Snake River Fall Chinook Population Status Update

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August 2013 LSRCP Review

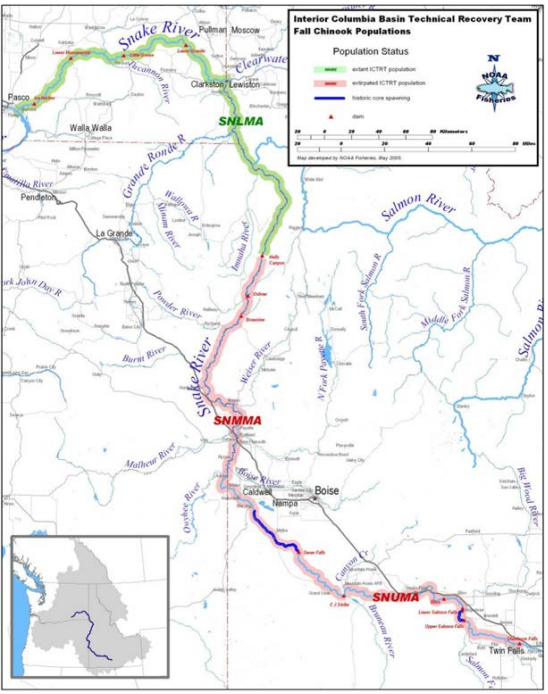
Recovery Objectives

The recovery goal for the Snake River fall Chinook, as for all ESUs/DPSs, is to ensure that the ESU is self-sustaining and no longer needs the protection of the ESA.

Objectives :

- Population level persistence in the face of year-to-year variations in environmental influences
  - Combination of abundance and productivity sufficient to sustain a population, demonstrating demographic resilience and maintaining genetic, life history and spatial diversity.
- Resilience to the potential impact of catastrophic events
  - Populations and spawning aggregations distributed in a manner that insulates against loss from a local catastrophic event and provides for recolonization…
- Maintaining long-term evolutionary potential
  - Sustaining natural production across a range of conditions, allowing for adaptation to changing environmental conditions

Derived from ICTRT Viability Rept 2007



SNAKE RIVER FALL CHINOOK
Major Spawning Areas

20 0 20 40 60 Kilometers
20 0 20 40 60 Miles

Map developed by NOAA Fisheries, May 2006.

Palouse Falls
Palouse R
Endicott
La Crosse
Colfax
Palouse
Potlatch
Bovill
Deary
Elk River
Hatton
Washtucna
Albion
Pullman
Moscow
Snake River
Troy
Connell
Kahlotus
Kendrick
Juliaetta
Colton
Genesee
Mesa
Lower Granite
Little Goose
Lower Monumental
Starbuck
Uniontown
Pomeroy
Tucannon River
Clearwater River
Orofino
Peck
Lapwai
Clarkston
Lewiston
Culdesac
Weipp
Asotin
Reubens
Pasco
Prescott
Dayton
Touchet River
Waitsburg
Winchester
Craigmont
Nezperce
Kamiah
Ice Harbor
Burbank
Finley
SNLMA-f
Ferdinand
Kooskia
Walla Walla R
Walla Walla
College Place
Cottonwood
Stites
Grande Ronde R
Milton-Freewater
Grangeville
Helix
Athena
Weston
Adams
Umatilla River
White Bird
Salmon River
Enterprise
Riggins
Imnaha River
Hells Canyon
Oxbow
SNMMA-f
Halfway
New Meadows
McCall

Current Fall Chinook Spawning
Historic ICTRT population
Current ICTRT population
Major Spawning Area (MaSA)
MaSA - mainstem Snake River
MaSA - independent tributary
MaSA - dependent tributary
Major Dam

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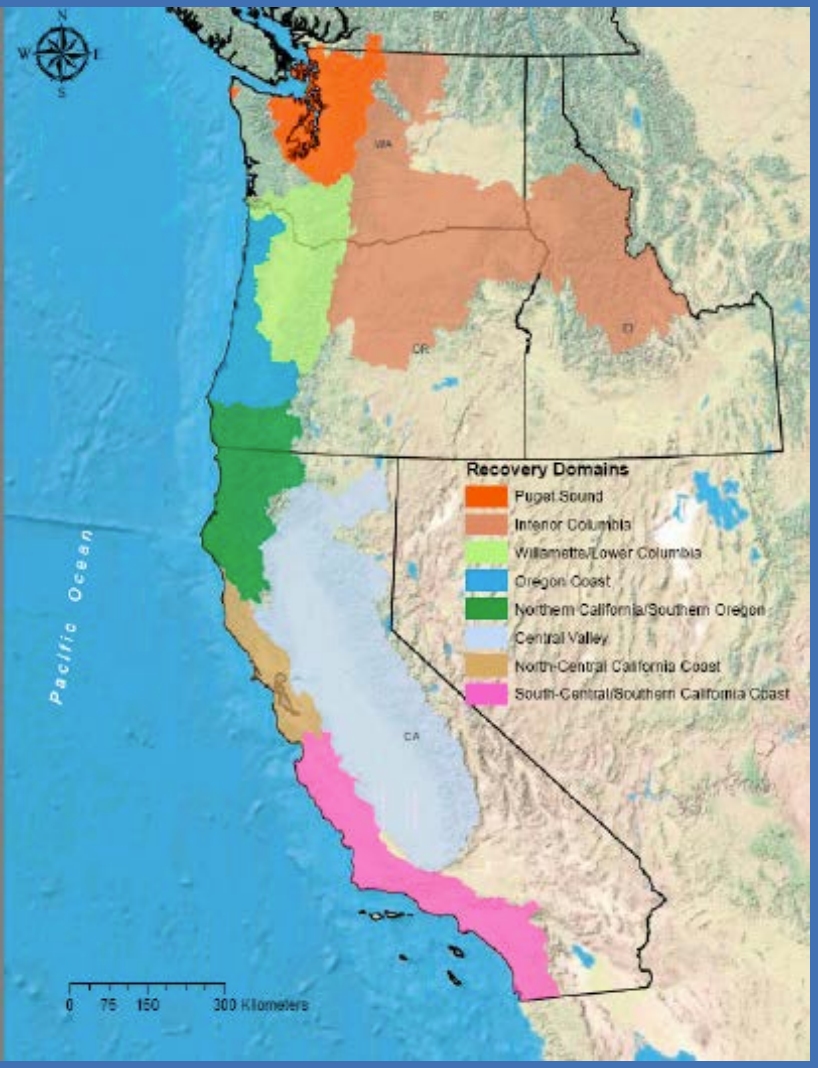
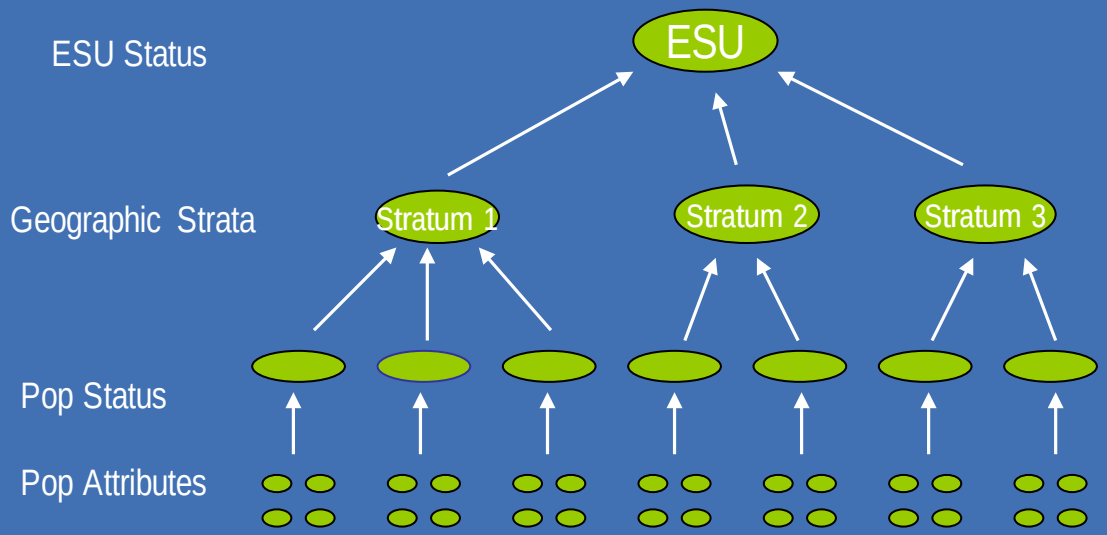
Viability Assessments





<u>Population status</u>:

- Abundance (e.g., natural-origin spawning)
- Productivity (trend, recruits/spawner, modeled)
- Spatial structure (distribution, habitat)
- Diversity (life-history, hatchery/wild)

Evaluating Natural Sustainability

- Key ESA Question: Would the population meet abundance & productivity requirements for highly viable in the absence of hatchery supplementation?

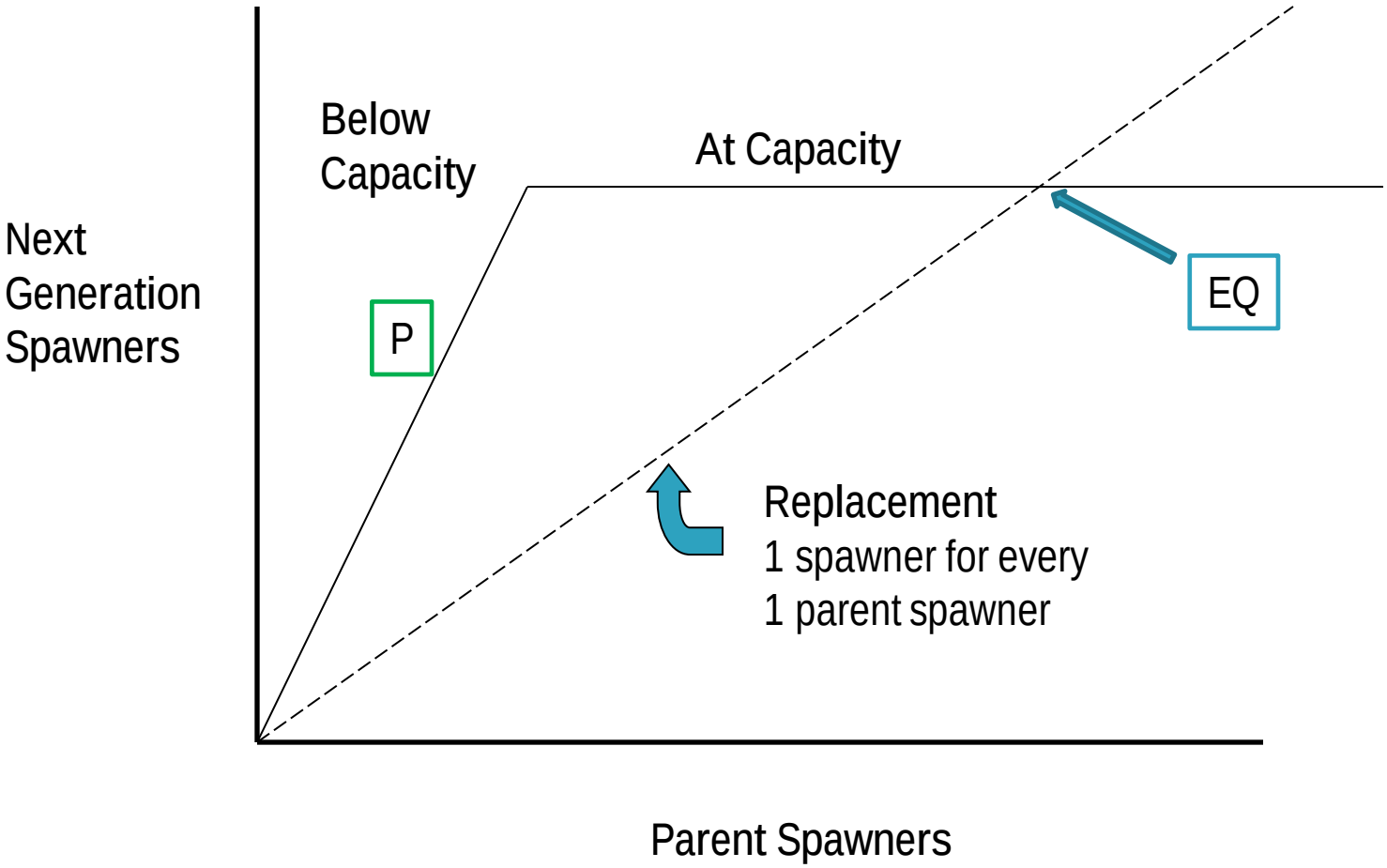
  - Assumptions:
    - current demographic parameters (estimates of productivity and equilibrium abundance)
    - future environmental patterns are similar to the recent past

- Projected performance substantially affected by assumptions about:
  - the shape of the density dependent juvenile production relationship.
  - relative effectiveness of hatchery spawners

Abundance/Productivity Criteria

- Abundance refers to the average number of spawners in a population over a generation or more.
- Productivity (or population growth rate) refers to the performance of the population over time.
- Abundance should be high enough that:
  - In combination with intrinsic productivity, declines to critically low levels would be unlikely assuming recent patterns of environmental variability
  - Risks from inbreeding depression and other genetic and demographic bottlenecks are minimized.
  - Compensatory processes provide resilience to the effects of short-term perturbations
  - Within population substructure is maintained (e.g., multiple spawning patches, etc)

Viability Curve: Basic Principles
Intrinsic Productivity



Excerpt from
ICTRT Viability Criteria
document (2007)
P 44

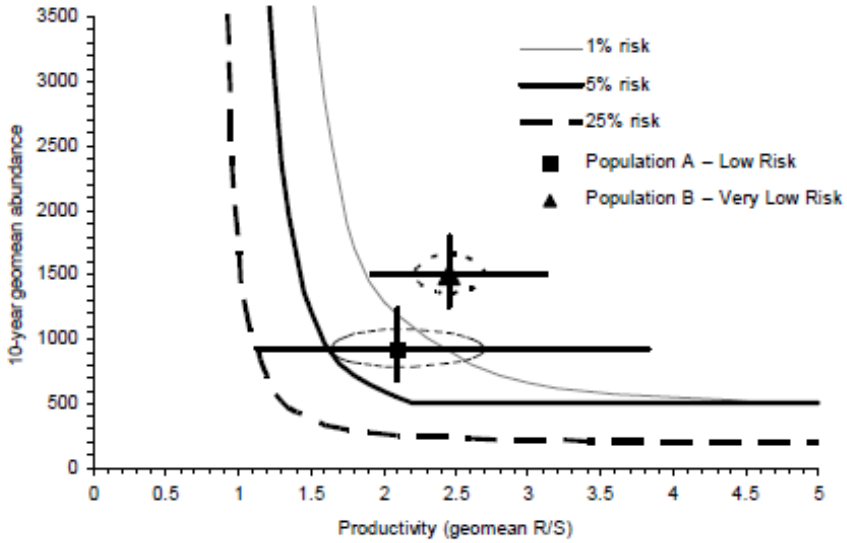


Figure 7. Evaluating the abundance and productivity of a population relative to the Viability Curve. Triangle and box symbols are point estimates of abundance and productivity for example populations. Ovals represent 1 standard error about mean values. Straight lines indicate 95% confidence limits on estimated abundance and productivity. Population A would be rated at Low Risk with respect to abundance/productivity, while Population B would get a Very Low Risk rating.

In general, all the analyzed options for treating uncertainty would result in a higher overall target (increasing the certainty that the population would "truly" be at or above the viability curve). Populations with higher variability require the greatest increases in the target, regardless of the option chosen. For a given variability level, the simple probabilistic buffer typically requires the greatest increase in the target, although there is some interaction with the level of variability of the population. Unlike the lower and moderately variable populations, a highly variable population would require a greater target to meet a stringent dual comparison than a simple probabilistic buffer. The following example illustrates the potential effect of using the

http://www.nwfsc.noaa.gov/trt/trt_documents/ictrt_viability_criteria_reviewdraft_2007_body.pdf

Spatial Structure and Diversity

- Goal A: Allow natural rates and levels of spatially mediated processes
  - 1) Number and distribution of spawning areas
  - 2) Spatial extent and range relative to historical
  - 3) Changes in gaps between spawning areas

- Goal B: Maintain Natural Levels of Variation
  - 1) Changes and loss of major life history strategies
  - 2) Variation and loss of phenotypic traits (e.g., run timing)
  - 3) Genetic variation
  - *4) Spawner composition (hatchery proportion and origin)*
  - *5) Changes in use of major habitat types (ecoregions)*
  - *6) Selective mortality factors (across the four H's)*

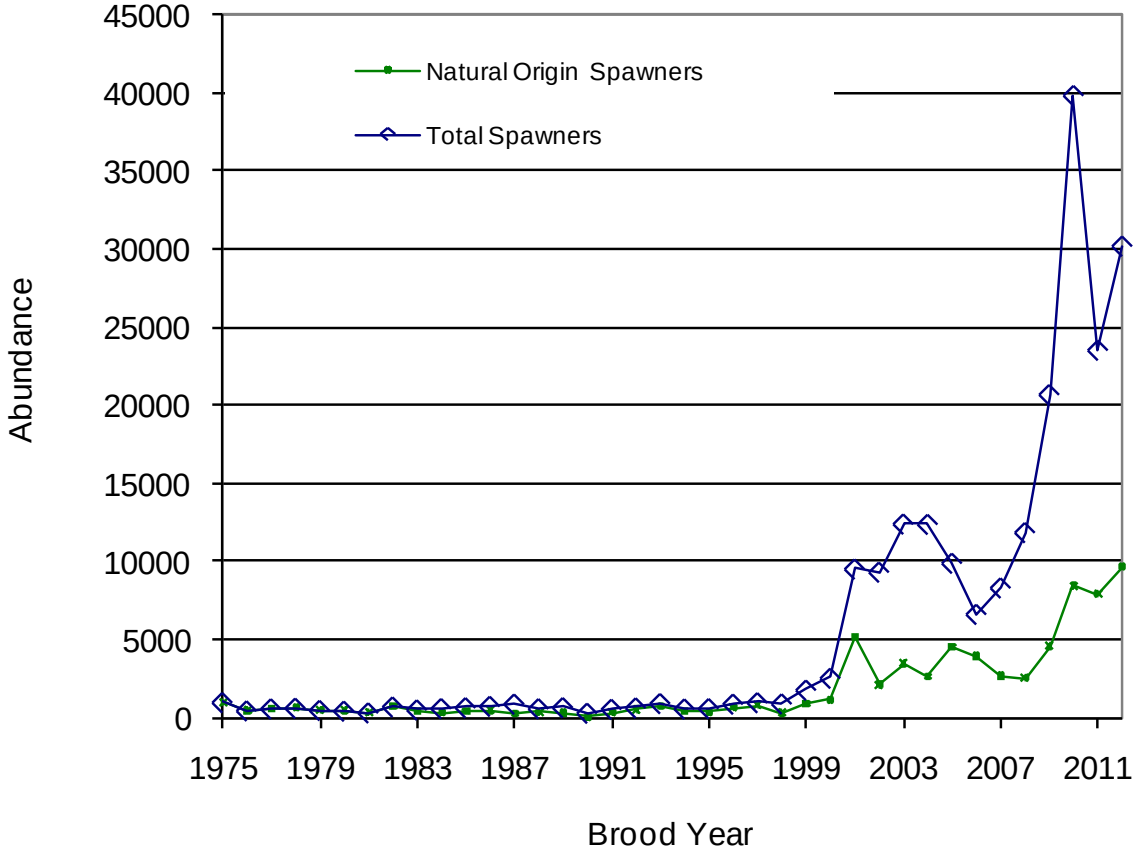
- Snake Fall Chinook
- Recent Trends: Total and natural origin spawner estimates substantially higher than earlier reviews.
  - High proportion of hatchery origin spawners (average of 78%)
  - 2002-2007 natural origin returns appear to be leveling off at or just below TRT minimum abundance threshold (10 yr geometric mean of 3,000)
- More recent returns: 2009 and 2010 above the range reported in status review. Hatchery proportions remain high.

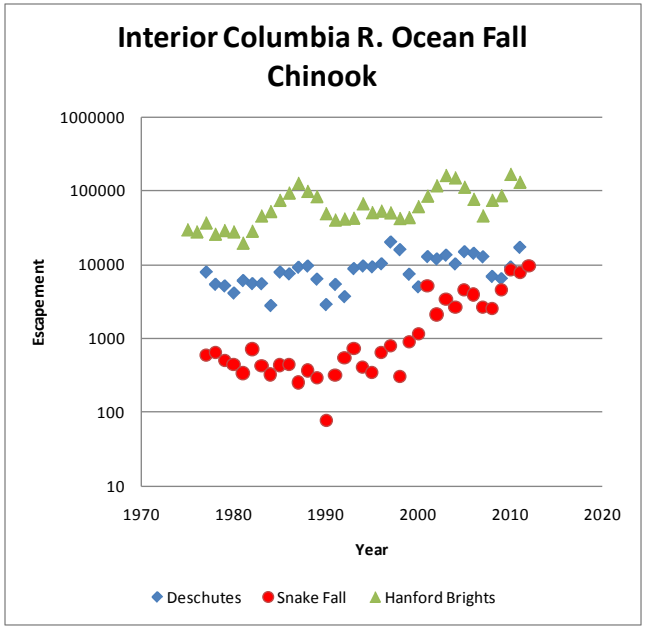
- Viability Status
- Overall rating remains at moderate risk.
  - 10 yr geometric mean natural origin abundance below threshold, uncertainty about productivity at low to moderate escapement levels, long term risk to genetic and life history diversity resulting from very high hatchery fractions.
- ICTRT recommendation is to target as highly viable given limited number of historical populations, loss of upper populations

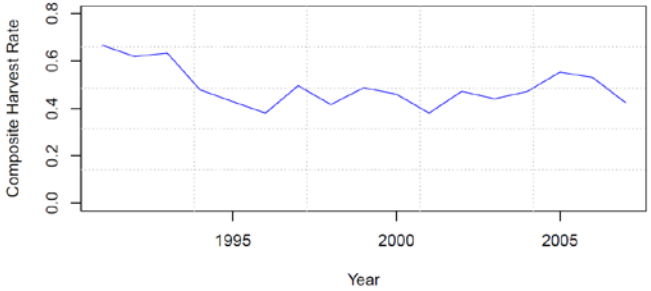
- Anticipated Information Improvements
- Continued application of 2009 improved run reconstruction methods (including redoing 2006-2008)
- Preliminary results from PBT studies

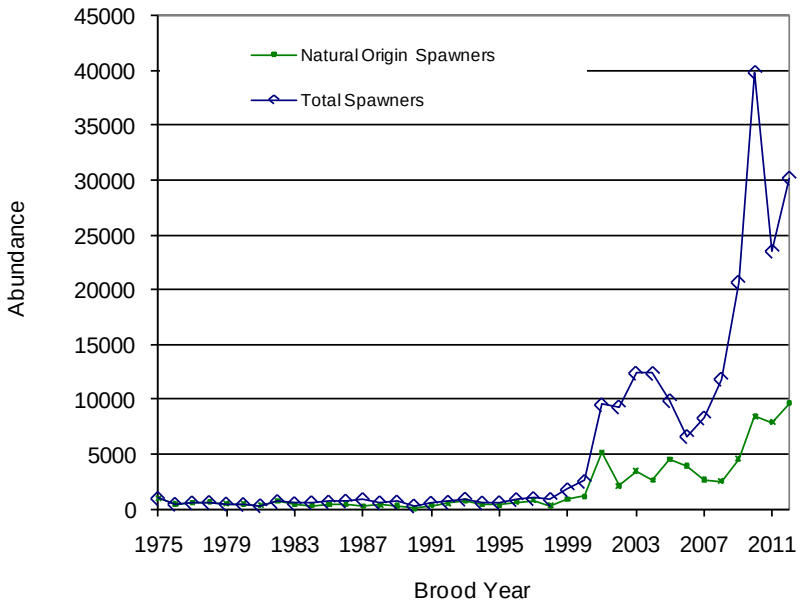
NWFSC Five Year Status Review (Ford et al. 2011)

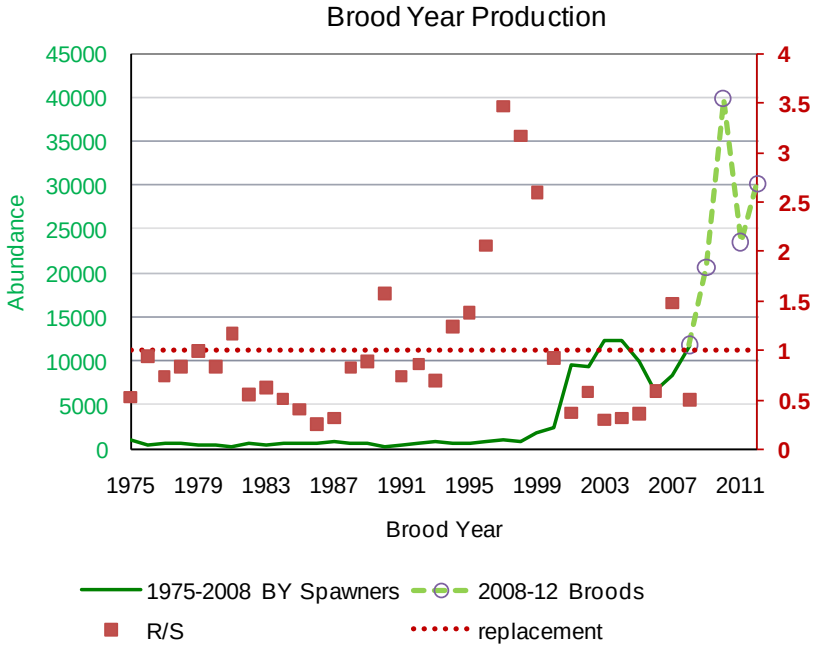
Returns over Lower Granite Dam

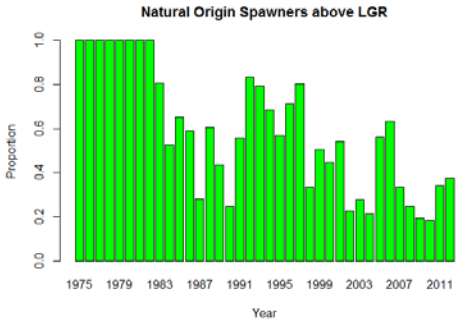


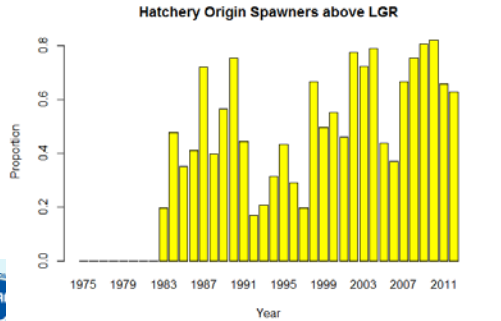








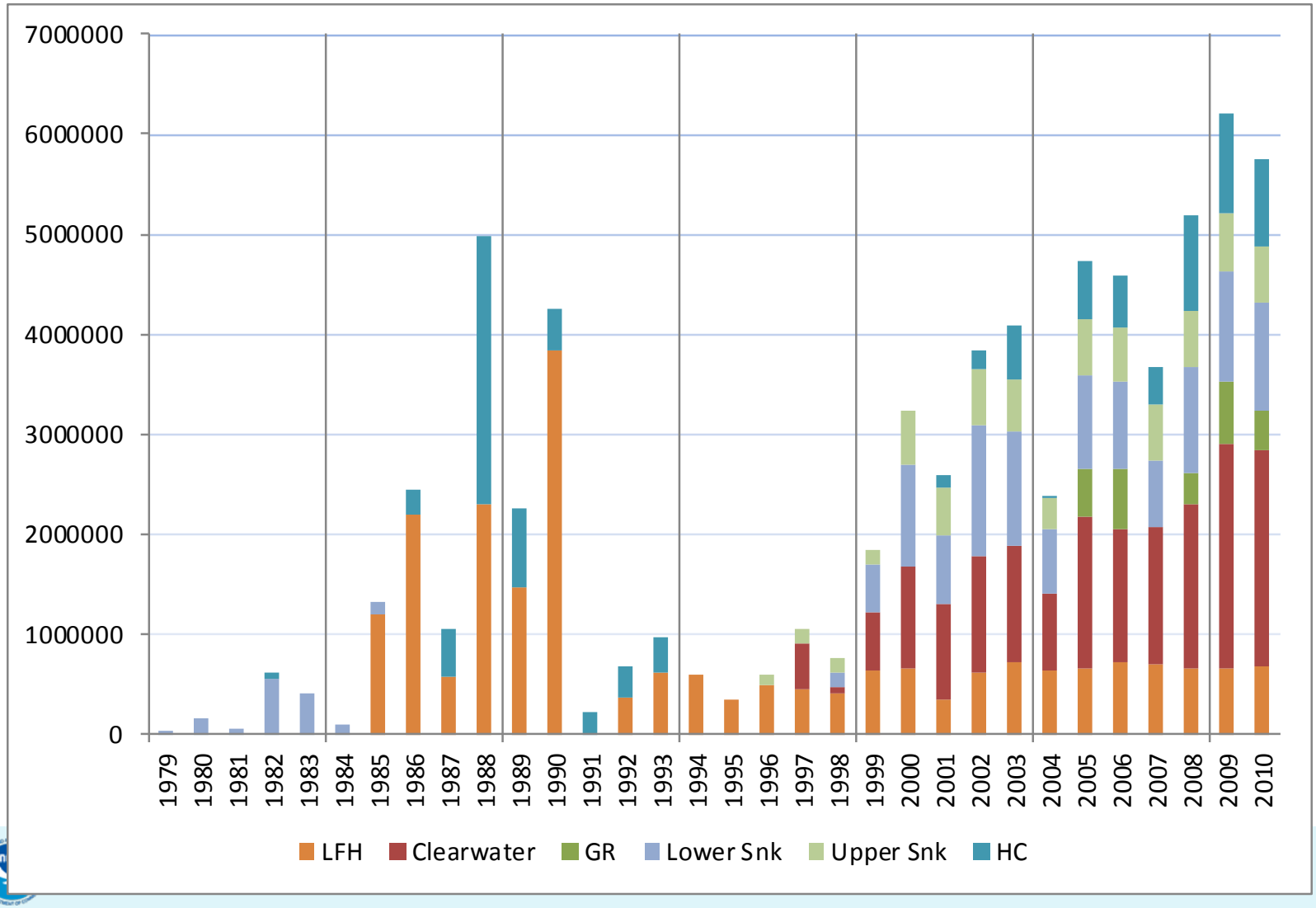




- Interior Columbia fall chinook stocks showed increases from 1990, higher increase for Snake R. (~5X vs. ~2X)
- Natural abundance increased with parent spawners augmented with hatchery returns in late 1990's
- Return per spawner generally below replacement in recent (high escapement) years.
- 1990-2005: substantial changes implemented in hydrosystem operations/transportation to benefit fall chinook.
  - Collection/trasport increased in the mid 1990s
  - Spill through June 20th beginning in 1994
  - Summer spill beginning in 2005 (2004 subyr brood)
  - RSWs installed 2003-2009

Added slide since Boise

Snake River Fall Chinook Hatchery Releases (by location)

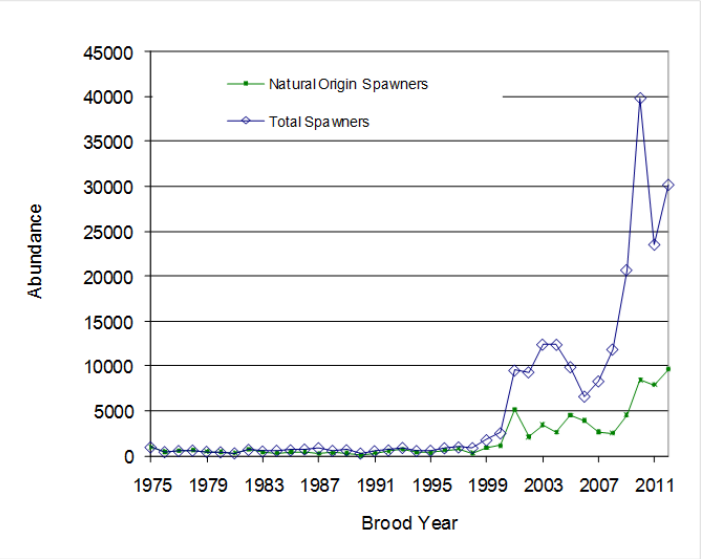


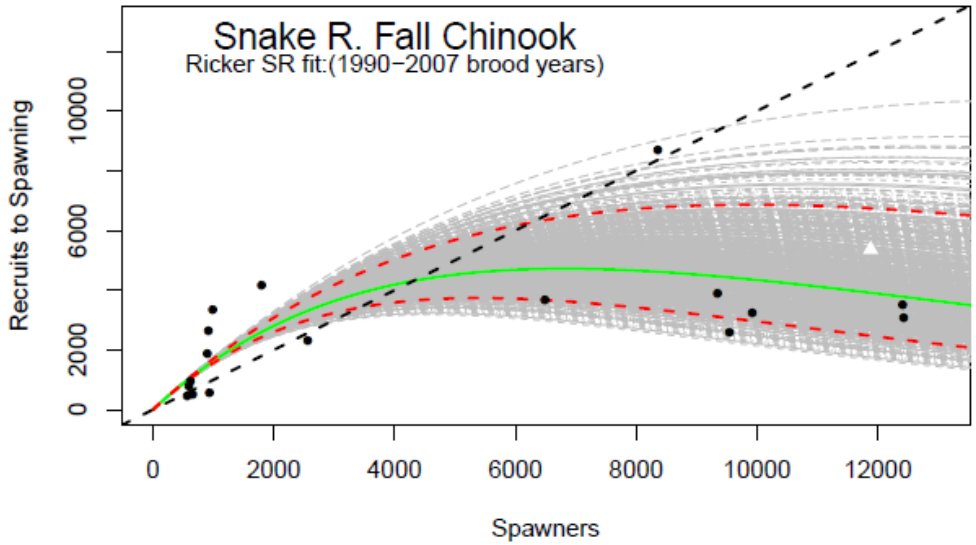
‘Simple’ Adult to Adult SR Models

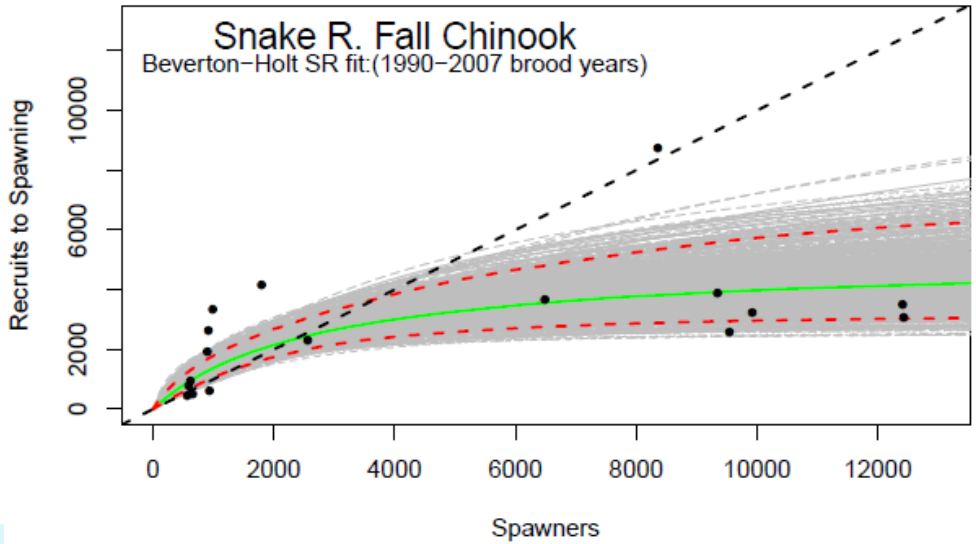
Beverton/Holt (BH) $R = A*S/(1+A/b*S)$

Ricker (RK) $R=A*S*\exp(-b*S)$

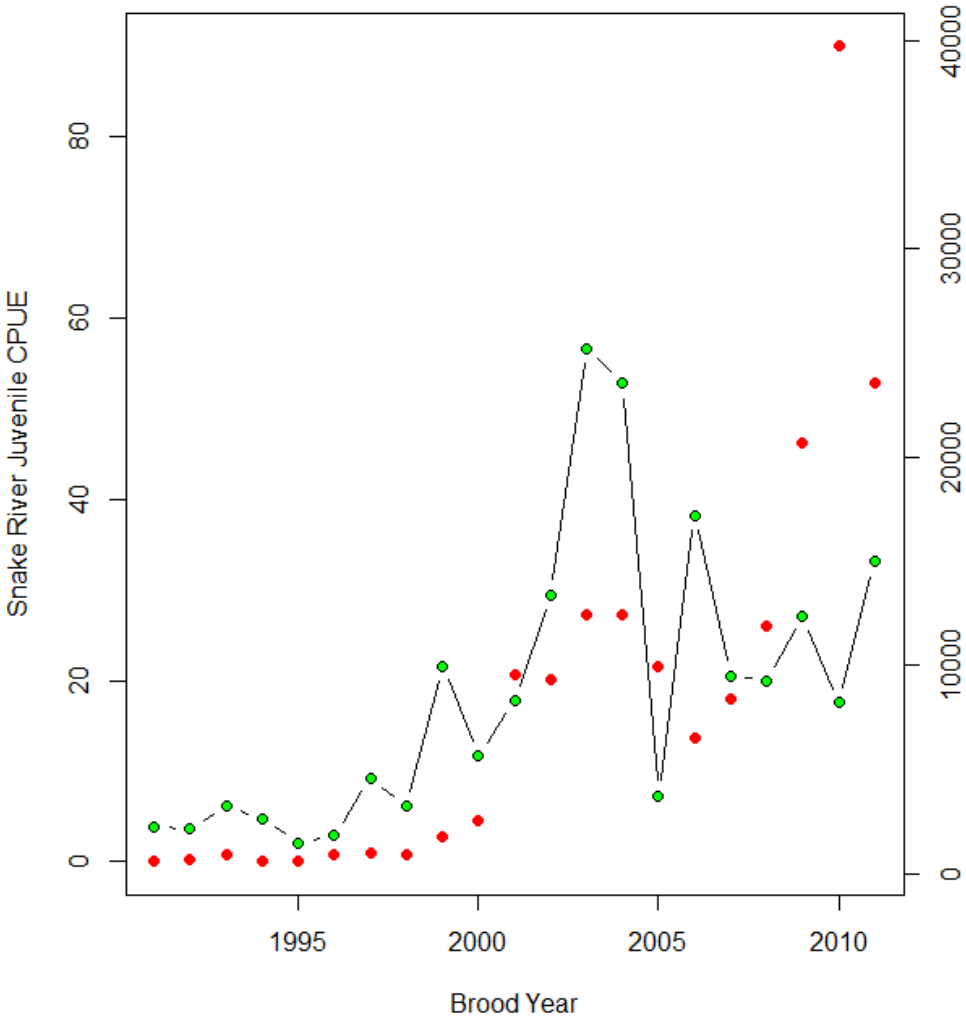
(fitted assuming lognormal error structure)
Adults (fish >57 cm) only in this analysis

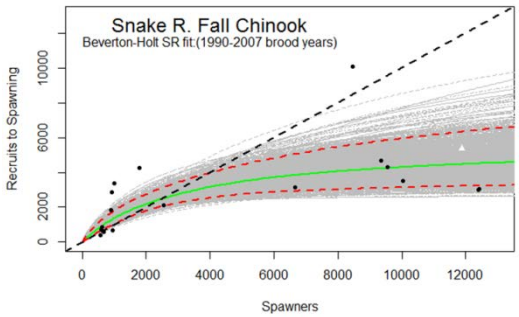

Natural Origin Spawners
Total Spawners
Abundance
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
Brood Year

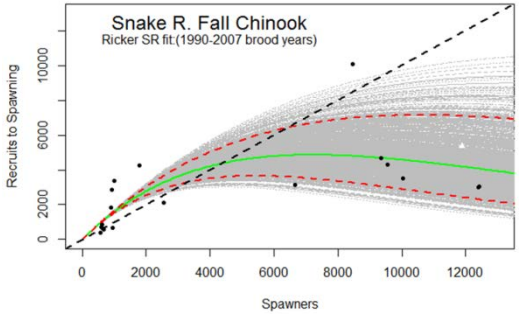

Snake R. Fall Chinook
Ricker SR fit:(1990−2007 brood years)
Recruits to Spawning
0
2000
6000
10000
0
2000
4000
6000
8000
10000
12000
Spawners


Snake R. Fall Chinook
Beverton−Holt SR fit:(1990−2007 brood years)
Recruits to Spawning
0
2000
6000
10000
0
2000
4000
6000
8000
10000
12000
Spawners

Juvenile production index contrasted to parent spawners







Snake River juvenile fall chinook CPUE vs. year (green circles)

data from W. Connor, July 2013

Parent Spawners (red pts)

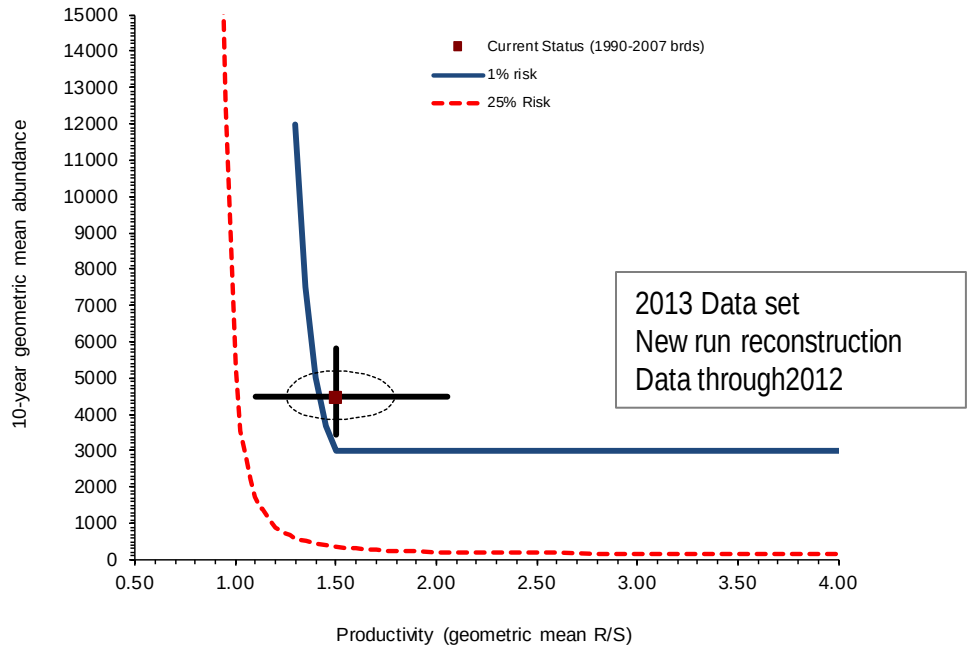
Updated run reconstruction July 2013

Snake Fall Chinook: Natural Production

- Annual abundance of naturally produced Snake Fall Chinook has increased substantially since the early 1990s.
- Possible contributing factors:
  - *Major changes in transportation and collection* (early 1990s) and in-river operations - e.g. screening and spill) (late 90s early 2000s)
  - Run of *relatively high ocean survivals since early 1990s*
  - *Improved flow and temperature regimes during spawning and rearing* for mainstem Snake River production areas
  - *Augmented production* resulting from large increase in hatchery origin spawners starting with the 1999-2004 brood cycle.
  - *Reduced average annual harvest rates*, sliding scale management

- Patterns in brood year production from parent escapements exceeding 5000-10,000 indicate strong density dependent effects.
  - Pattern apparent in adult brood year returns, juvenile indices.
  - Key uncertainty: the shape of the function at high escapements (e.g., low marginal rate of production vs decline).

- Majority of natural spawners in recent years likely had at least one hatchery origin parent from a common broodstock – substantial potential for 'disconnect' from natural selection



Most matings consist of two natural-origin parents (NxN) until pHOS rises above 0.29.

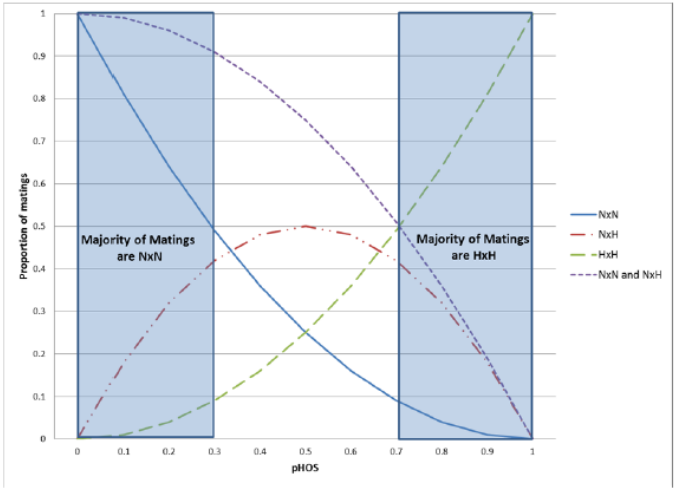
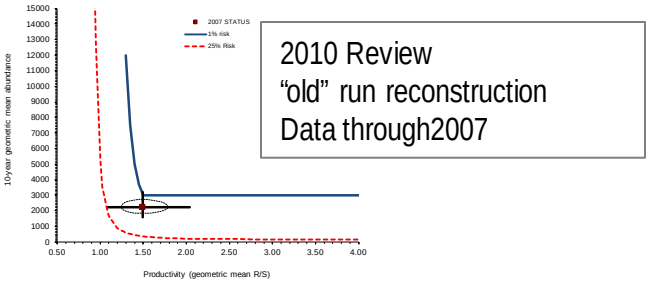


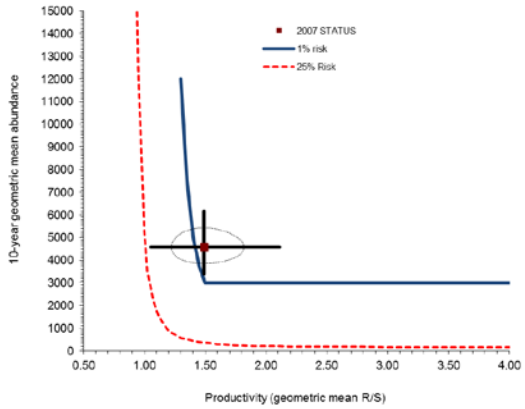
Figure 10. Expected proportion of mating types by fish origin as a function of pHOS

At a pHOS level of 0.71, most matings are HxH, with the proportion of NxN matings being 0.09.



Population Risk Rating

- ICTRT Population Risk Categories
  - Highly Viable
  - Viable
  - Maintained
  - High Risk



A&P RISK

SS/D RISK

	VL	L	M	H
VL	HV	HV	V	M*
L?	V	V	V *	M*
M?	M*	M*	M*	
H				

- Populations assigned to a category based on combined evaluation of A/P and SS/D, with consideration for uncertainty.

Hatchery programs in recovery

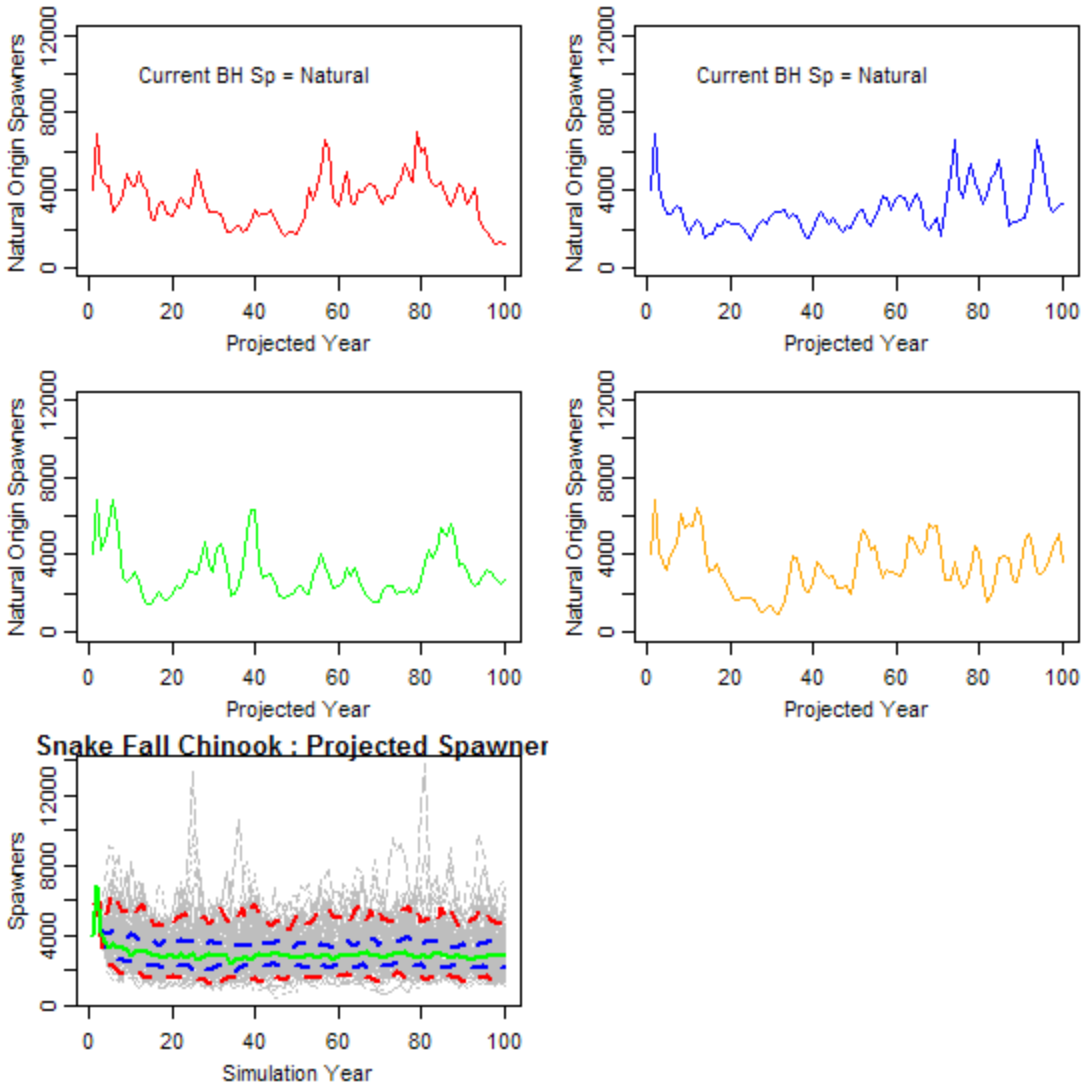
- Hatchery programs can serve an important conservation role when short term demographic risks of extinction are likely to exceed genetic and ecological risks to natural fish arising from supplementation.
- Key question for supplementation programs: At what point do genetic and ecological risks outweigh demographic benefits and hatchery supplementation should be scaled back?

NOAA Snake Fall Chinook Hatchery BiOP

- Demographic risk
- Outbreeding effects: *"..Snake fall Chinook salmon programs are quite risk averse with respect to controlling inflow of non-native genetic material".*
  - Strict controls on broodstock used in the program in the 1990s contributed to conserving genetic integrity of the population.
  - Current broodstock protocols strictly limit use of outside origin stock in programs.
- Hatchery Induced selection
  - RIST review: *…. less response in hatchery induced selection may be expected in subyearling programs because of shorter hatchery residence, the difference may not be that great because of factors independent of residence time.*
- Subpopulation structure
  - Current programs largely rely on a composite broodstock collected at Lower Granite Dam.
  - The degree of historical subpopulation genetic structure is uncertain
  - With the exception of the South Fork Clearwater NPT efforts, development or maintainance of subpopulation structure is not currently planned.

Example projection model trajectories

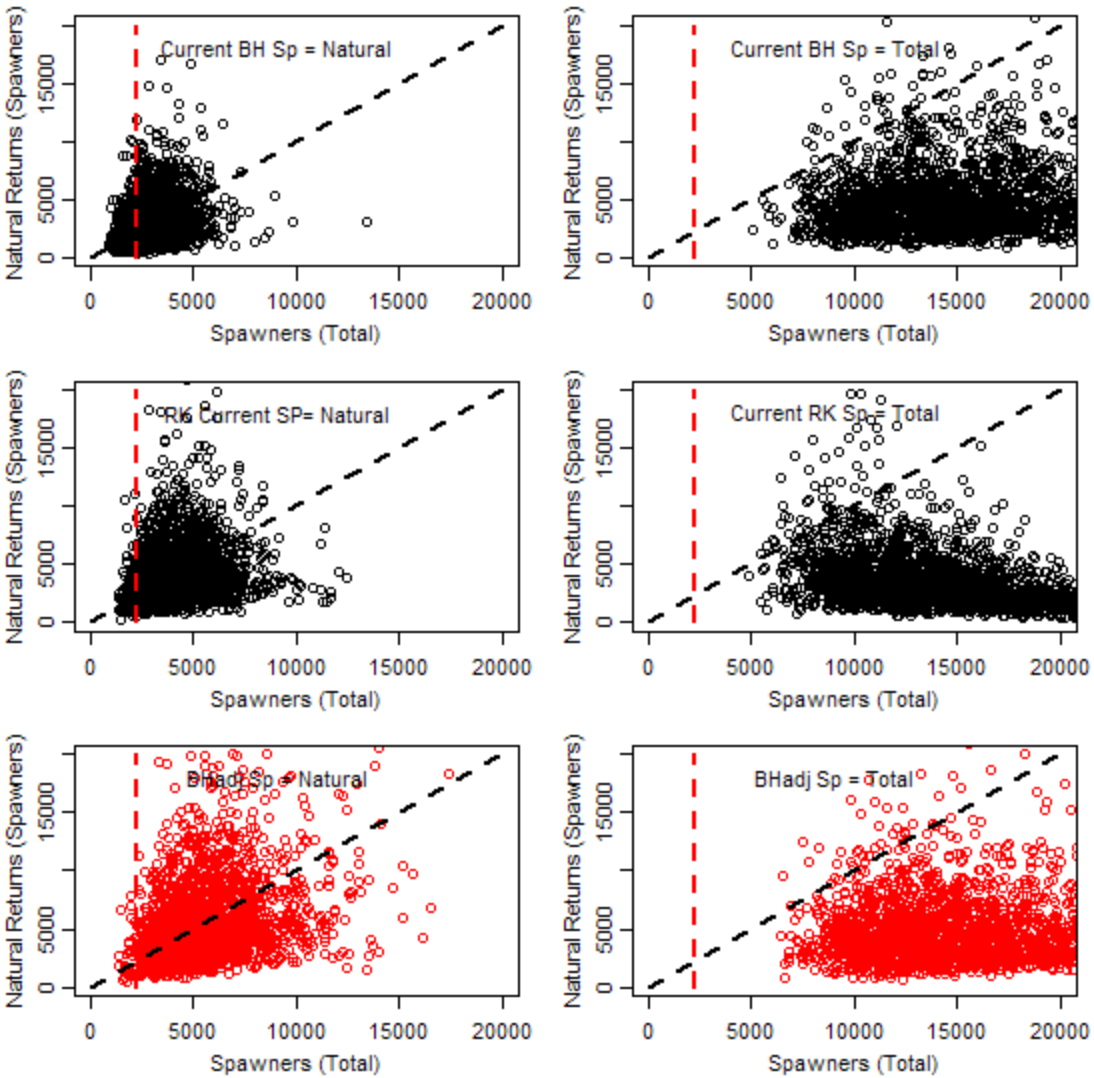
- Model incorporates results from fitted S/R relationship (including parameter uncertainty, year to year variability
- This example: BH: hatchery production diverted from natural area
- All other factors assumed as stationary (fluctuate as in base period)
  - Harvest, hydro, climate, etc
- First four panels: individual trajectories
- Last panel: 100 trajectories with statistics



Projected Natural Production Alternative SR models & Strategi

- Projections for BH vs. RK stock recruit models under two hatchery management scenarios.
  - All assume functions derived from 1990-2012 spawner to return data sets.
  - Two hatchery management scenarios:
    - a) Current,
    - b) No hatchery spawners in natural areas

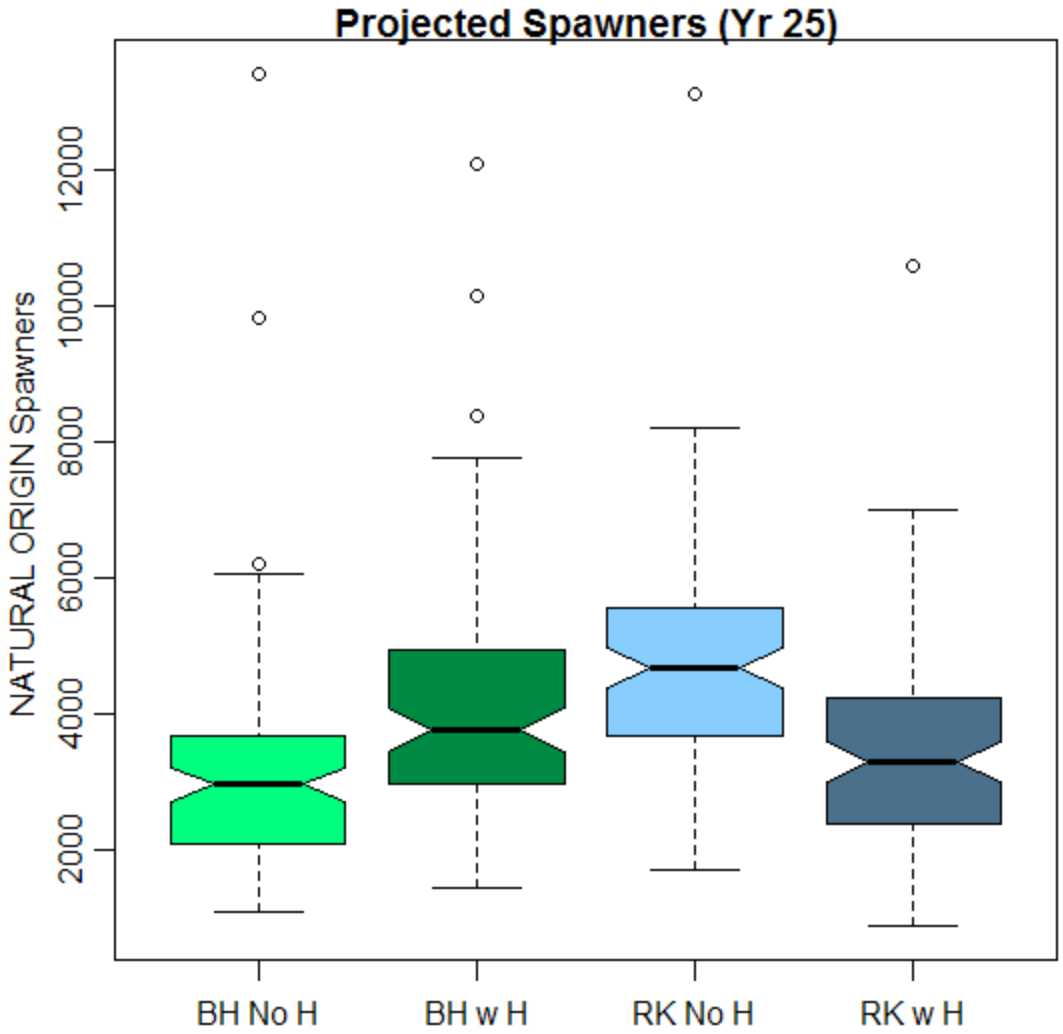
- Black dashed line: 1:1 Replacement
- Red dashed line: 75% of ICTRT minimum abundance threshold
- Sample of 20 years from 10 runs for each scenario, simulates ICTRT recommended minimum samples.



SR model projections (no difference in H vs N productivity)

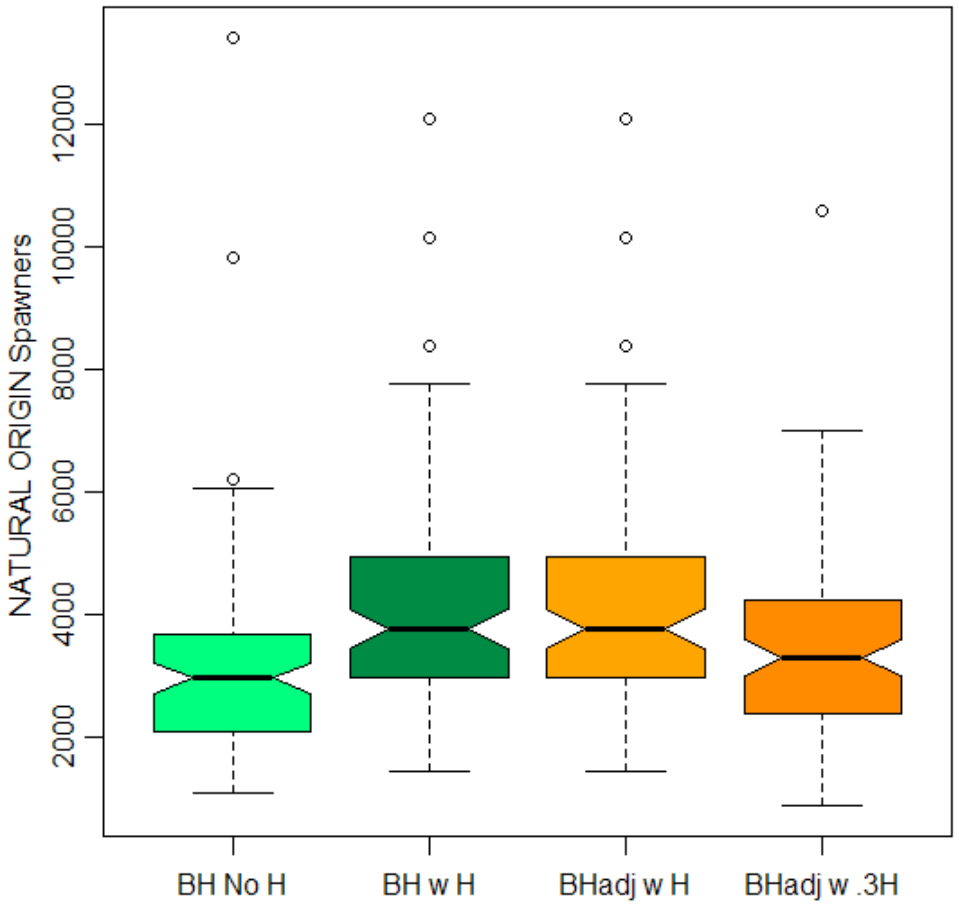
- BH model (green)
- RK model (blue)

- Two scenarios
  - No H: hatchery returns removed or directed from major spawning areas
  - H: hatchery program at current levels, returns onto spawning grounds
- Patterns
  - Differences in natural production returns with and without hatchery inputs for different SR function (form of density dependence at HIGH spawner levels)
  - Average natural returns projected to DECREASE from status quo iif BH and hatchery returns diverted, INCREASE if RK and hatchery returns diverted.



SR model projections (H effective capacity 40%)

- BH model (green)
- BH model w Hcap factor (Orange
- Two scenarios
  - No H: hatchery returns removed or directed from major spawning areas
  - H: hatchery program at current levels, returns onto spawning grounds
- Patterns
  - If hatchery proportions are translating into reduced effective capacity, partially compensates for reduction in total spawners



Summary

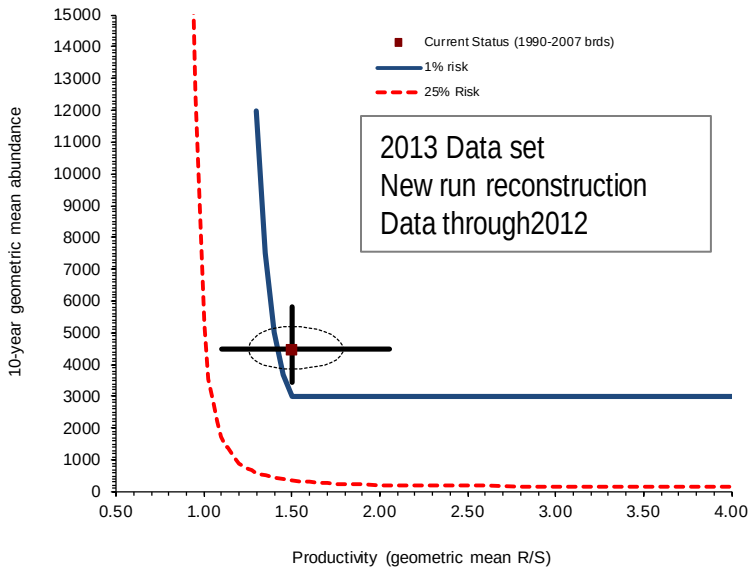
- Would the population sustain itself at or above minimum abundance threshold in the absence of supplementation?
    - Promising changes since the 1990s
    - High level of uncertainty regarding sustainability
        - Multiple contributing factors to recent increase, uncertainty in current natural productivity
        - Uncertainty about maintaining adaptations to natural environments
    - Ongoing monitoring and evaluation efforts coupled with more detailed life cycle models should provide improved insights

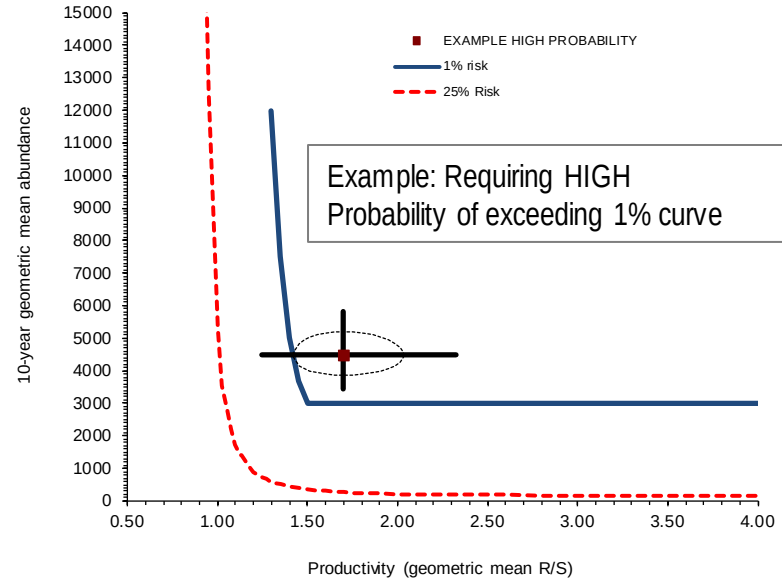
Next Steps

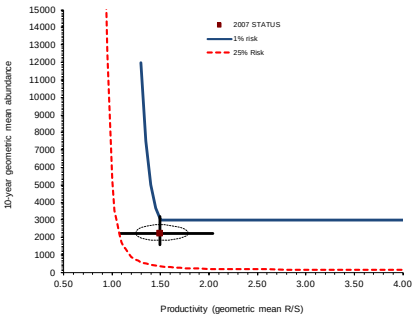
- Update population projection assessments based on a multiple stage model
  - Incorporate stage specific survival, dispersal and density dependent relationships based on results from ongoing studies.
  - Include partitioning into two or more spawning/initial rearing areas based on observed variation in stage specific dynamics.
- Incorporate analyses of status relative to recovery criteria into future NOAA five year status reviews.

Questions?

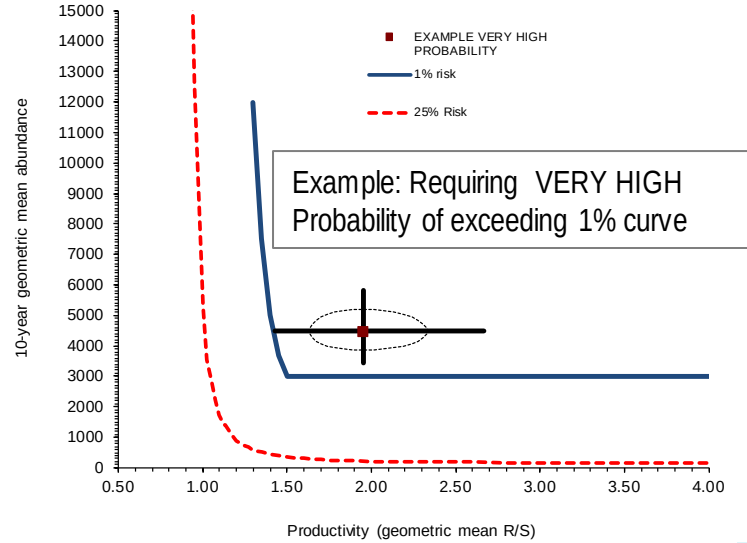
Extra slides for possible questions







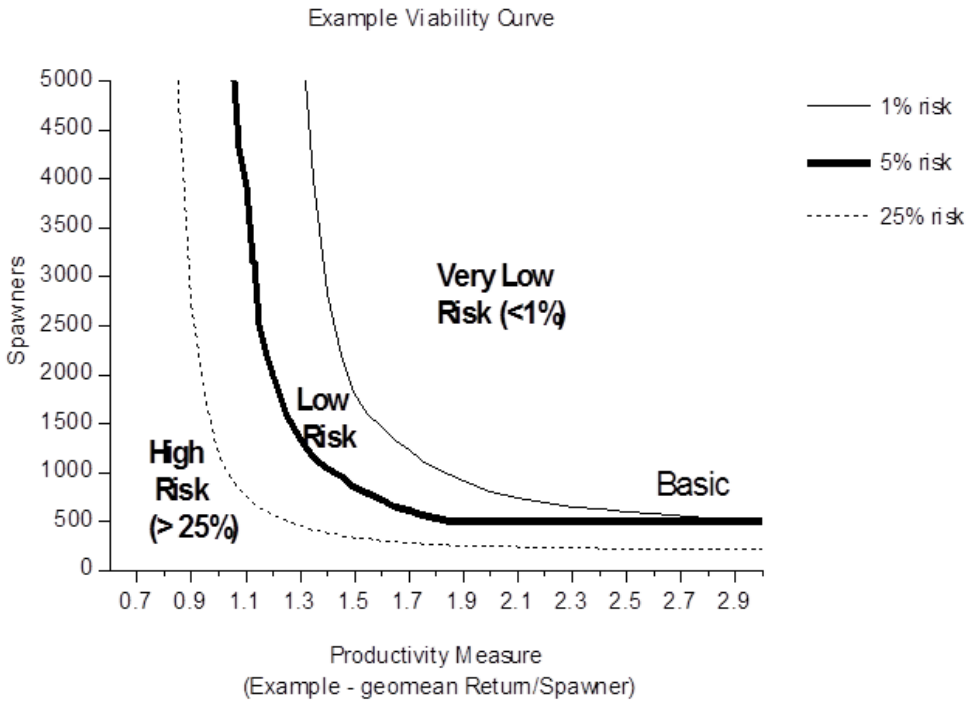
2010 Review
"old" run reconstruction
Data through2007

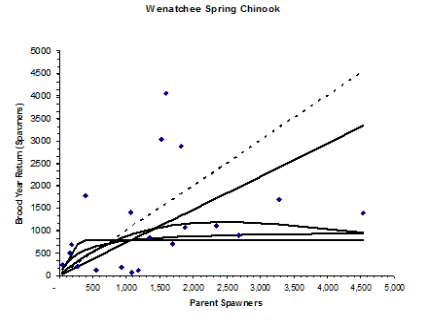


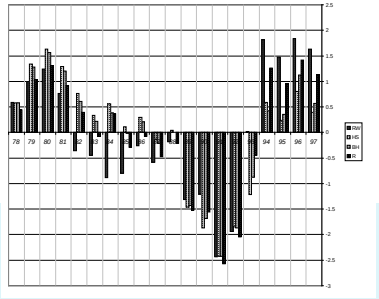
NOAA FISHERIES

ICTRT Viability Curves

- Expressed in terms of a simple hockey stick model (can generate curves for other functions)
- Quasi-extinction risk level of 50 spawners per year for four consecutive years (and a reproductive failure threshold =10)
- Minimum abundance thresholds (function of historical spawning area of each population)
- Modeling includes average age structure, estimated autocorrelation/variance in brood year productivity rates







Run Reconstructions

- Based on counts and sampling at Lower Granite Dam
  - 2005 to 2012 reconstruction methods
    - Dam count adjusted for fallback/reascensions
    - Trapping data used to apportion annual returns
      - by size/age. Hatchery by expansion, natural by subtraction
    - Annual age data derived from trapping results
  - 1990-2004:
    - Dam count of adults/jacks
    - Total return = dam count (jacks and adults)
    - CWT fish trapped and hauled to LFH, trap rate estimated
    - Estimated hatchery returns from expanded tag recoveries
    - Natural returns by subtraction (adults separate from jacks)
    - Age sampling of natural returns at LGR in some later years
      - Average annual age proportions applied to earlier years

Most matings consist of two natural-origin parents (NxN) until pHOS rises above 0.29.

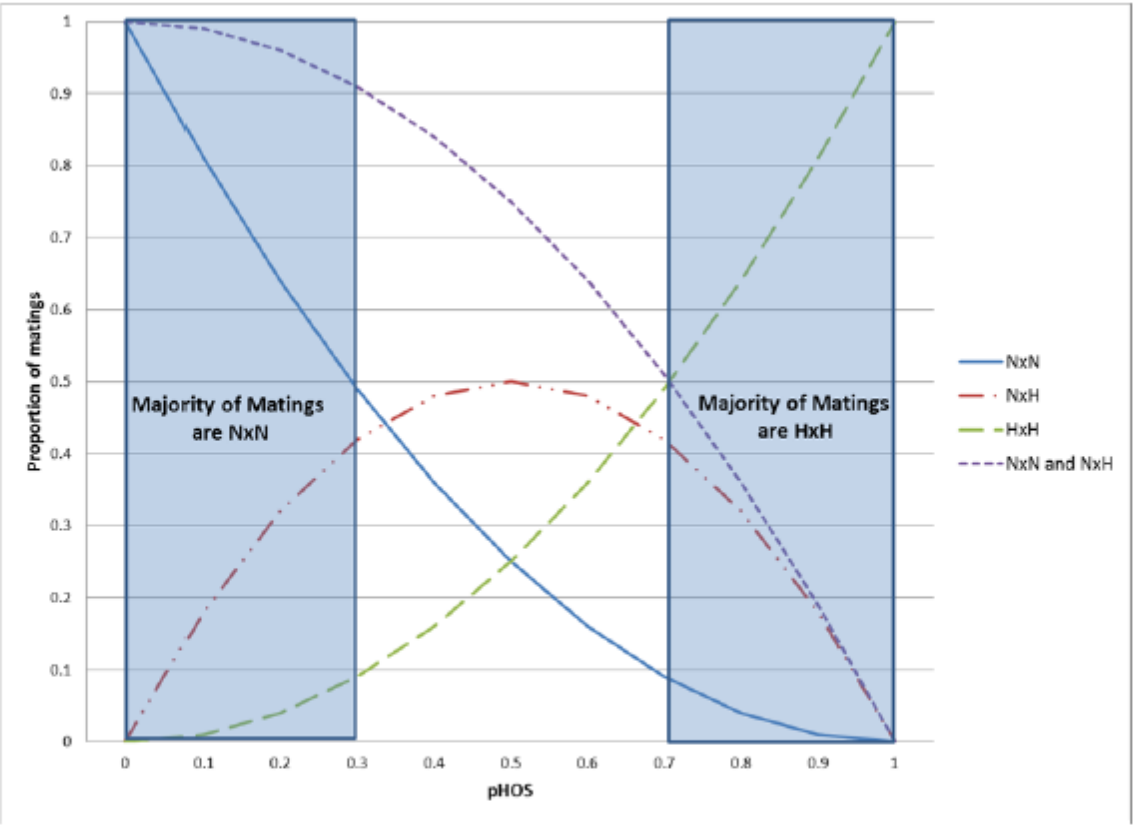
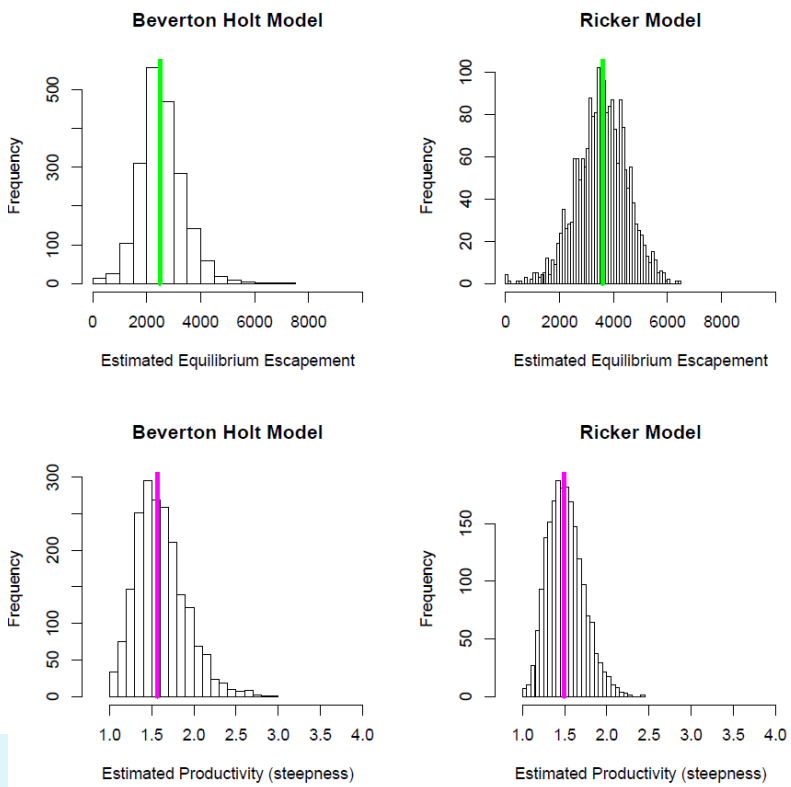


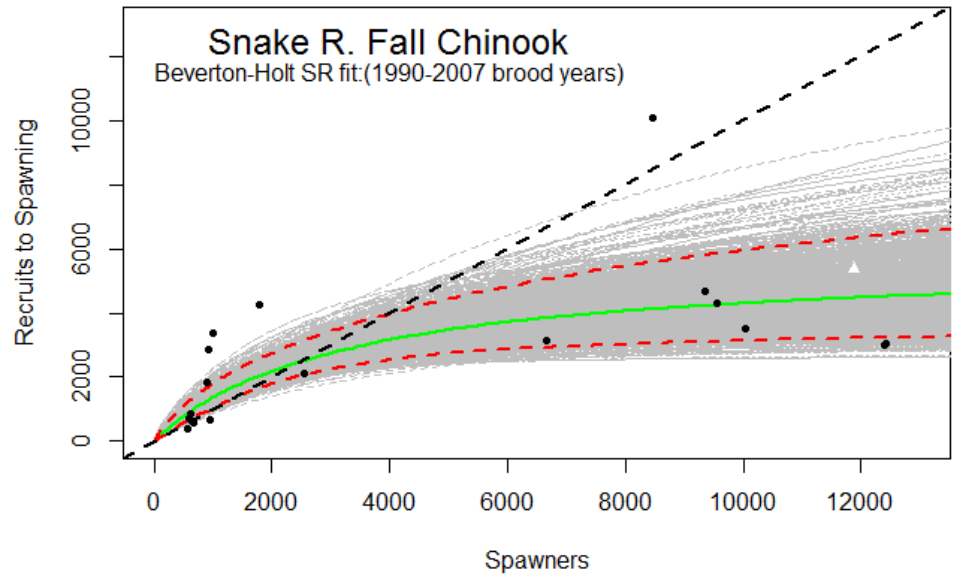
Figure 10. Expected proportion of mating types by fish origin as a function of pHOS

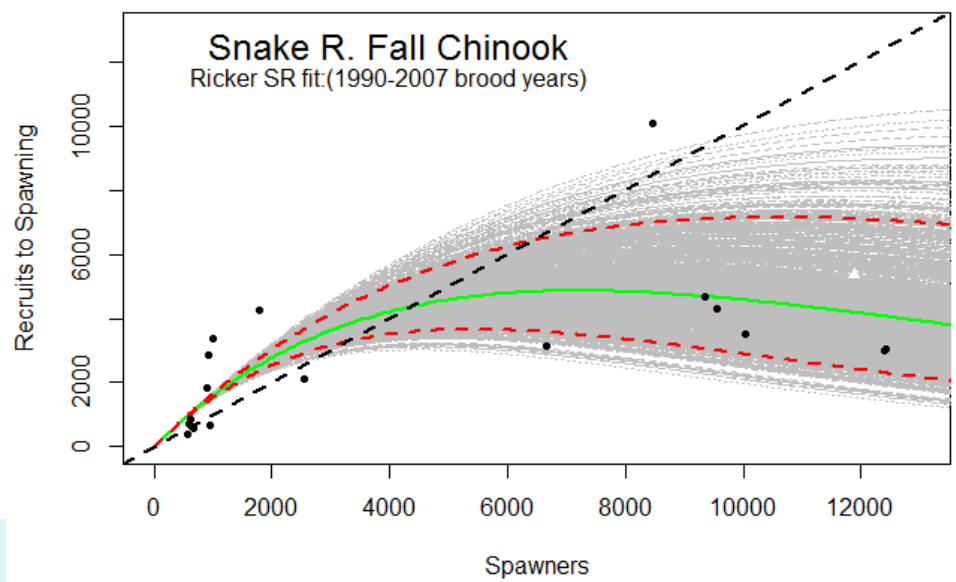
At a pHOS level of 0.71, most matings are HxH, with the proportion of NxN matings being 0.09.

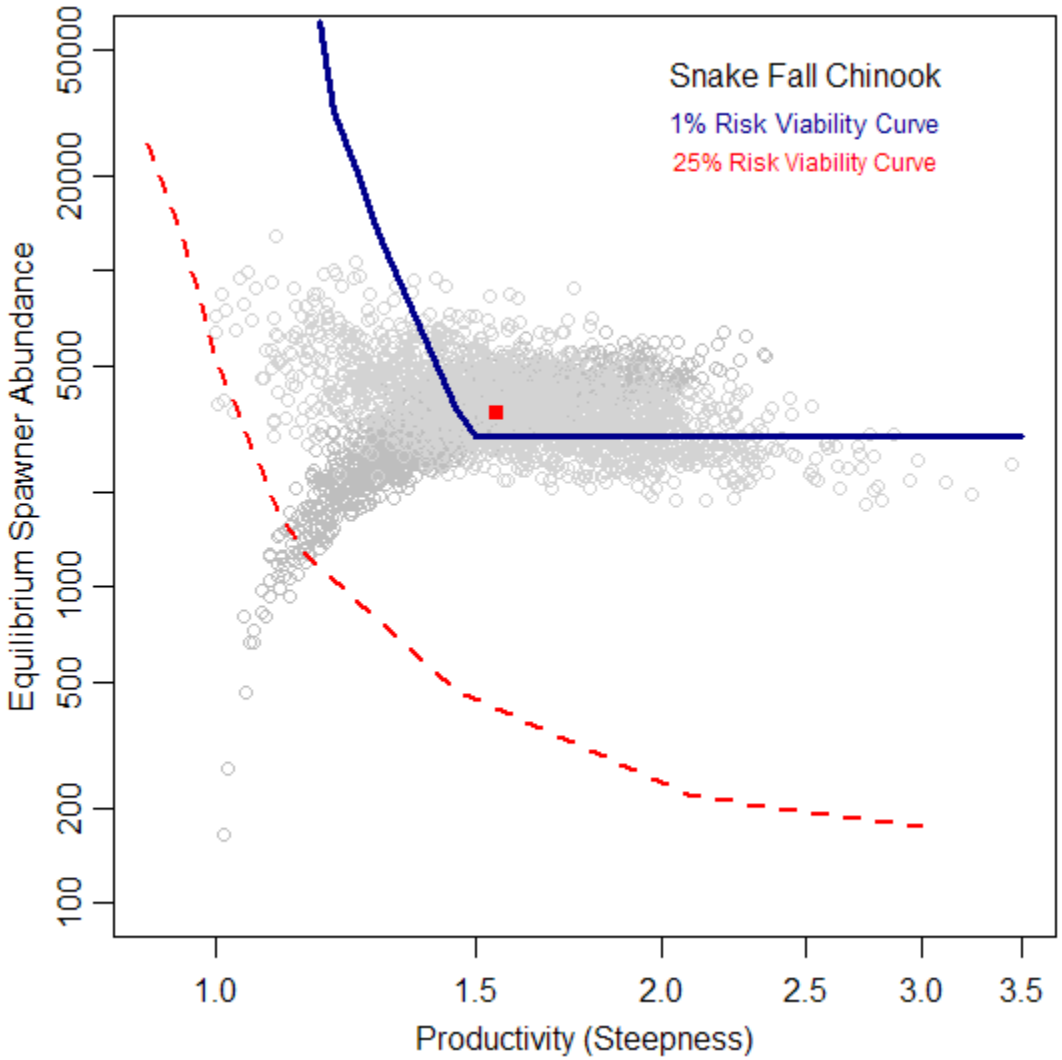
Updated since Boise

Method		Equilibrium Abundance	Productivity (steepness)
ICTRT (Empirical)		4655	1.51
	se	*0.157*	*0.183*
SR fit (BH)		2489	1.57
	se	*0.25*	*0.29*
SR fit (RK)		3589	1.49
	se	*0.2*	*0.19*








Snake Fall Chinook
1% Risk Viability Curve
25% Risk Viability Curve
Equilibrium Spawner Abundance
50000
20000
5000
1000
500
200
100
1.0
1.5
2.0
2.5
3.0
3.5
Productivity (Steepness)

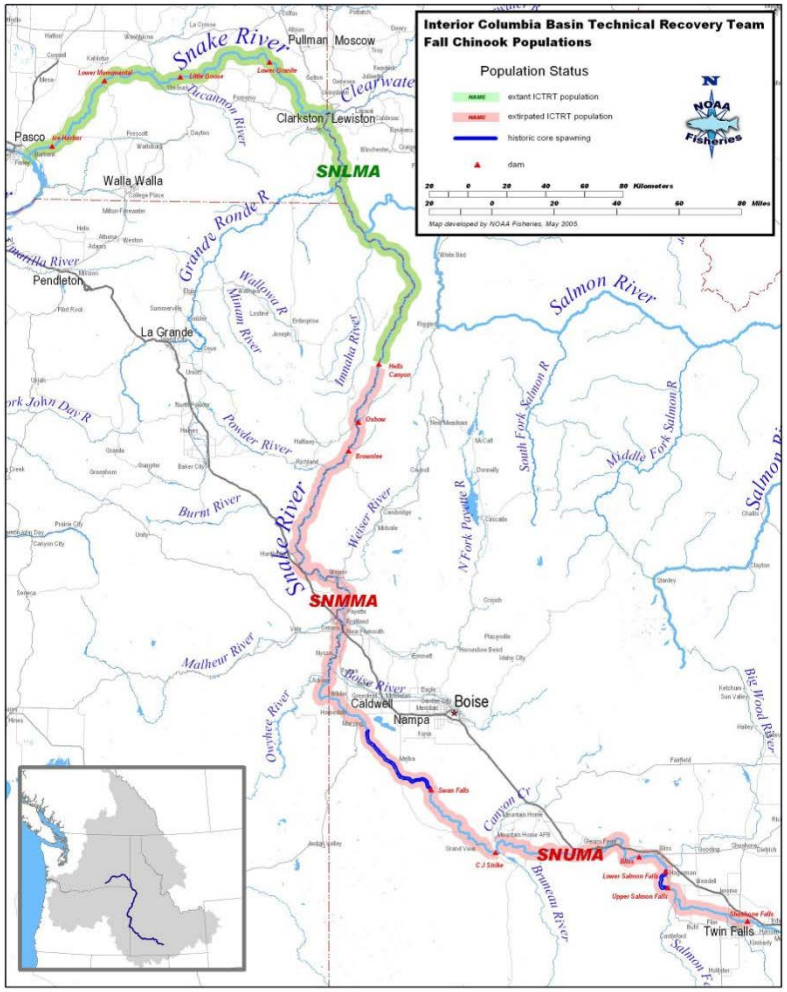
Integrating Across SSD Criteria

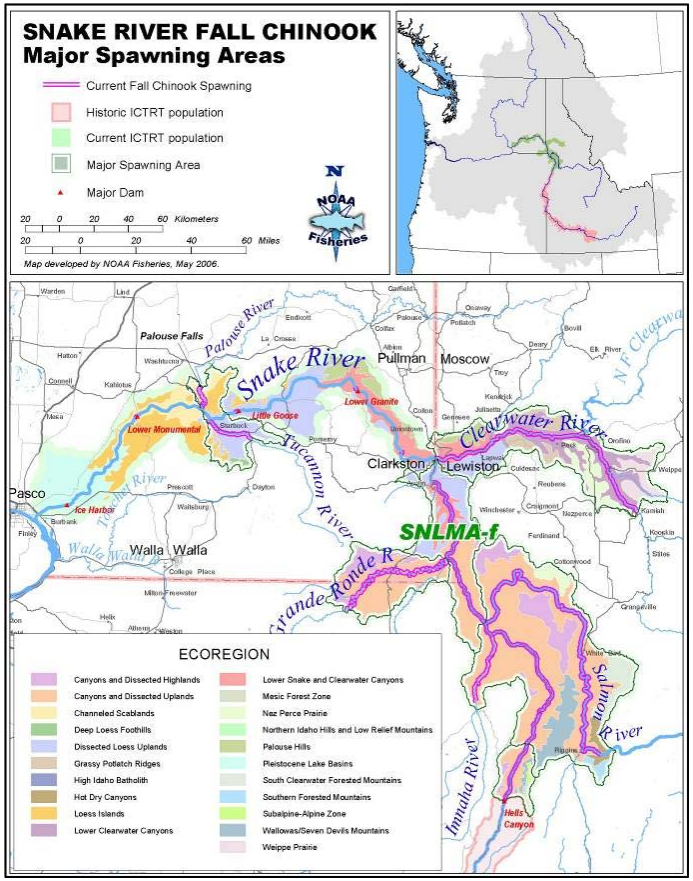
- Weighted score across elements, higher weight to direct measures of population characteristics
- A population would be rated at HIGH risk if:

  - Average rating across spatial distribution criteria is HIGH RISK OR
  - Rating for life history or direct genetic criteria at HIGH Risk

    OR
  - Average rating across Life history, genetics, habitat and selectivity criteria is HIGH

Snake River Fall Chinook ESU





- By 2017 we will have a <u>good understanding</u> of:

  - total escapement upstream of Lower Granite Dam (LGR),
  - abundance of natural-origin returns (NOR),
  - abundance of hatchery-origin returns,
  - percentage of the hatchery-origin fish in the naturally spawning population (pHOS) at the population scale,
  - percentage of the natural-origin fish used in hatchery broodstocks (pNOB)
  - age-at-return for natural and hatchery-origin fish,
  - spawning distribution,

  - genetic diversity and effective population size of natural and hatchery-origin population segments ,

  - fidelity of subyearling hatchery production groups to release site areas,
  - spawning distribution upstream of LGR of Lyons Ferry Hatchery on-station released fish,
  - relative performance of various hatchery life stage at release and release type strategies.

  - magnitude of predation on juvenile fall Chinook by smallmouth bass and channel catfish in the Snake River,

  - best management strategy for juvenile passage through hydrosystem (COE Consensus Study),
  - relative impacts of harvest and hydro mortalities to hatchery effects, and

<u>2011 HGMP Addendum pp 6-7</u>

- By 2017 we <u>may have an improved understanding</u> of:
  - productivity of the naturally spawning population,
  - percentage of the hatchery-origin fish in the naturally spawning population (pHOS) at spawning aggregate scales,
  - relative magnitude juvenile production from some spawning aggregates,
  - density dependent relationships between spawner abundance and juvenile production,
  - relationship of juvenile fish growth and survival to food availability and abundance,
  - range of juvenile spatial and temporal rearing patterns,
  - heritability of age-at-emigration, and
  - pre-season run forecasts.

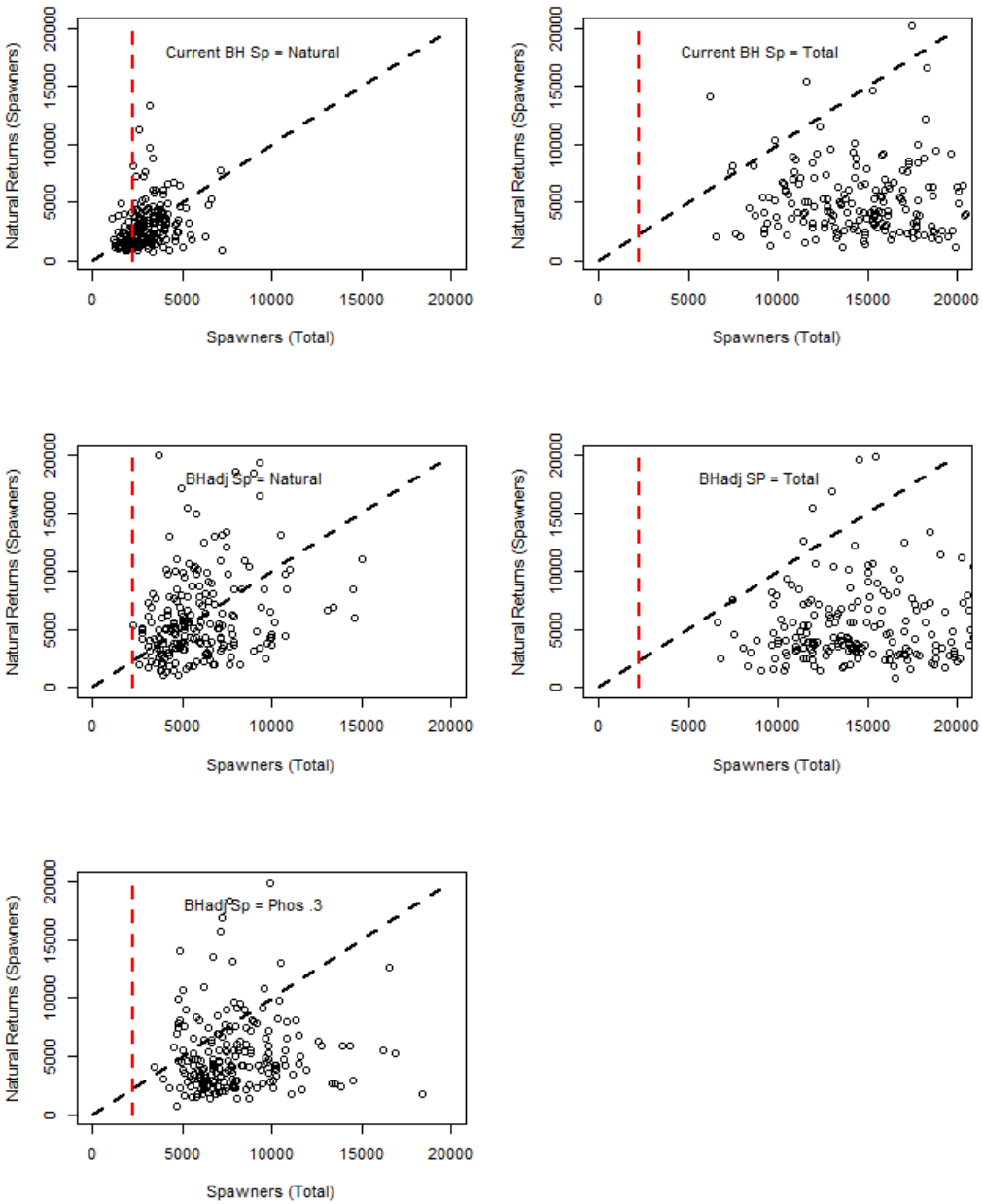
2011 HGMP Addendum pp 6-7

By 2017 we will still lack an understanding of:

- relative reproductive success of hatchery and natural-origin spawners,
- magnitude of mini-jack returns and their contribution to natural spawning,
- differential use of habitats by hatchery and natural-origin fish,
- abundance of basin-wide juvenile production,
- impact of sturgeon on juvenile production (egg consumption),
- impact of avian predation on juvenile fish upstream of Lower Granite Dam, and
- ecological processes supported (or hindered) by an abundance (or scarcity) of natural spawners.

2011 HGMP Addendum pp 6-7

Projected Natural Production Alternative SR models & Strategies

- Each graph is a different future scenario. All assume BH functions derived from 1990-2012 spawner to return data sets.
  - Two fitted functions: Current assumes no difference in r/s from hatchery vs. natural origin parents.
  - Hadj assumes BH capacity is a decreasing function of Phos (used relationship for spr/sum chinook derived by Buhle et al. 2013)
  - Three hatchery management scenarios:
    - a) Current,
    - b) No hatchery spawners in natural areas
    - c) manage for 30% Phos.

- Black dashed line: 1:1 Replacement
- Red dashed line: 75% of ICTRT minimum abundance threshold
- Sample of 20 years from 10 runs for each scenario, simulates ICTRT recommended minimum samples.