NTAP 2022 Restrictor Rope Experiment Data Exploration

VIMS/NEFSC

12/5/2022

Many efforts coordinating and performing field work

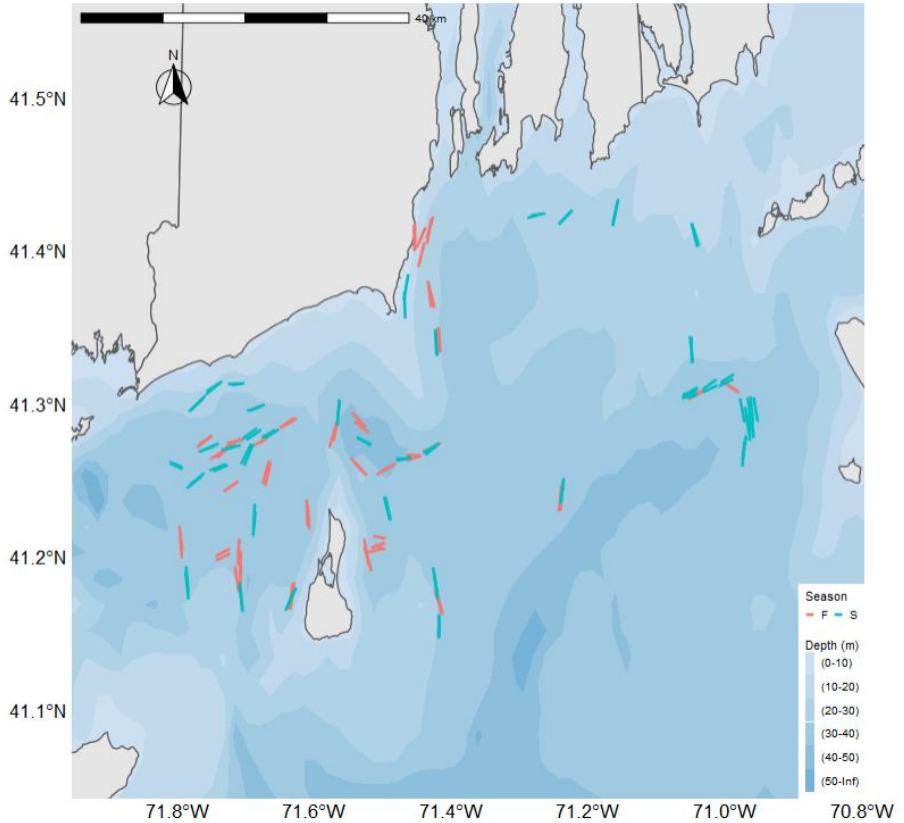
- Captain, crew from F/V Darana R
- VIMS staff
- RI DEM staff
- ROSA staff
- NEFSC staff

Summary of objectives

- Conducted paired tows on the F/V Darana R
- Evaluate catch data and gear performance
- Key metrics
  - Net width
  - Net height
  - Door width
  - Aggregate weights
  - Length specific counts

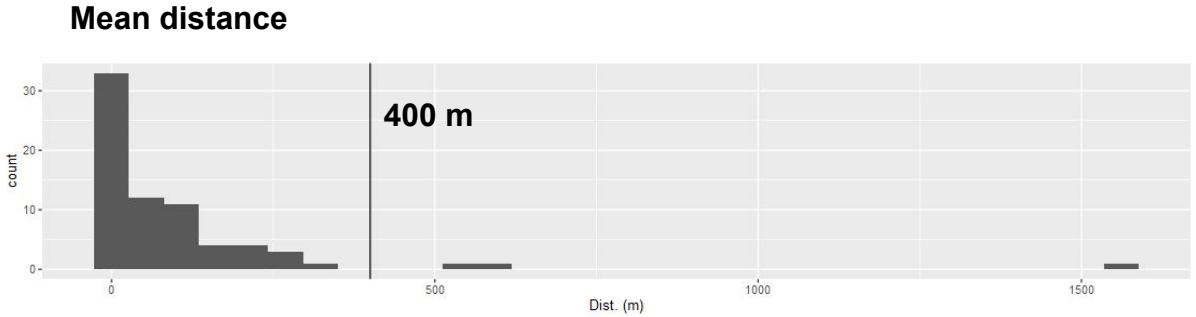
Summary of 2022 research sampling

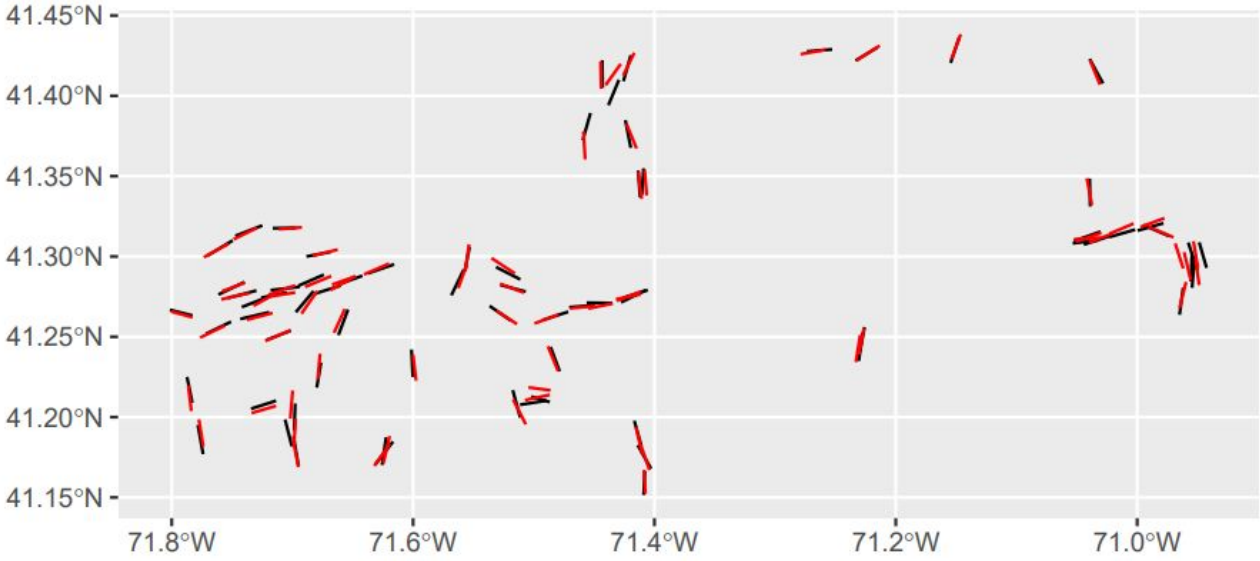
- Two sampling periods
  - Spring (5/30 - 6/6)
  - Fall (9/15 - 9/22)
- Completed 142 paired tows (71 pairs)
  - Depths between 60 ft and 200 ft
  - Sampling all in Block/Rhode Island Sounds
  - A few logistic challenges (hangs/weather) but very limited impact
  - 20 minute tows less than ¼ mile (~400 m) apart
  - Order of treatment varied (AB then BA)
- Samples processed using VIMS software and processing protocols
  - Individual lengths for all except the most common catch items
  - Weight based subsampling for most common/species
- Net performance measured with Simrad net mensuration system



Paired tow spacing

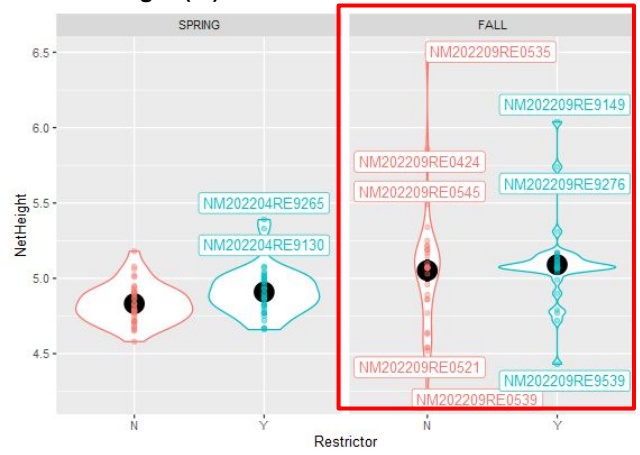
- Excellent job by F/V Darana R!
- Only three tows (2%) where mean distance is > 400 m
- Some tows appear to cross at various points (~40)
- Tow tracks could be slightly different than what was recorded (some GPS wobble)



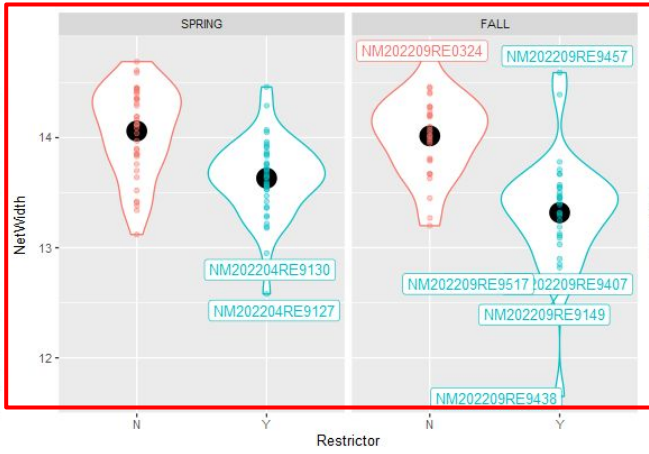


Gear metrics

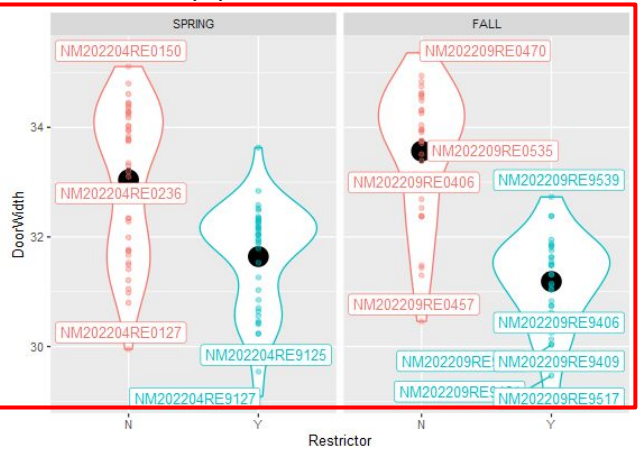
Net Height (m)



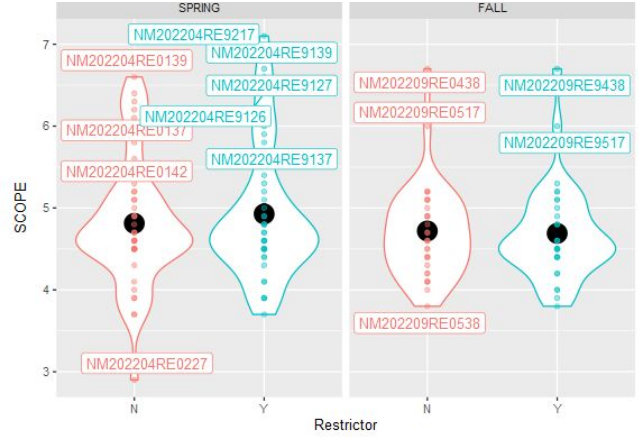
Net Width (m)



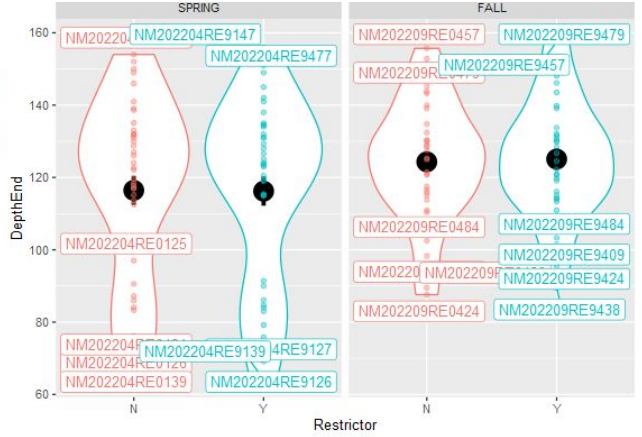
Door Width (m)



Scope



Depth (ft)



- Net width and door width smaller with restrictor
- Net height less variable in spring
- Net height less variable with restrictor, but only in fall season

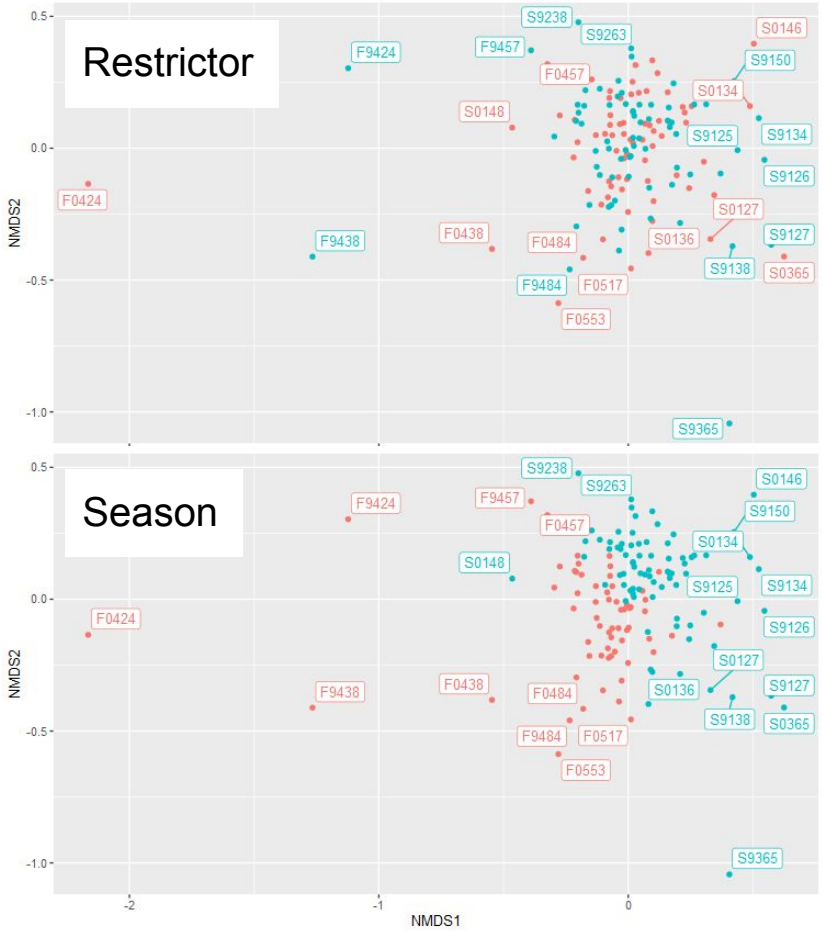
Gear metric thoughts

- There is a treatment effect on net performance
    - Net width is reduced and door width is reduced with restrictor rope
- Still working through whether variation generally is reduced with the restrictor rope
    - Need more input and discussion on this

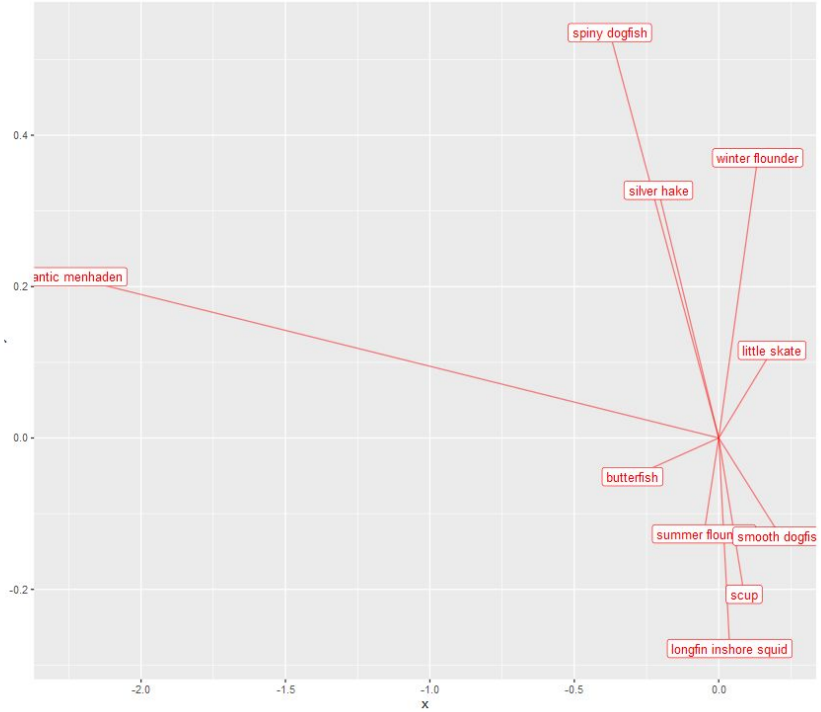
Comparing catches in paired tows

1. Investigating species prevalences and research objectives
2. Looking at aggregate catch (total weight by species) with and without the restrictor
3. Fit linear model to test for significant differences in aggregate catches

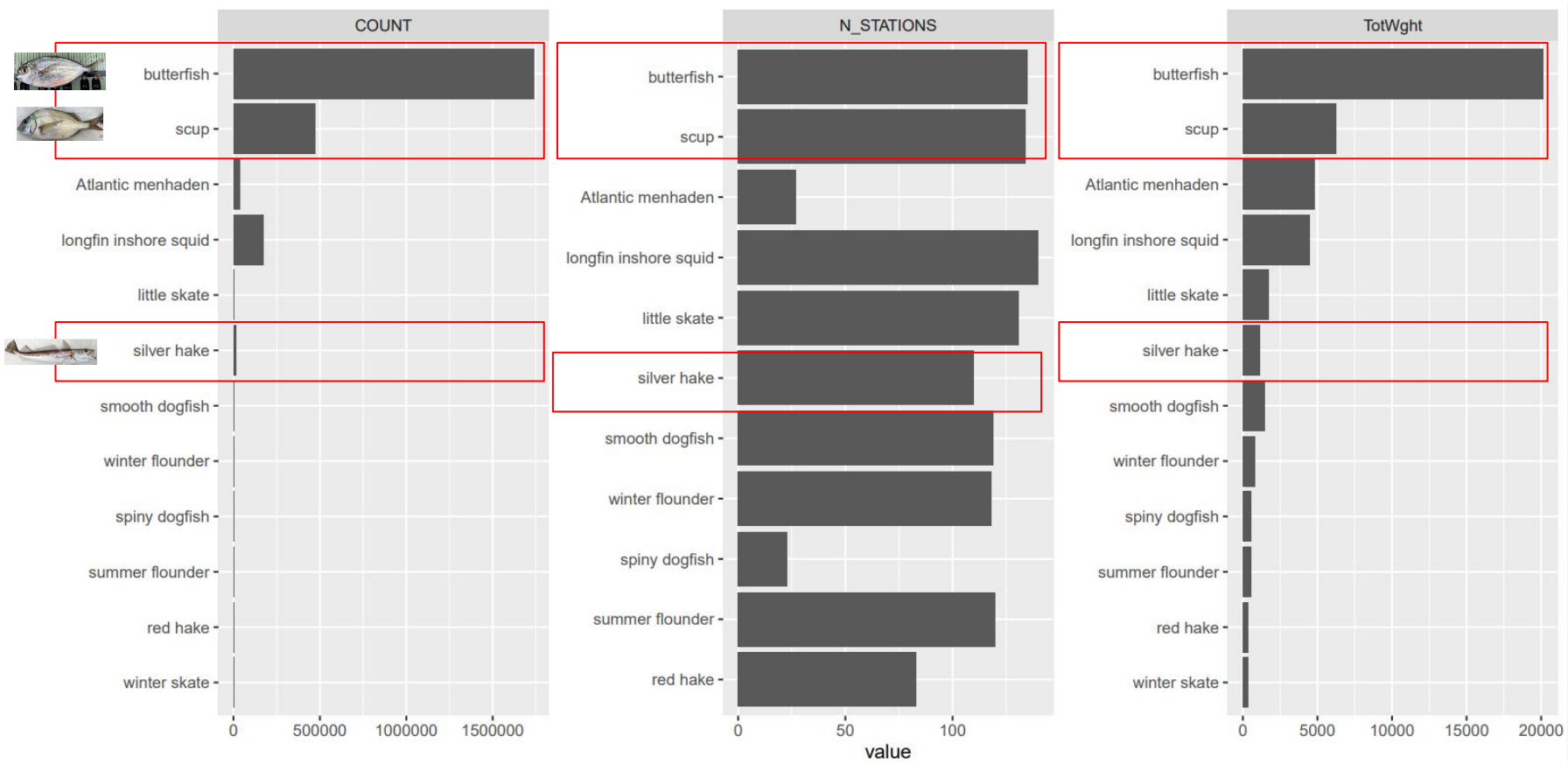
Plotting catches in two dimensions



- No clear effect of restrictor
- Some effect of season
- Differences between seasons relate to spiny dogfish and fluke

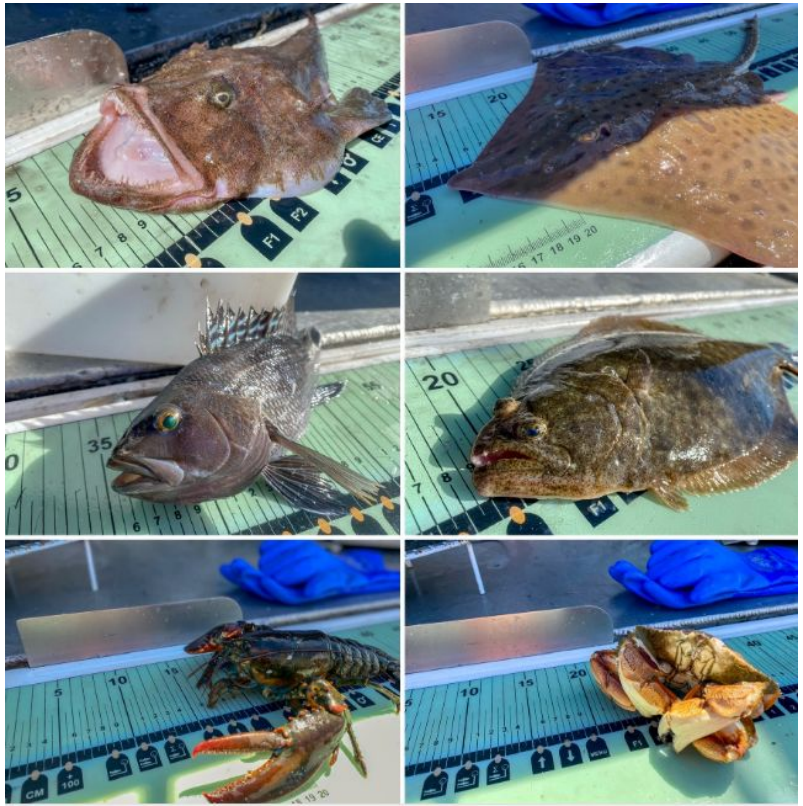


Prevalence of different species in tows



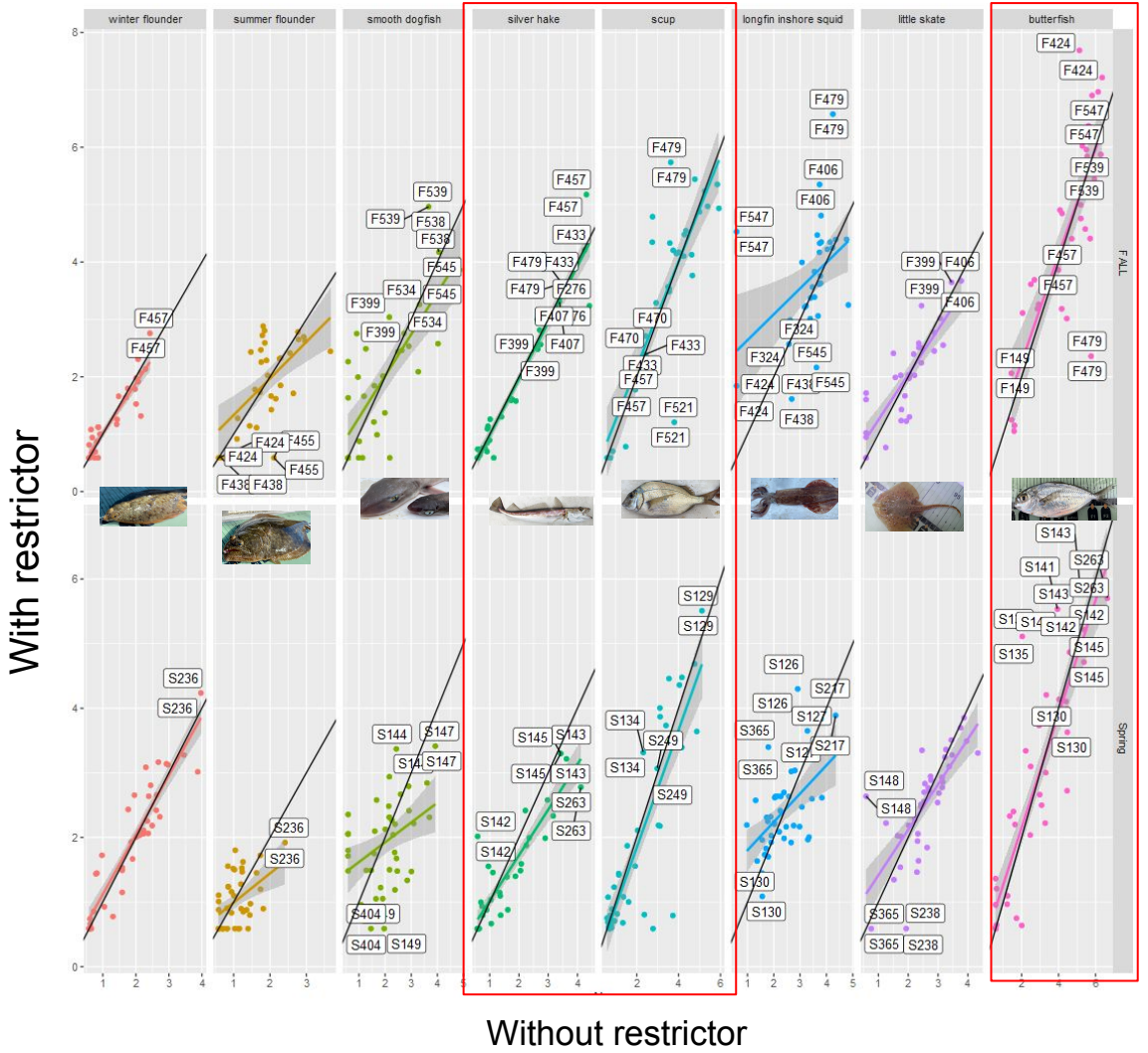
Species focus for analysis

- Focus of this work was on roundfish, most likely to be impacted
- In previous experiments focused on flatfish we narrowed scope down to the most commonly encountered species
- Scup, butterfish, and silver hake the roundfish most commonly encountered in the experiment
- Others less commonly caught, might be difficult to draw conclusions about



Aggregate catches

- Again, tows without restrictor (each pair is a point)
- Would expect 1:1 if **no** effect of the restrictor
- Weights transformed
- log10 transformed weights
    - Mean 10% of mean weight added to zero catches
- Cubic root transformation gives similar results



Aggregate catches

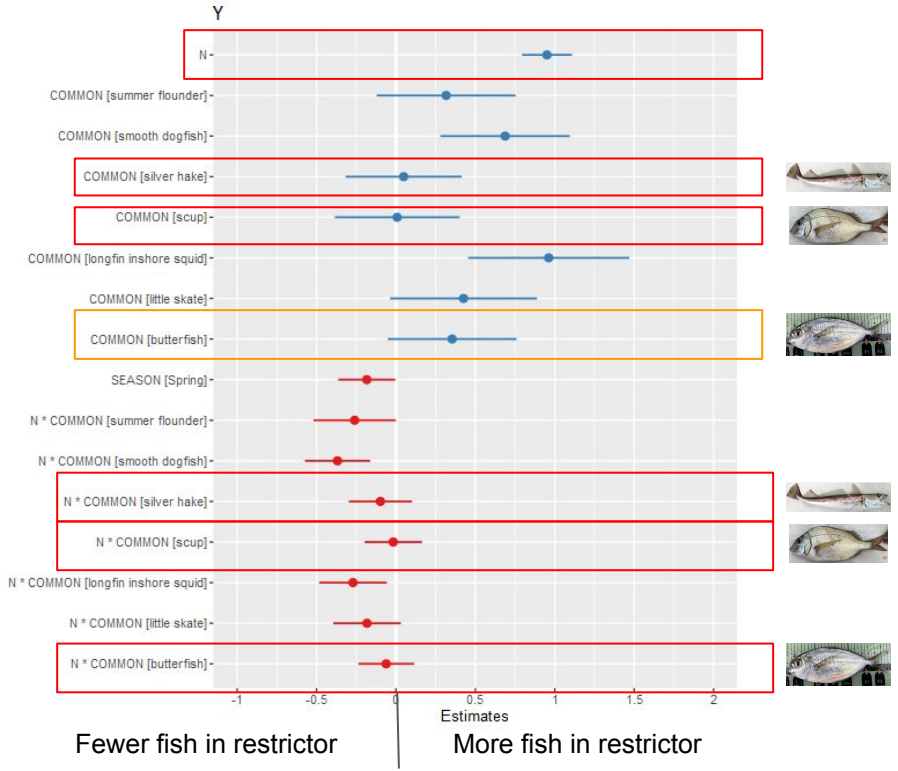
- Linear models suggest that there is no significant difference for these three species

```
> model <- lmer(Y ~ 1 + N * COMMON + SEASON + (1|PAIR), data = mod_data)
> summ(model)
MODEL INFO:
Observations: 1136
Dependent Variable: Y
Type: Mixed effects linear regression

MODEL FIT:
AIC = 2257.59, BIC = 2353.26
Pseudo-R² (fixed effects) = 0.79
Pseudo-R² (total) = 0.82

FIXED EFFECTS:
```

	Est.	S.E.	t val.	d.f.	p
(Intercept)	0.20	0.12	1.72	811.97	0.09
N	0.95	0.06	15.56	1108.58	0.00
COMMONsummer flounder	0.32	0.17	1.86	1092.50	0.06
COMMONsmooth dogfish	0.69	0.16	4.35	1099.01	0.00
COMMONsilver hake	0.05	0.14	0.34	1085.19	0.73
COMMONscup	0.01	0.15	0.05	1092.34	0.96
COMMONlongfin inshore squid	0.96	0.20	4.89	1095.29	0.00
COMMONlittle skate	0.43	0.18	2.37	1076.41	0.02
COMMONbutterfish	0.35	0.16	2.25	1097.74	0.02
SEASONSpring	-0.18	0.07	-2.64	77.40	0.01
N:COMMONsummer flounder	-0.26	0.10	-2.58	1098.87	0.01
N:COMMONsmooth dogfish	-0.37	0.08	-4.62	1106.98	0.00
N:COMMONsilver hake	-0.10	0.08	-1.27	1094.61	0.20
N:COMMONscup	-0.02	0.07	-0.24	1102.85	0.81
N:COMMONlongfin inshore squid	-0.27	0.08	-3.28	1102.84	0.00
N:COMMONlittle skate	-0.18	0.08	-2.21	1078.41	0.03
N:COMMONbutterfish	-0.06	0.07	-0.90	1107.29	0.37



Aggregate weight thoughts

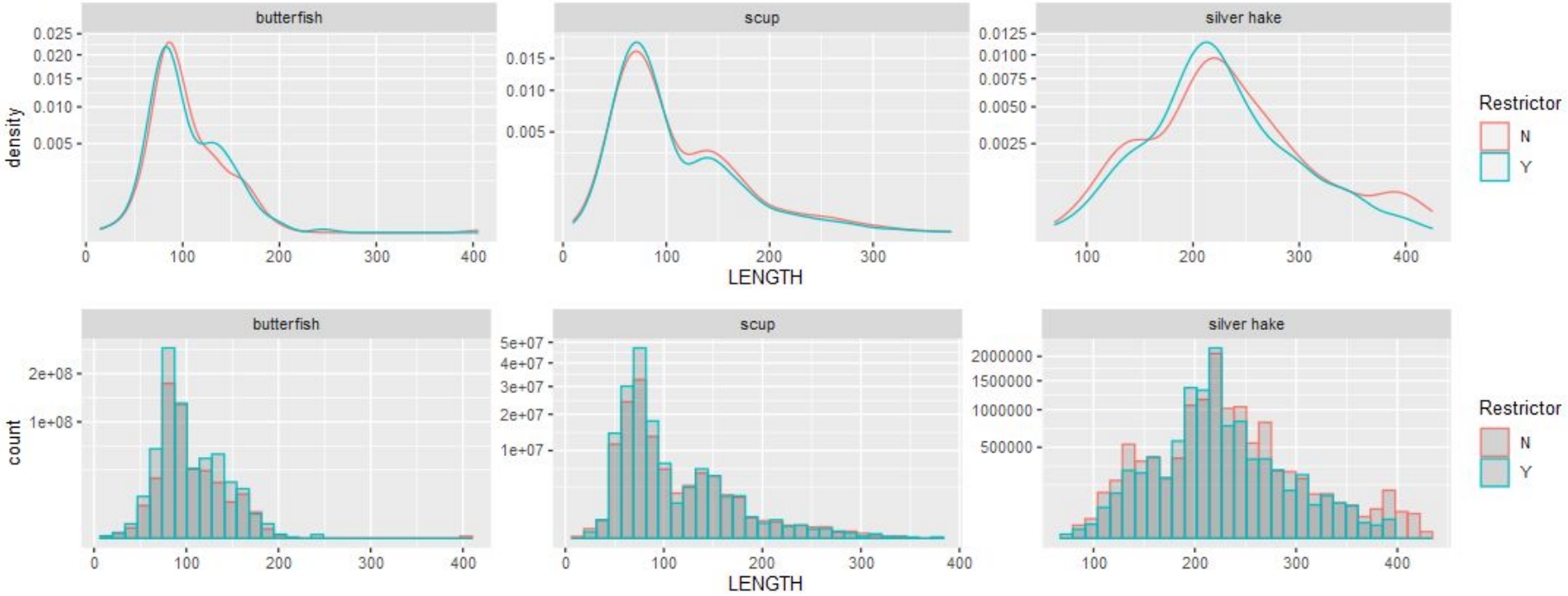
- Close to 1:1 when regressing catches without and catches with the restrictor rope
- No significant effects in the model we fit
- Suggests no detectable effect of the restrictor rope

Comparing catch in paired tows

1. Investigating species prevalences and research objectives
2. Looking at aggregate catch (total weight by species) with and without the restrictor
3. Fit linear model to test for significant differences in aggregate catches
4. Explored individual lengths for three of the most common roundfish species
5. Also fit statistical models to individual length data to test for statistical effects of the restrictor rope

Individual lengths

- Fit linear mixed models then generalized additive models



Individual lengths: Scup

- Linear mixed binomial models for scup
- No effect of length, order, or season
- Small positive effect of depth

```
> summ(length_mod_bi_5)
MODEL INFO:
Observations: 1612
Dependent Variable: cbind(Y, N)
Type: Mixed effects generalized linear regression
Error Distribution: binomial
Link function: logit

MODEL FIT:
AIC = 3897242.32, BIC = 3897285.40
Pseudo-R² (fixed effects) = 0.03
Pseudo-R² (total) = 0.82

FIXED EFFECTS:
-------------------------------------------------
                    Est.   S.E.   z val.      p
----------------- ------- ------ -------- ------
(Intercept)        -5.78   1.36    -4.24   0.00
LENGTH             -0.13   0.11    -1.15   0.25
DepthEnd            0.61   0.16     3.84   0.00
ORDERYN             0.35   0.62     0.56   0.57
SEASONS            -0.24   0.65    -0.37   0.71
-------------------------------------------------

RANDOM EFFECTS:
---------------------------------
 Group     Parameter    Std. Dev.
------- ------------- -----------
 PAIR    (Intercept)     11.91
 PAIR      LENGTH         0.99
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```
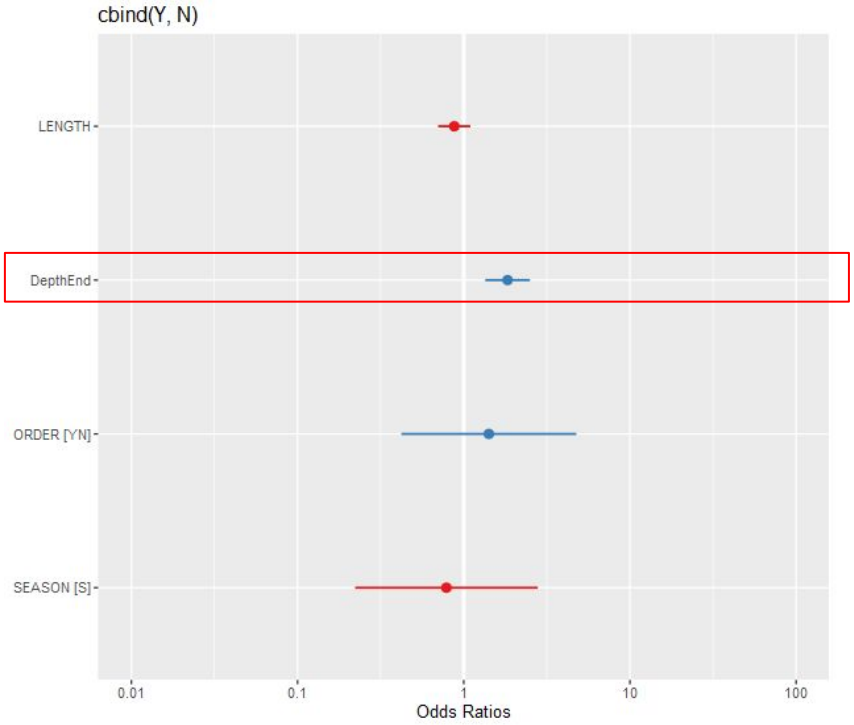
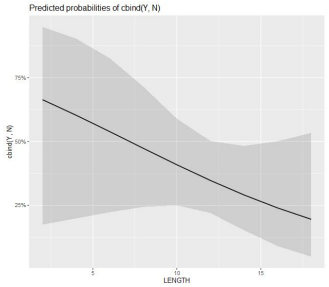
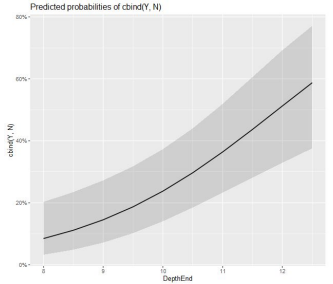



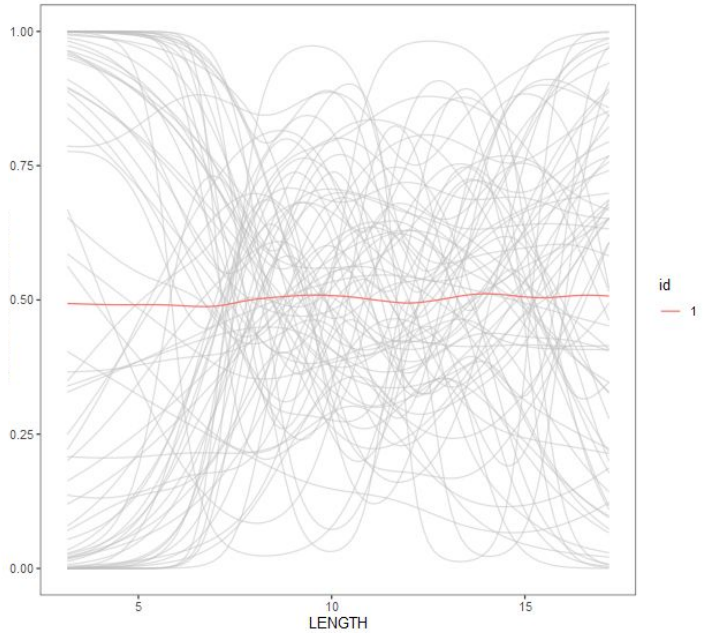


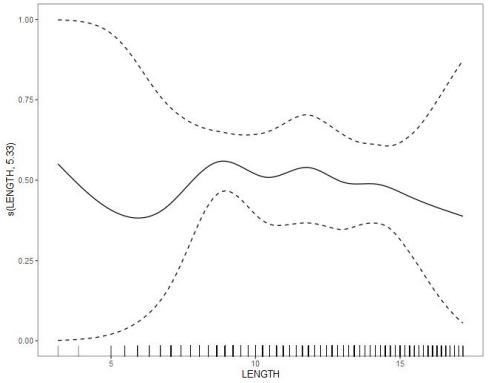


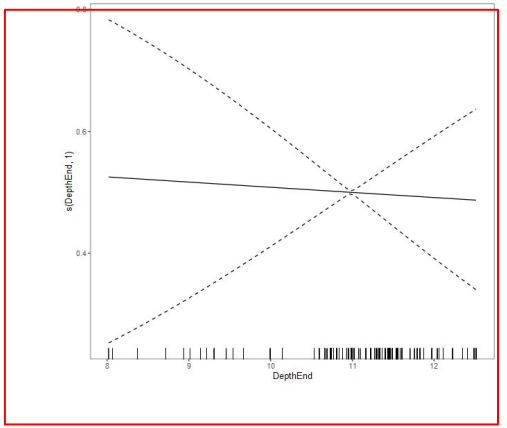
Individual lengths: Scup

- Quasibinomial GAM models for scup
- Results of model are no effects of depth, order, season, or length

```
> summary(length_mod_qb_5)

Family: quasibinomial
Link function: logit

Formula:
cbind(Y, N) ~ s(LENGTH, PAIR, bs = "fs") + ORDER + SEASON +
    s(DepthEnd, bs = "cr") + s(PAIR, bs = "re") +
    s(LENGTH, bs = "cr")

Parametric coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.007401   0.334616  -0.022    0.982
ORDERYN     -0.151023   0.373694  -0.404    0.686
SEASONS     -0.306846   0.412627  -0.744    0.457

Approximate significance of smooth terms:
                   edf  Ref.df      F p-value
s(LENGTH,PAIR) 215.9043 633.000 11.581  <2e-16 ***
s(DepthEnd)      1.0012   1.001  0.028   0.870
s(PAIR)          0.2439  66.000  0.002  <2e-16 ***
s(LENGTH)        5.3277   5.963  0.592   0.711
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.856   Deviance explained = 84.7%
GCV = 1510.6  Scale est. = 1262.4     n = 1612
```



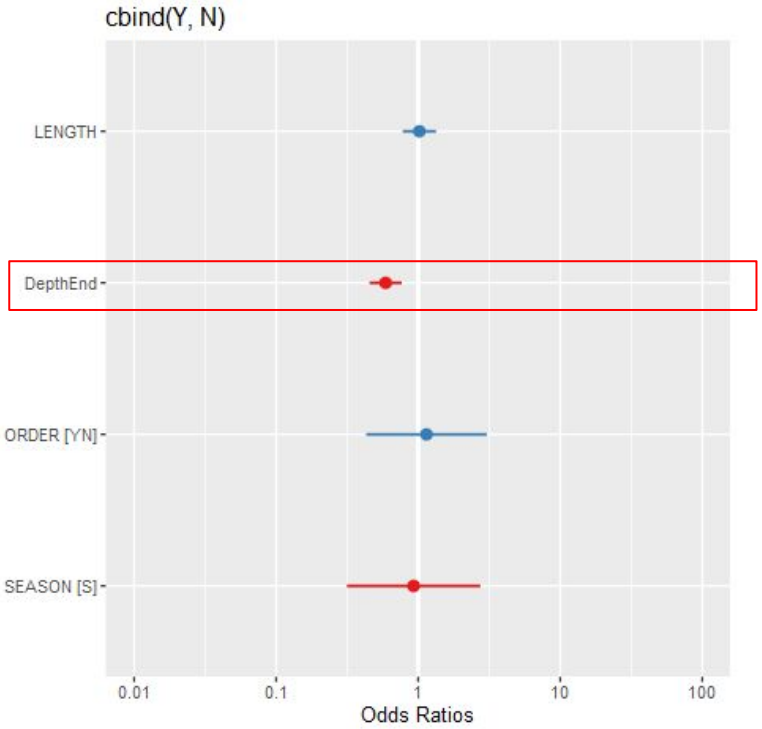


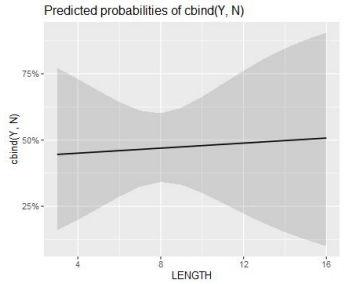


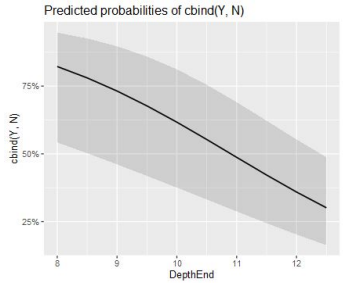
Individual lengths: Butterfish

- Linear mixed binomial models for butterfish
- No effect of length, order, or season
- Small negative effect of depth (decreasing catches with in R set)

```
> summ(length_mod_bi_5)
MODEL INFO:
Observations: 1500
Dependent Variable: cbind(Y, N)
Type: Mixed effects generalized linear regression
Error Distribution: binomial
Link function: logit

MODEL FIT:
AIC = 7706354.00, BIC = 7706396.51
Pseudo-R² (fixed effects) = 0.01
Pseudo-R² (total) = 0.86

FIXED EFFECTS:
----------------------------------------------------
                    Est.   S.E.   z val.      p
----------------- ------- ------ -------- ------
(Intercept)         5.52   1.13     4.87   0.00
LENGTH              0.02   0.14     0.14   0.89
DepthEnd           -0.53   0.13    -3.98   0.00
ORDERYN             0.14   0.50     0.27   0.79
SEASONS            -0.07   0.55    -0.13   0.89
----------------------------------------------------

RANDOM EFFECTS:
---------------------------------
 Group     Parameter    Std. Dev.
------- ------------- -----------
 PAIR    (Intercept)      9.79
 PAIR      LENGTH         1.19
---------------------------------
```



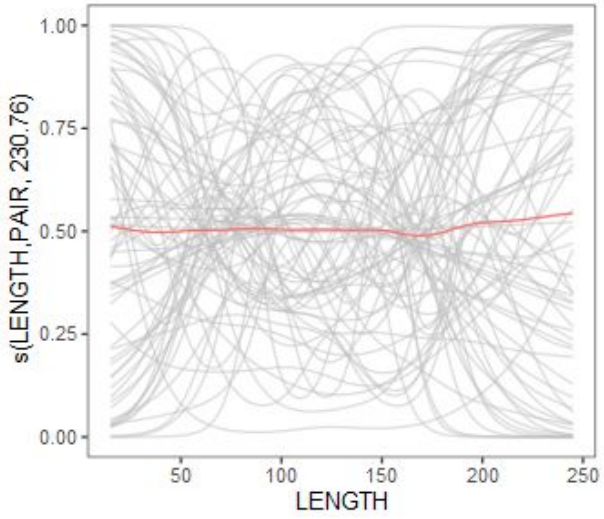


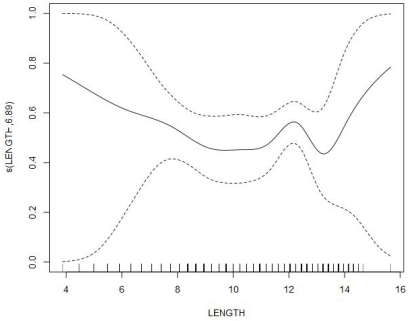


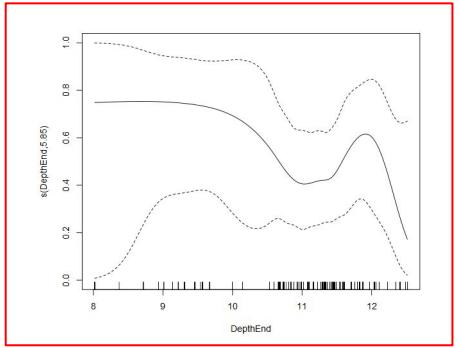
Individual lengths: Butterfish

- Quasibinomial GAM models for butterfish
- No effect of season, length, depth, or order

```
> summary(length_mod_qb_5)

Family: quasibinomial
Link function: logit

Formula:
cbind(Y, N) ~ s(LENGTH, PAIR, bs = "fs") + ORDER + SEASON +
    s(DepthEnd, bs = "cr") + s(PAIR, bs = "re") +
    s(LENGTH, bs = "cr")

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.09535    0.33918   0.281    0.779
ORDERYN      0.08001    0.39389   0.203    0.839
SEASONS      0.01418    0.41259   0.034    0.973

Approximate significance of smooth terms:
                    edf  Ref.df      F p-value
s(LENGTH,PAIR) 230.76285 652.000 11.570  <2e-16 ***
s(DepthEnd)      2.46769   2.571  1.929  0.2893
s(PAIR)          0.08169  66.000  0.001  <2e-16 ***
s(LENGTH)        6.44816   6.910  1.701  0.0931 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.919   Deviance explained = 91.9%
GCV = 3670.7  Scale est. = 2673.5     n = 1500
```







Individual lengths: Silver hake

- Linear mixed binomial models for silver hake
- No effect of length, order, depth, or season

```
> summ(length_mod_bi_5)
MODEL INFO:
Observations: 647
Dependent Variable: cbind(Y, N)
Type: Mixed effects generalized linear regression
Error Distribution: binomial
Link function: logit

MODEL FIT:
AIC = 394808.60, BIC = 394844.37
Pseudo-R² (fixed effects) = 0.00
Pseudo-R² (total) = 0.97

FIXED EFFECTS:
----------------------------------------------------
                      Est.   S.E.   z val.      p
----------------- -------- ------ -------- ------
(Intercept)         -11.09   3.79    -2.93   0.00
LENGTH                0.23   0.51     0.45   0.65
DepthEnd              0.71   0.65     1.09   0.27
ORDERYN               0.04   1.36     0.03   0.98
SEASONS               0.45   1.43     0.31   0.76
----------------------------------------------------

RANDOM EFFECTS:
---------------------------------
 Group     Parameter    Std. Dev.
------- ------------- -----------
 PAIR     (Intercept)     67.47
 PAIR       LENGTH        4.71
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```
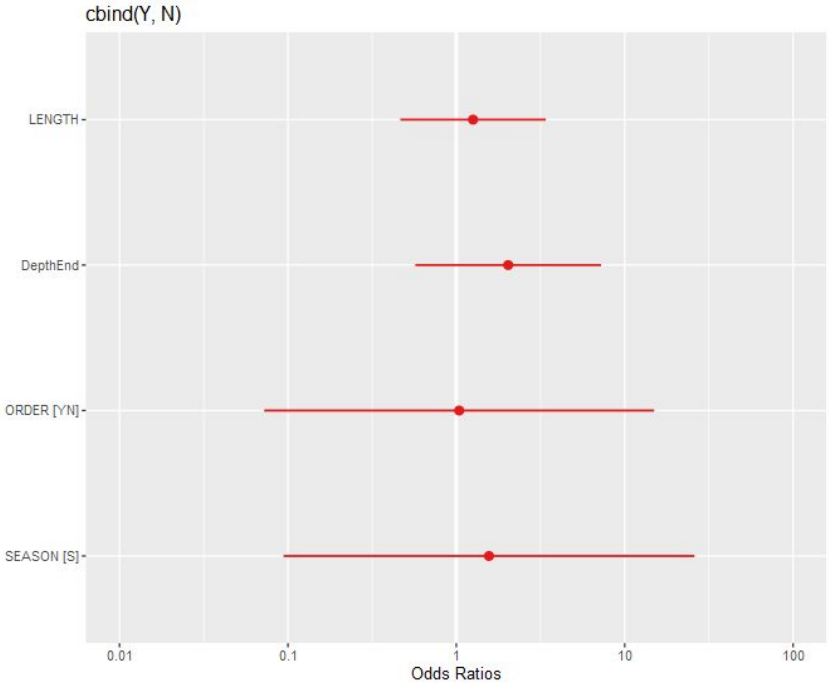
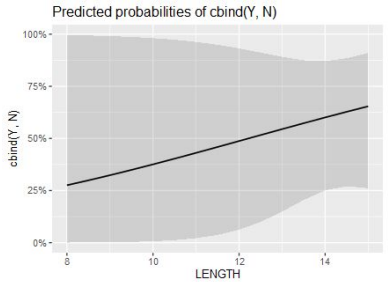
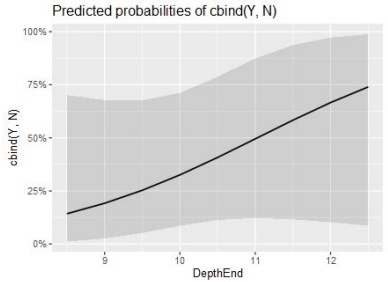



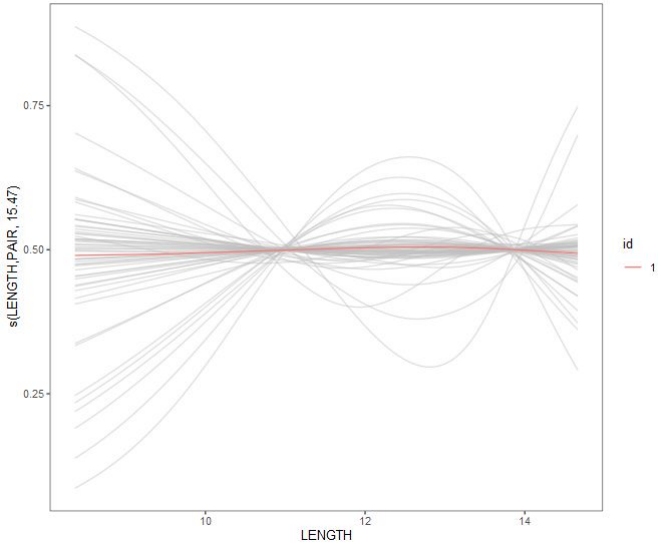


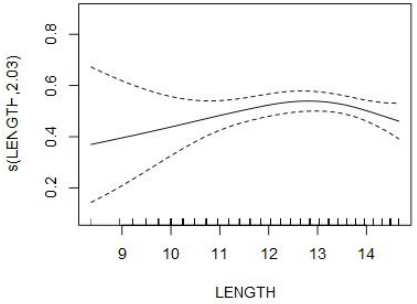


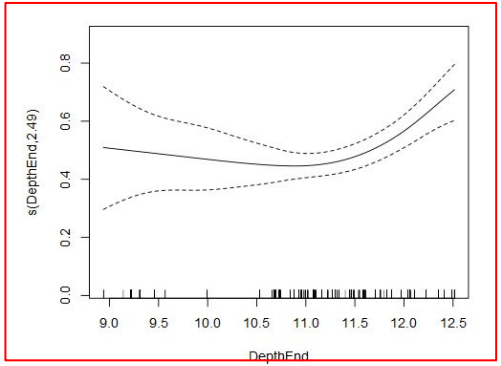
Individual lengths: Silver hake

- Quasibinomial GAM models for silver hake
- Effect of order and depth

```
> summary(length_mod_qb_5)

Family: quasibinomial
Link function: logit

Formula:
cbind(Y, N) ~ s(LENGTH, PAIR, bs = "fs") + ORDER + SEASON +
    s(DepthEnd, bs = "cr") + s(PAIR, bs = "re") +
    s(LENGTH, bs = "cr")

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.4773     0.2114   2.257 0.024341 *
ORDERNY      -0.6929     0.1915  -3.619 0.000321 ***
SEASONS      -0.2708     0.2074  -1.305 0.192314
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                edf  Ref.df     F  p-value
s(LENGTH,PAIR) 27.029 384.000 0.446 4.36e-06 ***
s(DepthEnd)     2.492   2.725 5.543  0.00182 **
s(PAIR)        14.423  52.000 1.051  < 2e-16 ***
s(LENGTH)       2.022   2.432 1.176  0.25884
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.479   Deviance explained =   45%
GCV = 724.09  Scale est. = 531.64    n = 647
```







Individual lengths thoughts

- GLMMs: Small effects of depth (pos for scup and neg for butterfish) on catches, but otherwise no detectable effects
- GAMs: Some hints at non-linearity, but difficult to assess. Potential effect of depth and order in silver hake
- No consistent effects across GAMs and GLMMs
- Suggests limit (or no) effect of restrictor rope on catches at length for the species examined
- Possible that small effects were not detected because of noise/sample sizes (similar to wingspread study)

Overall summary

Gear comparison

- Some effect on net width and door width
  - Wider without restrictor
- Potential effect on net height
  - More work needed to look at variability

Aggregate weights

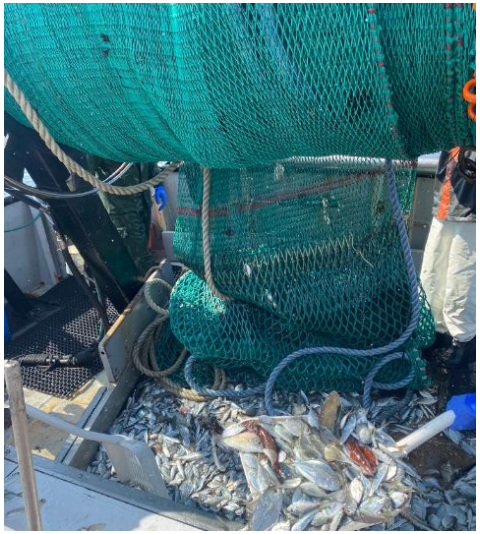
- No (or very subtle) effect on three focal species: butterfish, scup, or silver hake

Individual lengths

- GLMMs: Small effects of depth on catches, but otherwise no detectable effects
- GAMs: Some hints at non-linearity, but difficult to assess. Potential effect of depth and order in silver hake
- No consistent effects across GAMs and GLMMs

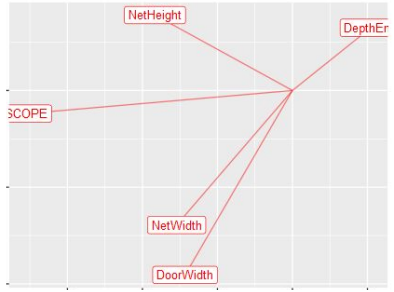
Questions?

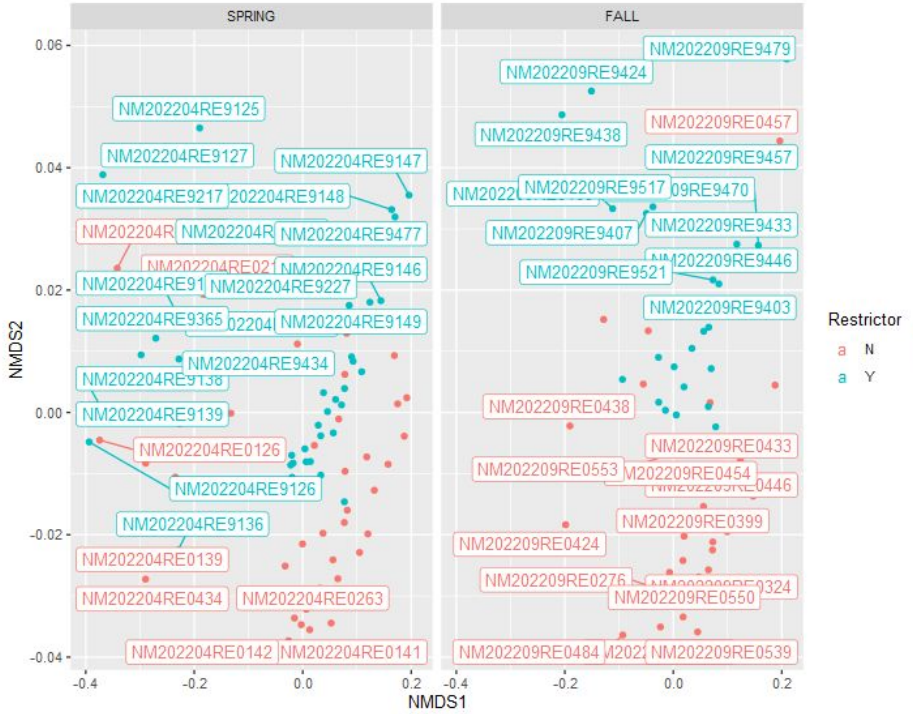
- Other species to include?
- Other ways to explore the data?
- Other modeling techniques to consider?
- Future direction for this research?
- Sufficient information for a publication?

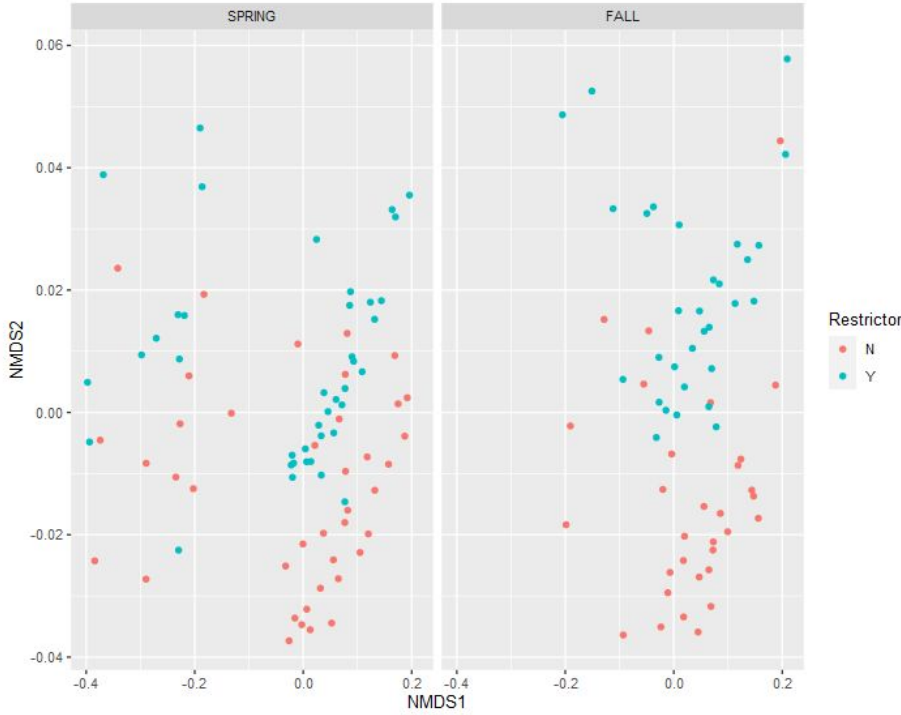


Results:

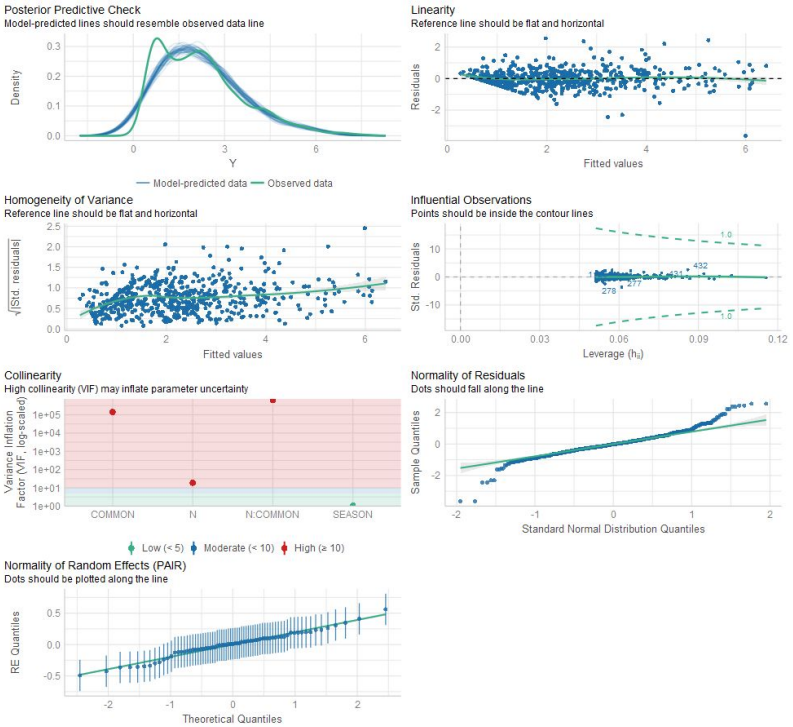
- Ordination to look at gear variation among stations
- Unique gear performance of tows with and without restrictor

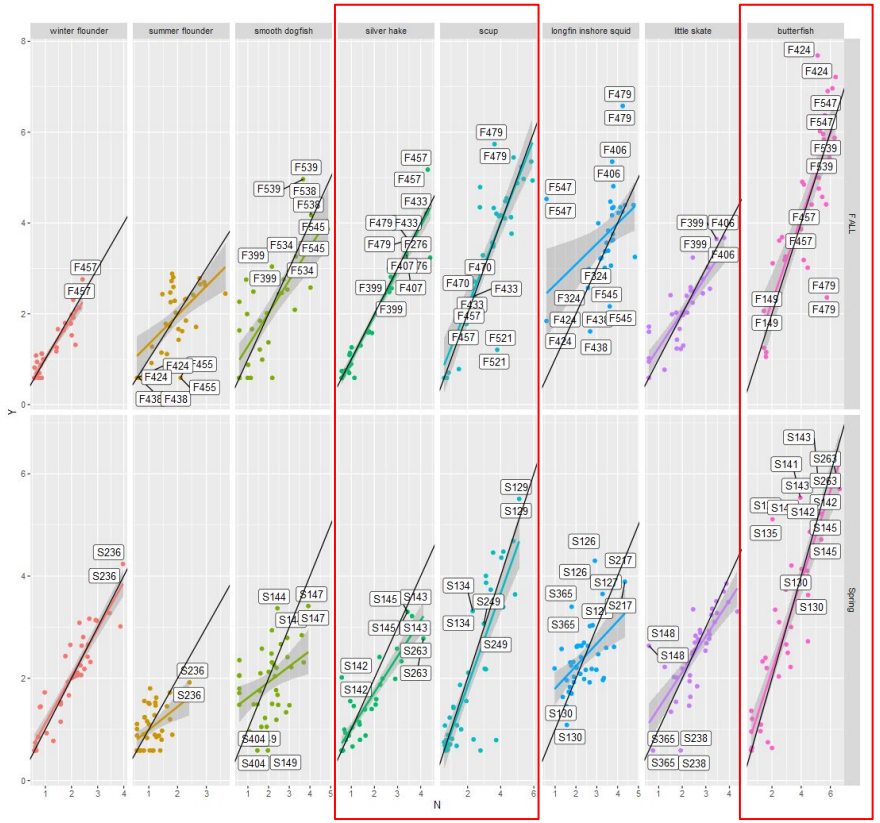




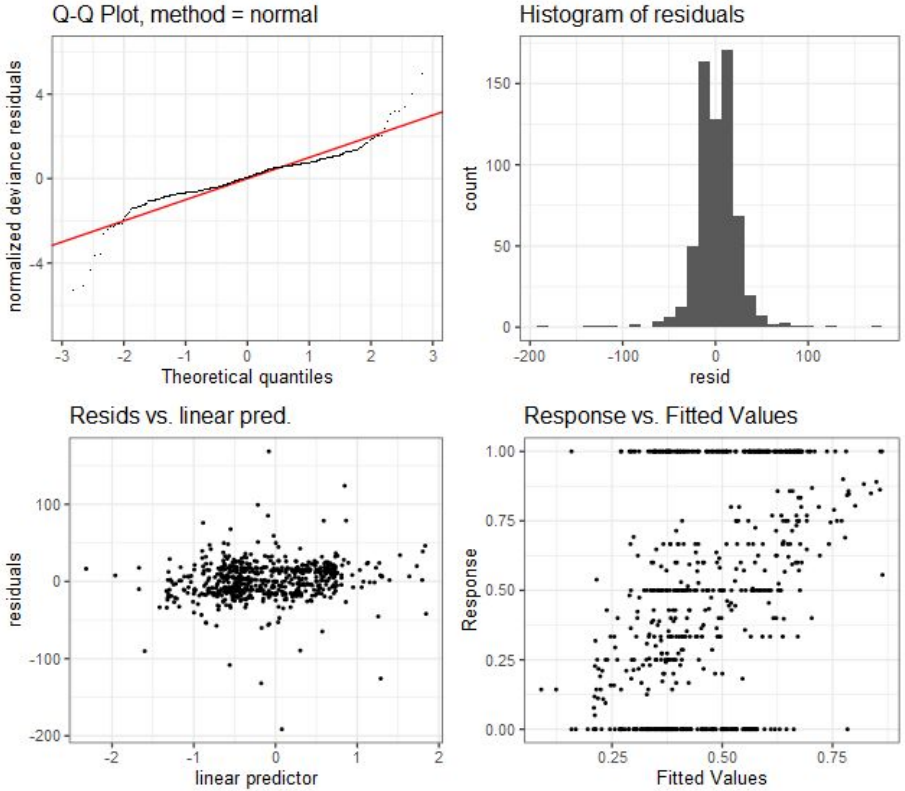


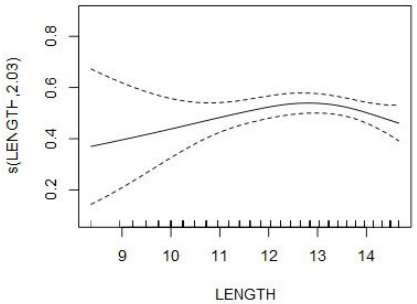
Results:

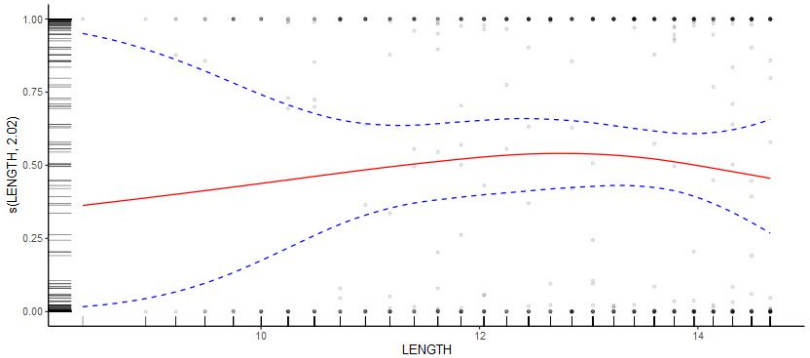

Posterior Predictive Check
Model-predicted lines should resemble observed data line
Density
Y
Model-predicted data
Observed data
Linearity
Reference line should be flat and horizontal
Residuals
Fitted values
Homogeneity of Variance
Reference line should be flat and horizontal
√|Std. residuals|
Fitted values
Influential Observations
Points should be inside the contour lines
Std. Residuals
Leverage (h_ii)
Collinearity
High collinearity (VIF) may inflate parameter uncertainty
Variance Inflation Factor (VIF, log-scaled)
COMMON
N
N:COMMON
SEASON
Low (< 5)
Moderate (< 10)
High (≥ 10)
Normality of Residuals
Dots should fall along the line
Sample Quantiles
Standard Normal Distribution Quantiles
Normality of Random Effects (PAIR)
Dots should be plotted along the line
RE Quantiles
Theoretical Quantiles


winter flounder
summer flounder
smooth dogfish
silver hake
scup
longfin inshore squid
little skate
butterfish
Y
N
F_FALL
S_SPRING

Other plots/results to include?







Other plots/results to include?