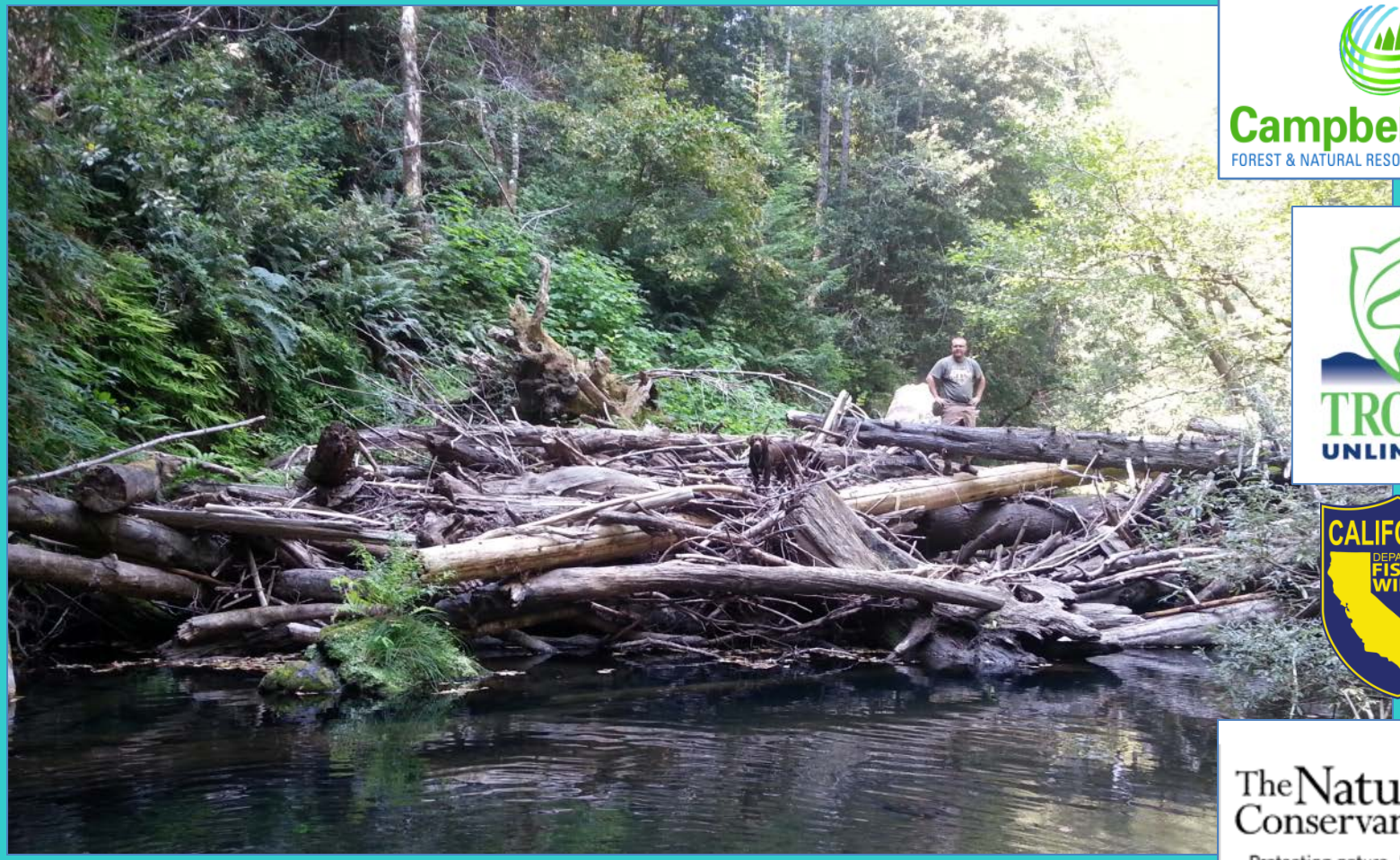
Using Large Wood to Increase Salmon Abundance in Pudding Creek: A BACI Experiment



CampbellGlobal
FOREST & NATURAL RESOURCE INVESTMENTS

TROUT UNLIMITED

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

The Nature Conservancy
Protecting nature. Preserving life.™

Introduction/Overview

- Why?
  - Others have found some relationship between LWD and salmonid abundance.
  - However, it has not been demonstrated in CA.

Introduction/Overview

- Who?
  - Campbell/Hawthorne
  - CDFW
  - Trout Unlimited
  - The Nature Conservancy
  - Chris Blencowe
  - Ken Smith

Introduction/Overview

- Where?
  - Pudding Creek, Mendocino County, CA (Treatment).
    - 9.9 miles.
  - Caspar Creek, Mendocino County, CA (Control).
    - 7.4 miles.

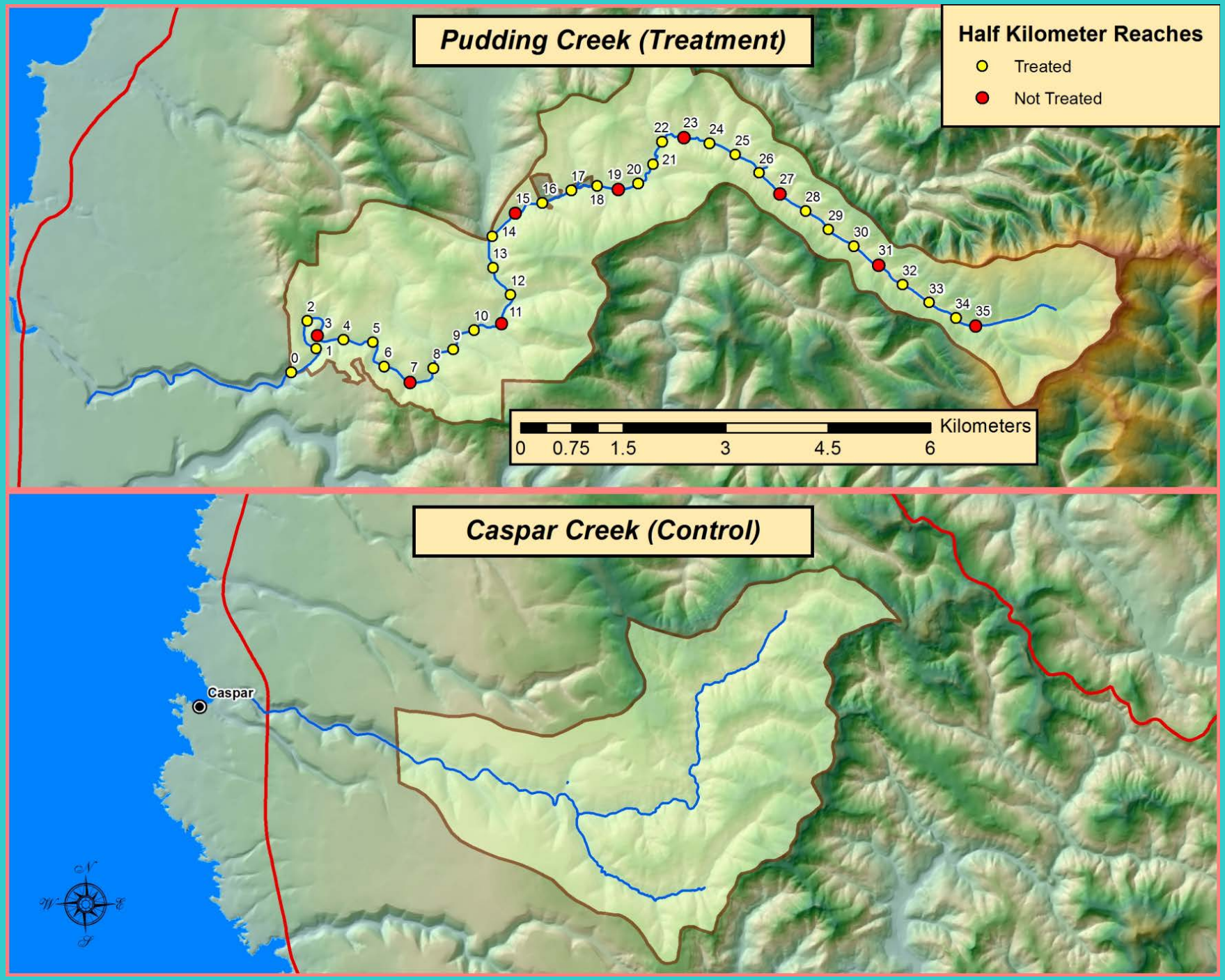
Introduction/Overview

- When?
  - At least three years of pre-treatment data collection on both streams.
  - Implementation in summer 2015.
  - At least three years of data collection following implementation.
  - Summary publication in 2018-2019.

Introduction/Overview

- What?
  - Approximately 7 miles of Pudding Creek will be treated with standard un-anchored LWD structures.
  - Caspar Creek will not receive any treatment.
  - Biological indices will/have been monitored for 3 years before and after treatment.
    - Smolt abundance monitoring.
    - Spawner abundance monitoring.
    - Summer juvenile abundance monitoring.
  - Physical indices will/have been monitored before and after treatment.
    - Habitat monitoring using Columbia Habitat Monitoring Program (CHaMP).


Pudding Creek/Caspar Creek BACI Study Areas
Westport
Highway 1
Fort Bragg
Caspar
Mendocino
Highway 20
Pudding Study Area
Caspar Study Area
Kilometers
0
2.5
5
10
15
20


Pudding Creek (Treatment)
Half Kilometer Reaches
Treated
Not Treated
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Kilometers
0 0.75 1.5 3 4.5 6
Caspar Creek (Control)
Caspar
N
W
E
S

Methods/Design

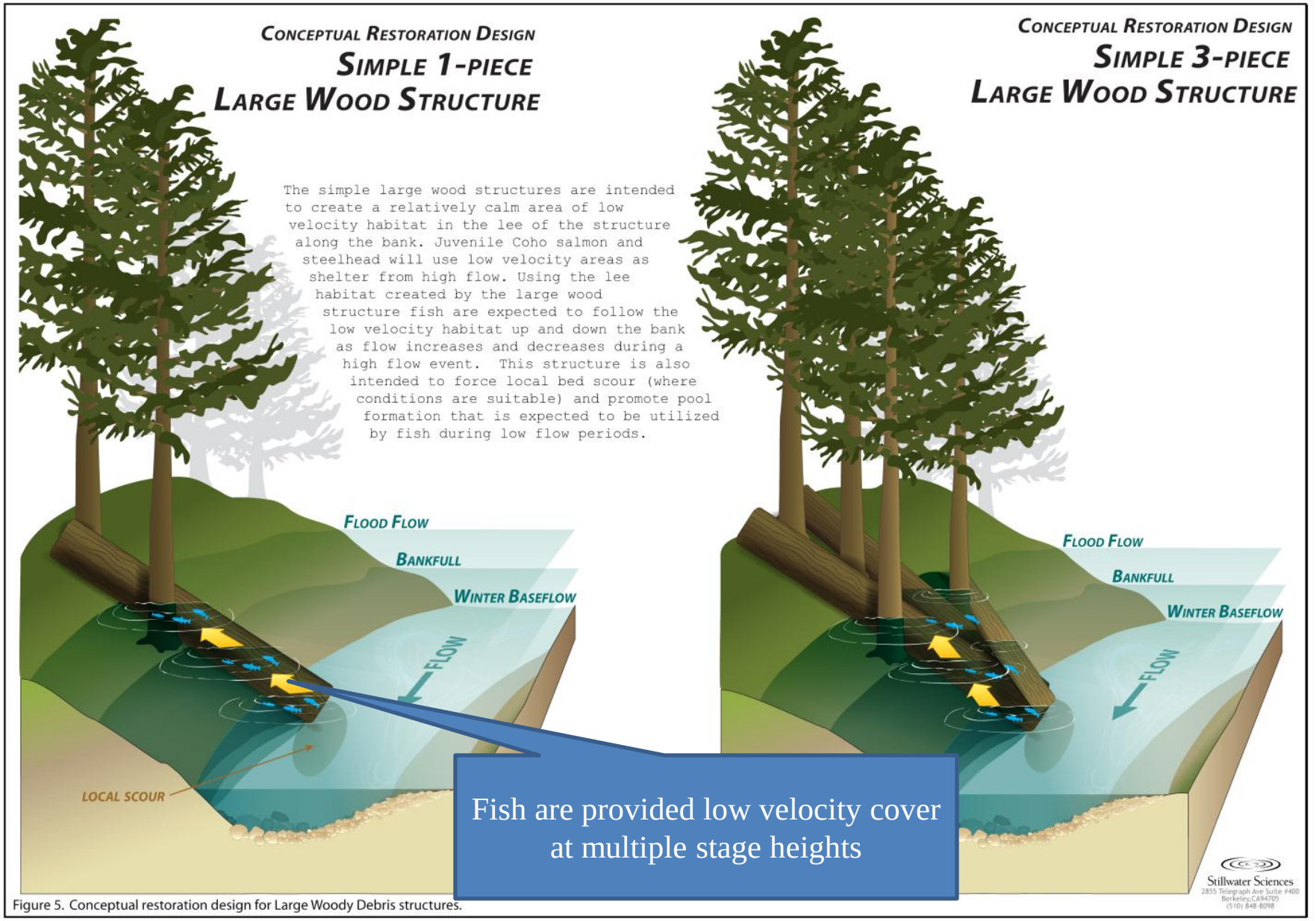
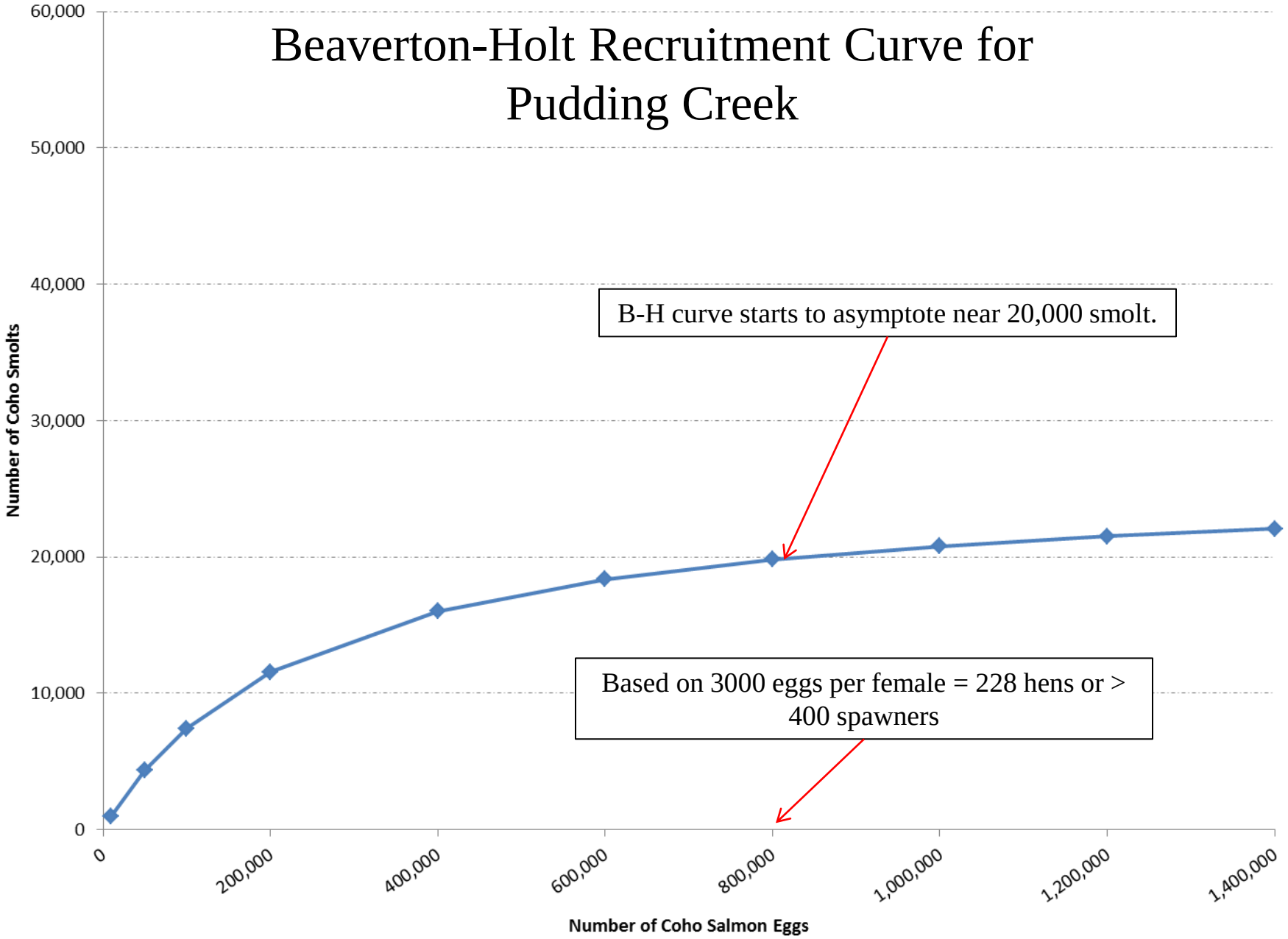


Figure 5. Conceptual restoration design for Large Woody Debris structures.

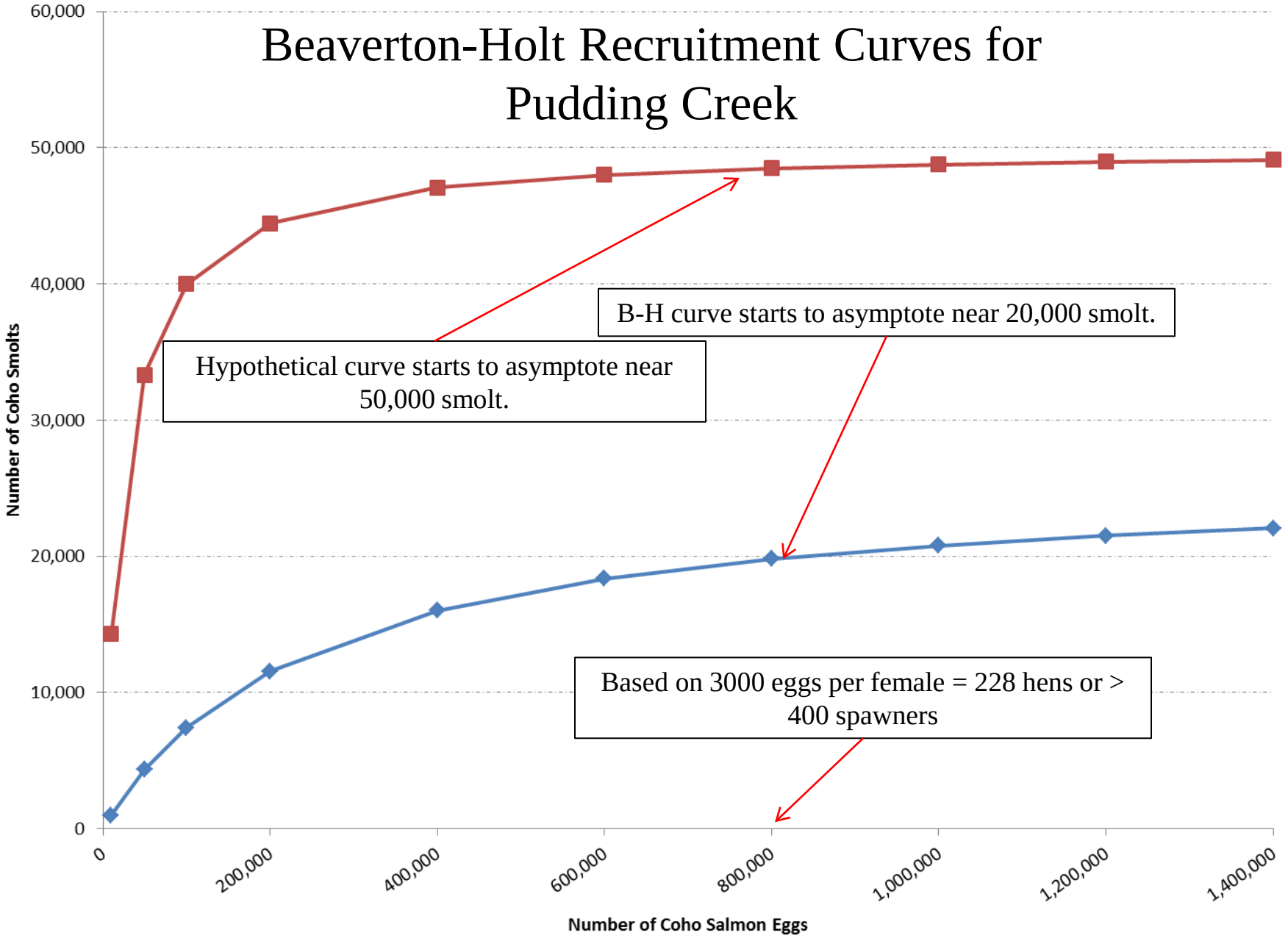
Fish are provided low velocity cover at multiple stage heights

Beaverton-Holt Recruitment Curve for Pudding Creek



Question: Will LWD treatment in Pudding Creek increase egg-to-smolt survival, i.e. carrying capacity?

Beaverton-Holt Recruitment Curves for Pudding Creek



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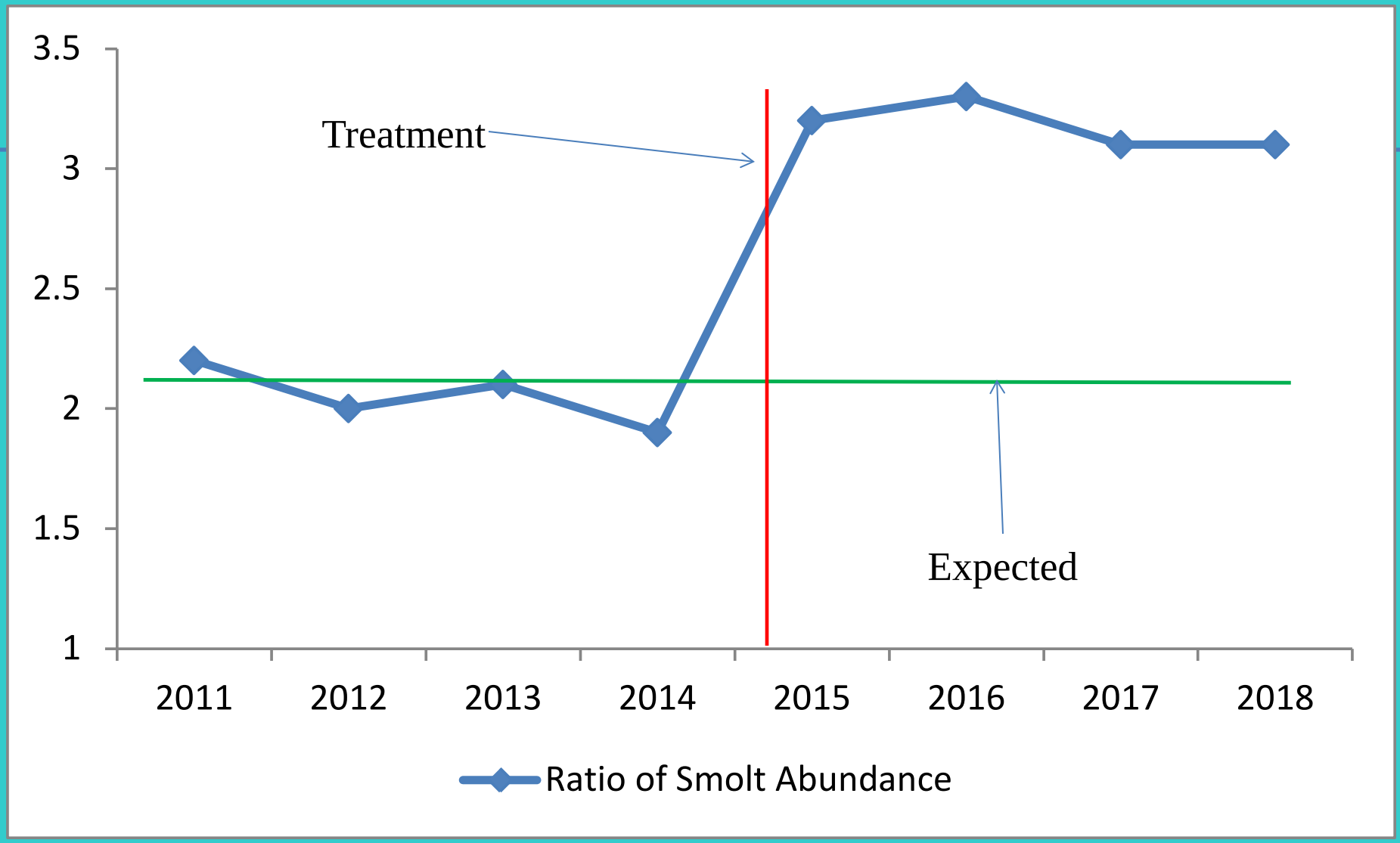
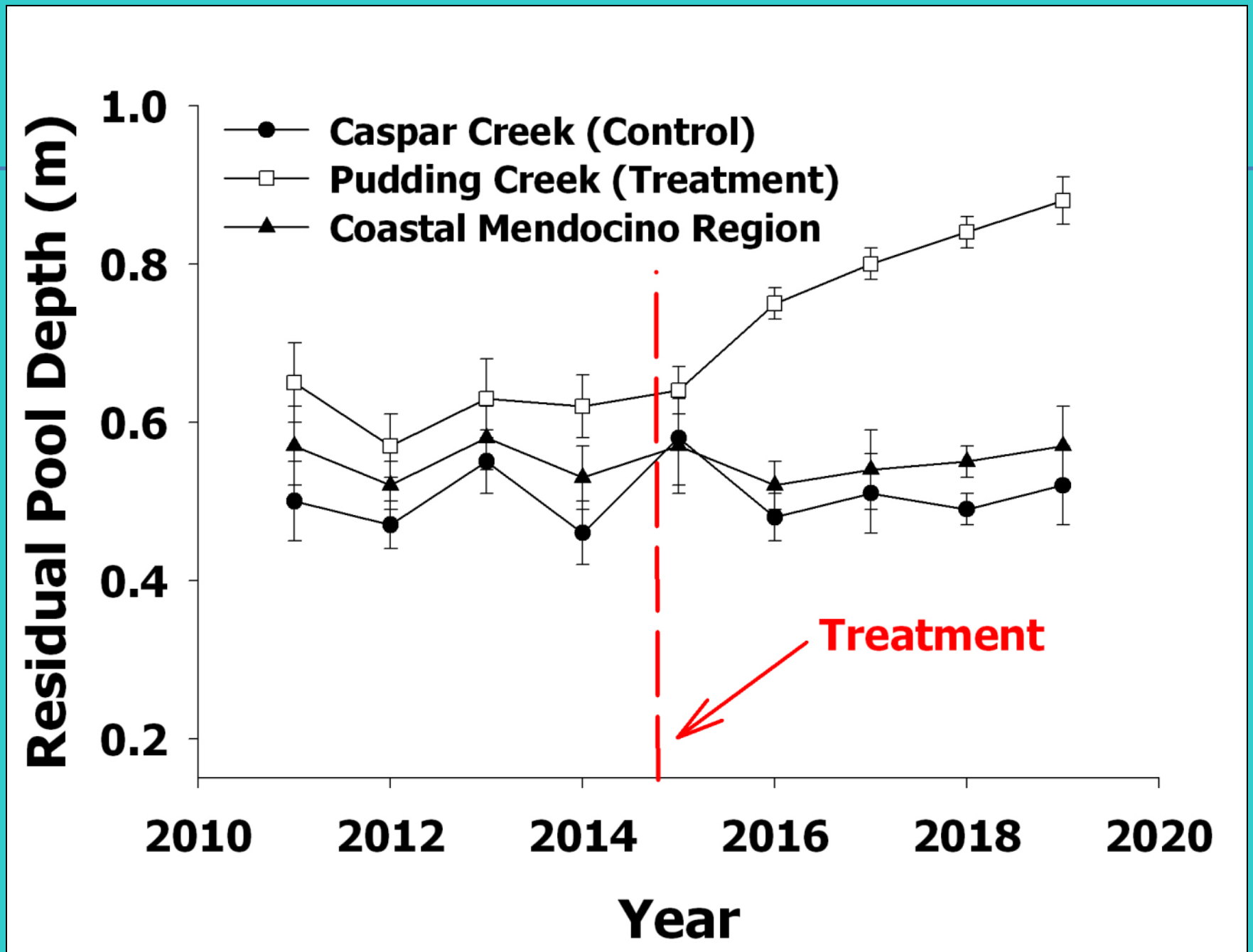
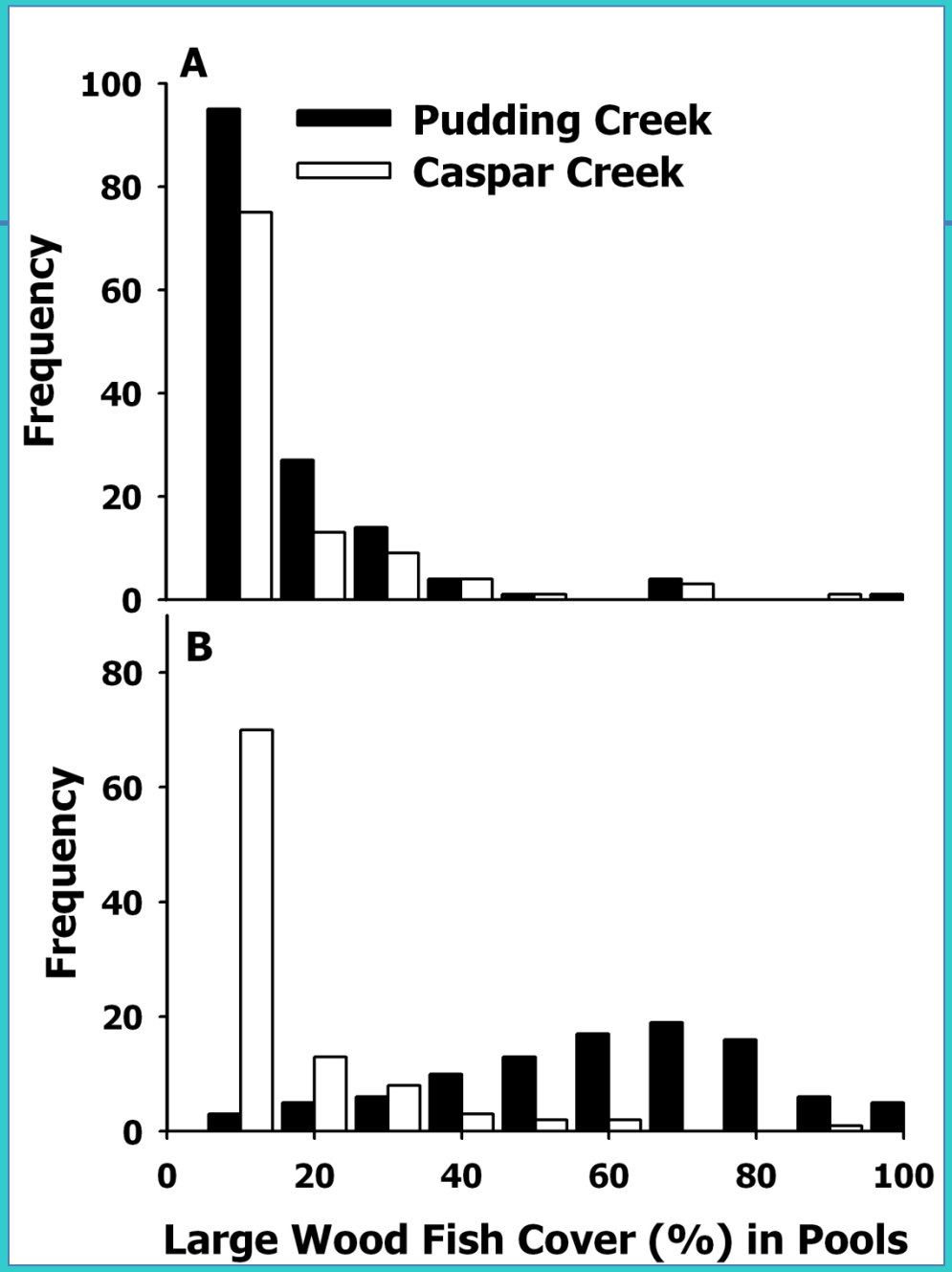


Hypothetical change in smolt ratios between Pudding and Caspar Creeks


Residual Pool Depth (m)
1.0
0.8
0.6
0.4
0.2
Caspar Creek (Control)
Pudding Creek (Treatment)
Coastal Mendocino Region
Treatment
2010
2012
2014
2016
2018
2020
Year


A
B
Pudding Creek
Caspar Creek
Frequency
Frequency
0
20
40
60
80
100
Large Wood Fish Cover (%) in Pools

Analytical layout of population and habitat metrics for the BACI Experiment.

Parameter			Data collection period		
Physical Habitat			Pretreatment Years	Transition	Post Treatment
	Summer and winter	Habitat number, size, volume, heterogenaity, and geomentry	2013-2015	2015	2016-2019
		Channel Morphology/ geometry, substrare compostion, sinuosity	2013-2015	2015	2016-2019
		Wood density, volume, and rate of input	2013-2015	2015	2016-2019
		Seasonal stream flow, water temperature, and others (Bouwes et al. 2011)	2013-2015	2015	2016-2019
	Winter only	Percent slow water habitat, Percent off channel habitat, floodplan channel length	2012-2014	2015	2016-2019
Biological					
	Summer	Steelhead 0+ abundance	2006 -2010, 2012, 2013, 2014	2015	2016-2019
		Coho abundance	2006 -2010, 2012, 2013, 2014	2015	2016-2019
		Coho and Steelhead Growth*	2011-2014	2015	2016-2019
		coho and steelhead Survival	2011-2014	2015	2016-2019
	Winter	Coho and Steelhead Growth*	2011-2014	2015	2016-2019
		coho and steelhead Survival	2011-2014	2015	2016-2019
	Annual	Coho salmon and Steelhead smolt abundance	2006 -2010, 2012, 2013, 2014	2015	2016-2019
		Coho salmon and Steelhead adult abundance	2006 -2010, 2012, 2013, 2014	2015	2016-2019
		Over-summer survival	2006 -2010, 2012, 2013, 2014	2015	2016-2019
		Winter survival	2006 -2010, 2012, 2013, 2014	2015	2016-2019
		Habitat specific survival and growth	2011-2014	2015	2016-2019
		Proportion of two-year old coho residents	2006 -2010, 2012, 2013, 2014	2015	2016-2019

* This will also be related to speficic habitat unit types and site fidelity (Bell et al. 2003).

Salmonid Unit Abundance:

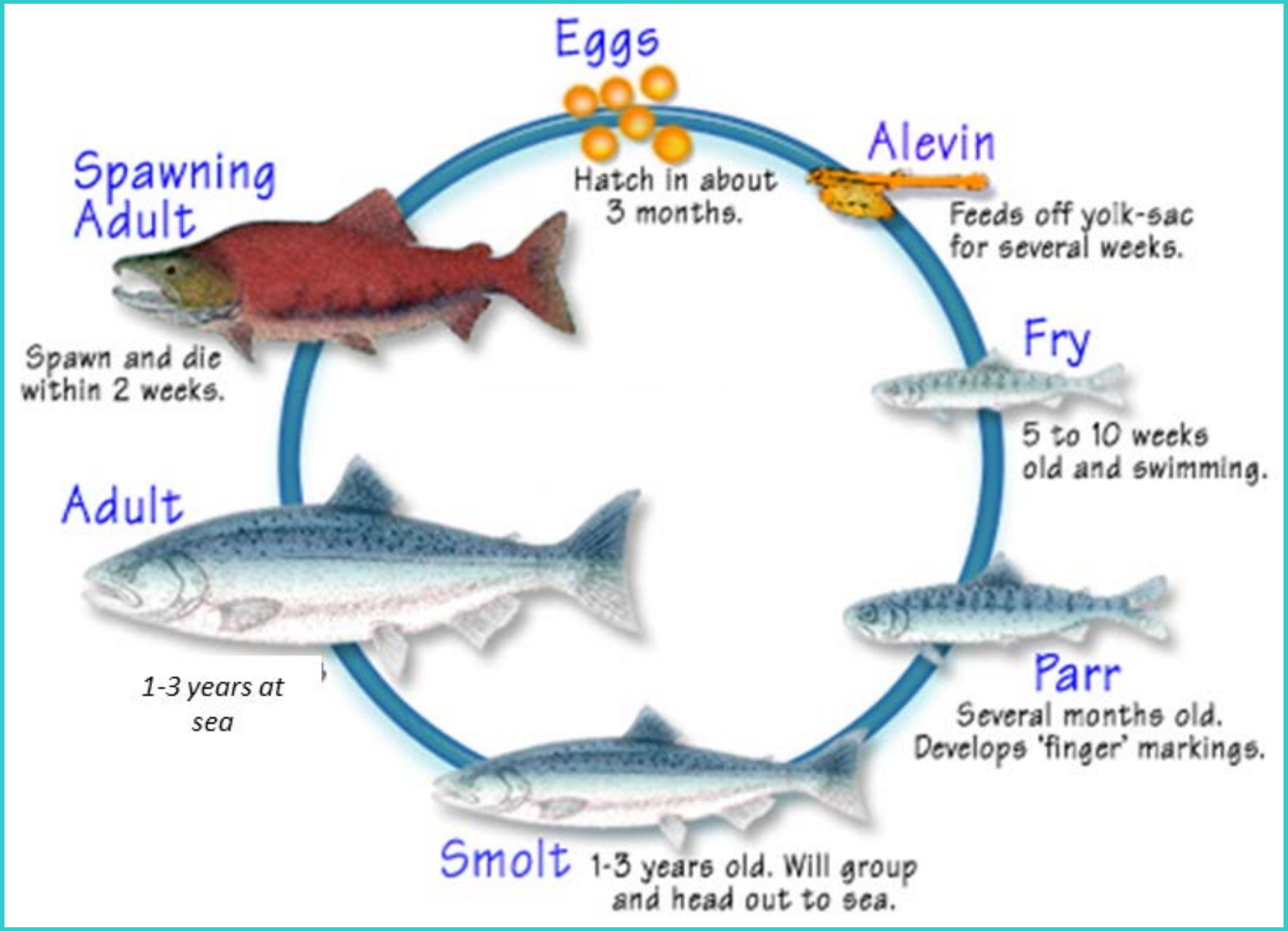
Coho Parr, Steelhead YOY, Y+, Y++

Habitat Unit Type	Percent Fish Cover	Substrate Composition	Measured Unit Variables	Calculated Unit Variables
Cascade*	Aquatic Vegetation	Bedrock	Average Depth	Residual Pool Depth[1]
Dam Pool*	Artificial Structures*	Boulders	Bankfull Width	Residual Pool Volume[1]
Dry Units*	Dead Woody Debris	Cobbles	Length	Unit Surface Area
Falls*	Live Overhanging Vegetation	Course Gravel	Maximum Depth[1]	Unit Volume
Non-Turbulent	No Cover	Fine Gravel	Pool Tail Crest Depth[1]	Dry LWD Abundance
Off Channel	Undercut Banks	Fines	Width	Wet LWD Abundance
Plunge Pool		Sand		Dry LWD Density
Rapid*		Pool Tail Fines < 2mm[1]		Wet LWD Density
Riffle		Pool Tail Fines 2-6mm[1]		
Scour Pool				

*Few or none encountered

[1] Pools only

Coho Three Year Juvenile Life History in Pudding Creek as Response to the Drought (2012-2015)


Eggs
Hatch in about 3 months.
Alevin
Feeds off yolk-sac for several weeks.
Fry
5 to 10 weeks old and swimming.
Parr
Several months old. Develops 'finger' markings.
Smolt
1-3 years old. Will group and head out to sea.
Adult
1-3 years at sea
Spawning Adult
Spawn and die within 2 weeks.

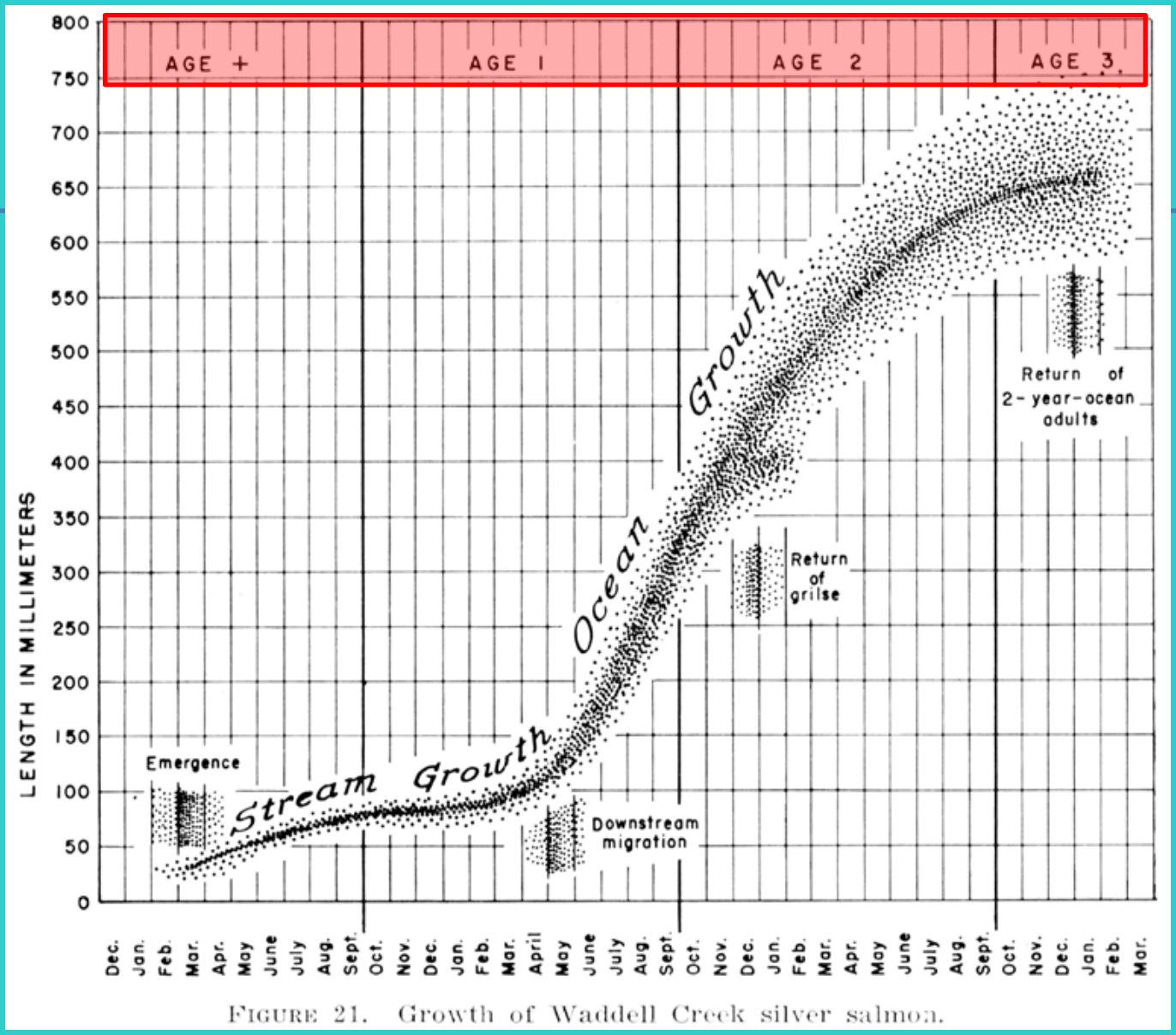
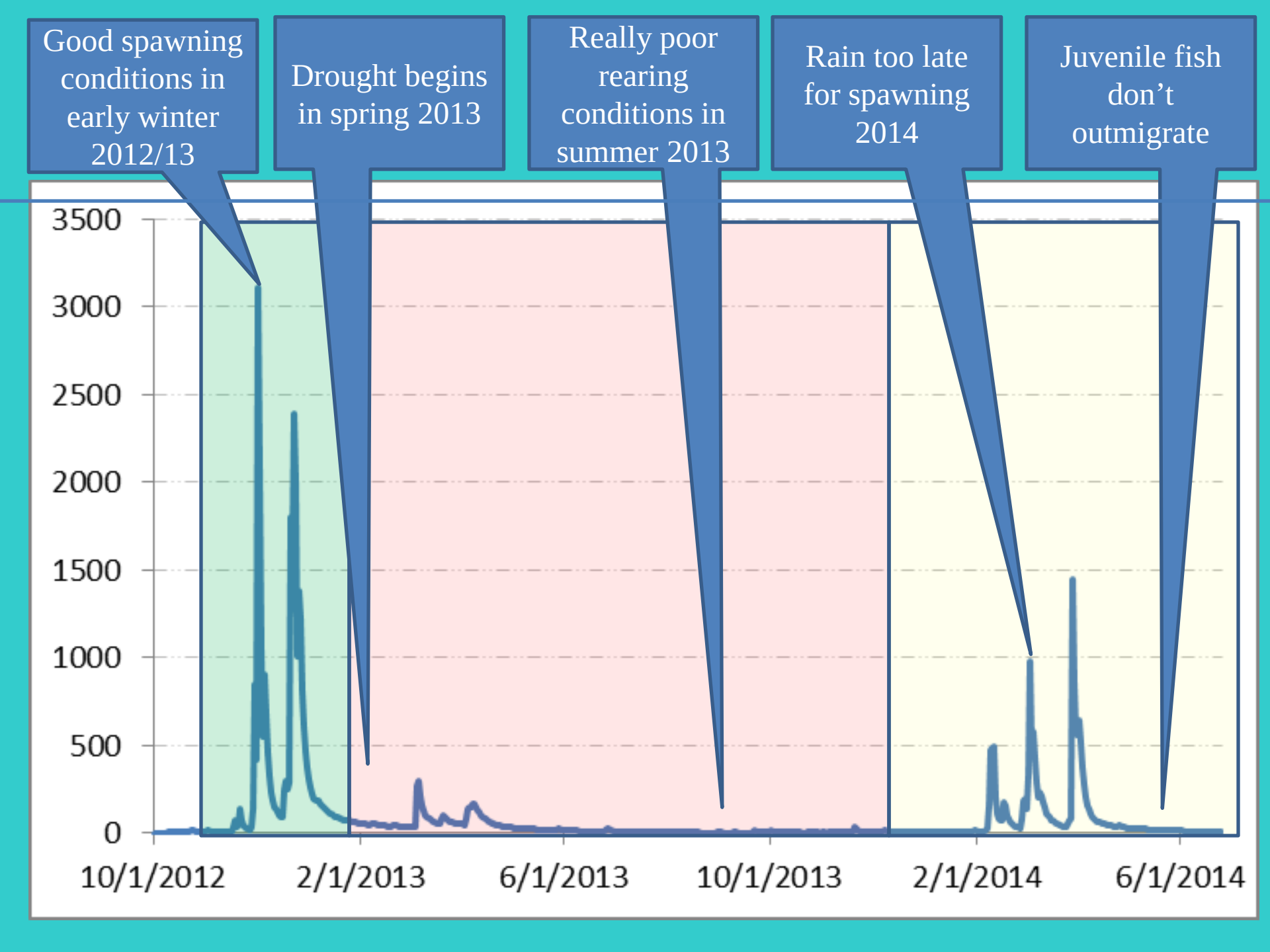
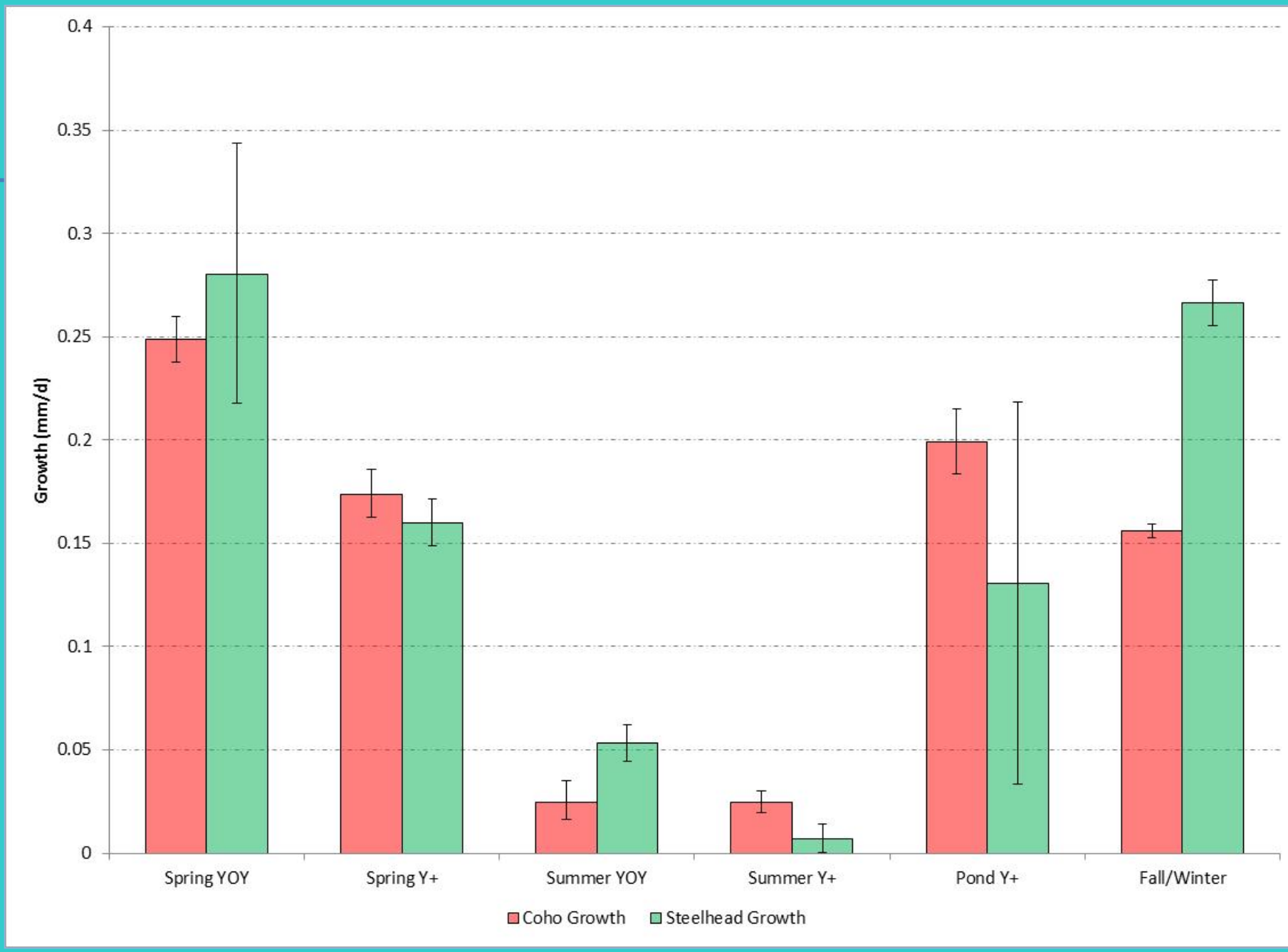


FIGURE 21. Growth of Waddell Creek silver salmon.

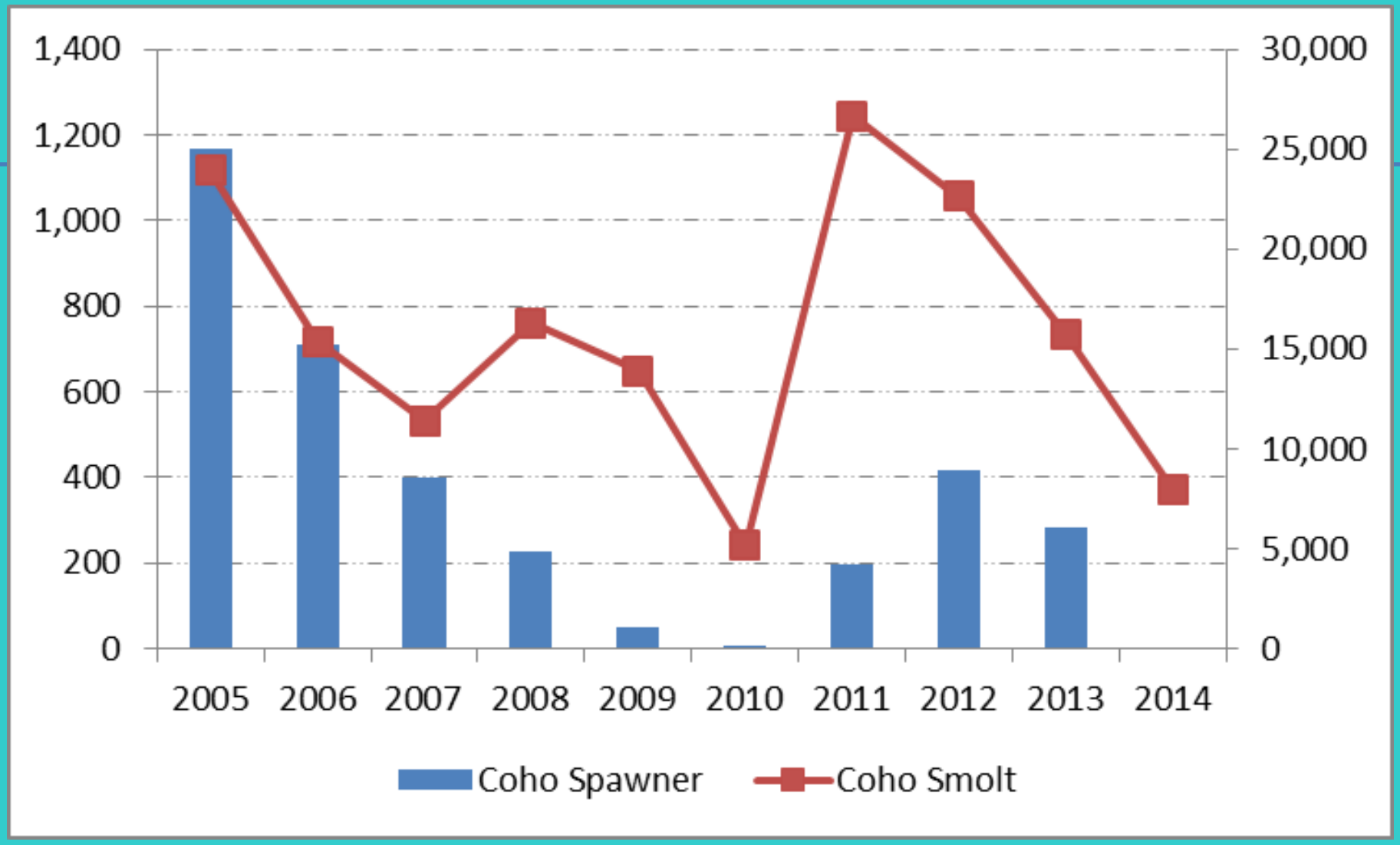
From Shapovalov and Taft 1954


Good spawning conditions in early winter 2012/13
Drought begins in spring 2013
Really poor rearing conditions in summer 2013
Rain too late for spawning 2014
Juvenile fish don't outmigrate
3500
3000
2500
2000
1500
1000
500
0
10/1/2012
2/1/2013
6/1/2013
10/1/2013
2/1/2014
6/1/2014

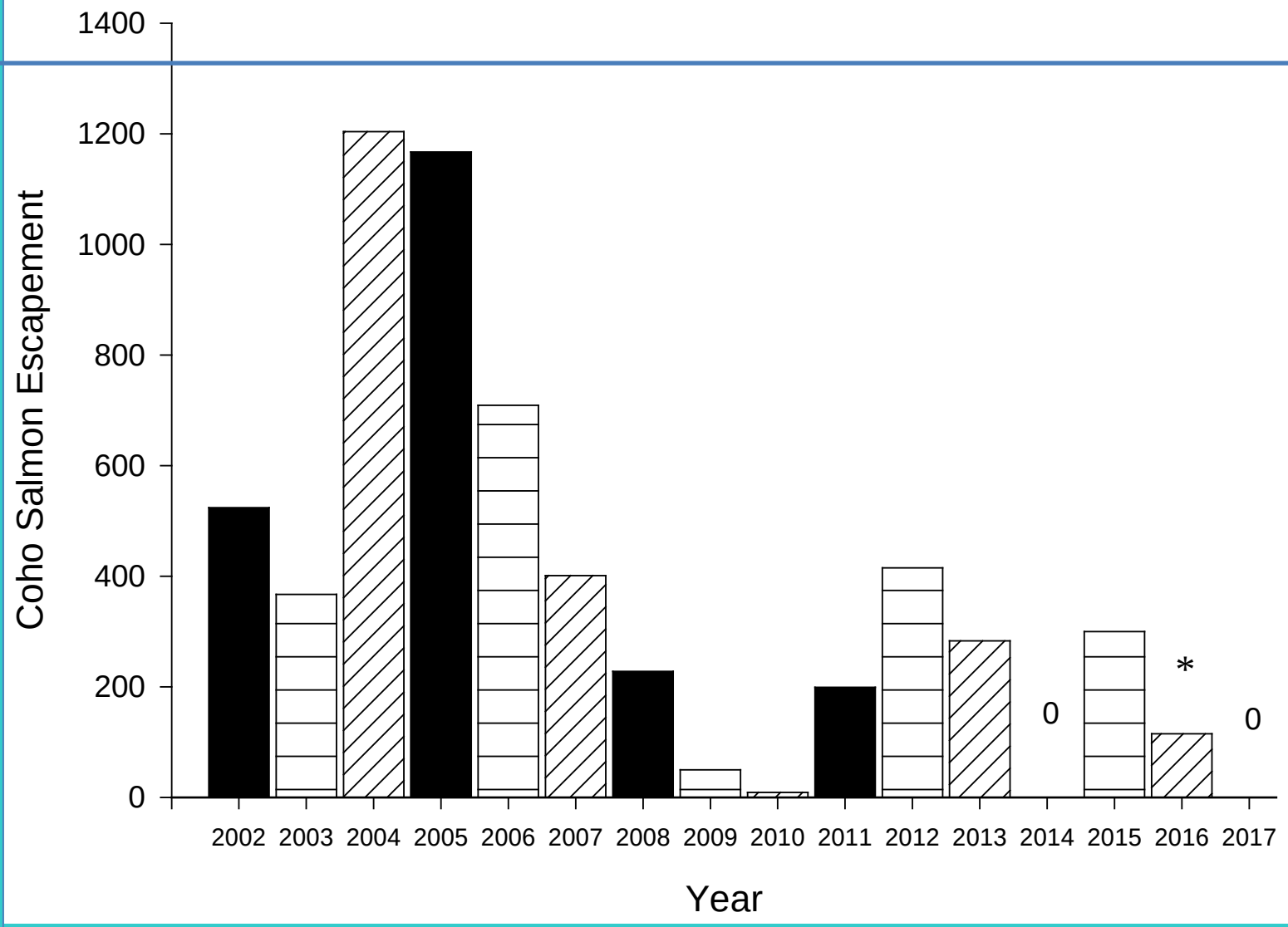

0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Growth (mm/d)
Spring YOY
Spring Y+
Summer YOY
Summer Y+
Pond Y+
Fall/Winter
Coho Growth
Steelhead Growth

How do we know there was no coho spawning in Pudding Creek in 2014?

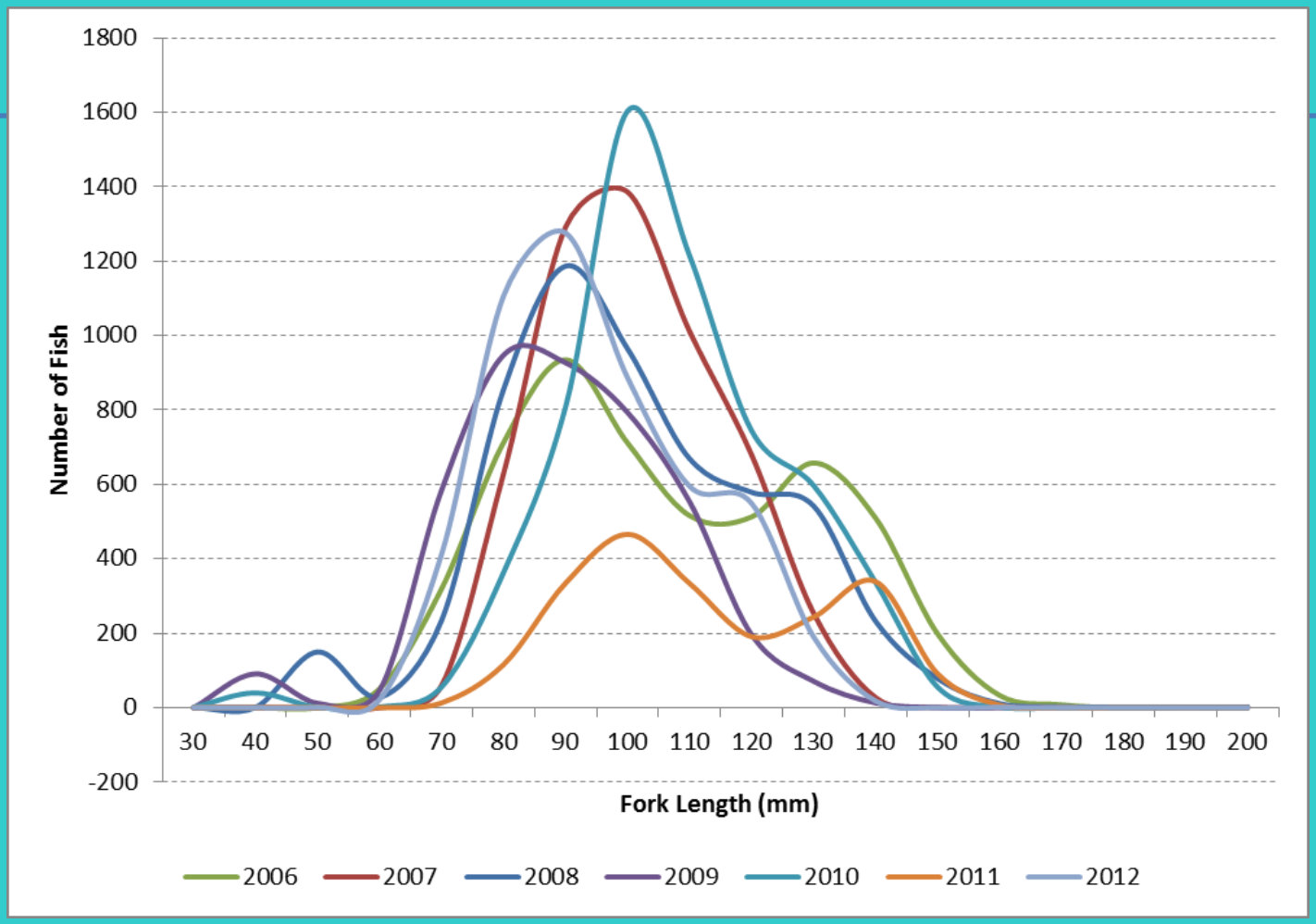
1. No adult coho were captured at the dam.
2. No spawners (or redds) were observed during biweekly spawning surveys (100% Census—4 months)
3. No YOY were captured at the rotary screw trap (spring 2014)
4. No YOY were captured during summer efishing surveys (2X—early summer, late summer, random sampling)
5. No YOY were found in random dive surveys throughout the creek
6. The sandbar did not open until late February



Pudding Creek Coho Spawner vs. Smolt (2005-2015)

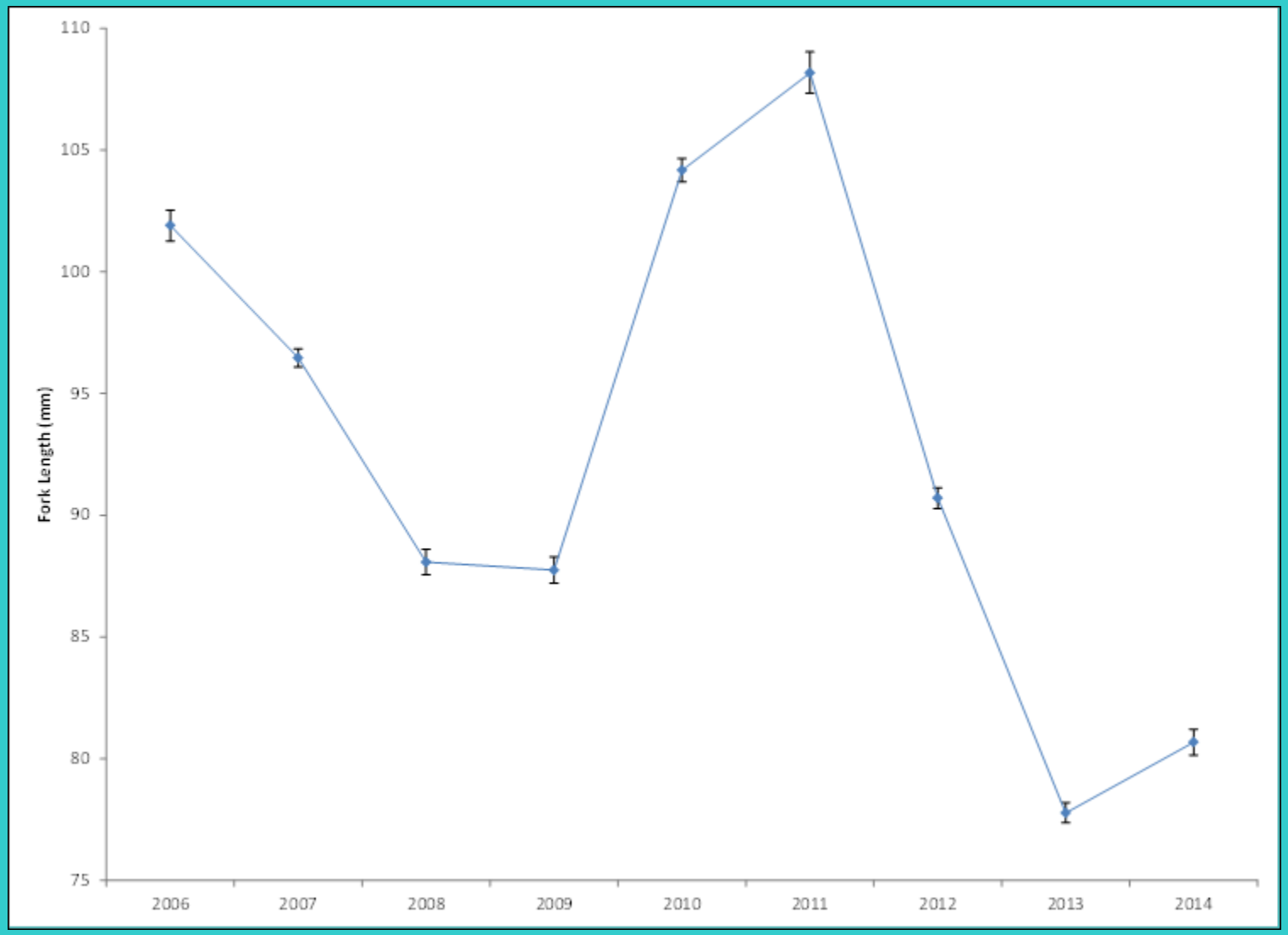

Coho Salmon Escapement
1400
1200
1000
800
600
400
200
0
0
*
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Year

Smolt Fork Lengths

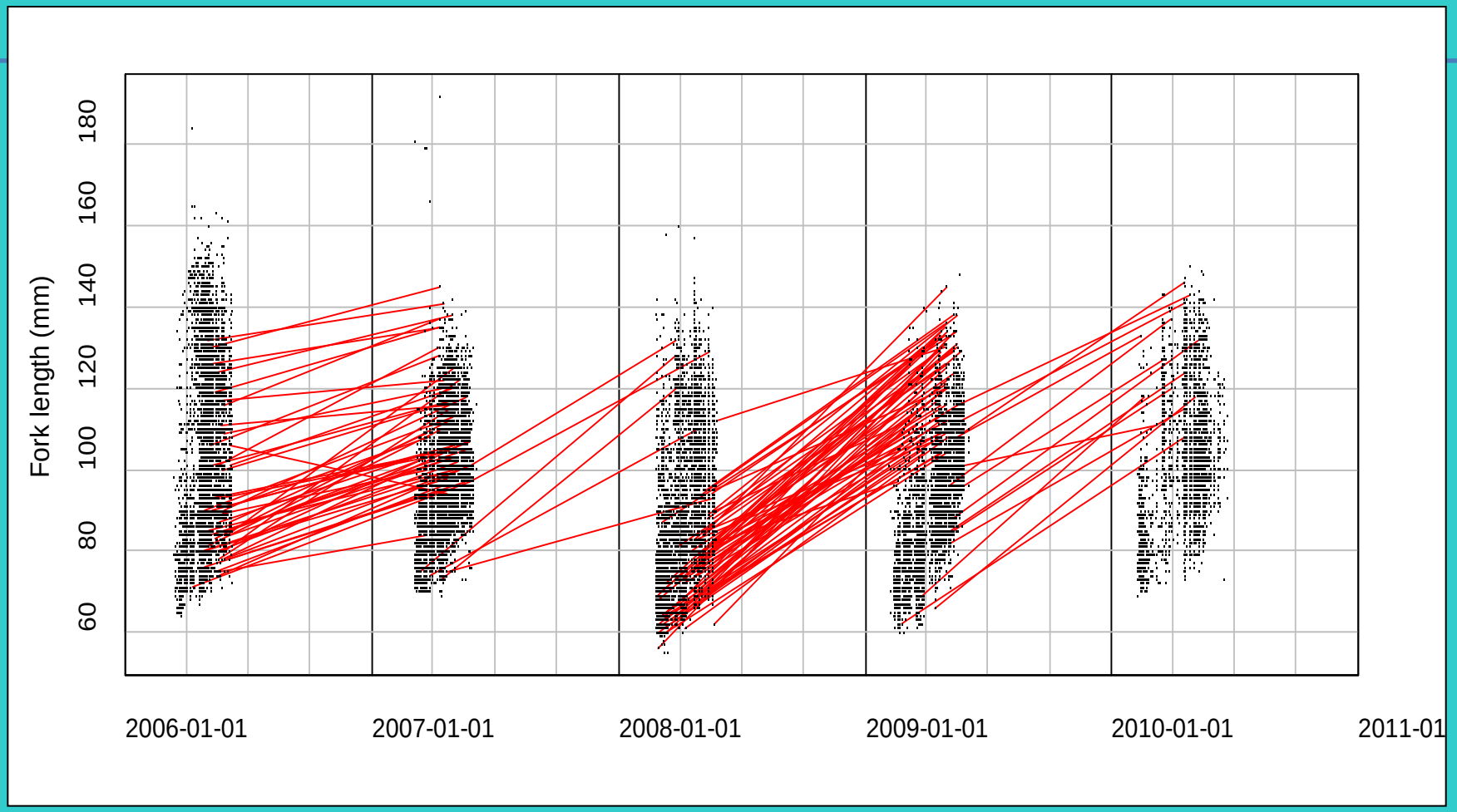


Smoothed histogram of coho salmon fork lengths at the outmigrant trapping station in Pudding Creek (2006-2010).

Coho Fork Lengths (2006-2014)

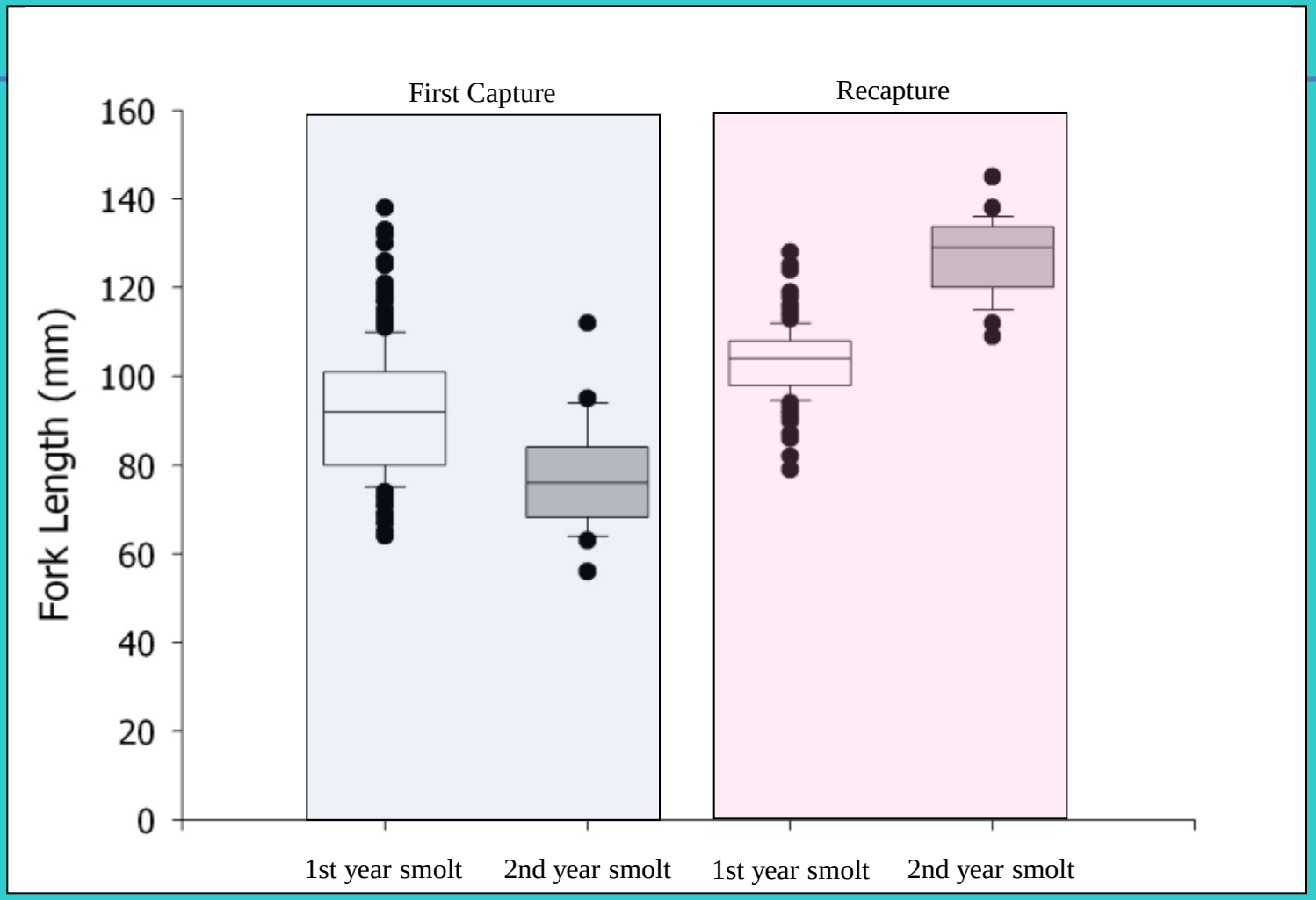


Second Year Juvenile Life-History



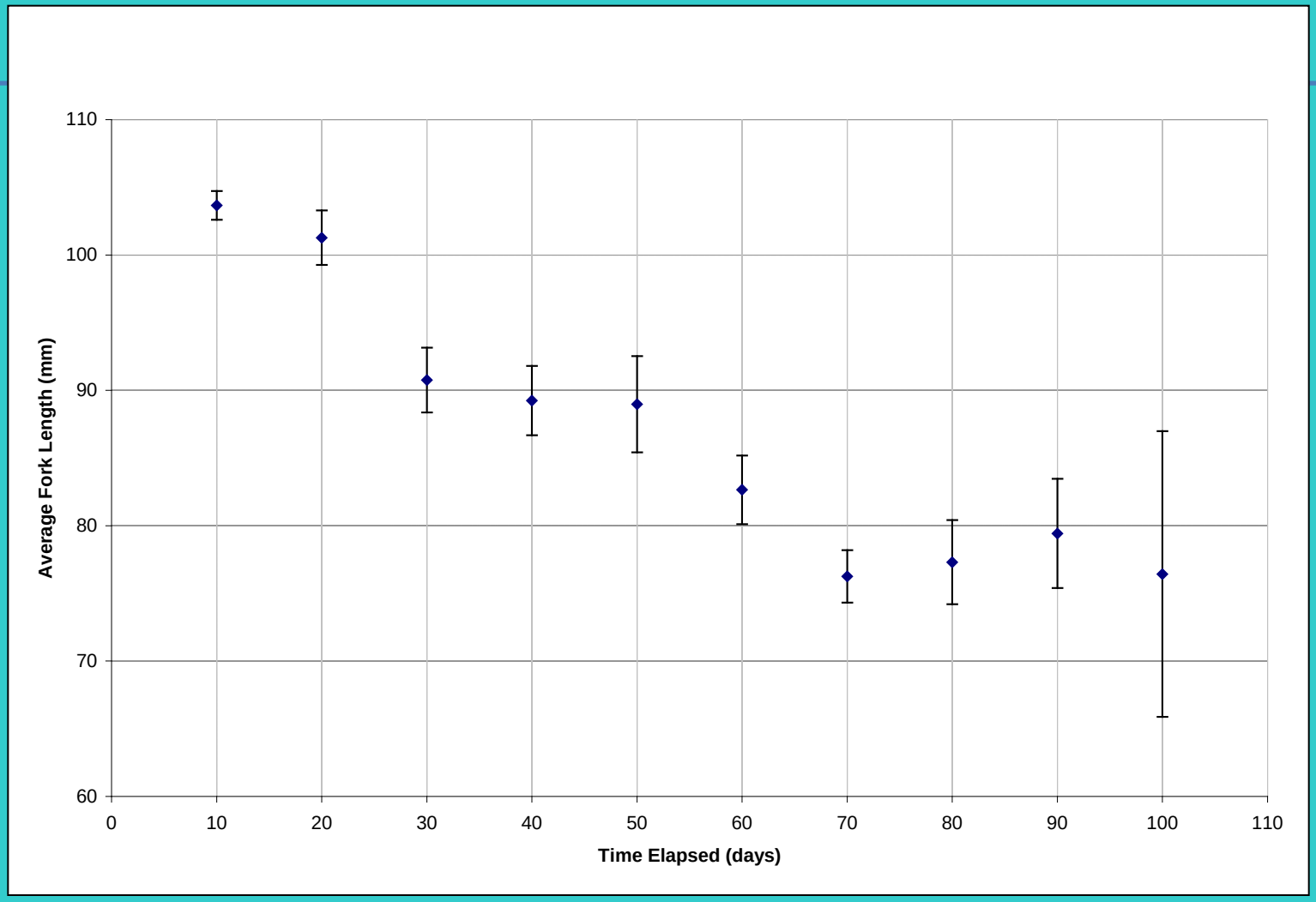
Length of individual coho salmon (*Oncorhynchus kisutch*) in Pudding Creek vs. time. The length of each fish measured in each spring survey is shown as a dot. Line segments join successive recoveries of the same individual PIT tag in spring surveys.

First vs. Second Year Smolt Size



Boxplot of fork lengths for 1 year old smolt (Y+) compared to 2 year old smolt (Y++) at first capture at the RST and recapture at the dam. Grey boxes indicate the Y++ cohort.

Smolt Length vs. Outmigration Time



Time elapsed between original capture at RST and subsequent detection at dam vs. initial measured fork length. Error bars are 95 percent confidence intervals.

Electro-Fishing Summer 2014


Two-year old
“Big Kahuna”

Three Year Life-History Questions:

- Is this a coho survival strategy for drought-prone Northern California?
- Are coho “programmed” to live exactly 3-years?
- If so, will all these fish return as jacks, and is this how most jacks originate?
- And, if this is so, what happens to females? Most jacks are identified as precocious males.
- Will the males return as jacks, but the females as 4-year old spawners?
- Do we need to re-think our present recovery strategy—based on Metapopulation Theory?