Effects of Forest Management - Part Two

Relating Salmonid Population Health to Natural Turbidity Regimes in Northwest Streams

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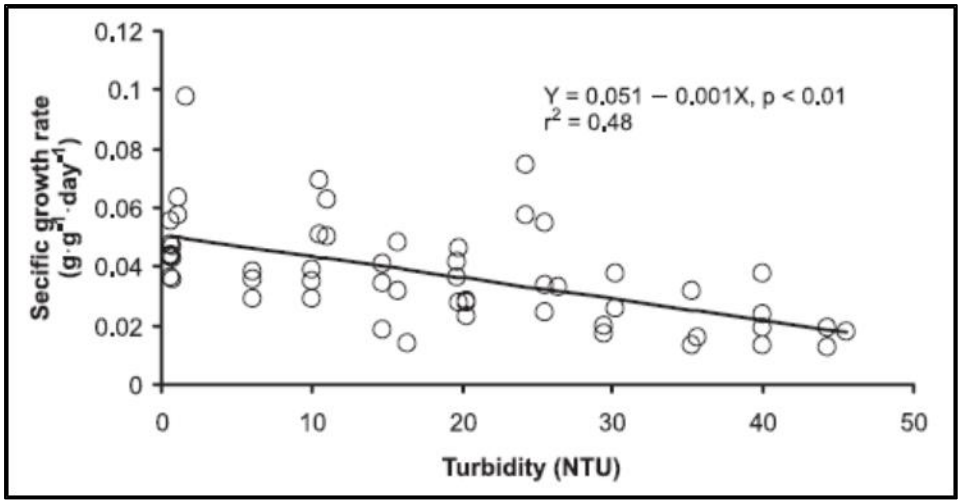
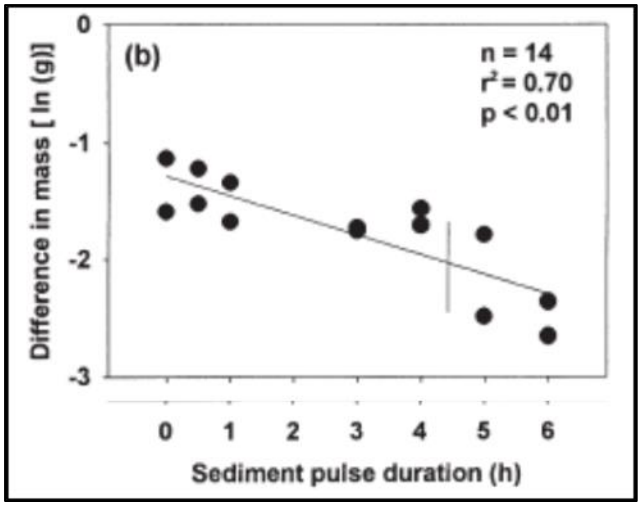
Western Forestry Conservation Association
September 8, 2016. Heathman Lodge, Vancouver WA.

Suspended Sediment/Turbidity Effects

Experimental studies in artificial streams indicate that fish growth declines with increasing concentration and duration of exposure.

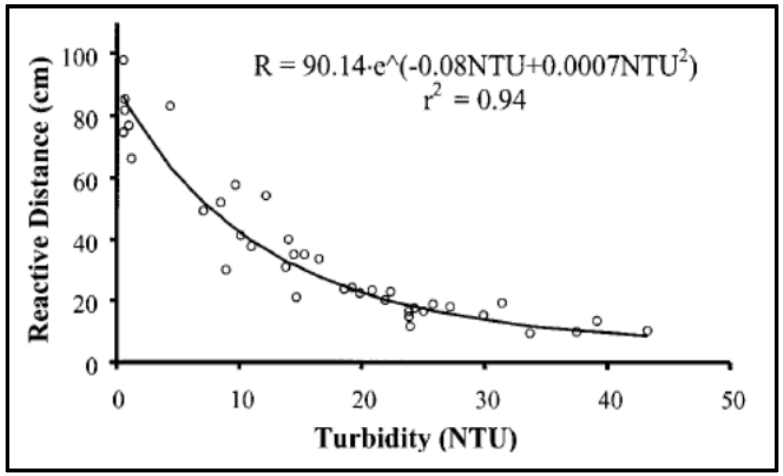


Sweka and Hartman 2001

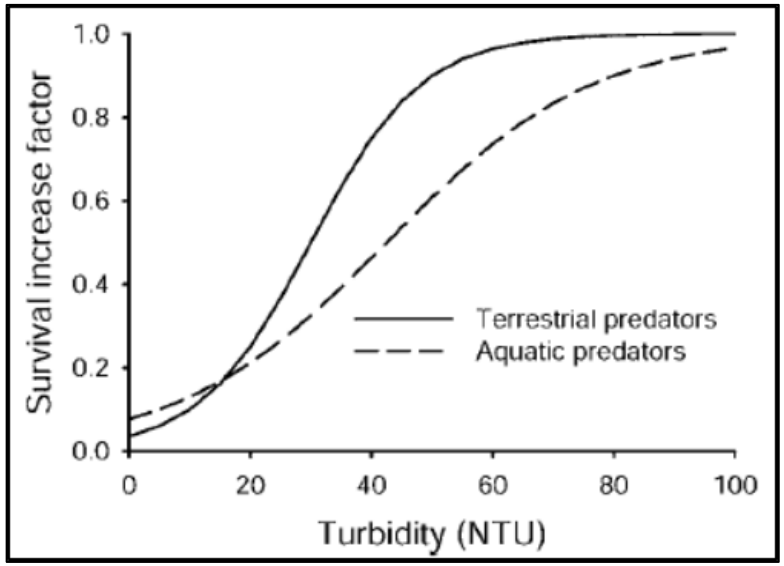


Shaw and Richardson 2001

Suspended Sediment/Turbidity Effects



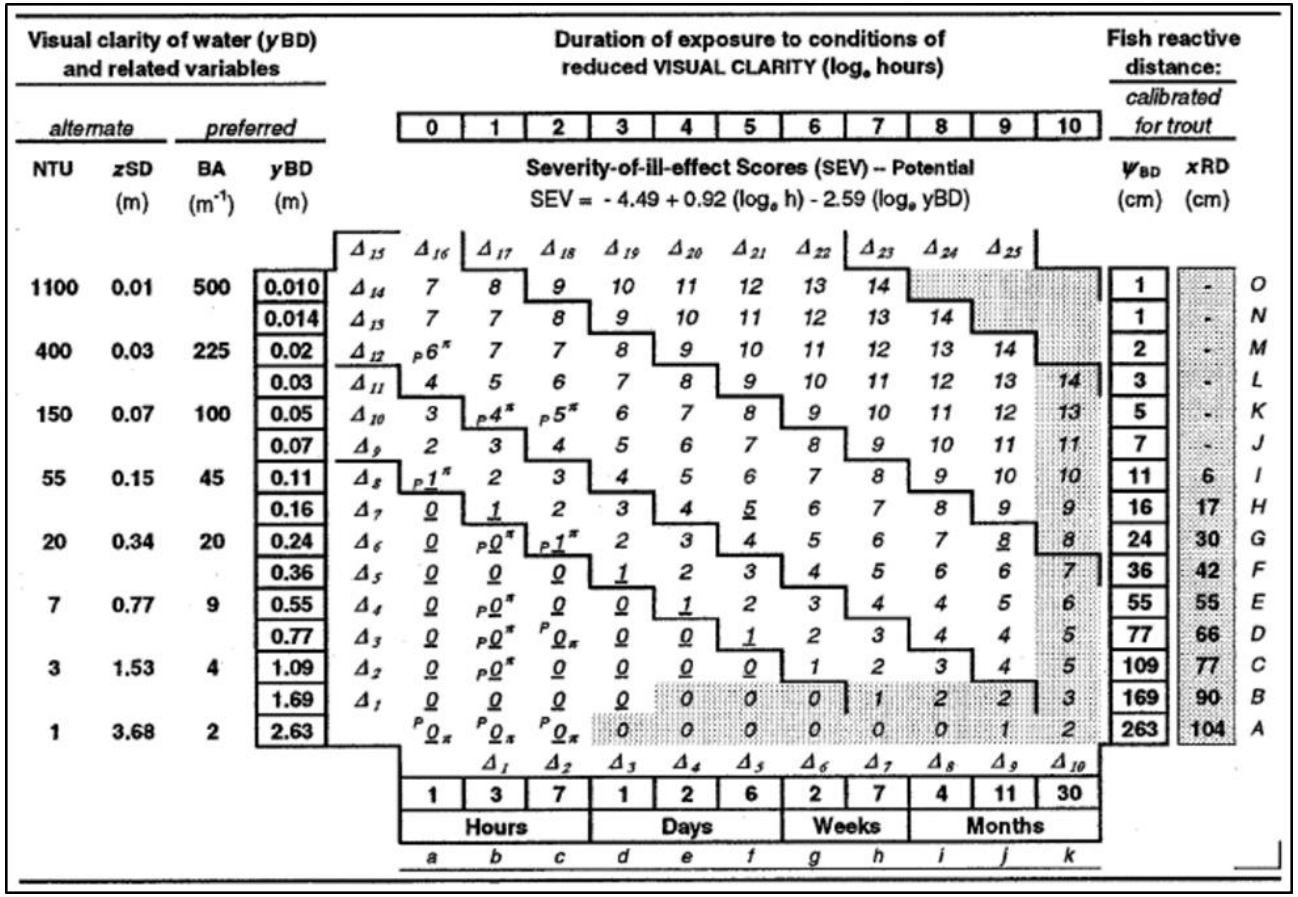
Reactive distance of brook trout decreased with increasing turbidity. Based on experimental studies in artificial streams (Sweka and Hartman 2001b)



Predation risk from predators decreases with increasing turbidity (Harvey and Railsback 2009)

Suspended Sediment/Turbidity Effects

Severity-of- ill-effect (SEV) on rearing success of clear water fish is a function of reduced visual clarity of water and duration of exposure for juvenile and adult life history phases (Newcombe 2003)



SEV	Description
1-3	Slightly Impaired Feeding and other behaviors begin to change
4-8	Significantly Impaired Marked increase in water cloudiness could reduce fish growth rate, habitat size, or both
9-14	Severely Impaired Profound increases in water cloudiness could cause poor "condition" or habitat alienation

Suspended Sediment/Turbidity Effects

High turbidity may cause extinction of trout populations under a drift-based food regime.

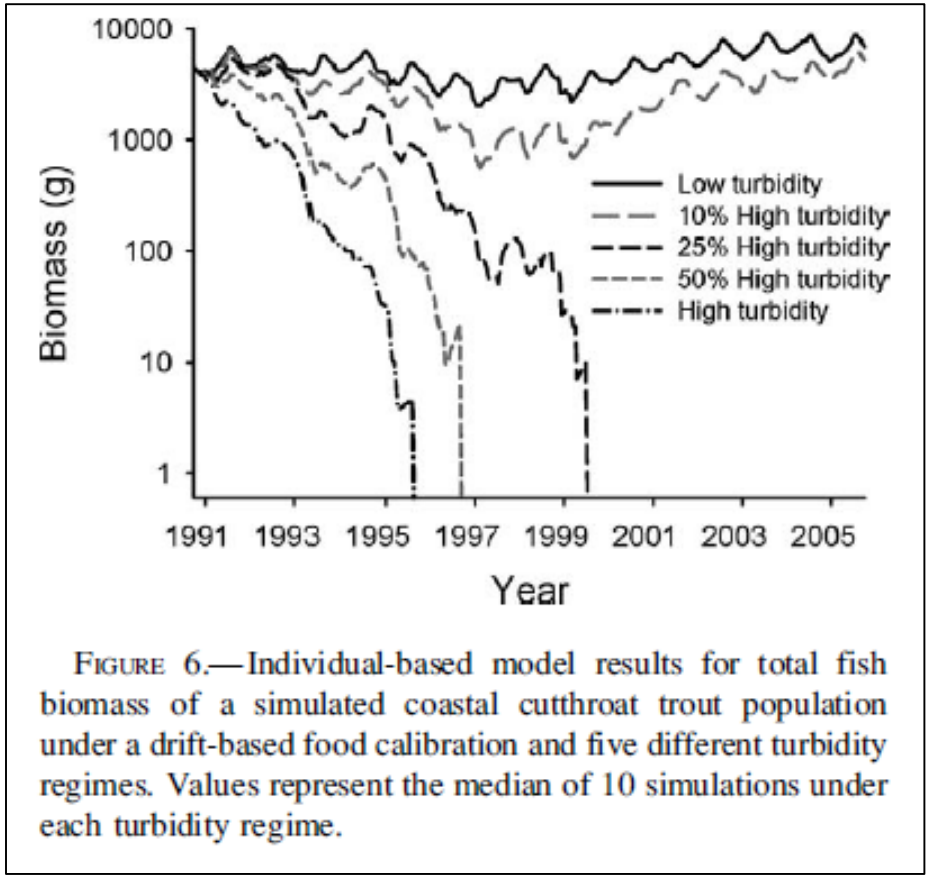


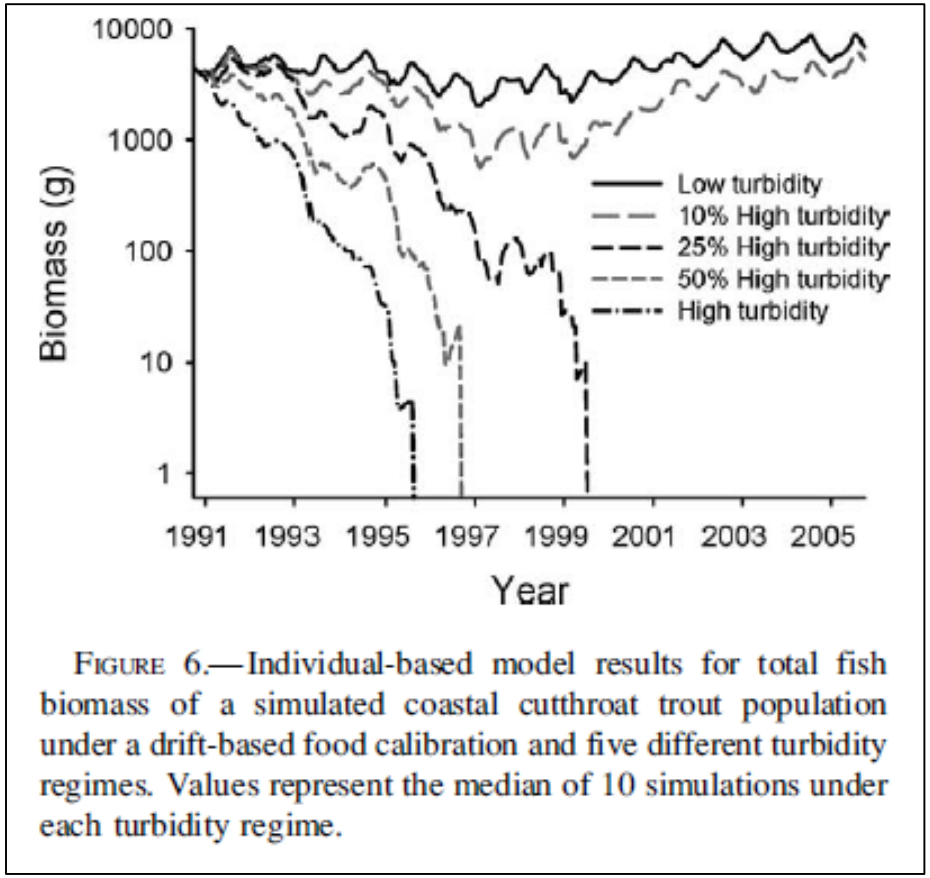
FIGURE 6.—Individual-based model results for total fish biomass of a simulated coastal cutthroat trout population under a drift-based food calibration and five different turbidity regimes. Values represent the median of 10 simulations under each turbidity regime.

Harvey & Railsback 2009

Suspended Sediment/Turbidity Effects

High turbidity may cause extinction of trout populations under a drift-based food regime.

Caveat: extinction prediction contrasts with field observations showing that salmonid populations have persisted in moderately turbid regimes



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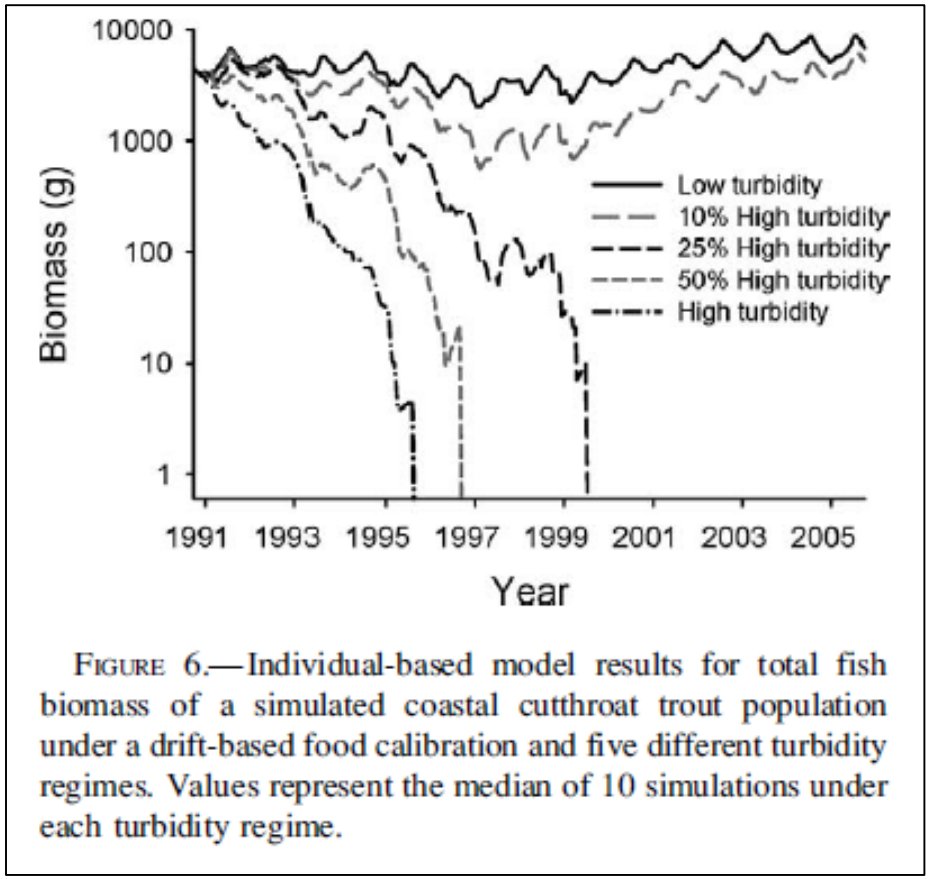
Results highlight need for better understanding of:

- food availability under turbid conditions
- capability of stream salmonids to use nonvisual cues in feeding.



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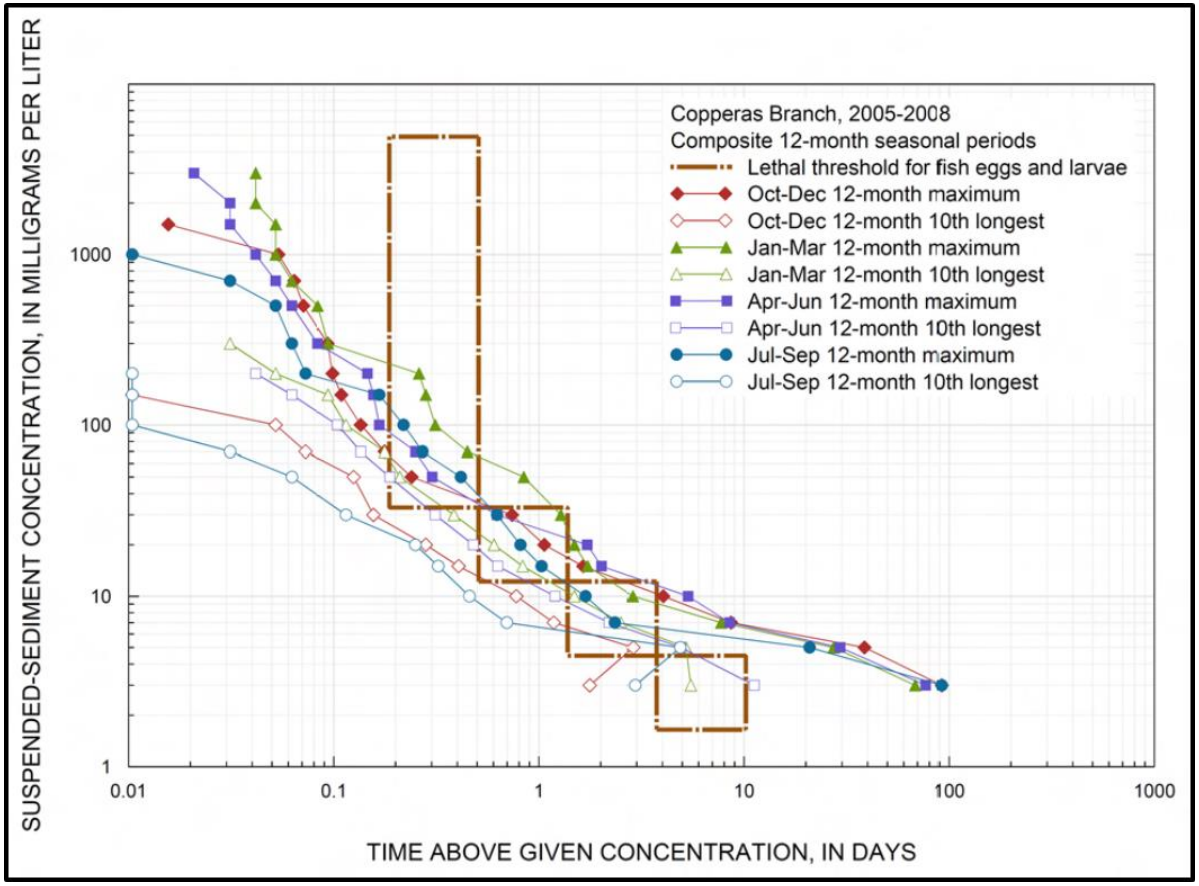
Suspended Sediment/Turbidity Effects

Natural suspended sediment regimes are not a good predictor of impairment in biological unimpaired streams with healthy fish populations (Diehl & Wolfe 2010)



Results indicate:
additional field studies are needed to describe SSC regimes in streams of varying basin scale, level of impairment, and region.

Comparisons of annual SSC-regime curves to a published thresholds for lethal effects on fish eggs and larvae

Issues:

- Studies relating biological impairment to natural (storm driven) turbidity regimes typical of NW streams are non-existent.
- We don't really know what turbidity regimes are associated with healthy (unimpaired) salmonid populations and we don't know the threshold for impairment.
- Current and proposed SSC/turbidity standards are designed around simple absolute or relative thresholds which are not linked to biological impairment.
- There is increasing interest by federal and state regulatory agencies to revise and strengthen the water quality standard for suspended sediment, with a focus on turbidity (e.g., ODEQ proposal).

Pudding Creek Coho Turbidity Study

Typical storm flow in Pudding Creek, Northern CA

Purpose:

To investigate a field-based approach for linking coho population health to natural turbidity regimes.

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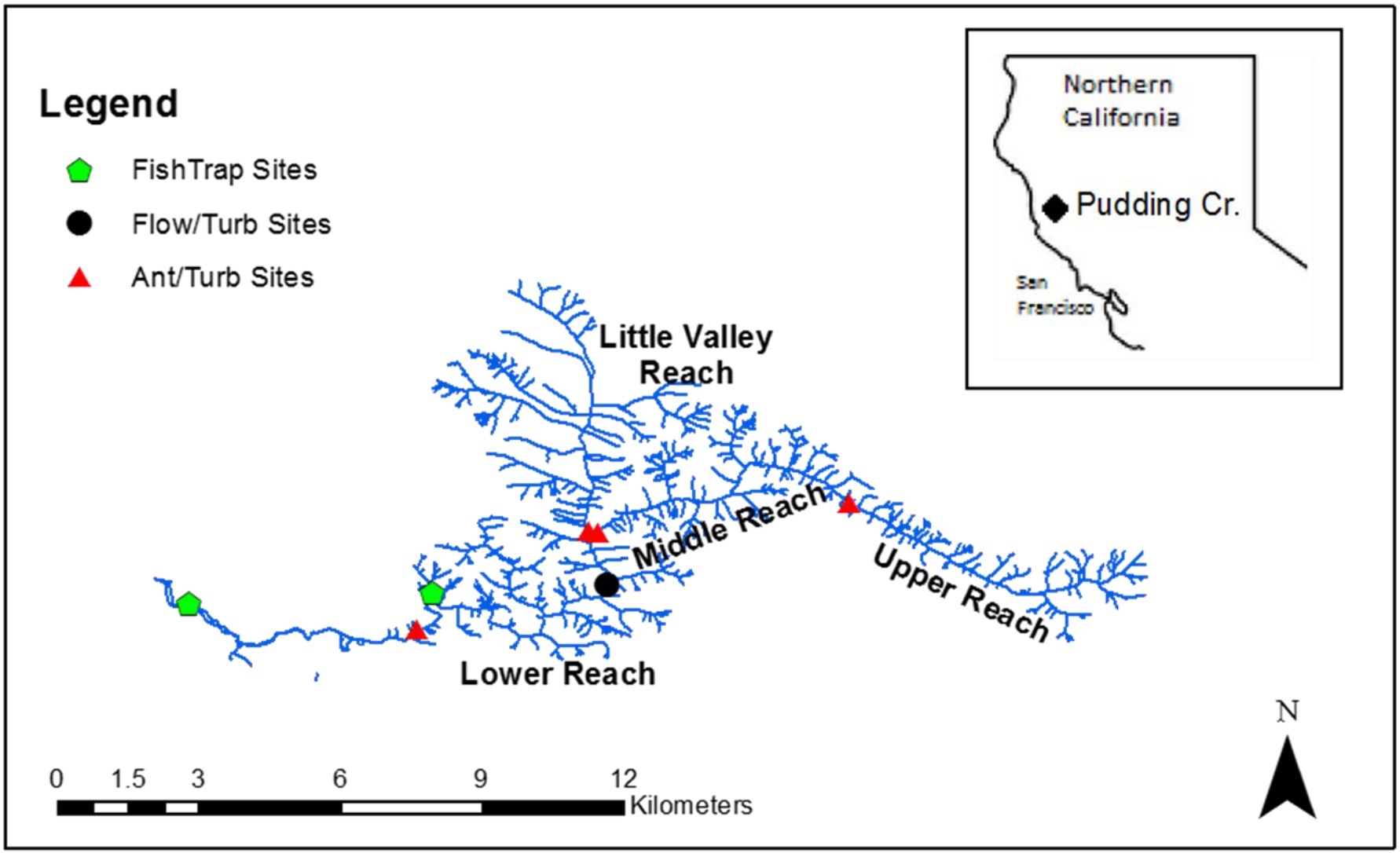
Objectives:

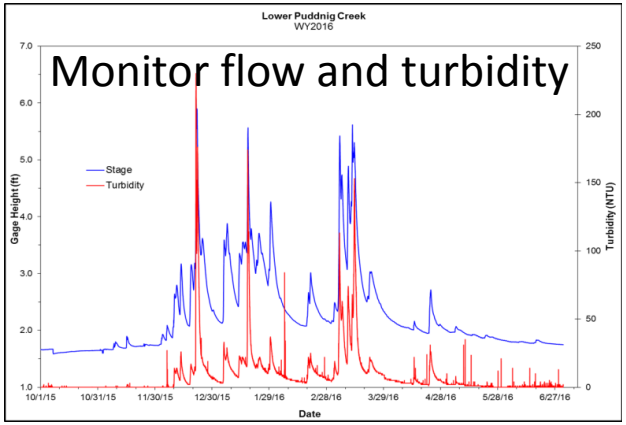
to measure coho growth and over-winter survival in association with measures of turbidity exposure

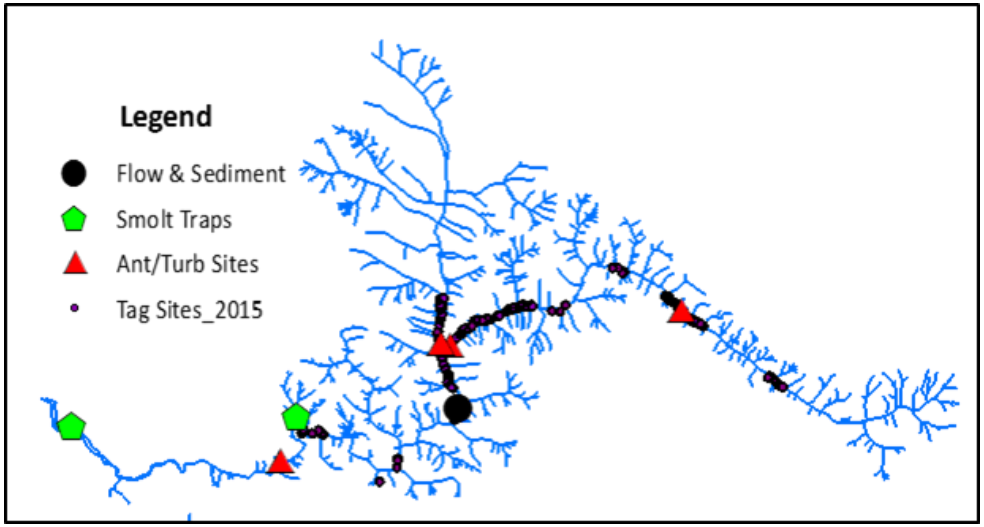
to identify useful metrics for relating turbidity to coho population health.

Pudding Creek Study Basin

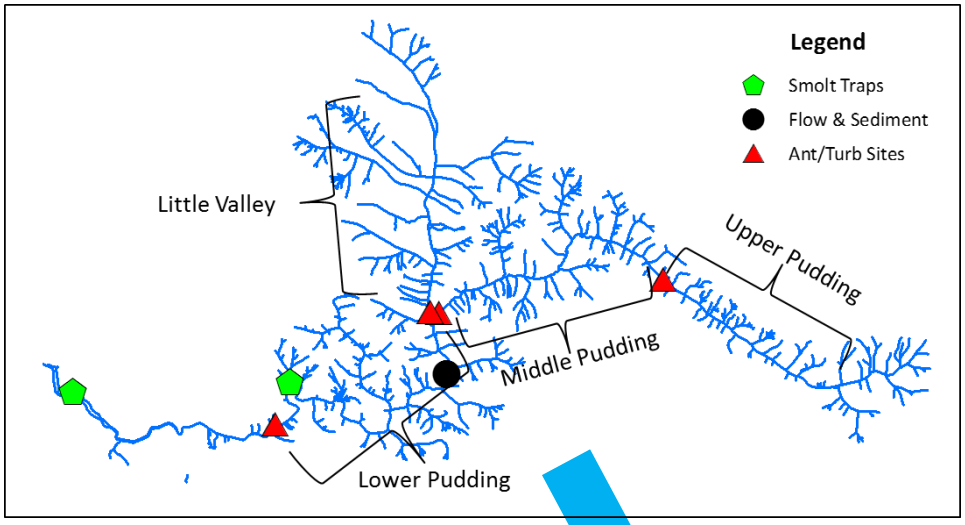


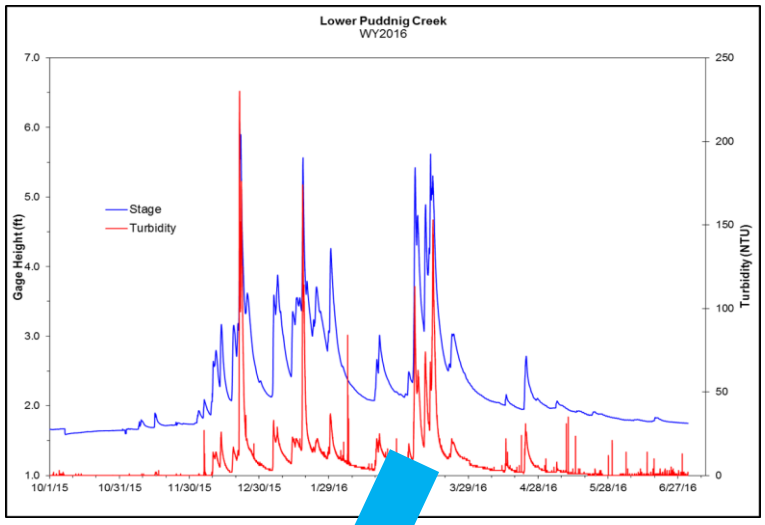
Coho Turbidity Study Methods



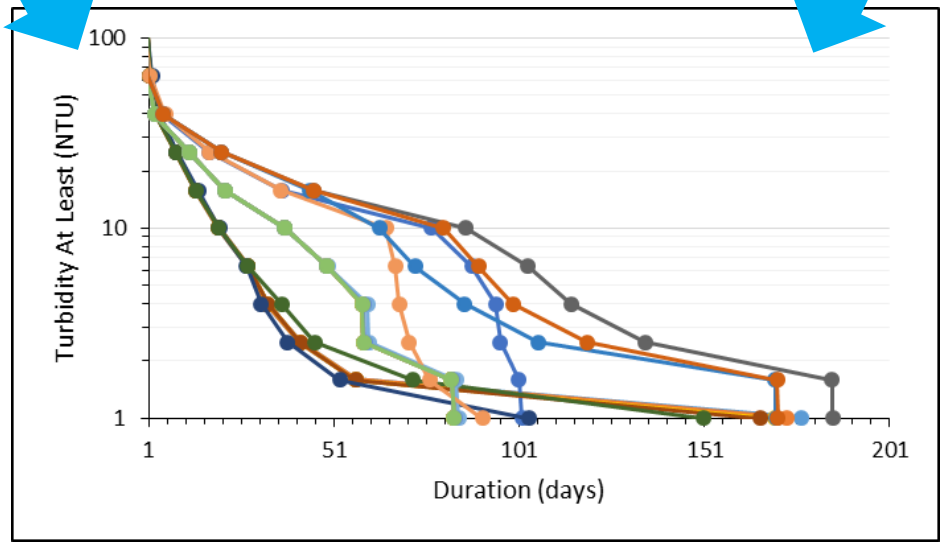


Coho Turbidity Study Design

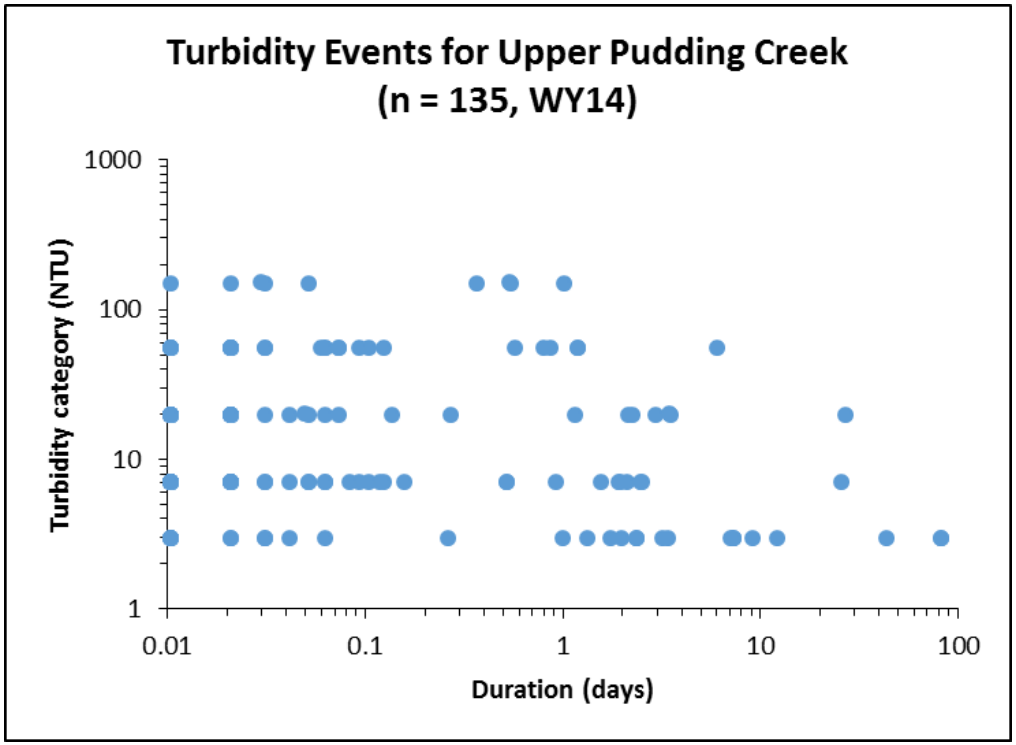




Turbidity exposure history constructed by joining reach-scale fish position with turbidity record

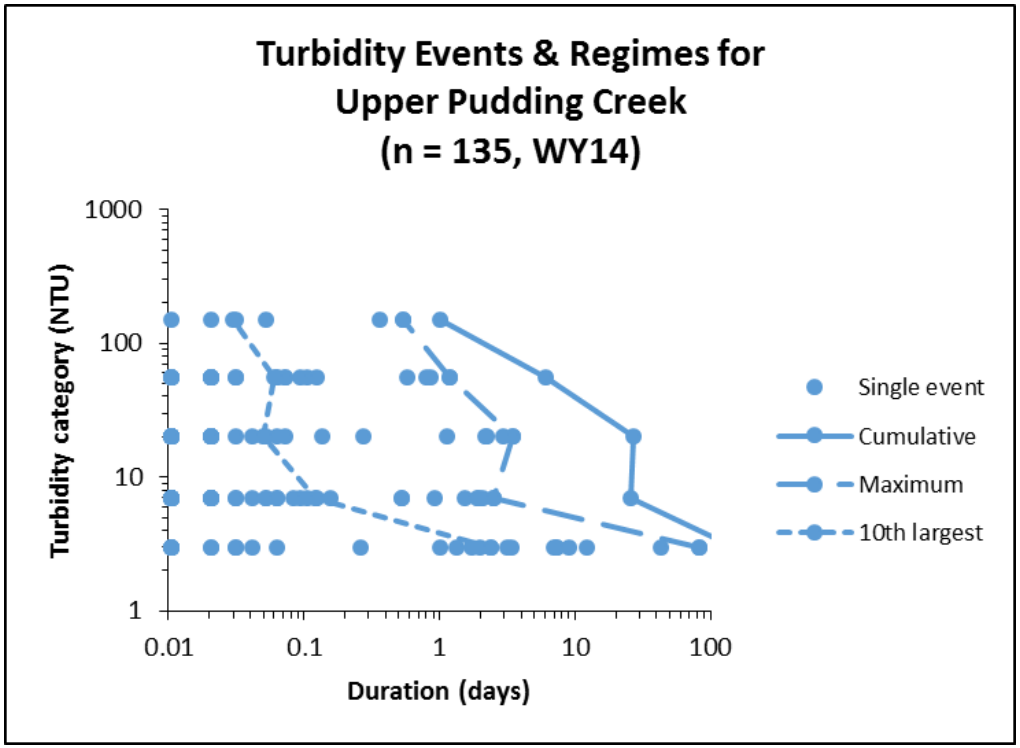


Exploring Turbidity Events



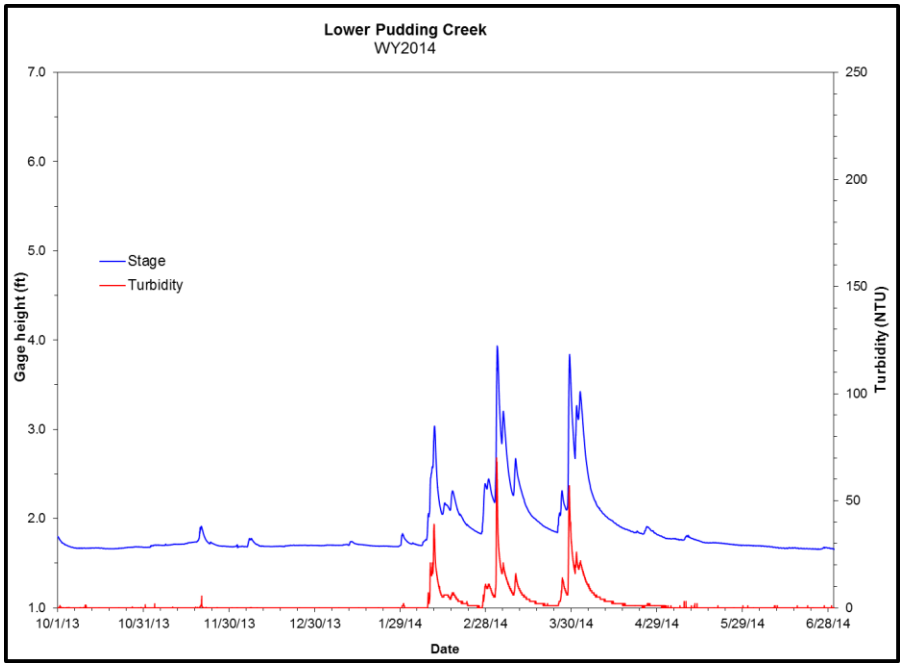
Upper Pudding Fish experienced 135 events of varying magnitude and duration

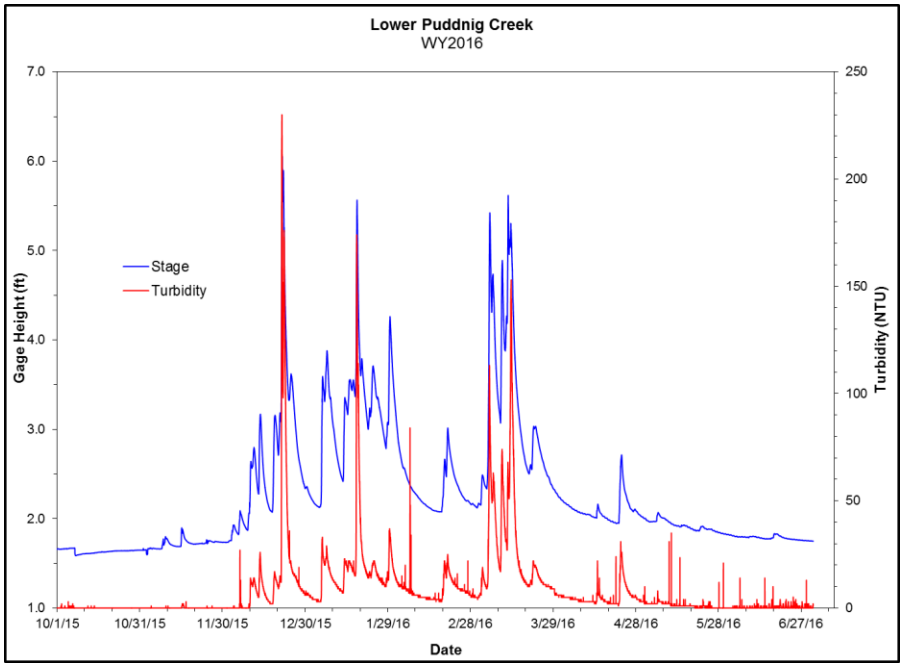
Exploring Turbidity Regimes



What turbidity regime (exposure history) influences growth and survival?

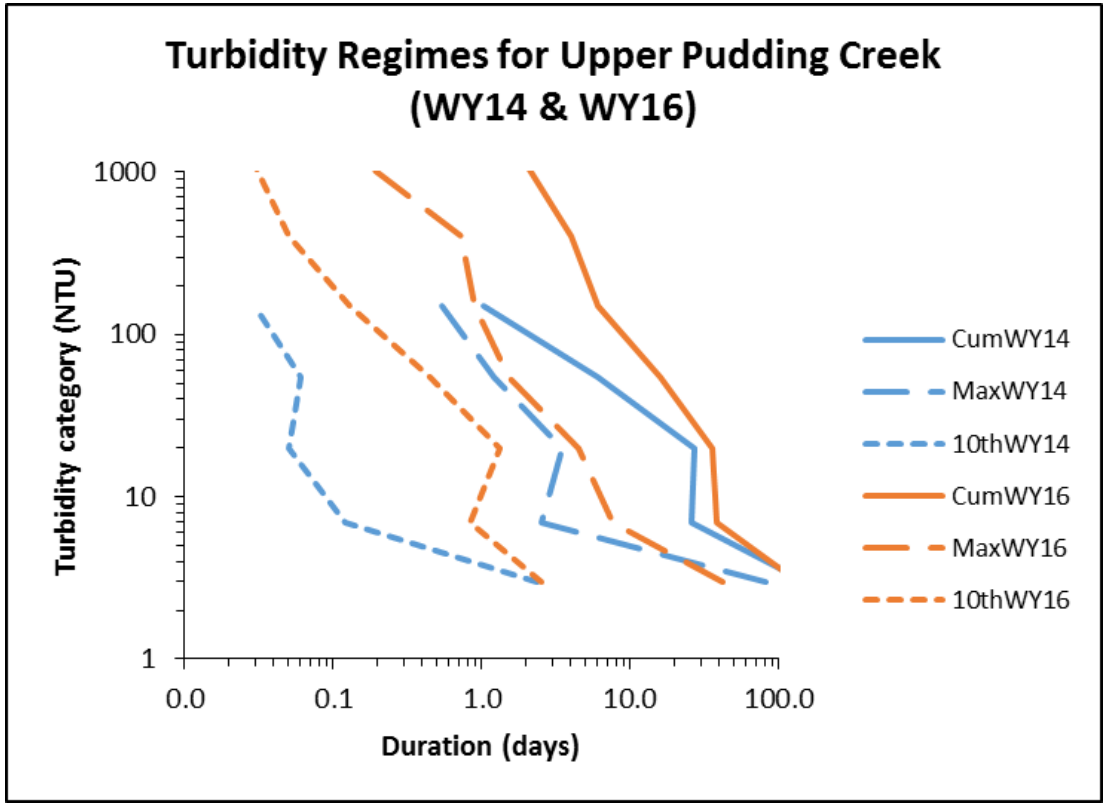
Stage and Turbidity for Lower Pudding Creek





Stream flow in WY14 was at drought levels; flows in WY16 near normal

Comparing Turbidity Regimes among Years



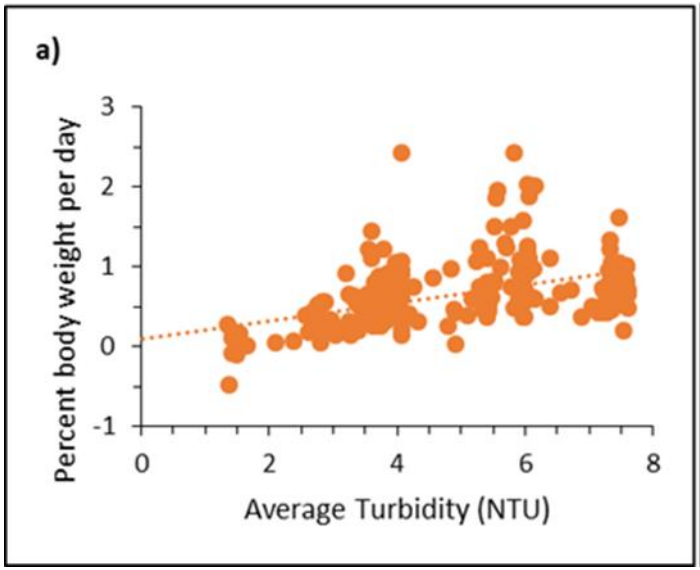
Turbidity in WY16 had both higher levels and longer durations of exposure

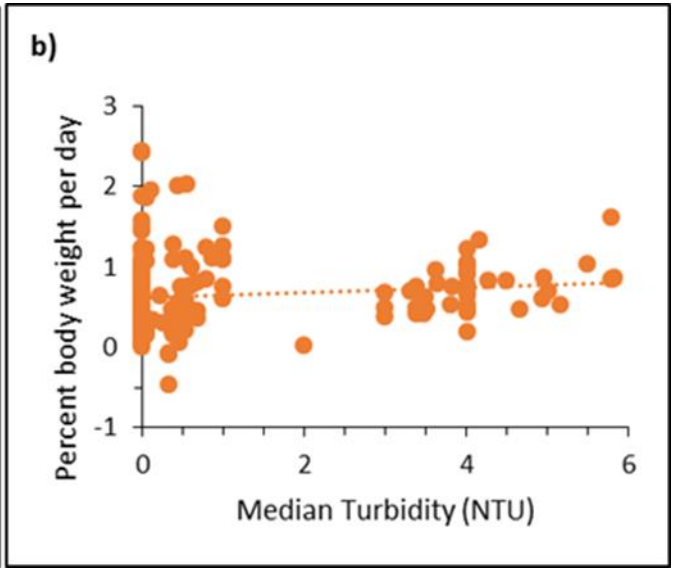
Juvenile Coho Tagging & Recapture

	WY2014			WY2016		
Reach	**Tagged**	**Recap. (no.)**	**Recap. (%)**	**Tagged**	**Recap. (no.)**	**Recap. (%)**
UP	101	21	21	57	21	37
MP	417	59	14	315	109	35
LP	641	99	15	348	100	29
LV	491	46	9	115	34	30
Total	1650	225	14	835	264	32

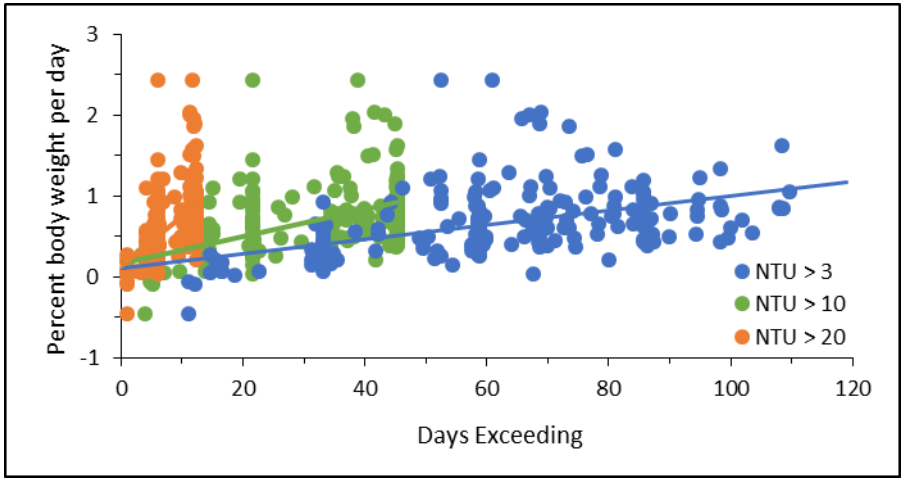
Overwinter survival substantially higher in WY16 compared to WY14

Coho growth for 216 smolts (WY14)



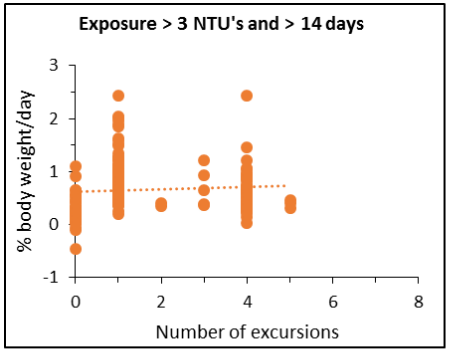


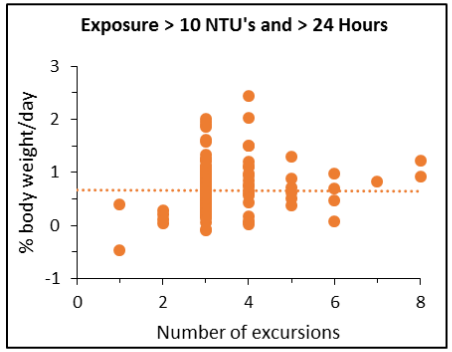
Growth positively correlate with turbidity; average, median, and cumulative duration of exposure

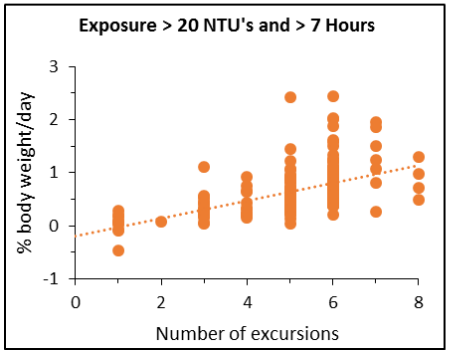


Growth as a Function of a Given Exposure Regime

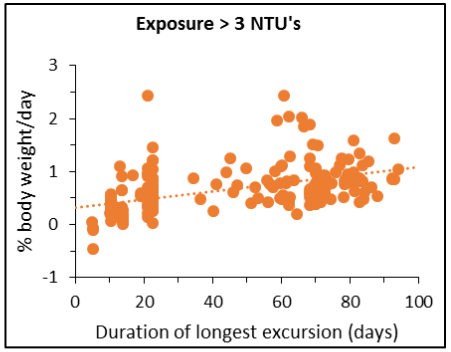
number of excursions

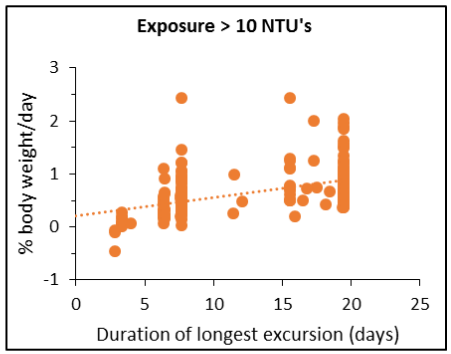


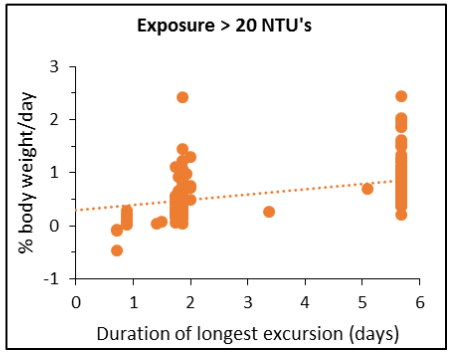




duration of excursions







Number of excursions		
Exposure	**Significance**	**Trend**
> 3 NTU for 14 days	*P = 0.067*	increasing
> 10 NTU for 1 day	P = 0.88	none
> 20 NTU for 7 hours	P < 0.000001	increasing

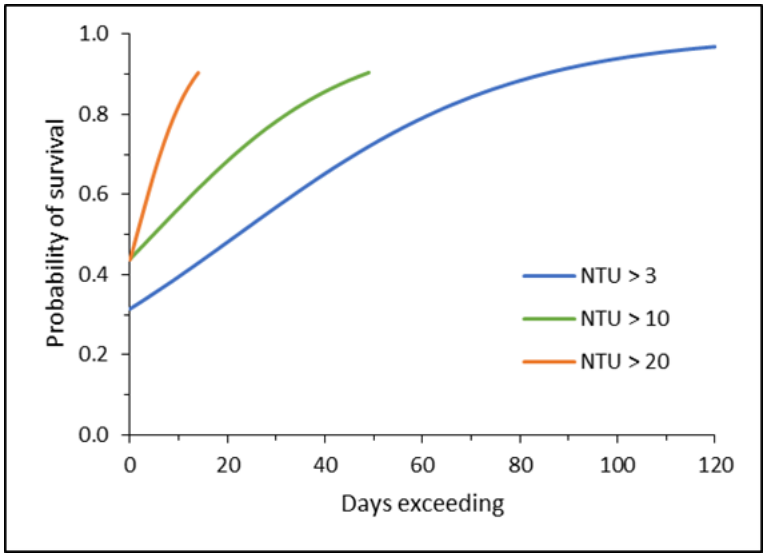
Duration of longest excursion		
Exposure	**Significance**	**Trend**
> 3 NTU	P < 0.000001	increasing
> 10 NTU	P < 0.000001	increasing
> 20 NTU	P < 0.000001	increasing

Observed positive growth for nearly all exposure regimes (WY 14)

Modeled Survival and Turbidity

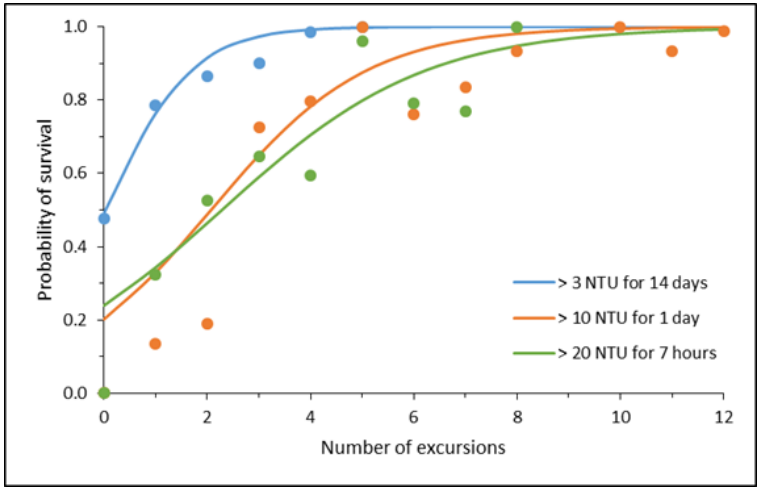
Survival as a function of total cumulative exposure to different turbidity level

Strong evidence of an increasing linear relationship
(ΔAIC = 125, 85, 79, respectively)



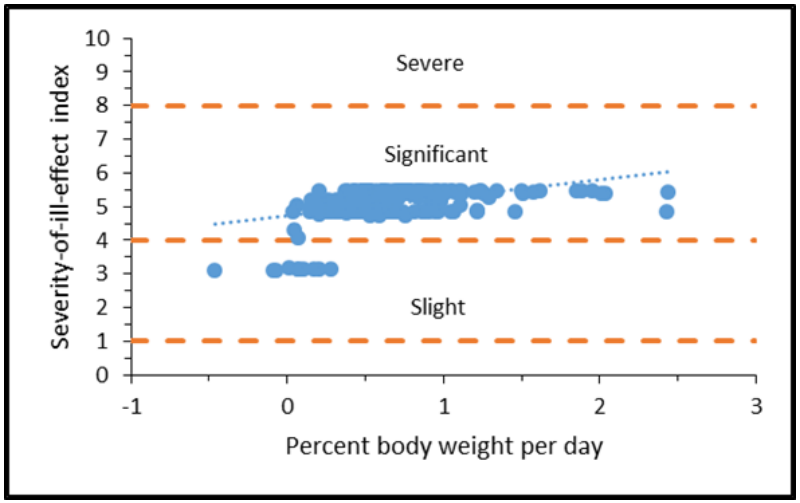
Survival as a function of the number of excursion for three different exposure regimes.

Strong evidence of an increasing linear relationship
(ΔAIC = 172, 203, 143, respectively)

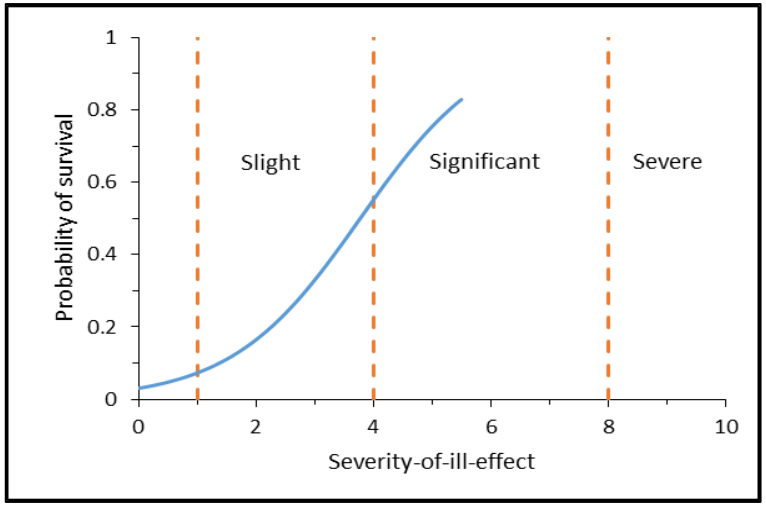


Turbidity and the Severity-of-ill-Effect (SEV)

Fish growth in relation to estimated max SEV
Growth increasing *(P* < 0.00001)



Fish survival as a function of estimated max SEV
Survival increasing ((ΔAIC = 103)



Observed growth and survival (WY14) are not consistent with predicted SEV

Findings

1. **Field-based approach** facilitated the examination of biological relationships with reach-scale turbidity regimes.

2. **Multiple metrics** may be used to discern the relation between fish growth, survival, and turbidity.

3. **Positive correlations between growth and survival and turbidity** suggests that population health of coho was unimpaired by the turbidity levels of Pudding Creek.

4. **Findings suggest** that published impairment thresholds for turbidity at the levels observed in this project, are not a reliable predictor of biological impairment to coho population

Future

- **Analysis** of WY16 is in progress
- **Monitoring** will continue for WY17
- **More data are needed** to characterize the biological significance and reliability of the exposure metrics
- **Other geographic locations** should be studied to evaluate the applicability of such information among different sites, periods, and biological communities.

Acknowledgements

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