# Genetic and ecological monitoring of early winter steelhead hatchery programs in Puget Sound

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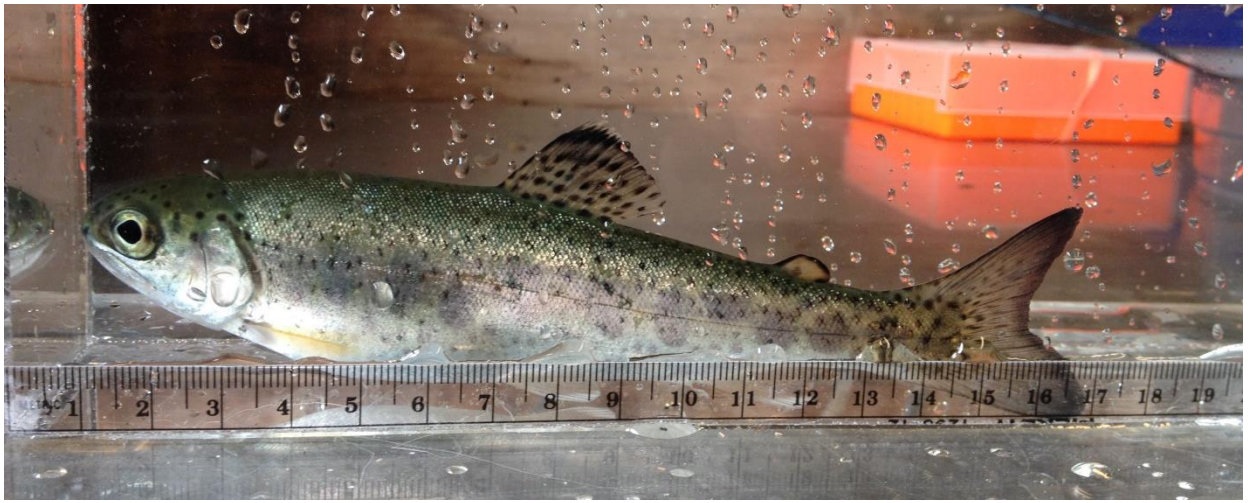

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# Early winter steelhead hatchery programs

- Support recreational and tribal fishing opportunities
- Designed as a segregated program to minimize reproduction with wild steelhead
- Hatchery stock developed from Chambers Creek in southern Puget Sound
- Intentional selection of early maturing fish to advance spawn timing


Photos: Larry Phillips, Tom Quinn

# Genetic and ecological concerns

Evidence that hatchery-origin fish have lower reproductive fitness than natural-origin fish

Araki et al. 2008 *Evol App,* Araki et al. 2009 *Biol Letters*, Christie et al. 2014 *Evo Apps*

Earlier spawn timing of early winter hatchery steelhead may be insufficient to prevent spawning with wild fish

Seamons et al. 2012 *Evol App*

Large hatchery releases may be associated with decreased survival of wild fish via ecological mechanisms

Kostow 2009 *Rev Fish Biol Fisheries*

- Competition for limited food or rearing territories
- Predation on smaller-bodied salmonids
- Attraction of predators

# Policy background and hatchery reform

**Puget Sound steelhead listed as threatened under U.S. Endangered Species Act (2007)**

**Washington Statewide Steelhead Management Plan (2008)**

- Segregated hatchery programs must yield < 2 % gene flow into wild populations

**NOAA Fisheries authorizes Puget Sound early winter steelhead hatchery programs via Biological Opinion (2016)**

- Nooksack, Stillaguamish, Skykomish, Snoqualmie, Dungeness rivers
- Stipulates < 2 % gene flow from hatchery programs into wild populations

**Significant operational changes to hatchery programs in last ten years**

**Strong need for comprehensive monitoring program to evaluate genetic and ecological effects**

# Puget Sound early winter steelhead monitoring

## Program goals

**Genetic**

1. Ensure proportion effective hatchery contribution (PEHC) < 2%
2. Describe factors affecting PEHC
    - PEHC through the steelhead life cycle
    - Hatchery operations

**Ecological**

3. Describe overlap in time and space between smolts released from hatchery and wild fish

# Estimating hatchery-wild introgression

Genetic methods required because direct observations of spawning rare or impossible

- No carcasses
- Winter/spring river conditions: turbid, high flows

Proportion effective hatchery contribution (PEHC)

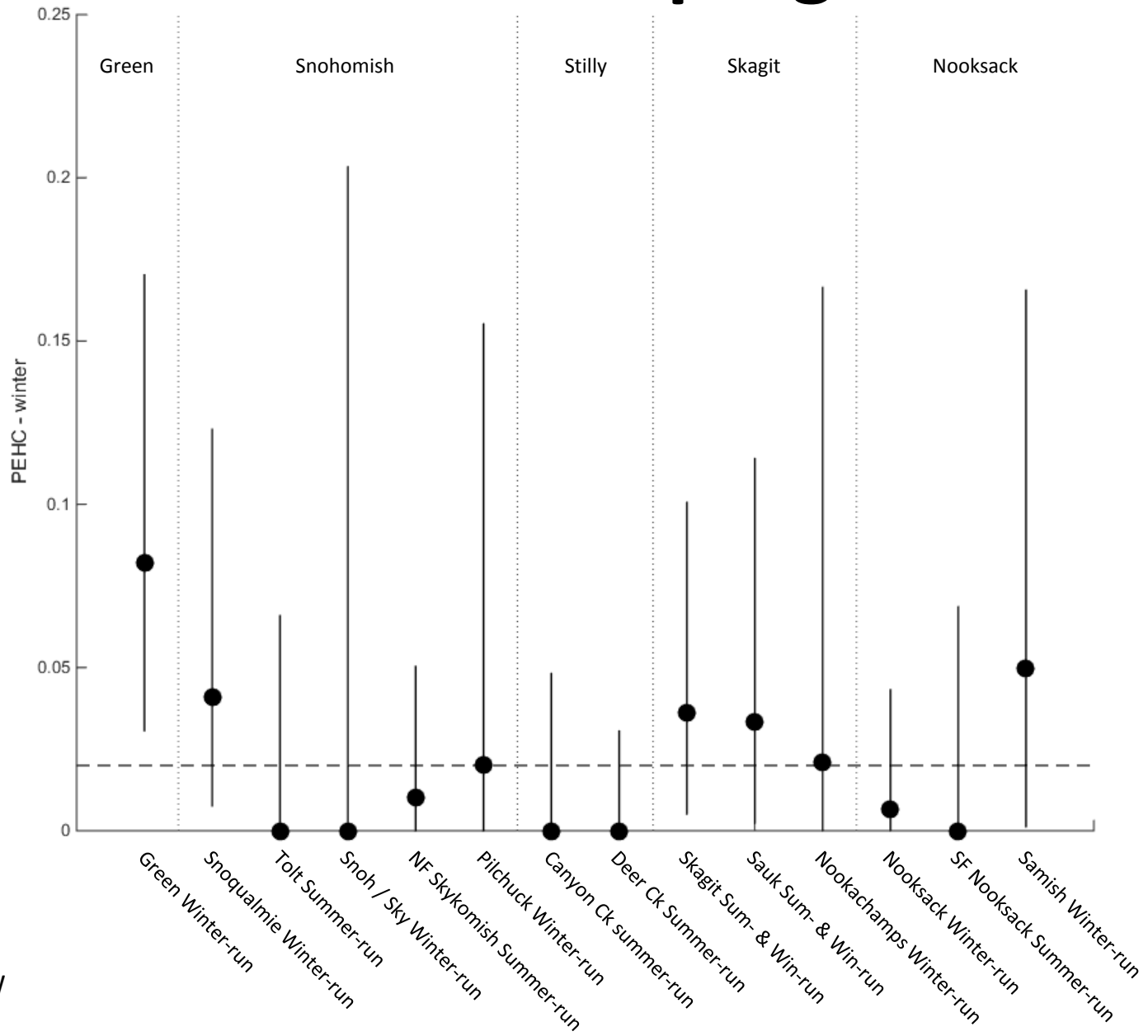
- Use offspring DNA samples to identify hatchery vs. wild origin of parents

$$PEHC = \frac{H\text{-}W + 2 * H\text{-}H}{2 * N}$$

← Number of matings in each category

← Total number of parents in sample

# PEHC – winter programs



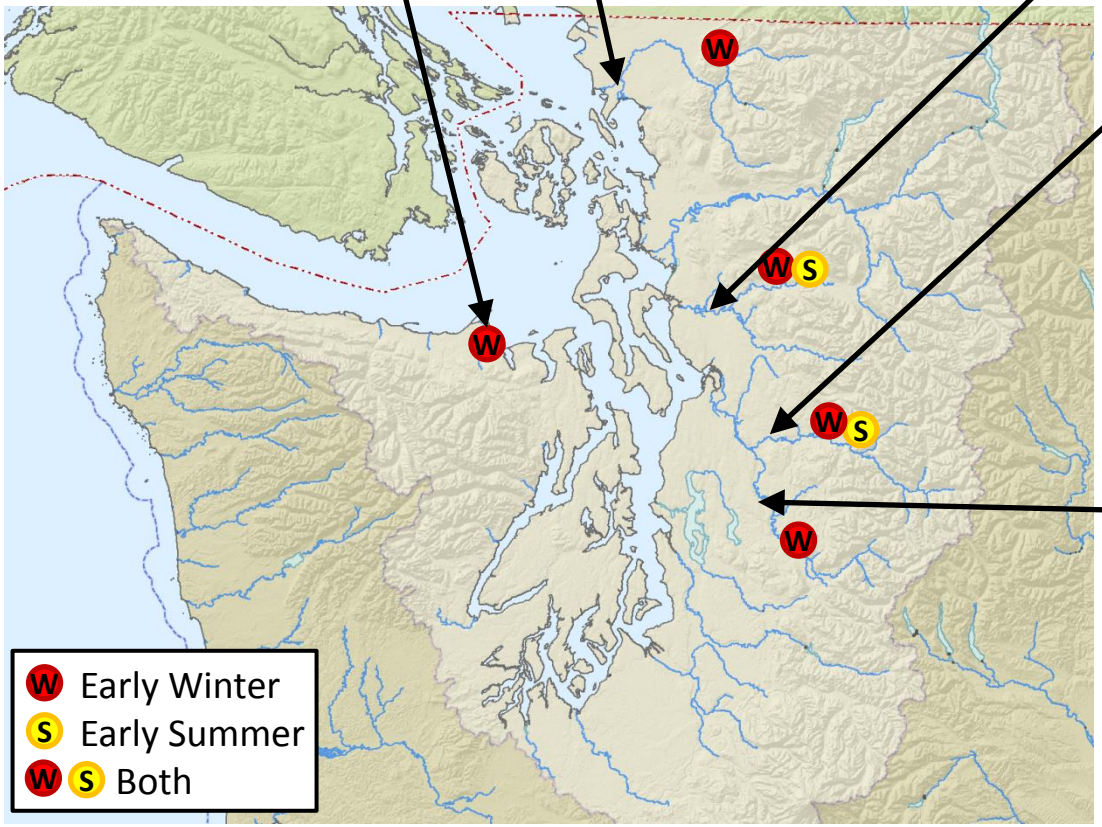

Warheit, WDFW
Unpublished

# Puget Sound smolt sampling

Dungeness: WDFW & Jamestown S'Klallam

Nooksack: Lummi Nation

Stillaguamish: Stillaguamish Tribe



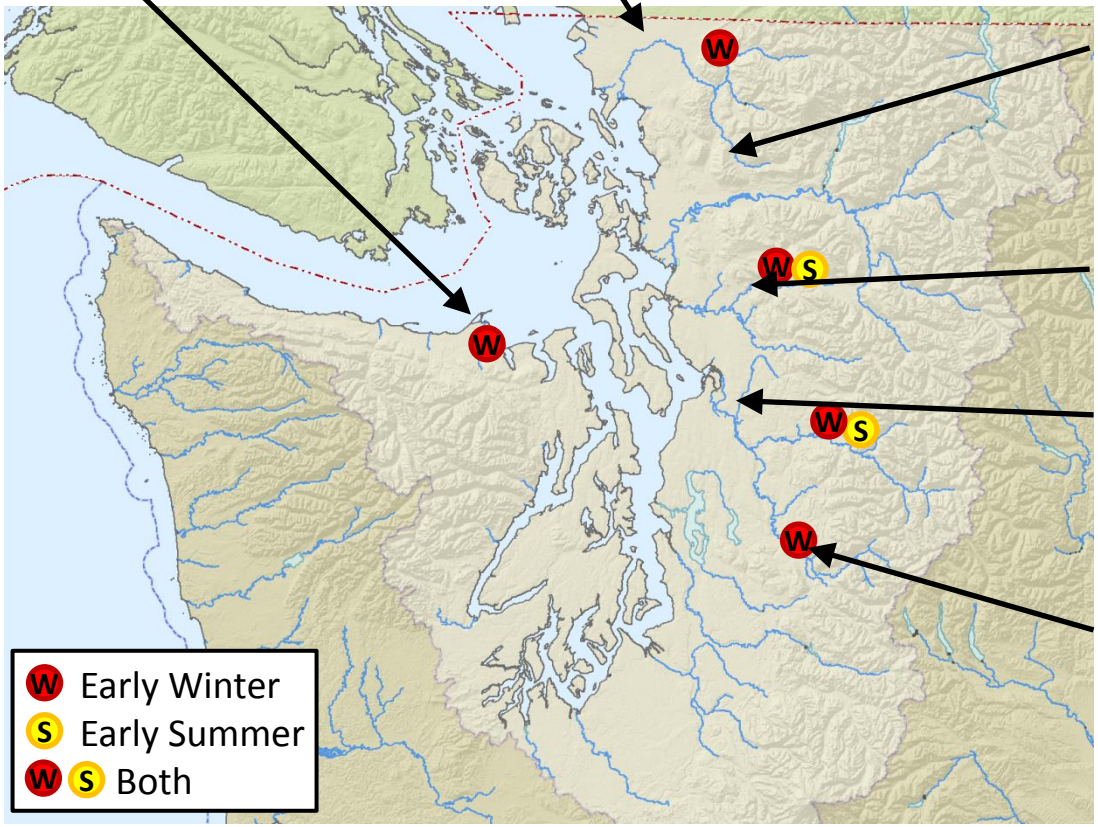

Skykomish: Tulalip Tribes

Snoqualmie: Tulalip Tribes

# Puget Sound adult sampling

**Dungeness**
Annually
Reason: life cycle assessment

**Nooksack winters**
Annually
Reason: life cycle assessment




**South Fork Nooksack summers**
3 year rotation
Reason: unique summer run life-history

**Deer Creek summers**
3 year rotation
Reason: unique summer run life-history

**Pilchuck**
3 year rotation
Reason: downstream from smolt trap

**Snoqualmie winters**
Annually
Reason: PEHC > 2 %, high value fishery

# DNA sample collections to date

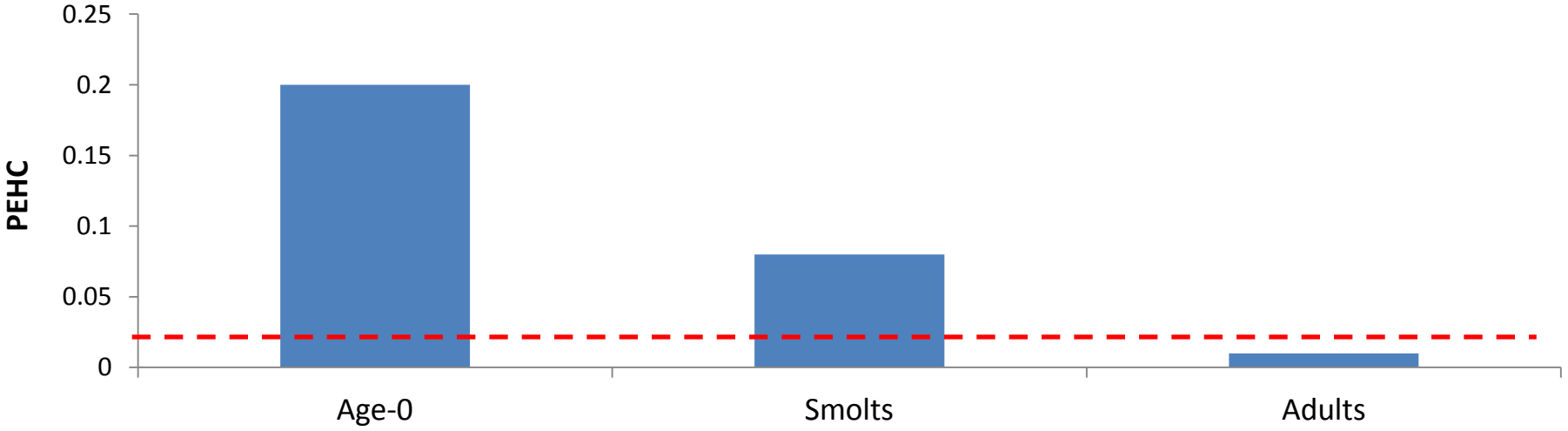
| Life stage | River | 2014 | 2015 | 2016 |
|---|---|---|---|---|
| Smolts | Nooksack | 139 | 32 | 60 |
| | Stillaguamish | | 81 | 39 |
| | Skykomish | | 28 | 89 |
| | Snoqualmie | | 9 | 20 |
| | Dungeness | 100 | 200 | 100 |
| Adults | Nooksack | 31 | 65 | 46 |
| | Snoqualmie | | 50 | 37 |
| | Dungeness | 26 | 51 | 0 |
| | Deer | | 8 | |
| | Pilchuck | | | 48 |
| | SF Nooksack | | | |

# PEHC through the life cycle

**Research question**

Is there evidence for differential survival of natural-origin fish with wild ancestry vs. natural origin fish with hatchery ancestry?

**Hypothetical example consistent with lower survival of fish with hatchery ancestry**

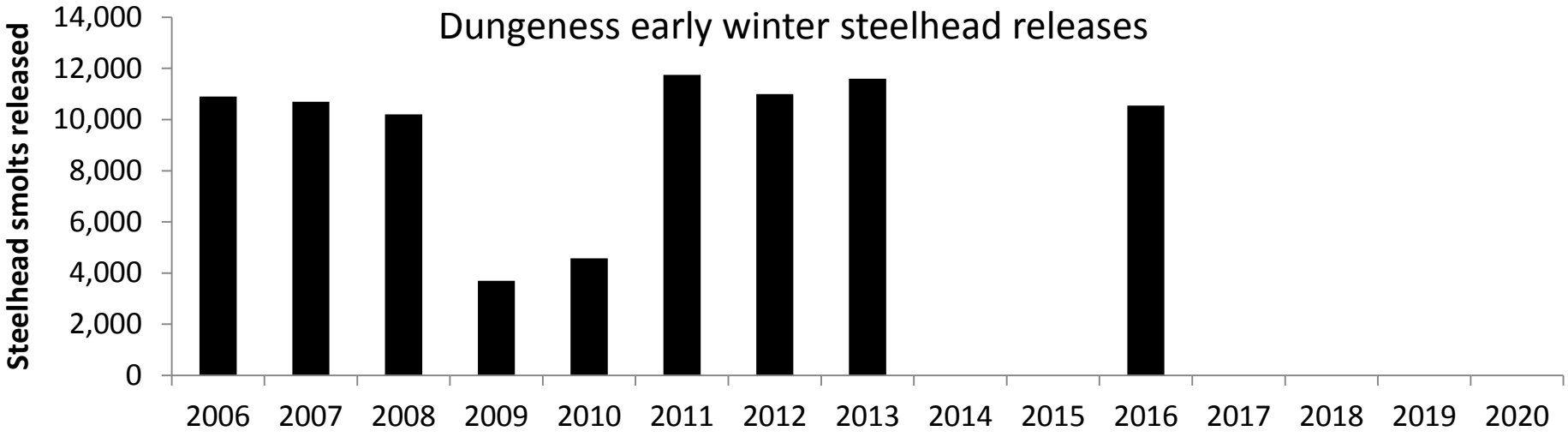



# Hatchery operations

**Research question**

Can we use annual estimates of PEHC to track operational changes to hatchery programs?

**An unplanned experiment**




**2016:** expect minimal returning hatchery adults

**2018:** reduced PEHC in unmarked age-2 smolts?

**2020:** reduced PEHC in unmarked age-4 adults?

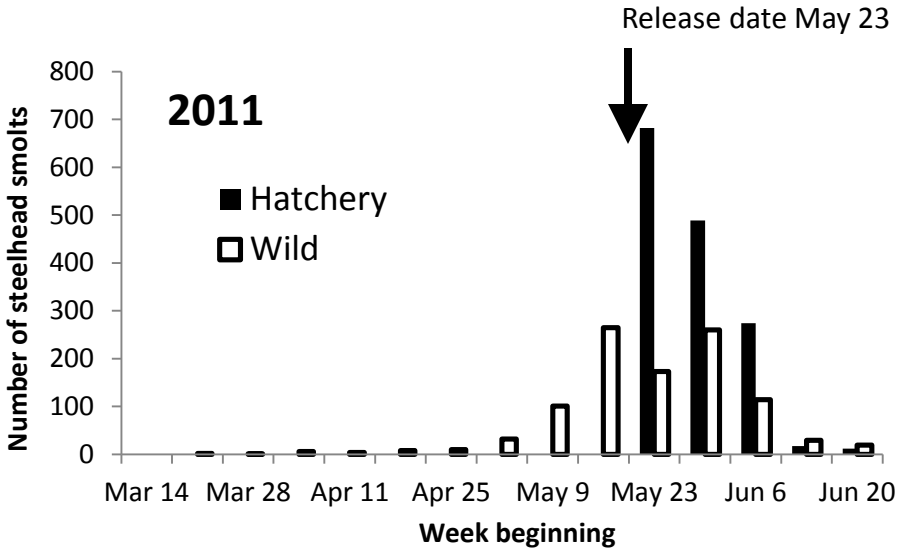
# Ecological monitoring

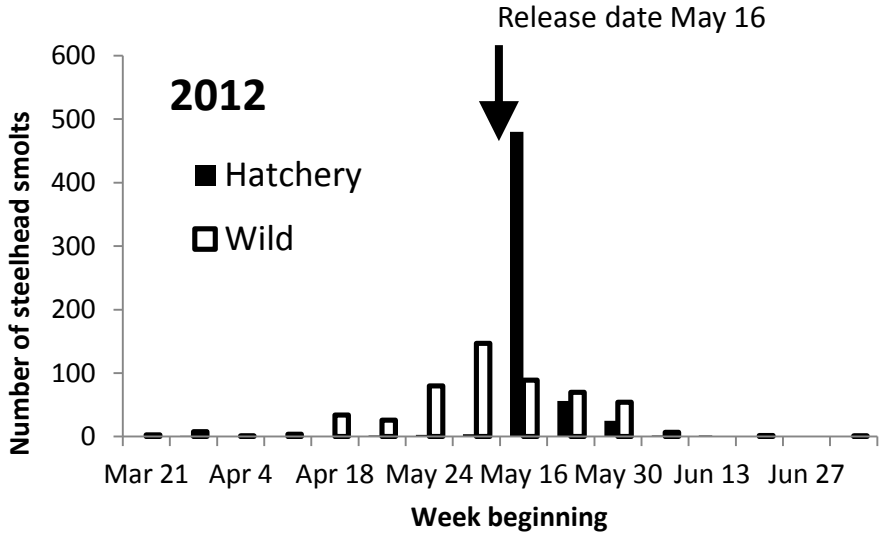
- Hatchery impacts such as competition or predation difficult to observe or measure directly but a prerequisite is overlap in time and space
- Hatchery management can encourage rapid migration following hatchery release through feeding regime, release timing and volitional release strategy

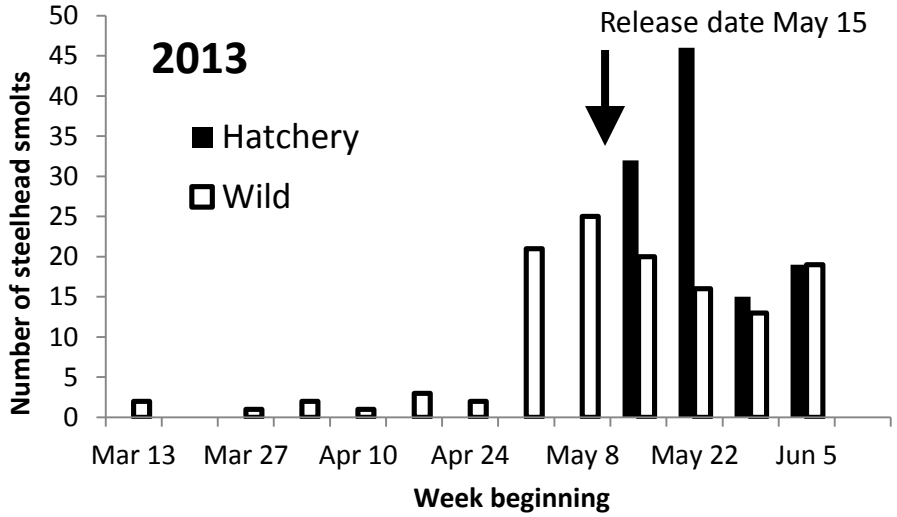

Dungeness smolt trap

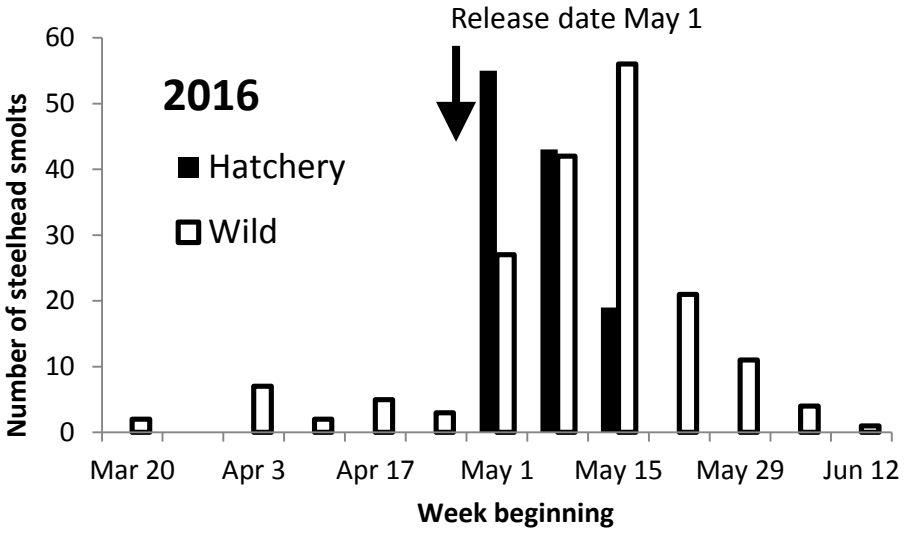
Dungeness hatchery

# Dungeness ecological monitoring



# Concluding remarks

- We know the risks of hatchery programs
- However, the magnitude of effect likely varies from basin to basin according to
    - hatchery demographics
    - hatchery operations
    - wild population demographics
    - environmental conditions
- Monitoring program designed to directly measure genetic introgression annually for early winter steelhead programs in Puget Sound
- Monitoring program measures *opportunity* for competition and predation but neither process directly

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