Analyses of wingspread effects on bottom trawl survey efficiency for four flatfish species

Northeast Trawl Advisory Panel (NTAP)
Webinar
Friday January 31st 2020

NOAA FISHERIES

Acknowledgements

- Captain Chris Roebuck and crew from *F/V Karen Elizabeth*
- Input from the Northeast Trawl Advisory Panel (NTAP)
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  - Dominique St. Amand (CRB)
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  - Tyler Pavlowich (OCB)
  - Calvin Alexander (CRB)
  - Chris Parkins (RI DEM/NTAP)
  - Paul Kostovick (ESB)
  - Giovanni Gianesin (CRB)
  - Jill Price (PBB)

New England
Fishery Management
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RI DEM

MID-ATLANTIC
FISHERY MANAGEMENT COUNCIL

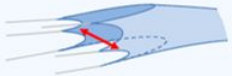
Motivation

Standard calculation of index estimates assumes:

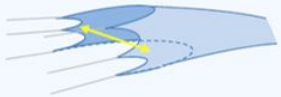
- All tows sample average area swept
- All tows have consistent fishing efficiency

Concern that the *FSV Henry B. Bigelow* gear does not perform equally across all tows

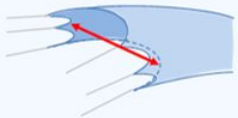
Wing spread varies with depth, presumably:



Under spread
at **shallow** stations



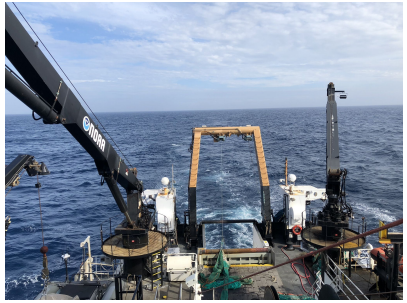
Optimal spread
at **intermediate** depth

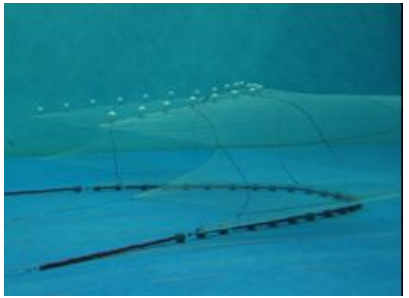


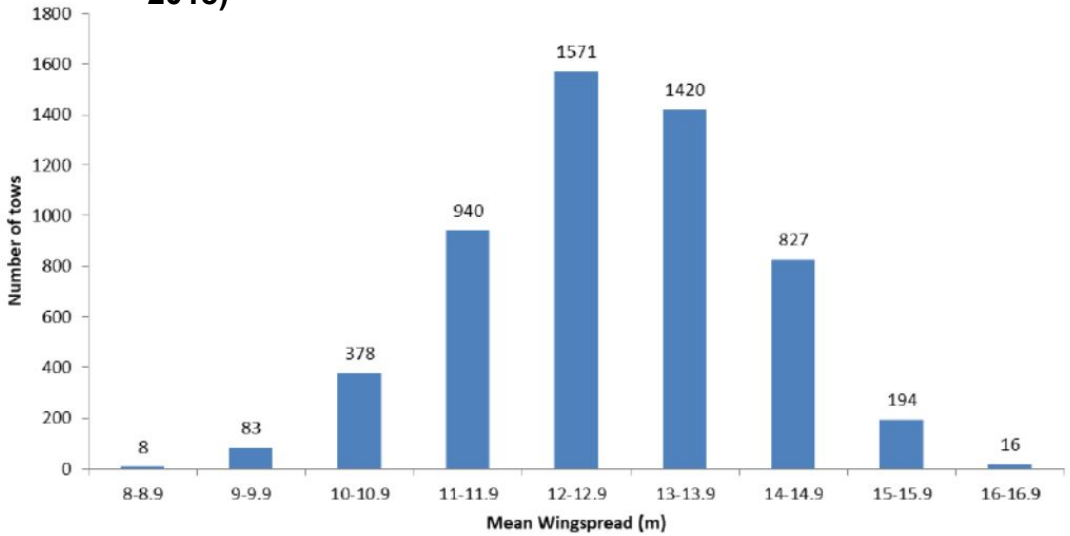
Over spread
at **deep** stations

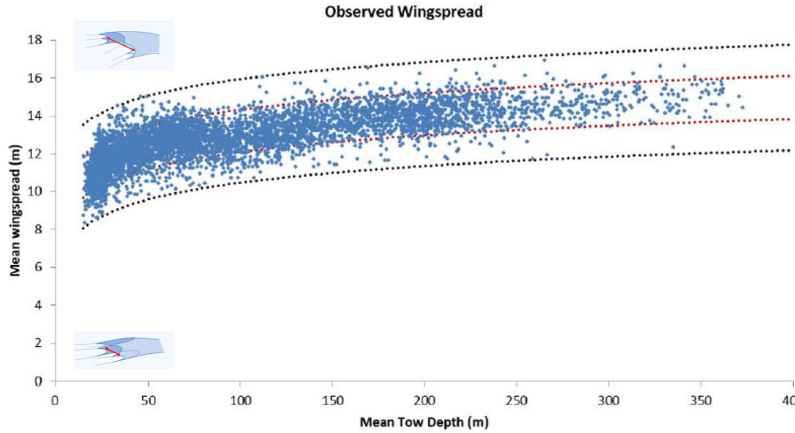
Motivation

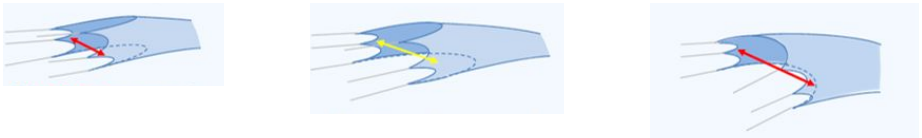
Historical data from NEFSC survey operations (through 2018)



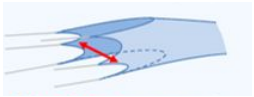


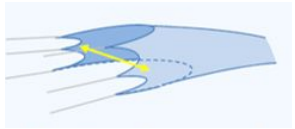


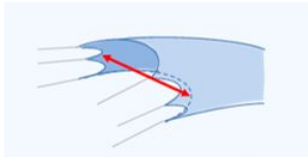




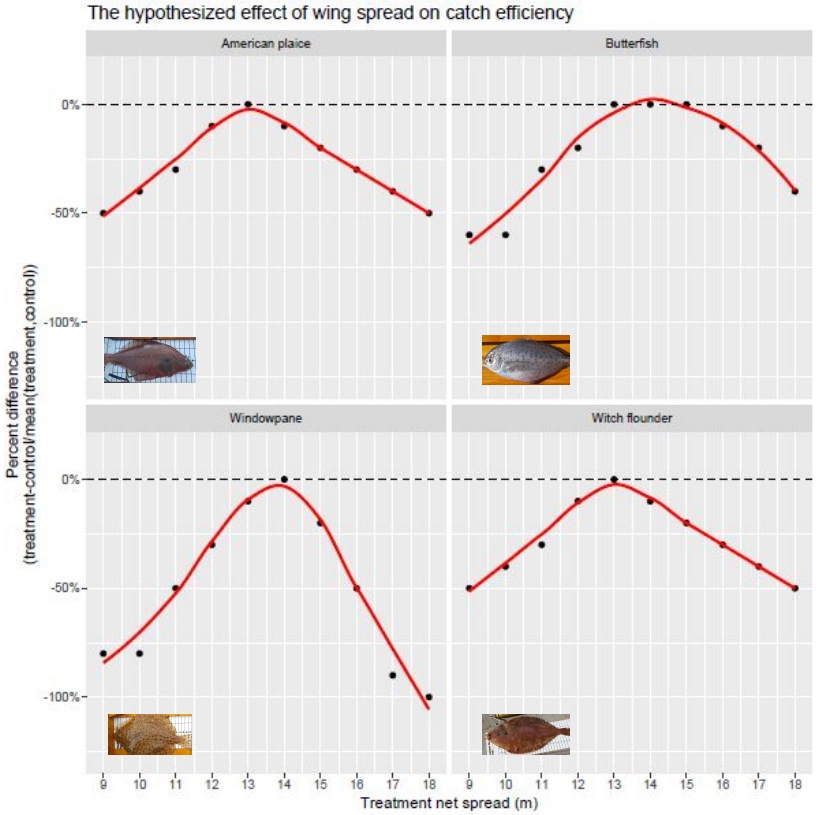
Motivation







- Interest in exploring the effect of net wingspread on catch efficiency
- Hypothesis based on fishermen's experience that net performance should be roughly unimodal
- That is: **catches should be best at optimal (~13 m) net widths**
- However, no experimental evidence to test this idea

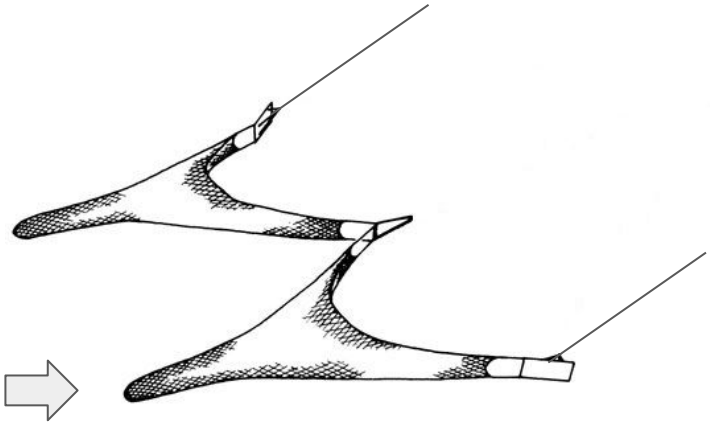


Prior Research

- The twin-trawl vessel *F/V Karen Elizabeth* has been used to do catch comparisons
- Experiments in 2015, 2016, & 2017 explored the differences in catchability between the standard survey and commercial sweeps

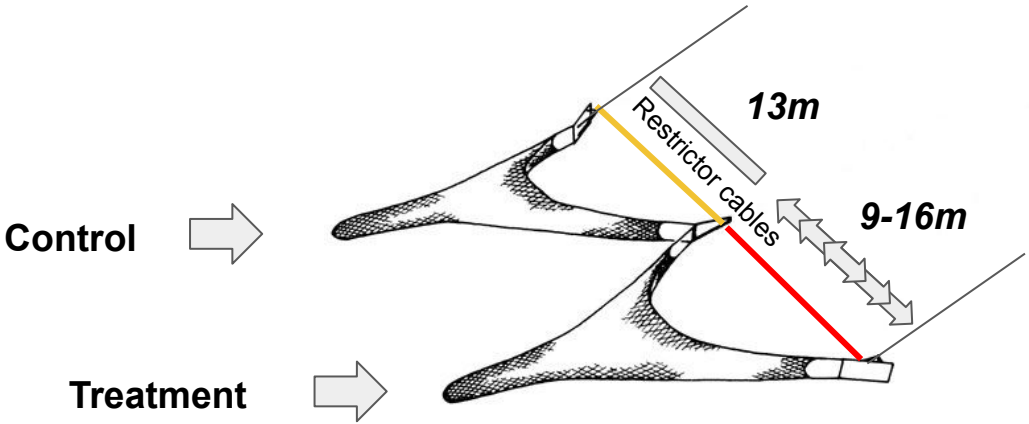
Chain

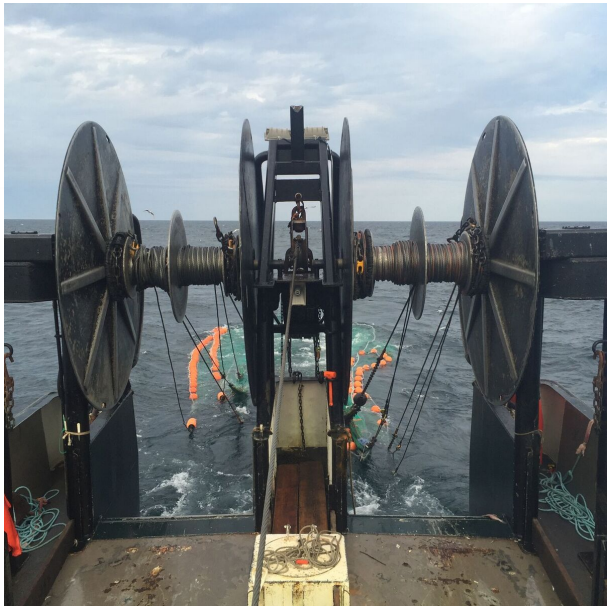
Rockhopper



Current Approach

- *F/V Karen Elizabeth was* used again to compare net configurations
- Tested the effect of different wingspreads on catch
- Varying net wingspreads (9 - 16 m range) for a treatment net (8 treatment widths)
- Net opening widths set with restrictor cables
- Treatment width compared to an ideal width (13 m)





Current Approach

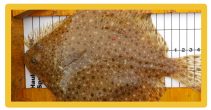
- Two legs spread over 14 days at sea
- In total accomplished 170 stations
    - ***1st leg*** was in the Gulf of Maine targeting deeper stations (red)
    - ***2nd leg*** was in Southern New England targeting shallower stations (yellow)
- Net width varied by station and the control net was deployed on both port and starboard
- Targeting four species of flatfish (but all catch recorded):

Plaice

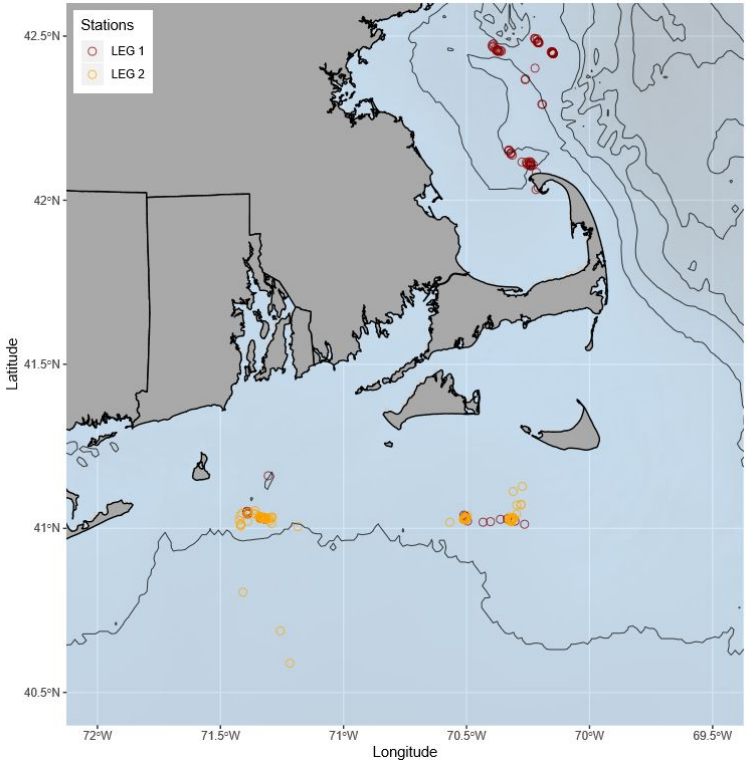
Winter flounder

Witch flounder

Windowpane



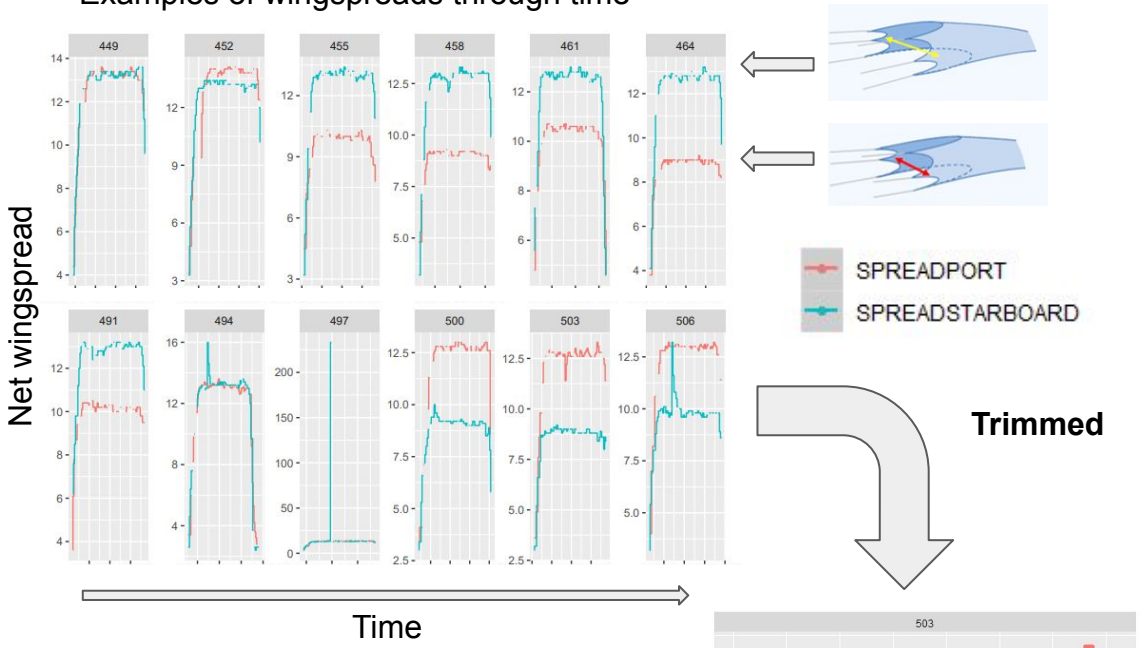
2019 Karen Elizabeth Stations



Data Processing

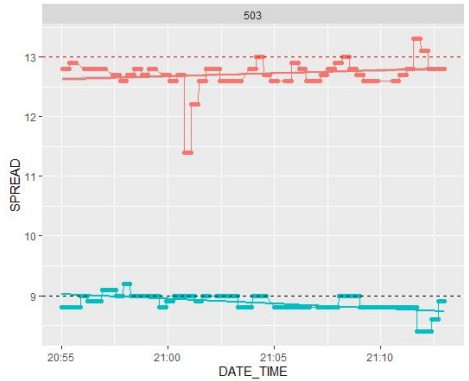
- Net wingspread varied over the tows for both nets
- Stations where the control net was > 0.5 m from 13 m target were removed
- Actual widths of treatment net used in analyses (rather than targeted width)

Examples of wingspreads through time



Dashed line = target wingspread for treatment and control

Solid line = mean wingspread for each net



Sample Size Summaries

Count of positive stations for each species at each net width

	Species	Treatment net widths (m)								Total
		9	10	11	12	13	14	15	16	
	American plaice	3	8	8	8	11	4	6	3	51
	Winter flounder	17	19	27	19	27	9	2	0	120
	Witch flounder	3	7	8	7	11	4	6	3	49
	Windowpane	14	10	20	12	17	6	0	0	79

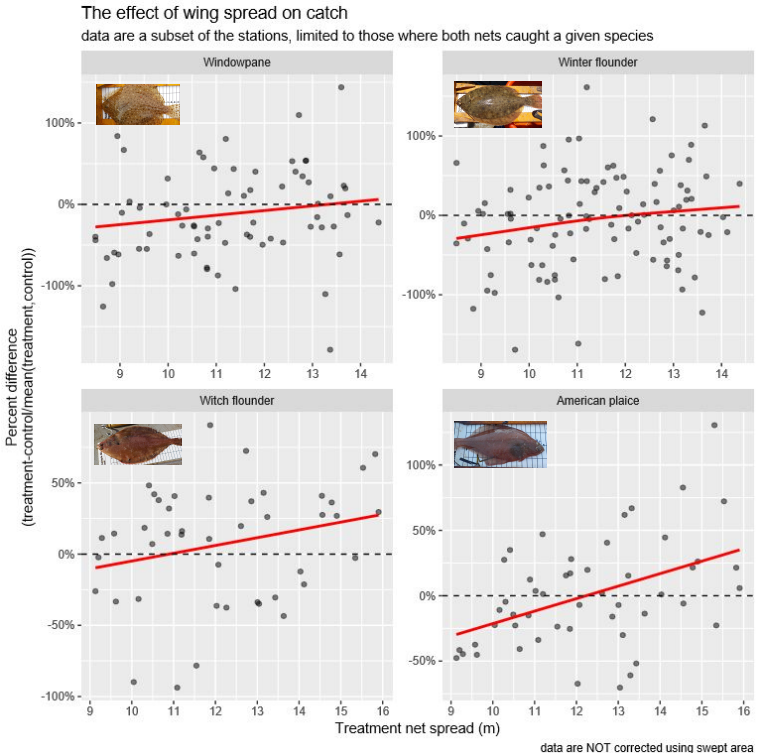
Counts represent totals after 25 non-representative stations were removed from the data set

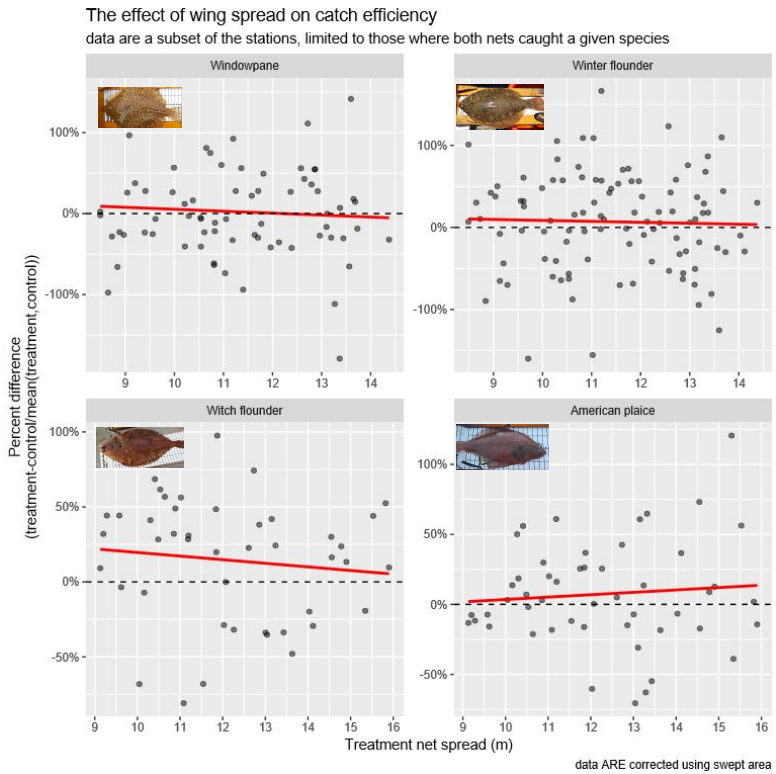
- On average ~8 stations (paired tows) per treatment net width
- Some species not caught in widest net widths (which corresponds with deepest stations -- and was to be expected)

Two Analyses

1. **Exploratory analysis of flatfish catch efficiency** (to provide rapid feedback to NTAP for cruise planning)
    - Species weights in each net were compared (kg/tow and kg/m^2)
    - *Presented in November 2019*
    - *Found limited evidence of a wingspread effect on efficiency*
2. **Length-based hierarchical generalized additive model** (GAM), similar to those used in previous sweep comparisons
    - Species counts at length were used

Exploratory Analysis Results





- **Limited effect of wingspread** on the percent difference in weight caught
- No real indication of the hypothesized unimodal pattern

Results for Mean Catch at Length

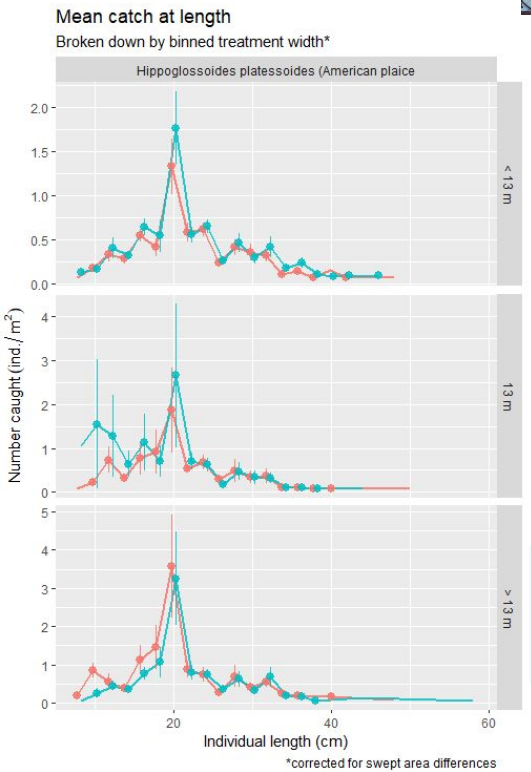
Mean ± SE shown

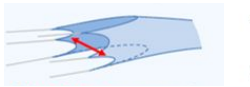
Underspread

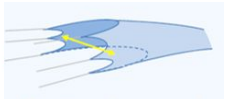
Control

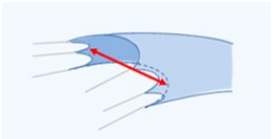
Overspread

Data for American plaice:

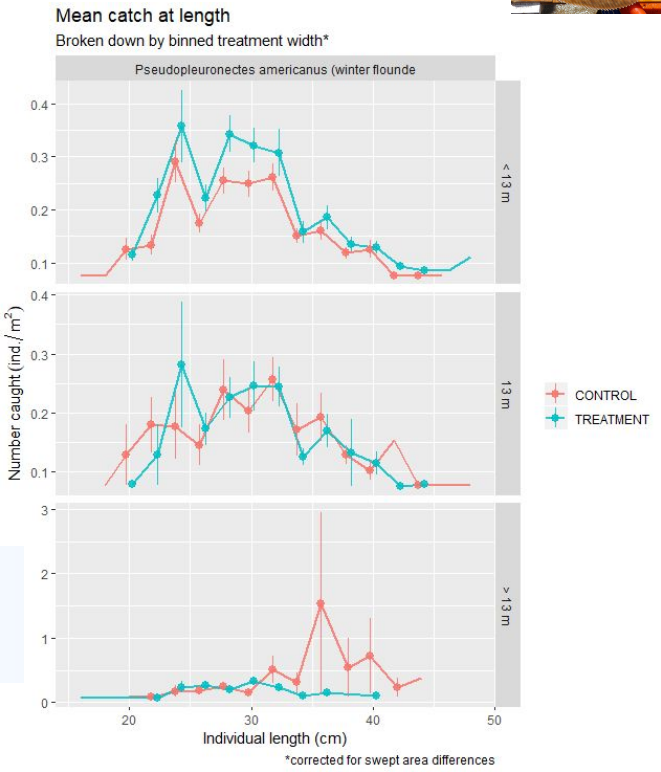








Data for winter flounder:



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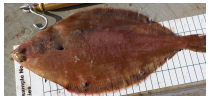
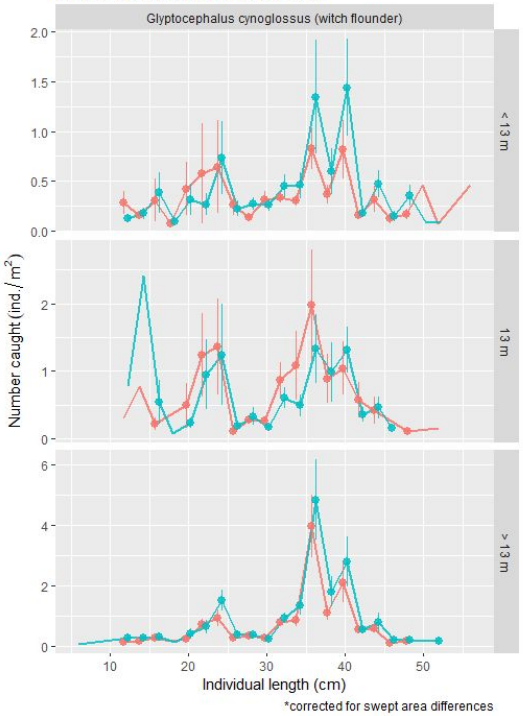
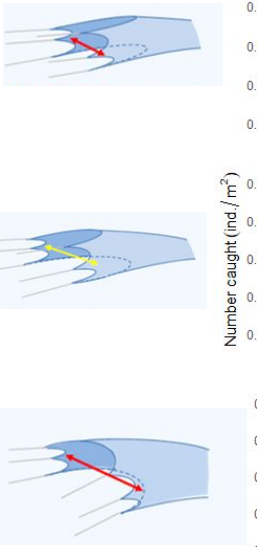
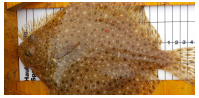
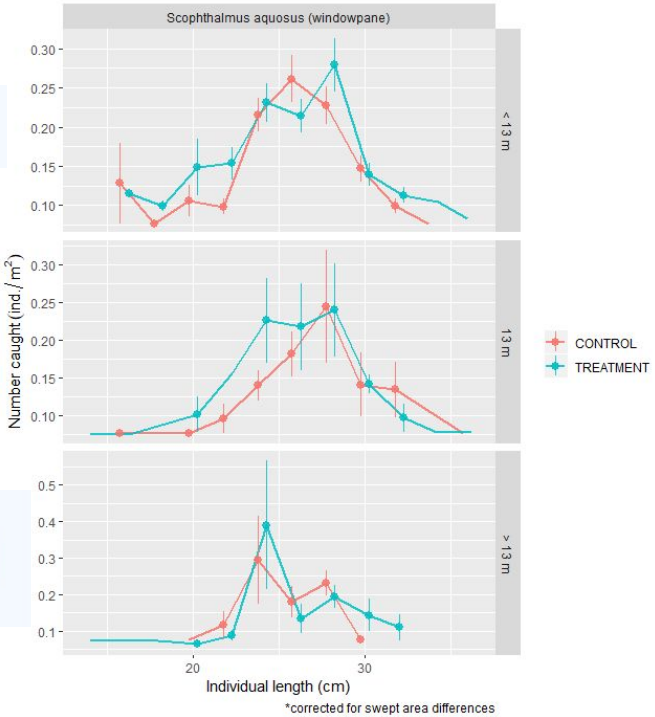






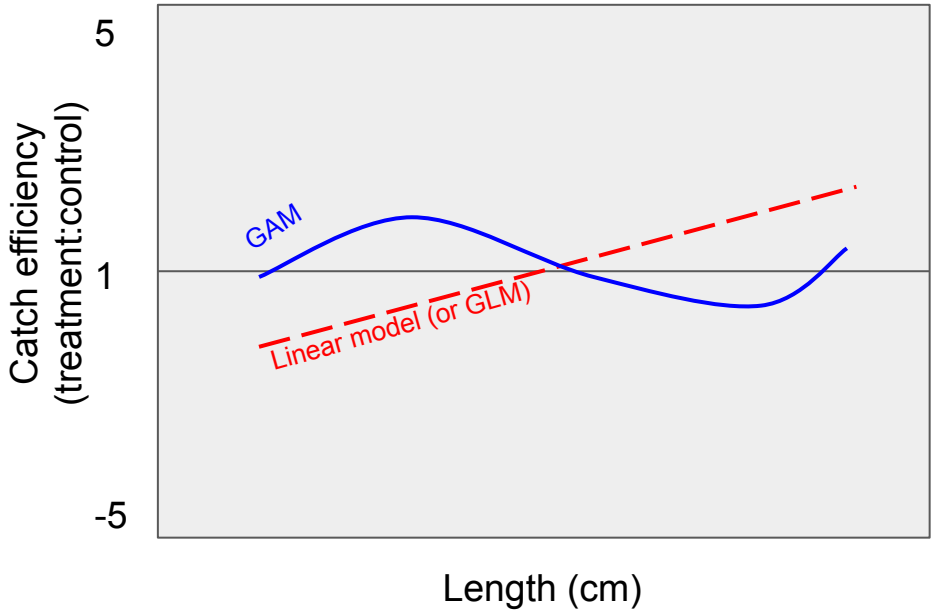
Data for windowpane:





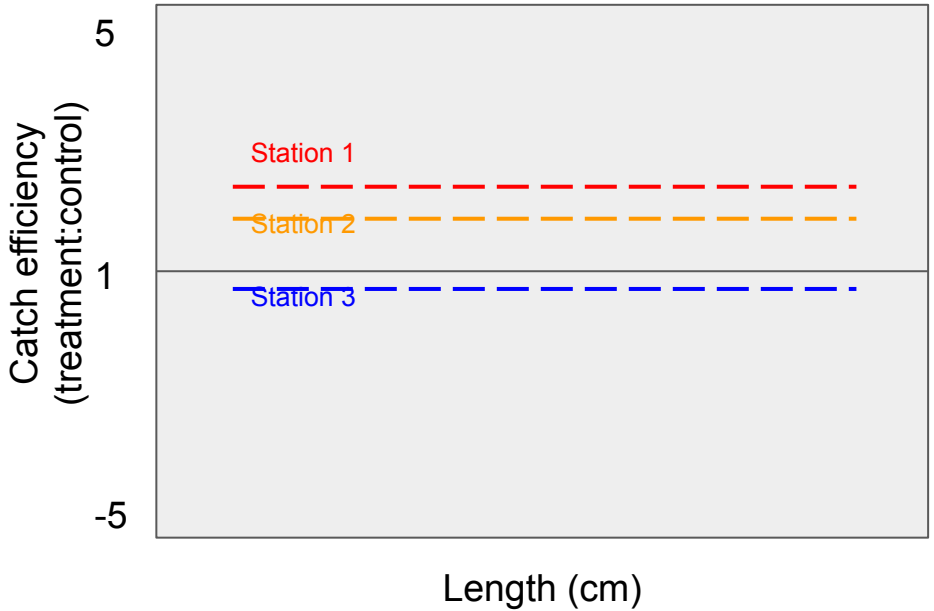
Length-Based Generalized Additive Model (GAM)

- What is a GAM?
- A generalized additive model (GAM) is a generalized linear model in which the prediction depends on the *smooth functions* of predictor variables (can be non-linear)
- Here to build this model we add components added sequentially
- Calculated Akaike's Information Criterion (AIC) for each model to evaluate performance
- *AIC is a common statistical metric that balances model fit with complexity*



Length-Based Model Components

- **Random variation in catch efficiency between stations**
- Size effect on mean relative efficiency
- Random variation in size effect on relative catch efficiency between stations
- Size effect on overdispersion parameter
- Wingspread effect on overall global mean relative efficiency
- Day/night effect on mean relative efficiency



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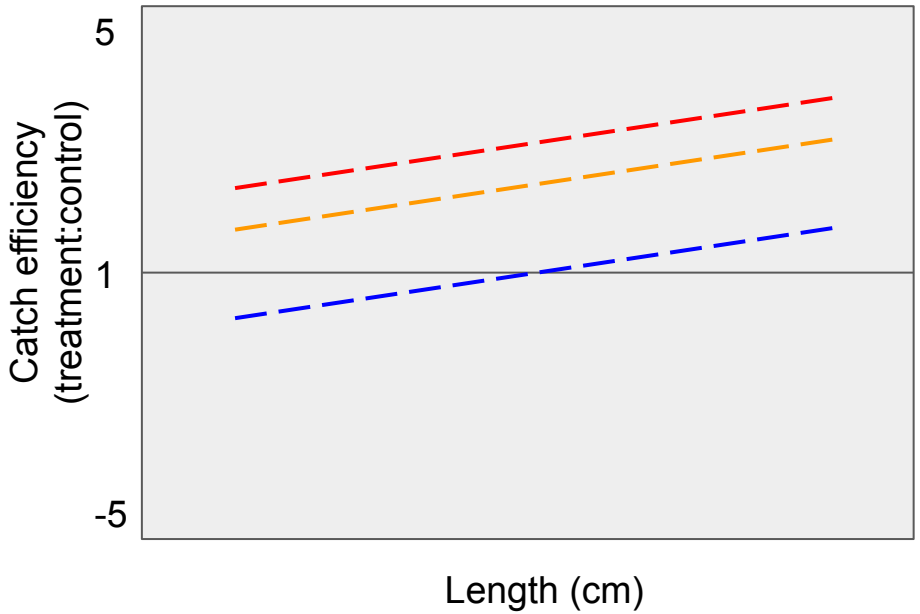

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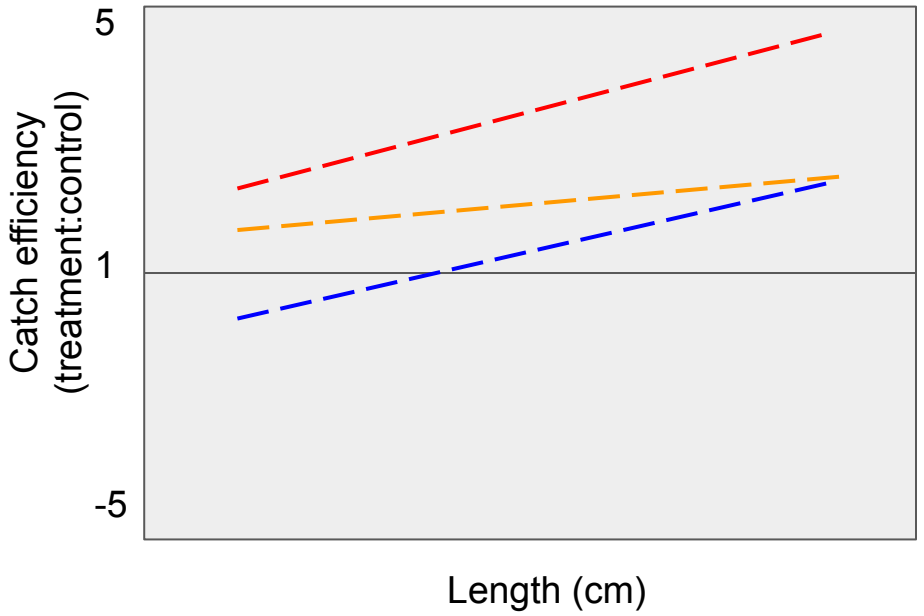

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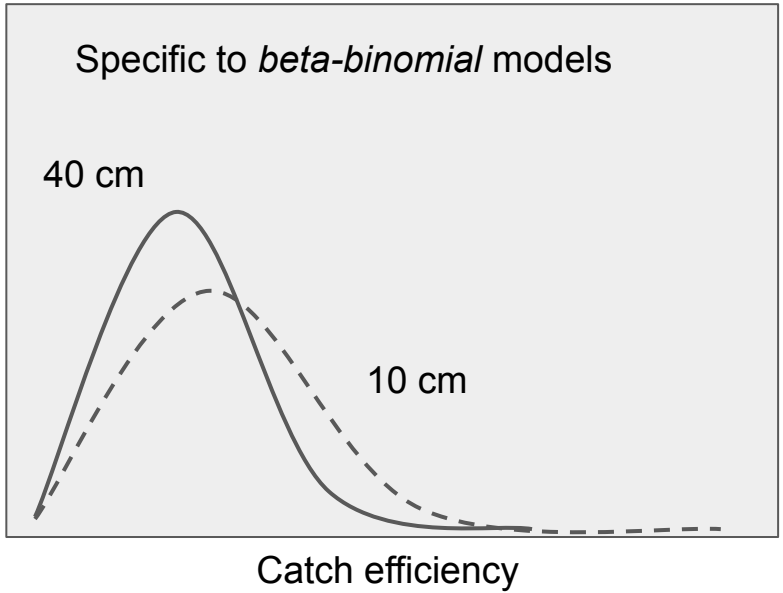

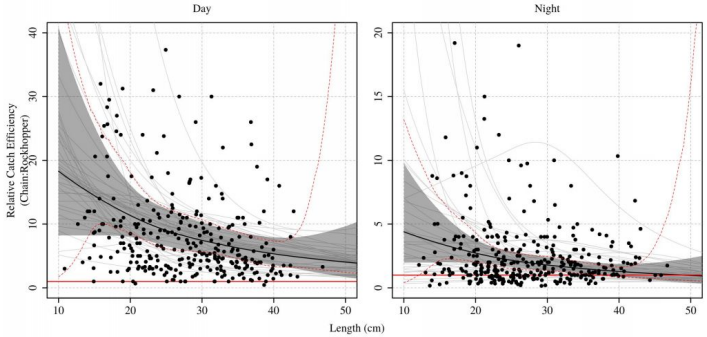

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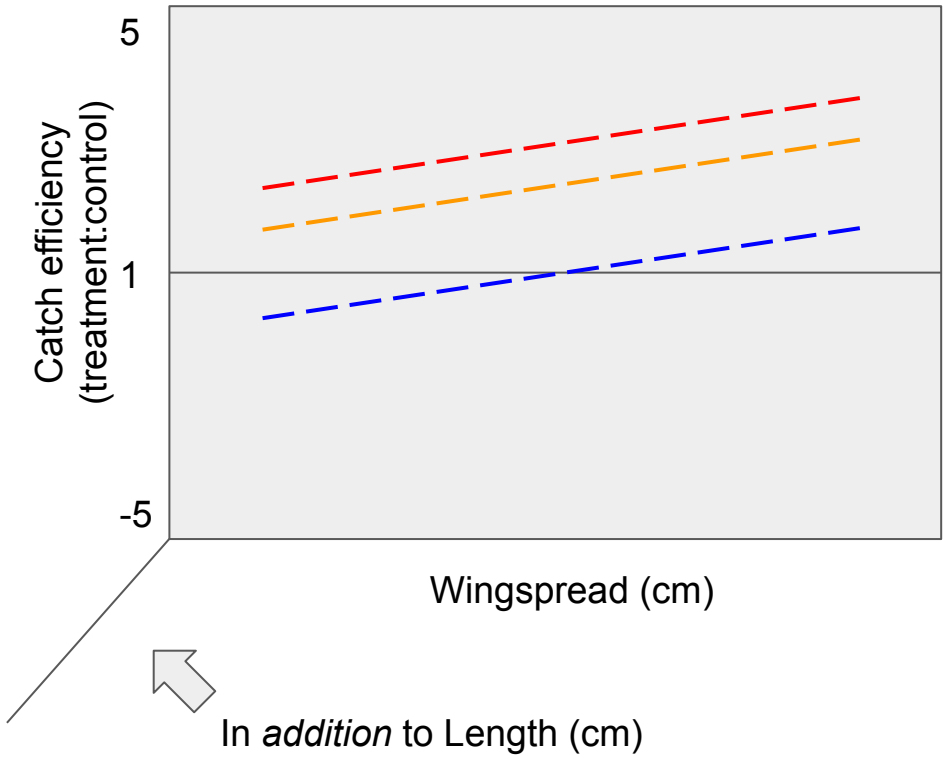

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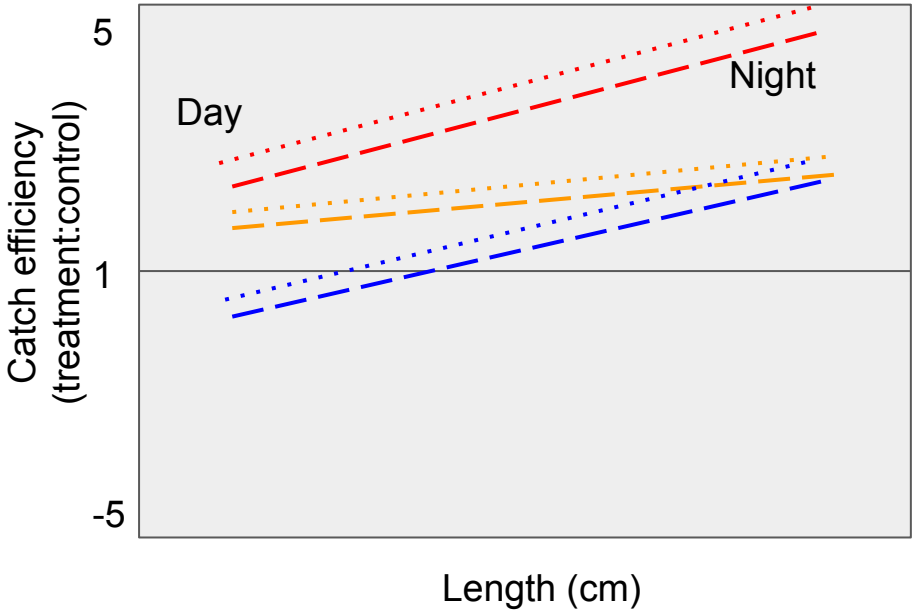

Length-Based Analysis Results

Best model = 0 ΔAIC

Wingspread effect

Model specifications

to estimate relative catch effciency

	Binomial					Beta-binomial					
	1	2	3	4	5	6	7	8	9	10	11
Species Delta AIC											
American plaice	97.858	34.515	36.486	40.442	38.379	50.024	13.526	0	1.353	5.284	3.336
Winter flounder	62.325	44.491	47.007	47.417	45.995	6.443	0.929	0	3.119	5.189	2.161
Witch flounder	23.674	17.549	20.418	295.678	19.307	4.565	0	0.659	8.317	11.77	5.515
Windowpane	0	5.529	7.472	11.282	8.772	0.727	6.392	8.241	10.561	14.434	11.991
Model component											
Day/night effect on mean relative efficiency	N	N	N	N	Y	N	N	N	N	N	Y
Size effect on mean relative efficiency	N	N	Y	Y	Y	N	N	N	Y	Y	Y
Size effect on overdispersion parameter	N	N	N	N	N	N	N	Y	Y	Y	Y
Random variation in size effect on relative catch efficiency between stations	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N
Wingspread effect on overall global mean relative efficiency	N	N	N	Y	N	N	N	N	N	Y	N
Random variation in catch efficiency between stations	Y	N	N	N	N	Y	N	N	N	N	N
Number model parameters	2	5	7	9	8	3	6	8	10	12	11

- Lowest AIC for beta-binomial models three of four species (allows for more variation)
- Models converging an issue for two (witch and winter)
- **Best models did not have a wingspread effect for any target species**

Analysis Results American Plaice

Model specifications

to estimate relative catch effciency

		Binomial					Beta-binomial				
		1	2	3	4	5	6	7	8	9	10	11
	Species Delta AIC											
	American plaice	97.858	34.515	36.486	40.442	38.379	50.024	13.526	0	1.353	5.284	3.336

Best model
= 0 ΔAIC

Model 8

- Beta-binomial
- Size effect on overdispersion parameter
- Random variation in size effect on relative catch efficiency between stations

Explanation

- Ample sample sizes to construct complex models
- But no … effect present

Analysis Results Winter Flounder

Model specifications

to estimate relative catch effciency

		Binomial					Beta-binomial				
		1	2	3	4	5	6	7	8	9	10	11
	Species Delta AIC											
	Winter flounder	62.325	44.491	47.007	47.417	45.995	6.443	0.929	0	3.119	5.189	2.161

Best model
= 0 ΔAIC

Model 8

- Beta-binomial
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Explanation

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Analysis Results Witch Flounder

Model specifications

to estimate relative catch effciency

	Binomial					Beta-binomial					
	1	2	3	4	5	6	7	8	9	10	11
Species Delta AIC											
 Witch flounder	23.674	17.549	20.418	295.678	19.307	4.565	0	0.659	8.317	11.77	5.515

Best model
= 0 ΔAIC

Model 7

- Beta-binomial
- Random variation in size effect on relative catch efficiency between stations

Explanation

- Ample sample sizes to construct complex models
- But no … effect present

Analysis Results Windowpane

Model specifications

to estimate relative catch effciency

	Binomial					Beta-binomial					
	1	2	3	4	5	6	7	8	9	10	11
Species Delta AIC											
 Windowpane	0	5.529	7.472	11.282	8.772	0.727	6.392	8.241	10.561	14.434	11.991

Best model
= 0 ΔAIC

Model 1

- Binomial
- Random variation in catch efficiency between stations

Explanation

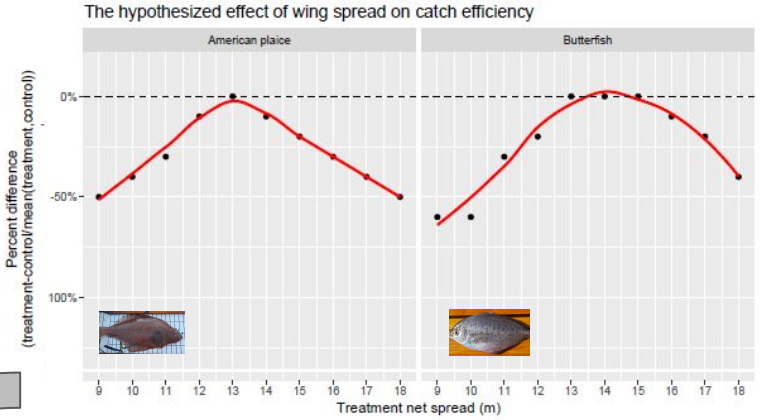
- Model fit is likely limited by the amount of data (smallest numbers of individuals among the four species)

Visualized Examples of Model Outputs

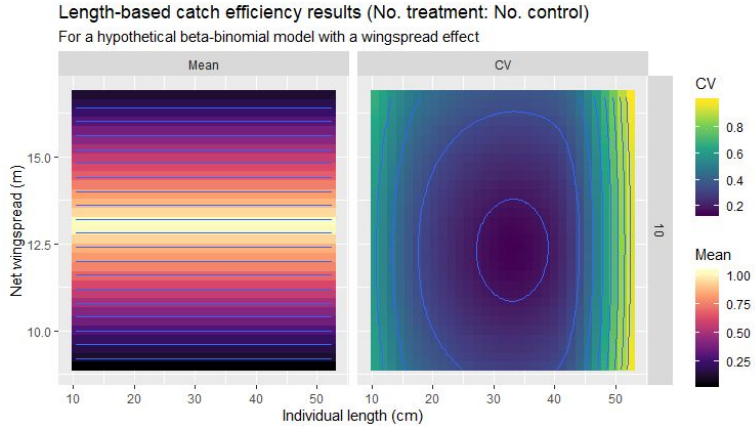
- Model results can be plotted as surfaces
- Mean estimates across wingspread and fish length
- **If a unimodal effect of wingspread exists we'd expect to see the lighter colors in a band near 13 m**

Hypothesized relationship as a surface

Unimodal 'humpshaped' pattern 2d



Unimodal 'humpshaped' pattern 3d

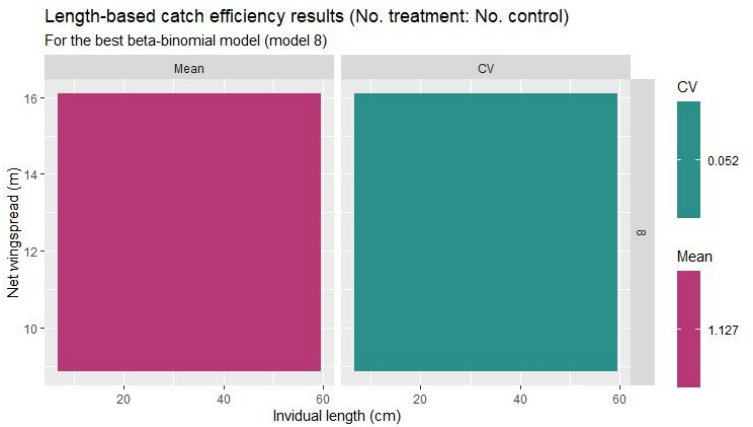


Visualized Examples of Model Outputs

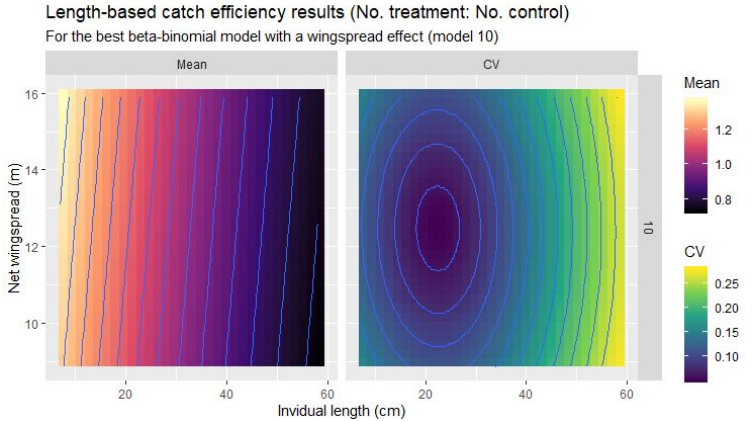
- If a unimodal effect of wingspread were there we'd expect to see the lighter colors in a band near 13 m
- **Pattern was not observed**
- Instead the best models are actually 'flat' across wingspread and length (e.g., efficiency doesn't change)
- Similar to weight based plots

Data for American plaice:

Best model



Best model *with* wingspread effect



Similar Results for Red Hake

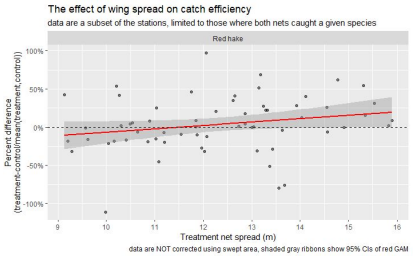
Length-based analysis:

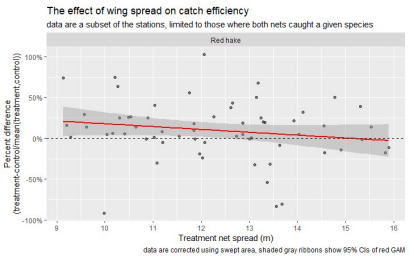
Model specifications

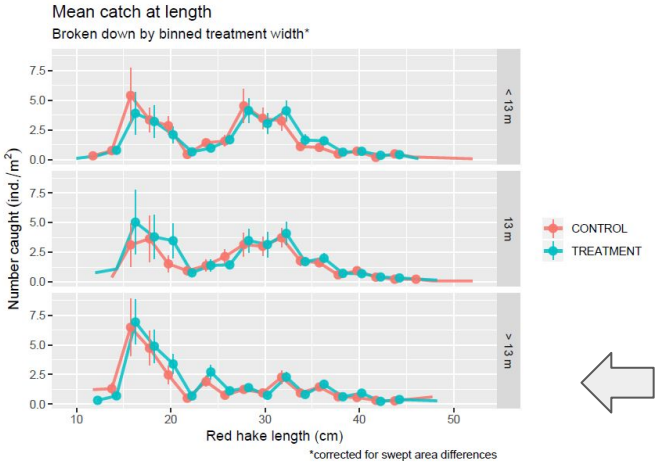
to eastimate relative catch effciency

Model component	Binomial					Beta-binomial					
	1	2	3	4	5	6	7	8	9	10	11
Model AIC difference	699.4	229.4	227.8	231.3	228.3	292.5	2	1.8	0	3.8	0
Number model parameters	2	5	7	9	8	3	6	8	10	12	11
Day/night effect on mean relative efficiency	N	N	N	N	Y	N	N	N	N	N	Y
Size effect on mean relative efficiency	N	N	Y	Y	Y	N	N	N	Y	Y	Y
Size effect on overdispersion parameter	N	N	N	N	N	N	N	Y	Y	Y	Y
Random variation in size effect on relative catch efficiency between stations	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N
Wingspread effect on overall global mean relative efficiency	N	N	N	Y	N	N	N	N	N	Y	N
Random variation in catch efficiency between stations	Y	N	N	N	N	Y	N	N	N	N	N

Exploratory results for red hake:



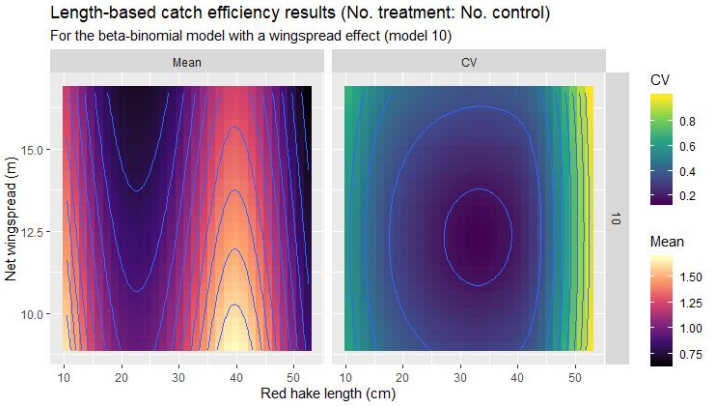




Lowest AIC models **do not** have wingspread effect

Mean ± SE shown

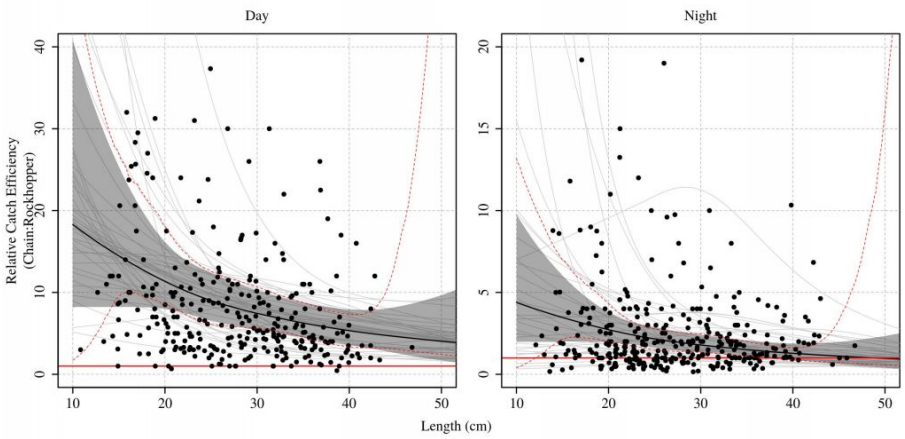
Best model *with* wingspread effect



Conclusions

- Congruent results from both analyses
- Results for each target species suggest there is limited evidence for the hypothesized unimodal relationship between catch efficiency and net wingspread
- **Models with wingspread not the best as measured by AIC**
- **Qualitative comparison to effect of chain sweep suggests more subtle effect**
- Impact of swept area a topic to potentially explore in the future

Qualitative comparison to chain sweep study for red hake



- Chain sweep caught 5-10 times as many fish
- Effects of wingspread here were quite small and *not* significant

Thank you for listening!

Photo: Calvin Alexander

Questions?

Data Summaries

Catch weights for each net width

Weights are summed kilograms for both nets

	Species	Treatment net widths (m)								Total
		9	10	11	12	13	14	15	16	
	American plaice	18.2	99.6	88.5	67.2	152.0	22.1	50.0	78.5	576.1
	Winter flounder	157.9	161.1	183.1	236.6	236.8	70.7	60.6	0.0	1,106.8
	Witch flounder	12.1	52.2	279.2	202.0	348.7	88.7	1,045.8	316.3	2,345.0
	Windowpane	37.3	19.8	72.7	52.2	52.0	24.5	0.0	0.0	258.6

Weights represent totals after 25 non-representative stations were removed from the data set

- 100s to 1000s of kgs of target species were caught
- Some variation across different wingspreads 10s to 100s of kgs

Data Summaries

Species catch counts for each net width

Counts are summed for both nets

	Species	Treatment net widths (m)								Total
		9	10	11	12	13	14	15	16	
	American plaice	193	997	942	670	1,888	267	561	1,131	6,649
	Winter flounder	468	424	509	599	531	169	186	0	2,886
	Witch flounder	44	193	792	629	1,167	318	3,147	1,109	7,399
	Windowpane	167	72	296	204	179	107	0	0	1,025
	Count totals	872	1,686	2,539	2,102	3,765	861	3,894	2,240	17,959

Counts represent totals after 25 non-representative stations were removed from the data set

- Generally, thousands of individuals per species caught
- Some variation across wingspreads
- Smaller number than used in chain sweep analysis (there 10s of thousands of individuals)