ODFW Coho Salmon Trend Analysis Development

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This presentation was partially supported under STAR Research Assistance Agreement No. CR-829096 awarded by the U.S. Environmental Protection Agency to Oregon State University. It has not been formally reviewed by EPA. The views expressed in this document are solely those of the authors and EPA does not endorse any products or commercial services mentioned in this publication.
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Goal

• Detect trends in Oregon Coastal and Southern Oregon-Northern California Coho per-mile densities
  – 27-year study (beginning 1998) of spatially-balanced probability sample of stream reaches
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Outline

• Sampling design

• Estimating distribution of trends

• Simulation of 27-year data set
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**Assumptions/characteristics**

- Spatial pattern of Coho densities

- Trends calculated from observations every 3\textsuperscript{rd} year and every 9\textsuperscript{th} year would be correlated with those calculated from annual data

- Coho 2-4 year life-cycle may induce density fluctuations

- Limiting capacities
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Sampling Design

• Assumes spatial pattern

• Spatially-balanced design produces estimates with smaller variance than simple random samples (SRS)

• Rotating panel design
  – Balance between extensive population coverage (for status) and repeat visits to same site (for trend)
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**Sampling Design**

- **Spatially-balanced panels:**
  - One panel of sites visited every year
  - Three panels of sites visited every 3 years
  - Nine panels of sites visited every 9 years
  - Twenty-seven panels of sites visited every 27 years

- **Four panels visited each year:**
  - the annual panel, a 3-year panel, a 9-year panel, and a 27-year panel

- **Multi-stage**
  - $S_4 \subset S_3 \subset S_2 \subset S_1$
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Site-specific trend response ($\tau$)

- Candidate measures of site-specific trend
  - Least-squares slope of per-mile density over 27-years
  - Other slope descriptors

Phase-4 ($S_4$) trends ($\tau_4$)
- Sites visited annually

Phase-3 ($S_3$) trends ($\tau_3$)
- 3-year panel sites and annual sites at 3-year intervals

Phase-2 ($S_2$) trends ($\tau_2$)
- 9-year panel sites, 3-year panel sites at every 3rd observation and annual sites at 9-year intervals
Regional Trend Description

- Goal – Characterize site-specific trend descriptor
- Characterize regional trend by distribution of site-specific trend descriptors
  - For example, cumulative distribution function (cdf) of least-squares slope given annual observations of coho density
  - Easy to get summary statistics from the cdf: mean, median, quantiles, percentages
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**Distribution (cdf) of trends**

- Proportion of site trends below $z$, where $z$ is in the interval spanning the range of (estimated) trends
- Response for cdf of trends
  
  \[ y = I[\tau < z] = \{1 \text{ if } \tau < z; \text{ otherwise } 0\} \]
- Difference estimator reduces variance of cdf estimator
  
  - Assume good correlation between 3-year/9-year trend measures and annually-visited trend measures
  
  - Extended for multi-stage sampling
Estimator for Trend cdf

\[
\hat{F}_\tau(b) = \frac{1}{|R|} \left\{ \sum_{s_i \in S_2} \frac{I(\tau_2 \mid s_i, b)}{13\pi_0} \right. \\
+ \sum_{s_j \in S_3} \frac{I(\tau_3 \mid s_j, b) - I(\tau_2 \mid s_j, b)}{4\pi_0} \\
+ \sum_{s_k \in S_4} \frac{I(\tau_4 \mid s_k, b) - I(\tau_3 \mid s_k, b)}{\pi_0} \right\}
\]

Estimates cdf of \( \tau_2 \)
Corrects for difference between (cdf of) \( \tau_3 \) and \( \tau_2 \)
Corrects for difference between (cdf of) \( \tau_4 \) and \( \tau_3 \)
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Preliminary results 1998-2001

Trend Slope
Cumulative Distribution

Stage 4 Estimate
Composite Estimate

\( \hat{V}(\hat{F}(\tau_4)) \)
\( \hat{V}(\hat{F}_4(\tau_4)) \)
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Further testing

- **Goal**
  - Determine if Trend-cdf estimators detect trends

- **Simulate 27-year data sets**
  - Base on 1998-2001 densities & trend characteristics

- **Use to exercise trend analysis algorithm**
  - Exercise 3-stage sample
  - Quantify increased power
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Simulation objectives

• Mimic the patterns of Coho per-mile density over time
  – Produce a 27-year multi-stage sampling design data set

• Underlying biological/ ecological/ environmental & anthropogenic mechanisms are not modeled

• Not intended to predict future of Coho
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1998-2001 Stage-4 patterns
One possible reference scenario

(Data from ODFW)
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Simulation

• Based on 1998-2001 ODFW Coho density data

• Set up a Coho per-mile density surface based on 2001 observations
  – Krige densities for all sites to be sampled over 27-year period from sites visited in 2001

• Set up empirical distribution of multiplicative effects \( (M_{emp}) \)
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Empirical multiplicative effects

25% are decreases
50% are increases
**ODFW Coho Analysis Development Simulation**

- For each year (after 2001) and for each site
  - Randomly draw (from $M_{emp}$)
  - Apply to site’s current density
  - Exponentially attenuate effect for densities exceeding a threshold
    - Induces population crashes
- For sites with zero density
  - Randomly select (’98-’01-empirically-based) proportion of sites to get “introductions”
  - Randomly select (’98-’01-empirically-based) magnitude of density of introduction
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Sample of realized profiles
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References

- The Oregon Plan for Salmon and Watersheds March 1997 (OPSW-ODFW-2002-07)


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