# Risks of Hatchery Programs on Wild Steelhead Populations

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Puget Sound Wild Steelhead Gene Banks
Educational Workshop
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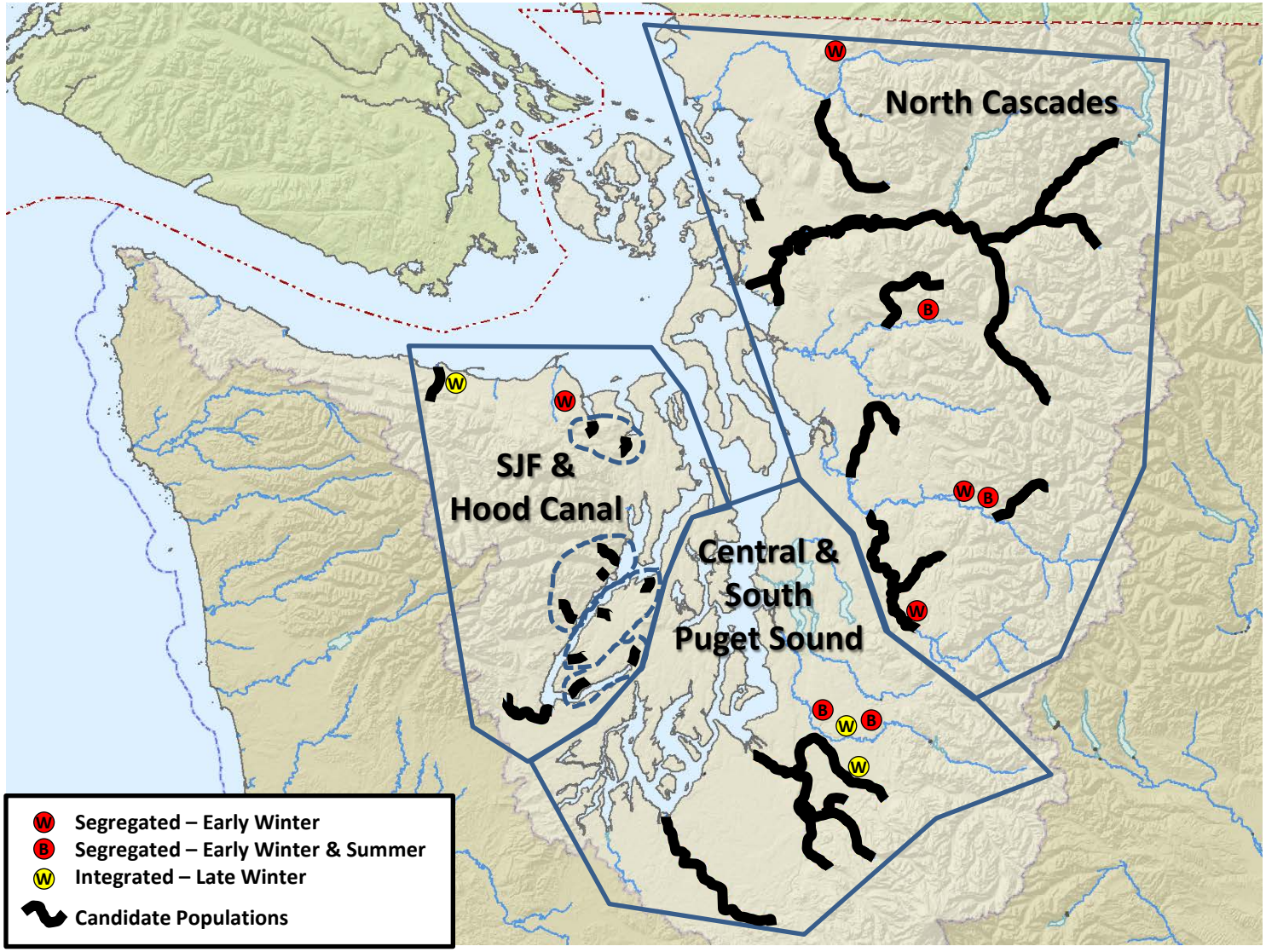
Washington Department of FISH and WILDLIFE

# Agenda

- Hatchery – wild ECOLOGICAL interactions
- Hatchery DOMESTICATION SELECTION
- PEHC and hatchery-wild gene flow
- Genetic DIVERSITY

# Steelhead Major Population Groups, Hatcheries, and Candidate Populations for WGB



# Potential Ecological Interactions
## (Individual Interactions)

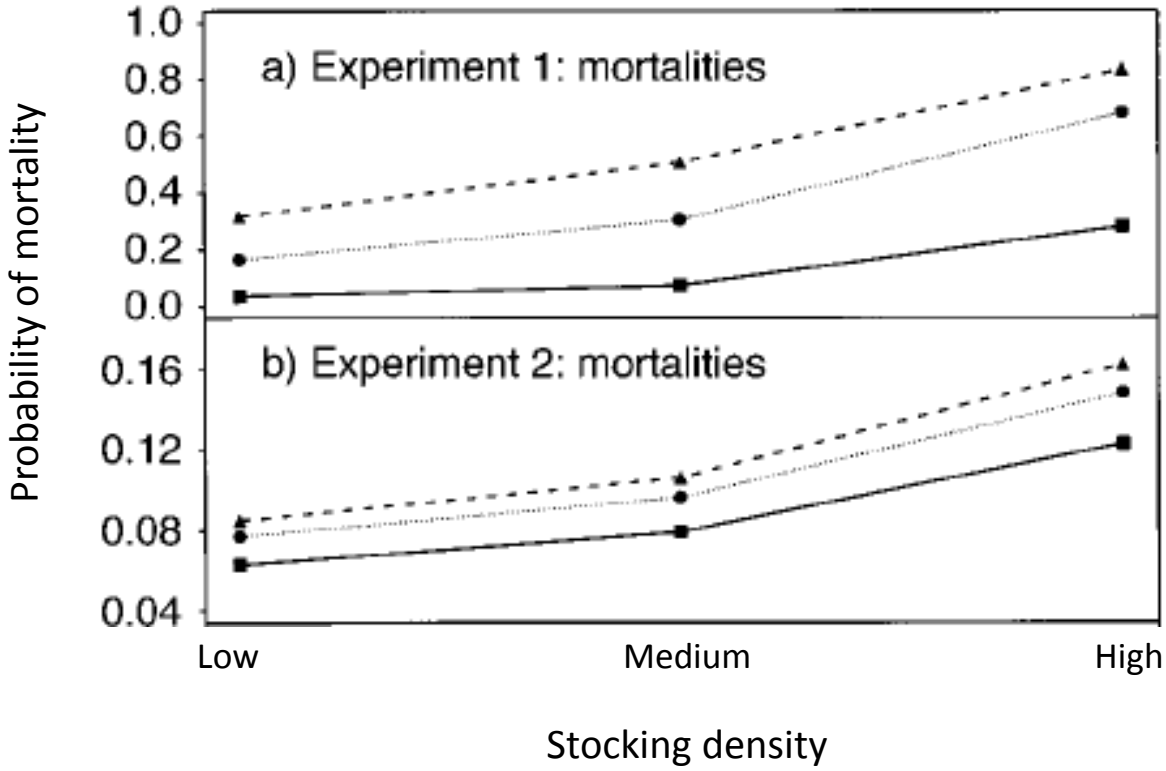
- Competition for food and space
- Predator attraction
- Predator buffering

Hatchery smolts are:

- In the river only ~2-4 weeks
- Any competition for food or space is brief and pulsed
- Unless hatchery fish residualize

# Potential Ecological Interactions
## (Population effects)

- Density dependence and hatchery effects



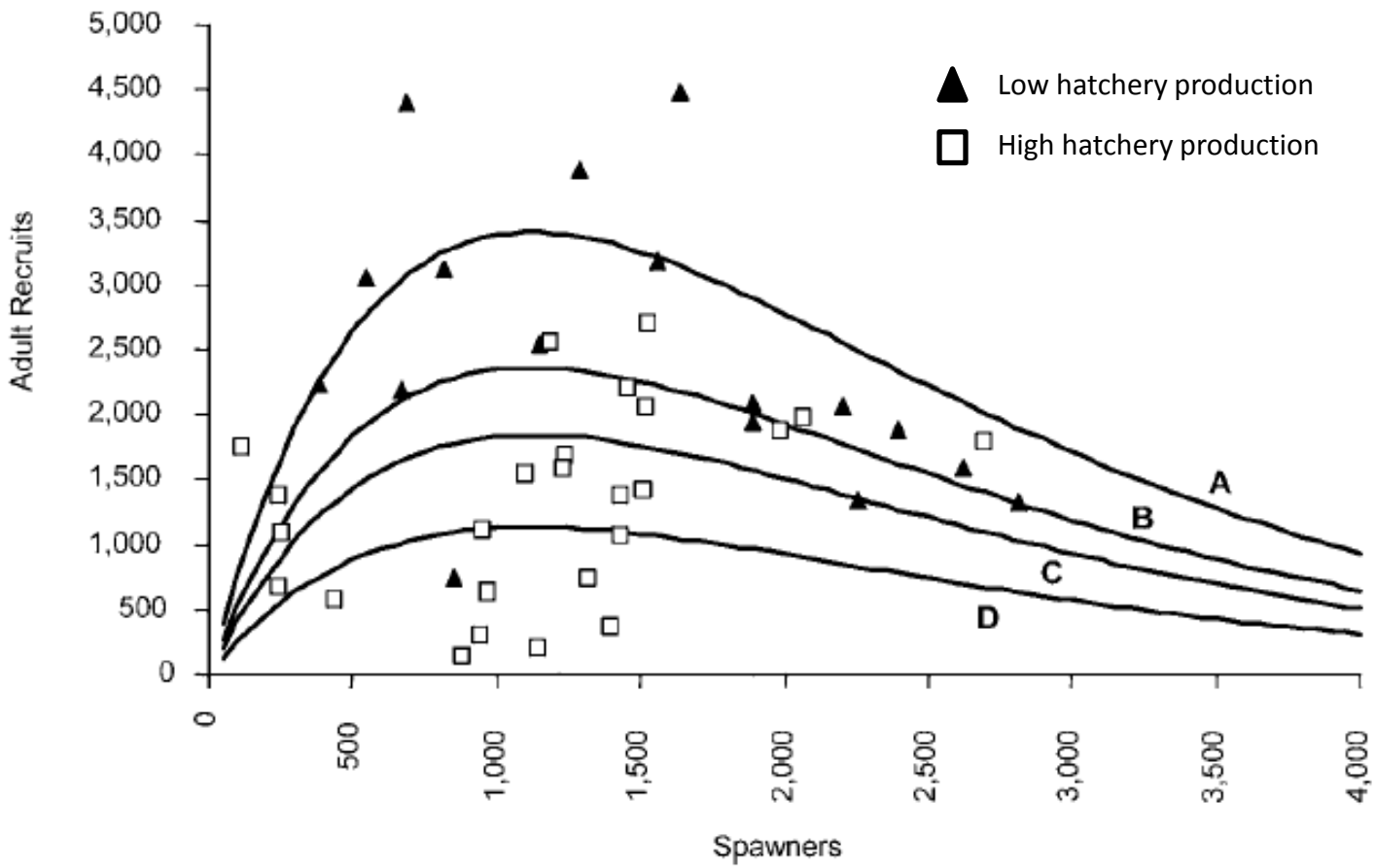

Evidence from experimental streams

Keeley 2000 *Ecology*

# Density dependence in steelhead

## North Fork Clackamas River

Evidence from natural populations




Kostow and Zhou 2006 *TAFS*

# Ecological Interactions Summary

- Potential for ecological direct/indirect interactions
- Low probability of direct predation by migrating hatchery steelhead on juvenile wild steelhead
- Potential competition for food or space during 2-4 week downstream migration or by residualized hatchery steelhead
- Potential for competition for spawning sites, but spawning for segregated hatchery-origin and wild populations are separated in time
- Potential for density dependent effects (e.g., NF Clackamas R).
  - Association between higher number of hatchery releases and lower number of recruits – BUT, *lower overall recruitment may not be caused by the larger size of hatchery release*

# Hatchery Domestication

"Domestication . . . is the cultivating or taming of a population of organisms in order to accentuate traits that are desirable to the cultivator or tamer."

*Wikipedia*

- Early maturation
- Rapid juvenile development
- Early spawn timing – segregated from wild spawning

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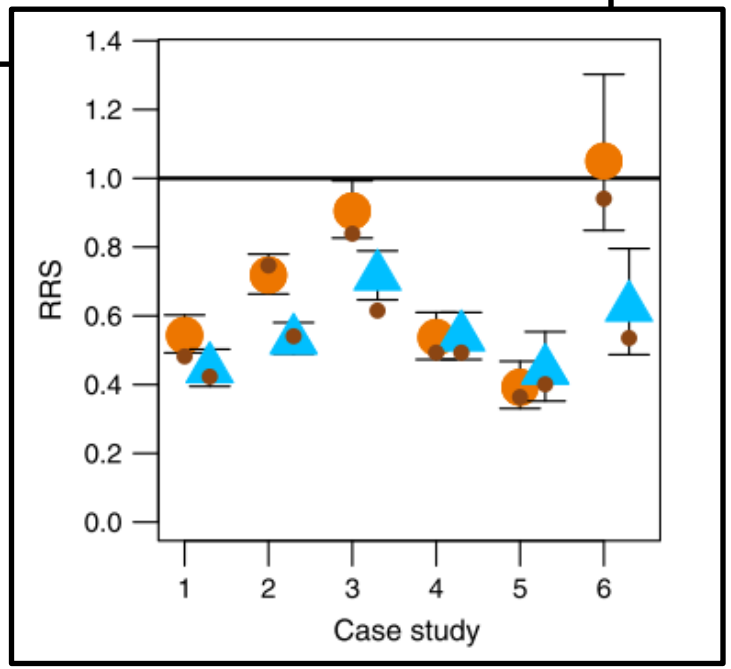
REVIEWS AND SYNTHESIS

# On the reproductive success of early-generation hatchery fish in the wild

Mark R. Christie,[1,2] Michael J. Ford[3] and Michael S. Blouin[1]

"Combining 51 estimates from six studies on four salmon species, we found that (i) early-generation hatchery fish averaged only half the reproductive success of their wild-origin counterparts when spawning in the wild, (ii) the reduction in reproductive success was more severe for males than for females, and (iii) all species showed reduced fitness due to hatchery rearing."

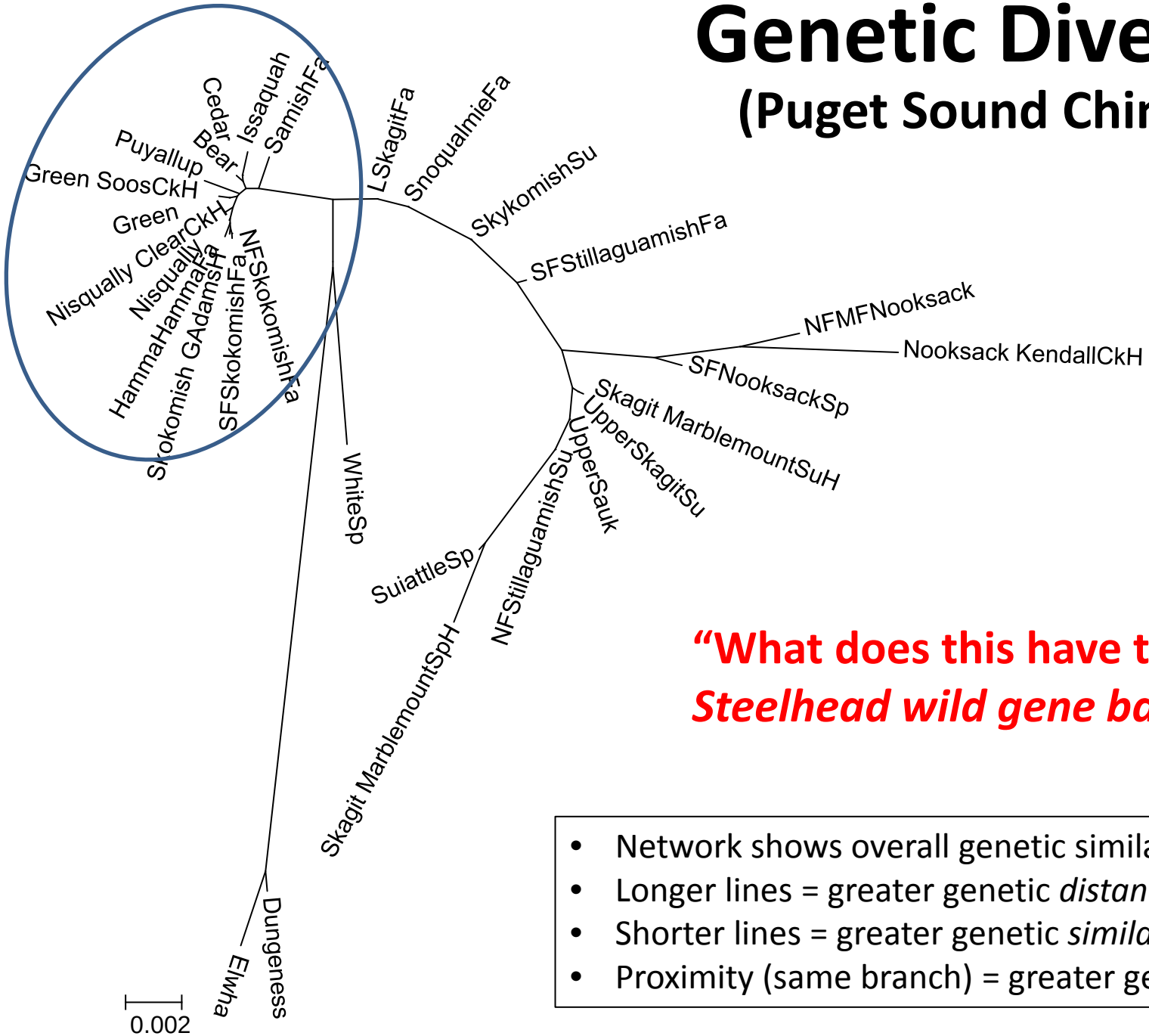
1. Spring Chinook – Wenatchee River
2. Coho – Umpqua River
3. Steelhead – Hood River
4. Atlantic Salmon – Malbaie
5. Steelhead – L. Sheep Creek
6. Spring Chinook – Johnson Creek



# Domestication Summary

- Hatchery environments are different from wild environments
- Compared with wild fish, hatchery-origin fish may be at a selective disadvantage when spawning in the wild – lower fitness
- Wild population productivity may decline if wild and hatchery-origin individuals spawn together, creating “hybrid” offspring of lower fitness
- Most data on salmonid hatchery-wild domestication effects are based on *integrated* hatchery programs
  - If hatchery and wild populations remain separated (*segregated* programs), domestication effects on wild populations may be reduced or avoided
  - Managers need to monitor (directly or indirectly) spawning ground interactions between hatchery-origin and wild fish: estimate *gene flow*

# Genetic Diversity
## (Puget Sound Chinook)




**"What does this have to do with *Steelhead wild gene banks?*"**

- Network shows overall genetic similarity
- Longer lines = greater genetic *distance*
- Shorter lines = greater genetic *similarity*
- Proximity (same branch) = greater genetic similarity

# Genetic Diversity

- **"What does this have to do with *Steelhead wild gene banks?*"**
  - Hatchery programs can have a genetic homogenizing effect, reducing among population genetic diversity.
  - Expected when a single hatchery stock is widely propagated and programs are integrated (e.g., Soos Creek Fall Chinook)
  - For steelhead EWH segregated programs, homogenizing effect is related to *gene flow*
    - Greater gene flow higher chance for homogenizing
    - Lower gene flow lower chance for homogenizing

# PEHC and Gene Flow

- Gene flow is the rate at which genes from a hatchery population are incorporated into a wild population.
- Occurs when hatchery fish escape and spawn in wild at same time/space as wild fish

# PEHC and Gene Flow

- Implications: If fitness of hatchery fish spawning in the wild is less than that of wild fish, hatchery-wild introgression can lower fitness of wild fish
- What does that mean?
  - If hatchery fish spawn with wild fish their offspring are less fit than offspring from wild parent
  - Lowers productivity of wild populations

# PEHC and Gene Flow

- How do we measure gene flow?
- **P**roportion **E**ffective **H**atchery **C**ontribution = PEHC
- PEHC = The proportion of the parental population that is of hatchery-origin

# PEHC and Gene Flow

$$PEHC = \frac{\left(2 \times HH\right) + HW}{2}$$

**Determined genetically:**

$HH$ = proportion of pop with two hatchery-origin parents

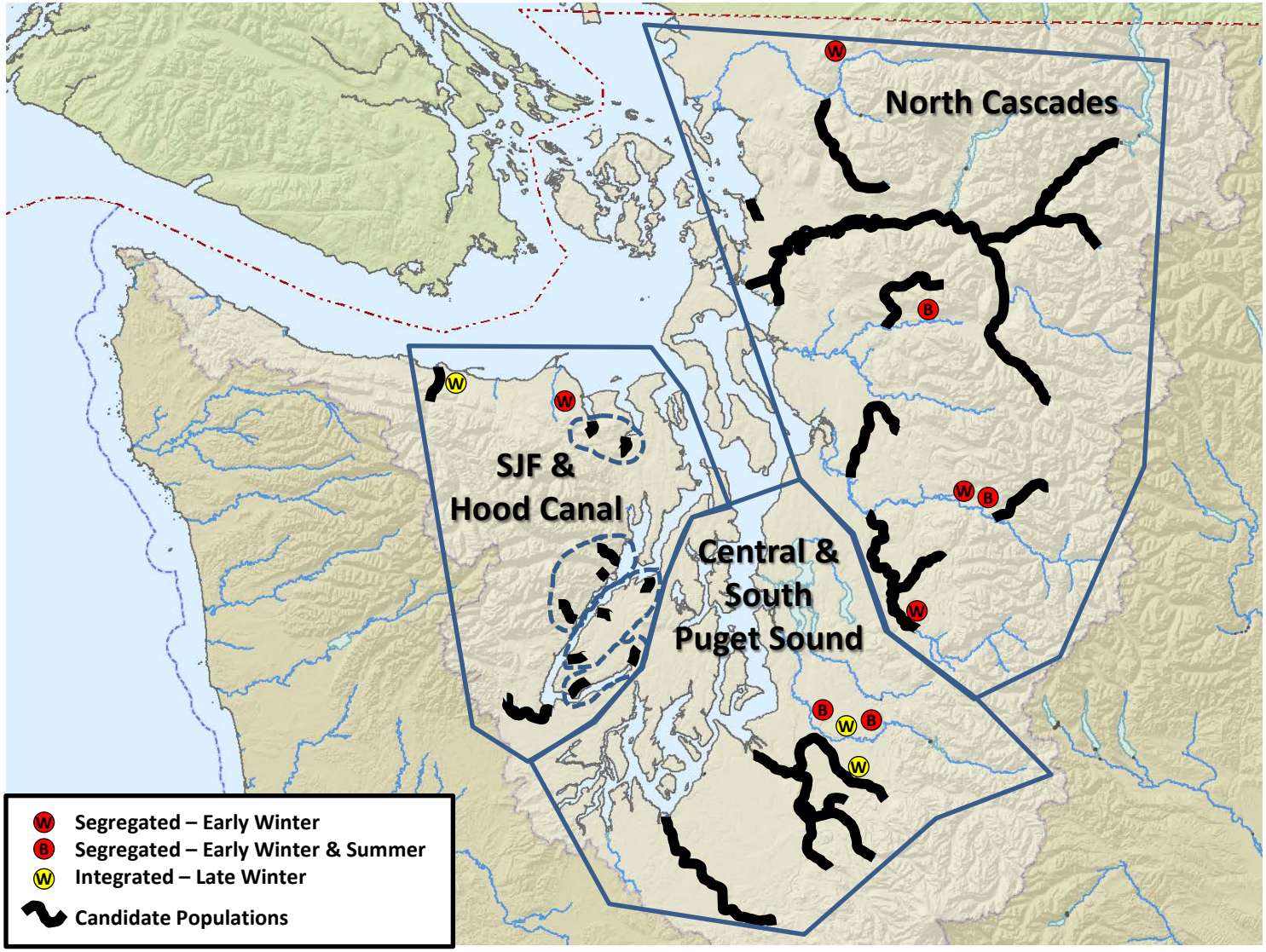
$HW$ = proportion of pop with one hatchery origin parent (a hybrid)

| MPG | Population | Run Type | PEHC Winter | PEHC Summer | PEHC Total | Ranking |
|---|---|---|---|---|---|---|
| North Cascades | South Fork Nooksack | Summer | 0% | 0% | 0% | **Preferred** |
| North Cascades | Samish | Winter | 6% | 0% | 6% | Adequate |
| North Cascades | Sauk | Summer & Winter | 4% | 0% | 4% | Adequate |
| North Cascades | Skagit | Summer & Winter | 2% | 1% | 3% | **Preferred** |
| North Cascades | Deer Creek | Summer | 0% | 2% | 2% | **Preferred** |
| North Cascades | Pilchuck | Winter | 1% | 3% | 4% | Adequate |
| North Cascades | NF Skykomish | Summer | 1% | 95% | 96% | *Poor* |
| North Cascades | Snoqualmie | Winter | 4% | 3% | 7% | *Poor* |
| North Cascades | Tolt | Summer | 1% | 69% | 70% | *Poor* |
| C & S Puget Sound | White | Winter | 1/ | 1/ | 1/ | Adequate |
| C & S Puget Sound | Puyallup/Carbon | Winter | 1/ | 1/ | 1/ | Adequate |
| C & S Puget Sound | Nisqually | Winter | 1/ | 1/ | 1/ | Adequate |
| Hood Canal & SJF | Skokomish | Winter | 1/ | 1/ | 1/ | Adequate |
| Hood Canal & SJF | East Hood Canal | Winter | 1/ | 1/ | 1/ | Adequate |
| Hood Canal & SJF | West Hood Canal | Winter | 1/ | 1/ | 1/ | Adequate |
| Hood Canal & SJF | South Hood Canal | Winter | 1/ | 1/ | 1/ | Adequate |
| Hood Canal & SJF | Sequim/Discovery Bay | Winter | 1/ | 1/ | 1/ | Adequate |
| Hood Canal & SJF | SJF Independent Tribs | Winter | 1/ | 1/ | 1/ | Adequate |
| Hood Canal & SJF | Elwha | Winter | 2/ | 2/ | 2/ | Adequate |

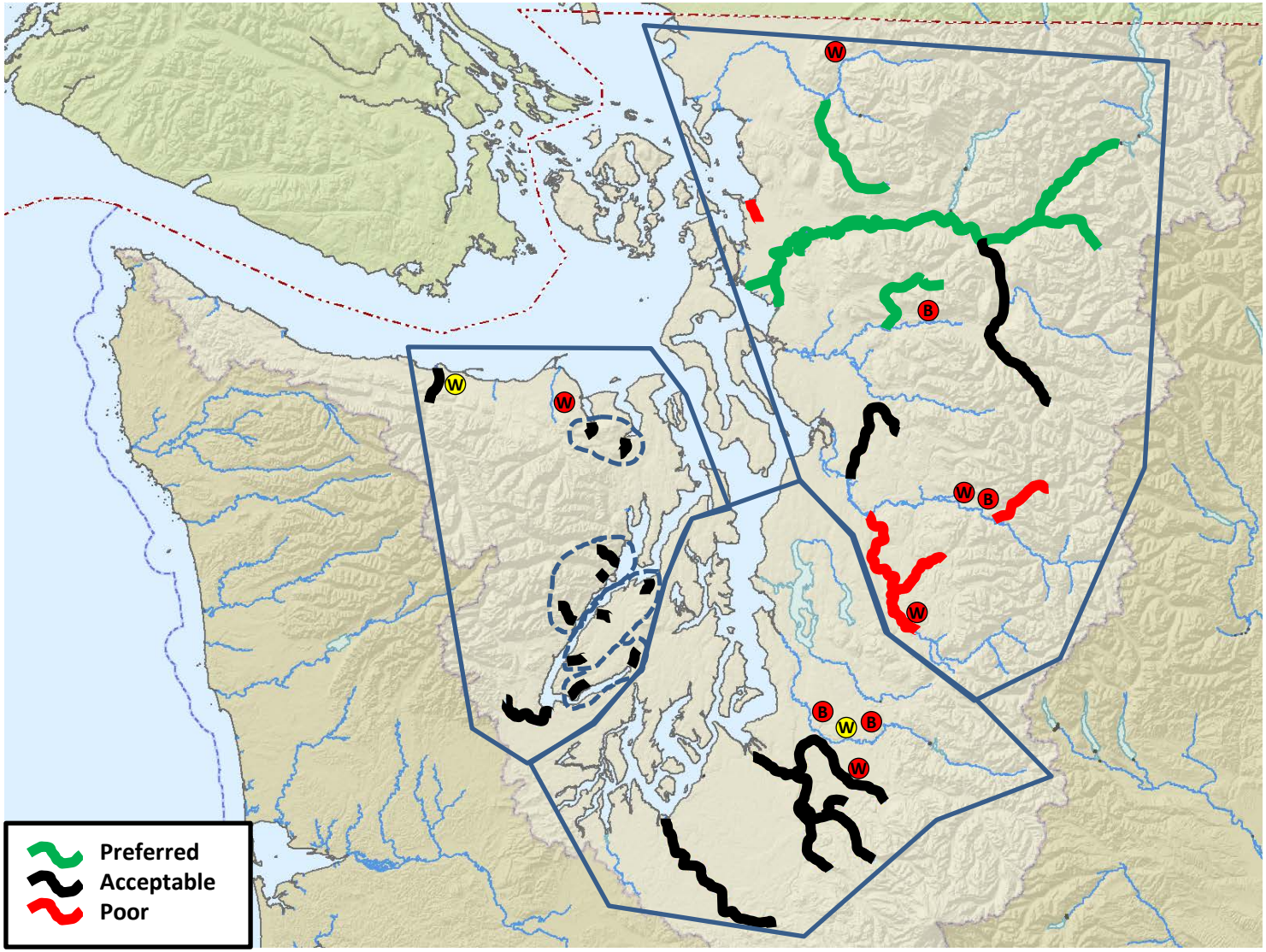
1/ No PEHC estimates available. No releases of EWH in more than 10 years

2/ No PEHC estimates available. EWH and wild populations remain genetically distinct (Winans et al. 2008, Van Doornick and Berejikian 2015)

# Steelhead Major Population Groups, Hatcheries, and Candidate Populations for WGB



# PEHC (Gene Flow) Rankings



# Overall Summary

- Ecology: Potential for ecological interactions between hatchery and wild populations

- Domestication: Hatchery & wild environments differ; compared with wild fish hatchery-origin fish may have lower fitness when spawning in the wild.
  - Yes in integrated programs; no data for segregated hatchery programs
  - Population productivity may decline when "hybrid" individuals of lower fitness are produced. More gene flow, lower productivity

- Genetic diversity: Hatchery to wild gene flow may produce a decline in among-population genetic diversity

- Gene flow: hatchery-wild gene flow can be monitored using PEHC
  - Steelhead population in Puget Sound vary in PEHC and therefore vary in their potential for being a *wild gene bank*

- Overall genetic effects: Tied to gene flow
  - More gene flow = greater effects
  - Less gene flow= fewer effects