Straying by adult salmon and steelhead: literature review results

Matthew Keefer & Chris Caudill

Department of Fish and Wildlife Sciences
University of Idaho

University of Idaho
College of Natural Resources

Straying Review

- Task 1: Review
  - General concepts: imprinting, homing, straying
  - Critical review of methods used to estimate straying
  - Comments on standardized terminology, ‘lexicon’
  - Summary of published straying data
    - Product: a “digestible” reference document

Straying Models

- Task 2: Modeling exercises
  - General model: Donor versus Recipient populations
  - Applied study: Snake River steelhead as donor pop.

    Barged vs. In-river juvenile migration histories

    Inputs: smolt index, barge rates, SARs, stray rates

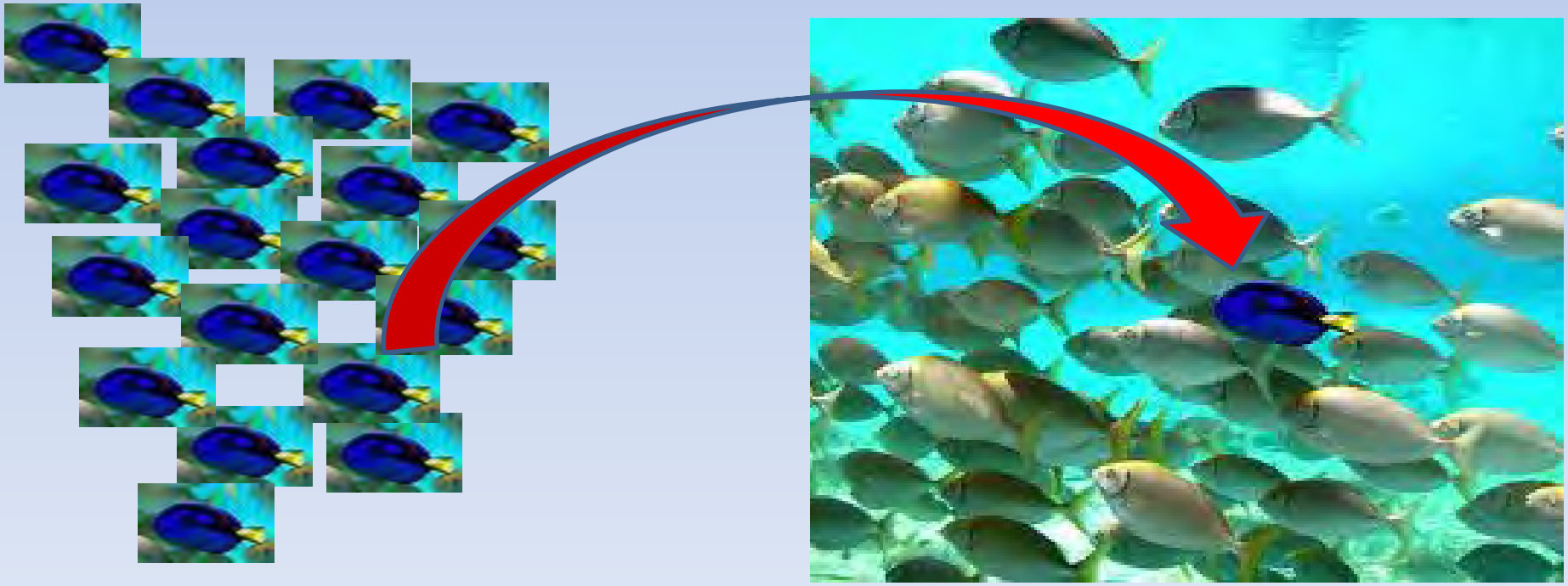
- Products: spreadsheet tool for regional managers + Synthesis of model scenarios

Straying lexicon

- Straying *from* vs. straying *into* a population

5% strayed *from* donor population

2% of recipient population is strays



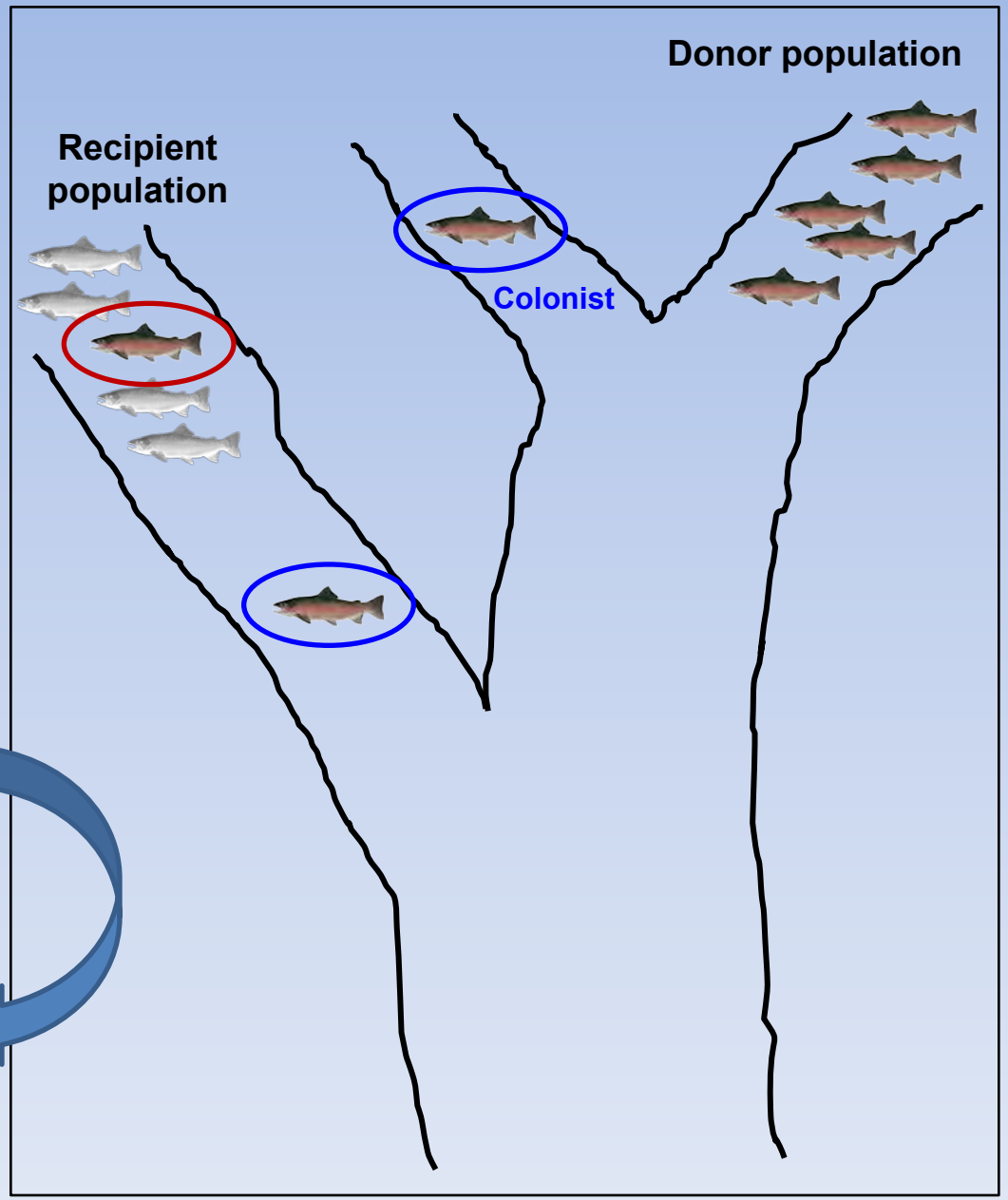
Population A

Population B

Straying lexicon

- Permanent straying
  - Some don't breed with recipient pop: loss from donor population, possible colonist
  - Breeders: donor loss + recipient gain

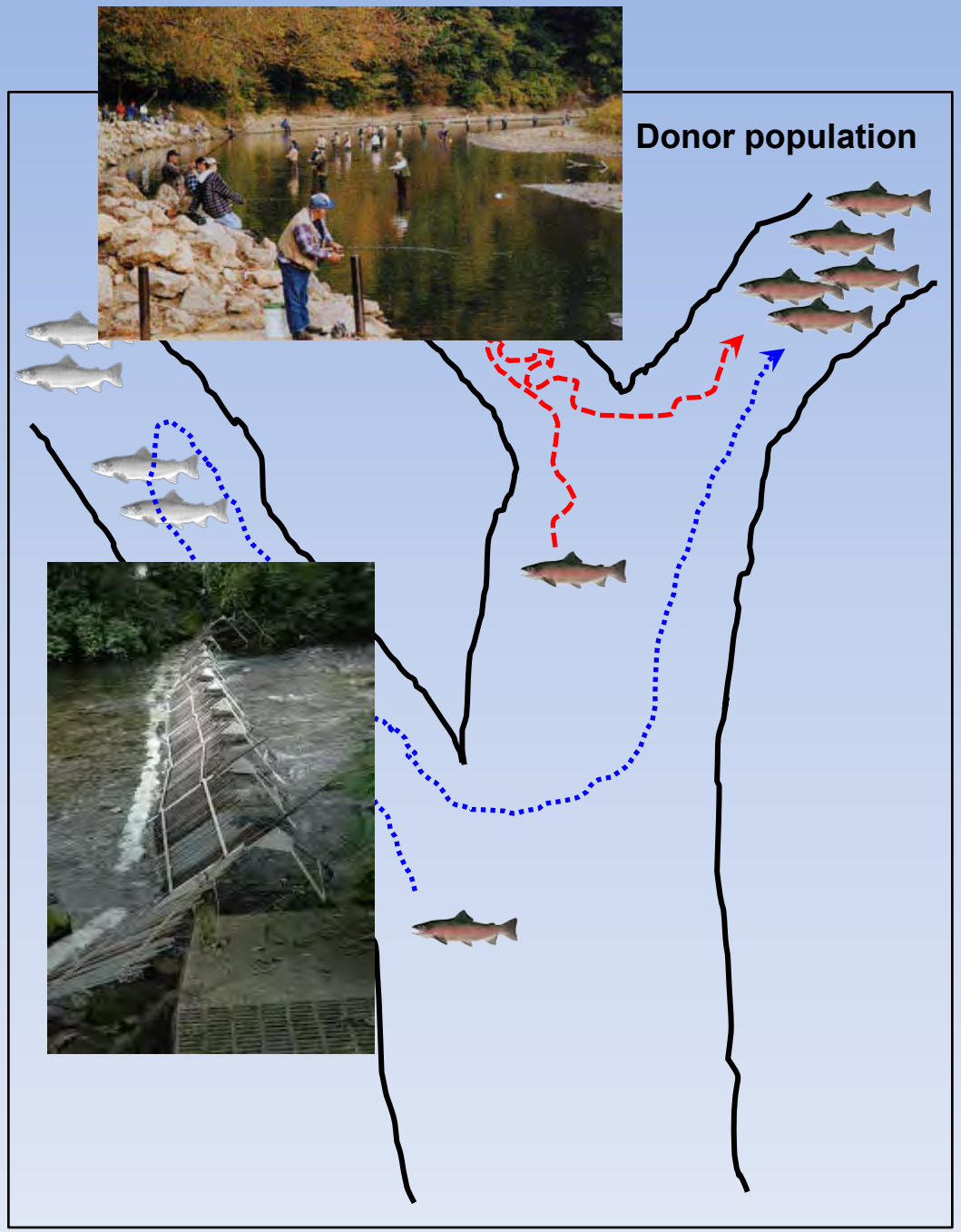
- 'Undesirable' breeding stray = recipient population risk



Straying lexicon

- Temporary straying
  - ‘Wandering’
    ‘Exploring’
    ‘Proving, Testing’
    ‘Thermoregulating’
  - Just a detour: Exit before breeding

- Differentiating permanent and temporary straying is often challenging due to ambiguous outcomes



The lexicon: how to estimate straying?

- Spatial scale is critical, yet difficult to define
  - Genetic distance more relevant than geographic distance; Hatchery practices confound
- All potential straying locations (and times) are rarely surveyed for donor populations
- All fish origins are rarely known for recipient populations
- Ambiguous outcomes are common

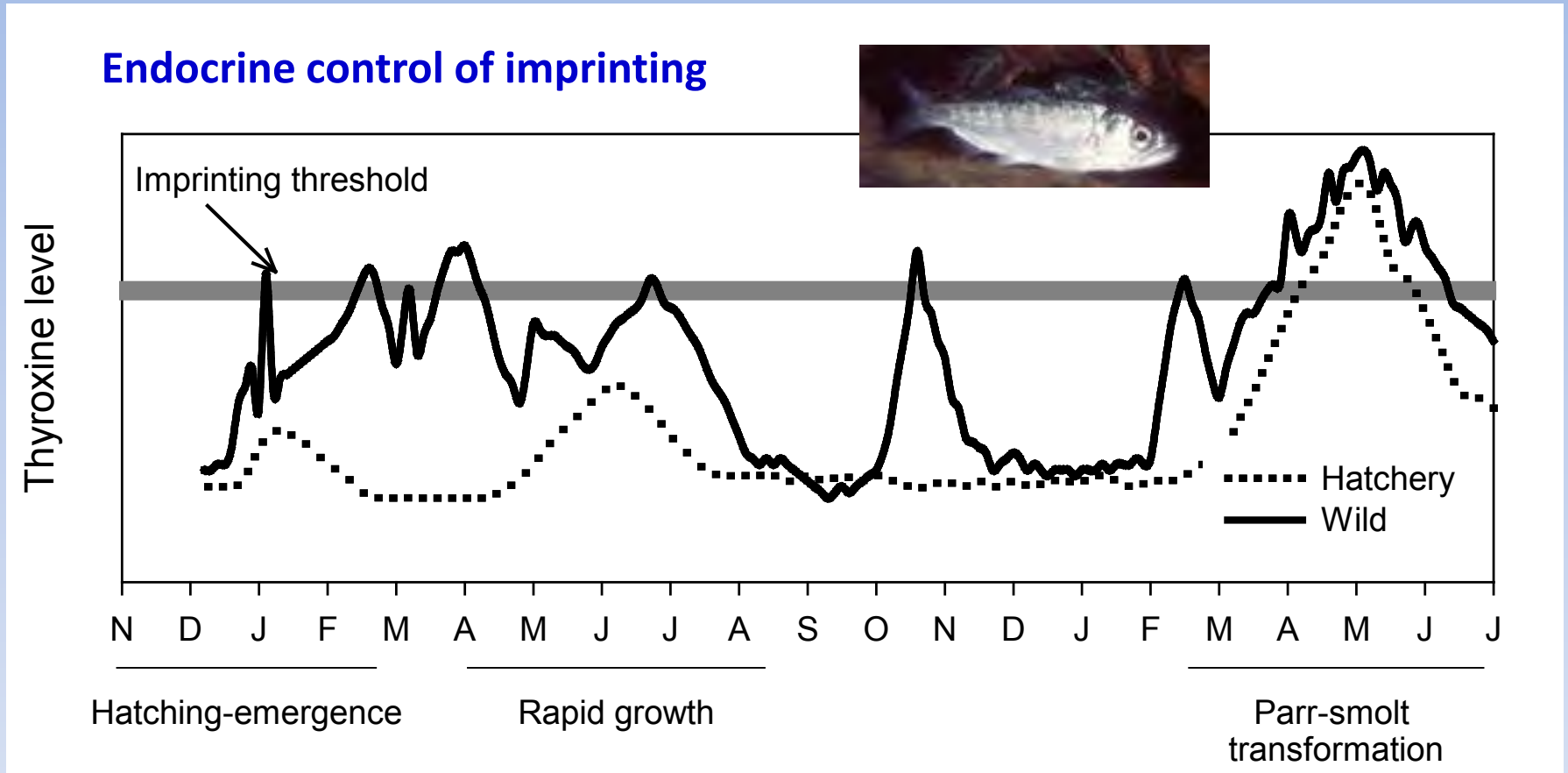
- Despite large straying literature, comparisons are challenging

Straying mechanisms

- Juvenile effects
  - Olfactory imprinting, sequential imprinting, neural development, endocrine physiology
  - Hatchery rearing

- Adult effects
  - Olfactory recognition, sensory failure, memory, age
  - Reproductive behaviors
- Environmental / Landscape effects
  - Thermal refuge; Catastrophe

Mechanism: insufficient imprinting



Modified from Dittman & Quinn (1996)

- Hatchery fish stray more: lower juv hormone levels, reduced neural development, retarded imprinting, etc.

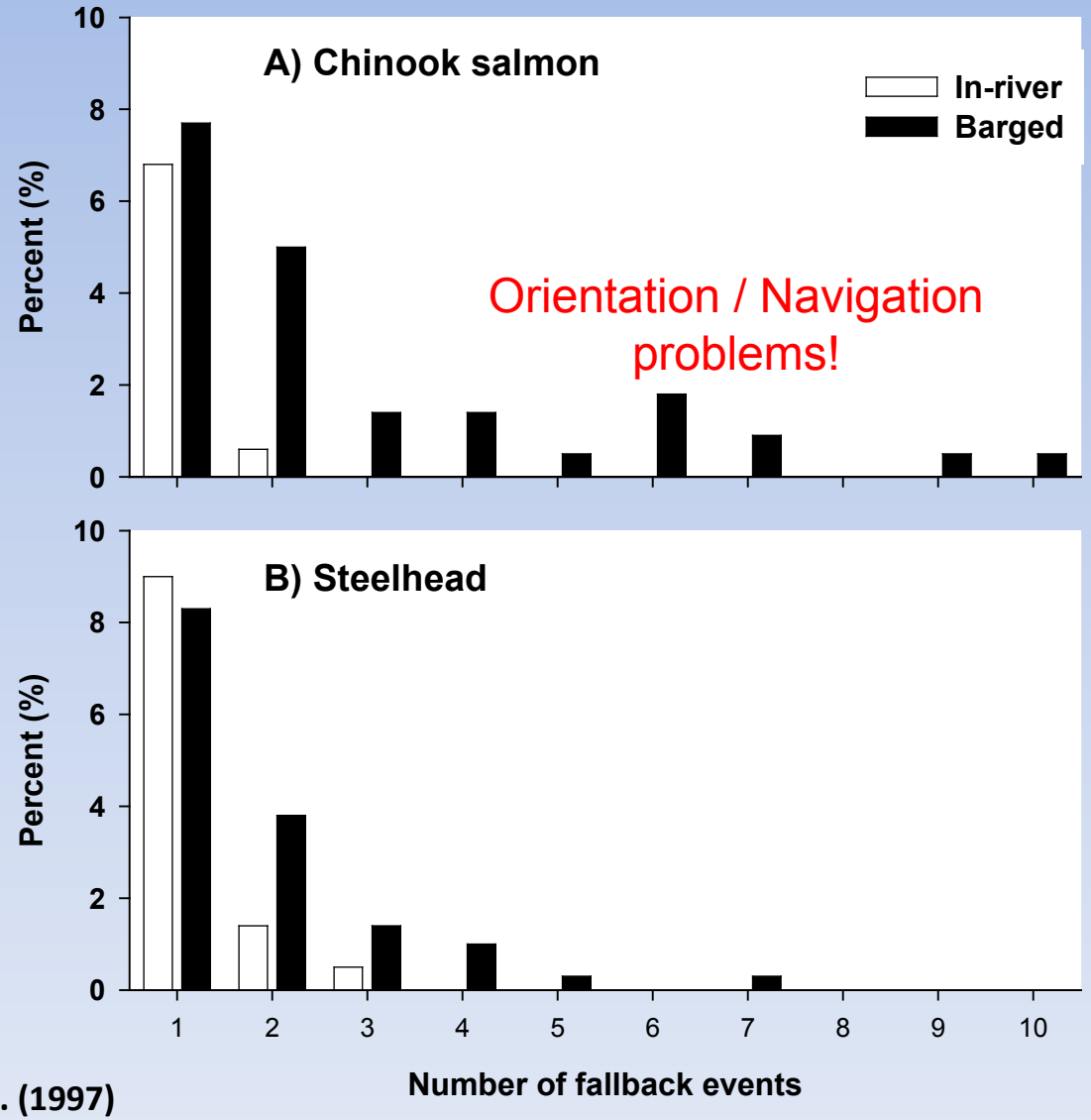
Mechanism: interrupted imprinting

- Barged steelhead: straying = 4-8% (Keefer et al. 2008, Marsh et al. 2012)
  - Barged steelhead: straying = 6-9% or more (Marsh et al. 2012)
- Trucked coho: straying = <0.1%, 3%, 6%, 21% (Solazzi et al. 1991)

Mechanism: adult behaviors

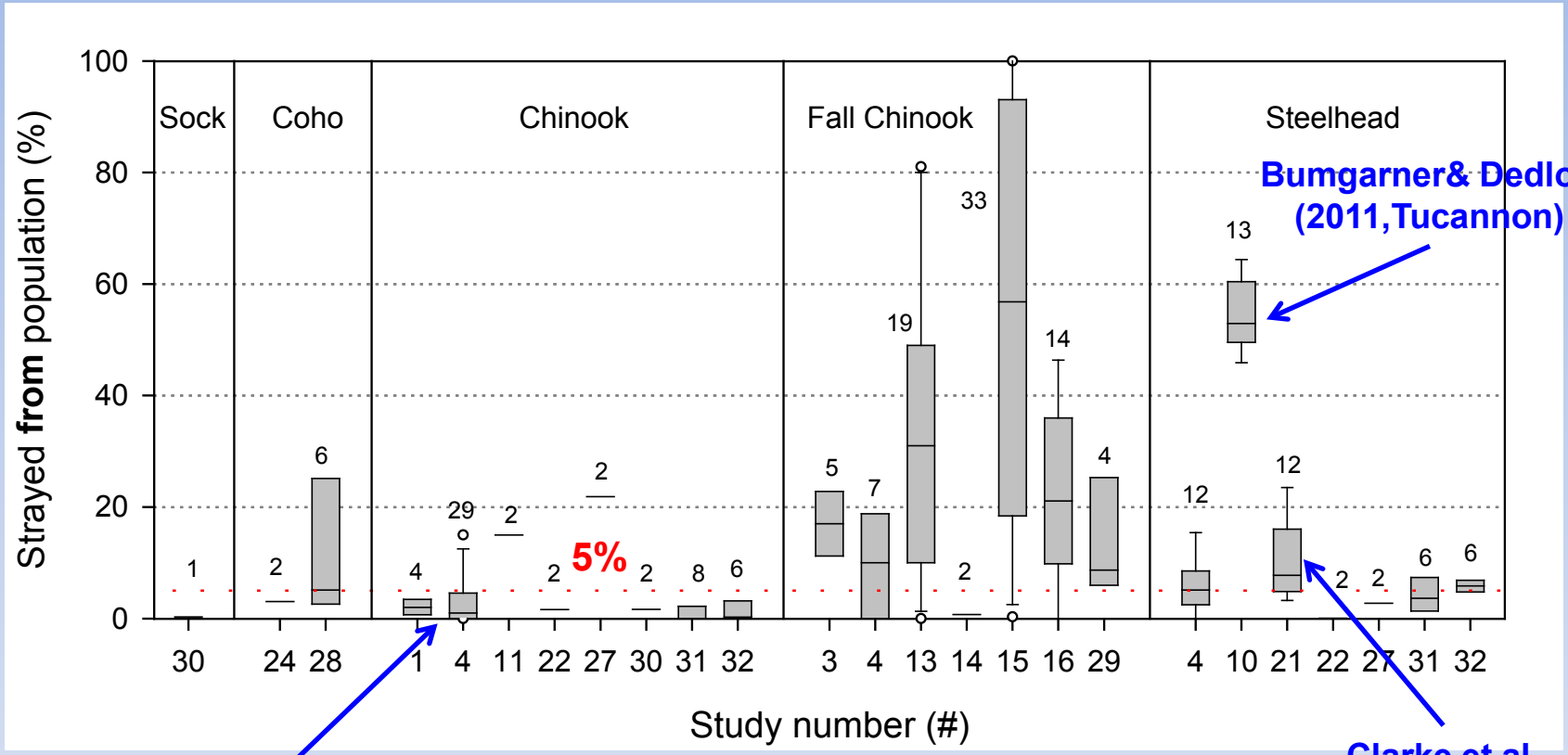
Barged Chinook salmon: ~3.8 times more likely to fall back at dams (P<0.001)

Barged steelhead: ~1.7 times more likely to fall back (P<0.023)



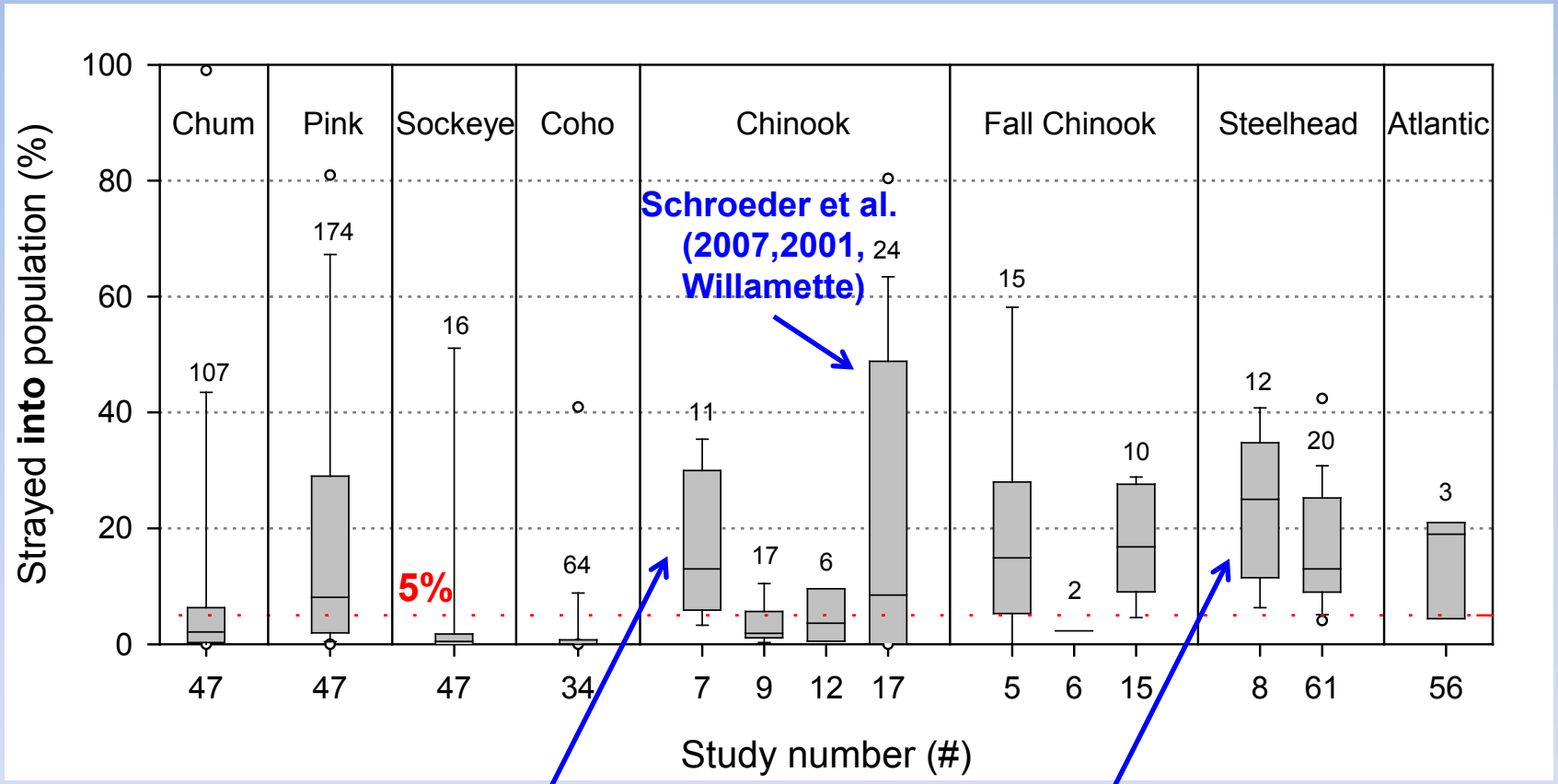
Keefer et al. (2008); also see Chapman et al. (1997)

Stray rate data: COL River donors



Methods different in each study

Stray rate data: recipients



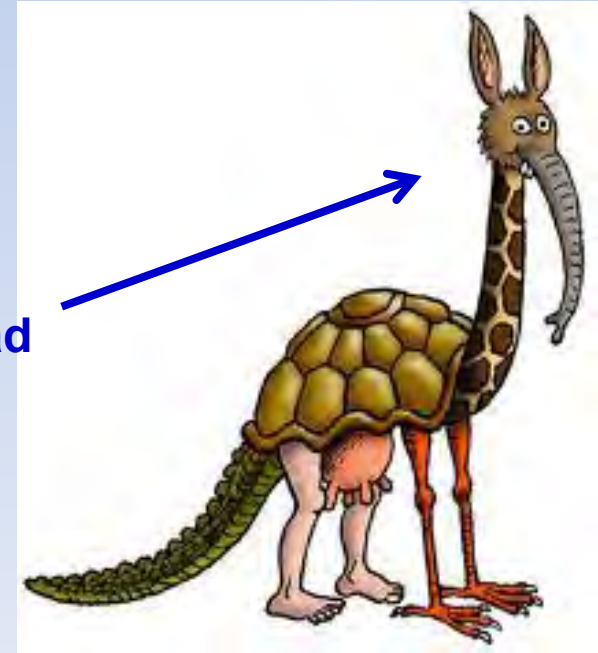
Narum et al.
(2008, John Day)

Ruzycki & Carmichael
(2010, John Day)

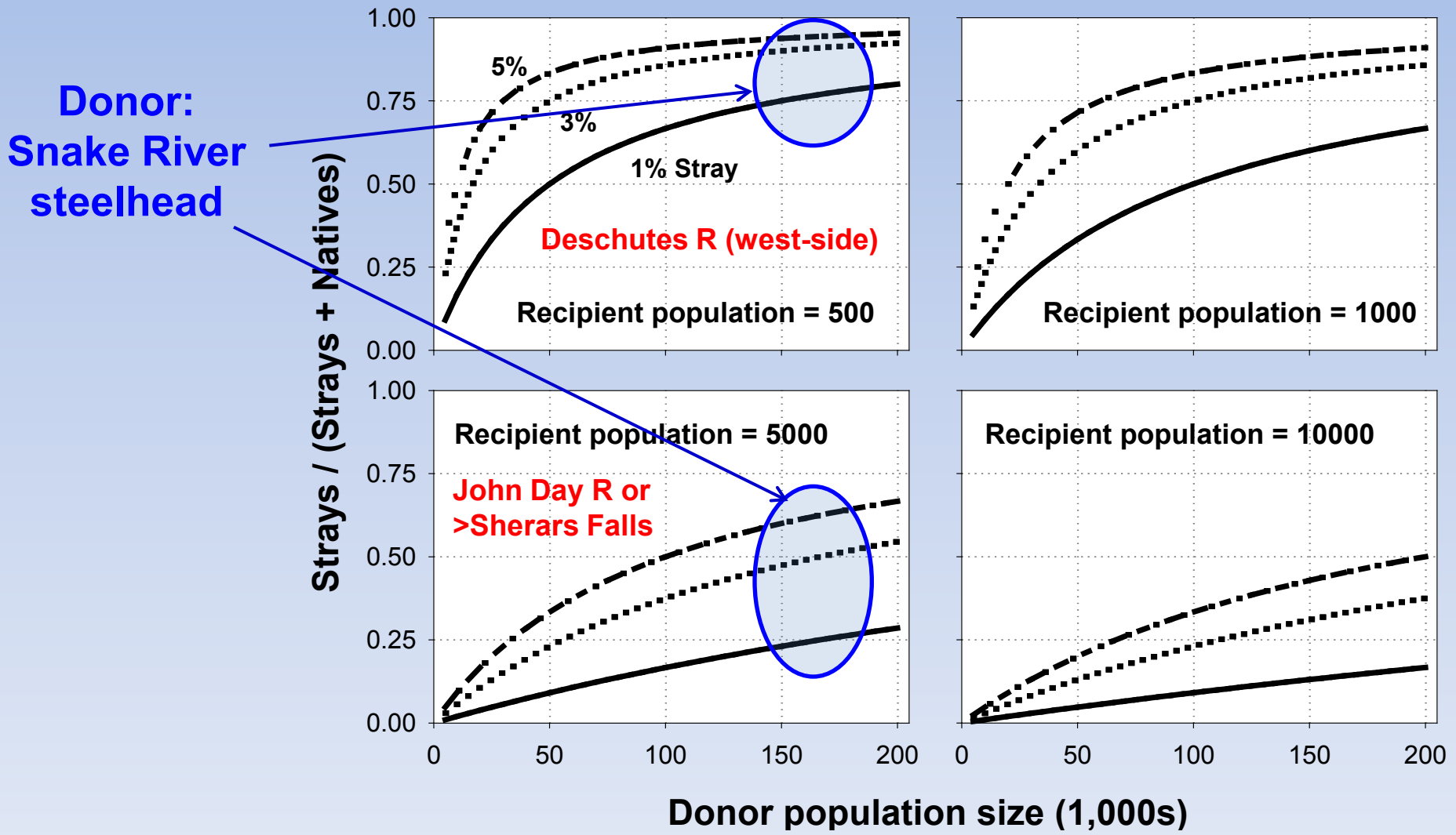
Modeling: Donor vs. Recipient populations

- Straying from large donor populations can create genetic and ecological risks for small recipient populations
- Risks are greatest when the donor population is less fit

Maladapted hatchery steelhead

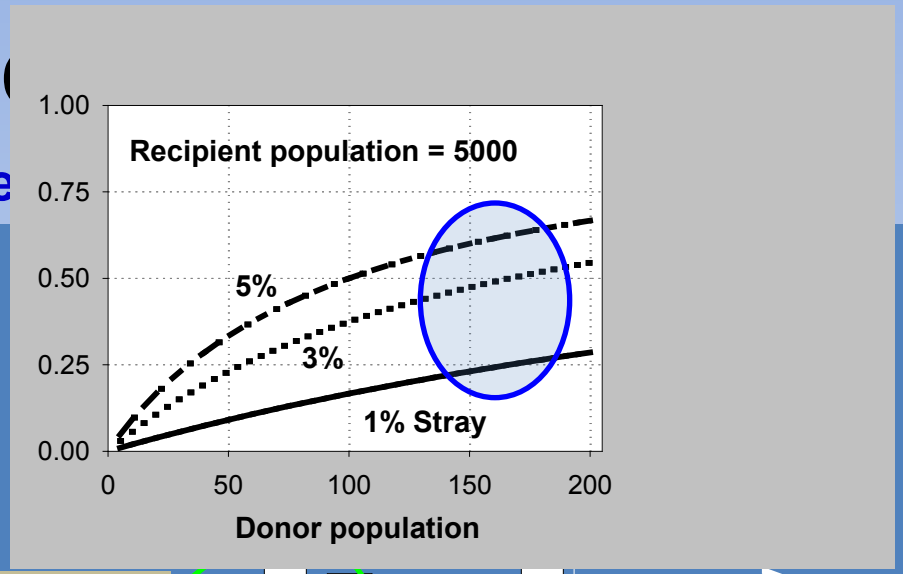


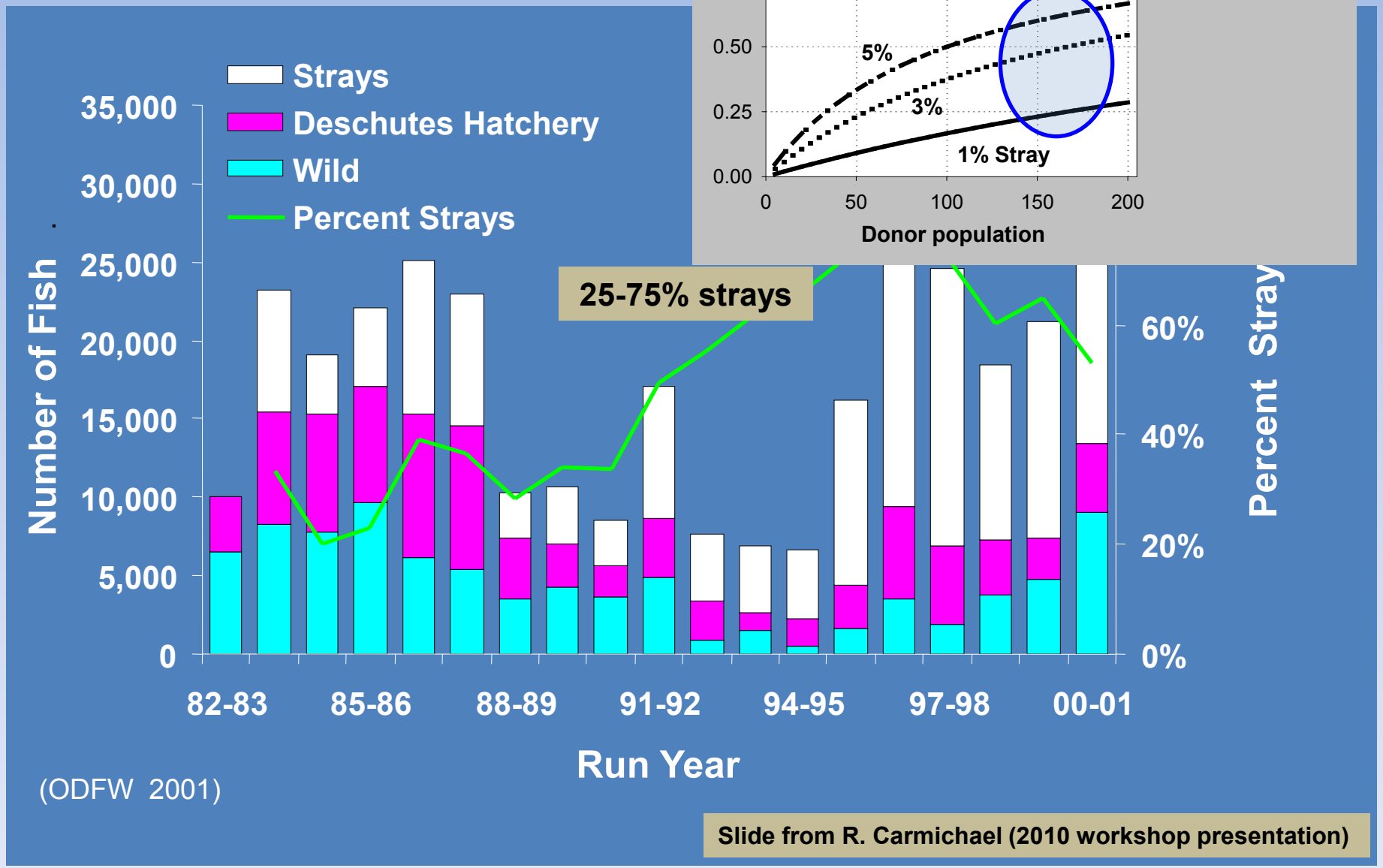
Donor vs. Recipient populations



Donor vs. Recipi

Summer steelhead escapeme





(ODFW 2001)

Slide from R. Carmichael (2010 workshop presentation)

Modeling: Can we predict the number of Snake River strays?

- How many smolts?
- How many transported vs. in-river?
- What are the Smolt-to-Adult Returns (SARs)?
- What is the adult stray rate?
  - Least reliable data

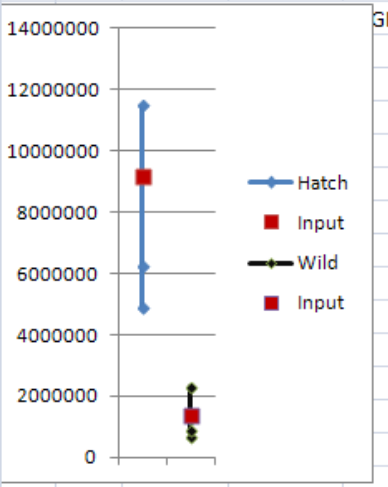
SNR steelhead model

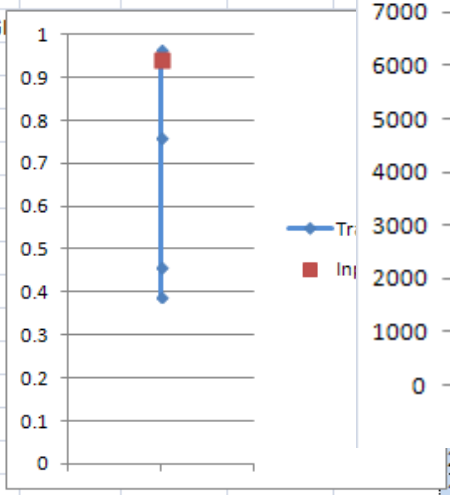
		Smolts at LGR		Transport proportion		
		H smolts	input		input	
min	1	4897819	9181718	1	0.39	0.94
max	1	11485828		1	0.964	
Q1	1	6246616		1	0.46	
Q3	1	9181718		1	0.76	
		W smolts	(13%)			
min	2	675549	1371981			
max	2	2297063				
Q1	2	934869				
Q3	2	1281196				

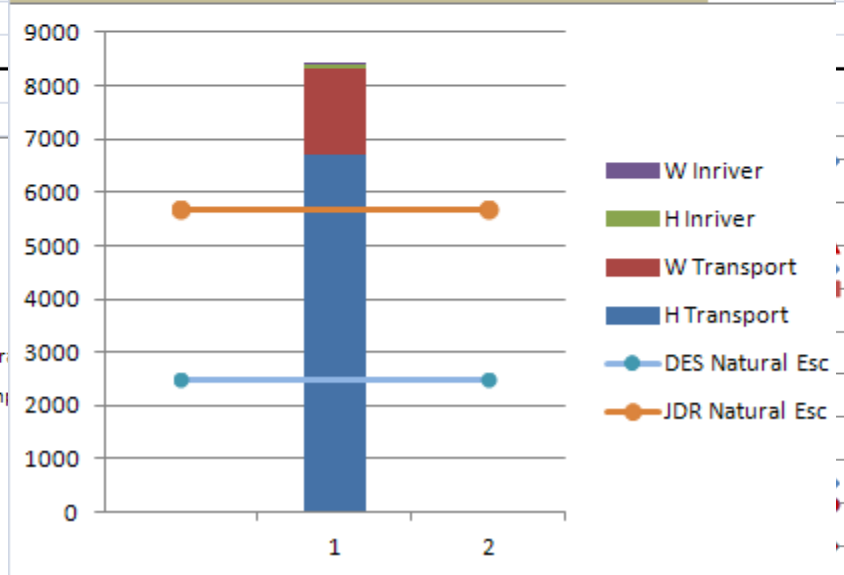
Calculations

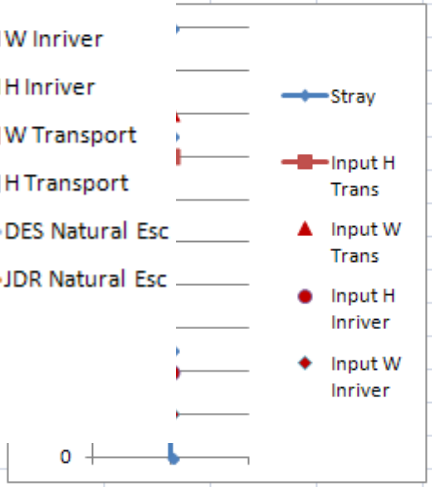
H smolts	9181718			
W smolts	1371981			
		SAR to LGR	BON adult (means)	Strays
H Trans	8630815	140035	191829	6714
W Trans	1289662	27910	40044	1602
H Inriver	550903	4742	6111	61
W Inriver	82319	885	1115	6

Stray rate (to single site: DES/JDR)	
H Trans	W Trans
0.035	0.04
H Inriver	W Inriver
0.01	0.005



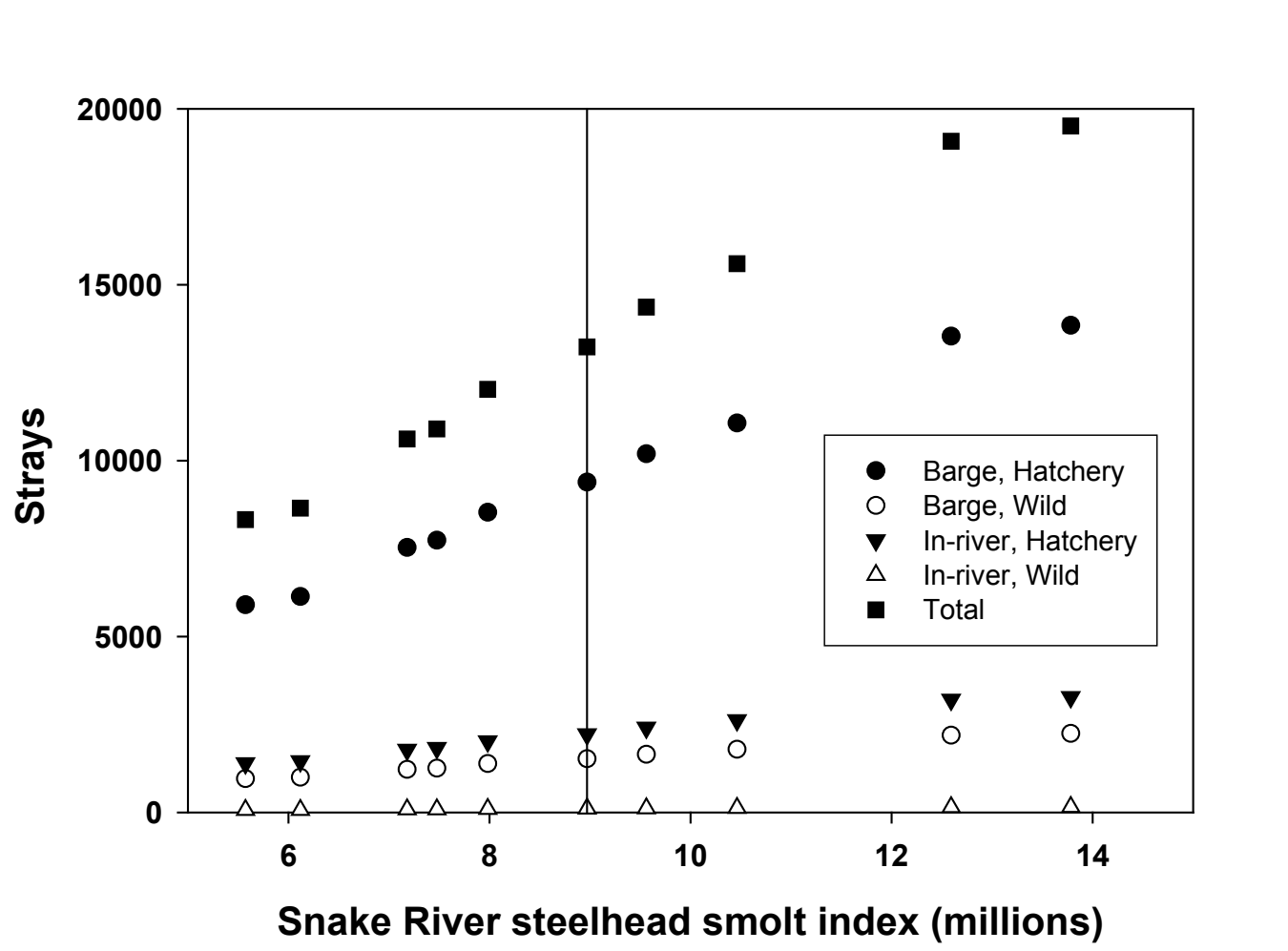






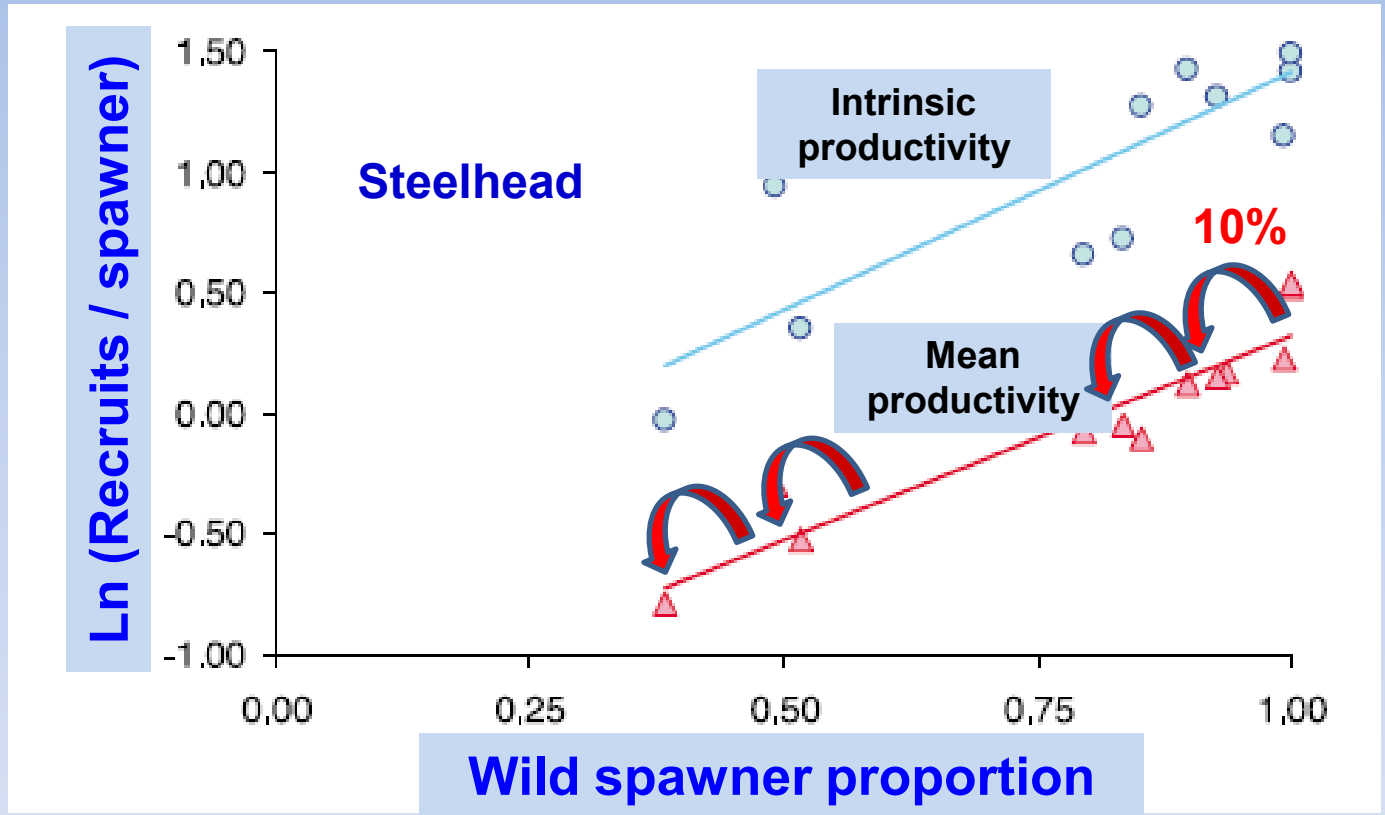
Straying model: varyingsmolt abundance

- Transport proportion = mean (0.64)
- SARs = means (1.62, 2.16, 0.86, 1.08)
- Stray = means (8.5%, 6.6%, 7.1%, 1.8%)



Hundreds of combinations are possible; includes recipient component

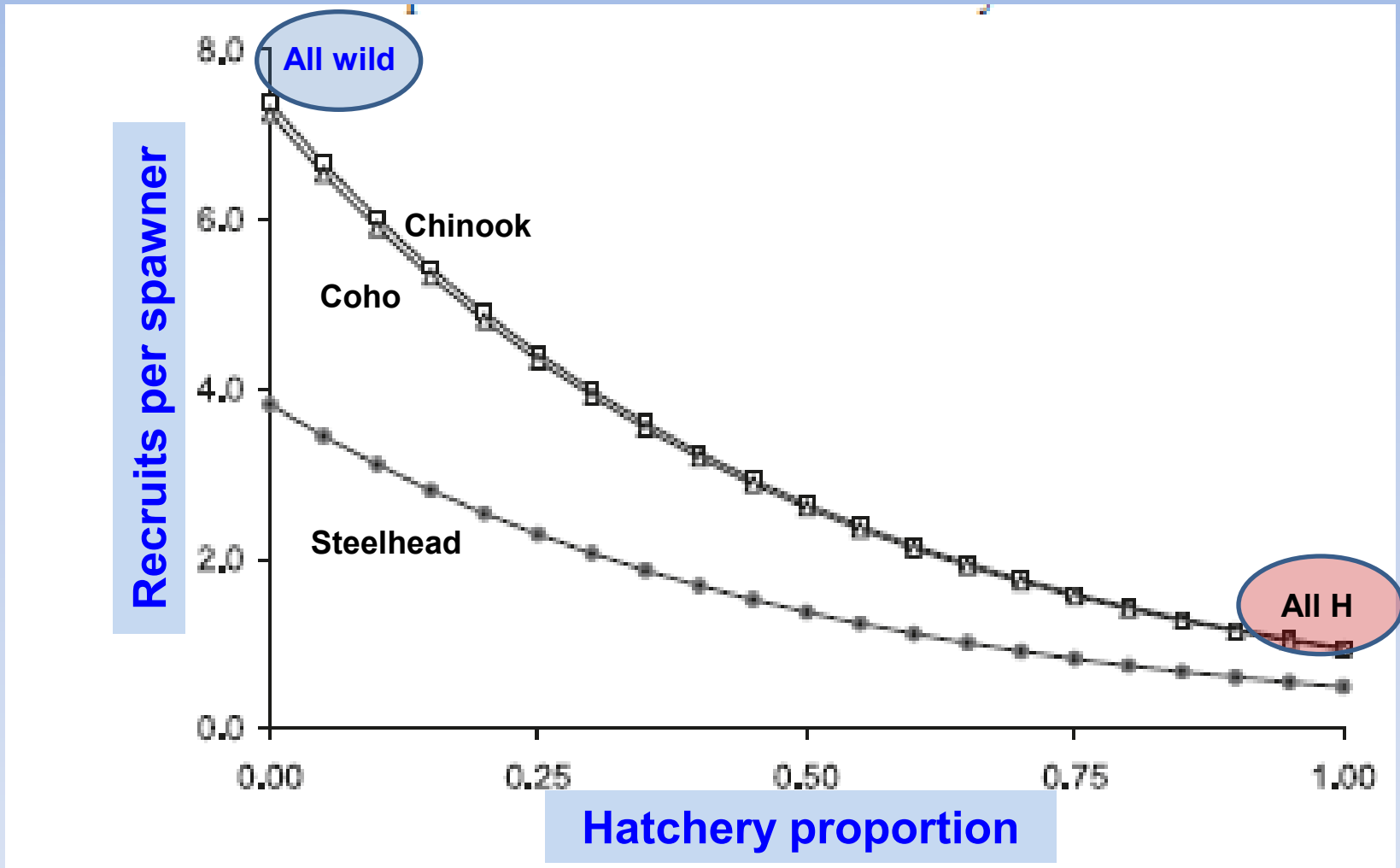
Why should we care?
Fitness effects: hatchery strays



Chilcote (2003)

Each 10% increase in hatchery spawners = 16% decrease in recruitment

Fitness effects: hatchery strays

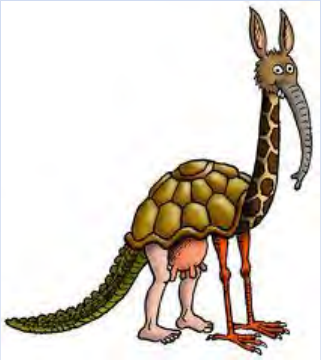


Chilcote et al. (2011)

Spawning population that is 100% hatchery fish is ~13% as productive

Straying information needs

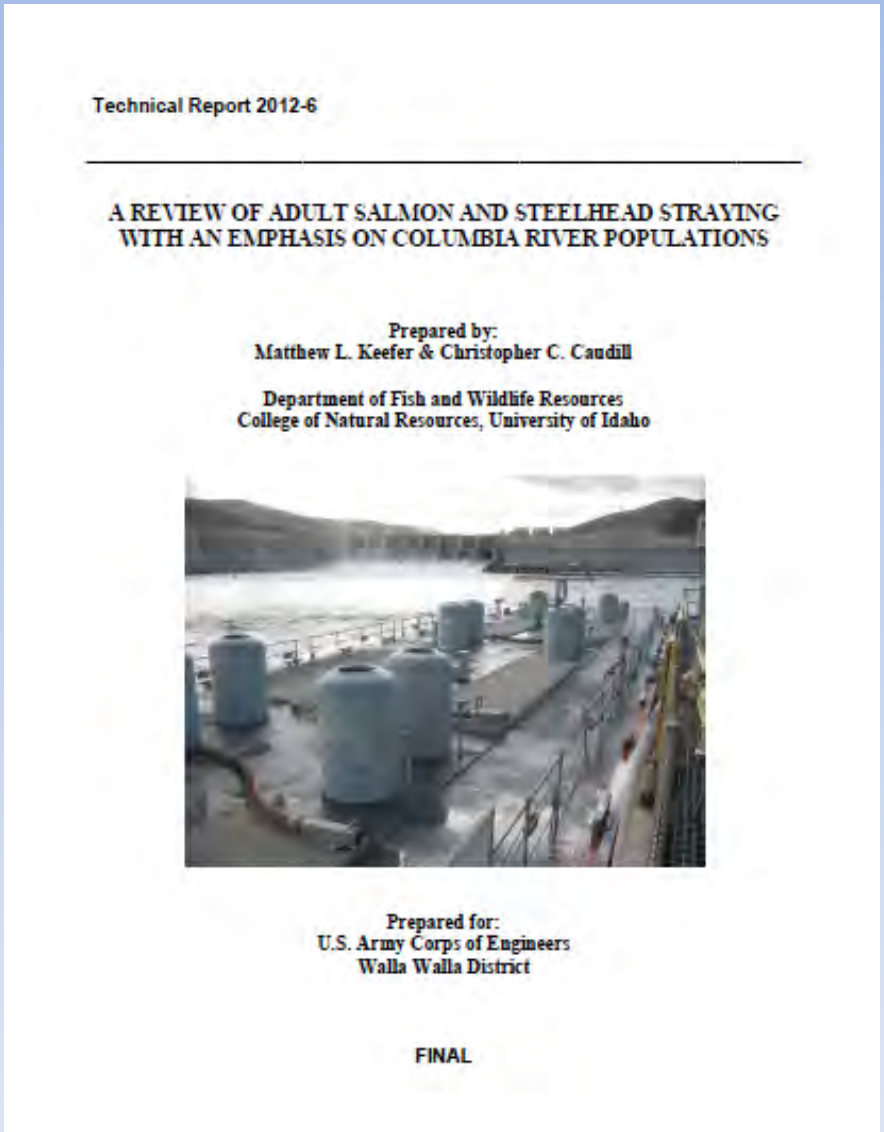
- Better accounting for strays
  - Increase carcass / angler surveys; Hatchery checks
  - Add monitoring sites (e.g., tributary PIT arrays)
  - Tag / Mark more juveniles
- Shift focus to Recipient populations
  - How many strays compete, breed with wild fish?
  - What are the genetic, population-level impacts?



Barging-straying information needs

- Identify mechanisms that reduce juvenile imprinting during barging
  - Chronological effects: transport too rapid?
  - Spatial effects: barges in wrong habitats?
  - In-barge effects: stress, contaminants?
  - Hatchery effects
    - Invest in hatchery reform + transport reform?

Questions?



Technical Report 2012-6

A REVIEW OF ADULT SALMON AND STEELHEAD STRAYING WITH AN EMPHASIS ON COLUMBIA RIVER POPULATIONS

Prepared by:
Matthew L. Keefer & Christopher C. Caudill

Department of Fish and Wildlife Resources
College of Natural Resources, University of Idaho

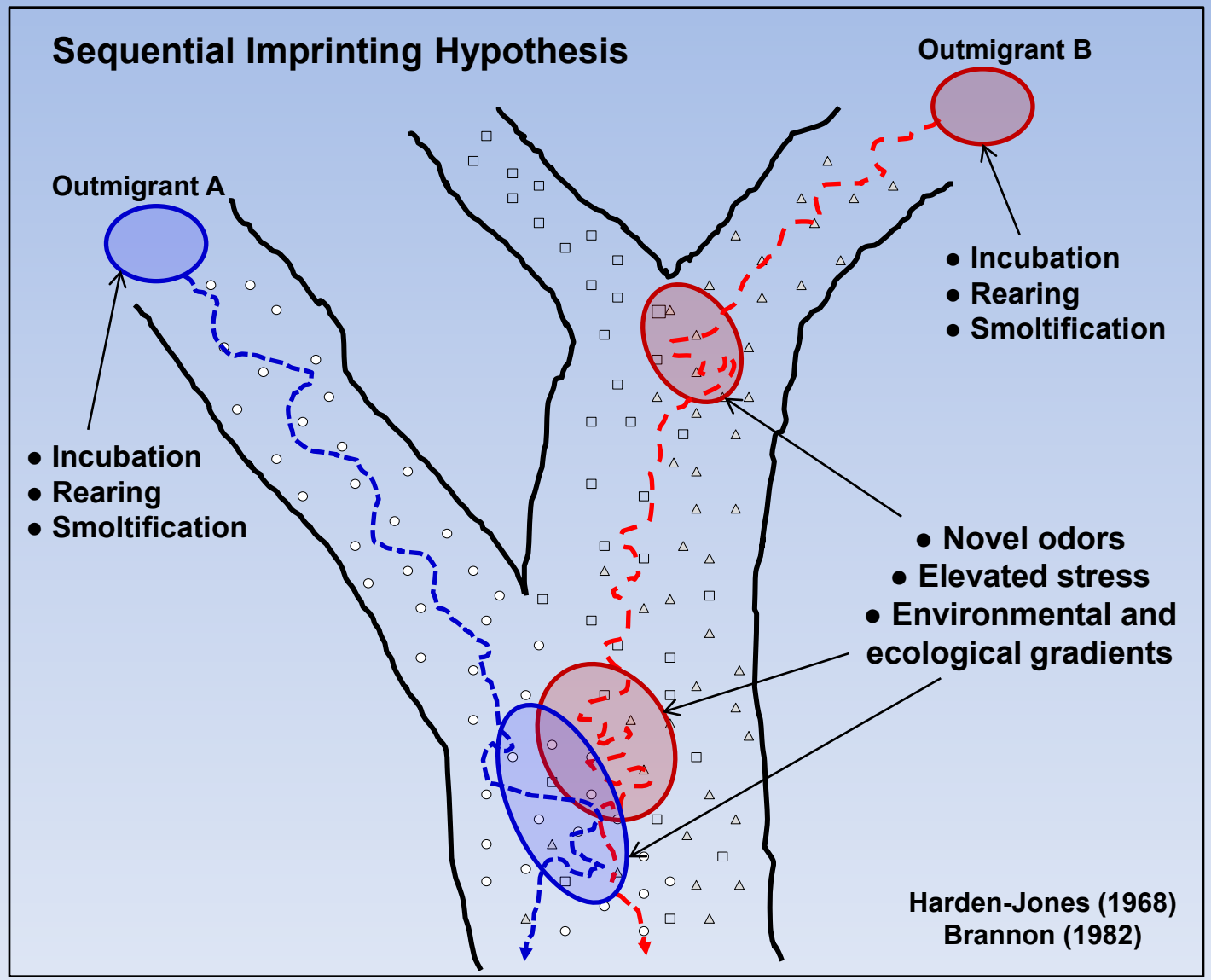
Prepared for:
U.S. Army Corps of Engineers
Walla Walla District

FINAL

http://www.cnr.uidaho.edu/uiferl/Reports.htm#Technical_Reports

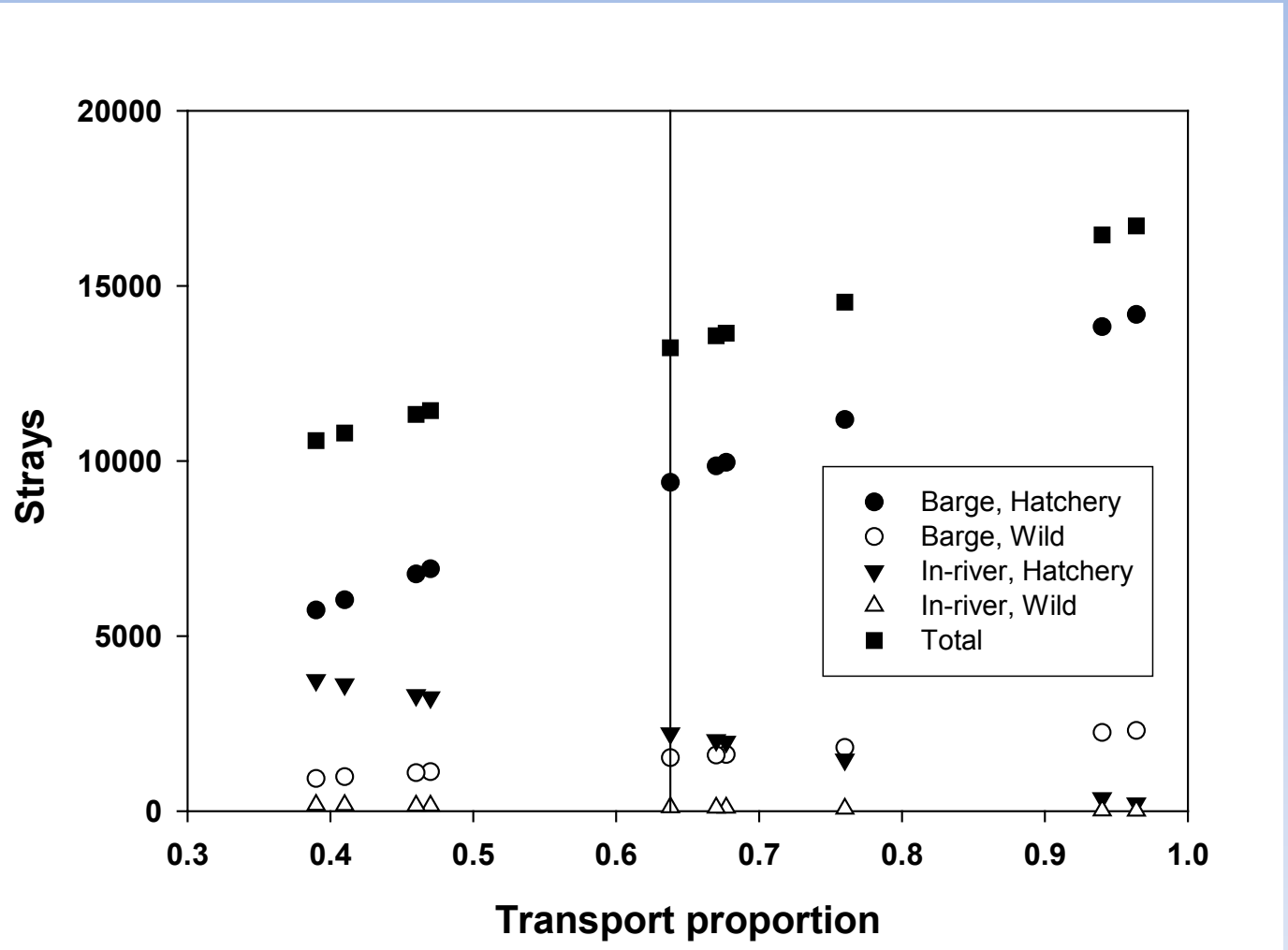
Mechanism: interrupted imprinting

- Migration stimulates imprinting
- Critical neural development and memory formation
- Long-distance or complex migrations may require more 'waypoints'



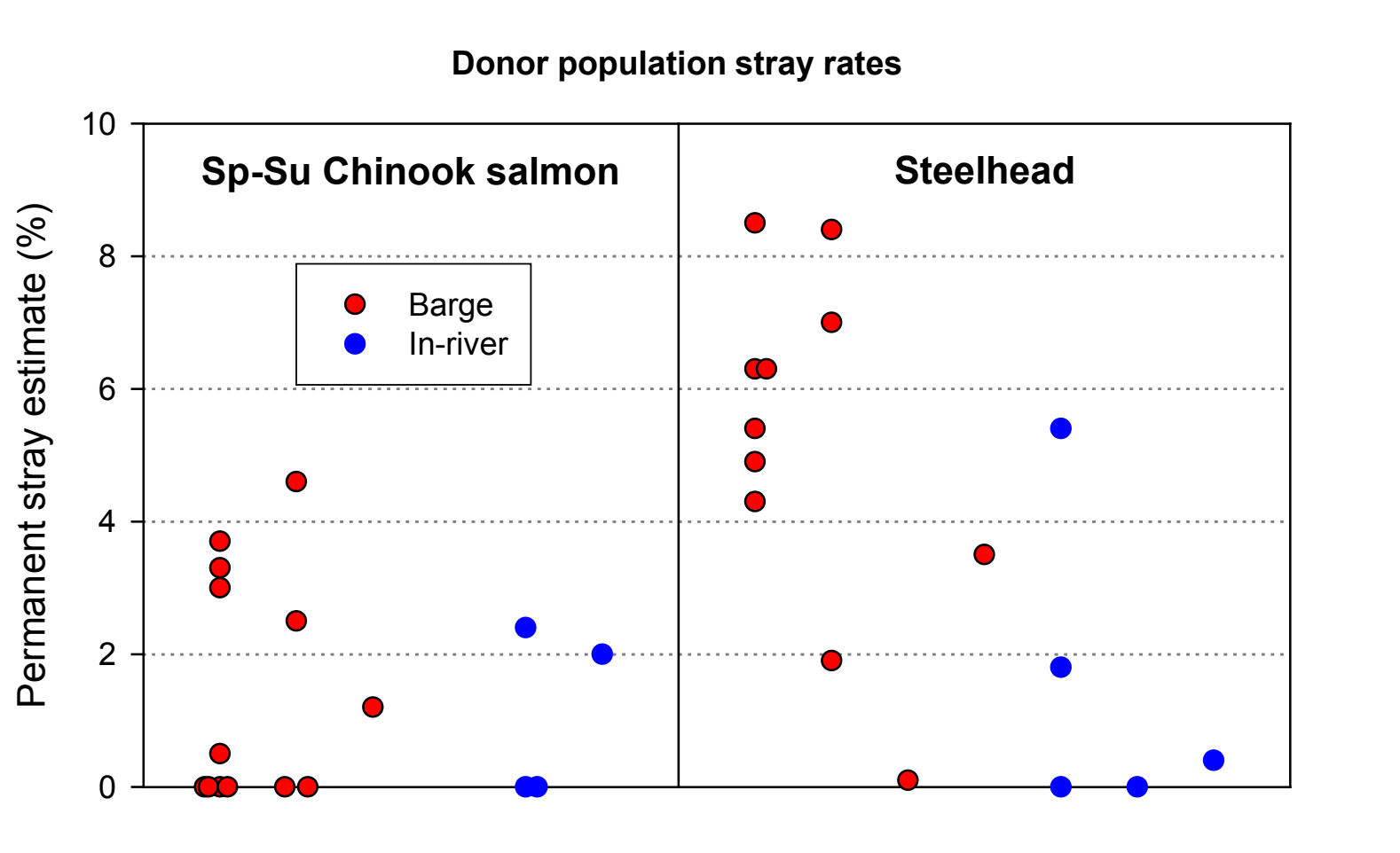
Straying model: transport rate

- Smolt index = mean (~9 million)
- SARs = means (1.62, 2.16, 0.86, 1.08)
- Strays = means (8.5%, 6.6%, 7.1%, 1.8%)



Hundreds of combinations are possible; includes recipient component

Stray rate data: Snake River transport



Annual estimates from: Marsh et al. (2012); Keefer et al. (2008); Ebel (1980); Ruzycki & Carmichael (2010)

All straying 'from', but Methods different in each study