Environmental Indicators and Pacific Salmon Conservation

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Outline

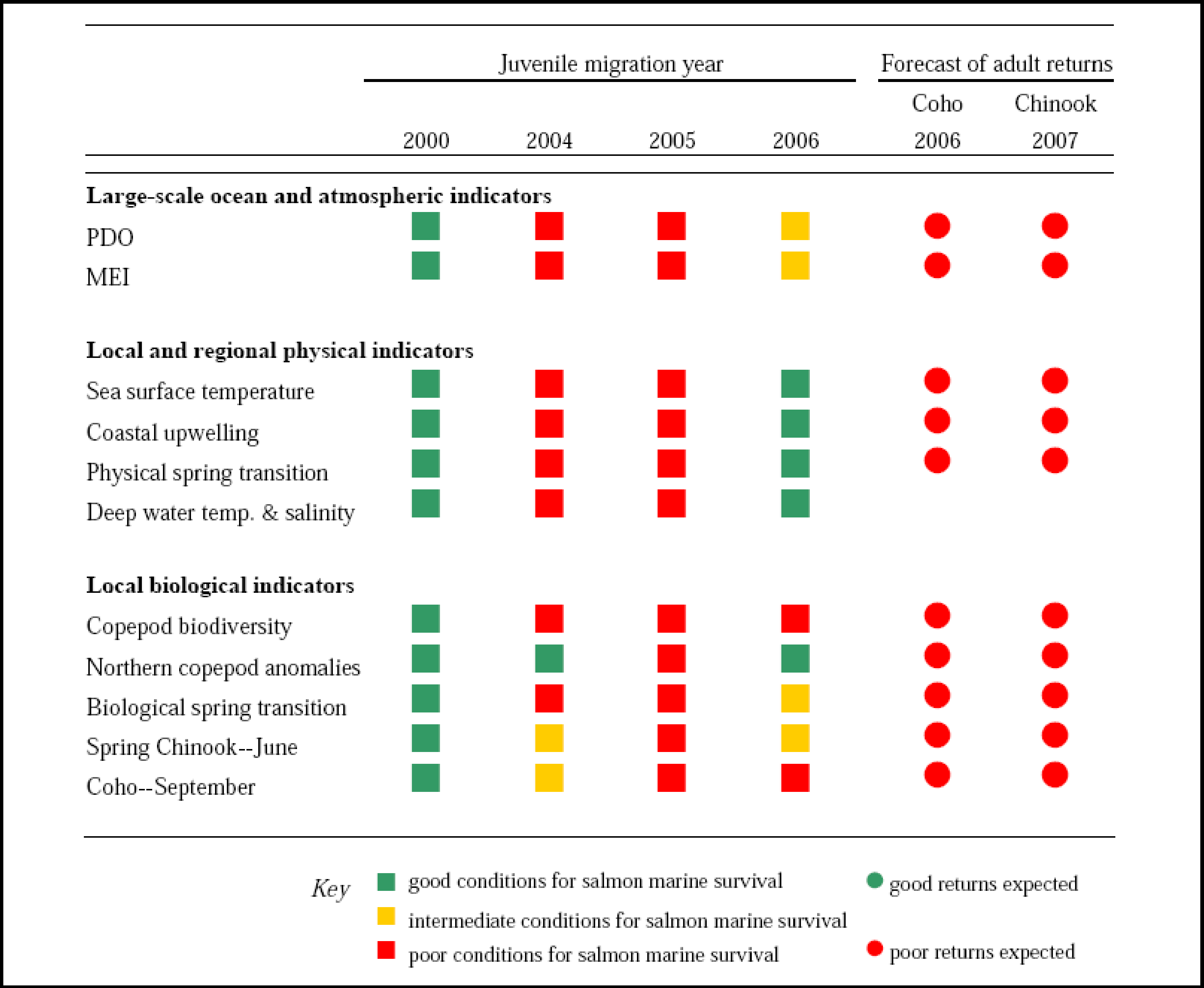
- Conservation of Pacific Salmon
  - Traditional Harvest Management (HM)
  - Conservation Biology (CB) [NOT TODAY!]
- Use of Environmental Indicators
  - Quantitative Forecasts
  - Qualitative “Warnings”
- Are Indicators Useful in Harvest Management?
- Concluding Advice

Salmon Harvest Management

- U.S. West Coast Perspective
- Three Steps
  - Assessment of Stock History
    - Spawner Abundance
      - Based on various kinds of surveys
    - Harvest Rates
      - Based on catch reporting, tag returns, models
  - Forecasts of Stock Abundance
    - Techniques vary by stock and agency
      - Stock-Recruit Models, Sibling Regressions, Environmental Regressions (one case)
  - Management Decisions
    - Stock-specific escapement goals
    - Allocation: time/area/species openings
      - “weak stock” management

How Can Indicators Be Used in HM?

- Quantitative Advice: Forecasts
  - Stock forecast regression models
    - Loggerwell et al., Scheurrell et al., etc.
  - Multi-Indicator Statistical Approaches
- Qualitative Advice: Warnings
  - Qualitative assessment of state of the environment
    - Example: El Niño
      - “An ENSO event is starting, returns will probably be low, we advise caution”
    - Example: Qualitative multi-indicator summaries
      - Peterson et al. approach



Peterson et al. (2006)

Using Indicators to Improve Forecasts

- Rationale
  - Salmon marine survival is the main determinant of returns
  - Marine survival depends on the state of the ocean
  - Indicators of ocean state (physics and ecology) correlate with recent trends in marine survival
  - Therefore, using indicators should improve forecasts and management

- This is intuitively obvious!

- But, does it work in practice?

What Requirements Must Be Met?

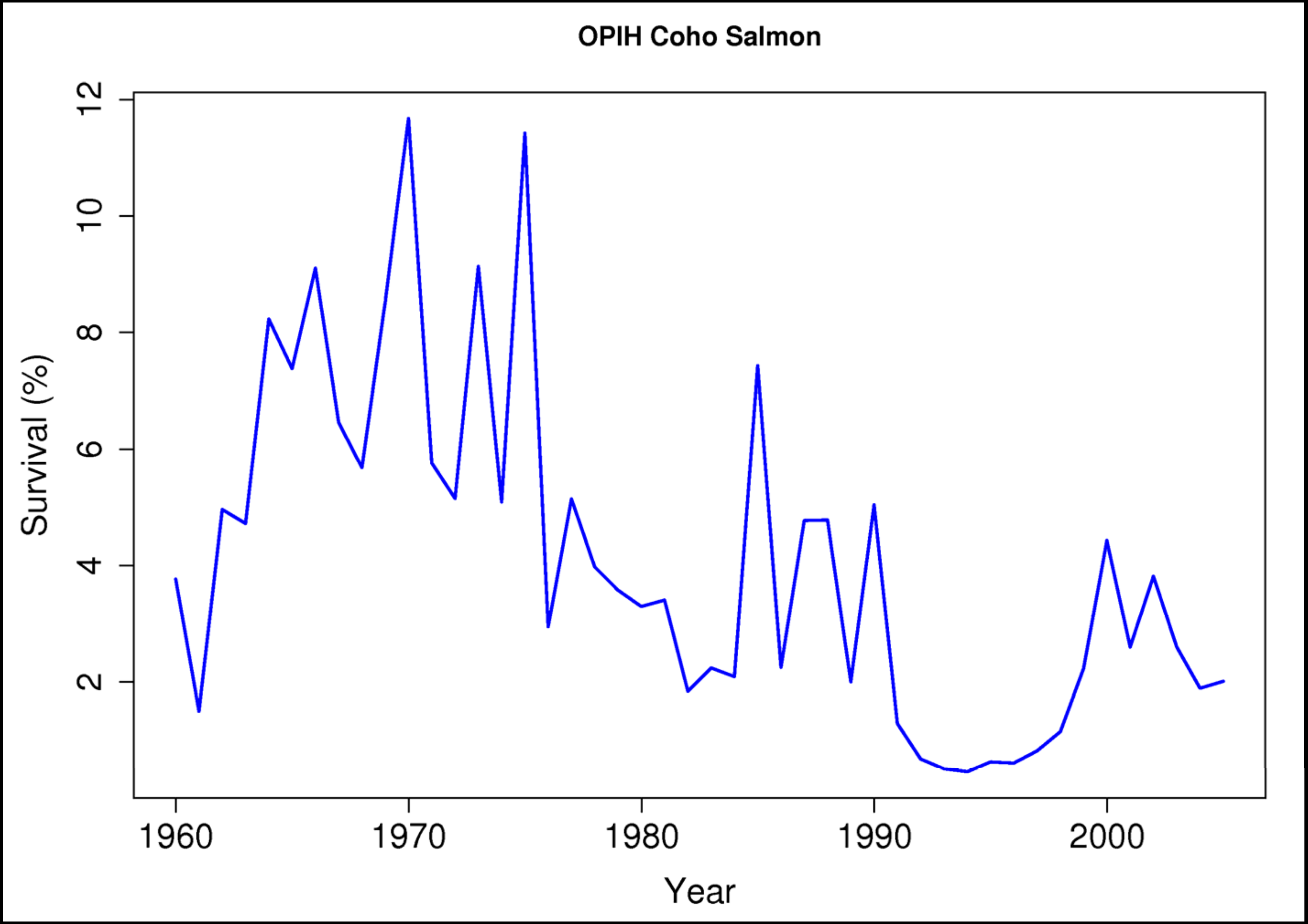
- Advice from Kaje & Huppert (2007, Nat. Res. Model.)

1. Forecasts must match the management system
   - in time and space
   - direct linkages of indicators to stock response
2. Forecasts must have sufficient skill
3. Forecasts must lead to a clear management response
4. Forecasts must be valuable
   - must increase economic value or improve meeting conservation goals
   - must be better than the existing management method

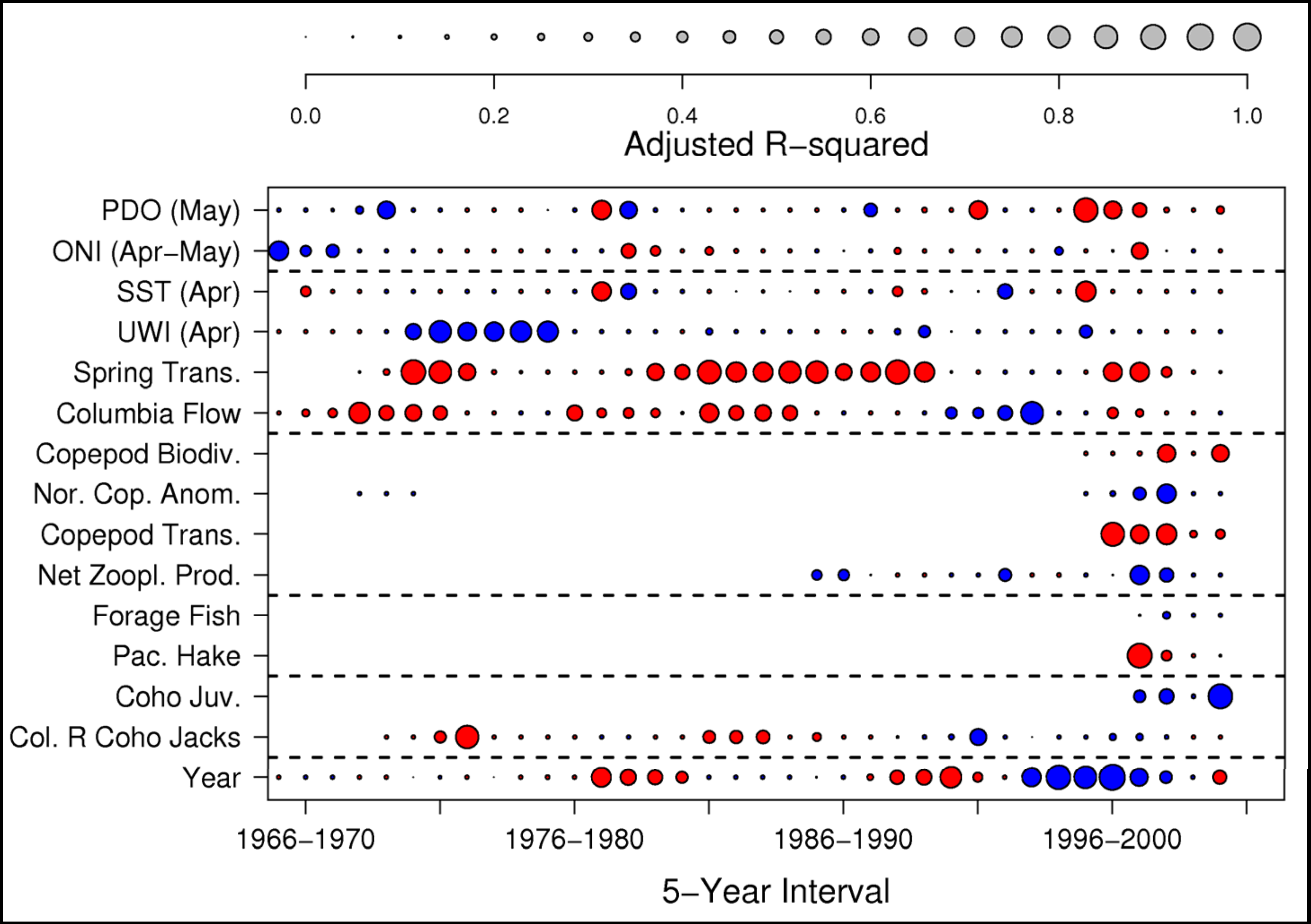
Case Study: OPIH coho salmon

- Attempt to quantify predictive relationships
- 3-step process:
  - Compute regressions of fish stock on individual indicators
  - Use regressions to forecast recruits 1-year ahead
  - Evaluate forecast skill
- Problems
  - Indicator time series lengths vary, many recently developed indicators have very short (< 10 years) series
  - Relationships vary over time

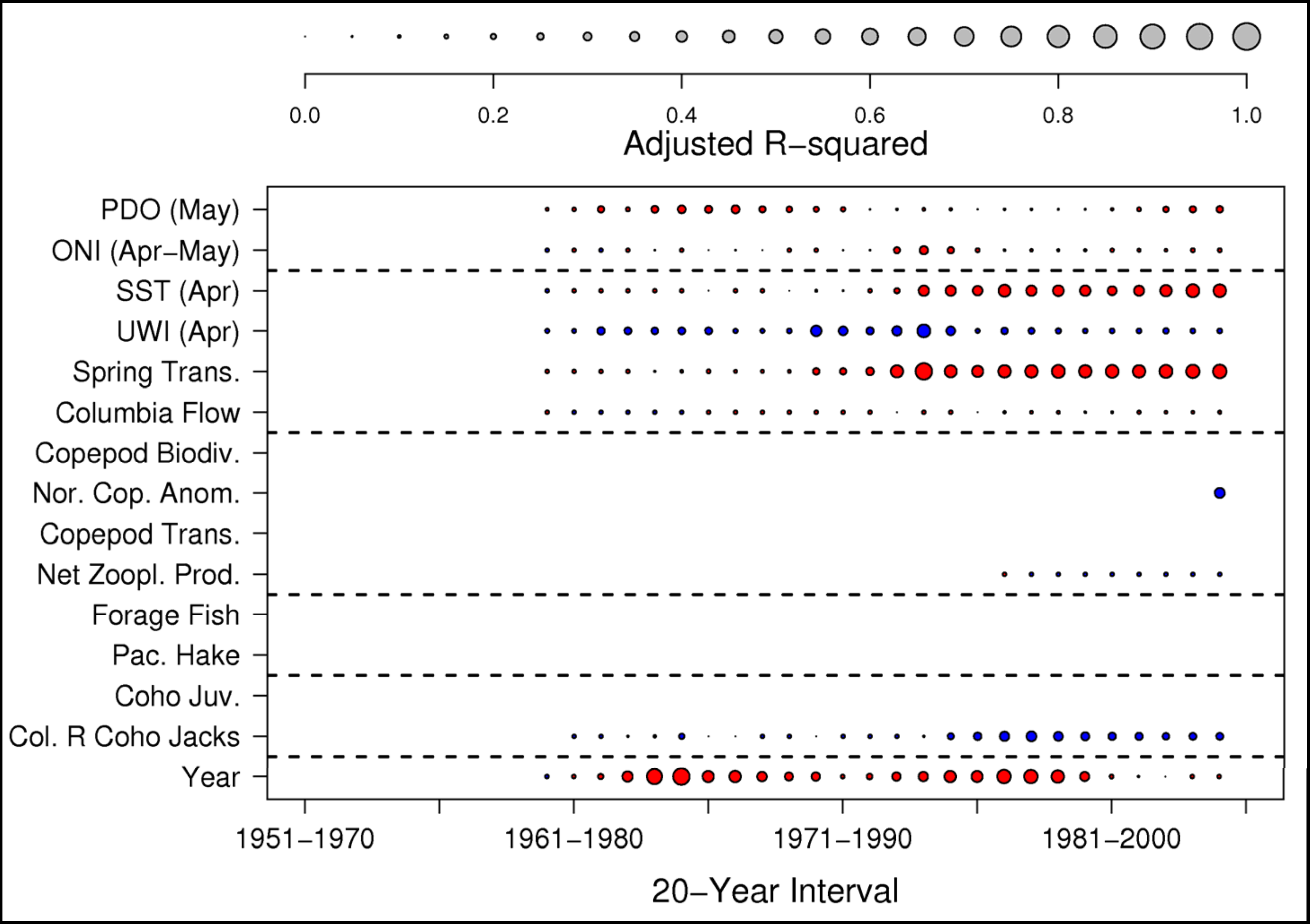
An Example: OPI Hatchery Coho



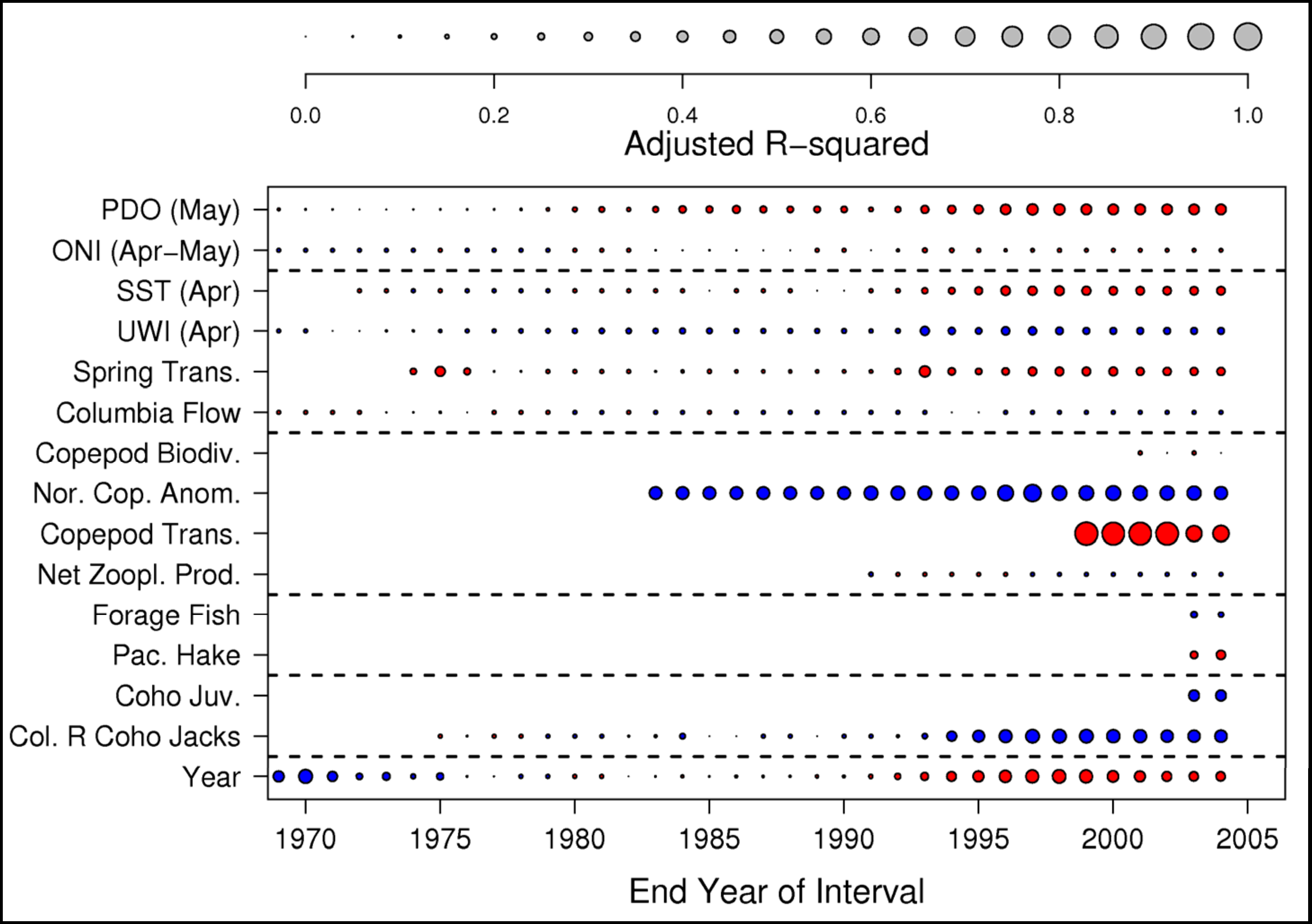
Correlations, 5-year Intervals



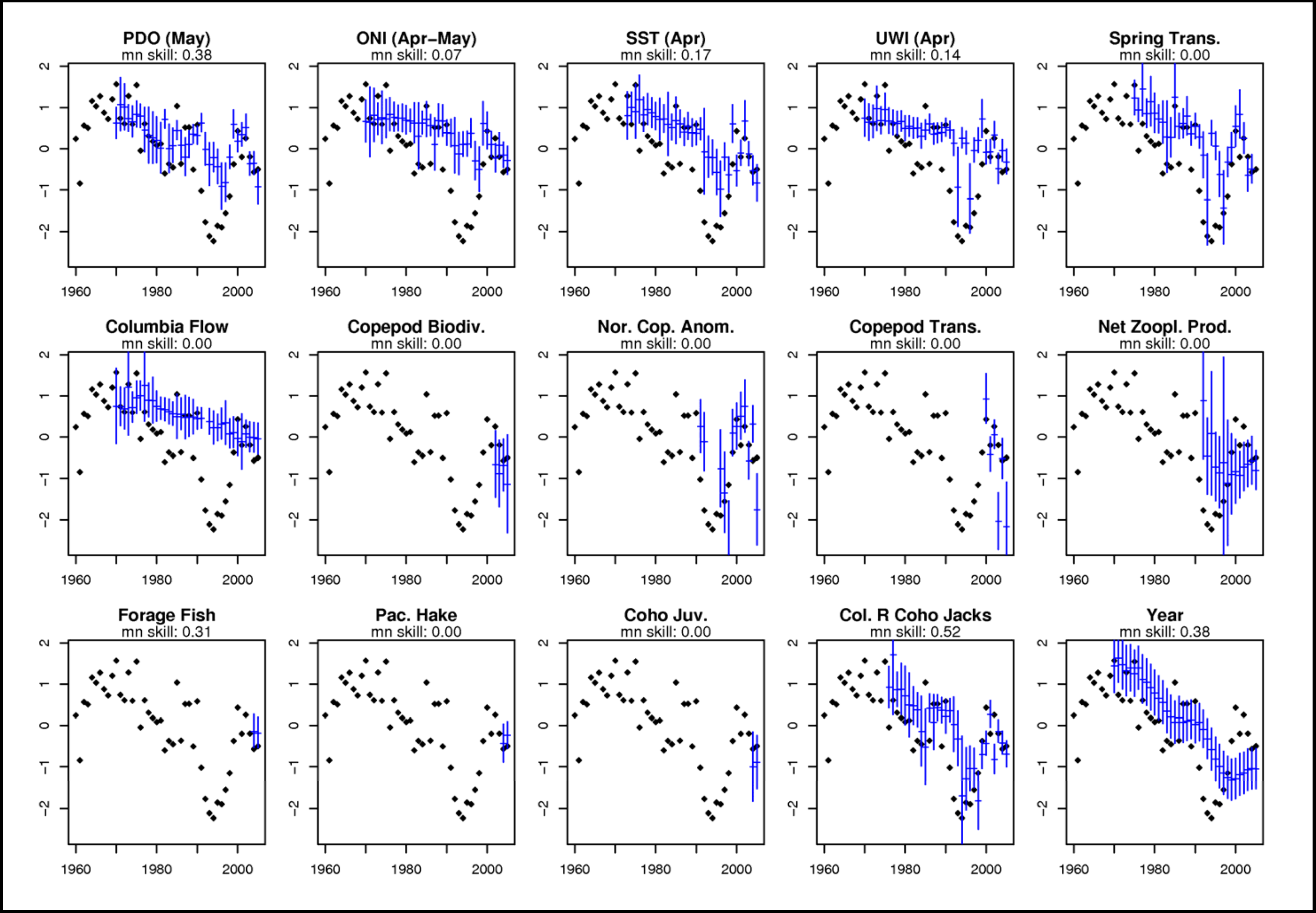
Correlations, 20-year Intervals



Correlations, Long-term Data



1-Step Ahead Forecasts



Conclusions

- Strong Short-term Correlations
  <DO NOT EQUAL>
  Long-term Relationships

- High “Hindcast” R^2
  <DOES NOT EQUAL>
  Forecast Skill

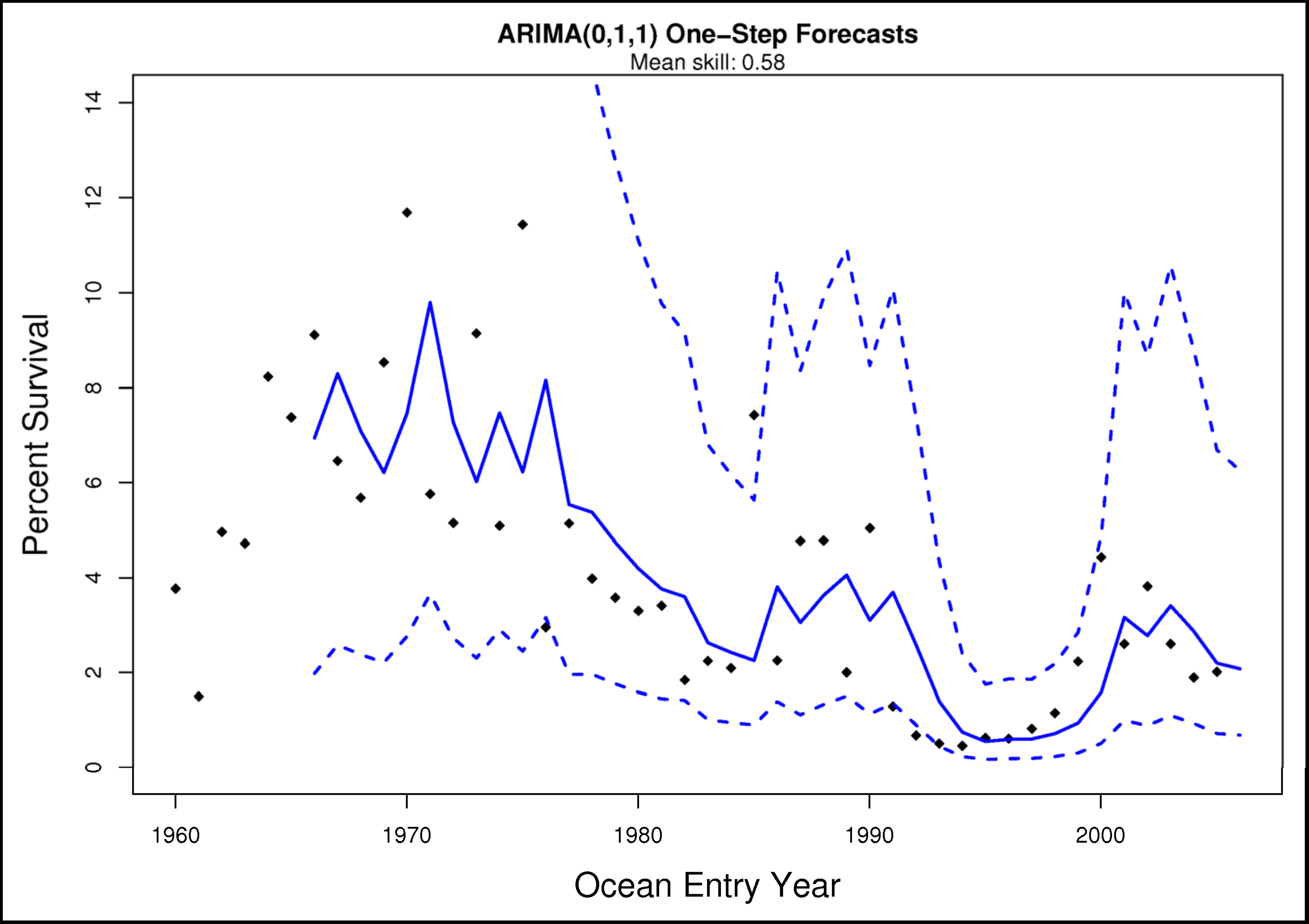
- More Direct Linkages
  <DOES EQUAL>
  Better Skill

Are These Indicators Useful?

- Revisiting Kaje & Huppert requirements

1. Forecasts must match the management system
   - in time and space -- YES, for regional indicators
   - direct linkages of indicators to stock response -- YES
2. Forecasts must have sufficient skill -- Marginal
3. Forecasts must lead to a clear management response -- YES
4. Forecasts must be valuable -- Not Evaluated
   - must increase economic value or improve meeting conservation goals
   - must be better than the existing management method

Simple Time-Series Forecast



Concluding Advice

- Nature is variable
  - climate regime changes and ecosystem phase shifts influence indicator relationships
- R^2 doesn't equal prediction
  - Little relationship with forecast skill, especially for short time series
- To provide management-relevant forecasts, we need to look at utility, not just explanatory power
  - At a minimum, evaluate forecast skill, not just hindcast goodness-of-fit
  - Best to evaluate predictors in a Management Strategy Evaluation (MSE) framework
- While Ecosystem Indicators may not be useful in tactical (short-term) harvest management, they are important in strategic planning