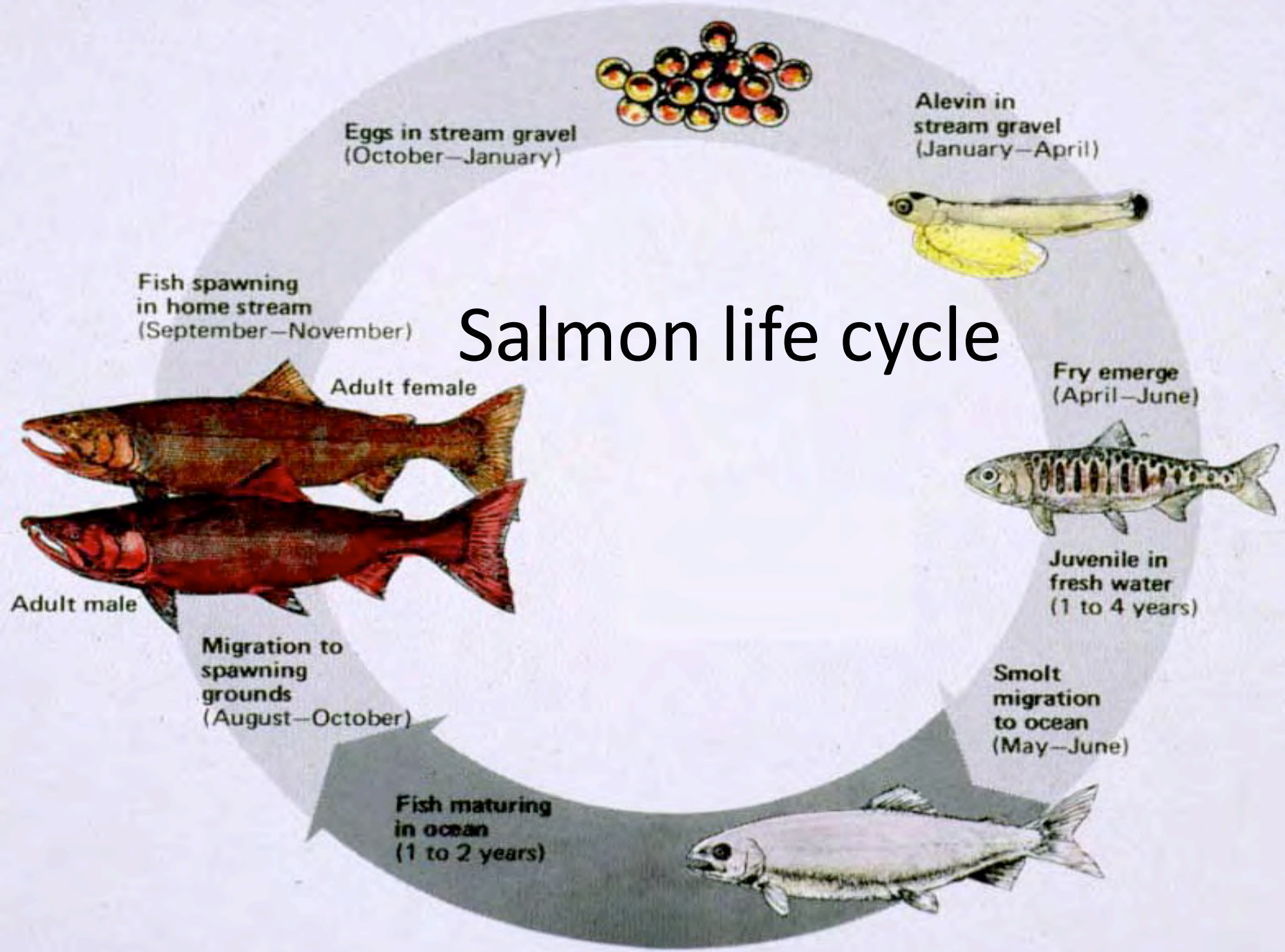
# Chinook & Steelhead Habitat Requirements

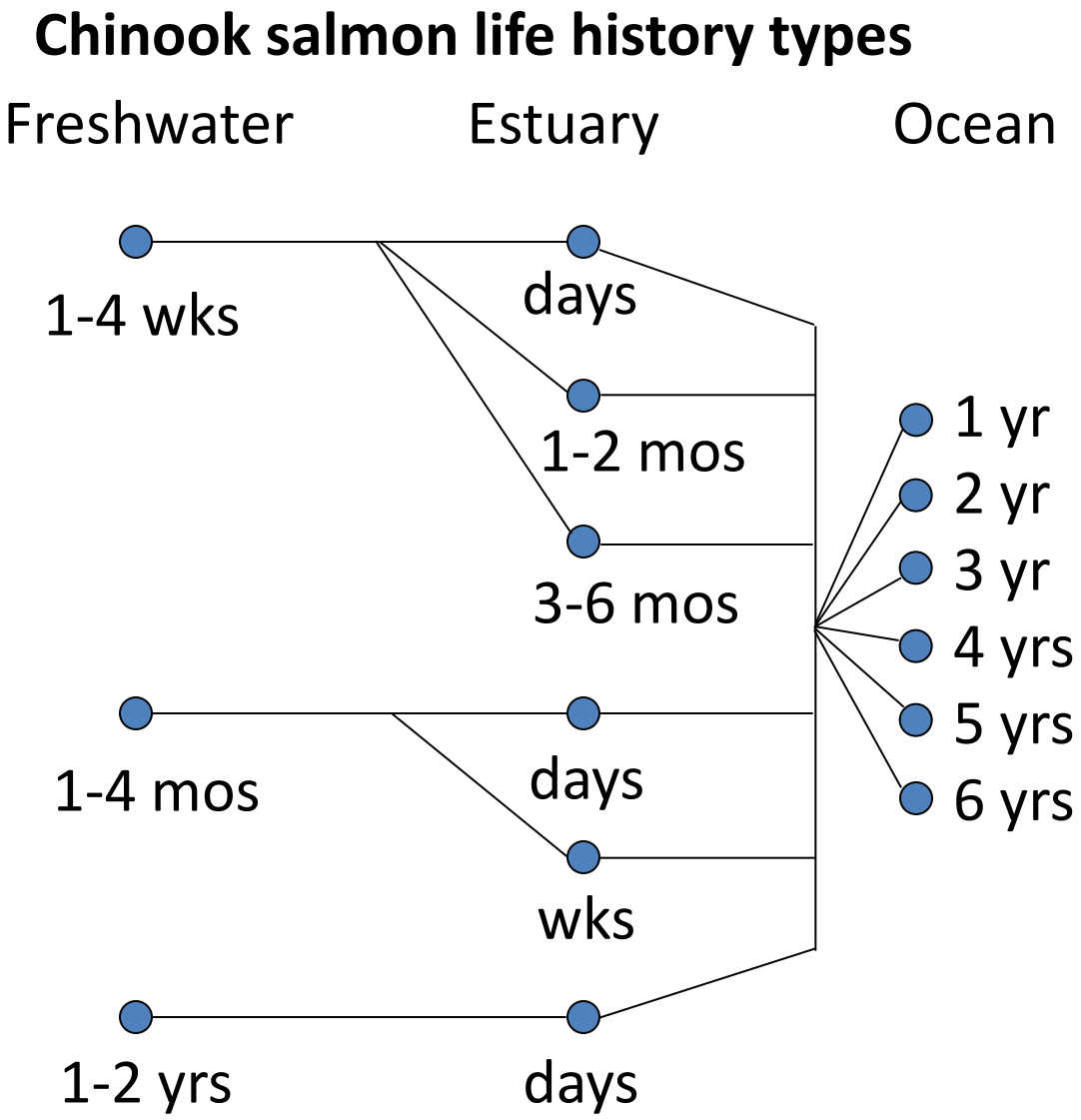

Phil Roni, George Pess & Tim Beechie
Watershed Program
Northwest Fisheries Science Center

Tracy Hillman
BioAnalysts, Inc.
Biose, Idaho

# Salmon life cycle

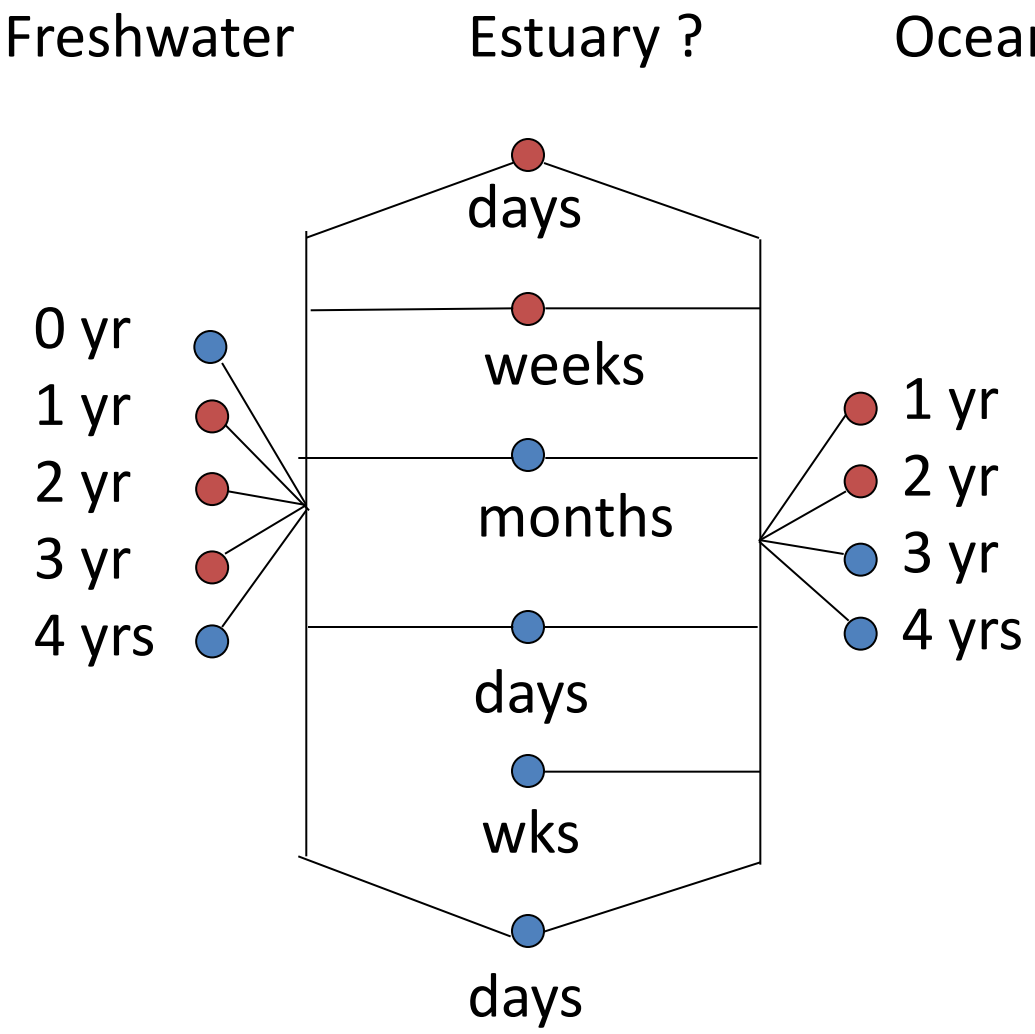


# Chinook Life history diversity

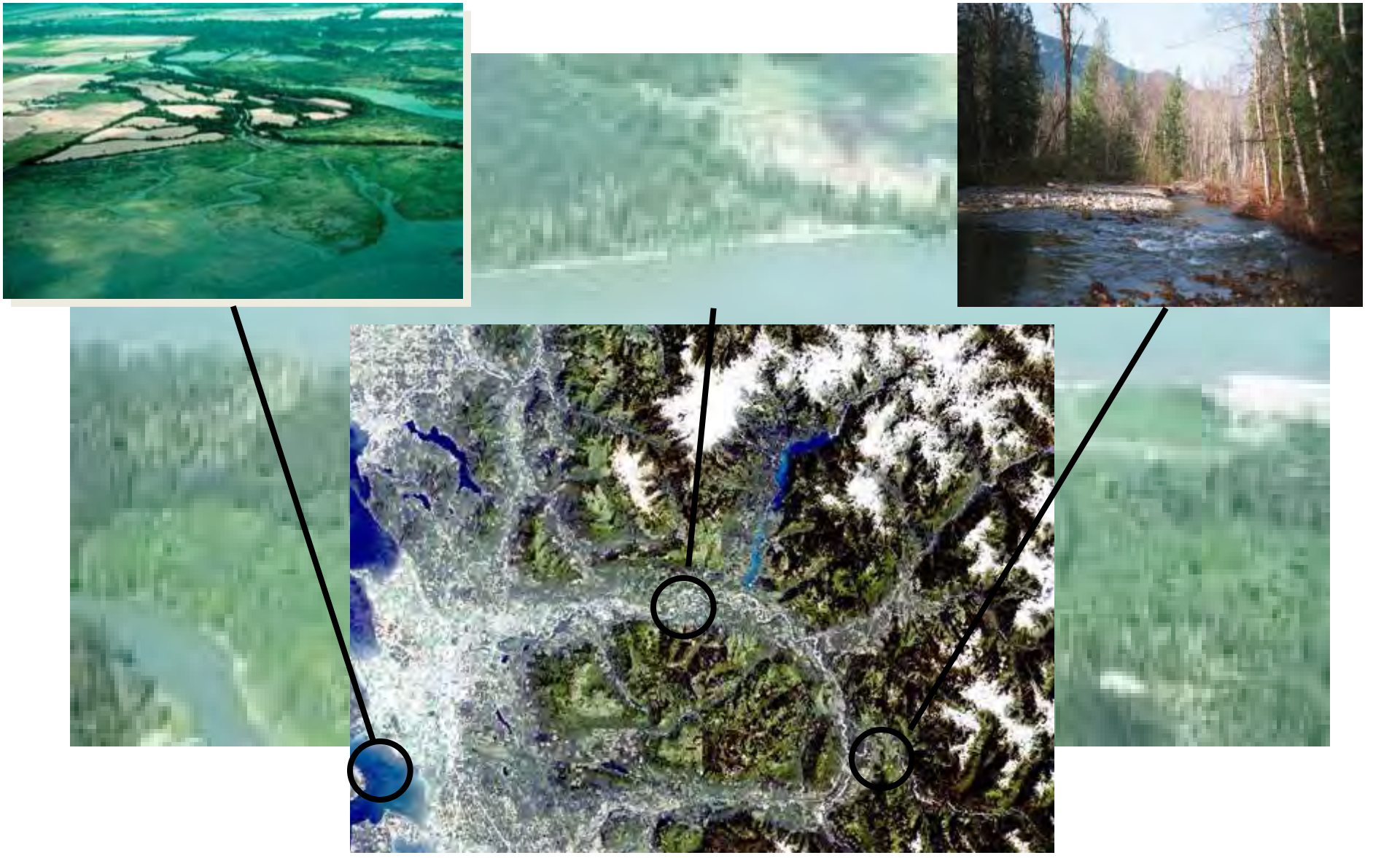



After C. Greene (unpublished) & Wissmar and Simenstad 1998

# Steelhead Life history diversity



# Landscape Scale Habitat Requirements

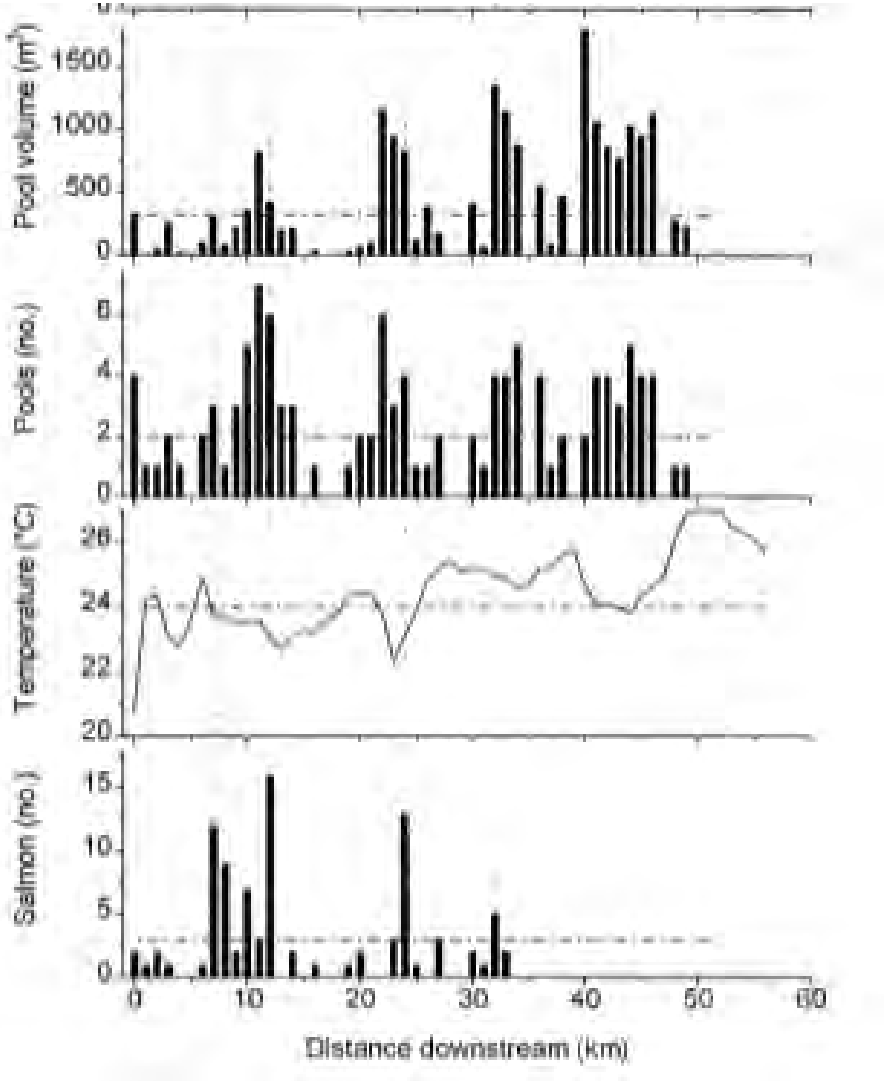


# II. Micro and Meso-Habitat Requirements

- Adult Holding Habitat
- Spawning Habitat
- Incubation Habitat
- Fry Habitat
- Summer Parr Habitat
- Winter Parr Habitat
- Smolt Migration Corridor

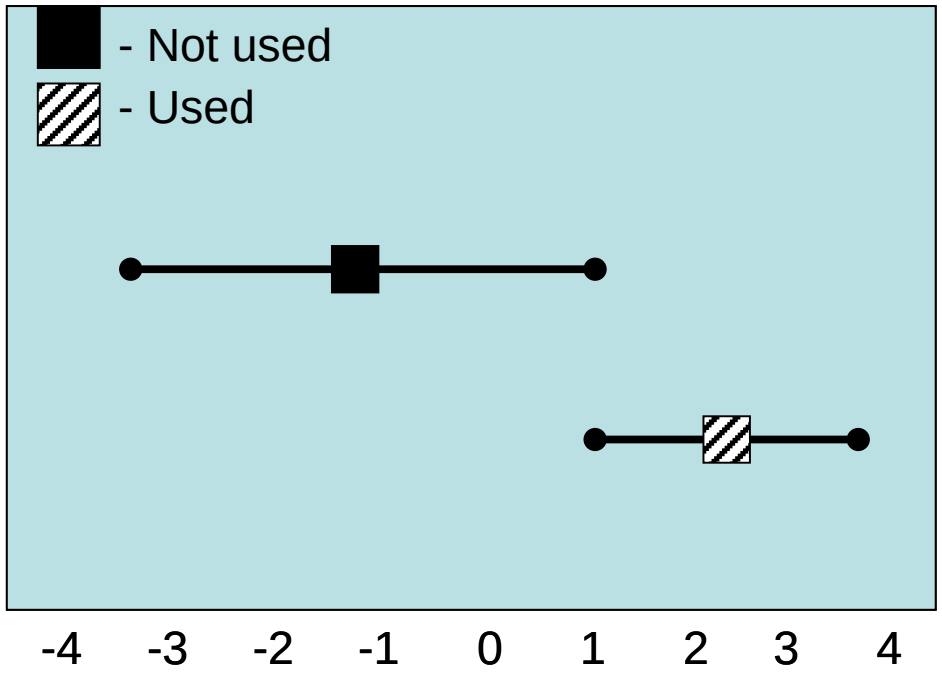

# Adult Holding – Chinook

- Adequate
  - Depth
  - Cover
  - Temperature
    - Cool H20 refuge areas
  - Proximity of pools to spawning areas




Torgersen et al. 1999

# Adult holding habitat requirements




- Summer steelhead
  - Colder water
  - Deeper pools
  - More cover
  - Larger substrate

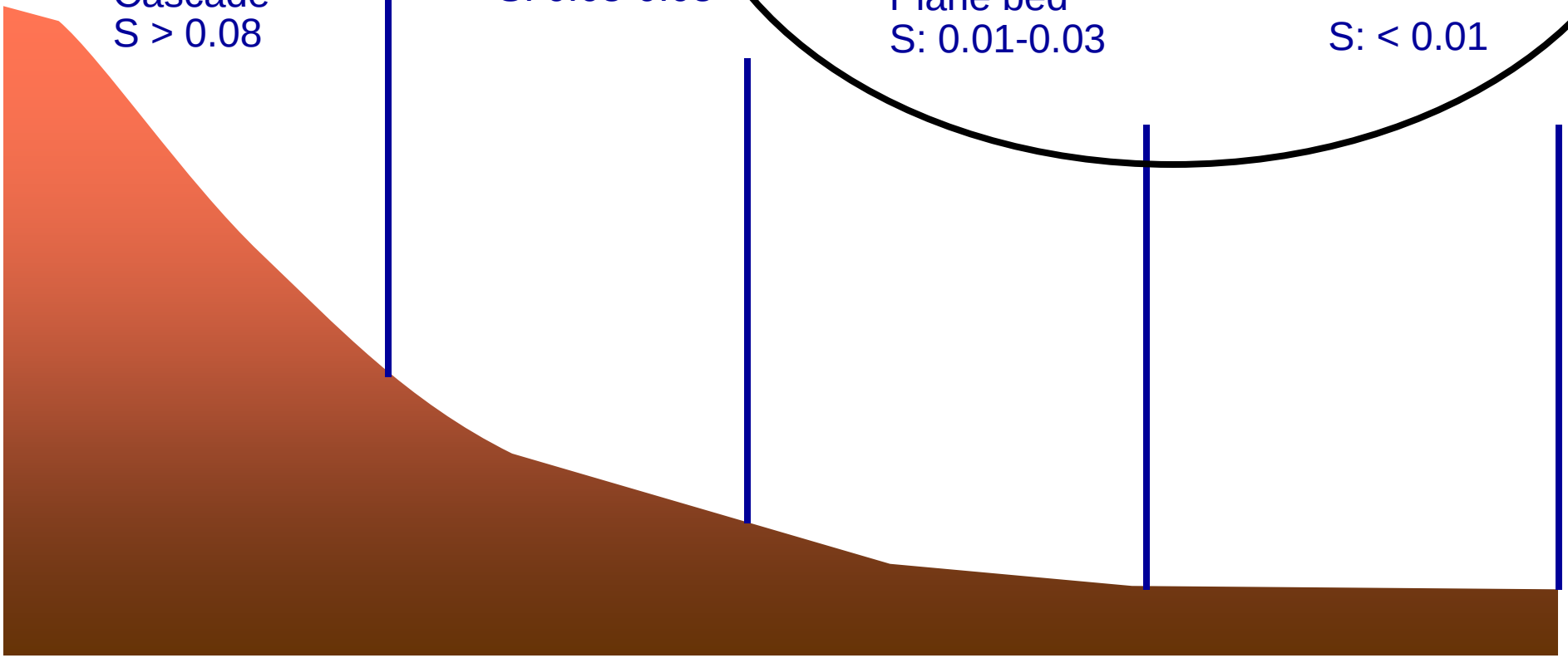
Baigun, C.R.M. 2003,
Nakamoto et al. 1994

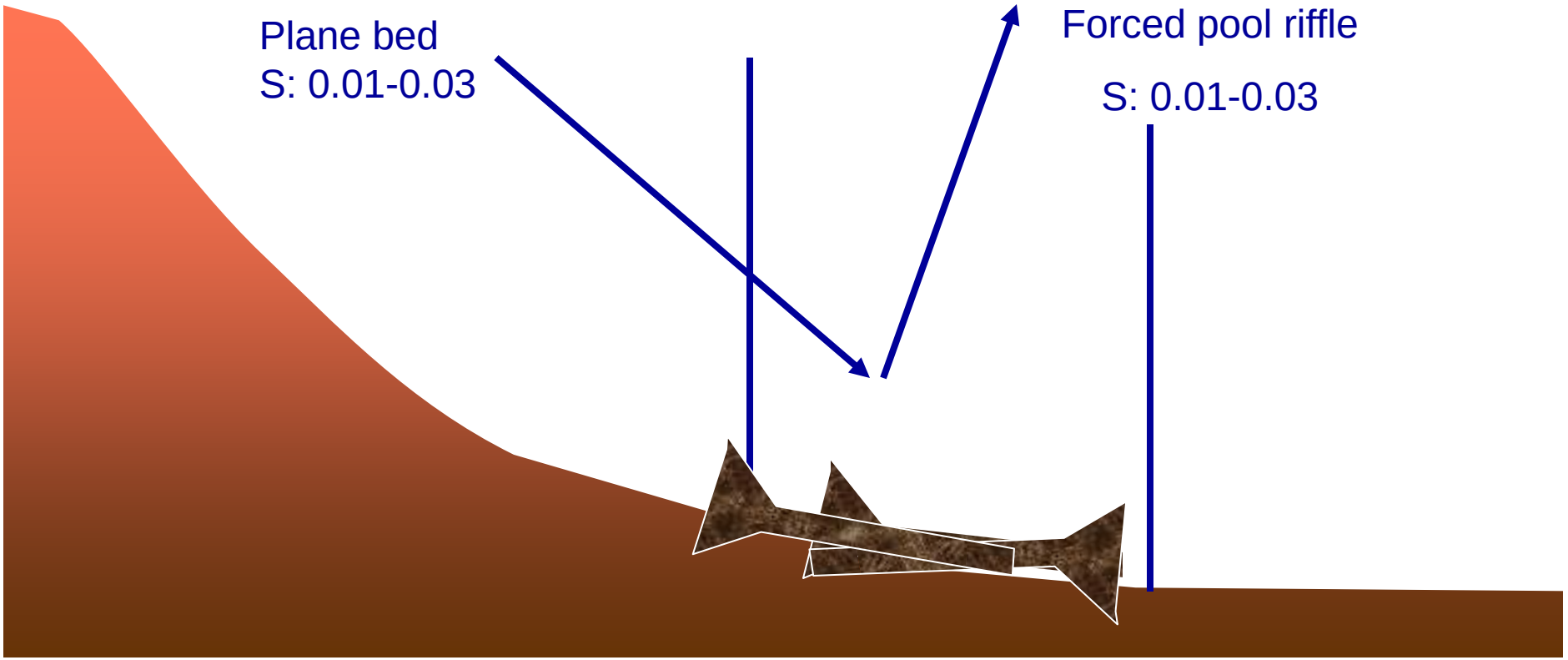
Cascade
S > 0.08

Step pool
S: 0.03-0.08

Plane bed
S: 0.01-0.03

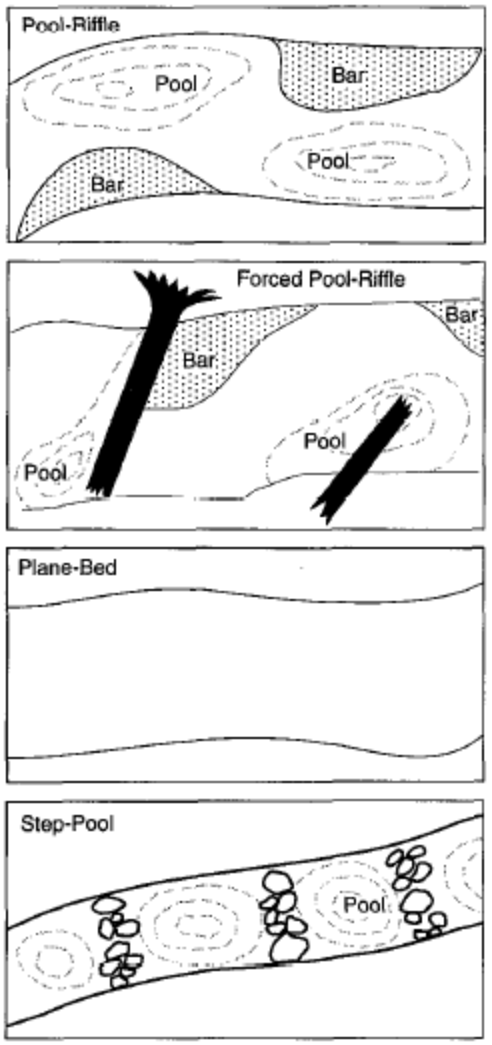
Pool riffle
S: < 0.01

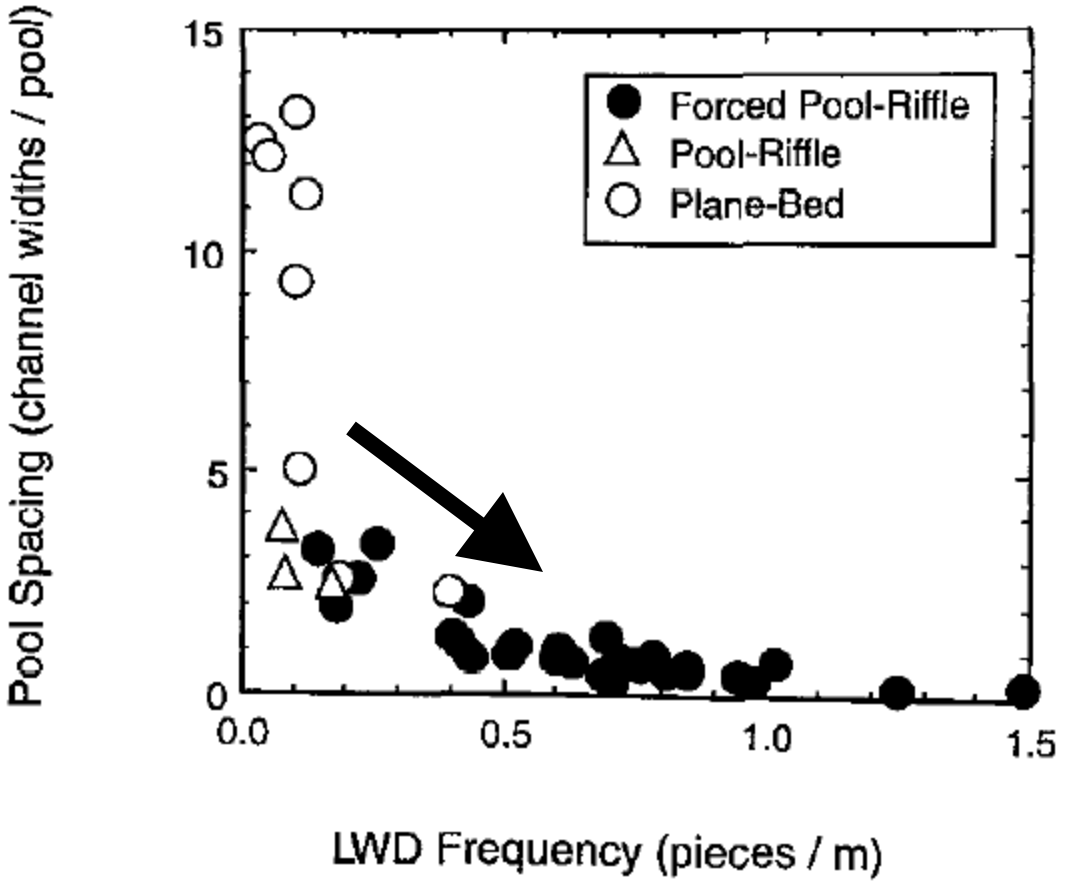



Plane bed
S: 0.01-0.03
Forced pool riffle
S: 0.01-0.03

# Adult holding & what it means to restoration

Increased LWD frequency = increased density of pools

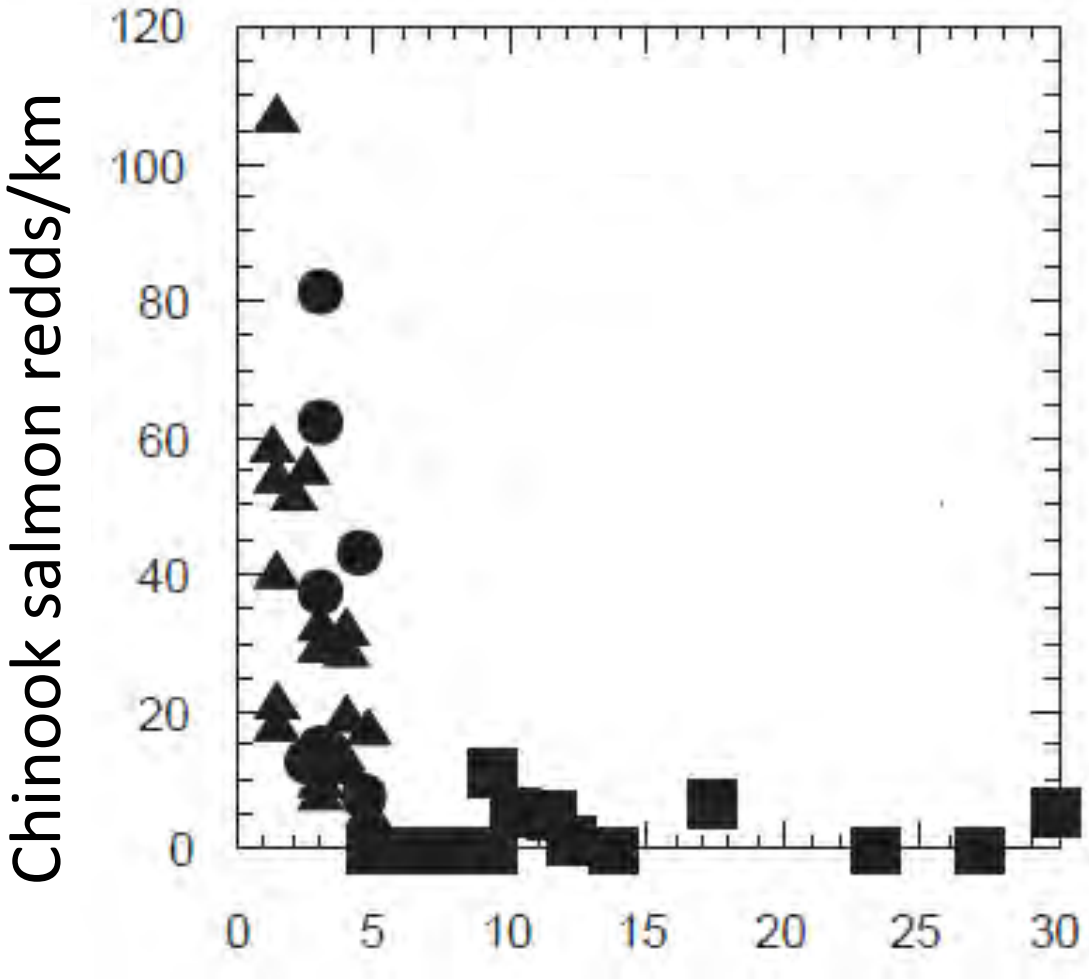



Montgomery et al. 1995

# Adult holding habitat & what it means to restoration

Increased pool density = increased redd density




Montgomery et al. 1999

# ~30 times as Chinook salmon redds in Forced Pool-Riffle Channels

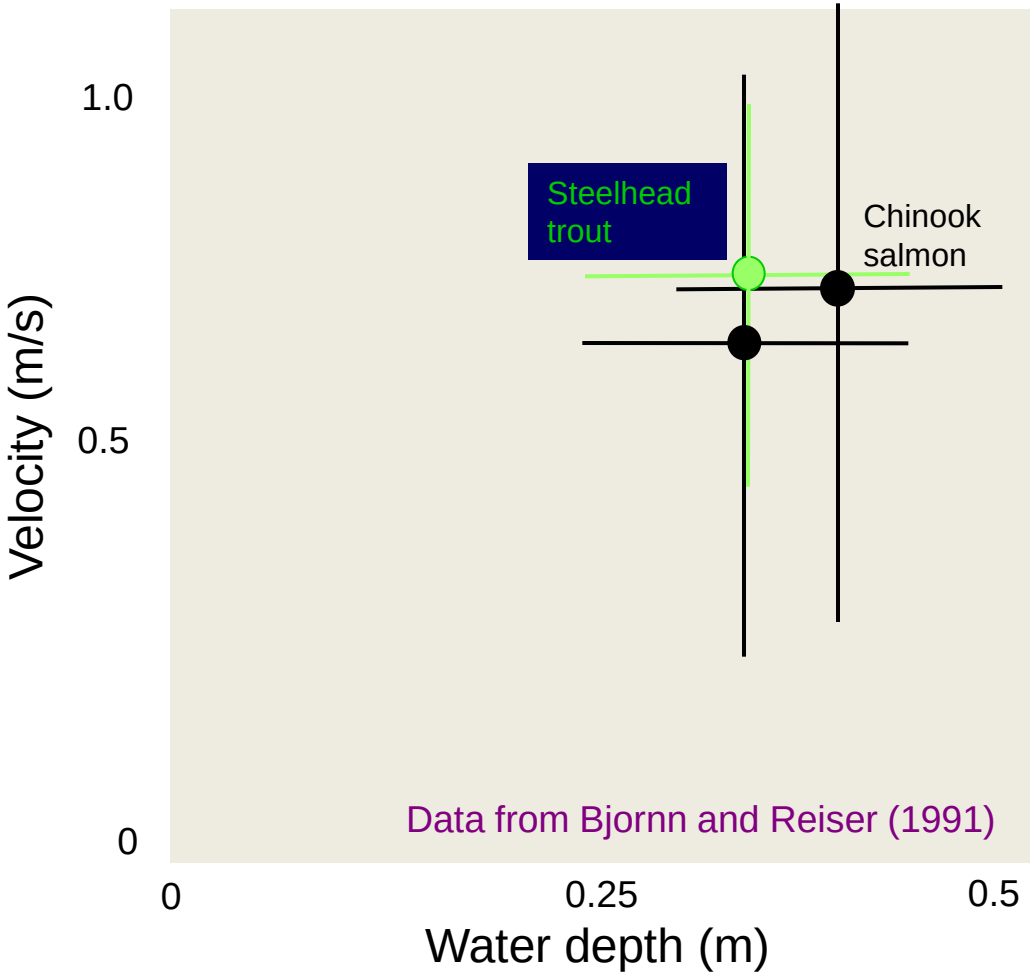
Forced-Pool Riffle Channel

Plane Bed Channel

# Adult Spawning Habitat

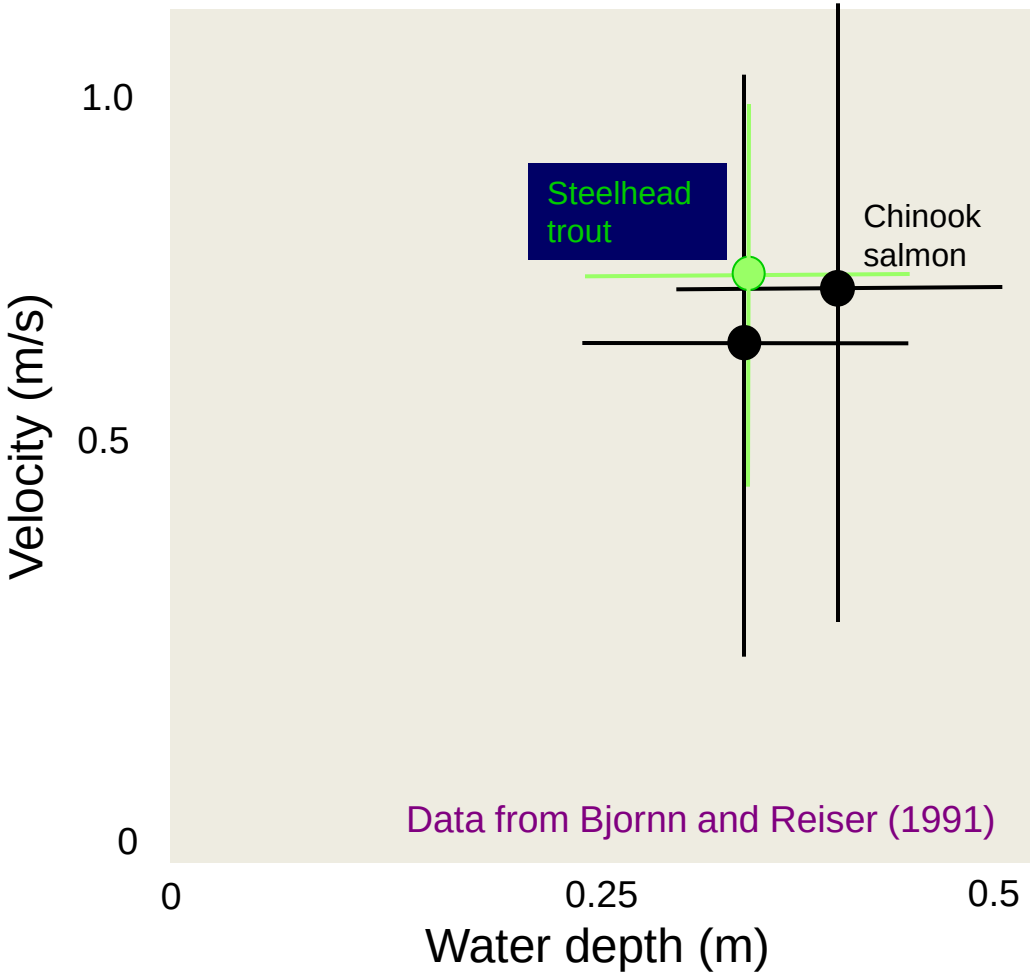
# Chinook Spawning Habitat

- Depth > 24 cm
- Velocity 30-91 (cm/s)
- Substrate 1.3-10.2cm
  - Fines < 20%
- Temp ~ 5 to 14°C



# Steelhead Spawning Habitat

- Depth > 24 cm
- Velocity 40-91 (cm/s)
- Substrate 0.6-10.2cm
  - Fines < 20%
- Temp ~ 4 to 10°C



# Adult Spawning

- Considerations for restoration project selection
  - Pools, cover and holding areas close to spawning areas (increase LWD, Riparian cover)
  - Adequate cool water refuges (deep pools)
    - Increase LWD, riparian cover,
    - Reduce excess sediment filling pools

J. McMillan photos

# Incubation Habitat

**Chinook**

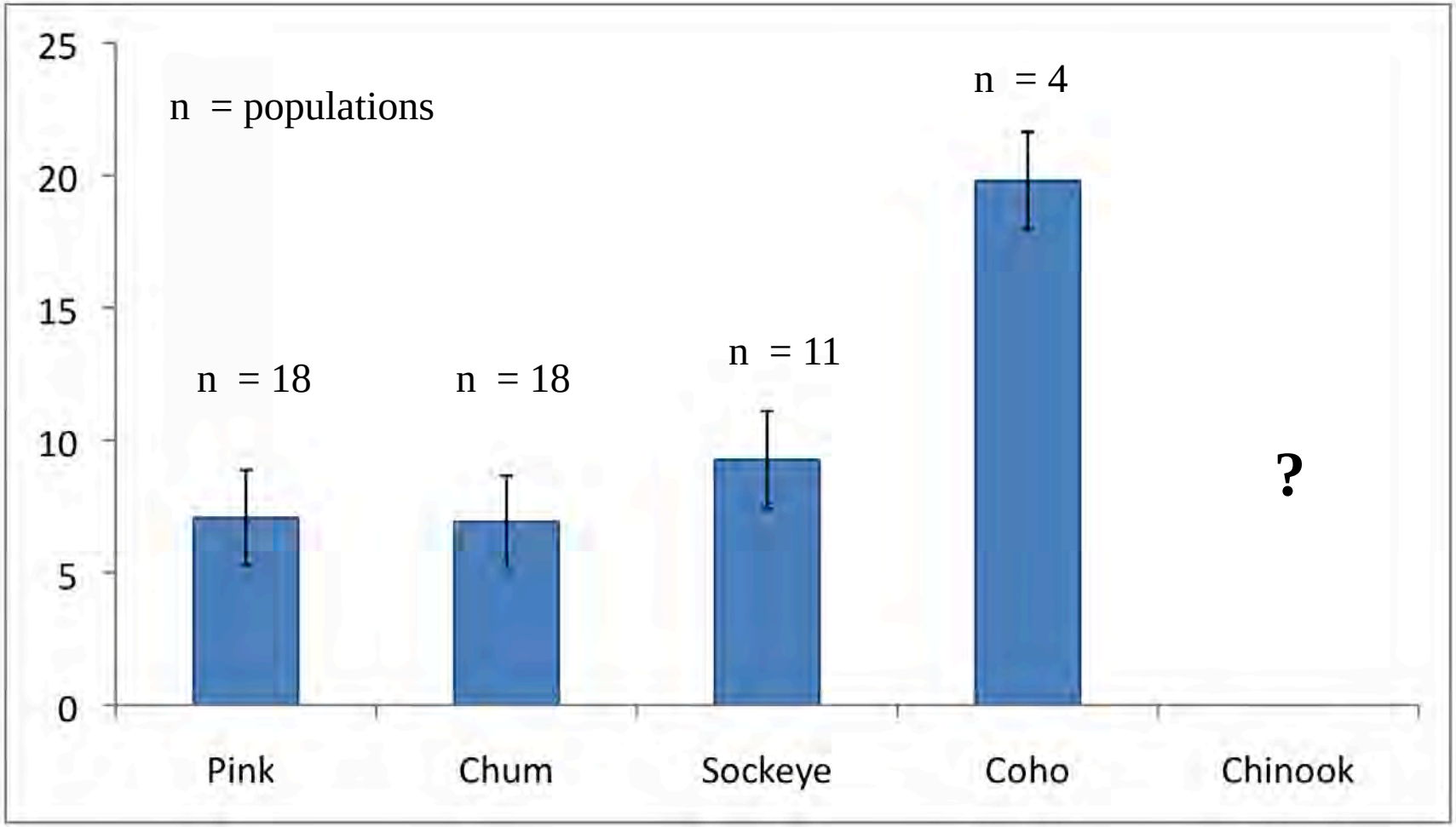
- Temperature 5 to 13 (but as low as 0.6) (Bell 1990; Bjornn & Riser 1991)
- Fines/infiltration < 20%
  - Jensen et al. 2009
- Limited scour/high flows
- DO – saturation (> 7mg/l)
  - Low DO groundwater?
  - % Organics?

**Steelhead**

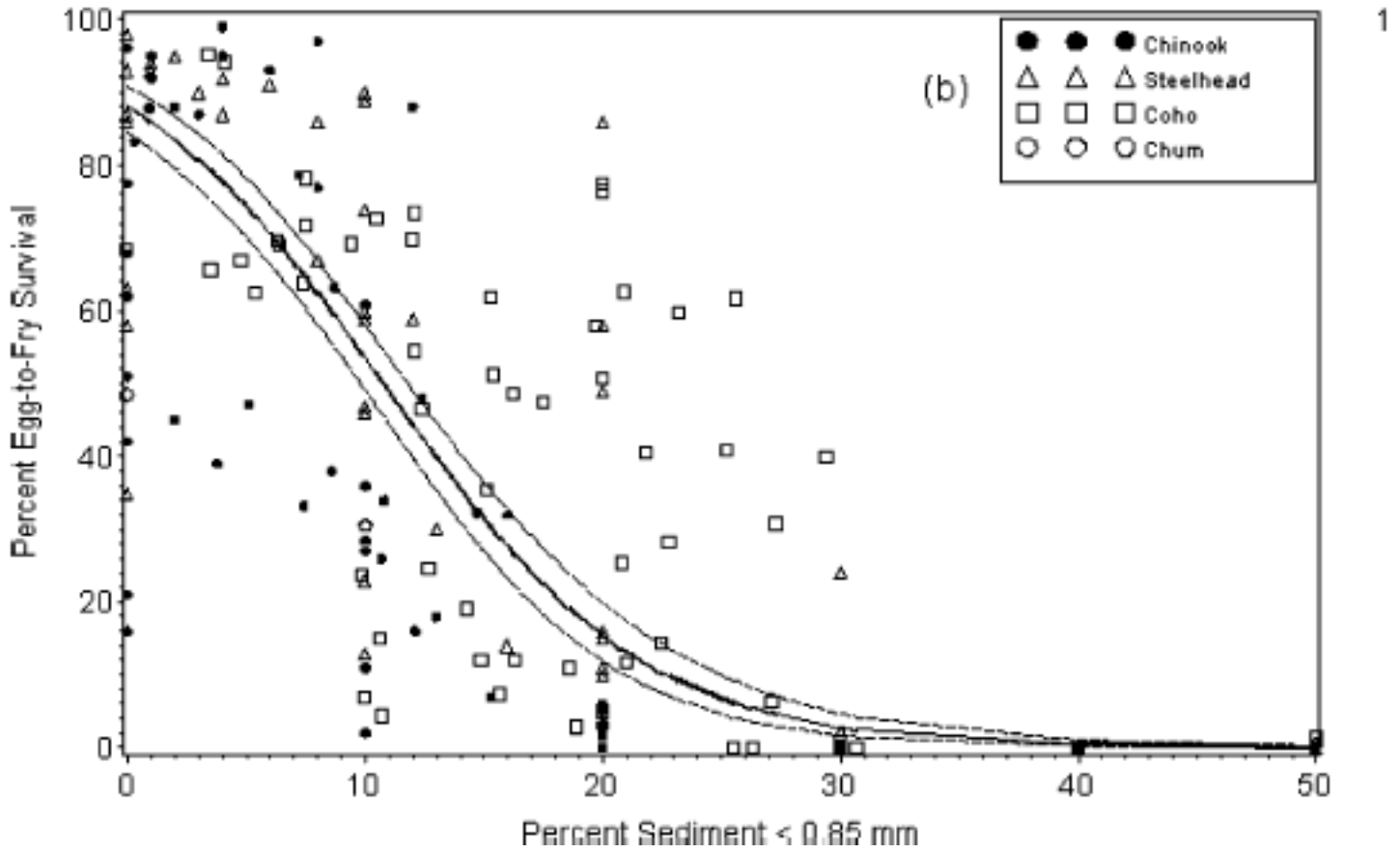
- Temperature ~4 to 13
- (Bell 1990)
- Fines/Infiltration < 20%
  - Jensen et al. 2009
- Limited scour/high flows
- DO – saturation (> 7 mg/l)
  - Low DO groundwater?
  - % Organics?

# Estimates of Salmonid Egg-to-Fry

## Bradford 1995



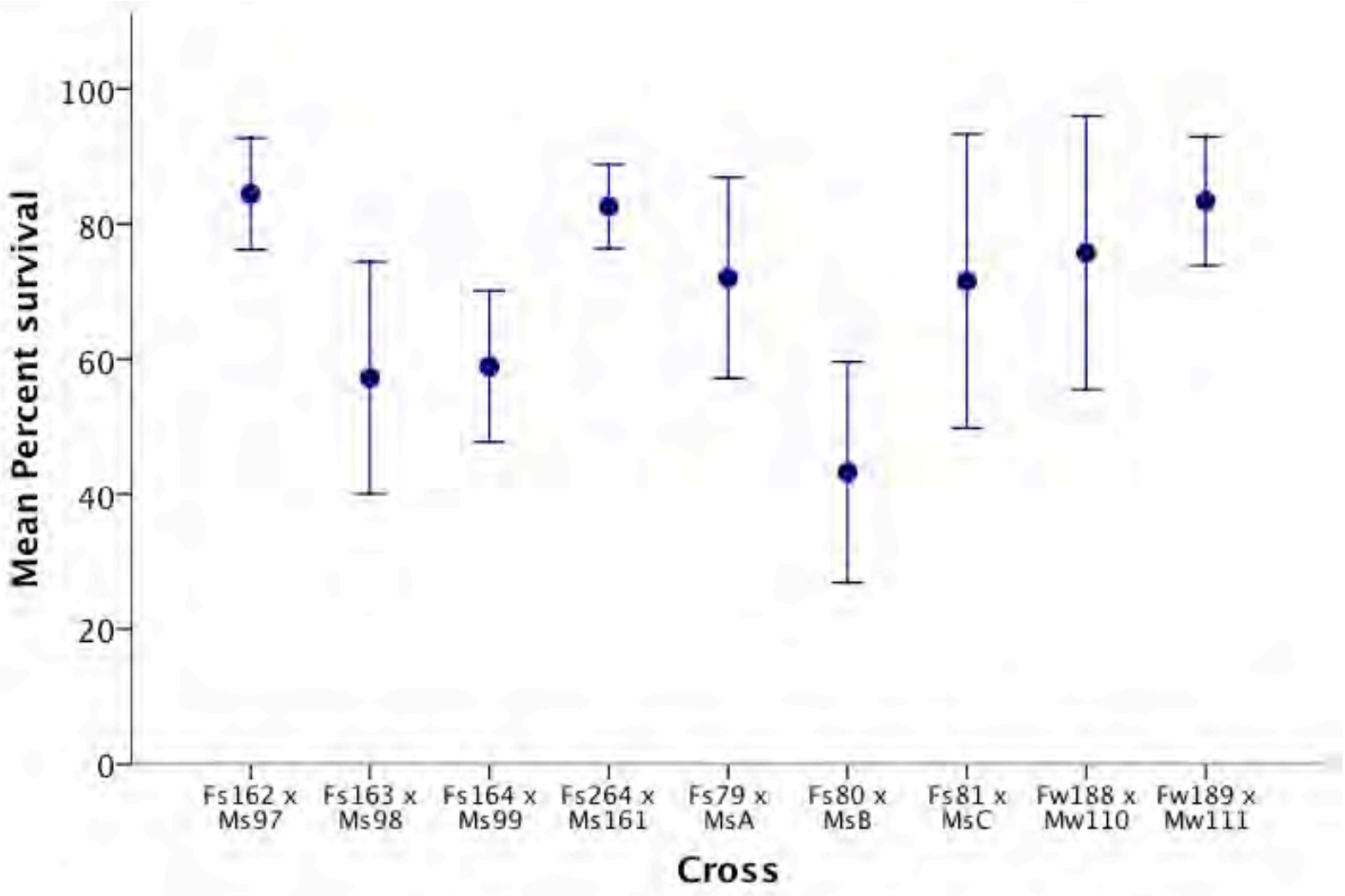
# Egg to Fry Survival




Jensen et al. 2009

# Adult Fitness Important

Yakima River Chinook Survival by Male-Female Cross




Johnson, Roni & Pess In press.

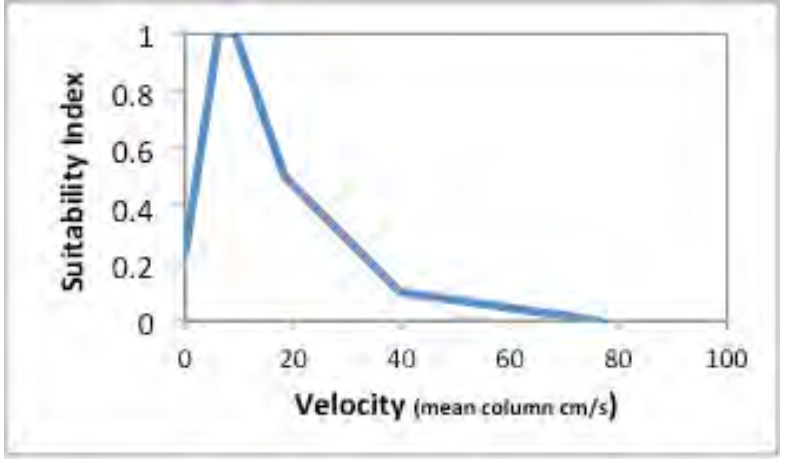
# Incubation Habitat

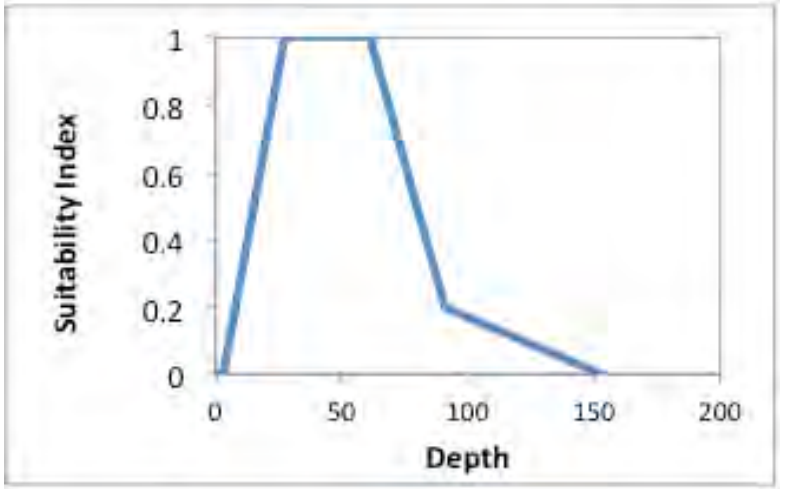
- Possible considerations for project selection
  - Reduce road, grazing, upland impacts, bank erosion (fines, temp, DO, scour)
  - Restore riparian areas (fines, scour, temp)
  - Remove channel confinement (scour)

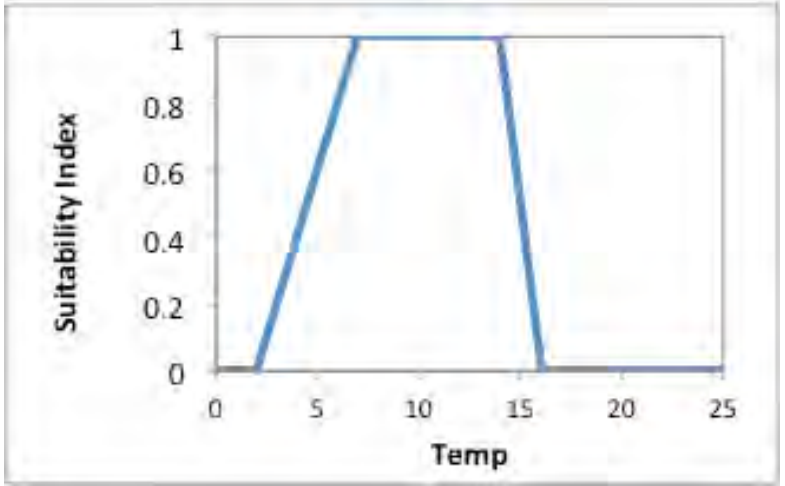
# Fry Habitat Requirements

# Chinook fry

- Low velocities
- Shallow water



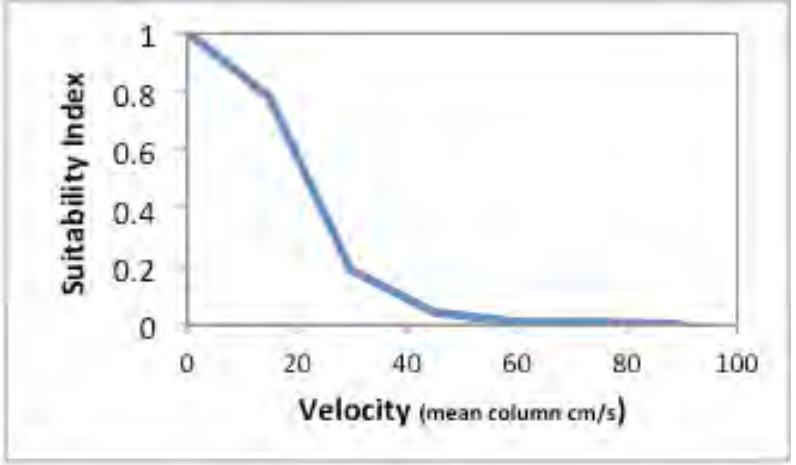



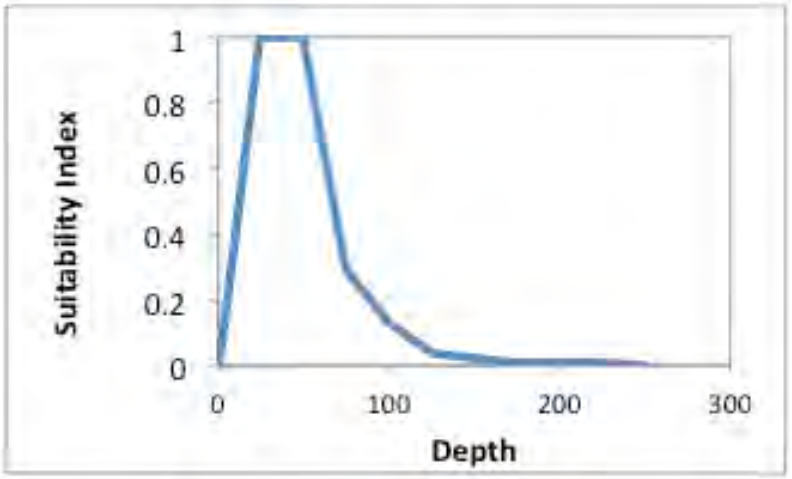



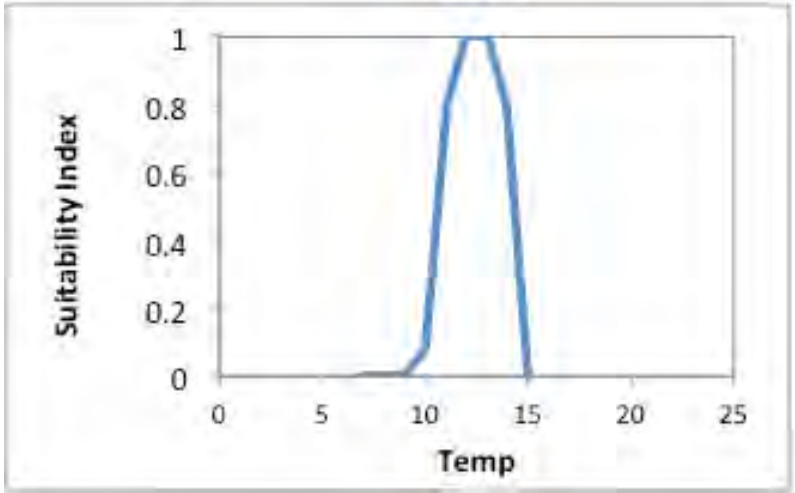
# Steelhead fry

- Low velocities
- Shallow water


John McMillan photo

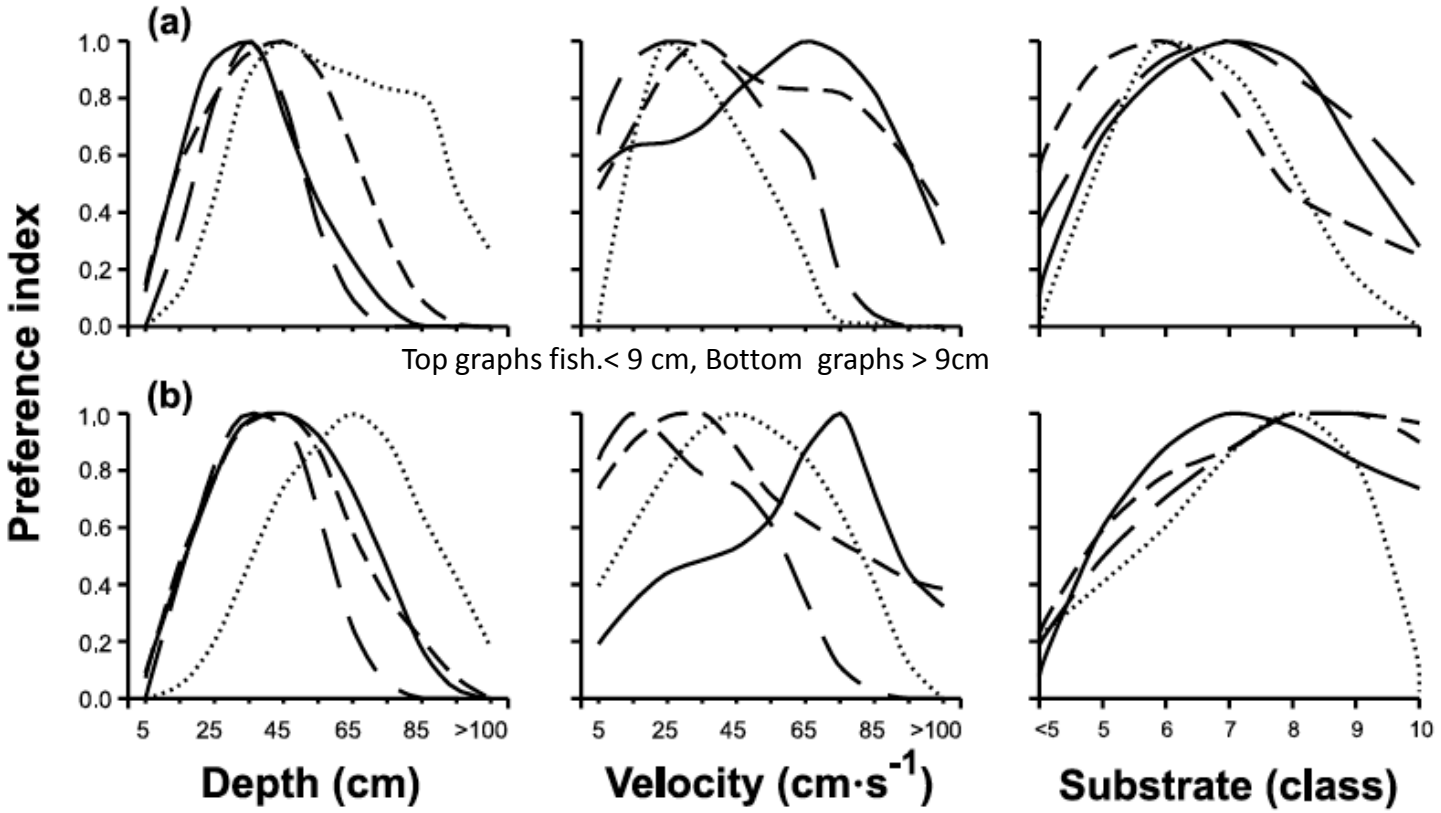


# Note About Habitat Suitability Curves

- General based on literature – varies based on ecoregion, watershed or even tributary
-




Top graphs fish.< 9 cm, Bottom graphs > 9cm

(—, Koitajoki; — —, Pyhäjoki; – –, Simojoki; ....., Tenojoki)

Source Maki-Petays et al. 2012

# Chinook and Steelhead Fry Habitat

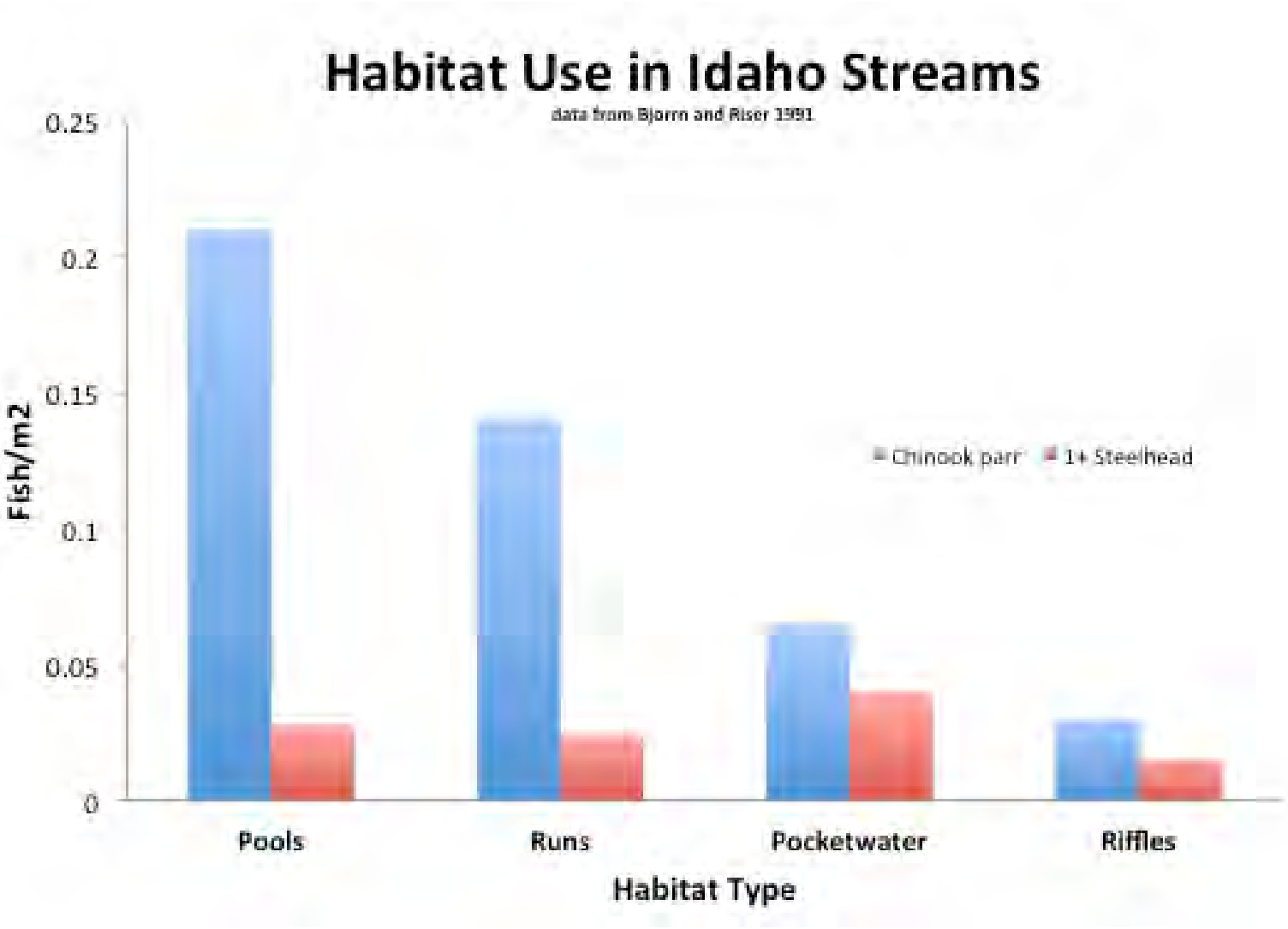
**Daytime Habitat**

- Post-emergent Chinook and steelhead cluster at stream margins in slow (0-10 cm/s) and shallow water (<60 cm).
- Chinook fry typically station over fine substrates with abundant vegetation cover (brush, grasses, and woody debris).
- Steelhead fry typically station over cobble and small boulder substrates.

**Nighttime Habitat**

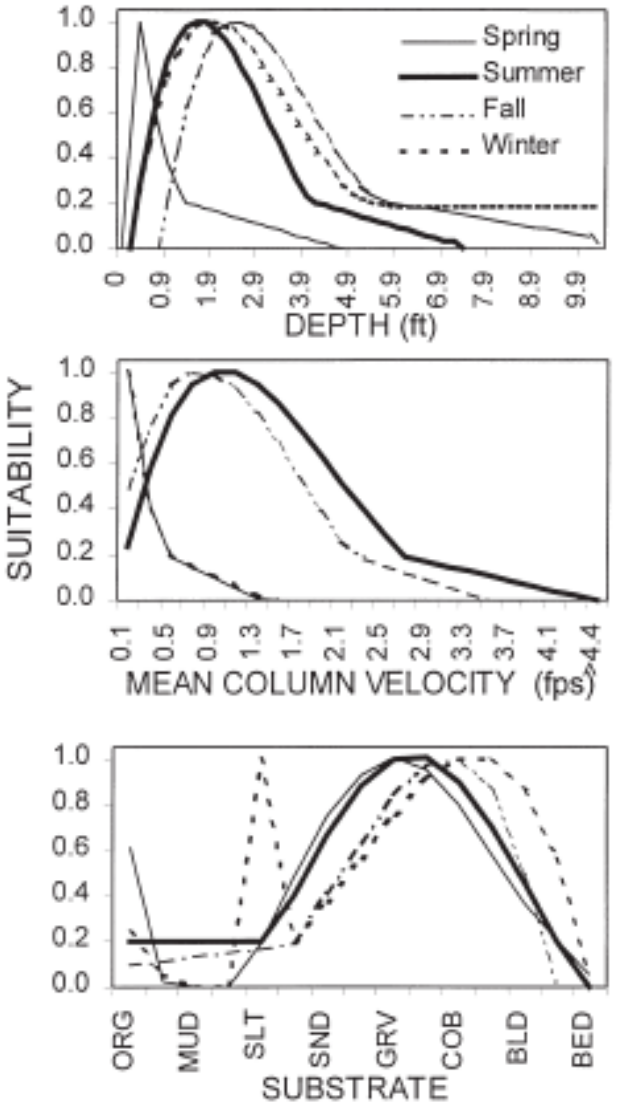
- Nighttime habitat selected by Chinook and steelhead fry is similar to their daytime habitat.
- Both species select shallow, quiet (<1 cm/s) water at night.
- Although both Chinook and steelhead fry select similar microhabitat, they are spatially segregated because of different emergent dates.

# Summer rearing



# Summer rearing

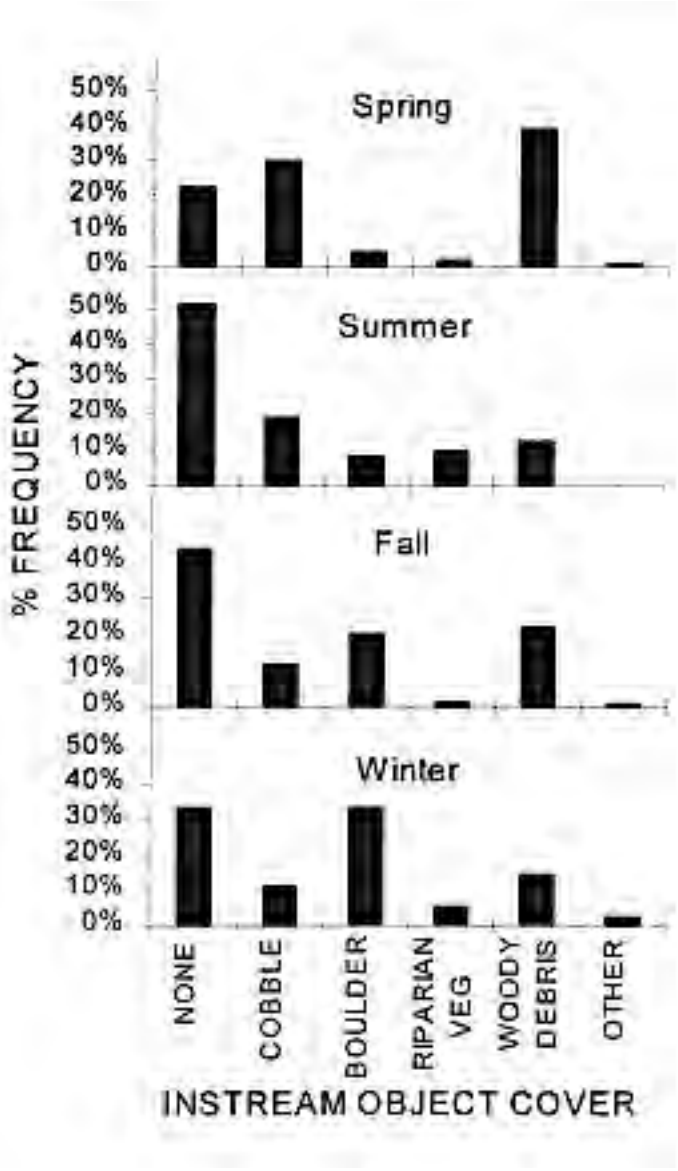
- Chinook
  - Temp ~ 12-14C
  - Vel 0-25 cm/s
  - 15-60 cm
- Steelhead
  - 10-13 C
  - 4 – 40 cm/s
  - 15 to 70 cm
- Changes with
  - Fish size
  - Season




Seasonal habitat preferences for Yakima River Chinook - Allen 2000

# Summer rearing – Seasonal Change in Cover

- Chinook
  - Temp ~ 12-14C
  - Vel 0-25 cm/s
  - 15-60 cm
- Steelhead
  - 10-13 C
  - 4 – 40 cm/s
  - 15 to 70 cm
- Changes with
  - Fish size
  - Season




Seasonal use of cover for Yakima River Chinook - Allen 2000

# Chinook and Steelhead Summer Parr Habitat Selection

**Daytime Habitat**

- As Chinook grow, they use faster (2-44 cm/s) and deeper (25-300 cm) water, and select brush, woody debris, or cobble/boulder cover.
- As steelhead grow, they use faster (2-34 cm/s) and deeper (19-190 cm) water, and use cobbles and boulders for cover.

**Nighttime Habitat**

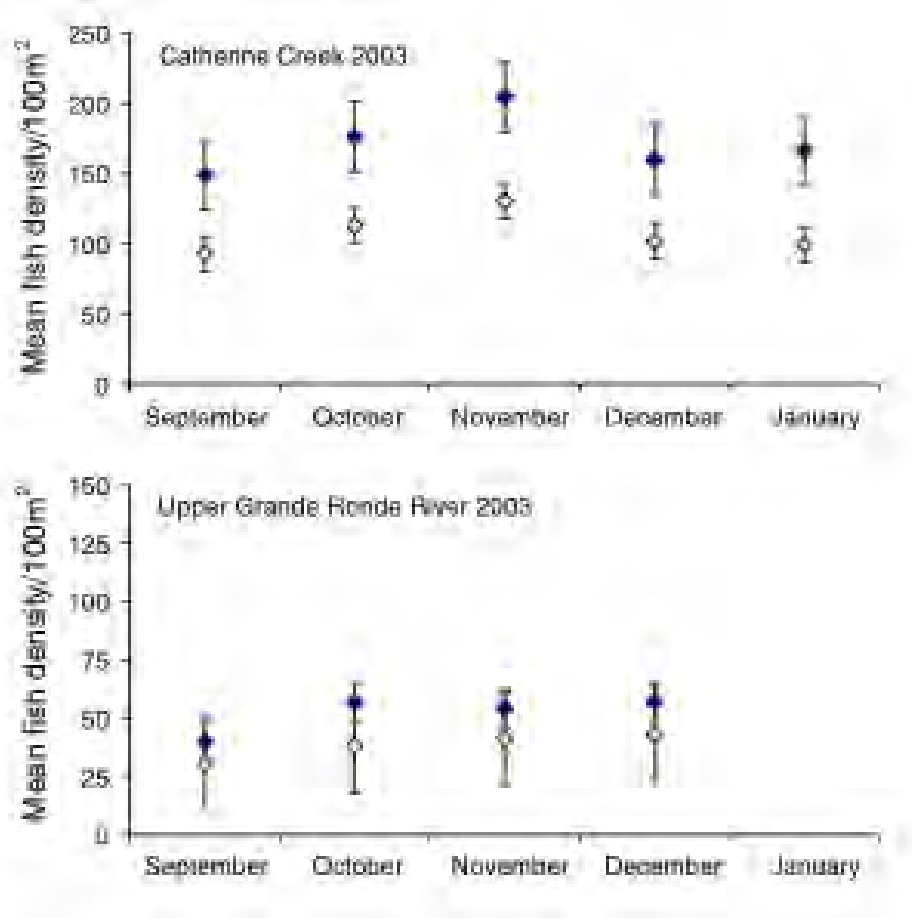
- At night, both Chinook and steelhead move into shallow, quite (<1 cm/s) areas and rest on or in the substrate.
- Both species use areas with fine sediments, bedrock, or coarse substrate.
- Larger fish use deeper (40-90 cm) water than smaller fish (15-60 cm)

# Summer rearing

- Day and Night Habitat Requirements
  - High temps fish hide/seek cover during day
  - Concealment, cover, substrate become even more important
- Changes in habitat requirements with growth.

# Winter Rearing

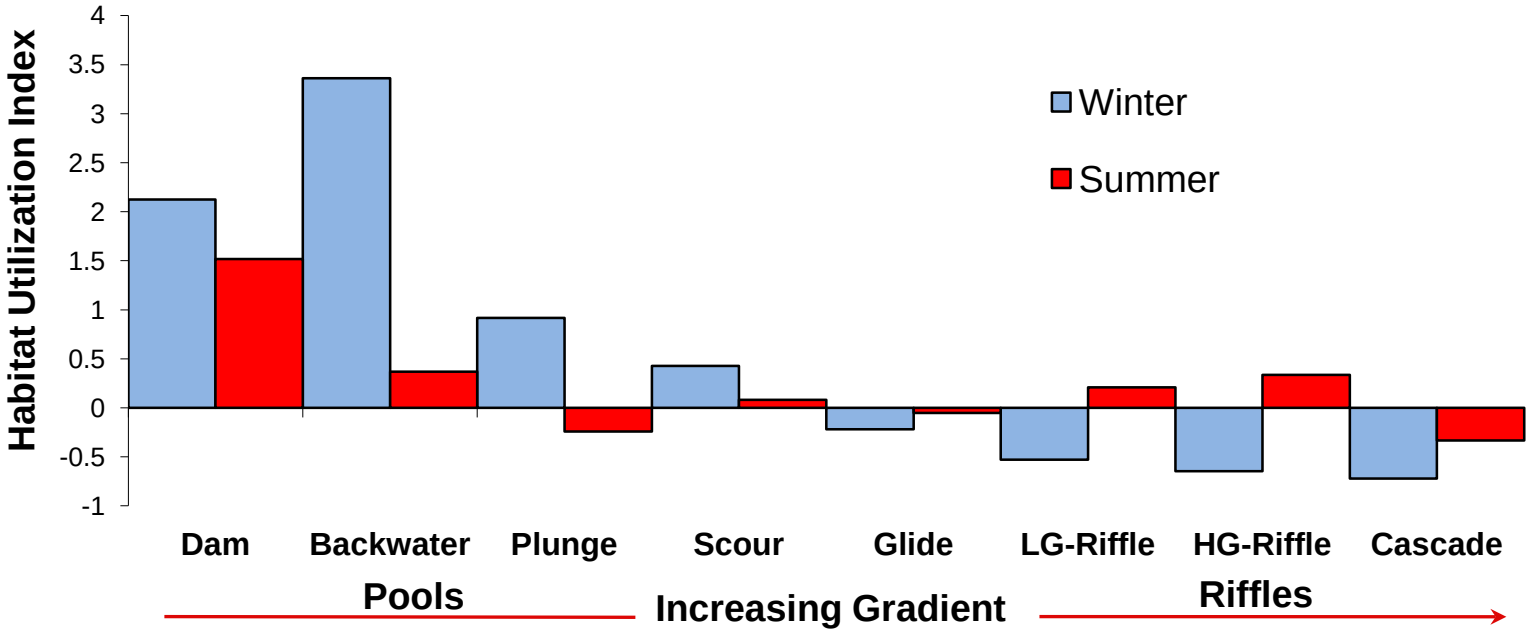
- Chinook
  - slower water
  - side channels/off-chann areas
  - Cobble/concealment habitat
- Steelhead
  - Cover/ concealment habitat
  - Day vs night habitat use




Mean juvenile spring Chinook densities in pools with high (blue diamonds) and low (open diamonds) winter concealment habitat scores. Source Van Dyke et al. 2009 (Grande Ronde River)

# Winter Rearing – Steelhead 1+

preferences change with season




Source Roni 2003 – data from 28 streams in Washington and Oregon

# Chinook and Steelhead Winter Parr Habitat Selection

**Daytime Habitat**

- During periods when temperatures are less than 10°C, both Chinook and steelhead parr remain concealed in cover (woody debris or coarse substrate).

**Nighttime Habitat**

- Both species emerge from cover at night and reside near the stream bed over sand, bedrock, or boulders in depths that range from 50-200 cm.
- Both species use velocities less than 2 cm/s at night.

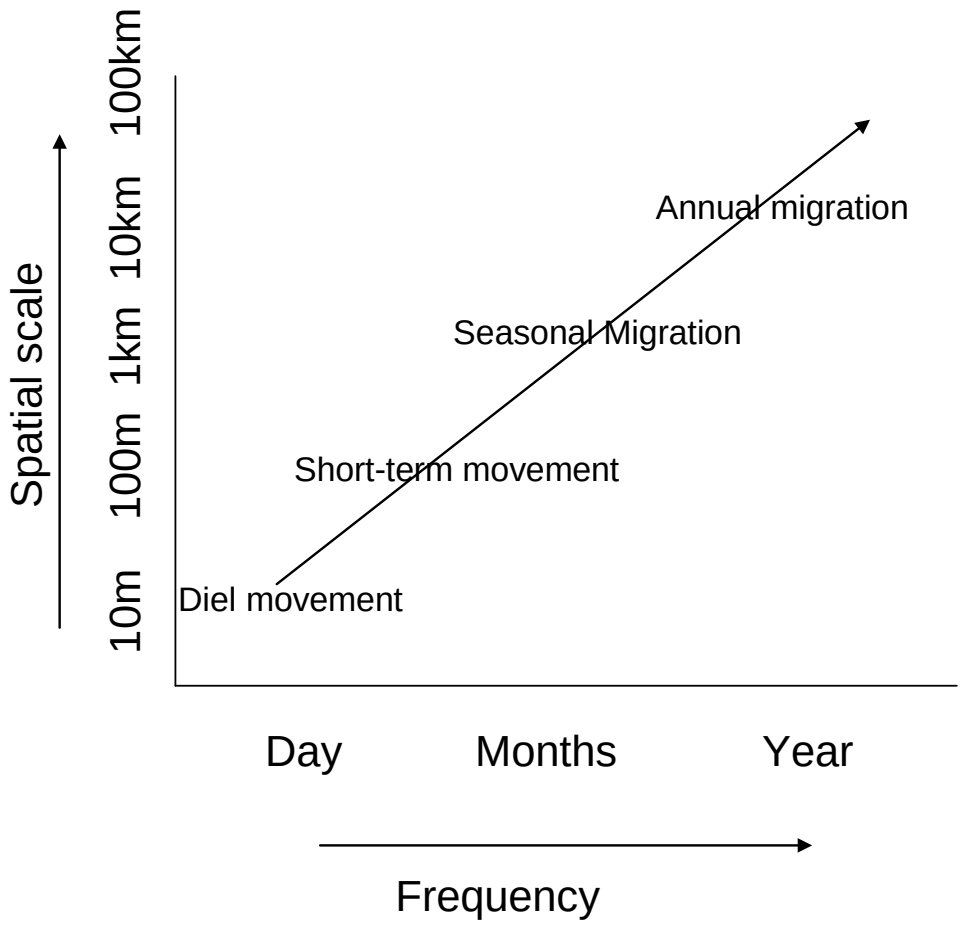
# Summer & Winter Rearing

- What it means to restoration
  - Restoration that improves/maintains
    - Temperature
    - Pools
    - Cover
    - Substrate size/embeddedness
    - Cool water refuge areas (off-channel or ground water)



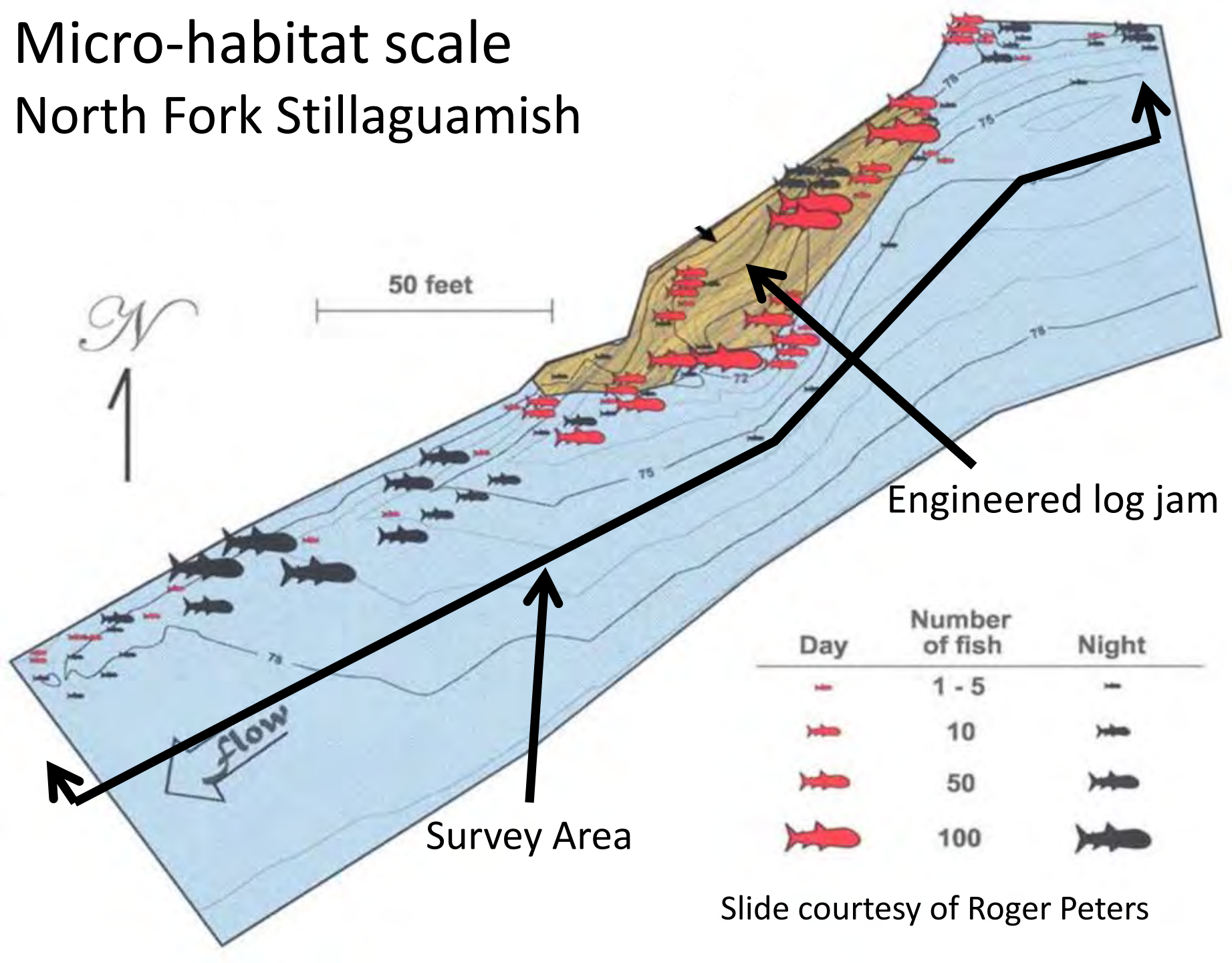
# Movement & Migration

- Important to consider movement and migration
  - Within reach
    - Often limited in summer and winter
  - Among reaches and habitat
    - Often large seasonal movements fall and spring



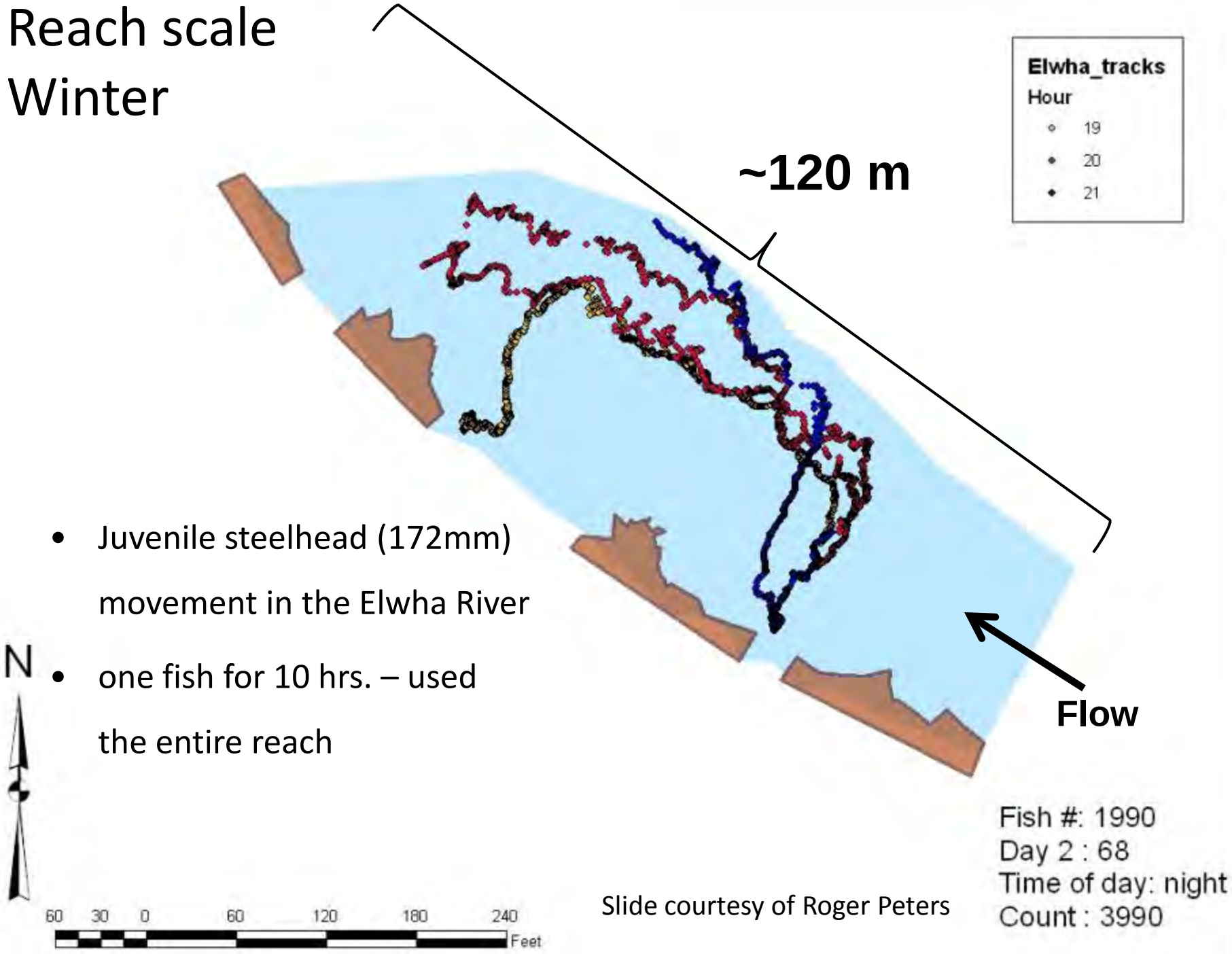
# Micro-habitat scale

## North Fork Stillaguamish




Slide courtesy of Roger Peters

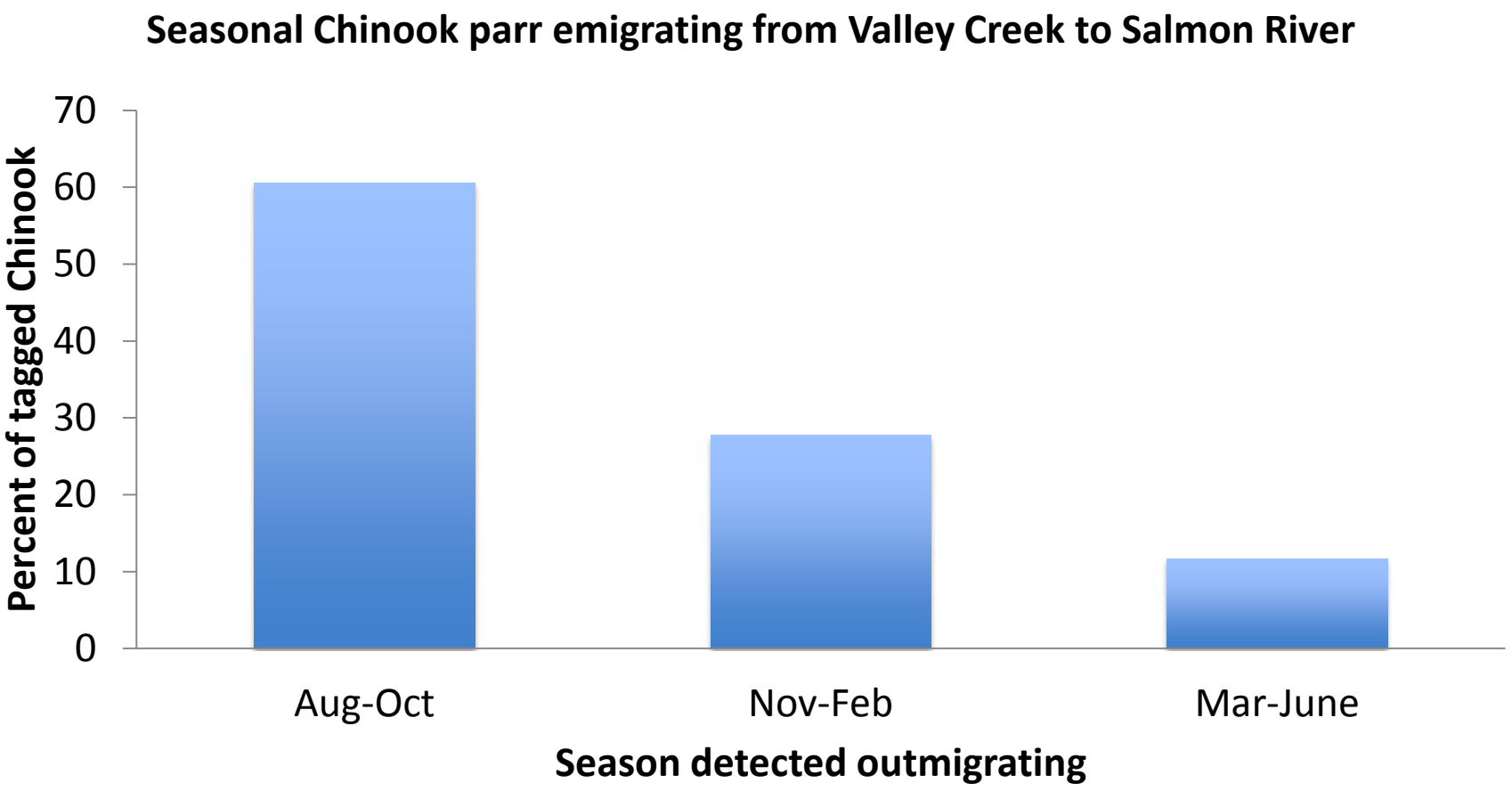
# Reach scale Winter




- Juvenile steelhead (172mm) movement in the Elwha River
- one fish for 10 hrs. – used the entire reach

Slide courtesy of Roger Peters

# Watershed Scale Movement

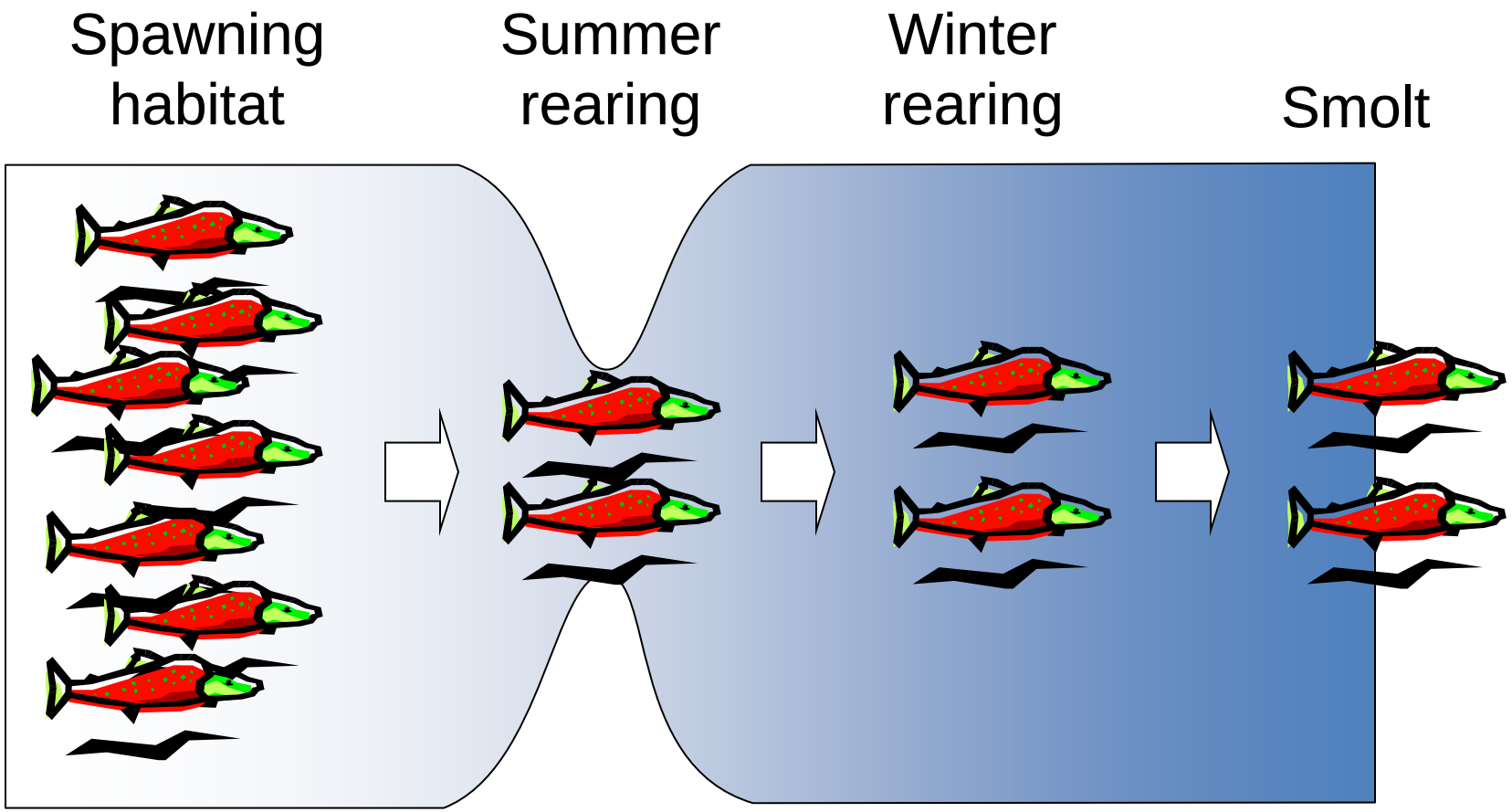



Source: Achord et al. 2012

# Smolt Migration

- Adequate Flow
- Suitable Temperature
- No barriers/diversions
- Predators

# Limiting Factors



# What is limiting factors analysis?

- Compares the relative carrying capacity of different habitat types in a freshwater system.
- Identifies “possible factors limiting production” in freshwater
- Valid across specific spatial scales such as the sub-basin and watershed.

# What is limiting factors analysis?
## Analysis steps

1. Classify habitat types

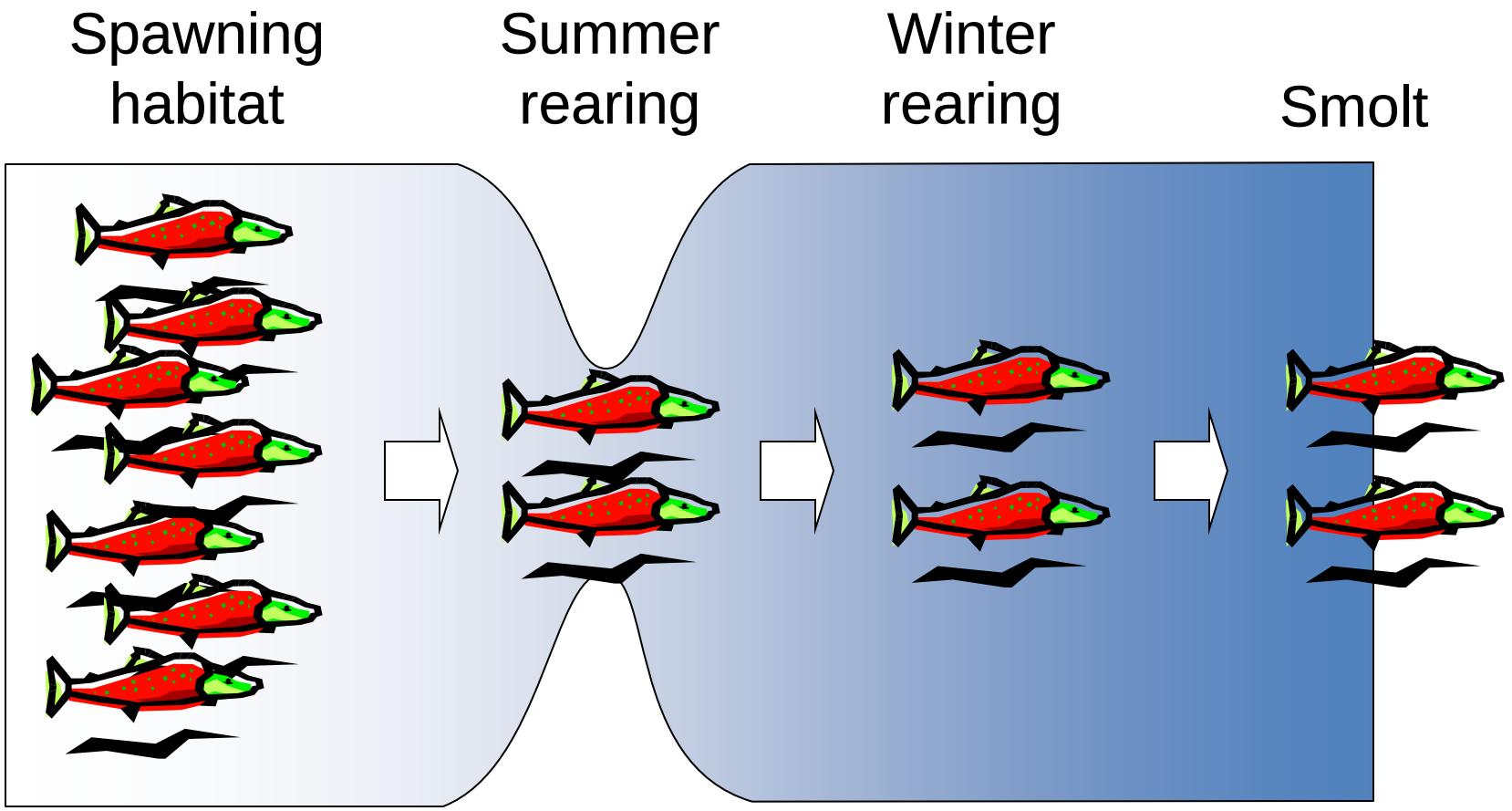
2. Identify fish use by habitat type

3. Devise methods of estimating change for each habitat type
   - Disconnected, lost, degraded, or restored habitats

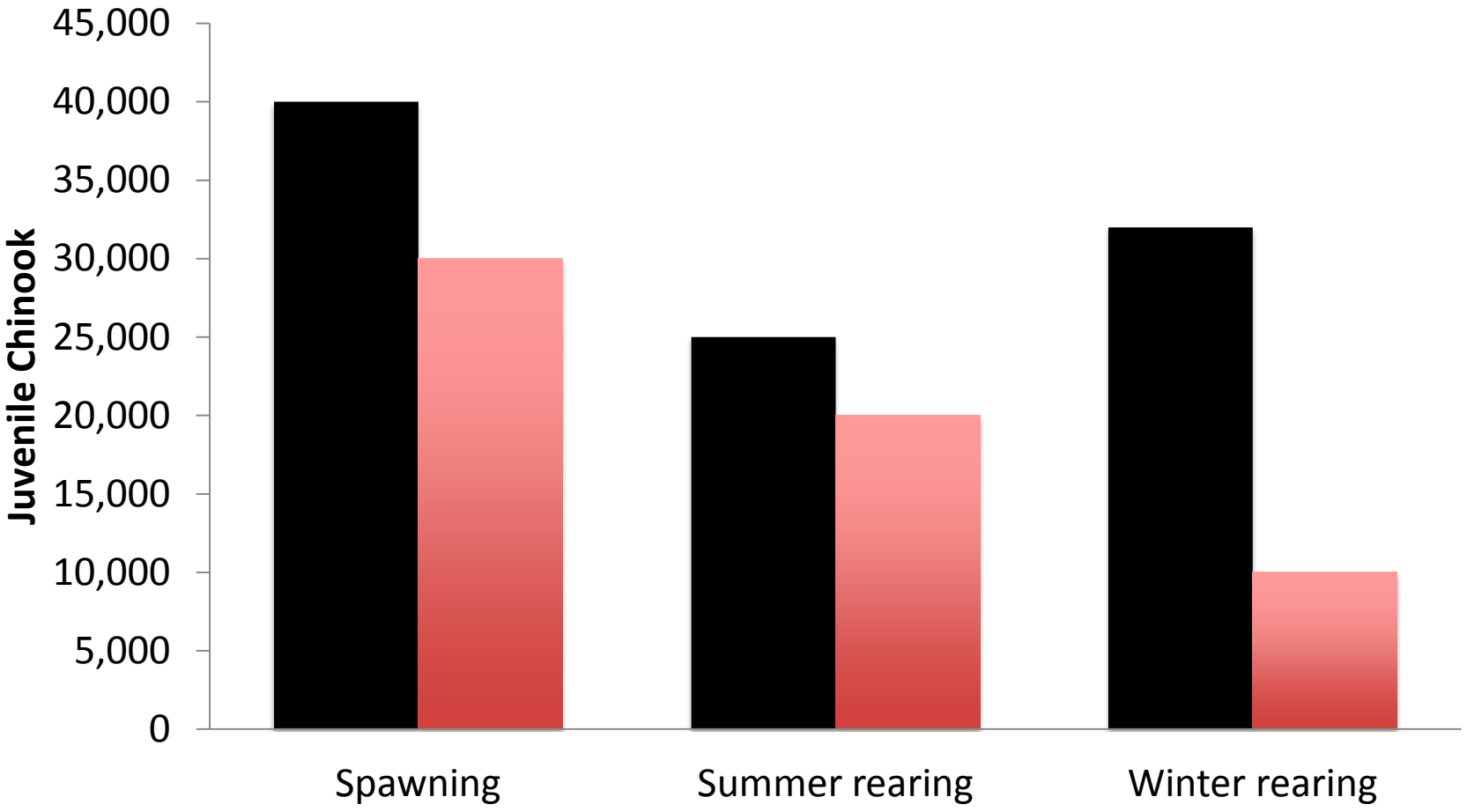
4. Assess habitat change – historic v. current, current v. restored

5. Estimate relative effects of each loss on production

# Habitats or habitat quality associated with a specific life stage or season may limit potential



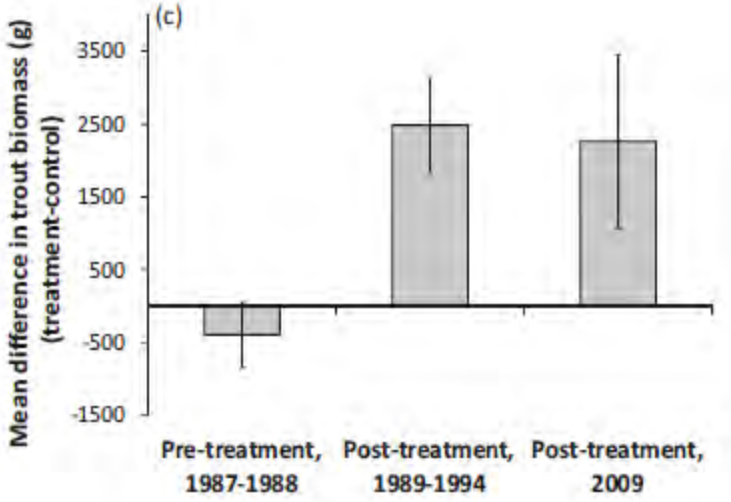
# What Habitat is Limiting?

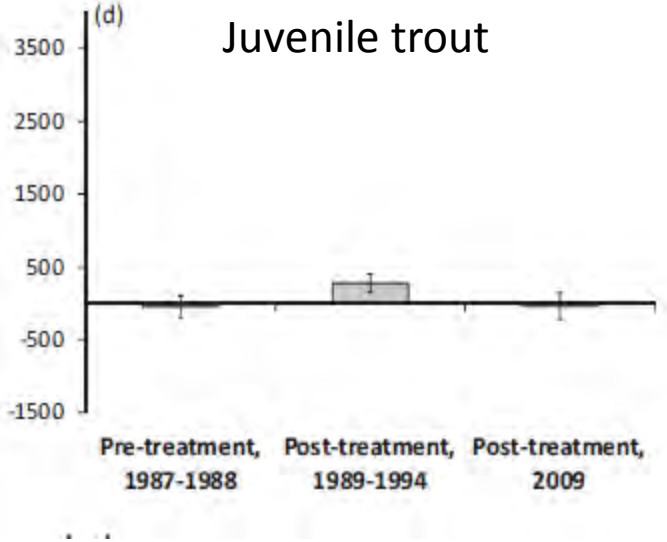


# Target the right life stage & focus on limiting factors

- Trout populations 20 years after wood placement
  - Adult trout abundance
    - increased rapidly after structures were installed
    - remained 53% higher in treatment sections 21 years later.
  - Juvenile trout abundance
    - No change detected
    - Fry recruitment is strongly influenced by effects of annual snowmelt runoff.

Adult trout

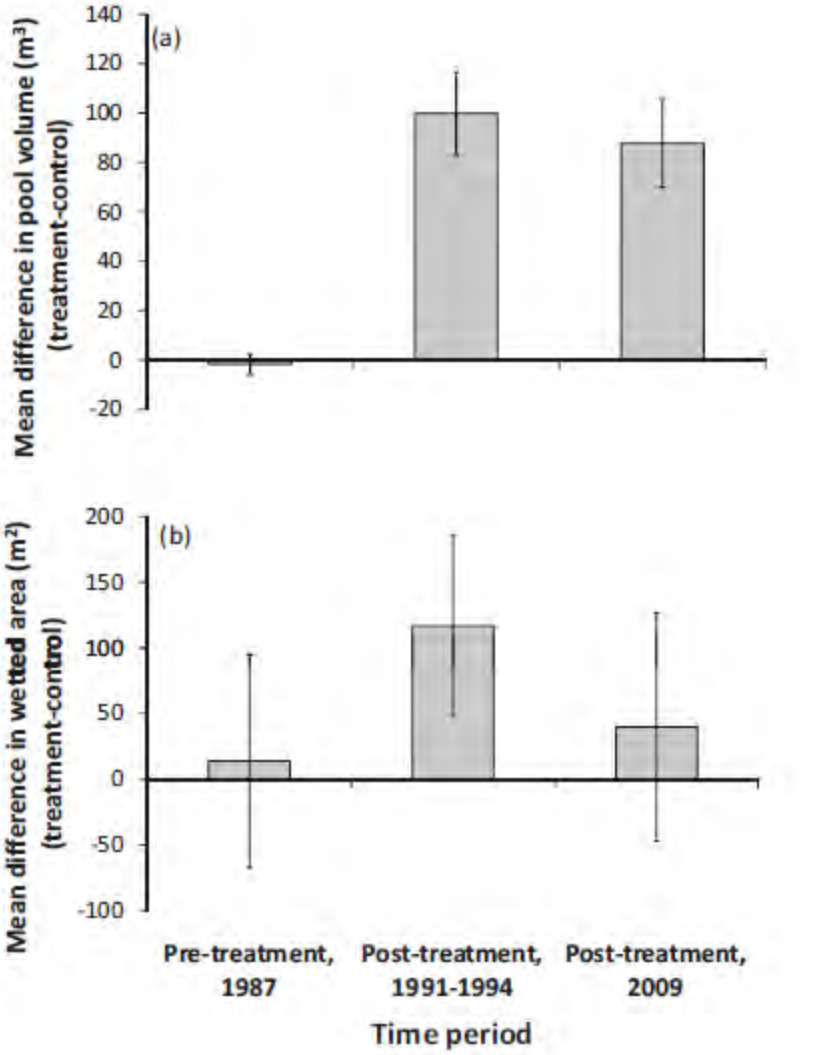



White et al. 2011

# Target the right life stage & focus on limiting factors

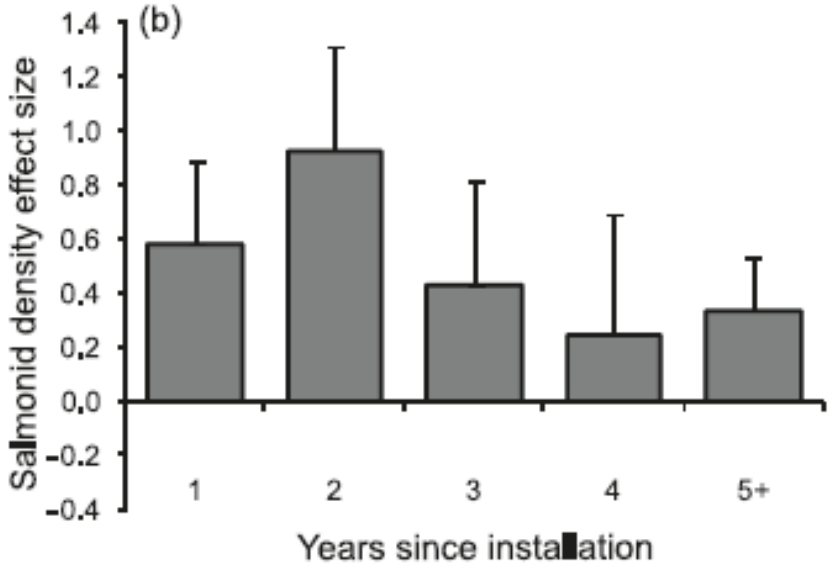
- Trout populations 20 years after wood placement
  - The increase in pool volume & wetted area has maintained over time.




White et al. 2011, Roni et al. 2002

# Discuss the longevity of restoration over time, what does it mean to the resource?

- Structures & fish abundance meta-analysis
  - Salmonid densities decrease after two years.
  - However, most studies do not go beyond 1 year monitoring.




Whiteway et al. 2010

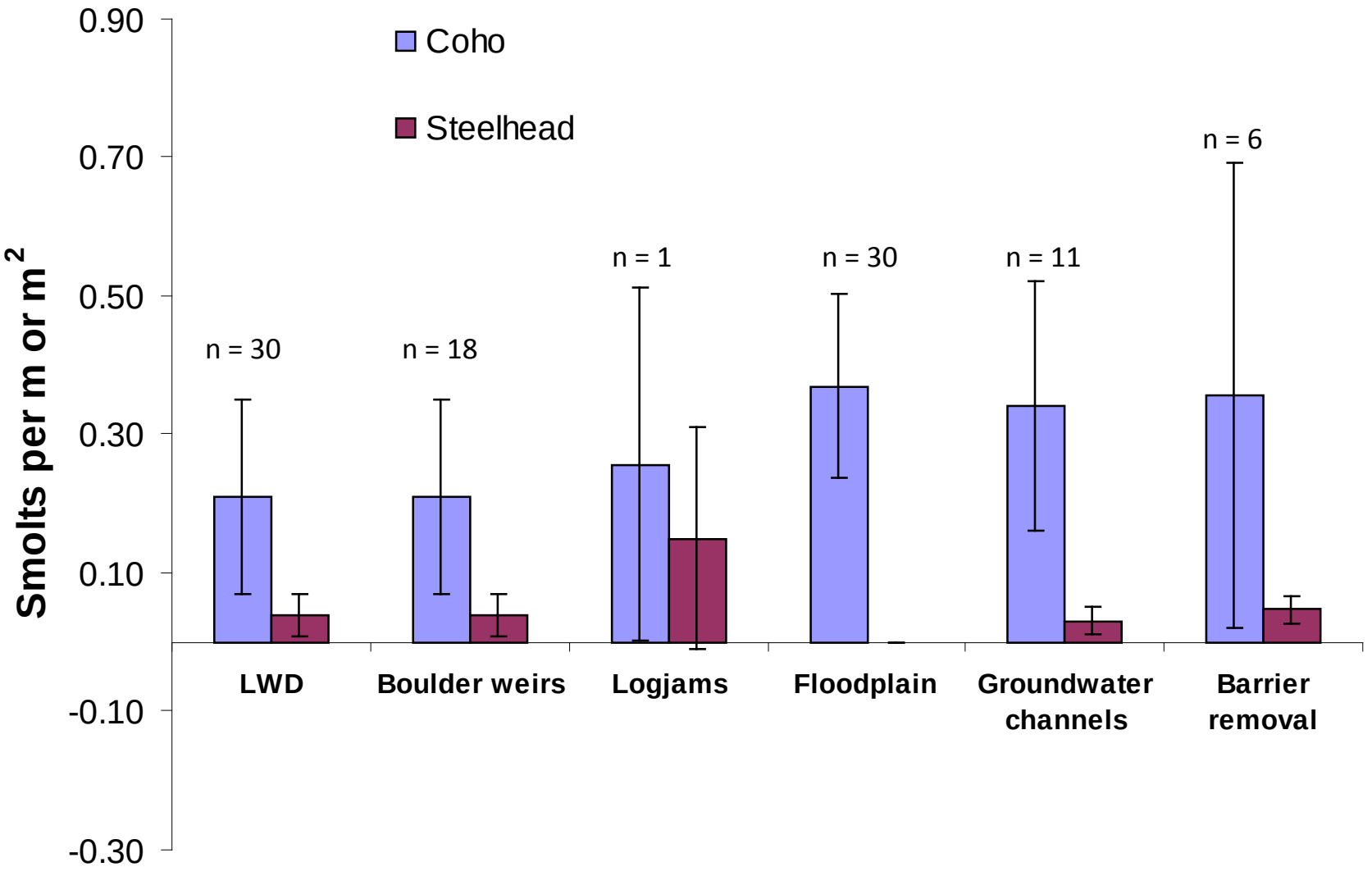
# Estimating Habitat Benefits

# Develop scenarios to compare current v. restored

| Salmon Habitat | Restoration type |
|---|---|
| Streams/Rivers | |
| small – accessible | Wood placement |
| small - inaccessible | Barrier removal |
| medium | Boulder weir placements |
| large | Logjam construction |
| | |
| Floodplain habitat | |
| lost side channels | Develop groundwater channels |
| lost sloughs | Floodplain reconnection |

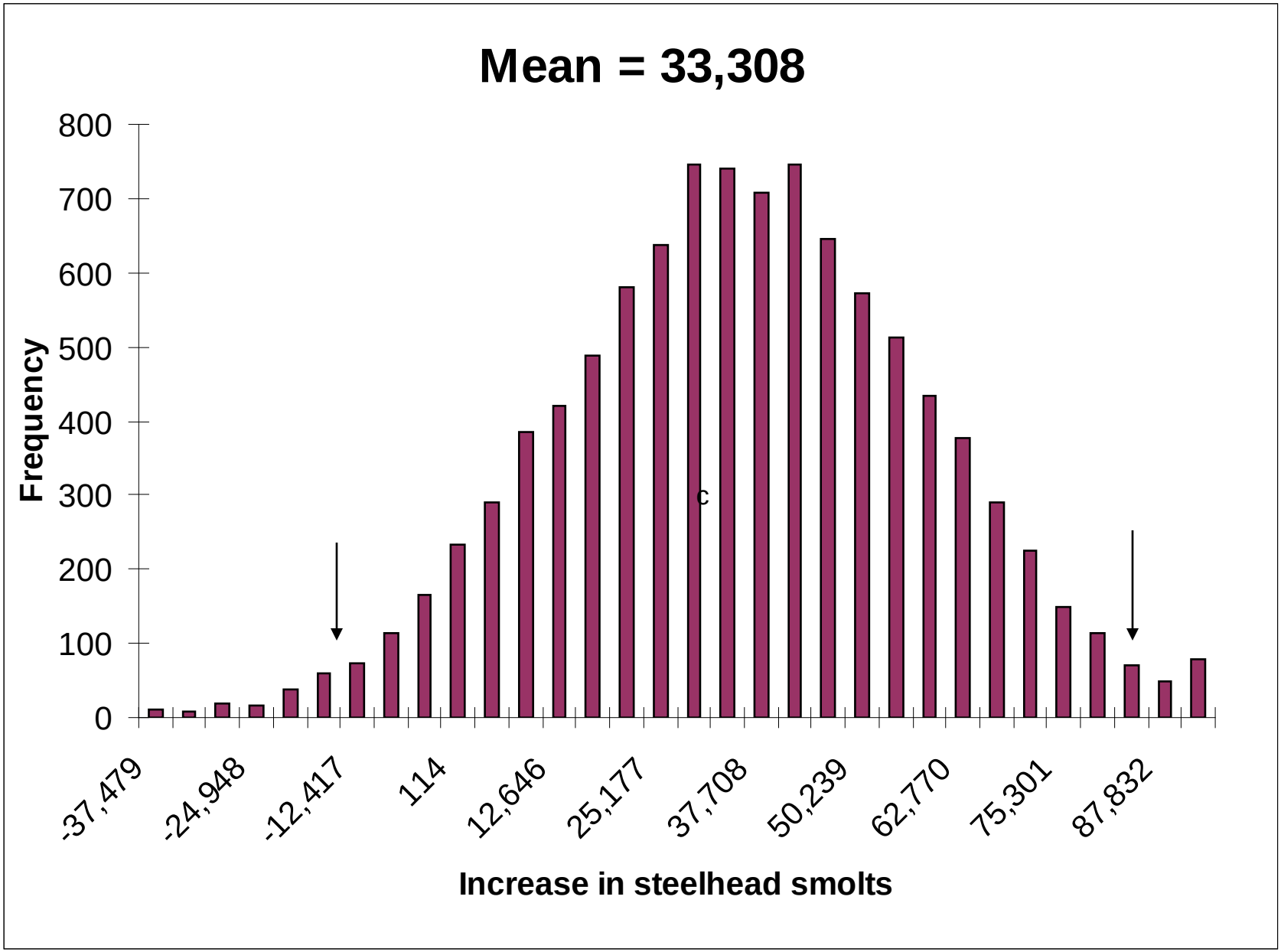
*Small = <15m bfw, medium = <25m bfw, large = >25m bfw

# Mean increase in smolts due to restoration actions

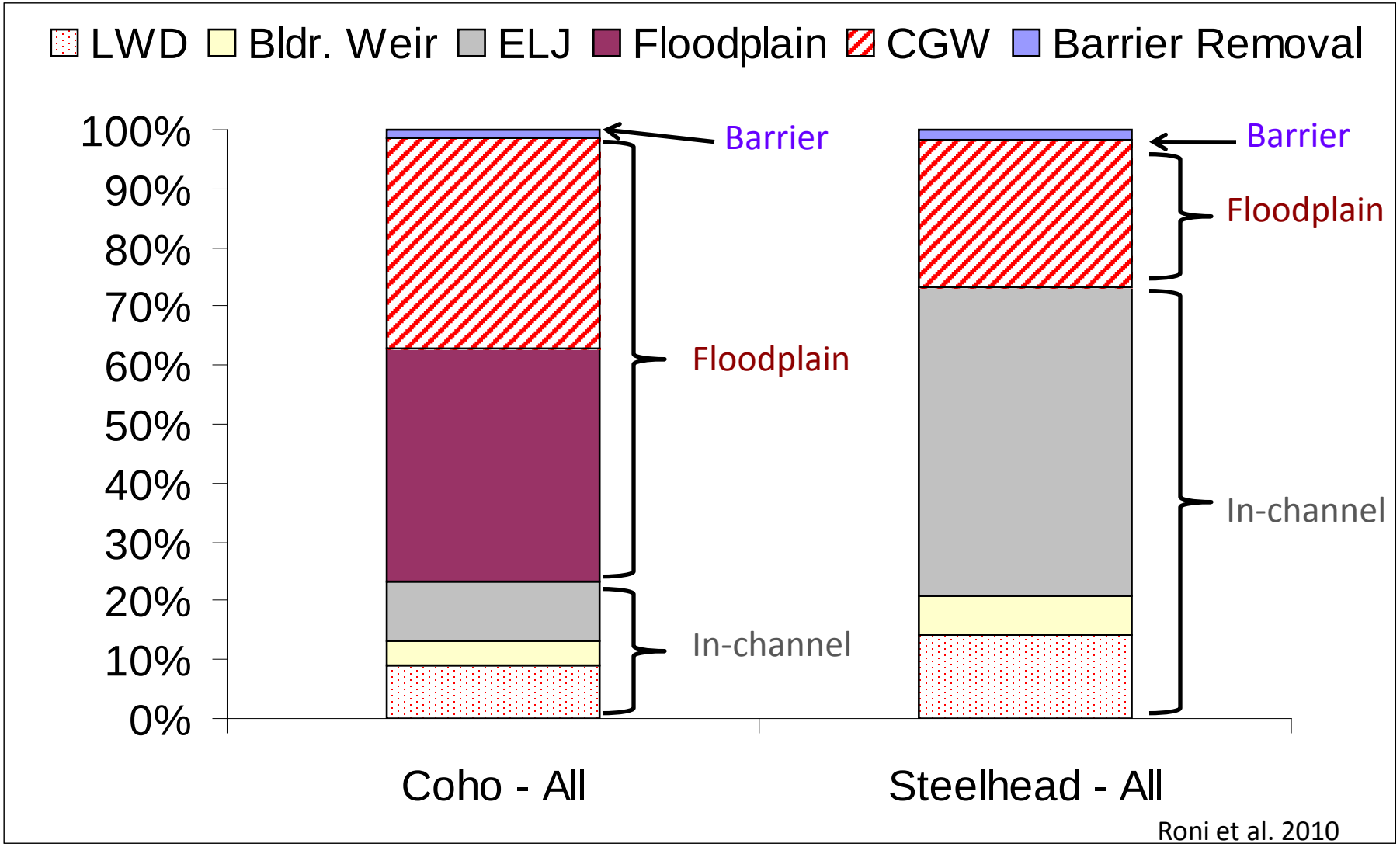



Roni et al. 2010

# Increase in Steelhead Smolts



# Compare virtual “increase by restoration action” to assess relative change in habitat capacity & fish use

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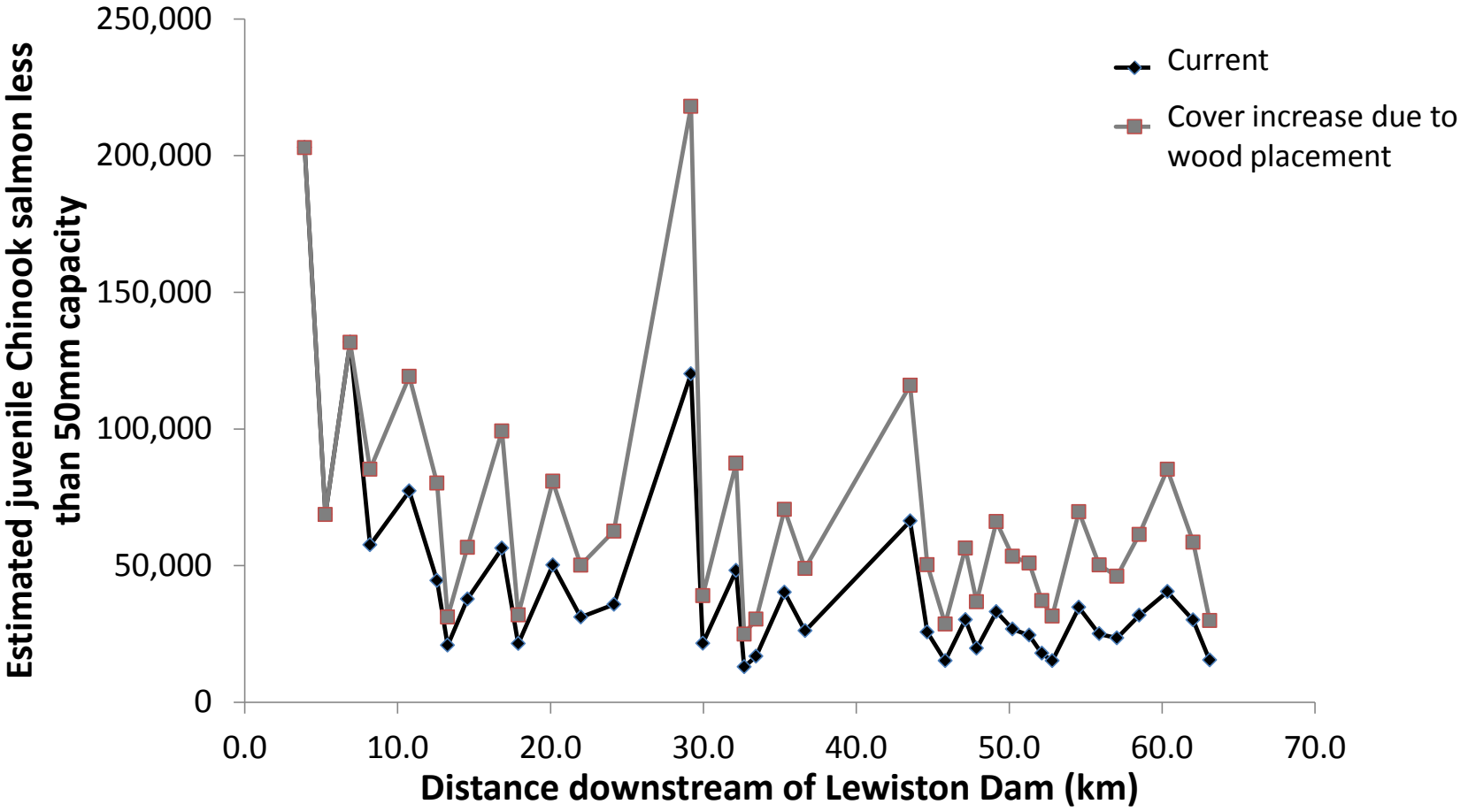
# Compare virtual “before v. after” to assess relative change in habitat capacity & fish use by a one or several restoration actions




Beechie et al. in press

# Conclusions & Key Points

- Important to understand habitat requirements when planning restoration
- Different restoration actions will address different habitat requirements
- Target the right life stage and focus on limiting factors
- However, fish use whole watershed and restoration/improvement needs to address this and restore watershed

# Conclusions & Key Points (cont.)

- Document approach for identifying current conditions and improvements due to restoration
- Acknowledge limitations of approach(es) used
- For long-term recovery need to couple
  - short-term habitat improvement with
  - long-term restoration

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