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

Spatial Models & FishSET

NOAA FISHERIES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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

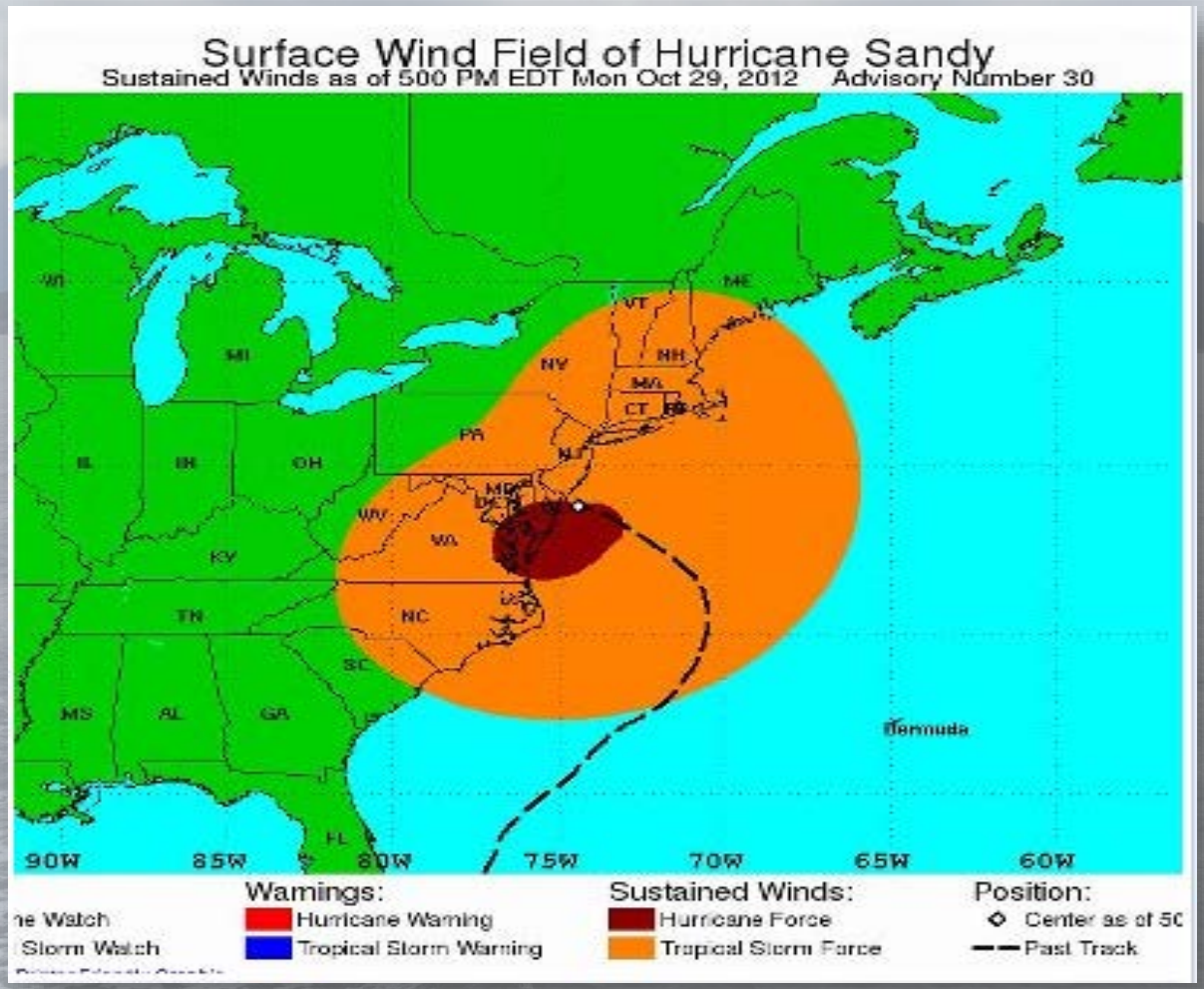
Alan Haynie, Alaska Fisheries Science Center, Seattle, WA

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

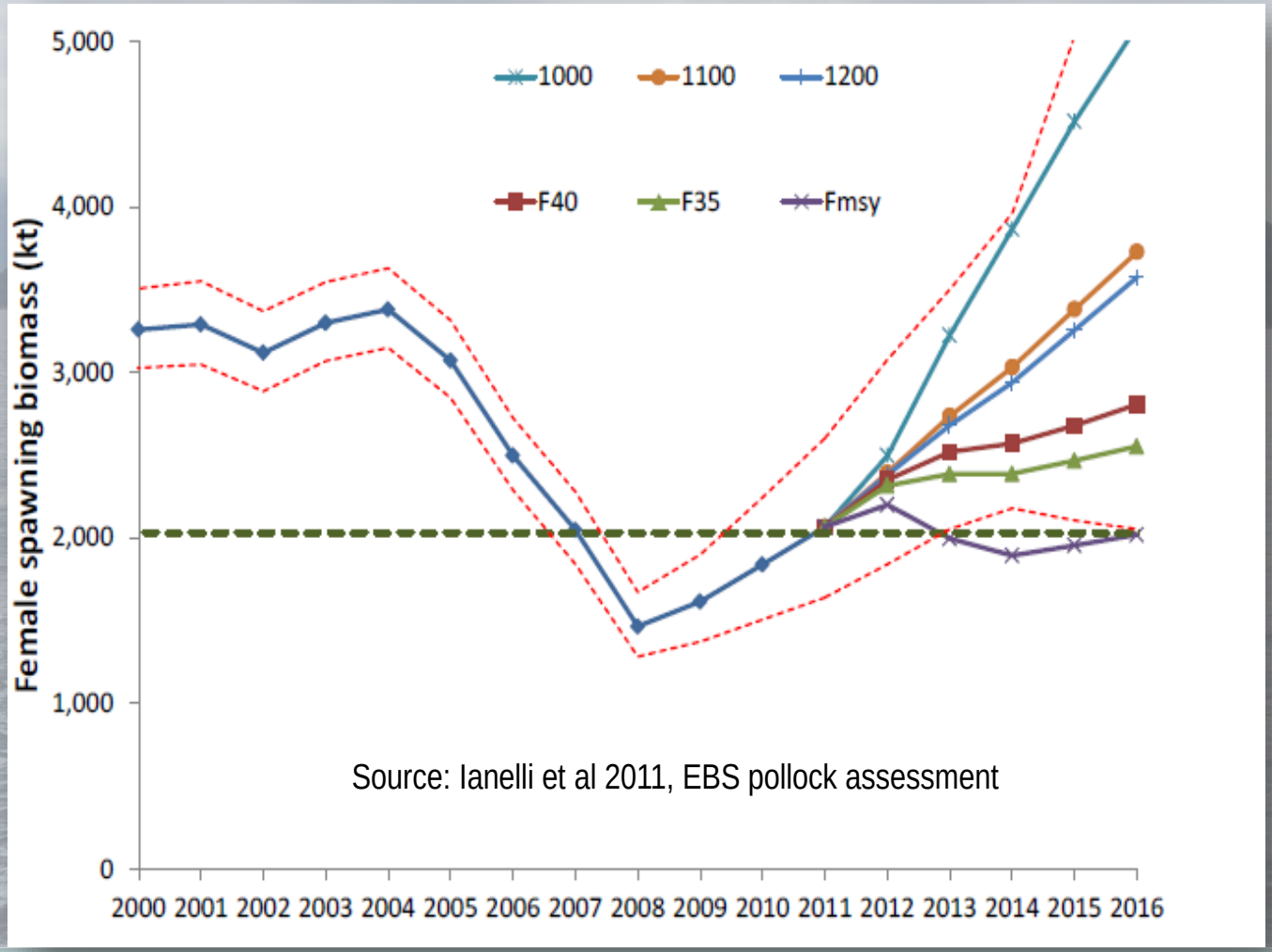
NOAA Predictions

From hurricane tracks…



NOAA Predictions

to fish biomass.



Source: Ianelli et al 2011, EBS pollock assessment

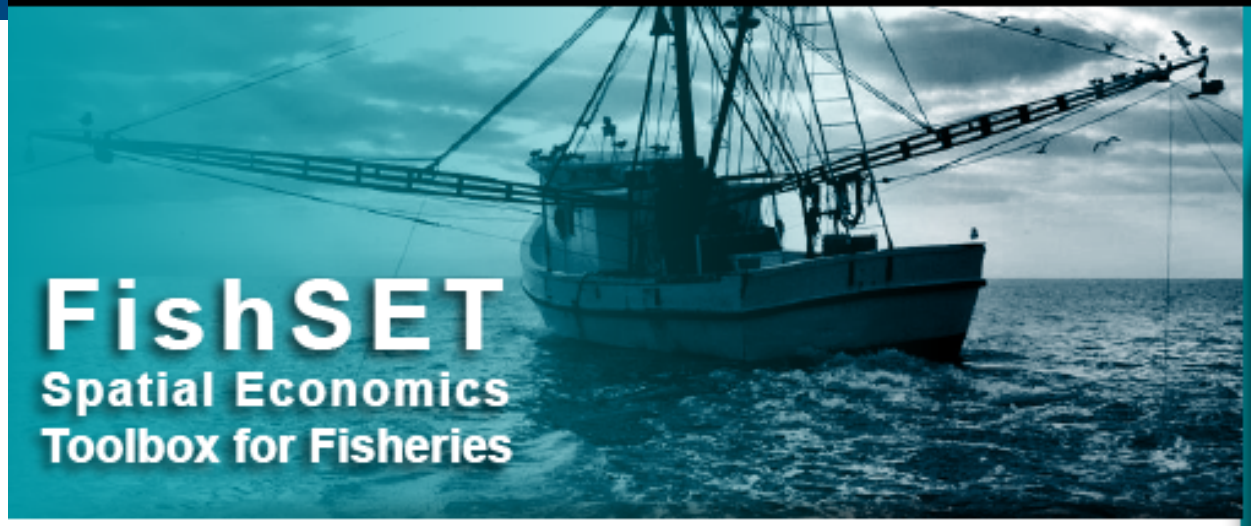
How do policy and the environment impact fishers and communities?

- 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



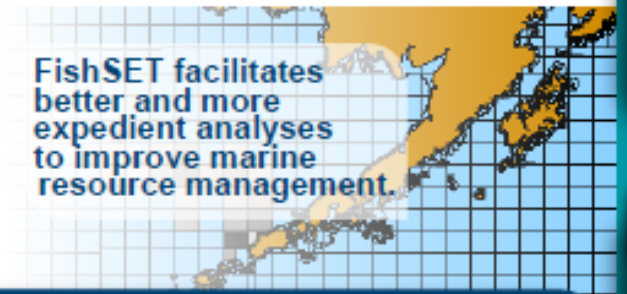
FishSET
Spatial Economics Toolbox for Fisheries

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 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 comparision 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

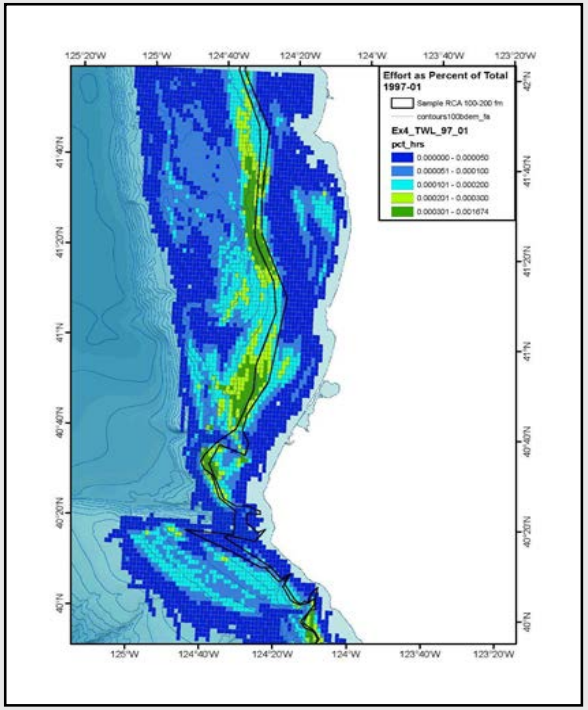
Model Comparison & Reporting Tool
Provides an extensive comparison of model performance and summarizes data, models, and results

Policy Tools

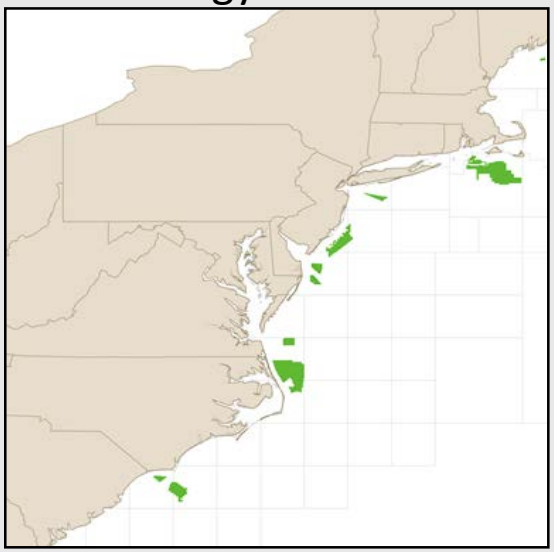
Policy Simulation Tool
Predicts location choices and estimates policy impacts

Pilot Projects across the USA

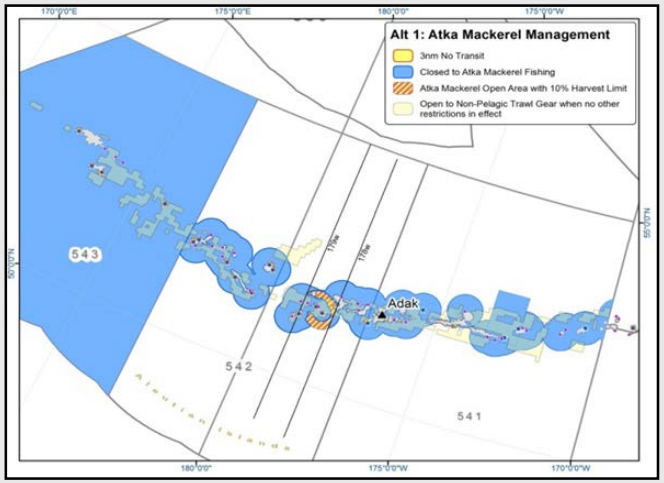
West Coast Rockfish Conservation Areas



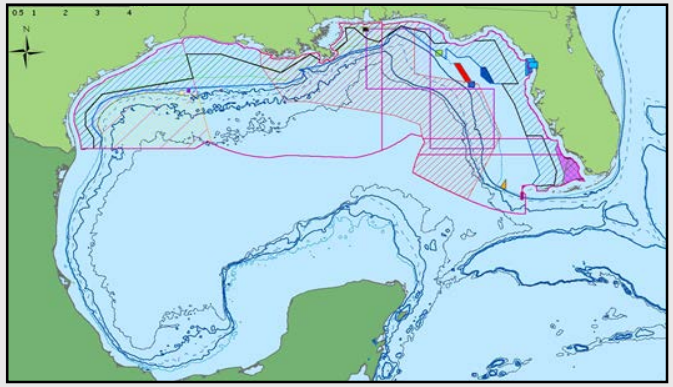
Bureau of Ocean Energy Management Project Wind Energy Site Evaluation



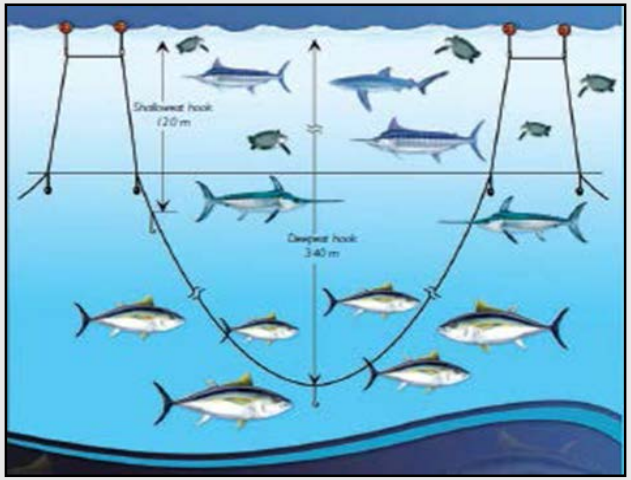
Steller Sea Lions



Turtle Protection Measures



Hawaii Longline Fishery



How do fishers choose where to fish?

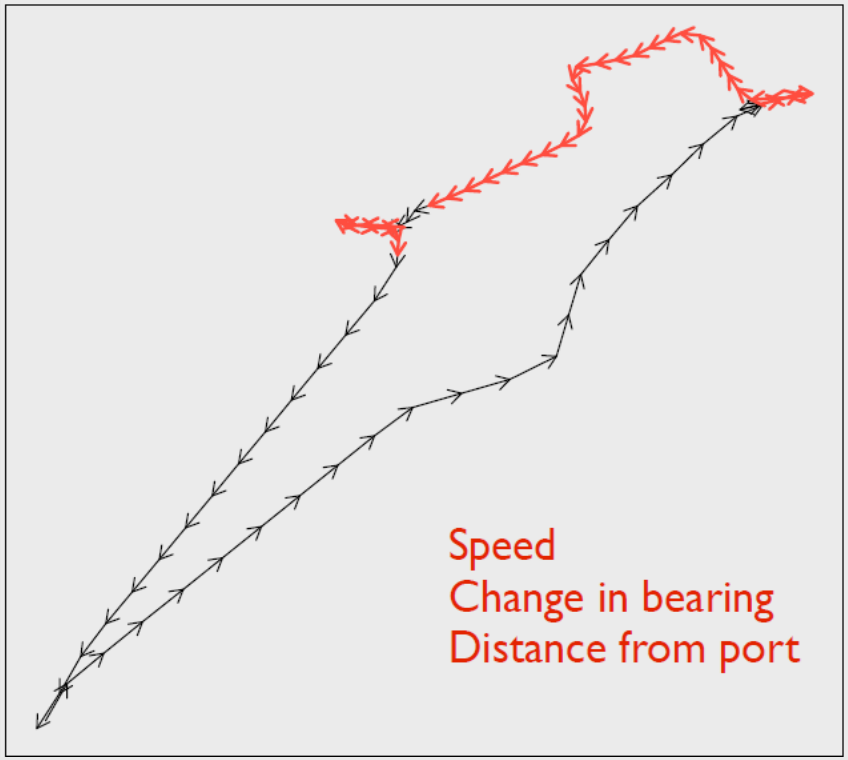
- Expected catch/revenue
- Travel costs
- Vessels size & character
- Biological & environmental characteristics of areas
- Regulations, quotas, and bycatch

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

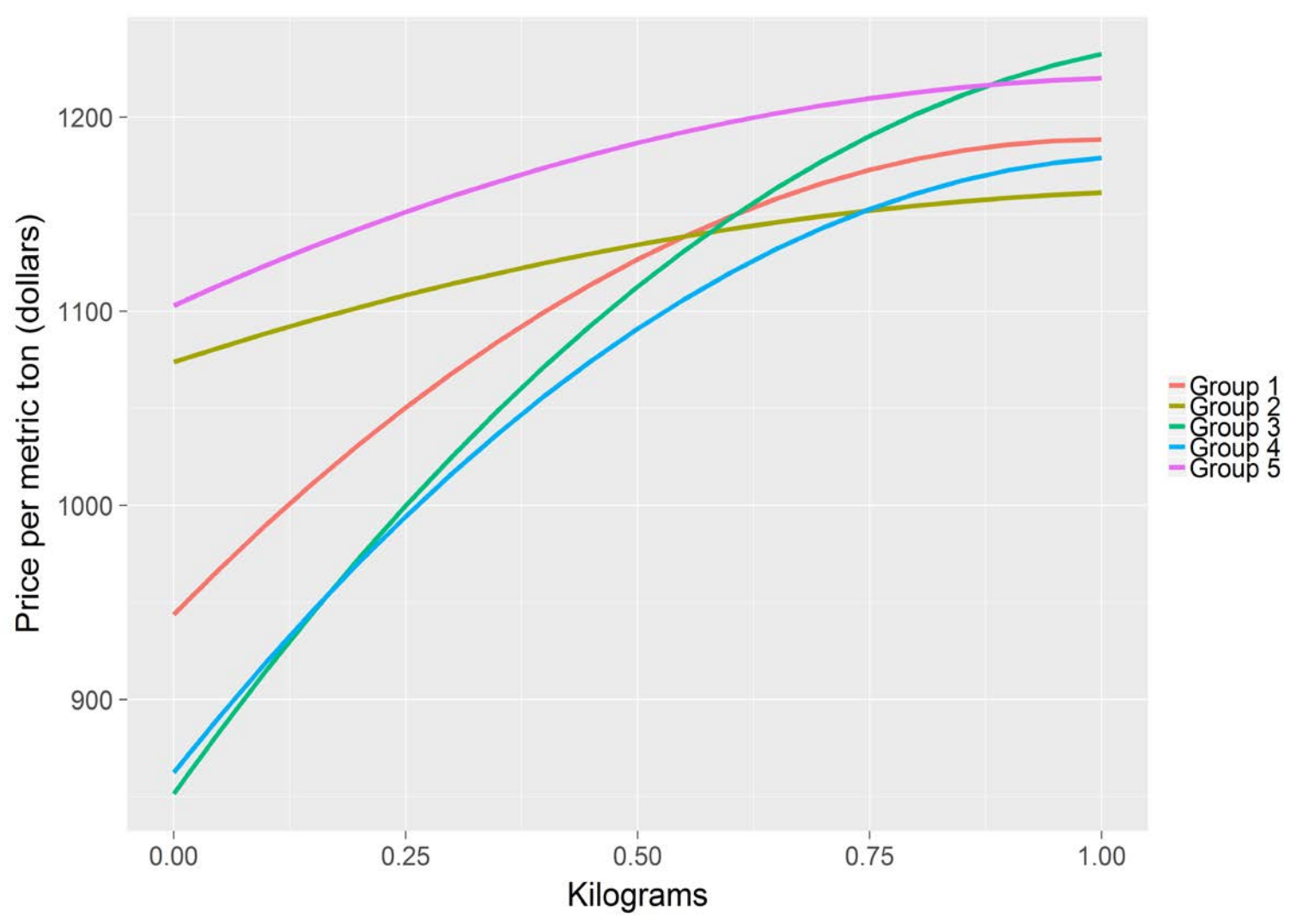
A Big Data Focus: Identifying Fishing from Vessel Monitoring System (VMS) Data



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)

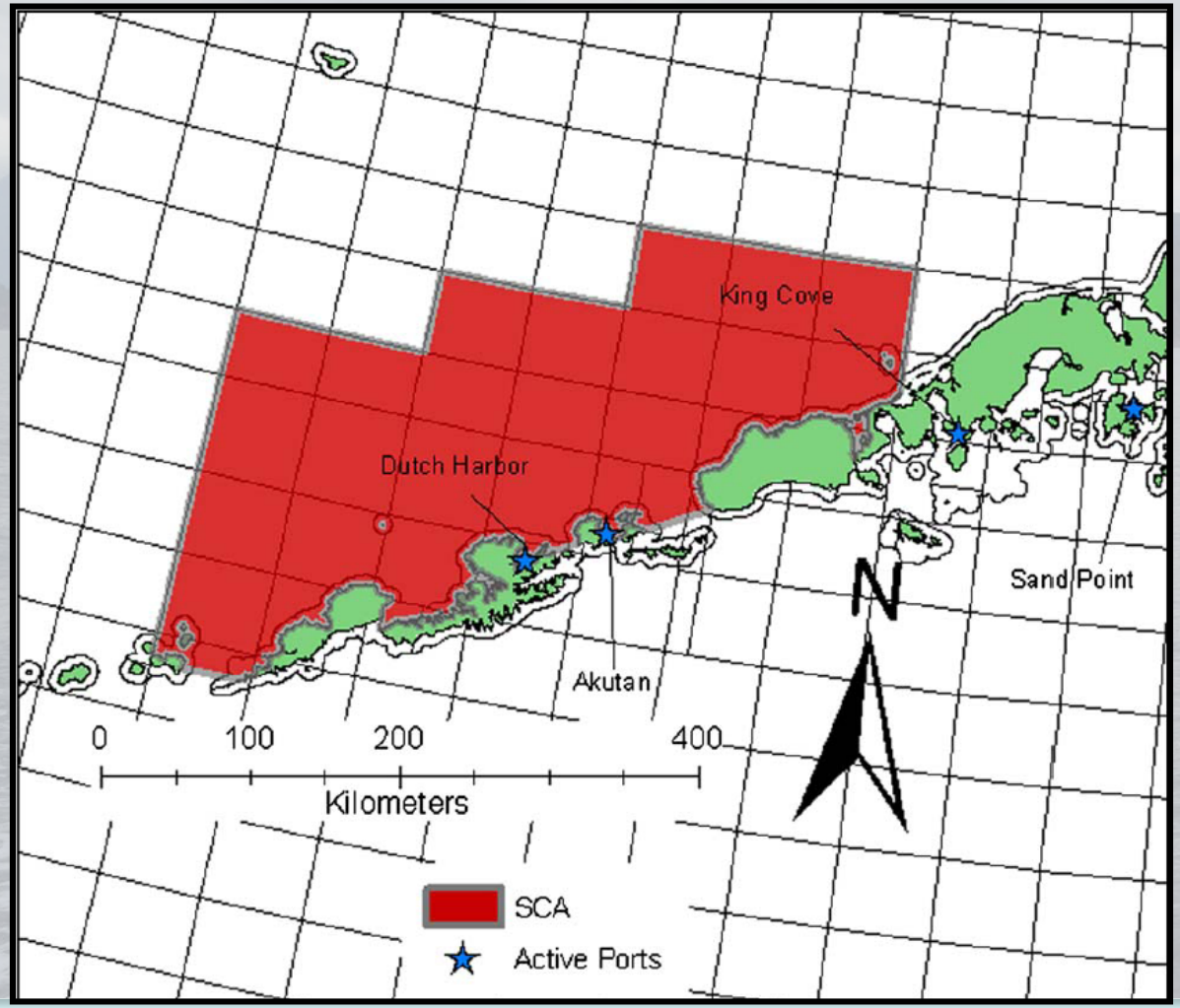
Example types of fisher location choice models

- Area-specific constant logit (ASC logit)

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

- 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

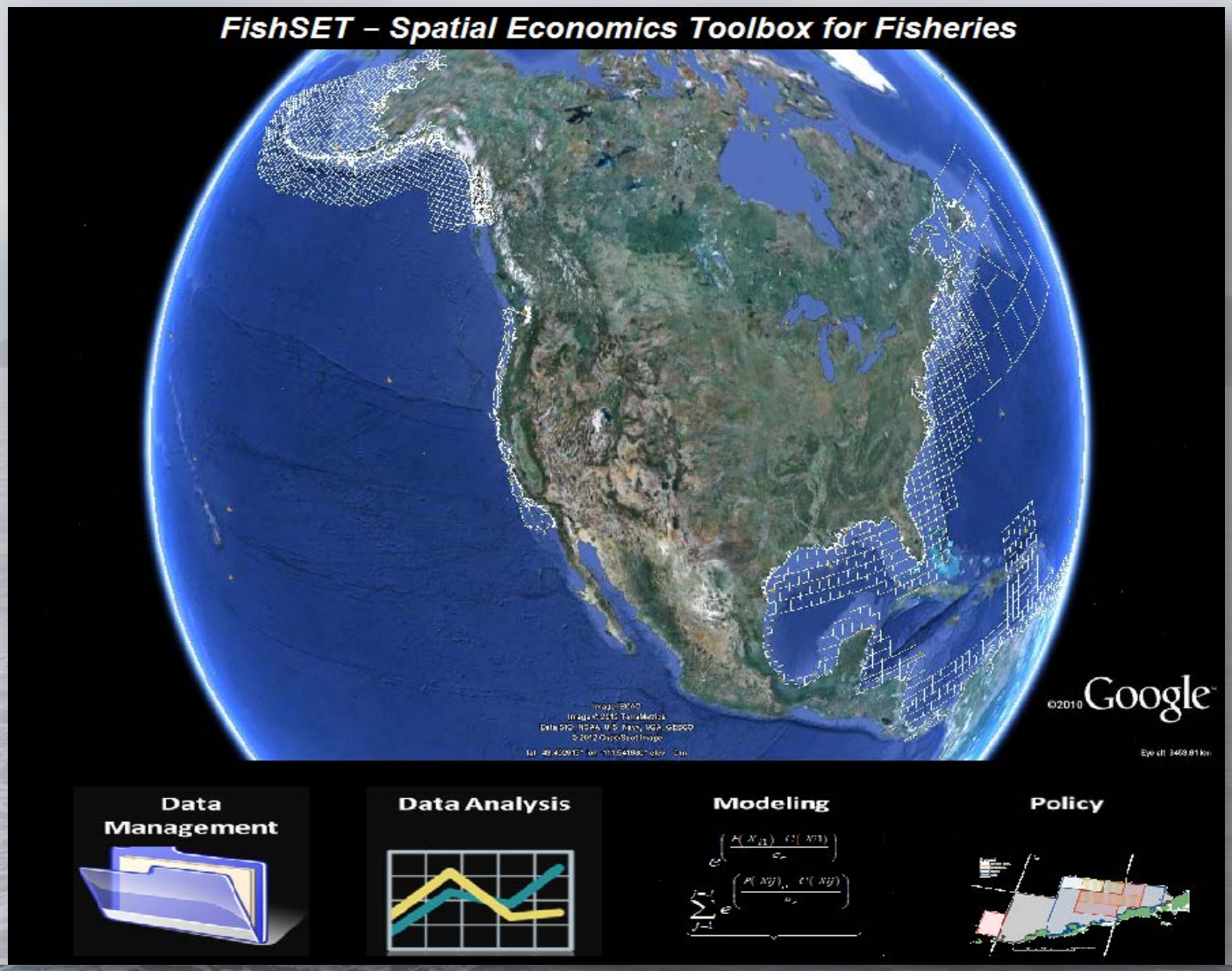


Example: SSL and pollock

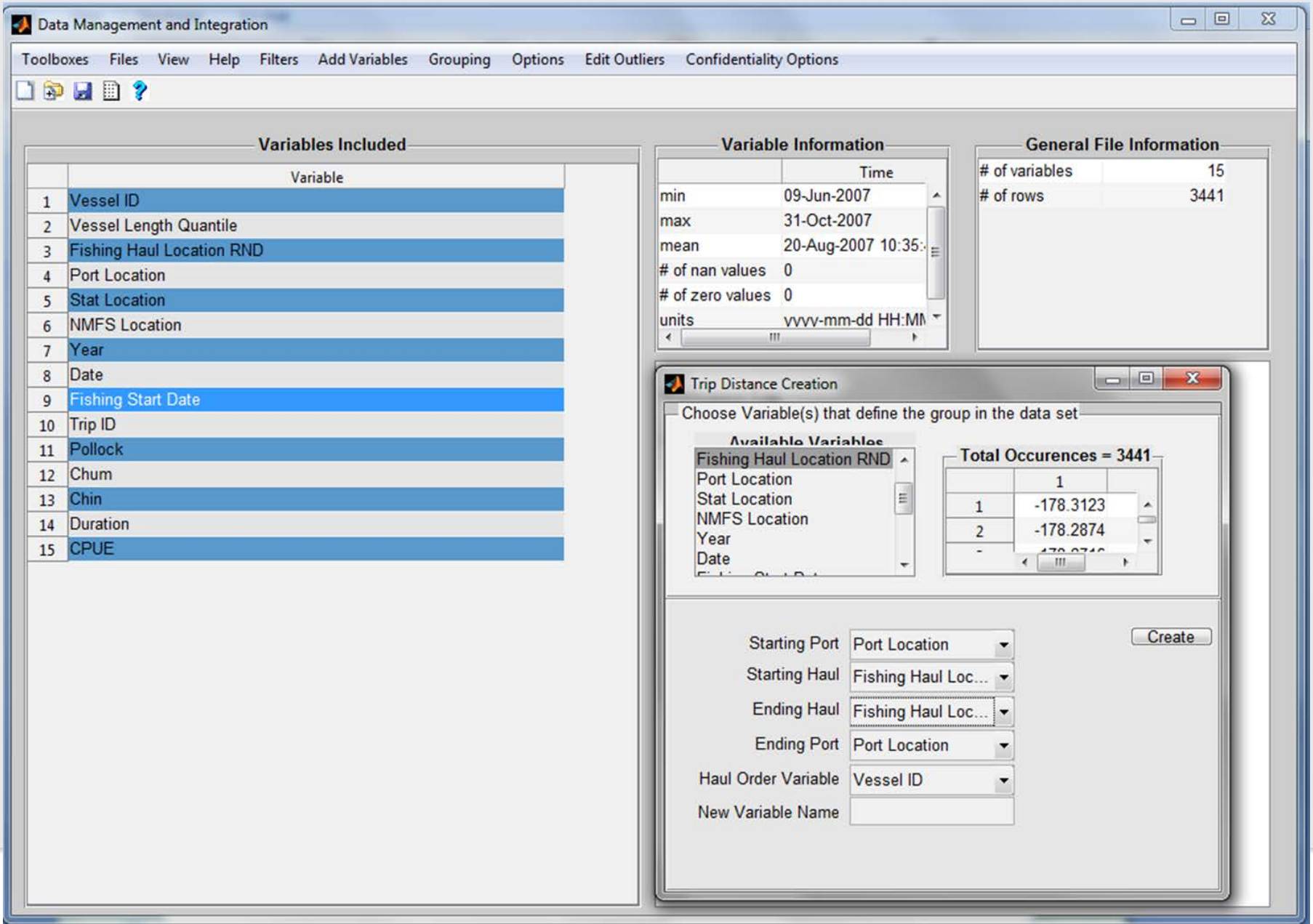
Haynie and Layton *JEEM* 2010 for details.

- Vessels adapted and caught total allowable catch (TAC)
- Estimated cost per trip was 13 % of net revenue (~$7,000).

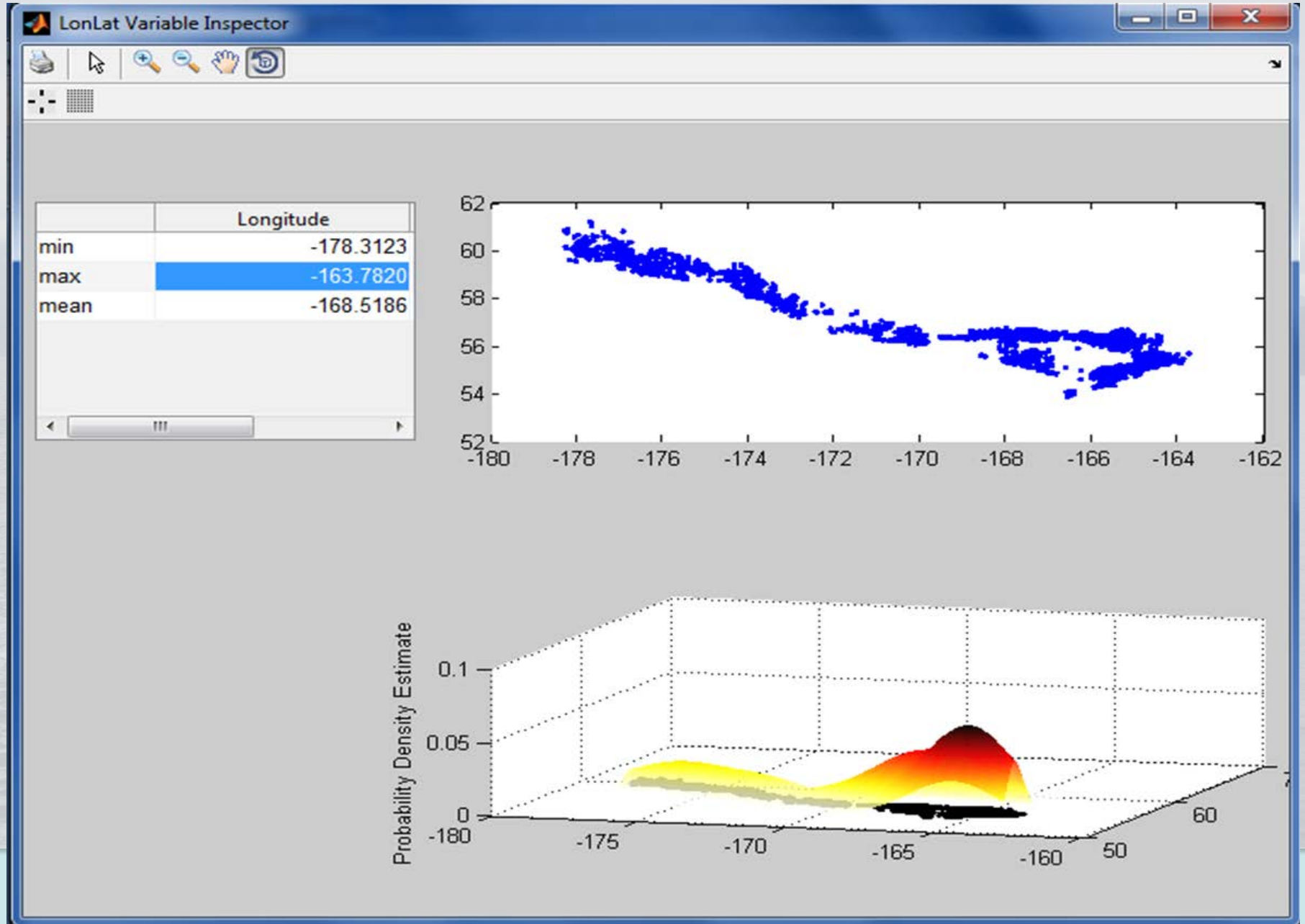
FishSET Tools

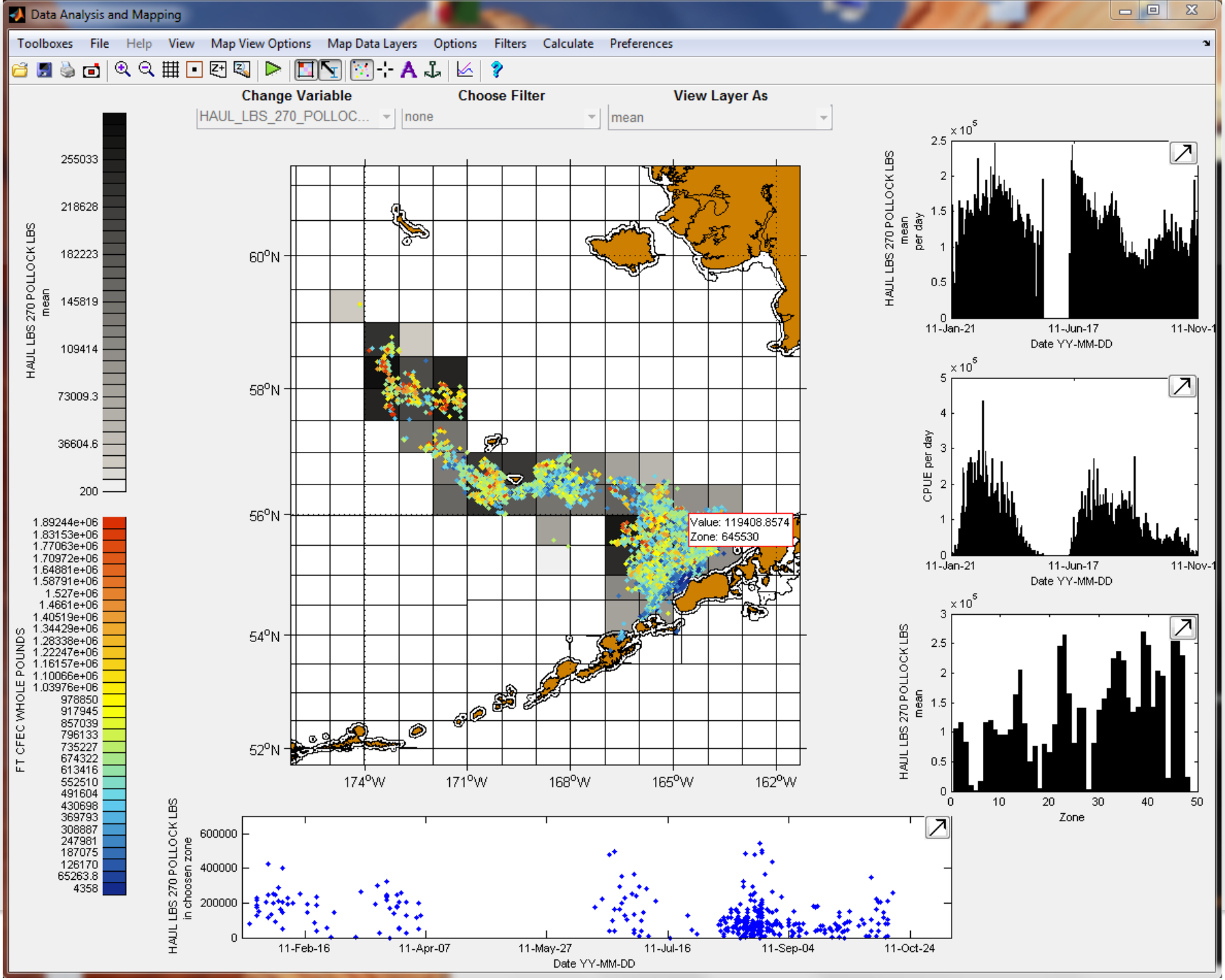


Data management and integration tool



Data Analysis Tools




Data Analysis and Mapping
Toolboxes File Help View Map View Options Map Data Layers Options Filters Calculate Preferences
Change Variable
HAUL_LBS_270_POLLOC...
Choose Filter
none
View Layer As
mean
HAUL LBS 270 POLLOCK LBS mean
255033
218628
182223
145819
109414
73009.3
36604.6
200
FT CFEC WHOLE POUNDS
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1.83153e+06
1.77063e+06
1.70972e+06
1.64881e+06
1.58791e+06
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1.4661e+06
1.40519e+06
1.34429e+06
1.28338e+06
1.22247e+06
1.16157e+06
1.10066e+06
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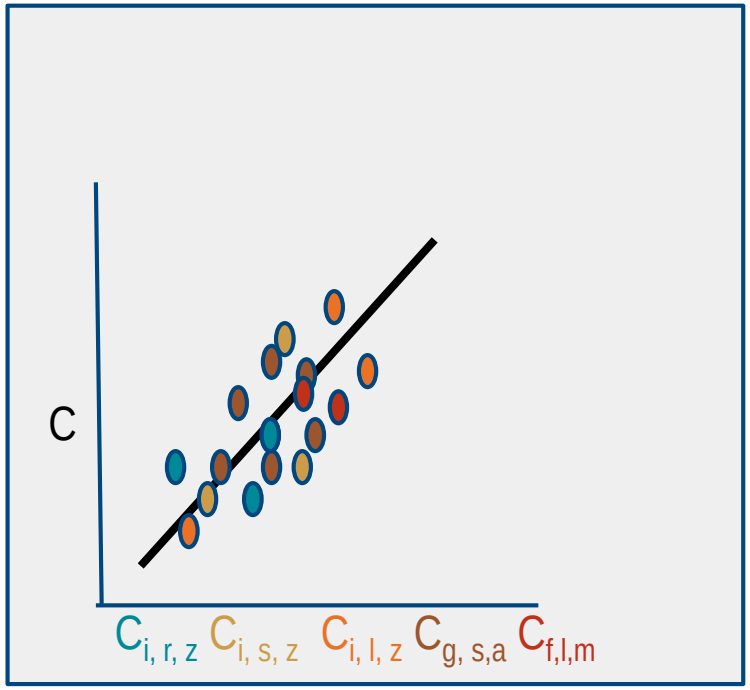
978850
917945
857039
796133
735227
674322
613416
552510
491604
430698
369793
308887
247981
187075
126170
65263.8
4358
60°N
58°N
56°N
54°N
52°N
174°W
171°W
168°W
165°W
162°W
Value: 119408.8574
Zone: 645530
HAUL LBS 270 POLLOCK LBS mean per day
x 10^5
11-Jan-21
11-Jun-17
11-Nov-1
Date YY-MM-DD
CPUE per day
HAUL LBS 270 POLLOCK LBS mean
Zone
HAUL LBS 270 POLLOCK LBS in choosen zone
600000
400000
200000
11-Feb-16
11-Apr-07
11-May-27
11-Jul-16
11-Sep-04
11-Oct-24

Flexible tools to form expectations

Menu…

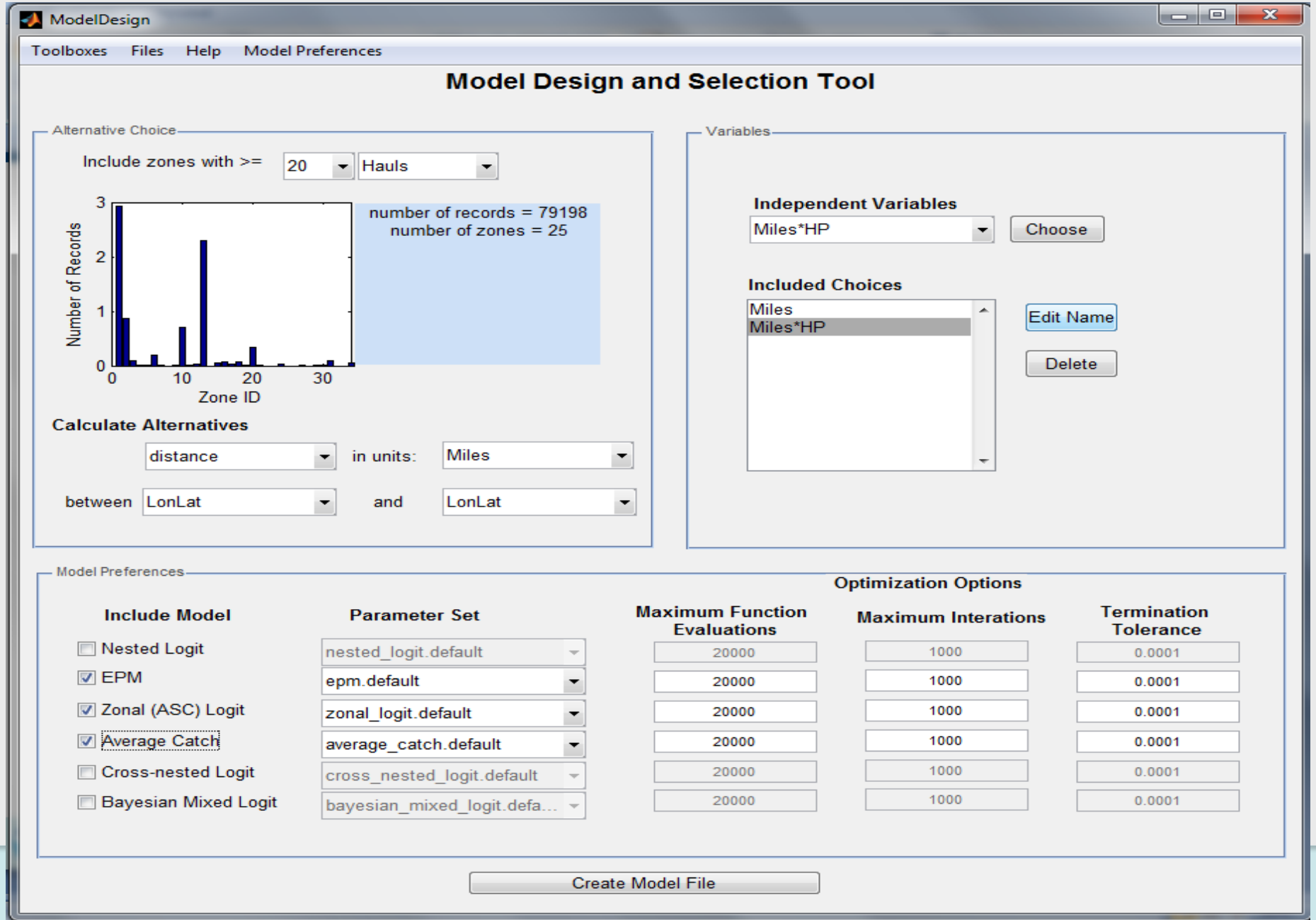
Equation Terms	Settings
Prediction	Catch (C)
Prediction Variable	Catch Var
Individual (i)	Vessel
Group (g)	Company
Fleet (f)	auto set All Vessels
Time Variable	Haul Date
Recent (r)	1 day
Short Term (s)	14 days
Long Term (l)	all time
Individual's Zone (z)	auto set
Area (a)	area variable
All zones on map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

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



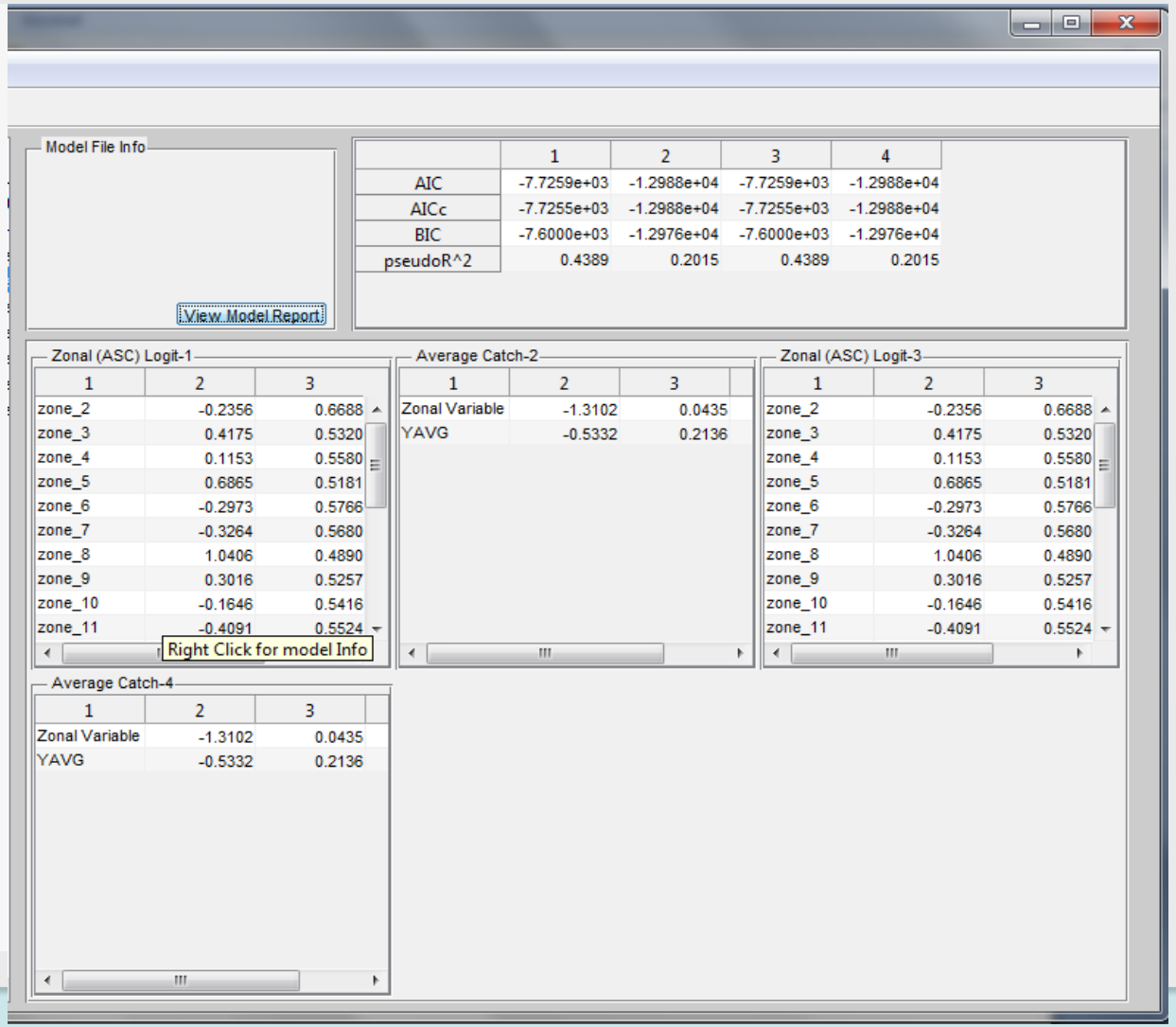
Linear Fit Results	
Rsqr	0.9999
β_0	0
$\beta_{i,\,r,\,z}$	
$\beta_{i,\,s,\,z}$	
$\beta_{,\,l,\,z}$	
$\beta_{g,\,s,a}$	
$\beta_{f,l,m}$	

Modeling Tools



Model Comparison & Reporting Tool

- Pseudo-R-squared
- AIC, AICc, BIC , etc.
- In-sample and <u>out-of-sample</u> predictive skill



	1	2	3	4
AIC	-7.7259e+03	-1.2988e+04	-7.7259e+03	-1.2988e+04
AICc	-7.7255e+03	-1.2988e+04	-7.7255e+03	-1.2988e+04
BIC	-7.6000e+03	-1.2976e+04	-7.6000e+03	-1.2976e+04
pseudoR^2	0.4389	0.2015	0.4389	0.2015

	1	2
zone_2	-0.2356	0.6688
zone_3	0.4175	0.5320
zone_4	0.1153	0.5580
zone_5	0.6865	0.5181
zone_6	-0.2973	0.5766
zone_7	-0.3264	0.5680
zone_8	1.0406	0.4890
zone_9	0.3016	0.5257
zone_10	-0.1646	0.5416
zone_11	-0.4091	0.5524

	1	2
Zonal Variable	-1.3102	0.0435
YAVG	-0.5332	0.2136

	1	2
zone_2	-0.2356	0.6688
zone_3	0.4175	0.5320
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zone_9	0.3016	0.5257
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zone_11	-0.4091	0.5524

	1	2
Zonal Variable	-1.3102	0.0435
YAVG	-0.5332	0.2136

Reporting tool

Generalized Inputs

I. *Data*

Variables for the following model runs were imported from\\nmfs.local\AKC-REFM\Users\alan.Haynie\My Documents\D-Drive\ahaynie\FishSET\TrialGUIFiles\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 on "distance"?, set to -0.1 for all coefficeints.

Altcoeff, coefficient on alternative choice?, set to 0 for all coefficeints.

Rand model inclusion, rand model inclusion, set to 1 for all coefficeints.

Modeling Output

I. *Zonal (ASC) Logit*

Ouput from optimization scheme can be found in the text file, Zonal (ASC) Logit_2013_07_15_11_32.txt Some text

Model Output

Variable	Estimate	SE	Estimate/SE
zone_2	1.6365	1.3536	1.209
zone_3	4.9164	2.0952	2.3465
zone_4	3.4949	1.948	1.7941
zone_5	6.365	2.1646	2.9405
zone_6	6.7852	3.2579	2.0827
zone_7	6.7507	2.349	2.8739
zone_8	9.2384	2.712	3.4065
zone_9	9.5128	3.1781	2.9933
zone_10	9.0111	3.5242	2.5569
zone_11	11.6873	3.7171	3.1442
zone_12	11.6335	3.8531	3.0192
zone_13	12.7541	3.9151	3.2577
zone_14	12.9133	4.0283	3.2056

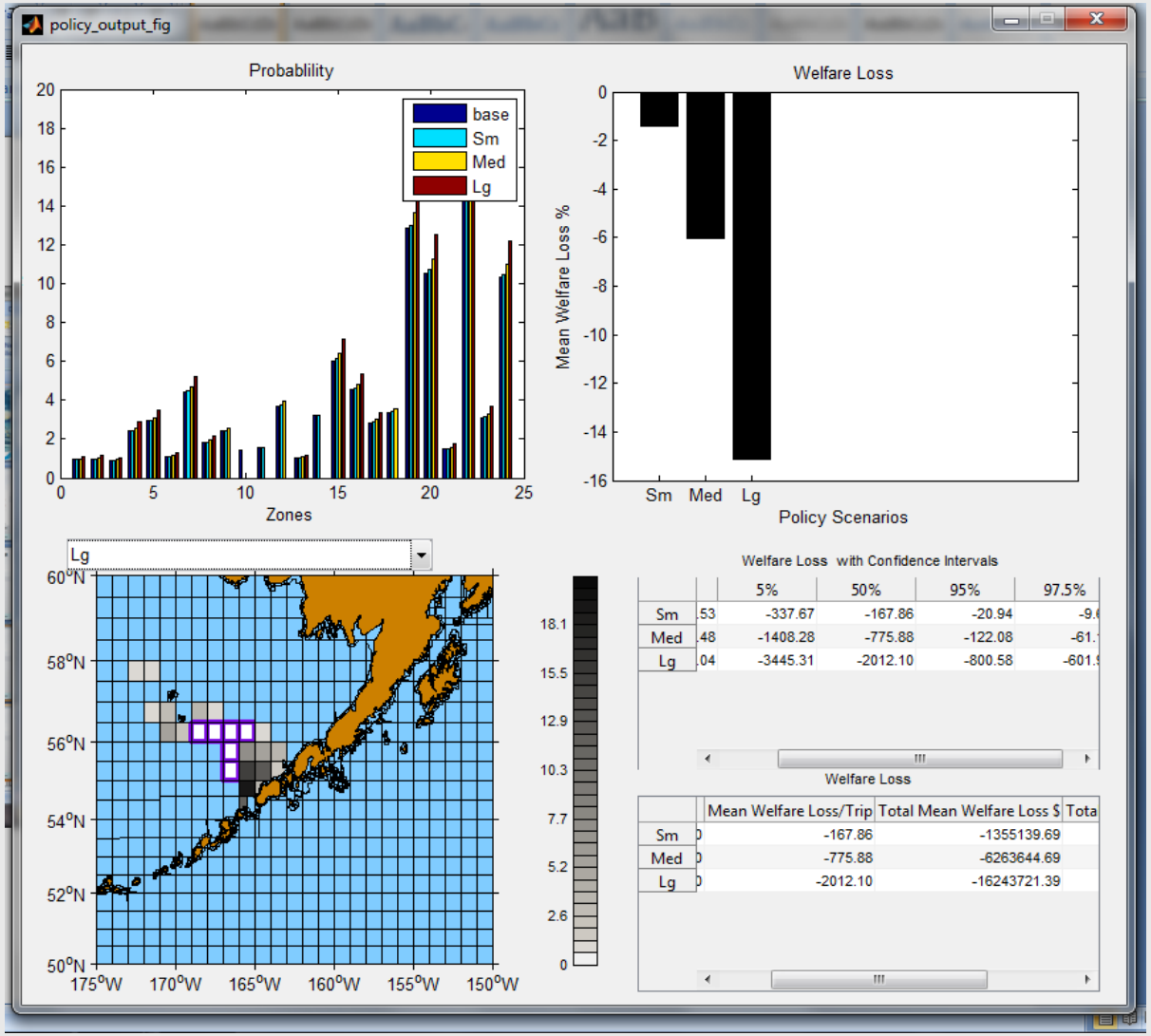
Modeling Comparison

I. *Zonal (ASC) Logit*

more things

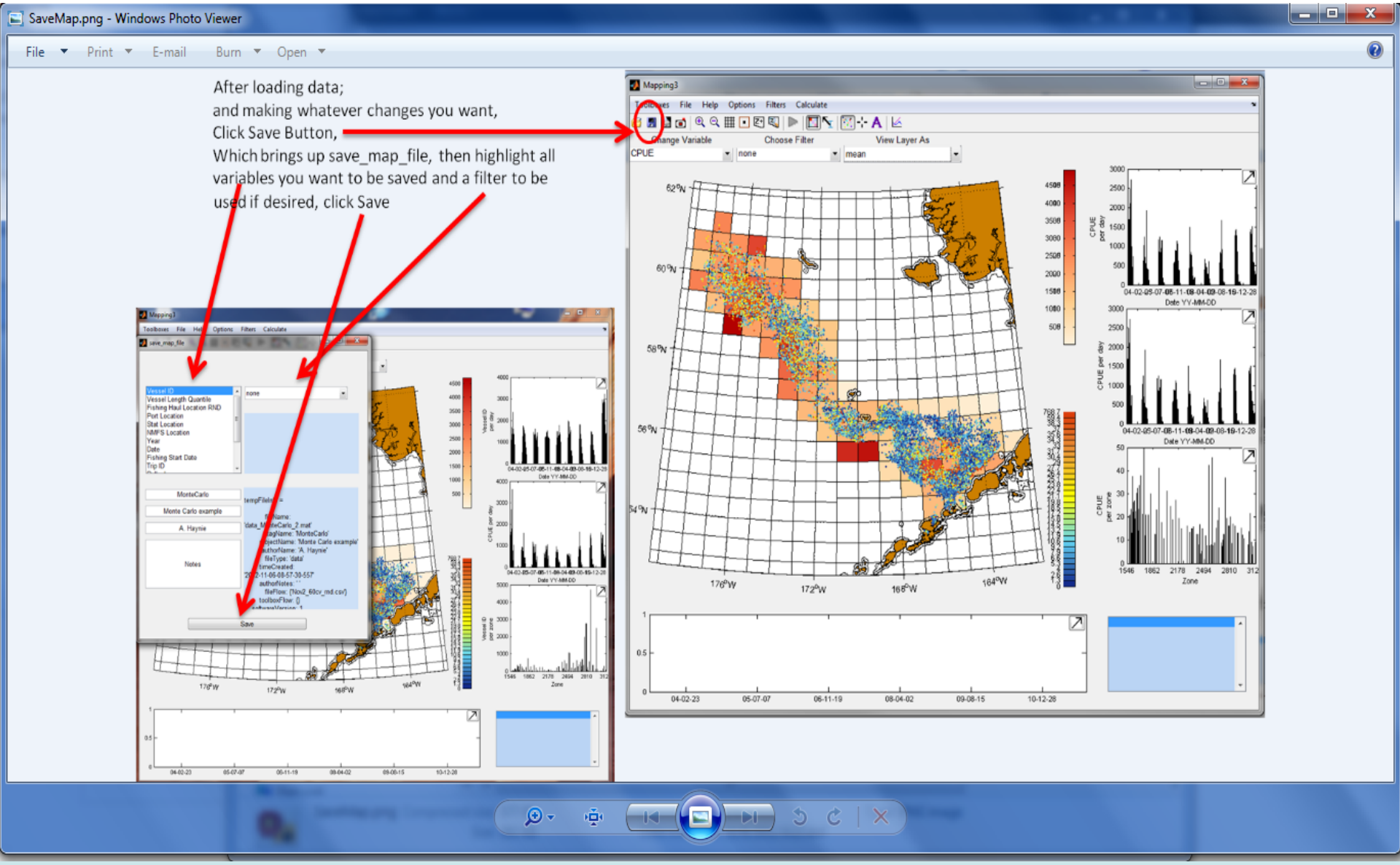
Model report log generated automatically on 15-Jul-2013 12:23:10 using the input file design_data_MonteCarlo_1_2013_07_15_11_32_33.'

Policy Simulation Tool

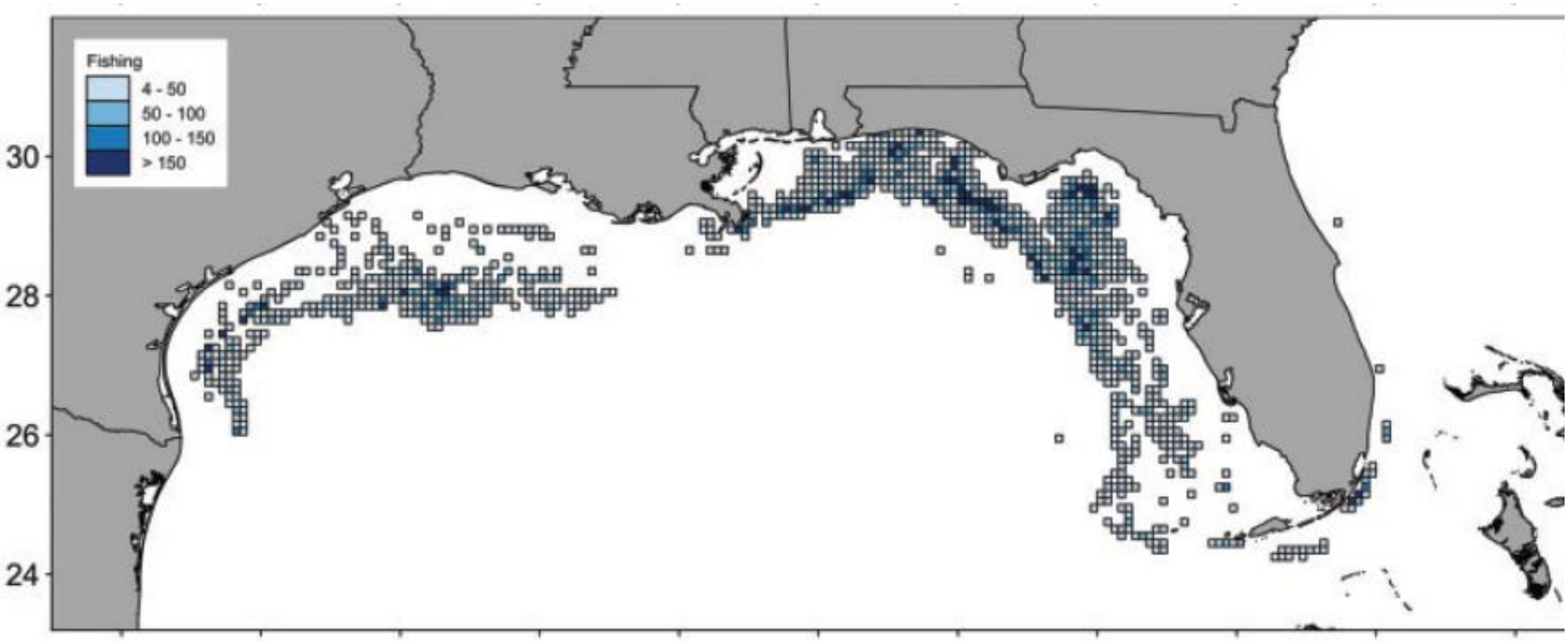


Allows analysts and policy-makers to compare the impacts of potential policies

Help & teaching tools …



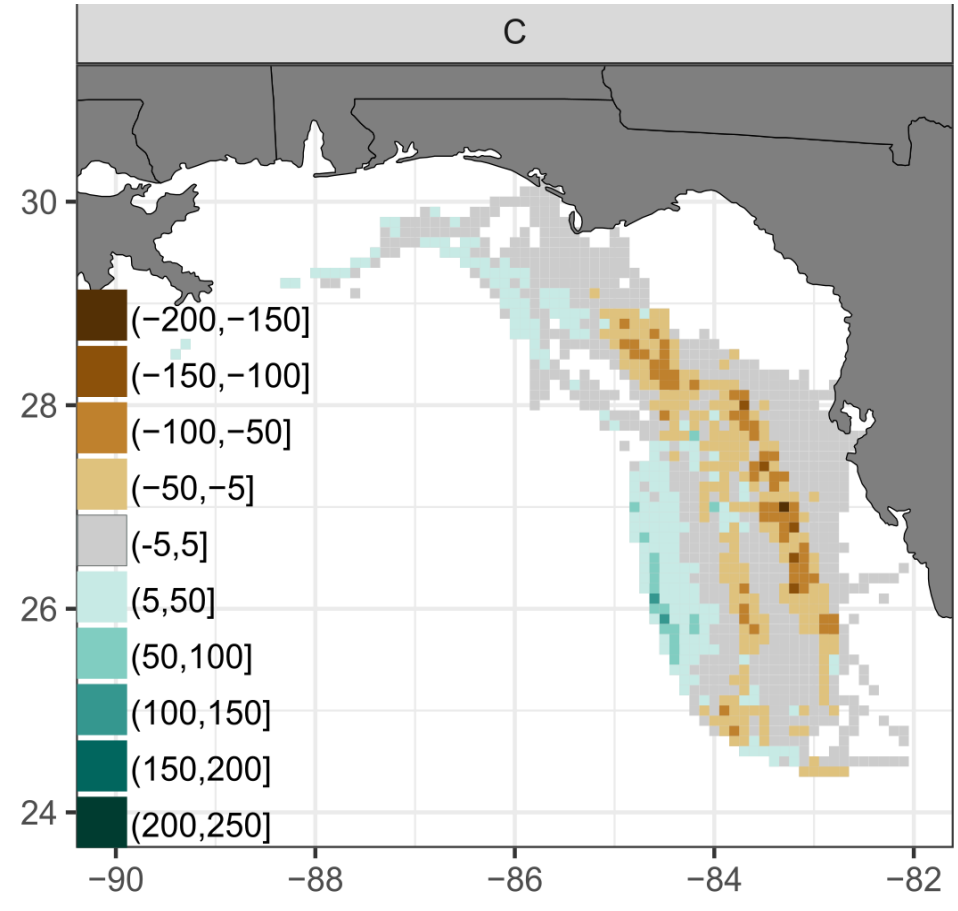
Gulf of Mexico Fishing Effort



- 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



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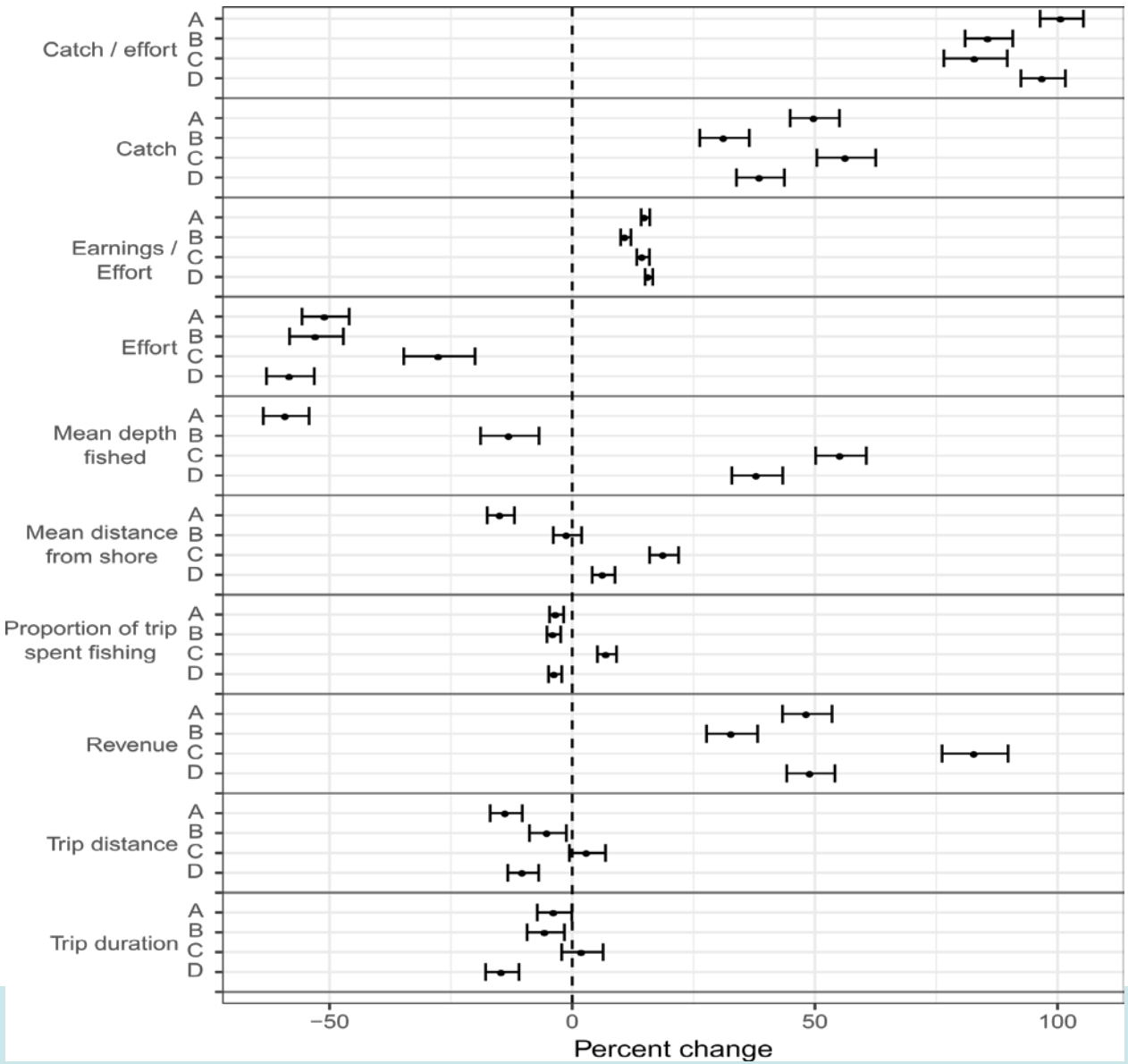


Case Study: Bering Sea and Aleutian Islands Amendment 80 (A80) Implemented in 2008

Goals:

- Catch, profits, flexibility ↑
- Bycatch & discards ↓

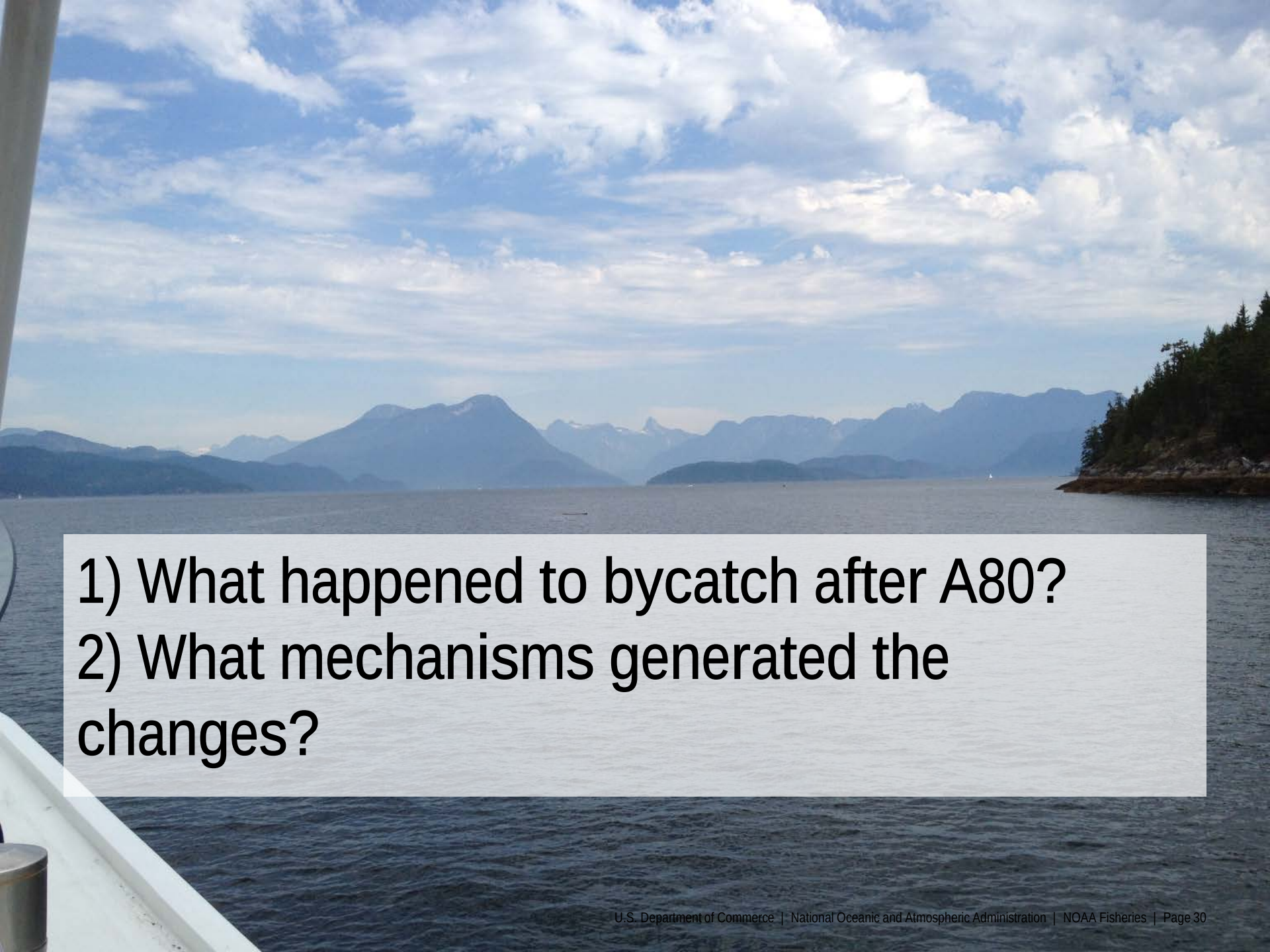
Vessels could:

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

Abbott, Haynie, and Reimer *Land Economics* 2015

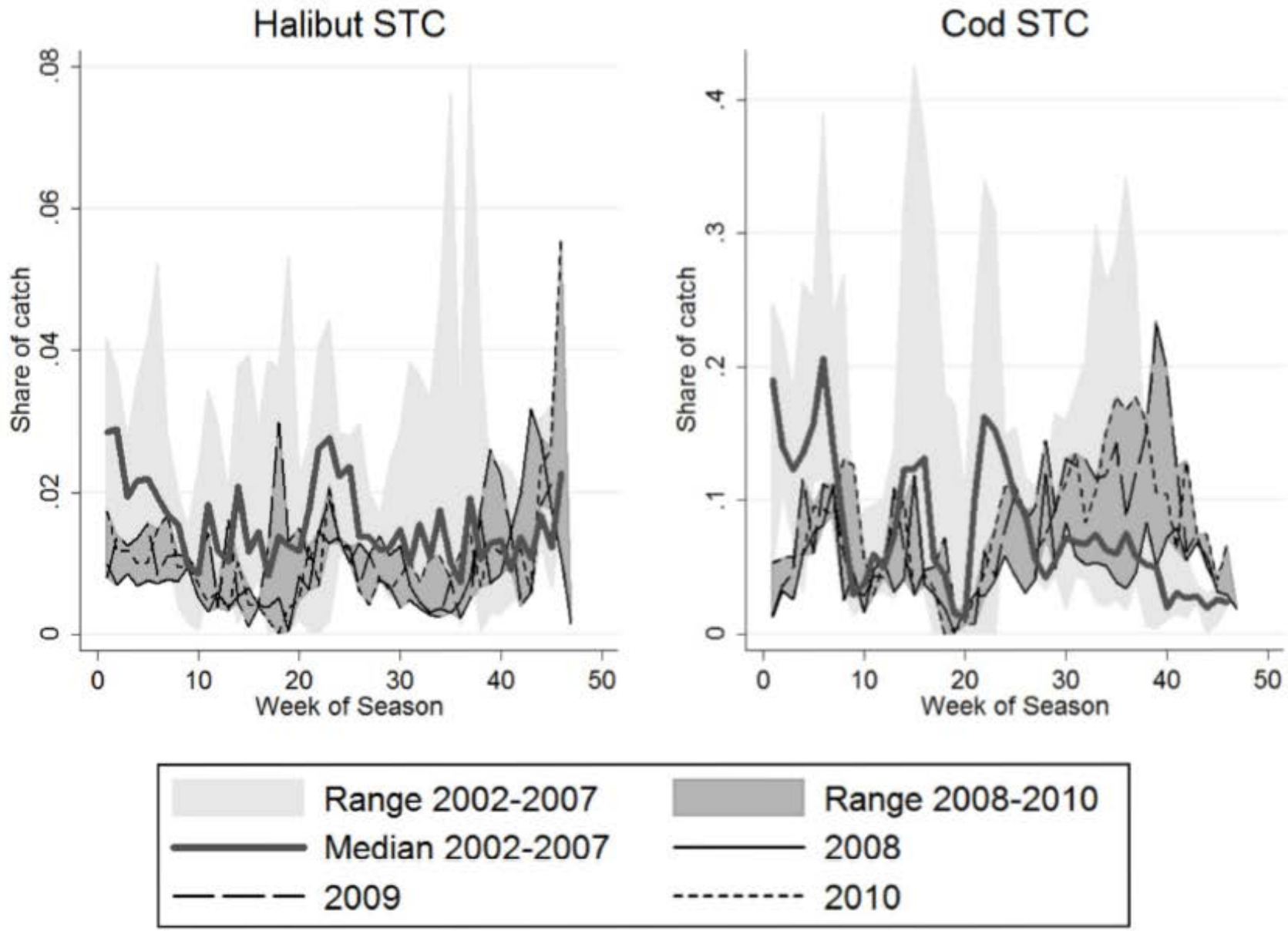
Also in 2008, Pacific cod allocation decreased.

Photo: Groundfish Forum



1) What happened to bycatch after A80?
2) What mechanisms generated the changes?

Weekly "Bycatch" Share of Total Catch



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

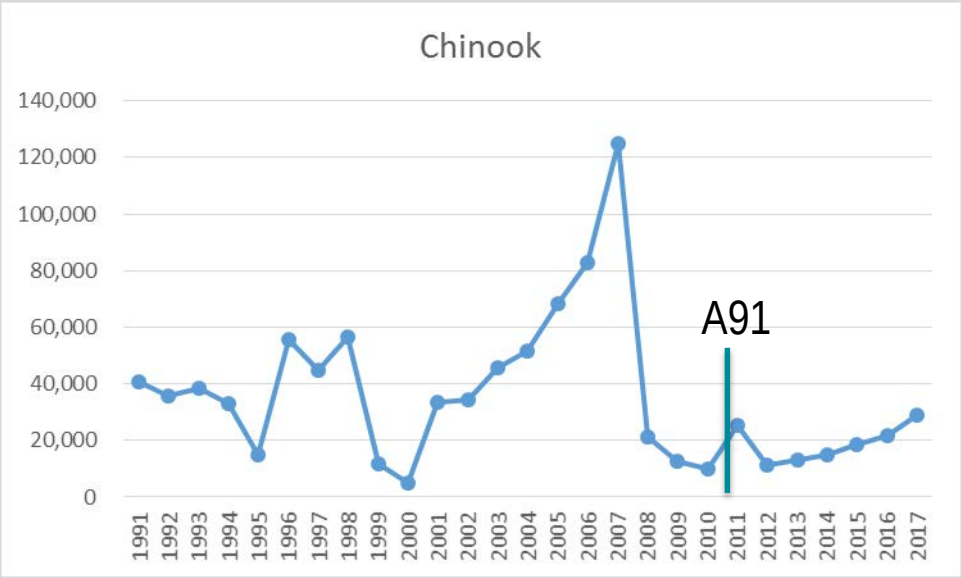
- No discernable-large scale pattern of avoidance
  - Consistent with a late-season relaxation of avoidance efforts after uncertainty over multi-species quota scarcity is resolved

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.

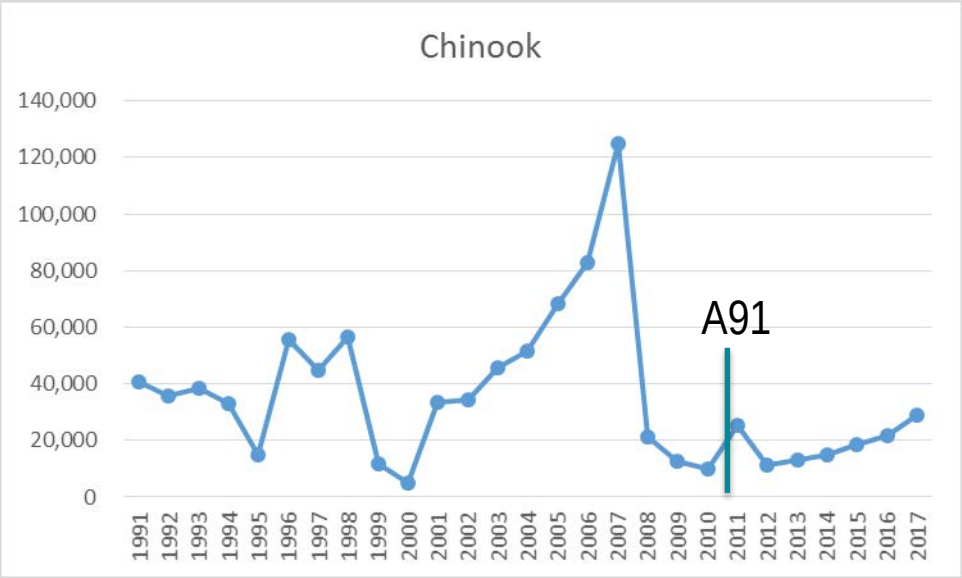
Chinook bycatch in the Bering Sea pollock fishery

- 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

Photo CSMphotos

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.

Alan.Haynie@noaa.gov

Photo:CSMphotos