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

Western Fisheries Research Center
U.S. Department of the Interior
U.S. Geological Survey
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

- 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:
  - Recently transformed from larval stage
    - Occurs ~ 30 mm
  - Have adult shape, but lack pigmentation
  - Weak swimmers with limited range
    - Commonly found near spawning beaches
  - 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>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>1.4%</td>
</tr>
<tr>
<td>YOY (May)</td>
<td>5.2%</td>
<td>6.2%</td>
</tr>
<tr>
<td>S Adult</td>
<td>7.0%</td>
<td>7.0%</td>
</tr>
<tr>
<td>M Adult</td>
<td>1.8%</td>
<td>5.5%</td>
</tr>
<tr>
<td>L Adult</td>
<td>1.8%</td>
<td>7.5%</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>% Lipid</th>
<th>Size (mm)</th>
</tr>
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<tbody>
<tr>
<td>Clayton</td>
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</tr>
<tr>
<td>1.8%</td>
<td>1.8%</td>
</tr>
<tr>
<td>50</td>
<td>106</td>
</tr>
<tr>
<td>124</td>
<td>142</td>
</tr>
<tr>
<td>142</td>
<td>150</td>
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<tbody>
<tr>
<td>Eagle</td>
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</tr>
<tr>
<td>7.6%</td>
<td>7.6%</td>
</tr>
<tr>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

[Graph showing Total PCBs (ng/g lipid) for YOY (April), YOY (May), S Adult, M Adult, and L Adult with comparison between Clayton and Eagle.]
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>
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</tbody>
</table>
Conclusions

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

<table>
<thead>
<tr>
<th>ng/g lipid</th>
<th>Eagle</th>
<th>Clayton</th>
</tr>
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<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 – 2nd - 3rd year spawners
  - Weaker trend in smaller fish – first year spawners

- New route of entry / re-entry of PCBs into food web
ACKNOWLEDGMENTS:
Special thanks to Ryan Tomka, Lisa Gee, and Lisa Weiland for field sampling and laboratory processing efforts.

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%