Mission

Puget Sound Steelhead Advisory Group

June 16, 2017

Our Mission is to:

> "Develop a broadly supported vision with forward-looking watershed-specific strategies that provides for the conservation and recovery of steelhead and, in a manner consistent with achieving conservation objectives, a diversity of sustainable recreational fishing opportunities across the rivers of Puget Sound."

Objectives

Puget Sound Steelhead Advisory Group

Draft June 16, 2017

Within eight months, we will be successful if we have developed a document for our Puget Sound steelhead, designated as Threatened under the Endangered Species Act, that:

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);
2) is developed through an iterative, coordinated process with feedback from the Puget Sound Steelhead Recovery Team;
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;
11) provides estimates of the funding necessary to implement the strategies;
12) enjoys broad support among stakeholders interested in steelhead, including anglers and those interested in steelhead as a part of the Puget Sound ecosystem; and
13) identifies subsequent action steps with comanagers, legislators, NOAA Fisheries, and stakeholders necessary to implement the plan.

Hood Canal & Strait of Juan de Fuca Planning Template

Draft July 24, 2017

Part A. Recovery Scenario

A recovery scenario is a combination of population designations that meets Technical Recovery Team (TRT) guidance for a viable Distinct Population Segment (DPS). The scenario represents one of many possible combinations of populations and recovery objectives that could meet DPS and Major Population Group (MPG)-level viability criteria. Different scenarios may fulfill the biological requirements for recovery but can have unique implications for various stakeholders. Selection of a scenario for incorporation into the recovery plan is in part a policy decision based on scientific, biological, social, cultural, political, and economic considerations (drawn with modification from Lower Columbia Salmon Recovery and Subbasin Plan (2004)).

The Lower Columbia Salmon Recovery Plan (2010) provides the following description of the population designations:

a. ***Primary populations*** are targeted for restoration to high (95-99% probability) or very high (> 99%) viability. These populations are the foundation of salmon recovery. Primary populations are typically the strongest extant populations and/or those with the best prospects for protection or restoration. These typically include populations at high or medium viability during the listing baseline.
b. ***Contributing populations*** are those for which some improvement will be needed to achieve a stratum-wide average of medium viability (75 – 94% probability). Contributing populations might include those of low to medium significance and viability where improvements can be expected to contribute to recovery. Varying levels of improvement are identified for contributing populations. Some contributing populations are targeted for substantial improvements whereas more limited increases are identified for others.
c. ***Stabilizing populations*** are those that would be maintained at baseline levels. These are typically populations at very low viability during the listing baseline. Stabilizing populations might include those where significance is low, feasibility is low, and uncertainty is high. While stabilizing populations are not targeted for significant improvement, substantive recovery actions will typically be required to avoid further degradation.

Task

Our first task is to develop an initial proposal for a recovery scenario for the entire Hood Canal/Strait of Juan de Fuca MPG.

Beginning with the scenario you developed for the Hood Canal populations (see notes from June 1, 2017 meeting), review Table 1 ("Factors to consider in the designation of Hood Canal/Strait of Juan de Fuca populations as Primary, Contributing, or Stabilizing") and designate each of the populations as Primary, Contributing, or Stabilizing.

In order to achieve the draft viability criteria for the MPG, a proposed recovery scenario should identify at least four populations as Primary (highest viability category) and the geometric mean score of all population designations for the MPG must be at least 2.20.

The spreadsheet “Hood Canal & SJDF Recovery Scenario” can be used to compute the geometric mean score and plot the recovery scenario.

Population	**Contribution to Recovery**	**Comments**
East Hood Canal Tributaries Winter Run		
South Hood Canal Tributaries Winter Run		
Skokomish River Winter Run		
West Hood Canal Tributaries Winter Run		
Sequim/Discovery Bay Independent Tributaries Winter Run		
Dungeness River Summer/Winter Run		
Strait of Juan de Fuca Independent Tributaries Winter Run		
Elwha River Winter Run		

Table 1. Factors to consider in the designation of Hood Canal/Strait of Juan de Fuca populations as Primary, Contributing, or Stabilizing.

Population or Watershed	Run Type	NOAA Intrinsic Potential (IP) [1/]	Average Spawners (2007-2016)	NOAA Viability Assessment P(Viable) [2/]	Past Early Winter Gene Flow	% Public Land	Hydrology [3/]
Skokomish	Winter	20,060	646	Low	[4/]	71%	40% Rain & Snow 25% Rain
East Hood Canal	Winter	2,540	85	Low	[4/]	23%	100% Lowland
West Hood Canal	Winter	7,217	165	Moderate	[4/]	76%	31% Rain & Snow 31% Lowland
South Hood Canal	Winter	5,970	95	Low	[4/]	38%	92% Lowland 8% Rain
Sequim/ Discovery Bay	Winter	1,024	22	Low	[4/]	32%	74% Lowland 17% Rain
Dungeness	Summer/Winter	4,930	531	Moderate	< 2%	86%	33% Rain & Snow 20% Snow 20% Lowland
SJDF Independents	Winter	1,456	149	Low	[3/]	58%	37% Lowland 24% Rain
Elwha	Winter	14,231	303[5/]	Low	[6/]	95%	39% Snow 36% Rain & Snow

[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, Table B-1, Puget Sound Technical Recovery Team 2013.

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

[4/] No releases of early winter steelhead for more than 10 years.

[5/] Average number of natural-origin spawners from 2014-2016; an average of 877 spawners from the conservation program also returned during that time period.

[6/] No releases of early winter steelhead since 2011; conservation program operated by Lower Elwha Klallam Tribe will be phased out as numbers of natural-origin steelhead increase.

Part B. Aspirational Objectives for Recreational Fishery

The aspirational objectives describe the desired future state for recreational fisheries. Aspirational objectives may not be achievable, particularly in the short-term, given conservation or resource constraints. Nevertheless, they are important to initiate the discussion of our vision for the future of Puget Sound steelhead. Through an iterative process we will "true up" our aspirational objectives with the conservation framework of the recovery scenario.

In developing the aspirational objectives, it may be helpful to recall several of the objectives the advisory group has identified:

1) describes a path toward diverse and sustainable recreational fishing opportunities, with benchmarks to assess our progress;
2) recognizes the importance of steelhead and steelhead fisheries to our rural communities, preservation of our cultural heritage, and state economy;
3) promotes greater understanding of steelhead populations through an experimental approach, and recognizes that adaptive management will be required to be successful;
4) is not constrained by previous fishery and hatchery management approaches;
5) identifies watershed-specific strategies for fisheries and artificial production programs designed to achieve specific seasons and fishery types in a manner consistent with achieving conservation objectives; and
6) enjoys broad support among stakeholders interested in steelhead, including anglers and those interested in steelhead as a part of the Puget Sound ecosystem.

Task

Our second task is to identify our aspirational objectives for recreational fisheries. Although there are many types of recreational fisheries, perhaps the two broadest categories are catch-and-release and catch-and-keep. For catch-and-release fisheries, please identify the months for the fishery and the approximate angler days (i.e., 1000 anglers each fishing 10 days would be 10000 angler days). For catch-and-keep fisheries, please identify the months for the fishery and the approximate catch.

Begin by reviewing the coarse scale assessment of the fishery and hatchery strategies that were previously developed for Hood Canal (see notes from June 1, 2017 meeting) and consider if any changes to the portfolio are needed. Then develop proposed fishery strategies for the Strait of Juan de Fuca populations.

Population	**Catch-and-Release**			**Catch-and-Keep**		
	Directed at Wild Steelhead?	Months	Angler Days	Directed at Wild Steelhead?	Months	Catch
East Hood Canal Tributaries Winter Run						
South Hood Canal Tributaries Winter Run						
Skokomish River Winter Run						
West Hood Canal Tributaries Winter Run						
Sequim/Discovery Bay Independent Tributaries Winter Run						
Dungeness River Summer/Winter Run						
Strait of Juan de Fuca Independent Tributaries Winter Run						
Elwha River Winter Run						

Notes

NOAA's criteria for limit 5 may help inform the development of the aspirational objectives for the recreational fishery. The 4(d) rule is under the Fishery and Hatchery tab of your notebook. Several key concepts are provided below:

- Proposed management actions must recognize the significant differences in risk associated with viable and critical population threshold states and respond accordingly to minimize the long-term risks to population persistence. Harvest actions impacting populations that are functioning at or above the viable threshold must be designed to maintain the population or management unit at or above that level. For populations shown with a high degree of confidence to be above critical levels but not yet at viable levels, harvest management must not appreciably slow the population's achievement of viable function. Harvest actions impacting populations that are functioning at or below critical threshold must not be allowed to appreciably increase genetic and demographic risks facing the population and must be designed to permit the population's achievement of viable function, unless the plan demonstrates that the likelihood of survival and recovery of the entire ESU in the wild would not be appreciably reduced by greater risks to that individual population.
- Set escapement objectives or maximum exploitation rates for each management unit or population based on its status and on a harvest program that assures that those rates or objectives are not exceeded. Maximum exploitation rates must not appreciably reduce the likelihood of survival and recovery of the ESU. Management of fisheries where artificially propagated fish predominate must not compromise the management objectives for commingled naturally spawned populations.
- Display a biologically based rationale demonstrating that the harvest management strategy will not appreciably reduce the likelihood of survival and recovery of the ESU in the wild, over the entire period of time the proposed harvest management strategy affects the population, including effects reasonably certain to occur after the proposed actions cease.

Part C. Potential Artificial Production Programs to Meet Fishery or Conservation Objectives

An artificial production program is a management action to help achieve fishery or conservation objectives. As discussed above for the aspirational objectives for the recreational fishery, we will need to "true up" our proposed hatchery programs with the conservation framework of the recovery scenario.

In general, a segregated hatchery strategy will only be appropriate for a catch-and-keep fishery, while an integrated hatchery strategy may be used for a conservation program, for a catch-and-keep fishery, or for a catch-release-fishery.

In evaluating options for hatchery programs, it may be helpful to recall several of the objectives the advisory group has identified:

1) Contributes to the conservation and recovery of Puget Sound steelhead;
2) is informed by our scientific understanding of steelhead and the factors affecting their abundance, productivity, diversity, and spatial structure;
3) promotes greater understanding of steelhead populations through an experimental approach, and recognizes that adaptive management will be required to be successful;
4) is not constrained by previous fishery and hatchery management approaches; and
5) identifies watershed-specific strategies for fisheries and artificial production programs designed to achieve specific seasons and fishery types (catch and release, catch and keep, rivers with no hatchery production).

Task

Our third task is to assess if an artificial production program might help achieve our conservation and aspirational fishery objectives. Please indicate in the tables below whether a hatchery program should be initially considered as a management action.

Begin by reviewing the coarse scale assessment of the fishery and hatchery strategies that were previously developed for Hood Canal (see notes from June 1, 2017 meeting) and consider if any changes to the portfolio are needed. Then develop proposed hatchery strategies for the Strait of Juan de Fuca populations.

Note that no new hatchery program should be proposed for the Elwha River as it has been designated as a Wild Steelhead Gene Bank.

Population	No Hatchery Releases	Conservation Program	Catch-and-Keep Hatchery Strategy		Catch-and Release Integrated Strategy
			Integrated	Segregated	
East Hood Canal Tributaries Winter Run					
South Hood Canal Tributaries Winter Run					
Skokomish River Winter Run					
West Hood Canal Tributaries Winter Run					
Sequim/Discovery Bay Independent Tributaries Winter Run					
Dungeness River Summer/Winter Run					
Strait of Juan de Fuca Independent Tributaries Winter Run					
Elwha River Winter Run	Wild Steelhead Gene Bank				

Notes

1) Guidance Dependent on Biological Phase of Population. An important consideration in developing and evaluating hatchery conservation programs is the status, or biological phase, of the population. The HSRG (2014) defined four biological phases (Preservation, Re-colonization, Local Adaptation, and Full Restoration) for a population and provided the following guidance regarding the objectives of an associated hatchery conservation program.

Table 3-3. Biological phases of restoration and objectives for different ecosystem conditions.

Biological Phases	Ecosystem Conditions	Objectives
Preservation	Low population abundance; habitat unable to support self-sustaining population; ecosystem changes pose immediate threat of extinction	Prevent extinction; retain genetic diversity and identity of existing population
Re-colonization	Underutilized habitat available through restoration and improved access	Re-populate suitable habitat from pre-spawning to smolt outmigration (all life stages)
Local Adaptation	Habitat capable of supporting abundances that minimize risk of extinction as well as tribal harvest needs; prevent loss of genetic diversity; and promote life history diversity	Meet and exceed minimum viable spawner abundance for natural-origin spawners; increase fitness, reproductive success and life history diversity through local adaptation
Full Restoration	Habitat restored and protected to allow full expression of abundance, productivity, life-history diversity, and spatial distribution	Maintain viable population based on all viable salmonid population (VSP) attributes using long-term adaptive management

Source: On the Science of Hatcheries, HSRG, 2014.

2) Guidance Dependent on Population Designation. The Department and Hatchery Scientific Review Group (2014) have provided the following guidance for broodstock management for programs designated as Primary, Contributing, or Stabilizing (pHOS – proportion hatchery-origin spawners; PNI – proportionate natural influence).

Hatchery Program Strategy	**Population Designation**	**PNI**	**Effective pHOS**	**Gene Flow**[1/]
Integrated	Primary Contributing Stabilizing	≥ 0.67 ≥ 0.50 1/	< 0.30 < 0.30 2/	NA
Segregated	Primary Contributing Stabilizing	NA	< 0.05 < 0.10 2/	< 0.02 < 0.04 2/

[1/] Department guidance for segregated steelhead programs.

[2/] Standards for Stabilizing populations are situation specific.

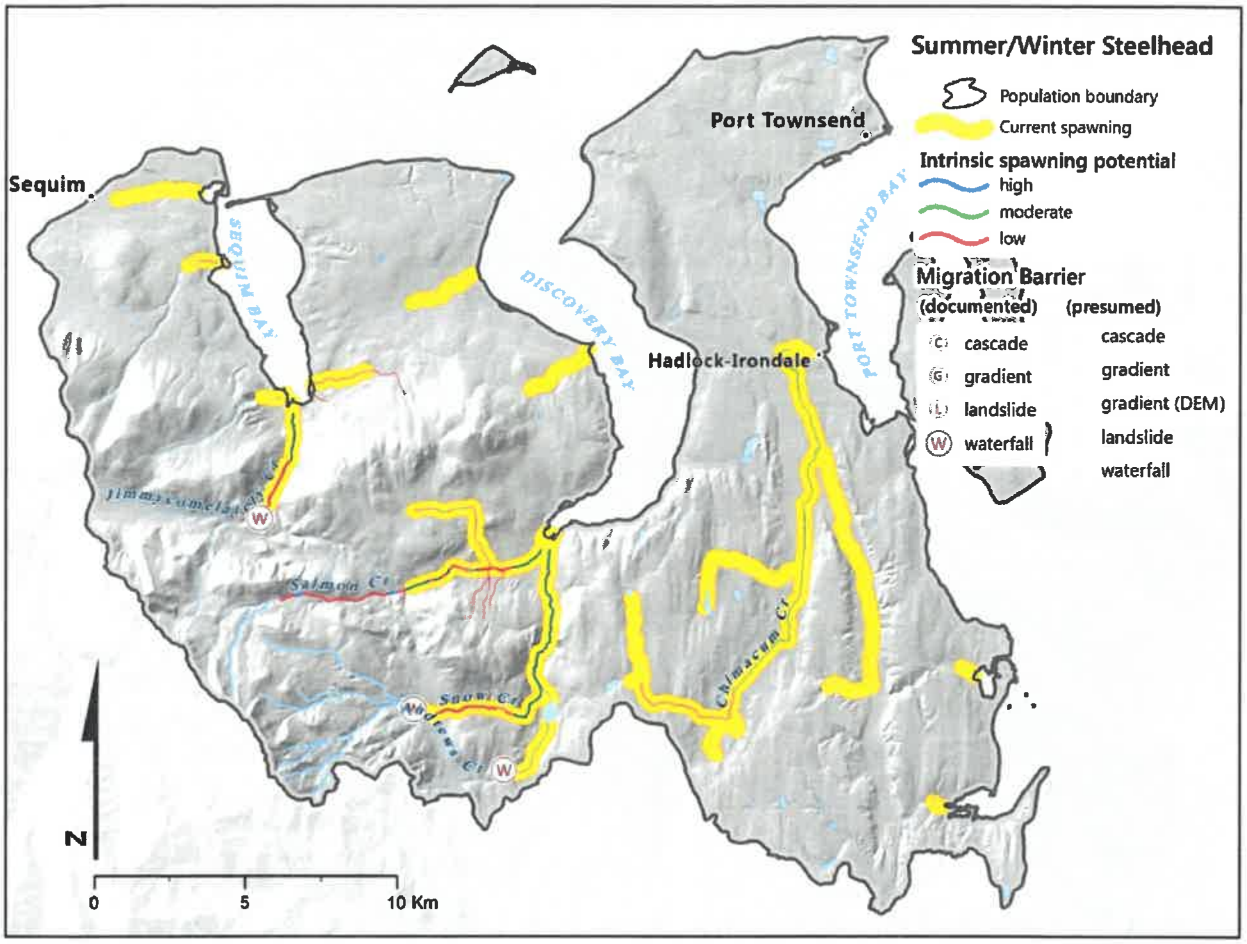

Figure E-89. Map of Sequim/Discovery Bays Tributaries Winter-Run population spatial structure, including migration barriers and spawning potential.

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

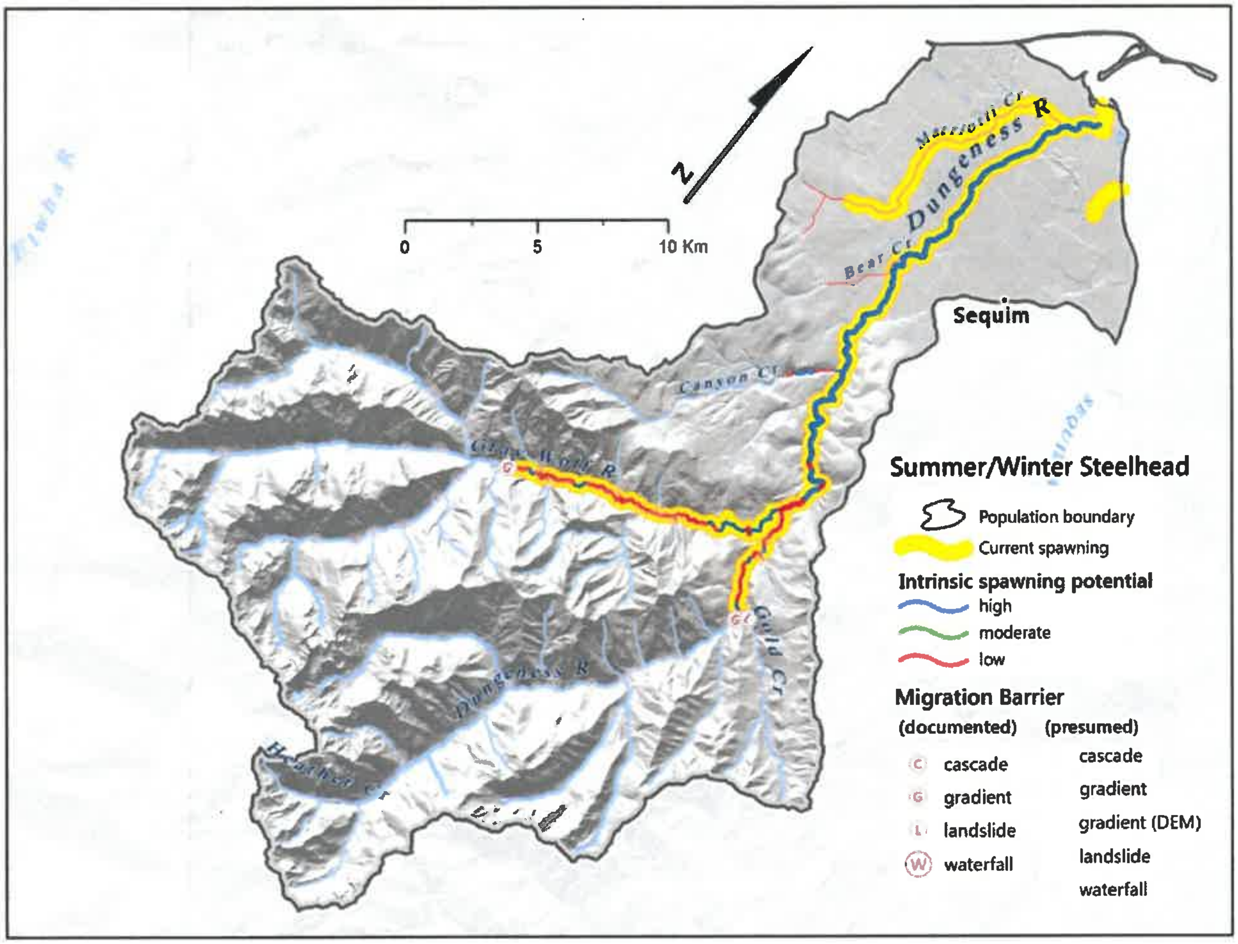

Figure E-92. Map of Dungeness River Summer-Run and Winter-Run population spatial structure, including migration barriers and spawning potential.

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

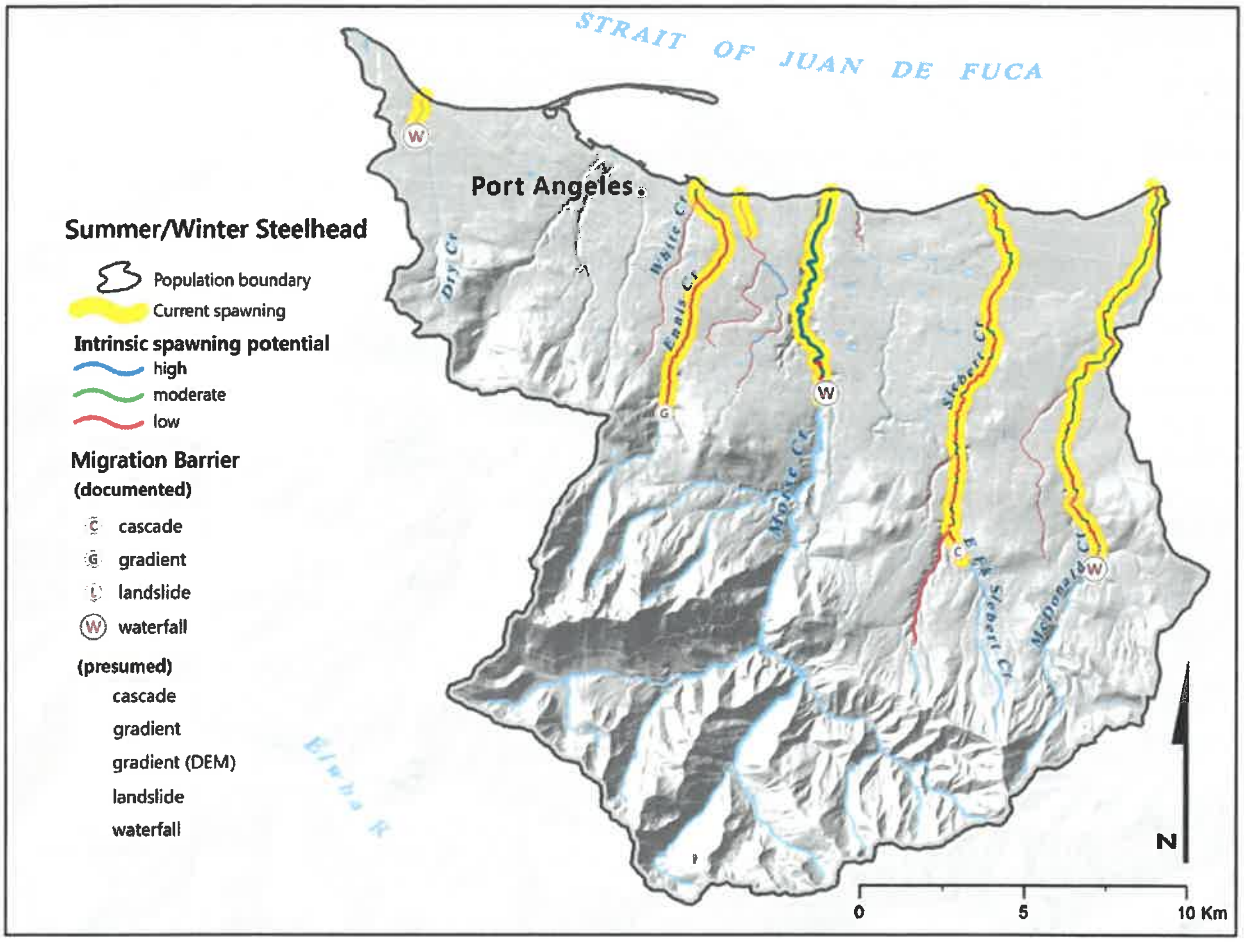

Figure E-95. Map of Strait of Juan de Fuca Tributaries Winter-Run population spatial structure, including migration barriers and spawning potential.

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

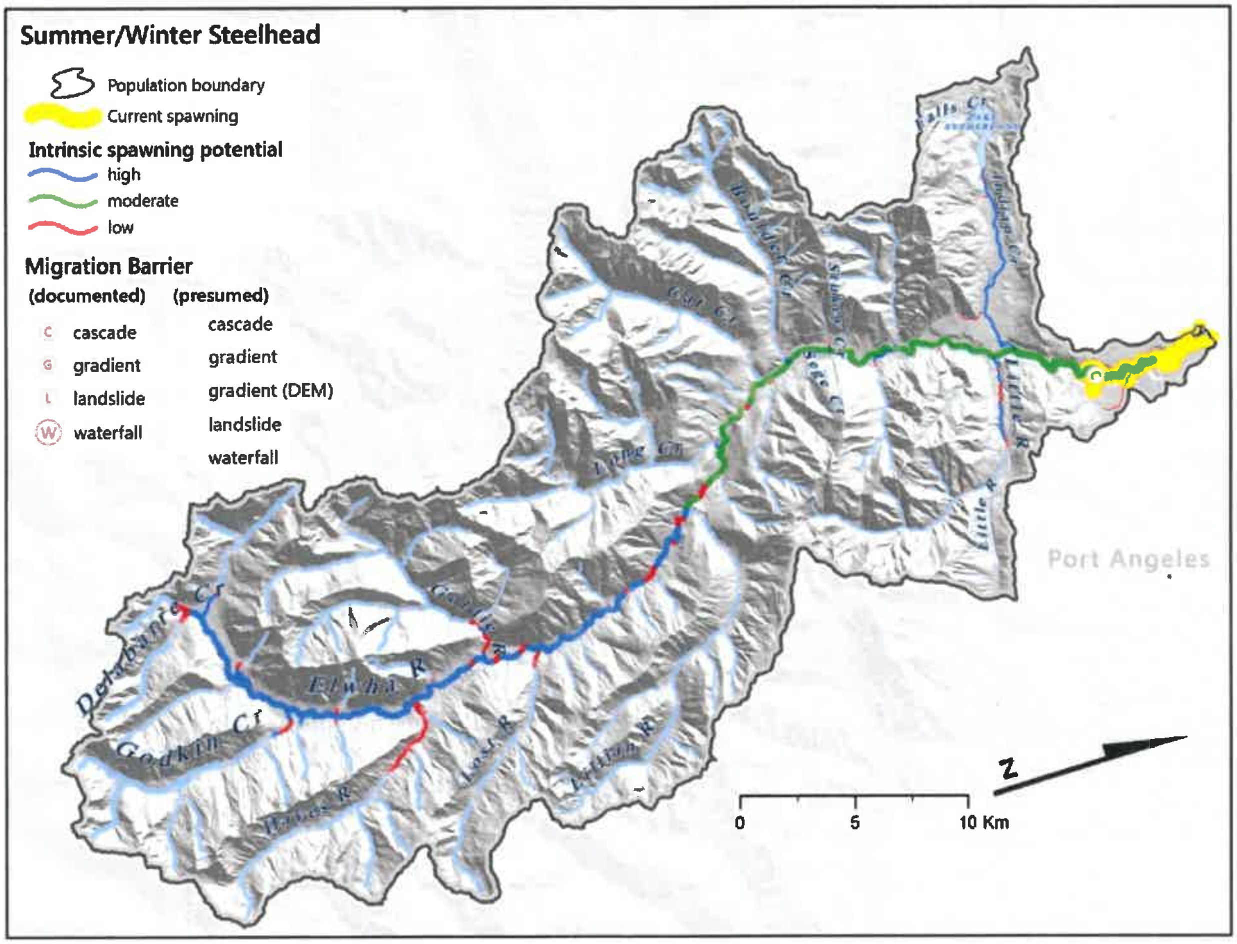

Figure E-98. Map of Elwha River Winter-Run population spatial structure, including migration barriers and spawning potential. The two dams constructed in the early 1900s at RKM 7.9 and RKM 21.6 are currently being removed.

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

Coarse Scale Assessment of Hood Canal Artificial Production Proposals

Draft July 20, 2017

Option	Population (river)	Designation	Program Strategy	Demographic Gene Flow Limit	Maximum Program Size	Projected Recreational Catch[b]	Projected Angler Days[c]
1	East Hood Canal Winter Run (Dewatto)	Stabilizing	Segregated	[a]	3,470	9 (6-13)	78 (47-109)
2	South Hood Canal Winter Run (Tahuya)	Contributing	Segregated	0.04	3,200	9 (5-12)	72 (43-101)
2	Skokomish River Winter Run	Contributing	Segregated	0.04	41,500 No Trap 165,500 Trap	112 (67-157) 446 (268-625)	933 (560-1,306) 3,720 (2,232-5,207)
2	West Hood Canal Winter Run (Quilcene)	Primary	Segregated	0.02	3,000 No Trap 12,000 Trap	8 (5-11) 32 (19-45)	67 (40-94) 270 (162-378)
3	East Hood Canal Winter Run (Dewatto)	Contributing	Segregated	0.04	3,470	9 (6-13)	78 (47-109)

[a] A gene flow limit for a Stabilizing population has not been defined, but would be anticipated to be less restrictive than a Contributing population. The analysis used the gene flow limit (0.04) applicable to a Contributing population.

[b] Project recreational catch based on Dungeness data. Assumes an average SAR of 1.08% (Dungeness average for BY 2000-2011) and a 25% recreational harvest rate with a range of 15% to 35%.

[c] Projected angler days assumes an average catch of 0.12 steelhead per trip.

Coarse Scale Assessment of Hood Canal Fishery Management Proposals

Draft July 20, 2017

Option	Population (river)	Designation	Fishery		Average Spawners	Management Breakpoint	Coarse Assessment Allowable Fishing Rate Above Breakpoint
			Directed at Wild Fish (Y or N)	Type			
1	East Hood Canal Winter Run (Dewatto)	Stabilizing	N	Catch & Keep	107	125	0.23
1	Skokomish River Winter Run	Primary	Y	Catch & Release Individual Permit	718	200	0.05
2	South Hood Canal Winter Run (Tahuya)	Contributing	N	Catch & Release	76	125	0.14
2	Skokomish River Winter Run	Contributing	N	Catch & Keep	718	200	0.14
2	Skokomish River Winter Run	Contributing	Y	Catch & Release	718	200	0.14
2	West Hood Canal Winter Run (Quilcene)	Primary	N	Catch & Keep	169	128	0.23
3	East Hood Canal Winter Run (Dewatto)	Contributing	N	Catch & Keep	107	125	0.14
3, 4	Skokomish River Winter Run	Primary	Y	Catch & Release	718	200	0.05

Coarse Scale Assessment of Fishery Management Options

Draft July 24, 2017

1. Introduction

The Puget Sound Steelhead Advisory Group is developing a portfolio of conservation objectives, fishery strategies, and hatchery strategies for Puget Sound steelhead. In developing this portfolio, the group recognizes that underlying habitat issues must be addressed to restore Puget Sound steelhead, and the importance of an integrated all-H recovery strategy. The advisory group anticipates that the completed portfolio will subsequently inform the development of a recovery plan and discussions of the Washington Department of Fish and Wildlife (WDFW) with the co-managers regarding fishery management and hatchery programs.

Within the advisory group, the portfolios will be developed through an iterative process that begins with the identification of conservation objectives (referred to as a recovery scenario), aspirational fishery objectives, and initial proposals for artificial production programs that may be helpful in achieving the conservation or fishery objectives. The proposed fishery management and artificial production programs are then evaluated for consistency with the conservation objectives, and the iterative process repeated until the fishery and artificial production strategies are aligned with the conservation objectives (Fig. 1).

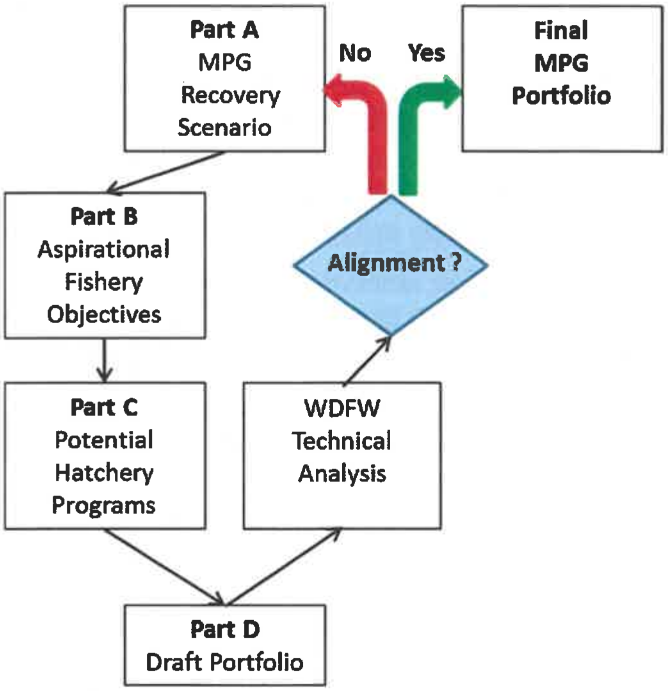

Figure 1. Iterative process used by the advisory group to align fishery and hatchery strategies with recovery scenario.

An initial, coarse-scale assessment is necessary to assess the consistency of proposed fishery and hatchery programs with the conservation objectives. Additional, more detailed analyses will be completed when fishery and hatchery plans are submitted to NOAA Fisheries as part of a resource management plan or other document.

The assessment framework was developed with both short-term and longer term considerations. These included:

1) promote improved management through the collection, analysis, and application of new information on steelhead populations;
2) effectively use existing information while recognizing data and model limitations;
3) incorporate the concepts of population status and status-specific impact rates as discussed in the 4(d) rule;
4) build on the concept of population designations (e.g., Primary, Contributing, and Stabilizing) with the potential for varying levels of acceptable risk among those designations;
5) initially focus on the quantification of allowable impact rates for simple fishery proposals such as a two-tiered abundance based approach employing a stop-loss rule (i.e., no fishing if a population is below a specified abundance level). More complex fishery regimes (i.e., multiple harvest rates at different tiers of abundance) may ultimately be considered, but this level of complexity is not necessary in the initial development of the portfolio; and
6) provide a qualitative assessment for all viable salmonid population (VSP) characteristics, recognizing that greater detail may be submitted to NOAA Fisheries for ESA-review.

2. Stock-Recruit Analysis

Estimates of the demographic characteristics of salmonid populations often provide the foundation for a risk analysis of proposed fishery management actions. Commonly used demographic models include the hockey stick, Beverton-Holt, and Ricker stock-recruit functions. Challenges in applying these tools include: a) measurement error in the estimates of spawners; b) data sets from a short period of time or a limited range of spawners; and c) large variability in recruitment resulting from highly variable marine survival or other factors.

Buehrens (2016) developed hierarchical, stock-recruit models based on estimates of spawners, habitat quantity, and the subsequent smolt production in 15 western Washington rivers. This approach has several advantages relative to other analytical methods, including:

1) The use of smolt production, rather than adult recruits, reduces the variability in estimates of management reference points that is often caused by highly variable marine survival rates.
2) The use of a hierarchical multi-stock model, rather than a stock-specific analysis, more effectively uses the existing data on spawners and smolt production.
3) The use of a hierarchical model with a habitat quantity variable facilitates estimation of management reference points for stocks without existing smolt production and spawner data.

However, the approach used by Buehrens (2016) also relies on many assumptions including most notably:

1) Freshwater habitat limits each steelhead population's recruitment to the smolt stage in a density dependent manner whereas survival after smolting for each population is density-independent.
2) Variation in smolt carrying capacity among watersheds may be explained to a large extent by habitat quantity (e.g., stream length, stream margin habitat, or stream surface area).

3) Wild spawner and smolt abundance estimates and smolt scale ages are not systematically biased, including wild equivalents estimated from hatchery spawners by multiplying their abundances by published relative reproductive success values. Although datasets may not contain systematic bias, they may be measured with random error.
4) The productivity (i.e., maximum per capita recruitment) and smolt capacity (after accounting for habitat quantity) of each population arise from common distributions (i.e., population is a random effect).
5) Further, when using the model to predict population parameters for unknown populations, these populations' parameters are drawn from identical distributions (i.e., for a specific unknown population there are not systematic differences in habitat, or fish population characteristics that cause productivity and capacity, after accounting for habitat quantity, to differ from the set of populations in the fitted dataset).
6) The net contribution of resident *O. mykiss* to smolt production (smolts produced by resident adults minus residents produced by anadromous adults) is assumed to be similar among study watersheds such that smolts produced by residents do not systematically affect productivity and capacity parameters.
7) The extent of habitat available to steelhead in watersheds with no fish data is accurately quantified.

2.1. Selecting a stock recruit model for the coarse harvest framework

Buehrens (2016) modeled steelhead spawner-smolt recruit relationships using both hockey-stick and Beverton-Holt models and provided the following discussion regarding the two models:

> The hockey-stick function results in a break-point linear regression shaped like a hockey-stick, which has attractive properties for modeling recruitment of stream rearing salmonids. First, estimates of maximum per-capita recruitment from this model are lower than those produced by both Ricker and Beverton-Holt models (Barrowman and Myers 2000), both of which tend to over-estimate recruitment at low spawner abundance (Meyers et al. 1994) potentially resulting in under-conservative estimates of sustainable exploitation rates. Additionally, the shape of the hockey stick curve may be particularly appropriate for territorial fishes such as steelhead, for which density-dependent mortality may be relatively minor until all territories are occupied (Bradford et al. 1997), resulting in relatively constant per-capita recruitment up to this threshold.
>
> The Beverton-Holt model is a useful alternative to the hockey-stick model for territorial fishes, particularly if territoriality is imperfect, or if suboptimal territories or habitat patches become progressively occupied as cohort abundance increases. In this scenario recruitment asymptotically increases even as spawner abundance surpasses equilibrium replacement levels. Additionally, the Beverton-Holt model assumes continuously increasing per-capita recruitment as abundance declines, thereby providing a useful upper bound for productivity in territorial fishes.
>
> Additional models that allow for overcompensation (e.g., Ricker) may be less appropriate for territorial fishes since territoriality allows for unequal resource sharing among individuals and thus the maintenance of high survival for those individuals which do successfully defend territories (Hilborn and Walters 1992). Such unequal resource-sharing and the maintenance of high survival for a subset of the population are not expected attributes of populations which exhibit overcompensation.

The discussion of models provided by Buehrens (2016) suggests that the Beverton Holt model may be more biologically realistic in its estimation of capacity than the hockey-stick because the capacity parameter increases asymptotically as more spawners are added well above equilibrium spawner abundance levels instead of being constant beginning at modest abundance levels. However, the discussion suggests that the Hockey-Stick model provides more conservative estimates of productivity and thus sustainable harvest rates. We have opted to develop a harvest management framework based on allowable harvest rates and therefore selecting the hockey-stick model represents the more risk averse approach relative to selecting the Beverton Holt model.

The hockey stick model follows the form:

$$R = min\ (\alpha S,\ \alpha S^*\ ) = \begin{cases} \alpha S, & S < S^* \\ \alpha S^*, & S \geq S^* \end{cases} \tag{1}$$

where R, the number of recruits, is the product of the productivity, α, and the spawner abundance S, when $S < S^*$. When $S \geq S^*$, recruitment is at carrying capacity, K, and is therefore constant (Figure 1.)

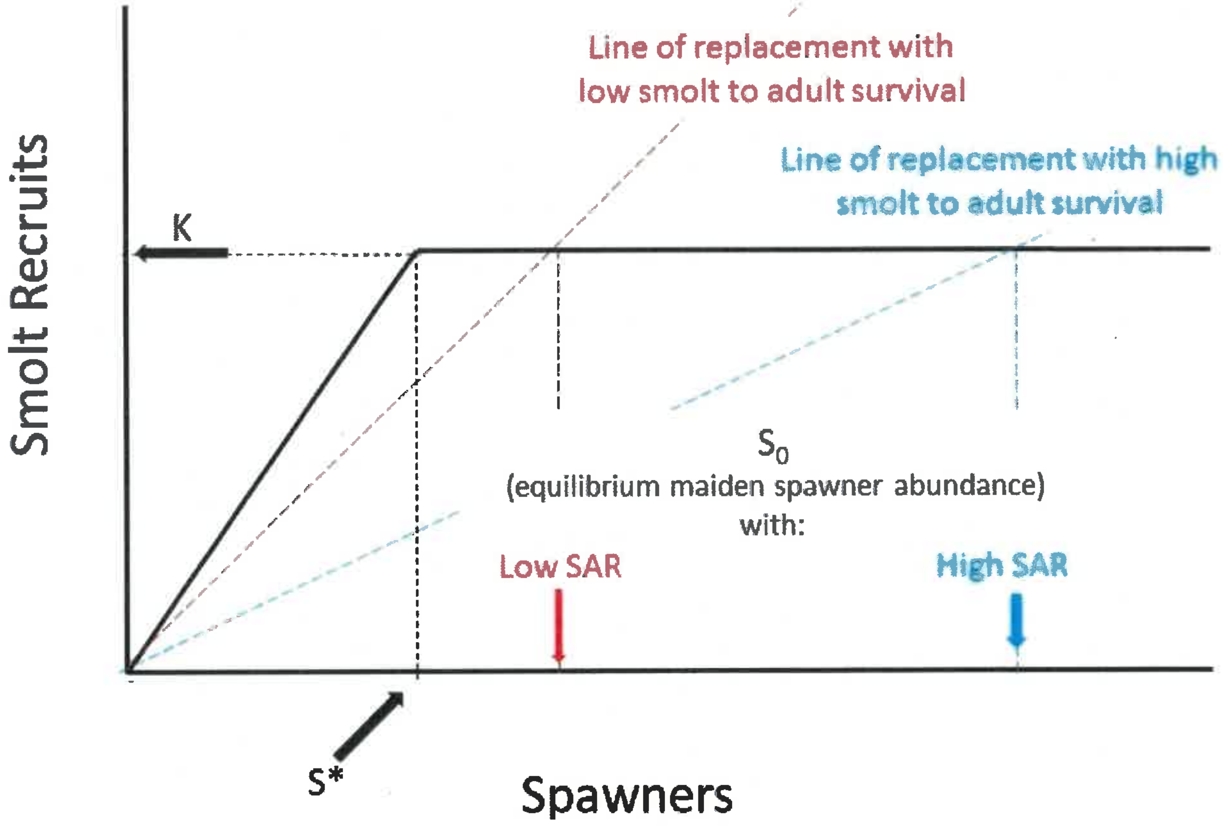

Figure 1. The hockey-stick stock-recruit model showing associated parameters.

2.2. Hockey-Stick Model Results

Estimates of productivity (α), smolt capacity (K), and the number of spawners associated with smolt capacity (S^*) from the Buehrens (2016) application of the hockey stick model are provided in Table 1.

Table 1. Accessible stream length and preliminary parameter estimates of α, K, and S^* for the hockey-stick model for Big Beef Creek, Snow Creek, the Nisqually River, and the hierarchical hockey stick model. (Source: Buehrens 2016, Tables 2, 4, 5).

Dataset	Accessible Stream Length (km)	α (80% CI)	K (80% CI)	S^* (80% CI)
Hierarchical Model		63 (35 - 124)		
Big Beef Creek	9	56 (41 – 77)	915 (741 – 1,163)	17 (11 - 24)
Nisqually River[1]:	162	86 (54 – 177)	55,633 (43,111 – 82,660)	619 (287 – 1366)
Snow Creek	10	51 (35 – 90)	1,317 (1,054 – 1,578)	26 (12 – 42)

To facilitate application of the hierarchical model to populations without estimates of smolt production, the hierarchical parameter estimates for S^* and K were estimated as a log-linear function of habitat quantity, which model selection criteria indicated was best quantified by kilometers of accessible stream habitat used by steelhead. Consequently, hierarchical model estimates of S^* and K and associated 80% CI are reported as densities to facilitate application to populations not included in the model (Table 2).

Table 2. Estimates of the spawners (S^*) and smolts at capacity (K) for the hierarchical model expressed relative to the kilometers of accessible area.

Parameter	Units	Lower 80% CI	Median	Upper 80% CI
D_{S^*}	Spawners @ S^* per km	0.000504	0.002074	0.008651
D_K	Smolts @ K per km	0.041036	0.134239	0.456631

3. Exploitation Rates

3.1. Populations Without Smolt Data

The hierarchical model discussed above provides an empirical basis for defining coarse-scale estimates of allowable exploitation rates for populations without smolt data or other stock-recruit analysis.

We developed the coarse-scale estimates of allowable exploitation rates with the following considerations:

1) Our understanding of the dynamics of populations lacking estimates of smolt production (or other stock-recruit analysis) is more uncertain than for the stocks with smolt data,

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[1] Note: The Nisqually River dataset modeled included only the area upstream of the smolt trap rather than the entire DIP.

particularly if characteristics of these populations and their habitats differ substantially from those modeled.

2) The estimates of the allowable exploitation rate from the hockey-stick model, relative to the Beverton-Holt model, are likely to be lower because per capita recruitment remains constant for spawners levels less than S^*, rather than increasing, which leads the hockey-stick model to produce systematically lower estimates of productivity (α) than the Beverton-Holt model. For this reason, use of the hockey-stick model is likely to provide more conservative estimates of allowable exploitation rates when populations are at low abundance (Barrowman and Myers 2000).

We defined the allowable exploitation rate μ as that which would provide an escapement of S^* maiden spawners based on a specified smolt-to-adult survival rate Θ, where the subscript q represents the quantile of the parameter estimate (e.g., lower 80% CI, median, upper 80%CI, etc.) (eq. 3):

$$\mu_{q,\theta} = \frac{\theta D_K - \theta D_{S^*}}{\theta D_K} \tag{2}$$

3.2. *Risk Aversion*

In addition to the lower productivities estimated by the hockey stick model relative to the Beverton-Holt, three additional factors may be considered in order to ensure sufficiently risk averse management using equation 3:

1) A specific quantile of the hierarchical estimate of μ may be chosen which ensures that the true μ for a particular proportion of populations is likely to be higher (e.g., if a value of $q = 0.1$ is used for the hierarchical μ this means the true μ for 90% of populations is greater than the value of μ selected).
2) This method assumes no iteroparity, which results in a lower harvest rate to achieve S^* than would methods which include iteroparity, thus iteorparity would only add to the escaping spawner abundance above and beyond S^* at a particular value of μ.
3) Since μ is calculated relative to a specific smolt to adult survival rate, application of this harvest rate when marine survival is at or above the survival rate of interest ensures that harvest rates do not exceed that which permit populations to produce S^* spawners.

The framework for the coarse-scale estimates of allowable exploitation rates for populations lacking smolt data (or other stock-recruit analysis) is provided in Table 3 and incorporates all of the above risk-averse measures.

Table 3. Framework for the coarse-scale estimates of allowable exploitation rates for populations lacking smolt data (or other stock-recruit analysis).

Population Designation	**Status**	
	Above Management Breakpoint	**Below Management Critical Threshold**
Primary	$\mu_{q,\theta}$ where $q \leq 0.10$	Exploitation rate no greater than average at time of listing.
Contributing	$\mu_{q,\theta}$ where $q \leq 0.25$	
Stabilizing	$\mu_{q,\theta}$ where $q \leq 0.50$	

Estimates of the average marine survival rates and allowable exploitation rates for each population are provided in Table 4.

Table 4. Estimates of the average marine survival rates and allowable exploitation rates for each population when the population is above the critical threshold.

Population	SAR (Θ)	Smolt Years Watershed (source)	Allowable Exploitation Rate		
			Primary	Contributing	Stabilizing
East Hood Canal Winter Run	≥ 0.02	2005 – 2010 Big Beef Creek (Kendall et al. 2017)	0.05	0.14	0.23
South Hood Canal Winter Run					
Skokomish Winter Run					
West Hood Canal Winter Run					

3.3. Populations With Smolt Data

{This section under development.}

3.4. Populations With Other Stock Recruit Analysis

{This section under development.}

4. Thresholds

Three methods were evaluated for establishing a critical thresholds below which the viability of a stock would be compromised: 1) the predicted number of spawners at the point of depensation; 2) the minimum number of spawners necessary to prevent genetic drift; and 3) a quasi-extinction threshold (QET).

Method 1 – Depensation. Peterman (1977, 1987) provided a rationale for depensation and suggested relating the escapement level at which depensation occurs to the size of the population in the absence of fishing (equilibrium spawner level). Based on Peterman's work, we established the critical level equal to 5% of the equilibrium spawner size. The equilibrium spawner size was estimated based on the upper 80th CI for smolt capacity, the estimated marine survival rate, and an assumed maiden spawner to repeat spawner survival of 25% with up to 4 repeat spawning events.

Method 2 – Effective Population Size. The number of effective breeders per year, rather than annual spawner abundance, determines the genetic stability of a salmonid population over time. Waples (1990) estimated through modeling that 100 effective breeders per year would maintain genetic variation in salmon populations for 25 generations, for populations with a four year generation cycle. Annual effective breeder abundance less than 50 was estimated to expose the population to high risk of allele loss through genetic drift. The number of annual effective breeders multiplied by the average age at reproduction (approximately four years for steelhead) equals the generational effective population size (N_e), thus N_e lower than 200 is also associated with high risk.

Although the annual number of successful spawners is not easily determined, the relationship between census size and effective breeders (N_b) has been estimated for both Chinook and steelhead. Waples (2004) found that the ratio of effective population size to spawner census (N_e/N_c) for Chinook could be expected to range from 0.05 to 0.3. Estimates of N_e/N_c in three British Columbia steelhead populations ranged from 0.06 to 0.29 (Heath et al. 2002). In a study of the Snow Creek steelhead, Ardren and Kapuscinski (2003) estimated relatively higher ratios of the annual number of effective breeders to spawner census (N_b/N_c), ranging from 0.16 to 2.4, depending on methodology. Most importantly they found higher N_b/N_c ratios when census size was low, indicating higher reproductive success when fewer spawners were present in this relatively small watershed.

We can refer to available information on the ratio of effective breeders to census size to estimate a minimum census size at which effective number of spawners may be expected to be large enough to maintain diversity and minimize inbreeding in a population, at least over the short-term.

A critical threshold values for annual spawning escapement was chosen such that, for each potential population, the annual effective size, or number of successful breeders, would not be lower than 50 if an N_b/N_c ratio of at least 0.40 was achieved. This results in a critical threshold of 125 spawners.

Method 3 – Quasi Extinction Threshold. Hard et al. (2015) developed estimates of the QET for each Puget Sound steelhead population based on the intrinsic habitat potential (IP) (see Table 7 in Hard 2015). Values for each population were interpolated from the relationship between the intrinsic habitat potential of a small basin (Snow Creek, QET = 24) and the largest basin (Skagit River Summer and Winter Run, QET = 157).

For the coarse scale assessment, we selected as the management breakpoint the largest of critical thresholds resulting from Method 1, Method 2, and four times the value from Method 3 (Table 5).

Table 5. Critical thresholds resulting from application of methods 1-3.

Population	Method 1	Method 2	Method 3	Management Breakpoint
East Hood Canal Winter Run	23	125	27	125
South Hood Canal Winter Run	41	125	30	125
Skokomish Winter Run	66	125	50	200
West Hood Canal Winter Run	58	125	32	128

5. Limitations and Future Work

The coarse-scale assessment was developed to provide a filter to assess the consistency of proposed fishery and hatchery programs with the conservation objectives. Additional, more detailed analyses will be completed when fishery and hatchery plans are submitted to NOAA Fisheries as part of a resource management plan or other document.

As we move toward these more detailed analyses, it is useful to review the limitations of the assessment and provide some initial perspectives on the development of analytical tools. This exploitation framework attempts to build upon and leverage the considerable amount of data collected, analysis conducted, and understanding gained since original harvest management plans were developed for steelhead in Washington State. Nonetheless, it is not without its limitations. First, the analysis by Buehrens (2016) is in draft form and is currently being finalized, meaning exact parameter estimates may change slightly in its final form. Secondly, we have applied results of Buehrens (2016) to watersheds which were not modeled and if these watersheds differ systematically from those modeled or are not representative, then parameter estimates may be biased. Finally, we relied on the uncertainty in population demographic rates use of the more conservative hockey-stick model, and application of risk averse parameter quantiles in order to develop a risk-averse management approach. However, increasingly, harvest strategies are being tested via simulation (e.g., Management Strategy Evaluation; MSE) in order to compare the results of alternative management options on population performance. In addition to uncertainty in demographic rates, these analyses are able to accommodate environmental stochasticity, bias or uncertainty in measurements of stock size and harvest rate, and so-called implementation error, where the true exploitation rate differs from that intended.

Future efforts could improve upon the approach described herein. First, obtaining fish data for watersheds with no data in Buehrens (2016) would greatly reduce uncertainty in demographic rates. This would have several advantages; not only would it help ensure the appropriateness of the model in application to specific populations, but the reduction of uncertainty, assuming no shift in the central tendency of parameter estimates, would result in elevated allowable harvest rates when using risk averse quantiles because those quantiles of the allowable harvest rate would shrink upward toward the median. Secondly, future efforts could use the demographic rates in Buehrens (2016) to develop an MSE that could incorporate other sources of uncertainty and potential bias and test the sensitivity of management options. Finally, efforts could be made to test assumptions in Buehrens (2016) and to validate the results of this coarse harvest framework. Lastly, a similar framework to that described herein, or potentially one incorporating some elements of the future work described above, could be used to develop harvest rates for application when marine survival is considerably greater than 2% and therefore enables greater exploitation.

6. References

Barrowman, N. J., R. A. Myers. 2000. Still more spawner-recruitment curves: the hockey stick and its generalizations. Can. J. Fish. Aquat. Sci. 57: 665–676.

Buehrens, Thomas. 2016. Estimates of biological reference points for coastal steelhead populations in Washington State. Report to NOAA Fisheries. WDFW, Olympia, WA. Pp. 68.

Myers, R.A., Rosenberg, A.A., Mace, P.M., Barrowman, N.J., and Restrepo, V.R. 1994. In search of thresholds for recruitment overfishing. ICES J. Mar. Sci. 51: 191–205.

Hood Canal Steelhead Hatchery Options

HATCHERY EVALUATION AND ASSESSMENT TEAM,

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

7/25/2017

Background – Demographic Gene Flow (DGF) Model

- Steelhead were historically out-planted in Hood Canal tributaries.
  - Discontinued in 2003 due to declines in natural populations and low survival of hatchery fish.

- The demographic gene flow model (Hoffman 2016), was used to assess potential hatchery program sizes in the four Hood Canal demographically independent populations (DIPs).
  - East Hood Canal
  - South Hood Canal
  - Skokomish
  - West Hood Canal

DGF Model

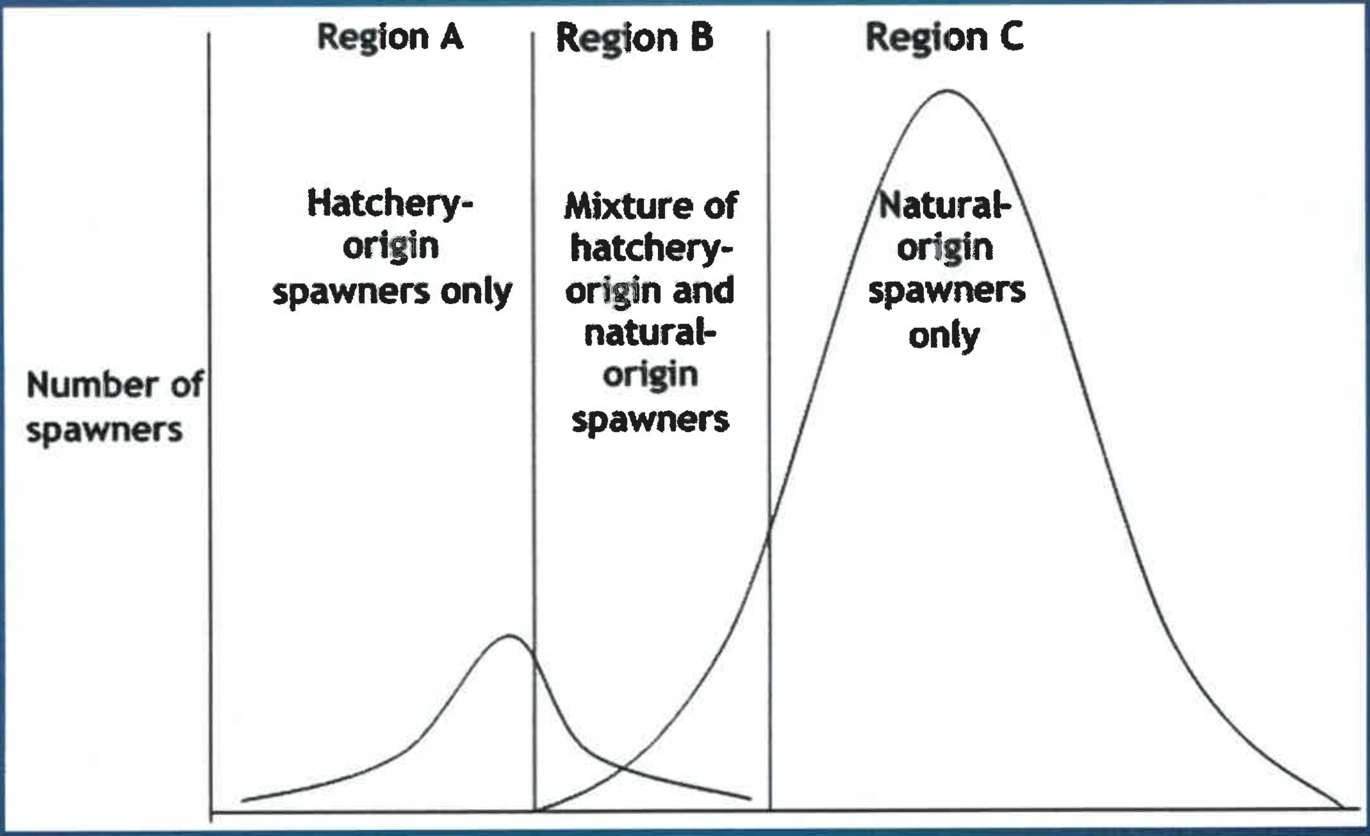
- The model was developed in 2014 when completing the HGMPs for WDFW's existing early-winter steelhead program.
  - Provides a way to assess the potential gene flow early-winter hatchery steelhead into natural populations at specific program sizes.
  - The model estimates gene flow using the methods of Scott and Gill (2008) with the correction provided by Busack (2014).

$$Gene \quad flow = \frac{b}{b + a(1-q)(1-o_N) + (1-q)^2 o_N{}^2}, \text{ where}$$

$$a = o_N + q(o_H - o_N)$$

$$b = k_1(aq(1-o_H) + q^2 o_H{}^2) + k_2 q(1-q) o_N o_H$$

Run Timing Overlap



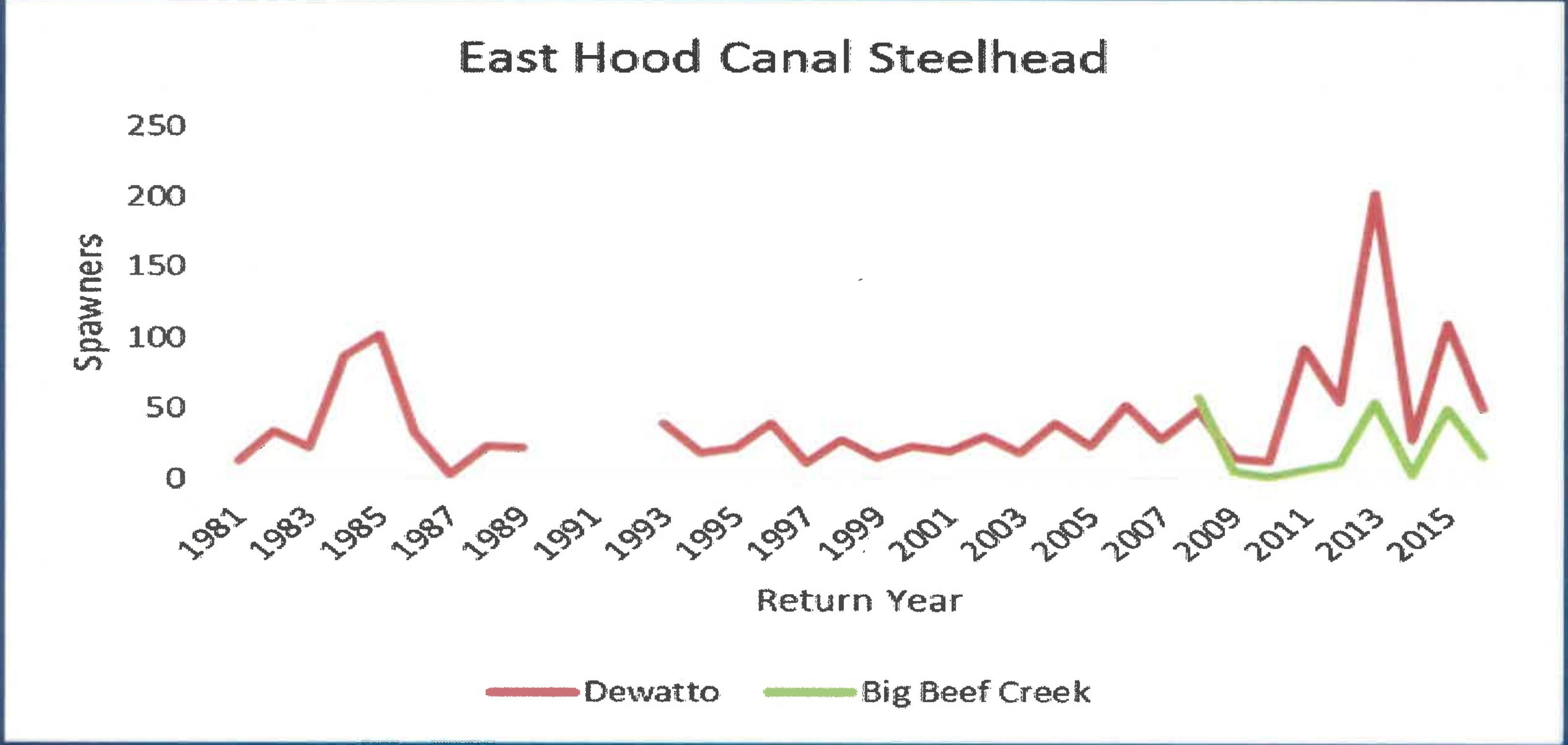
Model Parameters

- Spawn Timing of Hatchery-Origin Spawners (O_H)
  - Estimated from spawn and entry timing of early-winter steelhead into Dungeness Hatchery
  - Dungeness selected due to similarities with Hood Canal watersheds.
- Spawn Timing of Natural-Origin Spawners (O_N)
  - Based on spawn timing of each DIP and the spawn timing range for Snow Creek and the Clearwater River (Queets trib) to bracket estimates.

Model Parameters Continued…

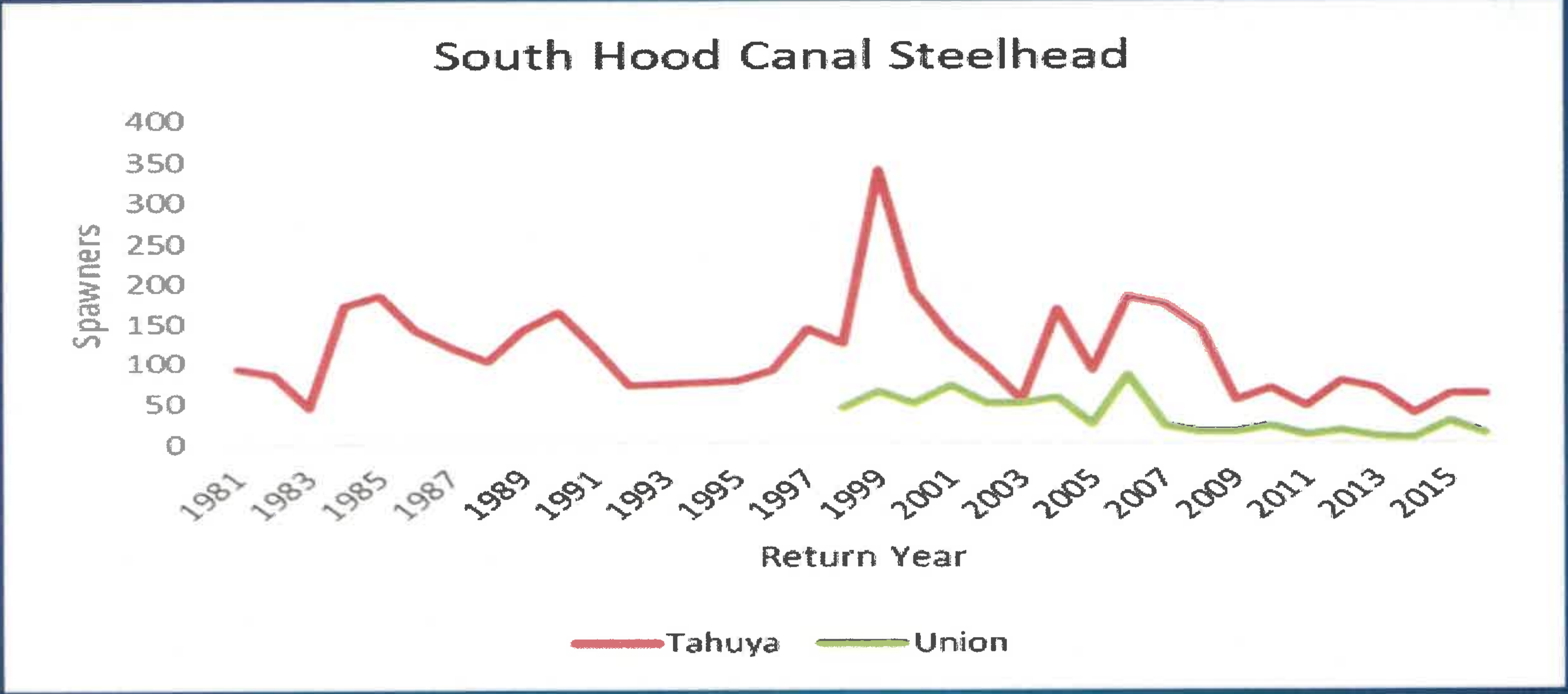
- Relative Fitness of HxH Crosses (k_1)
  - Due to a long history of hatchery domestication the fitness of early winter steelhead is expected to be low.
  - A 2% and 13% fitness assumed in model scenarios.
- Relative Fitness of HxW Crosses (k_2)
  - Fitness was assumed to be 54%
    - Halfway between the average HxH fitness (8.4%) and wild fitness (100%).
- Proportion of Total Natural Spawners of Hatchery-Origin (q)
  - Trap scenarios:
    - Either a 20% or 30% stray rate with the remainder removed at a trapping facility.
  - No trap scenarios:
    - Assumed at stray rate of 20% to 30% on top of observed Dungeness hatchery escapement, but all fish are placed on the spawning grounds.

East Hood Canal


East Hood Canal Steelhead

Maximum Program Size	Project Recreational Catch	Projected Angler Days
3,470	9 (6-13)	78 (47-109)

South Hood Canal

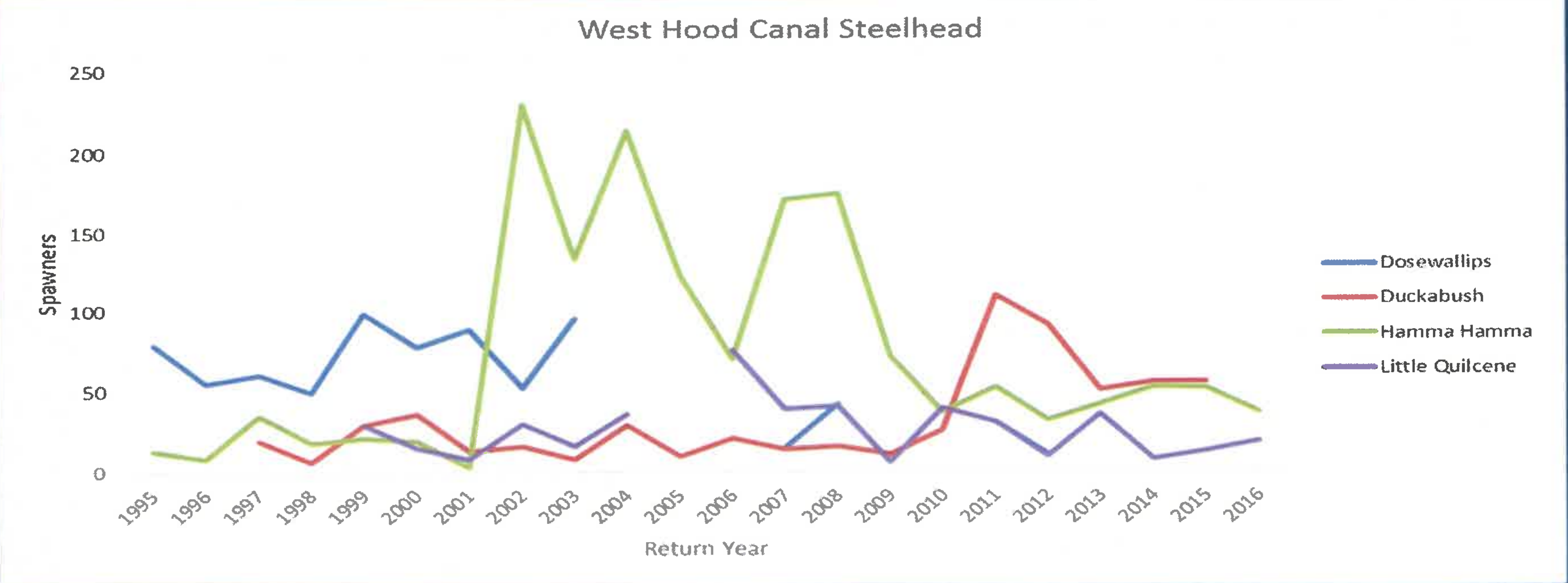


Maximum Program Size	Project Recreational Catch	Projected Angler Days
3,200	9 (5-12)	78 (43-101)

Skokomish River

Scenario	Maximum Program Size	Project Recreational Catch	Projected Angler Days
No Trap	41,500	112 (67-157)	933 (560-1,306)
Trap	165,500	446 (268-625)	3,720 (2,232-5,207)

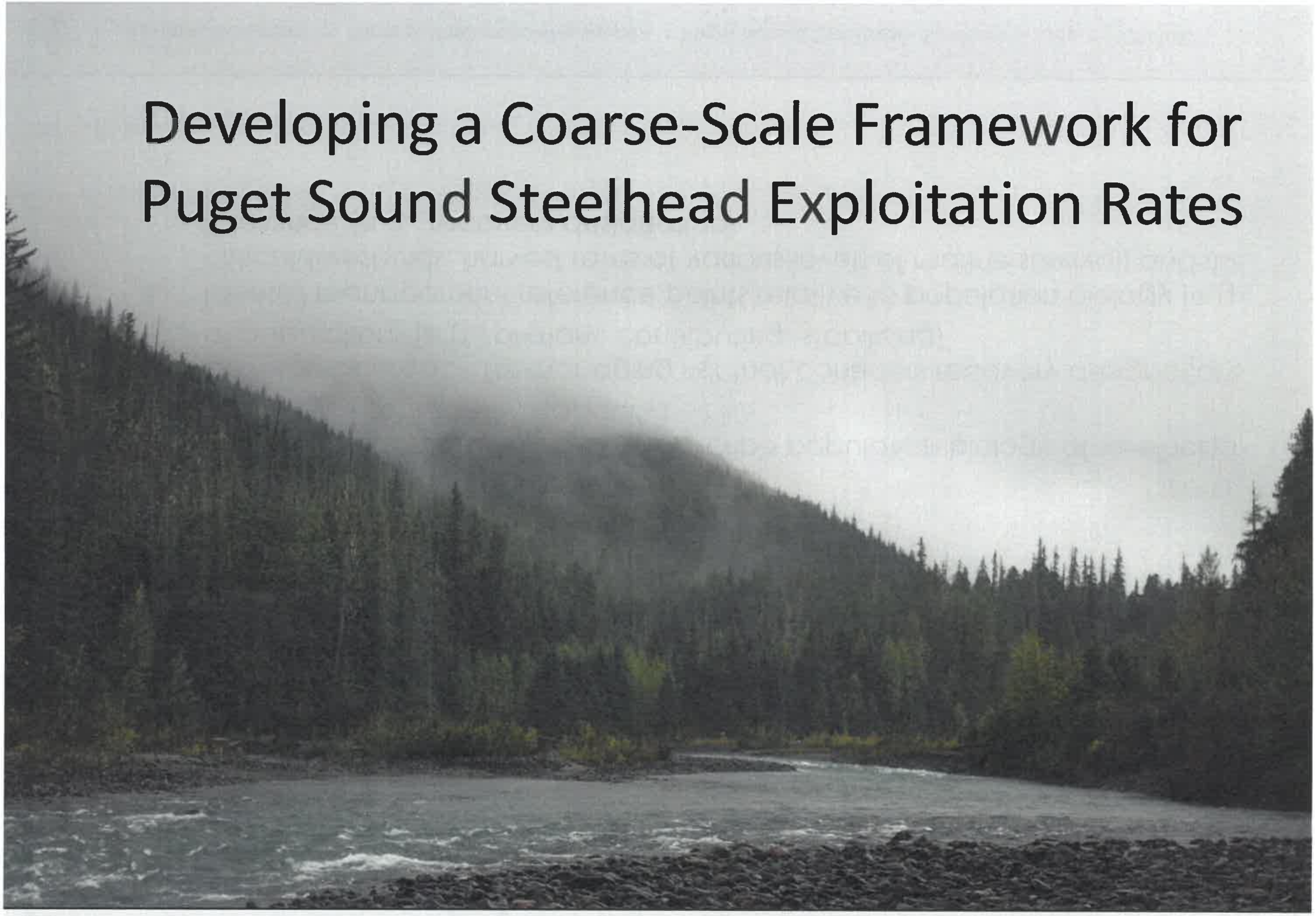
West Hood Canal


West Hood Canal Steelhead

Scenario	Maximum Program Size	Project Recreational Catch	Projected Angler Days
No Trap	3,000	8 (5-11)	67 (40 - 94)
Trap	12,000	32 (19-45)	270 (162 - 378)

Questions?

Developing a Coarse-Scale Framework for Puget Sound Steelhead Exploitation Rates



Thomas Buehrens • thomas.buehrens@dfw.wa.gov • Puget Sound Steelhead Advisory Group • 7/25/2017

Overview

- **Objective:** Develop framework for fisheries for Puget Sound steelhead that enables meeting short-term conservation objectives and allows populations to move toward recovery goals over the long term.

- Steps:
  1. Develop stock recruit models to describe population biology of steelhead and (e.g., productivity, capacity)
  2. Develop approach for managing risk that considers recovery designations of populations (e.g., primary, contributing, stabilizing)
  3. Identify management reference points relative to population biology (e.g., critical thresholds, harvest rates at various levels of marine survival) and risk tolerance (e.g., recovery designation)

Stock Recruit Models to Estimate Reference Points for Steelhead

- Management and conservation of steelhead require estimates of Biological Reference Points (BRPs)
  - (e.g., MSY, productivity, capacity)
  - Short Term: manage fisheries, establish escapement goals
  - Long Term: track status and trends of populations relative to recovery goals
- Previous attempts to estimate BRPs made with limited data, lots of assumptions
  - WA historical BRP estimates made with limited data
  - Limited data on juvenile (parr) densities
  - Estimated habitat quantity
  - 3-5 years of spawner data for 5 pops
  - Used to estimate MSY across western WA (Gibbons et al. 1985)
- Opportunity to revisit previous analysis
  - Abundance time series (smolt + adult) data are now available
  - More types and higher quality of habitat data available

Estimating BRPs using adult data

Classic approach :

Adult to adult spawner-recruit analysis to estimate density-dependent population parameters, separately

Problems:

- No/few data for some pops
- Full life-cycle data includes life-stages with both ***density-dependent*** AND ***density-independent*** survival
  - Smolt to adult survival-highly variable
  - Known 'regime shifts' in productivity
  - Both result in noisy SR analysis

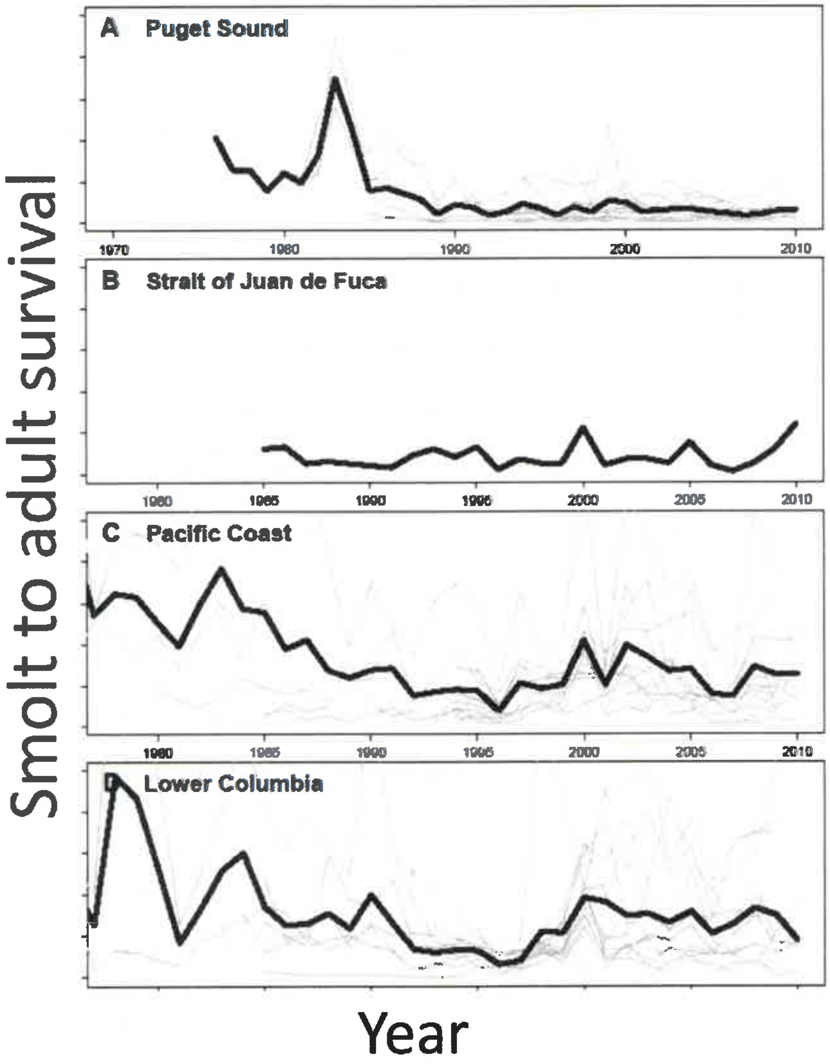
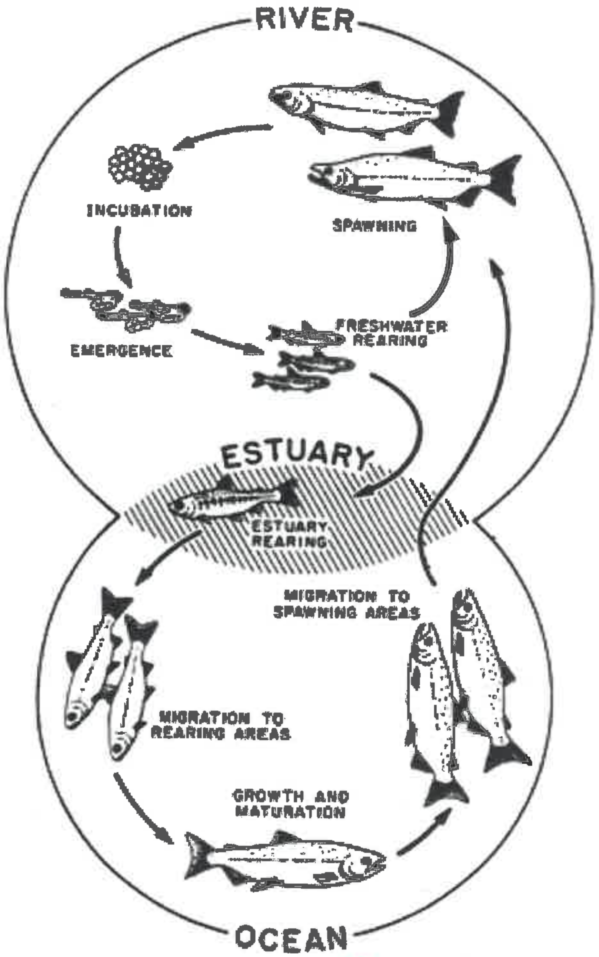


Figure provided by Neala Kendall

Steelhead Life Histories Enable Spawner-Smolt SR Models

Survival Density **Dependent**



Survival Density **Independent**

Freshwater

- Rear in natal watershed(1-4 years)
- Territorial resource competition *within* populations

Vs.

Marine

- Rapid movement away from river mouths
- Mixed stock rearing areas
- Resource sharing *among* populations
- Low correlations in abundance among populations

Goal: Estimate biological reference points for W. WA populations

- Eliminate "noise" in BRP estimates due to variable marine survival
- Use habitat data to explain among-population differences in BRPs
  - Empirically identify habitat features important to steelhead production
  - Enable estimation of BRPs for pops with no fish data
- Make use of very short time series (data limited pops)
- Accommodates use of inputs (fish, habitat data) that change over time
  - Existing management reference points are independent of fish, habitat data
  - New model should allow future SR data points to tell us how populations are responding to their habitats, independent of marine survival shifts

Approach: Bayesian state-space spawner smolt-recruit meta-analysis

Hockey Stick Model

Data

R = Smolt Recruits

S = Spawners

Parameters

α = Asymptotic recruits per spawner

K = Smolt recruits at carrying capacity

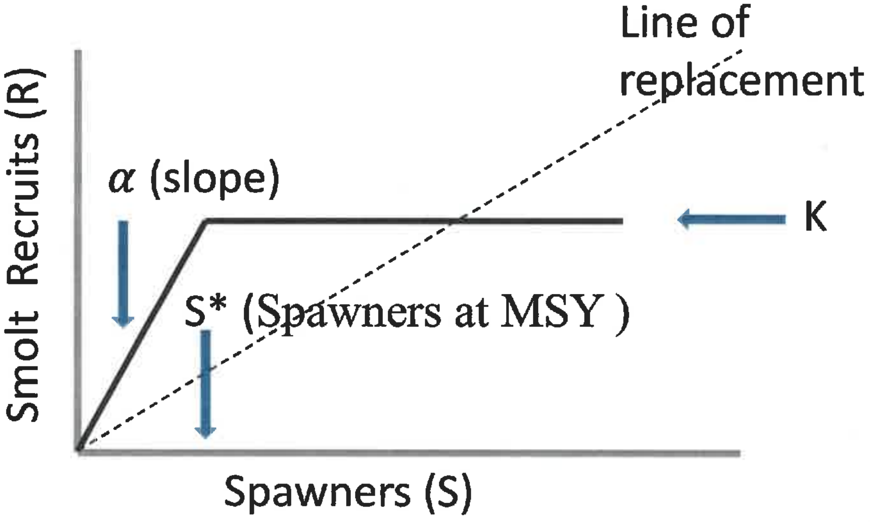
$S^{*} = \frac{K}{\alpha}$ = Spawners at MSY, full seeding

Modified Model

K = log-linear function of habitat variables

Standard Hockey Stick Model

$$R = \min\ (\alpha S, K) = \begin{cases} \alpha S, = \text{if } \alpha S < K \\ K, = \text{if } \alpha S \geq K \end{cases}$$



Why use Hockey Stick vs. Beverton Holt and Ricker models?

- BH model
  - higher estimates of productivity→higher allowable harvest rates→greater risk of over-harvest
  - Spawners at MSY changes with marine survival
- HS model
  - lower estimates of productivity→ lower allowable harvest rates→lower risk of over-harvest
  - Spawners at MSY does not change with marine survival (harvest rate does)

Why do we need habitat data for a stock-recruit analysis?

- Capacity parameter is standardized across populations as a function of habitat
- Ability to predict capacity for watersheds lacking fish data

Habitat Variables
Accessible Stream Length (km)
Surface Area (m2)
Surface Area (2 m margins)
Surface Area (4 m margins)
Surface Area (8 m margins)
Sum of Burnett IP Scores

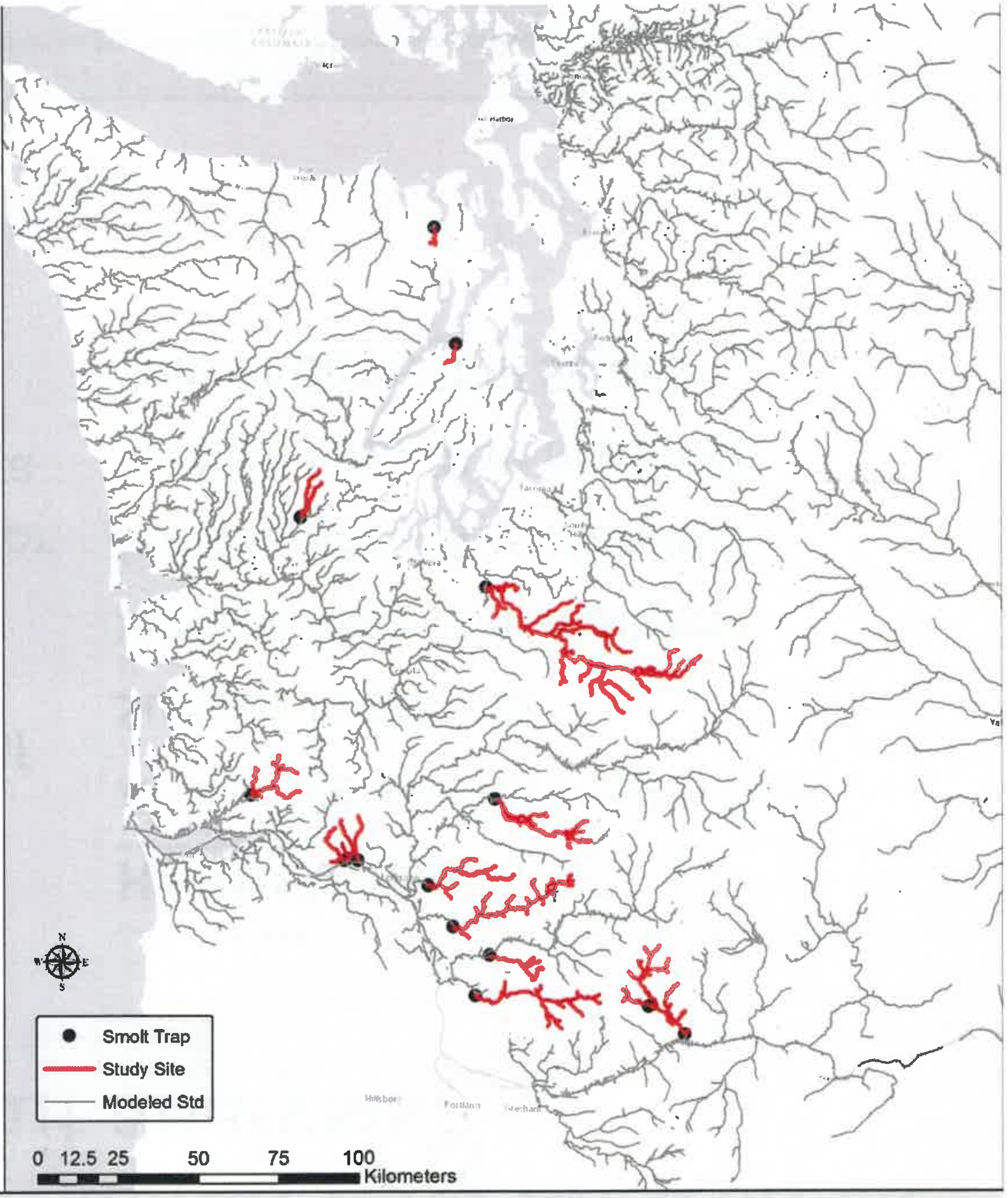
Data

- 15 populations (in process of adding up to ~ 5 more)

- 246 spawner and 201 smolt abundance estimates, 110 of which included smolt age data

- Used logistic regression to model fit to predict occupancy; truncated by barriers

- GIS habitat covariates modeled over 100's to 1000's of reaches (every 100 m reach in every river)

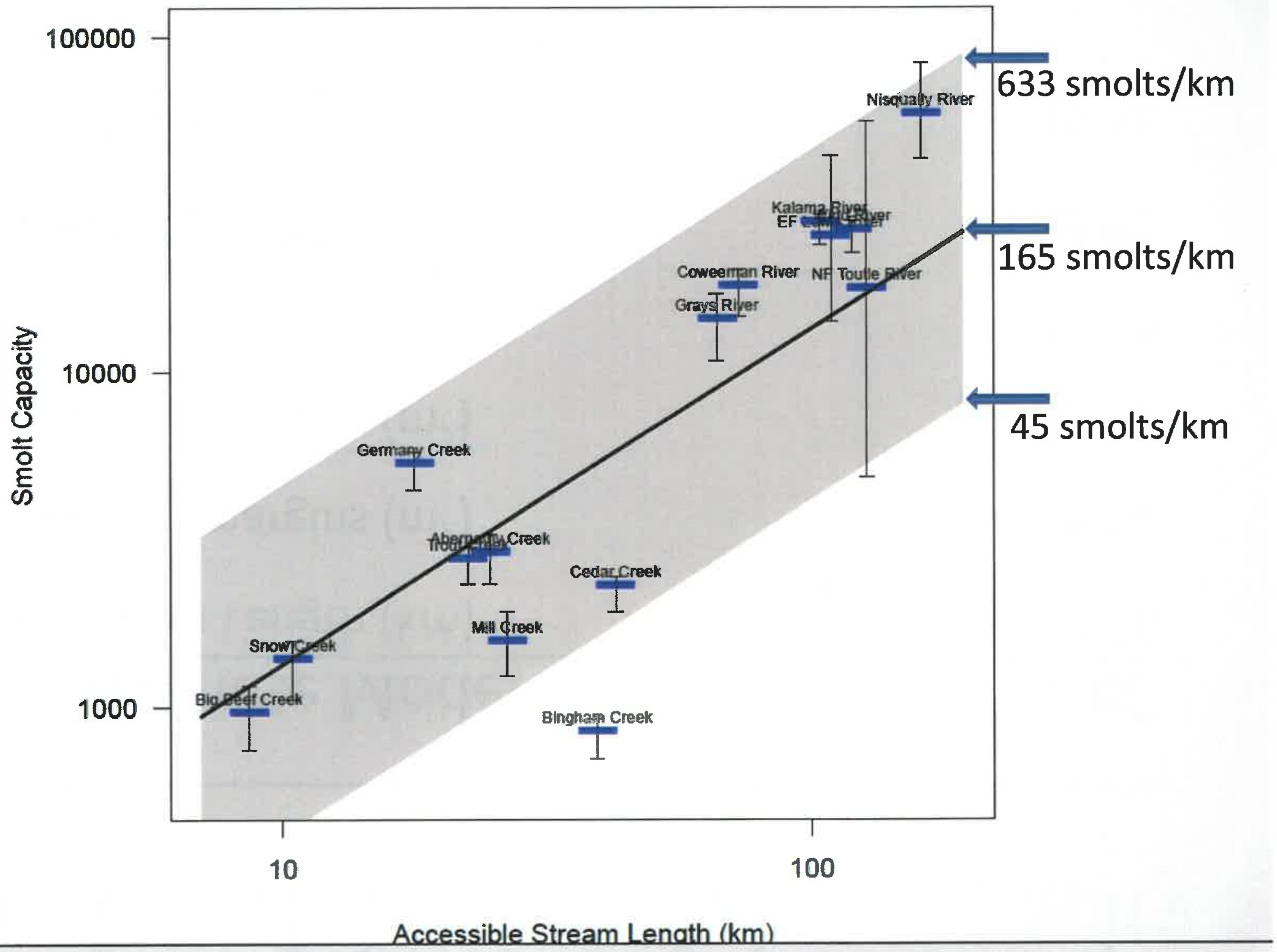


Stream length best explains capacity

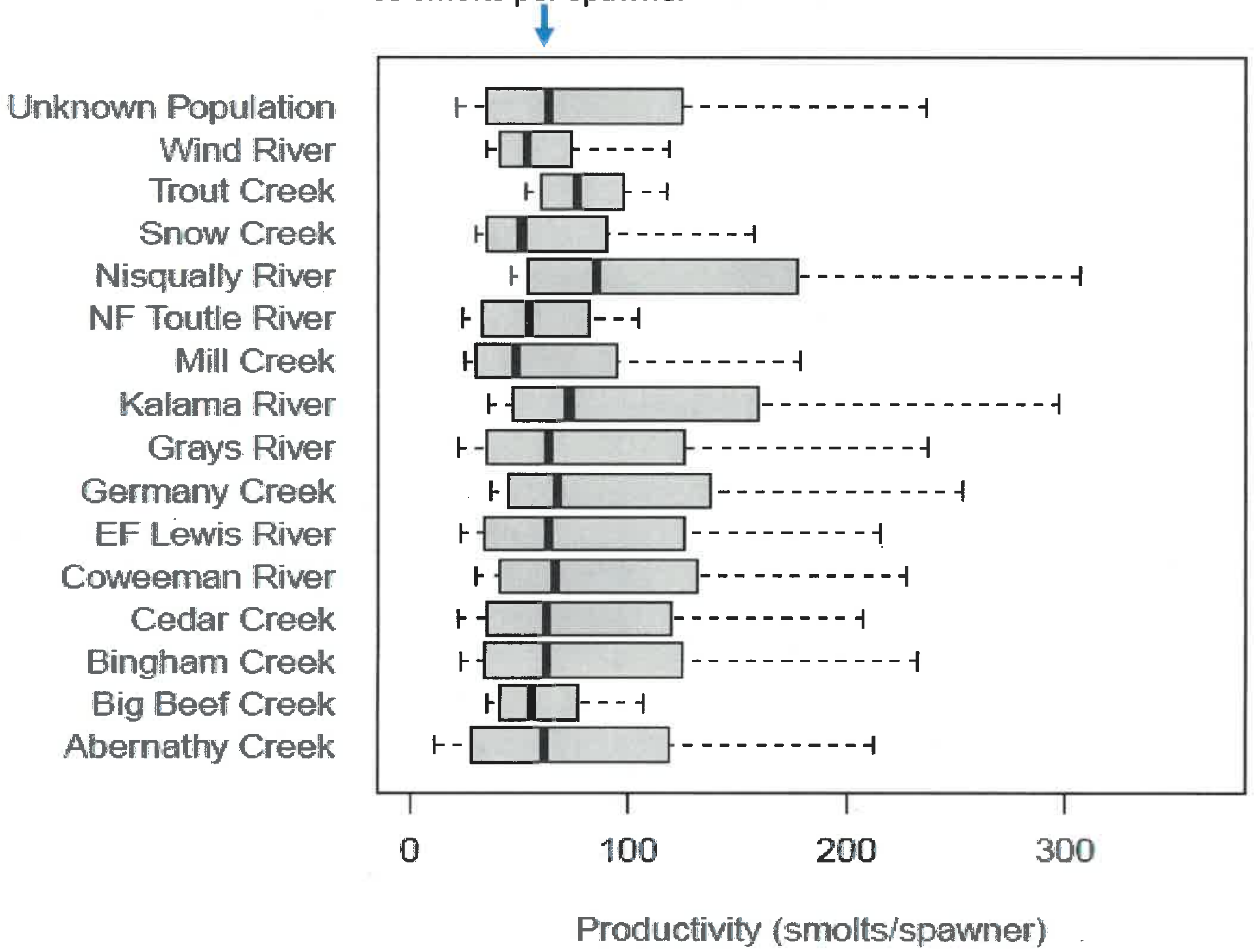
Habitat Covariate Model	ΔDIC
Accessible Stream Length (km)	0.00
Surface Area 2 m margins (m^2)	6.32
Surface Area 8 m margins (m^2)	10.27
Surface Area 4 m margins (m^2)	13.62
Sum of Burnett (2007) IP Scores	13.95
Surface Area (m^2)	18.53

Smolt Capacity (*K*) vs. Stream Length

- Capacity strongly correlated with stream length
- However, stream length alone is imprecise predictor of capacity
- 80% CI of hierarchical model includes median of all but one pop

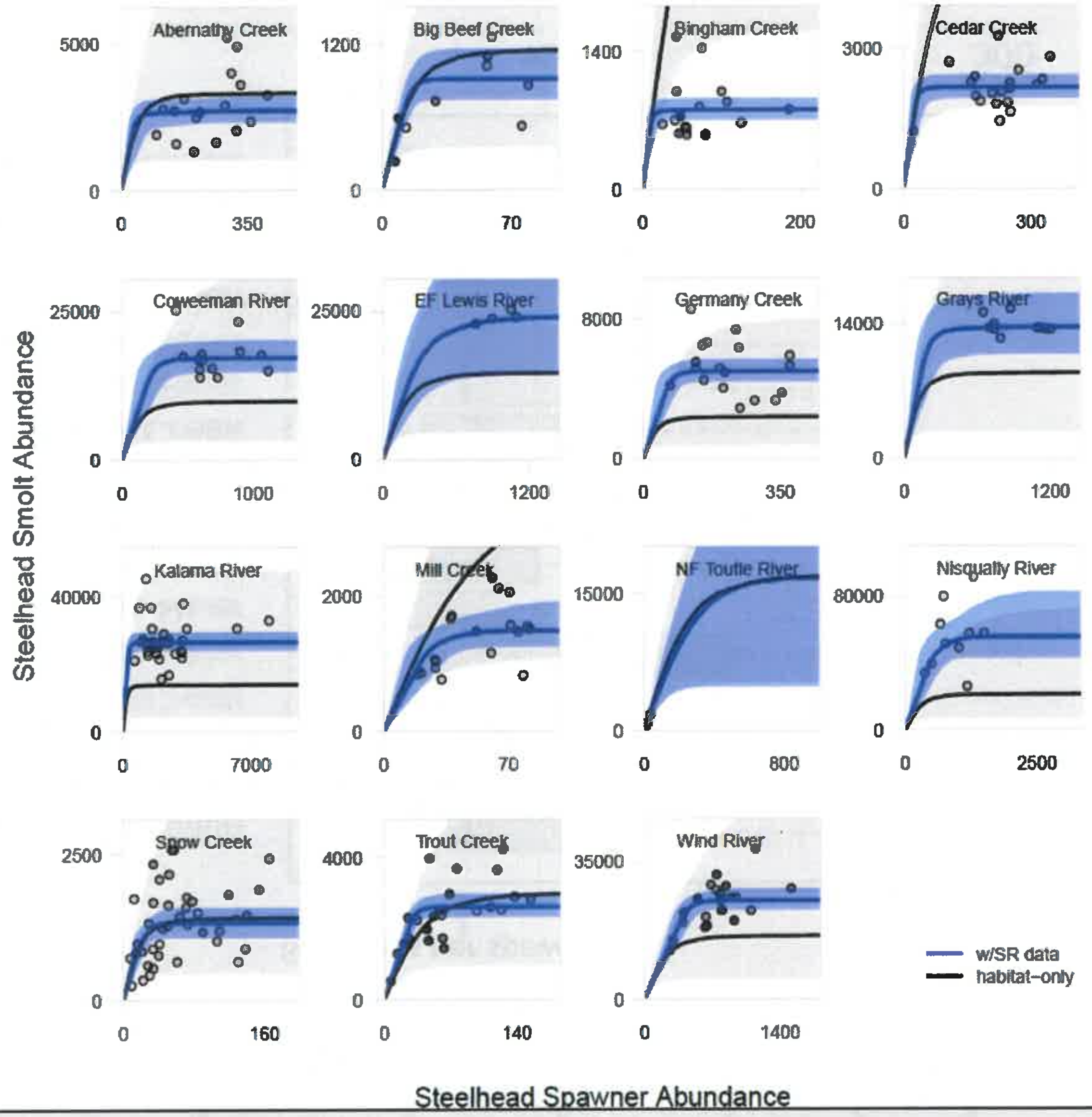


Productivity (α)


63 smolts per spawner

Hockey Stick SR fits

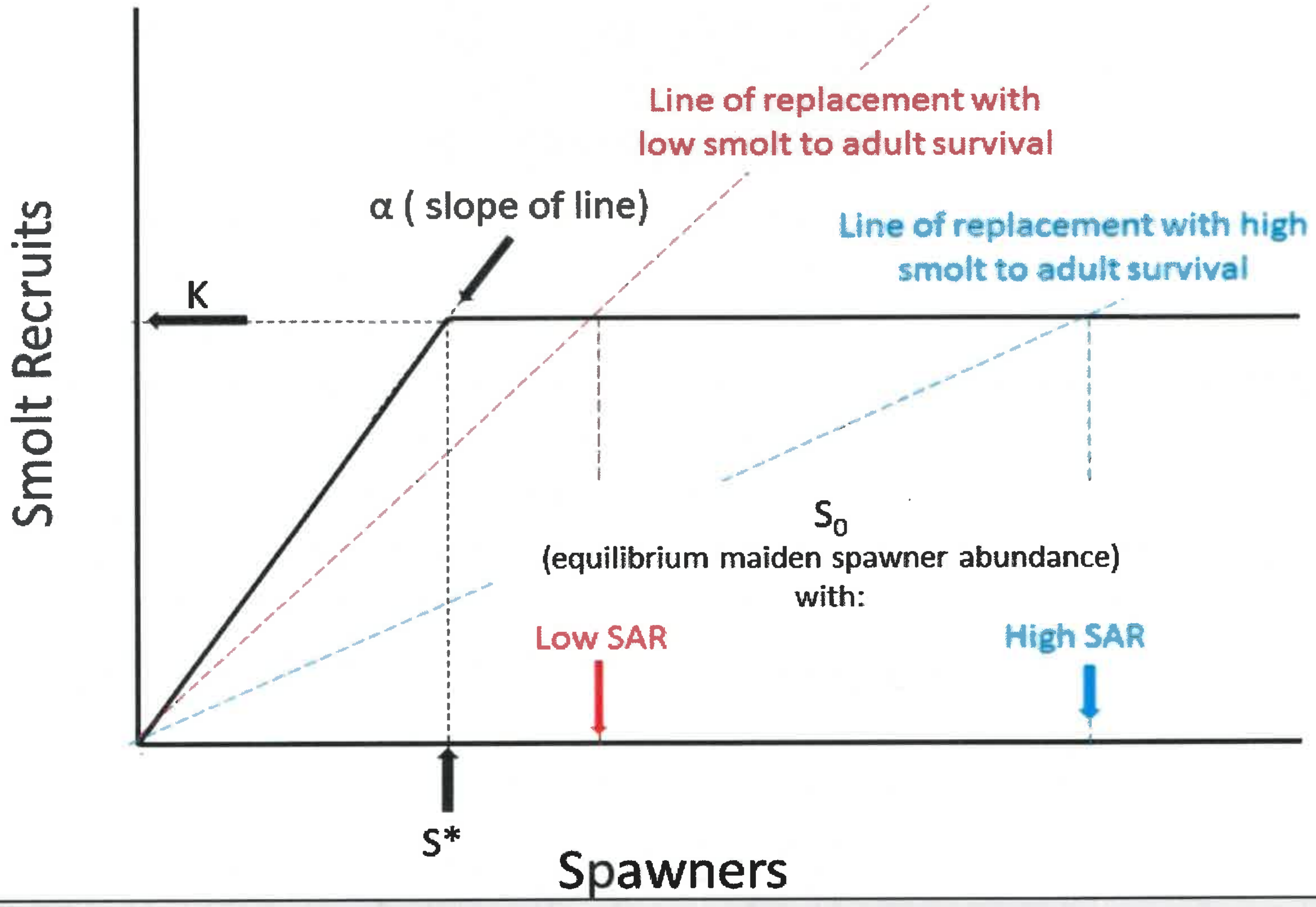
Note: curvature is caused by uncertainty in both capacity (K) and productivity (α)



Conclusions

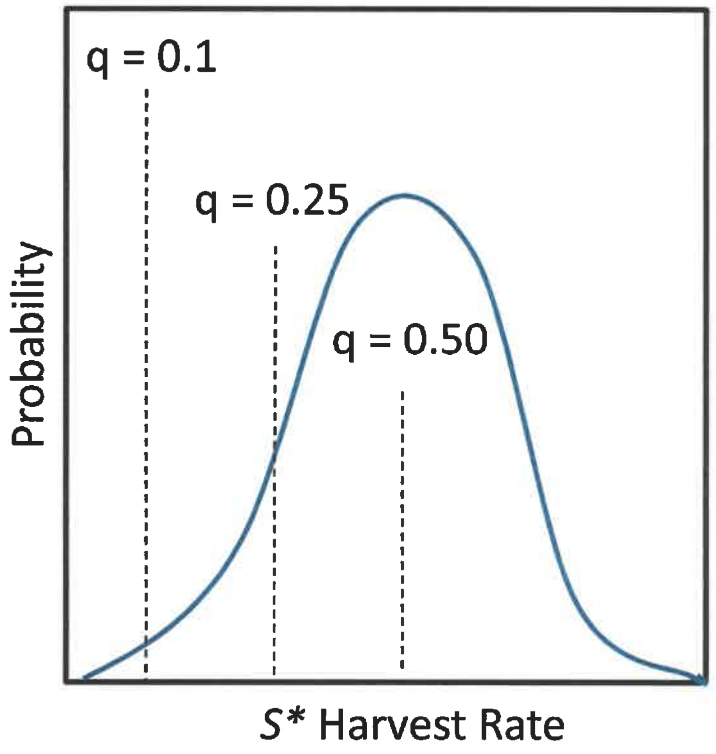
- Model fits data and enables estimates of productivity and capacity
- …But, LOTS of uncertainty for populations with no fish data
- More uncertainty in capacity parameter than productivity for pops with no fish data
- Therefore exploitation based on allowable harvest rate which is a function of productivity only
- However, need to identify threshold below which fishing curtailed

Estimating Harvest Rates at Varying Levels of Marine Survival



Translating Recovery Designations into Risk Tolerance

Population Designation	Status	
	Above Critical Threshold	Below Critical Threshold
Primary	$0.1 \geq q$	No greater than average since listing.
Contributing	$0.25 \geq q$	
Stabilizing	$0.5 \geq q$	



Applying SR model to Populations

Population	SAR (ϴ)	Smolt Years Watershed (source)	Allowable Exploitation Rate		
			Primary	Contributing	Stabilizing
East Hood Canal Winter Run	≥ 0.02	2005 – 2010 Big Beef Creek (Kendall et al. 2017)	0.05	0.14	0.23
South Hood Canal Winter Run					
Skokomish Winter Run					
West Hood Canal Winter Run					

Critical Thresholds

- Method 1: **Based on Depensation (Peterman (1977, 1987)**
  - Rationale for depensation and relating the escapement level at which depensation occurs to the size of the population in the absence of fishing (equilibrium spawner level).
  - Based on Peterman's work, we established the critical level equal to 5% of the equilibrium spawner size.
- Method 2: **Based on effective population size (Waples 1990)**
  - Estimated that 100 effective breeders per year would maintain genetic variation in salmon populations with a four year generation cycle. Annual effective breeder abundance <50 = high risk.
  - The number of annual effective breeders multiplied by the average age at reproduction (approximately four years for steelhead) equals the generational effective population size (N_e), thus N_e lower than 200 is also associated with high risk.
  - A critical threshold values for annual spawning escapement was chosen such that, for each potential population, the annual effective size, or number of successful breeders, would not be lower than 50 if an N_b/N_c ratio of at least 0.40 was achieved. This results in a critical threshold of 125 spawners.
- Method 3: **Puget Sound Steelhead QETs Hard et al. (2013)**
  - Puget Sound Steelhead Quasi-Extinction thresholds

Proposed Critical Thresholds

Population	M1	M2	M3	*S** (full seeding)			Proposed Critical Threshold (4 × Method 3 or max of M1-3)
				L 80%CI	Median	U 80%CI	
East Hood Canal Winter Run	23	125	27	19	78	324	**125**
South Hood Canal Winter Run	41	125	30	34	140	583	**125**
Skokomish Winter Run	66	125	50	55	225	937	**200**
West Hood Canal Winter Run	58	125	32	48	197	821	**128**

Options

Option	Population (river)	Designation	Fishery		Average Spawners	Management Breakpoint	Coarse Assessment Allowable Fishing Rate Above Breakpoint
			Directed at Wild Fish (Y or N)	Type			
1	East Hood Canal Winter Run (Dewatto)	Stabilizing	N	Catch & Keep	107	125	0.23
1	Skokomish River Winter Run	Primary	Y	Catch & Release Individual Permit	718	200	0.05
2	South Hood Canal Winter Run (Tahuya)	Contributing	N	Catch & Release	76	125	0.14
2	Skokomish River Winter Run	Contributing	N	Catch & Keep	718	200	0.14
2	Skokomish River Winter Run	Contributing	Y	Catch & Release	718	200	0.14
2	West Hood Canal Winter Run (Quilcene)	Primary	N	Catch & Keep	169	128	0.23
3	East Hood Canal Winter Run (Dewatto)	Contributing	N	Catch & Keep	107	125	0.14
3, 4	Skokomish River Winter Run	Primary	Y	Catch & Release	718	200	0.05

Questions

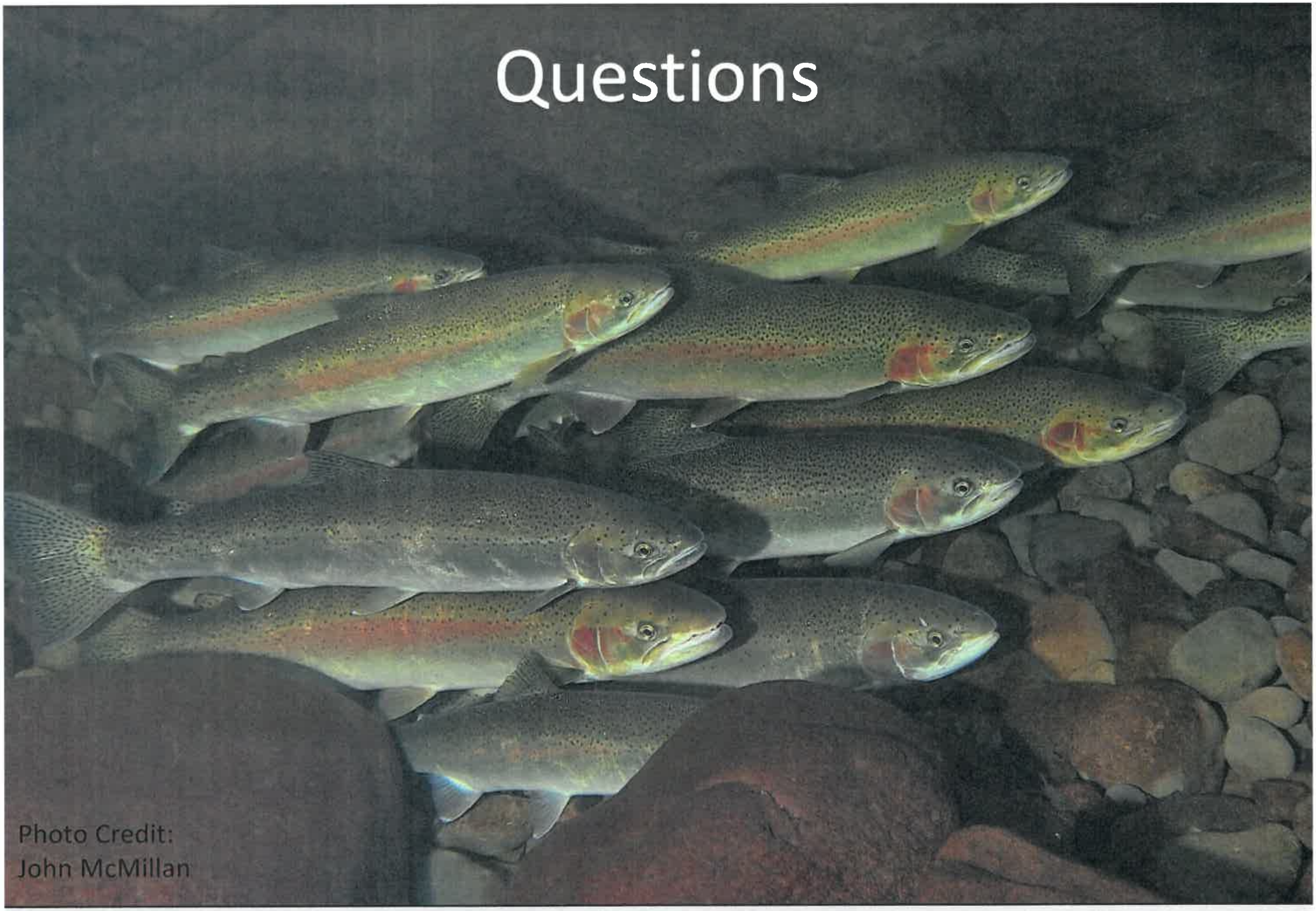


Photo Credit:
John McMillan