"Bayesian decision analysis for rebuilding a depleted salmon population and retrospective evaluations of criteria for conservation status"

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Outline

1. Bayesian decision analysis for evaluating recovery options: Cultus Lake, B.C. sockeye salmon

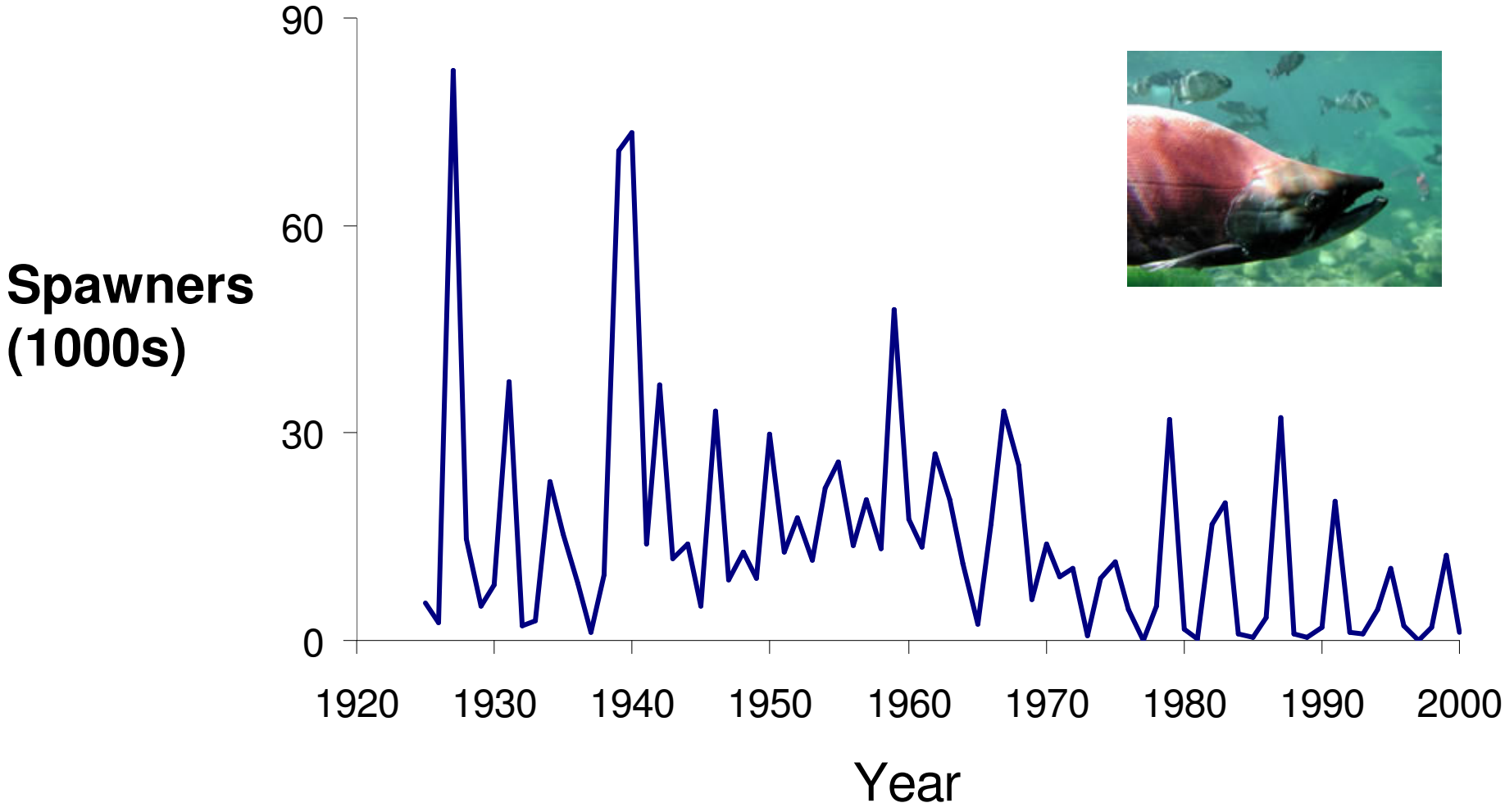
   - Inform trade-offs (economic vs. ecological)

2. Evaluation of criteria for "conservation-threat" status

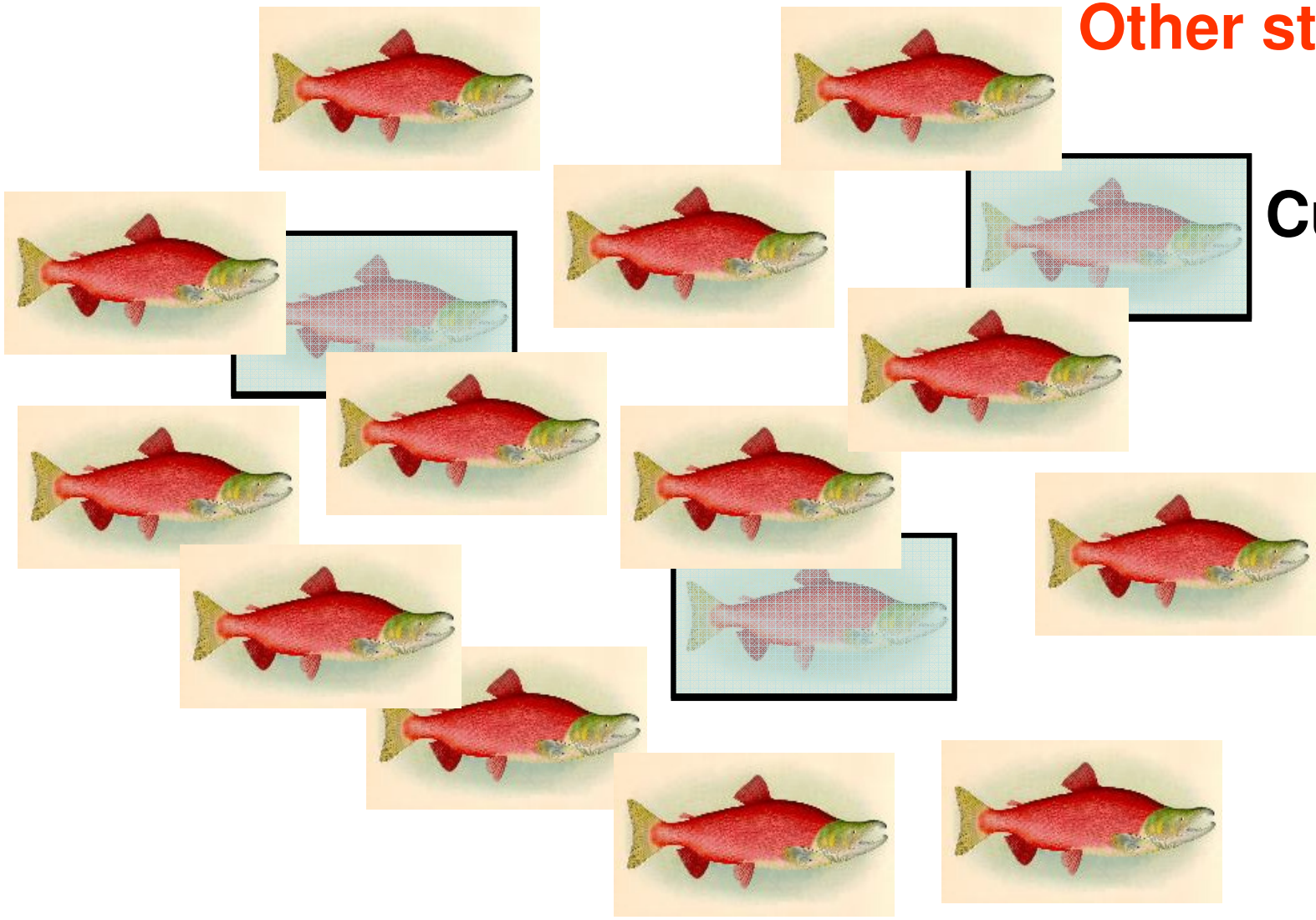
   - Some commonly used criteria are unreliable

Part 1. **Cultus Lake sockeye salmon**

Lynsey Pestes' Master's thesis



Problem: mixed-stock fisheries



Research objectives

- Find harvest strategies that meet recovery objectives
- Quantify trade-offs between salmon recovery and economic value of harvests

Method: Bayesian decision analysis

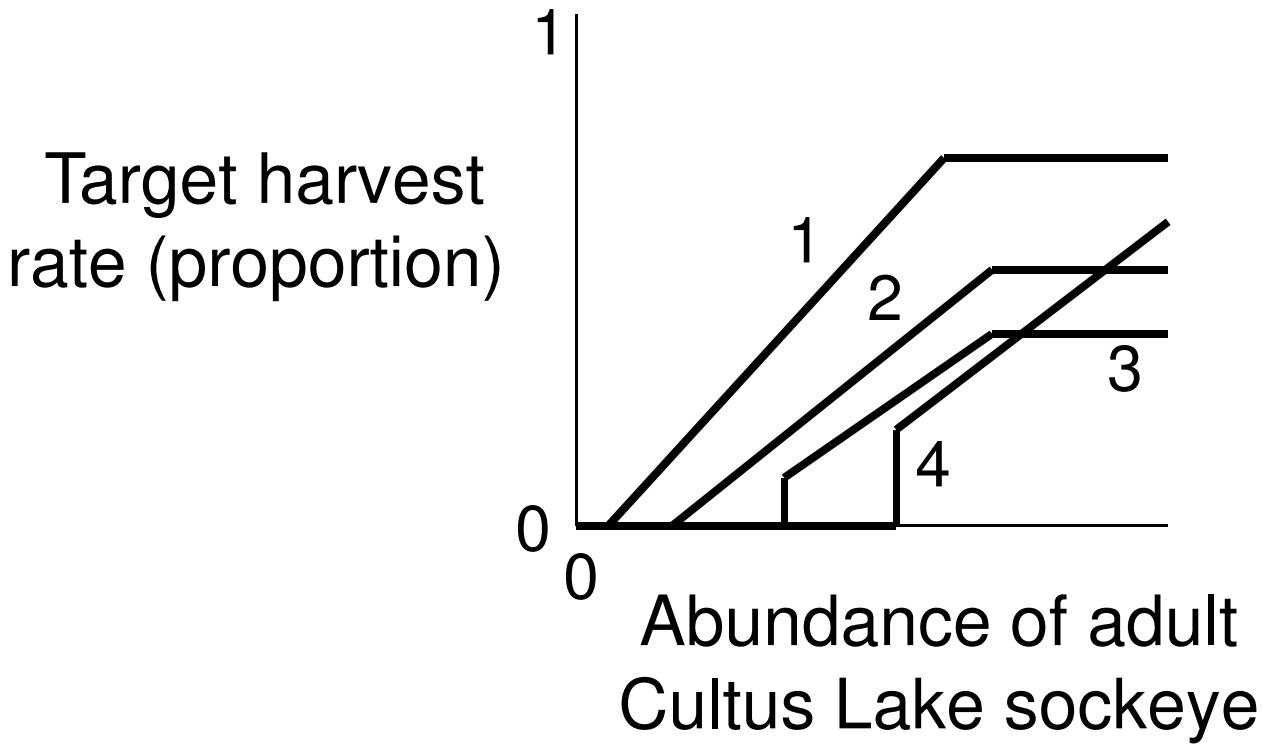
- Risk assessment
- Evaluates management options
- Takes uncertainties into account explicitly

Management objectives

- Rebuild Cultus Lake sockeye
  - High probability > 20,000 spawners in 20 years

- Maximize economic value of commercial fisheries on other co-migrating populations ***as long as first objective was met***

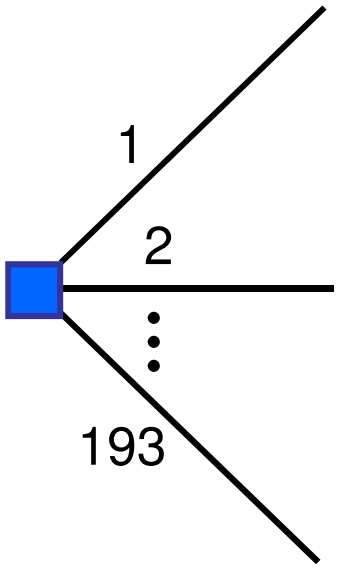
Fisheries management options:



(Pestes et al. 2008, Conserv. Biol. 22:351)

Actions

Harvest
rules



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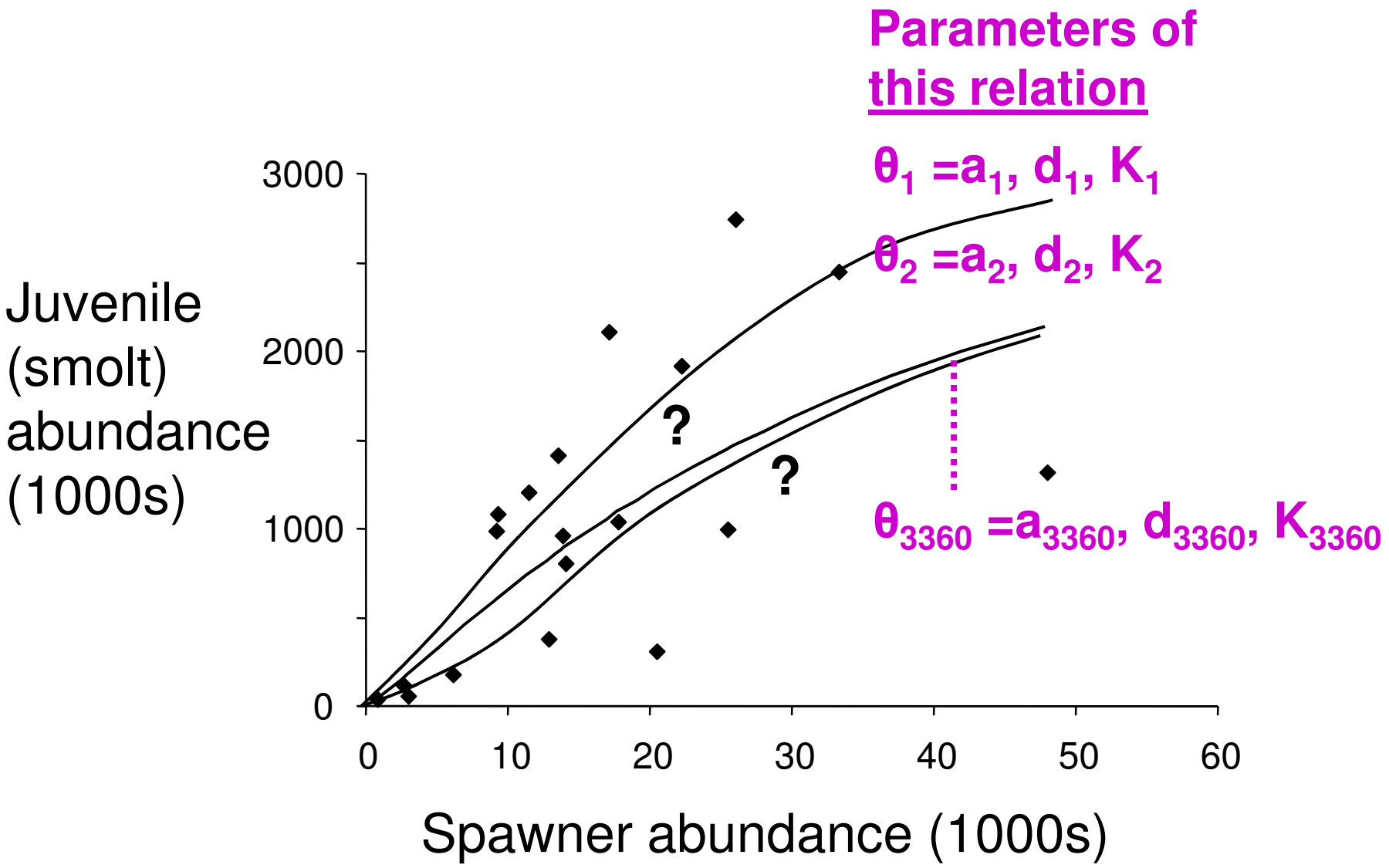

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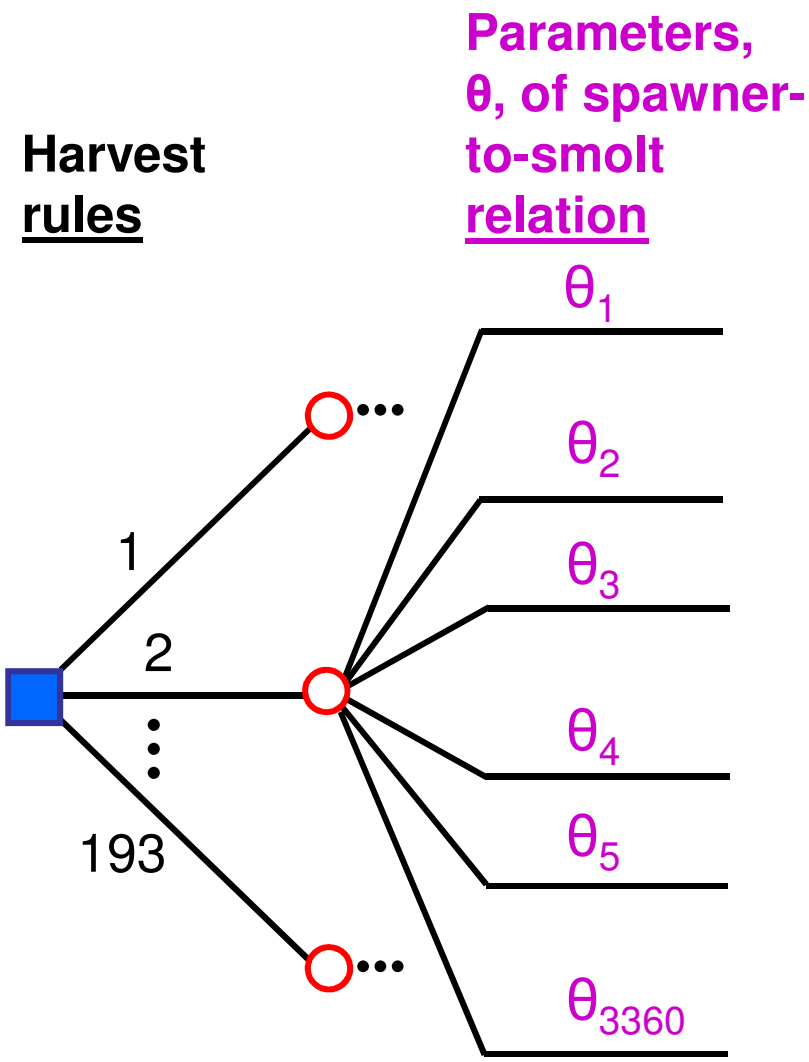
Actions Uncertainties (simplified)



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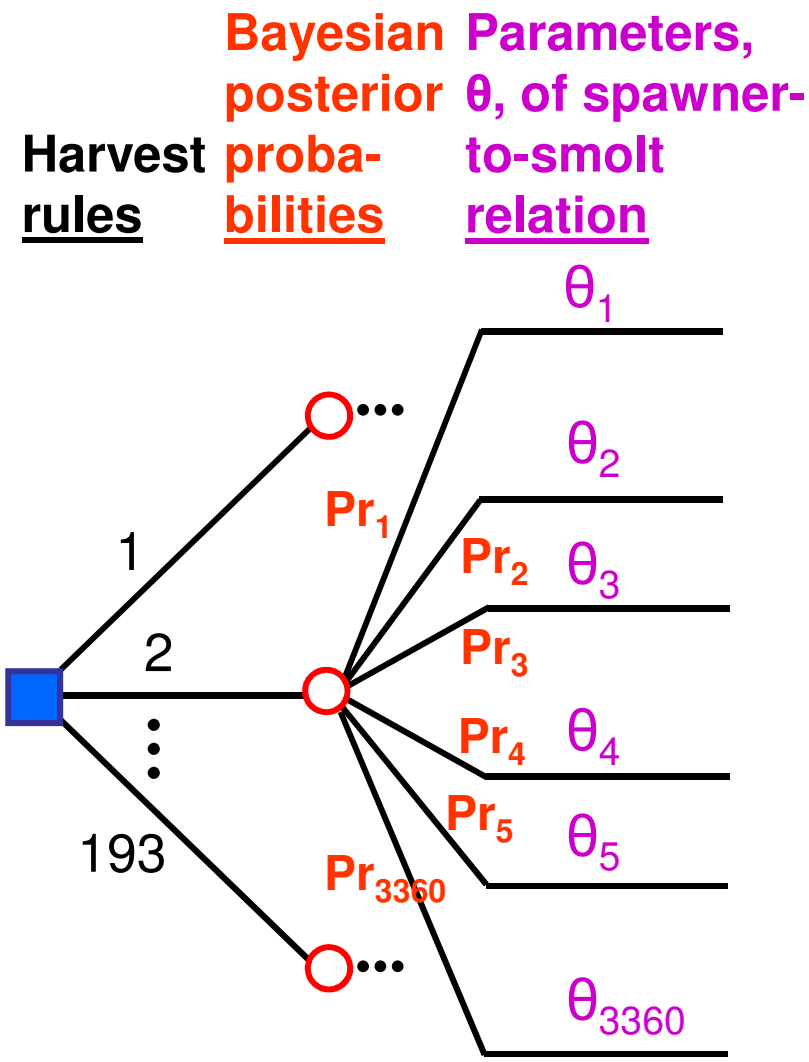
Actions | Uncertainties (simplified)



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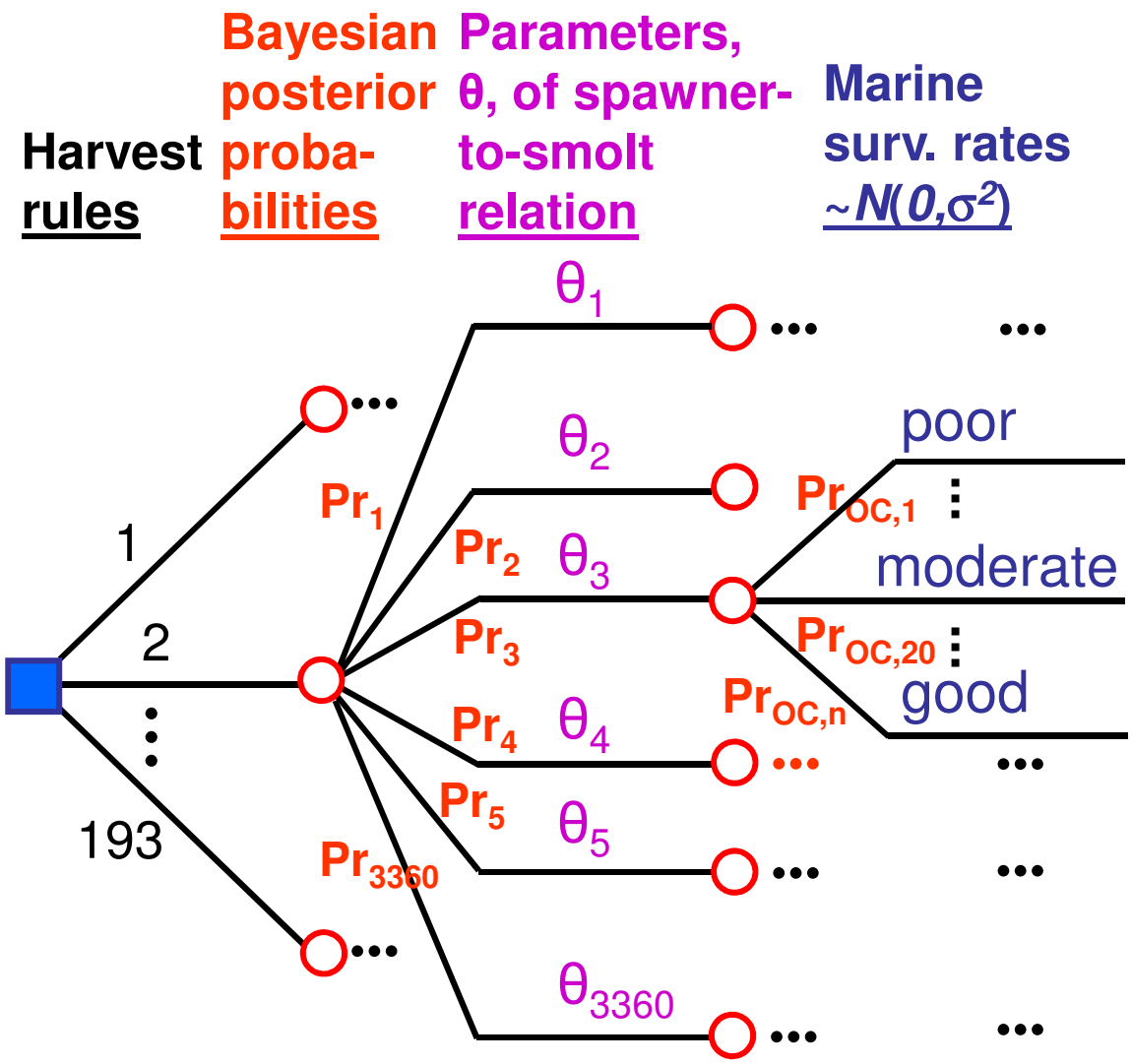
Uncertainties (simplified)



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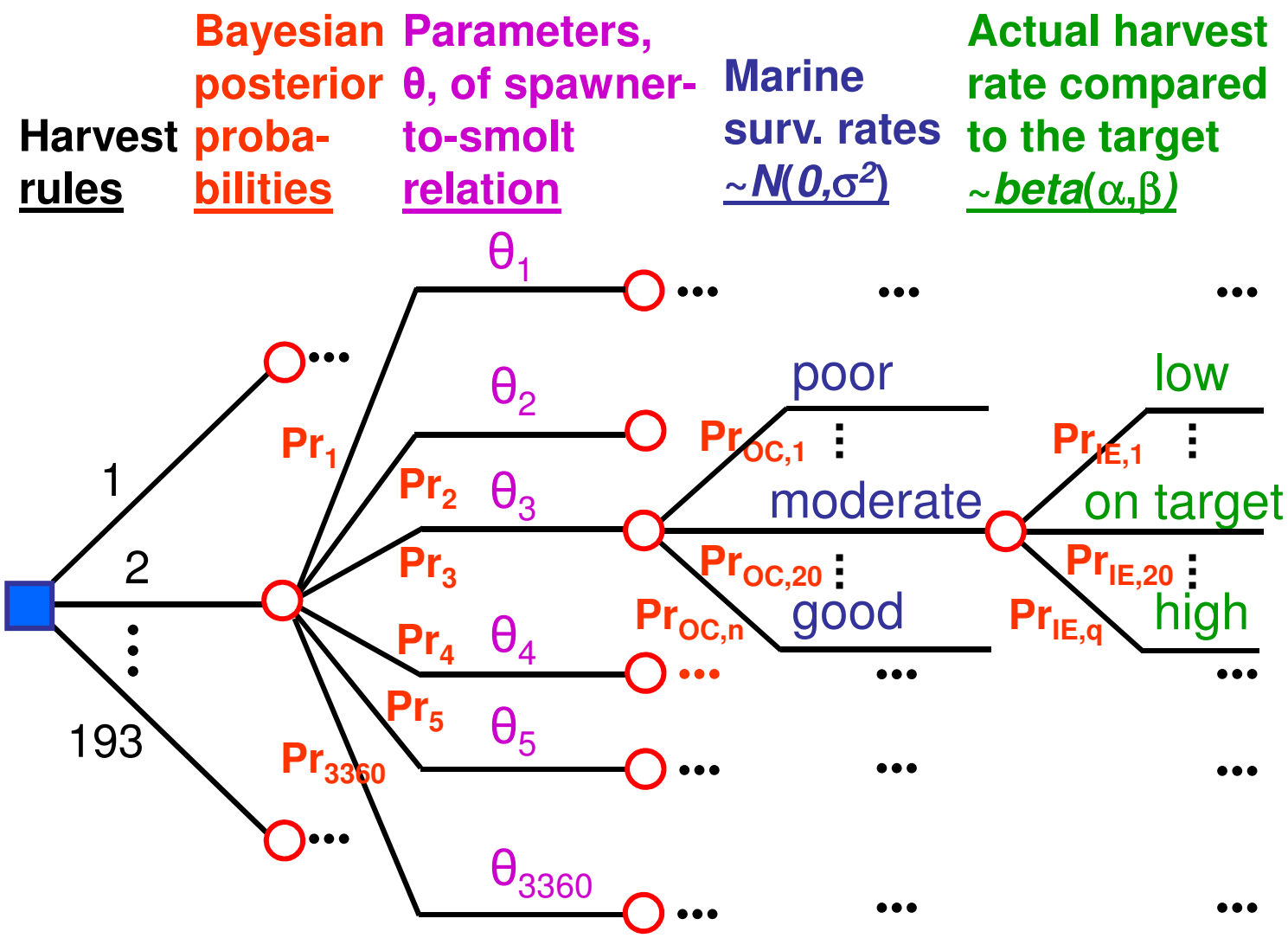
Actions

Uncertainties (simplified)



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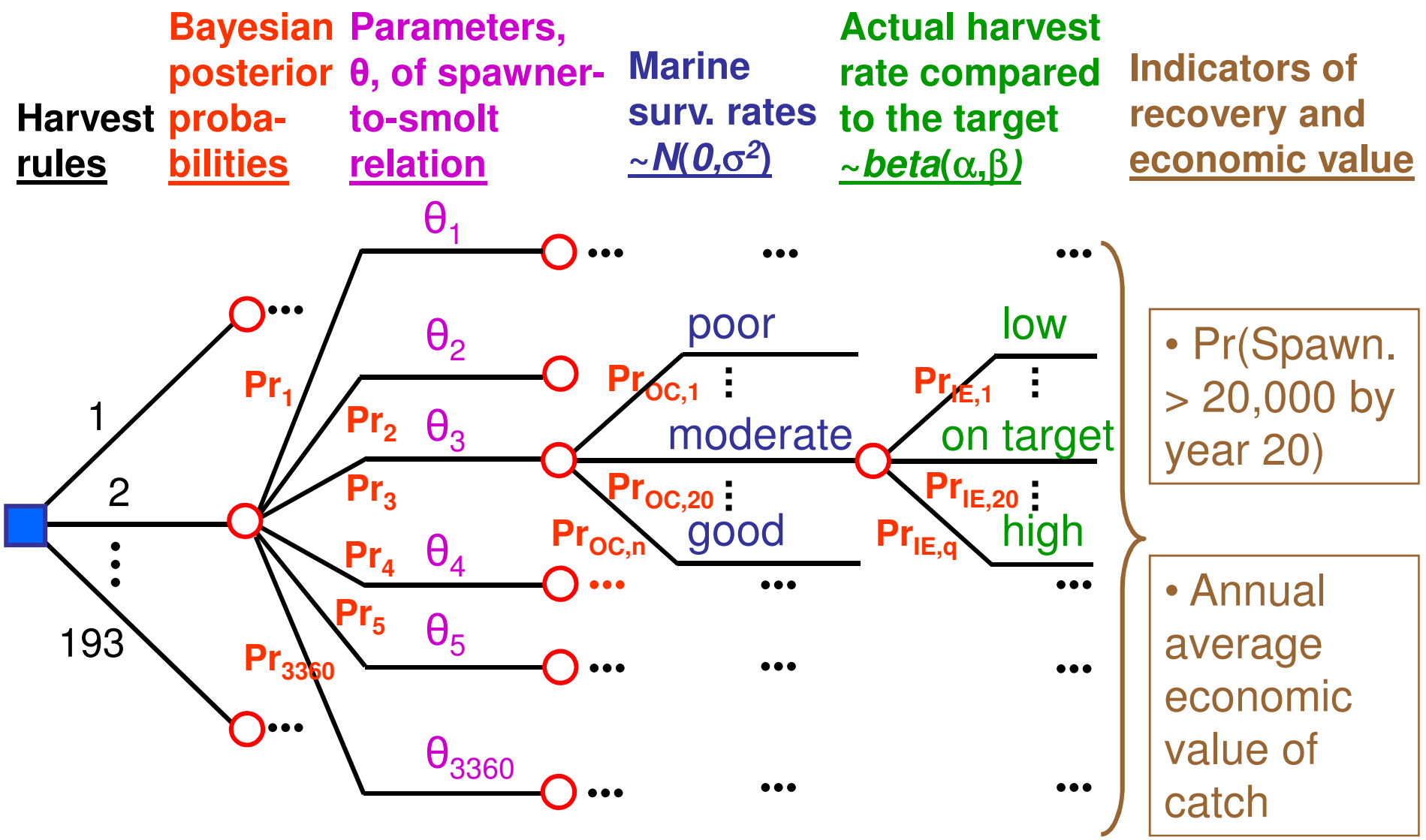
Actions | Uncertainties (simplified) | Outcomes



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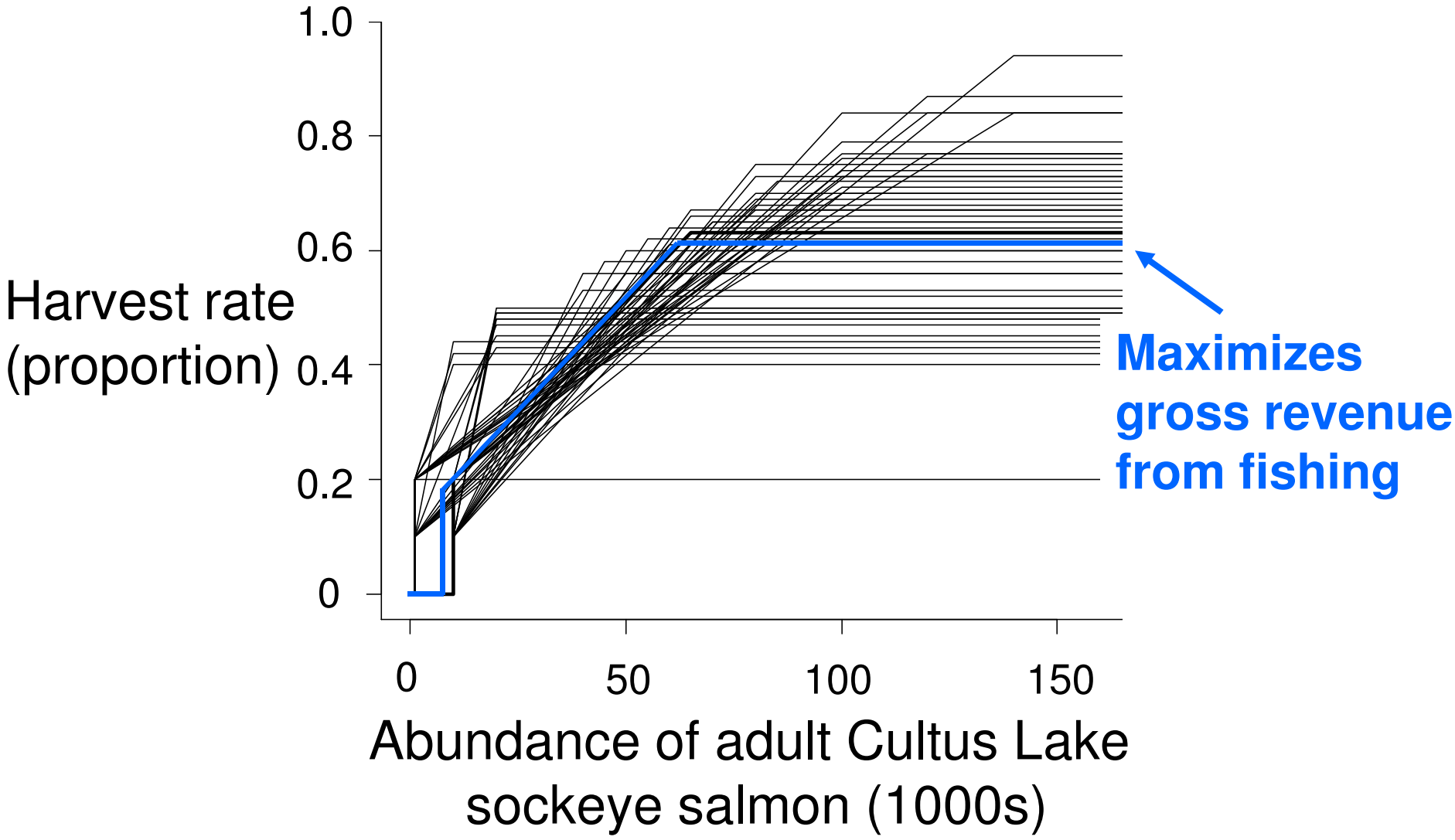
Results: Many harvest rules met recovery objective



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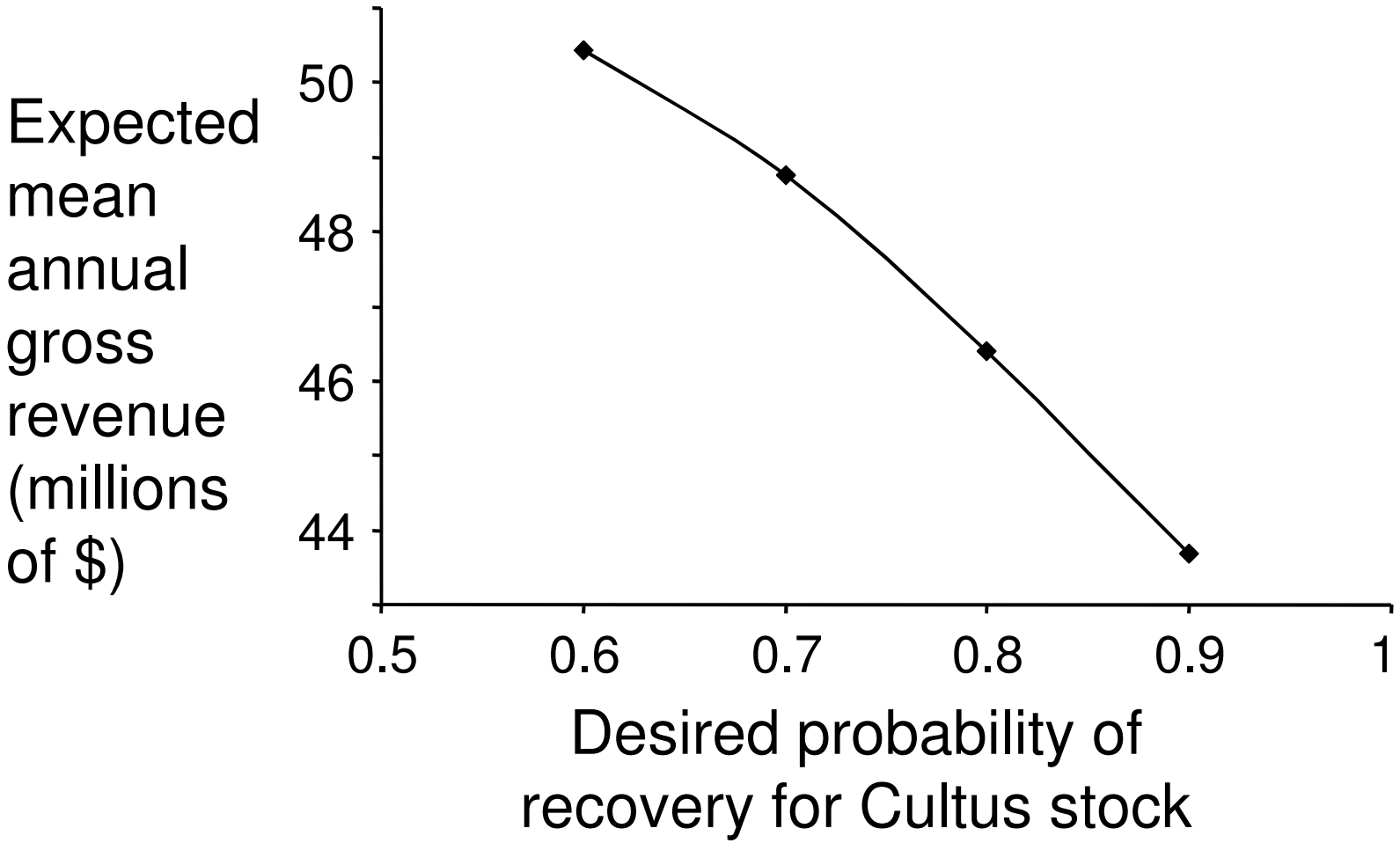
Trade-off



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Part 2. Evaluating effectiveness of criteria for indicating conservation concern

Erin Porszt's Master's thesis

Many criteria:

- IUCN (International)
- CITES (International)
- COSEWIC (Canadian)
- U.S. ESA (United States)

... others

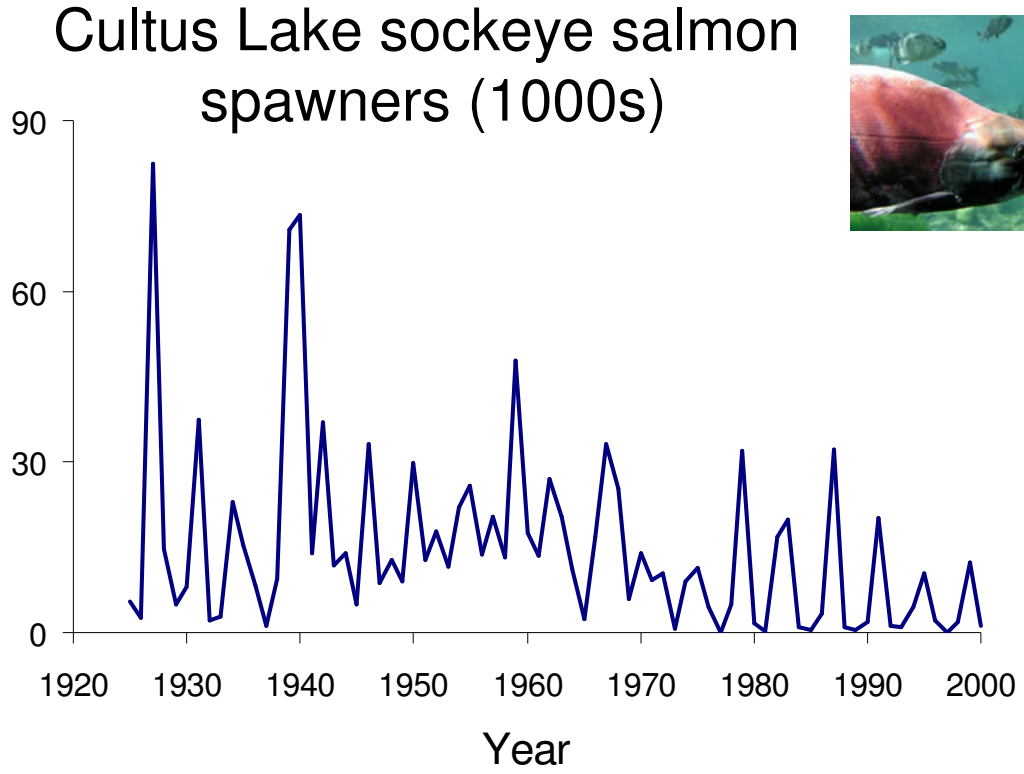
Measures of decline:

- Spawner abundances
  - Log-transformed or not
  - Smoothed or not
- Short-term (recent 3 generations)
- Long-term (from historical baseline to present)
- Combination

} Compared to thresholds of conservation concern: 30%, 50%, 70%

Research objective

Given large variability in salmon data, which quantitative criteria for estimating abundance trends are most reliable, i.e., most frequently correctly indicate whether salmon populations are truly declining?



For each of 22 decline criteria, we:

- Conducted retrospective analysis
  - For 18 sockeye conservation units (CUs)
  - Fraser River sockeye salmon (spawner data for 1950s - 2007; some as early as 1938)

For example:

Was there a 50% decrease over last 3 fish generations?

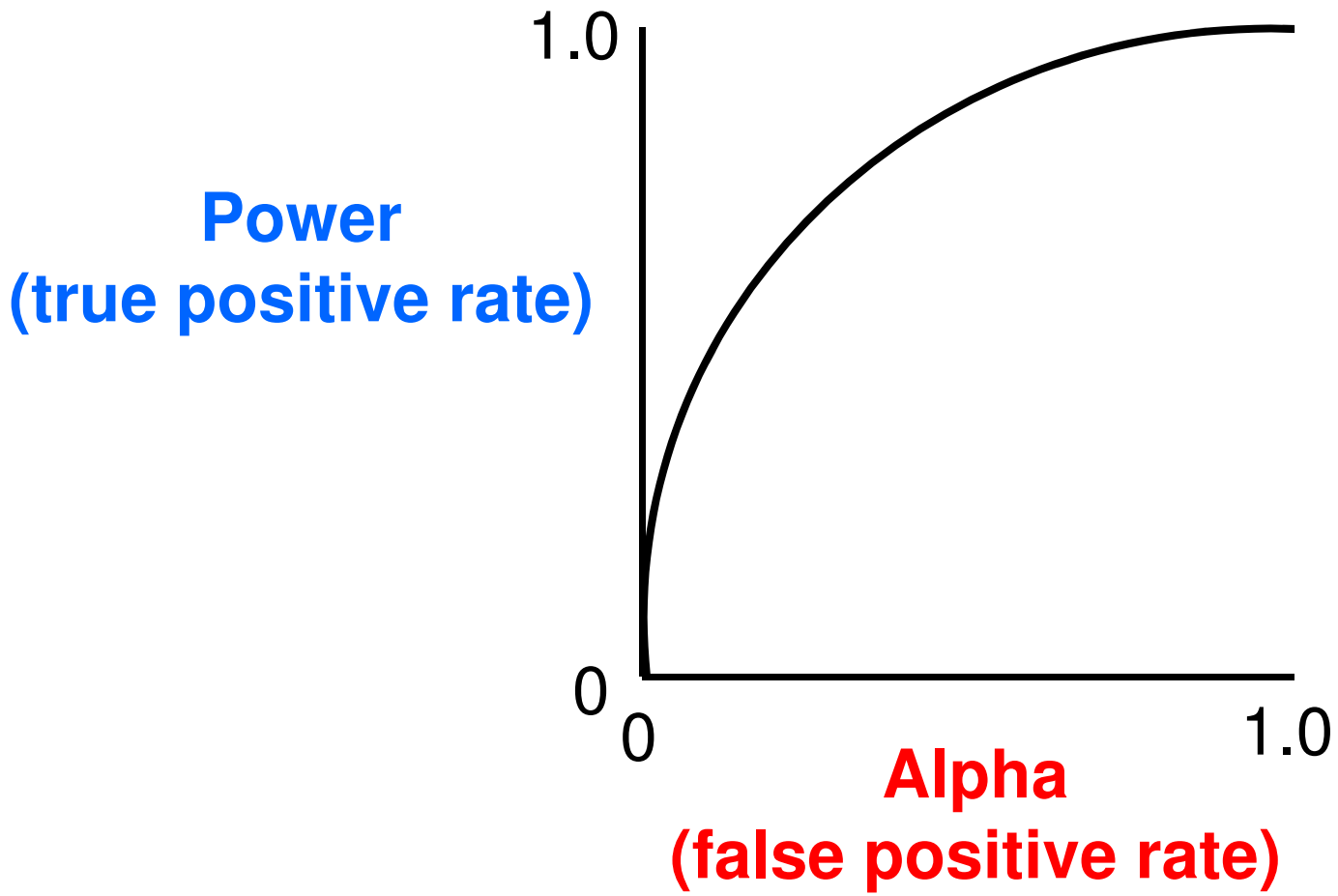
- Noted frequency of occurrence of estimated cases of "declining" and "not declining"
- Categorized subsequent true trend in spawners as "declining" or "not declining"
- Compared estimated and true categories

Tallied cases:

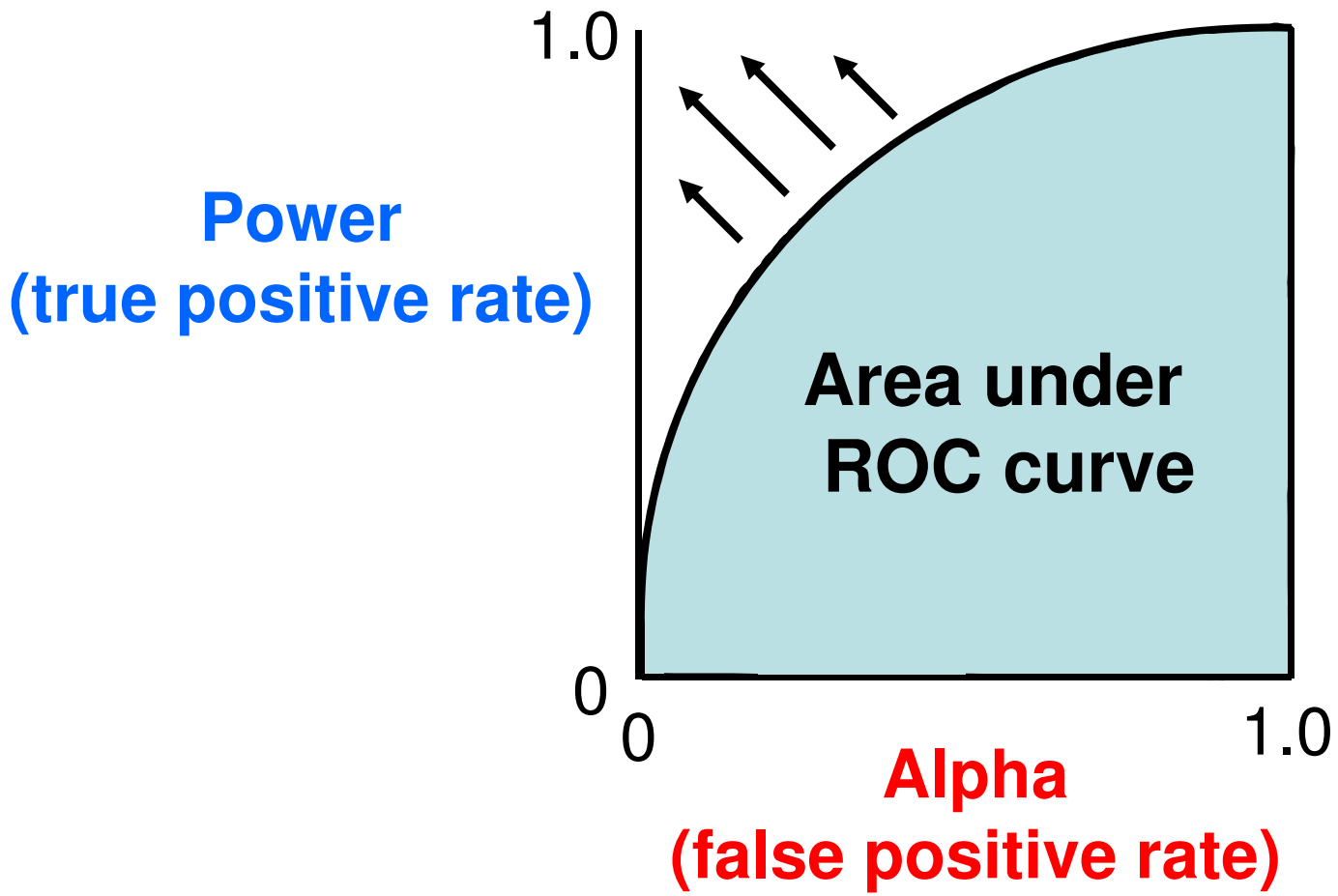
1. Correctly signalled decline (true positive)
2. Correctly did **not** signal a decline (true negative)
3. Incorrectly signalled decline (false alarm, false positive)
4. Incorrectly did **not** signal a decline (false negative)

- **Combined these measures of reliability using ROC curves from medical diagnostics (Andrew Cooper, Simon Fraser University)**

ROC curve from medical diagnostics

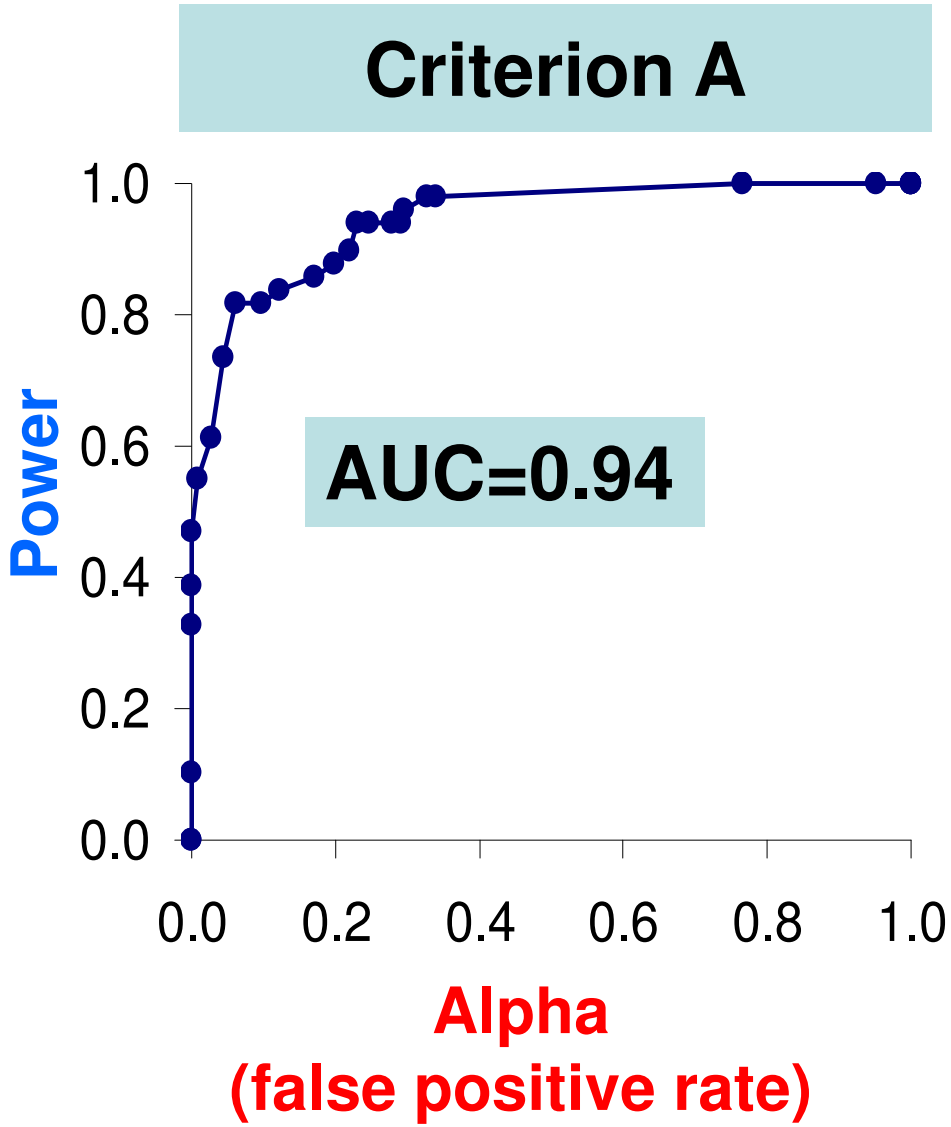


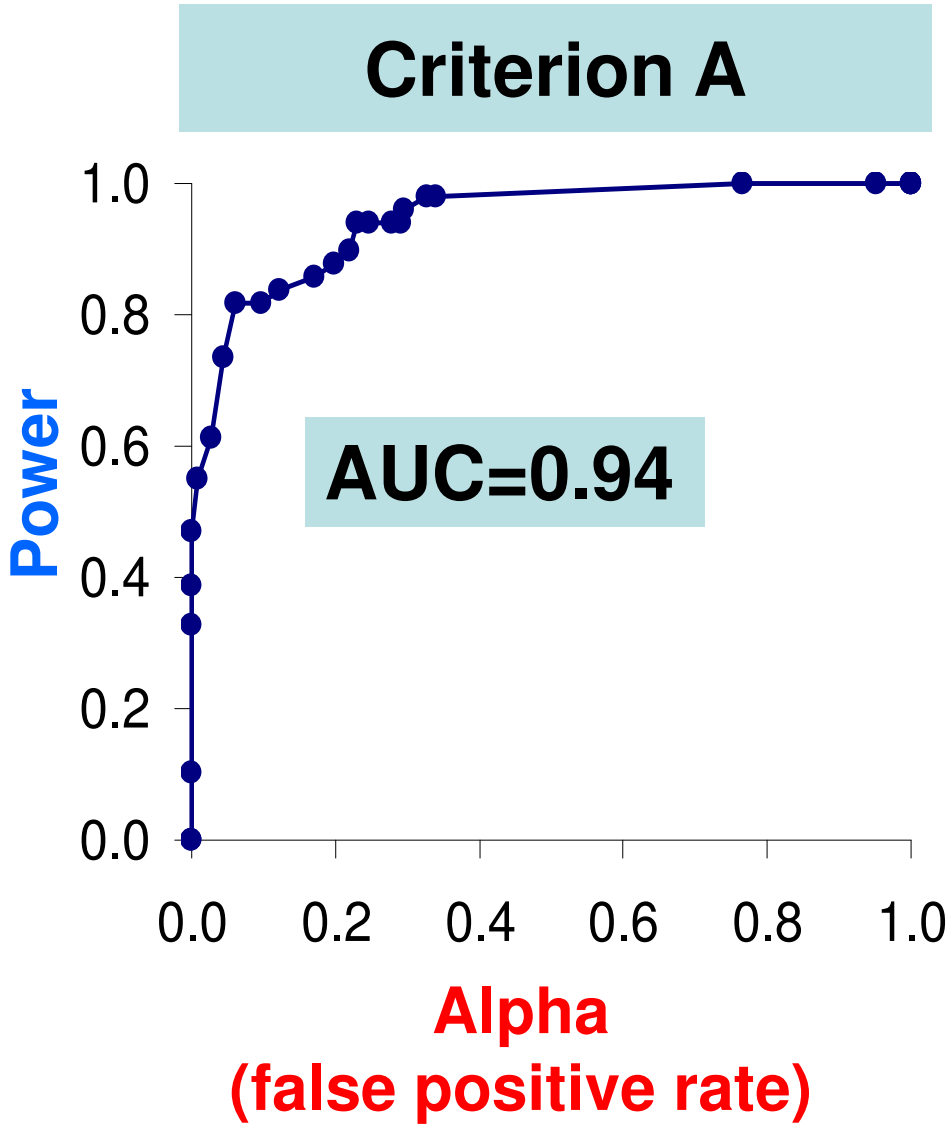
For one diagnostic criterion



Area under the curve (AUC) is:

The probability that the criterion will correctly distinguish between cases where spawner abundance is either declining or not declining.


Criterion A
AUC=0.94
Power
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Alpha
(false positive rate)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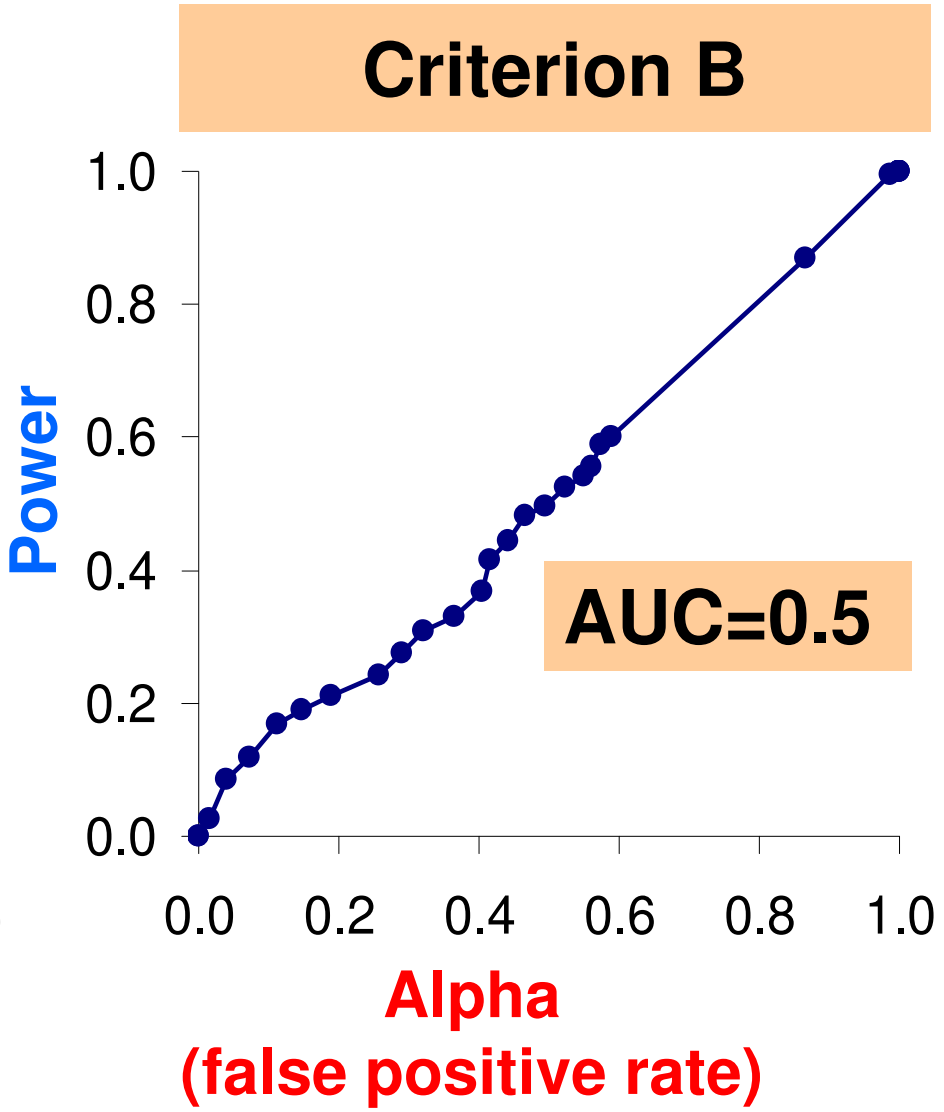
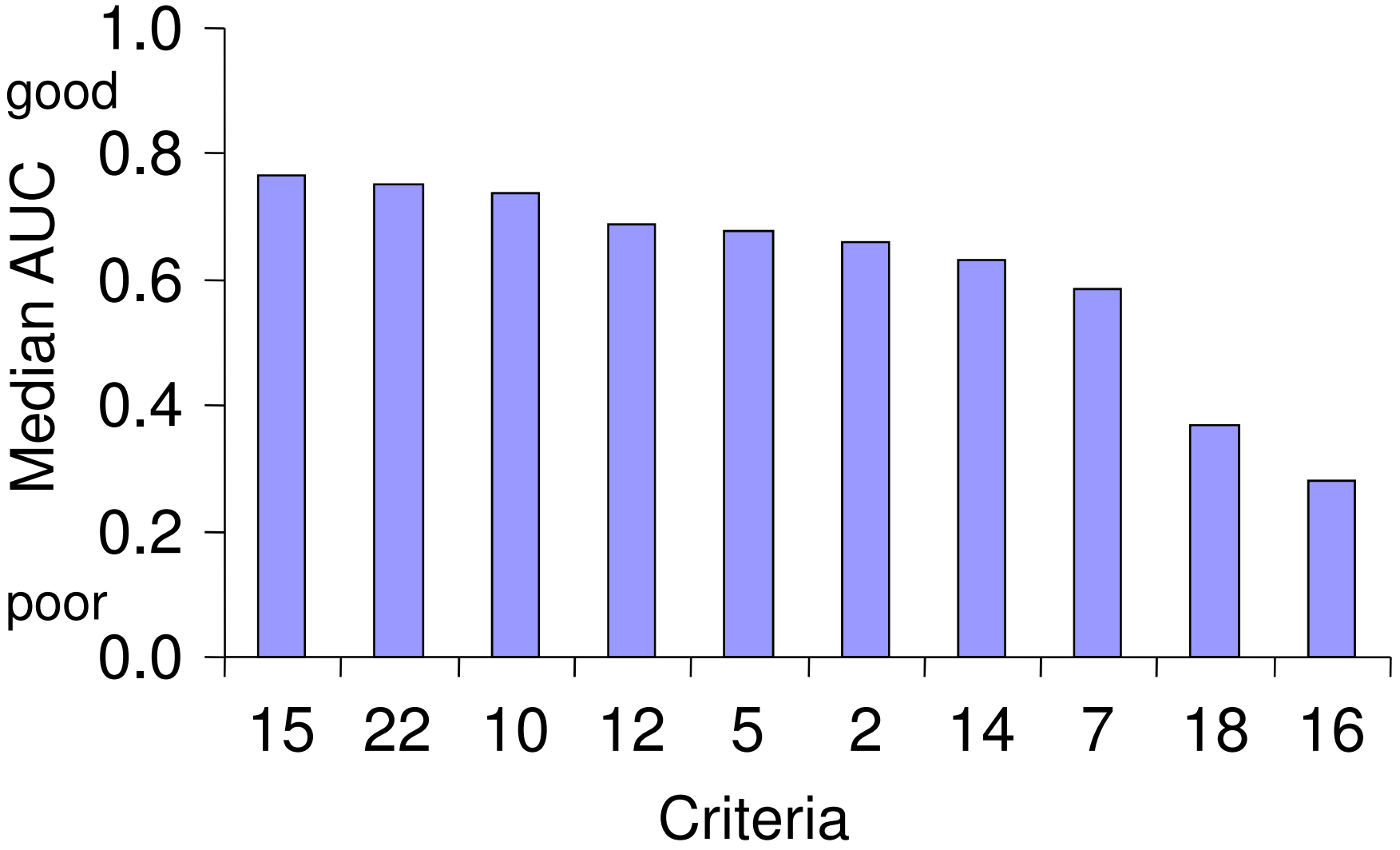
1.0
Alpha
(false positive rate)


Criterion B
Power
1.0
0.8
0.6
0.4
0.2
0.0
AUC=0.5
0.0
0.2
0.4
0.6
0.8
1.0
Alpha
(false positive rate)

Median AUC (probability of correctly classifying "decline status" of populations)



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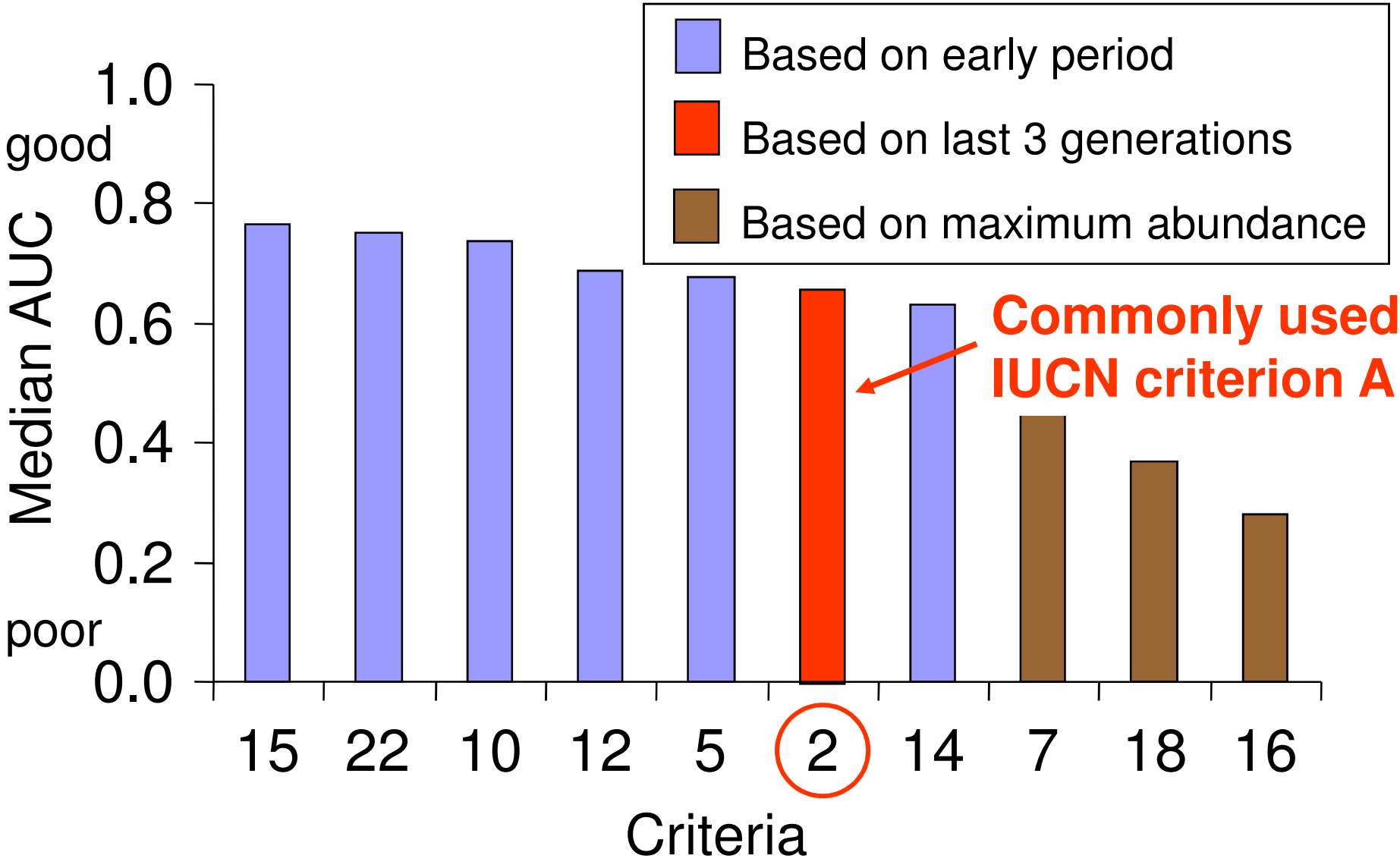
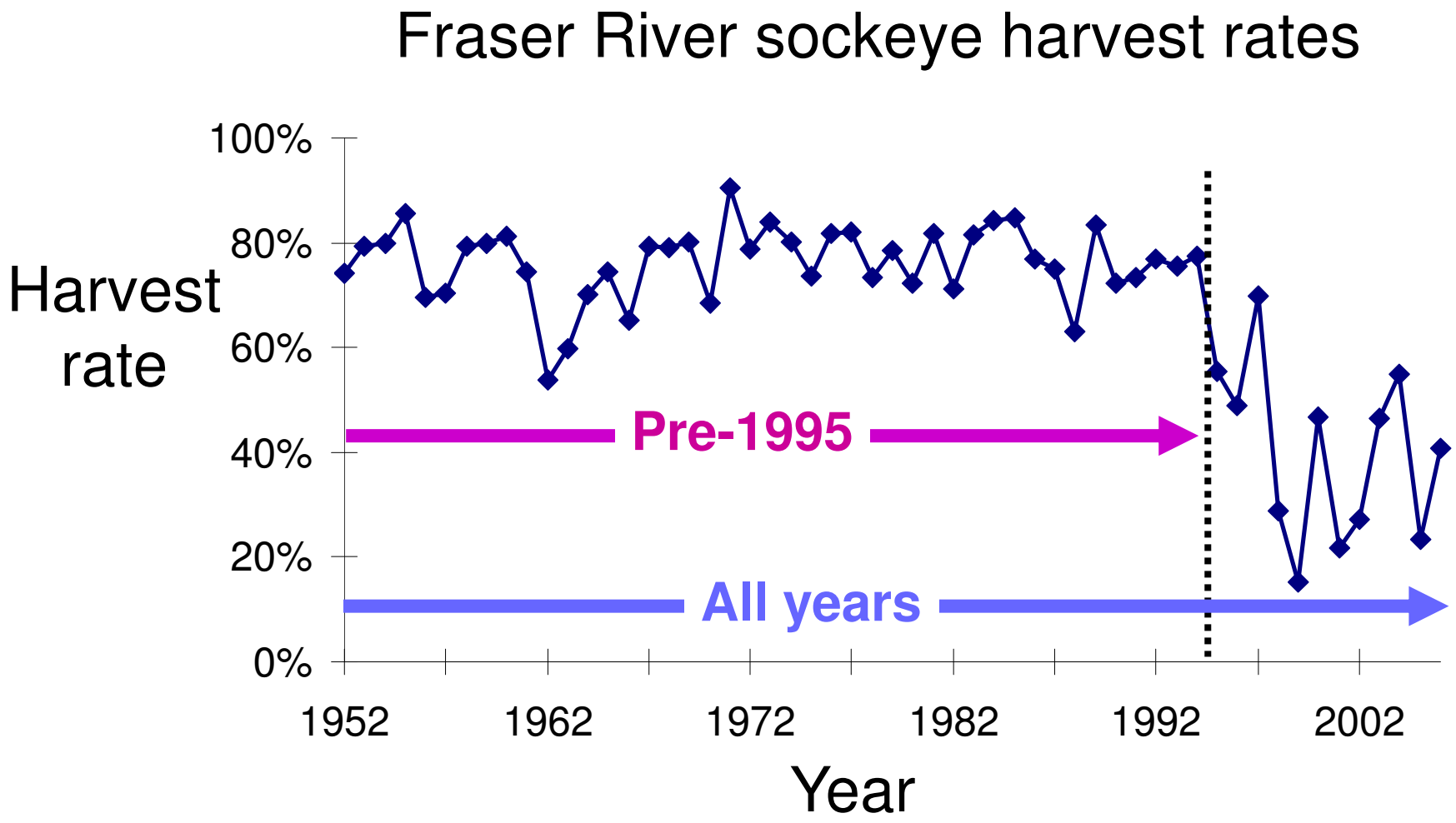
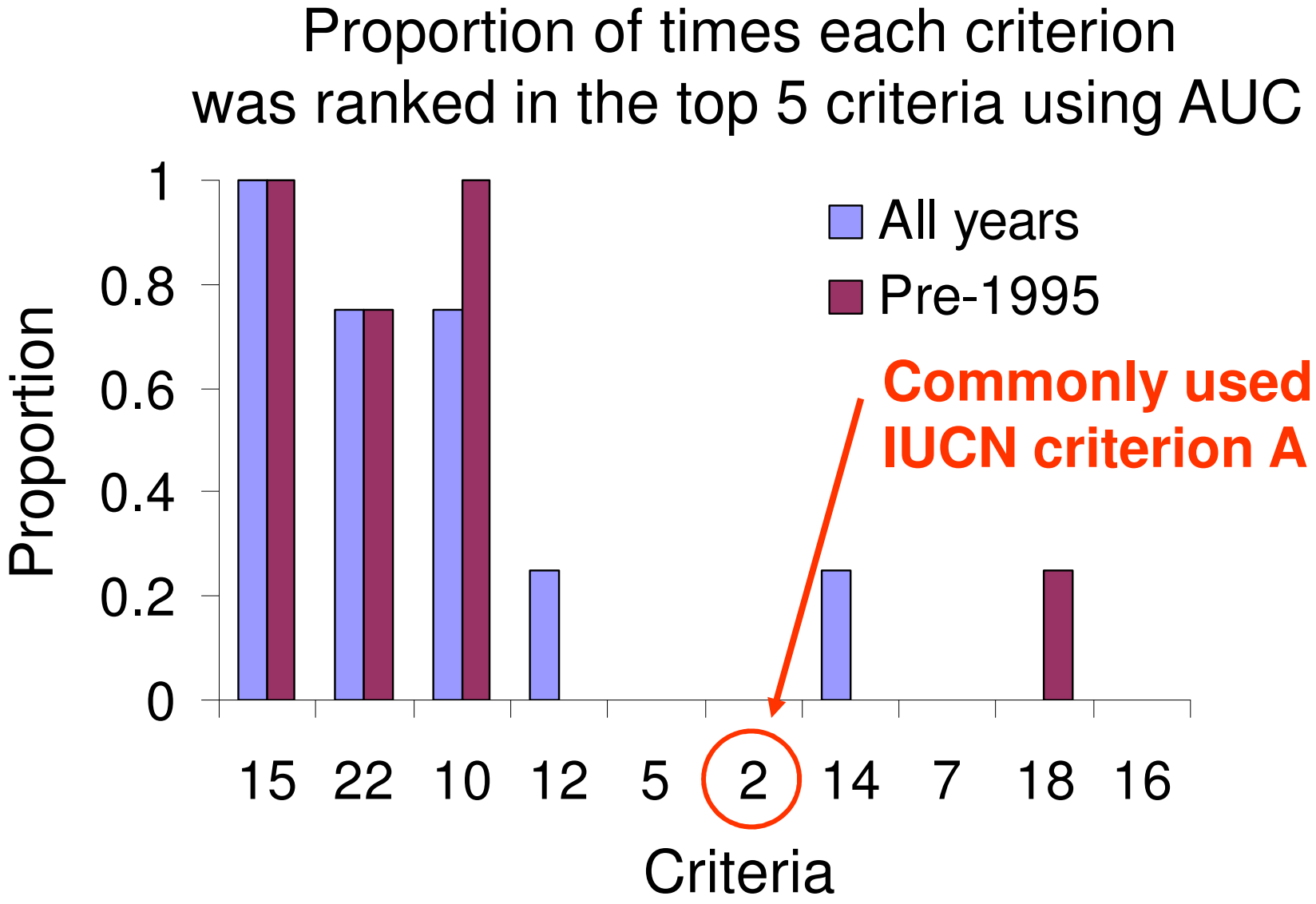


Sensitivity analysis: Confounding by harvest rates?



Result: Very similar rankings for criteria



Top-ranked criteria were based on:

- Long-term comparisons of spawner abundance
  - Measures of extent of decline compared to historical baseline

Top-ranked criteria:

- Criteria 10, 12, 15, 22 used one of:

- % decline since maximum of first 5 years (smoothed with 4-year moving averages)

- Ratio of mean abundance in current generation to mean of first generation in data series (smoothed)

  -- Overlapping or non-overlapping moving windows

- Annual rate of decline in abundance over entire time series (smoothed)

Conclusion

- Evaluate performance of criteria for classifying conservation status before using them

- Criteria based on long-term comparisons have greater chance of correctly identifying trends (either declining or not declining)
  - Fewer classification errors

Future work

Simulations to evaluate performance of classification criteria

Reference

Pestes, L.R. et al. 2008. Bayesian decision analysis for evaluating management options to promote recovery of a depleted salmon population. Conservation Biology 22(2):351-361.

Acknowledgments

- Pacific Salmon Commission
- Fisheries and Oceans Canada
- MITACS