Factors influencing scallop landings per unit effort (LPUE)

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Background

- LPUE/CPUE standardization
  - Build Generalized Linear Model with LPUE as a function of year and explanatory factors

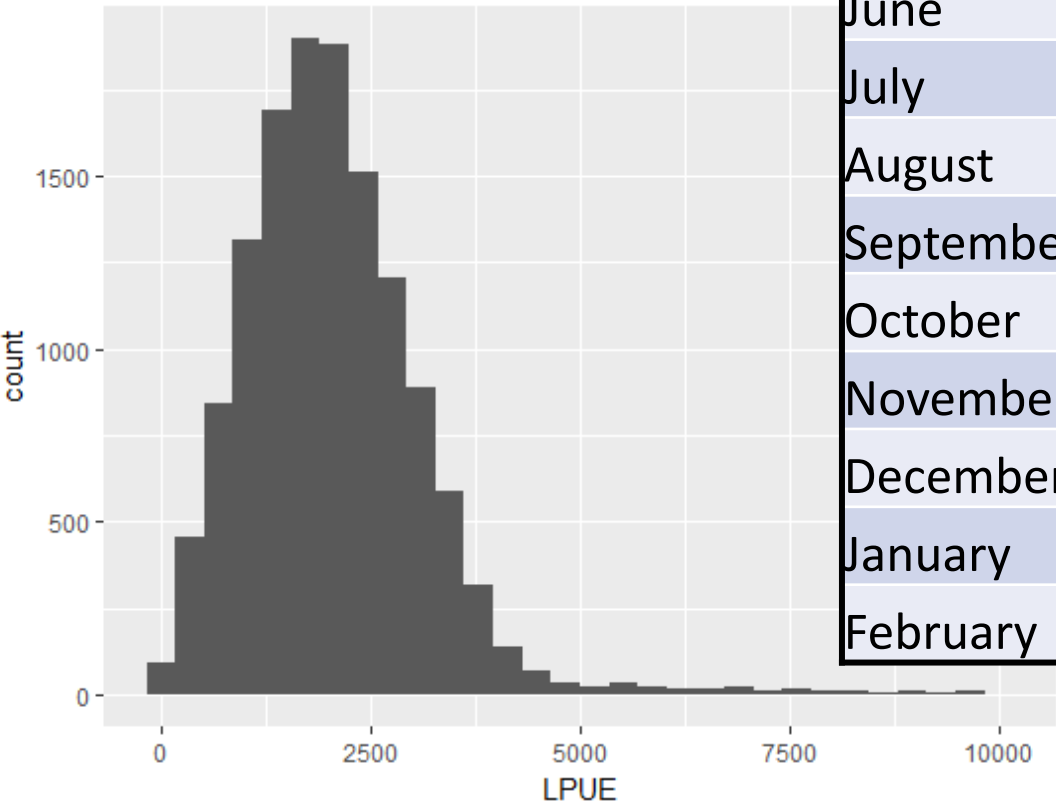$$\widehat{LPUE}_i = \beta_x X_i + \cdots + \beta_p P_i + \beta_{Year} Year$$

  - The year effect is a standardized index of relative stock size

  - Fishermen's insights from in-person meetings and written surveys

Data

N=12,375 trips

2007*-2016

- eVTR/logbook
- Dealer
- VMS

Month	Trips	
March	771	6%
April	1309	11%
May	2093	17%
June	1731	14%
July	1304	11%
August	1290	10%
September	1181	10%
October	865	7%
November	419	3%
December	324	3%
January	368	3%
February	720	6%

Vessel permit/size	Trips	
full time / large	9159	74%
full time / small	2003	16%
full time / trawl	498	4%
part time / large	41	<1%
part time / small	674	5%

Region	Trips	
Georges Bank	2016	16%
Great South Channel	3138	25%
Mid Atlantic	7221	58%

Statistical Methods

- GLMs built in R version 3.3.2

- Forward and backward step-wise selection based on AIC and % deviance explained

- **Distributional assumption: lognormal**
  - **Also evaluated: Gamma, negative binomial, Poisson**

- **10-fold cross validation**
  - **Mean absolute prediction error (MAPE)**
  - **% deviance explained**

$$MAPE = \frac{\sum_{i=1}^{n} abs(y_i - \hat{y}_i)}{n}$$

Results

- Permit type
  - Large vessels have greater LPUE than small vessels for both full-time and part-time permits
- Month
  - Highest LPUE March through May
  - LPUE decreases summer-fall
  - Minimum LPUE in November
- Fishing Region
  - Highest LPUE in Great South Channel
  - No significant difference between Mid Atlantic and Georges Bank

- **Sale Region**
  - **LPUE is greater for trips landed in New England than in Mid Atlantic**
- 10-20 price
  - LPUE decreases with increasing price
- **U10 proportion of landings**
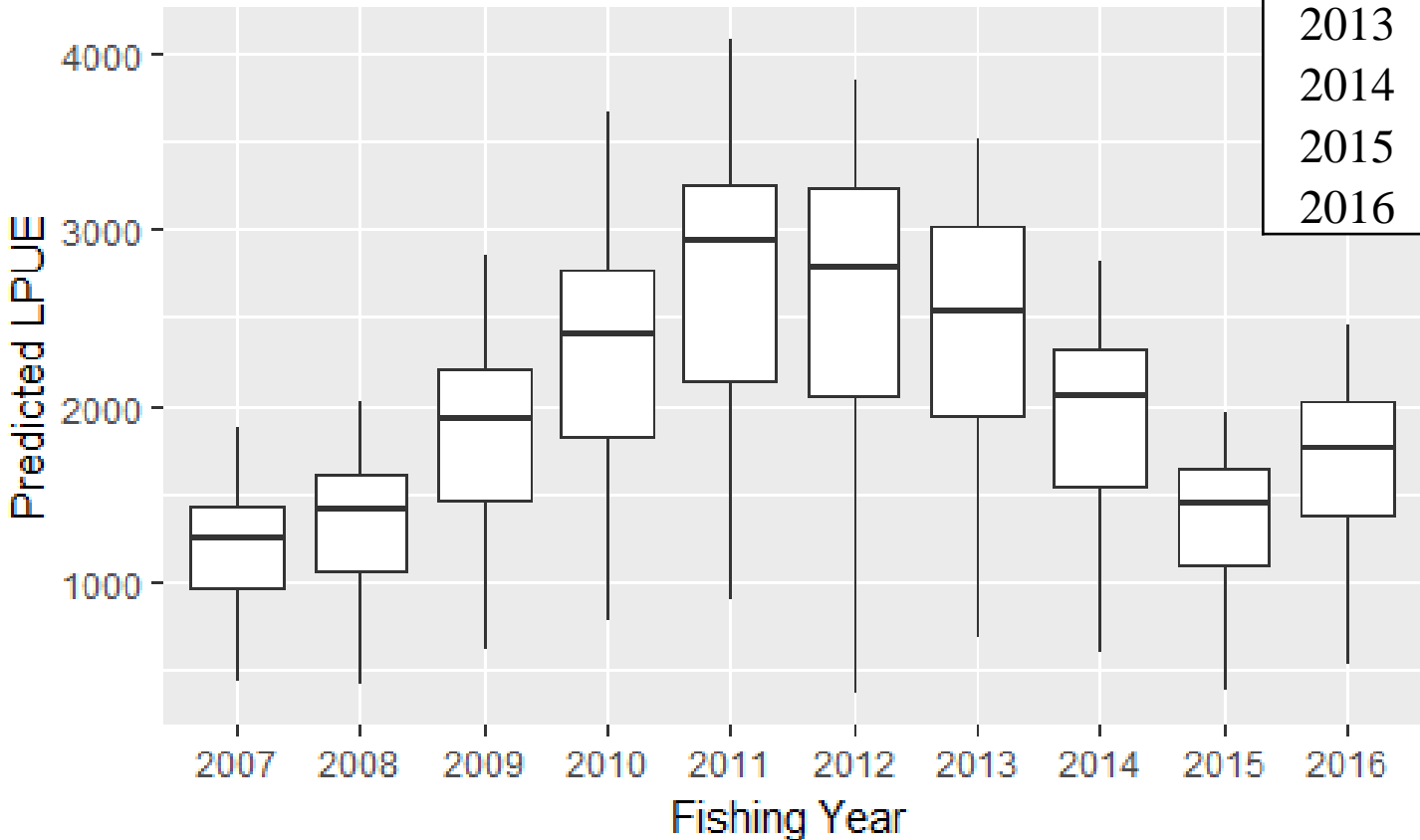 - **LPUE decreases curvilinearly with increasing proportion of U10s**

$$\log(LPUE) = \beta_{Year}X_{Year} + \beta_{PermitType}X_{PermitType} + \beta_{Month}X_{Month} + \ldots$$

$$LPUE = e^{\beta_{Year}X_{Year}} * e^{\beta_{PermitType}X_{PermitType}} * e^{\beta_{Month}X_{Month}} \ldots$$

Results

Model	AIC	% Deviance Explained (fit to full data set)	Average from 10-fold cross validation	
			% Deviance Explained	MAPE (lbs/day)
fishing year + vessel permit type + month + statistical area + state of sale + trip price of 10-20s + squared U10 proportion of landings + U10 proportion of landings	201754.9	42.3%	45.7%	493
fishing year + vessel permit type + month + statistical area + state of sale + trip price of 10-20s + squared U10 proportion of landings	201755.7	42.3%	45.7%	492
fishing year + vessel permit type + month + SAMS + state of sale + trip price of 10-20s + squared U10 proportion of landings	201761.8	42.2%	45.7%	492
fishing year + vessel permit type + month + statistical area + state of sale + average price of 10-20s + squared U10 proportion of landings	201773.5	42.2%	45.7%	492
fishing year + vessel permit type + month + statistical area + state of sale	201800.8	42.1%	45.7%	494
fishing year + vessel permit type + month + fishing region + state of sale + trip price of 10-20s + squared U10 proportion of landings	201809.1	42.0%	45.4%	493
fishing year + vessel permit type + month + fishing region + region of sale + trip price of 10-20s + squared U10 proportion of landings	**201826.9**	**41.8%**	**45.6%**	**494**
fishing year + vessel permit type + month + statistical area	201926.3	41.4%	45.3%	499
fishing year + vessel permit type + month	202425.4	38.9%	42.8%	517
fishing year + vessel permit type	203311.0	34.2%	38.0%	554
fishing year	205485.6	21.5%	18.3%	655
null	208470.4	--	-6.2%	799

Results – Year

Level	Coefficients	$e^{coefficient}$	95% Confidence Limits	
Fishing Year				
no standard				
2007	7.56	1928	(1797, 2068)	***
2008	7.59	1977	(1834, 2130)	***
2009	7.88	2640	(2470, 2823)	***
2010	8.10	3310	(3069, 3570)	***
2011	8.27	3902	(3555, 4283)	***
2012	8.24	3786	(3460, 4143)	***
2013	8.20	3654	(3300, 4045)	***
2014	8.04	3088	(2765, 3450)	***
2015	7.70	2198	(1967, 2455)	***
2016	7.88	2652	(2367, 2971)	***

Results – Permit Type

Factor	Level	Coefficients	$e^{coefficient}$	95% Confidence Limits	
Vessel Permit Type	full time small	-0.46	0.631	(0.615, 0.647)	***
standard: full time large	full time trawl	-0.02	0.979	(0.946, 1.013)	
	part time large	-0.01	0.988	(0.879, 1.111)	
	part time small	-0.62	0.538	(0.511, 0.567)	***
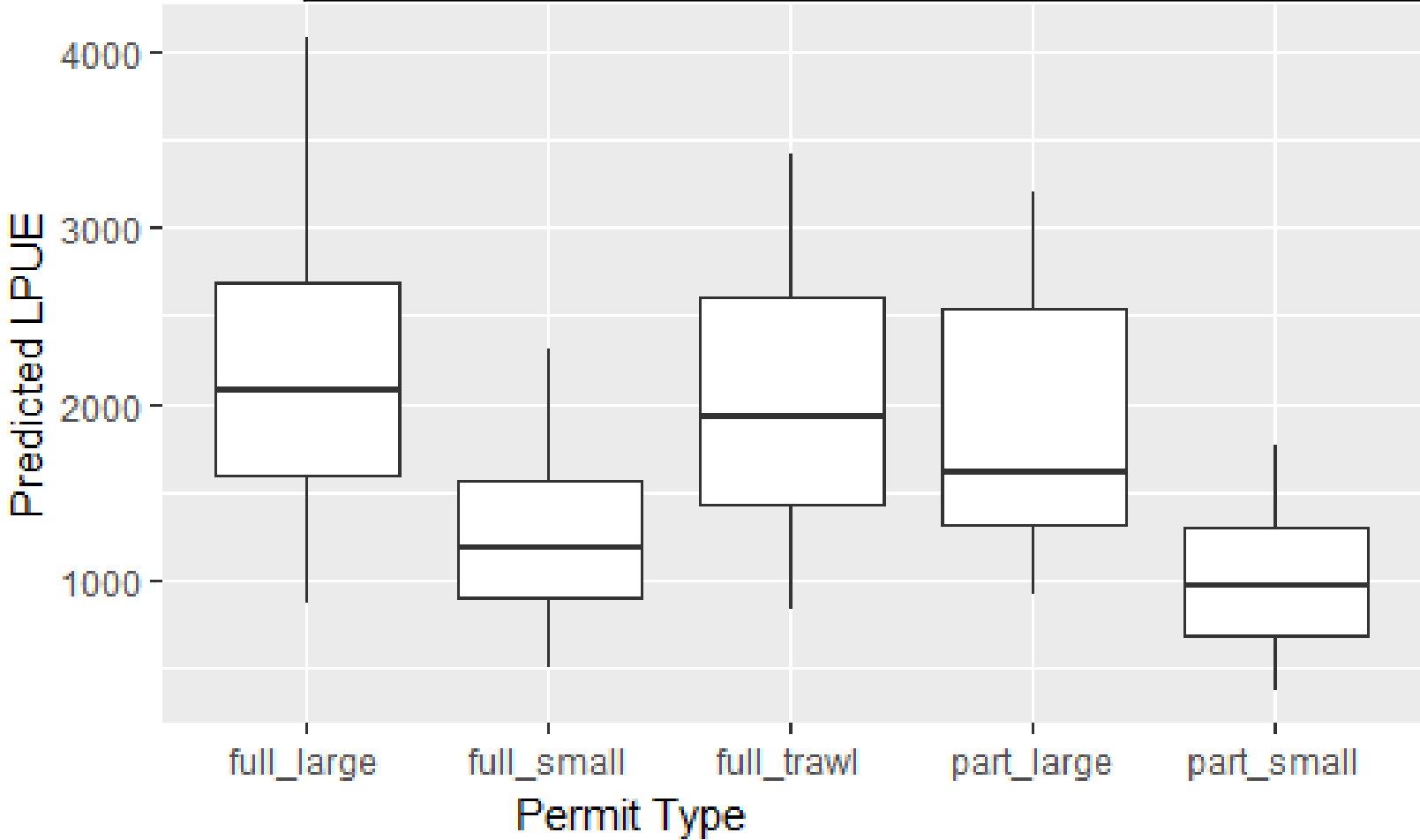
Results – Month

Factor	Level	Coefficients	$e^{coefficient}$	95% Confidence Limits	
Month	April	0.00	0.999	(0.97, 1.03)	
standard: March	May	-0.02	0.980	(0.952, 1.008)	
	June	-0.09	0.914	(0.887, 0.942)	***
	July	-0.12	0.885	(0.857, 0.915)	***
	August	-0.17	0.844	(0.816, 0.873)	***
	September	-0.24	0.786	(0.759, 0.815)	***
	October	-0.33	0.716	(0.687, 0.747)	***
	November	-0.37	0.691	(0.653, 0.732)	***
	December	-0.30	0.739	(0.698, 0.782)	***
	January	-0.13	0.882	(0.841, 0.925)	***
	February	-0.10	0.906	(0.872, 0.941)	***
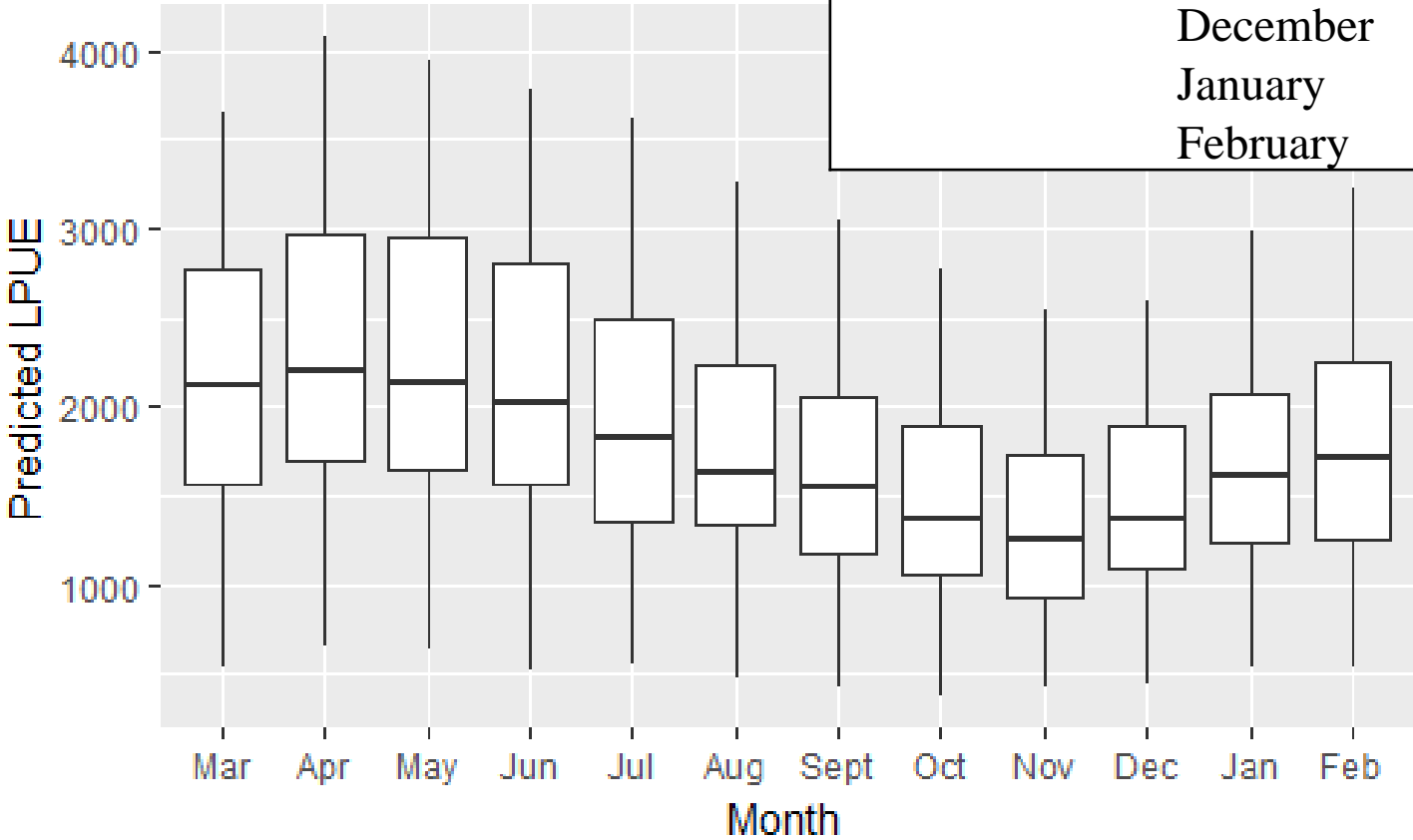
Results – Fishing Region

Factor	Level	Coefficients	$e^{coefficient}$	95% Confidence Limits	
Fishing Region	MidAtlantic	0.00	1.001	(0.978, 1.026)	
standard: Georges Bank	Great South Channel	0.08	1.088	(1.064, 1.113)	***
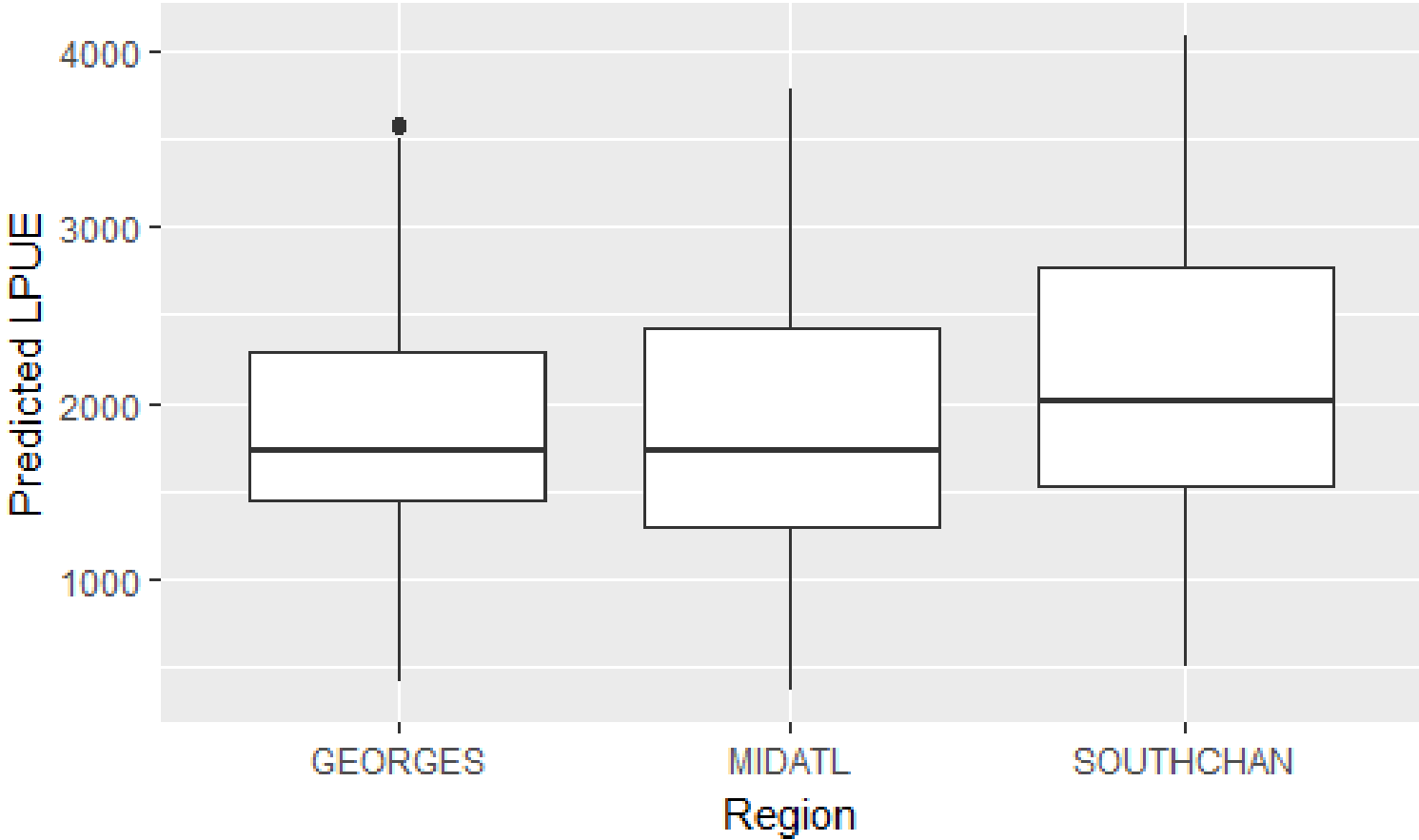
Results – Sale Port Region

Factor	Level	Coefficients	$e^{coefficient}$	95% Confidence Limits	
Sale Port Region *standard: Mid Atlantic*	New England	0.15	1.156	(1.135, 1.178)	***
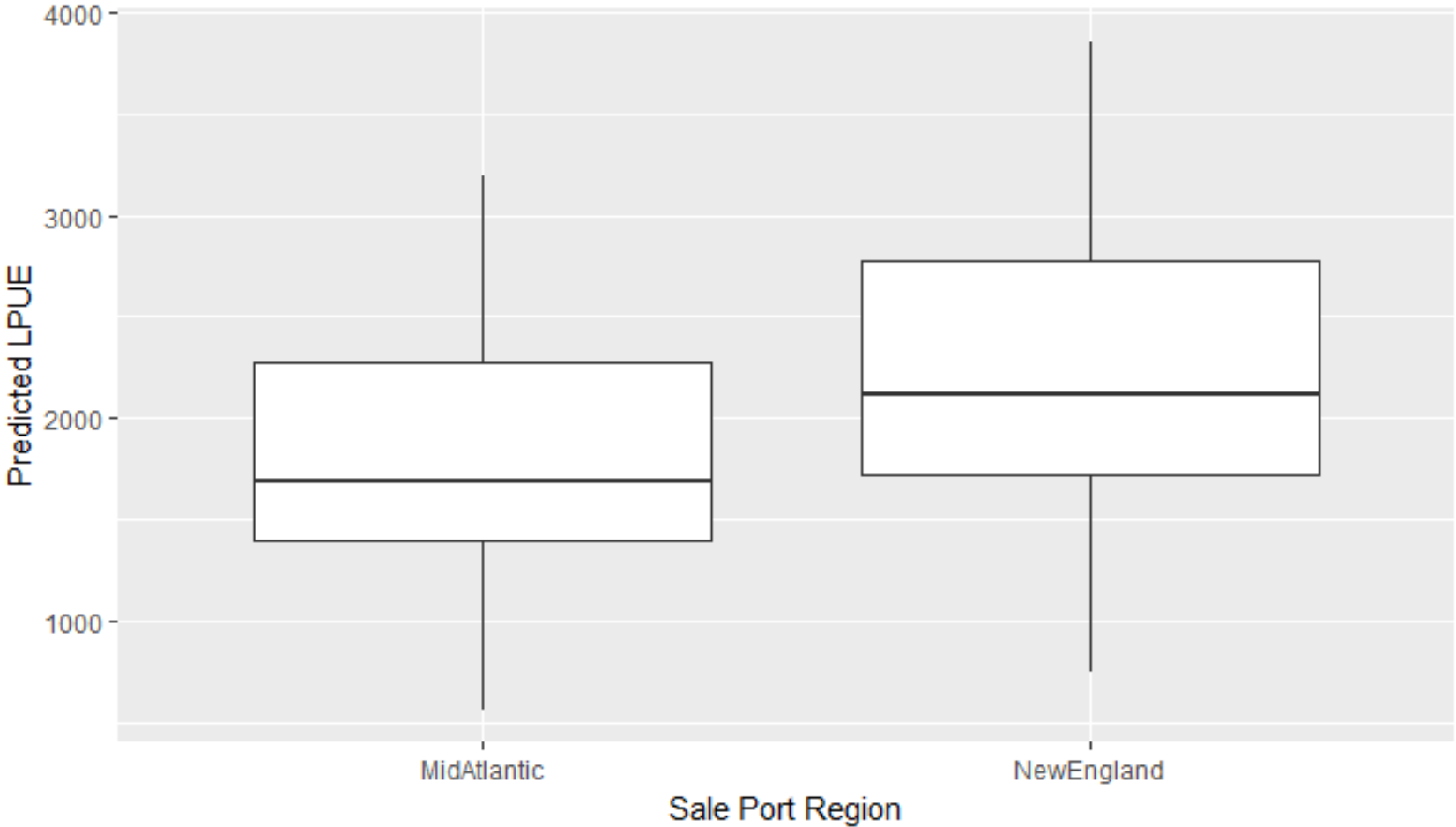
Results – Price

Factor	Coefficients	e^coefficient	95% Confidence Limits	
Price of 10-20s	-0.03	0.975	(0.967, 0.984)	***
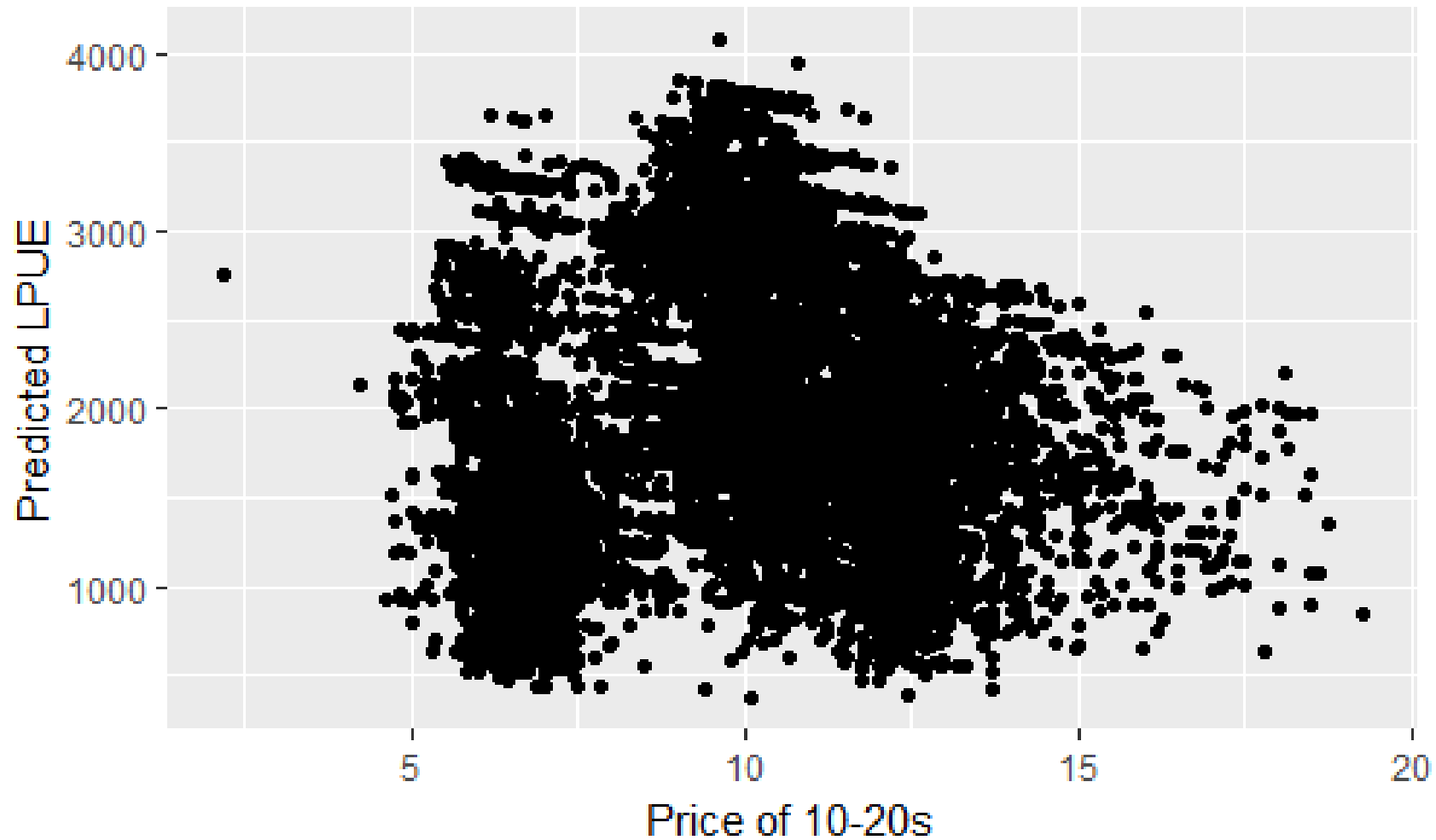
Results – Proportion of U10s

	Coefficients	$e^{coefficient}$	95% Confidence Limits	
(Percent of Landings U10)^2	-0.10	0.909	(0.867, 0.952)	***
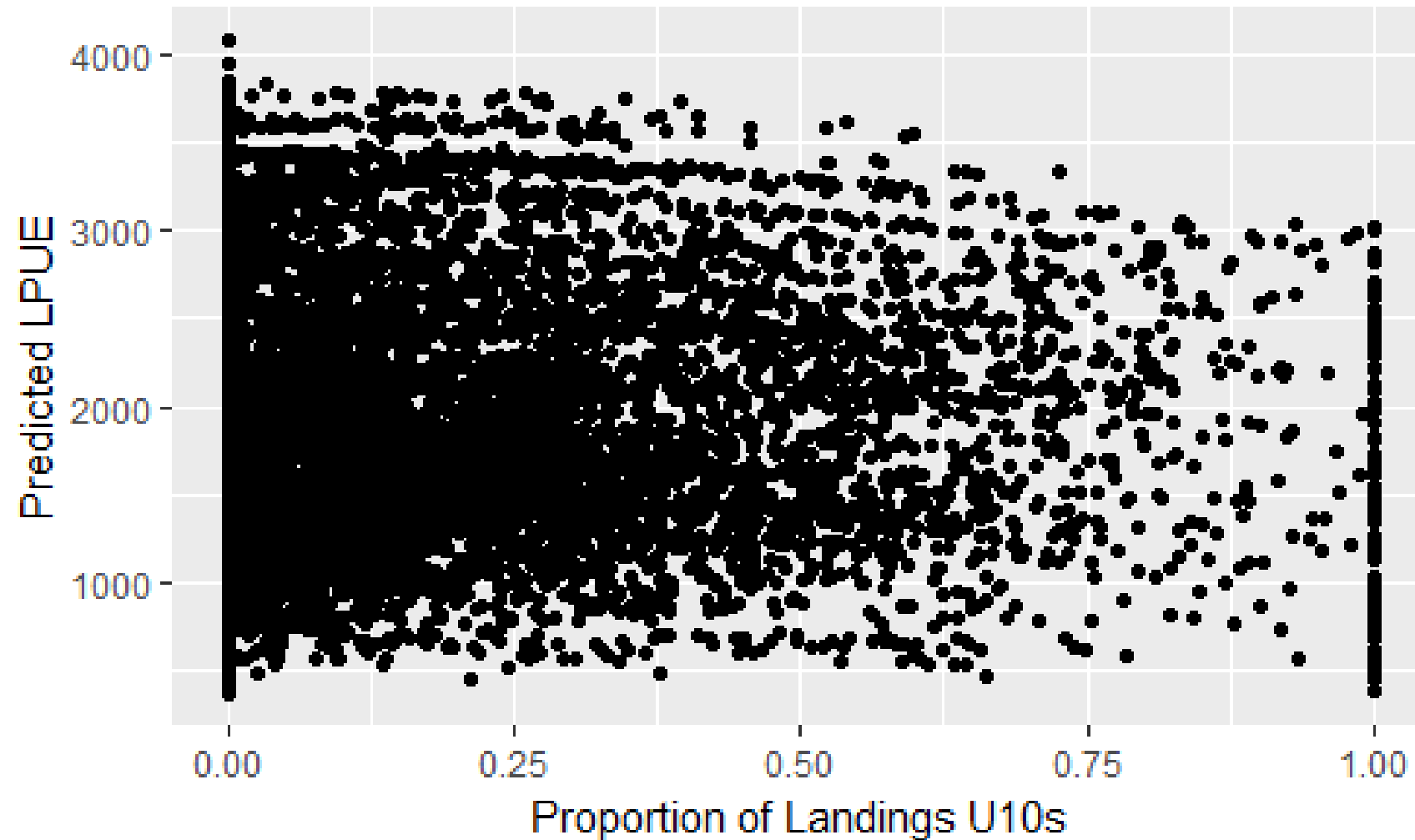
Next Steps

- Retrospective projections of LPUE 2008-2016 to validate predictive capability
  - Define multiple sets of conditions (e.g. permit type= full time, month = May, region = Georges Bank, state of sale = MA, price = 11$/lb, U10 percent of landings = 40%)
  - Assign a proportion of effort to each conditions set
  - Calculate aggregate LPUE based on the LPUE estimate under each set of conditions weighted by the proportion of trips made in each set of conditions

$$LPUE_A = e^{(\beta_{2008}X_{2008} + \beta_{FullTimePermit}X_{FullTimePermit} + \beta_{May}X_{May} + \dots)}$$

$$LPUE_B = e^{(\beta_{2008}X_{2008} + \beta_{PartTimePermit}X_{PartTimePermit} + \beta_{May}X_{May} + \dots)}$$

$$LPUE_C = e^{(\beta_{2008}X_{2008} + \beta_{FullTimePermit}X_{FullTimePermit} + \beta_{June}X_{June} + \dots)}$$

$$\dots$$

$$LPUE_{2009Aggregate} = A\%LPUE_A + B\%LPUE_B + C\%LPUE_C + \dots$$

For projections…

Assign proportion of effort as follows:

- Permit type: part time permits have 40% of full time permit days; status quo percentage of permit types
- Month: status quo pattern from previous fishing year
- Region:
  - fishing pattern from previous fishing year OR
  - **Based on SAMS projected exploitable biomass estimates**
- Port: status quo pattern from previous fishing year
- Percent of U10s:
  - **Pattern based on size distribution in SAMS projections**
- Price: average price of previous fishing year

Present projections at April 30-May 4 working group meeting