Modeling Fisher Behavior under Changing Policies, Economics, and Environmental Conditions:

Spatial Models & FishSET

Office of Science & Technology
Economics & Human Dimensions Program Review
Tuesday September 26, 2017

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Overview

• FishSET – the Spatial Economics Toolbox for Fisheries
• Select Applications in Alaska & Gulf of Mexico Fisheries
• Synergies with other research projects and management actions
• Future directions
NOAA Predictions

From hurricane tracks...
NOAA Predictions to fish biomass.

Source: Ianelli et al 2011, EBS pollock assessment
How do policy and the environment impact fishers and communities?

- Fish biomass
- Habitat & the environment
- Bycatch regulations
- Marine reserves
- Catch shares

Photo: maine-lylobster.com
What is FishSET?

Key Goals and Elements

1. Better integrate data
2. Develop best modeling practices
3. Develop a Toolbox of many models
   • Timely analysis
   • Test if new models are better
FishSET Spatial Economics Toolbox for Fisheries

FishSET’s goal is to enable NOAA Fisheries economists and social scientists to better inform policy decisions by predicting how a variety of factors might influence fish behavior.

Many modeling challenges exist. While predictive models are valuable tools for sustainable fisheries management and conservation, challenges to their development include preparing, integrating, and updating many data sources, choosing appropriate models, and interpreting results.

FishSET provides:

1. Superior data organization, analysis, and integration for spatial models.
2. Best management practices for data, modeling, and model comparison.
3. Many models in a single toolbox for ease of model comparison and use. Combines several fisheries economics modeling approaches in one toolbox.

FishSET facilitates better and more expedient analyses to improve marine resource management.

What tools are in the FishSET toolbox?

Data Tools
- Data Management & Integration Tool: Facilitates the development and integration of datasets for spatial modeling.
- Monte Carlo Tool: Simulates real fisheries data while preserving confidentiality, allowing better model testing and comparison.
- Data Analysis & Mapping Tool: Enables graphical and geographic data viewing and prepares data for spatial modeling.

Model Tools
- Model Design & Selection Tool: Enables modeling of different combinations of variables and models.
- Modeling Tool: Runs standard, cutting-edge, and user-designed models.
- Model Comparison & Reporting Tool: Provides an extensive comparison of model performance and summarizes data, models, and results.

Policy Tools
- Policy Simulation Tool: Predicts location choices and estimates policy impacts.
Pilot Projects across the USA

West Coast Rockfish Conservation Areas

Bureau of Ocean Energy Management Project
Wind Energy Site Evaluation

Turtle Protection Measures

Steller Sea Lions

Hawaii Longline Fishery
How do fishers choose where to fish?

- Expected catch/revenue
- Travel costs
- Vessels size & character
- Biological & environmental characteristics of areas
- Regulations, quotas, and bycatch
Data to explain the factors that impact fishing

- Spatial fishing information
- Vessel characteristics
- Price Info
  - From markets
  - From vessel surveys
- Biological survey info
- Environmental data
  - Satellite observations
  - Weather station data
  - Buoy data
  - Bathymetry; Ice data; ROMS; Habitat
- Other

Photo: CSMphotos
A Big Data Focus: Identifying Fishing from Vessel Monitoring System (VMS) Data

Models allow us to use VMS data to estimate where unobserved fishing is occurring.

Source: Watson & Haynie (unpublished)
Size-targeting and production strategies in the Bering Sea pollock catcher processor fishery

Chen & Haynie (in prep)
Example types of fisher location choice models

• Area-specific constant logit (ASC logit)

\[
\text{Prob}(\text{Choice} = \text{Area 1}) = \frac{\exp(\alpha_1 + \beta'X_{i1})}{\sum_{k \in C_j} \exp(\alpha_k + \beta'X_{ik})}
\]

• Nested logit model
  • Participation model
  • Models with bioeconomic linkages
• Mixed logit model(s)
• Plus: a variety of specialized fisher location choice models (E.g., EPM, DRUM, etc.)
Example: Steller Sea Lions (SSL) & the Bering Sea pollock fishery
Example: SSL and pollock

- Vessels adapted and caught total allowable catch (TAC)

- Estimated cost per trip was 13% of net revenue (~$7,000).

Haynie and Layton JEEM 2010 for details.
FishSET Tools
Data management and integration tool
Data Analysis Tools
Flexible tools to form expectations

<table>
<thead>
<tr>
<th>Equation Terms</th>
<th>Settings</th>
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<tr>
<td>Prediction</td>
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<td>Catch Var</td>
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<td>Vessel</td>
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<td>Area (a)</td>
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<td>All zones on map (m)</td>
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\[ C = C_{i, r, z} + C_{i, s, z} + C_{i, l, z} + C_{g, s,a} + C_{f, l, m} + E \]

**Linear Fit Results**

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Model Comparison & Reporting Tool

- Pseudo-R-squared
- AIC, AICc, BIC, etc.
- In-sample and out-of-sample predictive skill
Reporting tool

Generalized Inputs

I. Data

Variables for the following model runs were imported from:\n\%\% local\AKC-REFM\User\alan_haynie\My Documents\Desktop\algae\FishSET\Train\GUIFiles\FishSET\data\Folder\data\MonteCarlo_1.mat. Variables chosen for all models were:

1. Zonal Variable
2. Zonal Variable X Zonal Variable

Only data with more than 10 hauls were included.

II. Grid

All variables were assigned to grid cell location using the ADFG_short.mat grid.

III. Alternative Choice

The alternative choice matrix was created using distance in meters between the centroid of a grid location and the variable, Fishing Haul Location RND.

Model Design

I. Zonal (ASC) Logit

Parameter file: zonal_logit.default

Beta, coefficient on “distance”? set to -0.1 for all coefficients.
Altcoeff, coefficient on alternative choice?, set to 0 for all coefficients.
Rand model inclusion, rand model inclusion, set to 1 for all coefficients.
Policy Simulation Tool

Allows analysts and policy-makers to compare the impacts of potential policies.
After loading data; and making whatever changes you want, Click Save Button, Which brings up save_map_file, then highlight all variables you want to be saved and a filter to be used if desired, click Save.
Gulf of Mexico Fishing Effort

- O’Farrell et al. ICES 2017
- Random forest & other models show effort for bandit real fishing
Changes in Gulf of Mexico longline fishing after regulation(s)

- IFQs and other management changes occurred simultaneously
- Watson et al, under review
- 2007-2008 vs. 2011-2012 “C” Season
Changes in Gulf of Mexico longline fishing after regulation(s)

- Watson et al, under review
- 2007-2008 vs. 2011-2012
Case Study: Bering Sea and Aleutian Islands Amendment 80 (A80) Implemented in 2008

Goals:
- Catch, profits, flexibility
- Bycatch & discards

Vessels could:
1) join a cooperative (16 vessels) OR
2) stay in limited-access (6 vessels)

Also in 2008, Pacific cod allocation decreased.

Abbott, Haynie, and Reimer  *Land Economics* 2015

Photo: Groundfish Forum
1) What happened to bycatch after A80? 
2) What mechanisms generated the changes?
Weekly "Bycatch" Share of Total Catch

Halibut STC

Cod STC

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<td>Range 2008-2010</td>
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How did vessels reduce their bycatch?

“Multiple margins”

1. Large-scale choice of fishing ground
2. “Reactive” spatial avoidance
3. Reductions in night fishing
   • a decrease of 15 to 18% relative to 2007; pronounced seasonality in the reduction.

Excluders, too, but we don’t have data on usage.
Large-scale spatial avoidance: Sep - Dec

- No discernable-large scale pattern of avoidance

- Consistent with a late-season relaxation of avoidance efforts after uncertainty over multi-species quota scarcity is resolved
Industry response to late season halibut bycatch: Amendment 80 Halibut Bycatch Avoidance Plan

- Developed by industry in response to Council request, implemented by industry in 2016.
- Would impose large fines on high-bycatch vessels based on seasonal performance.
- Implemented through contractual agreement—no fines imposed because vessels were close to average and rates declined.
Chinook bycatch in the Bering Sea pollock fishery

- No total cap on Chinook bycatch prior to 2011
  - large area and rolling hotspot closures used

- Hard cap and other incentive measures implemented in 2011 with Amendment 91
Chinook bycatch in the Bering Sea pollock fishery

Spatial modeling can also help us to understand how to create management with better incentives.
Other Collaborations

- Alaska Climate Integrated Modeling (ACLIM)
- Abbott, Kasperski, Haynie Natural Capital
- Reimer, Abbott, Haynie, NPRB Dynamic modeling
- Haynie, Thorson and others – fishing behavior & stock assessment
- Additional Sanchirico and Murawski work, Gulf of Mexico
Next Steps

- Complete additional models and distribute Matlab Version of FishSET
- Complete and distribute R Version
- Link with other related projects like POSEIDON
- Develop standing models of key fisheries.
FishSET enables us to better understand how policy impacts marine resource management.
Thank you! Questions?

Thanks to Rita Curtis, NMFS S&T, Doug Lipton, Jordan Watson, Allen Chen, Pacific States, Drew Kitts, Josh Abbott, Matt Reimer, Lisa Pfeiffer, NPRB, Megan Stachura, Ron Felthoven, Steve Kasperski, Jim Ianelli, Diana Stram, Kim Sparks, Shay O’Farrell, Larry Perruso, Pat Sullivan, Jim Sanchirico, Maxime Desplan, Justin Hospital, Rob Hicks, Kurt Schnier, Amanda Faig, Brian Garber-Yonts, Jean Lee, and everyone else involved in FishSET.

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