Portfolio Analysis as a Management Tool

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Northeast Fisheries Science Center

Ecosystem Based Fishery Management Strategy Review

TOR 9: Review simulation tests and performance of the proposed management procedure incorporating the floors and ceilings approach

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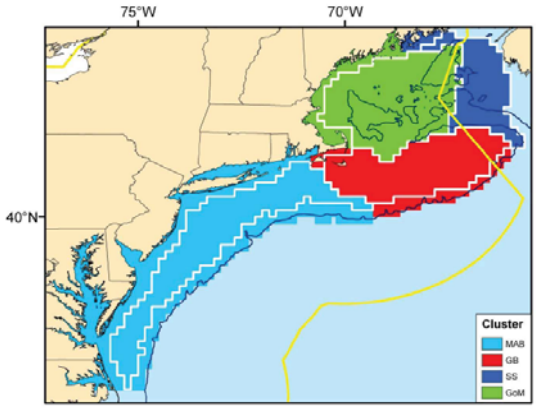
Woods Hole MA

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



NEFMC Risk Policy & Stability

- "Evaluating the trade-offs of minimizing variability while achieving the greatest overall net benefits to the nation…"

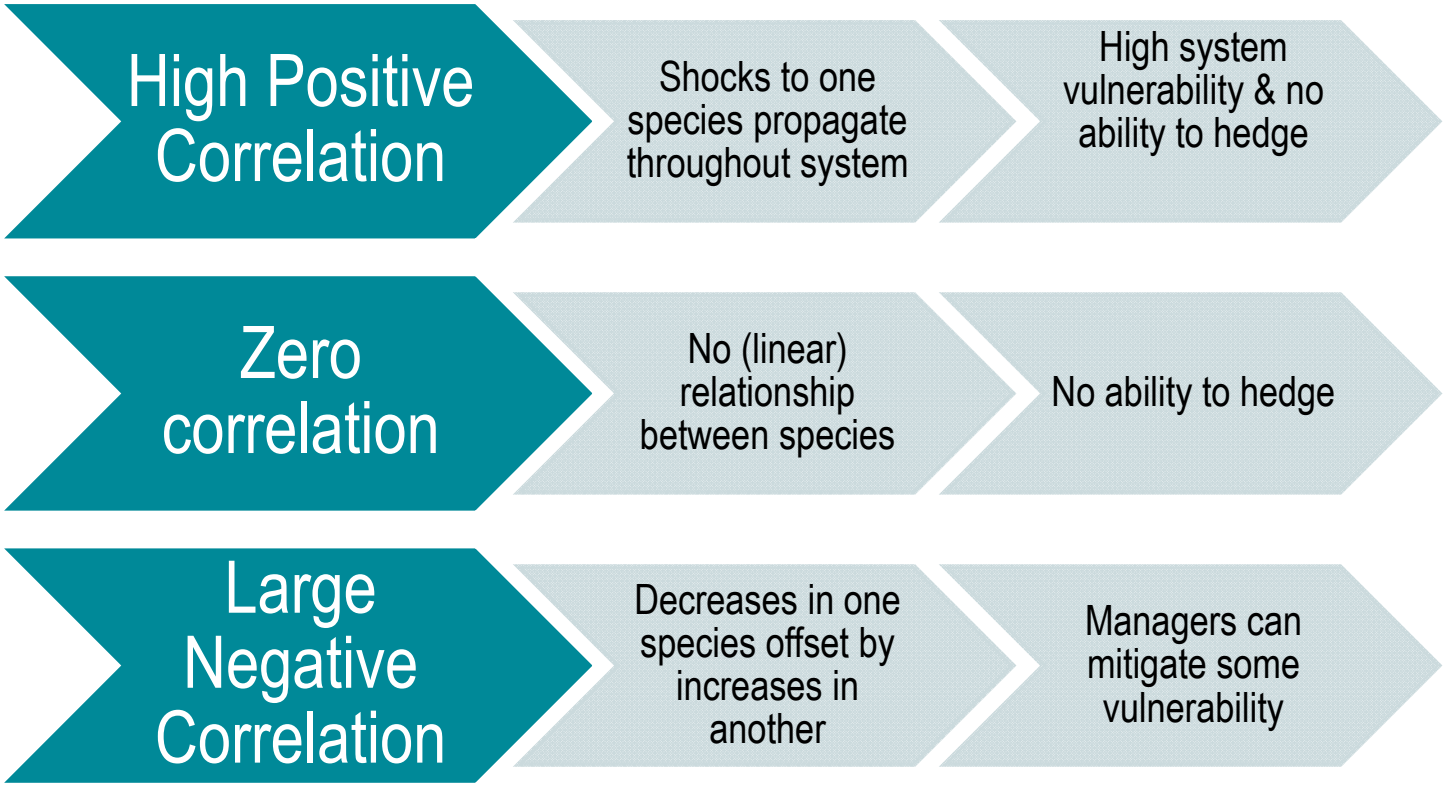
- "Metrics that monitor variability from year to year, e.g. in quotas, should be developed"

Risk Policy Working Group. 2016. Report from the Risk Policy Working Group: Risk Policy Road Map. New England Fishery Management Council, Newburyport, MA.

Why consider fluctuations (Variance)?

- Lottery ticket 1:
  - 50% chance of $0
  - 50% chance of $100,000
- Lottery ticket 2:
  - 100% chance of $50,000
- Both have an average (expected) value of $50,000
- However, much higher probability of actually getting paid in second lottery

Why consider covariance?



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

Portfolio Analysis

- Hedging through Mean-Variance tradeoff
  - Optimization
  - Trade-off analysis

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Applying Portfolio Management to Implement Ecosystem-Based Fishery Management (EBFM)

Di Jin, Geret DePiper & Porter Hoagland

Coupling biological and portfolio models

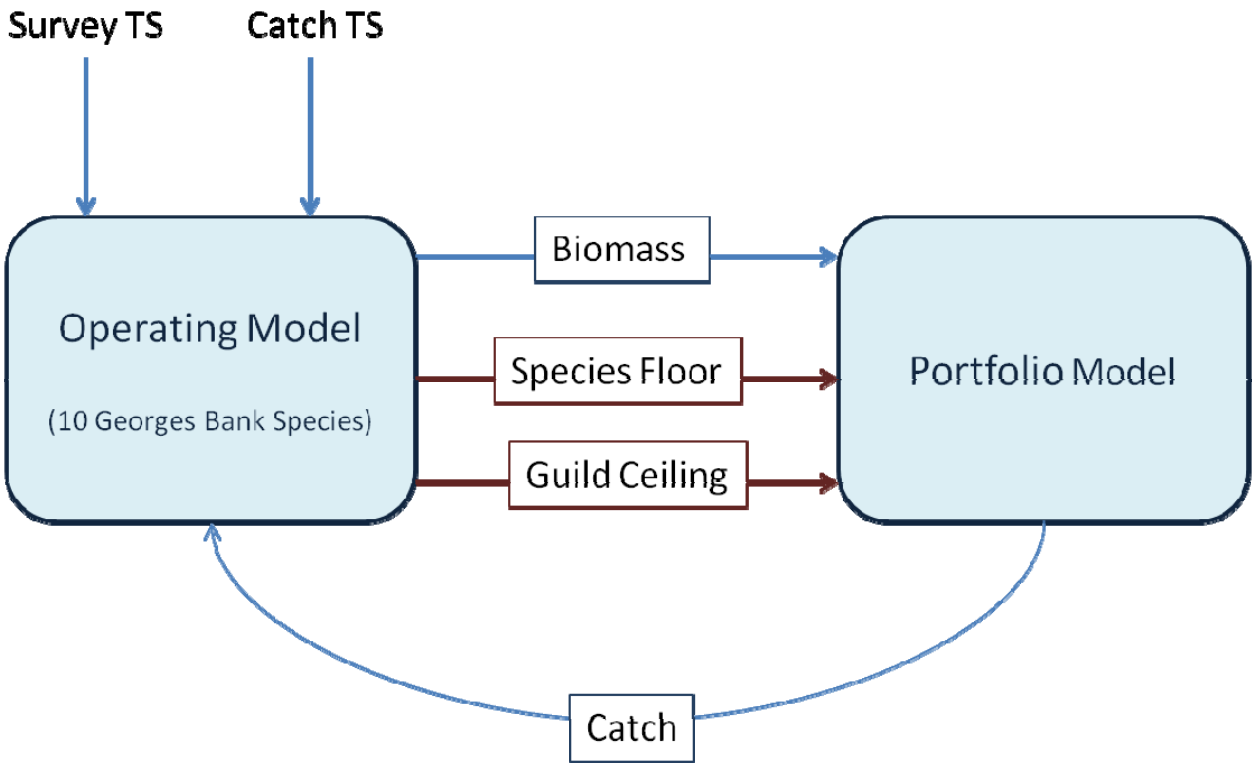
$$min_{\mathbf{w}_t} \mathbf{w}_t' \boldsymbol{\Sigma}_t \mathbf{w}_t \, , s.t. \mathbf{w}_t' \boldsymbol{\mu}_t \geq R_t, \;\; w_{i,t} \leq \frac{B_{i,t}}{\Omega_{i,t}} \; \forall \; i, \mathbf{w}_{G,t}' \boldsymbol{\Omega}_{G,t} \leq \boldsymbol{G}_t$$

Constraint 1: Revenue target

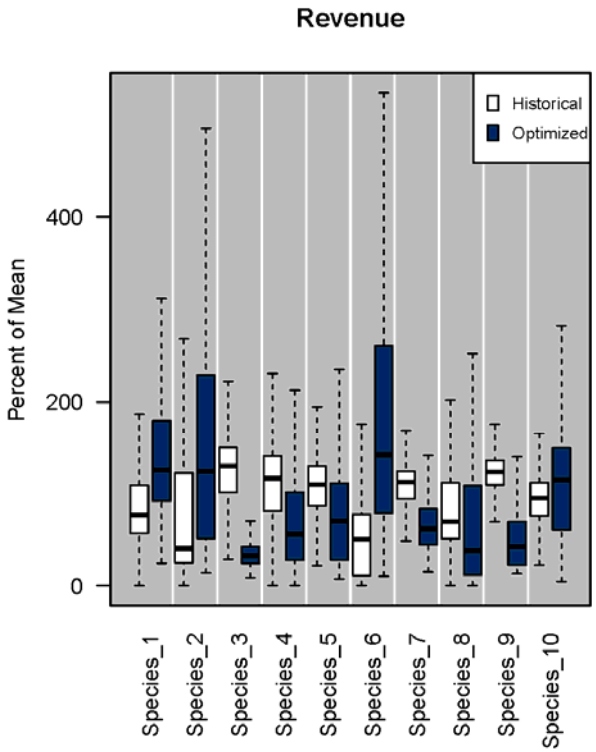
Constraint 2: The Species Floor (0.2 * the unfished biomass)

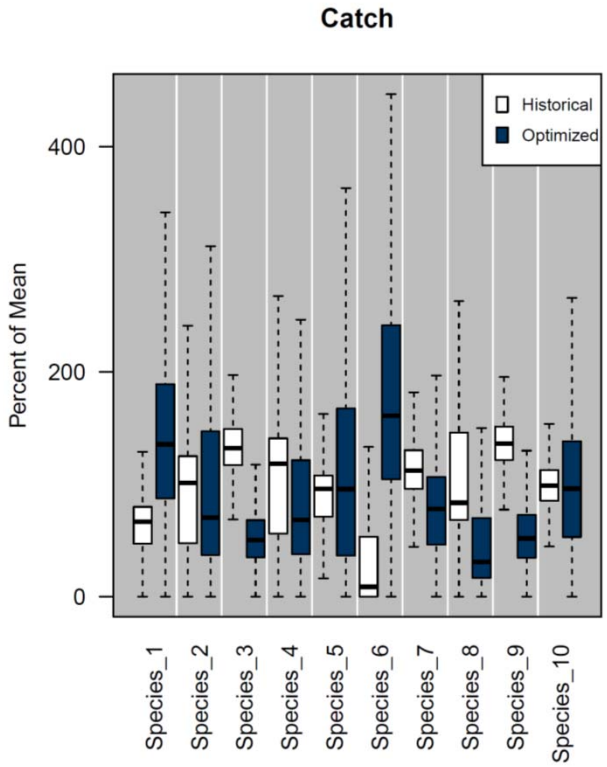
Constraint 3: The Guild Ceiling (0.18 * the guild sum)

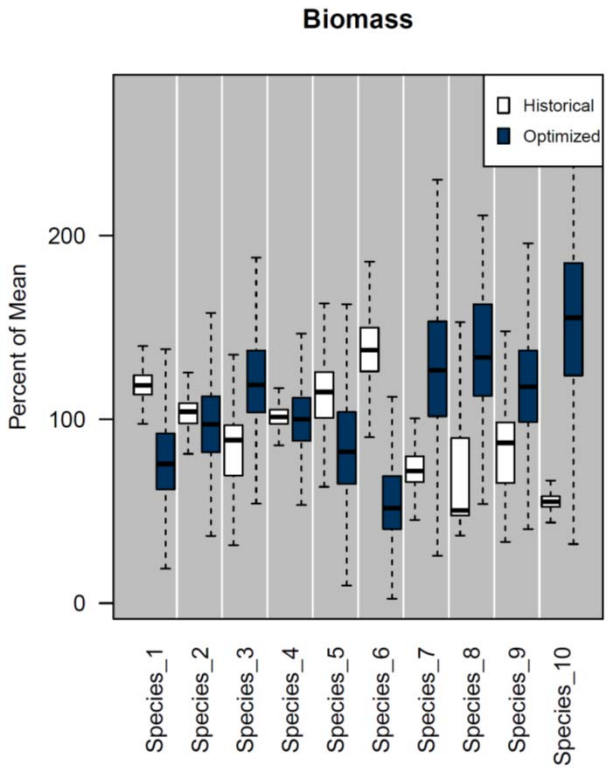
Diagram of work flow in coupled models



Coupled Portfolio Results

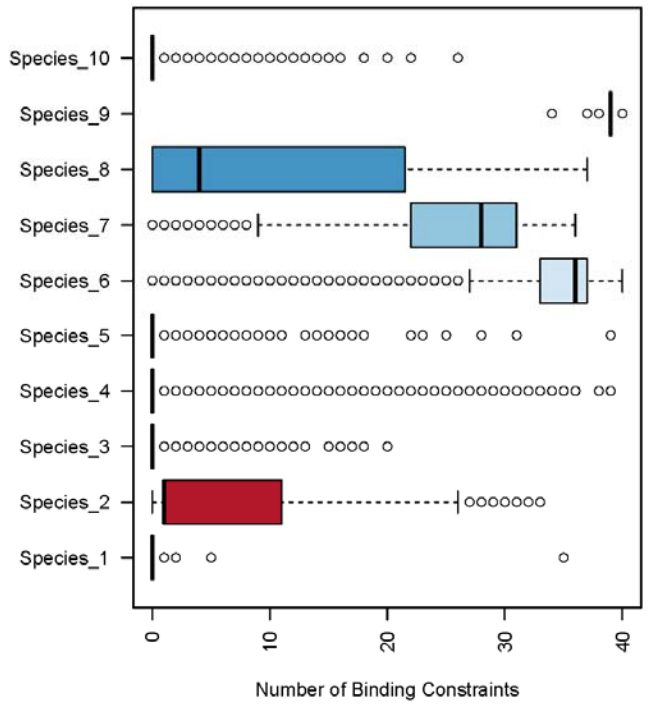




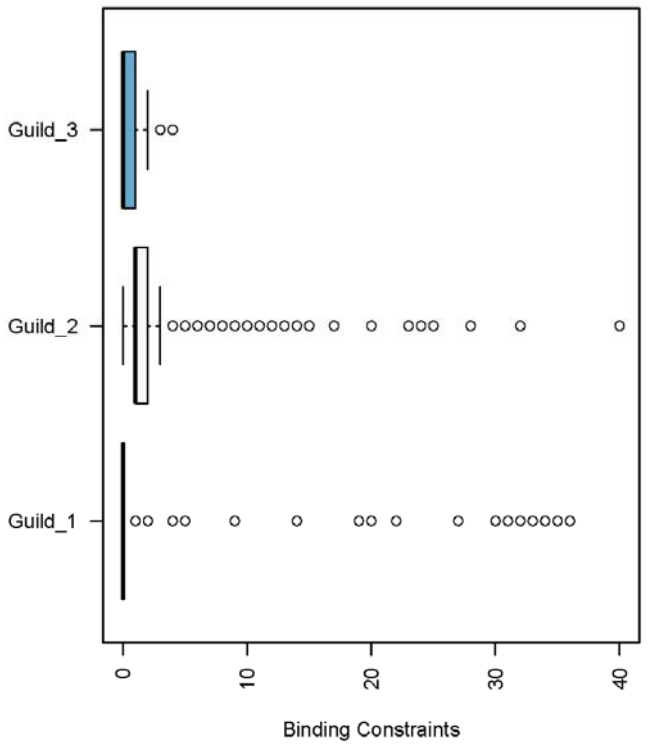


Binding Constraints

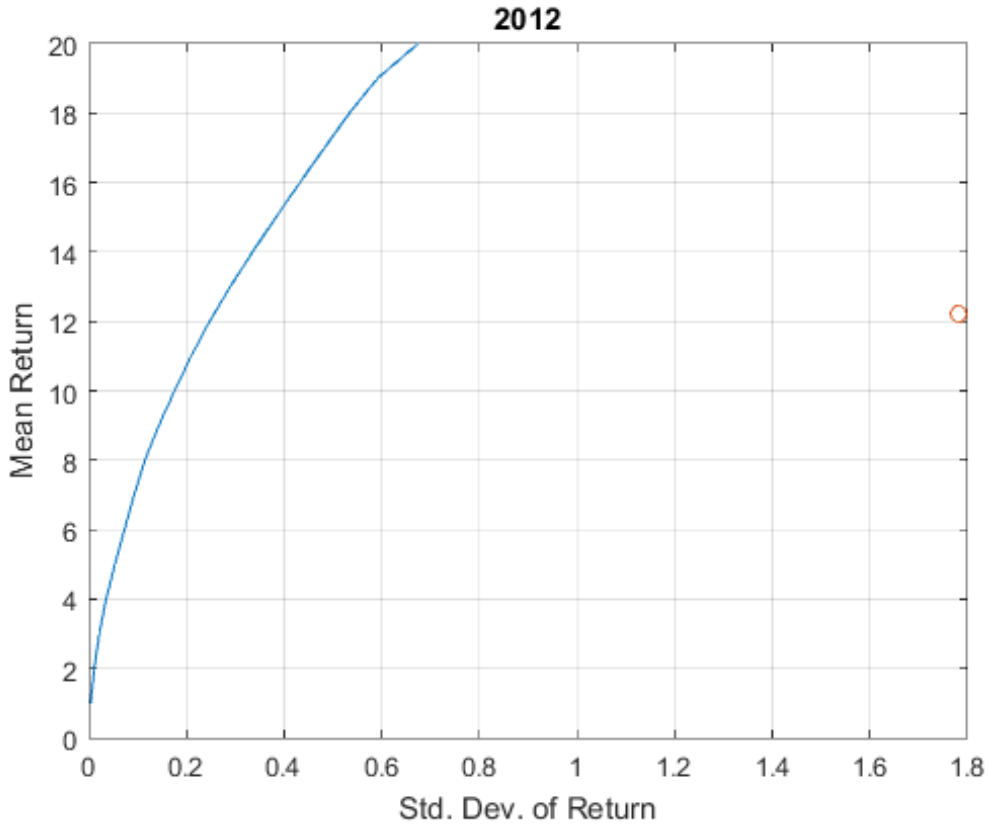
Species Floors



Guild Ceilings



Additional performance metric for trade-off analysis



Takeaways

- Portfolio analysis helps assess (& mitigate) risk to the system
  - Trade-off analysis
  - Optimization for setting catch advice

- Flexibility of modeling framework allows for coupling to numerous models at multiple spatial scales
  - Assess burden of risk

Questions?

Estimation of mean and Variance

- Exponential Smoother
  - λ = 0.549
  - 5% of weight remains after 5 years

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

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

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)