Hierarchical Bayesian meta-analysis to characterize cross-population variation in the stock-recruit relationship for bull trout (*Salvelinus confluentus*)

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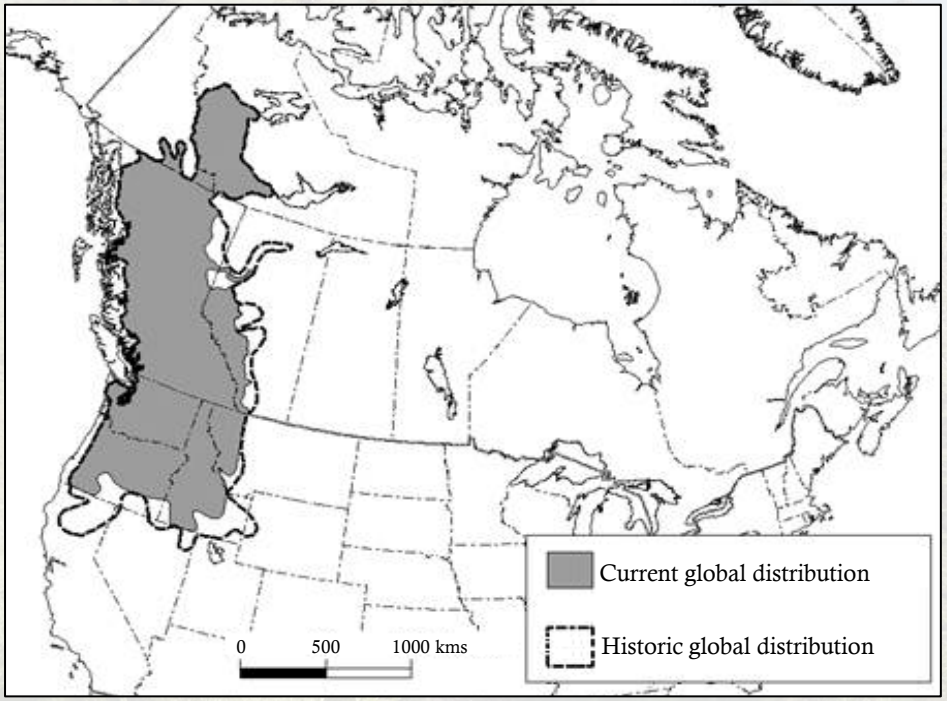
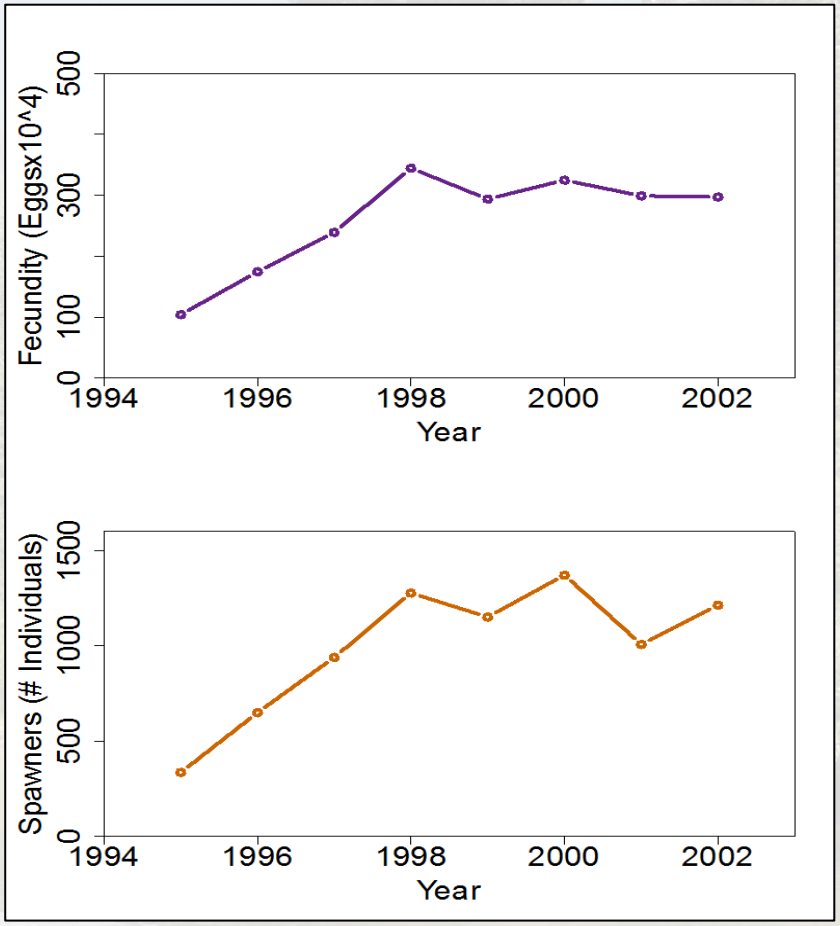
AFS Kelowna, 2018

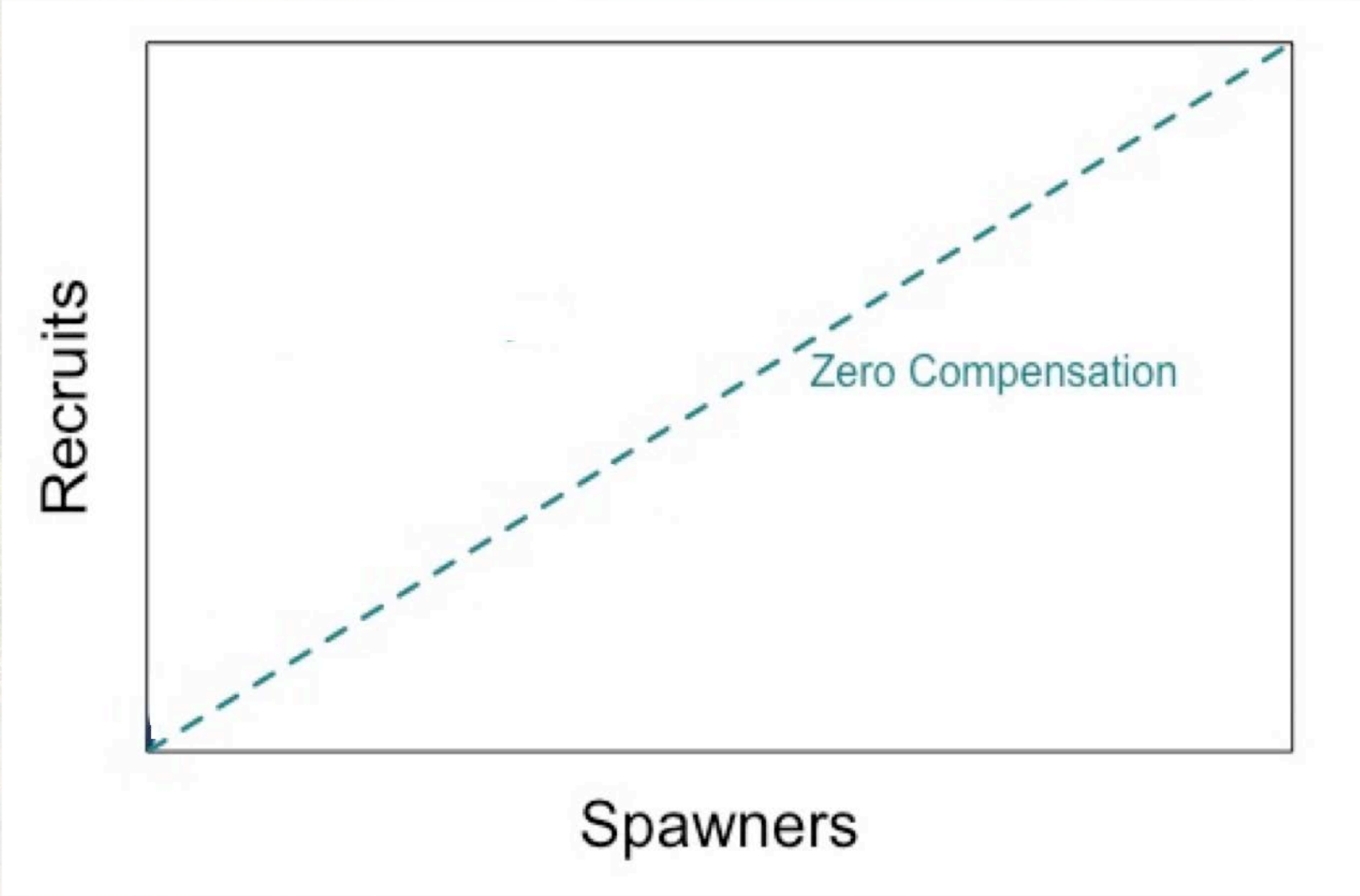
Bull trout: Conservation status and recovery





Lower Kananaskis Lake, Alberta
Data courtesy of Dr. John Post and Dr. Fiona Johnston

What is density dependent compensation (DD?)



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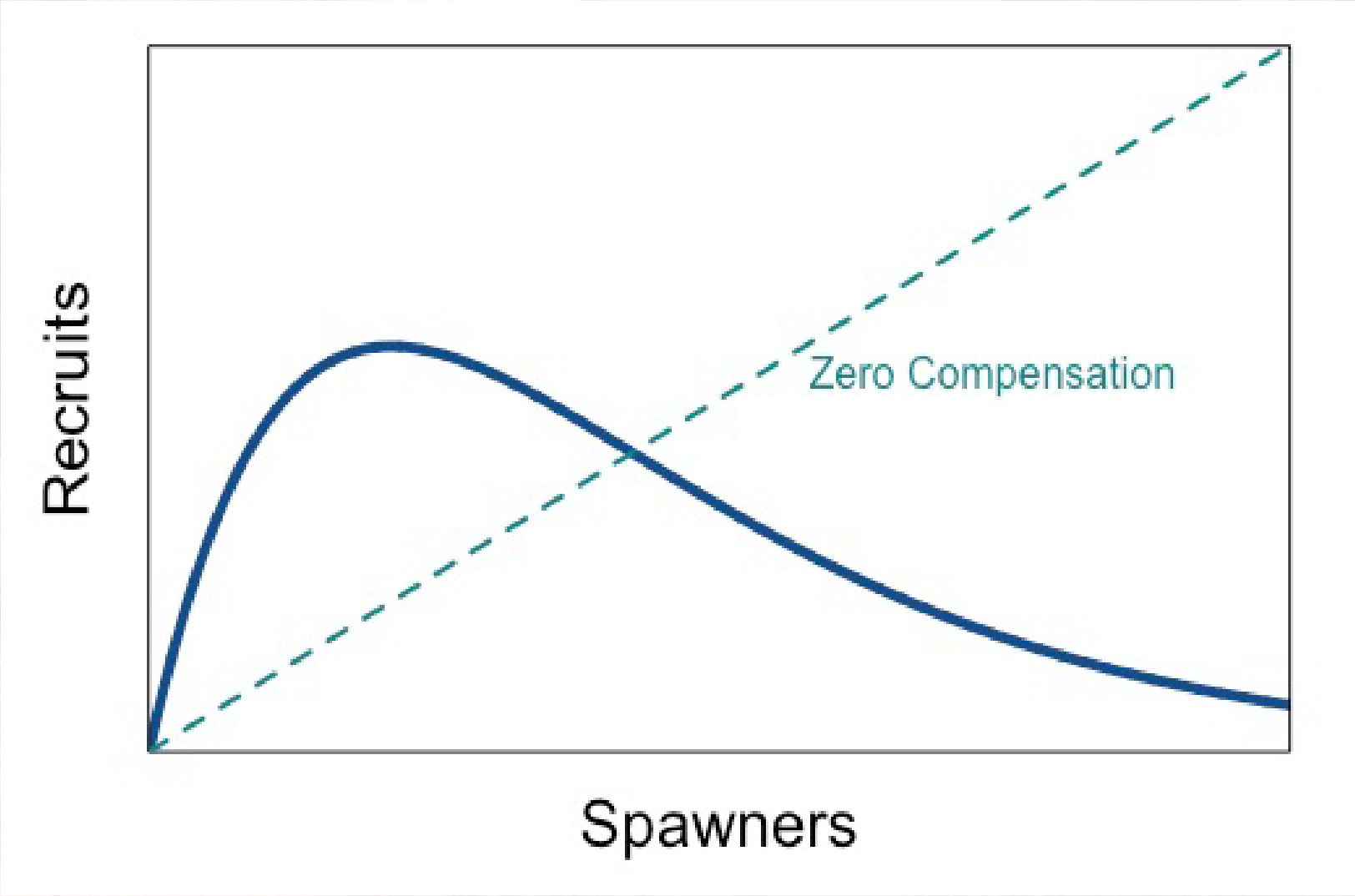

Importance of density dependent (DD) compensation

- Critical for population persistence
- Permits harvest and population survival despite stochastic perturbations
- Critical for estimating recovery rates and sustainable harvest

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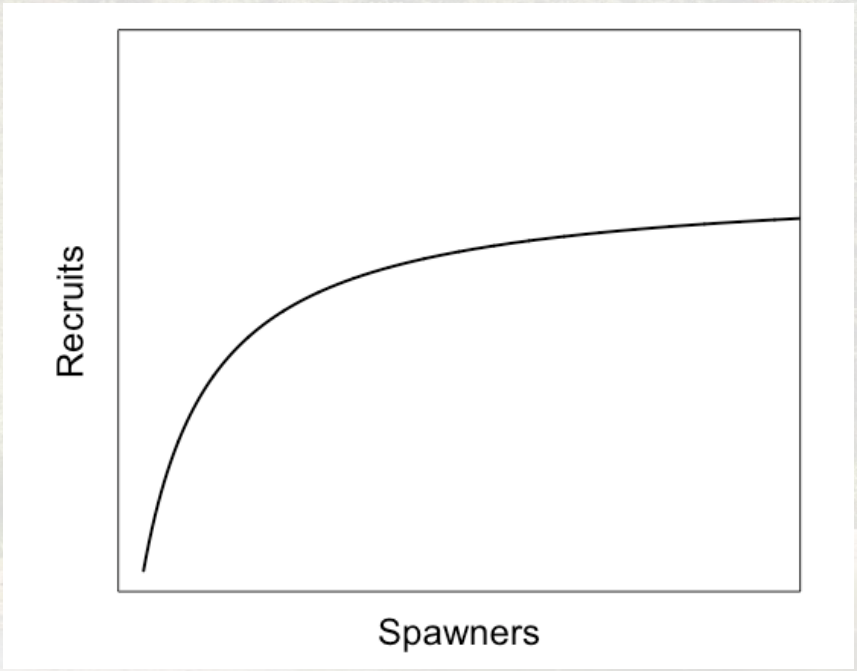
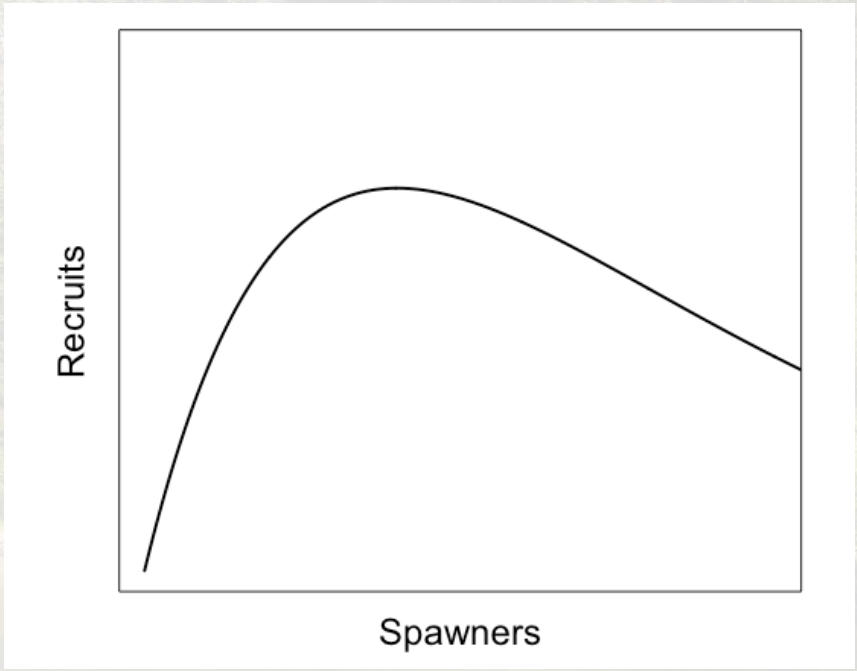
- **Has not been quantitatively explored for bull trout across species range**

Getting at DD compensation with Stock-recruitment models

Beverton-Holt

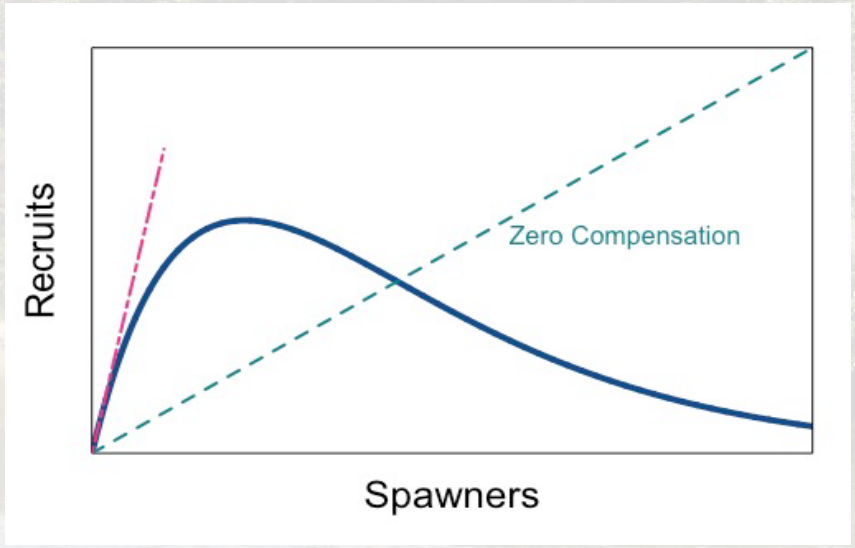


Ricker



Exploring compensation with the SR the Goodyear compensation ratio

- What is the CR?
  - Measures change in survival and fecundity parameters
  - Provides index of degree of compensation required for a fished population to persist



Exploring compensation with the SR the Goodyear compensation ratio

- What is the CR?
  - Measures change in survival and fecundity parameters
  - Provides index of degree of compensation required for a fished population to persist
- Why is it important?
  - Takes from SR function α to a parameter useful for:
    - Determining rates of recovery
    - Carrying out population viability analyses
    - Developing robust management
    - Exploring potential harvest opportunities

Difficulties in determining SR

- Key uncertainties result from:
  - Limited temporal and spatial scale of data
  - High variance in estimates of stock size and/or juvenile density
  - Spatial heterogeneity of populations
  - Difficulty explicitly defining stock and recruit

Hierarchical Bayesian meta-analysis

- Statistical model composed of multiple levels
- Combines data from several independent sources
- Estimates parameter values simultaneously for individual populations and meta-population(s)
- Gaining traction in SR analysis for data-limited situations and where data is uninformative

Benefits of Hierarchical Bayesian meta-analysis

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  - Provides smaller variance and more reliable parameter estimates
  - Predicts parameter probability distributions for un-sampled populations

Data collection

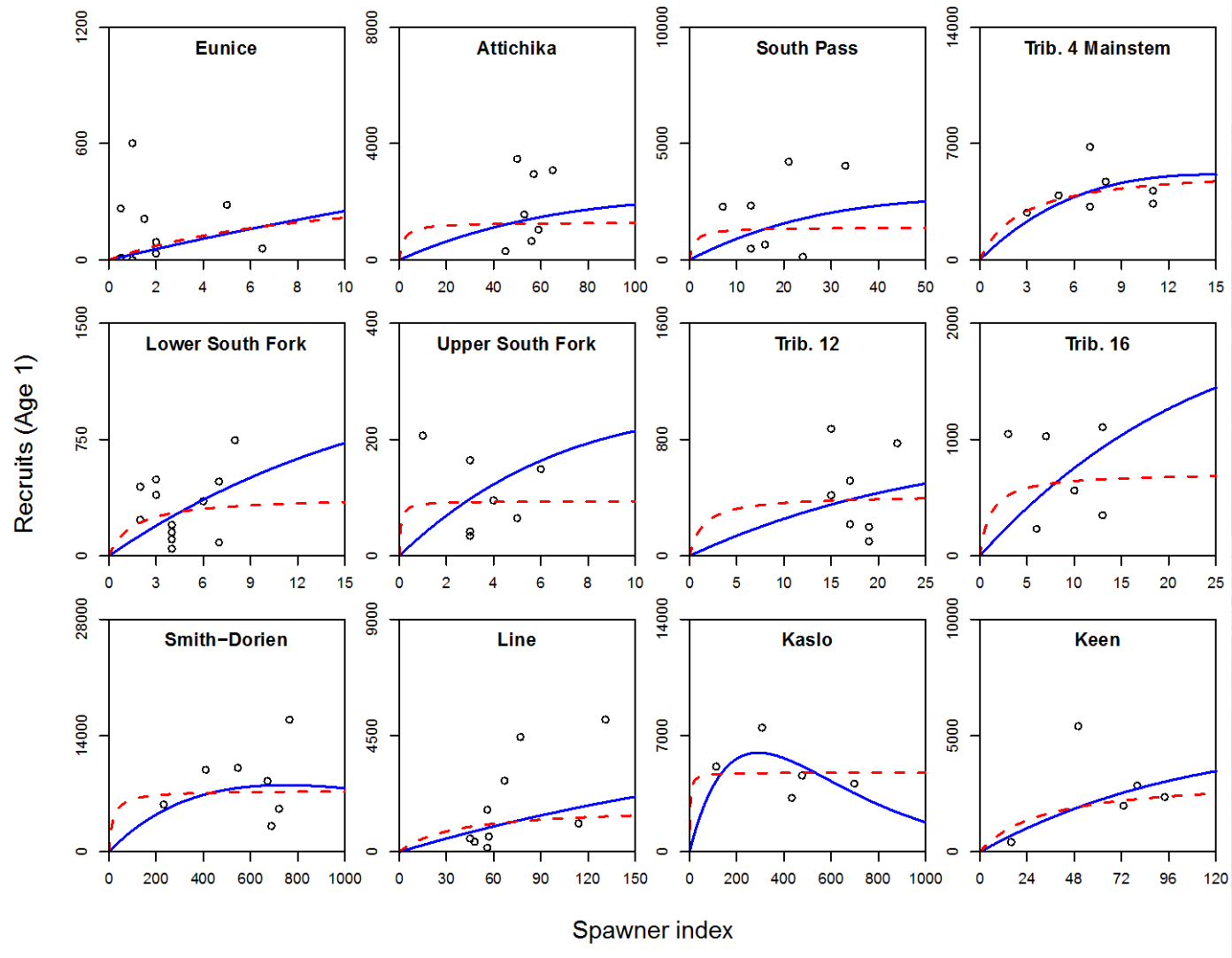
- Compiled for fluvial and adfluvial bull trout across species range
- Data obtained for 33 populations
- 21 excluded due to:
  - Short time series (<5 years)
  - Incomplete information
  - Substantial changes in productivity or carrying capacity

Description of bull trout stock-recruit datasets utilized in analysis.

System	Province	Life history	Data range (yrs.)	Data series length (yrs.)	Publication type
Eunice Creek	AB	Fluvial	1971-1983	10	Journal *
Smith-Dorrien Creek	AB	Adfluvial	1995-2001	7	Journal †
Attichika Creek	BC	Adfluvial	2001-2007	7	Research Document ‡
South Pass	BC	Adfluvial	2001-2007	7	Research Document ‡
Tributary 4 (Mainstem)	BC	Adfluvial	2001-2007	7	Research Document ‡
Tributary 4 (Upper South Fork)	BC	Adfluvial	2002-2007	12	Research Document ‡
Tributary 4 (Lower South Fork)	BC	Adfluvial	2003-2009	8	Research Document ‡
Tributary 12	BC	Adfluvial	2001-2007	7	Research Document ‡
Tributary 16	BC	Adfluvial	2001-2007	7	Research Document ‡
Line Creek	BC	Fluvial	1991-1999	9	Personal communication §
Kaslo River	BC	Adfluvial	2010-2014	5	Personal communication ‖
Keen Creek	BC	Adfluvial	2010-2014	5	Personal communication ‖

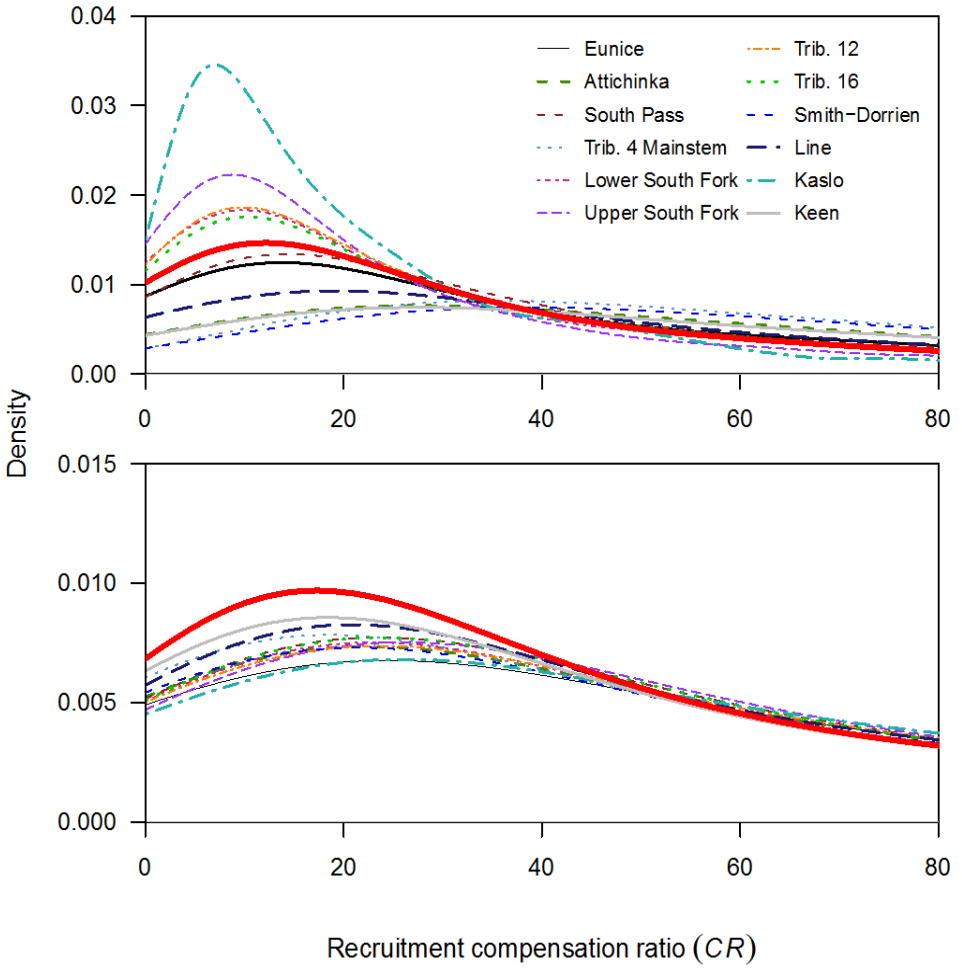
* Paul *et al.*, 2000
† Johnston *et al.*, 2007
‡ David Bustard and Associates LTD.
§ Jim Allen, Pisces Environmental Consulting 2016
‖ Greg Andrusak, BC FLNRO

Results: Fits to stock–recruit data under the assumption of Ricker SR function



Take home messages

- Provides **prior** for un-sampled populations
- CR estimate useful for:
  - Determining rates of recovery
  - Developing management
  - Exploration of potential harvest opportunities



Take home messages

- Bull trout have **large** scope for improvements in juvenile survival at low stock size

- Suggests bottleneck for population recovery likely habitat **quality** and **quantity**

Take home messages

- If this is important (which it is) people need to collect the data
  - Datasets uninformative
  - Lack of available stock-recruitment data
  - Lack of consistency in data collection approaches between regions

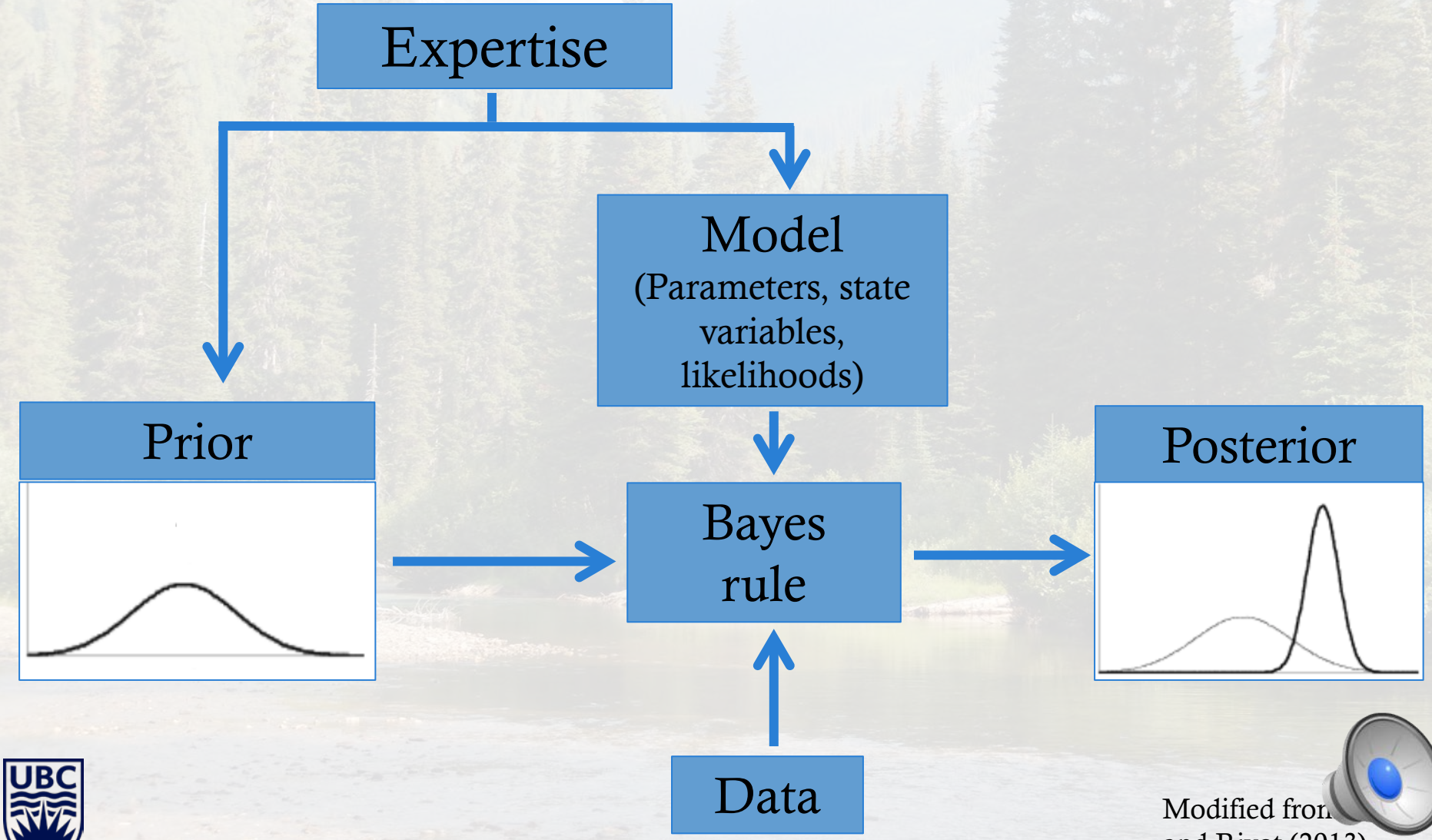
Thank you

- Collaborators:
  - Dr. Villy Christensen (UBC)
  - Dr. Rick Taylor (UBC)
  - Dr. Josh Korman (UBC, Ecometric Research Inc.)
  - Ministry of Forests, Lands and Natural Resource Operations – Fish and Wildlife Branch – Omenica Region
  - Mr. John Hagen (John Hagen and Associates)

- Funding
  - Habitat Conservation Trust Foundation (HCTF)

- Photos:
  - Map of approximate current and historic global distribution of *Salvelinus confluentus.* Modified from COSEWIC. 2012. Assessment and Status Report on the Bull Trout *Salvelinus confluentus* in Canada.
  - Juvenile bull trout. U.S. Fish and Wildlife Service.
  - Bull trout. Photo by Joel Sartore, U.S. Fish and Wildlife Service.
  - Parent, E. and Rivot, E. 2013. Introduction to hierarchical Bayesian modeling for ecological data. CRC Press. FL, USA.

Introduction to Bayesian models



Modified from
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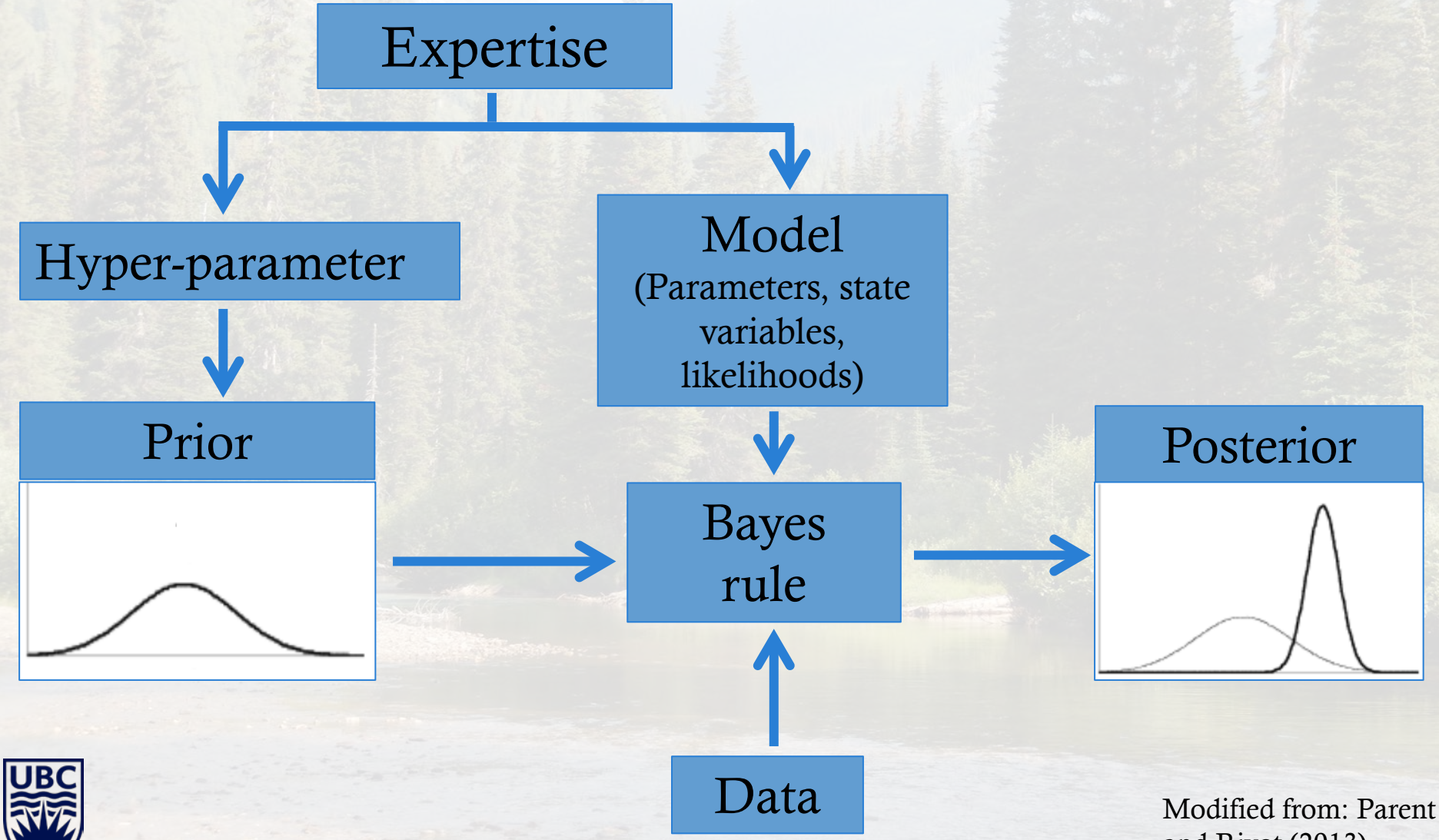
Hierarchical Bayesian models



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