Evaluation of spatial sampling designs for redd surveys

Martin Liermann¹, Dan Rawding², George Pess¹, Bryce Glaser²

¹ Northwest Fisheries Science Center,
² Washington Department of Fish and Wildlife.
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• GIS and data support: Steve VanderPloeg
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  Pacific Coast Salmon Recovery Fund, Pacific Salmon Commission’s Letter of Agreement (Chinook Technical Committee) and Southern Boundary Fund, NOAA-Fisheries Mitchell Act, the Washington State General Fund, and the Bonneville Power Administration through the Pacific Northwest Aquatic Partnership.
• Prior theoretical and applied salmon sample design research.
Question

What is the best way to choose a sub sample of reaches?
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Main points

• Redd locations are geographically clumpy
• This produces much more variable estimates (from sample to sample).
• There are effective strategies for reducing this variability.
  – Spatially balanced designs
  – Stratified designs
  – Regression estimators
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  – Stratified designs
  – Regression estimators
Approach

• Bin redds into 1km reaches.
  • Select a sample from the reaches based on a design (SRS, GRTS, stratified).
  • Repeat many times for each sampling design.
  • Summarize results.
Germany, Abernathy, and Mill, Steelhead 2007
Approach

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• Select a random sample from the reaches.

• Repeat many times for each sampling design.

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Approach

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Estimated total reds = 310
Estimated total reds = 420
Estimated total reds = 240
Approach

• Bin redds into 1km reaches.
• Select a random sample from the reaches.
• Repeat many times for each sampling design.
• Summarize results.
Sampling approaches

• Simple random sampling (SRS)
• Generalized Random Tessellation Stratified (GRTS)
• Stratified GRTS
• Peak count census + regression estimator
Sampling approaches

- SRS

![Graph showing reds distributions across different locations](image-url)
Sampling approaches

- SRS

![Redd distribution graphs for Abernathy, Germany, Mill, and Other locations along a river (River Km) with Redds on the y-axis.](image)
Sampling approaches

- SRS
- GRTS (Generalized Random Tessellation Stratified)
- Stratified GRTS
- Peak count census + regression estimator
Sampling approaches

- **SRS**
- **GRTS (Generalized Random Tessellation Stratified)**

![Bar chart showing Redds distribution across different locations and river kilometers.](chart.png)
Sampling approaches

• SRS
• GRTS (Generalized Random Tesselation Stratified)
• Stratified GRTS
• Peak count census + regression estimator
Stratified GRTS

River Km

Redds

0 10 20 30 40 50

0 5 10 15

Abernathy

Germany

Mill

Other

Redds

0 5 10 15

0 5 10 15 20

River Km

0 5 10 15 20
Stratified GRTS

River Km

Redds

Abernathy

Germany

Mill

Other

River Km
Stratified GRTS

- Abernathy
- Germany
- Mill
- Other

![Graph showing stratified GRTS](image-url)
Stratified GRTS

River Km
Redds
0 10 20 30 40 50
0 5 10 15
Abernathy
0 5 10 15
Germany
0 5 10 15
Mill
0 5 10 15 20
Other
Stratified GRTS

Abernathy
Germany
Mill
Other

River Km

Redds

0 5 10 15

20
Stratified GRTS

River Km

Redds

Abernathy

Germany

Mill

Other

Stratified GRTS

River Km

Redds

Abernathy

Germany

Mill

Other

Stratified GRTS

River Km

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River Km

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Stratified GRTS

River Km

Redds

Abernathy

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Stratified GRTS

River Km
Sampling approaches

- SRS
- GRTS (Generalized Random Tesselation Stratified)
- Stratified GRTS
- Peak count census + regression estimator
Peak count census + regression estimator
Results
Abernathy

Germany

Mill

Other
Abernathy
Germany
Mill
Other

Redds

River Km

[Graph showing bar charts for Abernathy, Germany, Mill, and Other. Abernathy has a significantly higher peak than the others.]
# Redd distribution

<table>
<thead>
<tr>
<th>Variance / mean</th>
<th>Mill, Abernathy &amp; Germany Cr</th>
<th>Coweeman River</th>
<th>East Fork Lewis River</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.23</td>
<td>9.30</td>
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Peak count census + regression estimator
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</tr>
<tr>
<td>$r$</td>
<td>0.90</td>
<td>0.96</td>
<td>0.94</td>
</tr>
<tr>
<td>$\sqrt{1 - r^2}$</td>
<td>0.40</td>
<td>0.29</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Conclusions

• Redd locations are geographically clumpy
• This produces much more variable estimates (from sample to sample).
• There are effective strategies for reducing this variability (GRTS, stratified, regression).
Implications

• Great data set that is likely representative of many other systems.
• Spatially balanced GRTS is a no-brainer.
• Stratified design effectiveness depends on the strata.
• Regression estimator depends on the auxiliary variable. Peak count census works well.
Further work

• Panel designs, etc...
• Other aux. vars. for regression estimators
• Redds to spawners expansion.
Steelhead redd distribution (IMW complex)
Sampling approaches

- SRS
- GRTS (Generalized Random Tessellation Stratified)
- Stratified GRTS
Sampling approaches

• SRS
• GRTS (Generalized Random Tessellation Stratified)
• Stratified GRTS
• Peak count census + regression estimator
Describe spatial distribution