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

Spatial Models & FishSET
Overview

- FishSET – the Spatial Economics Toolbox for Fisheries
- Amendment 80 multispecies fisheries impacts
  - Unintended consequences - Red King Crab Savings Area
  - Amendment 80 & halibut bycatch reduction
  - Steller Seal Lion protected area impacts
- Chinook bycatch: from spatial management to incentives
- Elephants!
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 fisher behavior.

Many modeling challenges exist. While predictive models are valuable tools for sustainable fisheries management and conservation, challenges to their development include preparing, integrating & 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.

To learn more, visit:
www.st.nmfs.noaa.gov/humandimensions/fishset/index
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Source: Watson & Haynie (unpublished)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)
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

(NOAA Fisheries)
How do fishers choose where to fish?

- Expected catch/revenue
- Travel costs
- Vessels size & character
- Biological & environmental characteristics of areas
- Regulations, quotas, and bycatch
Example types of fisher location choice models

- Area-specific constant logit (ASC logit)

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

- 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.)
FishSET Tools

FishSET – Spatial Economics Toolbox for Fisheries

Data Management

Data Analysis

Modeling

Policy
Data management and integration tool
Flexible tools to form expectations

\[
C = C_{i, r, z} + C_{i, s, z} + C_{i, l, z} + C_{g, s,a} + C_{f,l,m} + E
\]

<table>
<thead>
<tr>
<th>Equation Terms</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prediction</td>
<td>Catch (C)</td>
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<tr>
<td>Prediction Variable</td>
<td>Catch Var</td>
</tr>
<tr>
<td>Individual (i)</td>
<td>Vessel</td>
</tr>
<tr>
<td>Group (g)</td>
<td>Company</td>
</tr>
<tr>
<td>Fleet (f)</td>
<td>auto set All Vessels</td>
</tr>
<tr>
<td>Time Variable</td>
<td>Haul Date</td>
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<tr>
<td>Recent (r)</td>
<td>1 day</td>
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<tr>
<td>Short Term (s)</td>
<td>14 days</td>
</tr>
<tr>
<td>Long Term (l)</td>
<td>all time</td>
</tr>
<tr>
<td>Individual's Zone (z)</td>
<td>auto set</td>
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<tr>
<td>Area (a)</td>
<td>area variable</td>
</tr>
<tr>
<td>All zones on map (m)</td>
<td>auto set</td>
</tr>
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Linear Fit Results

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<tr>
<th></th>
<th>Rsqr</th>
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<tr>
<td>( \beta_0 )</td>
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<td>( \beta_{i, r, z} )</td>
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<td>( \beta_{i, s, z} )</td>
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<tr>
<td>( \beta_{f,l,m} )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Modeling Tools

Model Design and Selection Tool

Alternative Choice
Include zones with $\geq$ 20 Hauls

Number of records = 79,198
Number of zones = 25

Calculate Alternatives
Distance in units: Miles
Between LonLat and LonLat

Variables
Independent Variables
Miles*HP

Included Choices
Miles
Miles*HP

Model Preferences
Include Model
- Nested Logit
- EPM (default)
- Zonal (ASC) Logit (default)
- Average Catch (default)
- Cross-nested Logit
- Bayesian Mixed Logit

Parameter Set
- nested_logit.default
- epm.default
- zonal_logit.default
- average_catch.default
- cross_nested_logit.default
- bayesian_mixed_logit.default

Maximum Function Evaluations
- 20,000
- 20,000
- 20,000
- 20,000
- 20,000
- 20,000

Maximum Interations
- 1,000
- 1,000
- 1,000
- 1,000
- 1,000
- 1,000

Termination Tolerance
- 0.0001
- 0.0001
- 0.0001
- 0.0001
- 0.0001
- 0.0001

Create Model File
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\nmkhlocal.AKC.REFM\User\alas. HayesMy DocumentsD-\nDrive\shaynes FishSETTrialGUIFiles FishSetGUI dataFolder 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 or “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
Next Steps

- Complete additional models and distribute Matlab Version of FishSET
- Develop R Version
- Link with other related projects like POSEIDON
- Develop standing models of key fisheries.
Next: 2 stories are about the BSAI multispecies catcher-processor trawl fishery
Fish Story # 1

“What Are We Protecting? The Challenges of Marine Protected Areas for Multispecies Fisheries”

Josh Abbott and Alan Haynie, 2012.

Case Study: The Eastern Bering Sea Rock Sole/ Pacific Cod Fishery

• Group (<20) of trawl vessels
  • January to March
• Until 2008 faced common-pool TACs on target and prohibited species catch (PSC)
  • Red king crab
  • Pacific halibut
• Before 1995 when Red King Crab Savings Area was implemented, red king crab bycatch typically closed fishery
Q1: How did the distribution of fishing effort change in the wake of the closures?
Q3: How did the closures impact red king crab bycatch?

<table>
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<tr>
<th>Year</th>
<th>All Areas</th>
<th>Mean #/hr</th>
<th>Proportion $= 0$</th>
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<tr>
<td>1992</td>
<td></td>
<td>6.10</td>
<td>0.86</td>
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<tr>
<td>1993</td>
<td></td>
<td>15.20</td>
<td>0.74</td>
</tr>
<tr>
<td>1994</td>
<td></td>
<td>16.97</td>
<td>0.71</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>3.95</td>
<td>0.91</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td>1.87</td>
<td>0.92</td>
</tr>
<tr>
<td>1997</td>
<td></td>
<td>3.30</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Table S1: Annual comparisons of mean red king crab bycatch rates and proportion of hauls with zero bycatch from observer data relative to estimates of biomass. Means are weighted estimates calculated from haul-level data using the duration of haul as the weight.
Q3: How did halibut bycatch change as a result of displacement from the closure?

<table>
<thead>
<tr>
<th></th>
<th>All Areas</th>
<th>Non-Closure Data Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Halibut (kg/hr)</td>
<td>Mean</td>
</tr>
<tr>
<td>pre</td>
<td>81.54</td>
<td></td>
</tr>
<tr>
<td>post</td>
<td>118.09</td>
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<td></td>
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<tr>
<td>pre</td>
<td>96.82</td>
<td></td>
</tr>
<tr>
<td>post</td>
<td>118.09</td>
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</tbody>
</table>
Fish Story # 2

Changes with Amendment 80 to the BSAI Fishery Management Plan

“Hidden Flexibility: Institutions, Incentives and the Margins of Selectivity in Fishing.”

Amendment 80 (A80) 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.
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 these.
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; reported to the Council in December 2016.

- Would impose large fines on high-bycatch outlier vessels based on seasonal performance

- Implemented through contractual agreement—no fines were imposed because all vessels were close to average rates and rates declined.
The Economic Impacts of Spatial Closures: Evidence from the 2011-2014 Steller Sea Lion Protective Measures in the North Pacific

Matthew N. Reimer1 and Alan C. Haynie2

Introduction

Motivation: Spatial closures are a prominent tool for ecosystem-based management in commercial fisheries, but empirical estimates of the short-run costs incurred by the commercial fishing industry, such as increased costs and/or foregone revenue, are relatively rare.

Project goal: We conduct an ex post evaluation of the short-run economic impacts associated with the 2011-2014 spatial closures to the North Pacific groundfish fleet for the protection of the endangered western stock of Steller sea lions (SSL) in the Aleutian Islands (AI).

Background

In 2011, NMFS prohibited the retention of Atka mackerel and Pacific cod in management area 543 by both trawl and non-trawl gear, as well as in SSL critical habitat areas by trawl gear in management area 542 (Figure 1), resulting in a sharp decline in the total allowable catch (TAC) for Atka mackerel (Figure 2).

Methods

We conduct a comparative case study, which estimates the evolution of an outcome variable for units affected by a particular intervention and compare it to the evolution of the same outcome estimated for a control group of unaffected units.

Treated vs. Control Groups: Of the 18 vessels in our sample, only 7 actively targeted Atka mackerel and Pacific cod in the closed areas prior to the closures. These 7 vessels serve as the treated group. The other 11 vessels serve as the control group, which we use to estimate what net revenue would have been in the absence of the SSL protective measures.

We Estimate Three Model Types & Compare: We conduct a comparative case study, which estimates the evolution of an outcome variable for units affected by a particular intervention and compare it to the evolution of the same outcome estimated for a control group of unaffected units.

Synthetic Control Method (SCM): Constructs a "synthetic" intermediary effects

Results

Overall Effect: All estimators find a sizeable negative effect on net revenue in the first two years after the intervention (~30% reduction), approach zero by the third year, and become slightly positive by 2014 (Figure 5). However, average effects are not significantly different from zero at the 10% level for any year.

Mechanistic Effects: The SSL protective measures had a direct adverse (and significant) effect on variable cost, as well as the quota received by vessels (Figure 6). However, these were offset by direct increases in revenue (conditional on price and harvest) and wholesale prices (conditional on harvest).

Conclusion

There is little evidence of a negative effect of the SSL closures on the net revenue of affected vessels. However, our decomposition identifies multiple countering mechanisms. Vessels were negatively impacted through the reduction in Atka mackerel quota and from being displaced from historical fishing grounds, but were able to partially offset this by substituting to other species outside of the closure. These results confirm the common verdict that the short-run cost of a spatial closure will depend on the opportunities outside of the closure. Our results demonstrate the importance of understanding the mechanisms underlying the economic impacts of spatial closures, for both generalizing results beyond the setting at hand and for aiding policy makers in designing policies that foster mechanisms that achieve the intended policy objectives.

Data

Our main variable is annual net revenue as reported in the Economic Data Reports for each vessel in the Amendment 80 (ABO) fleet. We compute net revenue as annual gross revenue (e.g., product sales and income from other sources) minus annual variable cost (e.g., labor, fuel, maintenance and repair, food, packaging, and fish taxes). The A80 fleet consists of catcher processors that use non-pelagic trawl gear to target non-pollock groundfish species. A80 vessels receive a share of the TAC for six primary species and vest there in a cooperative. Our sample consists of 18 vessels that fished in all years during the period 2008-2014.

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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
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Opportunities
7. Incentives

Stakeholder input at the February 2017 workshop also noted the need for consideration of appropriate incentives when designing alternatives for analysis. The section below provides some further comments by stakeholders, analysts and other potential considerations. Minimizing halibut bycatch to the extent practicable involves balancing a number of national standards, with the goal of efficiently minimizing bycatch while achieving optimum yield. Halibut bycatch rates vary significantly across time and space in a manner that has both predictable and unpredictable characteristics. Halibut and target groundfish populations have different degrees of co-mingling and the cost of avoiding halibut is therefore not consistent across time. This means a well-designed bycatch management system will enable groundfish vessels to decide the best times and methods to reduce bycatch and providing for the best incentives to do so is an important consideration.

*From SSC Minutes:* “The incentives section (7) provided a very helpful discussion that should not get lost in the detailed evaluation of future alternatives. Incentives provide a supplement (and potentially even an alternative) to index-based approaches.”
Public goods provision of ideas

- Council settings (presentations, analyses, plan teams, etc.)
- IPHC
- IEA, ICES, PICES, MSEAS, SICCME, ESSAS, etc.
- Inter/multi/trans-disciplinary work
- Diverse scientific settings
Thanks!

Questions?

Photo CSMphotos