Abundance of Marine Debris Estimated from Hawai‘i Longline Observer Data

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**Stephanie Kung**, University of Hawai‘i
### Hawai‘i-based Pelagic Longline Fishery

<table>
<thead>
<tr>
<th>Deep Sector</th>
<th>Shallow Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bigeye tuna</td>
<td>• Swordfish</td>
</tr>
<tr>
<td>• 2400 hooks per set</td>
<td>• 1000 hooks per set</td>
</tr>
<tr>
<td>• 243m depth</td>
<td>• 64m depth</td>
</tr>
<tr>
<td>• 20 hour soak</td>
<td>• 20 hour soak</td>
</tr>
<tr>
<td>• Below 30°N</td>
<td>• Above 30°N</td>
</tr>
<tr>
<td>• Deploy after dawn</td>
<td>• Deploy at sunset</td>
</tr>
<tr>
<td>• Annual</td>
<td>• Winter</td>
</tr>
</tbody>
</table>

**Artwork:** Les Hata © Secretariat of the Pacific Community
Hawai‘i-based Pelagic Longline Fishery

North Pacific Ocean
Hawai‘i-based Pelagic Longline Fishery
NOAA Pacific Islands Region Observer Program

• Onboard longline observations initiated 1994
  o priority focus on longline gear and protected species interactions
  o shallow sector: 100% coverage; deep sector: 20%

• Marine debris longline observations initiated late 2007
  o report interactions with longline gear, vessel, species, at surface
Objective

• To estimate marine debris abundance using GLM to standardize CPUE as previously used for bycatch and incidental catch
Counts of marine debris per set

1. net
2. rope/line
3. monofilament
4. metal
5. cloth
6. plastic sheeting/tarp
7. floats buoys
8. FAD
9. other
10. lumber
11. natural
Generalized Linear Model to Standardize CPUE

• Zero-inflated negative binomial model
  • overdispersed count data
  • extra zeros from reporting error or survey error (or both)
  • 2 components: positive counts & probability of extra zeros
  • offset = number of hooks per set

• Predictor variables
  • year (2008-2016)
  • quarter (1st – 4th)
  • sector (shallow, deep)
  • observer type (high, low)
  • convergence zone (in, out)
  • begin-set latitude
  • begin-set longitude
  • fishing region (6)
  • total catch
  • soak duration

• Sampling unit = individual longline set (N = 40,572)
  • # sets deep: 32,130
  • # sets shallow: 8,442
How Much & What Type

- 858 sets with debris
  - 418 deep
  - 440 shallow
- 1326 total items
  - 51.8% net
  - 26.7% rope, line
- 1.2 - 1.6 items per set
  - min: 1
  - max: 9

In revision, Nature Scientific Reports
# Model Selection

## Negative binomial count model - positive counts

<table>
<thead>
<tr>
<th>Parameter</th>
<th>df</th>
<th>AIC</th>
<th>ΔAIC</th>
<th>ΔAIC/df</th>
<th>Median residual</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>10439.22</td>
<td>.</td>
<td>.</td>
<td>-0.1162</td>
<td>0.1912</td>
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<tr>
<td>Year</td>
<td>8</td>
<td>10328.39</td>
<td>110.82</td>
<td>13.85</td>
<td>-0.1140</td>
<td>0.0215</td>
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<tr>
<td>Quarter</td>
<td>3</td>
<td>10218.97</td>
<td>109.42</td>
<td>36.47</td>
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<td>0.1527</td>
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<tr>
<td>Sector</td>
<td>1</td>
<td>9628.69</td>
<td>590.28</td>
<td>590.28</td>
<td>-0.1174</td>
<td>0.0414</td>
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<tr>
<td>Latitude</td>
<td>1</td>
<td>9293.10</td>
<td>335.60</td>
<td>335.60</td>
<td>-0.1145</td>
<td>0.0529</td>
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</tbody>
</table>

## Logistic model for zero inflation - odds of extra zeros

<table>
<thead>
<tr>
<th>Parameter</th>
<th>df</th>
<th>AIC</th>
<th>ΔAIC</th>
<th>ΔAIC/df</th>
<th>Median residual</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitude</td>
<td>1</td>
<td>9206.19</td>
<td>86.91</td>
<td>86.91</td>
<td>-0.1118</td>
<td>0.1498</td>
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<td>Convergence zone</td>
<td>1</td>
<td>9184.95</td>
<td>21.24</td>
<td>21.24</td>
<td>-0.1130</td>
<td>0.1824</td>
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<td>Observer</td>
<td>1</td>
<td>8819.69</td>
<td>365.26</td>
<td>365.26</td>
<td>-0.0966</td>
<td>0.5098</td>
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<tr>
<td>Sector</td>
<td>1</td>
<td>8786.13</td>
<td>33.56</td>
<td>33.56</td>
<td>-0.0925</td>
<td>0.8377</td>
</tr>
</tbody>
</table>
### Results

**Neg binomial count model: expected positive counts per set**

- Increasing debris through 2011, decreasing thereafter
- Less debris in Q3 (July - September)
- Less debris in deep sector (40.5% ↓ in positive counts)
- More debris moving north (12% ↑ in positive counts for 1° ↑ in latitude)

*In revision, Nature Scientific Reports*
Logistic zero-inflation model: odds of zero counts per set

- More debris moving east (5% ↓ in odds for 1° ↓ in longitude)
- More debris inside convergence zone (56% ↓ in odds)
- More debris reported by experienced observers (79% ↓ in odds)
- Less debris in deep sector (127% ↑ in odds)
Annual Standardized CPUE

$R^2_{\text{adj}} = 0.95$
Annual Standardized CPUE By Sector

- Shallow sector
- Deep sector

Marine Debris Items Per Set vs. Year (2006-2018)
Key Findings

• Prevalence of derelict nets in STCZ & moving towards EPGP
  o consistent with model trajectories of surface drifters

• Debris likely snagged close to the surface
  o nets composed of buoyant polymers
  o net bundles float with some draft

• More debris in shallow sector despite less effort
  o overlap with surface & depth distribution of debris
  o target shallow sector for observations & removal

• Steady decline in marine debris over time
  o global moratorium on large-scale pelagic driftnets
  o organized removal from nearshore
  o some removal by fishermen
  o post-tsunami fleet reduction