Northwest **Power** and **Conservation** Council

March 4, 2014

MEMORANDUM

TO: Council Members

FROM: Tony Grover, Director
Fish and Wildlife Division

SUBJECT: NOAA Life cycle mode

Dr. Rich Zabel, NOAA Northwest Fisheries Science Center, will update the Council on developments toward a full life cycle model of salmon and steelhead in the Columbia River Basin. The Federal Columbia River Power System Biological Opinion (FCRPS BiOp), the 2009 Adaptive Management Implementation Plan calls for expanded life cycle modeling to support conservation planning and implementation as well as early-warning and contingency triggers.

The most recent status review for the runs addressed in the FCRPS BiOp is available at http://www.nwfsc.noaa.gov/assets/25/1730_01312012_150050_SRUpdateSal&SteelheadTM113WebFinal.pdf

The goal of this group is to expand, update, and incorporate recent data into new or existing models of salmon and steelhead life cycles.

Effects that will be incorporated into the models include:

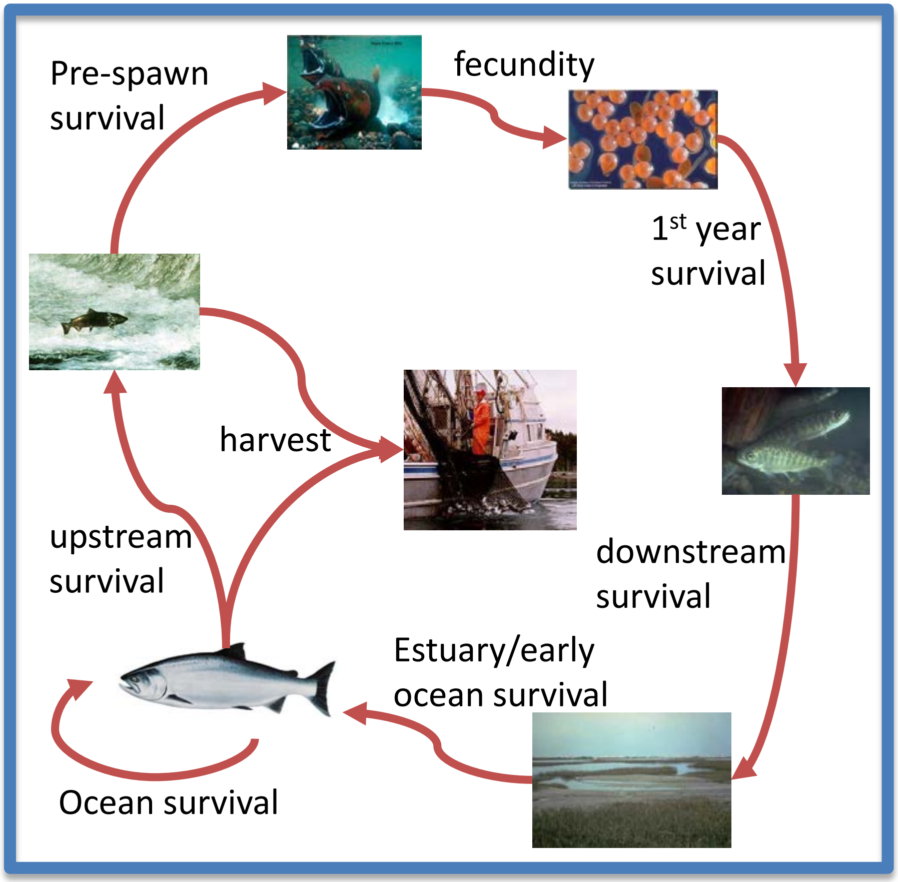
- Freshwater Habitat Relationships
- Hydro Actions — Recent improvements and alternative future scenarios
- Estuary/Ocean
  - Estuary Actions — Survival into estuary and ocean based on JSATS studies and potential decreases in avian predation
  - Ocean Conditions — Updated ocean survival analysis (Snake River spring/summer Chinook, Upper Columbia spring Chinook, Mid-Columbia steelhead, Snake River steelhead)
- Spatial Analyses

- Hatchery Effects

Documents:

- Report to ISAB June 2013: Life-Cycle models of salmonid populations in the interior Columbia River Basin
- ISAB Report: REVIEW OF LIFE-CYCLE MODELS OF SALMONID POPULATIONS IN THE INTERIOR COLUMBIA RIVER BASIN (JUNE 28, 2013 DRAFT")

Life-Cycle Modeling of Columbia River Basin Salmonid Populations: Translating Mitigation Actions into Population Viability Metrics



1) Background
2) Overview of Life Cycle Modeling
3) Examples from AMIP group
4) ISAB Review

Recovery and Management Options for Spring/Summer Chinook Salmon in the Columbia River Basin

Peter Kareiva,[1] Michelle Marvier,[2] Michelle McClure[1]*

www.sciencemag.org SCIENCE VOL 290 3 NOVEMBER 2000

2000

The Interplay between Climate Variability and Density Dependence in the Population Viability of Chinook Salmon

RICHARD W. ZABEL,* MARK D. SCHEUERELL, MICHELLE M. McCLURE, AND JOHN G. WILLIAMS
National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112, U.S.A.

Conservation Biology Volume 20, No. 1, 190–200

2006

Assessing the Impact of Environmental Conditions and Hydropower on Population Productivity for Interior Columbia River Stream-type Chinook and Steelhead Populations

Interior Columbia Technical Recovery Team and R. W. Zabel

2007

Adaptive Management Implementation Plan (AMIP)

2010-2013

Adaptive Management Implementation Plan (AMIP)

Life Cycle Model:

- GOAL: Assess benefit of mitigation actions across the life cycle
- Collaboration of small working groups

New Areas of Focus:

- More Populations
  Dynamic Database

New Areas of Focus:

- More Populations
- Effects of Habitat actions
  Development of “sub-modules”

New Areas of Focus:

- More Populations
- Effects of Habitat actions
- Link to monitoring activities
  Identify key information and data gaps

New Areas of Focus:

- More Populations
- Effects of Habitat actions
- Link to monitoring activities
- Hatchery impacts on wild populations long-term datasets

New Areas of Focus:

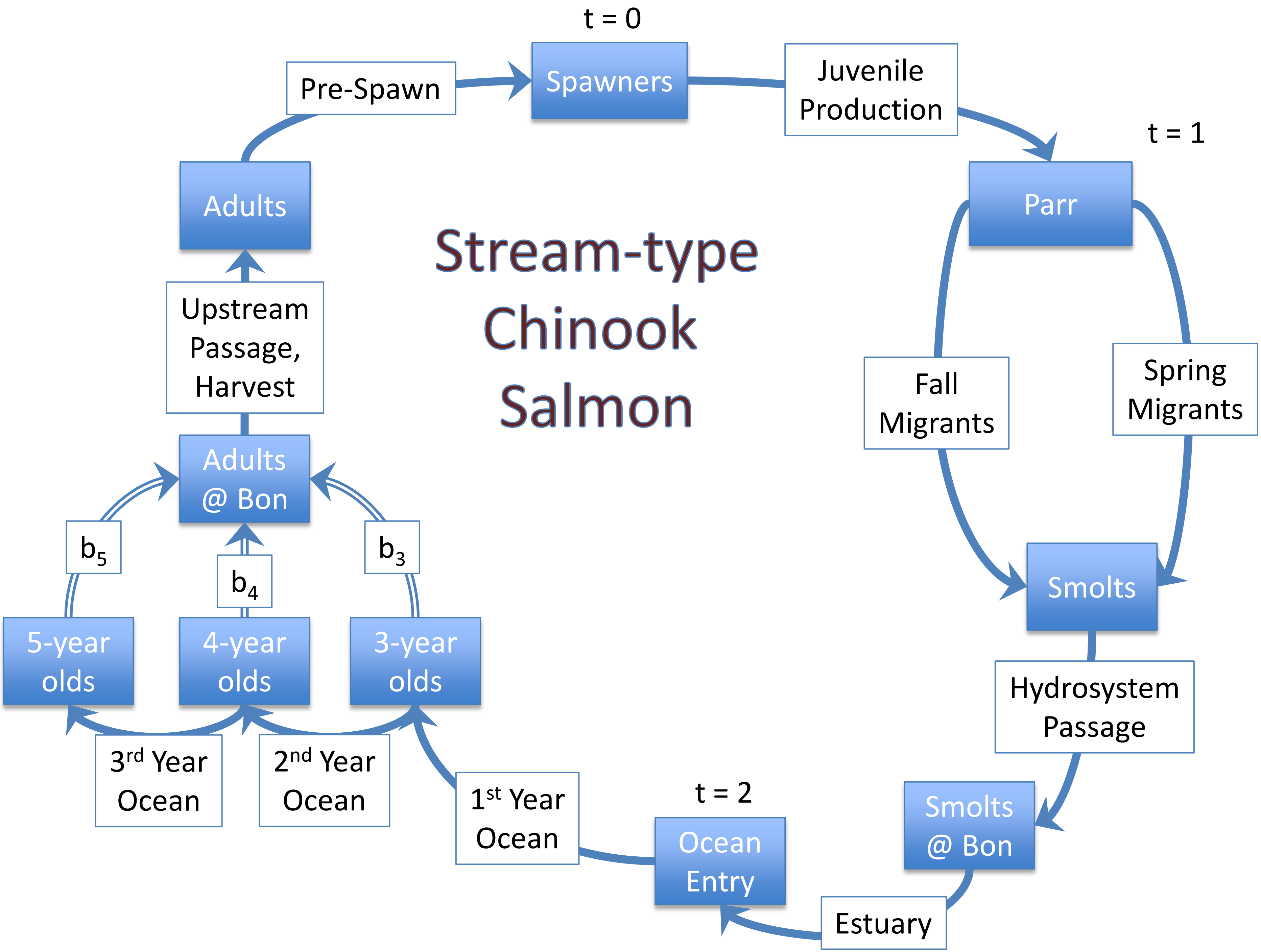
- More Populations
- Effects of Habitat actions
- Link to monitoring activities
- Hatchery impacts on wild populations
- Spatial Patterns
  - Identify isolated populations
  - Meta-population modeling

New Areas of Focus:

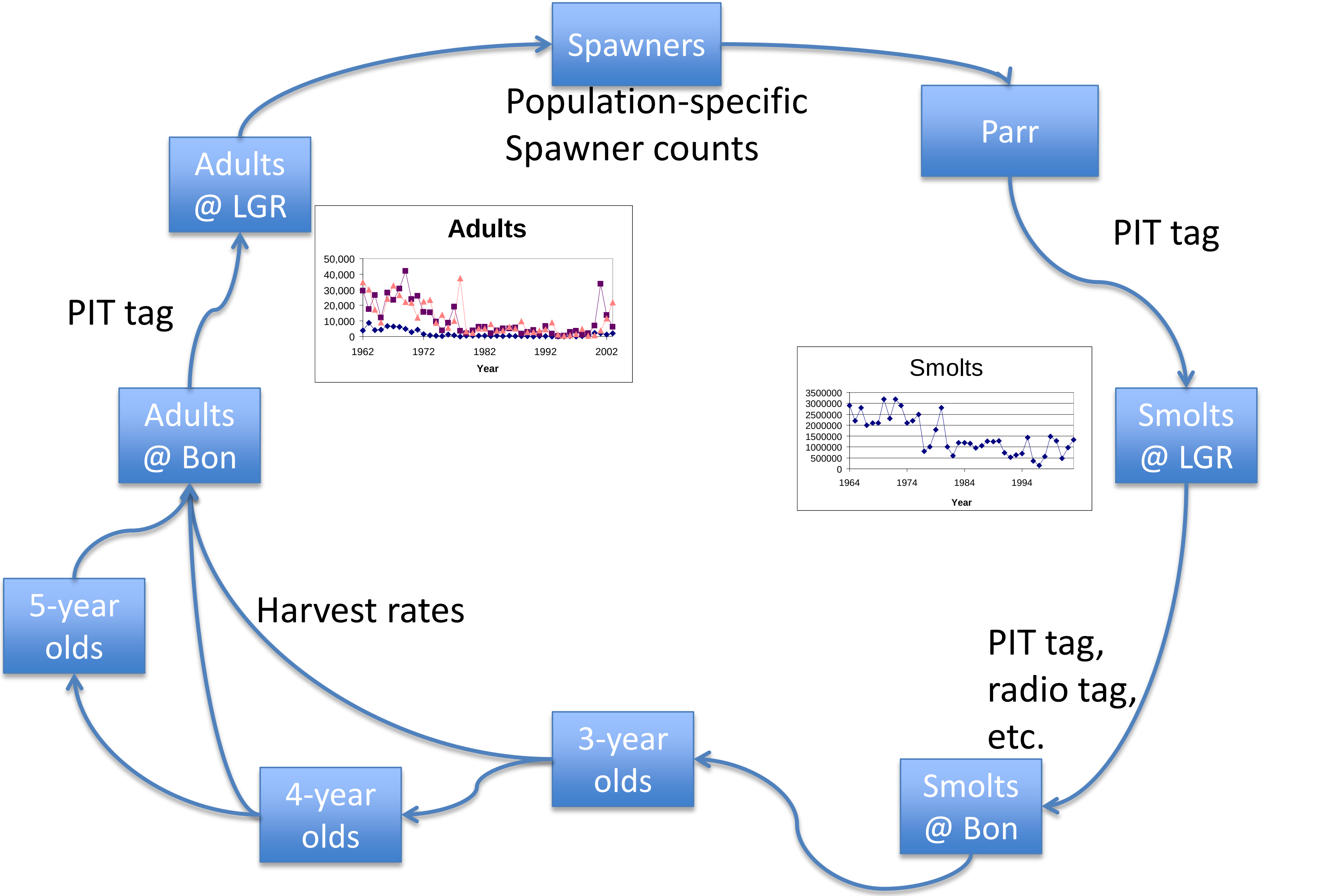
- More Populations
- Effects of Habitat actions
- Link to monitoring activities
- Hatchery impacts on wild populations
- Spatial Patterns
- Complex life histories
  e.g. Snake R fall Chinook
  steelhead/rainbow

Rich Zabel (NOAA Fisheries, NWFSC)
Tom Cooney (NOAA Fisheries, NWFSC)
Chris Jordan (NOAA Fisheries, NWFSC)
Richard W. Carmichael (ODFW)
Brian C. Jonasson (ODFW)
Edwin Sedell (ODFW)
Timothy L. Hoffnagle (ODFW)
Robert B Lessard (CRITFC)
Casey Justice (CRITFC)
Jeff Jorgensen (NOAA Fisheries)
Andrew Murdoch (WDFW)
Jeremy Cram (WDFW)
Charlie Paulsen (PEC)
Lisa G. Crozier (NWFSC)
Neala Kendall (WDFW)
William P. Connor (U.S. Fish & Wildlife Service)

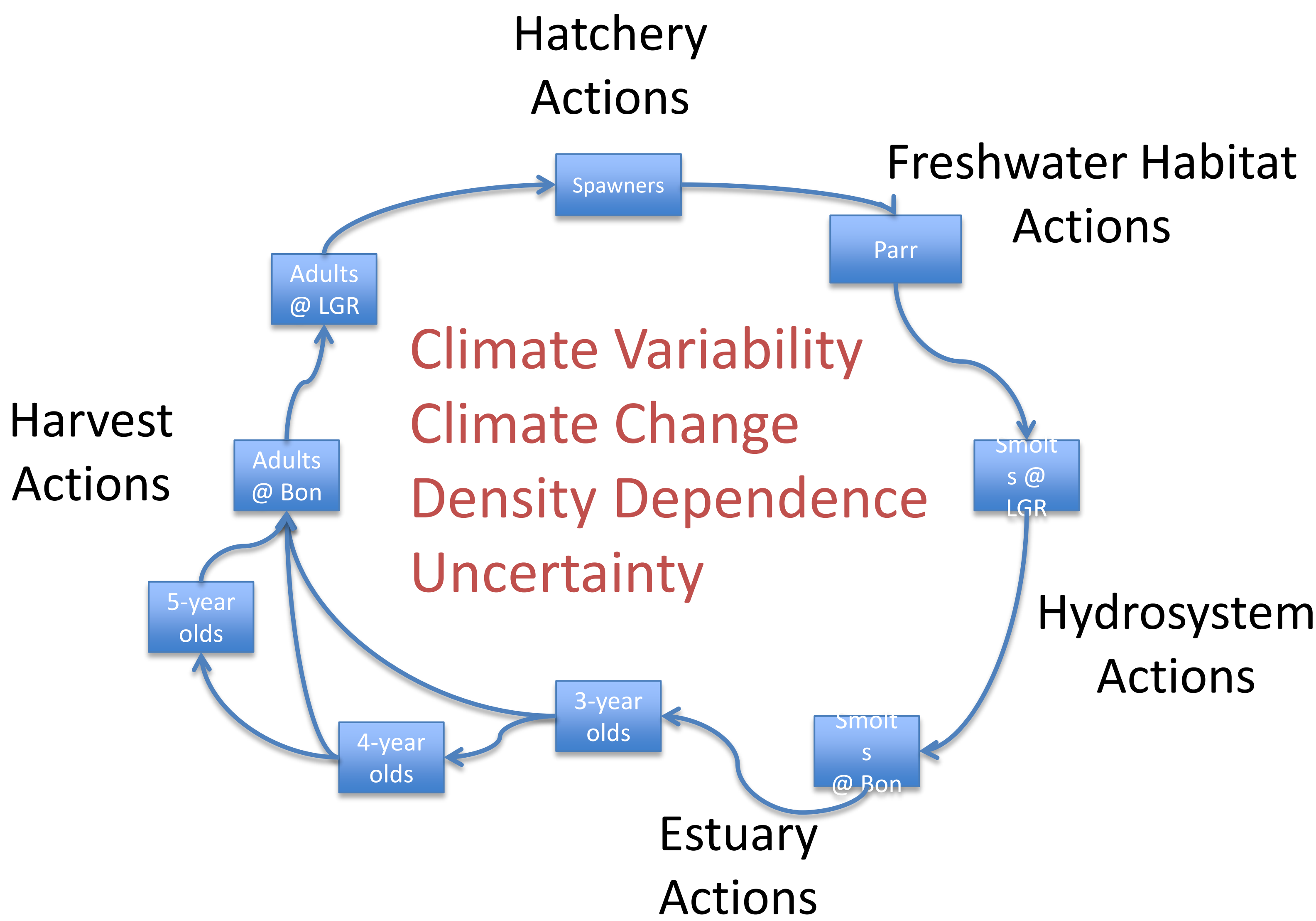
Ian Courter (Cramer Fish Sciences)
Chris Frederiksen (Yakama Nation)
Chris Beasley (Quantitative Consultants, Inc.)
Jody White (Quantitative Consultants, Inc.)
Matt Nahorniak (South Fork Research, Inc.)
William Young (Nez Perce Tribe)
Russell Perry and Kenneth F. Tiffan (USGS)
Michael Newsom (USBR)
Ryan Bellmore (USGS)
Charlie Snow (WDFW)
Alex Fremier (U of Idaho)
Aimee H. Fullerton (NOAA Fisheries, NWFSC)
Mark D. Scheuerell (NOAA Fisheries, NWFSC)
Eric R. Buhle (NOAA Fisheries, NWFSC)

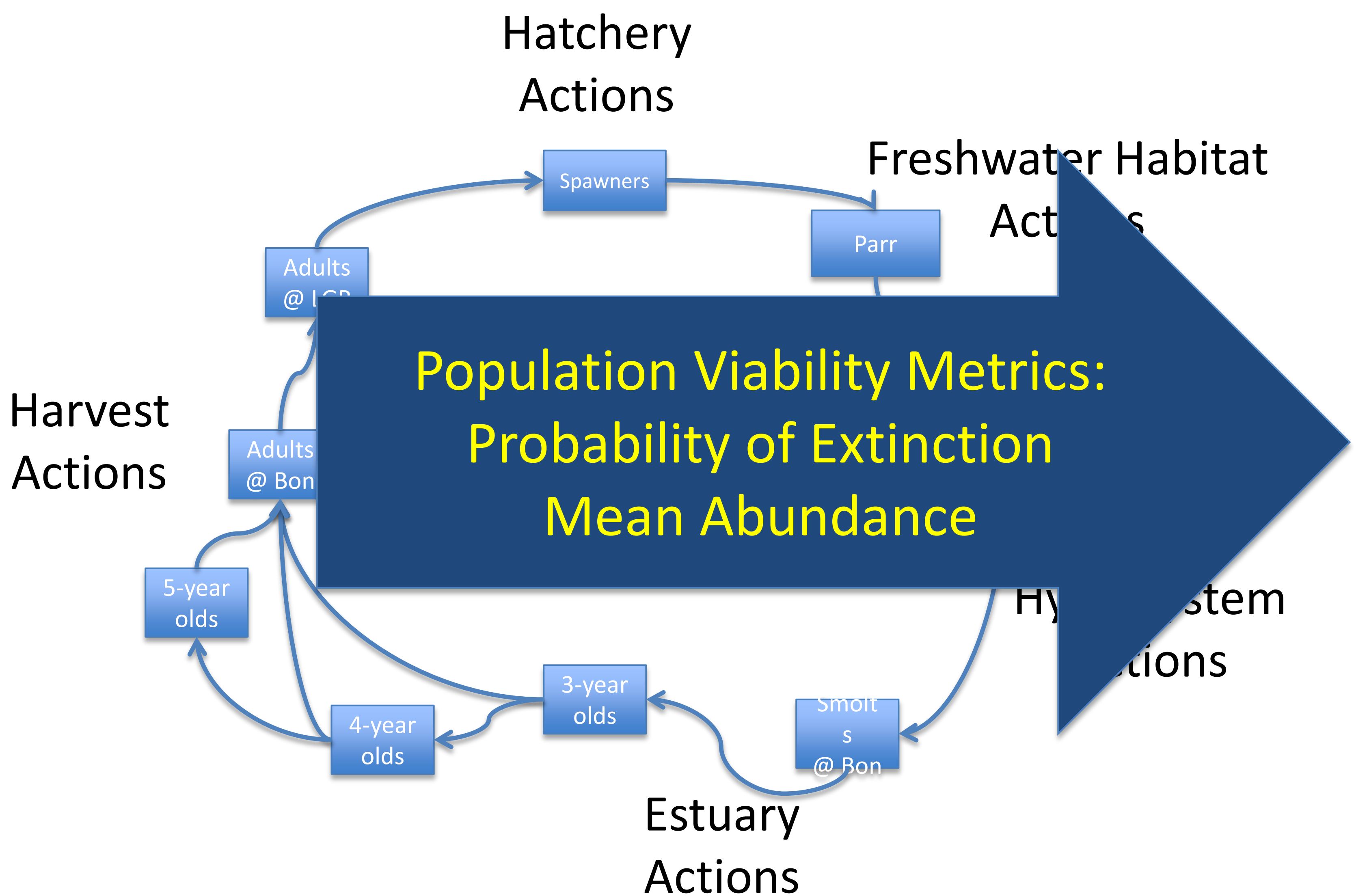


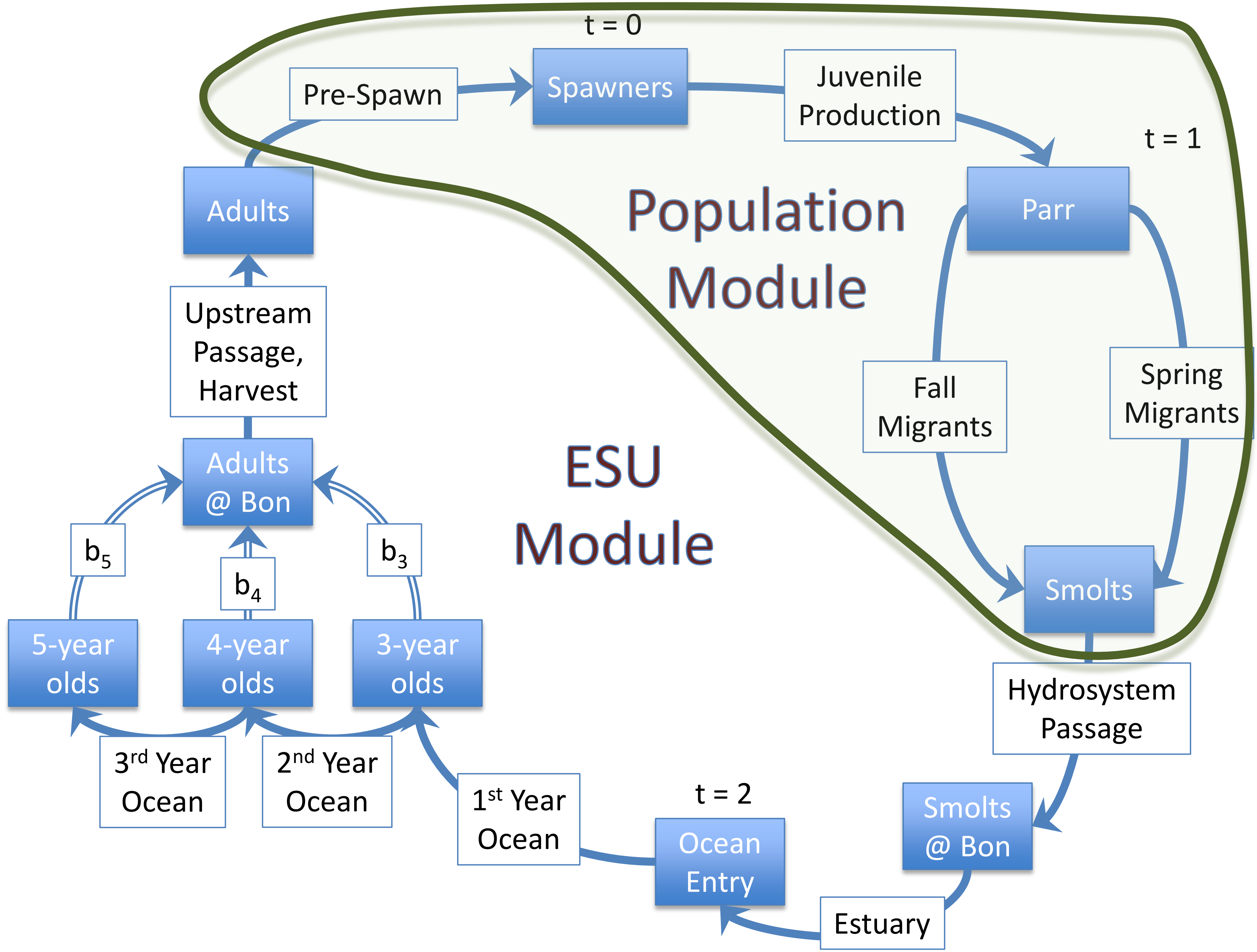
Stream-type
Chinook
Salmon
t = 0
Spawners
Juvenile
Production
t = 1
Parr
Fall
Migrants
Spring
Migrants
Smolts
Hydrosystem
Passage
Smolts
@ Bon
Estuary
t = 2
Ocean
Entry
1st Year
Ocean
2nd Year
Ocean
3rd Year
Ocean
3-year
olds
4-year
olds
5-year
olds
b3
b4
b5
Adults
@ Bon
Upstream
Passage,
Harvest
Adults
Pre-Spawn



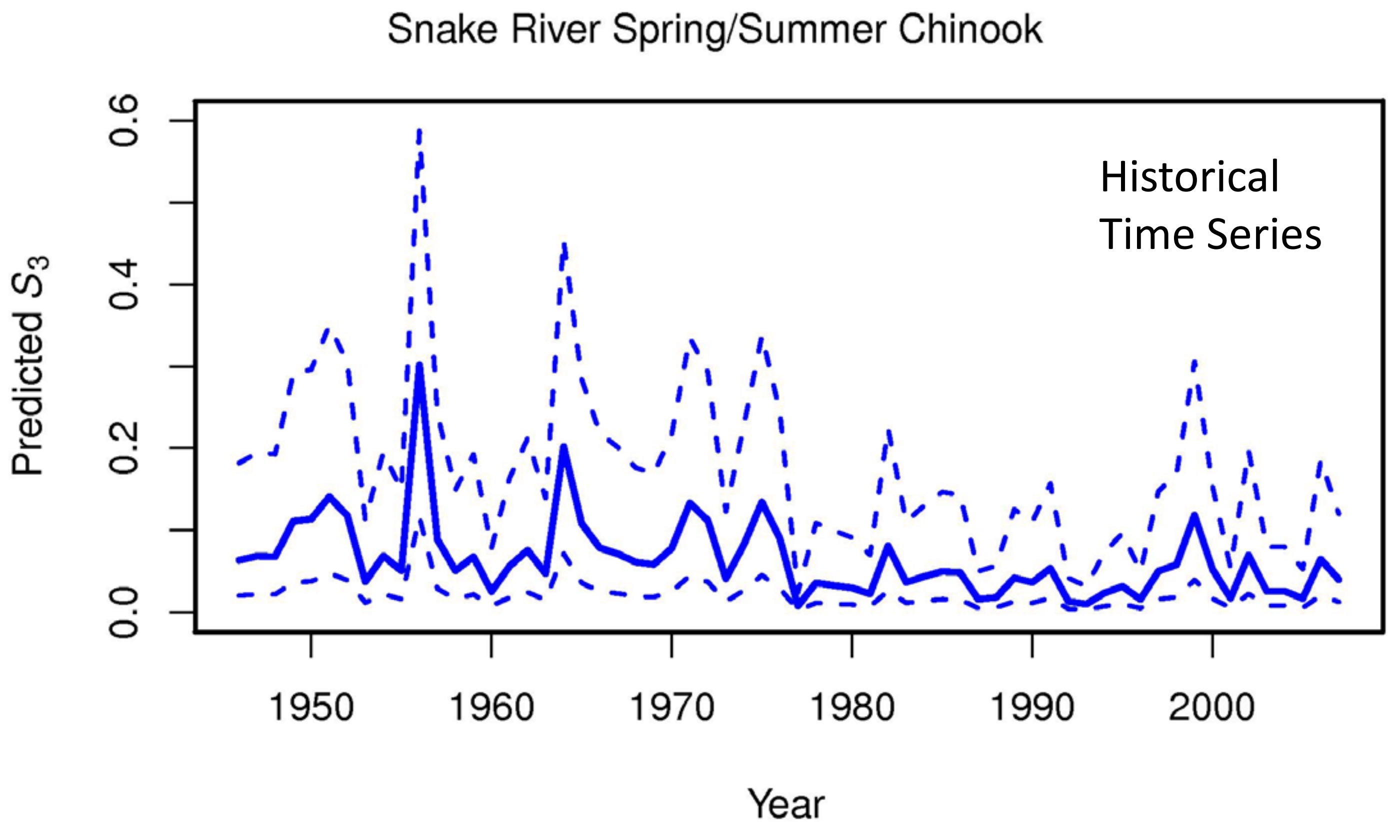
Spawners
Population-specific Spawner counts
Parr
PIT tag
Smolts @ LGR
Smolts
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
1964
1974
1984
1994
Year
PIT tag, radio tag, etc.
Smolts @ Bon
3-year olds
4-year olds
5-year olds
Harvest rates
Adults @ Bon
PIT tag
Adults @ LGR
Adults
50,000
40,000
30,000
20,000
10,000
0
1962
1972
1982
1992
2002
Year


Hatchery Actions
Freshwater Habitat Actions
Spawners
Parr
Adults @ LGR
Climate Variability
Climate Change
Density Dependence
Uncertainty
Harvest Actions
Adults @ Bon
Smolts @ LGR
Hydrosystem Actions
5-year olds
3-year olds
4-year olds
Smolts @ Bon
Estuary Actions

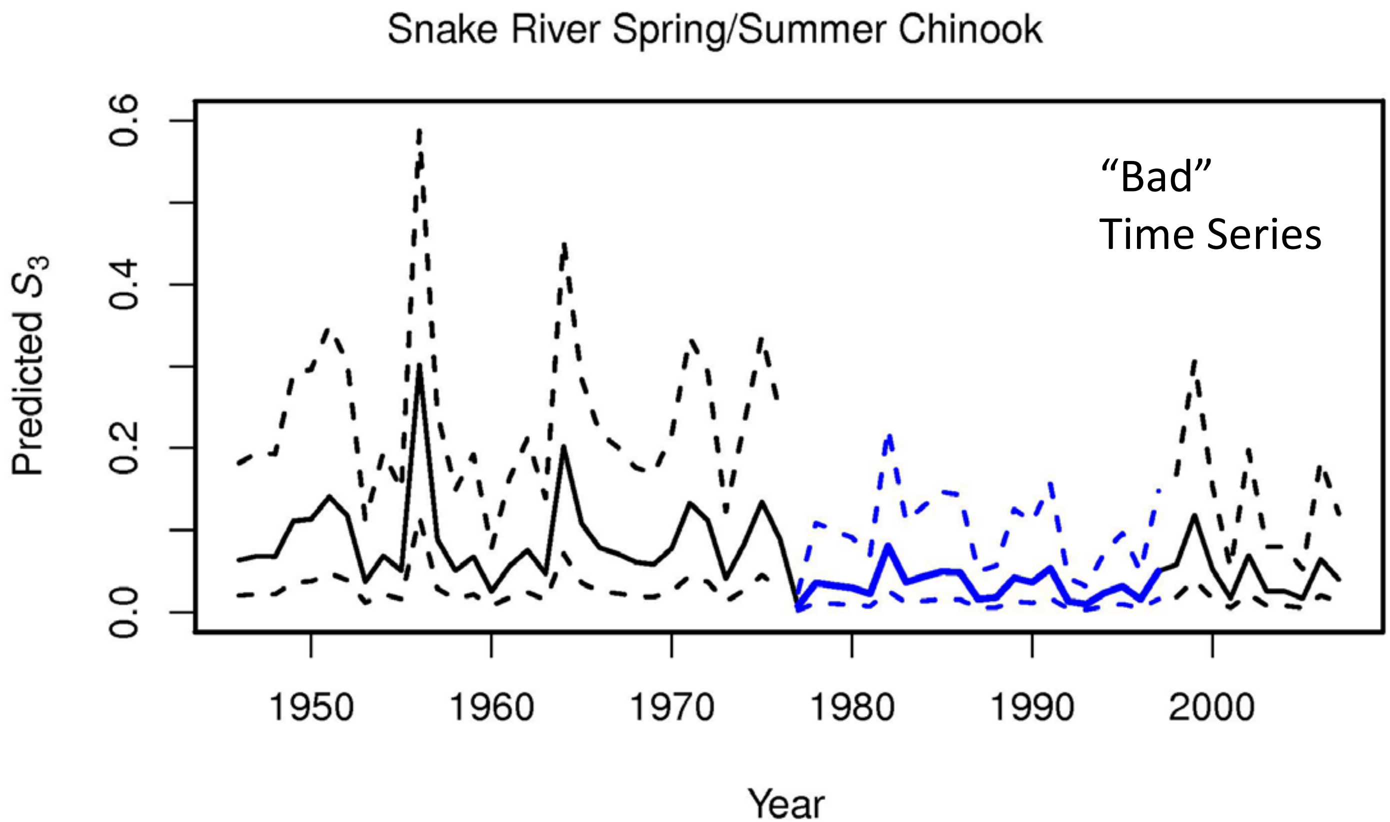

Hatchery
Actions
Spawners
Freshwater Habitat
Parr
Adults
Harvest
Actions
Adults
@ Bon
Population Viability Metrics:
Probability of Extinction
Mean Abundance
5-year
olds
3-year
olds
4-year
olds
Smolt
s
@ Bon
Estuary
Actions

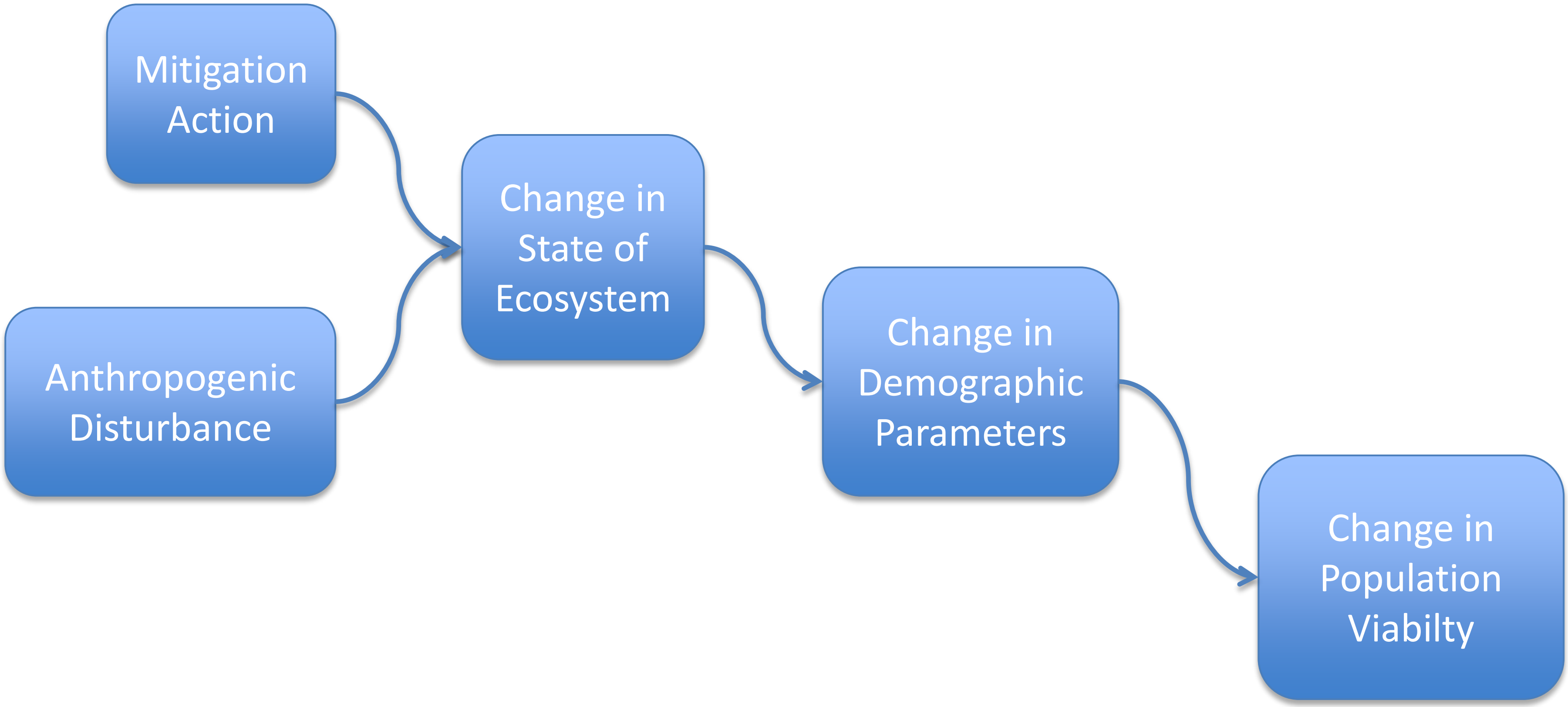


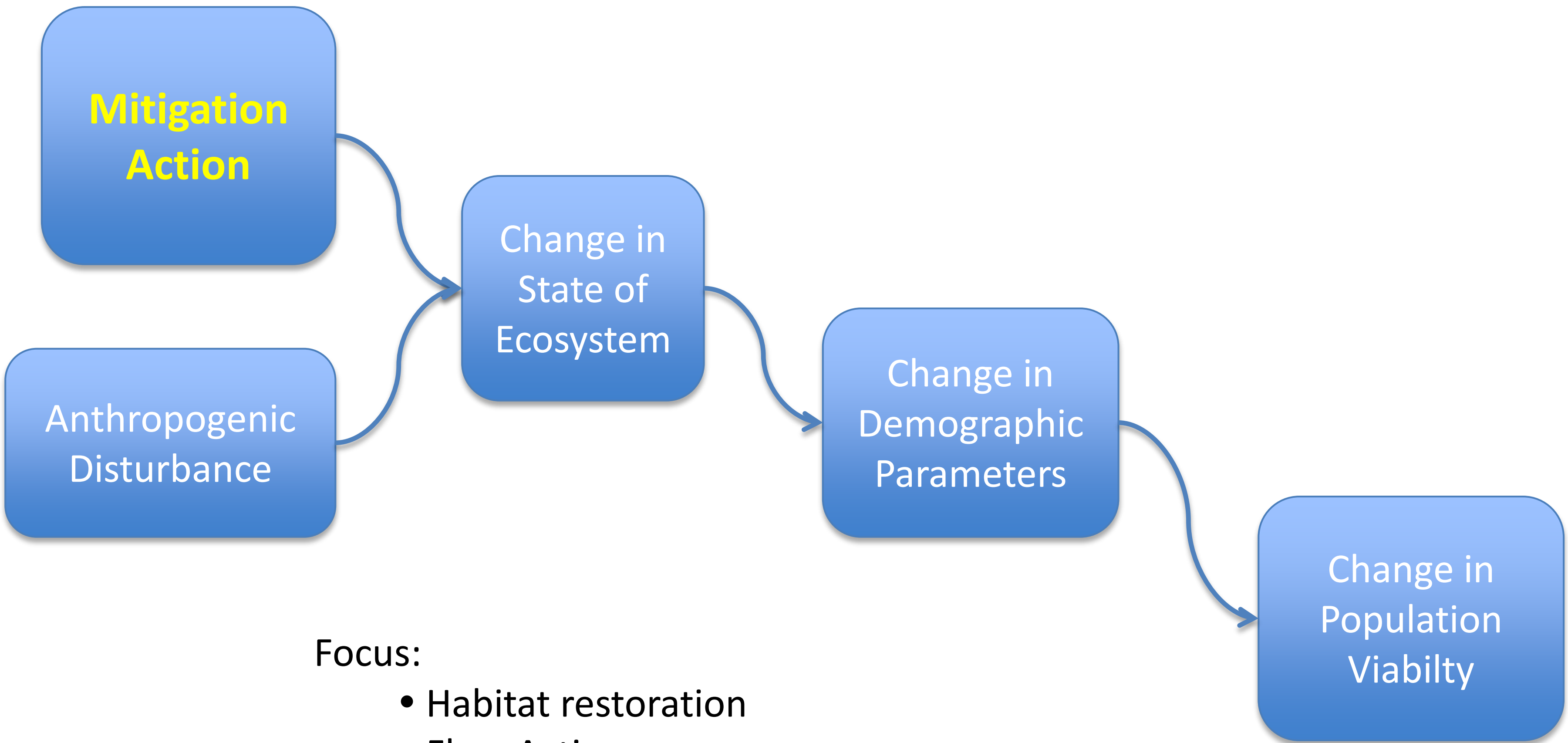
t = 0
Pre-Spawn
Spawners
Juvenile Production
t = 1
Parr
Population Module
Adults
Upstream Passage, Harvest
Fall Migrants
Spring Migrants
ESU Module
Adults @ Bon
b5
b4
b3
Smolts
5-year olds
4-year olds
3-year olds
Hydrosystem Passage
3rd Year Ocean
2nd Year Ocean
1st Year Ocean
t = 2
Ocean Entry
Smolts @ Bon
Estuary



Ocean survival related to PDO, upwelling and water travel time


Snake River Spring/Summer Chinook
"Bad"
Time Series
Predicted S_3
0.0
0.2
0.4
0.6
1950
1960
1970
1980
1990
2000
Year


Mitigation Action
Anthropogenic Disturbance
Change in State of Ecosystem
Change in Demographic Parameters
Change in Population Viabilty

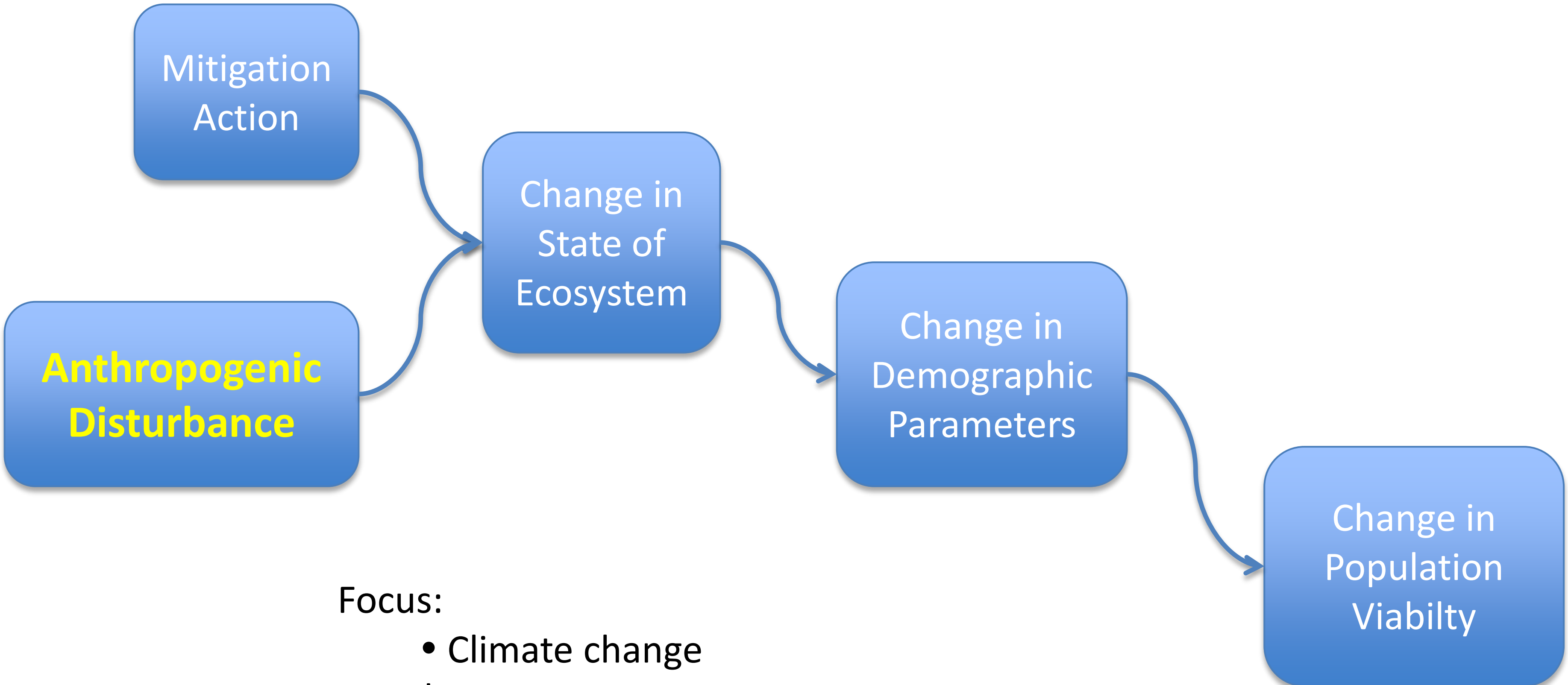


Focus:

- Habitat restoration
- Flow Actions

But also:

- Harvest reduction
- Hatchery actions
- Hydro Actions

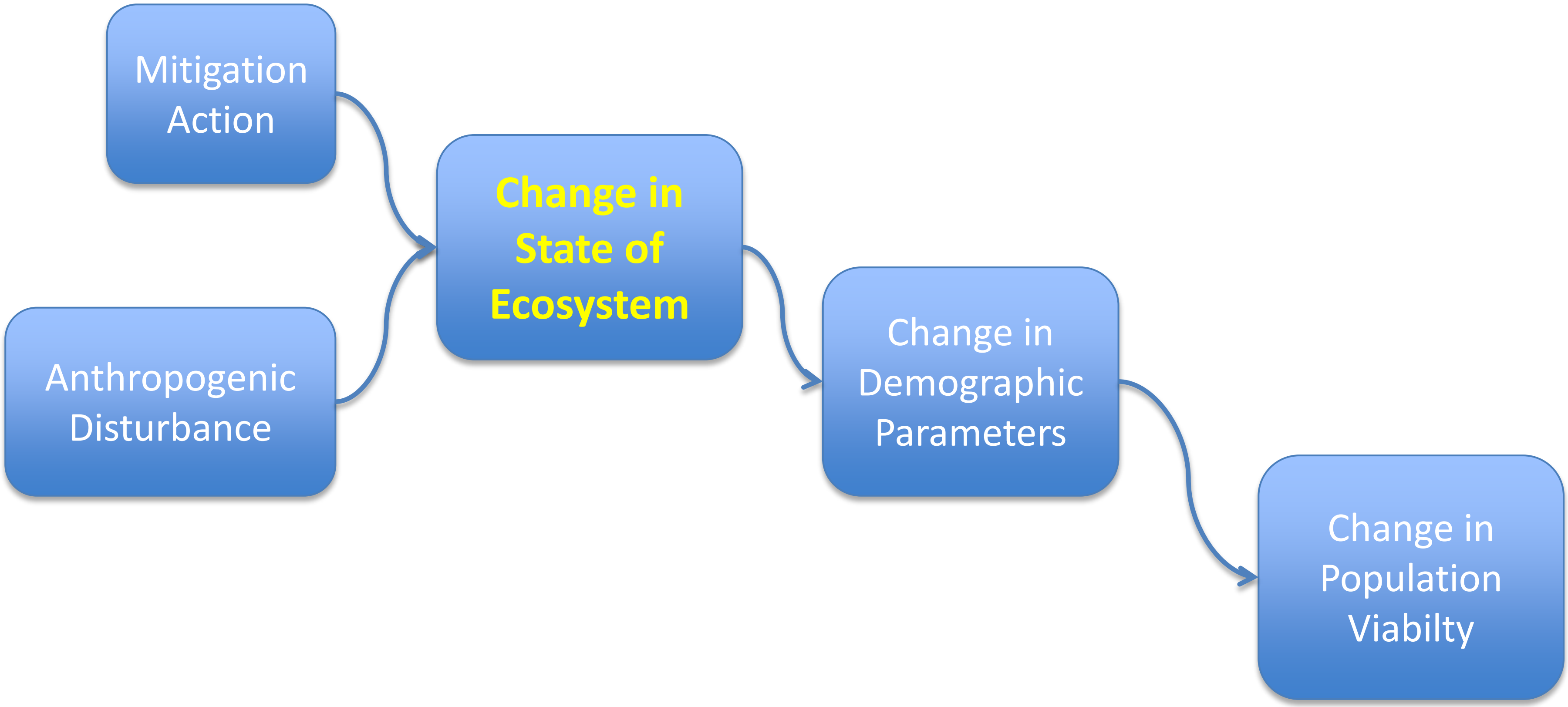


Focus:

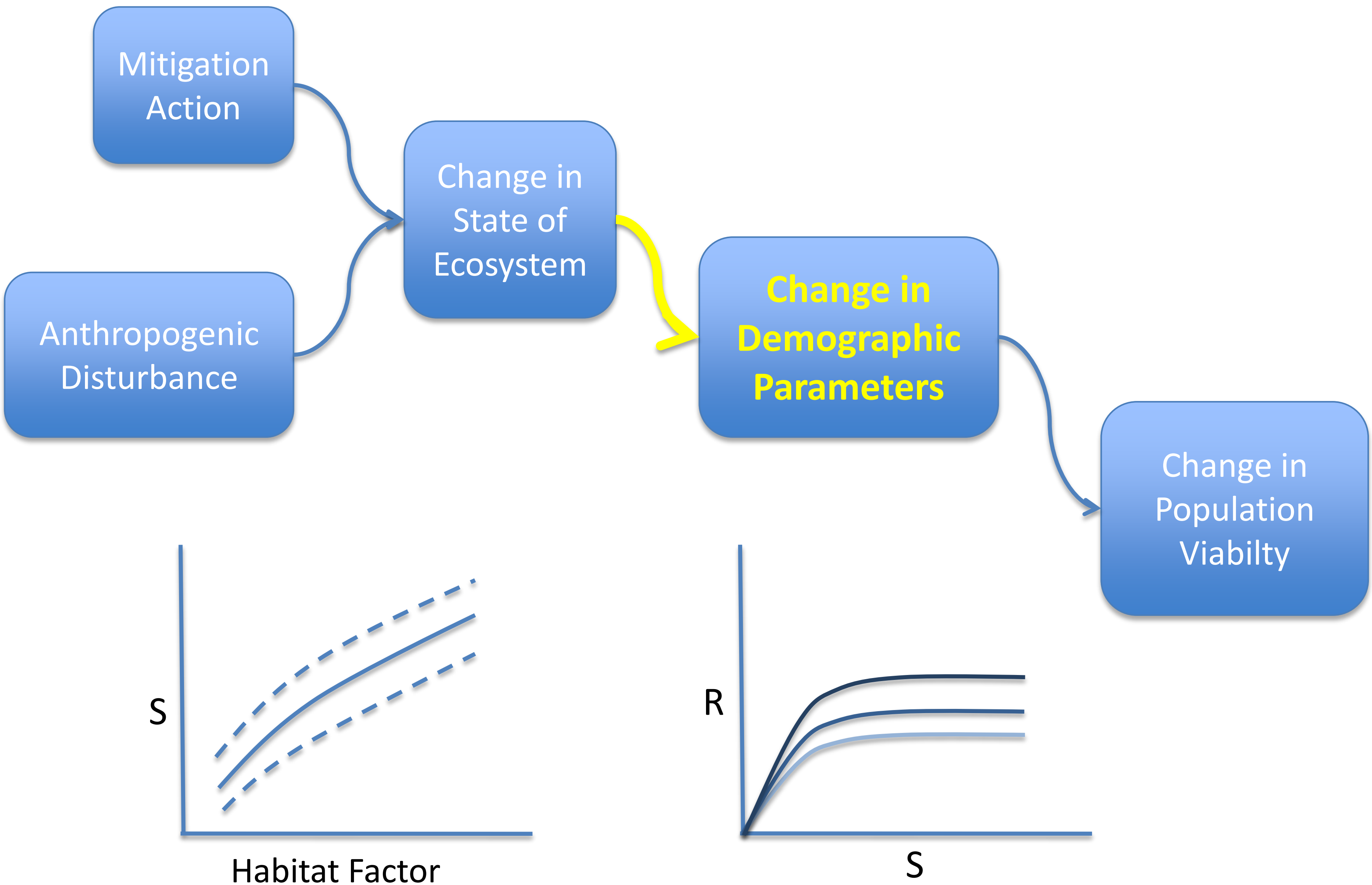
- Climate change

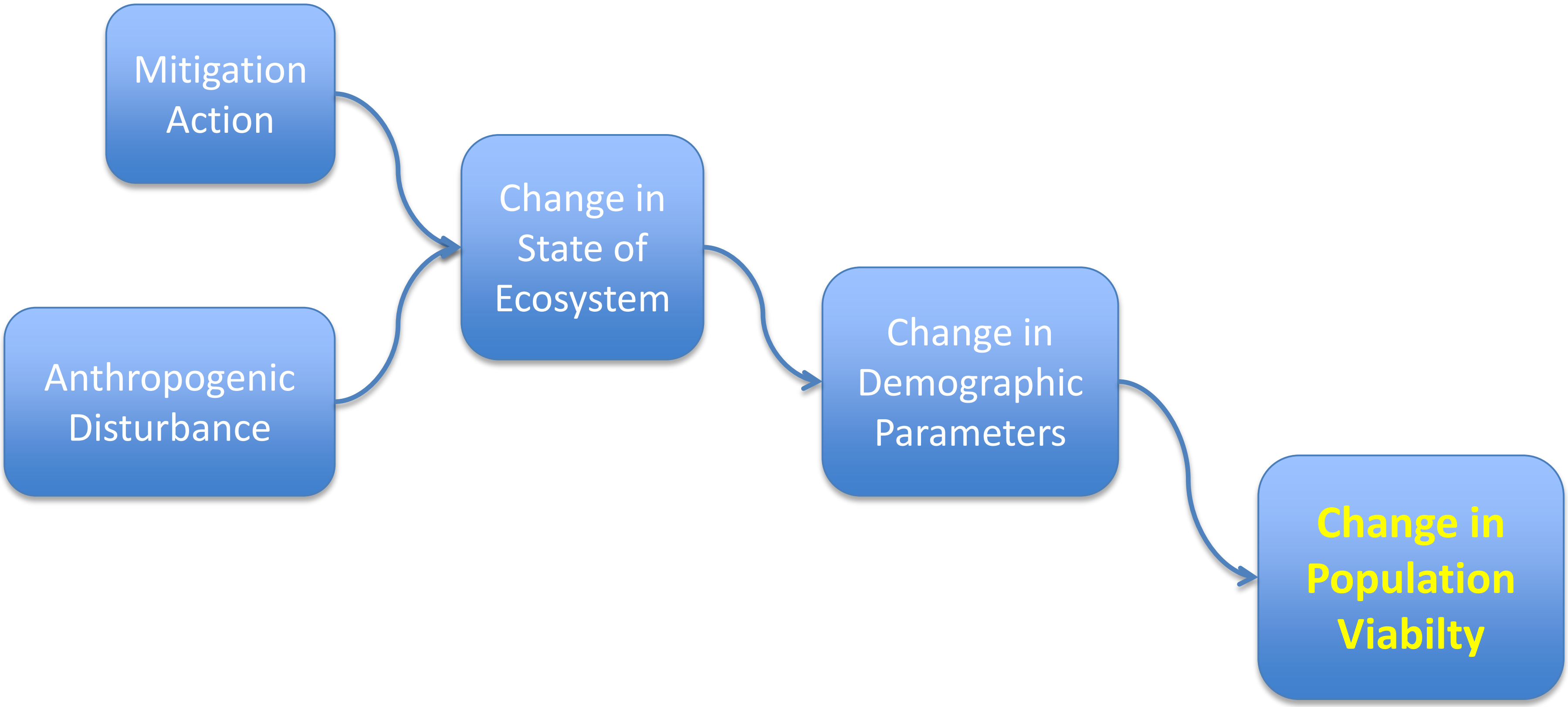
But also:

- Other habitat impacts (e.g. invasive spp.)



- Changes in river flows, temperatures
- Habitat
- Nutrients, community composition?
- pollutants?

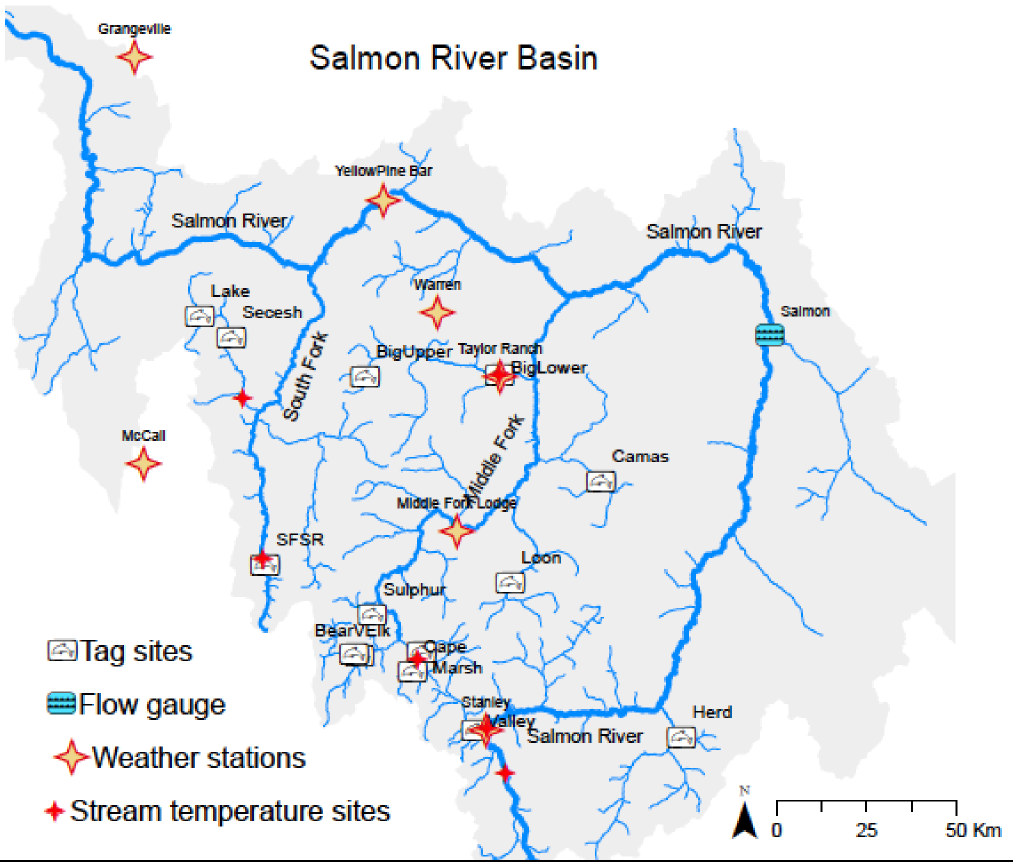

Mitigation Action
Anthropogenic Disturbance
Change in State of Ecosystem
Change in Demographic Parameters
Change in Population Viabilty
S
Habitat Factor
R
S



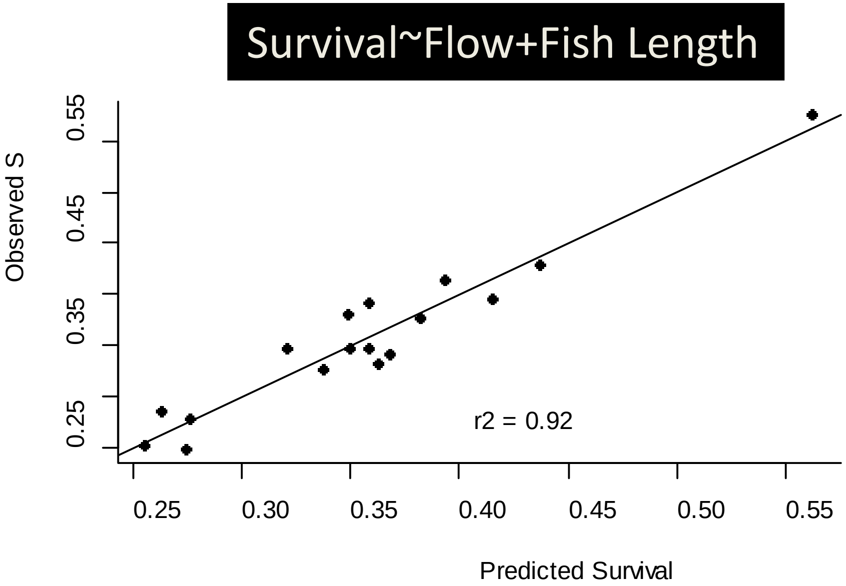
Probability of Extinction
Long Term Abundance
Productivity

2.4: Population responses of spring/summer Chinook salmon to projected changes in stream flow and temperature in the Salmon River Basin, Idaho

Lisa G. Crozier (NWFSC) and Richard W. Zabel (NWFSC)

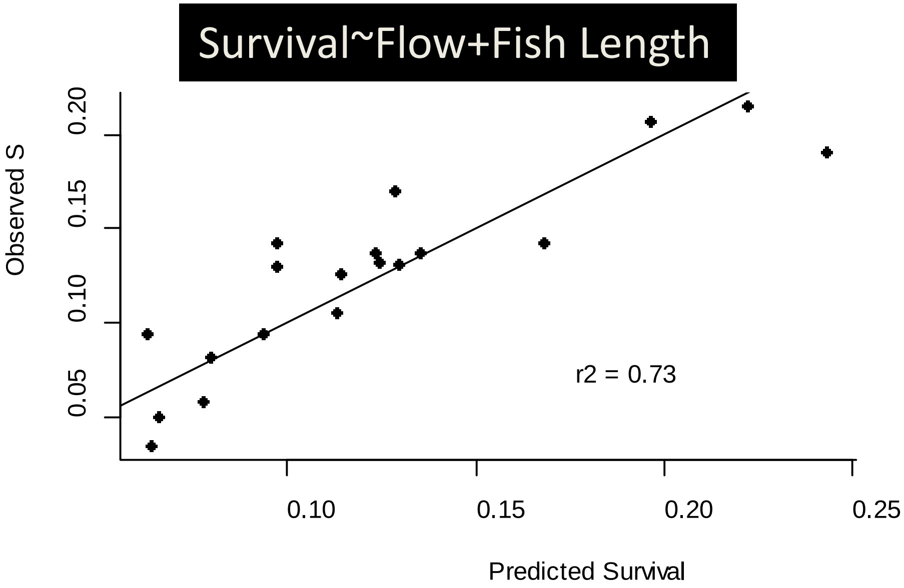


Updated analyses of parr to smolt survival: Environmental effects are important



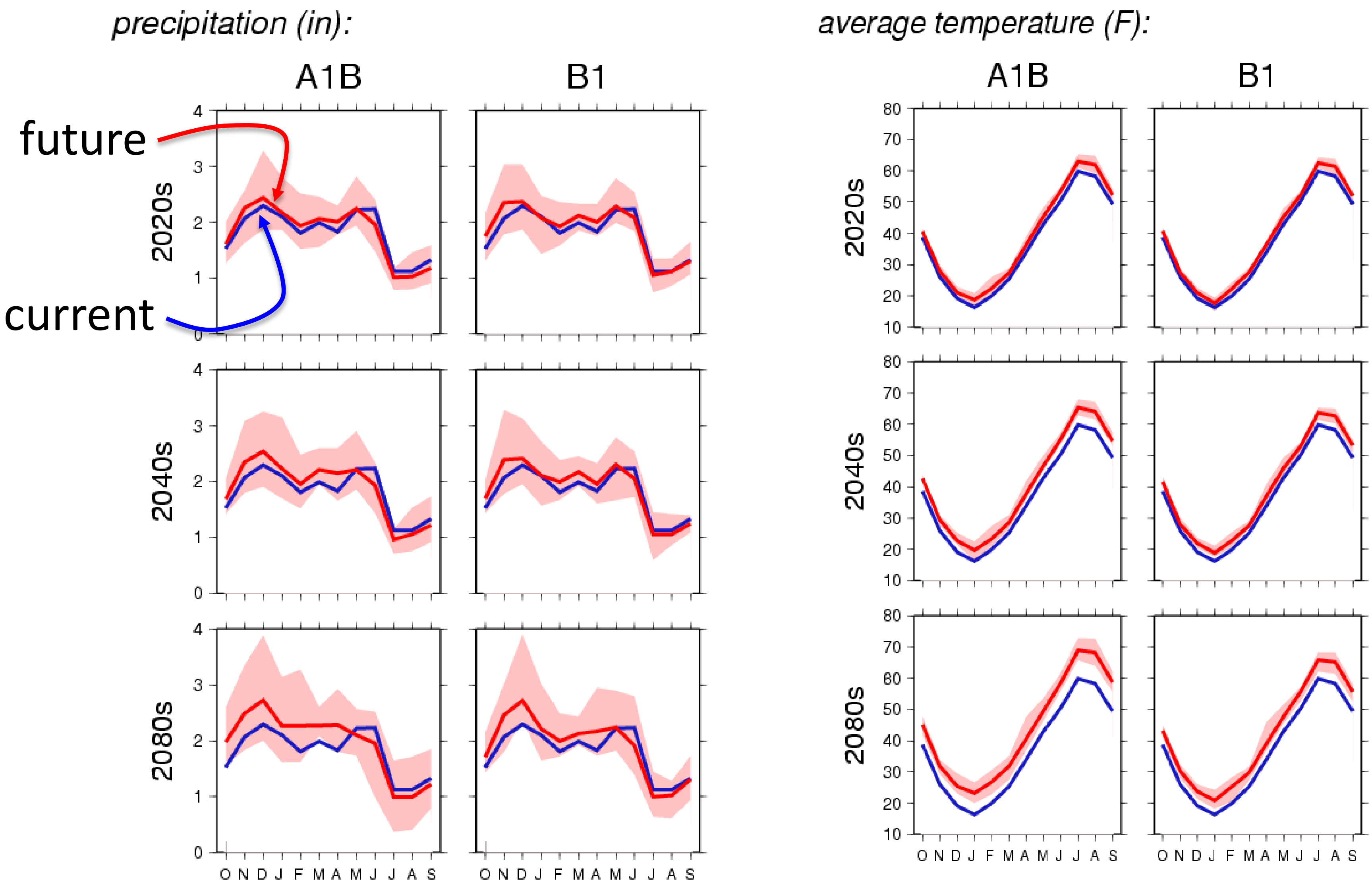
Marsh, Cape Horn, Bear Valley, Elk, Camas

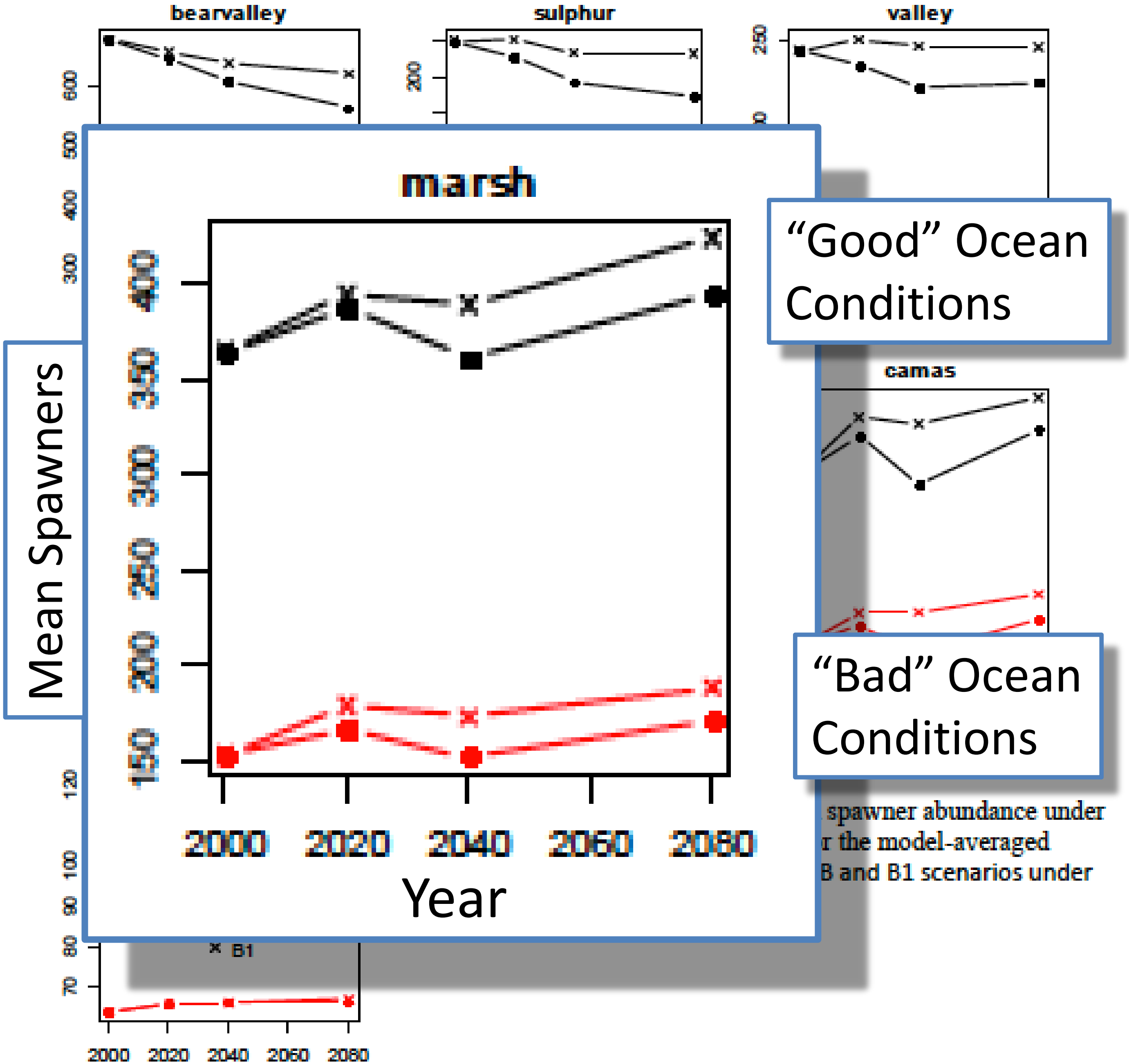
Lake, Secesh River, South Fork, Valley Creek



IPCC Climate scenarios

Hybrid delta scenarios





bearvalley
sulphur
valley
marsh
camas
Mean Spawners
Year
"Good" Ocean Conditions
"Bad" Ocean Conditions
150
200
250
300
350
400
2000
2020
2040
2060
2080
B1
spawner abundance under
r the model-averaged
B and B1 scenarios under

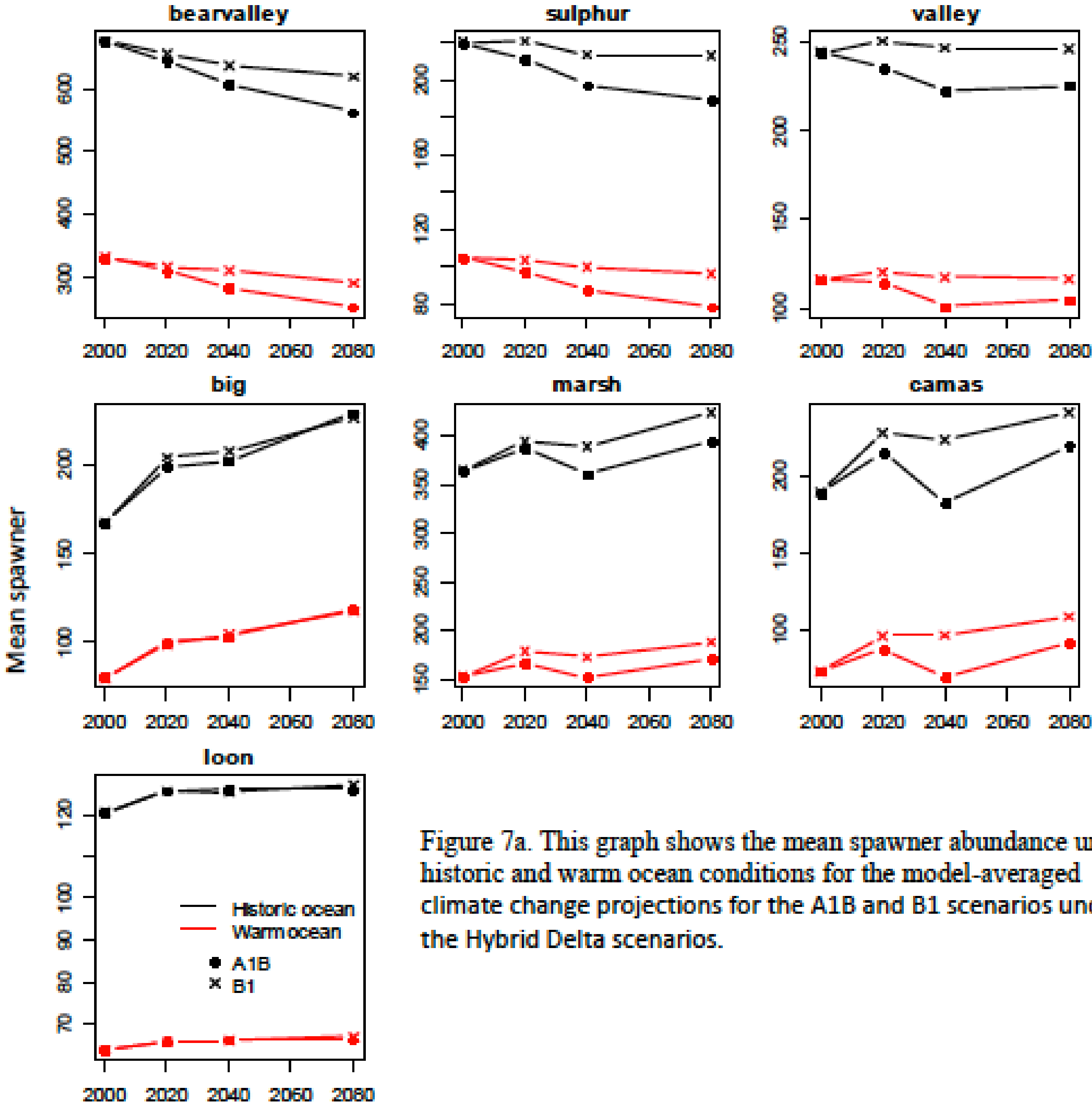


Figure 7a. This graph shows the mean spawner abundance under historic and warm ocean conditions for the model-averaged climate change projections for the A1B and B1 scenarios under the Hybrid Delta scenarios.

2.3: Upper Columbia River spring Chinook salmon

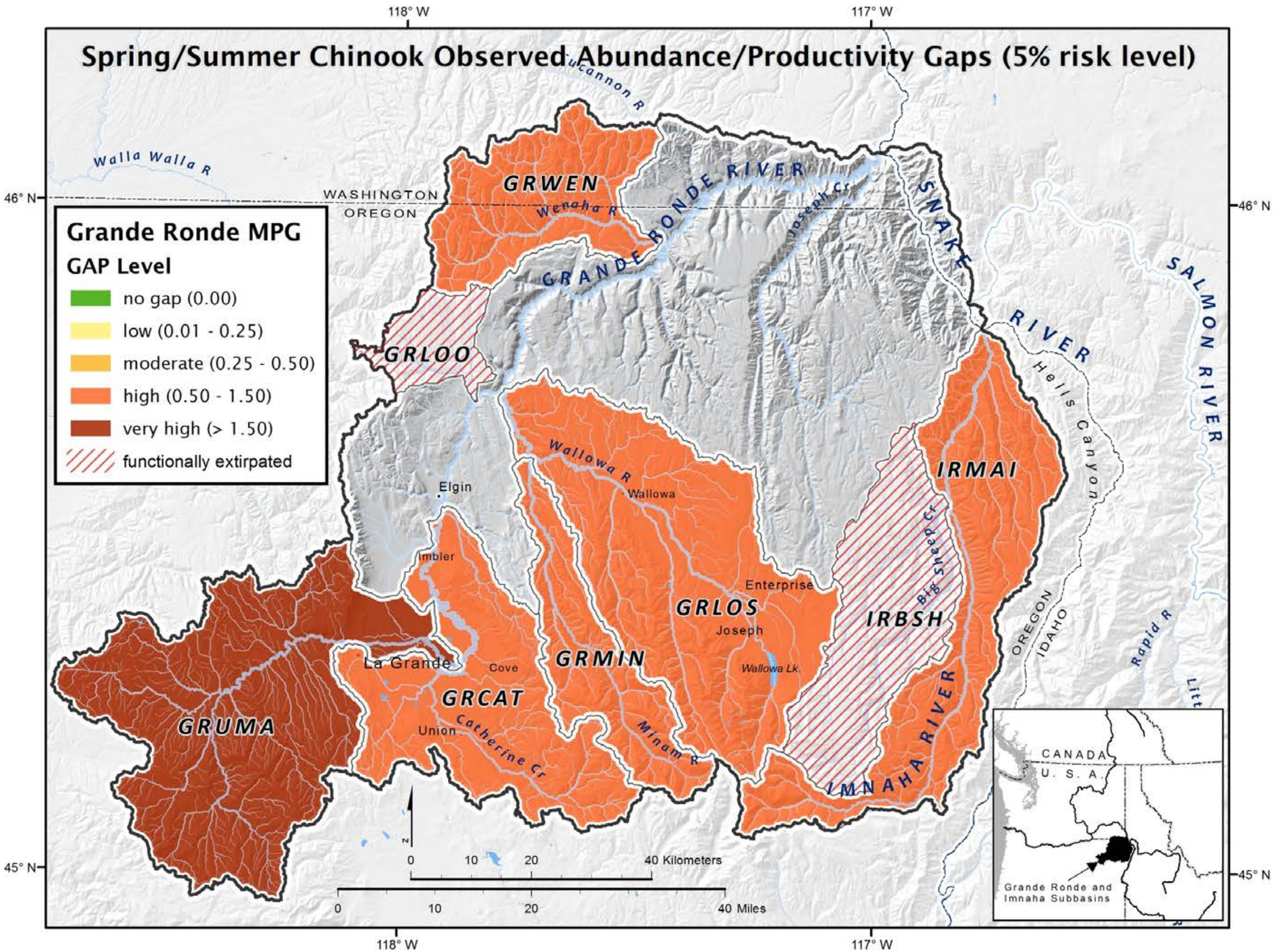
Jeff Jorgensen (NOAA Fisheries), Andrew Murdoch (WDFW), Jeremy Cram (WDFW), Charlie Paulsen (Paulsen Environmental Consulting), Tom Cooney (NOAA Fisheries), Rich Zabel (NOAA Fisheries), Chris Jordan (NOAA Fisheries)

Lake Chelan
Phelps Creek
Ice Cr
Napeequa River
White River
Indian Cr
Rock Cr
Entiat River
NF Entiat R
Little Wenatchee R
Panther Cr
Chiwawa R
Rainy Cr
Mad River
Mud Cr
Chiwawa Rearing Pond
Nason Creek
Whitepine Cr
Chiwaukum Cr
Chumstick Creek
Tillicum Cr
Entiat NFH
Roaring Cr
Eagle Creek
French Cr
Icicle Creek
Wenatchee River
Swakane Creek
Leavenworth NFH
Jack Creek
Mountaineer Cr
ROCKY REACH DAM
Peshastin Cr
Ingalls Creek
Mission Cr
Ruby Cr
Transen Cr
Scotty Cr
N
NOAA Fisheries
ROCK ISLAND DAM
5 0 5 10 15 20 Miles
5 0 5 10 15 20 Kilometers
Map prepared by NOAA Fisheries, December 2012

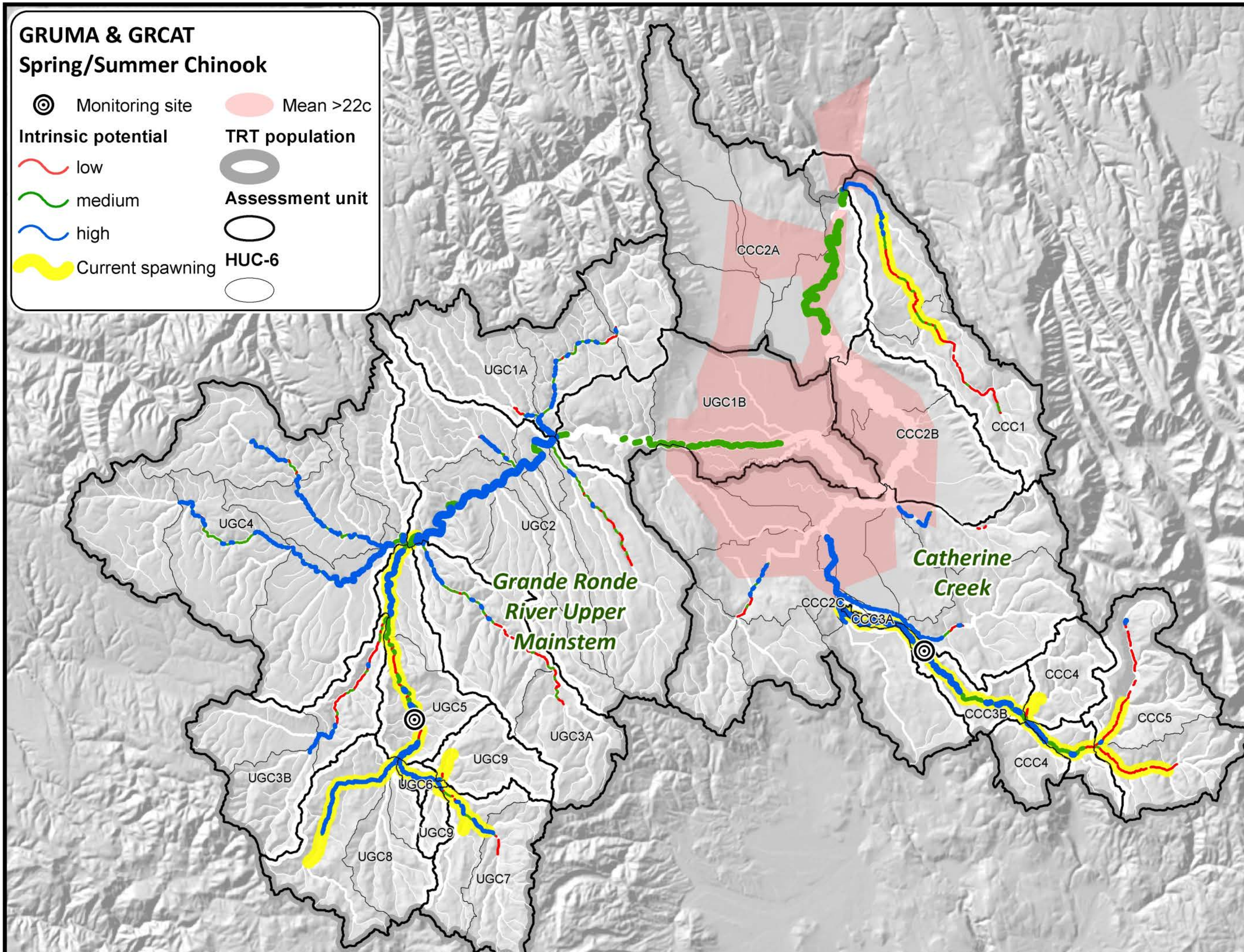
Location	Actions
Upper Wenatchee River	Riparian plantings for bank stabilization, connection to floodplain and/or oxbows, large wood enhancement
Chiwawa River	Culvert replacements, brook trout control, nutrient additions
Nason Creek	Floodplain restoration (plantings), increase large wood complexes, side- & off-channel reconnections, improved fish passage, nutrient additions
Little Wenatchee River	Reduce fine sediments (riparian restoration), restore riparian/floodplain function (road decommissioning, riparian plantings), nutrient additions
White River	Riparian restoration, nutrient additions

2.1: Grande Ronde Spring Chinook Population Models

Thomas D. Cooney (NWFSC), Richard W. Carmichael (ODFW), Brian C. Jonasson (ODFW), Edwin Sedell (ODFW) & Timothy L. Hoffnagle (ODFW)



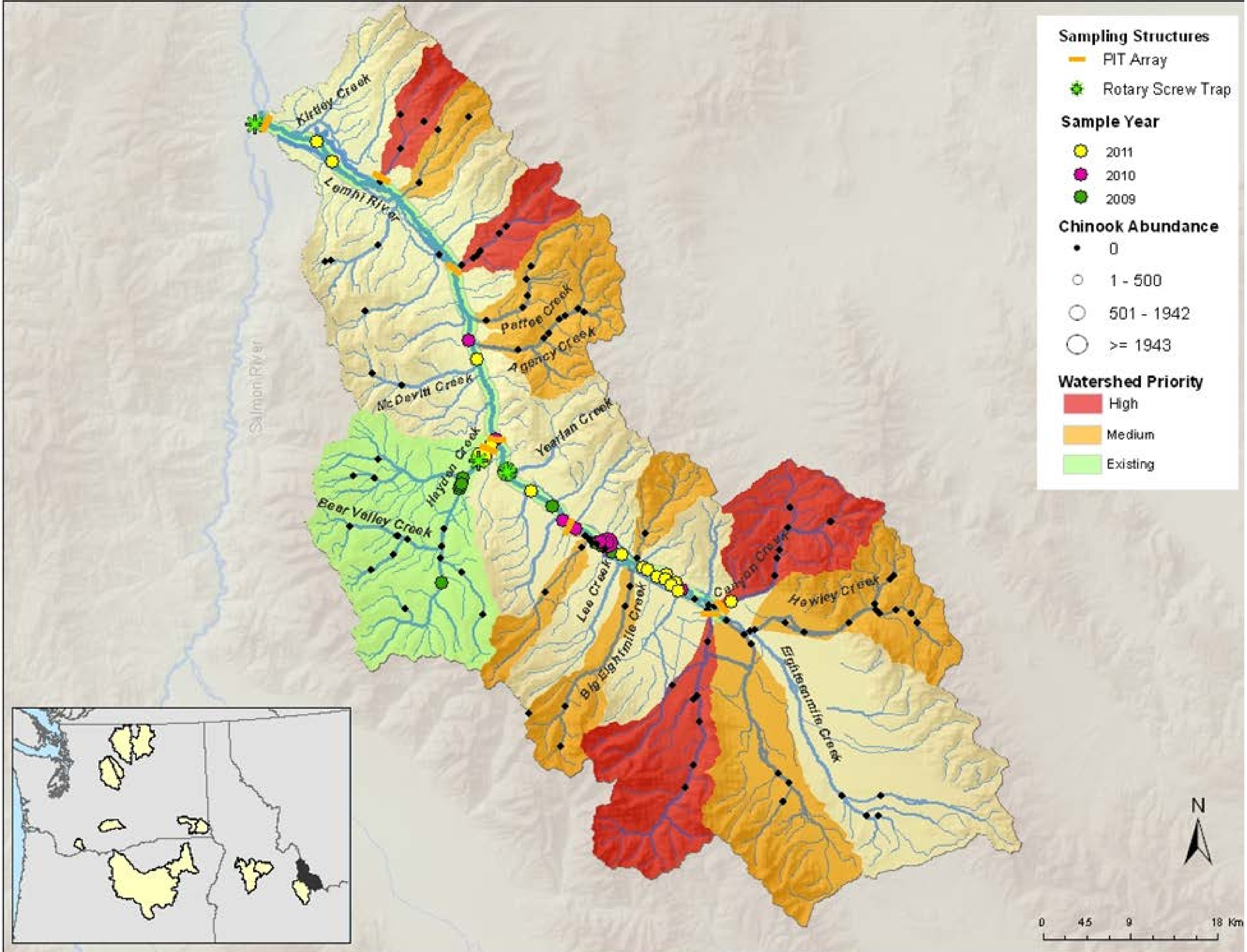
Spring/Summer Chinook Observed Abundance/Productivity Gaps (5% risk level)
Grande Ronde MPG
GAP Level
no gap (0.00)
low (0.01 - 0.25)
moderate (0.25 - 0.50)
high (0.50 - 1.50)
very high (> 1.50)
functionally extirpated
118° W
117° W
46° N
45° N
WASHINGTON
OREGON
Walla Walla R
Tucannon R
GRWEN
Wenaha R
GRANDE RONDE RIVER
Joseph Cr
SNAKE RIVER
SALMON RIVER
GRLOO
Hells Canyon
IRMAI
Wallowa R
Wallowa
Elgin
Imbler
Enterprise
GRLOS
Joseph
Big Sheep Cr
IRBSH
OREGON
IDAHO
Rapid R
La Grande
Cove
GRMIN
Wallowa Lk.
GRCAT
GRUMA
Union
Catherine Cr
Minam R
IMNAHA RIVER
0 10 20 40 Kilometers
0 10 20 40 Miles
CANADA
U. S. A.
Grande Ronde and Imnaha Subbasins



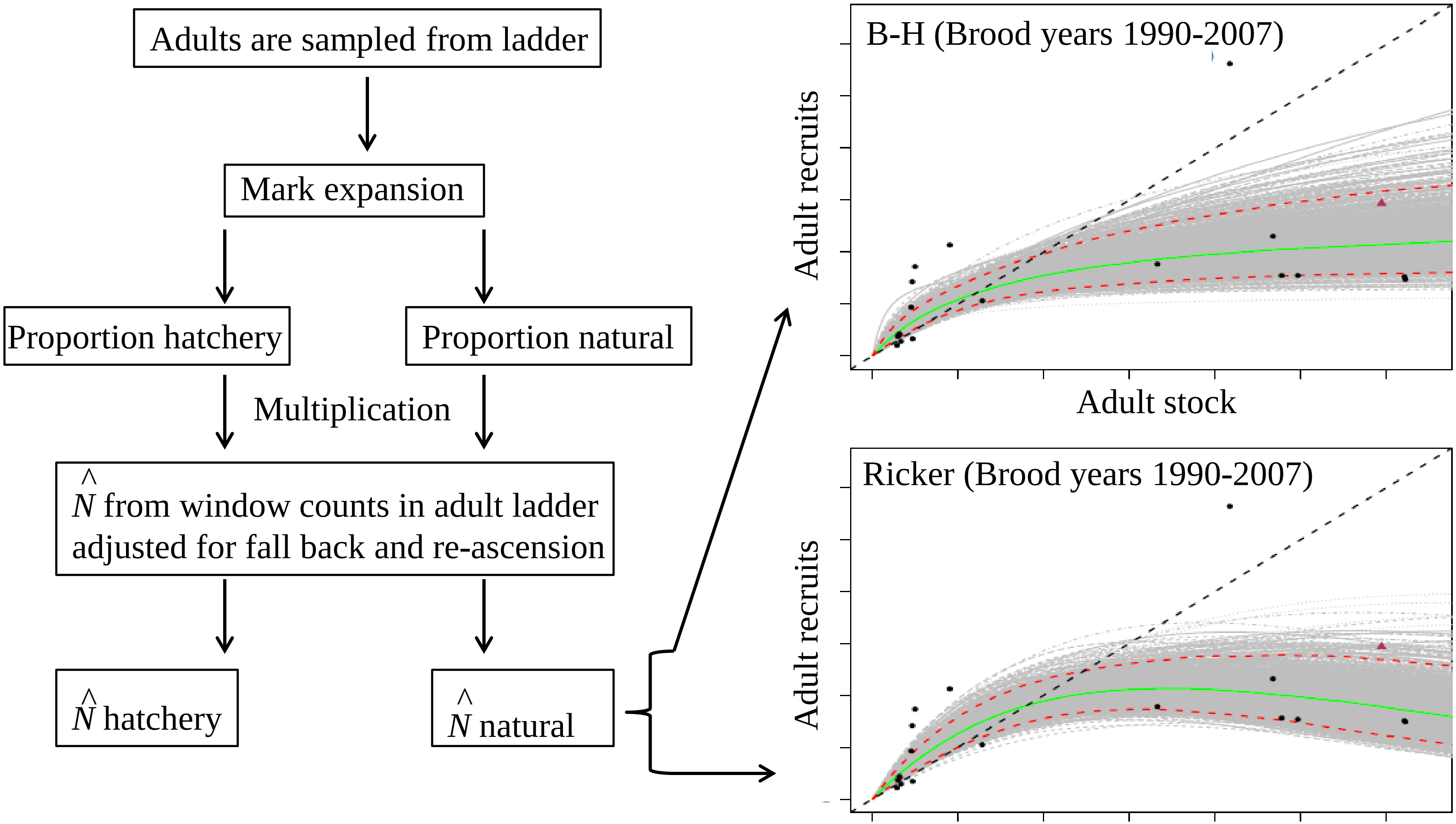
GRUMA & GRCAT
Spring/Summer Chinook
Monitoring site
Mean >22c
Intrinsic potential
low
medium
high
Current spawning
TRT population
Assessment unit
HUC-6
CCC2A
UGC1A
UGC1B
CCC2B
CCC1
UGC4
UGC2
Catherine Creek
Grande Ronde River Upper Mainstem
CCC2C
CCC3A
CCC4
UGC5
CCC3B
CCC5
UGC3A
UGC9
CCC4
UGC3B
UGC6
UGC9
UGC8
UGC7

2.2: Salmon Subbasin Integrated Status and Effectiveness Monitoring Project Watershed Model – Lemhi River

Chris Beasley (Quantitative Consultants, Inc.), Jody White (Quantitative Consultants, Inc.), Chris Jordan (NOAA Fisheries), Matt Nahorniak (South Fork Research, Inc.)


Sampling Structures
PIT Array
Rotary Screw Trap
Sample Year
2011
2010
2009
Chinook Abundance
0
1 - 500
501 - 1942
>= 1943
Watershed Priority
High
Medium
Existing
Kirtley Creek
Lemhi River
Pattee Creek
Agency Creek
McDevitt Creek
Yearian Creek
Hayden Creek
Bear Valley Creek
Lee Creek
Big Eightmile Creek
Canyon Creek
Hawley Creek
Eighteenmile Creek
Salmon River
N
0
4.5
9
18 Km

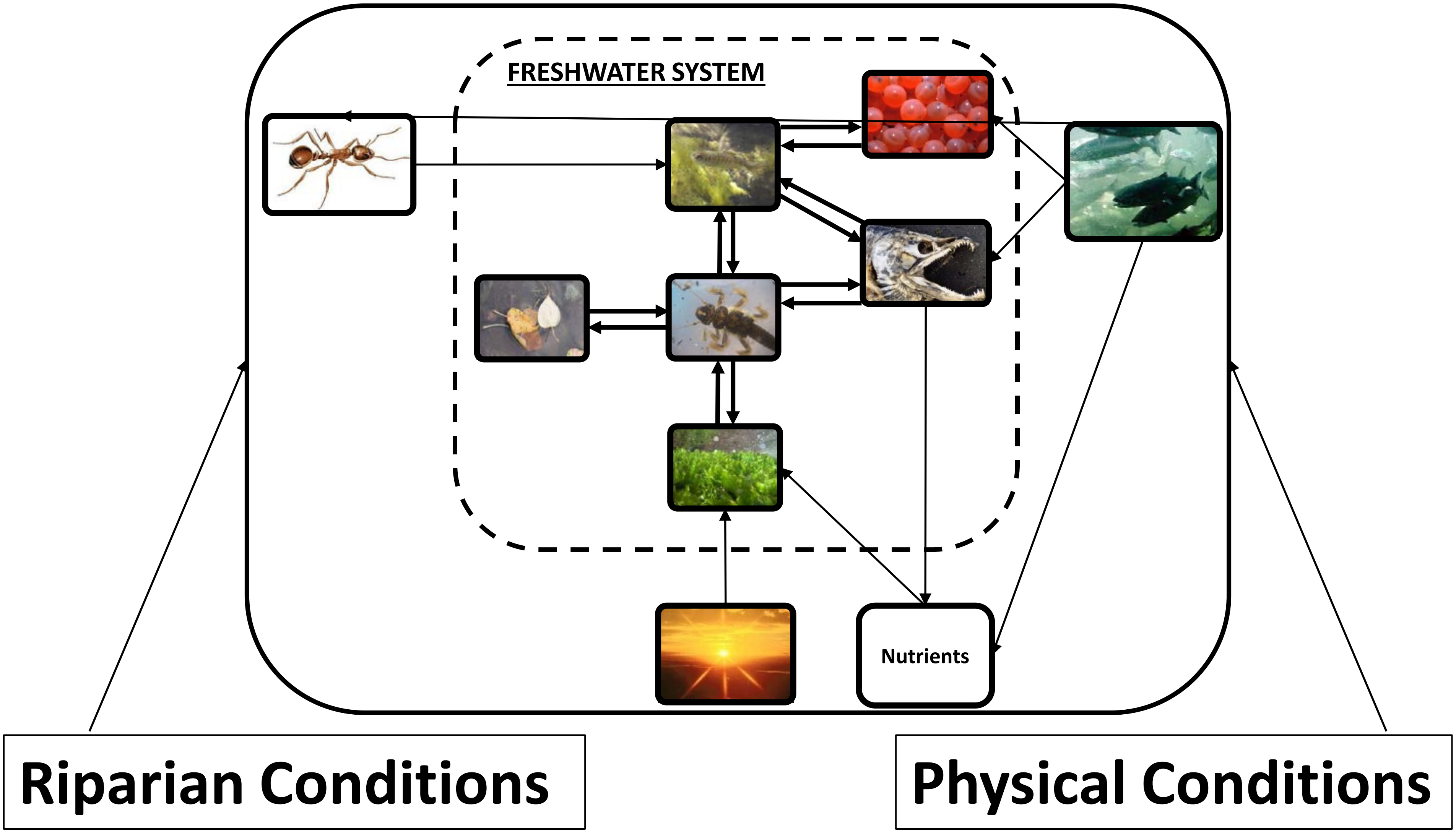
ESTIMATING ANNUAL PASSAGE ABUNDANCE* AT LOWER GRANITE FOR NATURAL ADULTS AND PRELIMINARY STOCK-RECRUITMENT ANALYSES



*Conceptual diagram with details in report

The Trophic Productivity Model: Incorporating Food Webs into the Life Cycle

Ryan Bellmore (USGS), Michael Newsom (BOR) & Alex Fremier (U. of Idaho)



Interior Columbia River basin populations

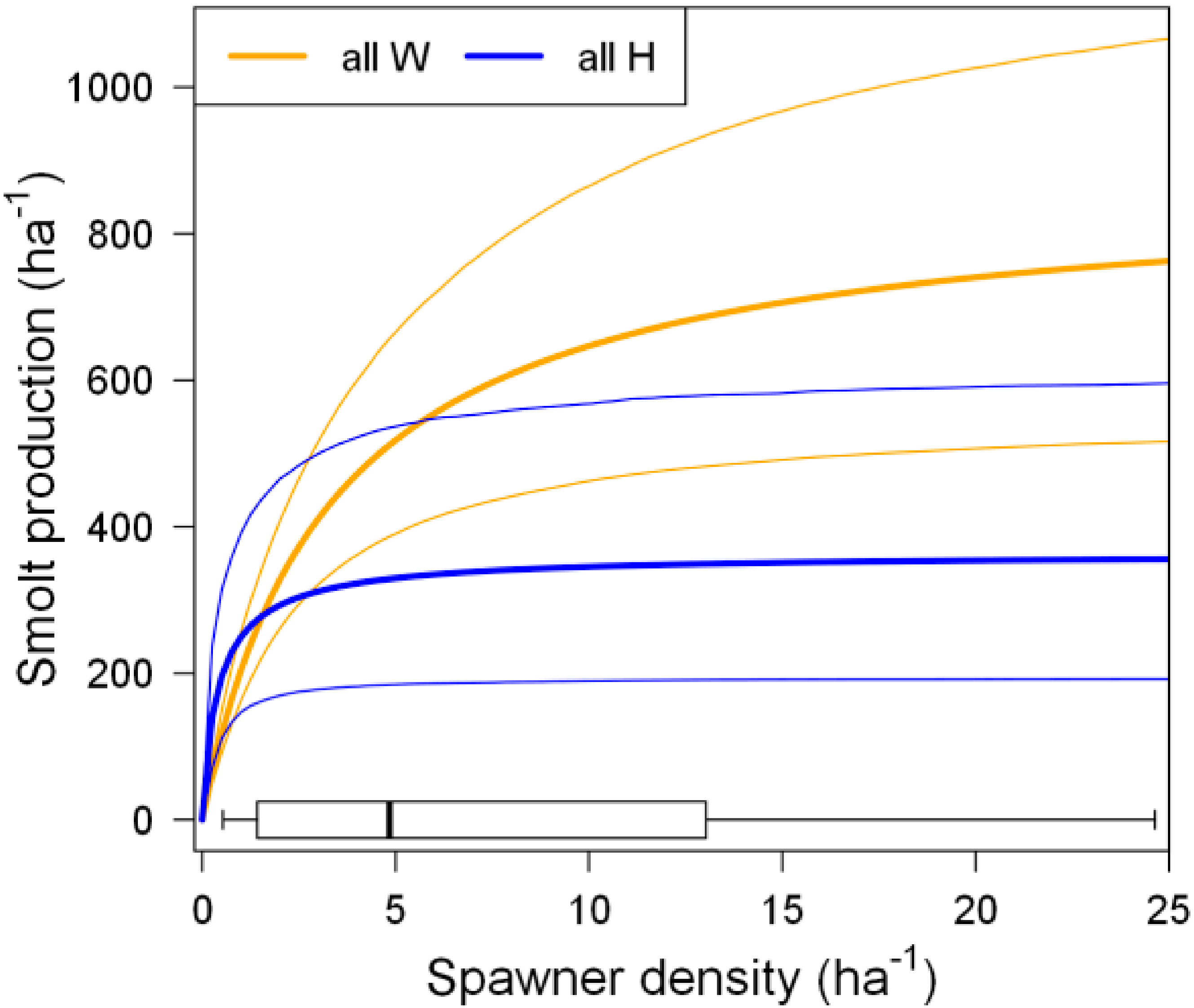
Neala Kendall (WDFW), Rich Zabel (NOAA Fisheries)

- Rapid River (Little Salmon River)
- Potlatch River
- Catherine Creek
- Umatilla River
- Toppenish Creek
- Naches River
- Satus Creek
- Upper Yakima River

Photo: John McMillan

	Survival with 50% reduction in bird predation:	% Survival Improvement
Yearling Chinook	0.776	1.8 %
Steelhead	0.625	10.6 %

Hatchery-Wild Interactions



Hydrosystem survival improvements

Snake River spring/summer Chinook

Year	s_I	p_T	D	s_d
2005	0.48	0.93	1.070	1.01
2006	0.57	0.66	0.470	0.50
2007	0.60	0.21	0.800	0.64
2008	0.66	0.46	0.820	0.73
2009	0.56	0.42	0.650	0.59
Average	**0.574**	**0.536**	**0.762**	**0.693**
Previous	0.472	0.8	0.466	0.460

Snake River steelhead

Year	s_I	p_T	D	s_d
2005	0.27	0.93	1.300	1.20
2006	0.58	0.65	0.520	0.53
2007	0.38	0.4	1.200	0.70
2008	0.49	0.41	0.600	0.53
2009	0.7	0.45	0.950	0.80
Average	**0.484**	**0.568**	**0.914**	**0.754**
Previous	0.268	0.838	0.783	0.686

New Data from CSS 2012

Hydrosystem survival improvements

Snake River spring/summer Chinook

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Snake River steelhead

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2008	0.49	0.41	0.600	0.53
2009	0.7	0.45	0.950	0.80
Average	**0.484**	**0.568**	**0.914**	**0.754**
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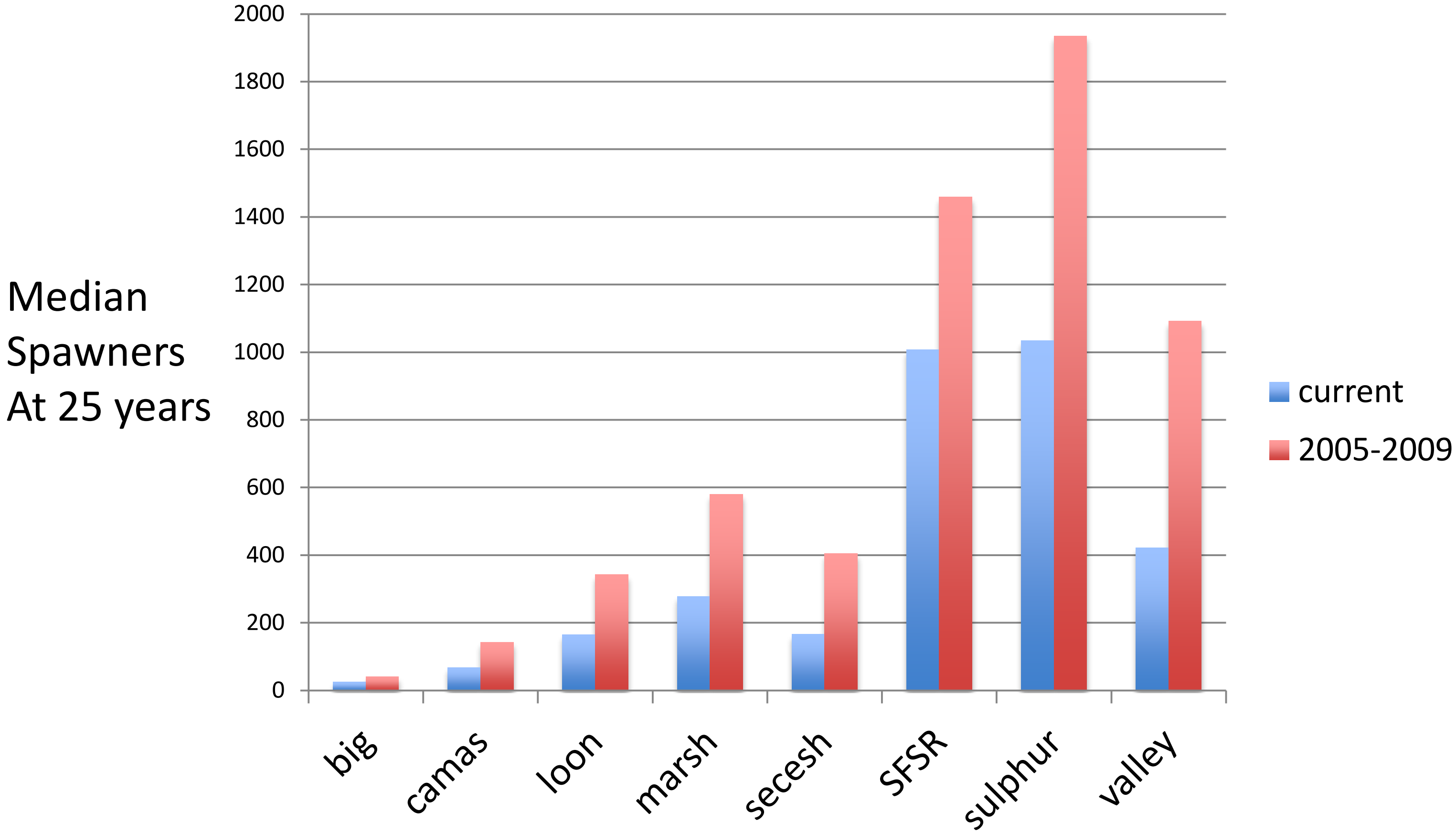
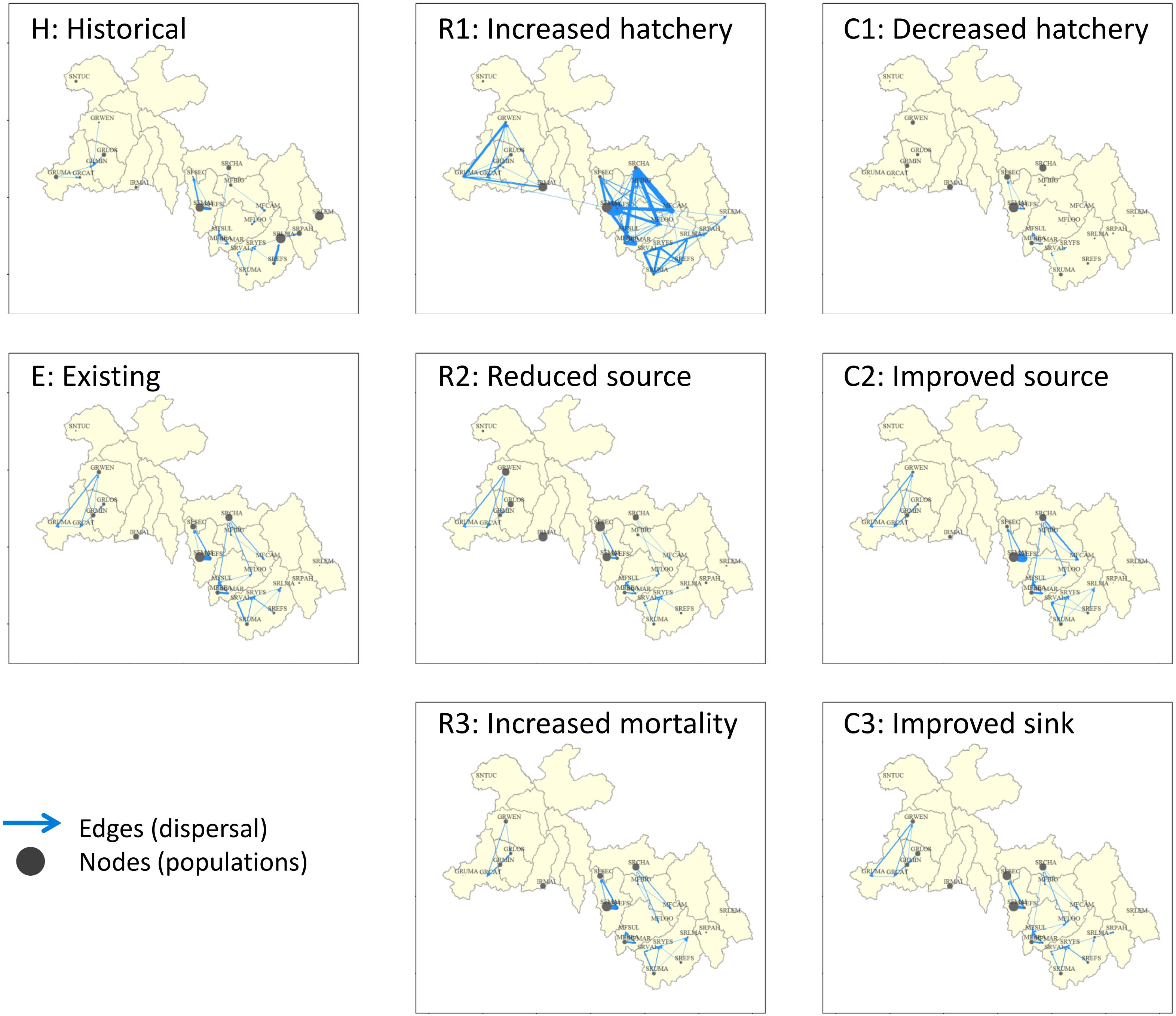
New Data from CSS 2012

Hydrosystem survival improvements




H: Historical
R1: Increased hatchery
C1: Decreased hatchery
E: Existing
R2: Reduced source
C2: Improved source
R3: Increased mortality
C3: Improved sink
Edges (dispersal)
Nodes (populations)

ISAB Review: General Comments

Life-cycle models represent a means to test or explore these hypotheses while also examining sensitivity of uncertain parameters or measurements on desired outcomes. Information from life-cycle models **can help with prioritizing restoration efforts.**

ISAB Review: Collaboration

The ISAB **encourages broader collaborations with the Watershed Program** in NOAA Fisheries and other experts on the freshwater ecology of salmon to develop quantitative fish/habitat relationships that could be incorporated within the life-cycle models.

ISAB Review: Hatchery Impacts

Chapter 4 describes a novel modeling approach for investigating the likely effects of hatchery supplementation on wild salmon population dynamics. The ISAB commends the extensive use of existing data here and in many of the other models.

We anticipate that this effort will be significant in informing policy and management in the Columbia Basin.

ISAB Review: Estuary Ocean

The ocean model builds upon some earlier efforts on factors affecting Chinook and steelhead survival at sea, but it is likely that additional effort could refine and **improve these relationships by considering additional variables examined by NOAA Fisheries ocean researchers**.

ISAB Review: Additional Factors

Two key factors not addressed, and that may slow salmon recovery, are the widespread proliferation of **nonnative species** and continued use and discharge of toxic chemicals in the subbasins. The ISAB encourages NOAA Fisheries scientists address nonnative species and toxic chemicals in subsequent life-cycle models.

ISAB Review: Summary

The incorporation of quantitative fish/habitat functional relations in tributaries and the estuary remains a key challenge

Although significant challenges remain, building life-cycle models is an effective means for identifying data needs. These data needs should be fulfilled whenever possible. The ISAB looks forward to seeing further progress on this important endeavor in the near future.