Modeling Contribution Rates of NW Chinook salmon stocks to the WCVI Chinook fishery

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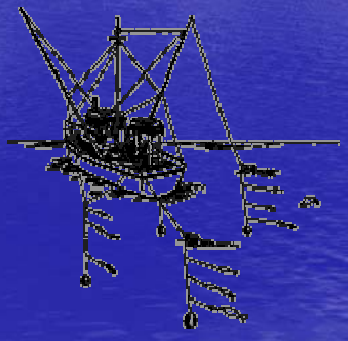
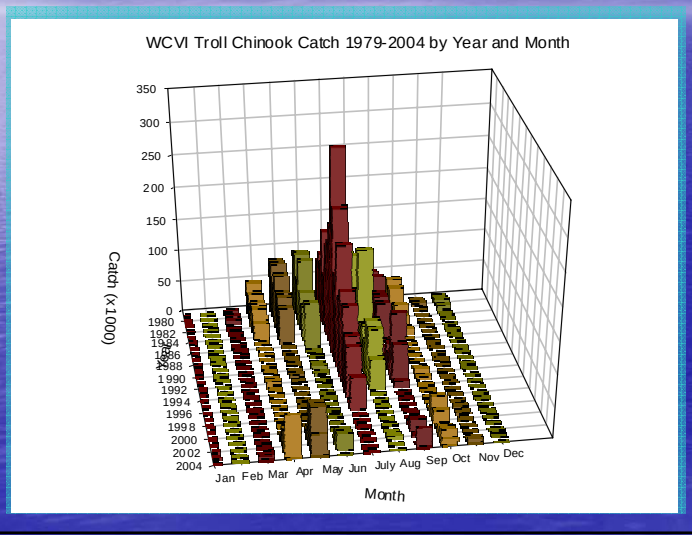
Outline

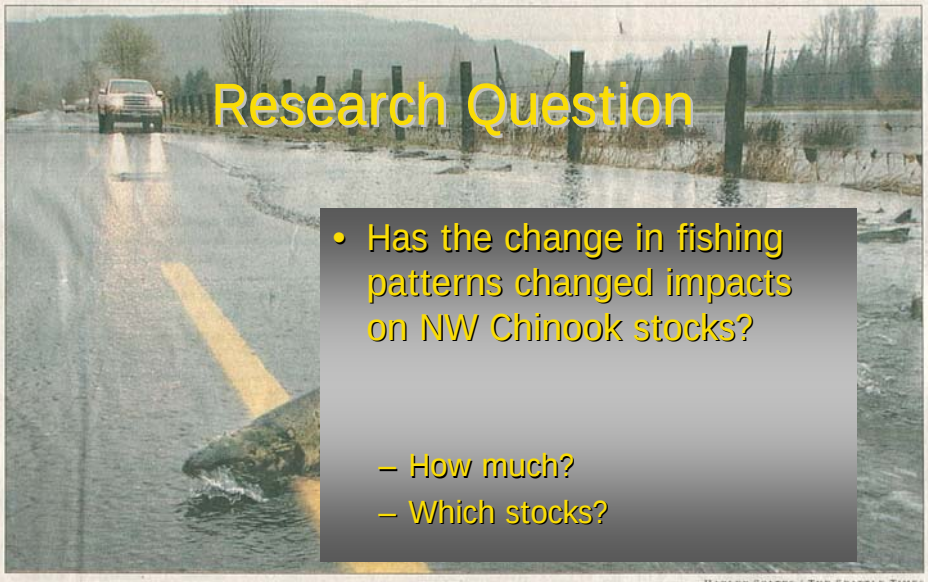
- Impetus
- Research Question
- Statistical Model
- Data Model
- Model Fitting Methods
- Results



Fishing Pattern Changes in the WCVI Chinook troll fishery



Why did the salmon cross the road?



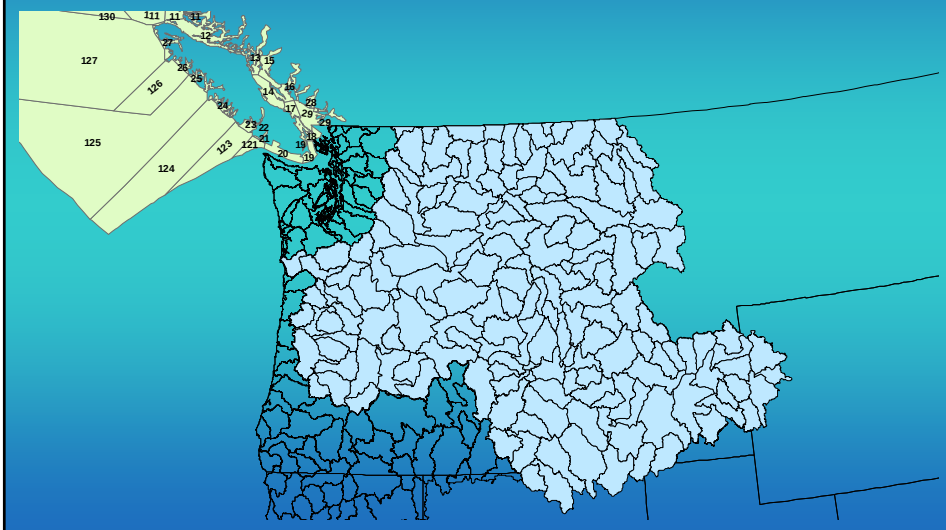
Research Question

- Has the change in fishing patterns changed impacts on NW Chinook stocks?
  - How much?
  - Which stocks?

HARLEY SOLTES / THE SEATTLE TIMES

A chum salmon *tries to get across Skokomish Valley Road yesterday to re-enter the Skokomish River north of Shelton, Mason County, and continue upstream. It and others, upper right, seemed to wait for the wake from passing vehicles to dash across the road from flooded fields.*

Spatial Mapping



Statistical Model for Tag recoveries

$$E(n_{ij.}) = R_i f_j \theta_{ij}$$

where

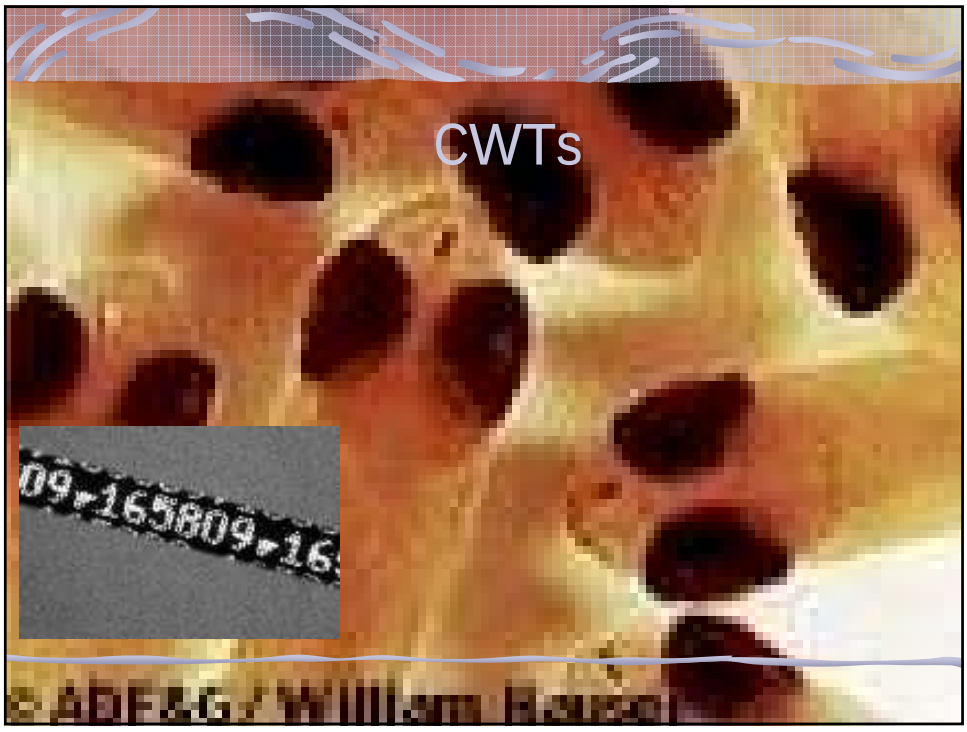
$E(n_{ij.})$ = expected # tags recovered, group i, stratum j

R_i = # of tags released, group i

$f_j = Sample_j / Catch_j$ = sampling fraction, stratum j

$\theta_{ij.}$ = contribution rate, group i, stratum j

- Mid-70s: large scale coded-wire tagging of hatchery Chinook stocks begins
- 1977: *Coordinated Coast-wide* CWT sampling program began



Statistical Model for CWT recoveries

$$f_j = \frac{S_j}{C_j} = \frac{n_j}{E_j} \qquad E_j = \frac{n_j}{f_j}$$

where $E =$ estimated number of tags if entire catch sampled

Statistical Model for CWT recoveries

$$E_{ij} = R_i \theta_{ij}$$

$$\ln(E_{ij}) = \ln(R_i) + \ln(\theta_{ij})$$

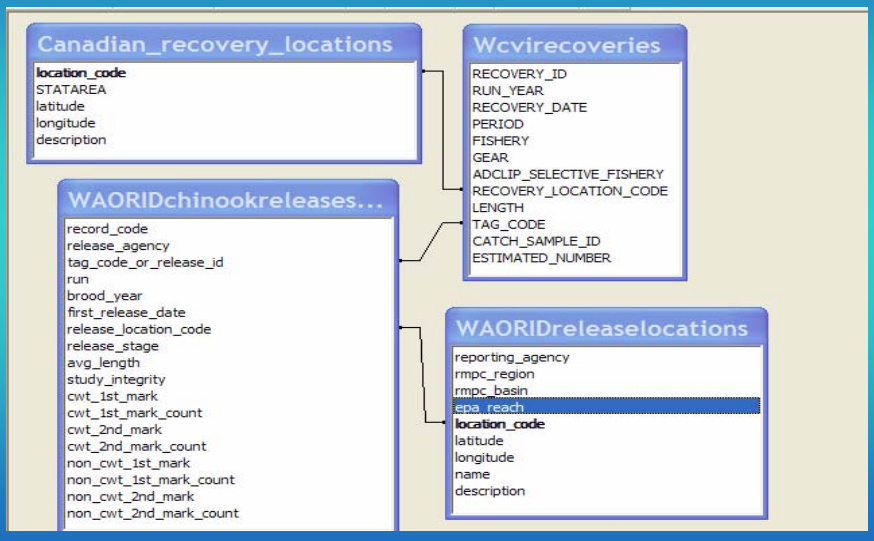
$$\theta_{ij} = \theta_g \theta_b \theta_a = e^{(\mu+\gamma+\beta+\alpha)}$$

$$\ln(\theta_{ij}) = \mu + \gamma + \beta + \alpha$$

Error Structure

- Discrete tag recoveries
- Not Normally distributed
- Poisson or Negative Binomial Errors to approximate multinomial-hypergeometric probability of recovery

Data Model



Model Fitting

- General Log-Linear model with Log link function and Negative Binomial error terms
- Iteratively Re-weighted Least Squares
- R Software
- MASS Library function from Modern Applied Statistics with S-Plus
  by Venables and Ripley

Model Selection

- Deviance = -2 * Log-Likelihood
- Differences between successive models
- Analogous to Residual Sum of Squares
- Simulations have shown Deviance performs better than Pearson's Chisquare or AIC for this model

Model Selection

- F statistic can be used to assess significance of each additional model term, like stepwise ANOVA
- Change in Deviance/df is good indicator of GOF, without knowing the exact dispersion parameter

Results

- Model Selection
  - Temporal Factors:
    - Brood year
    - Run year
    - Run year aggregate (3 levels)
    - Fishing season (4 levels)
    - Month
    - Statistical week

Results

- Model Selection
  - Spatial Factors:
    - Fishery gear (3 levels)
    - Fishery area/gear (6 levels)
    - Statistical management area (6 levels)
    - Hydrological sub-basin of stock
    - RMPC Basin aggregate

Results

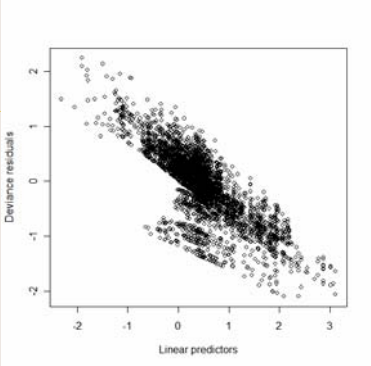
- Model Selection
  - Stock Factors:
    - Age (2,3,4,5,6)
    - Run type (spring, summer, fall)

Results

Response data:

- Observed recoveries
- Estimated recoveries
- Tagged release of each group
- Contribution rates

Results



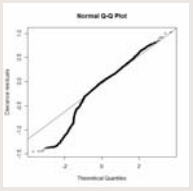
logEst ~ offset(logR) + Fbrood + Fhuc4 + Frun3 + Fstatarea

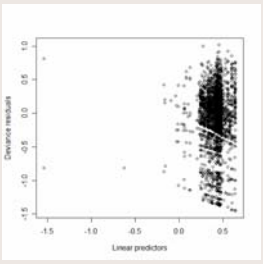
	Df	Deviance	AIC
<none>		1373.7	16186.5
- Frun3	2	1394.7	16256.5
- Fstatarea	7	1408.2	16293.7
- Fbrood	16	1630.2	17056.0
- Fhuc4	34	1668.0	17153.0

Results

-Model: Negative Binomial(1), link: log
-Response: logEst

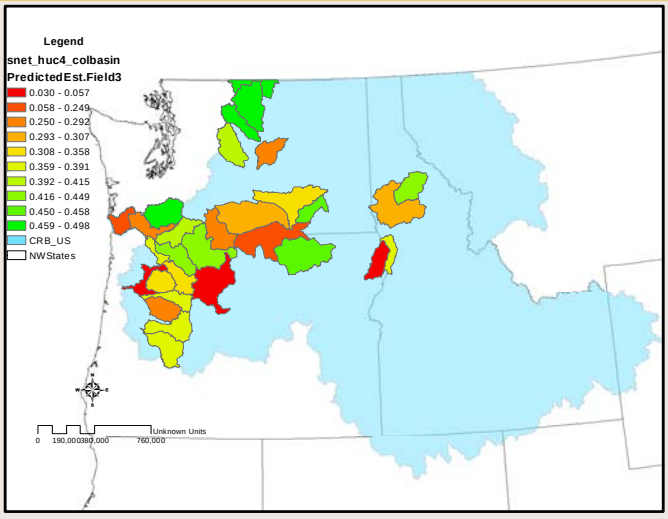
```
             Df Deviance Resid. Df Resid. Dev
NULL                          4543    2120.49
Fhuc4        34   461.42       4509    1659.07
logR          1   951.56       4508     707.51
Fhuc4:logR   29     8.17       4479     699.34
> summary(wcviarea.fit1)
glm(formula = logEst ~ Fhuc4 + logR + Fhuc4:logR
+ offset(logR)
```





WCVI Contribution Rate by Sub-basin

WCVI Contribution Rates by HUC 4 Sub-basin



Spatial Autocorrelation

- Moran's Index = -0.0331
- Expected Index = -0.0345
- Variance = 0.0016
- Z Score = 0.03547