NTAP 2022 Restrictor Rope Experiment Data Exploration

VIMS/NEFSC

1/19/2023

Many efforts coordinating and performing field work

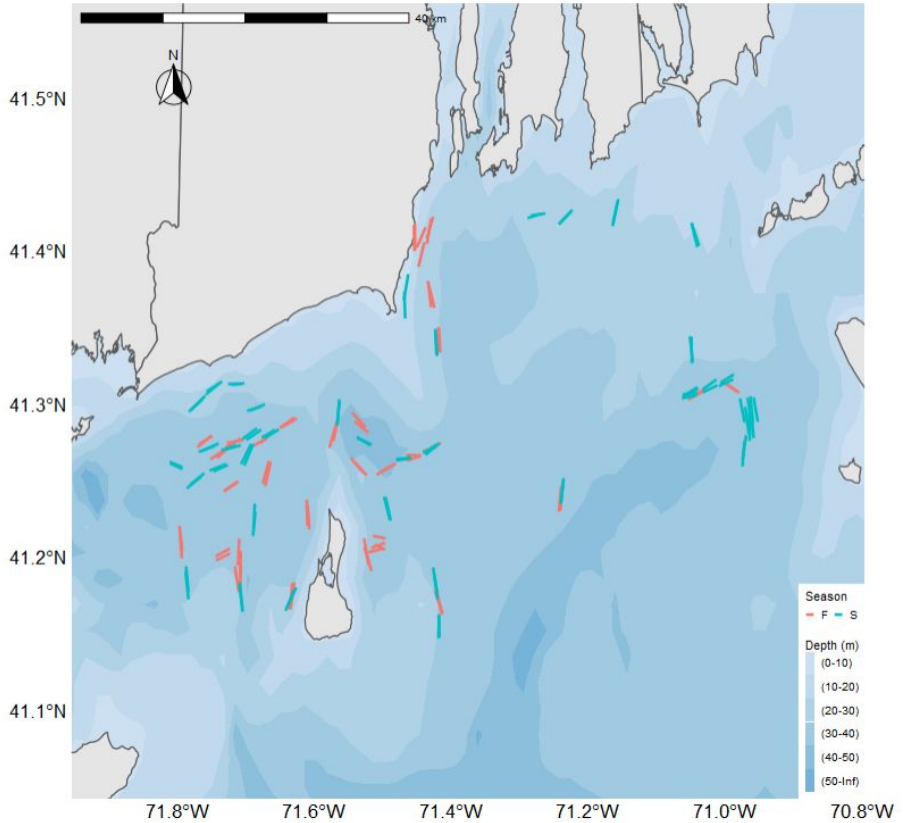
- Captain, crew from F/V Darana R
- VIMS staff
- RI DEM staff
- ROSA staff
- NEFSC staff

Summary of objectives

- Conducted paired tows on the F/V Darana R
- Evaluate catch data and gear performance
- Focus on neg. effects on catch

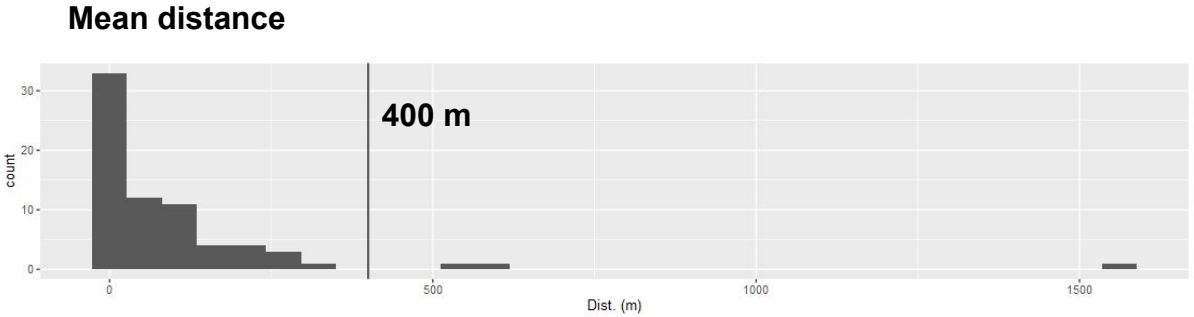
Summary of 2022 research sampling

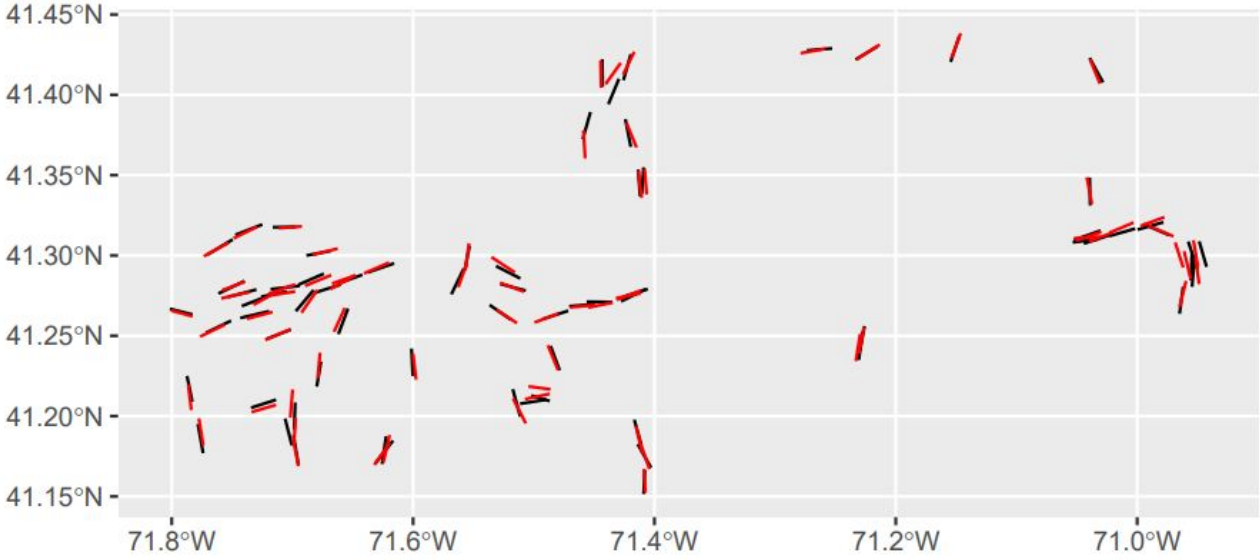
- Two sampling periods
  - Spring (5/30 - 6/6)
  - Fall (9/15 - 9/22)
- Completed 142 paired tows (71 pairs)
  - Depths between 60 ft and 200 ft
  - Sampling all in Block/Rhode Island Sounds
  - A few logistic challenges (hangs/weather) but very limited impact
  - 20 minute tows less than ¼ mile (~400 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



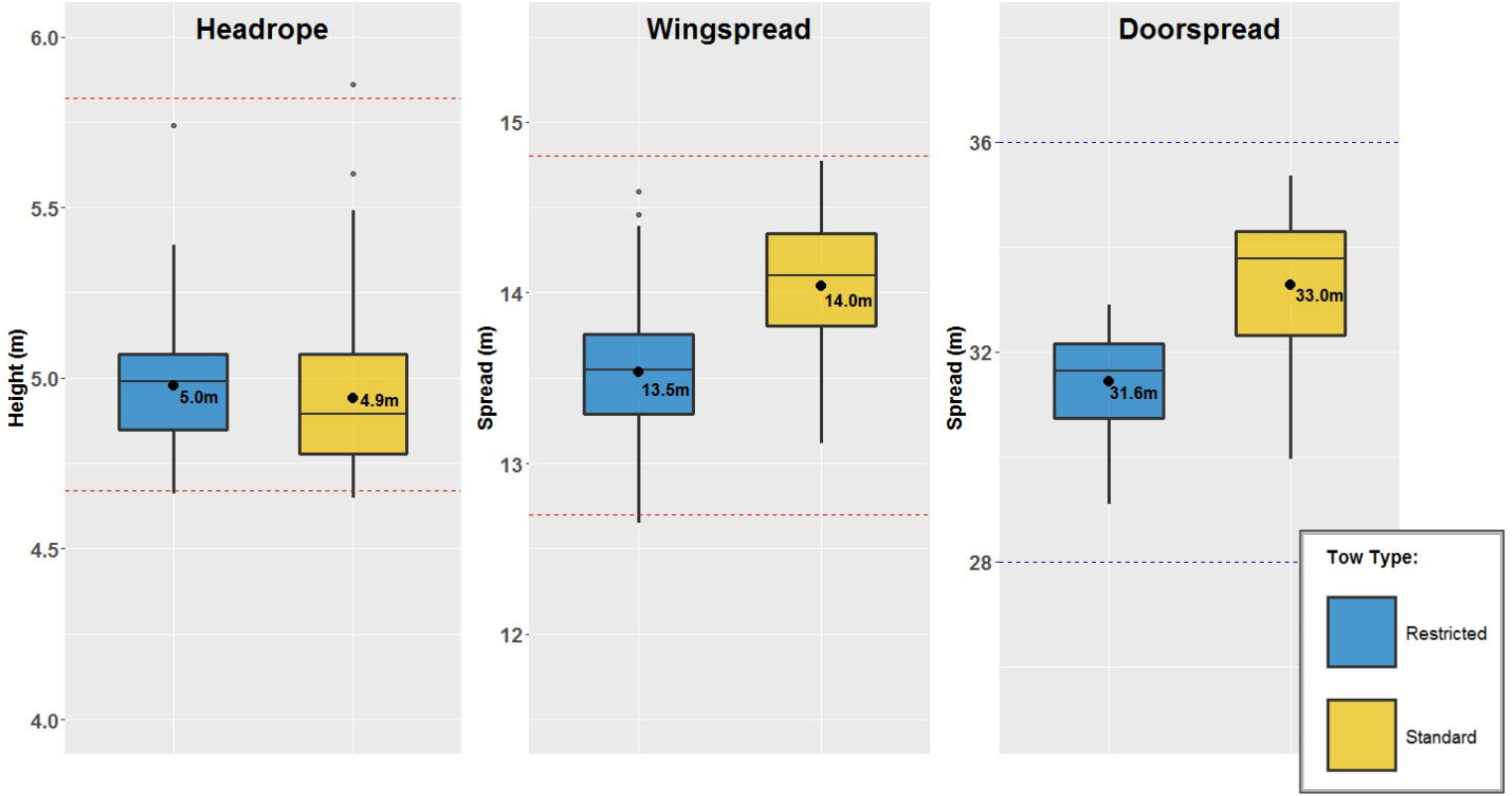
Paired tow spacing

- 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)



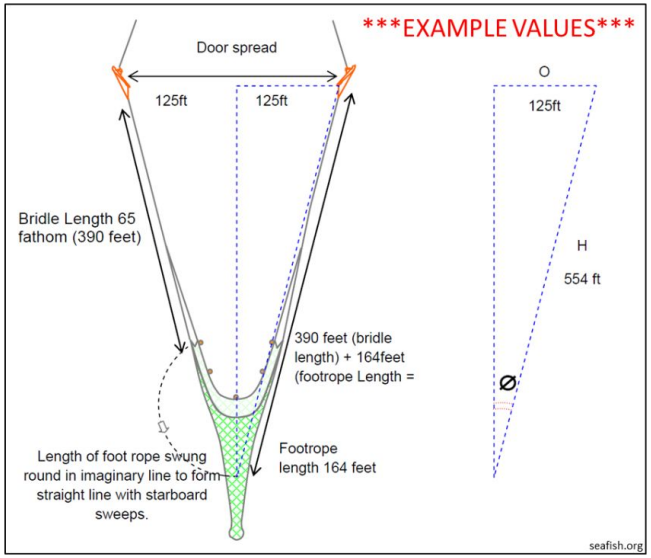


Gear metrics

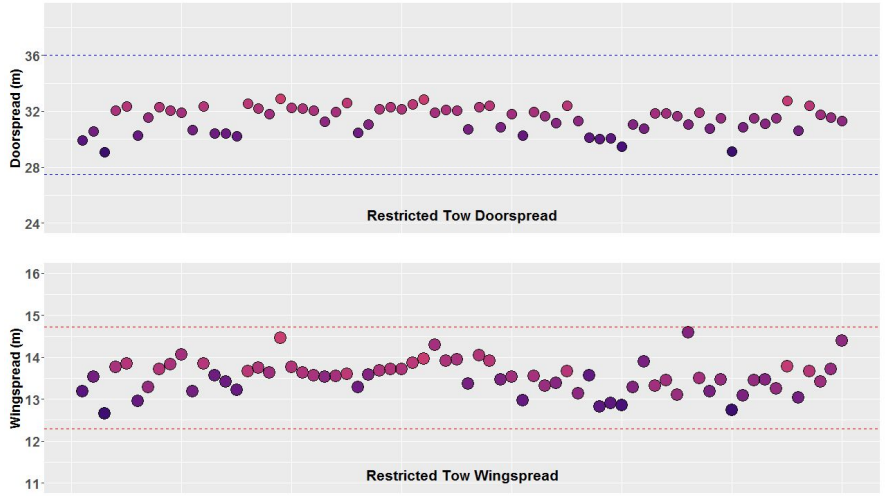


Gear metrics - Bridle angle

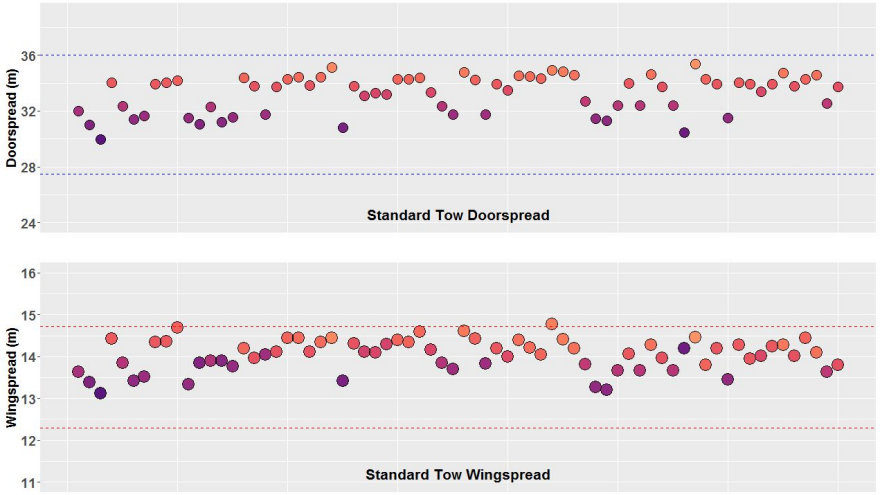
- Angle between trawl direction and bridles



Restricted



Standard



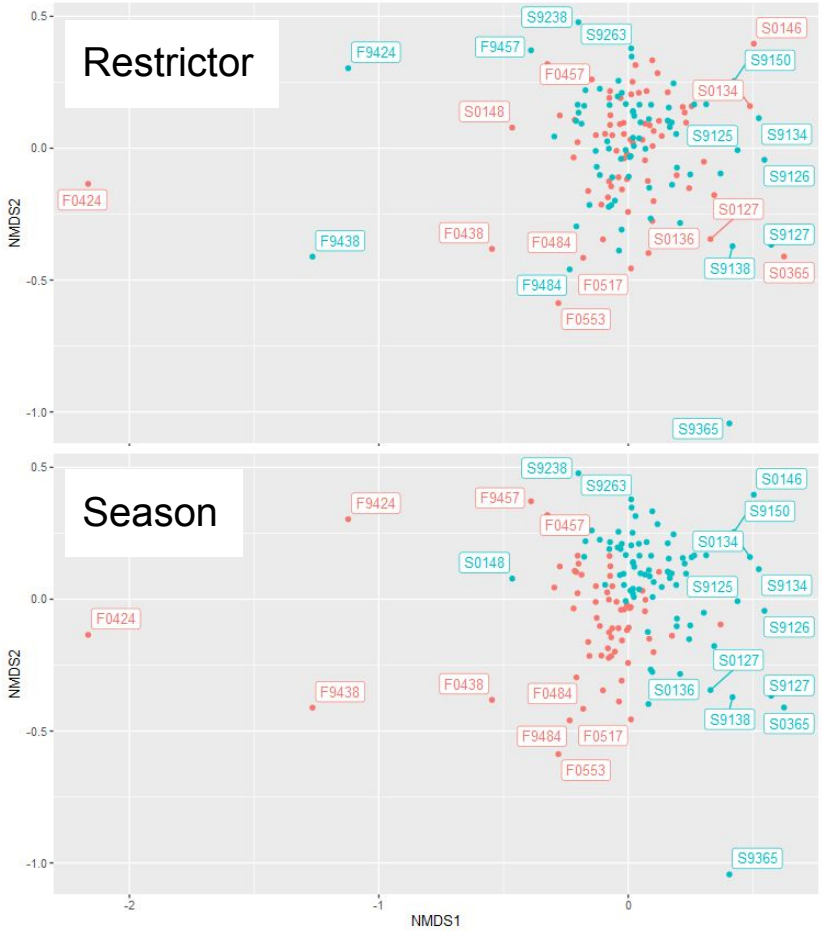
Gear metric thoughts

- There is a subtle treatment effect on net performance
- Bridal angle differences suggest restrictor is engaged and reducing variation in net geometry

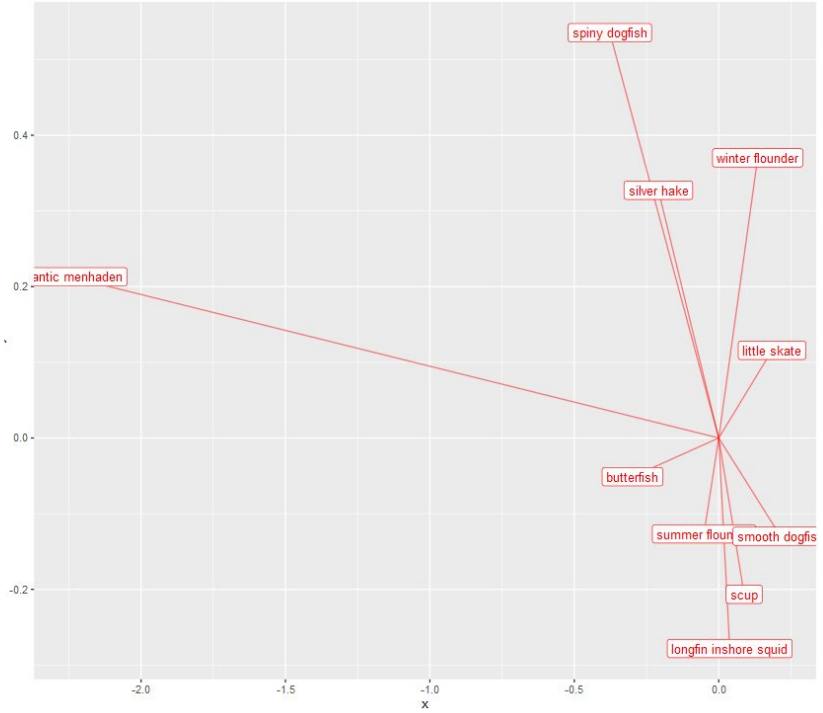
Comparing catches in paired tows

1. Investigating species prevalences and research objectives

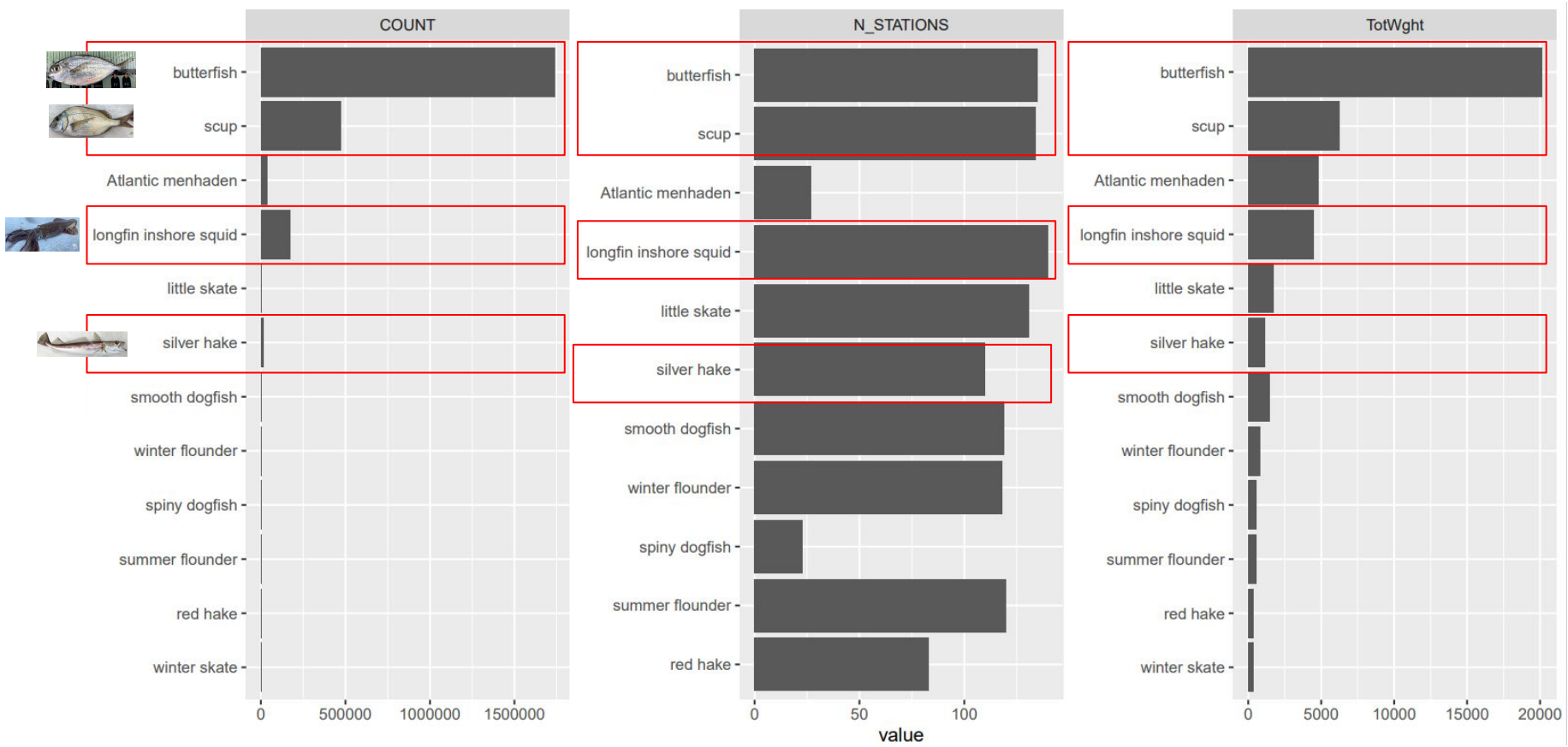
Plotting catches in two dimensions



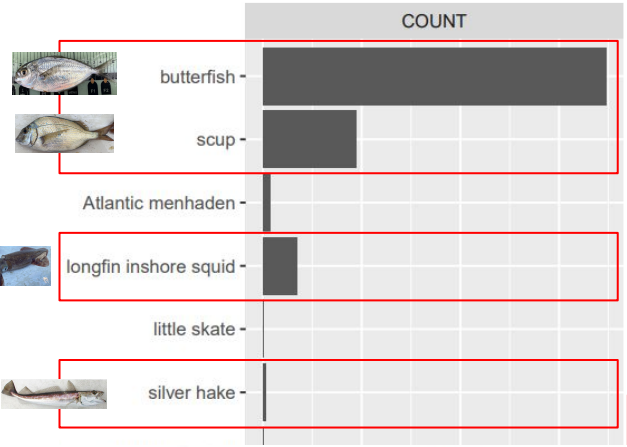
- No clear effect of restrictor
- Some effect of season
- Differences between seasons relate to spiny dogfish and fluke

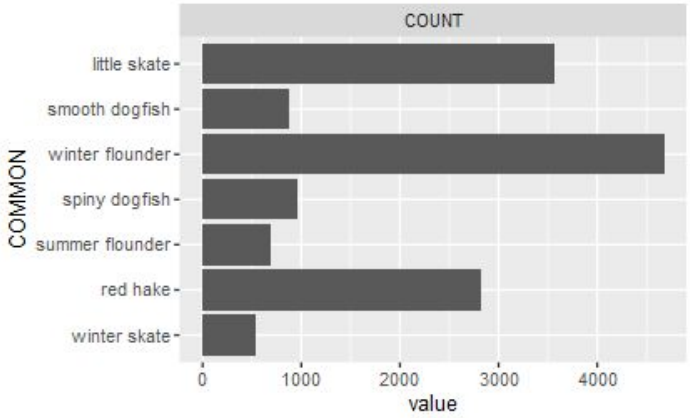


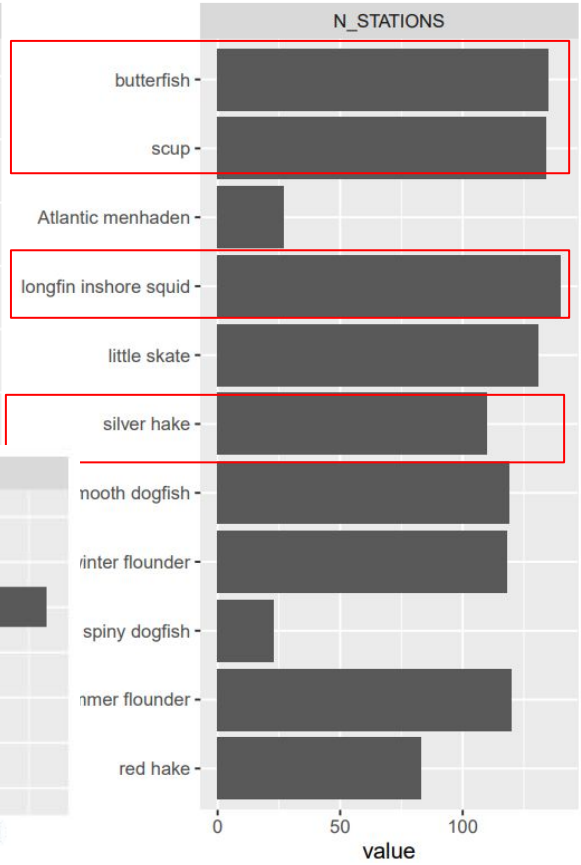
Prevalence of different species in tows

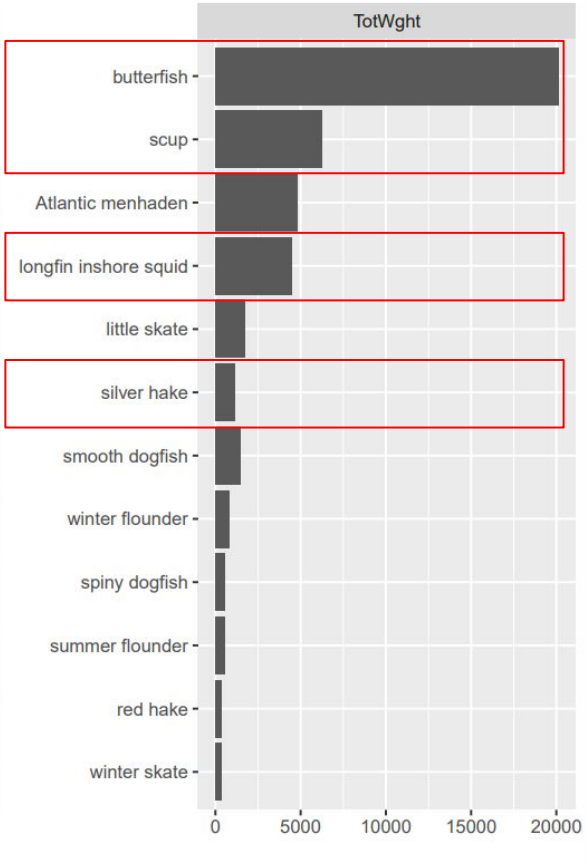


Prevalence of different species in tows



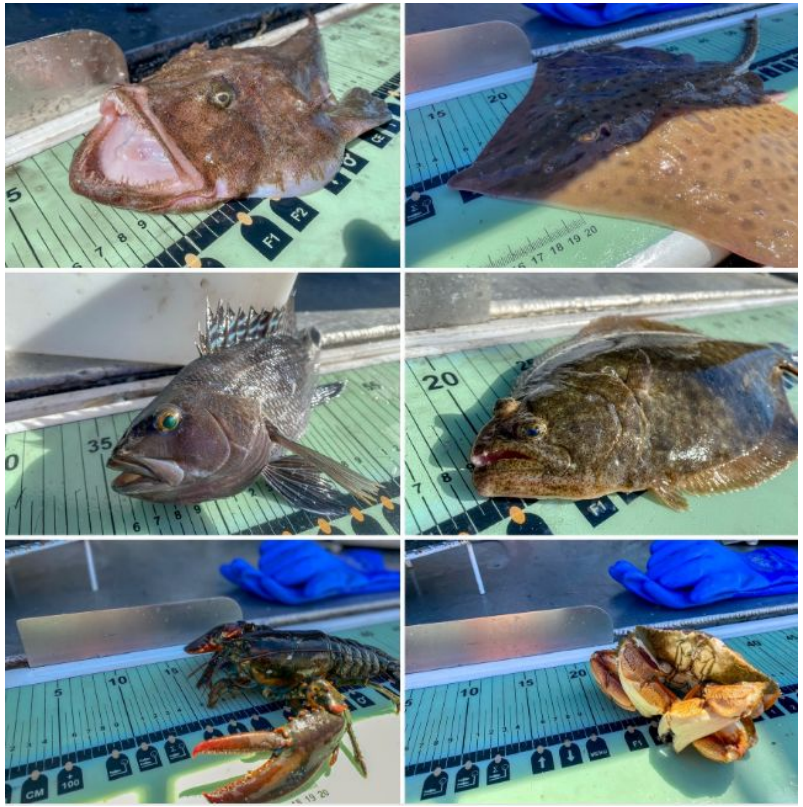






Species focus for analysis

- 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
- Interest in **longfin squid** as well mobile and thought to have good vision
- Others less commonly caught, might be difficult to draw conclusions about

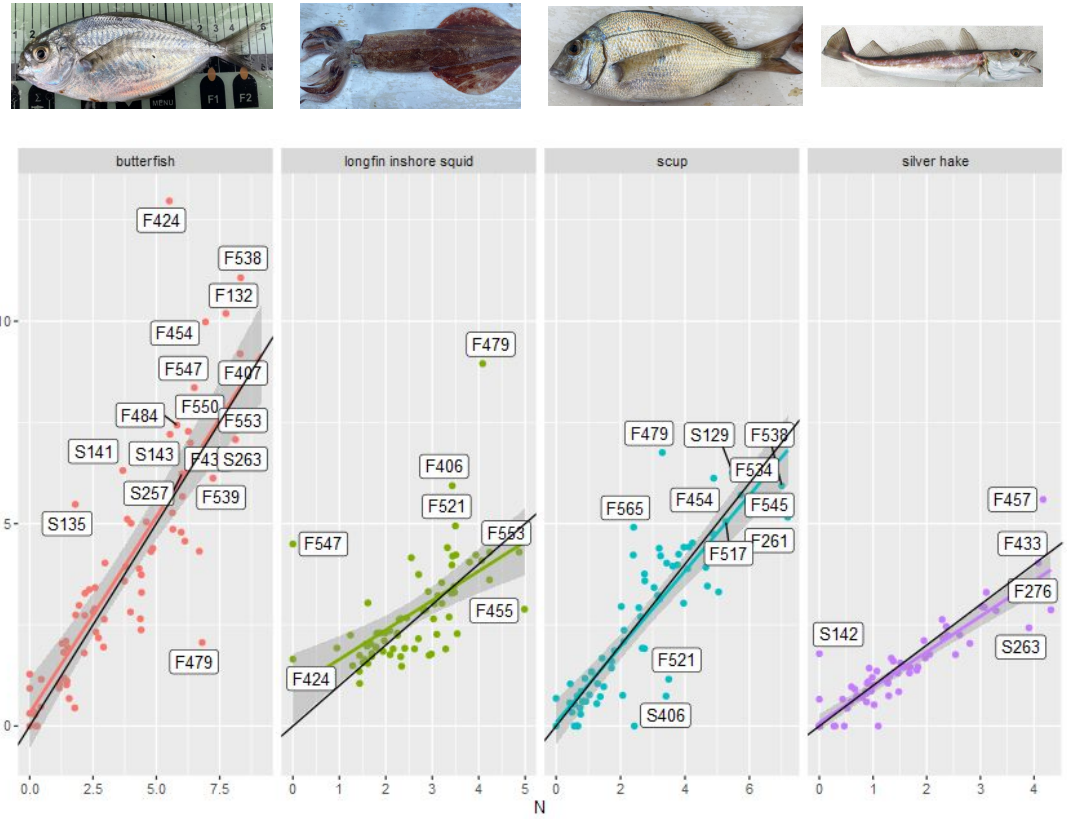


Comparing catches in paired tows

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

Aggregate catches

- First cubic root transformed catch data
- Each pair of points is a pair of stations
- X value is the station without a restrictor
- Y value is station with the restrictor
- Would expect 1:1 if there is a limited impact of the restrictor



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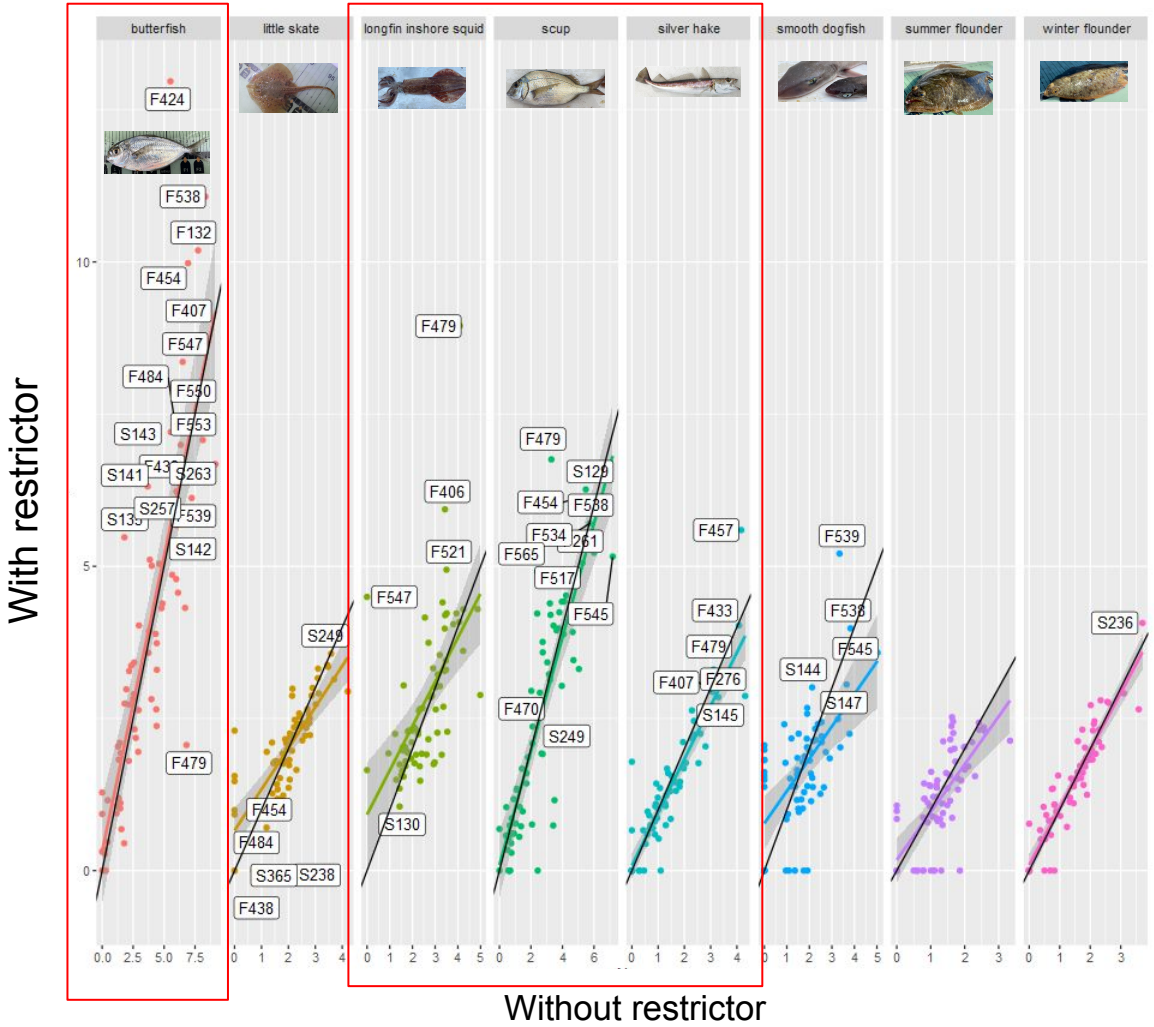


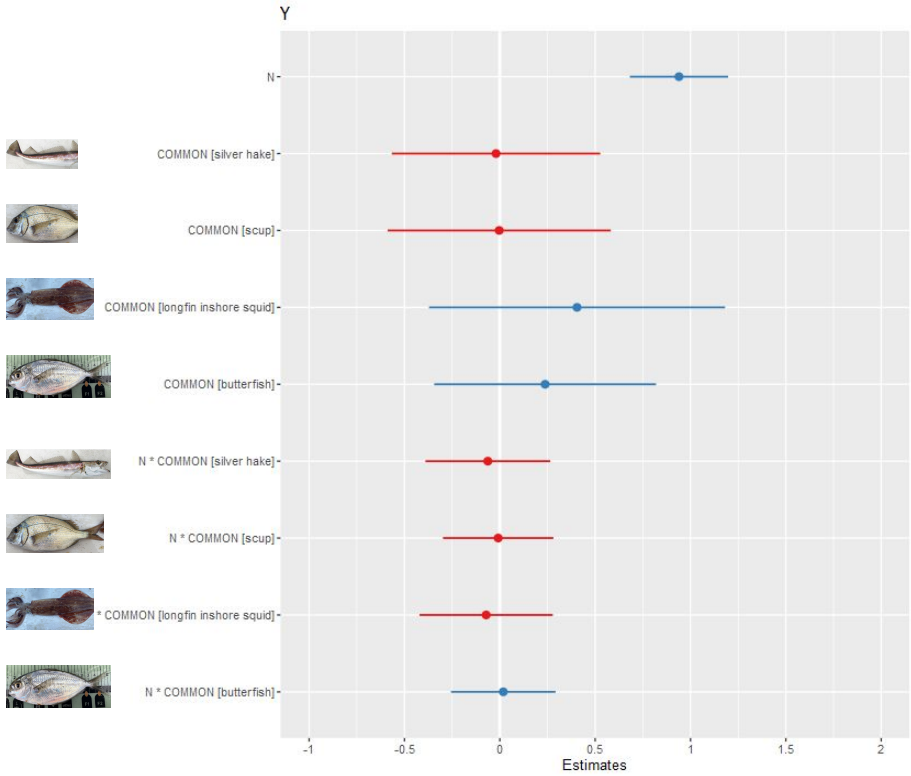
Aggregate catches

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

```
> summ(model_3)
MODEL INFO:
Observations: 355
Dependent Variable: Y
Type: OLS linear regression

MODEL FIT:
F(9,345) = 120.12, p = 0.00
R² = 0.76
Adj. R² = 0.75

Standard errors: OLS
------------------------------------------------------------
                                Est.   S.E.   t val.      p
---------------------------- ------- ------ -------- ------
(Intercept)                     0.09   0.21     0.44   0.66
N                               0.94   0.13     7.17   0.00
COMMONsilver hake              -0.01   0.28    -0.04   0.97
COMMONscup                     -0.00   0.30    -0.01   1.00
COMMONlongfin inshore           0.83   0.38     2.15   0.03
squid
COMMONbutterfish                0.22   0.30     0.75   0.45
N:COMMONsilver hake            -0.07   0.17    -0.40   0.69
N:COMMONscup                   -0.01   0.15    -0.05   0.96
N:COMMONlongfin inshore        -0.21   0.18    -1.22   0.22
squid
N:COMMONbutterfish              0.03   0.14     0.20   0.84
------------------------------------------------------------
>
```



Aggregate catch

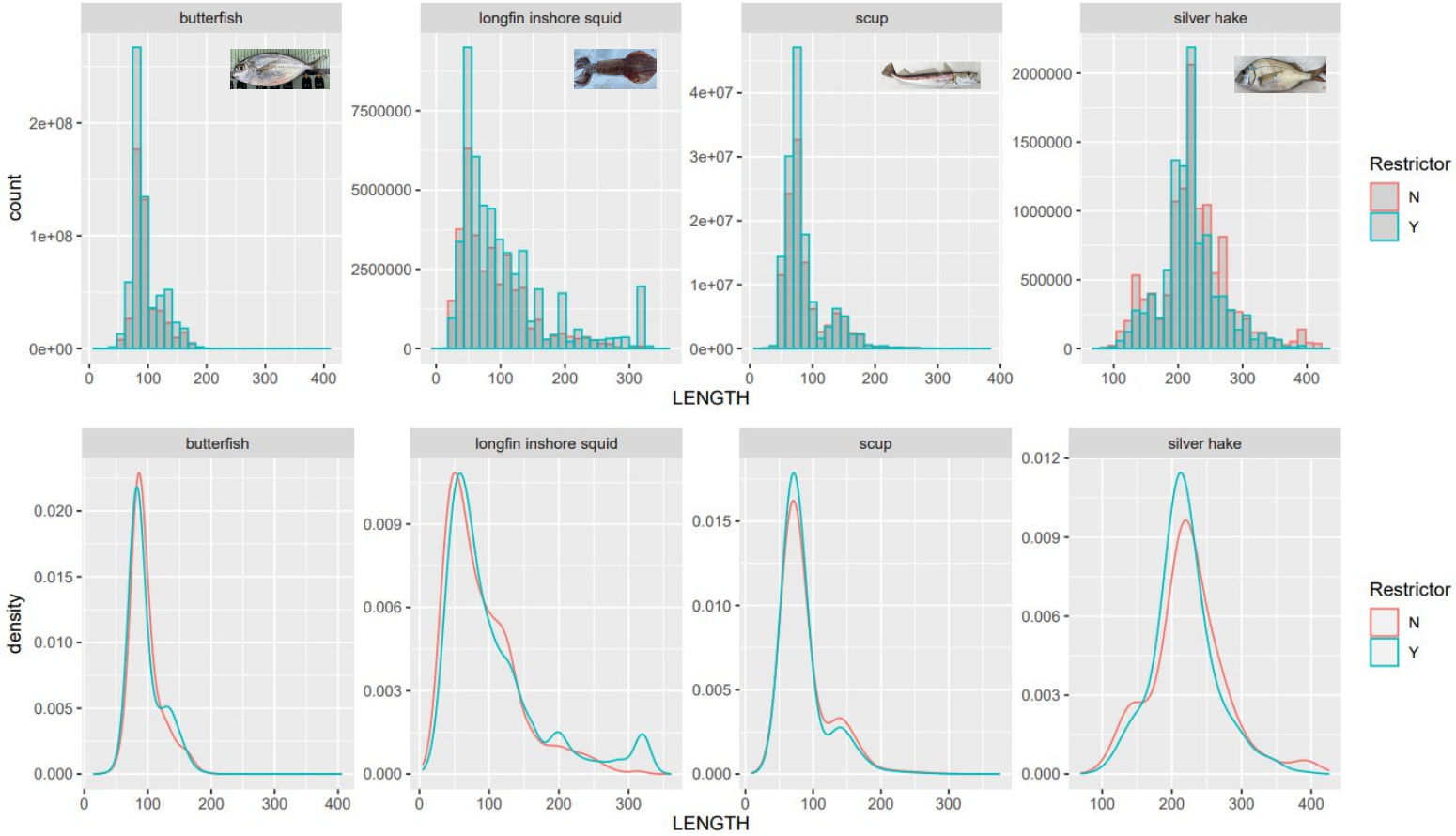
- Close to 1:1 when regressing catches without and catches with the restrictor rope
- No sig. effects in the model
- Many different model formulations result in similar results
- Suggests no detectable effect of the restrictor rope

Moving on to individual lengths

1. Explored individual lengths for three of the most common roundfish species (and squid)
2. Also fit statistical models to individual length data to test for statistical effects of the restrictor rope

Exploring ind. data

- Raw histogram and the kernel density



Comparing catch in paired tows

1. Fit GLMM and GAM models
2. Similar to Holst and Reville (2009)
3. Separate models for each species
4. Trimmed to lengths that were caught at >10 stations for each species
5. Included a set of variables in each model
    a. Depth, order, season, solar zenith angle, and length
6. Preliminary exploration of patterns

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journal homepage: www.elsevier.com/locate/fishres

A simple statistical method for catch comparison studies

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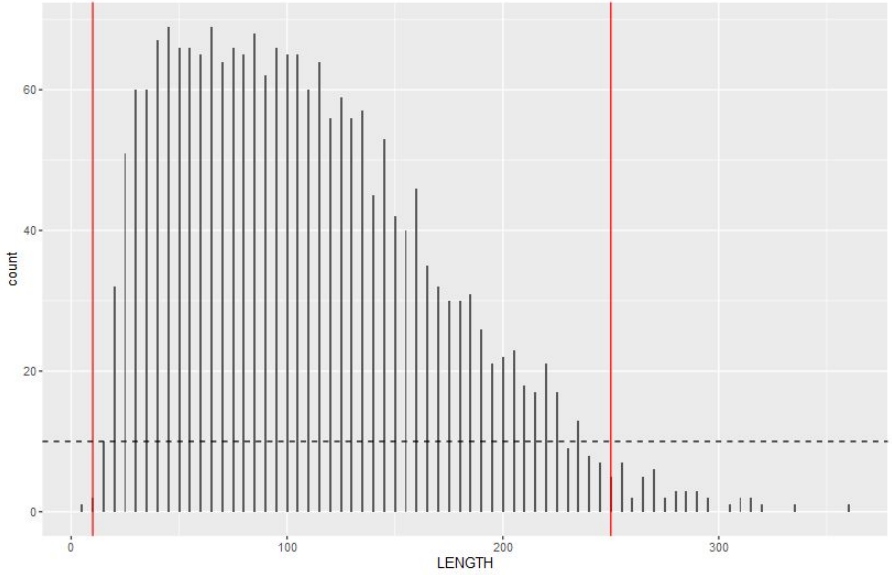
[b] Centre for Environment Fisheries & Aquaculture Science (CEFAS), Pakefield Road, Lowestoft, NR33 0HT, UK

Lengths used for modeling

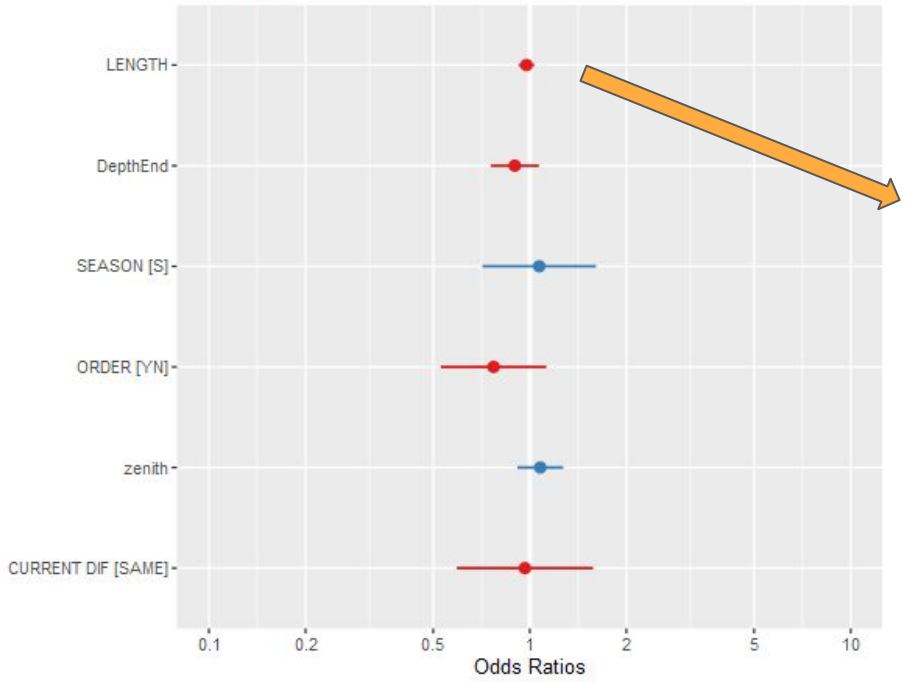


Individual lengths: longfin

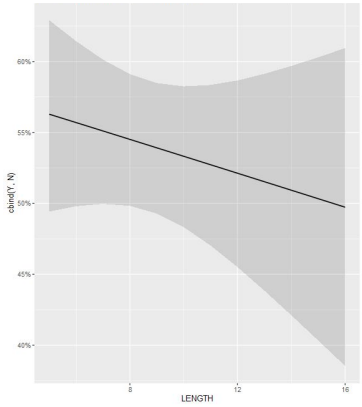
- Linear mixed binomial models for longfin squid
- No sig. effects

```
> summ(length_mod_bi_7)
MODEL INFO:
Observations: 2032
Dependent Variable: cbind(Y, N)
Type: Mixed effects generalized linear regression
Error Distribution: binomial
Link function: logit

MODEL FIT:
AIC = 3267111.62, BIC = 3267167.79
Pseudo-R² (fixed effects) = 0.01
Pseudo-R² (total) = 0.26

FIXED EFFECTS:
----------------------------------------------------
                        Est.   S.E.   z val.      p
---------------------- ------- ------ -------- ------
(Intercept)             1.15   1.15     1.00   0.32
LENGTH                 -0.02   0.03    -0.83   0.41
DepthEnd               -0.11   0.09    -1.22   0.22
SEASONS                 0.07   0.21     0.32   0.75
ORDERYN                -0.26   0.19    -1.34   0.18
zenith                  0.08   0.08     0.89   0.37
CURRENT_DIFSAME        -0.04   0.25    -0.14   0.89
----------------------------------------------------

RANDOM EFFECTS:
-----------------------------------
 Group    Parameter    Std. Dev.
------- ------------- -----------
 PAIR    (Intercept)     2.22
 PAIR      LENGTH        0.24
-----------------------------------

Grouping variables:
-------------------------
 Group   # groups   ICC
------- ---------- ------
 PAIR       69      0.60
-------------------------
```

Relative selectivity



Relative selectivity

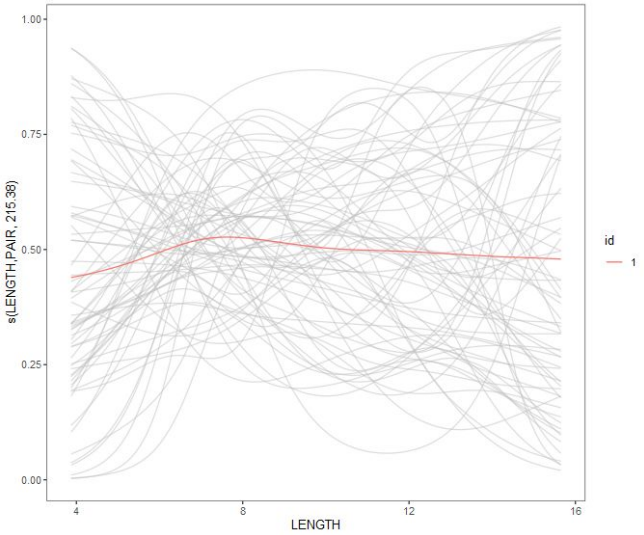


Individual lengths: longfin

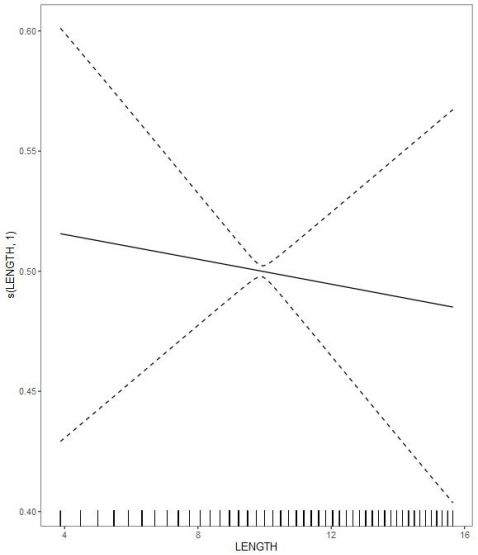
- Quasibinomial GAM models for longfin squid
- No effects of depth, order, season, length, or other covariates

```
> 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(zenith) + CURRENT_DIF +
    s(LENGTH, bs = "cr", k = 3)

Parametric coefficients:
                     Estimate Std. Error  t value Pr(>|t|)
(Intercept)          0.117078   0.198206  0.59069  0.55480
ORDERYN             -0.200478   0.203137 -0.98691  0.32381
SEASONS              0.168927   0.233179  0.72445  0.46888
CURRENT_DIFDIFFERENT -0.254338   0.256146 -0.99294  0.32087

Approximate significance of smooth terms:
                    edf    Ref.df       F  p-value
s(LENGTH,PAIR) 215.38309 683.00000 1.62136  < 2e-16 ***
s(DepthEnd)      7.54409   7.68575 1.97304 0.054838 .
s(zenith)        1.00282   1.00341 0.56813 0.451625
s(LENGTH)        1.00112   1.00127 0.12491 0.724103
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.541   Deviance explained = 53.6%
GCV = 1590.5  Scale est. = 1276.3     n = 2074
> |
```

Relative selectivity



Relative selectivity

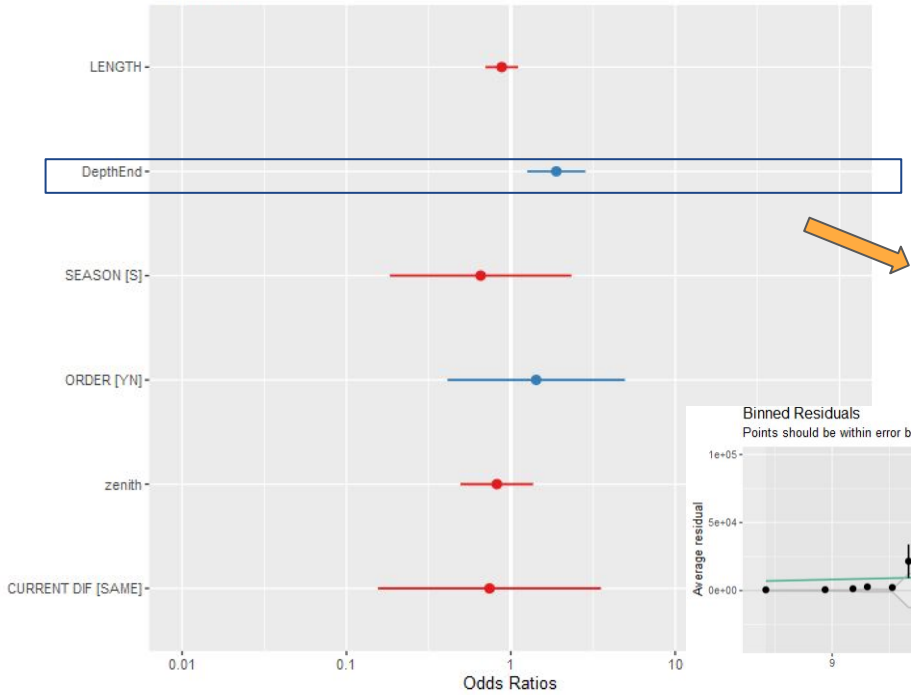


Individual lengths: Scup

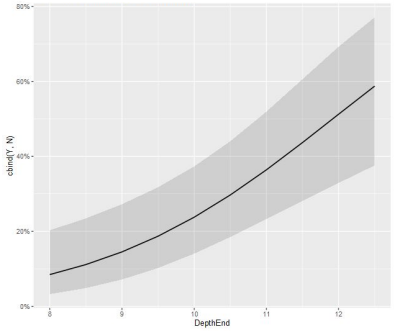
- Linear mixed binomial models for scup
- No effect of length, order, or season
- Small positive effect of depth

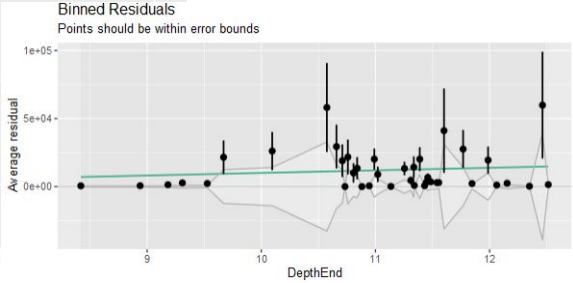
```
> summ(length_mod_bi_7)
MODEL INFO:
Observations: 1568
Dependent Variable: cbind(Y, N)
Type: Mixed effects generalized linear regression
Error Distribution: binomial
Link function: logit

MODEL FIT:
AIC = 3846337.64, BIC = 3846391.22
Pseudo-R² (fixed effects) = 0.03
Pseudo-R² (total) = 0.82

FIXED EFFECTS:
----------------------------------------------------
                         Est.   S.E.   z val.      p
---------------------- ------- ------ -------- ------
(Intercept)             -4.45   1.34    -3.34   0.00
LENGTH                  -0.13   0.12    -1.09   0.28
DepthEnd                 0.64   0.21     3.05   0.00
SEASONS                 -0.42   0.65    -0.65   0.52
ORDERYN                  0.36   0.63     0.56   0.57
zenith                  -0.20   0.26    -0.75   0.45
CURRENT_DIFSAME         -0.30   0.80    -0.37   0.71
----------------------------------------------------

RANDOM EFFECTS:
---------------------------------
 Group    Parameter    Std. Dev.
------- ------------ -----------
 PAIR    (Intercept)     12.10
 PAIR      LENGTH         1.01
---------------------------------

Grouping variables:
-------------------------
 Group   # groups   ICC
------- ---------- ------
 PAIR       70      0.98
-------------------------
```

Relative selectivity



Relative selectivity



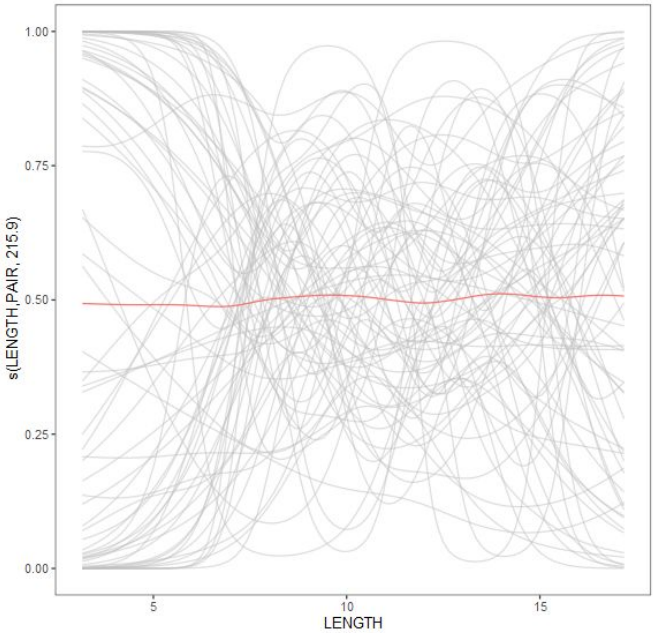


Individual lengths: Scup

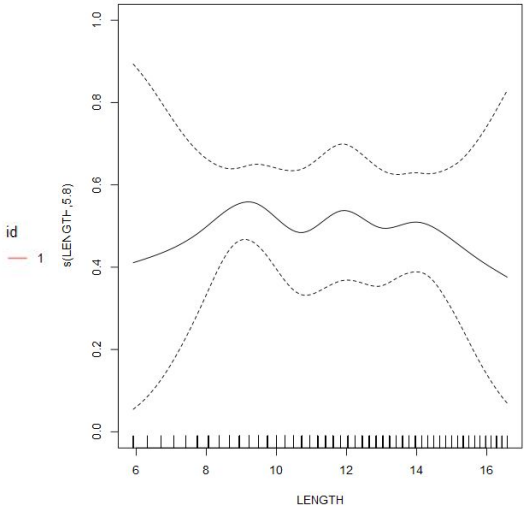
- Quasibinomial GAM models for scup
- No effects of depth, order, season, or length

```
> 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(zenith) + CURRENT_DIF +
    s(PAIR, bs = "re") + s(LENGTH, bs = "cr")

Parametric coefficients:
                          Estimate Std. Error  t value Pr(>|t|)
(Intercept)            -0.2133901  0.3601711 -0.59247  0.55364
ORDERYN                 0.0841887  0.4226045  0.19921  0.84213
SEASONS                -0.0650268  0.4579787 -0.14199  0.88711
CURRENT_DIFDIFFERENT -0.1765737  0.5079312 -0.34763  0.72817

Approximate significance of smooth terms:
                     edf    Ref.df        F p-value
s(LENGTH,PAIR) 182.77819 615.00000 16.52204 0.66807
s(DepthEnd)      2.97454   3.07053  1.00322 0.39857
s(zenith)        4.34857   4.49716  1.48376 0.19659
s(PAIR)         34.17290  64.00000  1.22452 < 2e-16 ***
s(LENGTH)        5.79715   6.43149  1.02987 0.60785
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.862   Deviance explained = 85.4%
GCV = 1506.2  Scale est. = 1263.3     n = 1568
```

Relative selectivity



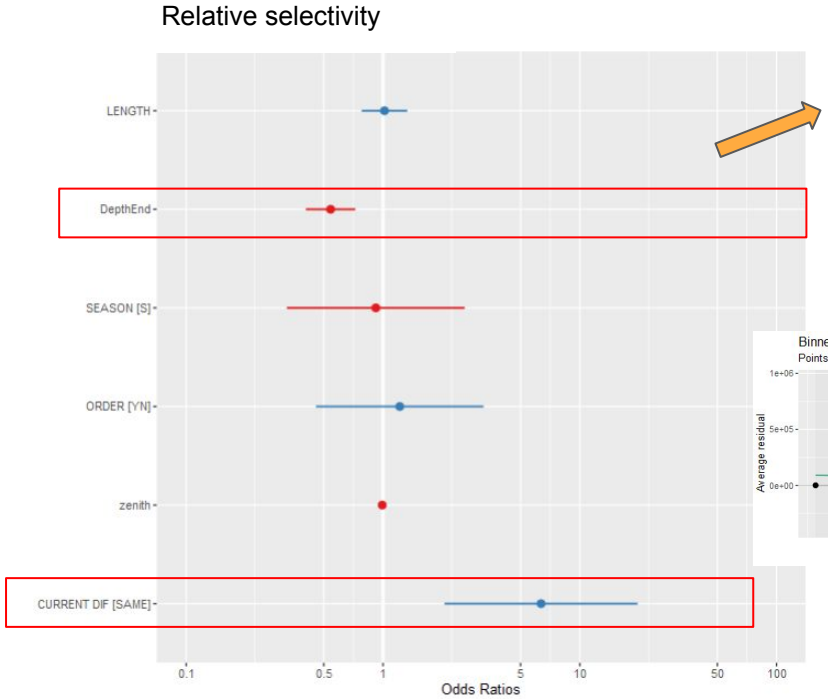
Relative selectivity

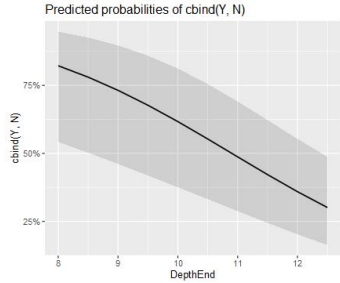


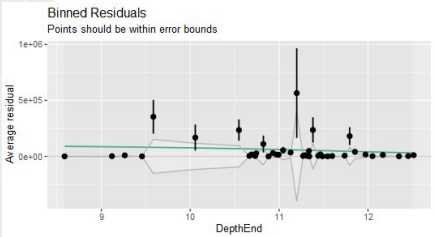
Individual lengths: Butterfish

- Linear mixed binomial models for butterfish
- No effect of length, order, or season
- Small negative effect of depth, positive effect of current direction

```
> summ(length_mod_bi_7)
MODEL INFO:
Observations: 1500
Dependent Variable: cbind(Y, N)
Type: Mixed effects generalized linear regression
Error Distribution: binomial
Link function: logit

MODEL FIT:
AIC = 7706351.10, BIC = 7706404.24
Pseudo-R² (fixed effects) = 0.03
Pseudo-R² (total) = 0.86

FIXED EFFECTS:
----------------------------------------------------------
                         Est.   S.E.   z val.      p
--------------------- -------- ------ -------- ------
(Intercept)              5.37   1.22     4.39   0.00
LENGTH                   0.02   0.14     0.13   0.90
DepthEnd                -0.61   0.15    -4.16   0.00
SEASONS                 -0.08   0.53    -0.16   0.87
ORDERYN                  0.20   0.50     0.39   0.69
zenith                  -0.01   0.02    -0.54   0.59
CURRENT_DIFSAME          1.85   0.58     3.21   0.00
----------------------------------------------------------

RANDOM EFFECTS:
---------------------------------
 Group     Parameter    Std. Dev.
------- ------------- -----------
 PAIR    (Intercept)     9.59
 PAIR      LENGTH        1.19
---------------------------------

Grouping variables:
-------------------------
 Group   # groups   ICC
------- ---------- ------
 PAIR       70      0.97
-------------------------
```





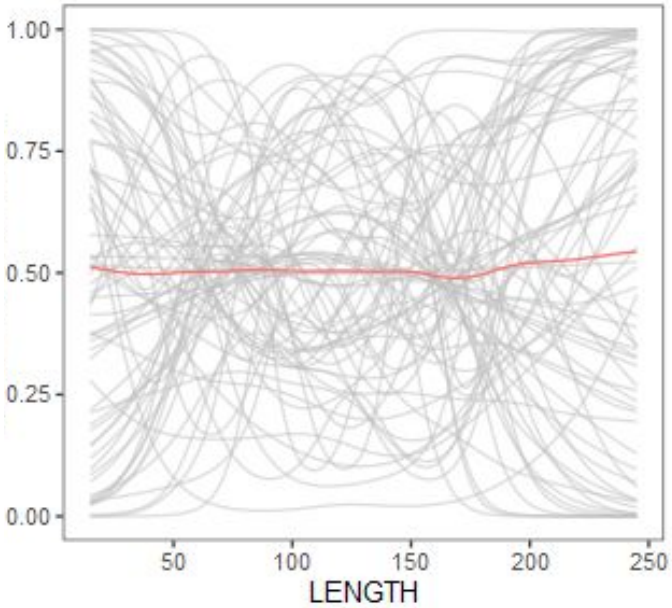


Individual lengths: Butterfish

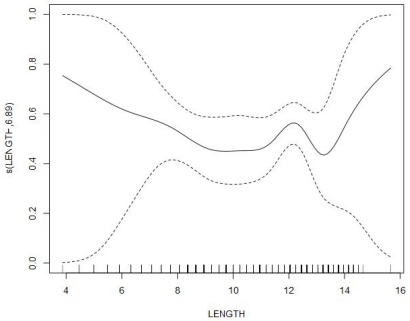
- Quasibinomial GAM models for butterfish
- No effect of season, length, depth, or order
- Sig effect of current

```
> 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(zenith) + CURRENT_DIF +
    s(PAIR, bs = "re") + s(LENGTH, bs = "cr")

Parametric coefficients:
                          Estimate Std. Error  t value Pr(>|t|)
(Intercept)             0.2438894  0.3570853  0.68300 0.494735
ORDERYN                 0.0740683  0.4020483  0.18423 0.853865
SEASONS                 0.0201877  0.4694217  0.04301 0.965704
CURRENT_DIFDIFFERENT -1.1580247  0.5510147 -2.10162 0.035789 *
---
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) 219.52539 649.00000 29.23857 0.43607
s(DepthEnd)      1.57535   1.65516  2.22637 0.23532
s(zenith)        3.47288   3.55665  0.11051 0.97177
s(PAIR)         10.78460  64.00000  0.14668 < 2e-16 ***
s(LENGTH)        6.99111   7.59104  1.24439 0.19441
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.922   Deviance explained = 92.2%
GCV = 3622.9  Scale est. = 2623.5     n = 1478
```

Relative selectivity



Relative selectivity



Individual lengths: Butterfish

- Similar result from more recent log-Gaussian Cox method (thank you Jim and Tim)
- No covariates included

ICES Journal of Marine Science

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Original Article

Intercalibration of survey methods using paired fishing operations and log-Gaussian Cox processes

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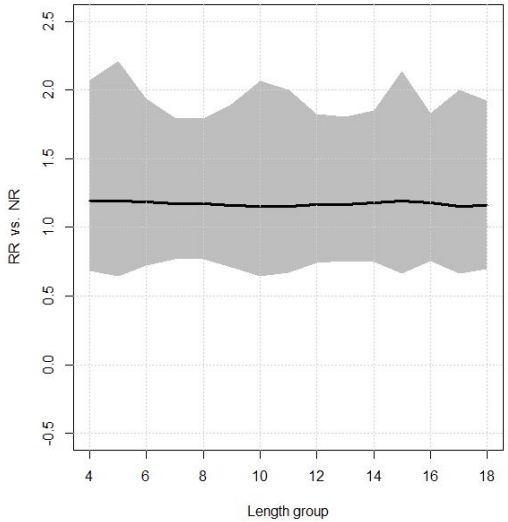
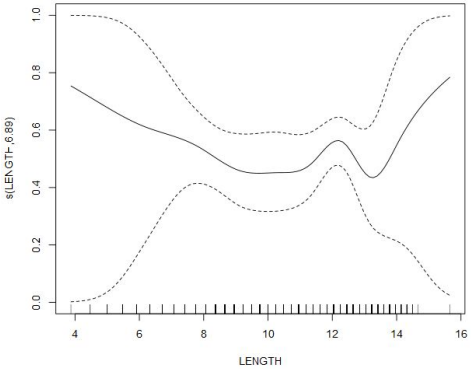
Received 6 February 2018; revised 13 November 2018; accepted 15 November 2018; advance access publication 8 January 2019.

Relative selectivity



Relative selectivity



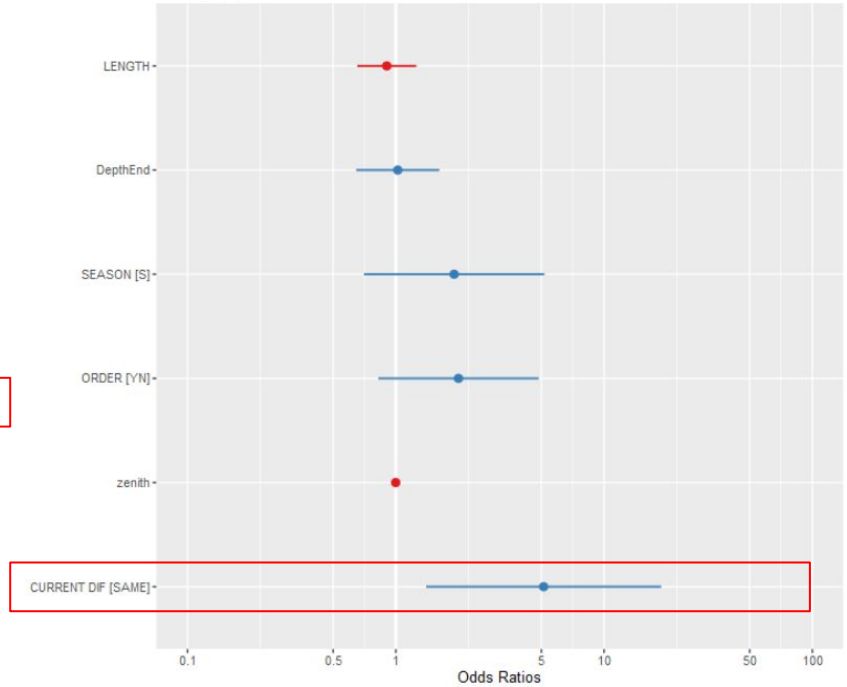
From previous GAM

Individual lengths: Silver hake

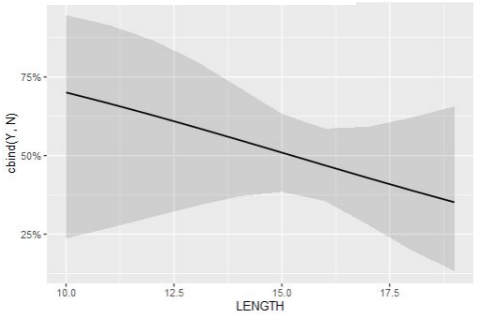
- Linear mixed binomial models for silver hake
- No effect of length, order, depth, or season
- Sig effect of current

```
> summ(length_mod_bi_7)
MODEL INFO:
Observations: 1253
Dependent Variable: cbind(Y, N)
Type: Mixed effects generalized linear regression
Error Distribution: binomial
Link function: logit

MODEL FIT:
AIC = 1097753.06, BIC = 1097804.39
Pseudo-R² (fixed effects) = 0.03
Pseudo-R² (total) = 0.86

FIXED EFFECTS:
----------------------------------------------------------
                         Est.   S.E.   z val.      p
---------------------- ------- ------ -------- ------
(Intercept)             -0.82   2.10    -0.39   0.70
LENGTH                  -0.10   0.17    -0.60   0.55
DepthEnd                 0.02   0.23     0.09   0.93
SEASONS                  0.64   0.51     1.27   0.21
ORDERYN                  0.69   0.45     1.53   0.13
zenith                  -0.00   0.01    -0.10   0.92
CURRENT_DIFSAME          1.63   0.66     2.47   0.01
----------------------------------------------------------

RANDOM EFFECTS:
---------------------------------
 Group    Parameter    Std. Dev.
------- ------------- -----------
 PAIR    (Intercept)     24.03
 PAIR      LENGTH        1.53
---------------------------------

Grouping variables:
-------------------------
 Group   # groups   ICC
------- ---------- ------
 PAIR       58      0.99
-------------------------
```

Relative selectivity



Relative selectivity

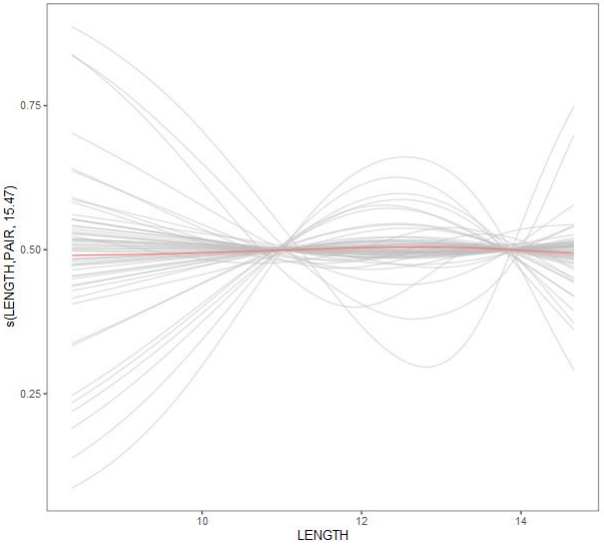


Individual lengths: Silver hake

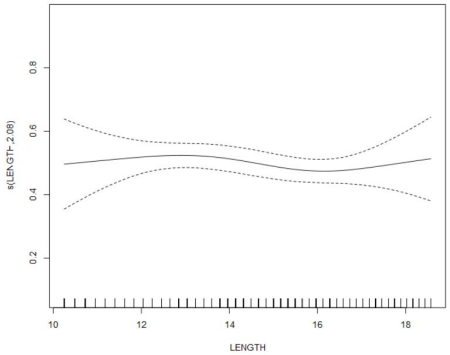
- Quasibinomial GAM models for silver hake
- Effect of order and depth

```
> 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(zenith) + CURRENT_DIF +
    s(PAIR, bs = "re") + s(LENGTH, bs = "cr")

Parametric coefficients:
                      Estimate Std. Error  t value Pr(>|t|)
(Intercept)          -0.2394571  0.1720403 -1.39187 0.164249
ORDERYN               0.4037645  0.1848330  2.18448 0.029141 *
SEASONS              -0.0209358  0.2340864 -0.08944 0.928752
CURRENT_DIFDIFFERENT -0.4296184  0.2971050 -1.44602 0.148462
---
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) 55.59066 493.00000 0.43192 < 2.22e-16 ***
s(DepthEnd)     1.93328   2.15342 3.54455   0.023707 *
s(zenith)       6.72345   7.21550 1.45595   0.186853
s(PAIR)         2.50451  52.00000 0.05744  1.041e-06 ***
s(LENGTH)       2.07817   2.48502 0.38051   0.534395
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.345   Deviance explained = 32.4%
GCV = 961.74  Scale est. = 723.47    n = 1155
```

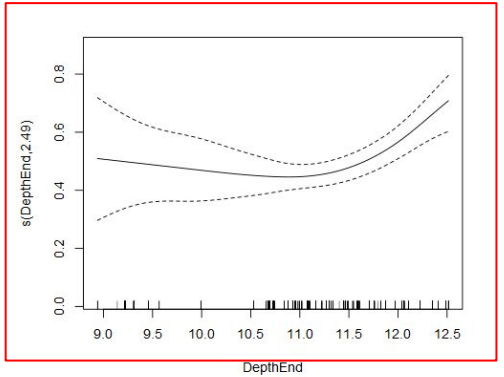
Relative selectivity



Relative selectivity



Relative selectivity



Individual lengths thoughts

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

Overall preliminary summary

Gear comparison

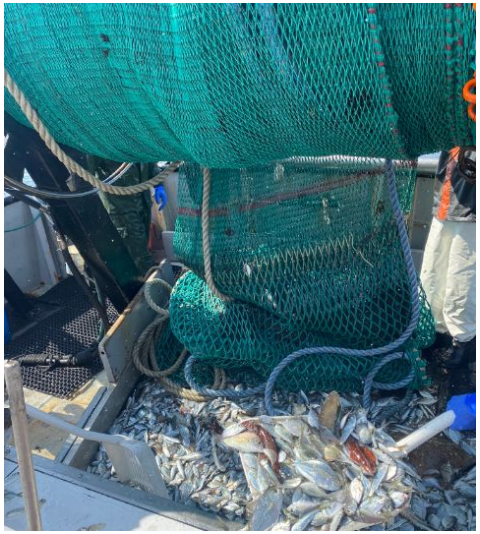
- Some effect on net width and door width
  - Wider without restrictor
- Impact on bridle angle

Aggregate weights

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

Individual lengths

- GLMMs: Small effects of depth and current
- GAMs: Some hints at non-linearity, but difficult to assess
- Very few 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?