence of infection and disease severity tend to occur in March. Adult salmon carcasses produce billions of myxospore in the low flow reach each fall to continue the parasite life cycle (myxospore shed from fish to polychaete worm, actinospore shed from polychaete to fish). Other background information on *Ceratonova shasta* can be found in Foott et al. (2016).

The objectives of the 2017 study season were:

1. Compare prevalence and severity of *C.shasta* and *Parvicapsula minibicornis* infection in natural Chinook juveniles in the low flow (Gateway trap) and high flow reaches (Gridley- Herringer trap) of the Feather River from January until out-migration tapers off in late spring.

2. Determine the level of *C.shasta* infectivity in a portion of the infectious zone (Gridley to Boyd's) from January through early May using a filtered water eDNA technique. Same day longitudinal water samples were also collected to further define the temporal and spatial aspects of the infectious zone.

3. Determine myxospore concentrations in the low flow reach by eDNA analysis after release from adult carcasses during and after spawning.

4. Document *C.shasta* infection in Feather R. Fish Hatchery Spring-run Chinook juveniles released in March and April at either Gridley or Boyd's Landing, and re-captured days later.

Methods:

Natural Chinook salmon (*Oncorhynchus tshawytscha*) juveniles were collected by California Department of Water Resource (DWR, Scientific Collection Permit 9611 and 13341) biologists from either rotary screw traps (Gateway [rm 59.6] and Herringer [rm 45.7]) as well as beach seine in the Gridley [rm 46 – 52] and Boyd's [rm 18 – 21] launch reaches between January and May (Table 1). Adipose-clip juveniles were collected by beach seine below the Boyd's ramp in March and April after CDFW release of Feather R. hatchery Spring-run Chinook juveniles into the Feather R (NMFS Section 10d permit 20745). A Spring-run Chinook sample was also collected from the hatchery on March 20. Tissues were fixed in Davidson's fixative for histological examination or frozen (intestine) for QPCR analysis.

Table 1. Natural juvenile Chinook sample numbers and mean (SD) fork length from Gateway trap and the Gridley ramp to Herringer trap reach over the 19 week study. The Monday date for each study week is reported for reference but may not be the actual sample date.

Week	Monday Date	Gateway	FL	Herringer trap / Gridley seine	FL
1	9-Jan			20	33 (1)
2	16-Jan				
3	23-Jan			10	ND
4	30-Jan	14	33 (2)	5	ND
5	6-Feb				
6	13-Feb				
7	20-Feb				
8	27-Feb				
9	6-Mar			20	48 (4)
10	13-Mar				
11	20-Mar				
12	27-Mar			11	46 (5)
13	3-Apr			11	ND
14	10-Apr			14	ND
15	17-Apr				
16	24-Apr			17	59 (8)
17	1-May			27	70 (11)
18	8-May				
19	15-May			4	86 (9)
	subtotals	14		139	
	total			**153**	

Laboratory assays were similar to 2015 (Foott et al. 2016) and water samples analyzed for *C.shasta* DNA by Oregon State University (Hallett et al. 2012). Water samples were collected by 3 methods over the course of the study period; 1) four 1-liter grab samples from the site (majority of water samples), 2) four 1-liter samples obtained from a 24h composite sample at the Herringer trap (Global Water Sampler WS700, 600 mL each hour), and 3) 1 liter subsamples from a 15 liter (4 gal) sample as described below.

During the 2016 fall spawning season through late January 2017, we employed a pilot method based on the assumption that myxospores will settle to the lower 1 liter layer of a 4 gallon sample within 24 h. Dr. Mike Deas (Watercourse Engineering, Inc) presented laboratory data at a 2016 Klamath Fish Health meeting that *C.shasta* myxospores settled at a rate of 0.33m/d (~ 13 inches) in still 20°C water. The height of the 4 gallon surface in a five gallon bucket is 13 inches. Another assumption in this analysis is that detected *C.shasta* DNA is from myxospores. It is based on high myxospore numbers associated with adult carcasses in the low flow reach near Riverbend (Foott and Imrie 2016) as well as the absence of actinospore infectivity to low flow reach salmon observed during the winter. This 1-liter "concentrate" was then filtered and assayed for *C.shasta* DNA. The spore/L data was divided by 15.1 (actual volume of sample). Water sample sites are listed in Table 2.

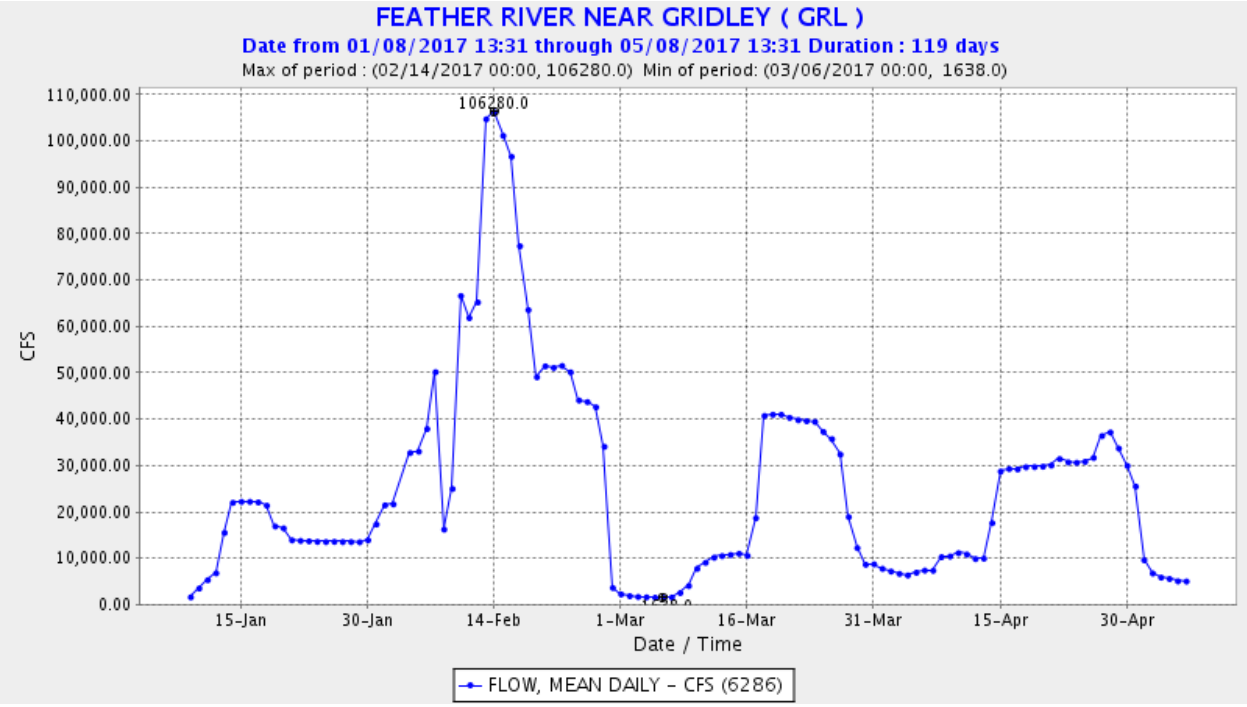
Table 2. Water sample sites, their abbreviation used in this report, and river mile.

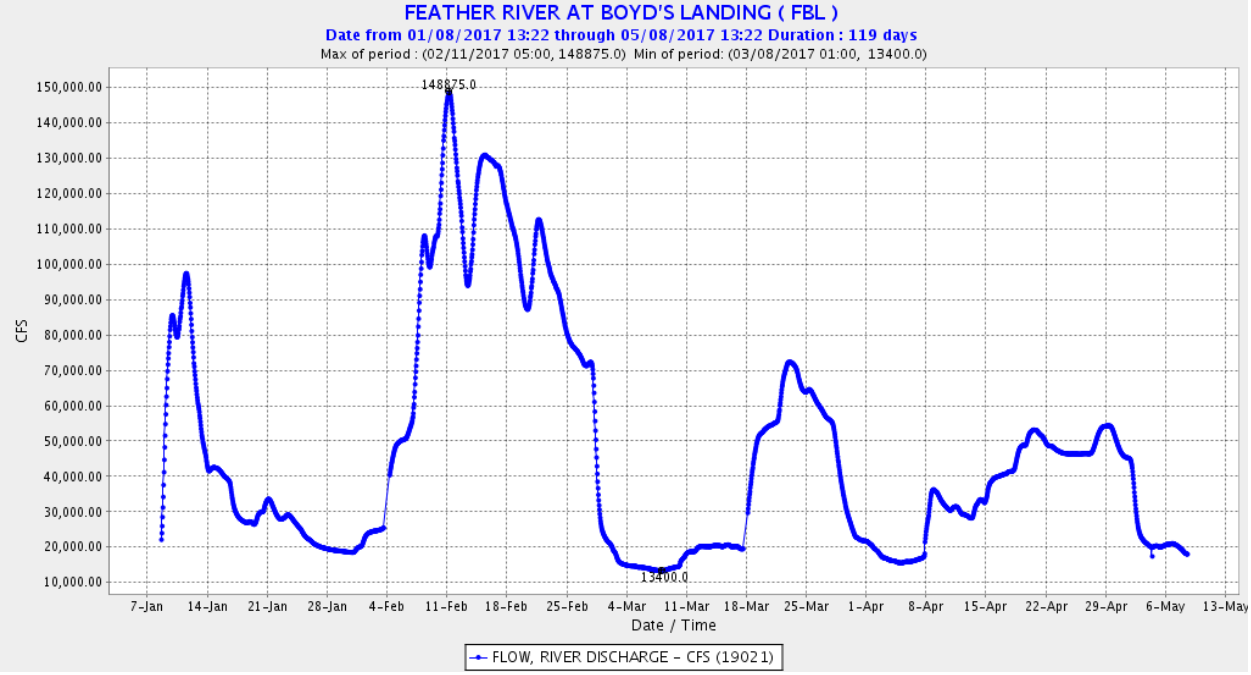
Site	Abbreviation	RiverMile
Riverbend	RIVB	65
Gateway	GTWY	59.6
Below TAO	BTAO	59
Above G-95	AG95	57.5
Palm	PALM	57
Developing Riffle	DRIF	52
Herringer	HERR	45.7
Live Oak	LVOK	41.5
Shawns Beach	SWNB	37.5
Train Bridge	TRBG	30.5
Boyds Landing	BYDS	22.3

Results:

The Feather River had abnormally high flows in the spring of 2017 with an early February peak of > 100,000 cfs in the study reach (Figure 1). Flows rarely dropped below 10,000 cfs and both rotary screw traps were inoperable after January. Beach seining was often conducted in off-channel pools formed after the river receded (see title page photo of isolated pools at the Marysville OHV Park on March 29). These difficult conditions resulted in a collection of approximately 30% of our initial targets and only one Gateway trap collection (January).

Figure 1. California Data Exchange Center River flow (cfs) data for the Feather River at Gridley and Boyd's landing between January and May 2017.





Gridley to Herringer reach- A total of 77 juveniles were collected between 11January and 16May with the mean fork length ranging from 33 to 86 mm (Table 1 and 3). *C.shasta* was first detected in the 05March histology sample set and by QPCR on 04April (Table 3). Initial *P. minibicornis* observation, by histology, occurred in the 29March collection group (Table 3). The prevalence of *C. shasta* infection (10% by histology and 48% by QPCR) was much lower than in previous surveys (Foott 2013 and 2014, Foott et al. 2016, Foott and Imrie 2016). The difference in prevalence between histology and QPCR may have been influenced by the larger QPCR sample set during the later infectious months (i.e. biased collection). Only 1 of 7 *C.shasta* infected histology samples and 1 of 31 QPCR samples were identified as "severe or diseased". Similarly, only one *P.minibicornis* infected kidney section of 19 positive samples showed glomerulonephritis (diseased) and none of the *Ichthyophthirius multifiliis* (Ich) positive gill sections had epithelial hyperplasia (Figure 1). No parasites were detected in the 26January Gateway trap sample group (5 histology, 9 QPCR). Nine of these Gateway fry were held for 4d at the DWR wet lab with no mortality.

Table 3. Occurrence of *P. minibicornis (*PM) in kidney*, Ichthyophthirius multifiliis* (Ich) on gill, and *C.shasta* (CS) within intestine of natural Chinook juveniles collected in the Gridley ramp to Herringer trap reach between January and May 2017. Data listed includes date of collection (Date), number of positive PM and CS samples rated as (1) infected no lesion or (2) infected with inflammation as well as prevalence of infection (POI) for all 3 parasites. *C.shasta* DNA was assayed by QPCR in a subset of fish with the cycle threshold (Ct) range reported for positive samples.

			Histology	Histology			Histology		QPCR	QPCR
Date	PM1	PM2	POI Pm	POI Gill Ich	CS1	CS2	POI Cs		POI Cs	Ct Range
11-Jan	0	0	0/10	0/10	0	0	0/10		0/10	na
27-Jan	0	0	0/9	0/10	0	0	0/10		ND	na
2-Feb	0	0	0/5	0/5	0	0	0/4		ND	na
5-Mar	0	0	0/5	1/5	1	0	1/5		0/15	na
29-Mar	2	0	2/11	0/12	1	0	1/11		ND	na
4-Apr	4	0	4/10	0/10	3	1	4/10		1/1	36.18
10-Apr	2	0	2/10	1/11	0	0	0/10		4/4	20.45 -35.97
24-Apr	2	0	2/5	1/5	0	0	0/5		8/12	30.33 -35.13
6-May	5	0	5/5	4/5	0	0	0/4		18/23	30.91 -37.56
16-May	3	1	4/4	0/4	1	0	1/4		ND	na
			19 / 74 (26%)	8/77 (10%)			7/73 (10%)		31/65 (48%)**	

** Majority of QPCR samples from April and May

ND not done

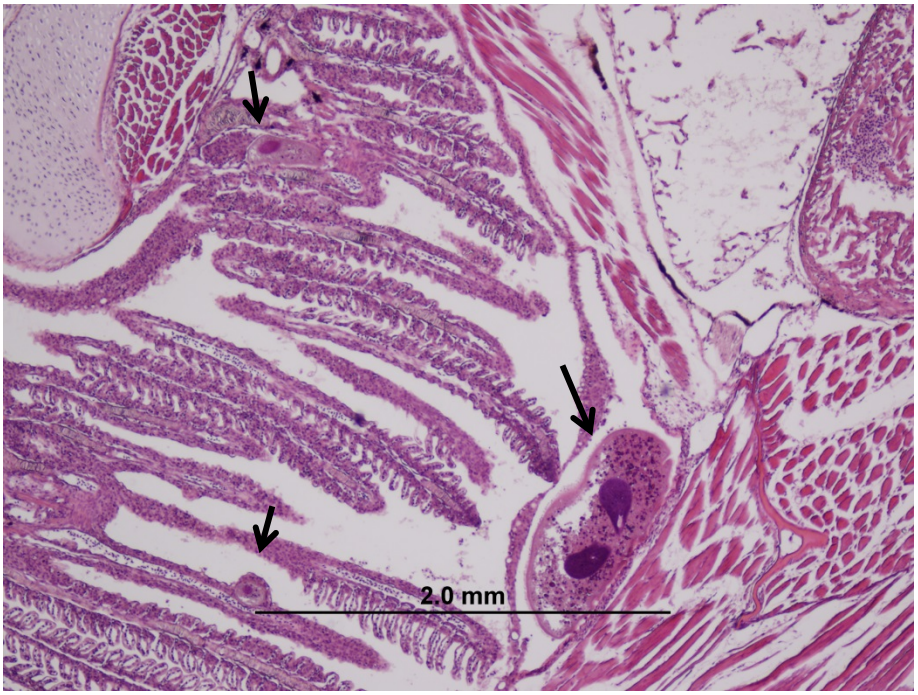


Figure 1. Low magnification micrograph of Chinook fry gill with various size *Ichthyophthirius multifiliis* trophozoites embedded within epithelia of lamellae and branchial cavity. Note lack of multifocal hyperplasia.

Feather R. hatchery Spring-run - A 15 fish sample was collected at the Feather R. hatchery annex on 20March. In-river collections of adipose fin clipped salmon (8 – 24d post release) occurred on 29March and 12April. Fork length ranged from 66 – 87 mm in March and 70 – 82mm in the April sample groups. No parasites were detected in the kidney, intestine, or gill of any FRH spring-run sample (Table 4). Moderate level of nephrocalcinosis was observed in the kidneys of both pre-release and post-release fish indicating a rearing environment or hatchery treatment effect. Coded wire tag codes were read by DWR (Table 5).

Table 4. Feather River Hatchery annex (FRH), Marysville to Star Bend (M-SB), and Boyd's to Star Bend reach (B-SB), and collections of adipose fin clip Spring-run Chinook for histology and C.*shasta* QPCR analysis. Data includes date of collection (Date), day post-release as per coded wire tag (DPR), number of positive histology samples for *P.minibicornis* (PM) and *C.shasta* (CS) rated as (1) infected no lesion or (2) infected with lesions as well as prevalence of infection (POI) for these parasites and *Ichthyophthirius multifiliis (Ich)* on gill tissue. *C.shasta* DNA within intestine was also assayed by QPCR in a subset of FRH fish.

					Histology	Histology			Histology		QPCR
Date	DPR	Site	PM1	PM2	POI Pm	POI Gill Ich	CS1	CS2	POI Cs		POI Cs
20-Mar	0	FRH	0	0	0/10	0/10	0	0	0/10		0/5
29-Mar	9	M-SB	0	0	0/20	0/20	0	0	0/20		ND
12-Apr	8	B-SB	0	0	0/11	0/8	0	0	0/11		ND
12-Apr	24	B-SB	0	0	0/3	0/3	0	0	0/3		ND

ND Not done

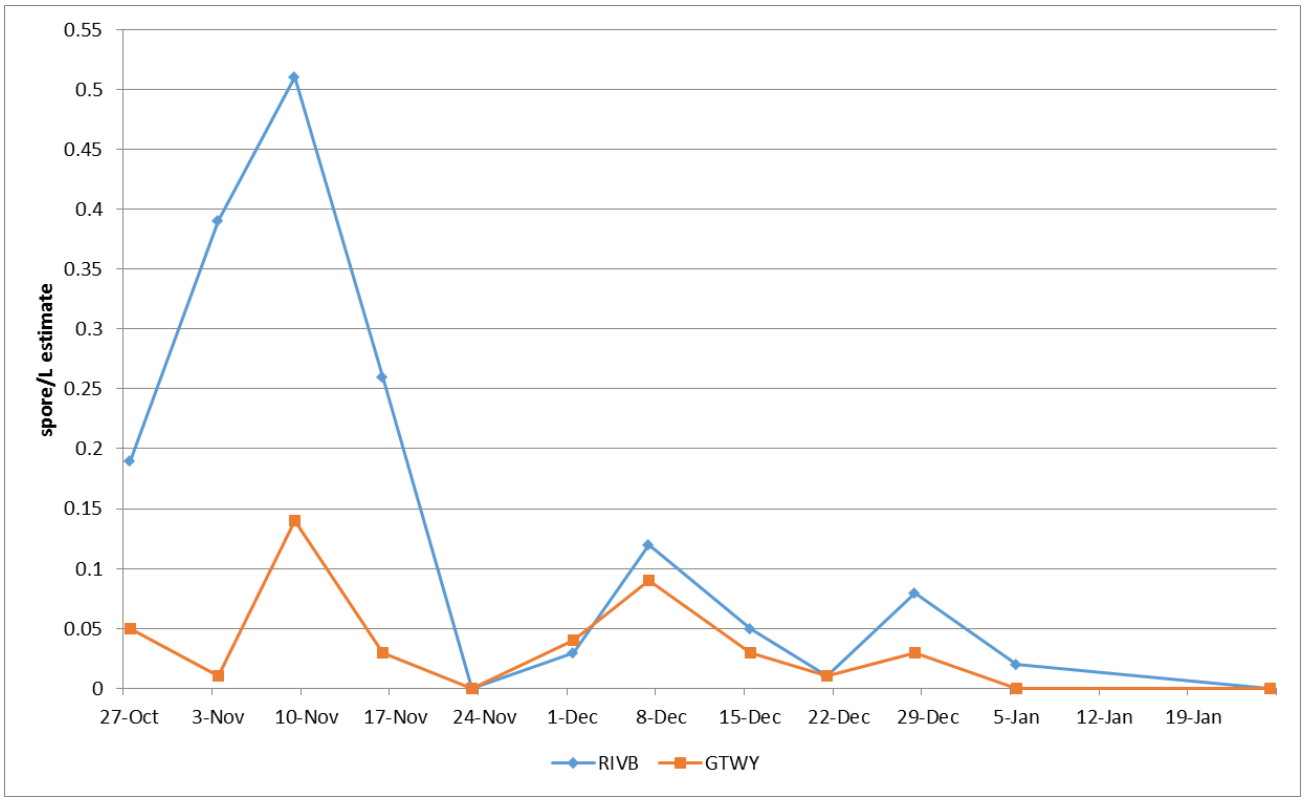
Table 5. Tag codes and numbers of samples (No.) of Feather R. Spring-run Chinook captured in river on 29March and 12April.

Date	Codes	No.
29-Mar	06 09 65	18
	06 09 64	2
12-Apr	06 09 65	2
	06 09 64	1
	06 09 66	10
	06 80 02	1

Signs of bacterial gill disease and infestation by an unidentified protozoan were observed in a 20April diagnostic histology sample of 10 juvenile Chinook held at the DWR wet lab for a potential Knages ranch release. This clinical picture of the moribund population suggests poor rearing conditions. No internal parasites were observed in the sections.

C.shasta DNA in river water- Inhibition of the Riverbend or Gateway filtrate occurred in 60% of the sample set and was likely due to sediment (Appendix 1). Despite this assay issue, detection occurred in 19 of 24 sample collections. The 23November zero detection is suspect given the positive findings on dates prior and after it. The spawning ground (Riverbend) samples tended to have higher spore/L values than the downriver Gateway site (Fig.2) however the adjusted spore/L values were all < 1 spore. Rain events and increased flows in January may have influenced the loss of signal at Gateway. This data indicates a relatively steady but low concentration of myxospores moving into the high flow reach after decomposition of adult carcasses.

Figure 2. Presumptive myxospore/L estimates from 15L concentrate water samples collected from 27October2016 through 5January2017 at Riverbend (RIVB) and Gateway (GTWY).



Longitudinal river samples from Gateway to Boyd's showed little to no actinospore concentrations in the study reach between January and May (Table 6). The 25January sample set had extremely low spore/L findings (one of 3 replicates) in the upper portion of the previous "infectious zone" that had started at the low to high flow reach transition. Low (2 -4) spore/L values were measured from Herringer to Boyd's at this time. No

detections occurred in April and only 3 of 10 sites had extremely low spore/L values in the 15May sample.

Table 6. Mean spore/L data from triplicate longitudinal river samples collected from Gateway (GTWY), below the after bay outlet (BTAO), above G-95 (AG95), Palm, Developing riffle (DRIF), Herringer (HERR), Live Oak (LVOK), Shawn's Beach (SWNB), Train Bridge (TRBG), and Boyd's Landing (BYDS) on 25January, 11April, and 15May 2017. Note when a zero occurred in triplicate sample set, all data is shown in parenthesis.

DATE	GTWY	BTAO	AG95	PALM	DRIF	HERR	LVOK	SWNB	TRBG	BYDS
25-Jan	0	0	0.05 (0,0,0.1)	0.3 (0.0.1.0.8)	1.2	3.4*	2.4	1.9	1	0.5
11-Apr	0	0	0	0	0	0	0	0	0	0
15-May	0	0	0	0.7 (2,0,0)	0.9 (1.7,0,0)	1.4 (4.2,0,0)	0	0	0	0

* Sample from 24h composite collection not a grab as other locations

Grab samples from the study reach (Gridley launch to Herringer (H-G) and Boyd's landing) showed little to no spore/L concentrations after early February (Table 7).

Table 7. Mean spore/L data from the Gridley to Herringer reach (H-G) and Boyd's launch between January and May 2017.

DATE	H-G	BOYDS
5-Jan	5.6*	ND
25-Jan	3.4*	0.5
2-Feb	2.2	ND
16-Mar	0	0
29-Mar	0	0
4-Apr	0	ND
11-Apr	0	0
7-May	0	ND
15-May	1.4	0

* 24h composite sample

ND not done

Discussion:

Seasonal prevalence of *C.shasta* infection, in natural Feather R. juvenile Chinook collected in the "infectious zone", has ranged from 46 to 68% (Foott 2014, Foott et al. 2016, and Foott & Imrie 2016). Many of these infected salmon were categorized as being in a clinically diseased state. In contrast, low *C.shasta* infectivity (10%) and severity was associated with high river flows during the spring of 2017. Similarly, hatchery spring-run chinook were likely unaffected by *C.shasta* infection during their out-migration in 2017. We hypothesize that these high flow conditions acted to disrupt polychaete habitat and therefore reduce the alternative host population in the historic infectious zone. This disruption of the lifecycle would result in fewer actinospores present in the river. Additionally, high flows would act to dilute actinospore concentrations. The longevity of reduced infectivity will be of interest in future years.

Low *C.shasta* infectivity in juvenile salmon is unlikely a result of reduced myxospore input into the high flow reach. The pilot water sample protocol, for myxospore analysis, detected *C.shasta* DNA in 79% of the samples. A positive signal in the Gateway samples (representing input into the infectious zone) occurred from October to the end of December. In contrast, *C.shasta* DNA detection in Gateway samples ceased by late November 2016 (Foott and Imrie 2106). The concentration of myxospores from a larger sample volume may have increased sensitivity in 2017. This collection method needs to be refined (e.g. extraction with soil sample kits to reduce inhibition issues) and validated with known number of myxospores prior to regular use in myxospore surveillance. Little to no *C.shasta* DNA detection occurred in water samples from the study reach over the winter and spring. This data supports the observed low infectivity in juvenile salmon.

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Appendix 1. *C.shasta* eDNA results

date	locality	bottle #	total volume (L)	comment	inhibition (delta IPC)	Spores per sample based on mean Cq	spores per liter	time	temp	mean	adj mean	sp/L15.1L
10/27/2016	Riverbend	1	1		2.6	6.8	6.8			2.9	1.0	**0.19**
10/27/2016	Riverbend	2	1		3.5	1.1	1.1					
10/27/2016	Riverbend	3	1		4.1	0.8	0.8					
10/27/2016	Gateway	4	1		6.2	0.4	0.4			0.8		**0.05**
10/27/2016	Gateway	5	1		6.7	0.4	0.4					
10/27/2016	Gateway	6	1		4.8	1.7	1.7					
11/3/2016	Riverbend	7	1		2.3	6.1	6.1			5.9		**0.39**
11/3/2016	Riverbend	8	1		2.6	7.0	7.0					
11/3/2016	Riverbend	9	1		3.2	4.6	4.6					
11/3/2016	Gateway	10	1		#VALUE!	0.0	0.0			0.2		**0.01**
11/3/2016	Gateway	11	1		8.9	0.0	0.0					
11/3/2016	Gateway	12	1		4.4	0.5	0.5					
11/9/2016	Riverbend	13	0.9		2.9	10.8	12.0			7.8		**0.51**
11/9/2016	Riverbend	14	1		4.0	2.6	2.6					
11/9/2016	Riverbend	15	1		1.9	8.7	8.7					
11/9/2016	Gateway	16	1		1.9	2.0	2.0			2.0		**0.14**
11/9/2016	Gateway	17	1		2.0	1.7	1.7					
11/9/2016	Gateway	18	1		2.2	2.4	2.4					
11/16/2016	Riverbend	19	1		1.4	2.0	2.0			3.9		**0.26**
11/16/2016	Riverbend	20	1		1.7	1.3	1.3					
11/16/2016	Riverbend	21	1		1.2	8.4	8.4					
11/16/2016	Gateway	22	1	Only 2 samples, bucket broke	2.7	0.8	0.8			0.4		**0.03**
11/16/2016	Gateway	23	1	Only 2 samples, bucket broke	9.8	0.0	0.0					
11/23/2016	Riverbend	24	0.7	24-700 mL	#VALUE!	0.0	0.0			0.0		**0.00**
11/23/2016	Riverbend	25	1		10.0	0.0	0.0					
11/23/2016	Riverbend	26	1		#VALUE!	0.0	0.0					
11/23/2016	Gateway	27	1	only 2 samples, one bucket didn't drain	8.9	0.0	0.0					
11/23/2016	Gateway	28	1	only 2 samples, one bucket didn't drain	10.6	0.0	0.0			0.0		**0.00**
12/1/2016	Riverbend	29	1	30- 900mL	2.5	0.0	0.0			0.4		**0.03**
12/1/2016	Riverbend	30	0.9		6.8	0.0	0.0					
12/1/2016	Riverbend	31	1		1.8	1.2	1.2					
12/1/2016	Gateway	32	1		0.8	1.1	1.1			0.6		**0.04**
12/1/2016	Gateway	33	1		2.3	0.3	0.3					
12/1/2016	Gateway	34	1		2.4	0.4	0.4					
12/7/2016	Riverbend	35	1		1.4	2.1	2.1			1.8		**0.12**
12/7/2016	Riverbend	36	1		2.6	1.3	1.3					
12/7/2016	Riverbend	37	1		2.5	1.8	1.8					
12/7/2016	Gateway	38	1		2.1	1.2	1.2			1.4		**0.09**
12/7/2016	Gateway	39	1		2.1	0.8	0.8					
12/7/2016	Gateway	40	1		1.5	2.1	2.1					
12/15/2016	Riverbend	41	1		2.0	1.5	1.5			0.7		**0.05**
12/15/2016	Riverbend	42	1		3.0	0.4	0.4					
12/15/2016	Riverbend	43	1		3.7	0.3	0.3					
12/15/2016	Gateway	44	1		2.6	0.6	0.6			0.5		**0.03**
12/15/2016	Gateway	45	1		2.4	0.1	0.1					
12/15/2016	Gateway	46	1		2.5	0.7	0.7					
12/21/2016	Riverbend	47	1		1.4	0.1	0.1			0.2		**0.01**
12/21/2016	Riverbend	48	1		1.5	0.4	0.4					
12/21/2016	Riverbend	49	1		0.6	0.0	0.0					
12/21/2016	Gateway	50	1		1.2	0.3	0.3			0.1		**0.01**
12/21/2016	Gateway	51	1		1.5	0.0	0.0					
12/21/2016	Gateway	52	1	52, 52B-500mL each	2.9	0.1	0.1					
12/28/2016	Riverbend	53	1		0.5	1.4	1.4			1.2		**0.08**
12/28/2016	Riverbend	54	1		0.1	1.3	1.3					
12/28/2016	Riverbend	55	1		0.0	0.9	0.9					
12/28/2016	Gateway	56	1		0.6	0.1	0.1			0.5		**0.03**
12/28/2016	Gateway	57	1		0.9	0.5	0.5					
12/28/2016	Gateway	58	1		1.3	0.8	0.8					

date	locality	bottle #	total volume (L)	comment	inhibition (delta IPC)	Spores per sample based on mean Cq	spores per liter	time	temp	mean	adj mean
1/5/2017	Herringer 24 hr composite	1	1		0.0	5.6	5.6		8.5	5.6	1.6883
1/5/2017	Herringer 24 hr composite	2	1		0.3	3.9	3.9		8.5		
1/5/2017	Herringer 24 hr composite	3	1		0.2	7.3	7.3		8.5		
1/5/2017	Riverbend	59	1		0.8	0.1	0.1			0.3	
1/5/2017	Riverbend	60	1	60 A&B, 61 A&B- 500 mL each	0.5	0.5	0.5				
1/5/2017	Riverbend	61	1	60 A&B, 61 A&B- 500 mL each	0.5	0.2	0.2				
1/5/2017	Gateway	62	1		0.4	0.0	0.0			0.0	
1/5/2017	Gateway	63	1		0.0	0.1	0.1				
1/5/2017	Gateway	64	1		0.3	0.0	0.0				
1/25/2017	Boyds	4	1	A=750mL, B=250mL	0.3	0.1	0.1	1000.0	8		
1/25/2017	Boyds	5	1	A=750mL, B=250mL	0.2	0.4	0.4	1000.0	8		
1/25/2017	Boyds	6	1	A=750mL, B=250mL	0.6	1.0	1.0	1000.0	8		
1/25/2017	Train Bridge	7	1	A=750mL, B=250mL	0.5	0.6	0.6	1113.0	8		
1/25/2017	Train Bridge	8	1	A=750mL, B=250mL	0.5	2.2	2.2	1113.0	8		
1/25/2017	Train Bridge	9	1	A=750mL, B=250mL	1.0	0.2	0.2	1113.0	8		
1/25/2017	Shawn's Beach	10	1		0.0	2.1	2.1	1210.0	8.5		
1/25/2017	Shawn's Beach	11	1		0.2	1.1	1.1	1210.0	8.5		
1/25/2017	Shawn's Beach	12	1		0.4	2.5	2.5	1210.0	8.5		
1/25/2017	Live Oak	13	1		0.2	2.0	2.0	1340.0	9		
1/25/2017	Live Oak	14	1		0.0	1.8	1.8	1340.0	9		
1/25/2017	Live Oak	15	1		0.3	3.4	3.4	1340.0	9		
1/25/2017	Developing	20	1		0.0	1.2	1.2	1407.0	9		
1/25/2017	Developing	21	1		0.1	1.5	1.5	1407.0	9		
1/25/2017	Developing	22	1		0.0	0.9	0.9	1407.0	9		
1/25/2017	Palm	23	1		0.0	0.0	0.0	1417.0	8.5		
1/25/2017	Palm	24	1		0.0	0.1	0.1	1417.0	8.5		
1/25/2017	Palm	25	1		0.1	0.8	0.8	1417.0	8.5		
1/25/2017	Above G-95	26	1		0.0	0.1	0.1	1425.0	8		
1/25/2017	Above G-95	27	1		0.0	0.0	0.0	1425.0	8		
1/25/2017	Above G-95	28	1		0.2	0.0	0.0	1425.0	8		
1/25/2017	Below TAO	29	1		0.8	0.0	0.0	1433.0	8		
1/25/2017	Below TAO	30	1		0.5	0.0	0.0	1433.0	8		
1/25/2017	Below TAO	31	1		0.3	0.0	0.0	1433.0	8		
1/25/2017	Gateway	32	1		0.0	0.0	0.0	1444.0	8		
1/25/2017	Gateway	33	1		0.6	0.0	0.0	1444.0	8		
1/25/2017	Gateway	34	1		0.7	0.0	0.0	1444.0	8		
1/25/2017	Riverbend	65	1	65 A&B, 66 A&B-500 mL each, 67A 750mL, 67B250mL	0.3	0.0	0.0				
1/25/2017	Riverbend	66	1	65 A&B, 66 A&B-500 mL each, 67A 750mL, 67B250mL	0.4	0.0	0.0				
1/25/2017	Riverbend	67	1	65 A&B, 66 A&B-500 mL each, 67A 750mL, 67B250mL	0.4	0.0	0.0				
1/25/2017	Gateway	68	1	68A&B-500mL each, 69A- 750 mL, 69B 250mL, 70A-750mL, 70B-250mL	0.5	0.0	0.0				
1/25/2017	Gateway	69	1	68A&B-500mL each, 69A- 750 mL, 69B 250mL, 70A-750mL, 70B-250mL	0.4	0.0	0.0				
1/25/2017	Gateway	70	1	68A&B-500mL each, 69A- 750 mL, 69B 250mL, 70A-750mL, 70B-250mL	0.2	0.0	0.0				
2/2/2017	Herringer-Grab	35	1		1.5	2.4	2.4	1500.0	9	2.2	0.7931
2/2/2017	Herringer-Grab	36	1		1.0	2.9	2.9	1500.0	9		
2/2/2017	Herringer-Grab	37	1		0.8	1.3	1.3	1500.0	9		
2/23/2017	Outlet Ramp	38	1		1.0	0.0	0.0	930.0	8	0.0	0
2/23/2017	Outlet Ramp	39	1		0.8	0.0	0.0	930.0	8		
2/23/2017	Outlet Ramp	40	1		1.1	0.0	0.0	930.0	8		
3/16/2017	Boyd's	41	0.7	all filters only 350 mL each; expedited	0.3	0.0	0.0	1120.0	10.0	0.0	0
3/16/2017	Boyd's	42	0.7	all filters only 350 mL each; expedited	0.3	0.0	0.0	1120.0	10.0		
3/16/2017	Boyd's	43	0.7	all filters only 350 mL each; expedited	0.3	0.0	0.0	1120.0	10.0		
3/16/2017	Boyd's	44	0.7	all filters only 350 mL each; expedited	0.3	0.0	0.0	1120.0	10.0	0.0	0
3/16/2017	Gridley	45	0.9	all filters only 450 mL each; expedited	0.3	0.0	0.0	1230.0	9.0		
3/16/2017	Gridley	46	0.9	all filters only 450 mL each; expedited	0.3	0.0	0.0	1230.0	9.0		
3/16/2017	Gridley	47	0.9	all filters only 450 mL each; expedited	0.3	0.0	0.0	1230.0	9.0		
3/16/2017	Gridley	48	0.9	all filters only 450 mL each; expedited	0.3	0.0	0.0	1230.0	9.0		
1/24-1/25	Herringer 24 hr composite	16	1	No fish collected with water samples	0.2	3.0	3.0			3.4	1.8051
1/24-1/25	Herringer 24 hr composite	17	1	No fish collected with water samples	0.0	1.4	1.4				
1/24-1/25	Herringer 24 hr composite	18	1	No fish collected with water samples	0.0	3.3	3.3				
1/24-1/25	Herringer 24 hr composite	19	1	No fish collected with water samples	0.0	5.8	5.8				

Notes:

High inhibition levels at values >2.0; final spores per liter values are questionable.

date	locality	bottle #	total volume (L)	comment	inhibition (delta IPC)	spores per liter
3/29/2017	Boyd's	49	1		0.5	trace
3/29/2017	Boyd's	50	1		0.0	0.0
3/29/2017	Boyd's	51	1		0.4	0.0
3/29/2017	Gridley	52	1		0.4	0.0
3/29/2017	Gridley	53	1		0.0	trace
3/29/2017	Gridley	54	1		0.2	<1sp/L
4/4/2017	Herringer 1/4 mile DS RL	55	1		0.4	0.0
4/4/2017	Herringer 1/4 mile DS RL	56	1		0.1	0.0
4/4/2017	Herringer 1/4 mile DS RL	57	1		0.3	0.0
4/10/2017	Herringer Trap	58	1	seined for fish DS RL	0.2	0.0
4/10/2017	Herringer Trap	59	1	seined for fish DS RL	0.1	0.0
4/10/2017	Herringer Trap	60	1	seined for fish DS RL	0.2	0.0
4/11/2017	Boyd's	61	1		0.0	trace
4/11/2017	Boyd's	62	1		0.0	trace
4/11/2017	Boyd's	63	1		0.1	trace
4/11/2017	Train Bridge	64	1		0.4	trace
4/11/2017	Train Bridge	65	1		0.5	0.0
4/11/2017	Train Bridge	66	1		0.3	0.0
4/11/2017	Shawn's Beach	67	1		0.0	0.0
4/11/2017	Shawn's Beach	68	1		0.0	0.0
4/11/2017	Shawn's Beach	69	1		0.0	0.0
4/11/2017	Live Oak	70	1	very turbid, washing own ramp	0.0	0.0
4/11/2017	Live Oak	71	1	very turbid, washing own ramp	0.2	0.0
4/11/2017	Live Oak	72	1	very turbid, washing own ramp	0.0	0.0
4/11/2017	Developing	73	1		0.0	trace
4/11/2017	Developing	74	1		0.0	0.0
4/11/2017	Developing	75	1		0.0	0.0
4/11/2017	Palm	76	1		0.0	0.0
4/11/2017	Palm	77	1		0.0	0.0
4/11/2017	Palm	78	1		0.2	0.0
4/11/2017	Above G-95	79	1		0.0	0.0
4/11/2017	Above G-95	80	1		0.0	0.0
4/11/2017	Above G-95	81	1		0.0	0.0
4/11/2017	Below TAO	82	1		0.0	0.0
4/11/2017	Below TAO	83	1		0.0	0.0
4/11/2017	Below TAO	84	1		0.0	0.0
4/11/2017	Gateway	85	1	assumed 1	0.0	0.0
4/11/2017	Gateway	86	1	assumed 1	0.0	0.0
4/11/2017	Gateway	87	1	assumed 1	0.0	0.0
5/7/2017	Herringer	88	1	2 x 500	0.0	0.0
5/7/2017	Herringer	89	1	2 x 500	0.0	0.0
5/7/2017	Herringer	90	1	2 x 500	0.0	0.0

date	locality	bottle #	total volume (L)	comment	inhibition (delta IPC)	spores per liter
5/15/2017	Boyd's	91	1	2 x 500	0.9	0.0
5/15/2017	Boyd's	92	1	2 x 500	0.9	0.0
5/15/2017	Boyd's	93	1	2 x 500	0.8	0.0
5/15/2017	Train Bridge	94	1	2 x 500	1.3	0.0
5/15/2017	Train Bridge	95	1	2 x 500	1.0	0.0
5/15/2017	Train Bridge	96	1	2 x 500	2.3	0.0
5/15/2017	Shawn's Beach	97	1	2 x 500	2.0	0.0
5/15/2017	Shawn's Beach	98	1	2 x 500	0.9	<1sp/L
5/15/2017	Shawn's Beach	99	1	2 x 500	0.9	<1sp/L
5/15/2017	Live Oak	100	1	2 x 500	0.6	0.0
5/15/2017	Live Oak	101	1	2 x 500	0.5	0.0
5/15/2017	Live Oak	102	1	2 x 500	0.7	trace
5/15/2017	Herringer	103	1	2 x 500	0.5	4.2
5/15/2017	Herringer	104	1	2 x 500	0.5	0.0
5/15/2017	Herringer	105	1	2 x 500	0.4	0.0
5/15/2017	Developing	106	1	2 x 500	0.5	0.0
5/15/2017	Developing	107	1	2 x 500	0.7	1.7
5/15/2017	Developing	108	1	2 x 500	0.6	trace
5/15/2017	Palm	109	1	2 x 500	0.5	0.0
5/15/2017	Palm	110	1	2 x 500	0.3	2.2
5/15/2017	Palm	111	1	2 x 500	0.0	0.0
5/15/2017	Above G-95	112	1	2 x 500	0.1	0.0
5/15/2017	Above G-95	113	1	2 x 500	0.2	trace
5/15/2017	Above G-95	114	1	2 x 500	0.2	0.0
5/15/2017	Below TAO	115	1	2 x 500	0.3	0.0
5/15/2017	Below TAO	116	1	2 x 500	0.3	0.0
5/15/2017	Below TAO	117	1	2 x 500	0.7	0.0
5/15/2017	Gateway	118	1	2 x 500	0.2	0.0
5/15/2017	Gateway	119	1	2 x 500	0.5	0.0
5/15/2017	Gateway	120	1	2 x 500	0.2	0.0