

**ALTERNATIVE METHODS TO SPATIALLY DISTRIBUTE FISHING EFFORT  
WITHIN THE HAWAIIAN LONGLINE FISHERY AND CORRESPONDING  
EFFECTS ON THE CALCULATION OF BYCATCH RATES**

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Bycatch in longline fisheries has been recognized as a threat to many endangered populations of sea turtles, sea birds, and marine mammals. The health of endangered species populations, combined with the economic and social importance of the fisheries, have led to studies that investigate the spatial distribution of longline fisheries effort to understand catch and bycatch rates. These analyses generally ascribe effort from an individual set to the point at which the gear is deployed or hauled. Typically, reported fishing effort summarizes these values over large areas ( $>1^\circ$ ). Although the set or haul locations may be sufficient for large-scale summaries of general fishing effort, finer-resolution models, such as those associating local oceanographic effects to catch or bycatch rates, may be strongly influenced by the method used to spatially allocate fishing effort. As part of a larger Duke University and Blue Ocean Institute bycatch assessment project (Project GLOBAL), we look at alternative methods (i.e., centroids, polylines, and polygons) for distributing fishing effort of the Hawaiian longline fleet. This assessment helps to determine the appropriate method for distributing fishing effort based on the resolution of the model.

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# Alternative Methods to Spatially Distribute Fishing Effort Within the Hawaiian Longline Fishery and Corresponding Effects on the Calculation of Bycatch Rates

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## Background

Bycatch (incidental catch) in longline fisheries has been recognized as a threat to many endangered populations of sea turtles, sea birds, and marine mammals. The health of endangered species populations, combined with the economic and social importance of the fisheries, have led to studies that investigate the spatial distribution of longline fisheries effort. It is in the interest of both the fishing industry and the conservation community to gain a better understanding of these bycatch events. This includes characterizing fishing effort (spatially and temporally) and the environment (oceanographic conditions). Improvements for estimating/modeling fishing effort and bycatch are considered prime commercial and conservation objectives.

### Factors for estimating fishing effort/bycatch:

- Exact location of fishing gear or a bycatch event is generally unknown
- Fishing effort is traditionally ascribed to the point at which the longline set begins
- Longline gear may span 10s of kilometers, limiting fishing effort/bycatch studies to be summarized at large scales ( $\geq 1^\circ$ ) studies

### Better information is available for characterizing fishing effort/bycatch events:

- Alternative methods for distributing fishing effort
  1. Polylines (i.e., from the beginning of the set to the end of the haul)
  2. Polygons (i.e., Minimum Convex Hulls [MCHs] using known fishing points)
- High resolution remotely sensed oceanographic data (1km – 9km)

### Goals in current study:

- Estimate fishing effort using alternative methods
- Compare fishing effort values among methods at different scales
- Recommend best method for each scale investigated

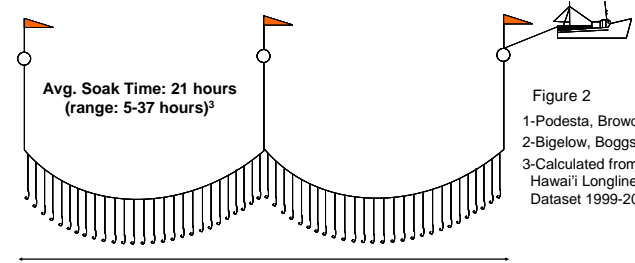


Figure 2  
 1-Podesta, Browder et al. 1993  
 2-Bigelow, Boggs et al. 1999  
 3-Calculated from NOAA NMFS Hawai'i Longline Observer Dataset 1999-2005

Avg. Length of Mainline:  
 8-32 km (Florida-style) or 24-64km (traditional New England)<sup>1</sup>  
 (Hawai'i Longline avg. 48-64km)<sup>2</sup>

## Workflow



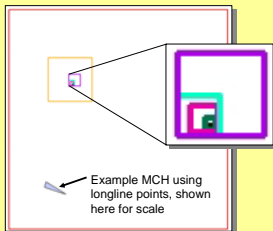
## Methods

• Five methods of distributing longline effort were examined using observer data from the NOAA's National Marine Fisheries (NMFS) 1999-2005 Hawai'i longline fishery (Fig. 1)

- Lines were created and centroids taken using XTools extension for ArcGIS 9.x (<http://www.xtoolspro.com>)
- Minimum Convex Hulls (MCHs) were created using Hawth's Tools extension for ArcGIS 9.x (<http://www.spatial ecology.com/htools>)

- For lines/polygons, the proportion of the line/polygon in a given area was multiplied by the number of hooks in the set to determine effort values in the given area
- Effort was calculated using these distribution methods for 30 randomly selected cells within the study area at seven scales:

- 5 degree
- 1 degree
- 30 km
- 9 km
- 15 km
- 4 km
- 2 km



• Spearman's Rank Sum Correlation Statistic was used to compare summed effort values within each grid cell.

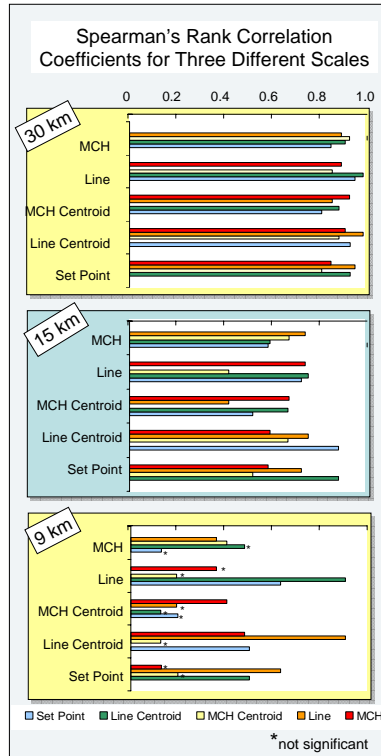
Figure 1

### Longline Effort Distribution Methods



## Results

- Effort values were significantly correlated among distribution methods for large scales (>15 km).
- Mostly no significant correlation of effort values among distribution methods for fine scales (<9 km)
- Large variability in effort values at small scales (<15 km), especially with point distribution methods
- Lower variability in effort values resulted with the MCH distribution approach



## Conclusions

- All methods of distributing effort yield similar fishing effort values (number of hooks) at large scales (>15 km)
- However, at fine scale (<15 km) analyses, fishing effort values within an area are highly dependent on the method of distributing effort
- Therefore, we suggest a polygon or minimum convex hull approach as a better representation of fishing effort at fine scales (<15 km)
- The polygon approach takes into consideration the possibility of drifting longline gear due to fishing effort characteristics (i.e., long soak time, long mainline length; Fig. 2)
- For small scales, the likelihood of over/under-estimating bycatch rates (number of species/unit fishing) will be reduced when using the polygon approach
- Future studies that involve small scale characterizations (use of oceanographic data) need to take into account the method used to distribute fishing effort/bycatch events

## Acknowledgements

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## Works Cited

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- Podesta, G.P., J.A. Browder, et al. (1993) Exploring the association between swordfish catch rates and thermal fronts on U.S. longline grounds in the western North Atlantic. *Continental Shelf Research* 13: 253-277.

For more information on Project GloBAL:  
<http://bycatch.env.duke.edu>

