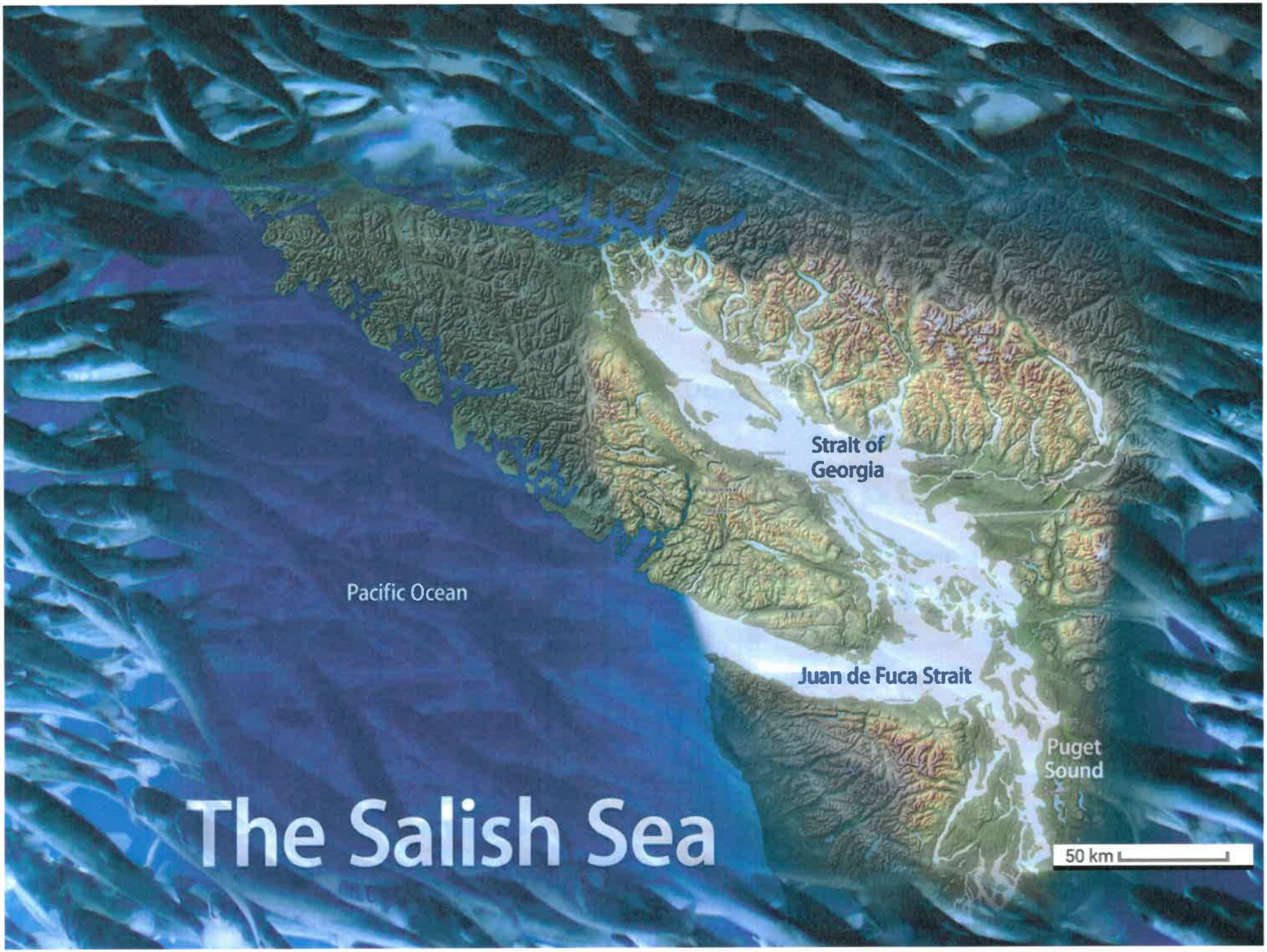
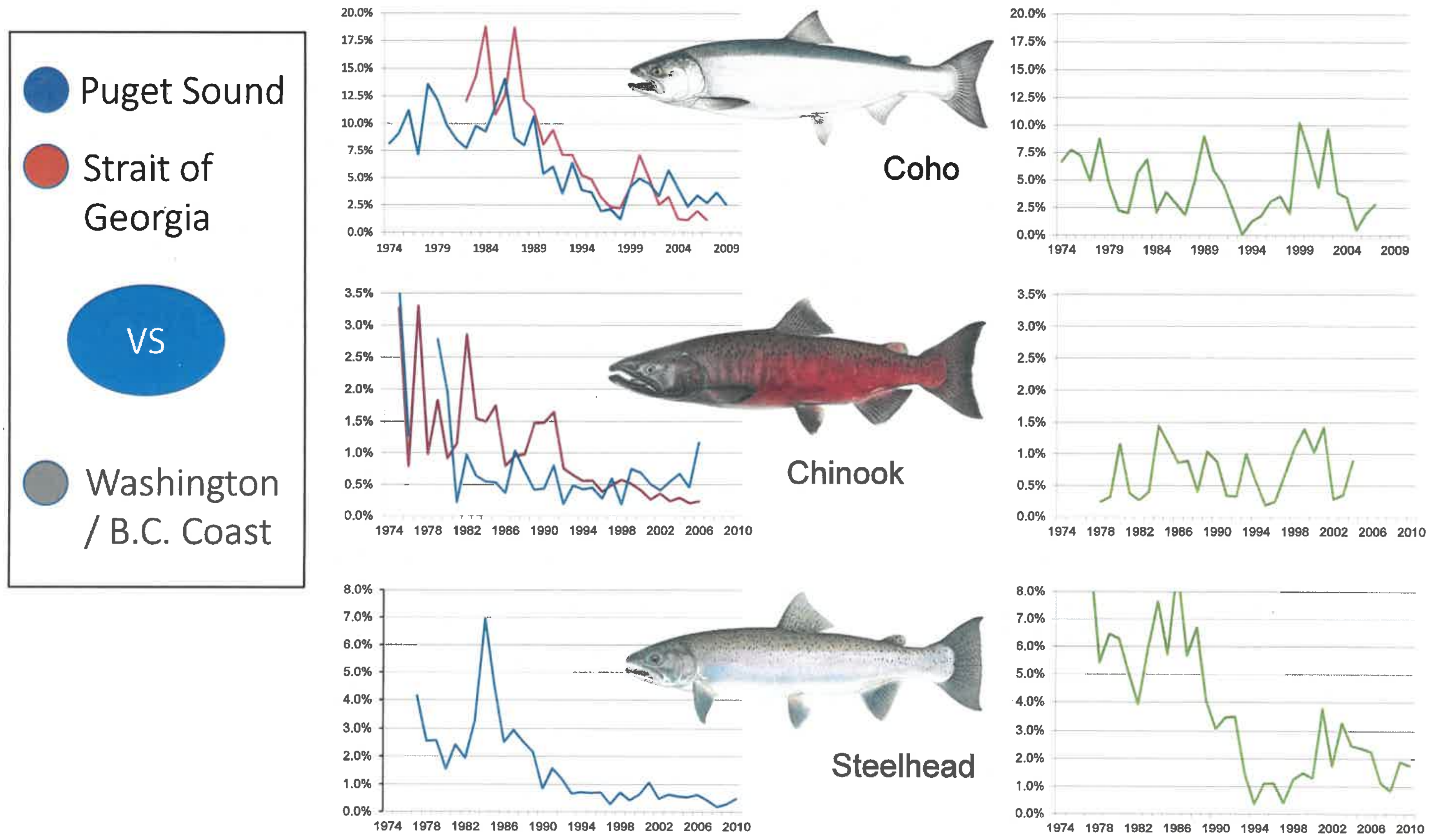
SALISH SEA

MARINE SURVIVAL PROJECT

An update on Puget Sound steelhead research


The Salish Sea
Pacific Ocean
Strait of Georgia
Juan de Fuca Strait
Puget Sound
50 km

Up to 10x Decline in Salish Sea Marine Survival



200+ participants	80+ studies	$20 million	5 years	2 countries	1 question

Why are juvenile Chinook, coho & steelhead dying in the Salish Sea marine environment?

SALISH SEA
MARINE SURVIVAL PROJECT

60+ Partners

PACIFIC SALMON FOUNDATION
LONG LIVE THE KINGS
PACIFIC SALMON COMMISSION
Government of Canada / Gouvernement du Canada
Canada

VENUS
Pacific Salmon
VULCAN
A Paul G. Allen Company
THE SEAL OF THE STATE OF WASHINGTON 1889
NWIFC
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE
NOAA
GOLDCORP

University of Victoria
SFU SIMON FRASER UNIVERSITY
ENGAGING THE WORLD
Canada
Department of Fisheries & Oceans
Sea Grant
Washington
EAGLE WING TOURS

UBC
W
BOEING
sitka foundation
MUCKLESHOOT INDIAN TRIBE
TULALIP TRIBES
LUMMI NATION
TREATY OF 1855

Port of Seattle
EPA
United States Environmental Protection Agency
USGS
science for a changing world
PORT METRO vancouver
CANFISCO
KWIÁHT

Squaxin Island Tribe
NATIONAL FISH AND WILDLIFE FOUNDATION
NFWF
NISQUALLY INDIAN TRIBE
WASHINGTON STATE RECREATION AND CONSERVATION OFFICE
Salmon Recovery Funding Board
KINTAMA

The Port Gamble S'KLALLAM TRIBE
Genome BritishColumbia
PACIFIC NORTHWEST Salmon Center
King County
TROUT UNLIMITED
PugetSoundPartnership
LEADING PUGET SOUND RECOVERY

Hypotheses

A. **Processes that drive prey availability** have changed, and salmon aren't able to compensate.

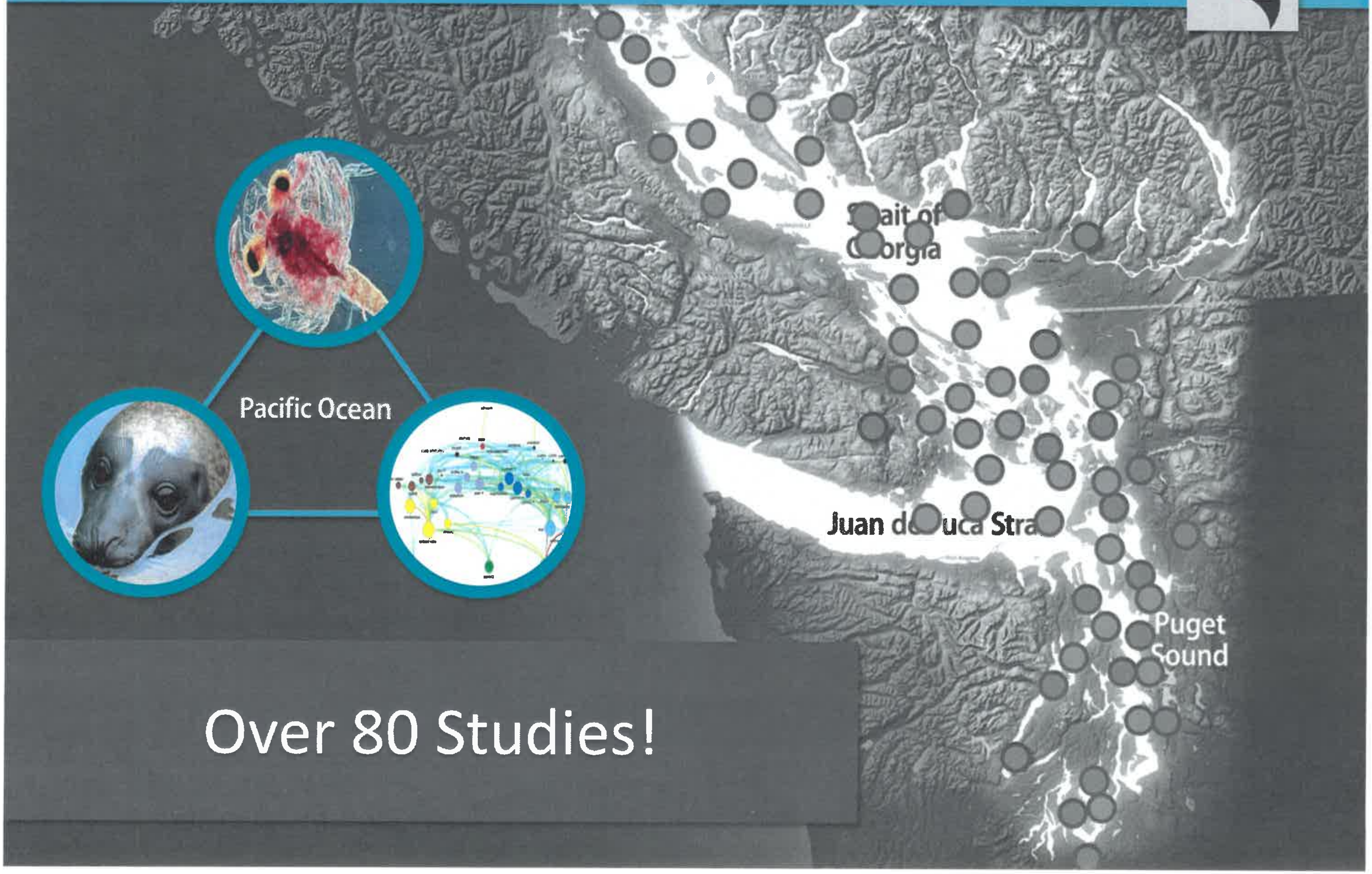
B. **More predators** are making situation worse, eating juvenile steelhead, salmon and forage fish.

C. **Multiple factors may compound the problem**:
- Disease
- Contaminants
- Hatchery management
- Habitat loss
- Cumulative effects

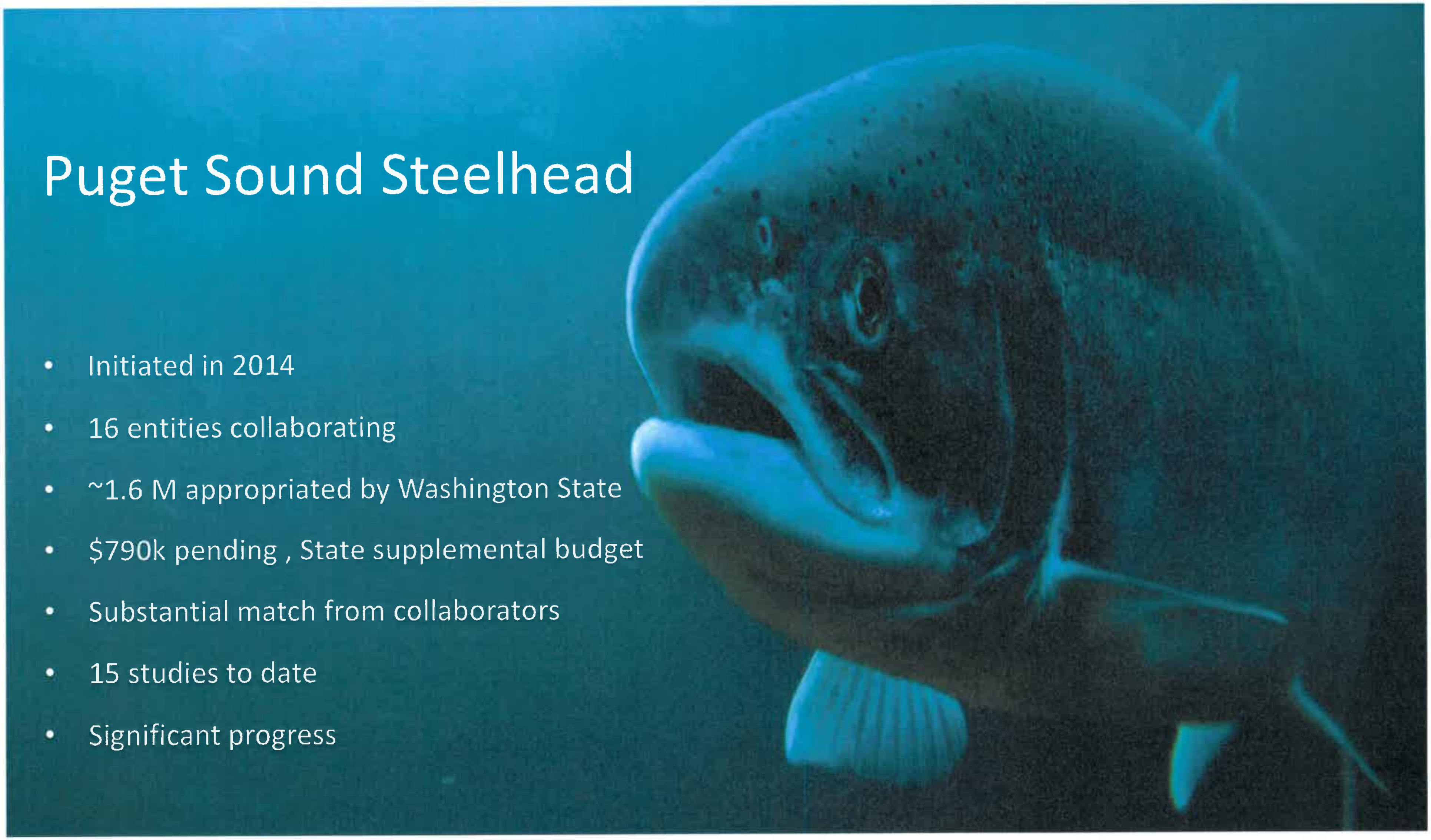
Ultimately, must weigh the contribution of:

- Local, human influence (water quality, predation management, hatchery management)
- Regional or global impacts (climate change, ocean acidification, natural cycles)

Research Across the Salish Sea



Over 80 Studies!


Puget Sound Steelhead
Initiated in 2014
16 entities collaborating
~1.6 M appropriated by Washington State
$790k pending , State supplemental budget
Substantial match from collaborators
15 studies to date
Significant progress

Steelhead: where are we now?

Steelhead dying at high rate in PS

Predation **IS** proximate/ direct cause of mortality

Predation **IS NOT** proximate/ direct cause of mortality

Ultimate or Contributing Cause (→ Predation IS proximate/direct cause of mortality)

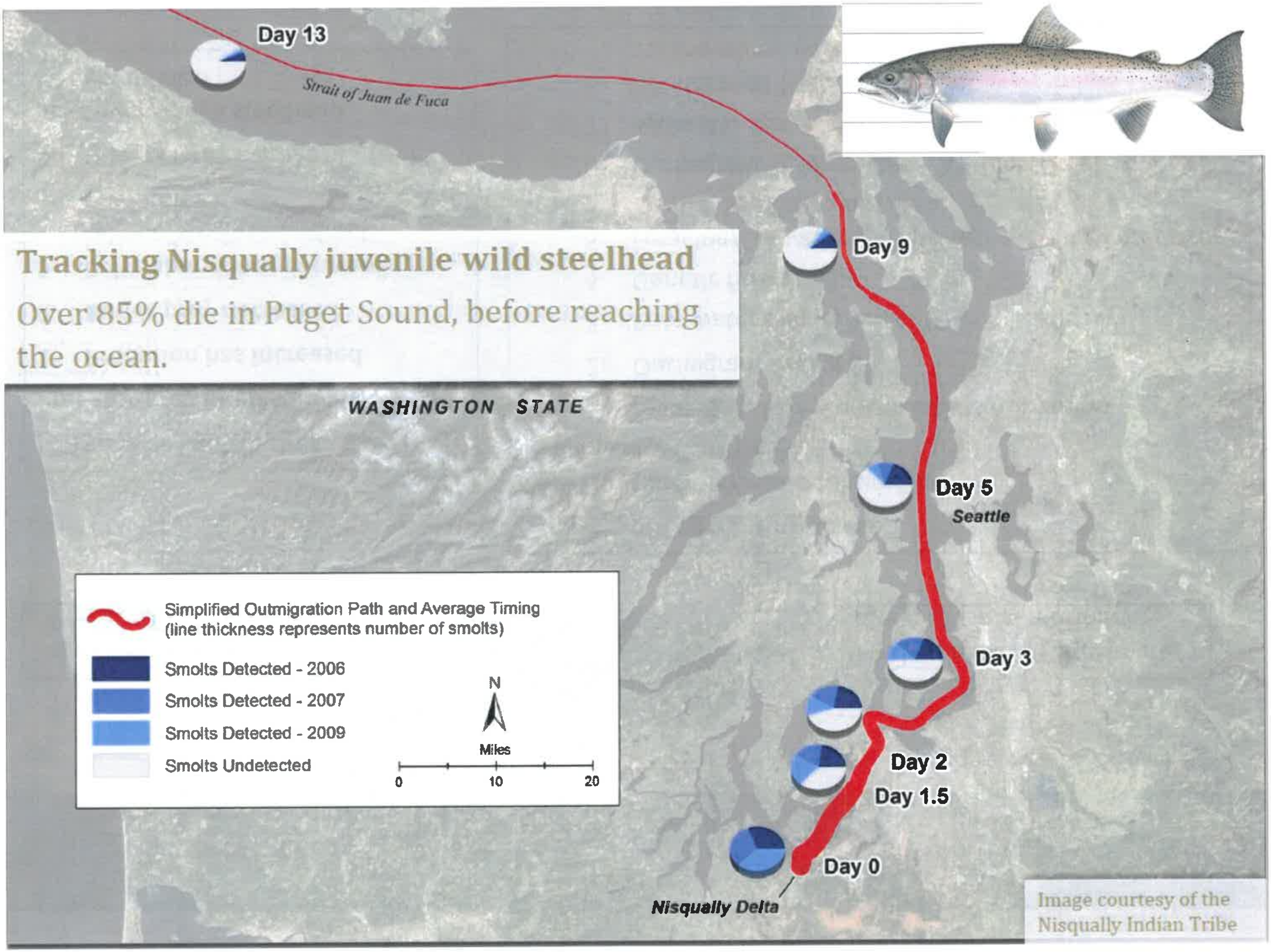
Predator-prey interactions

1. **Predation has increased**
2. **Buffer prey decreased**
3. Pulse abundance of juvenile salmon/steelhead attracts predators?
4. Water clarity increased
5. Low juvenile steelhead abundance [not likely]

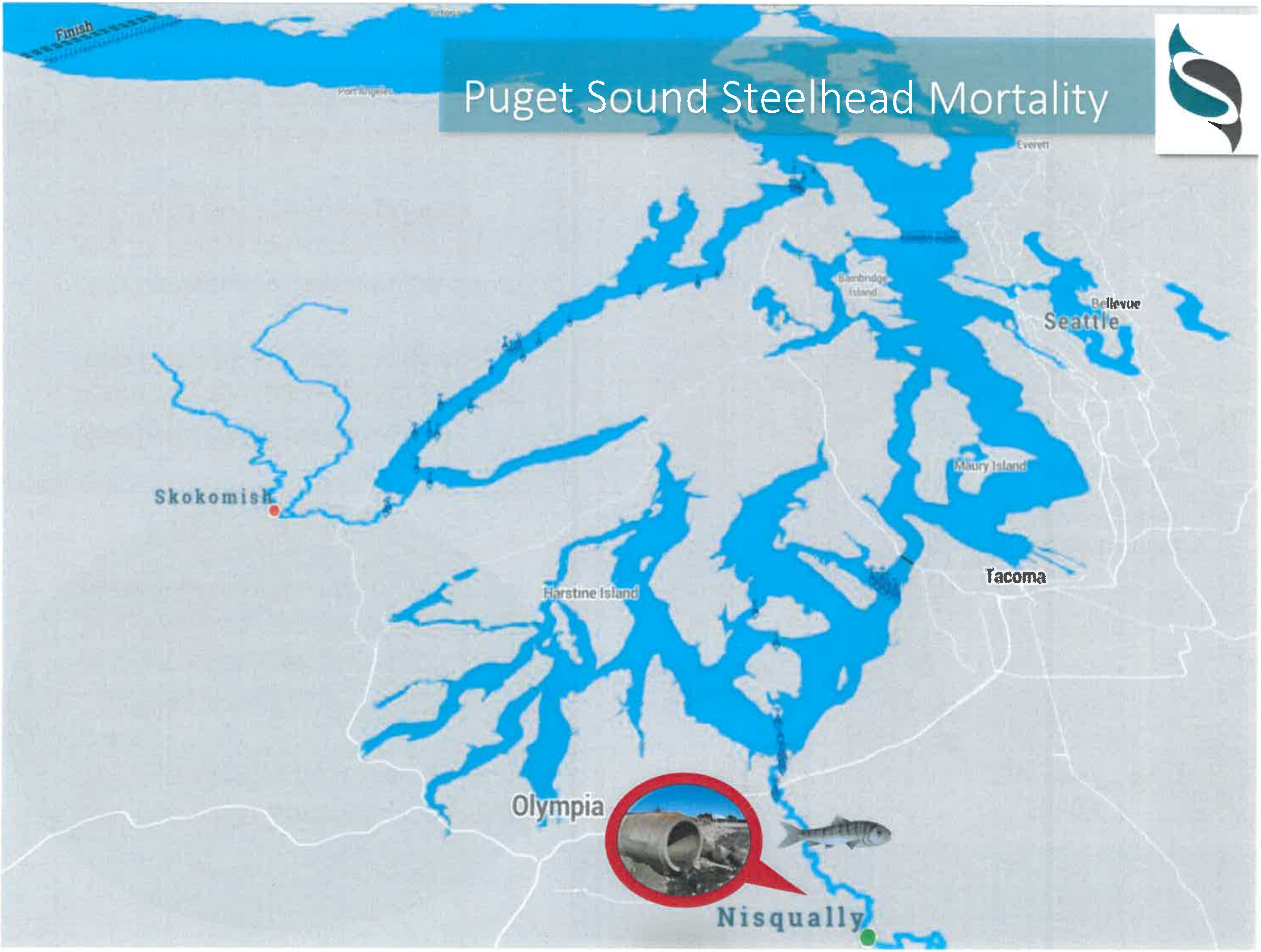
Ultimate or Contributing Cause (→ Predation IS proximate / IS NOT proximate)

Poor fish condition and/or altered behavior
freshwater (F) or marine (M) derived

1. **Disease (F/M) – Central & South P. Sound**
2. Outmigrant timing (F)
3. Poor water quality/toxics (F/M) – Nisqually
4. Genetic fitness (F)
5. Foraging/Starvation (M) [foraging induced predation maybe. Starvation not likely]
6. Outmigrant size/growth (F/M) [not likely]
7. HABs (M) [not likely]
8. Habitat modifications (M) [not likely unless associated w/ buffer prey]


Tracking Nisqually juvenile wild steelhead
Over 85% die in Puget Sound, before reaching the ocean.
Day 13
Strait of Juan de Fuca
Day 9
WASHINGTON STATE
Day 5
Seattle
Day 3
Day 2
Day 1.5
Day 0
Nisqually Delta
Simplified Outmigration Path and Average Timing (line thickness represents number of smolts)
Smolts Detected - 2006
Smolts Detected - 2007
Smolts Detected - 2009
Smolts Undetected
N
Miles
0
10
20
Image courtesy of the Nisqually Indian Tribe

Puget Sound Steelhead Mortality



Fish Health - Contaminants

Steelhead **PCB levels** generally low: 1.4 – 2.2x **lower** than Chinook at same locations.

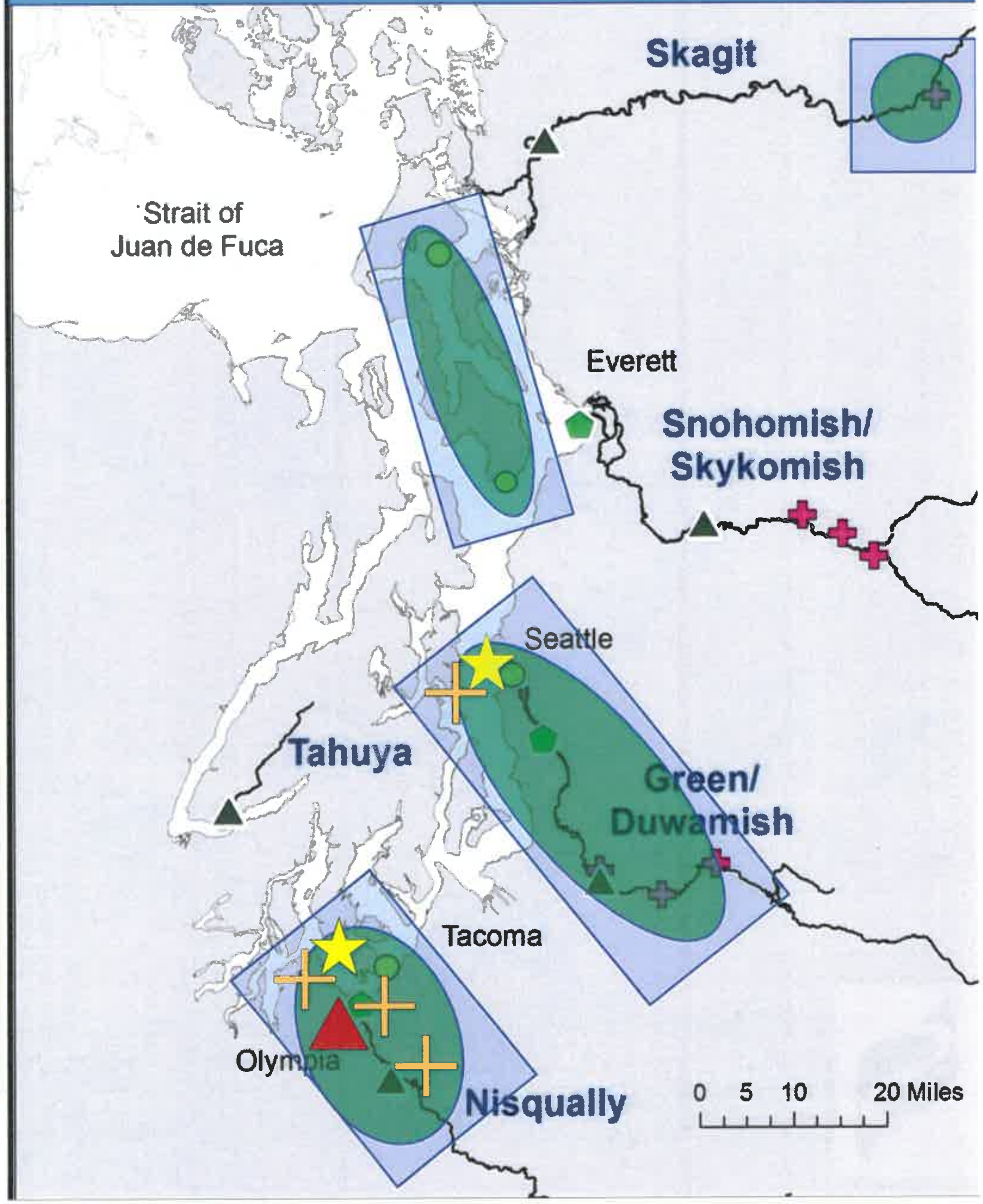
★ 16.7% Central and 25% South Puget Sound samples exceeded PCB adverse effects threshold.

Steelhead **PBDE levels** high in Nisqually, and 1.1 to 3 times **higher** than Chinook at same locations.

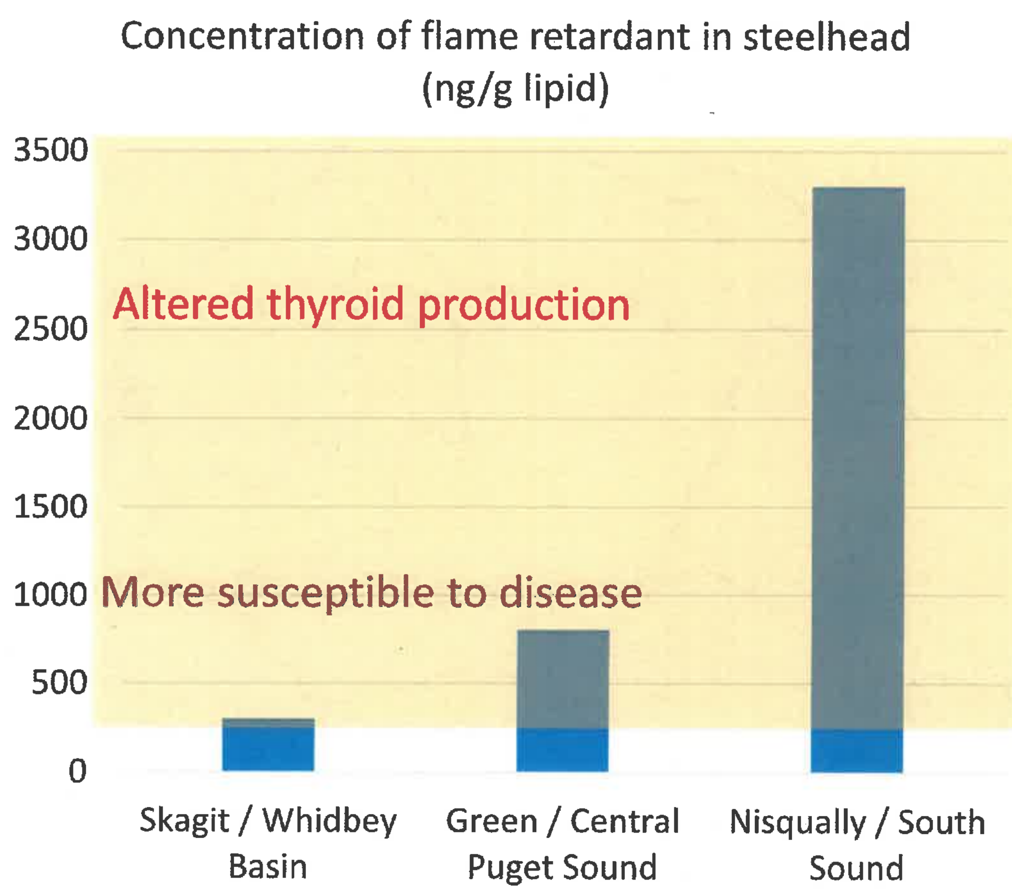
+ 25% Central and South Puget Sound, and 33% Nisqually River samples = increased disease susceptibility

▲ 33% Nisqually estuary samples = altered thyroid production

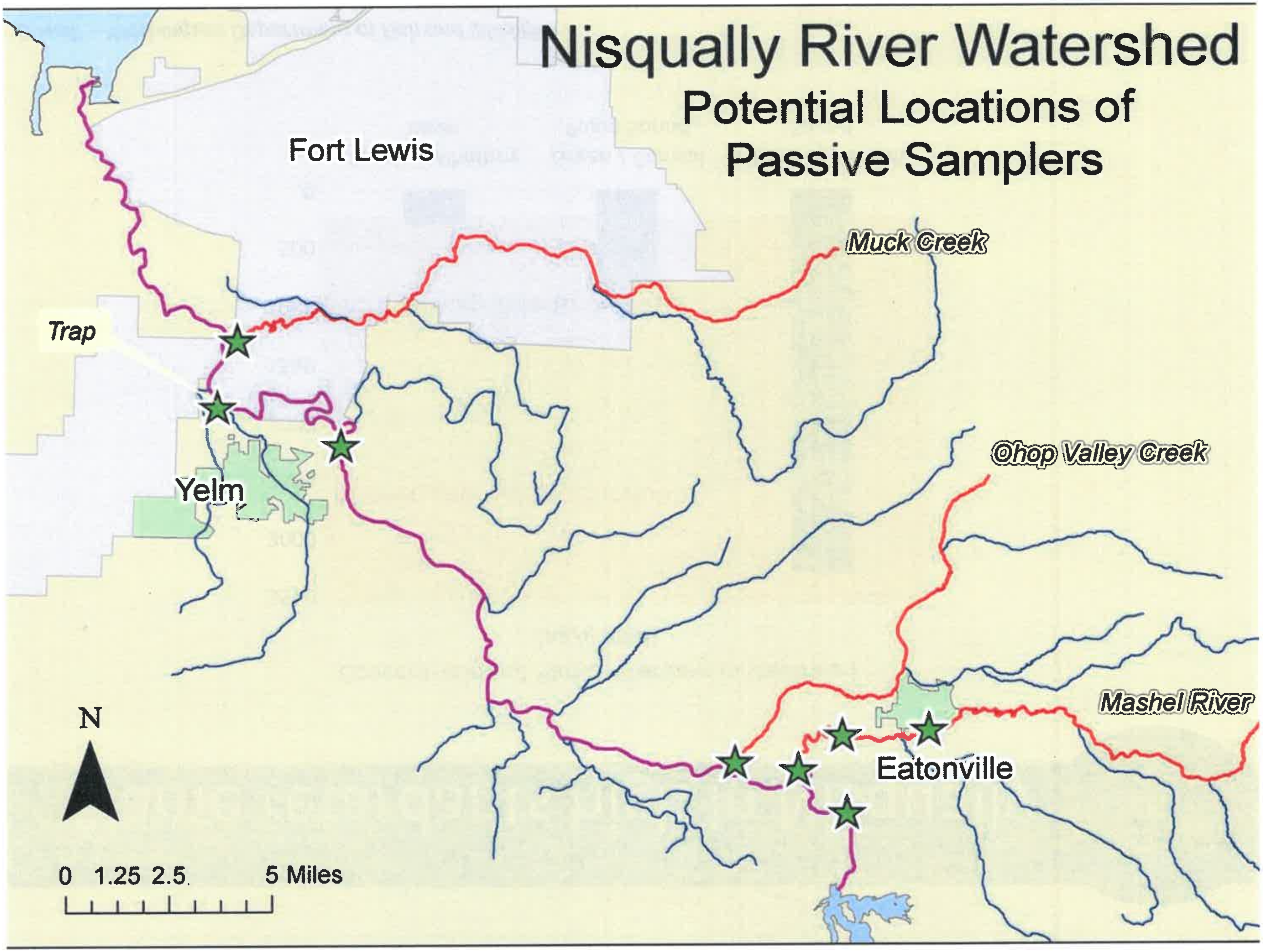
O'Neil et al (WDFW)



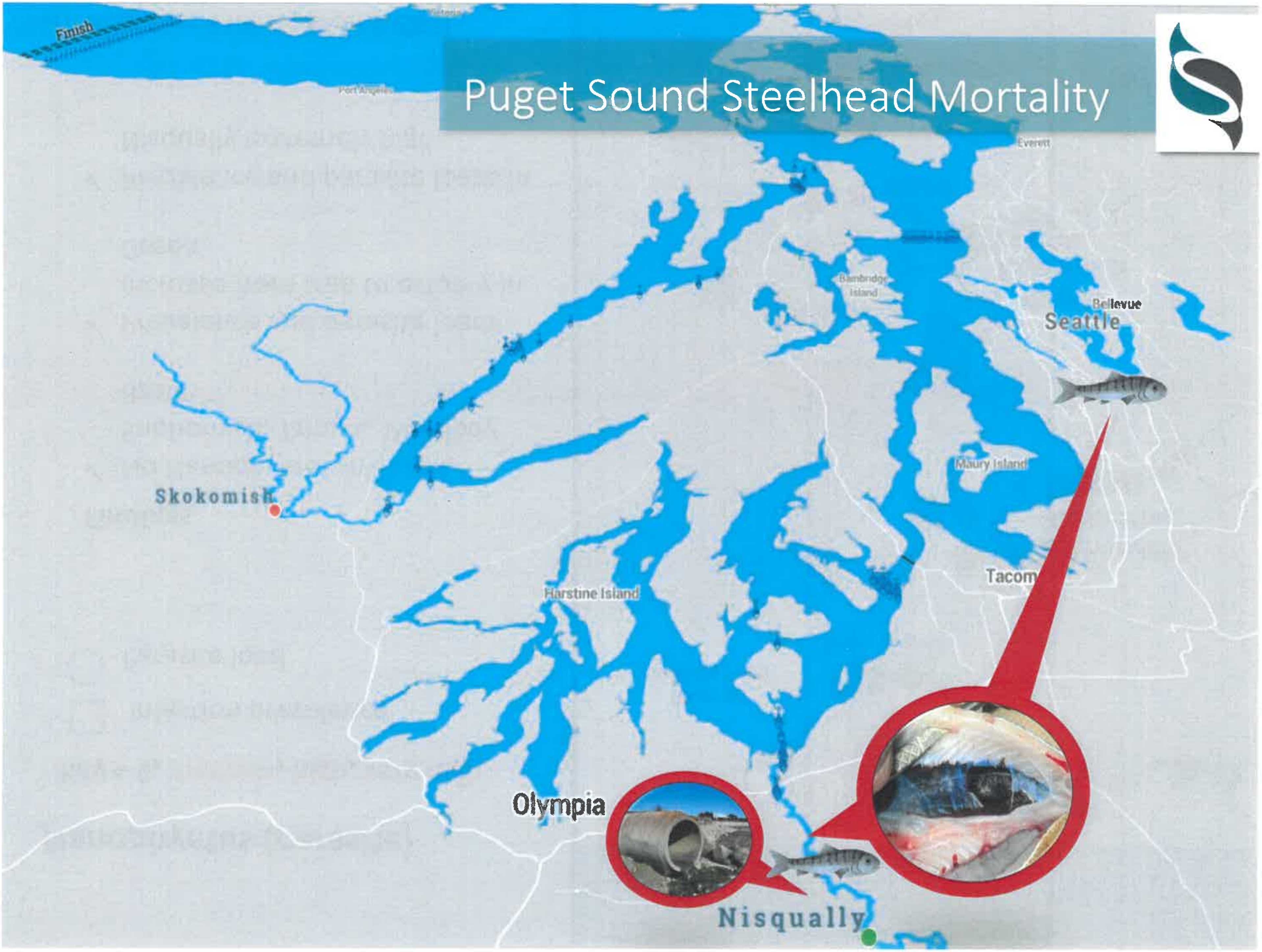
Flame retardants high in Nisqually



O'Neill – Washington Department of Fish and Wildlife


Nisqually River Watershed
Potential Locations of
Passive Samplers
Fort Lewis
Muck Creek
Trap
Yelm
Ohop Valley Creek
Mashel River
Eatonville
N
0 1.25 2.5 5 Miles

Puget Sound Steelhead Mortality



Nanophyetus (parasite)

Key = 0, medium, high, very high

☐ Infection prevalence

○ Parasite load

Findings

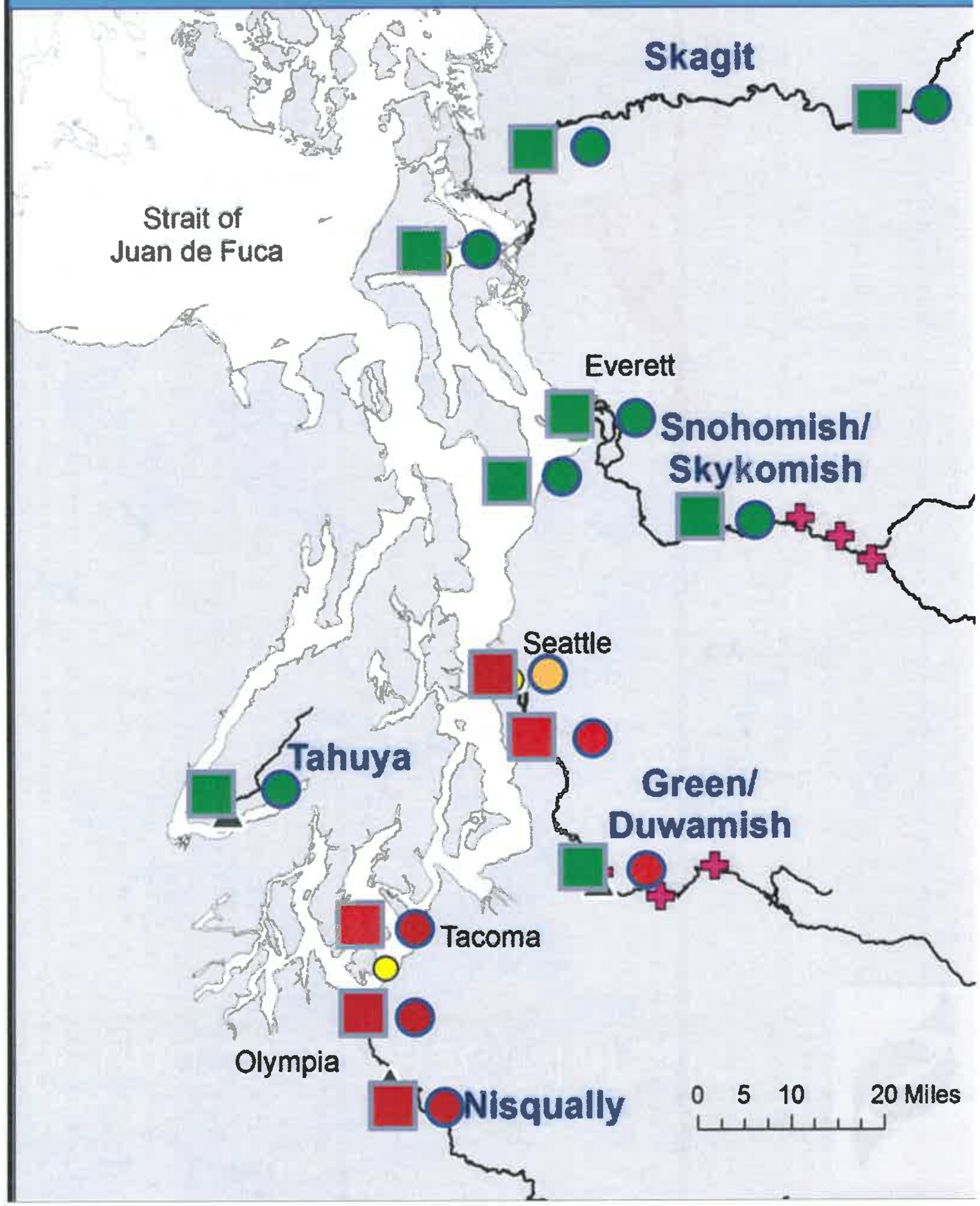
✓ No Nanophyetus in Skagit, Snohomish, Tahuya, Whidbey Basin

✓ Prevalence and parasite loads increase from trap to estuary in Green.

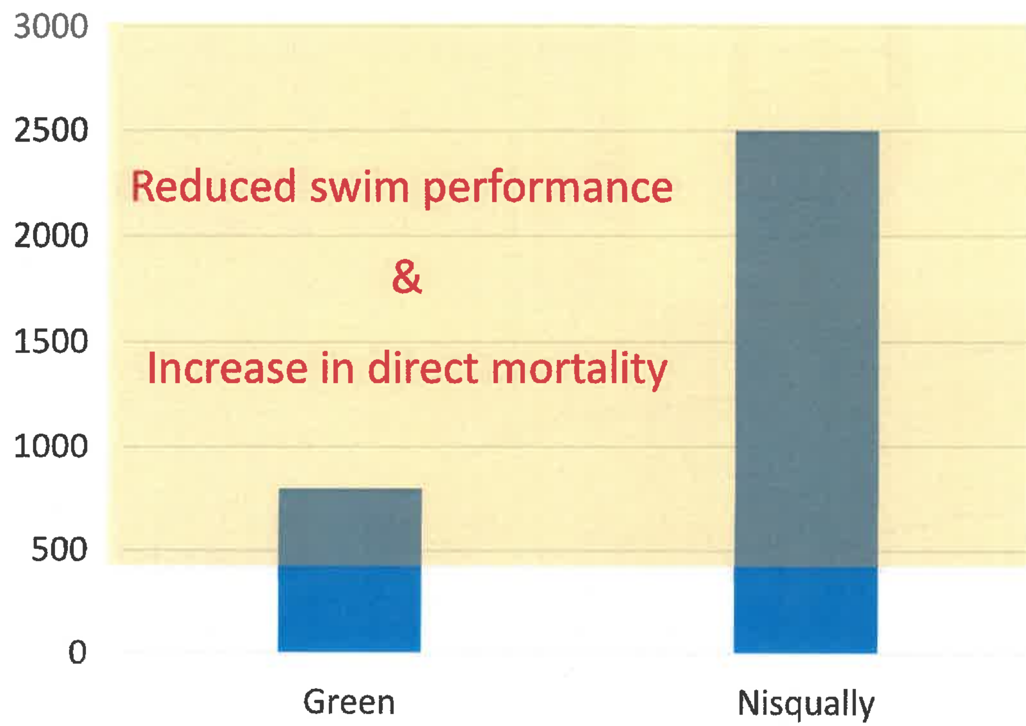
✓ Prevalence and parasite loads in Nisqually extremely high.

Chen (NWIFC) and Hershberger (USGS)

Fish Health - Disease

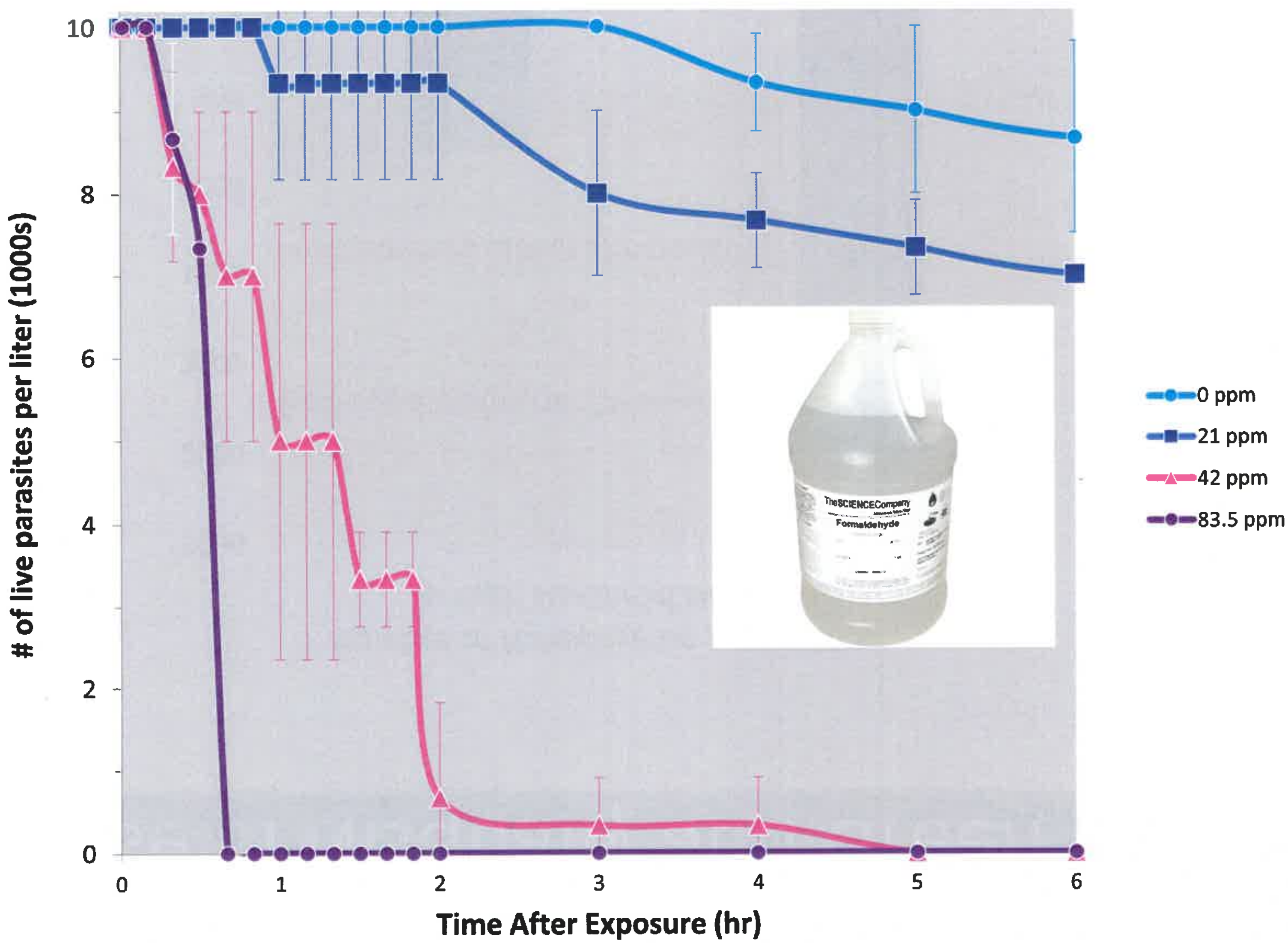


Disease in Nisqually and Green



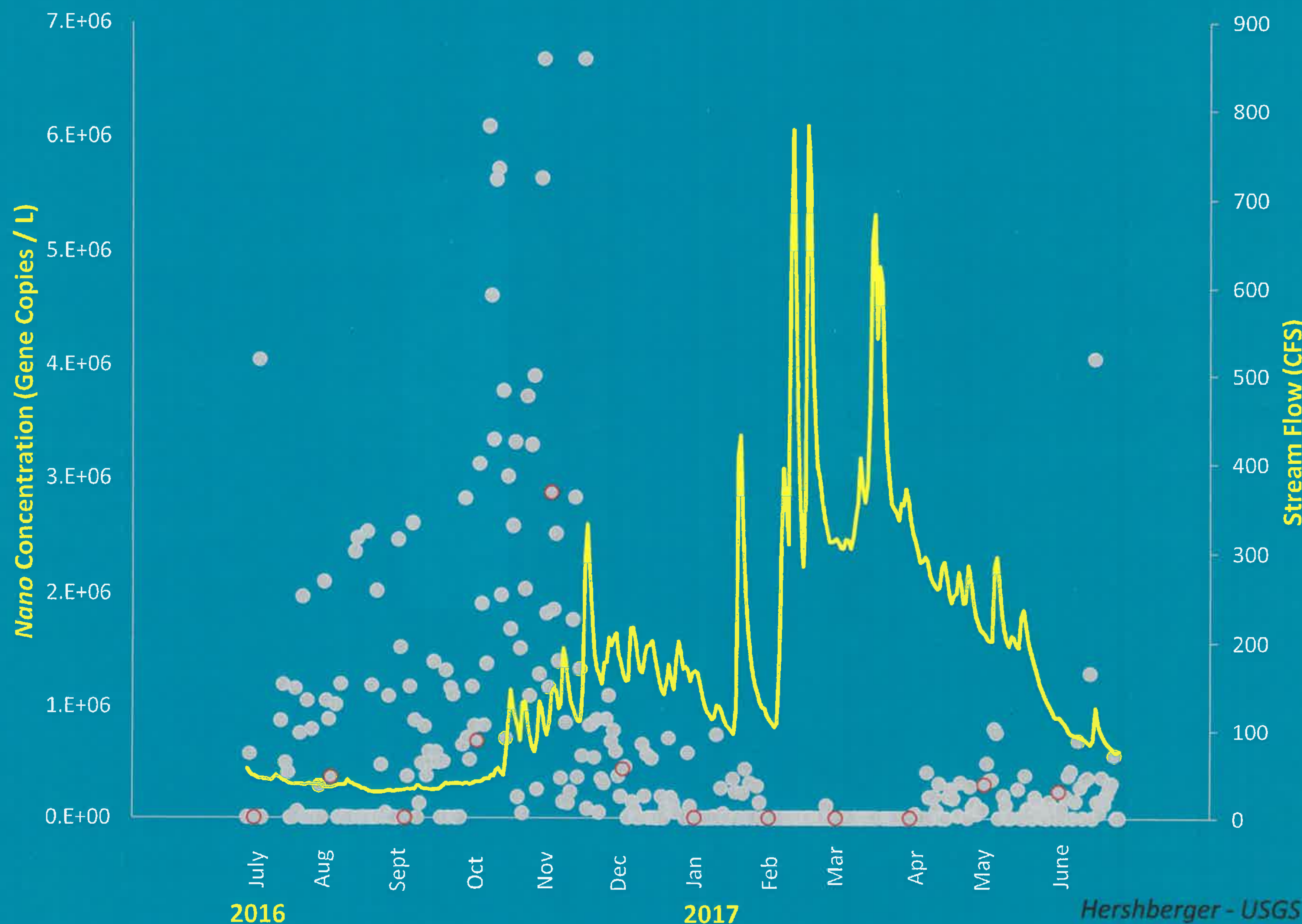
Chen, O'Neill & Hershberger – NWIFC, WDFW, USGS, WDFW

Formalin treatment for Nanophyetus parasite

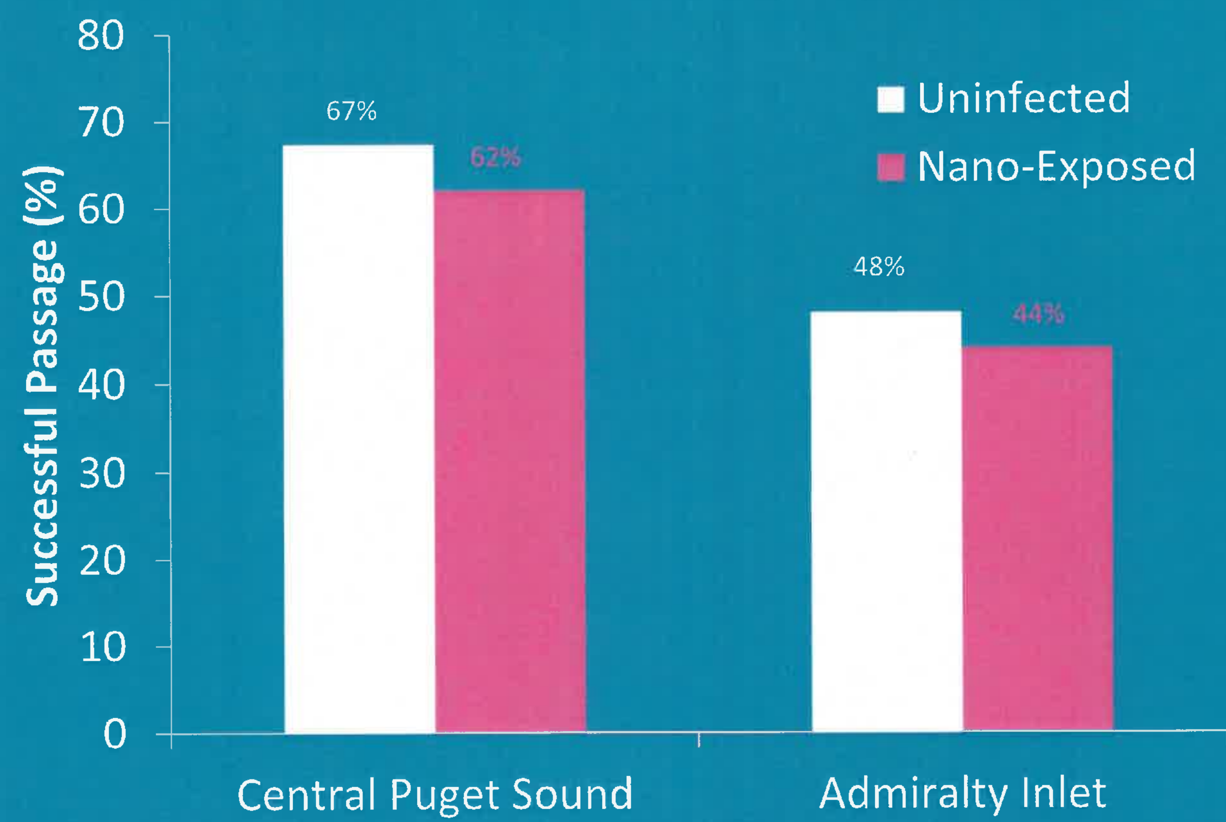


Hershberger et al unpublished 2016

Nano Relationship to Stream Flows



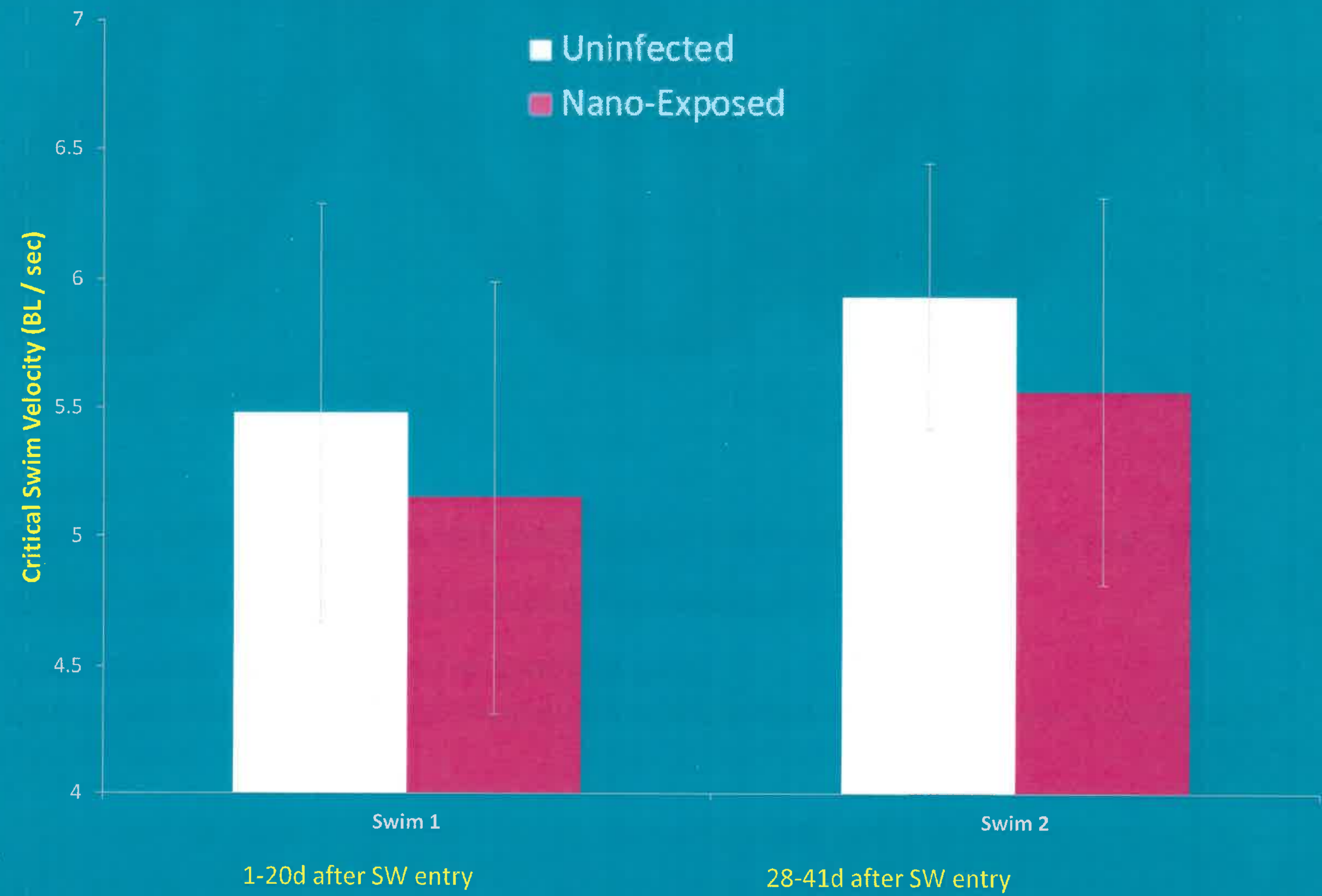
Open Water: Passage through Puget Sound



Metacercaria / post. kidney	2016 Released Fish	2014 Nisqually River
Mean	232 (n=81)	2,546 (n=30)
Range	30 - 865	10 - 9,844

Hershberger - USGS

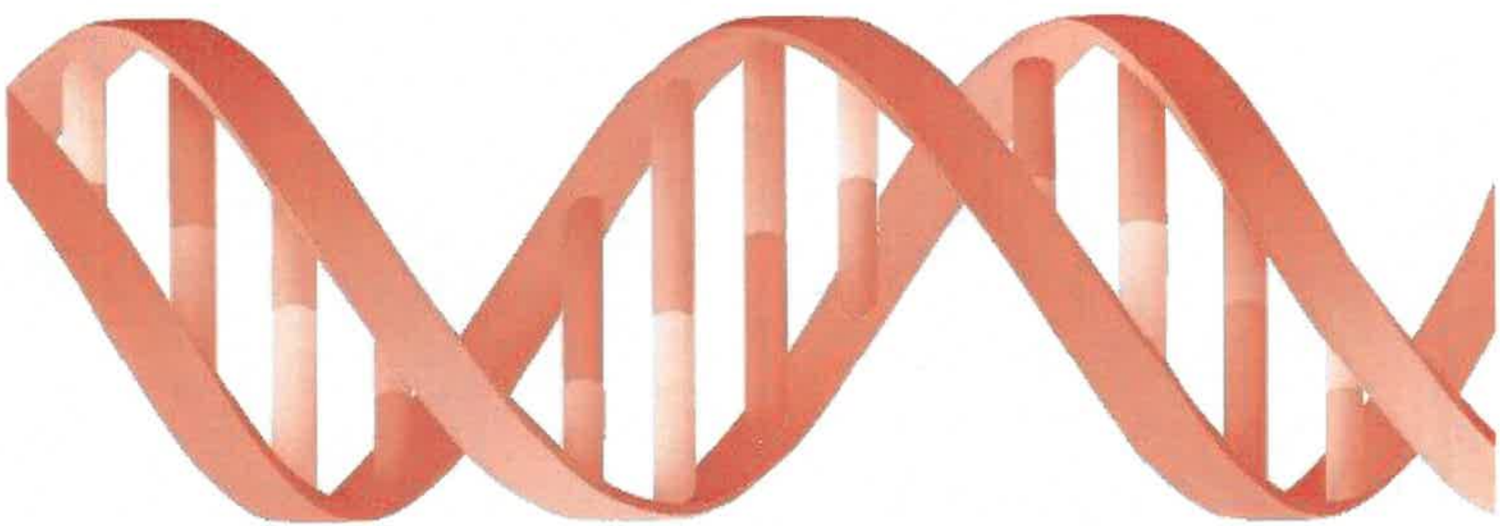
Lab Trials: Swimming Performance



Hershberger - USGS

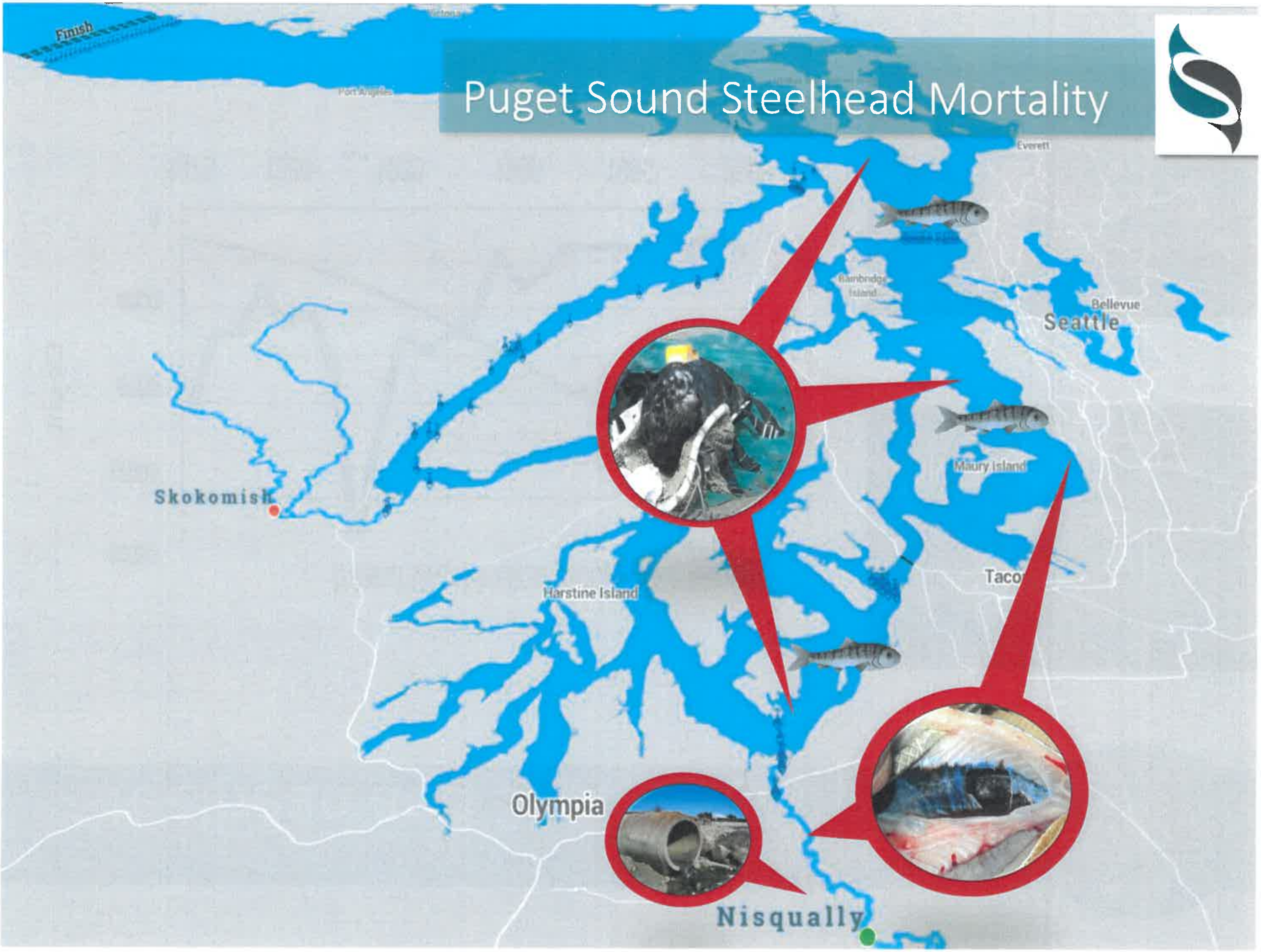
Genome-wide Association Study

- Omy05 genotypes may reduce probability of survival or result in a higher *Nanophyetus* count. Greater signal in Green vs Nisqually River.
- Omy05 may be associated with residency vs anadromy.
- Other loci appear associated with Nano counts and survival, but they are difficult to discern.

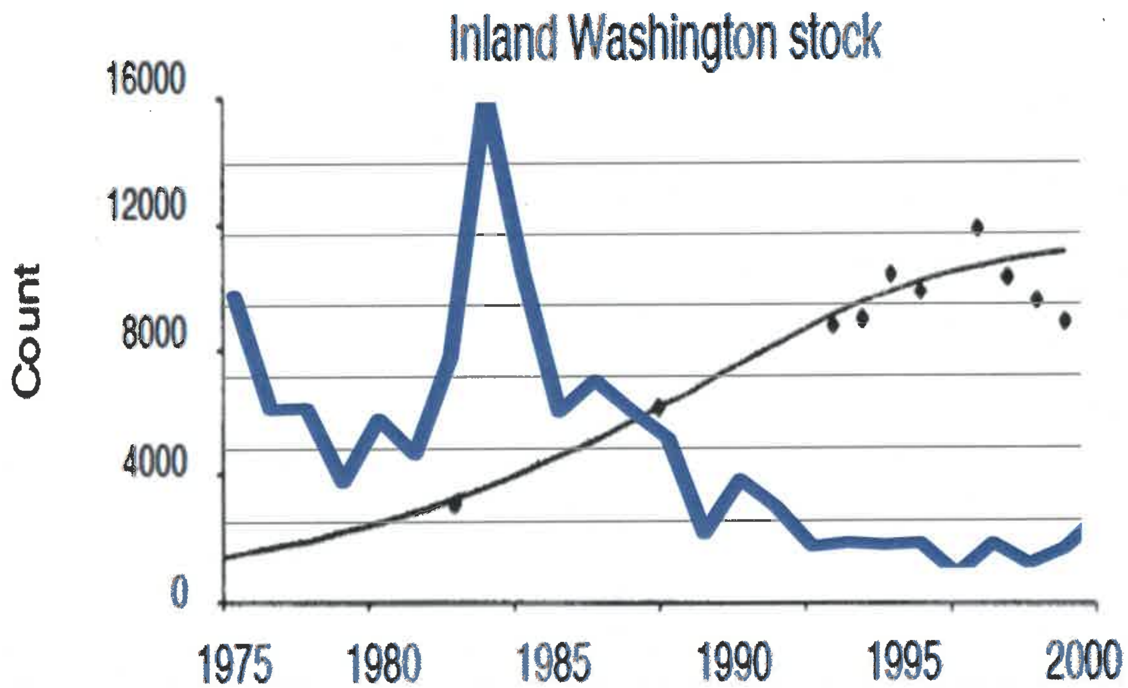


Warheit - WDFW

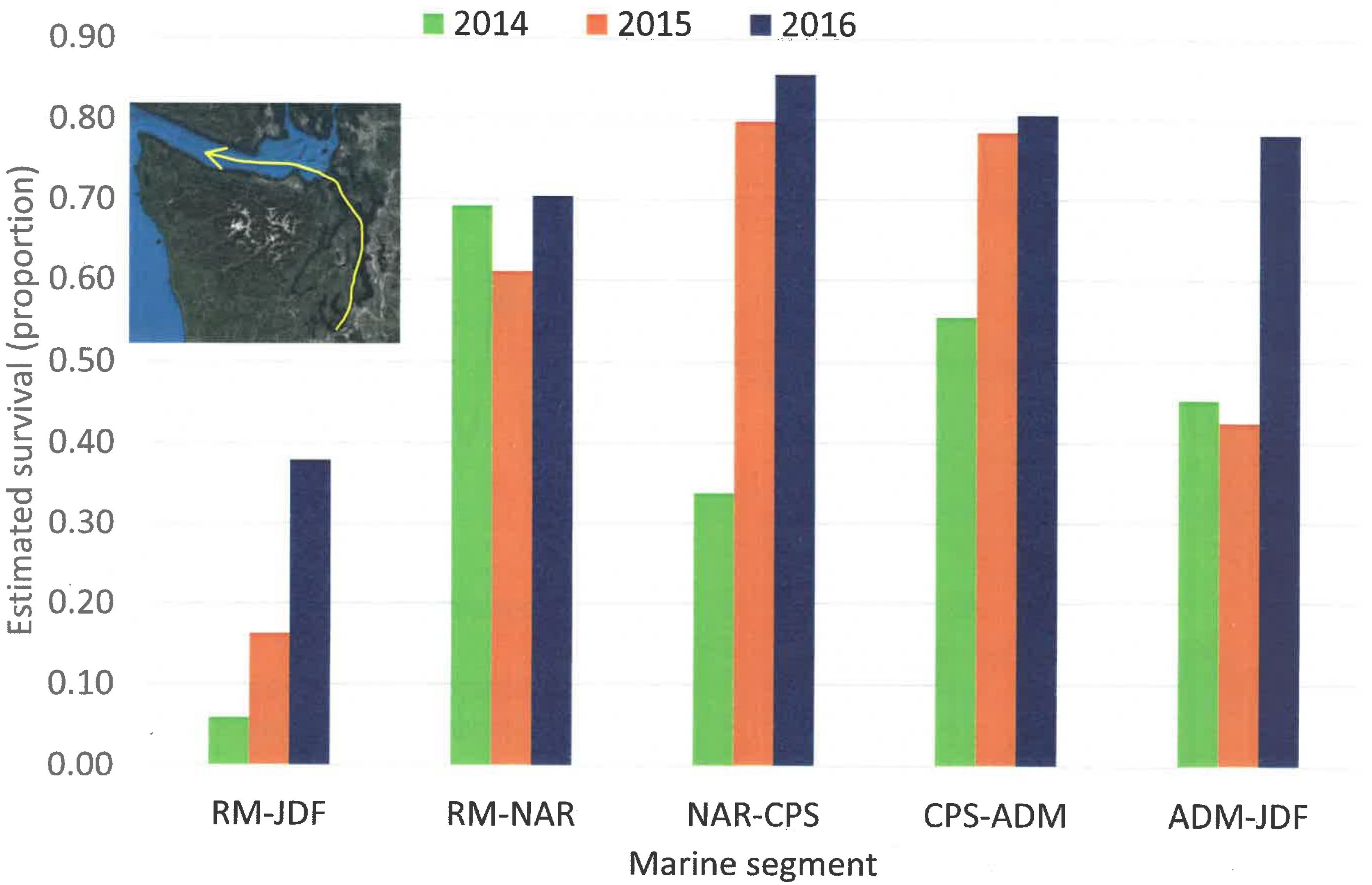
Puget Sound Steelhead Mortality



Steelhead and Seals



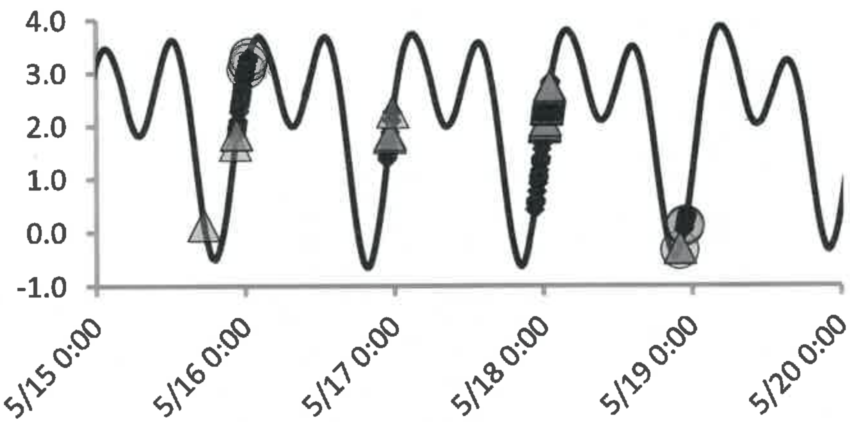
2014 -2016 Nisqually steelhead survival estimates



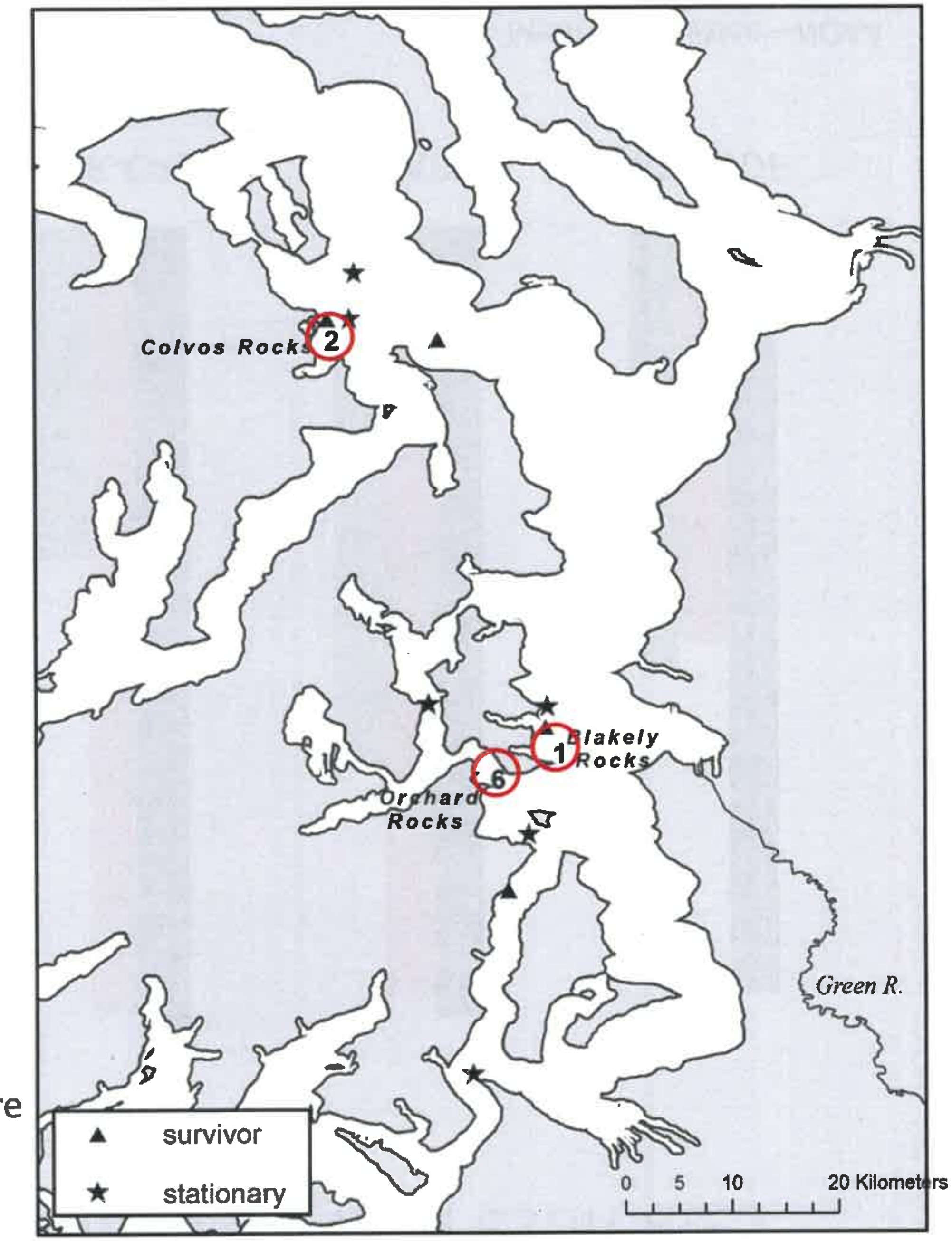
Moore, Berejikian – NOAA

2014 Results

- Stationary steelhead tags repeatedly detected by harbor seals at haulouts
- Tag detection patterns consistent with harbor seal movements



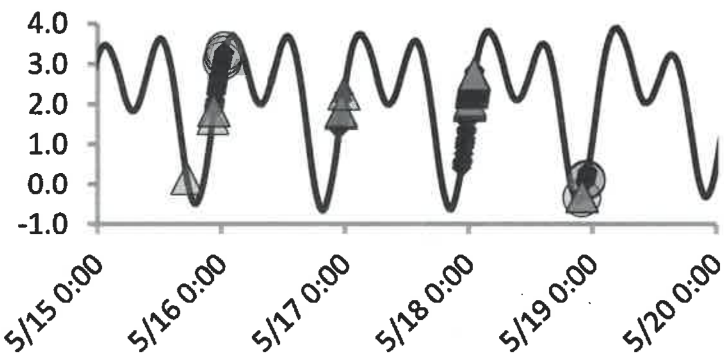
- Higher proportions of stationary tags and total seal-detected tags in Central Puget Sound where mortality was greatest

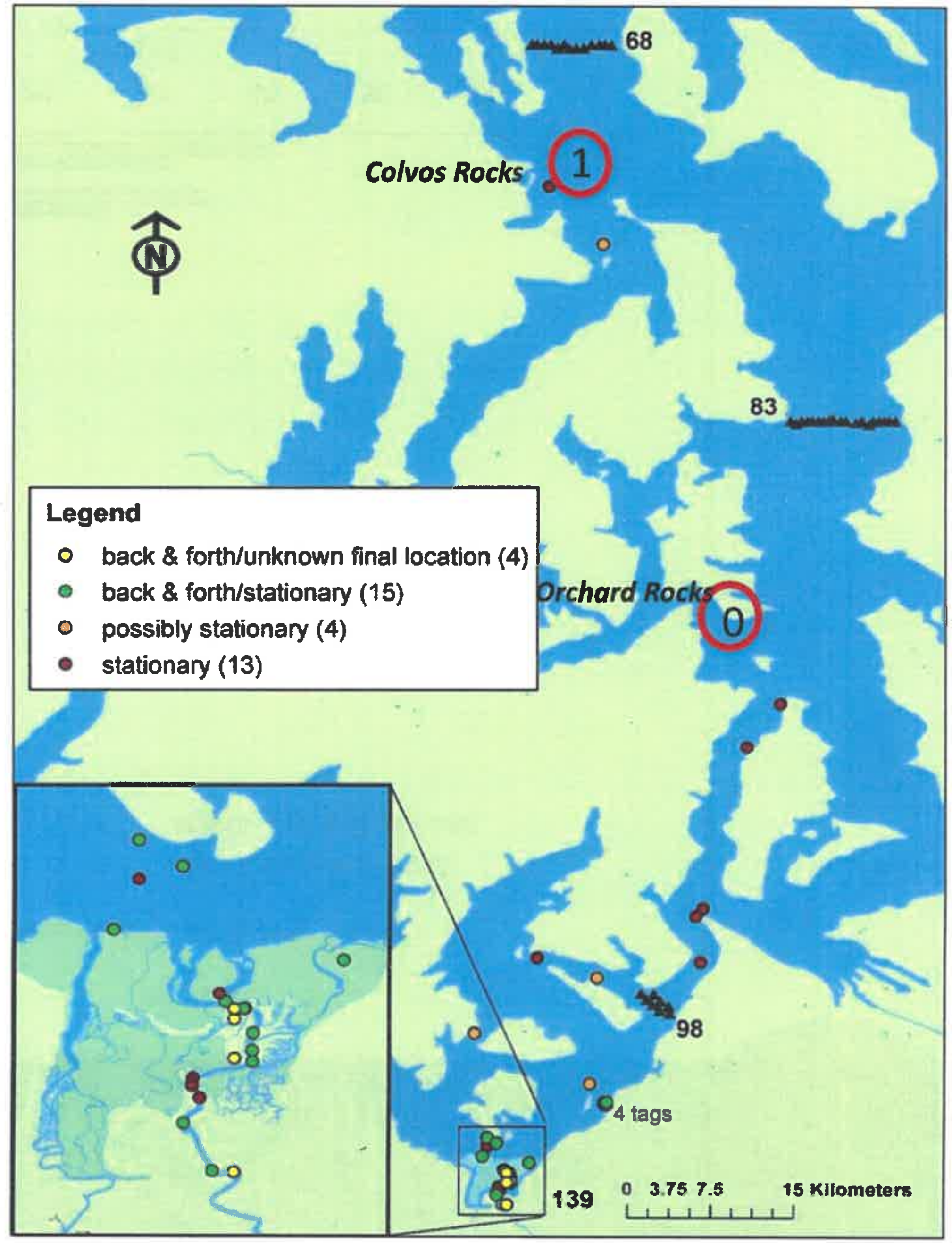


Berejikian et al. 2016. Mar. Ecol. Prog. Ser.

2016 Results

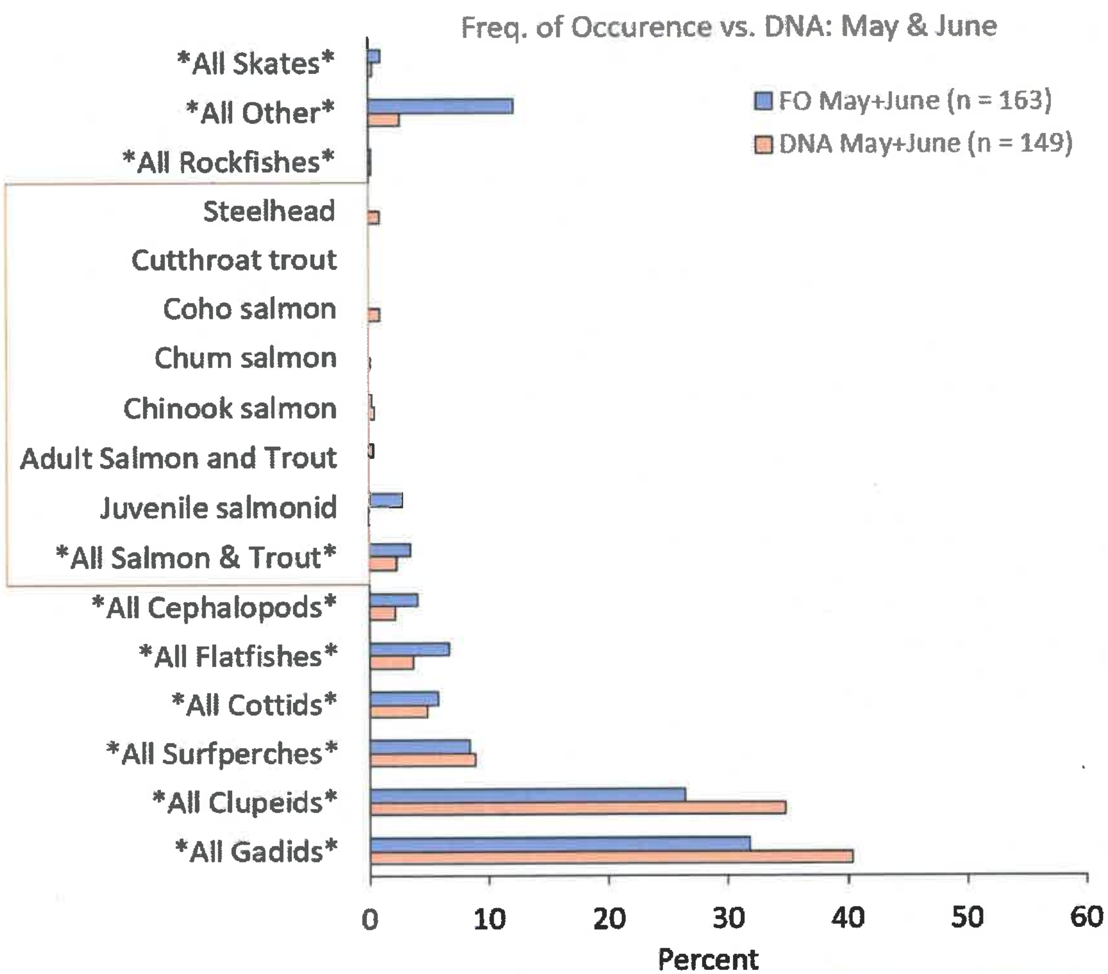
- No stationary steelhead tags detected by harbor seals at haulouts
- Tag detection patterns consistent with harbor seal movements in the Nisqually Estuary have increased





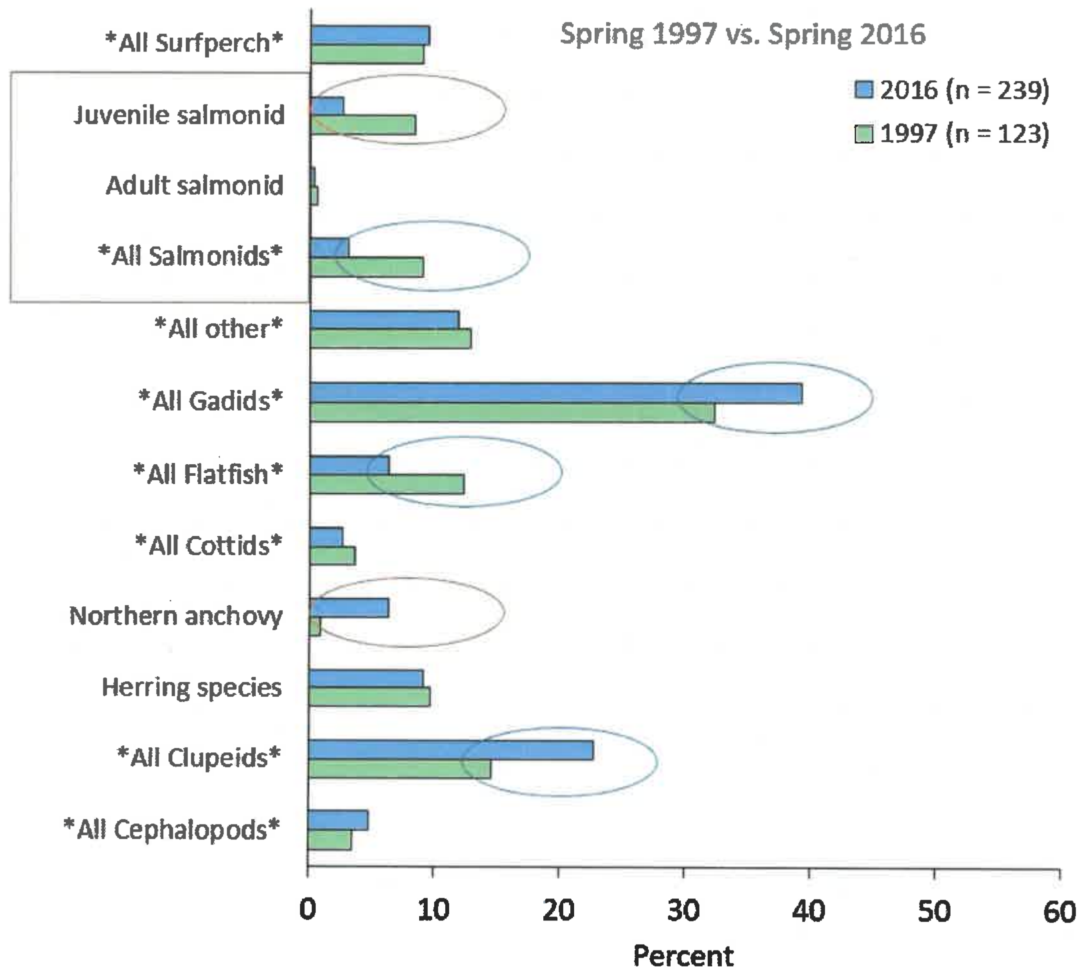
Berejikian et al. 2016. Mar. Ecol. Prog. Ser.

2016 Seal Scat Analysis Results

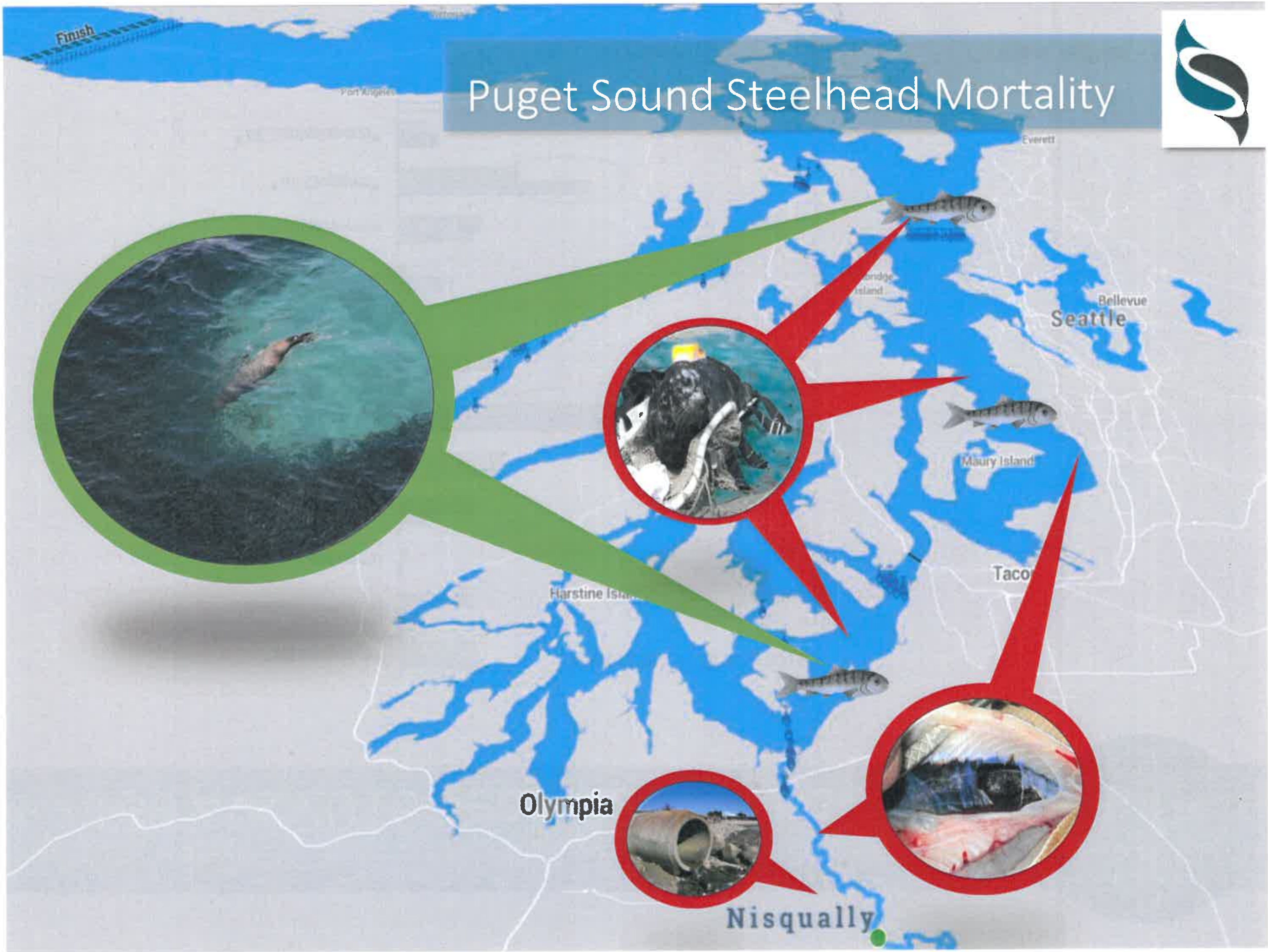


Thomas, Pearson, Jeffries – Smith Root, WDFW

1997 vs 2016 Seal Scat Analysis

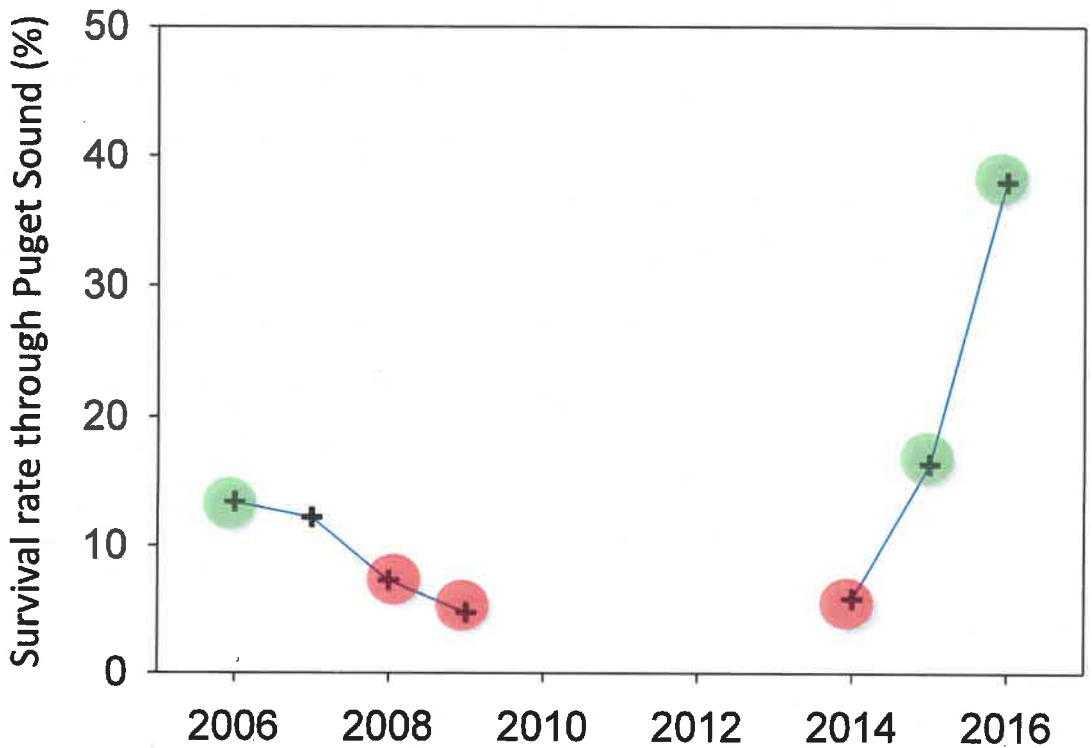


Pearson, Jeffries – WDFW

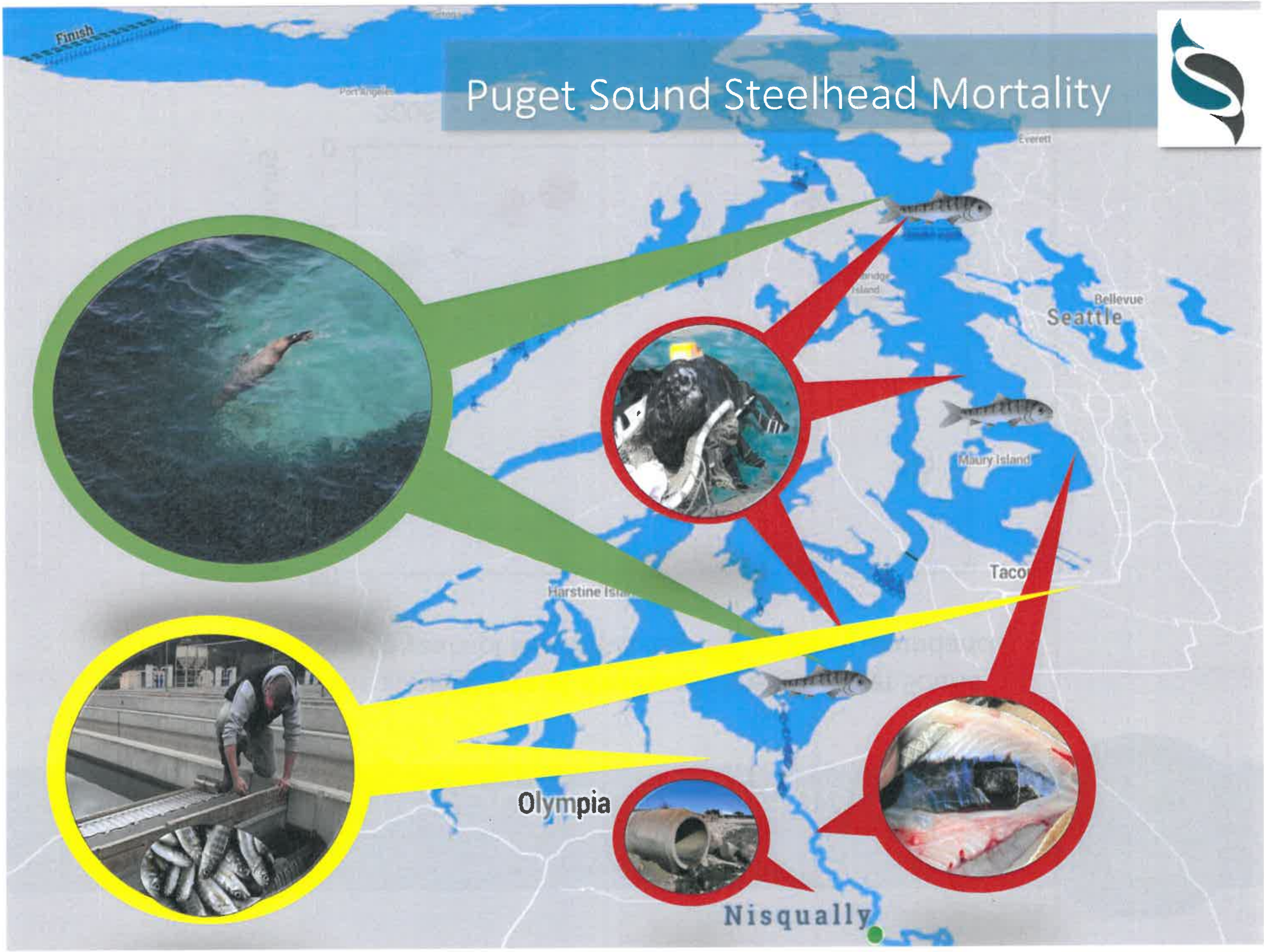

Puget Sound Steelhead Mortality
Finish
Port Angeles
Everett
Bellevue
Seattle
Maury Island
Olympia
Nisqually

Are Anchovies Buffering Predation?

Marine survival rate of steelhead through Puget Sound relative to years of low vs. high anchovy abundance



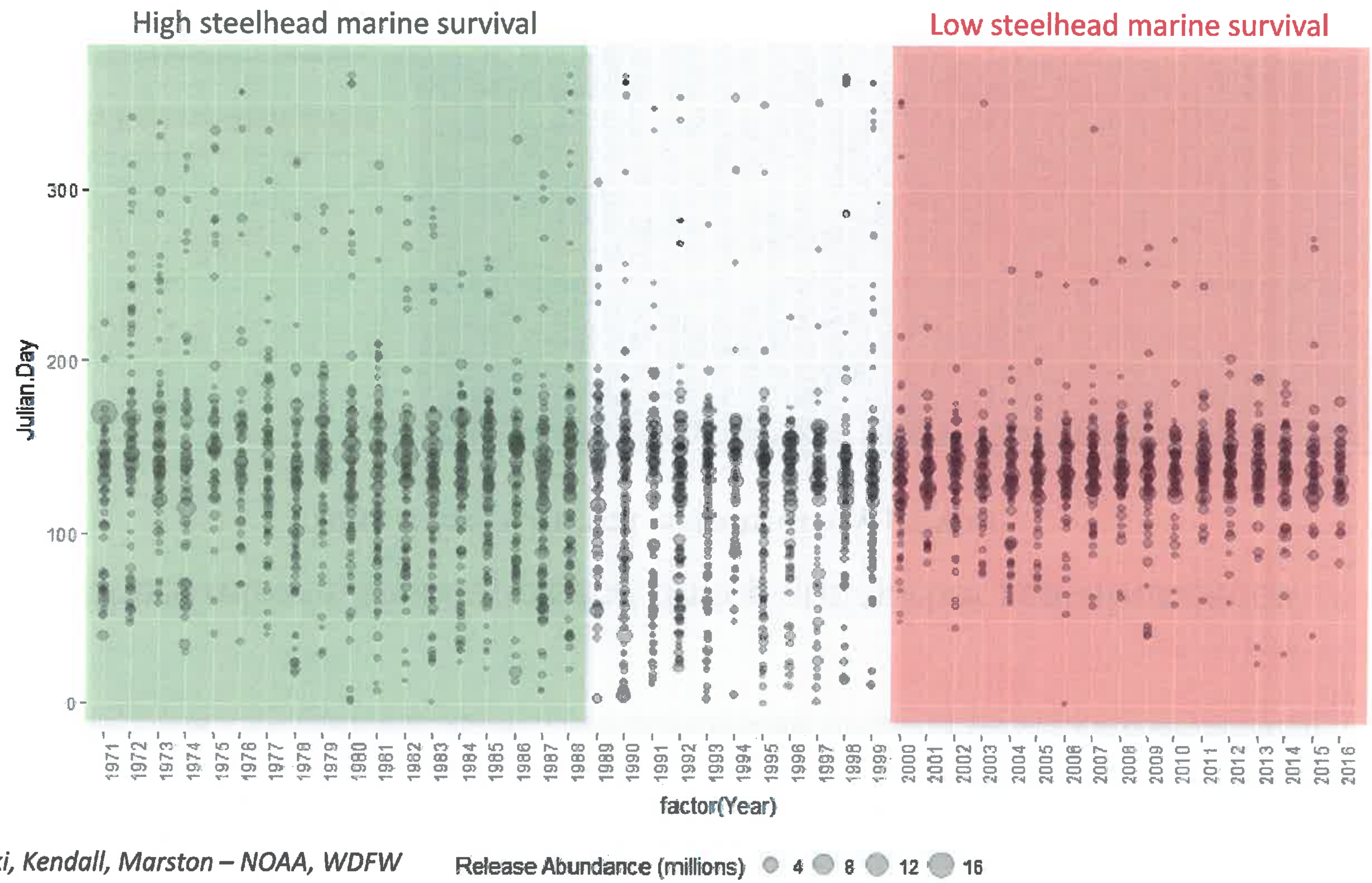
Moore, Duguid – NOAA, U. of Victoria



Puget Sound Steelhead Mortality
Finish
Port Angeles
Everett
Bellevue
Seattle
Maury Island
Taco
Harstine Isla
Olympia
Nisqually

Do Pulses of Hatchery Fish Attract or Buffer?

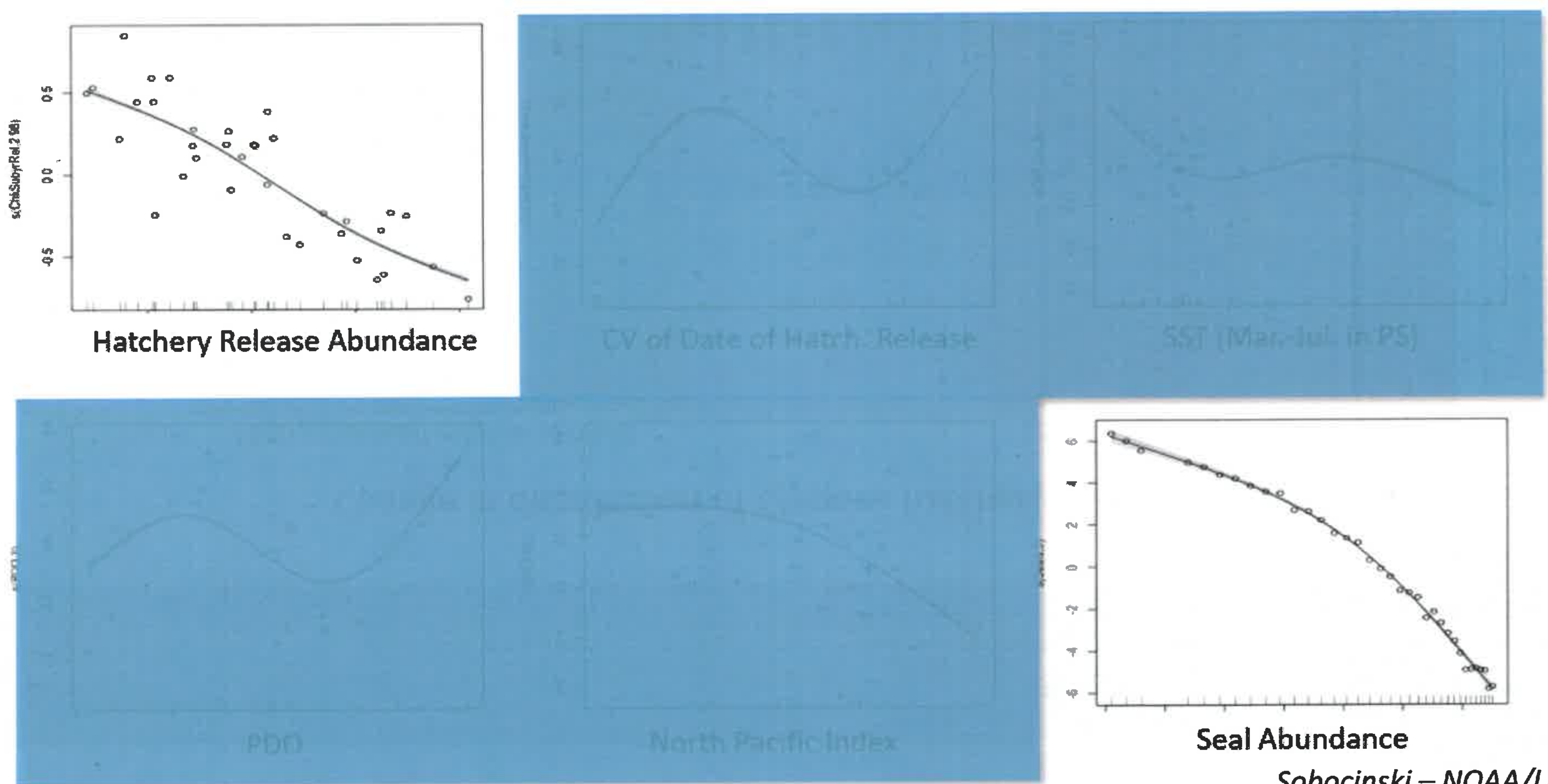
Change in distribution of Chinook hatchery releases by year



Sobocinski, Kendall, Marston – NOAA, WDFW

Ecosystem Indicators Analysis

Hatchery release abundance and timing and harbor seal abundance had the strongest explanatory power



Sobocinski – NOAA/LLTK

Summary

Fish Condition

1. Nanophyetus parasite at very high loads for Green and Nisqually River steelhead
2. Flame retardants high loads in Nisqually River
3. Omy05 (residency gene?) and other loci may be contributing

Predation

1. Seals are eating steelhead
2. Lower mortality in years with increased buffer prey (e.g. anchovies)
3. Questions regarding potential influence of Chinook/coho hatchery releases on predator behavior

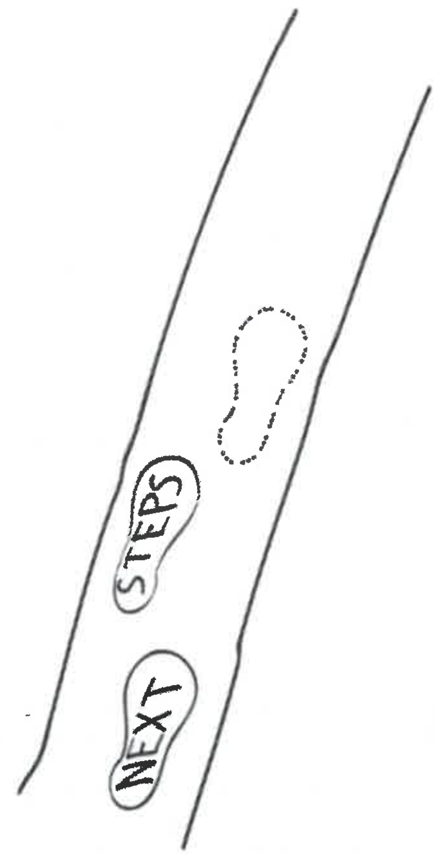
Next Steps

Obtain final funds Washington State legislature. Supplemental budget appropriation ($793k to WDFW)

Complete the final research

- Isolate source of flame retardants in Nisqually River.
- Confirm severity of nanophyetus and identify "hot spots" of parasite and host snail in rivers.
- Continue to assess seal and steelhead interactions.
- Assess potential influence of hatchery Chinook releases.

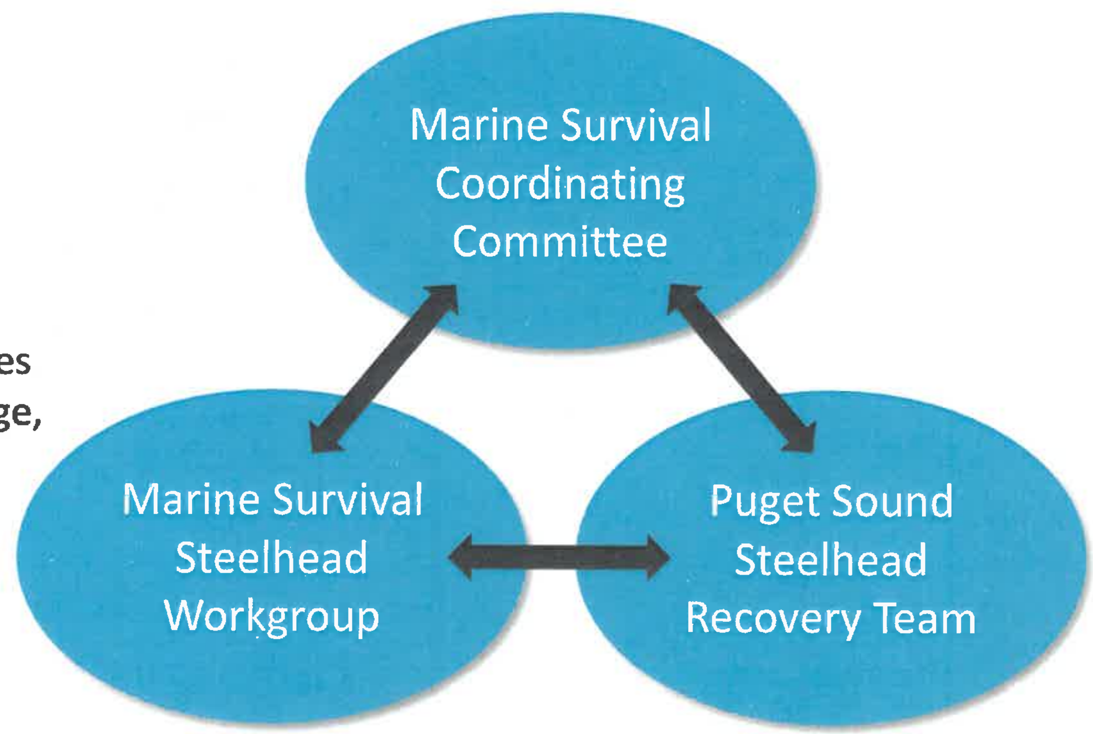
Incorporate results into Steelhead Recovery Plan and other management plans. Begin testing solutions



Example Actions*

*Dependent on study results

- Eliminate Nano parasite in hatcheries and manage host snail in rivers
- Remove sources of flame retardants
- Alter hatchery releases to discourage predation
- Address infrastructure that exacerbates predation (false haul-outs, locks, bridge, net pens, lighting)
- Address conflicts between marine mammal protection act and ESA
- Support forage fish recovery



Summary of Juvenile Steelhead use in Tributaries to the Sammamish River

Aaron Bosworth, Washington Department of Fish and Wildlife

January 8, 2018

Summary

Primary tributaries to the Sammamish River where steelhead might spawn include Swamp, North, Little Bear, Big Bear, Cottage Lake, and Issaquah Creeks. Available data suggests that steelhead generally do not spawn or rear in these streams. Very small numbers of adult steelhead (less than 5) may stray into these streams and spawn successfully in some years, but the Sammamish River tributaries do not currently support a viable steelhead population. Surveys are not conducted for adult steelhead spawners, but surveys for juvenile steelhead indicate that small numbers of juveniles are present in some streams in some years.

Adult Spawning Data

Adult spawning surveys for steelhead are not conducted in tributaries to the Sammamish River. Adult steelhead may stray into various Sammamish River tributaries in some years, but adults are not thought to spawn in these streams in large numbers. Sexually mature adfluvial rainbow trout from Lake Washington are known to migrate up the Sammamish River in the winter/spring. These adfluvial rainbows presumably spawn in Sammamish River tributaries and may produce juvenile rainbow trout.

Juvenile Use Data

There are two types of monitoring efforts that would detect juvenile steelhead in the Sammamish River tributaries: 1) Smolt trap data from the Big Bear Creek smolt trap, and 2) Electro-fishing data from King County monitoring efforts.

1) Smolt trap data from the Big Bear Creek smolt trap

A smolt trap located near the mouth of Big Bear Creek is operated from mid-January through mid-June each year by WDFW. The primary goal of the trap is to estimate annual Chinook production, but all species are caught and enumerated. Steelhead smolts are not encountered at the trap in most years. In years when smolts are encountered, the number of individuals encountered is very small (Table 1).

Table 1. Smolt Trap Data from Big Bear Creek. Steelhead smolts encountered at the Big Bear Creek smolt trap from 2006 to 2016.

Smolt Trap Year, or Year of Out-Migration	Steelhead Smolts Sampled	Comments
2006	0	
2007	1	no length
2008	1	no length
2009	0	
2010	0	
2011	0	
2012	0	
2013	0	
2014	0	
2015	0	
2016	2	192mm and 258mm in length

2) Electro-fishing data from King County small streams monitoring

King County conducted annual electrofishing surveys for 5 consecutive years (2009-2013) at a number of different sites in the Issaquah Creek basin and in tributaries to the Sammamish River (Figure 1). Fifteen sites in the Sammamish River tributaries were monitored (Table 2) and thirteen sites in the Issaquah Creek basin were monitored (Table 3). Few rainbow trout were observed in any of these surveys. In the 15 sites located in the Sammamish River tributaries 1,390 juvenile coho and 6,643 cutthroat trout were captured during the 5-year sampling period while only 9 rainbow trout (1 in North Creek and 8 in Bear Creek) were observed (Table 2). In the 13 sites located in the Issaquah Creek basin 2,736 juvenile coho and 4,281 cutthroat trout were captured during the 5-year sampling period while only 3 rainbow trout were observed (Table 3).

Table 2. Salmonid species sampled during annual electro-fishing surveys conducted annually from 2009-2013 (5 sampling years) in Sammamish River tributaries.

Basin	Creek	Site #	Coho	Cutthroat	Rainbow	Unid trout
Big Bear	Bear Creek	1	7	63	0	4
	Bear Creek	2	123	127	0	3
	Bear Creek	3	19	61	8	11
	Bear Creek	4	17	116	0	3
	Evans Creek	1	4	333	0	18
	Cottage Lake Creek	1	53	224	0	5
	Mackey Creek	1	0	616	0	13
Little Bear	Little Bear Creek	1	18	431	0	17
	Little Bear Creek	2	40	589	0	13
North	North Creek	1	373	537	0	23
	North Creek	2	1	143	1	0
	North Creek	3	510	670	0	36
	Sitka Creek	1	55	564	0	12
Swamp	Scriber Lake Creek	1	120	617	0	2
	Swamp Creek	1	50	1552	0	0
Totals			1,390	6,643	9	160

Table 3. Salmonid species sampled during annual electro-fishing surveys conducted annually from 2009-2013 (5 sampling years) in the Issaquah Creek basin.

Basin	Creek	Site #	Coho	Cutthroat	Rainbow	Unid trout
Issaquah	Issaquah Creek	1	228	82	1	8
	Issaquah Creek	2	95	302	0	24
	Issaquah Creek	3	64	177	0	25
	Issaquah Creek	4	103	76	1	1
	Issaquah Creek	5	235	480	0	47
	Issaquah Creek	6	57	26	1	0
	East Fork Issaquah	1	283	564	0	126
	East Fork Issaquah	2	962	645	0	109
	East Fork Issaquah	3	491	459	0	127
	East Fork Tributary	1	0	490	0	31
	Holder Creek	1	0	137	0	10
	Carey Creek	1	127	309	0	108
	Carey Creek	2	91	534	0	47
Totals			2,736	4,281	3	663

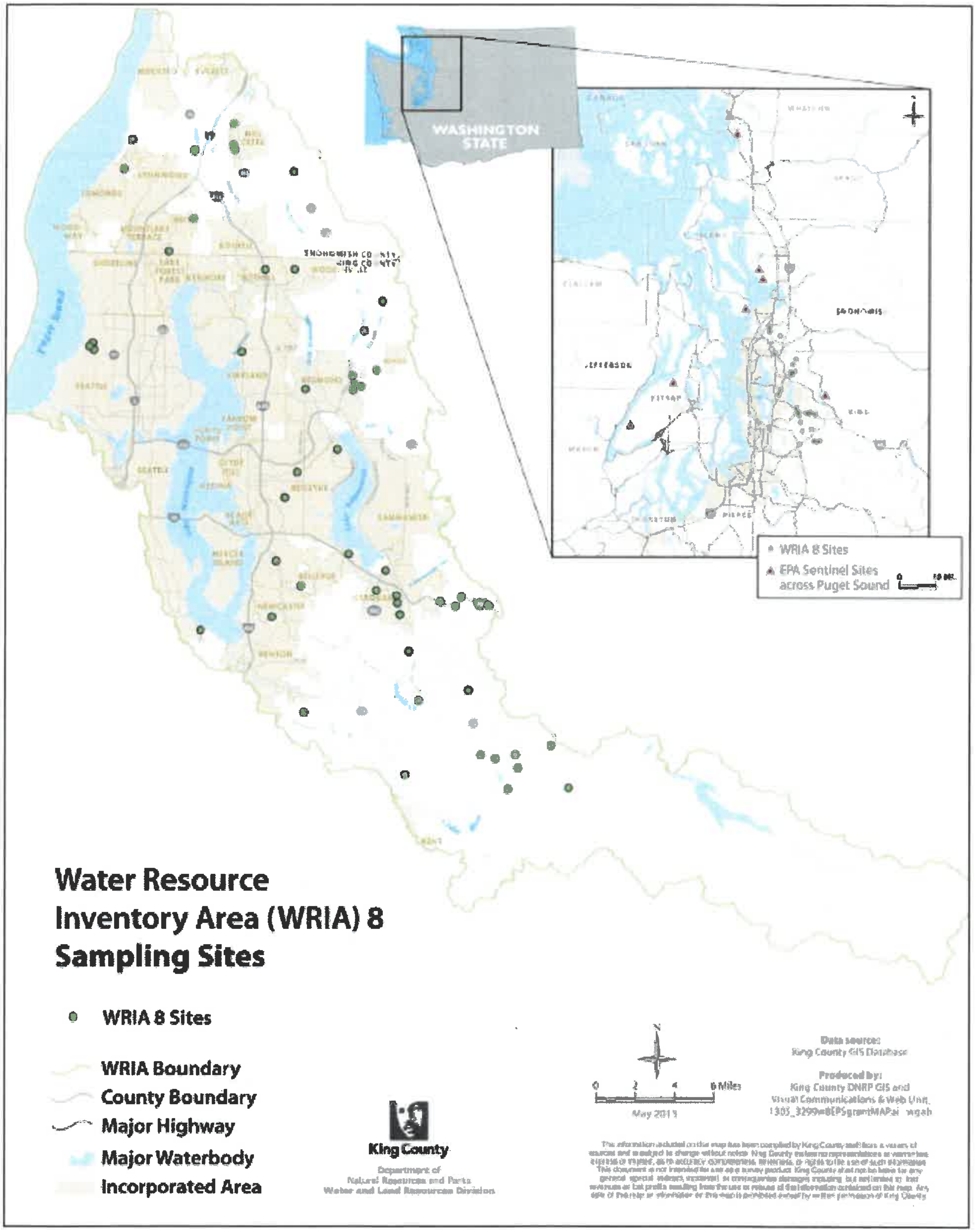


Figure 1. Map of King County electro-fishing sampling locations.

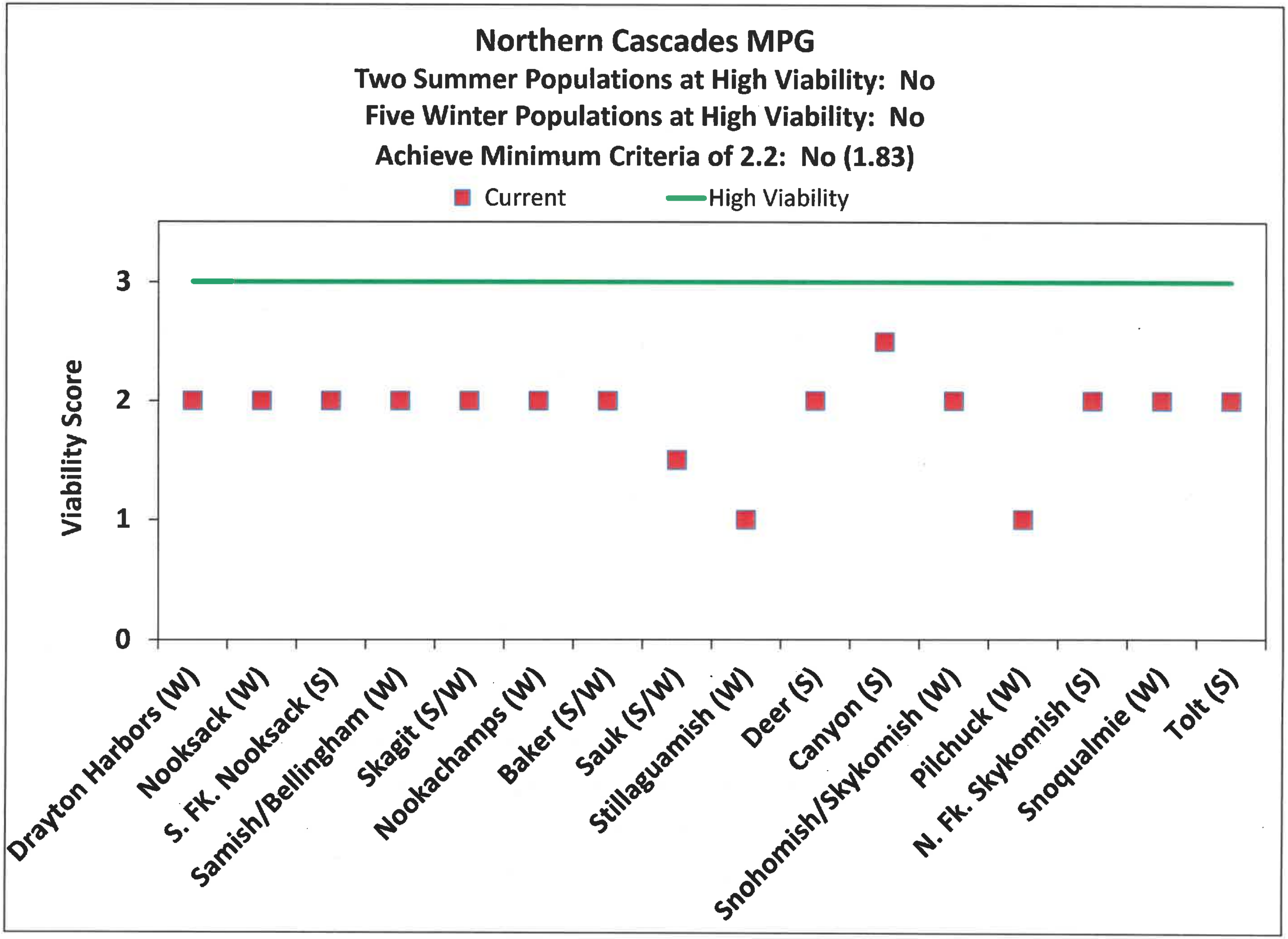

Northern Cascades MPG
Two Summer Populations at High Viability: No
Five Winter Populations at High Viability: No
Achieve Minimum Criteria of 2.2: No (1.83)
Current
High Viability
Viability Score
3
2
1
0
Drayton Harbors (W)
Nooksack (W)
S. FK. Nooksack (S)
Samish/Bellingham (W)
Skagit (S/W)
Nookachamps (W)
Baker (S/W)
Sauk (S/W)
Stillaguamish (W)
Deer (S)
Canyon (S)
Snohomish/Skykomish (W)
Pilchuck (W)
N. Fk. Skykomish (S)
Snoqualmie (W)
Tolt (S)

Table 1. Factors to consider in the designation of Northern Cascades populations as Primary, Contributing, or Stabilizing.
Draft: January 17, 2018

Population or Watershed	Run Type	NOAA Intrinsic Potential (IP) [1/]	Average Spawners (2007-2016)	NOAA Viability Assessment P(Viable) [2/]	Past Segregated Hatchery Gene Flow [3/]	% Public Land	Hydrology [4/]
Drayton Harbor	Winter	4,852	Not Available	Moderate	-	< 1%	100% Lowland
Nooksack	Winter	44,091	1,680	Moderate	1% (W) 0% (S)	40%	31% Lowland 22% Highland 17% Snow
S.F. Nooksack	Summer	2,273	Not Available	Moderate	0% (W) 0% (S)	59%	41% Snow 30% Highland 23% Rain & Snow
Samish/ Bellingham	Winter	6,386	854	Moderate	5% (W) 0% (S)	19%	50% Lowland 41% Rain
Skagit	Summer/Winter	129,551	6,163	Moderate	4% (W) 1% (S)	61%	47% Highland 18% Snow 13% Rain & Snow
Nookachamps	Winter	2,462		Moderate	2% (W) 0% (S)	31%	45% Lowland 40% Rain
Baker [5/]	Summer/Winter	10,056		Moderate	-	90%	46% Highland 22% Snow 19% Rain
Sauk	Summer/Winter	46,460		Low-Moderate	3% (W) 0% (S)	94%	54% Highland 21% Snow
Stillaguamish	Winter	38,236	1,746	Low	1% (W) 17% (S)	59%	35% Rain 33% Lowland 14% Rain & Snow
Deer	Summer	3,144	Not Available	Moderate	0% (W) 0% (S)	70%	44% Snow 28% Rain & Snow
Canyon	Summer	243	Not Available	Moderate-High	0% (W) 0% (S)	62%	44% Snow 36% Rain & Snow

Table 1. Factors to consider in the designation of Northern Cascades populations as Primary, Contributing, or Stabilizing (cont.)
Draft: January 17, 2018

Population or Watershed	Run Type	NOAA Intrinsic Potential (IP) 1/	Average Spawners (2007-2016)	NOAA Viability Assessment P(Viable) 2/	Past Segregated Hatchery Gene Flow 3/	% Public Land	Hydrology 4/
Snohomish/ Skykomish	Winter	42,779	1,029	Moderate	0% (W) 5% (S)	79%	45% Lowland 21%Rain 13% Rain & Snow
Pilchuck	Winter	10,386	720	Low	2% (W) 2% (S)	35%	56% Lowland 35% Rain
N.F. Skykomish	Summer	1,325	39 6/	Moderate	1% (W) 95% (S)	100%	61% Highland 27% Snow
Snoqualmie	Winter	33,479	812	Moderate	4% (W) 3% (S)	56%	28% Rain 24% Lowland 18% Highland
Tolt	Summer	641	82	Moderate	0% (W) 68% (S)	42%	31% Snow 31% Rain & Snow 26% Rain

1/ Source: Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Table B-1, Puget Sound Technical Recovery Team 2013.

2/ Source: Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Fig. 57, Puget Sound Technical Recovery Team 2013.

3/ Estimates of PEHC are for historical segregated programs and do not generally reflect program changes implemented with approved Hatchery Genetic Management Plans.

4/ Source: Identifying Historical Populations of Steelhead Within the Puget Sound Distinct Population Segment, Appendix 4, Puget Sound Technical Recovery Team 2013.

5/ Regarding this historical population, the TRT states "Many of the TRT members and reviewers considered the Baker River DIP to have been extirpated, although resident *O. mykiss* in the Baker River Basin may retain some of the historical genetic legacy of this population." Identifying Historical Populations of Steelhead Within the Puget Sound Distinct Population Segment, page 74, Puget Sound Technical Recovery Team 2013.

6/ Infrequent and incomplete surveys likely result in an underestimate of spawners.

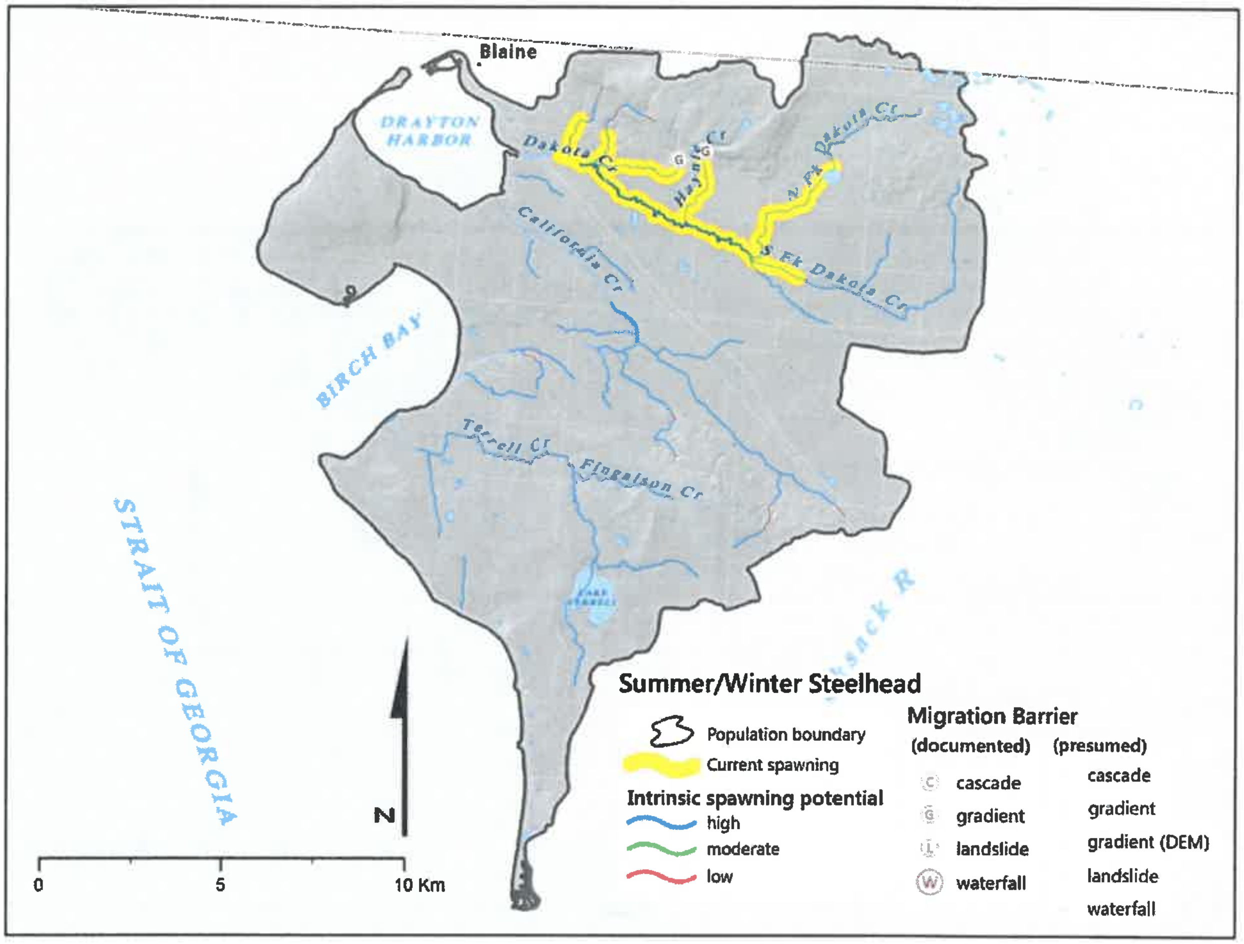


Figure E-2. Map of Drayton Harbor Tributaries Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

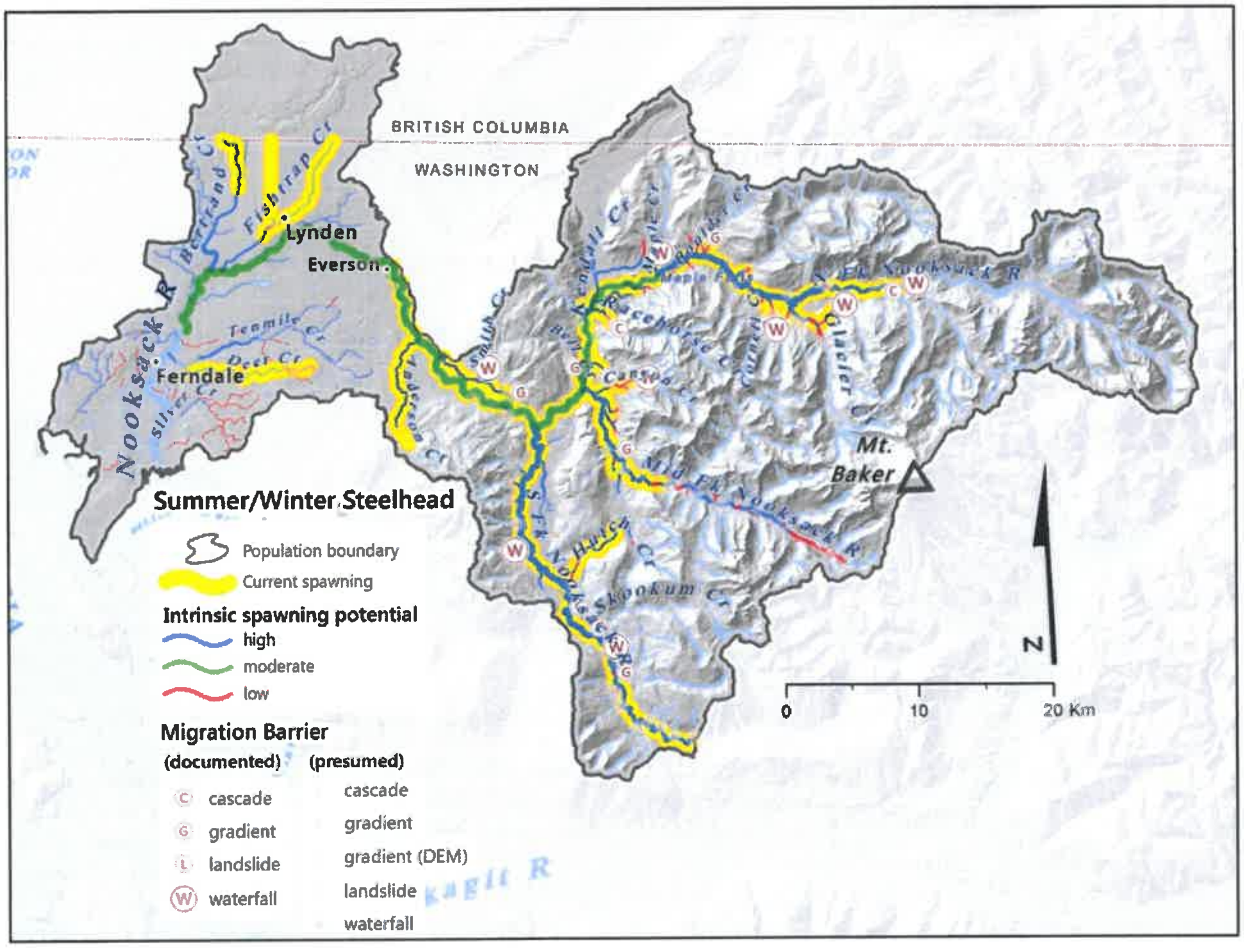


Figure E-5. Map of Nooksack River Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

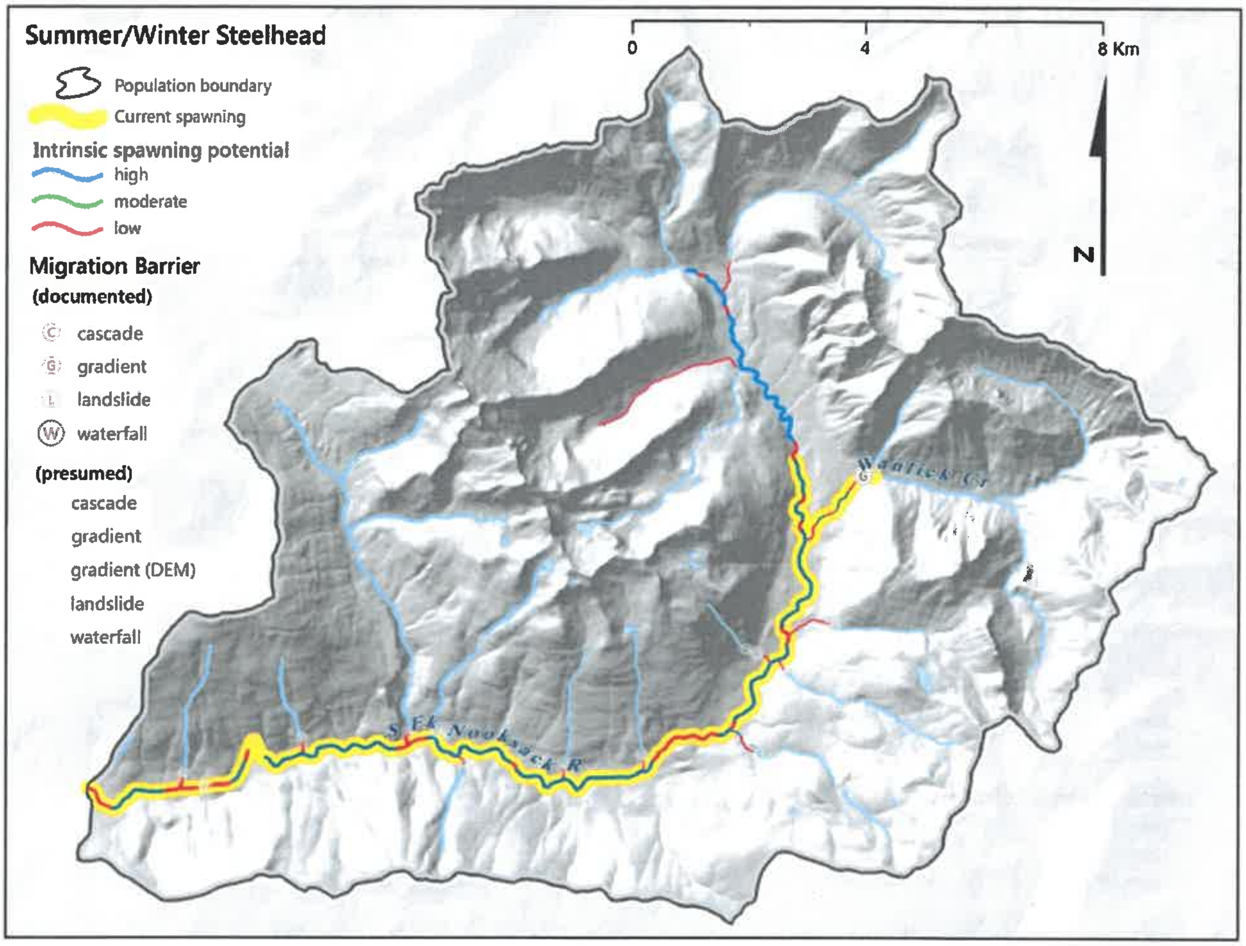


Figure E-8. Map of South Fork Nooksack River Summer-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

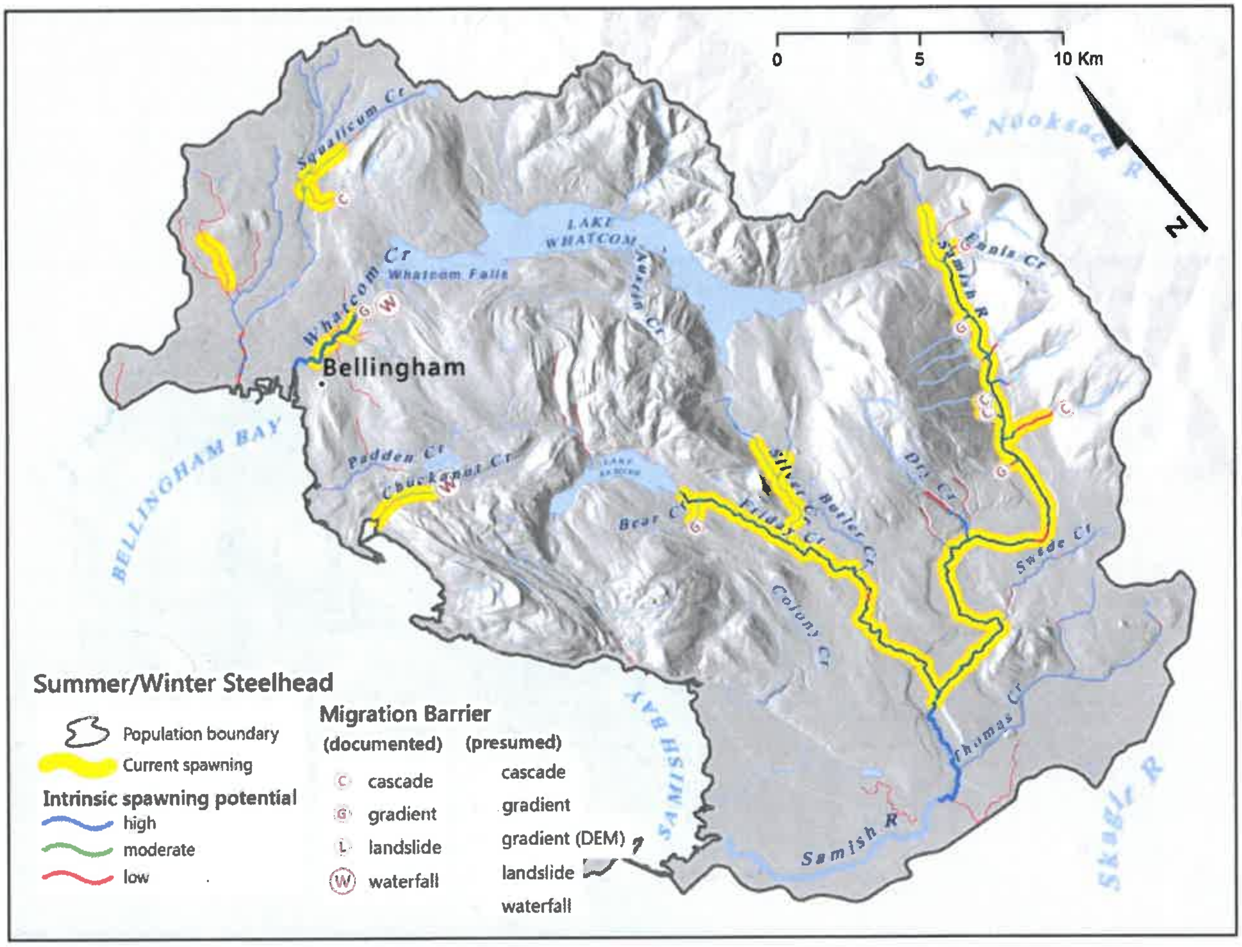


Figure E-11. Map of Samish River and Bellingham Bay Tributaries Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

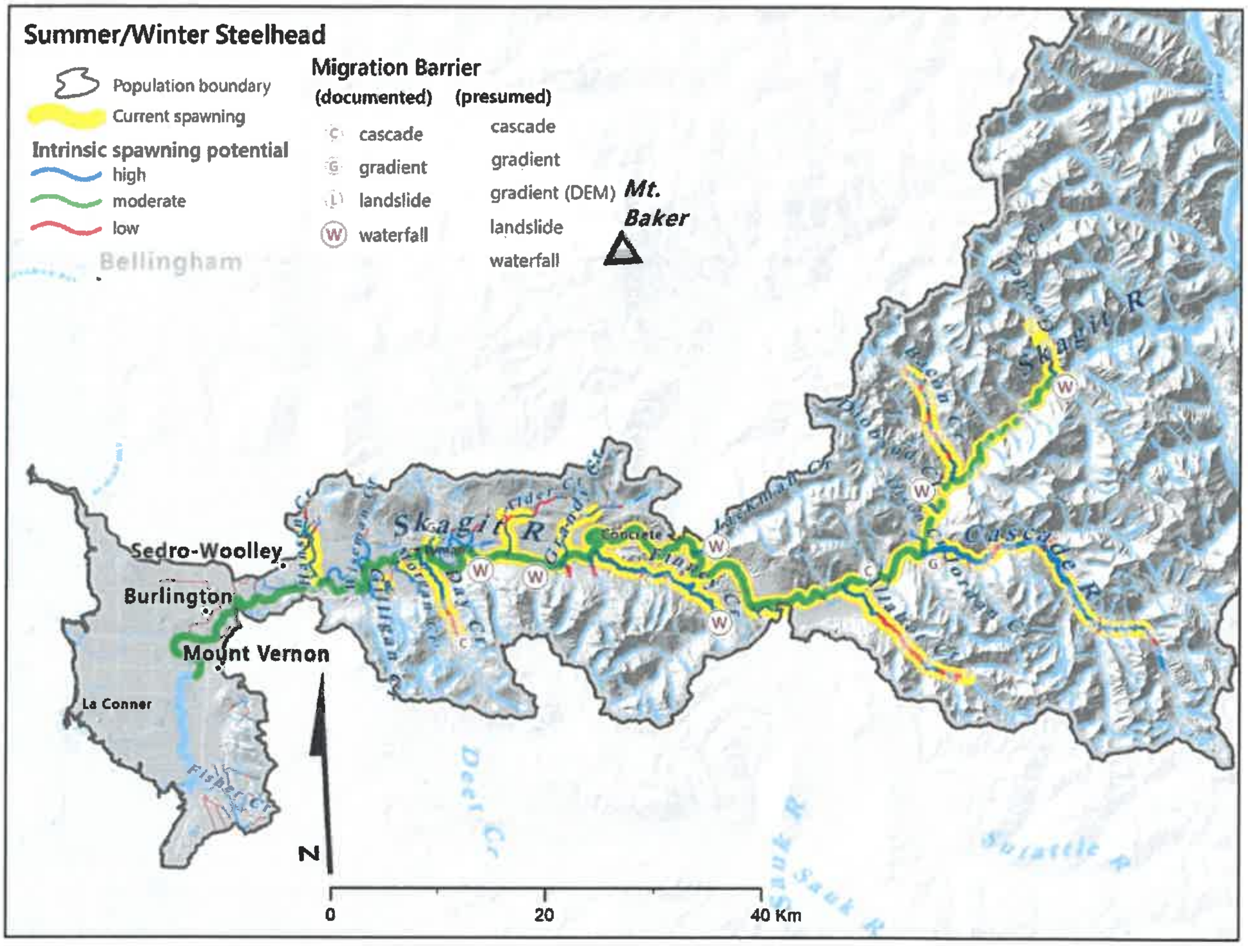


Figure E-14. Map of Skagit River Summer-Run and Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

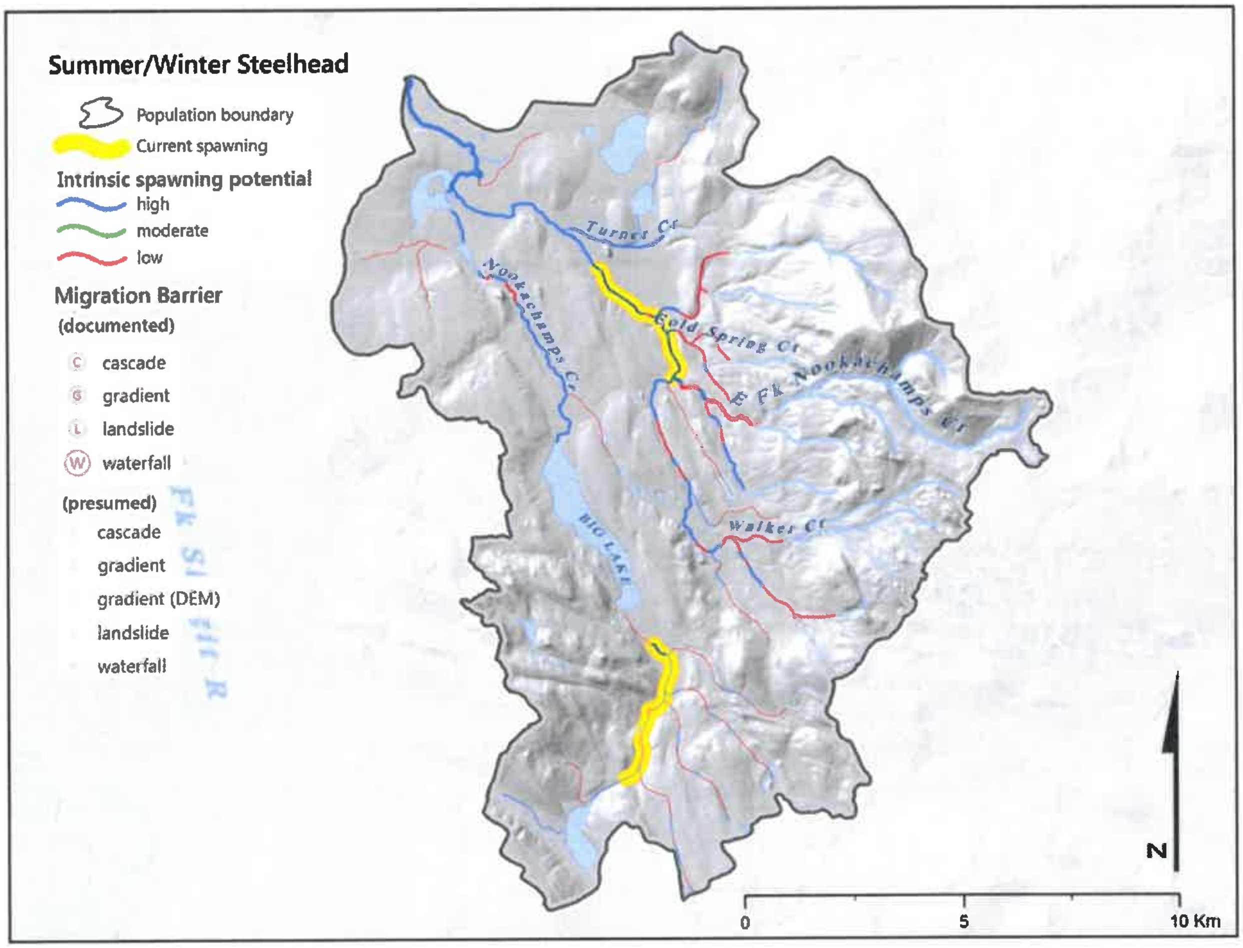


Figure E-17. Map of Nookachamps Creek Winter-Run population spatial structure, including migration barriers and spawning potential

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

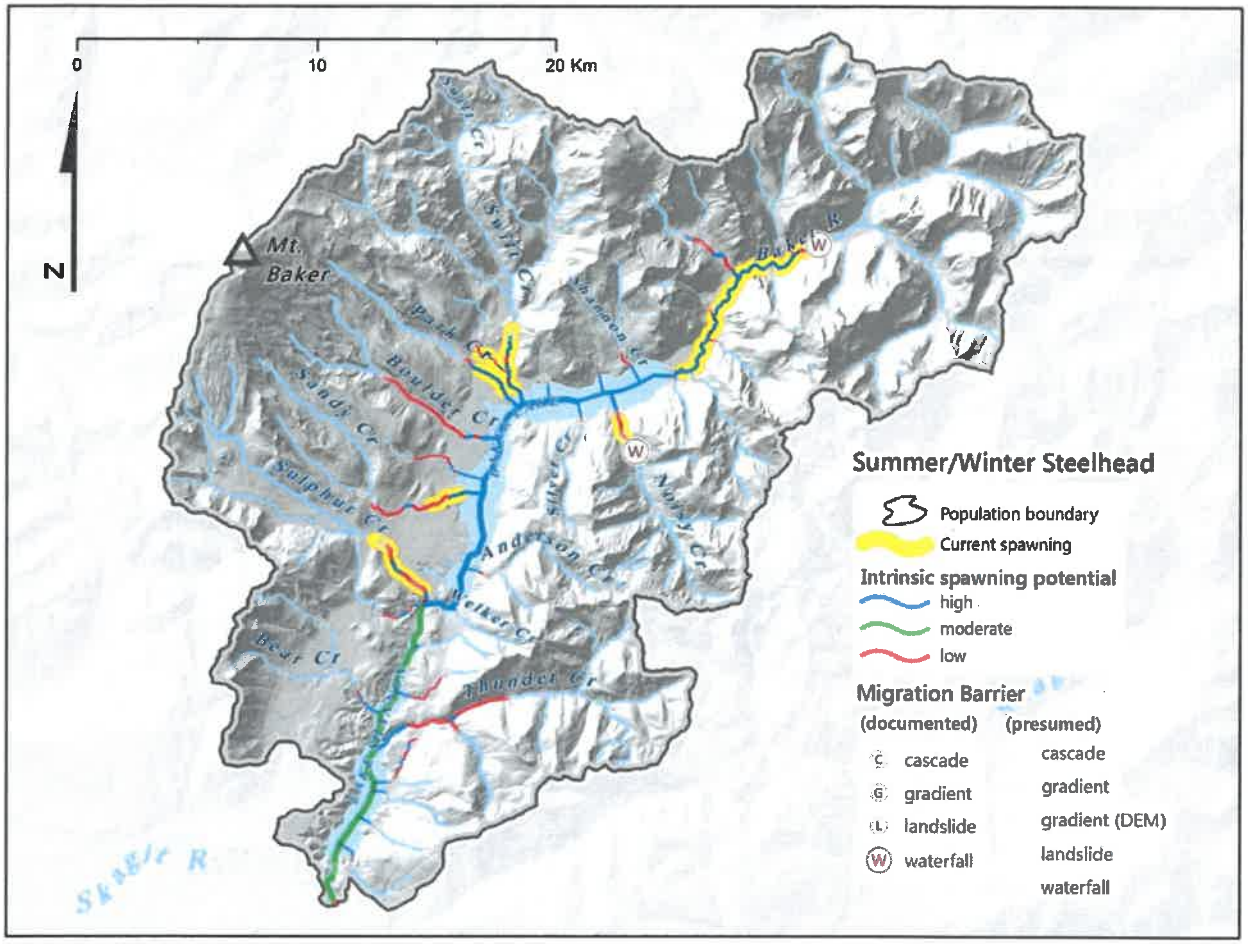


Figure E-20. Map of Baker River Summer-Run and Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

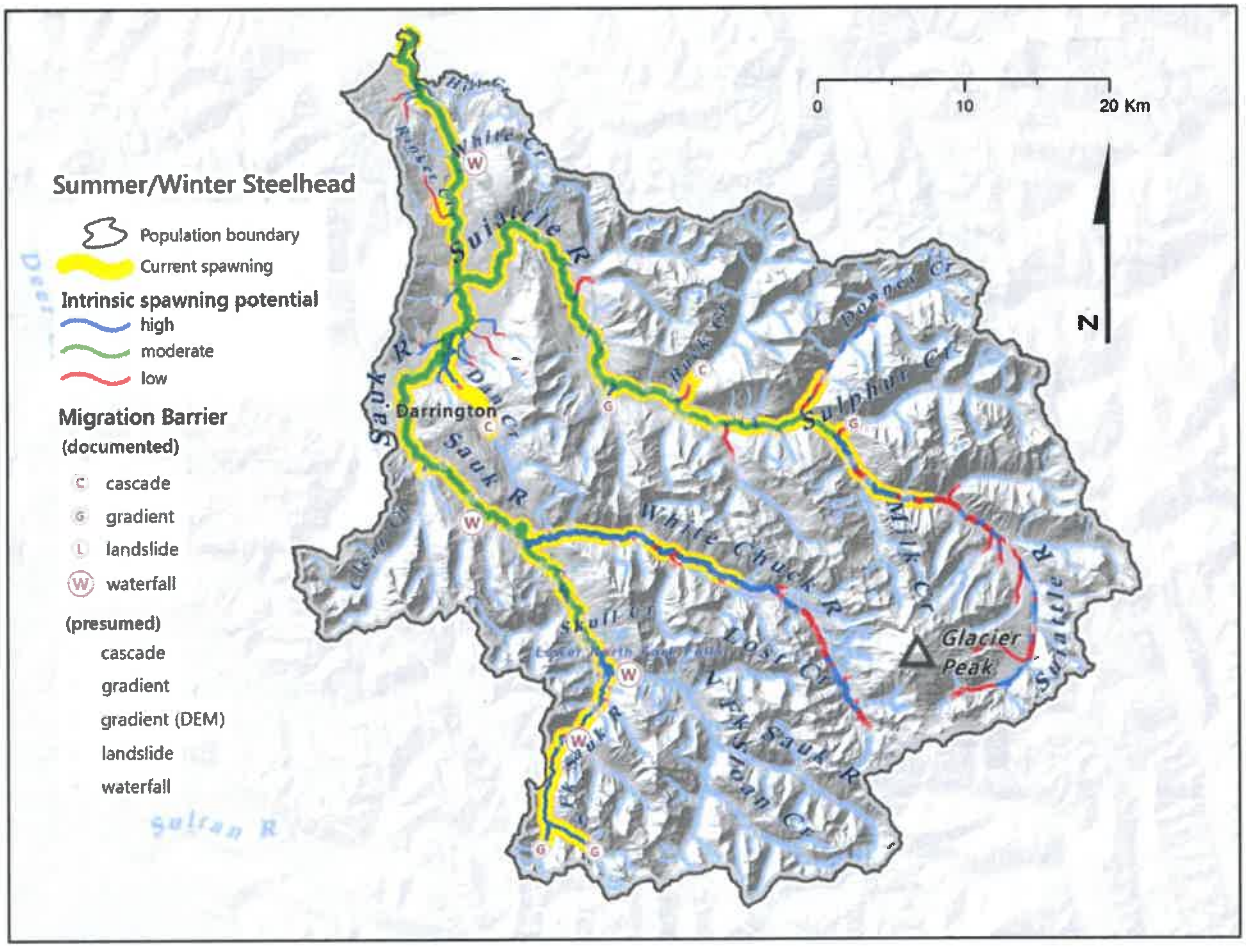


Figure E-23. Map of Sauk River Summer-Run and Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

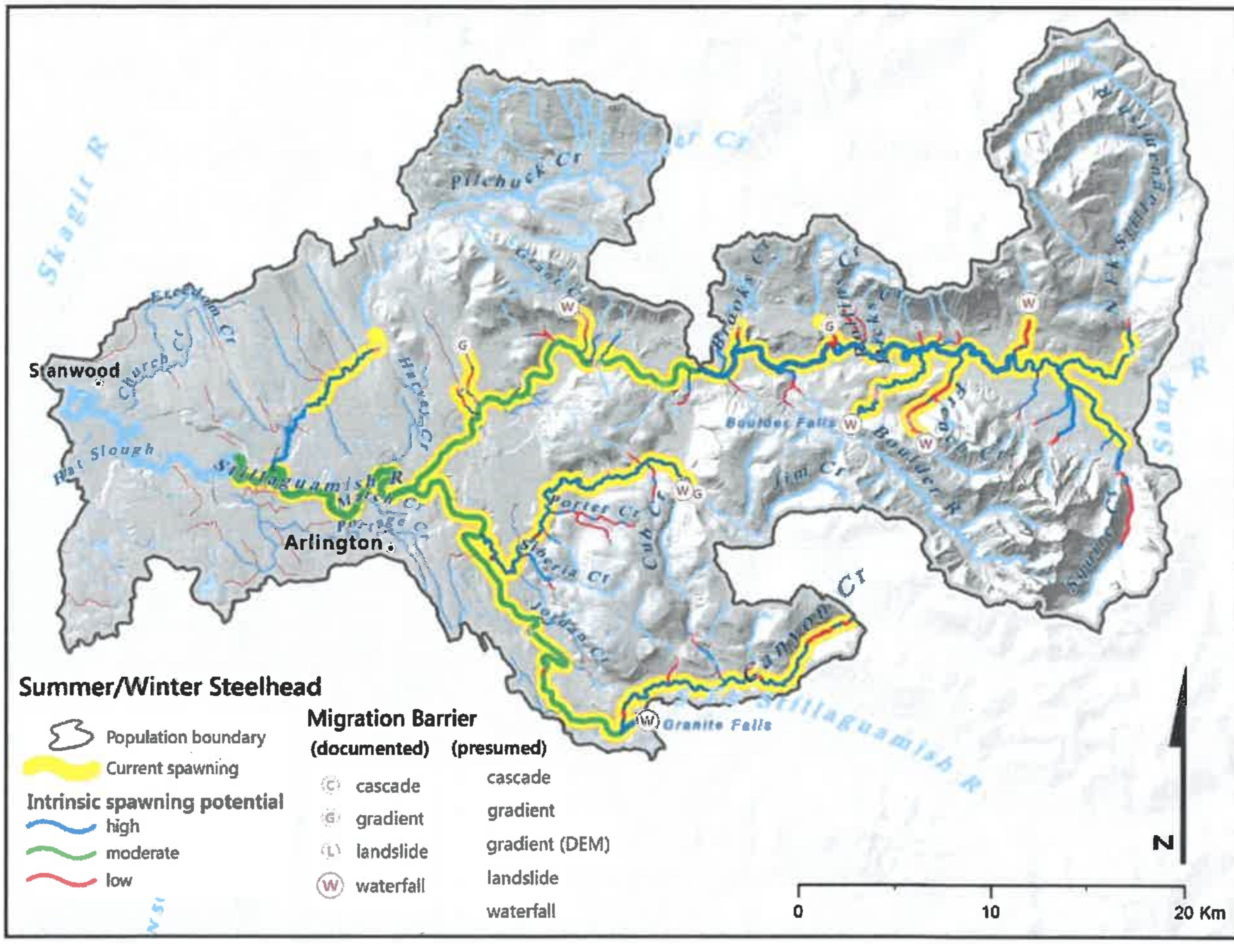


Figure E-26. Map of Stillaguamish River Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

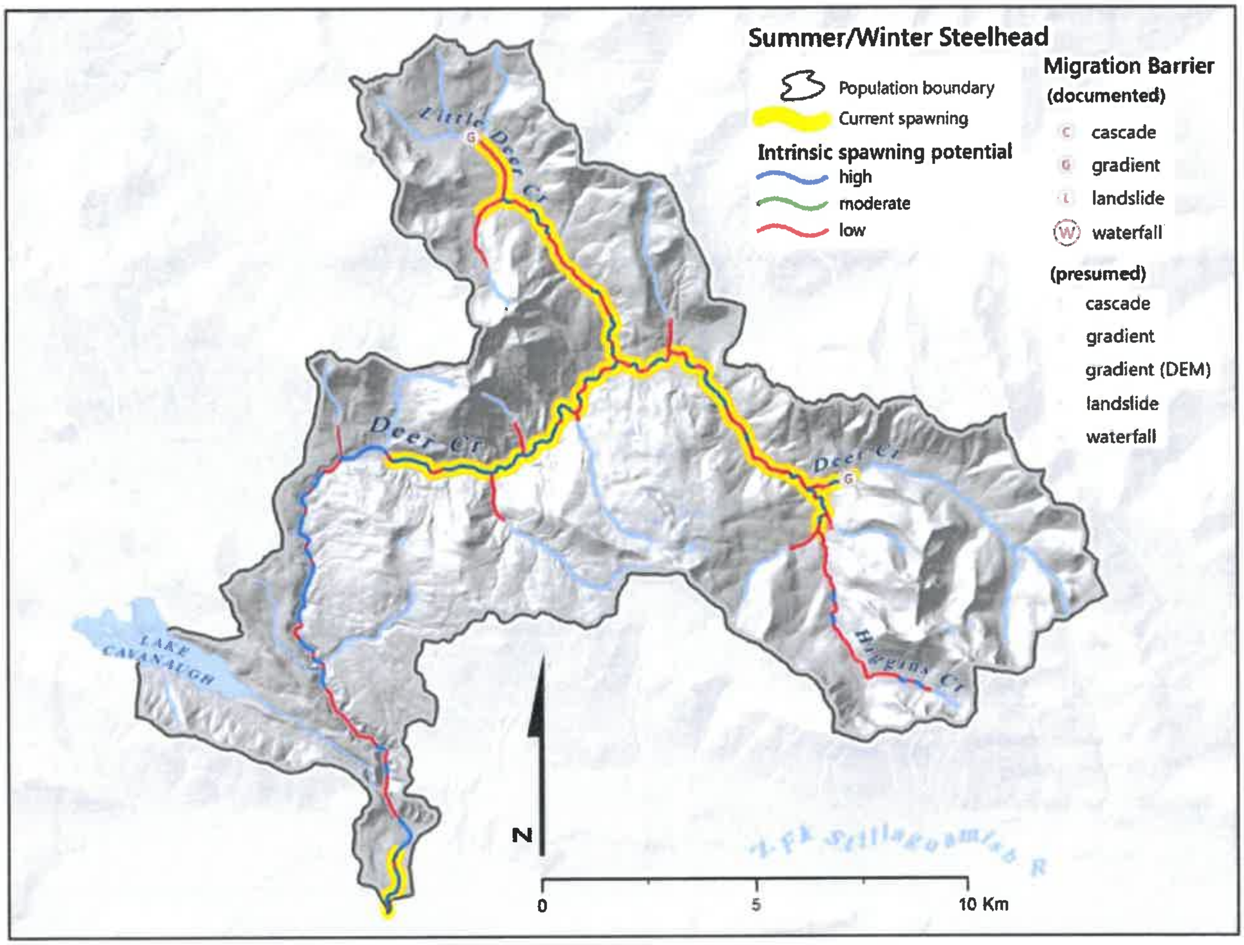


Figure E-31. Map of Deer Creek Summer-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

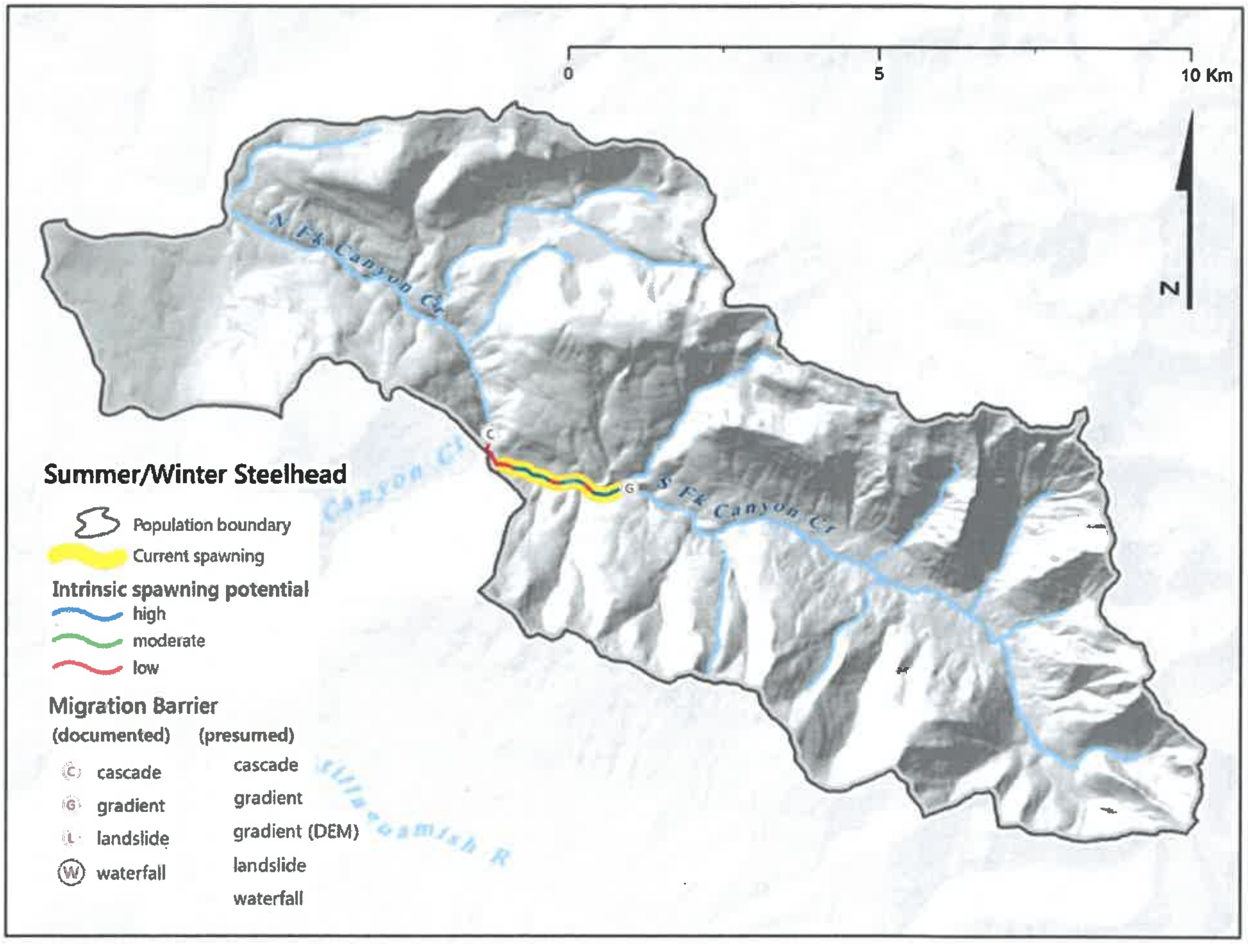


Figure E-34. Map of Canyon Creek Summer-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

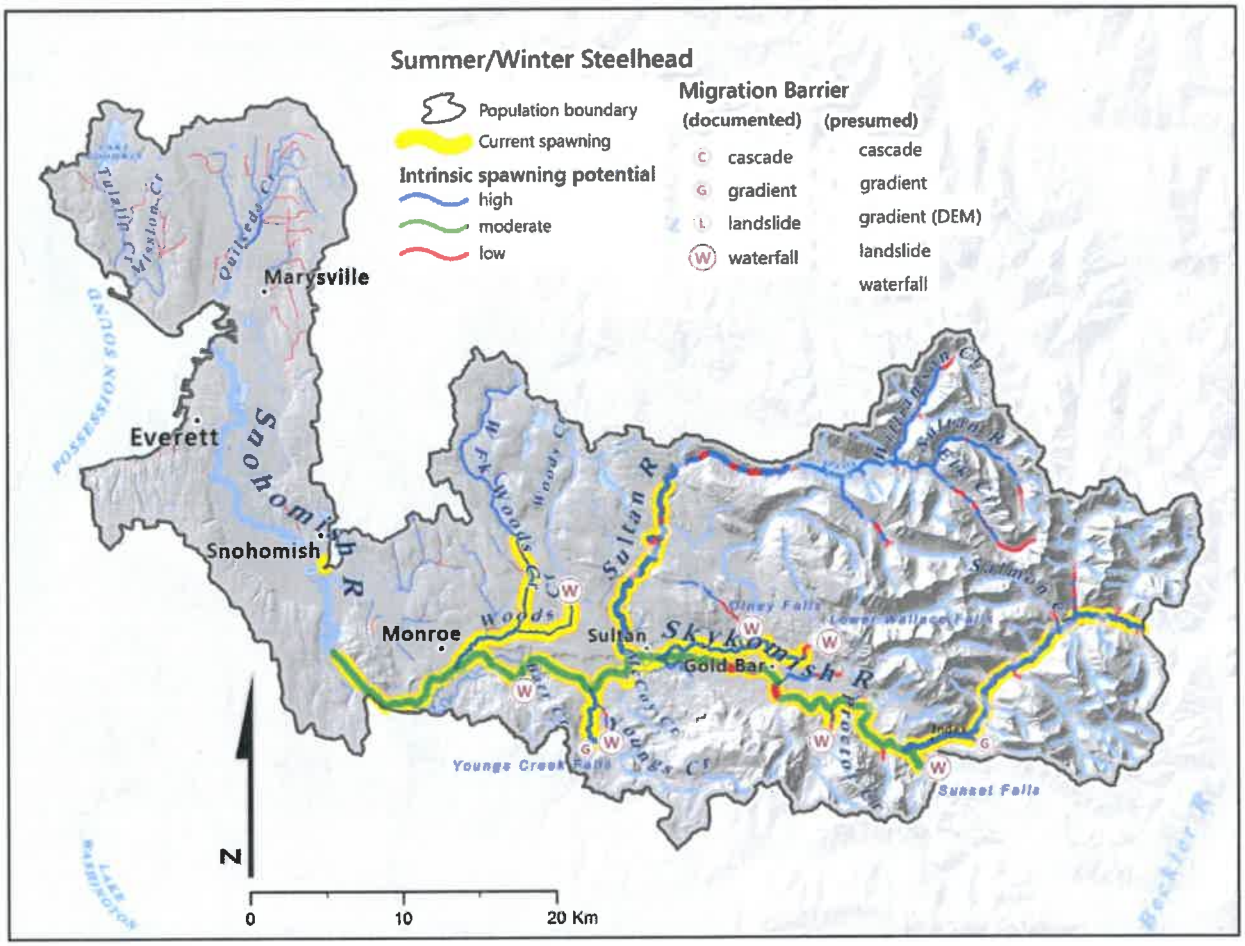


Figure E-37. Map of Snohomish/Skykomish Rivers Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

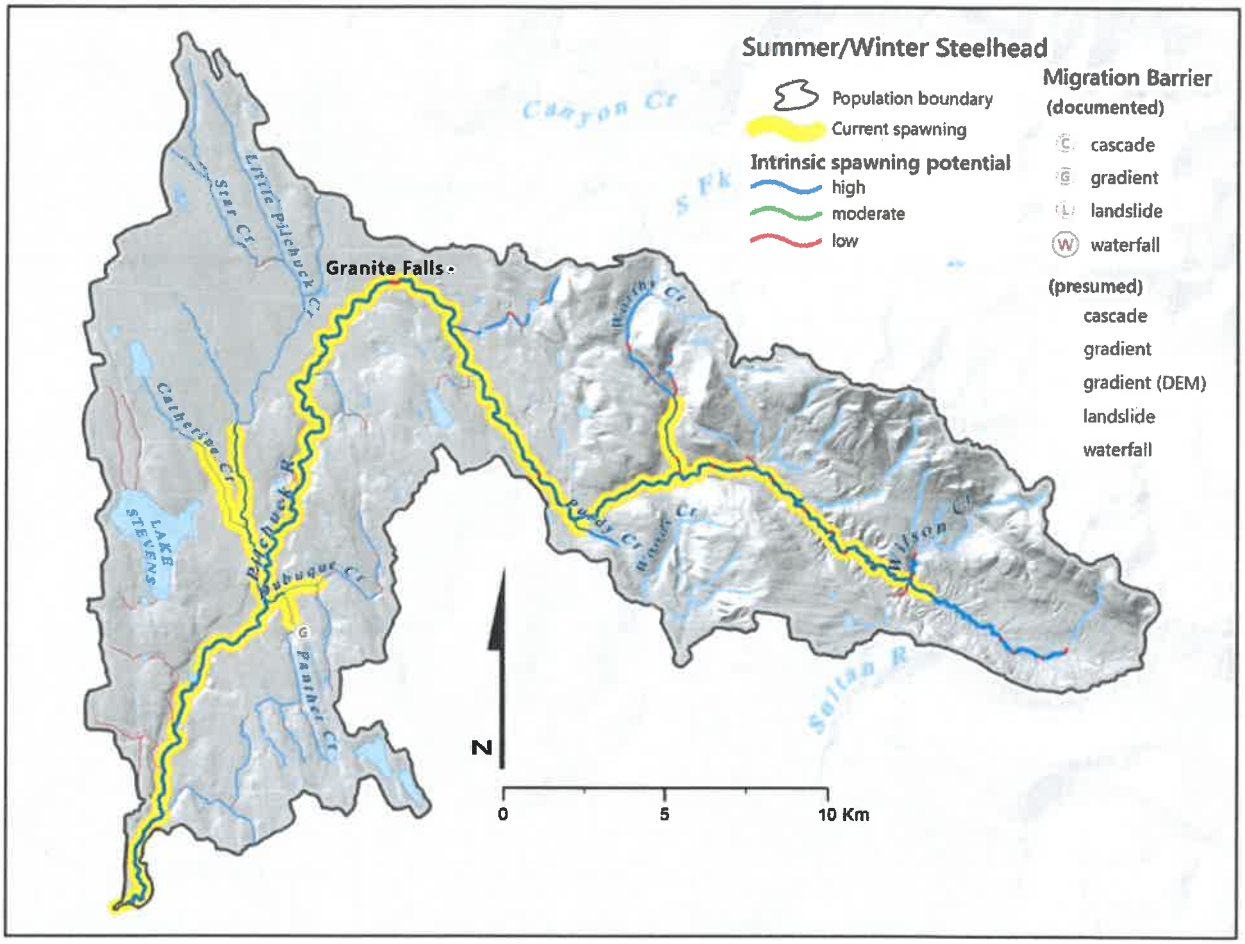


Figure E-40. Map of Pilchuck River Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

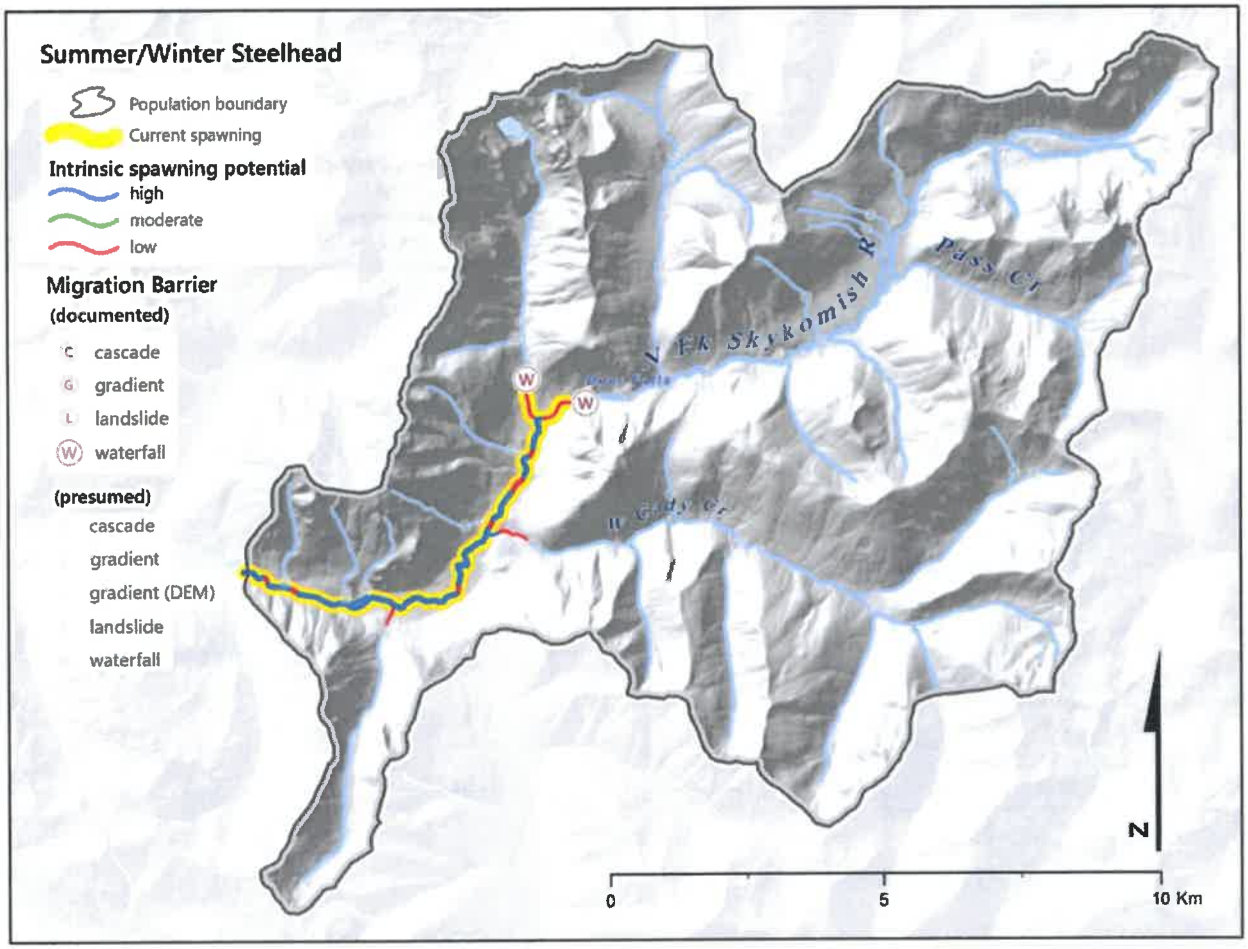


Figure E-43. Map of North Fork Skykomish River Summer-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

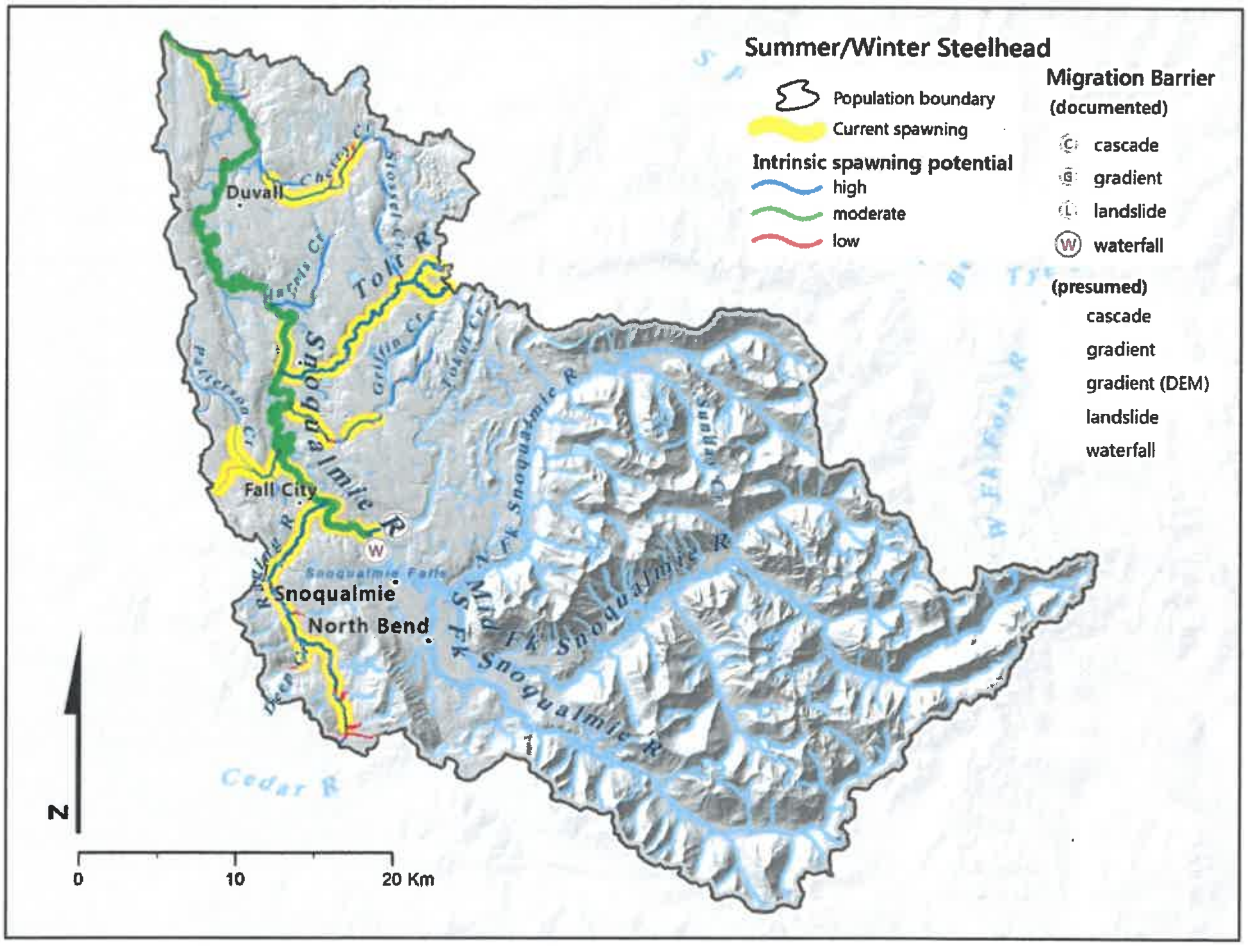


Figure E-46. Map of Snoqualmie River Winter-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

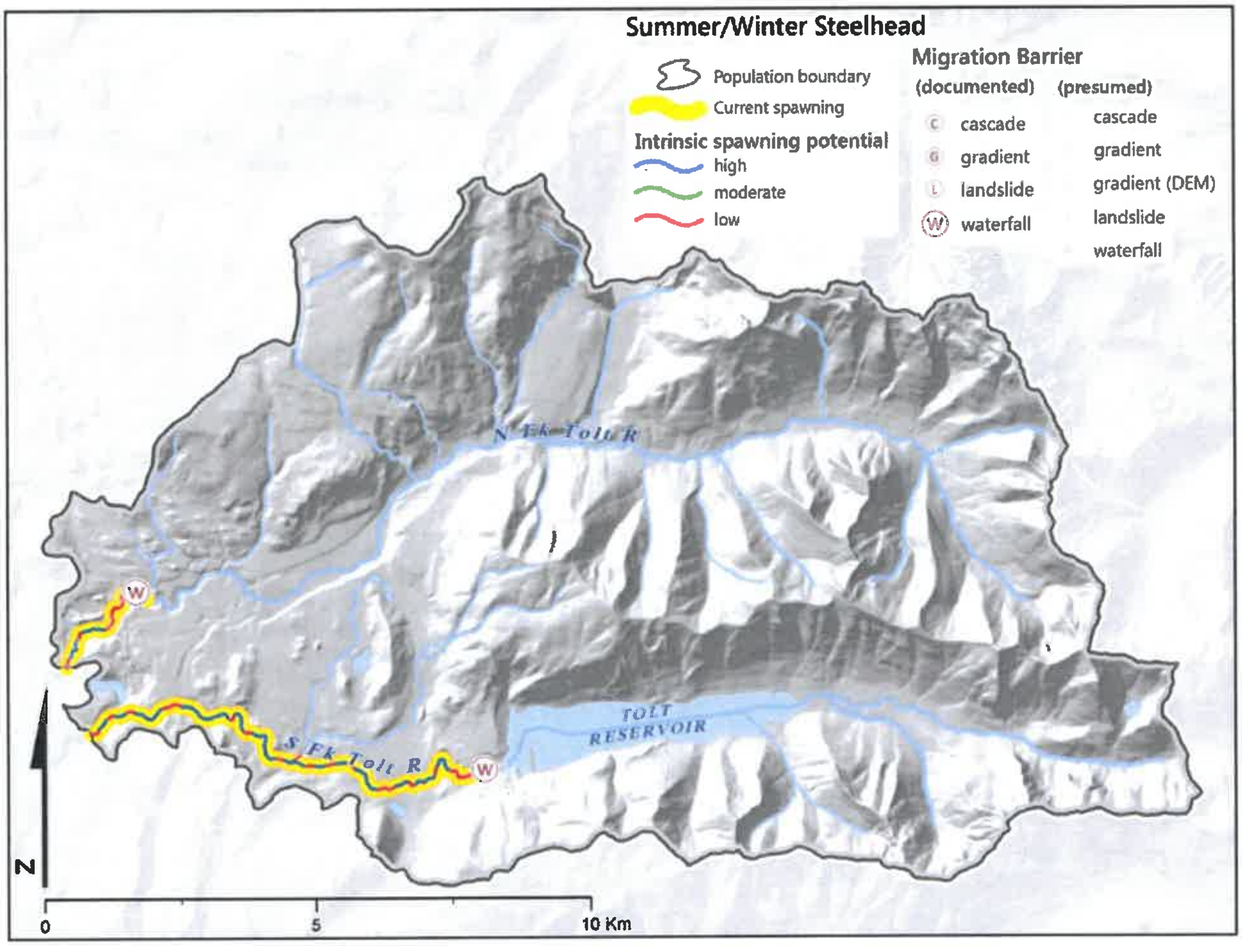


Figure E-49. Map of Tolt River Summer-Run population spatial structure, including migration barriers and spawning potential.

Source. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Puget Sound Technical Recovery Team, 2013.

Nooksack River Winter-run Steelhead Runsize

Puget Sound DPS
Nooksack/Samish MU
Nooksack River System Winter-run Steelhead — **WRIA 01.0120** — **Whatcom County**

1May-30Apr

Return	Sport Harvest (1Nov-30Apr)			Tribal Harvest (1Nov-30Apr)			Escapement			Total Runsize			Smolt ~May Release	Revised: July 25, 2017 Comments
Year (N)	Hatchery	Wild	H&W Total	Hatchery	Wild	H &W Total	Hatchery*	Wild a/	H&W Total	Hatchery	Wild	H&W Total	Return N+2	Sport Estimates taken from WDFW CRC Data
1960/61													0	System EG = 3,700
1961/62			1079										19,848	No E. G. for any of the 3 SaSI stocks in this system
1962/63			1272										0	N.F. wild river entry: E. Dec - E. Jul
1963/64			1347										0	N.F. wild spawn: E. Mar - E. Jun
1964/65			1486										1,000	M.F. spawn: E. Mar - M. Jun
1965/66			1484										0	Segregated harvest hatchery program
1966/67			1538										0	L. Dec - Mar. broodstock collection
1967/68			854										0	S.F. Spawn: M.Feb - M. Jun
1968/69			1194										0	**Excludes Squalicum Cr. and Whatcom Cr.**
1969/70			664			490							3,600	
1970/71			965										0	
1971/72			958			655							95,000	
1972/73			955										36,338	
1973/74			770			1,853							43,450	
1974/75			787			4,352							34,219	
1975/76			269			3,551							57,400	First SSH smolt release (20,028 into South Fork)
1976/77			339			2,930							20,019	
1977/78			584			2,251							44,760	
1978/79			637			1,590							34,772	40,000 SSH smolt release also
1979/80			722	1,522	623	2,145							57,759	
1980/81			642	523	374	897							55,803	3,078 SSH smolt release also
1981/82			531	545	199	744							77,703	10,818 SSH smolt release also
1982/83			414	561	217	778							65,884	
1983/84			793	641	145	786							153,725	
1984/85			2075	1,102	115	1,217							143,377	
1985/86			757	1,260	131	1,391							110,081	
1986/87	605	26	631	856	89	945							123,831	
1987/88	489	14	503	931	475	1,406							130,971	
1988/89	496	0	496			1,142							117,045	
1989/90	111	0	111			208							109,411	
1990/91	75	0	75			152							100,045	
1991/92	307	0	307			16							55,010	SaSSI status: all 3 stocks Unknown
1992/93	142	5	147			5							47,446	
1993/94	51	22	73			1							81,788	
1994/95	100	0	100			38							70,479	
1995/96	140	4	144			68							75,977	
1996/97	99	19	118			31							89,325	
1997/98	47	10	57			6							43,302	
1998/99	83	12	95	4	1	5							63,850	
1999/00	60	5	65	28	9	37							33,900	Kendall Creek Hatchery begins SH release program
2000/01	305	96	401	37	2	7	18						35,000	
2001/02	302	10	312	34	6	22	193						30,500	2002 SaSI status: all 3 stocks Unknown
2002/03	238	0	238	1	1	6	7						34,800	
2003/04	173	0	173	8	0	0	73	1,592	1,665	247	1,592	1,838	160,000	Begin new total wild escapement data set
2004/05	447	0	447	9	4	16	376						175,500	Escapement calculation not agreed to by co-managers
2005/06	238	0	238	10	0	0	219						63,400	
2006/07	216	0	216	3	3	12	66						165,000	
2007/08	147	0	147	66	19	76	159						160,000	
2008/09	49	0	49	15			36	772					164,000	
2009/10	56	0	56	28			96	1,901					146,500	
2010/11	106	0	106	47			158	1,774					106,200	
2011/12	69	0	69	116	54	170	156	1,747					99,999	
2012/13	83	0	83	84	83	167	55	1,805					116,360	
2013/14	104	0	104	53	18	71	169	1,521					118,806	
2014/15	110	0	110	70	35	105	446	2,081					0	
2014/15					50 morts frm 60 encounters	126 encounters								
2015/16	17	0	17		9 mortalities frm 49 release encounters	92 encounters		1,840					0	
2016/17														

a/ Escapement estimtes & Tribal Harvest from 2016/17 Nooksack River HMP.
Other Hatchery releases: Steelhead releases into the Nooksack River System began in 1933. Data quality very erratic.
*Total number of adults trapped (from WDFW Final Hatchery Escapement Report) only. Therefore, total hatchery runsize components such as fish that spawn or die below the hatchery, fish that are recycled or released to the stream and become trapped again, or fish that pass the trap undetected have not been accounted for.
****Sport Harvest:** CRC recorded harvest before 1974/75 has a 0.6 bias corection (P. Hahn, WDFW).

Nooksack System Components: Nooksack River, Nooksack River and Mid Fork, Nooksack River and North Fork, Nooksack River South Fork, Nooksack River below North Fork, Nooksack River Mid Fork, and Nooksack River North Fork.

tribal harvest updated bl 07/08/2010, from Alan Chapman data set via Brett
Through 2007/2008 bl 03/11/2015

Samish River Winter-run Steelhead Runsize

Puget Sound DPS
Nooksack/Samish MU
Samish River Winter-run Steelhead

WRIA 03.0005 **Skagit County**

1May-30Apr

Revised: June 29th, 2017 bl

Return	Sport Harvest (1Nov-30Apr)			Tribal Harvest (1Nov-30Apr)			Escapement			Total Runsize			Smolt	Comments
Year (N)	Hatchery	Wild	H&W Total	Hatchery	Wild	H&W Total	Hatchery	Wild	H&W Total	Hatchery	Wild	H&W Total	~May Release Return N+2	
1960/61													43,380	Sport Estimates taken from WDFW CRC Data
1961/62			1,215										49,360	
1962/63			2,234										42,100	
1963/64			2,123										50,860	
1964/65			1,578										55,912	
1965/66			2,473										57,210	
1966/67			3,439										53,267	
1967/68			2,695										38,604	
1968/69			2,614										73,151	
1969/70			1,488										55,440	
1970/71			2,839										62,678	
1971/72			2,496										60,642	
1972/73			704										41,960	
1973/74			658										43,477	
1974/75			849										24,492	
1975/76			181										40,013	
1976/77			895										77,860	EG=700
1977/78			1,257										150,748	
1978/79	922	57	979	2	0	2	1,339	224	1,563	2,384	281	2,673	160,328	Wild river entry: L. Oct - L. Mar
1979/80	841	32	873	148	13	161	766	80	846	2,139	125	2,278	153,040	Wild spawn: M. Feb - E. Jun
1980/81	158	100	258	231	158	389	388	142	530	787	400	1,193	90,589	
1981/82			754			644							41,042	Segregated harvest hatchery program
1982/83			307			75							40,078	
1983/84			385			0							46,951	
1984/85			1,411			87		1,052					45,138	
1985/86			750			422							30,075	
1986/87	415	168	583			57		836					27,770	
1987/88	226	78	304			167		606					29,904	
1988/89	188	95	283			3		244					40,881	
1989/90	89	43	132			0		106					39,019	
1990/91	48	15	63			0							50,050	
1991/92	427	38	465			0							13,920	1992 SaSSI stock status Depressed
1992/93	149	21	170			0							27,000	
1993/94	55	11	66			0		941					19,632	
1994/95	65	0	65			0		918					6,588	
1995/96	47	12	59			0		797					39,357	
1996/97	68	14	82			0							31,213	
1997/98	13	0	13			0		586					22,924	
1998/99	55	0	55			0		617					47,906	
1999/00	28	60	88			0		676					12,117	
2000/01	36	8	44			0		908					25,000	
2001/02	54	31	85			0		859					30,950	2002 SaSI stock status Healthy
2002/03	18	0	18			0		915					30,000	0 = from 2003/2004 HMP
2003/04	35	0	35			0		930					0	
2004/05	14	0	14			0		597					35,092	
2005/06	30	2	32			0		791			793		35,212	
2006/07	35	0	35			0		494					40,444	
2007/08	14	0	14			0		432					0	
2008/09	5	0	5			0		434					34,800	
2009/10	0	0	0			0		697					0	
2010/11	2	0	2			0		1,028					0	
2011/12	0	0	0			0		524					0	
2012/13	0	0	0			0		916					0	
2013/14	0	0	0			0		680					0	
2014/15	3	0	3			0		1,876					0	
2015/16	0	0	0			0		1,456					0	
2016/17														

Steelhead Historical Database

WDFW Fish Mgmt HQ, 600 Capitol Way N, Olympia 98501, (360) 902-2820/2817

Puget Sound DPS
Stillaguamish/Snohomish MU
Stillaguamish River System Winter-run Steelhead   WRIA 05.0001

Includes: Mainstem, North Fork, and South Fork of the Stillaguamish, Pilchuck and Canyon Creeks

1May-30Apr

Return	Sport Harvest (1Nov-30Apr)			Tribal Harvest (1Nov-30Apr)			Escapement			Smolts	Revised: June 28, 2017 bl
Year (N)	Hatchery	Wild	H&W Total	Hatchery	Wild	H&W Total	Hatchery*	*Wild Index*	*Wild Expanded*	~May Release Return N+2	Comments Sport Estimates taken from WDFW CRC Data
1960/61										42,414	*Estimated System EG = 1,800*
1961/62			4550							51,592	*Index EG=754 for portion of NF above Deer Creek*
1962/63			4994							66,301	Only 4 months (Jan-Apr) sport harvest available
1963/64			7115							36,641	Wild river entry: L. Nov - L. Apr
1964/65			6655							68,663	Wild spawn: M. Mar - M. Jun
1965/66			10558							87,416	
1966/67			8272							116,946	Whitehorse ponds
1967/68			8342							103,140	Segregated harvest hatchery program
1968/69			5098							95,220	Dec - Mar local hatchery returns broodstock collection
1969/70			4242							105,569	
1970/71			6088							110,645	
1971/72			6317							95,521	
1972/73			3633							115,728	
1973/74			4149							120,830	
1974/75			5605							87,808	
1975/76			1343			422				106,009	
1976/77			2461			1,063				217,296	
1977/78			2829			1,783				139,513	
1978/79			2353			2,398				116,779	
1979/80			2285			2,444				96,578	
1980/81			1697			3,062				91,789	
1981/82			1005			2,195				119,744	
1982/83			740			2,482				98,455	
1983/84			1481			1,872				87,589	
1984/85			3285			4,614		*1,542*		109,977	No run size calculation using index escapement data
1985/86			3028			4,052		*2,226*		114,618	
1986/87	1,834	636	2,470			4,558		*1,892*		117,408	
1987/88	1,848	640	2,488			3,407		*1,222*		128,798	Smolt numbers include Canyon and Pilchuck creeks
1988/89	1,432	432	1,864			2,329		*1,718*		116,120	*NOTE: Escapements are index numbers (italics)*
1989/90	755	250	1,005			2,247				145,227	
1990/91	331	194	525			720		*950*		19,894	
1991/92	1,463	319	1,782			1,547				137,991	1992 SaSSI status: Healthy
1992/93	2,371	639	3,010			1,507		*1,178*		100,354	
1993/94	798	545	1,343			203		*1,118*		133,256	
1994/95	1,399	481	1,880			171		*1,556*		140,642	
1995/96	694	169	863			0	210	*1,094*		122,967	
1996/97	608	160	768			25	138			115,911	
1997/98	190	24	214			0	94	*1,185*		90,175	
1998/99	752	184	936			0	288	*917*		152,561	
1999/00	1,207	71	1,278		65		188	*463*		97,390	
2000/01	1,070	10	1,080		14		91	*630*		88,640	
2001/02	1,404	23	1,427		50		410	*354*		113,036	2002 SaSI status: Depressed
2002/03	536	0	536		0		65	*660*		133,914	*133900 - March 1-June 15, 2002*
2003/04	512	0	512		15.		188	*740*	*3,002*	146,437	161,600 = 15,200 Canyon Crk+146,400 NFStilly
2004/05	733	0	733	15	1	16	300	*462*	*1,874*	144,801	155,025 = 10,224 PilchuckCrk + 144,801 NF
2005/06	625	0	625	32	22	54	373	*674*	*2,734*	152,427	152,427 = 10,000 PilchuckCrk + 142,427 NF OK
2006/07	852	0	852	14	30	44	140		*2,726*	148,760	*148760 - 10,004 PilchuckCrk + 138,756 NF_OK_April 15-May 31, 2006*
2007/08	521	0	521	4	2	6	133	*306*	*1,241*	153,900	OK
2008/09	116	0	116	1	1	2	67	*120*	*487*	154,730	OK
2009/10	108	0	108			0	108	*372*	*1,509*	125,165	OK
2010/11	105	0	105	5	1	6	170	*362*	*1,501*	76,600	OK
2011/12	282	0	282	7	*1*	8	227	*340*	*1,371*	128,066	OK
2012/13	430	0	430	0	1	1	172	*514*	*2,085*	152,599	OK
2013/14	266	0	266			0	175	*362*	*1,469*	86,725	OK
2014/15	89	0	89			0	172	*566*	*2,296*	0	OK
2015/16	23	0	23			0	7	*684*	*2,775*	0	OK
2016/17										*122,311*	

2002/03
2003/04
2004/05
2005/06
2006/07
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17

Other Hatchery Releases: Steelhead releases into the Stillaguamish System began in 1933. Data quality very erratic.

*Total number of adults trapped (from WDFW Final Hatchery Escapement Report) only. Therefore, total hatchery runsize components such as fish that spawn or die below the hatchery, fish that are recycled or released to the stream and become trapped again, or fish that pass the trap undetected have not been accounted for.

Steelhead Historical Database

WDFW Fish Mgmt HQ, 600 Capitol Way N, Olympia 98501, (360) 902-2820/2817

Puget Sound DPS

Stillaguamish/Snohomish MU

Snohomish River System Winter-run Steelhead — WRIA 07.0012 — Snohomish County

Includes: Pilchuck, Raging, Skykomish, Snohomish Snoqualmie, Sultan, Tolt, and Wallace rivers, Tokul, Purdy, and Woods creeks

1May-30Apr	Sport Harvest (1Nov-30Apr)			Tribal Harvest (1Nov-30Apr)			Escapement			Total Runsize			Smolt
Return Year (N)	Hatchery	Wild	H&W Total	Hatchery	Wild	H&W Total	Hatchery	Wild	H&W Total	Hatchery	Wild	H&W Total	~May Release Return N+2
1960/61													113,023
1961/62			9,375										127,484
1962/63			13,959										166,834
1963/64			17,142										228,163
1964/65			15,069										121,530
1965/66			16,609										197,317
1966/67			16,096										182,485
1967/68			13,411										153,051
1968/69			12,971										193,301
1969/70			6,273										276,518
1970/71			11,697										186,670
1971/72			16,757										225,035
1972/73			8,635										217,325
1973/74			13,887										252,363
1974/75			16,114										251,341
1975/76			8,600										391,923
1976/77			6,661			1,623	1,652						364,139
1977/78			24,978			5,745	99						437,428
1978/79			14,630			5,423	249						385,086
1979/80			18,386			10,402	82						340,937
1980/81			7,233	5,898	1,506	7,404	108	2,954	3,062	6,006	4,460	10,466	413,193
1981/82			4,921	4,819	1,397	6,216	25	4,160	4,185	4,844	5,557	10,401	367,832
1982/83			6,357	3,947	1,202	5,149	177	5,158	5,335	4,124	6,360	10,484	349,034
1983/84			9,720	4,056	237	4,293	31	6,432	6,463	4,087	6,669	10,756	383,919
1984/85			11,106	10,997	622	11,619	4,392	6,536	10,928	15,389	7,158	22,547	326,432
1985/86			9,204	7,886	765	8,651	404	7,790	8,194	8,290	8,555	16,845	359,910
1986/87	9,397	1,190	10,587	9,764	630	10,394		7,464			9,284		361,870
1987/88	10,142	2,479	12,621	5,362	979	6,341	330	7,744	8,074	15,834	11,202	27,036	230,056
1988/89	6,060	2,187	8,247	1,825	493	2,318	601	7,078	7,679	8,486	9,758	18,244	439,956
1989/90	6,349	1,888	8,237	3,705	197	3,902	700	5,498	6,198	10,754	7,583	18,337	424,911
1990/91	4,663	835	5,498	873	225	1,098	644	5,936	6,580	6,180	6,996	13,176	351,722
1991/92	10,254	1,205	11,459	1,913	35	1,948	955	8,588	9,543	13,122	9,828	22,950	347,600
1992/93	10,556	1,364	11,920	832	39	871	1,002			12,390			349,606
1993/94	5,299	411	5,710	79	6	85	688	6,992	7,680	6,066	7,409	13,475	441,519
1994/95	7,726	213	7,939	296	19	315	1,253	7,722	8,975	9,275	7,954	17,229	341,834
1995/96	5,250	397	5,647	235	17	252	1,257			6,742			288,619
1996/97	3,015	319	3,334	218	23	241	813			4,046			414,926
1997/98	2,072	100	2,172	55	3	58	536	5,250	5,786	2,663	5,353	8,016	206,290
1998/99	4,307	1,063	5,370	146	36	182	816	6,371	7,187	5,269	7,470	12,739	479,402
1999/00	3,959	184	4,143	212	100	312	403	2,822	3,225	4,574	3,106	7,680	473,550
2000/01	4,360	118	4,478	34	18	52	483	3,122	3,605	4,877	3,258	8,135	402,239
2001/02	8,642	114	8,756	416	79	495	1,148	2,234	3,382	10,206	2,427	12,633	407,616
2002/03	2,420	0	2,420	0	0	0	458	3,599	4,057	2,878	3,599	6,477	418,618
2003/04	6,845	0	6,845	44	28	72	1,362	6,432	7,794	8,251	6,460	14,711	428,208
2004/05	7,993	0	7,993	265	21	286	748	4,514	5,262	9,006	4,535	13,541	448,016
2005/06	3,943	0	3,943	126	85	211	907	5,474	6,381	4,976	5,559	10,535	429,560
2006/07	4,315	0	4,315	10	22	32	846	4,100	4,946	5,171	4,122	9,293	442,113
2007/08	3,944	0	3,944	33	16	49	578	3,653	4,231	4,555	3,669	8,224	456,400
2008/09	1,929	0	1,929	41	22	63	588	2,203	2,791	2,558	2,225	4,783	439,350
2009/10	2,168	0	2,168	31	35	66	504	1,688	2,192	2,703	1,723	4,426	370,254
2010/11	2,659	2	2,661	46	15	61	902	2,366	3,268	3,607	2,383	5,990	339,500
2011/12	4,564	0	4,564	28	2	30	1,506	2,516	4,022	6,098	2,518	8,616	323,400
2012/13	3,961	0	3,961	0	4	4	1,335	2,658	3,993	5,296	2,662	7,958	365,387
2013/14	2,754	0	2,754	2	1	3	828	2,684	3,512	3,584	2,685	6,269	201,606
2014/15	4,289	0	4,289	7	1	8	1,879	2,914	4,793	6,175	2,915	9,090	178,812
2015/16	2,729	0	2,729	0	0	0	945	3,120	4,065	3,674	3,120	6,794	
2016/17													240,672

Guidance for Selection of Wild Steelhead Gene Banks
Revised January 17, 2018 with Focus on Northern Cascades MPG

Statewide Steelhead Management Plan

The Statewide Steelhead Management Plan (SSMP) includes the following strategy to conserve and recover wild steelhead:

> *"Establish a network of wild stock gene banks across the state where wild stocks are largely protected from the effects of hatchery programs. At least one wild stock gene bank will be established for each major population group in each steelhead DPS. Each gene bank will have the following characteristics and management:*
>
> a. *Each stock selected for inclusion in the gene bank must be sufficiently abundant and productive to be self-sustaining in the future.*
> b. *No releases of hatchery-origin steelhead will occur in streams where spawning of the stock occurs, or in streams used exclusively by that stock for rearing.*
> c. *Fisheries can be conducted if wild steelhead management objectives are met as well as any necessary federal ESA determinations."*

Puget Sound Hatchery Action Advisory Committee

The Washington Department of Fish and Wildlife (Department) created the Puget Sound Hatchery Action Advisory Committee (PSHAAC) in 2011 to help guide the prioritization of hatchery reform actions needed to reduce the risks posed by the state's hatchery operations in the Puget Sound region. The group was provided with information regarding the status of natural populations of salmon and steelhead as well as the performance and economic benefits of hatchery program throughout the Puget Sound. Based on these data, the PSHAAC suggested watersheds in which steelhead would not be released from state-operated hatcheries (Table 1).

Table 1. PSHAAC recommendations for WSGBs (HEAT 2013).

Major Population Group	Population or Watershed	Run Type	Comments
Northern Cascades	South Fork Nooksack	Summer	
	Samish	Winter	
	Sauk	Summer & Winter	
	Skagit	Summer & Winter	High ranking candidate by most members but not a consensus selection.
	Pilchuck	Winter	
	NF Skykomish	Summer	
	Tolt	Summer	
Central & South Puget Sound	White	Winter	Recommended when supplementation program has ended.
	Puyallup/Carbon	Winter	
	Nisqually	Winter	

Table 1. PSHAAC recommendations for WSGBs (HEAT 2013) (continued).

Major Population Group	Population or Watershed	Run Type	Comments
Hood Canal & Strait of Juan de Fuca	Skokomish	Winter	Recommended when supplementation program has ended.
	East Hood Canal	Winter	Recommended when supplementation program has ended.
	West Hood Canal	Winter	Recommended when supplementation program has ended.
	Sequim/Discovery Bay	Winter	
	Elwha	Winter	Recommended when supplementation program has ended.

WSGB Selection Guidance

The Department built upon the general WSGB strategy identified in the SSMP to develop additional guidance to inform the selection of WSGBs. Four population or watershed attributes were defined: 1) Abundant and Productive; 2) Self-Sustaining in the Future; 3) Wild Stock; and 4) Population Diversity.

The Department assessed each attribute and categorized the population as either a "Preferred", "Adequate", or "Poor" match with an ideal WSGB (Table 2).

Abundant and Productive. This attribute was assessed using analyses of extinction risk, the long-term change in the number of spawners, and the short-term change in the number of spawners (Appendix Table 1). The extinction risk of each population was predicted using the time trend of spawners and a population-specific quasi-extinction threshold. The quasi-extinction threshold is a number below which extinction is likely due to genetic of demographic risks. Additional information can be found in Cram and Kendall (2015).

Self-Sustaining in the Future. The Department assessed the likelihood that a population would be self-sustaining in the future by analyzing existing habitat ownership (Appendix Table 1). We assumed that federal, tribal, state, or local government ownership was likely to provide habitat protection suitable to ensure the maintenance of steelhead populations in the future. We recognize that other types of land ownership can protect and restore steelhead habitat, and used this information where available.

Wild Stock. The Department assessed the extent that the genetic characteristics of a population may have been affected by gene flow from a hatchery program (Appendix Table 1). Gene flow is the rate at which genes from a hatchery population are incorporated into a wild population. Hatchery-wild gene flow occurs when hatchery fish spawn successfully with wild fish on the spawning grounds. The greater the number of hatchery-wild hybrids produced, the greater the gene flow. The proportion effective hatchery contribution (PEHC) is a method to estimate gene flow using genetic analysis of tissue samples. Additional information can be found in Warheit (2014) and Hoffmann (2014).

Population Diversity. The Department compiled information on the run-timing type (Summer or Winter) of each population and the hydrographic type of the associated watershed (Appendix Table 1). The hydrographic type is one attribute that can be used to assess the diversity of watersheds. The Puget Sound Technical Recovery Team (2013) classified the percentage of the watershed associated with each population that was in the following categories: Highland, Lowland, Rain Dominated, Rain/Snow Dominated, and Snow Dominated. Appendix Table 1 identifies the two most prevalent hydrographic types.

The Department recognizes that in some cases the current status of steelhead populations may require the selection of populations that do not meet the criteria for "Preferred" or "Adequate".

Table 2. Attributes and guidance for identification of WSGBs.

Attribute	Preferred	Adequate
Abundant & Productive	Probability of extinction 10% or less in 20 years. Spawner numbers declined less than 60% since 1980.	Probability of extinction 20% or less in 20 years. Insignificant decline in spawners during last 12 years.
Self-Sustaining in the Future	Habitat Protection. More than 70% of watershed with existing habitat protection measures (e.g., national park, national forest, state forest, Habitat Conservation Plan).	Habitat Protection. More than 50% of watershed with existing habitat protection measures (e.g., national park, national forest, state forest, Habitat Conservation Plan).
Wild Stock	Proportion Effective Hatchery Contribution (PEHC) or gene flow less than 2%.	PEHC or gene flow less than 5%.
Population Diversity	Each major population group has representation of winter and summer run timing, if applicable, and a variety of hydrographic types.	Each major population group has representation of winter and summer run timing, if applicable.

WSGB Assessment

The Department assessed the attributes of all populations recommended by the PSHAAC and two additional populations (Deer and Snoqualmie). Results from the assessment are presented in Table 3.

Selection of Wild Steelhead Gene Banks

The Department will select the WSGBs after review of the public comments, assessment of the fishery and economic implications, and discussion with the tribal co-managers.

Table 3. Summary of candidate populations relative to selection guidance.

Major Population Group: Northern Cascades

Population	Run Type	Abundant & Productive	Self-Sustaining in the Future	Wild Stock
South Fork Nooksack	Summer	No Data	Adequate	Preferred
Samish	Winter	Preferred	Poor	Poor
Sauk	Summer & Winter	Preferred	Preferred	Adequate
Skagit	Summer & Winter		Adequate	Preferred
Deer Creek	Summer	No Data	Preferred	Preferred
Pilchuck	Winter	Preferred	Poor	Adequate
NF Skykomish	Summer	No Data	Preferred	Poor
Snoqualmie	Winter	Preferred	Adequate	Poor
Tolt	Summer	Poor	Poor	Poor

References

Cram, J., and N. Kendall, editors. 2015. Washington State steelhead: Evaluating risk and prioritizing actions. Washington Department of Fish and Wildlife, draft report, Olympia, WA.

Hatchery Evaluation and Assessment Team. 2013. Puget Sound Hatchery Action Advisory Committee Final Report. Washington Department of Fish and Wildlife, Unpublished report, Olympia, WA. 28pp.

Hoffmann, A. 2014. Estimates of gene flow for Puget Sound hatchery programs. Washington Department of Fish and Wildlife, Unpublished report, Olympia, WA. 22pp.

Puget Sound Technical Recovery Team (PSSTRT). 2013. Identifying historical populations of steelhead within the Puget Sound Distinct Population Segment. Final Review Draft. NOAA Fisheries, Northwest Science Center, Seattle, WA. 149pp.

Van Doornik, D.M., and B.A. Berejikian. 2015. Landscape factors affect the genetic population structure of *Oncohynchus mykiss* populations in Hood Canal, Washington. Environ. Biol. Fish 98: 637-653.

Warheit, K.I. 2014. Measuring reproductive interaction between hatchery-origin and wild steelhead (*Oncohynchus mykiss*) from north Puget Sound populations potentially affected by segregated hatchery programs. Washington Department of Fish and Wildlife, Unpublished report, Olympia, WA. 91pp.

Winans, G.S., McHenry, M.L., Baker, J., Elz, A., Goodbla, A., Iwamoto, E., Kuligowski, D., Miller, K.M., Small, M.P., Spruell, P., and Van Doornik, D. 2008. Genetic inventory of anadromous pacific salmonids of the Elwha River prior to dam removal. Northwest Science, 82(sp1): 128-141.

Appendix Table 1. Information on Candidate Populations

Draft January 17, 2018

Major Population Group: Northern Cascades

Population	PSHAAC Recommended	Run Type	Extinction Risk	Longterm Abundance Trend	Short Term Decline	Past Hatchery Gene Flow	% Public Land	Hydrology [2/]
South Fork Nooksack	Yes	Summer	-	-	-	0% (W) 0% (S)	59%	41% Rain 23% Rain & Snow
Samish	Yes	Winter	4%	+193%	No	6% (W) 0% (S)	19%	50% Lowland 41% Rain
Sauk	Yes	Summer & Winter	0%	-38%	No	4% (W) 0% (S)	94%	54% Highland 21% Snow
Skagit [/3]	Yes [1/]	Summer & Winter				2% (W) 1% (S)	61%	47% Highland 18% Snow
Deer Creek	No	Summer	-	-	-	0% (W) 2% (S)	70%	44% Snow 28% Rain & Snow
Pilchuck	Yes	Winter	6%	-47%	No	1% (W) 3% (S)	35%	56% Lowland 35% Rain
NF Skykomish	Yes	Summer	-	-	-	1% (W) 95% (S)	100%	61% Highland 27% Snow
Snoqualmie	No	Winter	0%	-55%	No	4% (W) 3% (S)	56%	28% Rain 24% Lowland
Tolt	Yes	Summer	25%	-19%	No	1% (W) 69% (S)	42%	31% Snow 31% Rain & Snow

[1/] High ranking candidate by most members but not a consensus selection.

[2/] Source: Puget Sound Technical Recovery Team 2013.

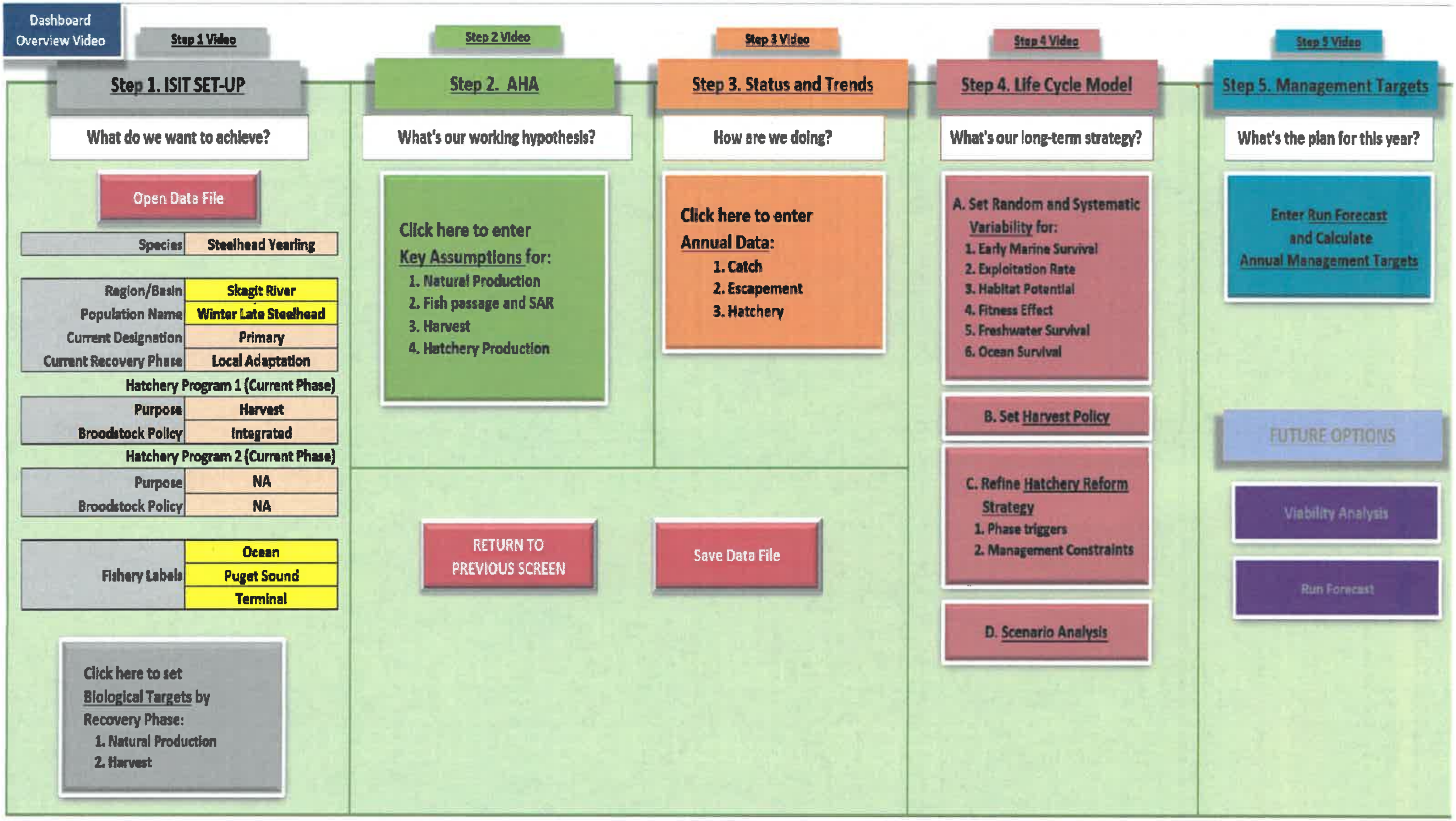
[3/] Estimates of steelhead spawners are available only for the entire Skagit River watershed – not individual populations. Statistics for the Extinction Risk, Longterm Abundance Trend, and Short Term Decline are reported for the aggregate of the Skagit , Sauk, and Nookachamps populations.

Skagit Steelhead AHA/ISIT Modeling

HATCHERY EVALUATION AND ASSESSMENT TEAM
WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
JANUARY 17TH 2018

AHA/ ISIT Model

- Data intensive model developed by Lars Mobrand, that uses habitat, hatchery and harvest data to predict harvest and impact on natural origin populations.
- The AHA Model was used to estimate the impact of hatchery programs (pHOS and PNI) on natural populations.
- Model primary needs:
  - Goals for transitioning between harvest phases
  - Requires smolt capacity and productivity and SAR% data for the natural population.
  - Harvest rates
  - Hatchery SAR% and Stray Rate
  - Hatchery Fitness Loss
  - Release data, broodstock data (pNOB and pHOB), Spawning Ground data (NOS and HOS).
- Has a built in life cycle model that incorporates the Pacific Ocean Decadal Oscillation (PDO).


Dashboard Overview Video
Step 1 Video
Step 1. ISIT SET-UP
What do we want to achieve?
Open Data File
Species: Steelhead Yearling
Region/Basin: Skagit River
Population Name: Winter Late Steelhead
Current Designation: Primary
Current Recovery Phase: Local Adaptation
Hatchery Program 1 (Current Phase)
Purpose: Harvest
Broodstock Policy: Integrated
Hatchery Program 2 (Current Phase)
Purpose: NA
Broodstock Policy: NA
Fishery Labels: Ocean, Puget Sound, Terminal
Click here to set Biological Targets by Recovery Phase:
1. Natural Production
2. Harvest
Step 2 Video
Step 2. AHA
What's our working hypothesis?
Click here to enter Key Assumptions for:
1. Natural Production
2. Fish passage and SAR
3. Harvest
4. Hatchery Production
RETURN TO PREVIOUS SCREEN
Step 3 Video
Step 3. Status and Trends
How are we doing?
Click here to enter Annual Data:
1. Catch
2. Escapement
3. Hatchery
Save Data File
Step 4 Video
Step 4. Life Cycle Model
What's our long-term strategy?
A. Set Random and Systematic Variability for:
1. Early Marine Survival
2. Exploitation Rate
3. Habitat Potential
4. Fitness Effect
5. Freshwater Survival
6. Ocean Survival
B. Set Harvest Policy
C. Refine Hatchery Reform Strategy
1. Phase triggers
2. Management Constraints
D. Scenario Analysis
Step 5 Video
Step 5. Management Targets
What's the plan for this year?
Enter Run Forecast and Calculate Annual Management Targets
FUTURE OPTIONS
Viability Analysis
Run Forecast

Upper Skagit General Model: Natural Origin Parameters

- Primary Population
  - PNI Threshold > 0.67
  - pHOS < 30%
- Natural Origin Parameter Overview
  - Smolt productivity = 110 smolts per female
  - Capacity = 112,105 smolts
  - SAR% = 4%
- Harvest Phases
  - Phase 1: 4% Wild and 22% Hatchery: ≤ 2,004 NORs
  - Phase 2: 10% Wild and 55% Hatchery: 2005 - 3,006 NORs
  - Phase 3: 20% Wild and 60% Hatchery: 3,007 - 4,008 NORs
  - Phase 4: 25% Wild and 62.5% Hatchery: ≥ 4,009 NORs
    - Thresholds based on proportion of overall population in the Skagit DIP

Hatchery Parameters

- Program Size:
  - Maximum program size is 200,000 smolts
- In basin stray rate
  - Assumed that 70% of fish return to the hatchery
- Fitness Effect = 20% Fitness loss
- Hatchery SAR = 0.5%
- For PDO cycles:
  - 1954 (Good Conditions)
  - 1989 (Poor Conditions)

Model Scenarios

- Used model to assess impacts under different scenarios.
  - General model
  - Reduced fitness = 60% Fitness loss
    - Fitness loss so small that this was negligible.
  - Reduced homing to the hatchery
    - 75% stray rate after fisheries.
  - What natural and hatchery SAR% to hit 30% pHOS
  - No Hatchery Entire Skagit Model

Model Outputs

- The model predicts the following between 2017 and 2041:
  - Number of Natural Origin Spawners
  - Percent Hatchery origin spawners (pHOS)
  - Proportion of Natural Influence (PNI)
  - Natural Origin (NOR) Catch
  - Hatchery Origin (HOR) Catch
  - Population Fitness at 2041
- Provides the average and 95% Confidence Intervals.
- Results vary based on PDO cycle.
- Used the average of 25 model iterations.

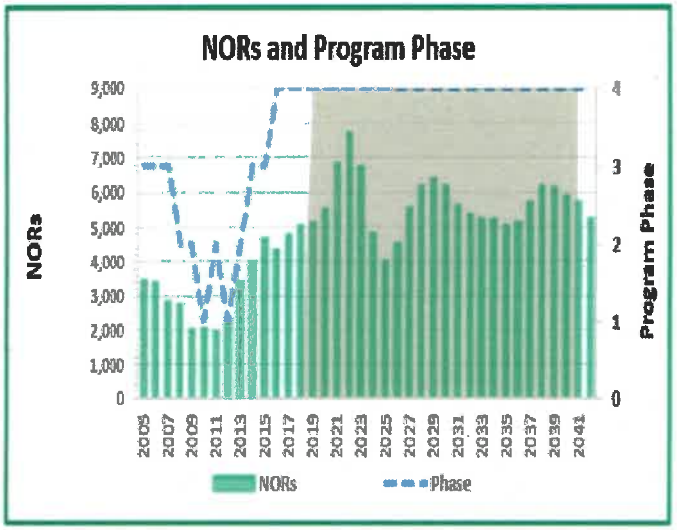
Model Sensitivity

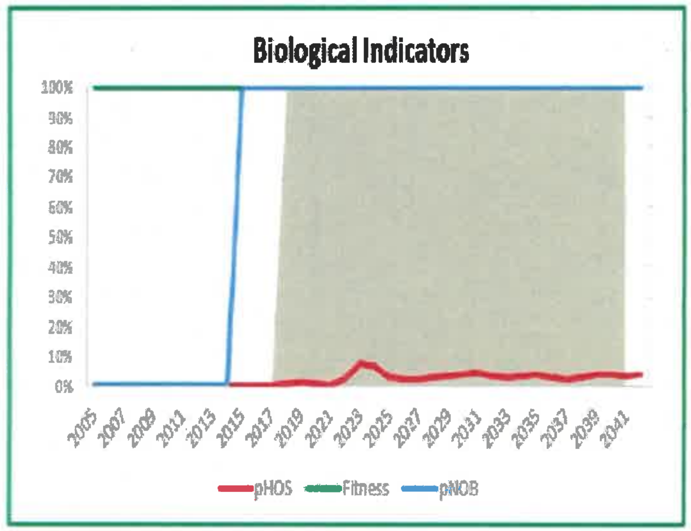
- The model is most sensitive to SAR%
- Fitness had little impact on the outputs.
  - Due to using 100% NOB and low hatchery SAR% and robust natural population.
- Stray rate had a slight impact on the model outputs.

Modeled Outcomes versus Biological Targets for each Phase

*Average, minimum and maximum values from 2017 to 2041

	Harvest Phase 1 (4% NOR; 22% HOR)	Harvest Phase 2 (10% NOR; 55% HOR)	Harvest Phase 3 (20% NOR; 60% HOR)	Harvest Phase 4 (25% NOR; 62.5% HOR)		Actual Status in 2016	Projected Status in 2017	Average		
								Average	Range*	95% CI
NOS	> 2,004	> 2,005	> 3,007	> 4,008		3,920	4,503	4,282	2,677 - 7,055	3,936 - 4,629
pHOS	< 30%	< 30%	< 30%	< 30%		5.6%	1.1%	3.0%	0.2% - 7.8%	2.3% - 3.7%
PNI	-	> 0.67	> 0.67	> 0.67		0.93	0.99	0.97	0.927 - 0.998	0.965 - 0.978
NOR Harvest	-	> 0	> 0	> 0		0	1,118	1,398	892 - 2,352	1,277 - 1,518
HOR Harvest	-	> 0	> 0	>0		0	64	851	64 - 1,597	695 - 1,006
Fitness	-	-	-	-		0	100	1.000	0.999 - 1	NA

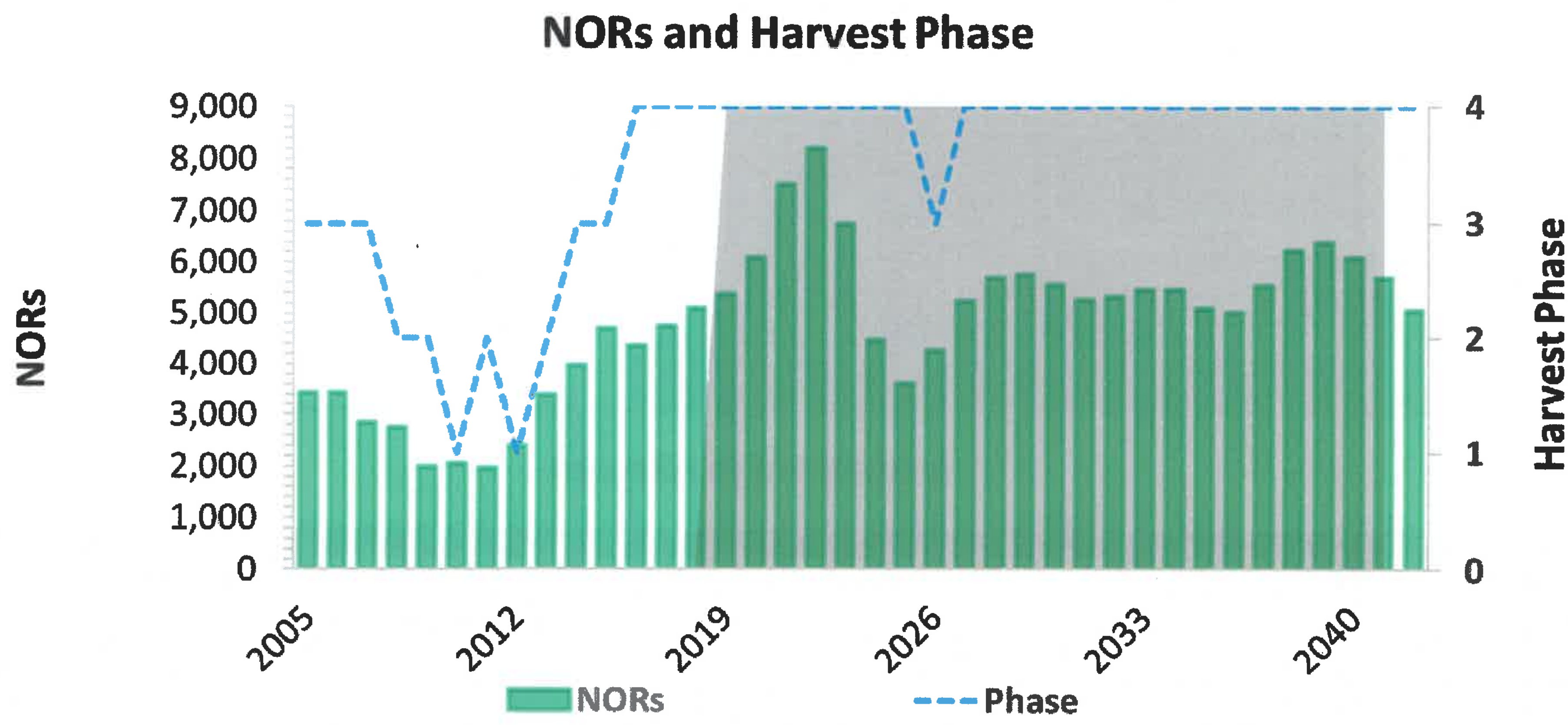




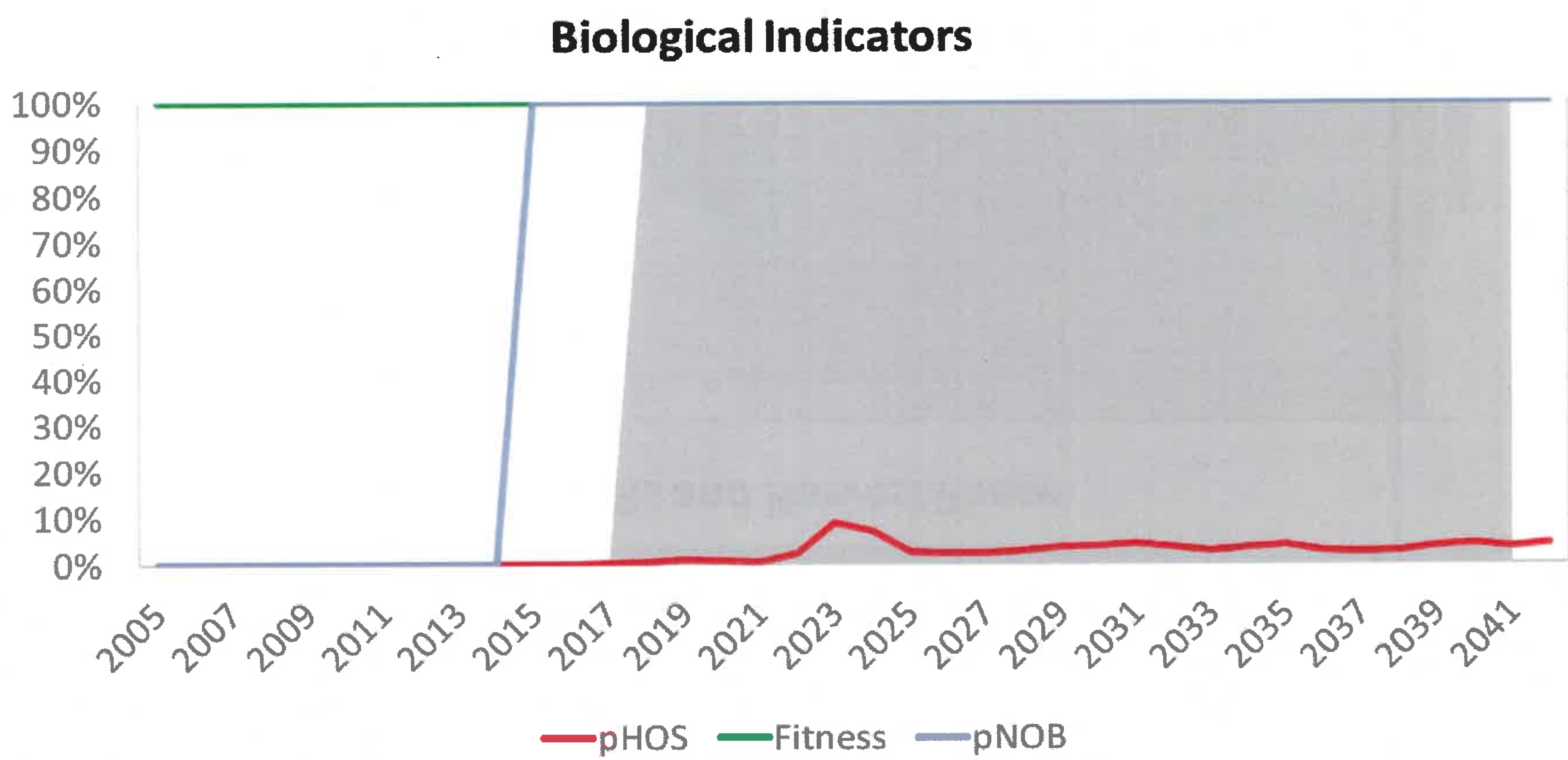
Upper Skagit Steelhead Base Model Results

- Good Ocean Conditions
- Population Fitness in 2041 (99.9%)
  - NOS – 4,183 (95% CI: 3,815 – 4,551)
    - Primarily in the top harvest phase
    - (25% NOR and 62.5% HOR)
  - pHOS – 2.9% (95% CI: 2.24.3% - 3.7%)
  - PNI – 0.97 (95% CI: 0.96 – 0.98)
  - NOR Harvest – 1,349 (95% CI: 1,222 – 1,476)
  - HOR Harvest – 831 (95% CI: 790 – 1,082)

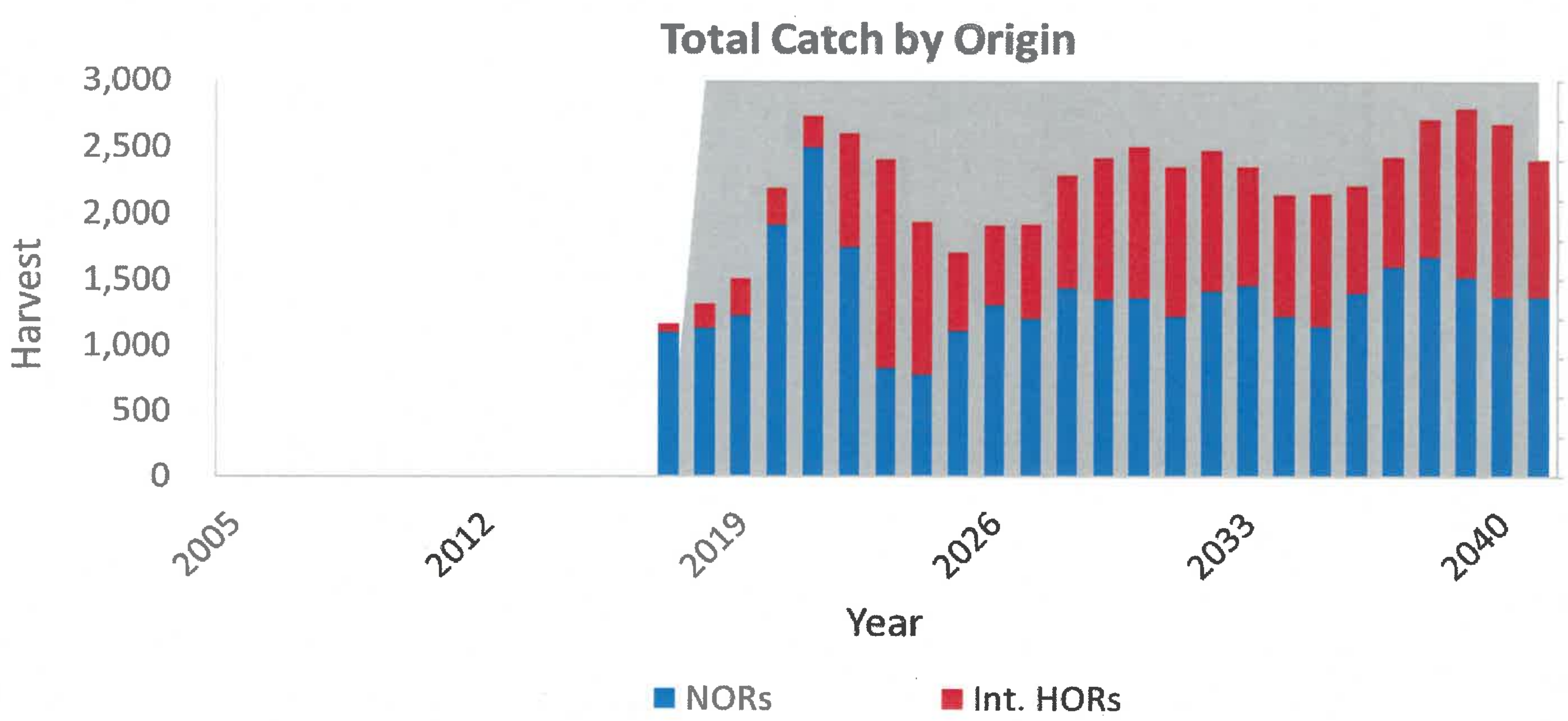
Upper Skagit Steelhead Base Model Results



Upper Skagit Steelhead Base Model Results



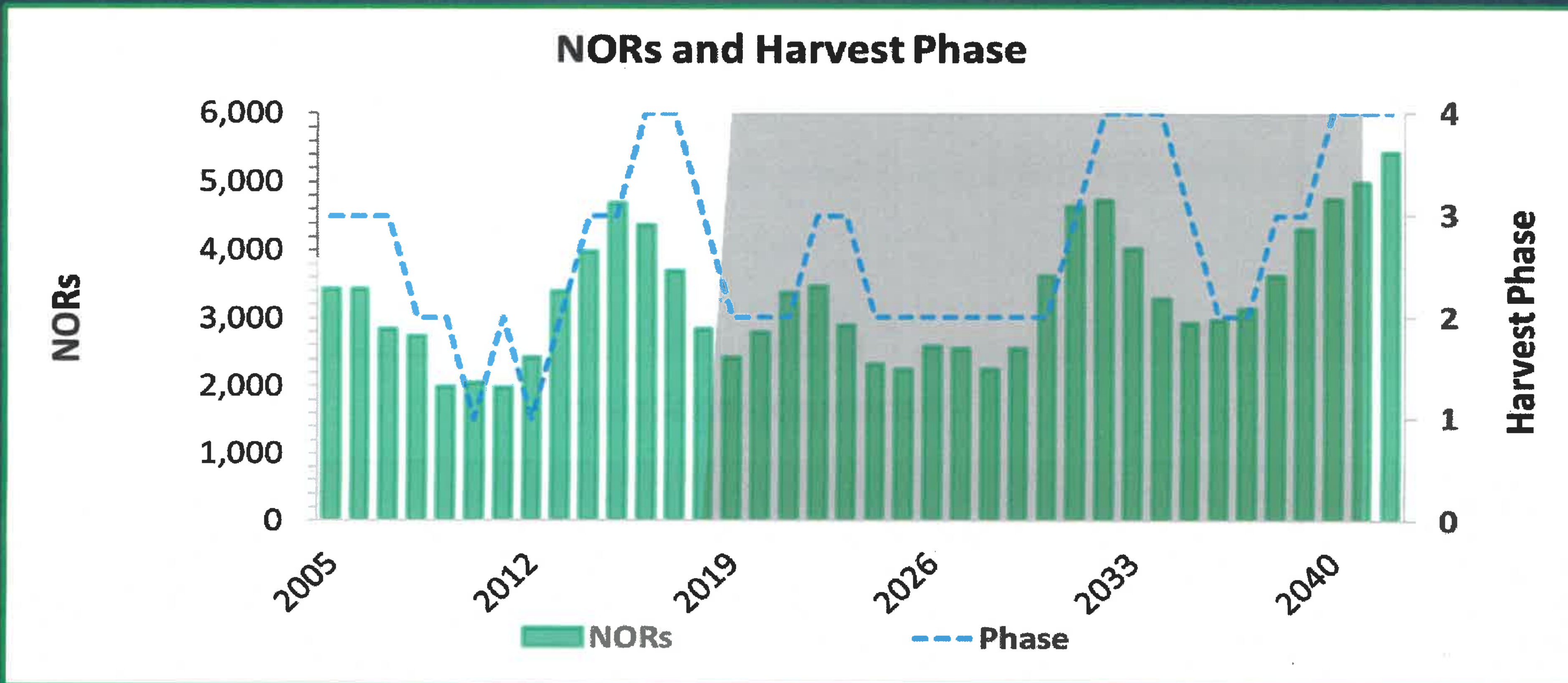
Upper Skagit Steelhead Base Model Results



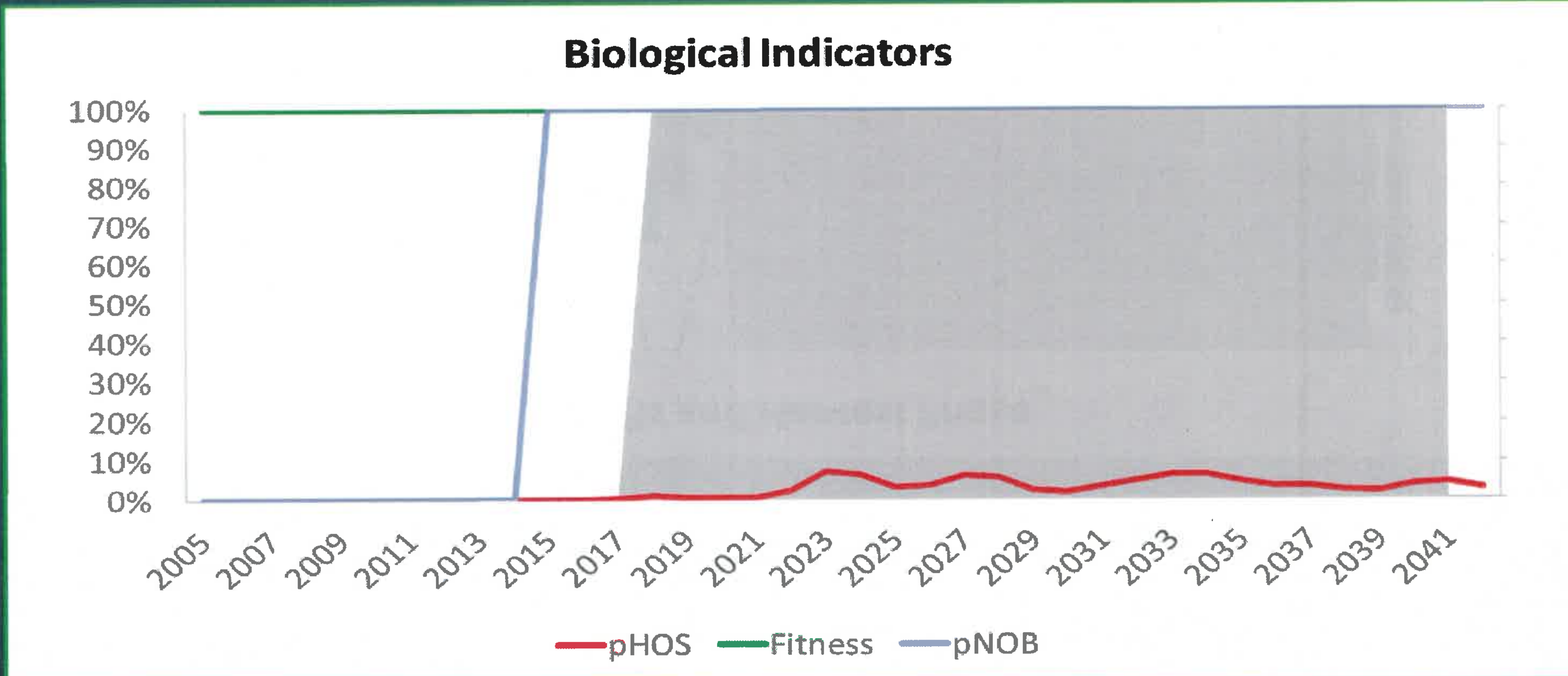
Upper Skagit Steelhead Base Model Results

- Poor Ocean Conditions
- Natural Origin Fitness in 2041 (99.9%)
  - NOS – 2,817 (95% CI: 2,422– 3,211)
    - Primarily in the middle two harvest phases
    - (10% to 20% NOR and 55% to 60% HOR)
  - pHOS – 3.4% (95% CI: 2.6% - 4.2%)
  - PNI – 0.97 (95% CI: 0.96 – 0.98)
  - NOR Harvest – 559 (95% CI: 436 – 683)
  - HOR Harvest – 503 (95% CI: 370 - 635)

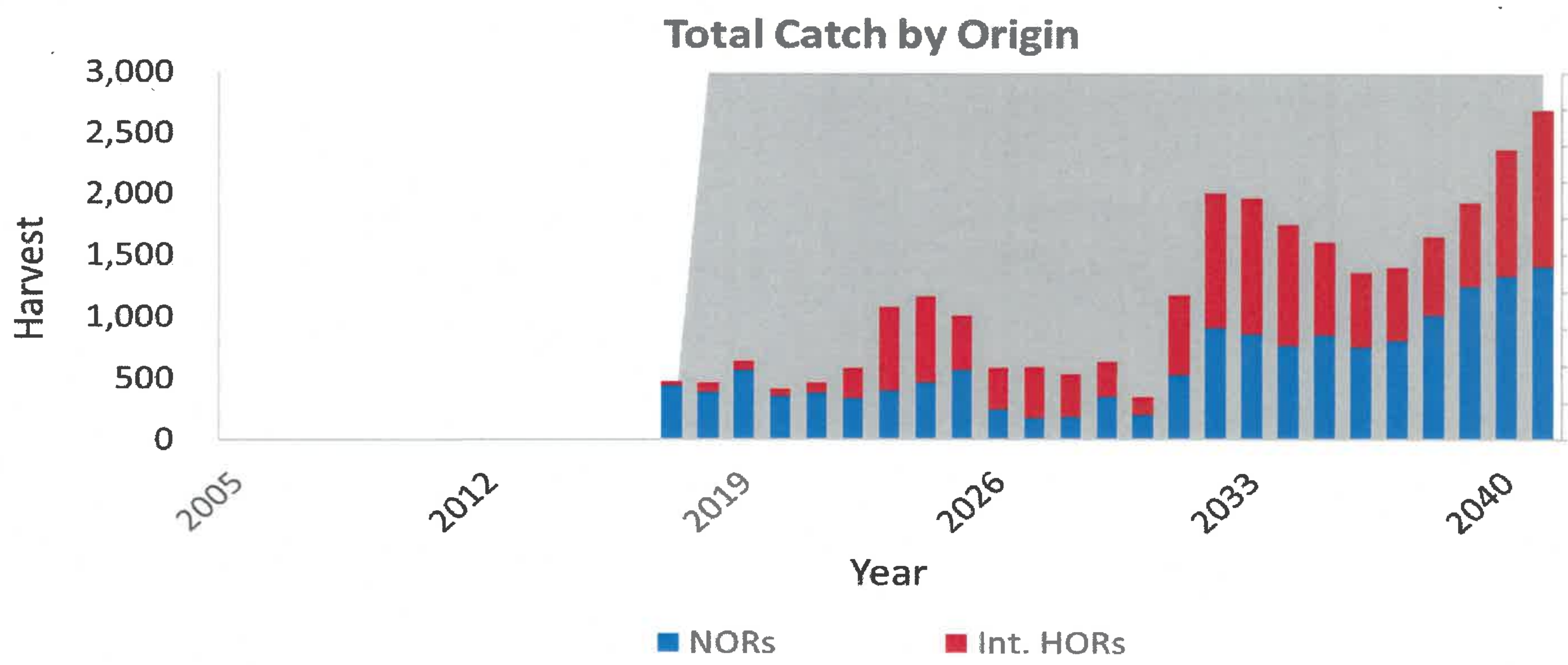
Upper Skagit Steelhead Base Model Results



Upper Skagit Steelhead Base Model Results



Upper Skagit Steelhead Base Model Results



Increased Straying – Only 25% return to hatchery after fisheries

- Good Ocean Conditions
  - pHOS – 7.0% (95% CI: 5.4% - 8.7%)
  - PNI – 0.940 (95% CI: 0.92 - 0.95)

- Poor Ocean Conditions
  - pHOS– 8.0% (95% CI: 6.2% - 9.8%)
  - PNI – 0.93 (95% CI: 0.91 - 0.94)

What SAR% to hit 30% pHOS

- Poor Ocean Conditions
- Natural SAR = 2.5%
- Hatchery SAR = 2.0%

- Results
  - Fitness in 2041 = 96.5%
  - NOS – 1,825 (95 CI: 1,545 - 2,105)
  - pHOS– 25.0% (95% CI: 20.0 % - 30.0%)
  - PNI – 0.80 (95% CI: 0.766 - 0.835)
  - NOR Harvest – 153 (95% CI: 196 - 380)
  - HOR Harvest – 1,276 (95% CI: 818 – 1,733)

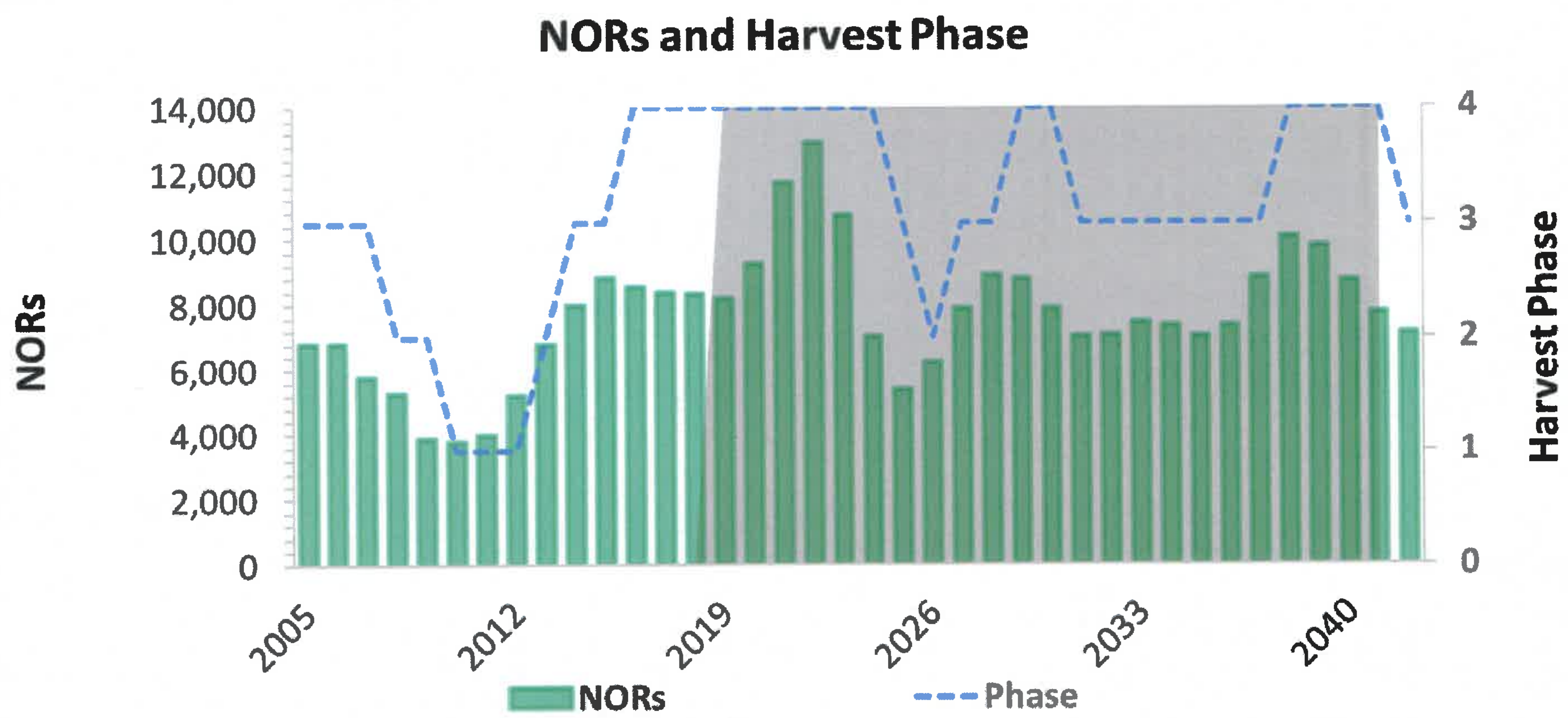
No Hatchery Scenario

- Used a model parameterized for the entire Skagit Basin (Skagit, Sauk, Nookachamps)
- Natural Origin Parameter Overview
  - Smolt productivity = 110 smolts per female
  - Capacity = 168,841 smolts
  - SAR% = 4%
- Harvest Phases
  - Phase 1: 4% Wild: ≤ 4000 NORs
  - Phase 2: 10% Wild: 4001-6000 NORs
  - Phase 3: 20% Wild: 6001-8000 NORs
  - Phase 4: 25% Wild: ≥ 8001 NORs

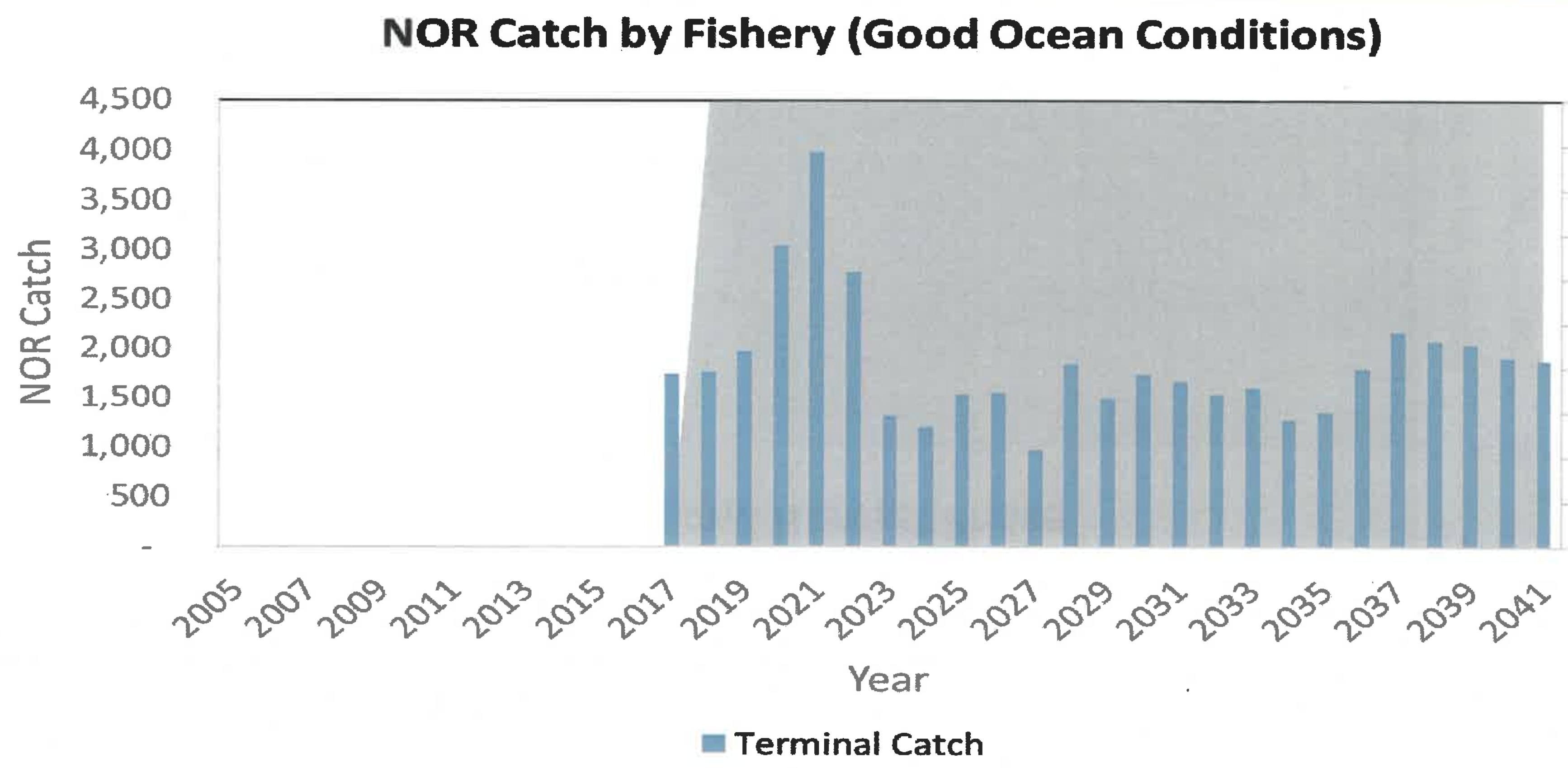
No Hatchery Model Results

- Preliminary Results (Based on entire Skagit watershed)
- Good Ocean Conditions
  - Primarily in the top two harvest phases (20% to 25%)
  - Average harvest 1,868 (95% CI: 1,689 – 2,047)
- Poor Ocean Conditions
  - Primarily in the middle two harvest phases (10% to 20%)
  - Average harvest 610 (95% CI: 454 - 766)

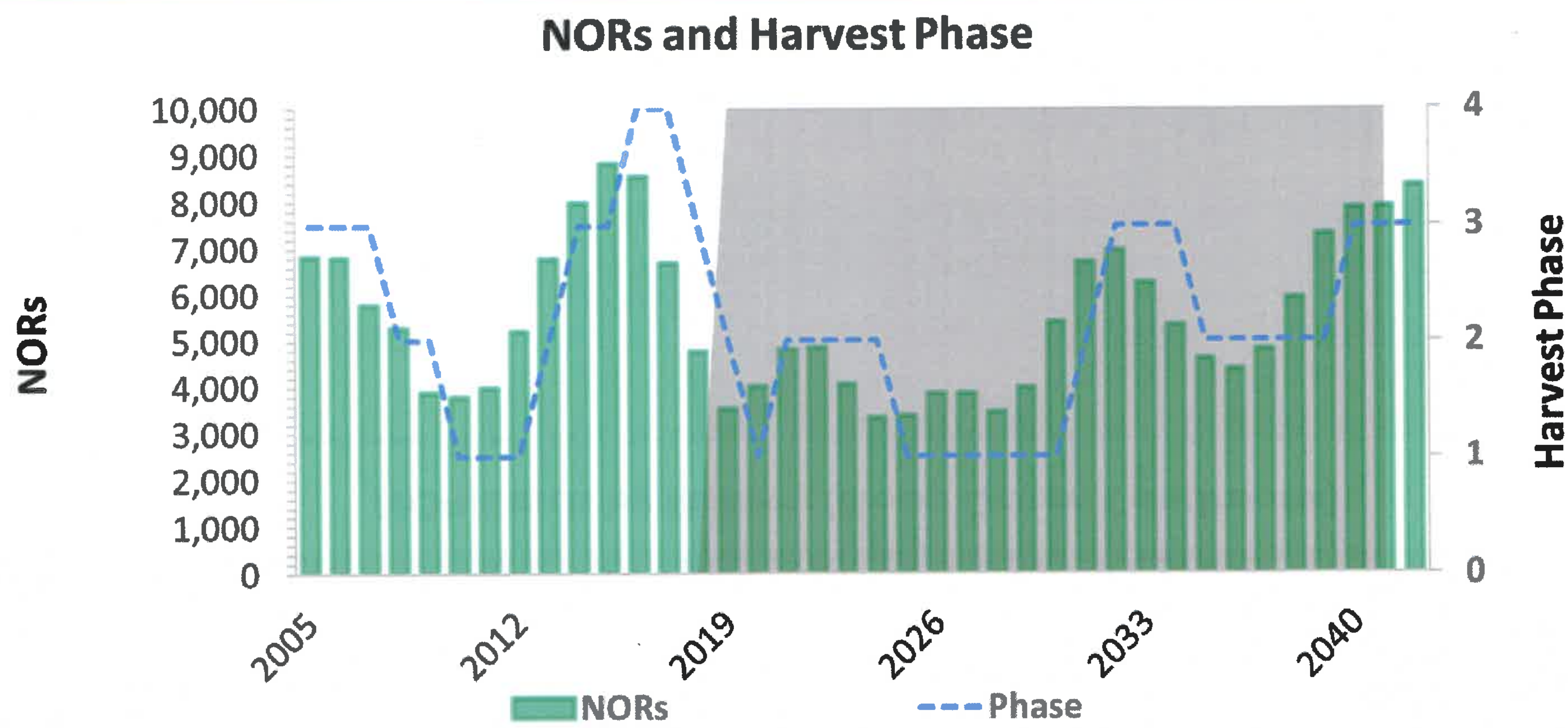
No Hatchery Model Results – Good Ocean Conditions



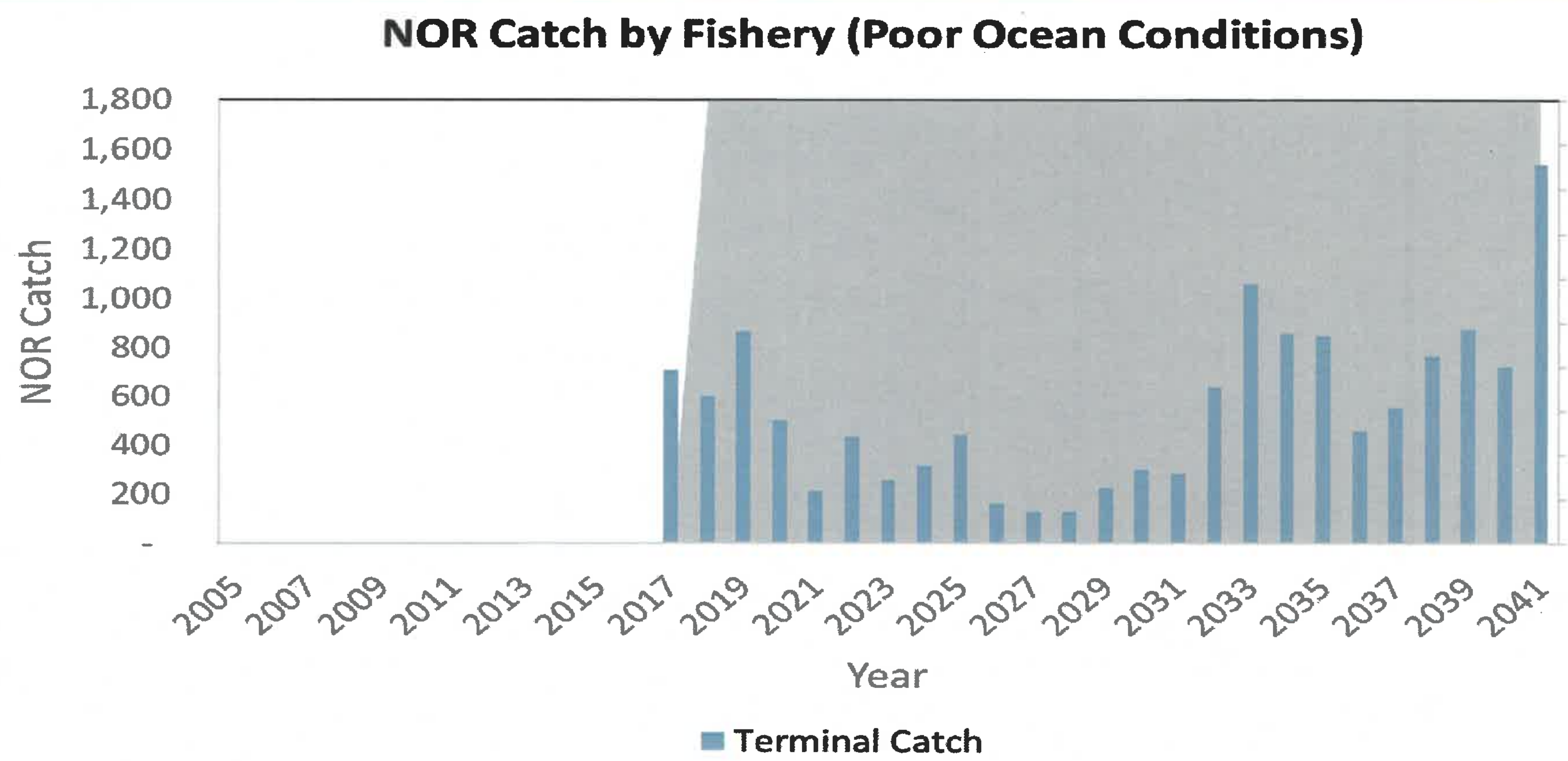
No Hatchery Model Results – Good Ocean Conditions



No Hatchery Model Results – Good Ocean Conditions



No Hatchery Model Results – Good Ocean Conditions



Ecological Impacts – Hatchery Residuals

- Literature values suggest 0 - 17% residual rate for hatchery steelhead (Hausch and Melynchuck 2012).
  - Average 5.6%
- Data from Duckabush River suggests a 7.5% residual rate.
  - Two year old smolts
  - Likely included cutthroat hybrids
  - Out-planted
  - Most concentrated near release sites
- At 7.5% and a 200,000 release would anticipate ~15,000 residuals
  - Would be expected to hold near the hatchery
  - Expected that volitional release will reduce residual rate

Questions?