Migration Behavior Changes of Juvenile North Pacific Albacore linking to Environmental Variability

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We generate science necessary for the conservation and management of living marine resources in the California Current, Pacific Ocean and in Antarctica.
About the Species

• Highly migratory
• Juvenile age 2-5, size 57-110cm
• Good omega-3 sources
• Sushi/sashimi
• Canning
• Currently healthy stock status
Background & Objectives

• The albacore surface fishery (troll and pole-and-line) is the most important commercial tuna fishery on the US and Canada West Coast.

• Previous research study showed that albacore distribution is associated with sea surface temperature gradient and SST front over large spatial (northeast Pacific) and temporal scales (30 years, 1982-2011). Higher CPUE were observed at places with greater SST gradient longitudinally. (Xu et al., 2015, Progress in Oceanography, In Press)

• Our objective is to study albacore behavior changes (movement, diving, ambient water and body temperature changes, etc) in different study areas identified by SST gradients and fronts, using archival tagging data.
SST gradient decrease from west to east, reaching min@130W, before rapidly increase near the coast.

Albacore CPUE generally has higher value in the transition zone, and reaching min@132-135W, and rapidly increase near the coast.
Data

- Archival tags (manufactured by Wildlife Computers, USA and Lotek Wireless, Canada)
- 920 tags were deployed in 2004-2014 (123 tags in 2015)
- 29 recoveries (recover rate 3.2%)
- 13 albacore crossed all interested regions
- Time, light level, depth, body temperature, and water temperature were measured and recorded from the tags.
Estimate Sunrise/Sunset from Light level

\[
sunrise: \max\left(\frac{d\text{LightLevel}}{Dt}\right) \quad sunset: \min\left(\frac{d\text{LightLevel}}{Dt}\right)
\]
<table>
<thead>
<tr>
<th>Tag number</th>
<th>Type</th>
<th>Release</th>
<th>Recover</th>
<th>Days at liberty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Date</td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td>B2381</td>
<td>Lotek</td>
<td>2004/07/01</td>
<td>44.53</td>
<td>-125.63</td>
</tr>
<tr>
<td>B2398</td>
<td>Lotek</td>
<td>2004/07/01</td>
<td>44.52</td>
<td>125.62</td>
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<td>B2393</td>
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<td>2004/06/30</td>
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<tr>
<td>0490306</td>
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<td>46.07</td>
<td>-124.87</td>
</tr>
<tr>
<td>0690078</td>
<td>Wildlife</td>
<td>2006/10/06</td>
<td>46.11</td>
<td>-125.14</td>
</tr>
<tr>
<td>D1045</td>
<td>Lotek</td>
<td>2006/08/06</td>
<td>46.02</td>
<td>-124.95</td>
</tr>
<tr>
<td>A0394</td>
<td>Lotek</td>
<td>2011/08/03</td>
<td>44.82</td>
<td>-126.35</td>
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<td>Wildlife</td>
<td>2011/08/04</td>
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<td>-126.34</td>
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<td>A0396</td>
<td>Lotek</td>
<td>2011/08/03</td>
<td>44.89</td>
<td>-126.38</td>
</tr>
<tr>
<td>1090251</td>
<td>Wildlife</td>
<td>2011/08/03</td>
<td>44.80</td>
<td>-126.35</td>
</tr>
<tr>
<td>1190241</td>
<td>Wildlife</td>
<td>2011/10/08</td>
<td>46.51</td>
<td>-124.99</td>
</tr>
</tbody>
</table>

(N=13)
Results

• Percentage of time in vertical water columns (day/night)
• Percentage of time in vertical water columns (dawn/dusk)
• Ambient Water Temperature
• Body Temperature
• Average Horizontal Daily Speed
• Average Cumulative Vertical Daily Speed
Mean Percentage of Time Spent at Depth during Day/Night

West of 145W

130W to 145W

East of 130W

Depth (m)

West

Middle

East

Time spent (%)
Ambient Water Temperature

West of 145W

130W to 145W

East of 130W

n=10
Body Temperature

West of 145W

130W to 145W

East of 130W

Time spent (%)

Body Temperature (°C)

West

Middle

East

n=10
### Average Water & Body Temperature

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>West of 145W (West)</th>
<th>130W to 145W (Middle)</th>
<th>East of 130W (East)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (daytime)</td>
<td>15.28±2.00</td>
<td>13.89±2.57</td>
<td>16.67±3.41</td>
</tr>
<tr>
<td>Water (nighttime)</td>
<td>16.14±1.57</td>
<td>15.29±1.20</td>
<td>17.41±2.55</td>
</tr>
<tr>
<td>Body (daytime)</td>
<td>18.61±1.83</td>
<td>17.05±1.75</td>
<td>19.52±2.30</td>
</tr>
<tr>
<td>Body (nighttime)</td>
<td>17.92±1.65</td>
<td>17.07±1.30</td>
<td>18.78±1.69</td>
</tr>
</tbody>
</table>

- The average ambient water temperature is cooler in the middle region.
- The averaged body temperature in the middle region is cooler than western and eastern region.
Horizontal Daily Speed

<table>
<thead>
<tr>
<th>Region</th>
<th>West of 145W (West)</th>
<th>130W to 145W(Middle)</th>
<th>East of 130W(East)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Horizontal Speed (km/day) Mean±SD</td>
<td>50.45±10.31</td>
<td>80.31±16.40</td>
<td>32.70±8.96</td>
</tr>
</tbody>
</table>

(n=11)
Data Analysis

Fit data to generalized linear mixed-effects model (GLME)

<table>
<thead>
<tr>
<th>Model Formula</th>
<th>Intercept</th>
<th>Area_mid</th>
<th>Area_east</th>
<th>AIC</th>
<th>BIC</th>
<th>Log Likelihood</th>
<th>Deviance</th>
<th>Dispersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Fish</td>
<td>3.98</td>
<td>0.42</td>
<td>-0.35</td>
<td>10922</td>
<td>11011</td>
<td>-5446.9</td>
<td>10894</td>
<td>0.86</td>
</tr>
<tr>
<td>All Fish</td>
<td>3.99</td>
<td>0.28</td>
<td>-0.34</td>
<td>10811</td>
<td>11028</td>
<td>-5371.6</td>
<td>10743</td>
<td>0.85</td>
</tr>
<tr>
<td>All Fish</td>
<td>3.75</td>
<td>0.42</td>
<td>-0.35</td>
<td>10946</td>
<td>10977</td>
<td>-5467.8</td>
<td>10936</td>
<td>0.86</td>
</tr>
<tr>
<td>All Fish</td>
<td>3.78</td>
<td>0.40</td>
<td>-0.41</td>
<td>10857</td>
<td>10921</td>
<td>-5418.7</td>
<td>10837</td>
<td>0.85</td>
</tr>
</tbody>
</table>

All the model showed similar results.

Model log(speed)~ 1+area+fish+area:fish shows the minimum AIC and maximum log-likelihood.
Model Diagnostics

\[ \log(\text{speed}) \sim 1 + \text{area} + \text{fish} + \text{area:fish} \]
Cumulative Daily Vertical Speed

Tag No. A0396 Depth Time Series

Depth (m)

Nov 08, 00:00  Nov 08, 12:00  Nov 09, 00:00  Nov 09, 12:00  Nov 10, 00:00  Nov 10, 12:00  Nov 11, 00:00  Nov 11, 12:00  Nov 12, 00:00
Average Cumulative Daily Vertical Speed

<table>
<thead>
<tr>
<th>Average Speed (km/day)</th>
<th>West of 145W (West)</th>
<th>130W to 145W (Middle)</th>
<th>East of 130W (East)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Daytime</strong></td>
<td>10.08±3.18</td>
<td>9.88±3.99</td>
<td>7.03±3.20</td>
</tr>
<tr>
<td><strong>Nighttime</strong></td>
<td>4.29±1.99</td>
<td>2.72±1.56</td>
<td>3.08±1.25</td>
</tr>
</tbody>
</table>

- The average cumulative vertical daily speed in the middle region during daytime is similar to west region and slightly higher than the east region.

- During nighttime, the average speed in the middle region is the slower than the west and east region.
Summary

Middle region characteristics:

- Albacore spent more time in surface waters during night. During daytime, albacore spend more time than the east region, and less time than the west region.
- Ambient water temperature is cooler at night. During daytime, bigger proportion in cold water may due to long distance diving.
- Body and water temperature is cooler both daytime and nighttime.
- The horizontal daily speed is faster than west and east region.
- Cumulative vertical speed during nighttime is slower.

Future work:

- Update geolocation information
- Statistical analyses
- Publication
Acknowledgement

- NOAA-Southwest Fisheries Science Center
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How does explicit treatment of spatial variability in environmental conditions affect simulated anchovy recruitment?

Will be presented October 22nd, 2015