Entry and transfer of polychlorinated biphenyls (PCBs) in the Pacific sand lance life cycle, Puget Sound, Washington

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Entry and transfer of polychlorinated biphenyls (PCBs) in the Pacific sand lance life cycle, Puget Sound

T. Liedtke, K. Conn, R. Dinicola, and R. Takesue
Background

- Pacific sand lance and other forage fishes
  - Pacific herring, surf smelt, Northern anchovy
  - Small, abundant, schooling planktivores
  - Rich in lipids
  - Critical link in marine food web
  - Consumed by fish, marine mammals, and birds

- Sand lance basic biology and status poorly understood
  - Contaminants may play a role

- Status of forage fish influences status of other species
  - Contamination may drive new or higher contamination levels
Sand lance

- Beach spawners
  - Small eggs on upper intertidal areas for ~4 weeks
  - Risk of contaminations from terrestrial sources
- Burrow regularly in sediments
  - Potential contamination risk
- Fall - Winter spawning
  - Spawning sites consistent over decades
- Sexually mature at 1-2 years (> 100 mm)
- Fish over 3 years rarely found in quantity
- No known large-scale migrations
Synoptic Survey

- First data on contaminants in sand lance
- 9 sites
- Collected 2010-2014
- PCBs, PAHs, legacy pesticides & flame retardants
- Samples processed by AXYS Analytical Services
- PCBs
  - EPA method #1668
  - 209 congeners
## Synoptic Survey: PCBs

### Total PCBs (ng/g lipid)

- **Large (~150 mm)**
- **Med (115-125 mm)**
- **Small (< 100 mm)**

### Site Data

<table>
<thead>
<tr>
<th>Site</th>
<th>Nisq Delta</th>
<th>Eld Inlet</th>
<th>Comm Bay</th>
<th>Eagle Hrbr</th>
<th>Eagle Hrbr</th>
<th>Lib Bay</th>
<th>Agate Pass</th>
<th>N Bbrdge Isl</th>
<th>Lopez Isl</th>
<th>Clay Bch</th>
<th>Clay Bch</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Lipid</td>
<td>4.2</td>
<td>1.6</td>
<td>2.7</td>
<td>4.6</td>
<td>4.4</td>
<td>4.5</td>
<td>3.9</td>
<td>7.6</td>
<td>2.6</td>
<td>2.2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

### South and North

- **South**
- **North**
Synoptic Survey: PCBs

- PCBs in immature fish (less than ~ 1 year old, ~ 80 mm)

- Interested in pathways for entry of PCBs
  - Are very young fish contaminated?

- Compare Eagle Harbor and Clayton Beach
  - Opposite ends of the continuum and regular spawning/rearing sites
  - Sampled early juveniles and adults at both sites in Spring 2016
Outside of spawning period
- No gonad development, adults not dimorphic
- Sex ratio likely 1:1

Young of the year (YOY) or Age-0 fish
- Definition includes all of first year
- Our samples more focused:
  o Recently transformed from larval stage
    o Occurs ~ 30 mm
  o Have adult shape, but lack pigmentation
  o Weak swimmers with limited range
    o Commonly found near spawning beaches
  o Growing very quickly

**Goal:** collect YOY in April & May at both sites
- Measure changes in PCB concentrations over short period
### Eagle Harbor vs. Clayton Beach--Spring

<table>
<thead>
<tr>
<th></th>
<th>Total PCBs (ng/g lipid)</th>
<th>Clayton</th>
<th>Eagle</th>
</tr>
</thead>
<tbody>
<tr>
<td>YOY (April)</td>
<td>1.8%</td>
<td>44</td>
<td>1.4%</td>
</tr>
<tr>
<td>YOY (May)</td>
<td>5.2%</td>
<td>106</td>
<td>6.2%</td>
</tr>
<tr>
<td>S Adult</td>
<td>7.0%</td>
<td>142</td>
<td>% Lipid</td>
</tr>
<tr>
<td>M Adult</td>
<td>1.8%</td>
<td>5.5%</td>
<td>7.5%</td>
</tr>
<tr>
<td>L Adult</td>
<td>44</td>
<td>107</td>
<td>124</td>
</tr>
</tbody>
</table>
Clayton Beach -- Spring

- **Lipid Normalized:**
  - Highest levels in smallest YOY
    - 1.8% lipid
  - May YOY similar to all 3 sizes of adults
    - 1.5% lipid YOY
    - 5 - 7% lipid adults
  - Very early juveniles are contaminated
Eagle Harbor vs. Clayton Beach--Winter

- Collecting eggs from spawning beaches not viable option
  - Small eggs (< 1 mm) covered in sand grains
  - Potential PCB exposure on beaches

- Collected sexually mature males and females at both sites

- Assayed whole body males (including gonads)

- Removed eggs from females and assayed whole body without eggs
  - Egg samples represent the individual females assayed
  - Eggs were 15-25% of total body mass
Eagle Harbor vs. Clayton Beach--Winter

**Approach:**
- Evaluate several size classes of males and females
- Use co-collected males and females

**November 2016 field collection — completed in 4 days**

**Divided fish at each site into:**
- Small (~100 mm), estimated to be first year spawners
- Large (> 100 mm), estimated to be 2nd or 3rd year spawners

**Mean fork lengths:**

<table>
<thead>
<tr>
<th></th>
<th>Eagle Harbor</th>
<th>Clayton Beach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Females</td>
<td>100 mm</td>
<td>97 mm</td>
</tr>
<tr>
<td>Small Males</td>
<td>100 mm</td>
<td>97 mm</td>
</tr>
<tr>
<td>Large Females</td>
<td>139 mm</td>
<td>133 mm</td>
</tr>
<tr>
<td>Large Males</td>
<td>140 mm</td>
<td>133 mm</td>
</tr>
</tbody>
</table>
Conclusions

- Sand lance have restricted range / site fidelity
  - Eagle Harbor values >10x higher than Clayton Beach

<table>
<thead>
<tr>
<th></th>
<th>Eagle</th>
<th>Clayton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td>2900</td>
<td>270</td>
</tr>
<tr>
<td>Lowest</td>
<td>600-700</td>
<td>65-70</td>
</tr>
<tr>
<td>Mean</td>
<td>~1100</td>
<td>~175</td>
</tr>
</tbody>
</table>

- Evidence of bioaccumulation
  - Winter collection shows a size effect
  - Higher concentrations in large fish
  - Clear trend for males and females at both sites
Conclusions

- Our findings in relation to:
  - 3 year old Pacific herring (from West et al. 2008)
    - From 3 sites in Puget Sound
    - PBC concentrations from 1500-2500 ng/g lipid
    - Sand lance concentrations were lower
      - Large males at Eagle Harbor were similar

- Environmental samples
  - Fine bed sediment, nearshore suspended sediment, & suspended particulate matter near fish locations
  - Much lower than sand lance concentrations
  - Typically >10x lower on a dry weight basis
Conclusions

- Sand lance demonstrate maternal transfer of PCBs to their eggs
  - Eggs from both sites & size classes contain PCBs

- Concentrations in females and their eggs were similar
  - Lipid content 6.5 – 8.5% in eggs, and 2-3% in females and males

- Concentrations in males were higher than females and eggs
  - Especially in large fish – 2\(^{nd}\) - 3\(^{rd}\) year spawners
  - Weaker trend in smaller fish – first year spawners

- New route of entry / re-entry of PCBs into food web
ACKNOWLEDGMENTS:
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Russel Barsh at KWIAHT (center for the historical ecology of the Salish Sea) For providing samples from Lopez Island.

QUESTIONS?
% Lipid summary for sand lance samples

- Eggs \(6.5 - 8.5\%\)
- YOY \(1 - 2\%\)
- Adults \(5 - 8\%\)