Caught in the middle: Bottom-up drivers of top-down impacts on Chinook salmon

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Objectives

Characterize the distributions of Common Murre in central California during years of increased local forage production and during years of poor local production.

Quantify the relative impact of predation on juvenile Chinook salmon with a varying forage base.
Overview
Overview

• Background of the questions
  • Data sources and methodologies
  • Results
  • Taking an ecosystem perspective
Background of the questions

- Seabirds may make up a significant impact on salmon survival. In central California, juvenile salmon make up 10% of the diet of piscivorous birds.

- There is the potential for increased overlap between predators and salmon as the prey field and environment vary.

- This impact on salmon may be greater as alternative prey resources are limited.
Overview

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## Data sources and methodologies

<table>
<thead>
<tr>
<th>Type</th>
<th>Series</th>
<th>Source</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common murre</td>
<td>Abundance (ind.)</td>
<td>Point Blue</td>
<td>1983-2012</td>
</tr>
<tr>
<td></td>
<td>At-sea density (km²)</td>
<td>RREAS</td>
<td>1996-2010</td>
</tr>
<tr>
<td></td>
<td>Diet composition (% FO)</td>
<td>Point Blue</td>
<td>1983-2012</td>
</tr>
<tr>
<td></td>
<td>Trip duration (minutes)</td>
<td>Point Blue</td>
<td>1984-2012</td>
</tr>
<tr>
<td></td>
<td>Size of prey (mm)</td>
<td>Point Blue</td>
<td>1983-2012</td>
</tr>
<tr>
<td>Forage base</td>
<td>Rockfish (ln(CPUE+1))</td>
<td>RREAS</td>
<td>1983-2012</td>
</tr>
<tr>
<td></td>
<td>Northern anchovy (CPUE)</td>
<td>RREAS</td>
<td>1983-2012</td>
</tr>
<tr>
<td>Chinook salmon</td>
<td>Length at Chipps Isl. (mm)</td>
<td>USFWS</td>
<td>1983-2012</td>
</tr>
<tr>
<td></td>
<td>Survival (%)</td>
<td>RMIS</td>
<td>1983-2012</td>
</tr>
<tr>
<td>Environment</td>
<td>March upwelling at 39°N (m³/sec./100 m of coastline)</td>
<td>PFEL</td>
<td>1983-2012</td>
</tr>
<tr>
<td></td>
<td>Average discharge during April (cfs; USGS station 11390500)</td>
<td>USGS</td>
<td>1983-2012</td>
</tr>
</tbody>
</table>
Data sources and methodologies

Relate survival to variability in freshwater flow, upwelling, prey, Common Murre population size.

\[
\text{betareg}(\text{Survival} \sim \text{Freshwater discharge in April} \\
+ \text{Upwelling in March} \\
+ (\text{Upwelling March})^2 \\
+ \text{Rockfish Abundance} \\
+ \text{Murre Population} \\
+ \text{Interaction(Rockfish*Murre)}
\]
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Common Murre distribution and population size

- Population size is increasing
Common Murre distribution and population size

- Population size is increasing

- During year of improved production locally Murre are dispersed

- During years of reduced production locally Murre concentrate on shelf where anchovy or more abundant.
Common Murre diet

Rockfish

Anchovy

http://www.seadocsociety.org/newsarchive/october2012update.html
Common Murre diet

[Graph showing the diet of Common Murres with Rockfish and Anchovy as prey]

Length (mm)
# Modeling salmon survival

<table>
<thead>
<tr>
<th>Covariate</th>
<th>estimate</th>
<th>Std. Error</th>
<th>Z-Score</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-4.78</td>
<td>0.11</td>
<td>-43.94</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ln(Discharge April+1)</td>
<td>0.49</td>
<td>0.12</td>
<td>4.07</td>
<td>&lt;0.0001</td>
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<tr>
<td>March upwelling</td>
<td>1.58</td>
<td>0.54</td>
<td>2.91</td>
<td>0.0036</td>
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<tr>
<td>(March upwelling)^2</td>
<td>-1.61</td>
<td>0.54</td>
<td>-2.99</td>
<td>0.0028</td>
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<tr>
<td>Ln(Rockfish CPUE + 1)</td>
<td>0.53</td>
<td>0.11</td>
<td>4.74</td>
<td>&lt;0.0001</td>
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<tr>
<td>Common murre abundance</td>
<td>-0.05</td>
<td>0.11</td>
<td>-0.52</td>
<td>0.6154</td>
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<tr>
<td>Interaction between rockfish and common murre</td>
<td>0.23</td>
<td>0.11</td>
<td>2.17</td>
<td>0.0301</td>
</tr>
</tbody>
</table>
Modeling salmon survival

There is indication of survival being substantially lower when rockfish abundance is low and Common Murre population size great.
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Taking an ecosystem perspective

Evidence indicates that freshwater practices can improve survival by promoting larger fish.

As well, winter preconditioning (upwelling) is critical to setting up an environment conducive to early salmon survival.

Common Murre prey on salmon more when the local environment does not promote local production of prey and leads to increases of anchovy on the shelf.

As the population of Common Murre continues to increase, there may be an associated increase in variability of salmon survival.
Taking an ecosystem perspective

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Modeling salmon survival

It is worth noting that detrended data does not have interaction.