NOAA FISHERIES

NEFSC
Social Sciences Branch

Human Dimensions

Geret DePiper and Lisa Colburn

NEFSC Ecosystem and Climate Science Review,
Woods Hole MA
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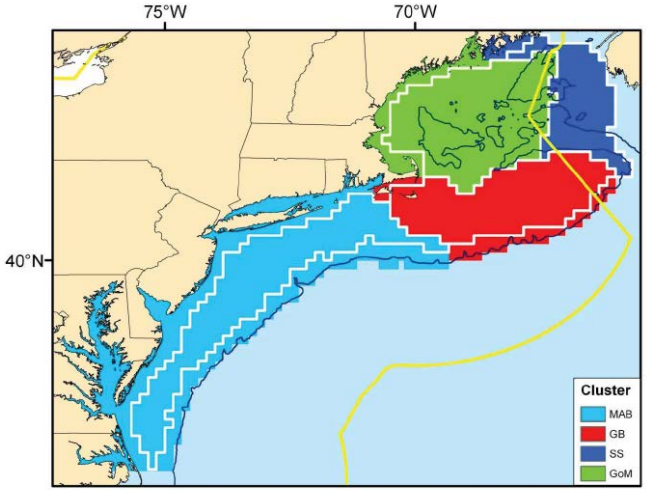
Overview

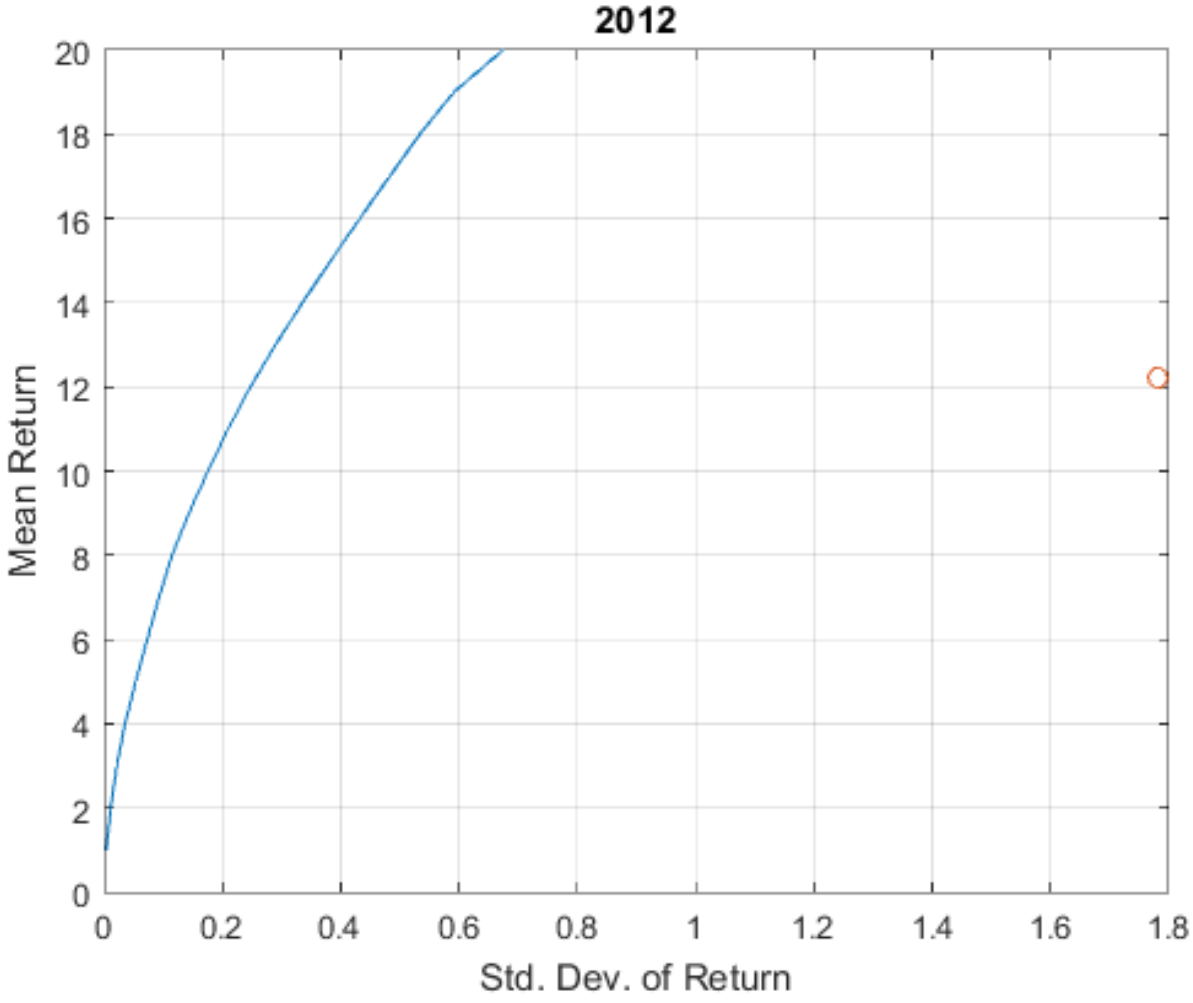
- Economic Portfolio Diversification
- Estimates of Diversity
    - Landings
    - Fleet
- Community Vulnerability Measures
- Theme 3 (Ecosystem Modeling & Analysis) unless otherwise noted

What type of economic model is needed?

- Flexibility is paramount
  - Suite of multispecies biological models
    - Highly aggregated biological production models
    - Species specific length-based models
    - Multiple “Ecological Production Units”
  - Multi-model inference
  - Precautionary Management



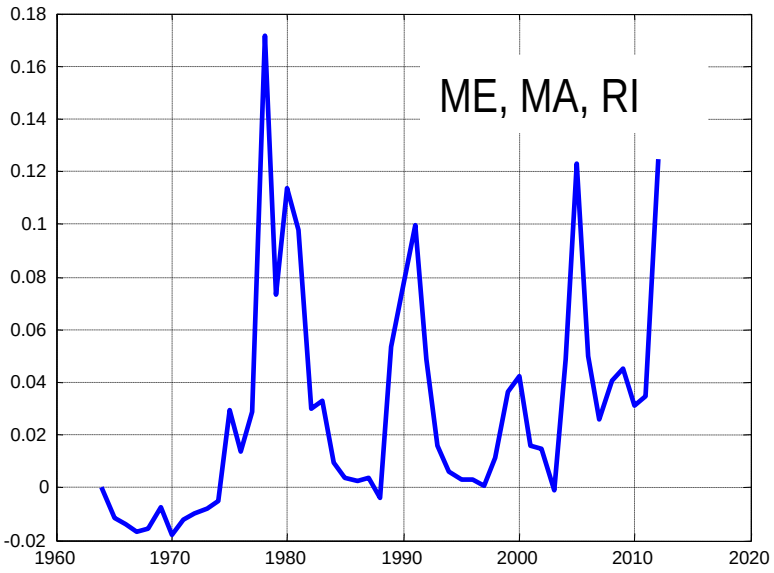
Portfolio Theory

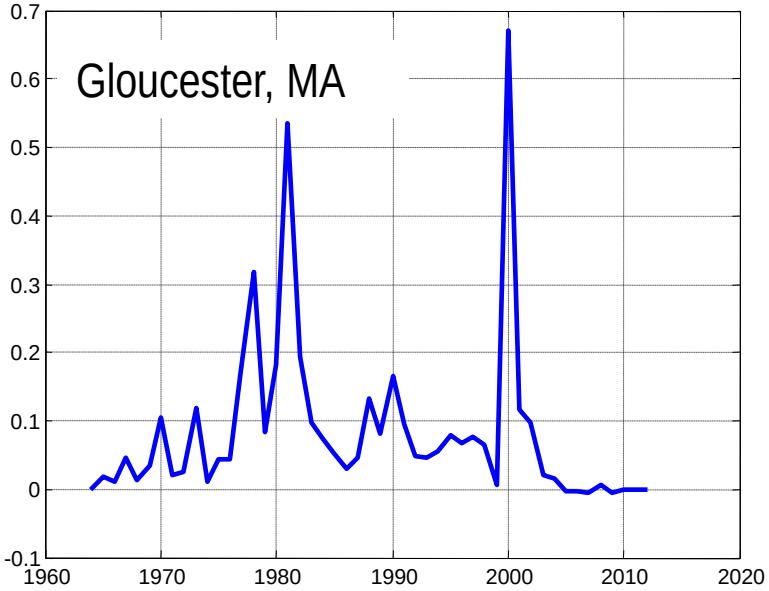


Model Outputs

- Risk Gap

$$g_t = \frac{\sqrt{\tilde{w}_t' \Sigma_t \tilde{w}_t} - \sqrt{\hat{w}_t' \Sigma_t \hat{w}_t}}{\tilde{w}_t' \mu_t}$$





Georges Bank Correlations 1978 - 1991

Species	Monkfish	Atlantic cod	Winter flounder	Yellowtail flounder	Haddock	Atlantic herring	Atlantic mackerel	Winter Skate	Silver hake	Spiny dogfish
Share	5%	34%	15%	18%	13%	7%	1%	0%	6%	1%
Mean	$15,033,080	$98,561,990	$42,376,199	$53,510,880	$37,637,220	$19,846,934	$3,547,732	$436,483	$18,431,208	$1,937,874
Std	$10,760,294	$17,576,273	$5,904,831	$18,574,113	$23,213,573	$11,127,272	$2,442,152	$630,914	$3,333,502	$1,711,598
N	14	14	14	14	14	14	14	14	14	14
Monkfish	1.00									
Atlantic cod	0.62	1.00								
Winter flounder	-0.38	-0.25	1.00							
Yellowtail flounder	-0.64	0.06	0.18	1.00						
Haddock	-0.83	-0.13	0.35	0.73	1.00					
Atlantic herring	-0.35	-0.01	-0.07	0.09	0.60	1.00				
Atlantic mackerel	0.92	0.75	-0.45	-0.45	-0.67	-0.21	1.00			
Winter Skate	0.82	0.72	-0.54	-0.34	-0.64	-0.22	0.88	1.00		
Silver hake	0.43	0.20	-0.14	-0.30	-0.45	-0.05	0.34	0.40	1.00	
Spiny dogfish	0.58	0.84	-0.37	0.02	-0.30	-0.22	0.71	0.89	0.22	1.00

Georges Bank Correlations 2002 - 2012

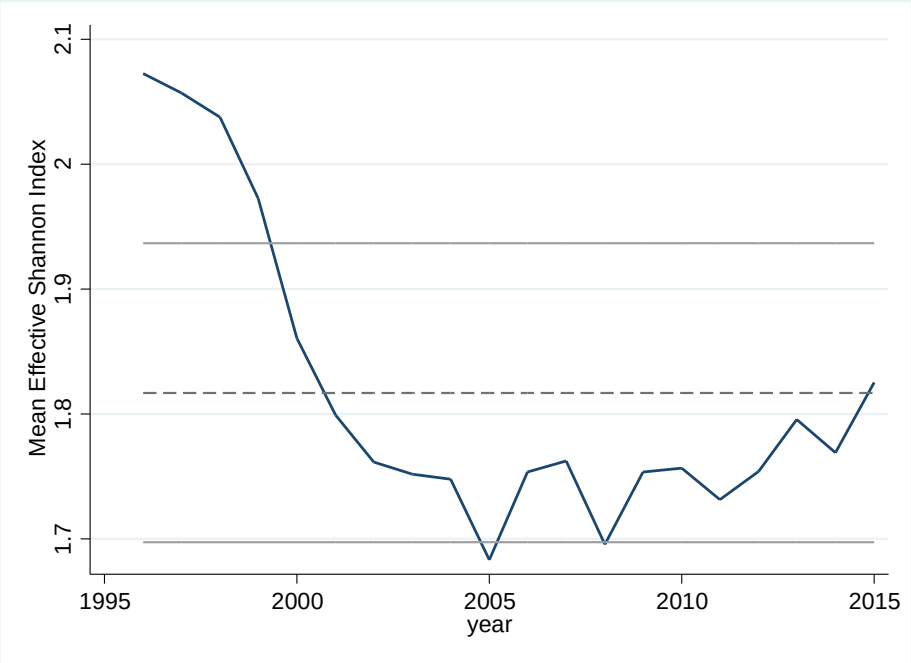
Species	Monkfish	Atlantic cod	Winter flounder	Yellowtail flounder	Haddock	Atlantic herring	Atlantic mackerel	Winter Skate	Silver hake	Spiny dogfish
Share	23%	20%	8%	6%	12%	15%	6%	1%	7%	1%
Mean	$37,918,268	$31,788,411	$13,260,082	$10,384,428	$ 19,324,001	$ 24,156,298	$ 9,302,787	$ 2,246,556	$ 11,186,146	$ 2,167,461
Std	$14,033,251	$6,831,240	$4,398,308	$6,274,444	$6,492,094	$2,816,465	$6,097,368	$729,133	$1,740,705	$1,573,777
N	11	11	11	11	11	11	11	11	11	11
Monkfish	1.00									
Atlantic cod	0.51	1.00								
Winter flounder	0.90	0.60	1.00							
Yellowtail flounder	0.94	0.65	0.92	1.00						
Haddock	0.66	0.68	0.54	0.75	1.00					
Atlantic herring	-0.09	-0.59	-0.13	-0.28	-0.64	1.00				
Atlantic mackerel	0.57	-0.12	0.57	0.48	0.26	0.42	1.00			
Winter Skate	-0.04	0.15	-0.12	0.09	0.29	-0.58	-0.38	1.00		
Silver hake	0.38	0.28	0.25	0.55	0.68	-0.58	0.07	0.63	1.00	
Spiny dogfish	-0.78	-0.38	-0.74	-0.77	-0.72	0.15	-0.74	0.16	-0.44	1.00

Management Strategy Evaluation (Theme 4)

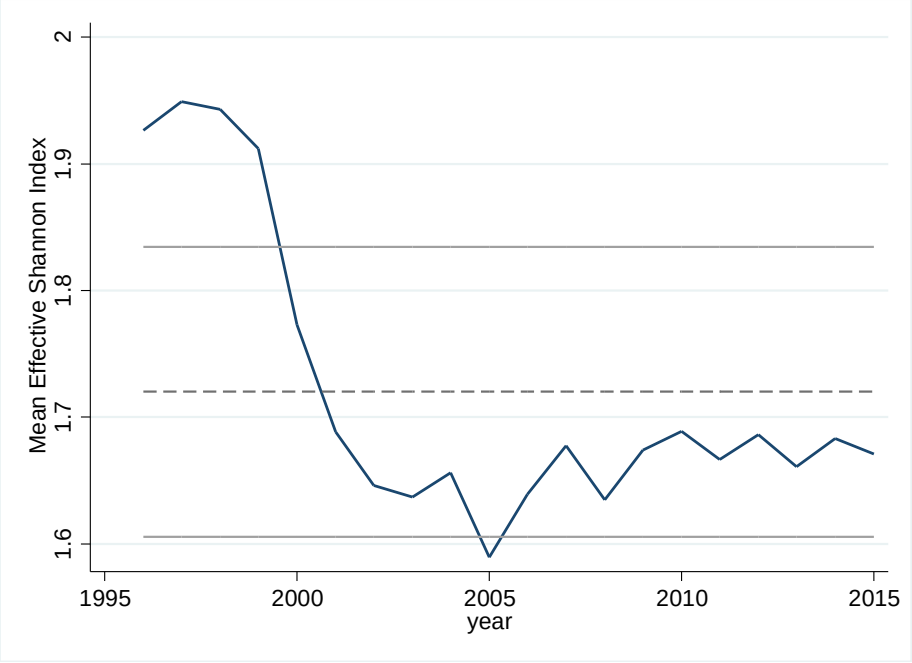
- Couple to multispecies models
  - Project risk scenarios
    - Understand multispecies trade-offs
  - Assess trade-offs across objectives
    - Additional risk of (latent) objectives

Permit level Species Diversity

Mid-Atlantic

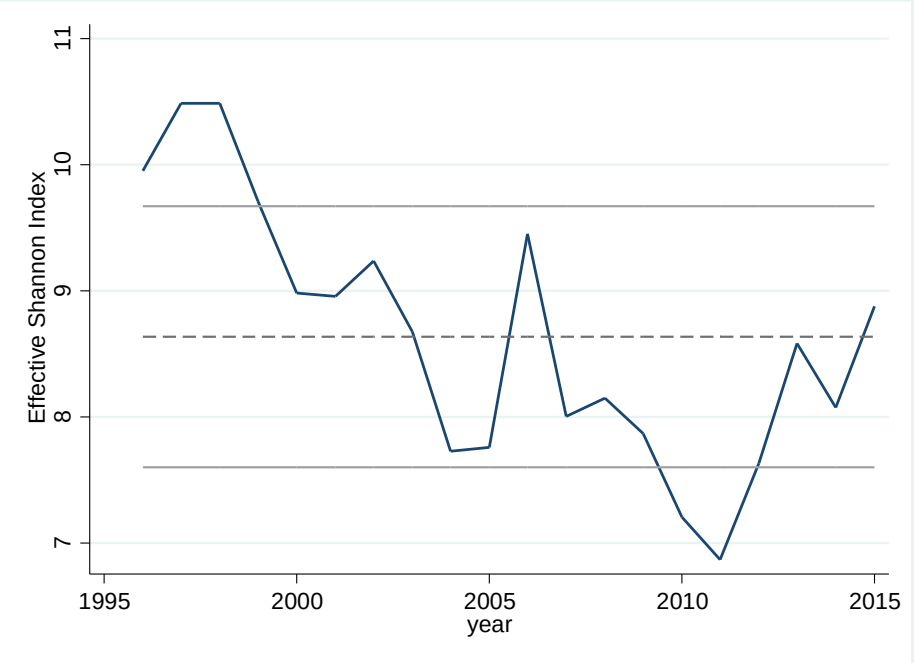


New England

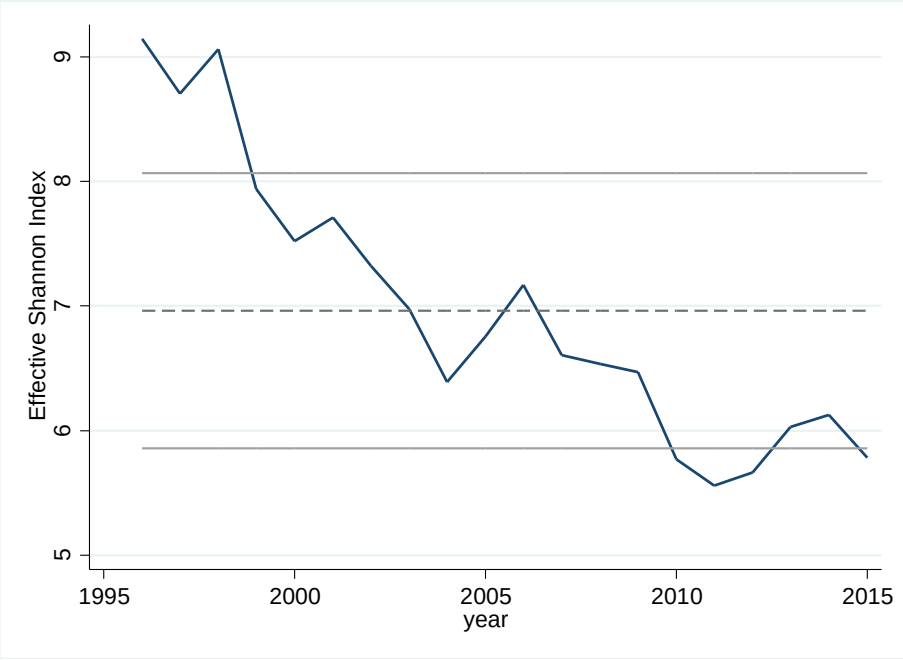


Fleet Diversity

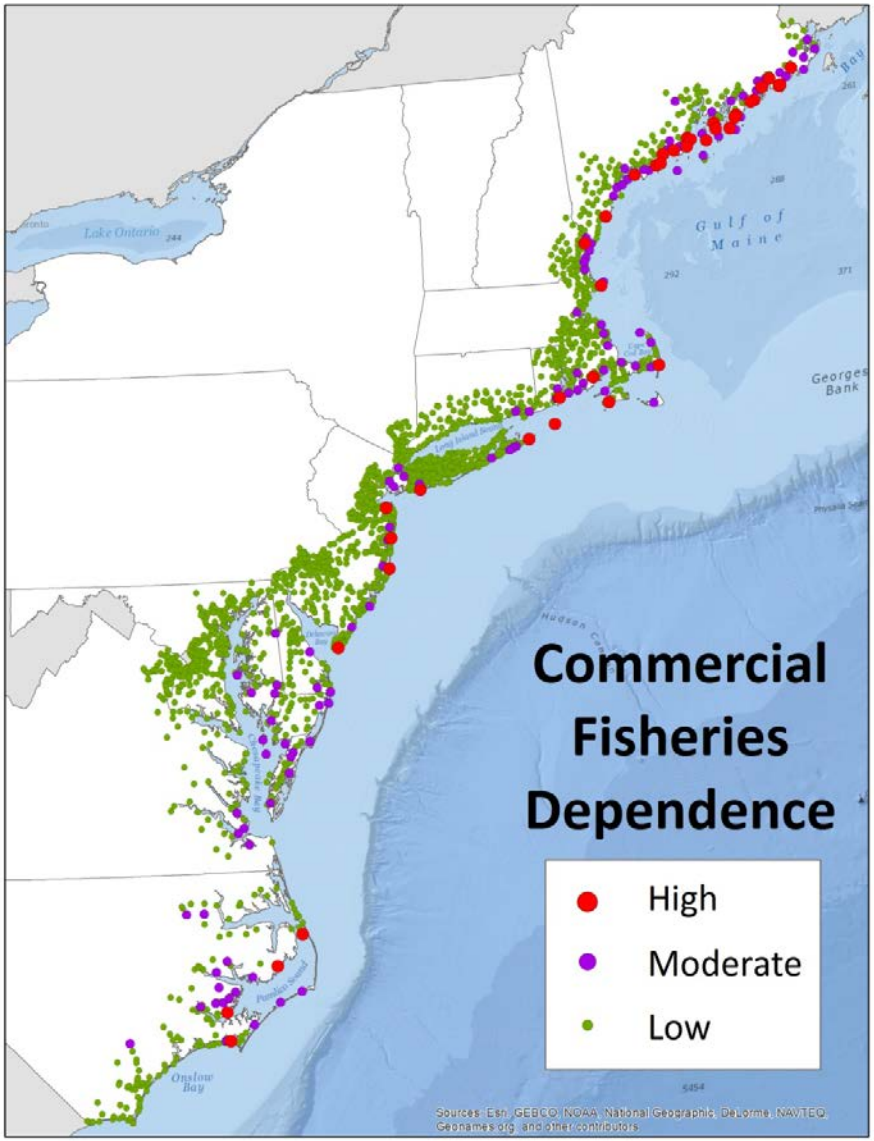
Mid-Atlantic

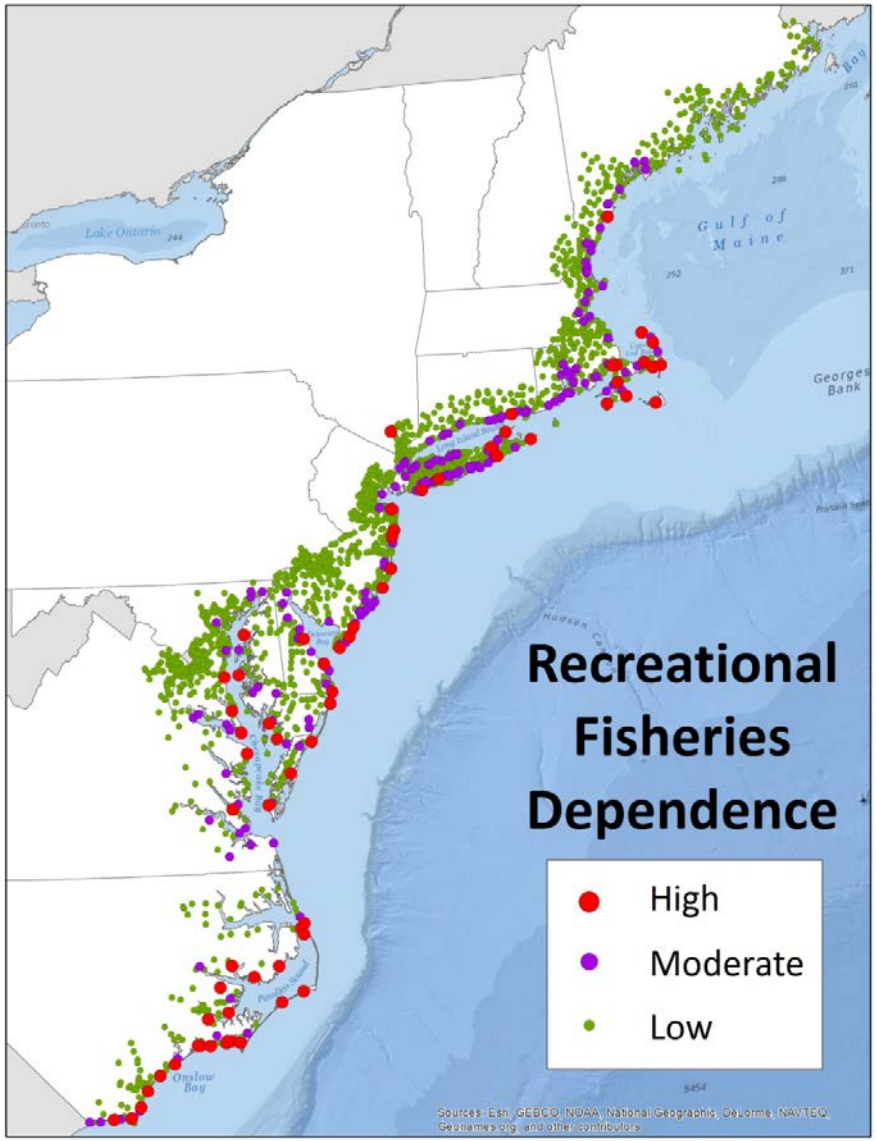


New England

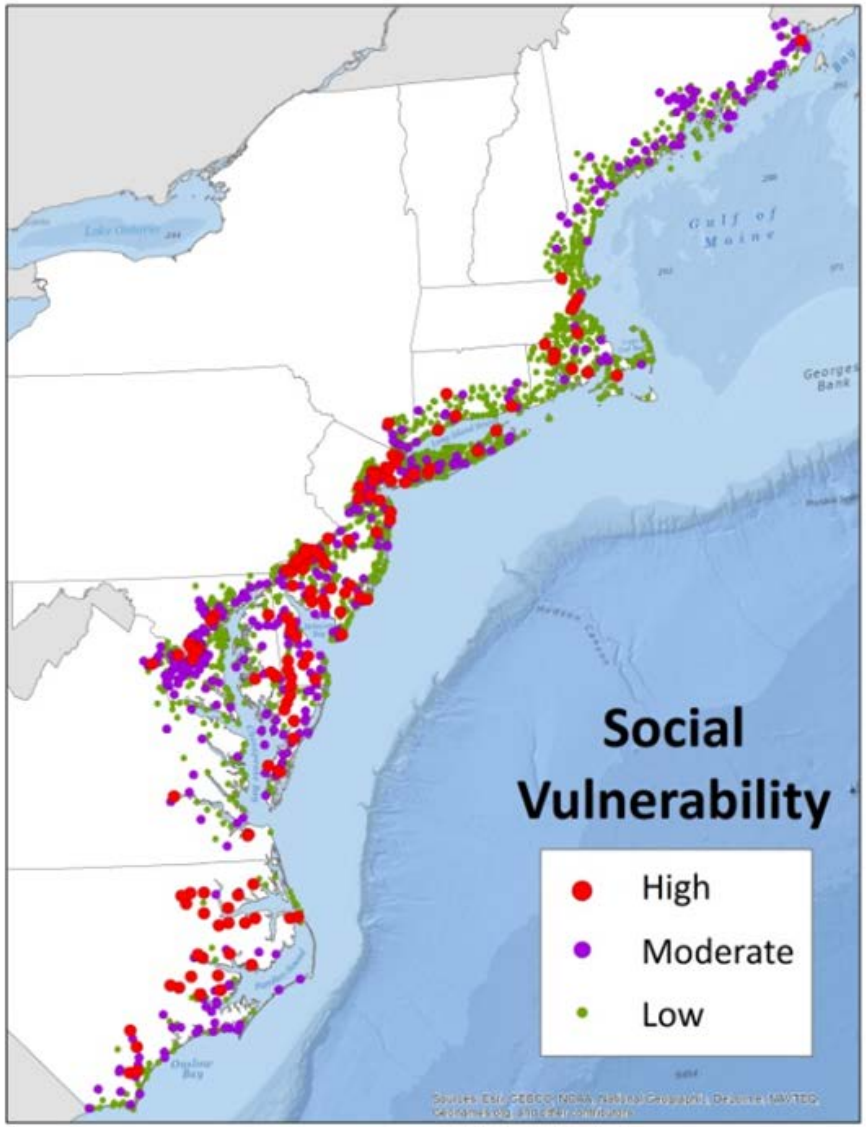


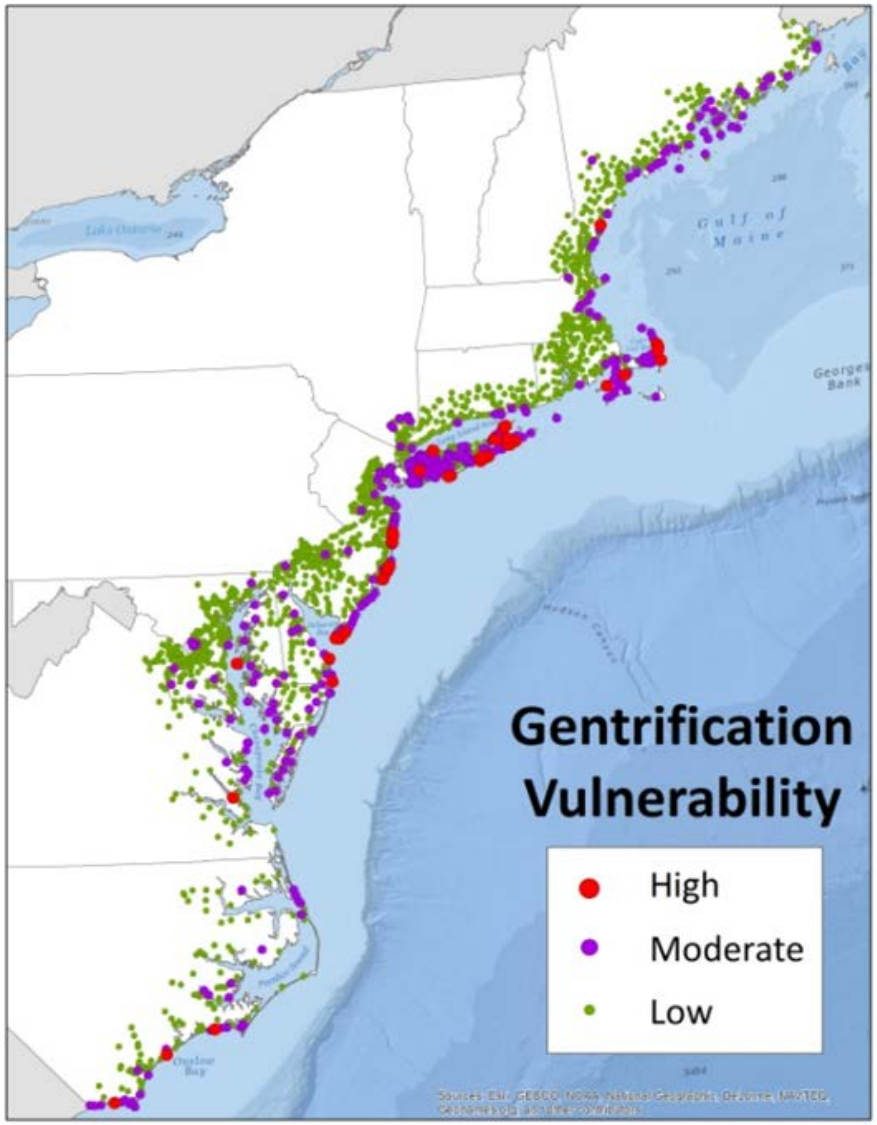
Community involvement in fishing





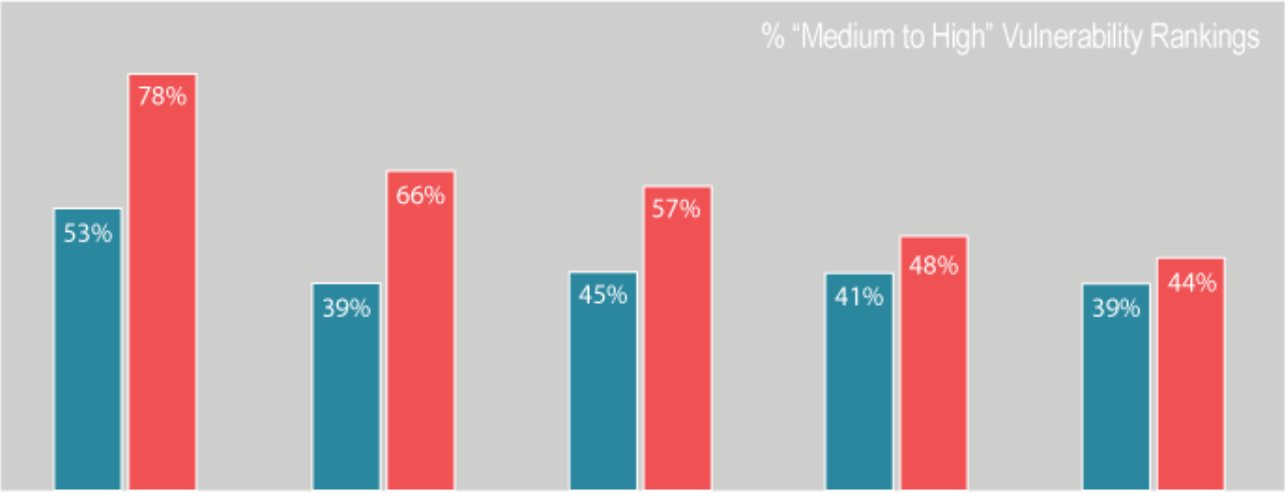
Non-fishing Vulnerability





Social Vulnerability in Commercial Fishing Communities

Percentage of "Medium to High" Vulnerability Rankings by Community Type for Social Vulnerability Indicators



Housing Characteristics

Measures infrastructure vulnerability, such as how vulnerable housing may be to coastal hazards.

Poverty

Measures economic and social position based on income.

Personal Disruption

Measures an individual's ability to respond to change due to personal circumstances, such as education or employment status.

Labor Force

Characterizes the strength and stability of the labor force and employment opportunities.

Population Composition

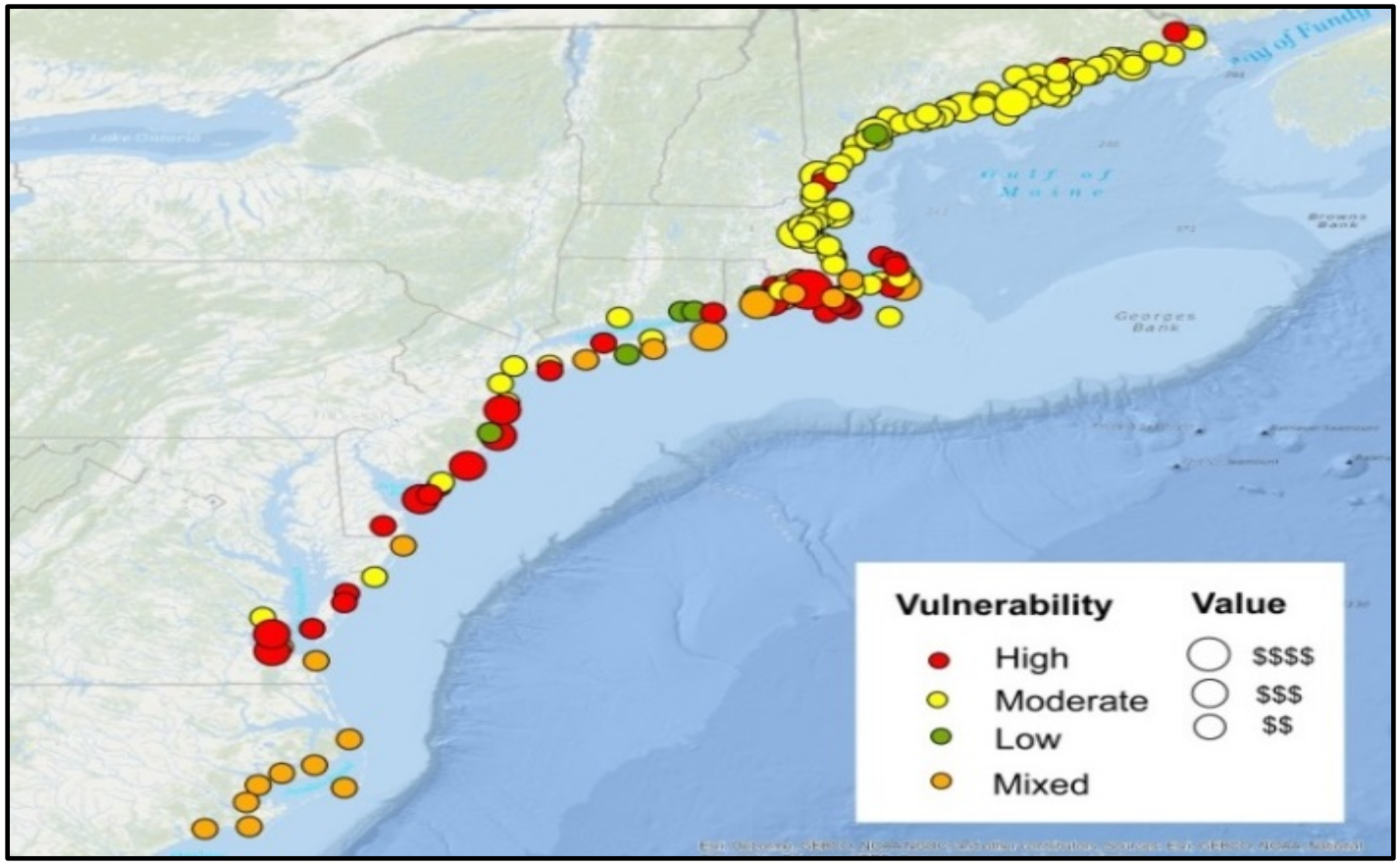
Shows the presence of more vulnerable populations, such as those with fewer resources.

Community Types

Commercial Fishing Communities
"High" Engagement in or Reliance on Commercial Fishing

Other Communities
"Low to Medium High" Engagement in or Reliance on Commercial Fishing

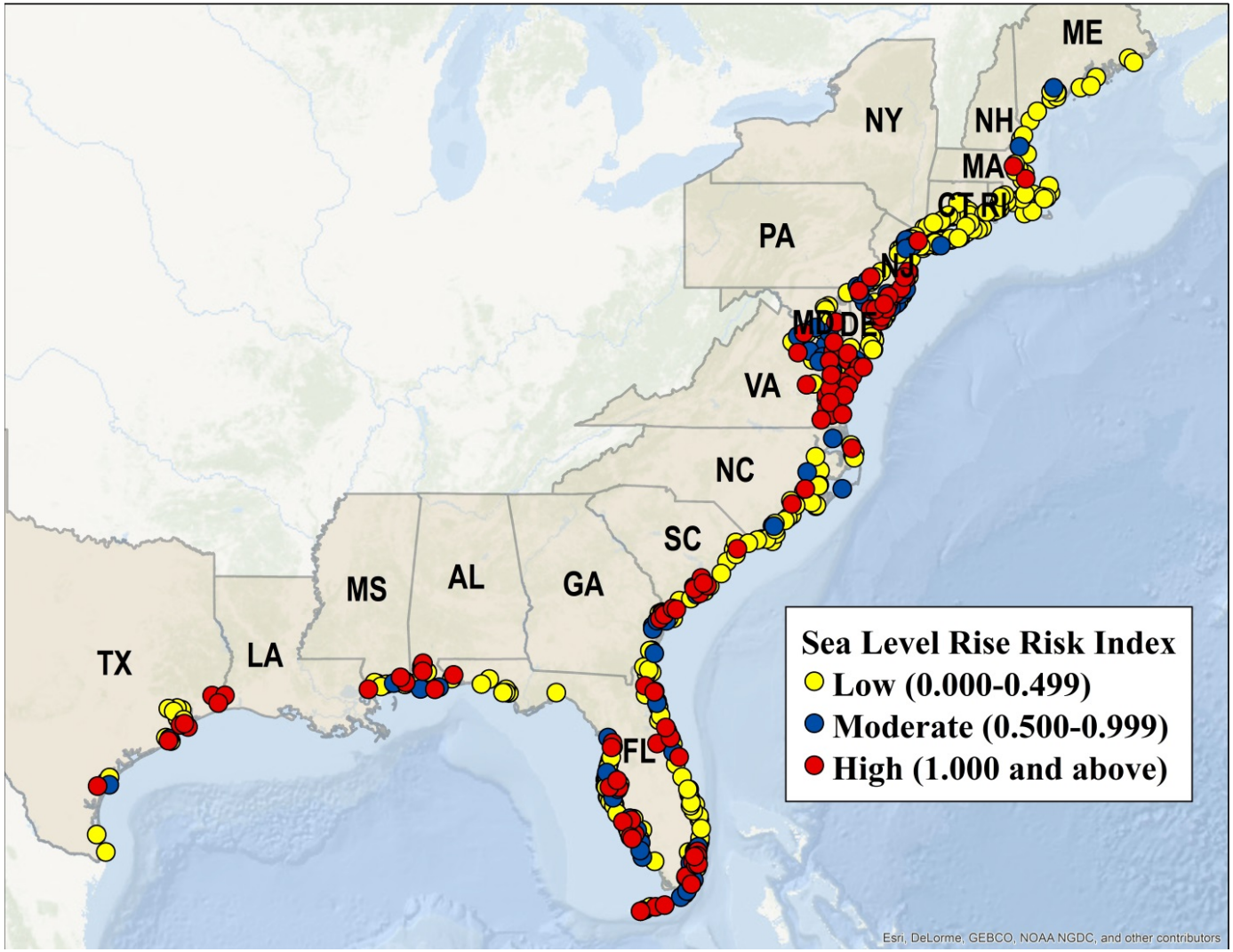
Northeast region stock vulnerability



Vulnerability rankings based on Hare et. al., 2016 and Morrison et al., 2015.

(For more information contact Jon Hare (Northeast Fisheries Science Center) and Wendy Morrison (Office of Science and Technology)

Broader Vulnerability to Climate Change



Incorporation into Management (Theme 4)

- Social Vulnerability
  - National Rollout
  - Omnibus Amendment 2 (NEFMC Habitat PDT)
- Portfolio Analysis
  - NEFMC EBFM PDT
  - MAFMC as part of EAFM WG
- Diversity Measures
  - MAFMC White Paper “A Framework for Incorporating Species, Fleet, Habitat, and Climate Interactions into Fishery Management”

Communication and Peer Review (Theme 5)

- Social Vulnerability
  - Colburn, L. L., and M. Jepson. 2012. Social indicators of gentrification pressure in fishing communities: A context for social impact assessment. *Coastal Management* 40(3): 289-300.
  - Colburn, L.L., M. Jepson, C. Weng, T. Seara, J. Weiss, J.A. Hare. In Press. Indicators of Climate Change and Social Vulnerability in Fishing Dependent Communities Along the Eastern and Gulf Coasts of the United States. *Marine Policy*.
- Portfolio Analysis
  - Jin, D., G. DePiper, and P. Hoagland. 2016. Applying Portfolio Management to Implement Ecosystem-Based Fishery Management. *North American Journal of Fisheries Management 36:*652-69.
- Diversity Measures
  - Gaichas, S., R. Seagraves, J. Coakley, G. DePiper, V. Guida, J. Hare, P. Rago, and M. Wilberg. In Review. A Framework for Incorporating Species, Fleet, Habitat, and Climate Interactions into Fishery Management.

Challenges

- Portfolio Analysis
  - More rigorous treatment of variance needed
- Diversity Measures
  - Manager defined métiers preferable
  - No clear theoretical linkage to trends
- Social Vulnerability
  - Time series based on 5 year averages
    - ACS 2005-2009 is comparable to ACS 2010-2014

Strengths

- Portfolio Analysis
  - Scalable through multiple areal extents
  - Integrable with multispecies stock models
  - Strong theoretical basis
- Diversity Measures
  - Flexible baseline analysis
- Social Vulnerability
  - Holistic assessment of community
  - Ecosystem Based Management

Questions?

This research was supported through NOAA CINAR grant NAO90AR4320129

Current portfolio

- 25 stocks/species groups
  - NEUS Atlantis, length-based stock model, production surplus model

- Multiple scales
  - Northeast LME, States, Ports

What exactly is the framework?

- Expected utility maximization
  - Mean-variance representation

$$E(U(\pi)) = E(\pi) - \lambda V(\pi)$$

$$\min_w V(\pi(w)) \; s.t. \; E(\pi) \geq R$$

Two step implementation

Follows Sanchirico et al. (2008):

1. Estimation of Revenue
   - Mean
   - Variance-covariance matrix
2. Optimization
   - Target returns
   - Choose weights to minimize variance
   - Subject to biological constraints

Step 1

- Exponential Smoother
  - $\lambda = 0.549$
  - 5% of weight remains after 5 years

$$\sum_{i,j,t} = \frac{\sum_{k=1}^{t} \lambda^{t-k+1} (r_{t-k+1,i} - \mu_{t,i})(r_{t-k+1,j} - \mu_{t,j})}{\sum_{k=1}^{t} \lambda^{t-k+1}}$$

$$\mu_{i,t} = \frac{\sum_{k=1}^{t} \lambda^{t-k+1} r_{t-k+1,i}}{\sum_{k=1}^{t} \lambda^{t-k+1}}$$

Step 2

- Quadratic programming

$$\min_{W_t} W_t' \Sigma W_t \ s.t. \qquad W_t' \mu_t \geq R;$$

$$w_{i,t} \leq \frac{\kappa_{i,t} B_{i,t}}{\Omega_{i,t}} \ \forall \ i,t$$

$$\text{where } \Omega_{i,t} = \frac{\sum_{k=1}^{t} \lambda^{t-k+1} p_{i,k} y_{i,k}}{\sum_{k=1}^{t} \lambda^{t-k+1} p_{i,k}}$$

$$B_{i,t} = \text{maximum sustainable revenue}$$

$$\kappa_{i,t} = \text{sustainability parameter}$$

Future work

- Formal time series modeling of mean and variance
- Multispecies models to identify biological constraints
- Extend analysis to Ecological Production Units

Model extended to fisheries

- Focus specifically on managers' problem
  - Price, biology, technology, management
- Edwards et al. (2005)
  - Theoretical motivation
- Sanchirico et al. (2008)
  - Empirical application

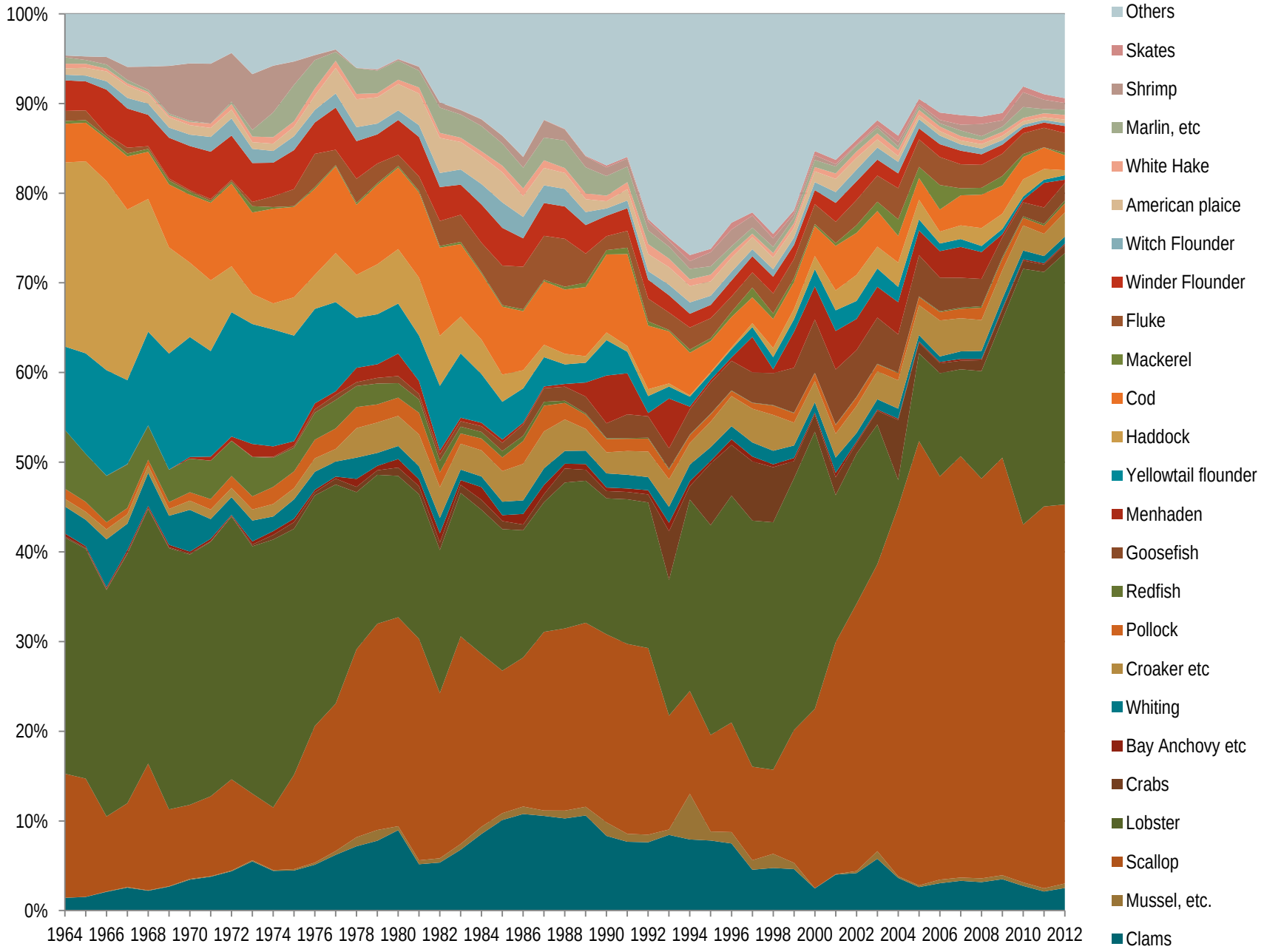
Mean-variance representation of Expected Utility

- Relies on one of the following (Meyer 1987):
  - Normality of returns
  - Quadratic utility
  - Single linear stochastic argument
- Kolmogorov-Smirnov test of normality
  - Failed to reject null (p-value = 0.6930)

Plans for formal time series

- VAR mean estimation

- GARCH variance-covariance estimation
  - Time-varying correlations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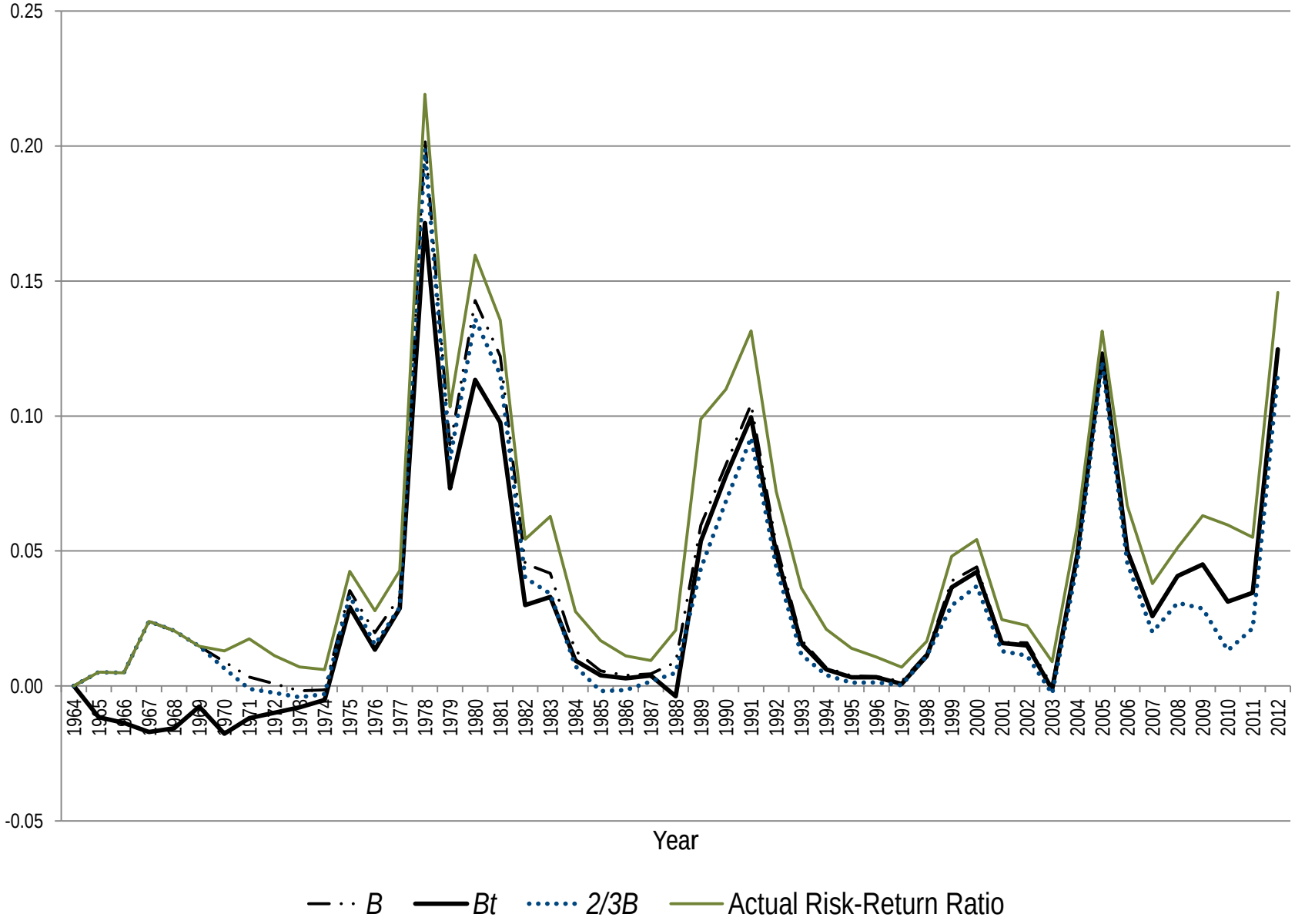
1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
Others
Skates
Shrimp
Marlin, etc
White Hake
American plaice
Witch Flounder
Winder Flounder
Fluke
Mackerel
Cod
Haddock
Yellowtail flounder
Menhaden
Goosefish
Redfish
Pollock
Croaker etc
Whiting
Bay Anchovy etc
Crabs
Lobster
Scallop
Mussel, etc.
Clams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Actual Risk-Return Ratio