The Use of Temperature-Depth-Recorders in the Hawaii-based Longline Fishery to Characterize Bigeye tuna (Thunnus obesus) Fishing Grounds

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Project Overview

- History: deployed TDRs early 1990s to evaluate Hawaii-based longline fishing gear targeting albacore tuna; Boggs 1992; Hawn and Seki 2001, pilot study to examine hooking depths and temperatures of large pelagics; and 2006-present

- Data sources and platforms: Pacific Islands Regional Observer Program, PIFSC logbook catch records and Hawaii Longline Association

- Investigate fishing gear behavior and generate mathematical models describing average patterns. Why? For extrapolation of fleet wide estimates of fishing effort by depth

- Collect systematic oceanographic data to quantify climate variability within the fishing grounds - a vertically stratified approach and a method for comparison to profiling drifter buoy data (e.g., Advanced Research and Global Observation-ARGO floats)

- To promote and maintain a reliable data collection system which supports gathering the best scientific information available for stock assessment purposes (management measures under the National Standards of the Magnuson-Stevens Act)
With the use of Temperature-Depth-Recorders (TDRs) and catch data

- Define and provide better understanding of commercial fishing gear behavior with respect to depth and temperature exposures throughout the Hawaii’s longline fishing grounds (surface area > 15,000,000 km²)

- Improve upon the catenary curve approach that has been biased for describing the complexity of gear behavior

- Improve standardization of catch rates and develop improved indices of bigeye tuna abundance

- Characterize the physical oceanographic environment of bigeye tuna habitat

- Relay contemporaneous information back to the user (fishers) to improve fishing gear performance with the intent to increase bigeye tuna catches with the potential to reduce incidental takes of unwanted species
Temperature-Depth-Recorders (TDRs) and Data

- **Lotek Wireless LTD_1110 1,000m**
  - Temperature Accuracy: 0.3°C
  - Pressure Accuracy: +/- 1%

- **Sea-Bird’s 911plus CTD**
  - Temperature Accuracy: 0.001 °C
  - Pressure Accuracy: 0.015%

- **6 TDRs per fishing operation**
  - Heavy polyvinyl chloride with stainless steel longline snap gear (dimensions and weight: 11 mm X 32 mm and 134.0 grams), 14 to 56 second intervals depending on trip duration

- **Hawaii longline vessels 26 – 34 m**

- **Monofilament mainline and monofilament leader (branchline)**

- **First branchline 1 m≥**

- **TDR positions**
Operational and gear specification data sheets
Temperature-Depth-Recorders (TDRs) and Data

Graphs showing temperature and pressure data over time.
339 Fishing operations (set, soak and haul)

<table>
<thead>
<tr>
<th>Position</th>
<th>Sample size</th>
<th>Range (m)</th>
<th>Depth (m)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow</td>
<td>309,212</td>
<td>0 - 203.2</td>
<td>Mean 73.0</td>
<td>S. D. 18.6</td>
</tr>
<tr>
<td>Deep section</td>
<td>314,377</td>
<td>0 - 470.5</td>
<td>Mean 267.0</td>
<td>S. D. 74.1</td>
</tr>
</tbody>
</table>

| Shallow       | Range 13.9 - 30.7 | Mean 23.5 | S. D. 3.5 | Median 23.4 | Mode 26.0 |
| Deep section  | Range 6.9 - 31.0  | Mean 13.0  | S. D. 3.4 | Median 12.1 | Mode 13.0 |

Subtropical Front

North Equatorial Counter Current
Diurnal gear behavior

Operational times of interest

Start setting 8:02 AM
End setting 12:21 PM
Start hauling 6:25 PM
End Hauling 4:31 AM
Total mean time 20.5 hours
Mean profiles of depth and temperature

Points of interest

- Shallow
- Deep
Mean profiles of depth and temperature

Points of interest

Means

73 m
267 m
23.5°C
13.0°C
Mean profiles of depth and temperature

Points of interest

- Maximum velocity sinking at 12 min and 123.8 m (rate: 11 m/min)
- Maximum depth at 73 min and 290 m

Shoaling rate

- Shallow: 0.4 m per hour
- Deep: 1.9 m per hour
Points of interest

Maximum velocity sinking at 12 min and 123.8 m (rate: 11 m/min)

Maximum depth at 73 min and 290 m

Shoaling rate

Shallow: 0.4 m per hour
Deep: 1.9 m per hour

2 Gompertz curves and a straight line (—) were used to characterize the average gear profile. These are essential for projection of results onto non-TDR-instrumented sections of gear and unobserved trips within the fishery.

\[ D_L = GS_L \times L \times GH_L \]
\[ D_D = GS_D \times L \times GH_D \]

where:

- \( GS \): Gompertz parameter
- \( L \): Linear parameter
- \( GH \): Gompertz parameter

Shallow
Deep
Generalized Additive Model Smoothing Functions for Bigeye tuna CPUE

Why? Exploratory data analysis with many variables and potentially non-linear effects

Domed effect of temperature differences for CPUE
Generalized Additive Model for Temperature

Powerful tool for predicting and understanding temperature dynamics throughout bigeye tuna habitat in our fishing grounds

High percent (96%) of deviance explained (i.e., the GAM performs very well at predicting temperature at depth and any location and time)
Common and scientific names of catch with numbers

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bigeye tuna</td>
<td>Thunnus obesus</td>
<td>4,407</td>
</tr>
<tr>
<td>Yellowfin tuna</td>
<td>Thunnus albacares</td>
<td>505</td>
</tr>
<tr>
<td>Albacore tuna</td>
<td>Thunnus alalunga</td>
<td>89</td>
</tr>
<tr>
<td>Skipjack tuna</td>
<td>Katsuwonus pelamis</td>
<td>405</td>
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<tr>
<td>Blue marlin</td>
<td>Makaira nigricans</td>
<td>45</td>
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<tr>
<td>Striped marlin</td>
<td>Kajikia audax</td>
<td>122</td>
</tr>
<tr>
<td>Sailfish</td>
<td>Istiophorus platypterus</td>
<td>6</td>
</tr>
<tr>
<td>Shortbill spearfish</td>
<td>Tetrapturus angustirostris</td>
<td>136</td>
</tr>
<tr>
<td>Broadbill swordfish</td>
<td>Xiphias gladius</td>
<td>77</td>
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<tr>
<td>Opah</td>
<td>Lampris guttatus</td>
<td>298</td>
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<tr>
<td>Sickle pomfret</td>
<td>Taractichthys steindachneri</td>
<td>982</td>
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<tr>
<td>Oilfish</td>
<td>Ruvettus pretiosus</td>
<td>681</td>
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<tr>
<td>Dolphinfish</td>
<td>Coryphaena hippurus</td>
<td>1,318</td>
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<tr>
<td>Wahoo</td>
<td>Acanthocybium solandri</td>
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<tr>
<td>Blue shark</td>
<td>Prionace glauca</td>
<td>388</td>
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<tr>
<td>Shortfin mako</td>
<td>Isurus oxyrinchus</td>
<td>51</td>
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<tr>
<td>Thresher shark</td>
<td>Alopias spp.</td>
<td>63</td>
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<tr>
<td>Silky shark</td>
<td>Carcharhinus falciformis</td>
<td>2</td>
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<tr>
<td>Oceanic whitetip shark</td>
<td>Carcharhinus longimanus</td>
<td>25</td>
</tr>
<tr>
<td>Pelagic stingray</td>
<td>Pteroplatytrygon violacea</td>
<td>2</td>
</tr>
<tr>
<td>Ocean sunfish</td>
<td>Mola mola</td>
<td>1</td>
</tr>
<tr>
<td>Longnose lancetfish</td>
<td>Alepisaurus ferox</td>
<td>291</td>
</tr>
<tr>
<td>Snake mackerel</td>
<td>Gempylus serpens</td>
<td>135</td>
</tr>
</tbody>
</table>

Total: 10,278

Group disposition

- Bigeye tuna 42.9%
- Other tuna 9.8%
- Billfish 3.4%
- Other bony fish 34.4%
- Sharks 5.1%
- Discards 4.3%
Pacific biotic provinces with mean deep scattering layer daytime depths

Subarctic (295 m)
North Pacific Transition Zone (358 m)
Central (394 m)
Equatorial (350 m)

(Tont 1976)

PFRP Principal Investigators Workshop, November 18 - 19, 2008
Bigeye tuna vertical movement and vulnerability to longline gear

17 days

80-300 m

11 days
Bigeye tuna vertical movement and vulnerability to longline gear

29 tags: 1,149 Days at liberty (Fish < 45 kg)

TDRs and hook timers

* Fishing gear has potential to occupy a large percentage of bigeye tuna habitat
What’s next

- Continue to collect fishery TDR data for the 2008-09 season, this also includes instrumenting TDRs on swordfish gear
- Analysis of GAM outputs with special attention focused towards gear interactions with protected species and bycatch
- Improve upon seasonal depth and temperature forecasting models and ARGO ground truthing
- Provide TDR users with new TDRs (LAT1400s)
- Provide high quality data for Center users
- Work in progress!

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