Puget Sound Steelhead Advisory Group Recommendations

Summary of Options for Northern Cascades Portfolio

Draft March 28, 2018

Population or Watershed	Run Timing	Designation	Fishery		Integrated Hatchery			Segregated Hatchery			Comments
			Early Timed (angler days)	Native-Timed (angler days)	Purpose	PNI Limit (Proposed)	Proposed Program Size	Purpose	DGF Limit (Proposed)	Proposed Program Size	
Drayton Harbor Tributaries	Winter	Stabilizing									
		Contributing									
Nooksack River	Winter	Primary	C&K Analyze					Harvest	0.02 (0.004)	150,000	Early Winter program of 150,000 approved by NOAA.
			C&K Analyze	C&R Analyze				Harvest	0.02 (0.004)	150,000	Install sonar counter to improve assessment of the number of spawners.
				C&R Analyze							
South Fork Nooksack River	Summer	Primary									
Samish River & Bellingham Bay Tributaries	Winter	Contributing or Primary									
		Contributing		C&R Analyze							
		Primary		C&R Analyze							
Skagit River	Winter	Primary		C&R Analyze							
				Mark Selective Analyze	Harvest	≥ 0.67 (0.97)	200,000				
Nookachamps Creek	Winter	Contributing									
		Primary									
Baker River	Summer/ Winter	Stabilizing									
		Contributing									
Sauk River	Summer/ Winter	Primary		C&R Analyze							
Stillaguamish River	Winter	Contributing	C&K Analyze						≤ 0.04 (0.005)	130,000	Early Winter program of 130,000 approved by NOAA.
			C&K Analyze	C&R Analyze					≤ 0.04 (0.005)	130,000	Install sonar counter to improve assessment of the number of spawners.
		Primary	C&K Analyze		Conservation	≥ 0.50 (X)	Identify Program Size		≤ 0.02 (0.005)	130,000	
Deer Creek	Summer	Primary									
Canyon Creek	Summer	Contributing									
		Primary									

Snohomish & Skykomish Rivers	Winter	Contributing	C&K Analyze					Harvest	≤ 0.04 (0.018_	167,000	Early Winter program of 167,000 approved by NOAA.
			C&K Analyze	C&R Analyze				Harvest	≤ 0.04 (0.018)	167,000	
		Primary	C&K Analyze	C&R Analyze	Conservation	≥ 0.67 (X)	Identify Program Size	Harvest	≤ 0.02 (0.018)	167,000	
Pilchuck River	Winter	Primary									
				C&R Analyze							
N.F. Skykomish River	Summer	Stabilizing	C&K Analyze (Summer Fishery)		Harvest	High	Identify Program Size				Evaluate replacement for Reiter Ponds Skamania program.
		Contributing	C&K Analyze (Summer Fishery)		Harvest	≥ 0.50 (X)	Identify Program Size				
		Primary			Conservation	≥ 0.67 (X)	Identify Program Size				
Snoqualmie River	Winter	Contributing	C&K Analyze					Harvest	≤ 0.04 (0.014)	74,000	Early Winter program of 74,000 approved by NOAA.
			C&K Analyze	C&R Analyze				Harvest	≤ 0.04 (0.014)	74,000	
		Primary	C&K Analyze					Harvest	≤ 0.02 (0.014)	74,000	
Tolt River	Summer	Contributing									
		Primary									

Assessment of potential pHOS resulting from precocial males and residuals

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Puget Sound Steelhead Advisory Group
March 29, 2018

Residual estimate from February PSSAG meeting

200K release * 10% residualism = 20,000 residuals

75% male * 42% mature/maturing = 6,300 mature male residuals

100,000 – 250,000 wild steelhead smolts
* 8.1% residual-specific pHOS = 8,100 – 20,250 hatchery residuals

pHOS: percent Hatchery-Origin Spawners

Hatchery	Wild
Adult spawners	**Adult spawners**
Hatchery residuals precocial males	**Wild residuals** precocial males*

$$pHOS = HOS_A + HOS_R / HOS_A + HOS_R + NOS_A + NOS_R$$

*We did not include wild rainbow trout

"Cumulative" pHOS

	Hatchery			pHOS	Wild	
Year	Adults	Precocial Males			Adults	Precocial Males
1						
2						
3						
4						
5						
6						
7						
8						

Adult spawners

Hatchery

Program Size	200,000
SAR	0.0050
Total adult returns	1000
Adults after 55% harvest rate	450
Adult stray rate	0.3
Adults to hatchery	315
Adults to spawning grounds	135

Wild

4000 adult spawners

$$pHOS_A = HOS_A / HOS_A + NOS_A$$

$$=3.38\%$$

Precocial male residuals

Precocial males = New residuals + Previous survivors

- Residual rate
- % male by age
- % maturity by age
- Survival rate by age

New residuals (age-1)

Hatchery

Program size	200,000
Residual rate	0.056
New residuals	11,200

Wild

Adults on spawning grounds	4,000
Females on spawning grounds	2,222
Fecundity	5,700
Eggs in gravel	12,666,667
Egg to fry survival	0.20
age 0 fish produced	2,533,333
Survival age-0 to age-1	0.22
age-1 wild parr	557,333
residual rate	0.10
New residuals	55,733

Residuals: percent male

Hatchery

age-1	0.75
age-2	0.80
age-3	0.85
age-4	0.85
age-5	0.90
age-6	0.95
age-7	1.00

Wild

age-1	0.45
age-2	0.60
age-3	0.75
age-4	0.80
age-5	0.90
age-6	0.95
age-7	1.00

Residuals: percent mature males

Hatchery

mature at release (age-1)	0.42
age-2	0.75
age-3	1
age-4	1
age-5	1
age-6	1
age-7	1

Wild

mature at age-1	0.42
age-2	0.75
age-3	1
age-4	1
age-5	1
age-6	1
age-7	1

Residuals: survival rate

Hatchery	
age-1 to age-2	0.05
age-2 to age-3	0.25
age-3 to age-4	0.40
age-4 to age-5	0.50
age-5 to age-6	0.65
age-6 to age-7	0.85

Wild	
age-1 to age-2	0.25
age-2 to age-3	0.30
age-3 to age-4	0.40
age-4 to age-5	0.50
age-5 to age-6	0.65
age-6 to age-7	0.85

pHOS estimates

	Hatchery			Wild	
Year	Adult	Precocial Males	pHOS	Adult	Precocial Males
1	135	3,528	0.20	4,000	10,534
2	135	3,864	0.16	4,000	16,804
3	135	3,983	0.15	4,000	19,939
4	135	4,031	0.14	4,000	21,276
5	135	4,056	0.14	4,000	22,029
6	135	4,073	0.14	4,000	22,545
7	135	4,089	0.14	4,000	23,007
8	135	4,102	0.13	4,000	23,399

Sensitivity analysis

	Vary wild adults, everything else constant				
	Wild adults				
	8000	6000	4000	2000	1000
Year	pHOS	pHOS	pHOS	pHOS	pHOS
1	0.11	0.14	**0.20**	0.34	0.50
2	0.09	0.11	**0.16**	0.28	0.43
3	0.08	0.10	**0.15**	0.26	0.41
4	0.08	0.10	**0.14**	0.25	0.40
5	0.07	0.10	**0.14**	0.24	0.39
6	0.07	0.10	**0.14**	0.24	0.39
7	0.07	0.09	**0.14**	0.24	0.39
8	0.07	0.09	**0.13**	0.24	0.38

	Vary hatchery release, everything else constant				
	Release				
	50,000	100,000	200,000	300,000	500,000
Year	pHOS	pHOS	pHOS	pHOS	pHOS
1	0.06	0.11	**0.20**	0.27	0.39
2	0.05	0.09	**0.16**	0.22	0.32
3	0.04	0.08	**0.15**	0.21	0.30
4	0.04	0.07	**0.14**	0.20	0.29
5	0.04	0.07	**0.14**	0.19	0.29
6	0.04	0.07	**0.14**	0.19	0.28
7	0.04	0.07	**0.14**	0.19	0.28
8	0.04	0.07	**0.13**	0.19	0.28

Sensitivity analysis

	Vary wild residual rate, everything else constant				
	Wild residual rate				
	0.3	0.2	0.15	0.1	0.056
Year	pHOS	pHOS	pHOS	pHOS	pHOS
1	0.09	0.13	0.16	**0.20**	0.27
2	0.07	0.10	0.12	**0.16**	0.23
3	0.06	0.09	0.11	**0.15**	0.21
4	0.06	0.08	0.10	**0.14**	0.21
5	0.06	0.08	0.10	**0.14**	0.20
6	0.06	0.08	0.10	**0.14**	0.20
7	0.05	0.08	0.10	**0.14**	0.20
8	0.05	0.08	0.10	**0.13**	0.20

Vary hatchery residual rate, everything else constant					
	hatchery residual rate				
	0.056	0.1	0.15	0.2	0.3
Year	pHOS	pHOS	pHOS	pHOS	pHOS
1	**0.20**	0.31	0.40	0.47	0.57
2	**0.16**	0.25	0.34	0.40	0.50
3	**0.15**	0.23	0.31	0.37	0.47
4	**0.14**	0.22	0.30	0.37	0.46
5	**0.14**	0.22	0.30	0.36	0.46
6	**0.14**	0.22	0.29	0.36	0.45
7	**0.14**	0.22	0.29	0.35	0.45
8	**0.13**	0.21	0.29	0.35	0.45

Sensitivity analysis

hatchery residual rate = 0.3 + vary wild adults

	wild adults				
	8000	6000	4000	2000	1000
Year	pHOS	pHOS	pHOS	pHOS	pHOS
1	0.40	0.47	0.57	0.72	0.84
2	0.33	0.40	0.50	0.67	0.80
3	0.31	0.37	0.47	0.64	0.78
4	0.30	0.36	0.46	0.63	0.77
5	0.30	0.36	0.46	0.63	0.77
6	0.29	0.36	0.45	0.62	0.77
7	0.29	0.35	0.45	0.62	0.77
8	0.29	0.35	0.45	0.62	0.76

Density dependence, hatchery releases and environmental conditions explain annual variation in productivity of Skagit River wild steelhead

Mark D. Scheuerell[1], Casey P. Ruff[2], Joseph H. Anderson[3], and Eric Beamer[2]

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[2]Skagit River System Cooperative

[3]Washington Department of Fish and Wildlife

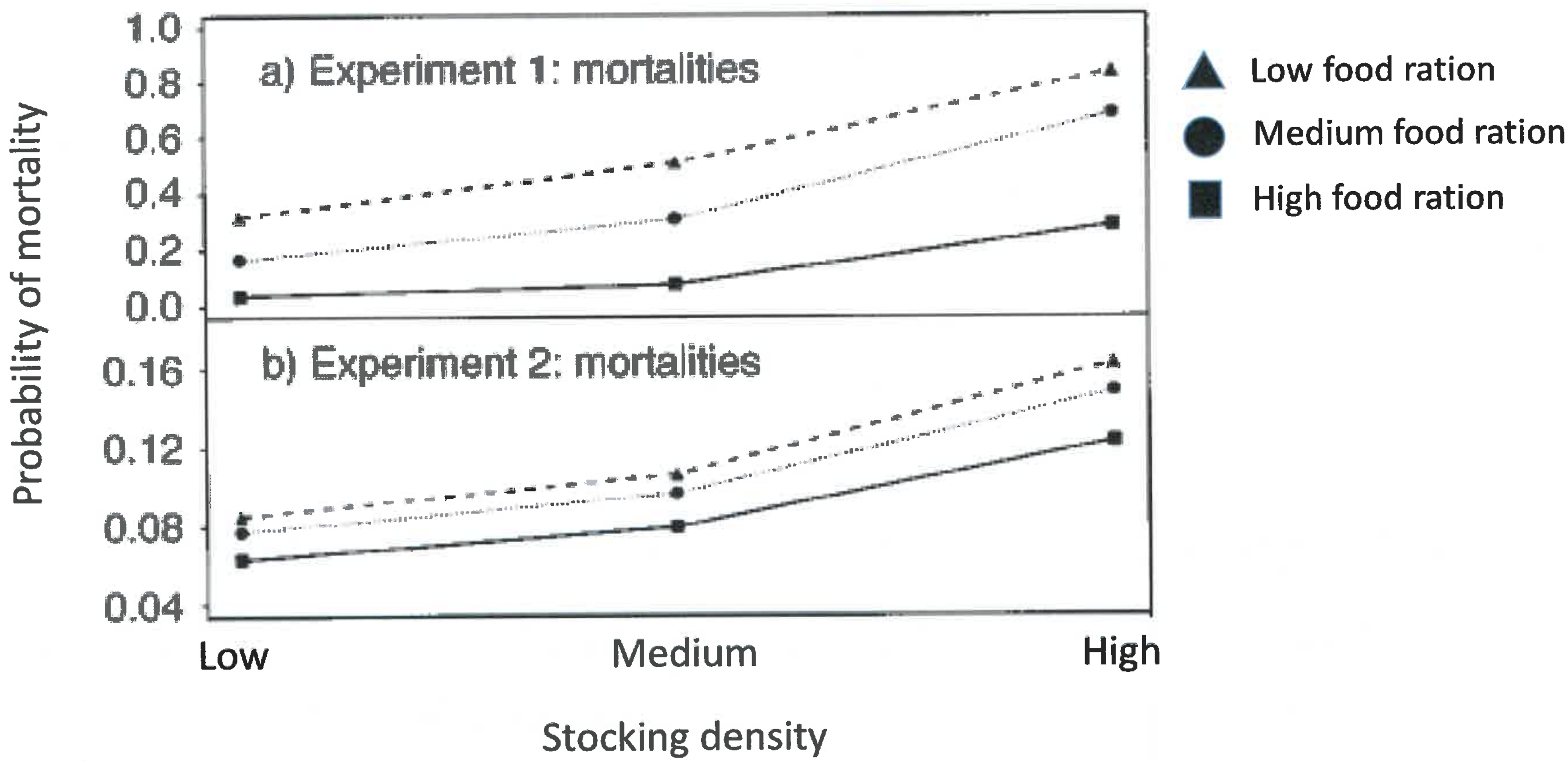
Puget Sound Steelhead Advisory Group

Lynnwood WA

March 29 2018

Density dependence in steelhead

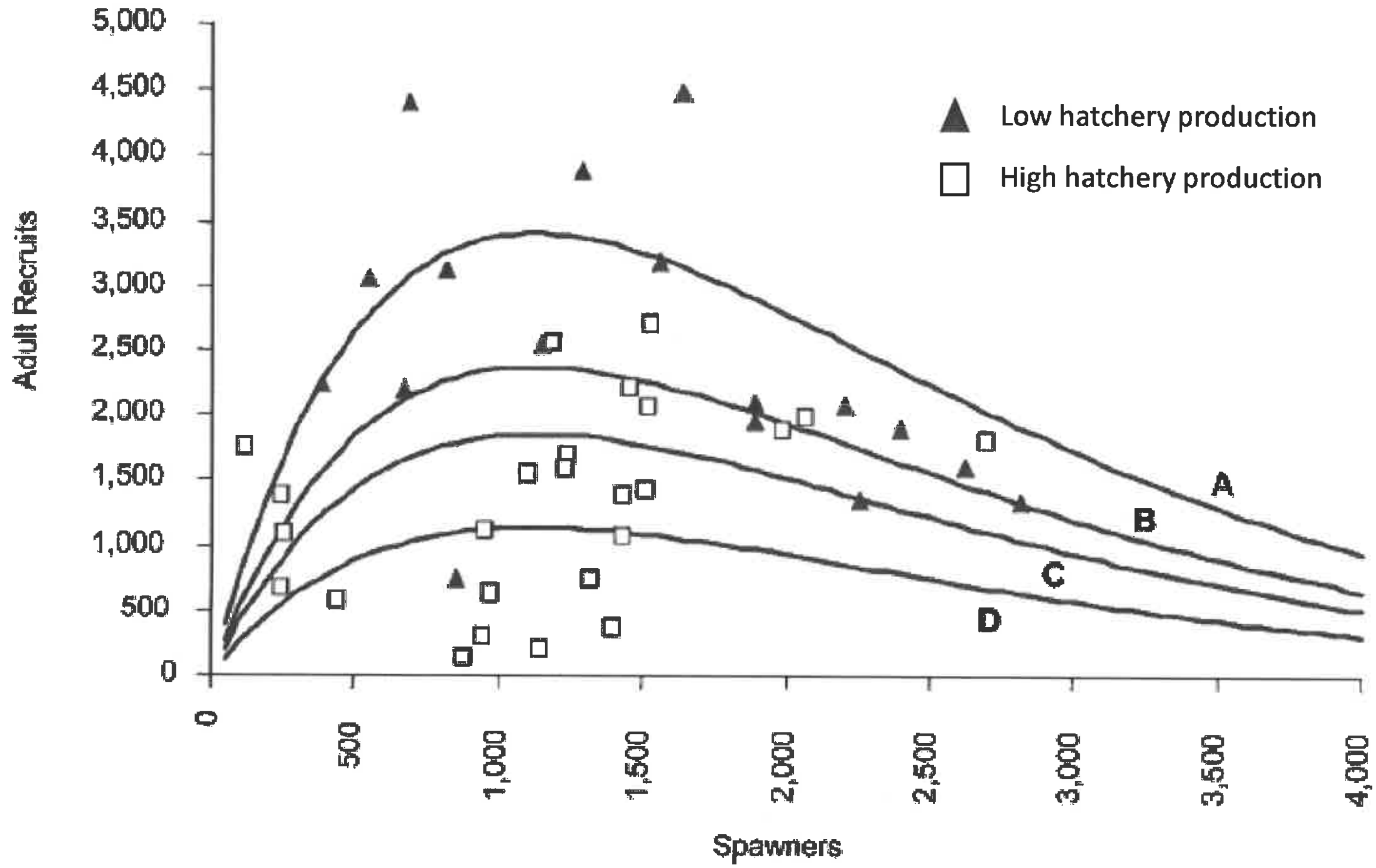
Evidence from experimental streams



Keeley 2000 *Ecology*

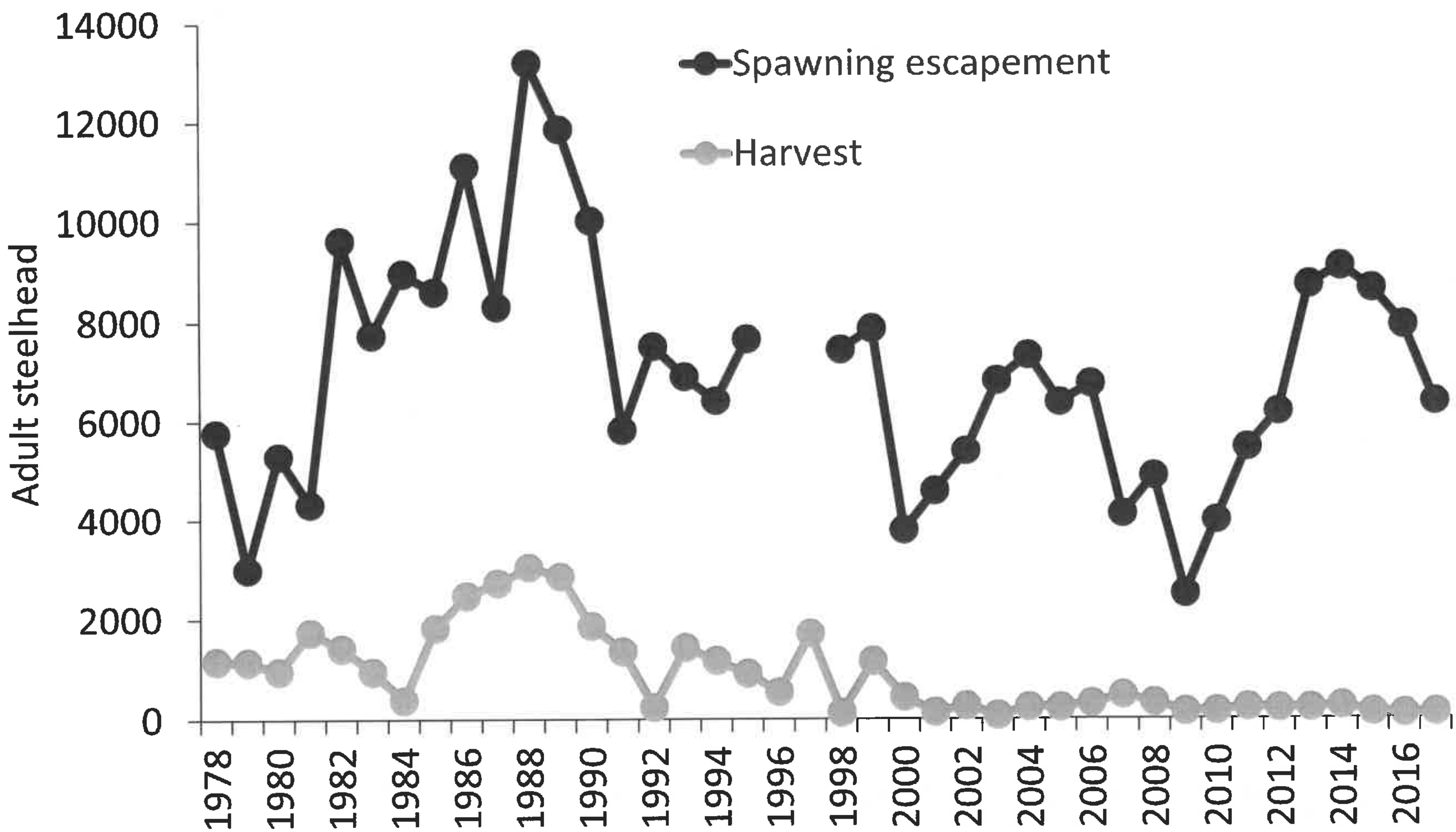
Density dependence in steelhead

Evidence from natural populations

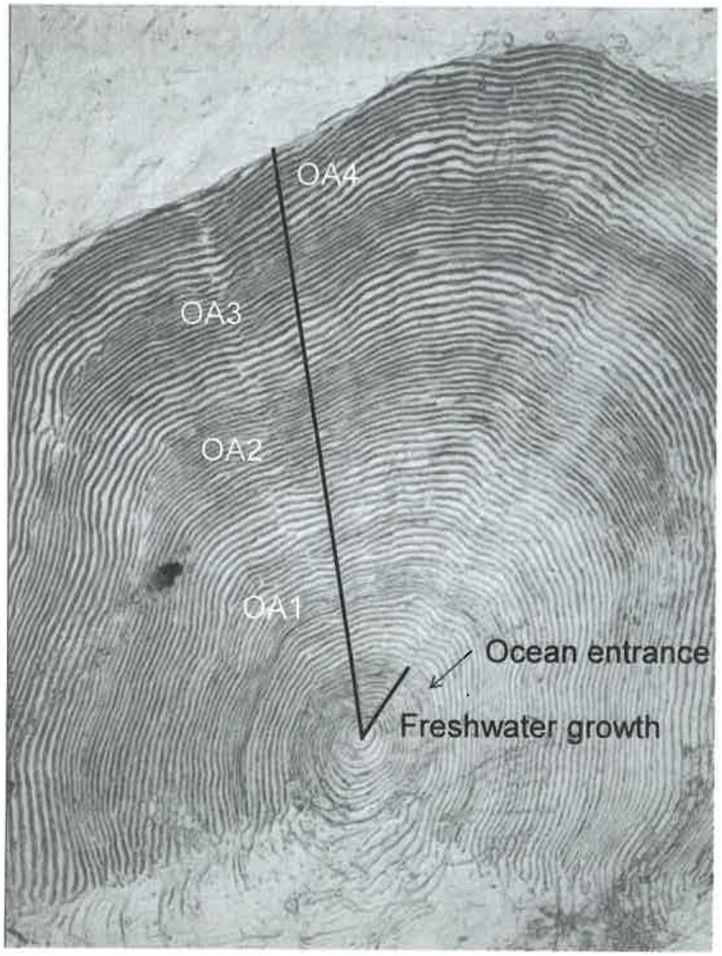


Kostow and Zhou 2006 *TAFS*

Skagit River Steelhead



Skagit River Steelhead



Age data 1978 - 2017

N = 4,332 scale samples

Age	Percent
Age-3	1.6 %
Age-4	35.2 %
Age-5	46.6 %
Age-6	14.7 %
Age-7	1.6 %
Age-8	0.3 %

12 years with ≤ 12 samples, including
7 years with no samples

Images: Lance Campbell, WDFW Fish Ageing and Otolith Laboratories

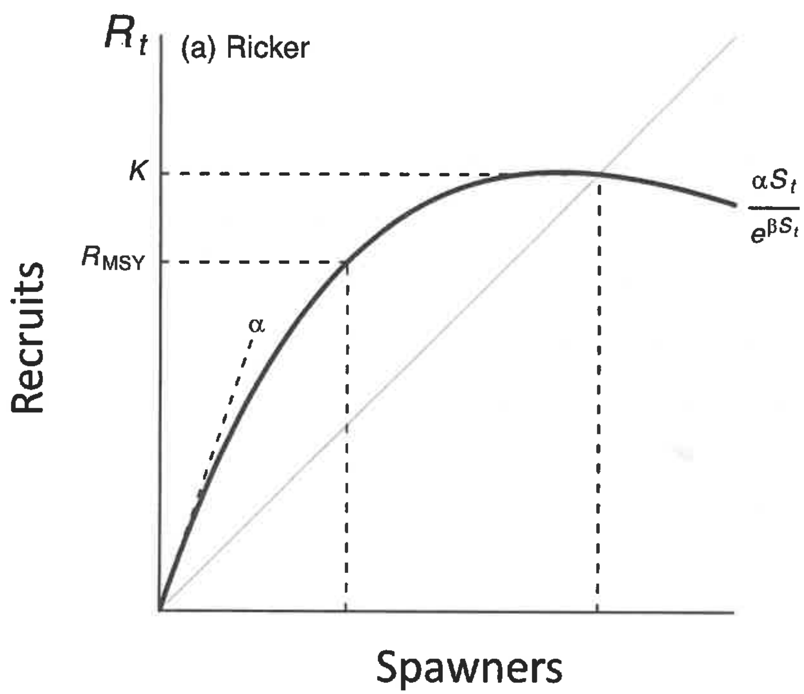
Research questions

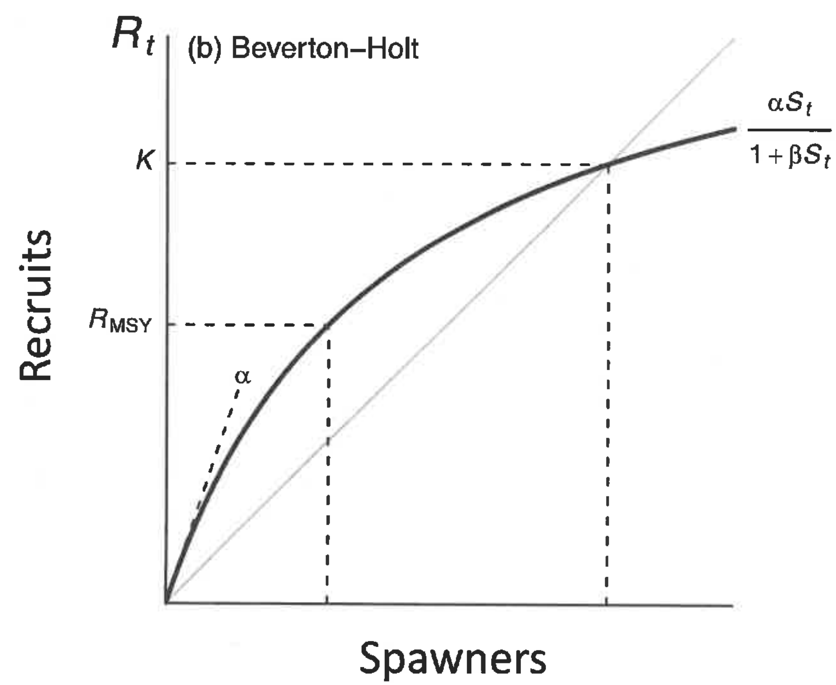
1. Is there evidence for density dependent productivity of wild Skagit River steelhead?

2. Is there any relationship between wild Skagit River steelhead productivity and river discharge or marine conditions?

3. Is there any relationship between wild Skagit River steelhead productivity and releases of hatchery steelhead?

Productivity model





Conventional Method

		Adult recruits							
Year	**Spawners**	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	**Total**	**Productivity**
1978	5757								
1979	2982								
1980	5288								
…									

Conventional Method

		Adult recruits							
Year	Spawners	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Total	Productivity
1978	5757	98	3881	4047	1369	168	34	9597	
1979	2982								
1980	5288								
...									

Conventional Method

		Adult recruits							
Year	**Spawners**	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	**Total**	**Productivity**
1978	5757	98	3881	4047	1369	168	34	9597	1.7
1979	2982								
1980	5288								

...

Integrated Population Model

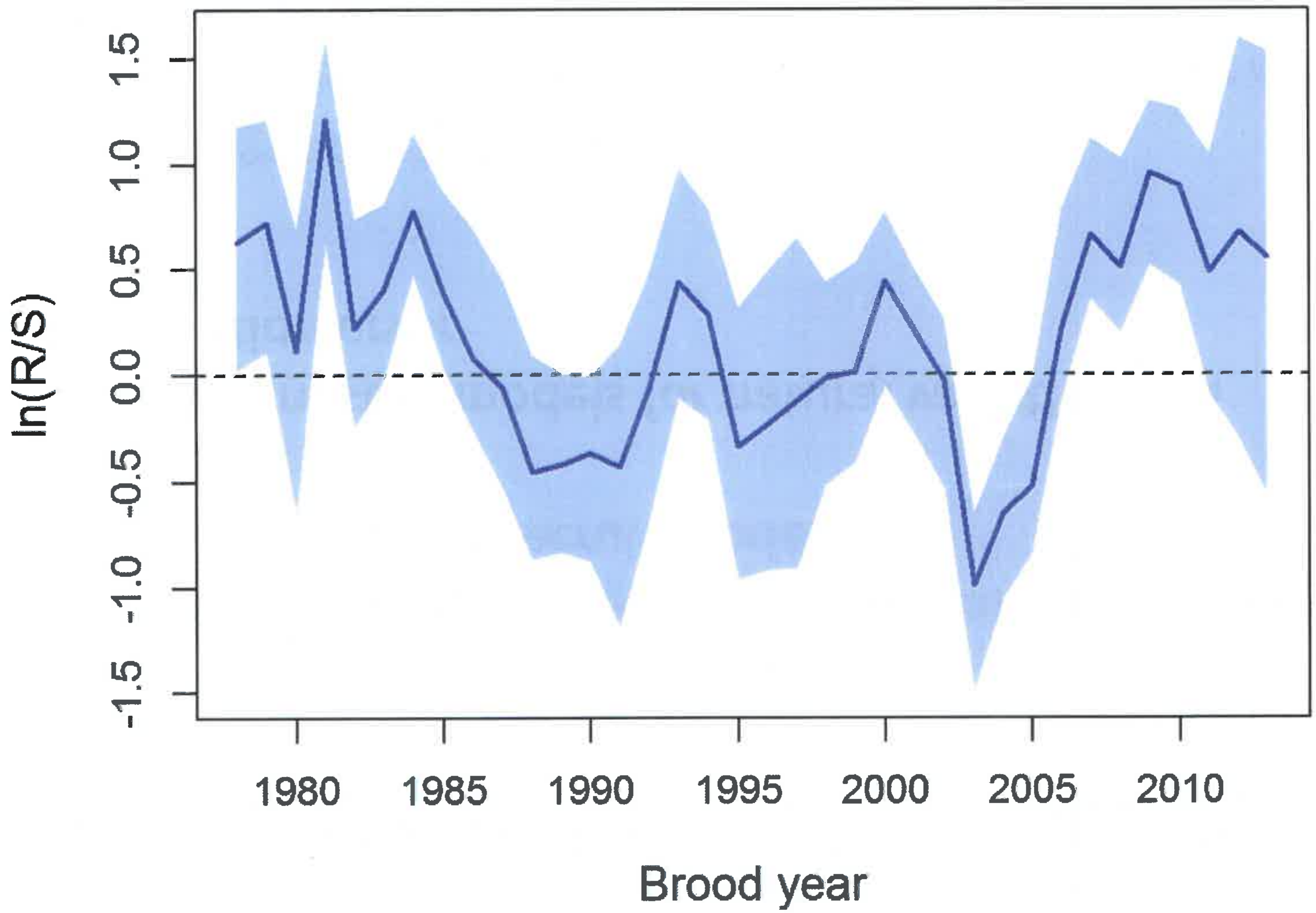
Models for age structure, environmental variation nested within larger stock-recruit model

Separate, nested models for natural variation and observation error

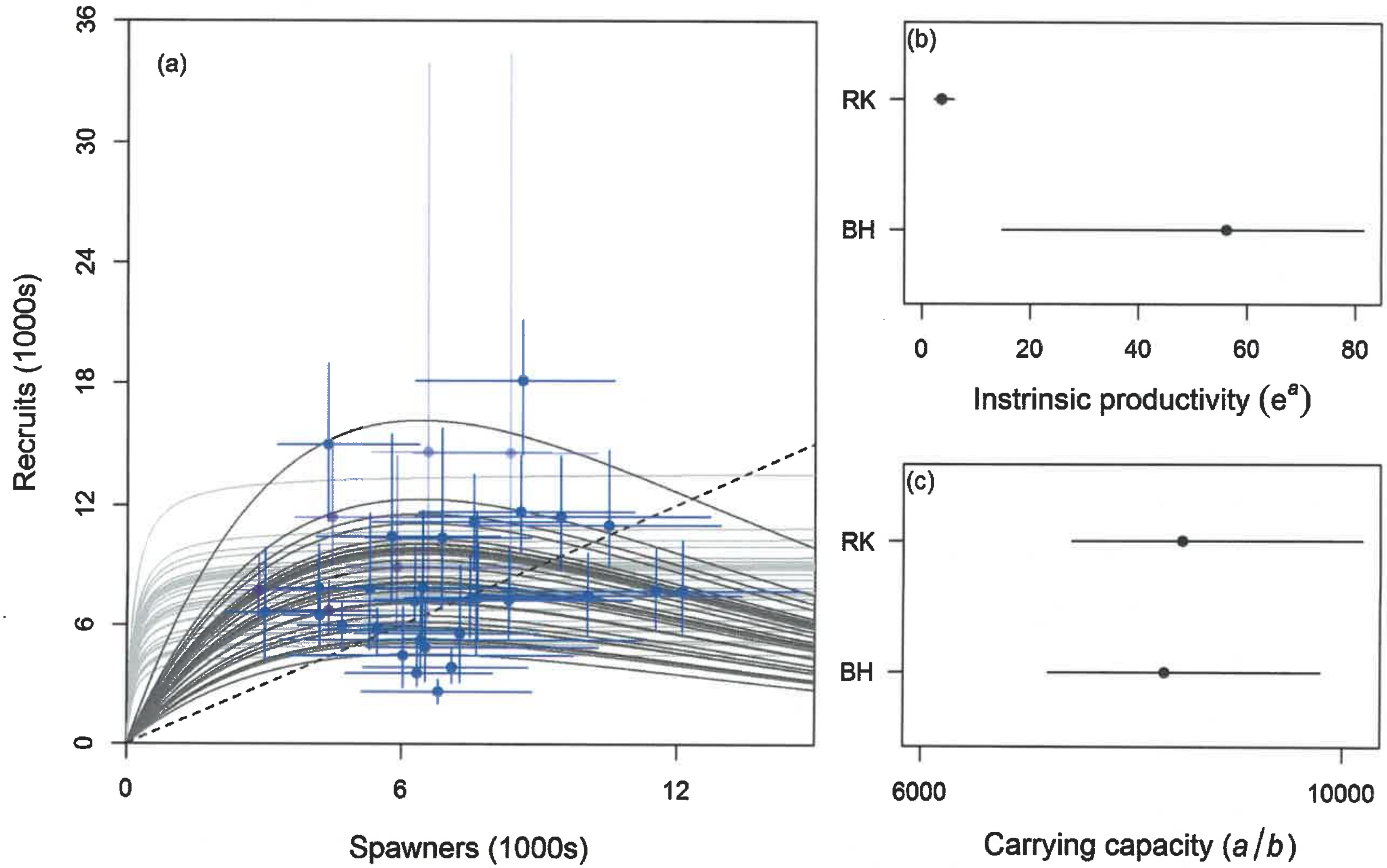
Advantages over conventional method

- Handles uncertainty and error in a more statistically robust manner
- Provides estimates of uncertainty for biological observations
- Allows for missing data points
- Accounts for autocorrelation

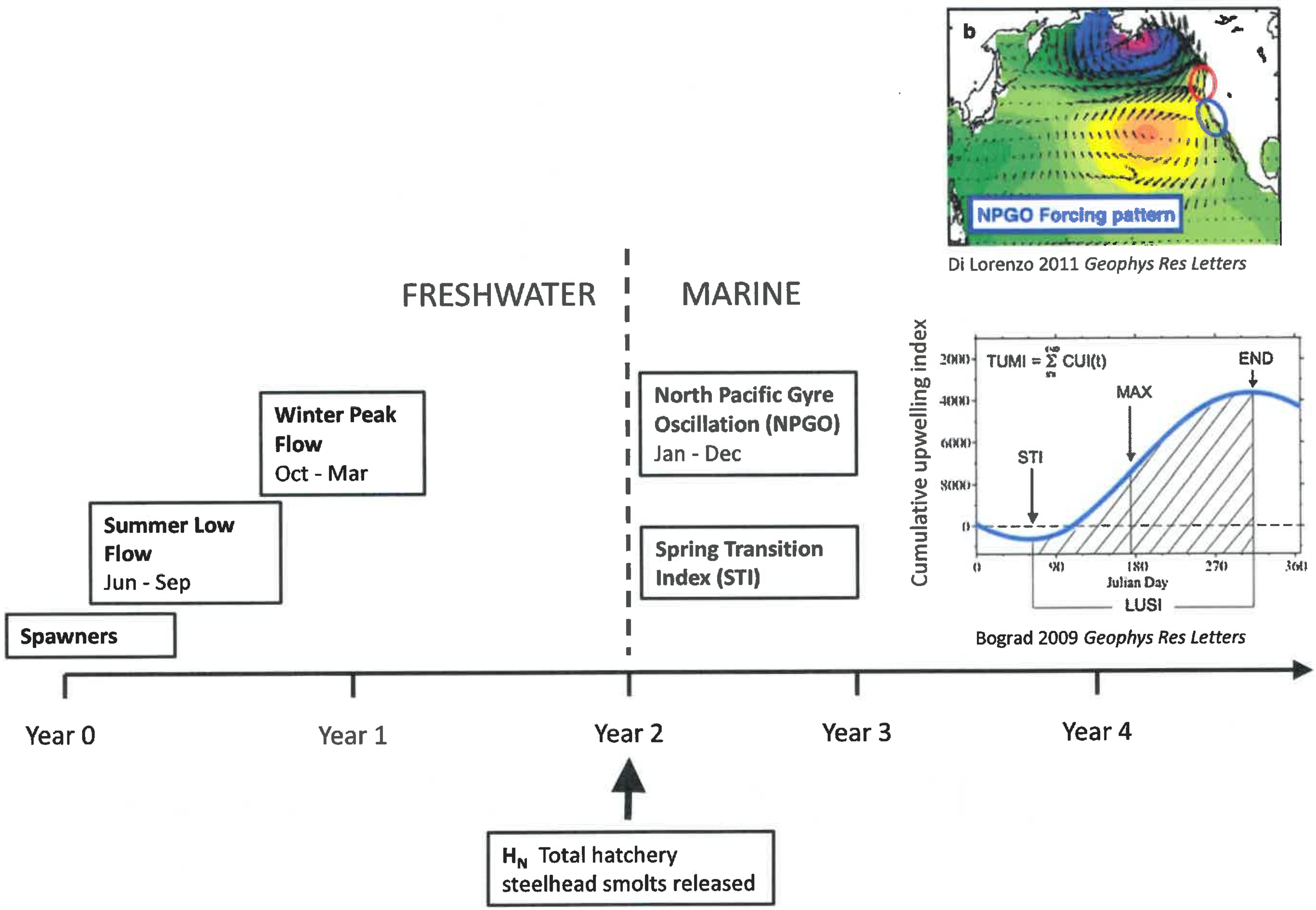
Skagit River steelhead productivity

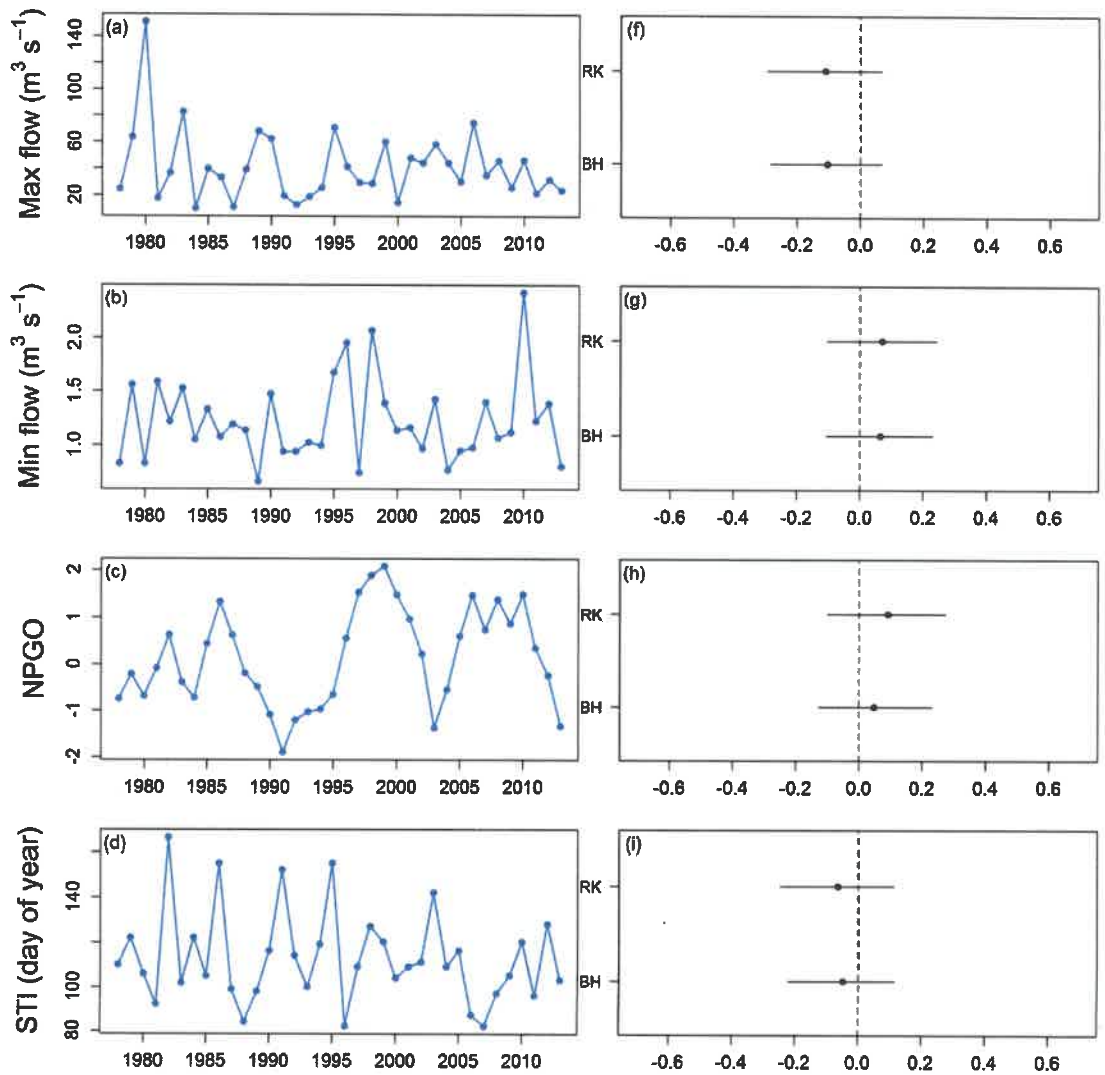


Evidence for density dependence

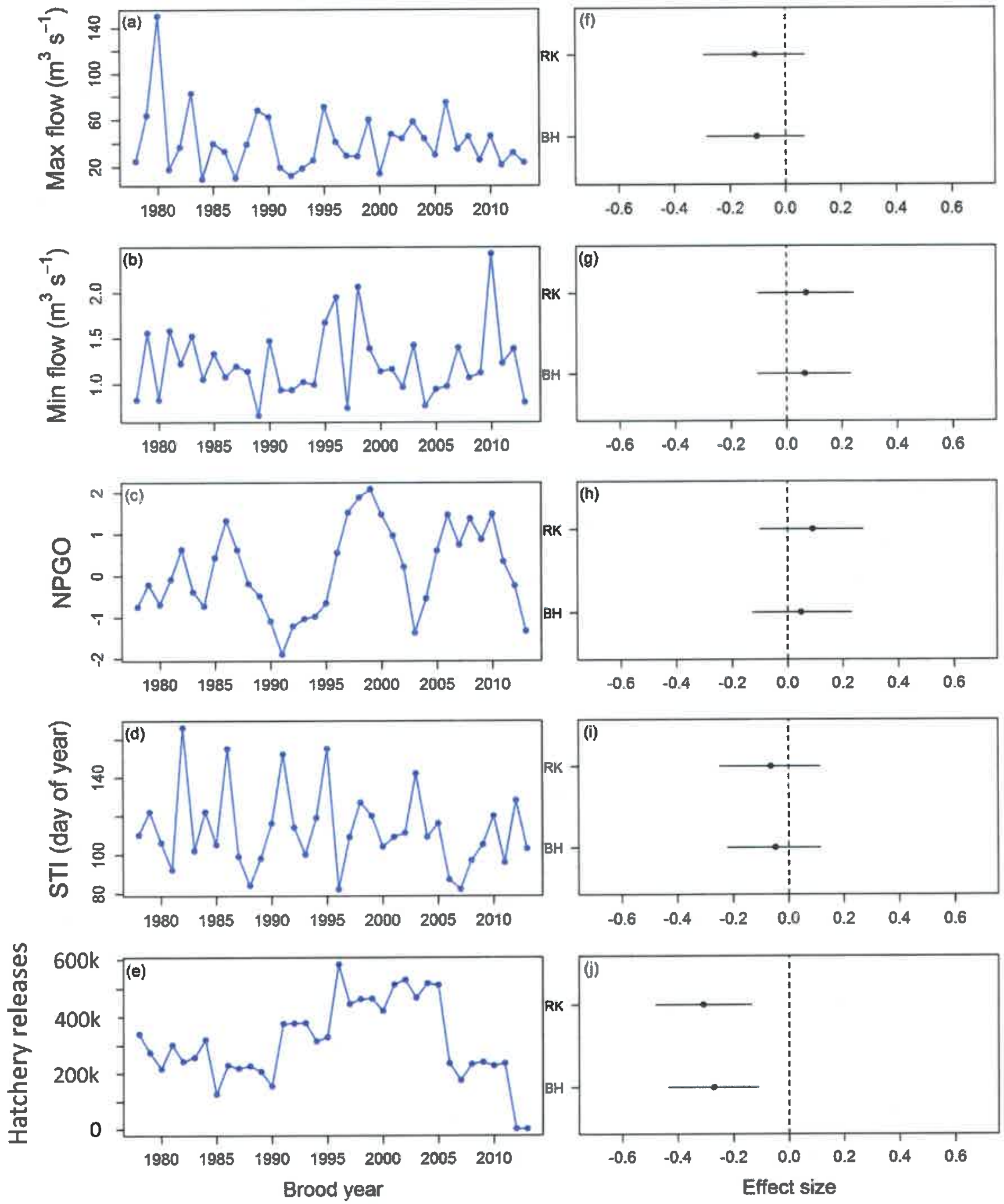


Predictors for productivity model





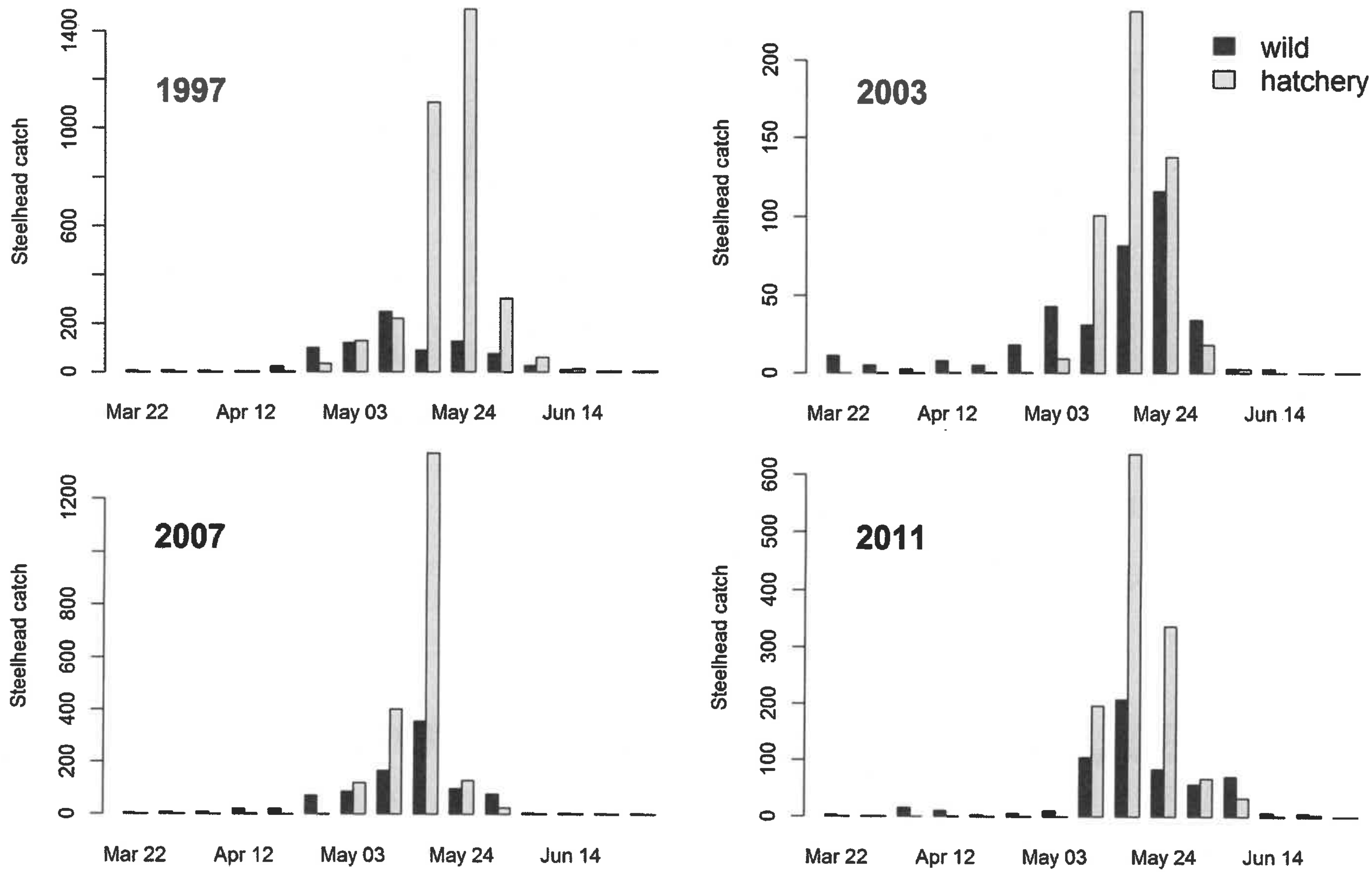
Max flow (m3 s-1)
(a)
(f)
Min flow (m3 s-1)
(b)
(g)
NPGO
(c)
(h)
STI (day of year)
(d)
(i)
RK
BH
1980 1985 1990 1995 2000 2005 2010
-0.6 -0.4 -0.2 0.0 0.2 0.4 0.6



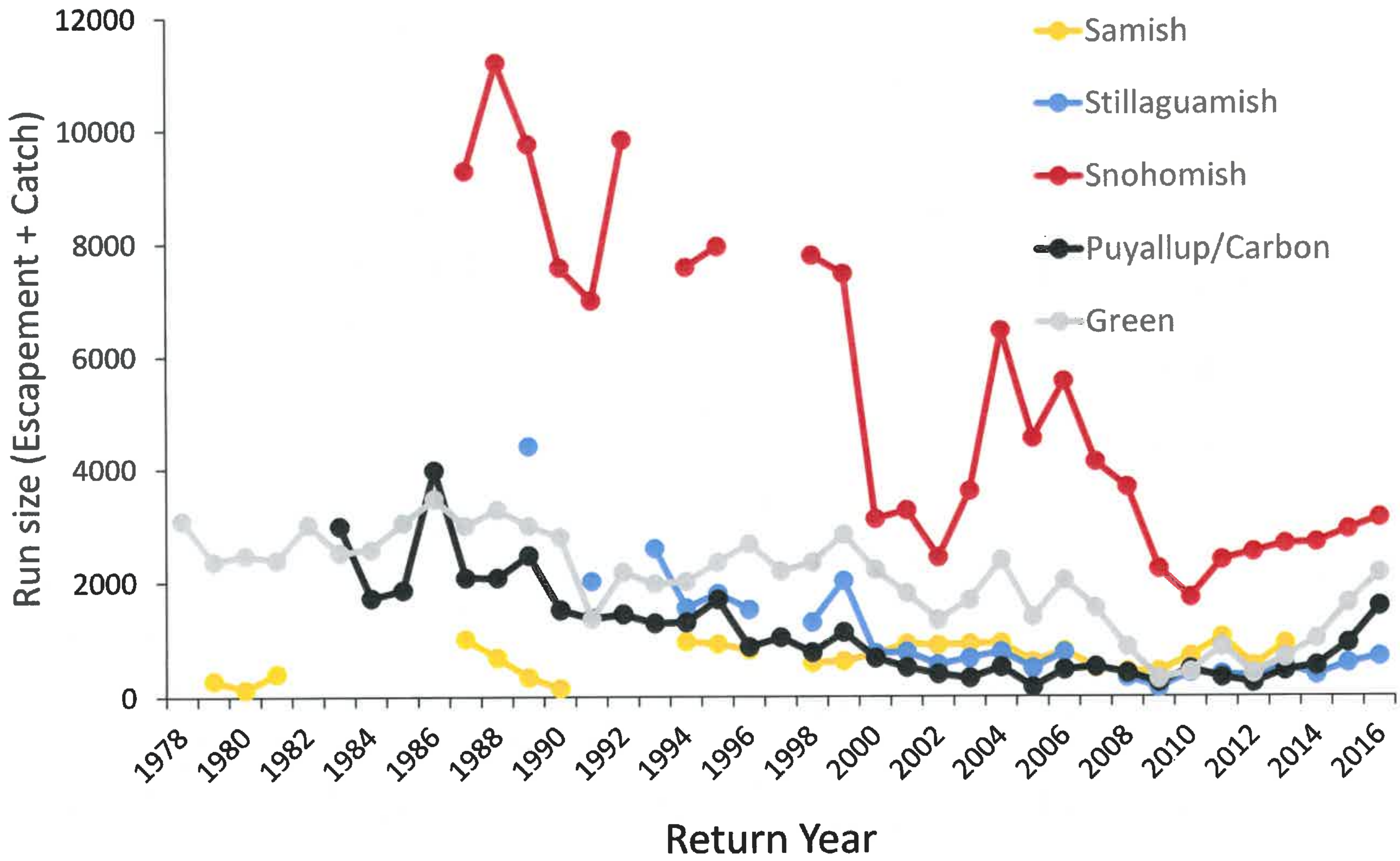
Mean = 328,000 smolts
1 standard deviation = 124,000 smolts
Predicts 25-30% decrease in productivity

Mechanism of potential interaction?

Smolt trap data indicate overlap in time and space



Common trends in abundance



Conclusions

- Evidence for density dependence in wild Skagit Steelhead
    - Growing appreciation that resource limitation is common in low abundance, threatened populations
    - Density dependence can operate at small spatial scales due to clumping

- Negative correlation between number of hatchery fish released and productivity of wild population
    - Additional examples from Oregon coho salmon, Snake River spring Chinook salmon, and Clackamas River steelhead

- Freshwater and marine indicators explain some variation in wild productivity

Acknowledgements

Skagit steelhead data, ecology, and management

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Pete Kairis

Model Advice

James Thorson
Eric Buhle

Additional Follow-up Questions and Analyses
Potential Skagit River Integrated Hatchery Program
Updated Draft March 27, 2018

1) **What would be the total cost (i.e., including monitoring, catch estimation, or other activities associated with implementation) of the potential hatchery program?**

The estimated cost of a program releasing 200,000 smolts, including associated monitoring programs, is $208,024 per year. This annual cost is comprised of the following elements:

Broodstock Collection:	
Salaries & Benefits	Existing Staffing
Travel	$5,000
Hatchery Culture	
Salaries & Benefits	$61,206
Fish Food	$56,200
Utilities	$28,333
Goods & Services	7,900
Virology	$2,580
Marking	$9,600
Monitoring	
Sexual Maturity of Juveniles	Existing Staffing
Estimate of Catch	1/
Estimate of pHOS	2/
Enforcement	3/
Indirect	$37,205
Total	$208,024

1/ No additional cost to estimate catch if monitoring already required to estimate mortalities in the catch & release fishery.

2/ Assumes pHOS estimated using change in ratio method using estimated mortalities in fishery, returns to hatchery, natural spawners, and catch composition of the tribal test fishery below the Sauk River. Method will require further development.

3/ No additional costs for enforcement beyond those necessary for the catch & release fishery.

2) What would a recreational fishery season look like with and without the potential hatchery program?

The potential effect of a hatchery program on the length of the recreational season was assessed using the average exploitation rates from the 1980-1981 through 1982-1983 recreational fisheries. These years were selected as a creel study was in place, wild fish retention was allowed, estimates of the hatchery-wild catch composition are available, and the season extended at least through March. Since the effectiveness of the recreational fishery may have increased since that time, or more anglers may now wish to fish the Skagit River, we assessed the sensitivity of the results to the exploitation rates by doubling rates that occurred in the early 1980s.

The analysis assumes that the fishery will be managed consistent with the tiered fishing rates proposed in the comanager Resource Management Plan. Rather than a specific prediction for the length of the recreational fishery, the results are most informative as a comparative assessment.

The recreational fishing season is projected to run from February 1 through April 30 when the run size in greater than 6000 fish. In general, the implementation of a hatchery program is projected to reduce the length of the season when abundance is low (tiers 1 and 2). This is projected to occur because an increased percentage of the allowable wild impacts are used by the non-selective tribal fishery to catch the tribal share.

The recreational fishery catch of hatchery-origin steelhead ranged from approximately 60 (with Tier 1 natural-origin abundance) to 400 (with Tier 4 natural-origin abundance) fish.

Natural-Origin Terminal Run Size	Total Allowable Impact Rate	Recreational Fishery Exploitation Rate	With Hatchery	Without Hatchery
Tier 1 Run ≤ 4,000	≤ 4%	Base	March 15	April 15
		Doubled	Feb. 28	March 15
Tier 2 4,001 ≤ Run ≤ 6,000	≤ 10%	Base	April 30	April 30
		Doubled	March 31	April 30
Tier 3 6,001 ≤ Run ≤ 8,000	≤ 20%	Base	April 30	April 30
		Doubled	April 30	April 30
Tier 4 8,001≤ Run	≤ 25%	Base	April 30	April 30
		Doubled	April 30	April 30

3) **What might the tribal fishery season look like with and without the hatchery program?**

A similar approach was used to assess the potential effect of a hatchery program on the length of the tribal fishery. The average exploitation rates were compiled for the years 1986 through 2015 and, as with the recreational fishery analysis, the base rates were doubled to assess the sensitivity of the results to assumptions about the tribal fishery exploitation rates. Again, the analysis is most useful as a comparative assessment rather than a prediction of the specific length of the tribal fishery.

The initiation of a hatchery program is projected to result in a longer tribal fishery under some conditions. With natural-origin abundance in Tier 2 or Tier 3, and the base tribal fishery exploitation rate doubled, the length of the tribal season increased due to the greater number of harvestable fish associated with the implementation of the hatchery program.

The tribal fishery catch of hatchery-origin steelhead ranged from approximately 10 (with Tier 1 natural-origin abundance) to 100 (with Tier 4 natural-origin abundance) fish.

Natural-Origin Terminal Run Size	Total Allowable Impact Rate	Tribal Fishery Exploitation Rate	With Hatchery	Without Hatchery
Tier 1 Run ≤ 4,000	≤ 4%	Base	March 15	March 15
		Doubled	Feb. 15	Feb. 15
Tier 2 4,001 ≤ Run ≤ 6,000	≤ 10%	Base	April 15	April 15
		Doubled	March 15	Feb. 28
Tier 3 6,001 ≤ Run ≤ 8,000	≤ 20%	Base	April 15	April 15
		Doubled	April 15	March 15
Tier 4 8,001 ≤ Run	≤ 25%	Base	April 15	April 15
		Doubled	April 15	April 15

4) What would be the economic benefits of the recreational fishery?

The economic benefits of the recreational fishery were assessed based on the fishery analysis described above and the following assumptions:

a) The local personal income generated by each angler day of fishing is $65.40 (PFMC 2016).

b) The fishery exploitation rate per angler day is double the rate that occurred in the period 1980-1981 through 1982-1983.

c) The average length of a recreational fishing day is 10 hours.

As was stressed in the responses to questions 2 and 3, this preliminary economic analysis is most useful as a comparative assessment rather than a prediction of the specific number of angler days or the local personal income generated by the fishery.

As would be expected, the preliminary analysis indicates that the number of angler days decreases as abundance decreases. This occurs because the season length is projected to be shorter when the adult return is low and exploitation rates are constrained to less than 4% (Tier 1) or 10% (Tier 2). The implementation of the hatchery program can further reduce the number of angler days and economic benefits under these conditions for the reasons discussed in the response to question 2.

The recreational fishery is projected to generate a local personal income of approximately $1 million when natural-origin abundance is in tiers 2-4.

Natural-Origin Terminal Run Size	Angler Days		Local Personal Income	
	With Hatchery	Without Hatchery	With Hatchery	Without Hatchery
Tier 1 Run ≤ 4,000	6,706	11,113	$438,600	$726,800
Tier 2 4,001 ≤ Run ≤ 6,000	14,268	18,692	$933,100	$1,222,400
Tier 3 6,001 ≤ Run ≤ 8,000	18,692	18,692	$1,222,400	$1,222,400
Tier 4 8,001 ≤ Run	18,692	18,692	$1,222,400	$1,222,400

Skagit River Discussion

March 29, 2018

Group A

What would the Skagit River look like <u>with</u> an integrated hatchery program?

Rob Masonis
Curt Wilson
Gary Butrim
Rich Simms
Andy Marks
Curt Kraemer
Mark Spada

Group Discussion Questions:

1) How would the <u>initiation</u> of a hatchery program on the Skagit River be consistent or not consistent with the objectives of the PSSAG (see table on back)?
2) Where a hatchery program on the Skagit River may not be consistent with PSSAG objectives:
    a) How could the hatchery program be modified so that outcomes would be more closely aligned with the PSSAG objectives?
    b) How could the PSSAG shape the remainder of the Northern Cascades portfolio so that outcomes would be more closely aligned with PSSAG objectives?
3) What are the potential consequences of initiating a hatchery program now?

Group B

What would the Skagit River look like <u>without</u> an integrated hatchery program?

Al Senyohl
David Yamashita
Derek Day
Jonathan Stumpf
Roger Goodan
Jamie Glasgow

Group Discussion Questions

1) How would the <u>lack</u> of a hatchery program on the Skagit River be consistent or not consistent with the objectives of the PSSAG (see table on back)?
2) Where the lack of a hatchery program on the Skagit River may not be consistent with PSSAG objectives:
    a) What adaptive management actions could be implemented so that outcomes would be more closely aligned with the PSSAG objectives?
    b) How could the PSSAG shape the remainder of the Northern Cascades portfolio so that outcomes would be more closely aligned with PSSAG objectives?
3) What are the potential consequences of not initiating a hatchery program now?

PSSAG Objectives for Consideration in the Development of Northern Cascades Portfolio

Objective	Consistent?	Adjustments in Skagit River (question 2a)	Adjustments in Northern Cascades Portfolio (question 2b)
1. Helps preserve a legacy of Puget Sound wild steelhead for future generations by contributing to the conservation and recovery of Puget Sound wild steelhead with fishery and hatchery management aligned with habitat protection and restoration (all-H integration)."			
3. Has sufficient flexibility to be compatible with the recovery plan adopted by NOAA Fisheries.			
4. Describes a path toward diverse and sustainable recreational fishing opportunities, with benchmarks to assess our progress.			
5. Recognizes the importance of steelhead and sustainable steelhead fisheries to our rural communities, preservation of our cultural heritage, and state economy.			
6. Is informed by our scientific understanding of steelhead and the factors affecting their abundance, productivity, diversity, and spatial structure			
7. Promotes greater understanding of steelhead populations through an experimental approach, and recognizes that adaptive management will be required to be successful.			
8. Is not constrained by previous fishery and hatchery management approaches.			
9. Identifies, considers, and where possible, addresses the major factors limiting the abundance, productivity, spatial structure, and diversity of Puget Sound steelhead.			
10. Identifies watershed-specific strategies for fisheries and artificial production programs designed to achieve specific seasons and fishery types in a manner consistent with achieving conversation objectives.			
12. Enjoys broad support among stakeholders interested in steelhead, including anglers and those interested in steelhead as a part of the Puget Sound ecosystem			