Science, Service, Stewardship

Choice Sets for Fishery Location Choice Models in the Presence of Fine-scale Spatial and Temporal Heterogeneity

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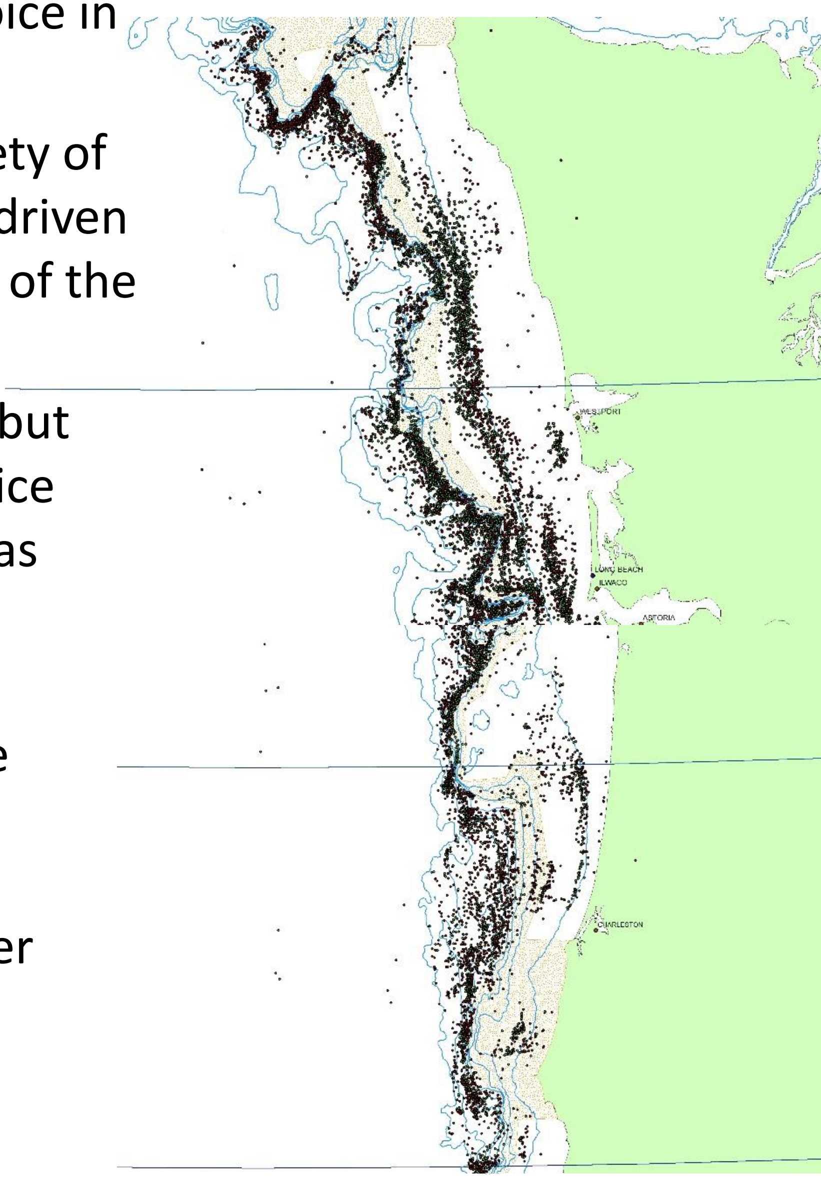
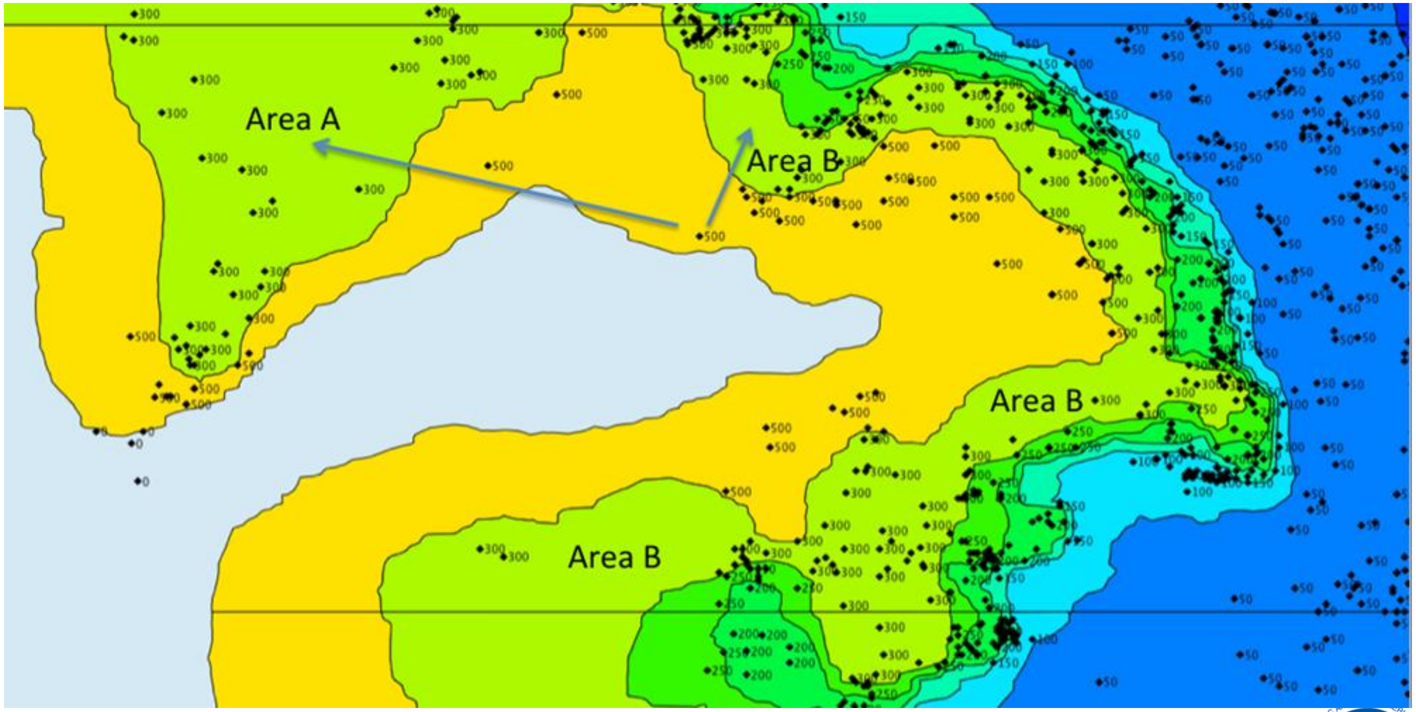
Introduction

- We model tow-by-tow fishing location choice in the West Coast groundfish trawl IFQ
- The fishery uses trawl gear to catch a variety of species with patchy distributions that are driven by the complex and fine-scale bathymetry of the West Coast Continental Shelf
- We use standard conditional logit models but we developed and compared location choice definitions based on irregular discrete areas with point-based choice sets
- We used a Monte Carlo to compare performance of the approaches when true parameters are known
- The Monte Carlo suggested a point-base approach may reduce bias in key parameter estimates and prediction is superior in the empirical application



Defining the Choice Set

- “Traditional” approach is to define choice set as discrete areas (often a grid) but in this fishery choices are clearly influenced by depth which creates an extremely irregular choice set
- We define discrete areas by depth bands and .25 degree latitude bands



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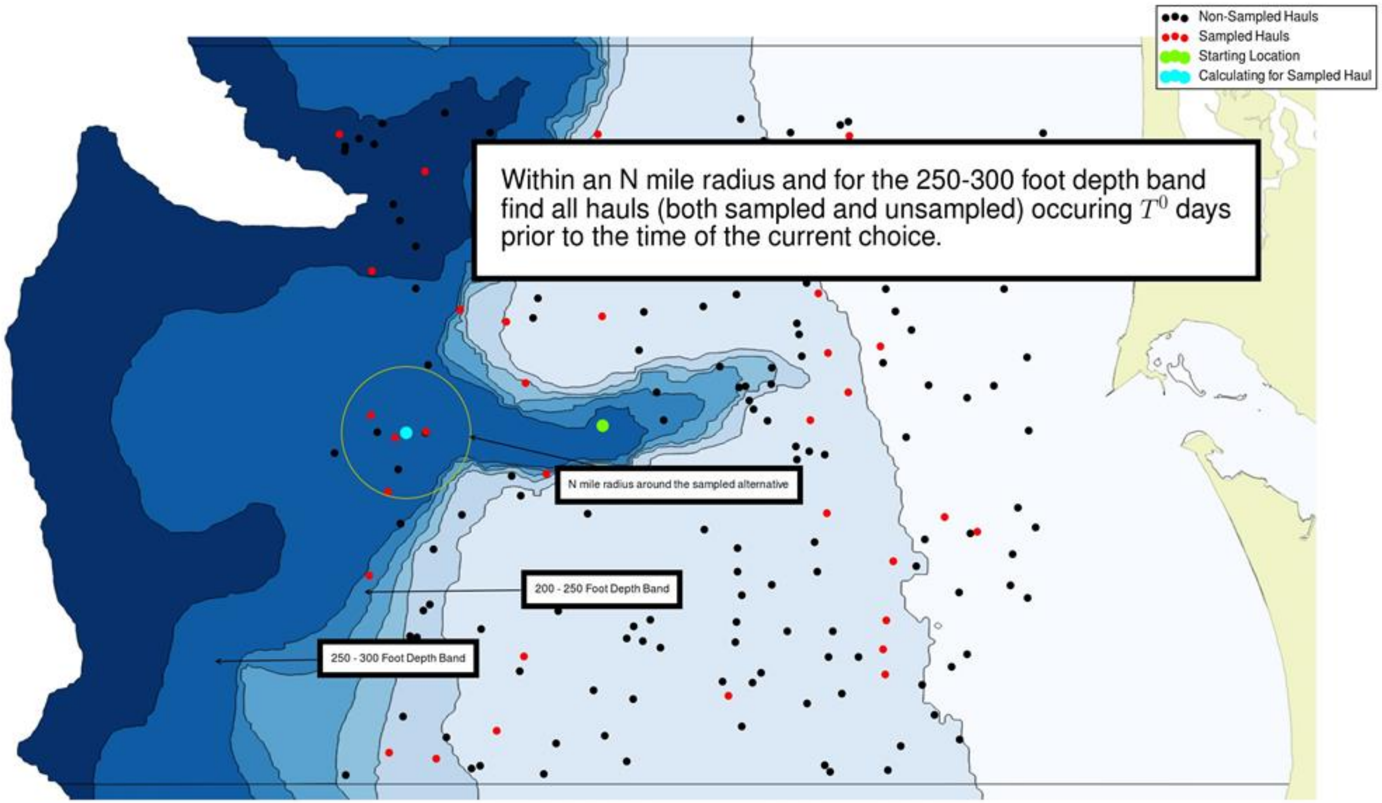
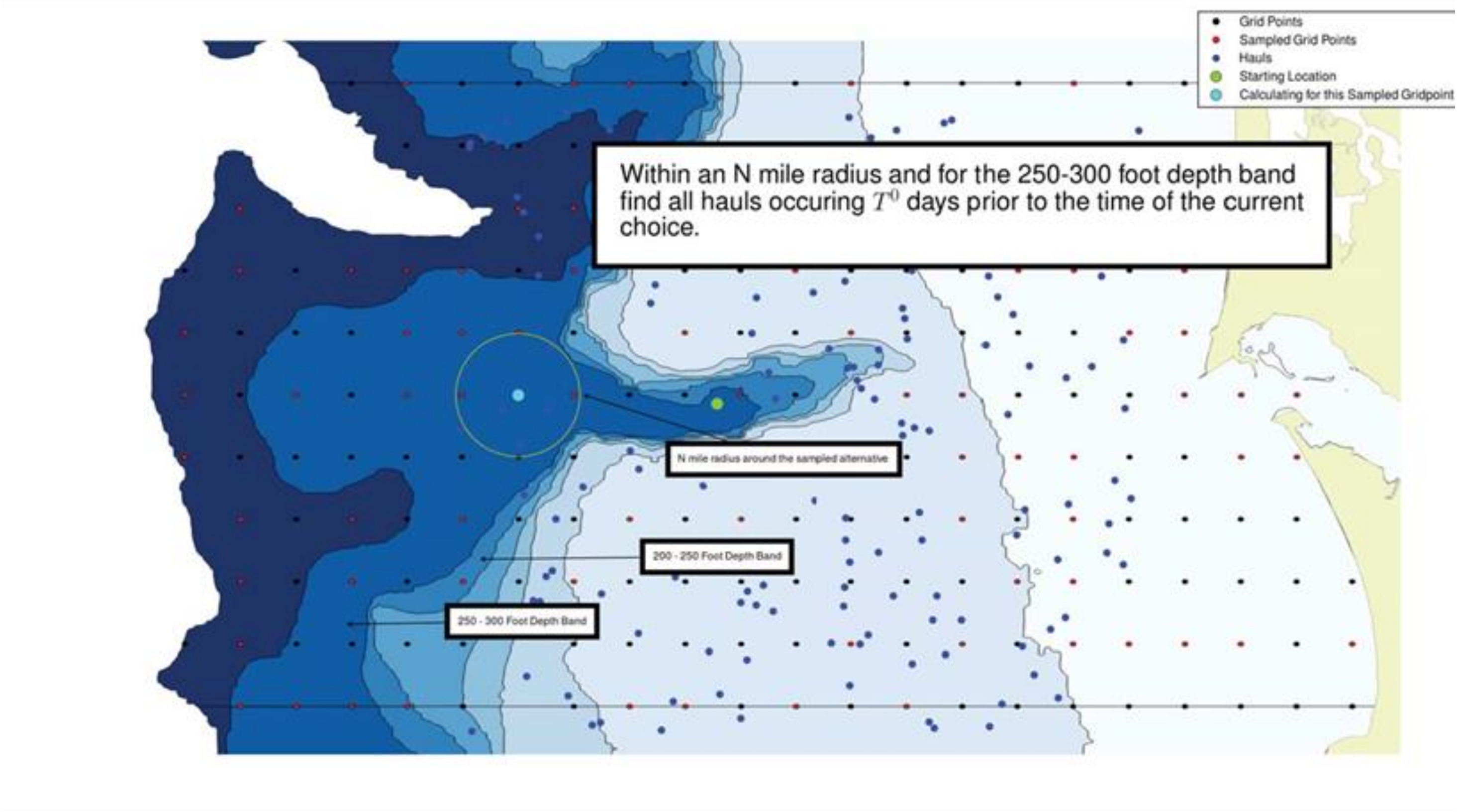
Activity-based Sampling Approach

- Define 50 choices as specific locations sampled from previously fished locations for that fleet including chosen location



Grid Sampling Approach

- Define 50 choices as specific locations sampled from a fine scale uniform grid (3.5 miles between points) of all fishable locations.



Empirical Application- Pacific Groundfish Trawl IFQ

Fleet	Vessel Count	State	Major Ports
1	7	CA	Moss Landing & San Francisco
2	6	CA	Fort Bragg
3	9	CA	Eureka
4	6	OR	Crescent City & Brookings
5	12	OR	Charleston
6	8	OR	Newport
7	18	OR	Astoria
8	5	WA	Ilwaco & Westport

Variable Name	Description
$Distance$	Distance (in miles) to Tow Choice Location
$Distance_{First}$	Distance (in miles) to Tow Choice Location for 1st Tow of Trip
$Revenue$	Expected Revenues (in $100)
$Revenue_{First}$	Expected Revenues (in $100) for 1st Tow of Trip
$Dum_{Missing}$	(=1) if no observations in support of Expected Revenue calculation
$Habit_{30}$	(=1) if vessel has previously fished within 3 miles of site within 30 days
$Habit_{Year}$	(=1) if vessel has previously fished within 3 miles of site in 30 day of preceding year

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Parameter estimates for the eight fleets estimated within the Pacific groundfish fishery

			Activity-Based Model		
Parameter	Fleet 1	Fleet 2	Fleet 3	Fleet 4	Fleet 5
Distance	-0.107***	-0.074***	-0.073***	-0.049***	-0.077***
$Distance_{First}$	-0.030***	-0.027***	-0.039***	-0.056***	-0.048***
Revenue	0.016***	0.001	0.005**	0.013***	0.004
$Revenue_{First}$	0.051***	0.014***	0.012***	0.016***	0.024***
$Dum_{Missing}$	1.422***	0.013	0.553***	0.399***	0.442***
$Habit_{30}$	2.853***	1.055***	1.390***	1.027***	1.573***
$Habit_{Year}$	0.323***	0.254***	0.279***	0.076	0.681***
			Grid-point Model		
Parameter	Fleet 1	Fleet 2	Fleet 3	Fleet 4	Fleet 5
Distance	-0.117***	-0.082***	-0.077***	-0.055***	-0.087***
$Distance_{First}$	-0.031***	-0.022***	-0.053***	-0.064***	-0.049***
Revenue	0.021***	0.009***	0.004*	0.015***	0.010***
$Revenue_{First}$	0.057***	0.019***	0.014***	0.012**	0.031***
$Dum_{Missing}$	0.1163	-0.682***	-0.824***	-0.645***	-0.508***
$Habit_{30}$	2.709***	1.008***	1.444***	1.051***	1.698***
$Habit_{Year}$	1.331***	0.766***	0.979***	0.759***	1.140***
			Traditional Model		
Parameter	Fleet 1	Fleet 2	Fleet 3	Fleet 4	Fleet 5
Distance	-0.133***	-0.076***	-0.074***	-0.050***	-0.092***
$Distance_{First}$	-0.043***	-0.030***	-0.052***	-0.056***	-0.067***
Revenue	0.006	0.001	-0.000	0.001	-0.004*
$Revenue_{First}$	0.014*	0.011***	0.014***	0.007	0.025***
$Dum_{Missing}$	-1.314***	-1.032***	-1.410***	-1.033***	-1.560***
$Habit_{30}$	0.551***	0.027	0.319***	0.267**	0.193**
$Habit_{Year}$	1.280***	0.843***	0.459***	1.109***	0.594***
Observations	1451	1185	1496	895	2148

Prediction Performance Metrics

- All metrics relate to prediction of choice into discrete areas to allow comparison of traditional and point-based approaches
- Prediction Method 1 (termed the '**Correct Prediction**' approach) calculates the percentage of correct predictions (i.e. where the highest probability choice occurred with the same discrete area as the actual choice)
- Prediction Method 2 (termed the '**Correct Prediction Summed**' approach) calculates the summed probabilities of correctly predicted choices
- Prediction Method 3 (termed the '**Probability Mass**' approach). Uses the total probability mass in the chosen area (irrespective of whether it is the highest probability choice), and reports the mean over the sample.
- Prediction Method 4 (termed the '**Distance**' approach) calculates the mean distance (D) from predicted choice to the actual chosen point.

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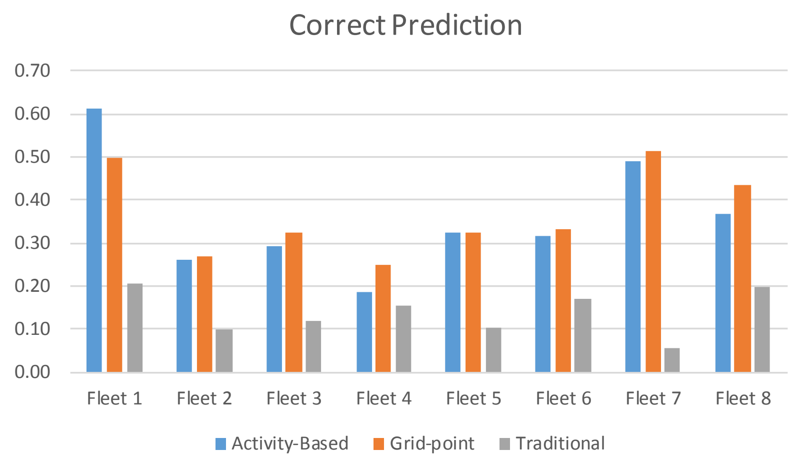
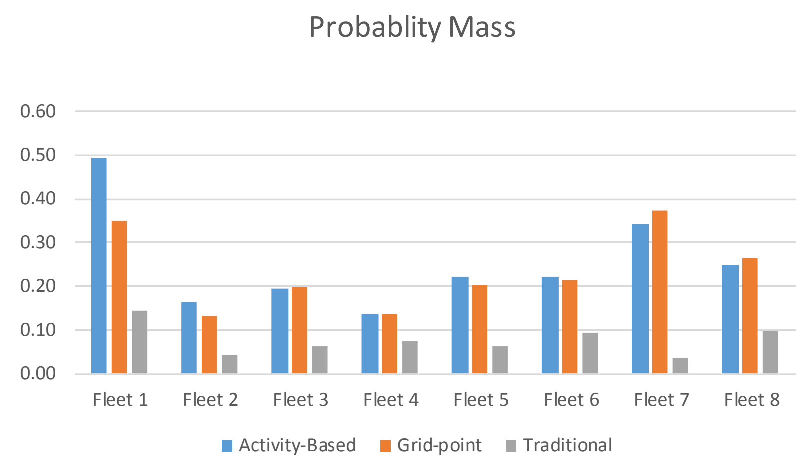
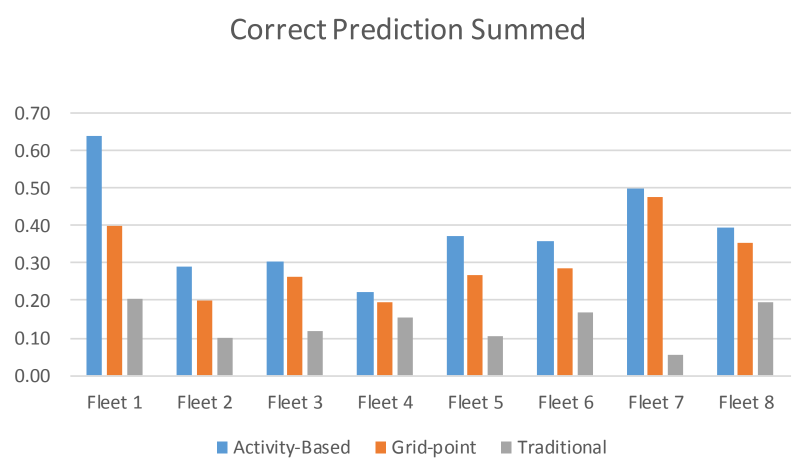
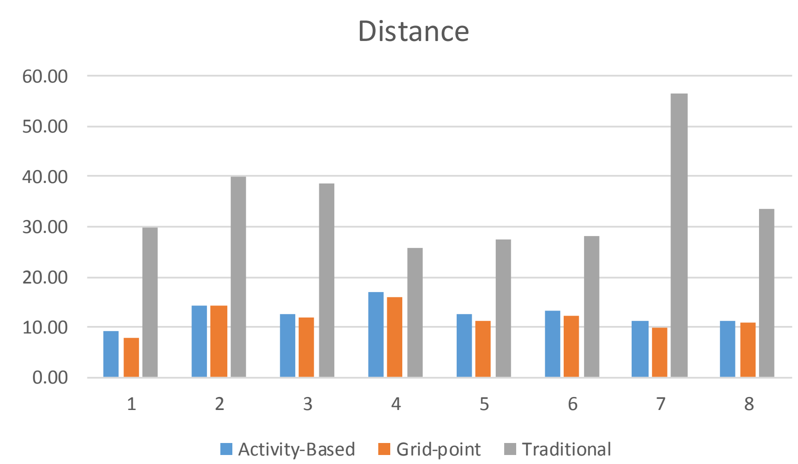
Predictive accuracy measures for the Pacific groundfish









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Monte Carlo

- Generate a patchy fish distribution over a fine scale 64x64 grid (4096 locations) by seeding the grid with a set number of patches and then diffusing those fish to partially smooth the surface
- Generate logbook data where choices are based on expected catch observed with error and distance using specified utility function values. Error is then added to actual catch in logbook data as well.
- Generate RUM data and run RUM models for different choice definitions
  - Traditional (divide grid into regular areas of 16, 64, or 256 cells)
  - Grid (each cell is a grid point – draw 50 random points including actual choice to construct choice sets)
  - Activity-Based (same as grid but draw only from locations actually chosen by the fleet)
- Run RUM models and store parameter values as well as prediction metrics

Monte Carlo

- MC Variables
  - Clumps – number of cells seeded in grid before fish are diffused (64,128,256)
  - Diffusion rate – degree fish spread from seeds (0.05, 0.075, 0.10, 0.20)
  - Scale – scale of GEV I site-specific errors (20, 30)
  - Distance Scale – adjust the radius around sampled points for expected catch (1,3)
  - Standard Deviation of Error added to Expected Catch (10,20)
  - Standard Deviation of Error added to Actual Catch (10,20,40)
  - Aggregation Factor (grid cells per area for traditional model) (16,64,256)
- 864 combinations of parameters
- Run 100 replications of each model with each set of MC variables
- 86,400 total model runs
- Save parameter estimates from each model run
- Save average prediction performance for each MC variable combination
- Regress performance (bias, prediction) against dummy variables for MC variables

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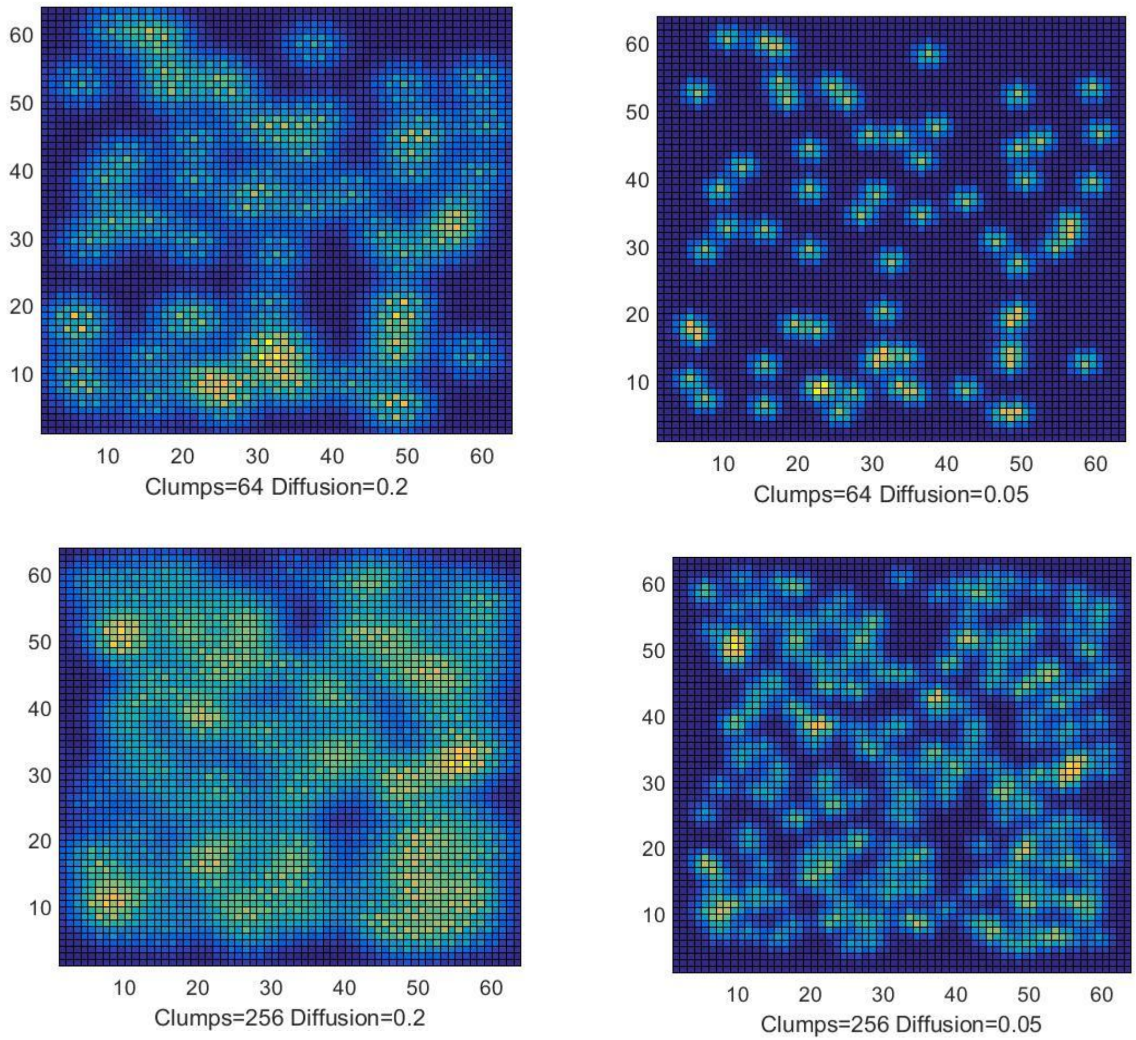
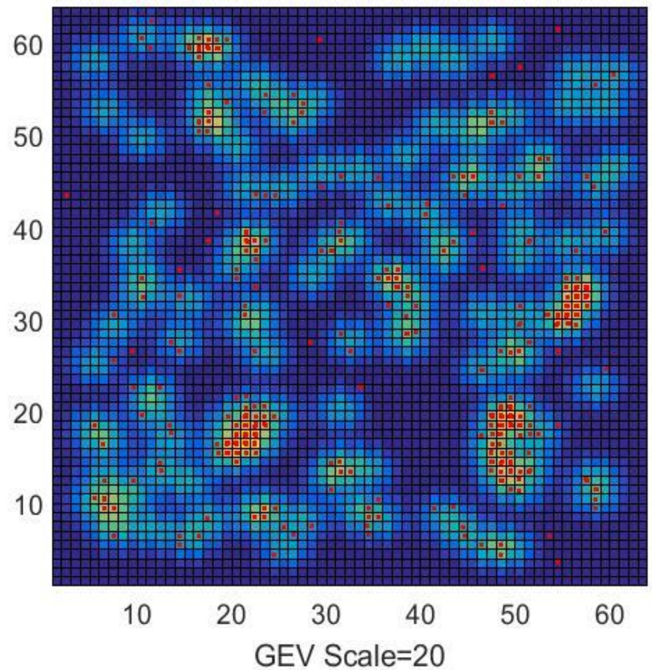
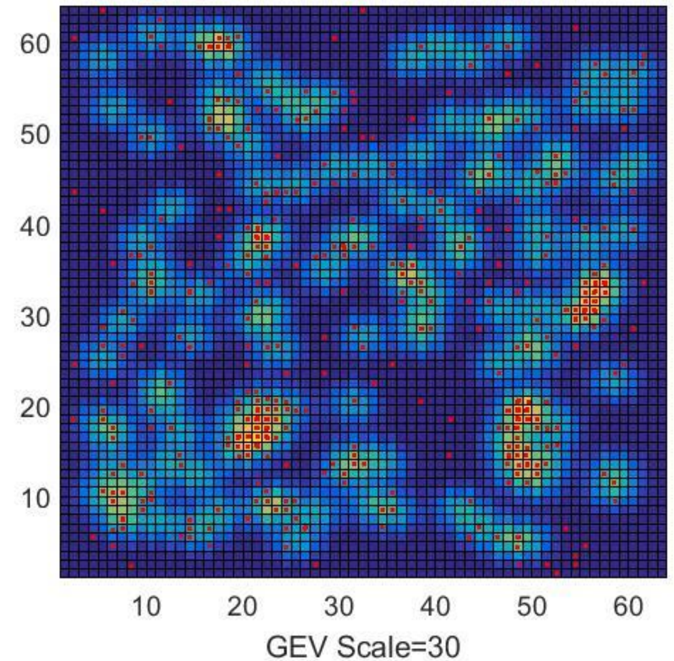
Graphical illustration of the resource spatial distribution, Z^1_{ijt}, for alternative clumps and spatial diffusion rates, δ, of the resource.

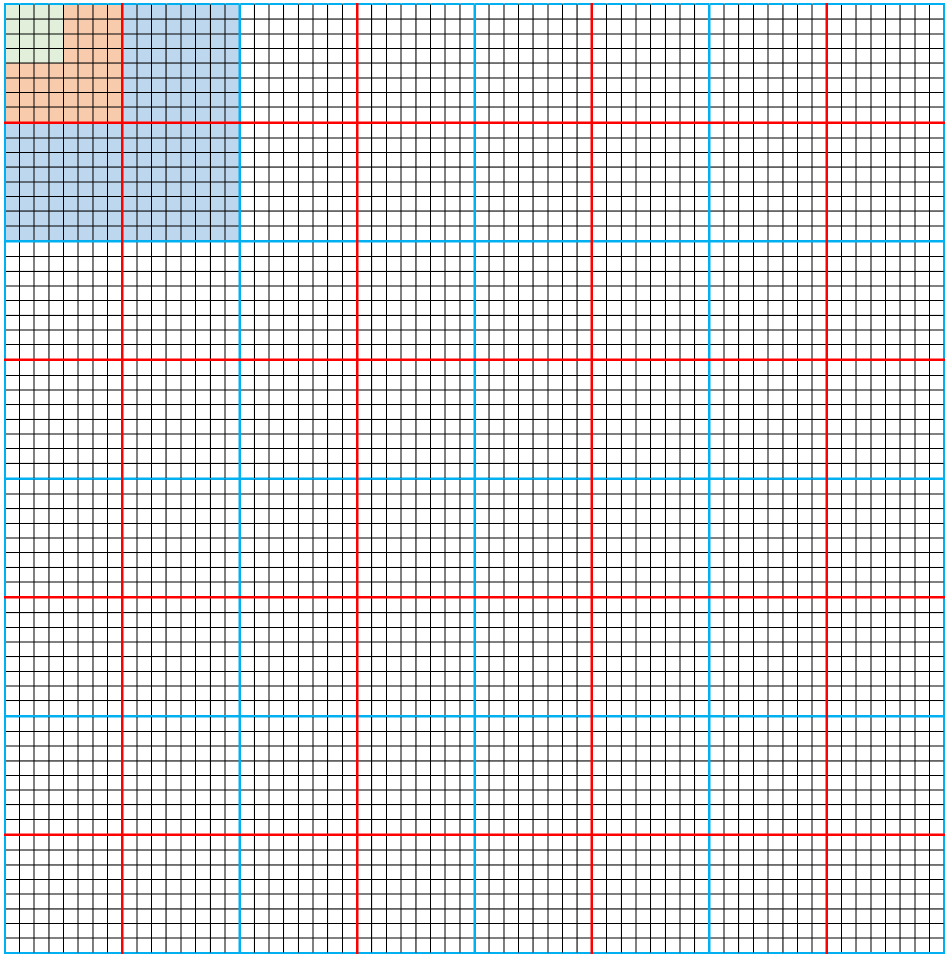


Spatial resource surface generated using 128 clumps and diffusion parameter $\delta = 0.75$ and spatial discrete choices generated using the two GEV parameters in the Monte Carlo analysis, $\zeta = 20$ (left panel) and $\zeta = 30$ (right panel).





Aggregation Factor (16,64,256)



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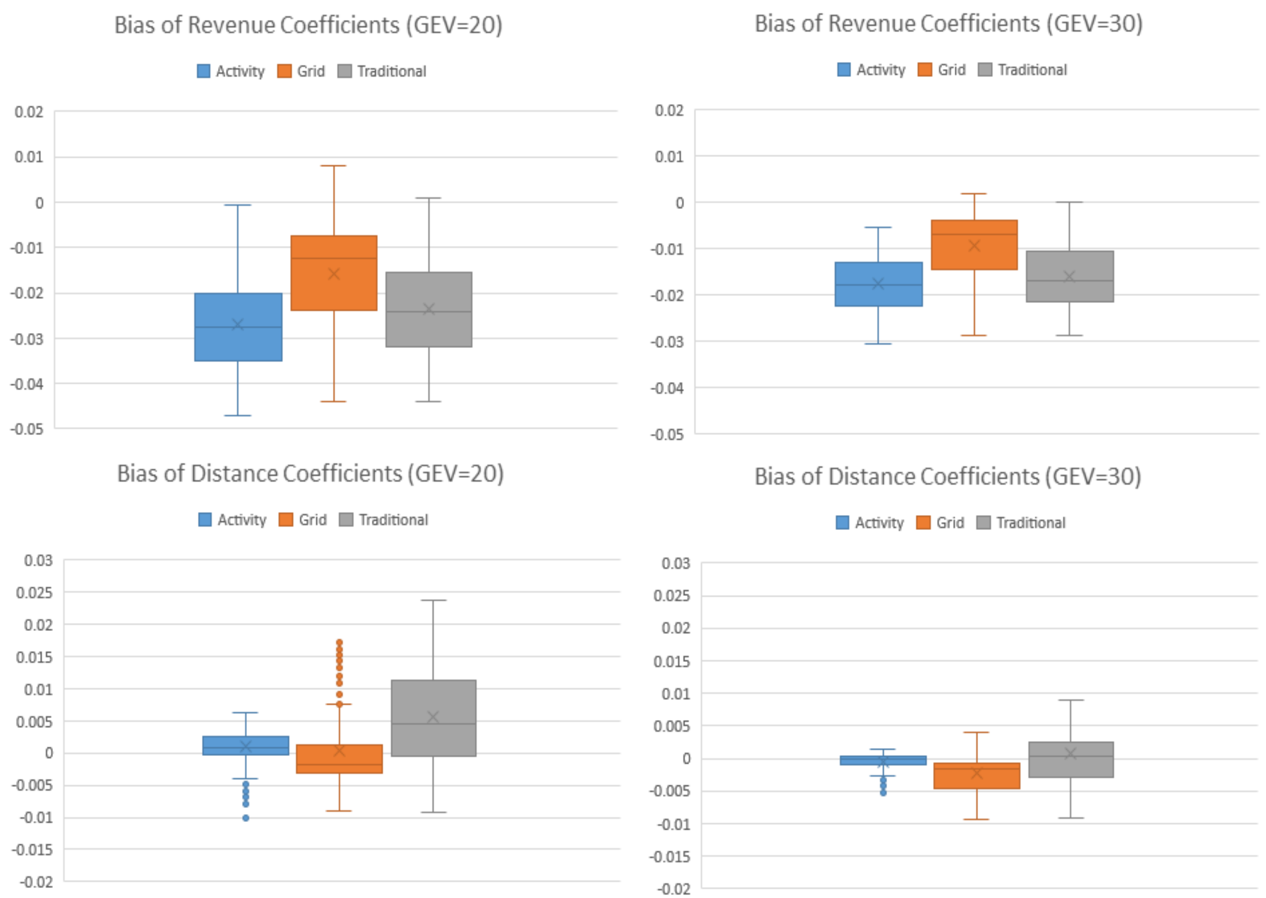
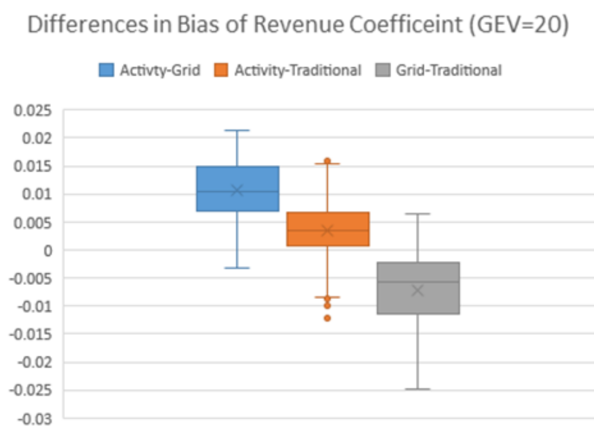
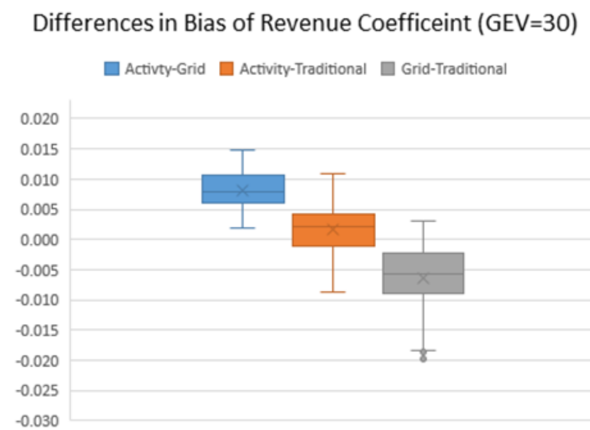
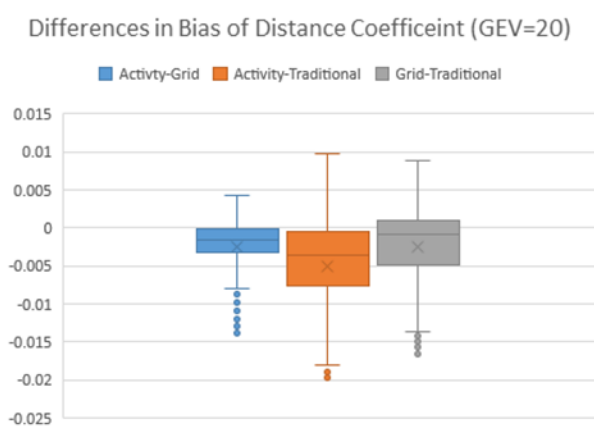
Box plots of bias of in revenue and distance coefficients from Monte Carlo analysis

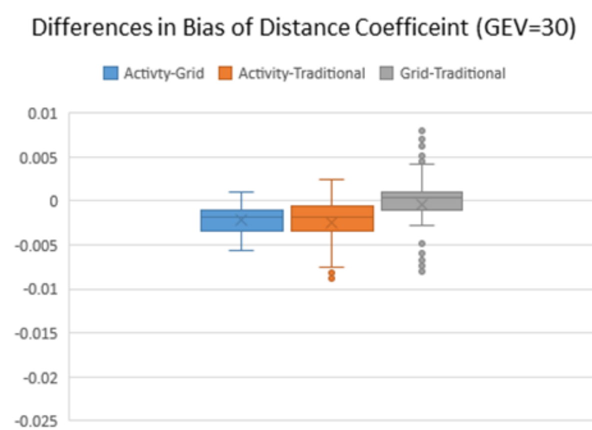


Box plots of difference in the absolute value of bias of in revenue and distance coefficients from Monte Carlo analysis.









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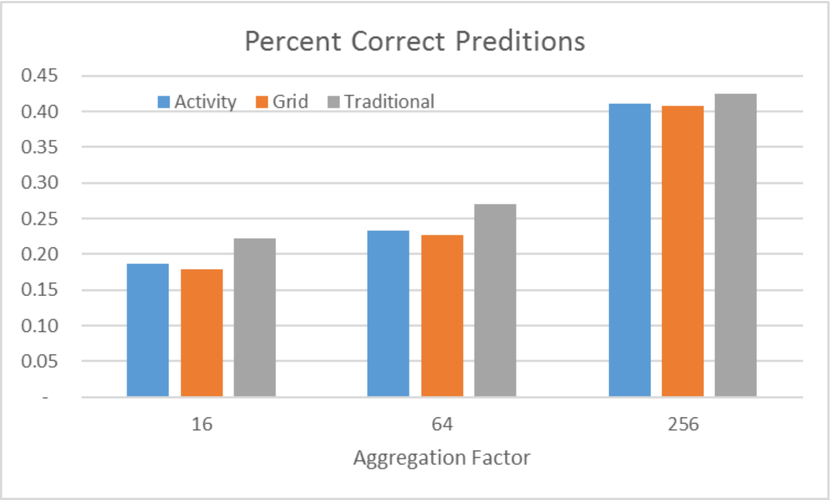
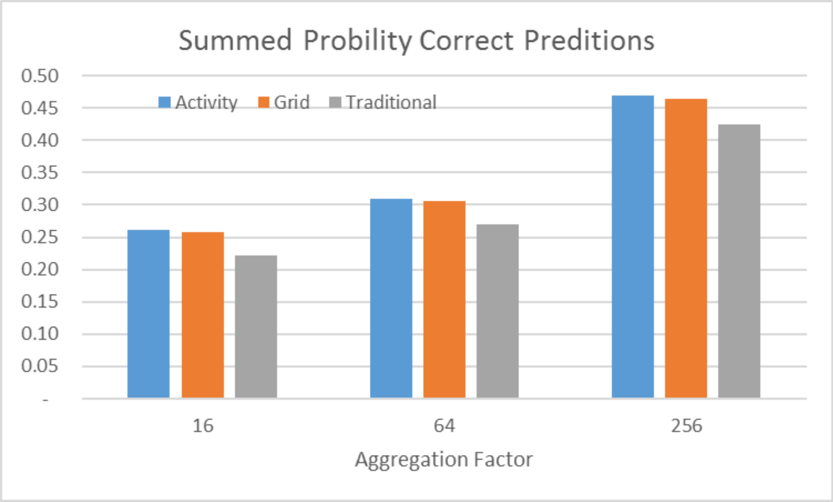
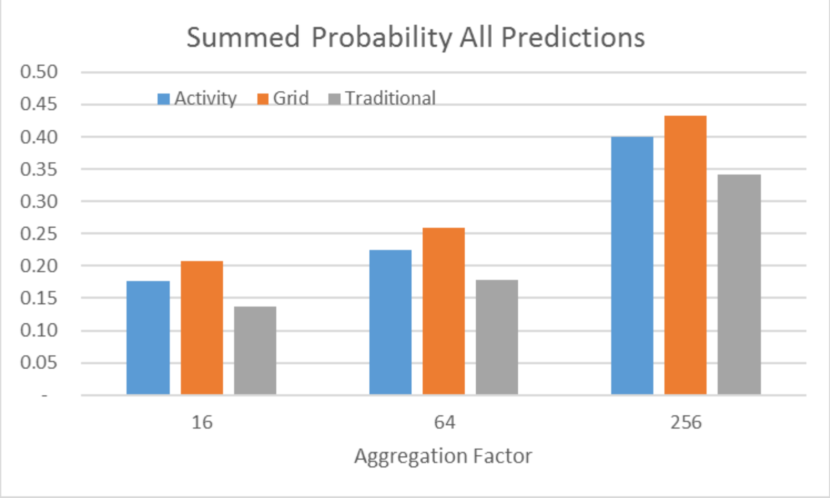
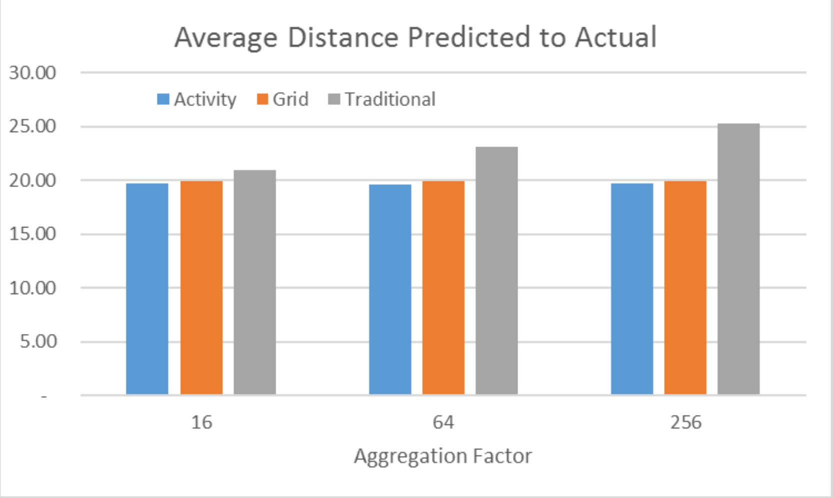
MC Average Prediction Results









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Conclusions

- The study suggests that the grid-point model may perform the best if the objective is accurate estimates of coefficients and derived welfare estimates.
- The advantage of the grid-point model will diminish as the size of discrete areas for the traditional model is reduced and as resource becomes less patchy
- Our empirical application suggested a clear advantage for the activity-based and grid-point models in terms of predictive accuracy, but the Monte Carlo did not demonstrate this.
- If ratio of revenue and distance coefficients is used to estimate welfare impacts (e.g. cost of an area closure) all models may overestimate impacts due to negative bias in revenue coefficient but the Grid Model may be more accurate due to lower bias in the expected revenue coefficient

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