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Northeast Fisheries Science Center

Bridle Herding Efficiency of a Survey Bottom Trawl with Different Bridle Lengths

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Bridle Herding Efficiency Field Experiments

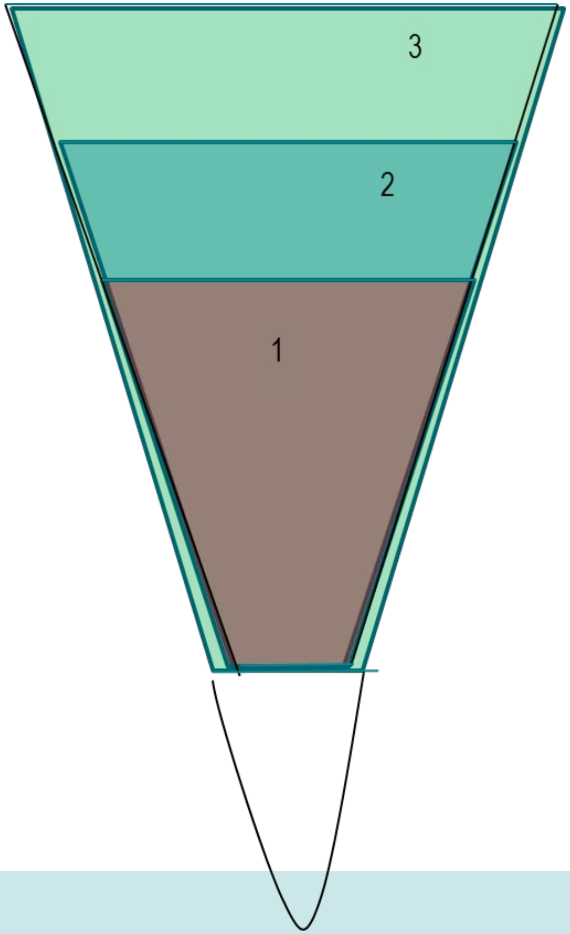
- Objectives
  - Quantify species and length specific bridle herding efficiency of the NEFSC standard survey bottom trawl gear
  - Examine diel differences in bridle herding efficiency
  - Focus on Georges Bank flatfish
  - Observe flatfish behavioral response along survey trawl bridle and at the ground-gear via underwater video

- 19 sea days completed during fall 2014 aboard the F/V Karen Elizabeth
  - September 15 – 24, 10 days (Eastern Georges and Cultivator Shoals)
    - Bridle efficiency experiments only
  - September 29 – October 7, 9 days (South of Martha’s Vineyard)
    - Bridle efficiency and underwater video

Methods – Field Experiment

- Compare catch between three lengths of bridles
  - Equivalent 12fm increases in bridle length – Standard (20fm), Medium (32fm), Long (44fm)
  - Assumption that increased catch is proportional to the increase area swept by the bridles

- 1 – Standard Length – 36.6m
  - 12°
  - DS=32m WS=13m
  - Area door=59264m²
  - Area wing=24076m²
- 2 – Medium Length – 58.2m
  - 12°
  - DS=41m WS=13m
  - Area door=75932m²
  - Area wing=24076m²
- 3 – Long Length – 80.5m
  - 12°
  - DS=50m WS=13m
  - Area door=92600m²
  - Area wing=24076m²



Methods – Field Experiment

- Randomized Block Design
  - Each block assumed unique and uniform fish density, physical parameters (temp, light, bottom etc.)
  - Randomized towing order of configurations
  - 3 tows per block (each bridle length towed once)

- Towing Protocols
  - NEFSC standard speed and duration – 20min @ 3.0kts
  - 20min on-bottom tow duration – determined by net mensuration
  - Consistent setting and hauling procedures throughout study
  - Offset tows by 0.25nm
  - Direction of tows – attempted minimize current effects
  - 24hr operations
    - All tows within a block were completed under the same day/night condition
    - Full sun down and full sun up

Methods – Field Experiment

- Consistent Trawl Geometry
  - Used restrictor rope between large, oversized trawl doors
  - 7/8” Samson UltraBlue - buoyant
    - Lengths adjusted to achieve target spread
  - Confident the bridle remained off-bottom

- Gear and Environmental Parameters Measured
  - Door and wing spread, trawl depth – ITI sensors
  - Speed of ground and depth – GPS and EK60

Methods – Bridle Configurations

- 1 – Standard Length – 36.6m
  - 12°
  - DS=32m WS=13m
  - Area door=59264m²
  - Area wing=24076m²
- 2 – Medium Length – 58.2m
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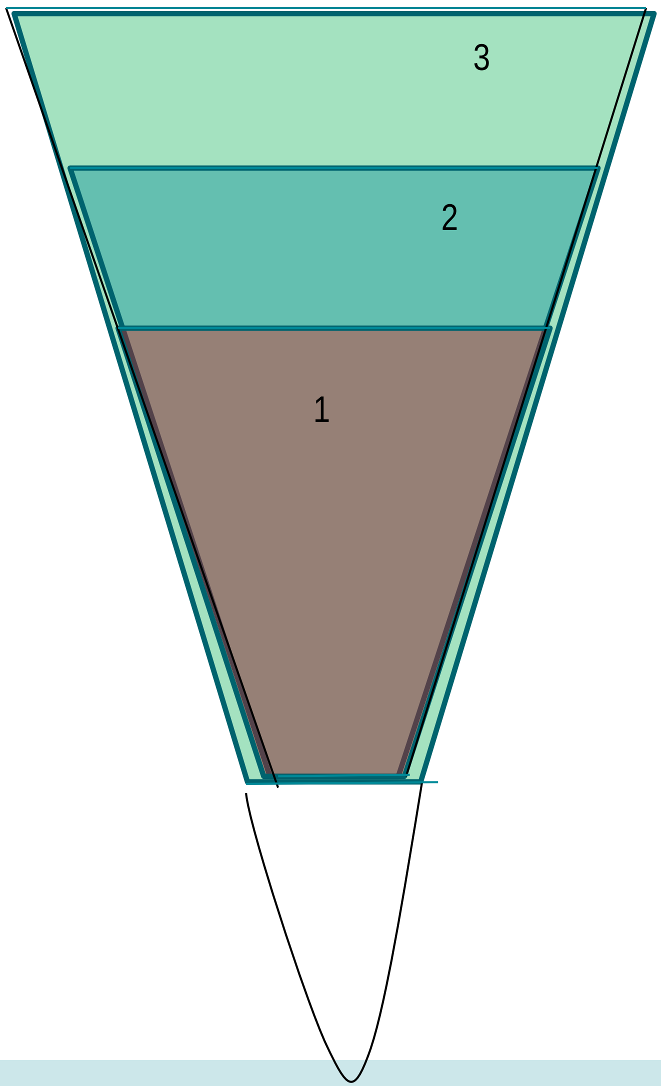


Methods – Data Analysis: Model 1

- Estimate bridle efficiency by modeling the catch as a function of the proportion of fish in the path of the net actually captured by the net plus the proportion of fish in the path of the bridle width captured (Somerton & Munro 2001)
  - Block, gear configuration and fish length specific

$$N_{ijl} = En_{il}D_{il}An_{ij} + En_{il}D_{il}Eb_{l}Ab_{ij} + \varepsilon$$

Subscripts

i = block

j = bridle length configuration

l = fish length class

ε = error term

- D_{il} and En_{il} assumed constant within a block but vary between blocks
- An_{ij} and Ab_{ij} are measured values
- D_{il} and En_{il} combined, k, to reduce the number of parameters to be estimated
- Parameters estimated by non-linear least squares

$$N_{ijl} = k_{il}An_{ij} + k_{il}Eb_{l}Ab_{ij} + \varepsilon$$

Methods – Data Analysis: Model 2

- Condition on total catch per block to reduce the number of parameters to be estimated
  - Parameters estimated by maximum likelihood

- Expected proportion of catch for an individual gear configuration given the total catch of all gear configurations within a block is expressed as:

$$E\{N_{ij}|N_i\} = \frac{En_i D_i An_{ij} + En_i D_i EbAb_{ij}}{\sum_i (En_i D_i An_{ij} + En_i D_i EbAb_{ij})}$$

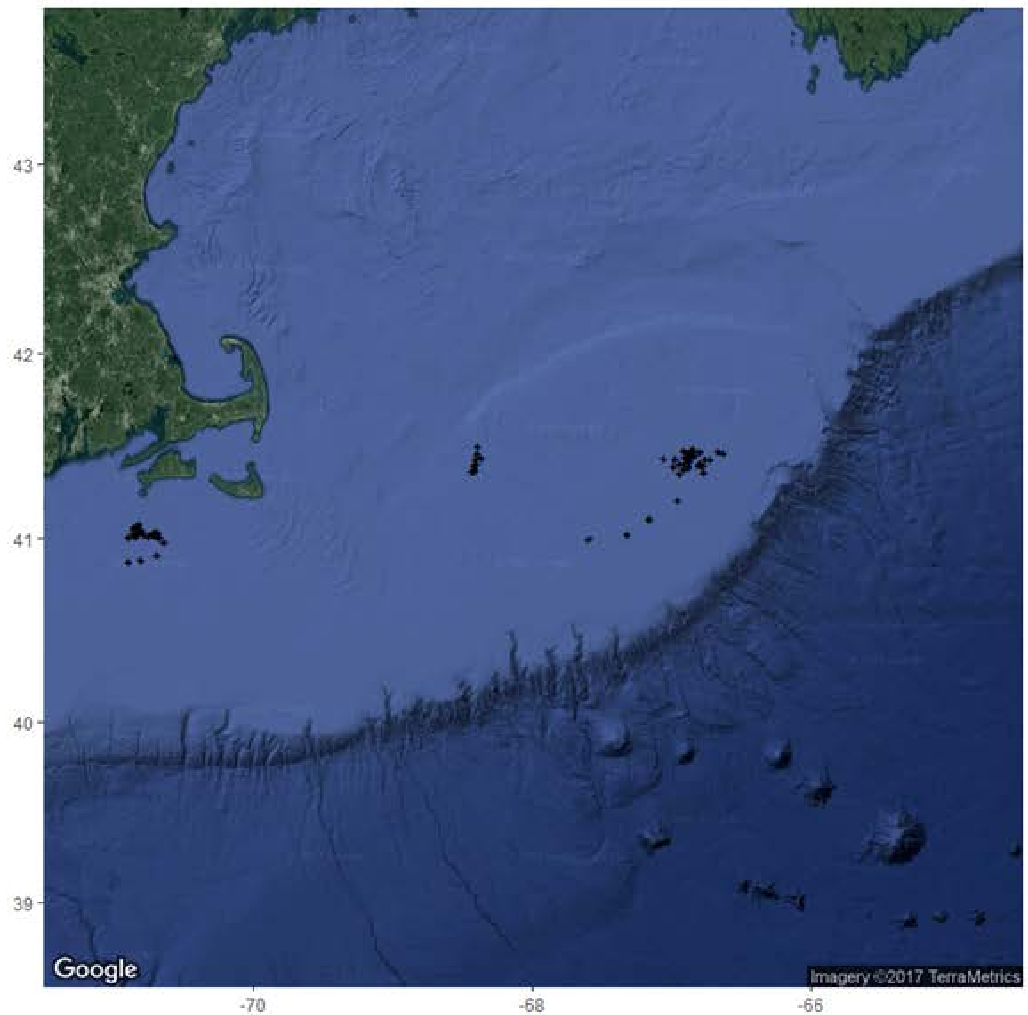
- Net efficiency, En, and fish density, D, terms cancel out
- Net and bridle area swept values, An and Ab, are measured values
- Efficiency of the bridle, Eb, is the only parameter to be estimated

$$E\{N_{ijl}|N_{il}\} = \frac{An_{ij} + Eb_l Ab_{ij}}{\sum_i (An_{ij} + Eb_l Ab_{ij})}$$

Results

- 73 total representative blocks
  - 41 day, 32 night
  - All yellowtail measured (no subsampling)
- Current was a significant issue around Eastern Georges Bank
  - All tows made in the same direction as current direction for the remainder of the study
- Tows and blocks did overlap due to availability of fish and current issues
  - Mainly eastern Georges Bank
  - Current and fish distribution was less of a concern at Cultivator Shoals and South of Marth's Vineyard
- Obtained data for six species of flatfish
  - Yellowtail flounder – 4062 lengths
  - Winter flounder – 2834 lengths
  - Summer flounder – 2933 lengths
  - Fourspot flounder – 3892 lengths
  - Windowpane flounder – 2148 lengths
  - Gulfstream flounder – 14130 lengths
  - Mixed skates, Scallops, Goosefish, Lobster – Weights obtained starting block 33

Results – Tow Locations



Results

- Consistent trawl geometry and bridle angles between blocks, bridle length configurations and areas sampled

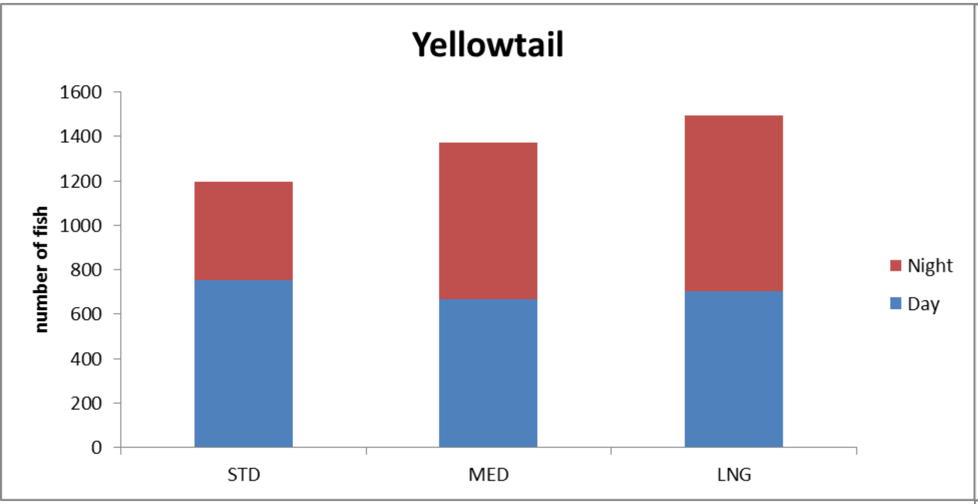
AREA	Gear Configuration	Bridle Length(m)	Total Blocks	Day Blocks	Night Blocks	Mean Depth (m)	Door Spread (m)	Wing Spread (m)	Bridle Angle (deg)
Eastern Georges	Standard	46.6	37	23	14	68.7	33.1 ±0.3	12.8 ±0.3	12.6 ±0.3
	Medium	69	37	23	14	68.2	42.8 ±0.7	13.0 ±0.3	12.5 ±0.3
	Long	91	37	23	14	68.4	51.2 ±1.1	13.1 ±0.5	12.1 ±0.3
Cultivator Shoals	Standard	46.6	10	7	3	59.2	33.0 ±0.2	12.6 ±0.3	12.6 ±0.3
	Medium	69	10	7	3	59.4	42.6 ±0.5	13.3 ±0.3	12.2 ±0.2
	Long	91	10	7	3	59.8	51.5 ±0.6	13.4 ±0.4	12.1 ±0.2
South of Martha's Vineyard	Standard	46.6	26	11	15	42.5	32.8 ±0.1	12.7 ±0.2	12.5 ±0.1
	Medium	69	26	11	15	42.5	42.3 ±0.4	13.1 ±0.4	12.2 ±0.2
	Long	91	26	11	15	43.1	50.4 ±0.7	13.2 ±0.4	11.8 ±0.2

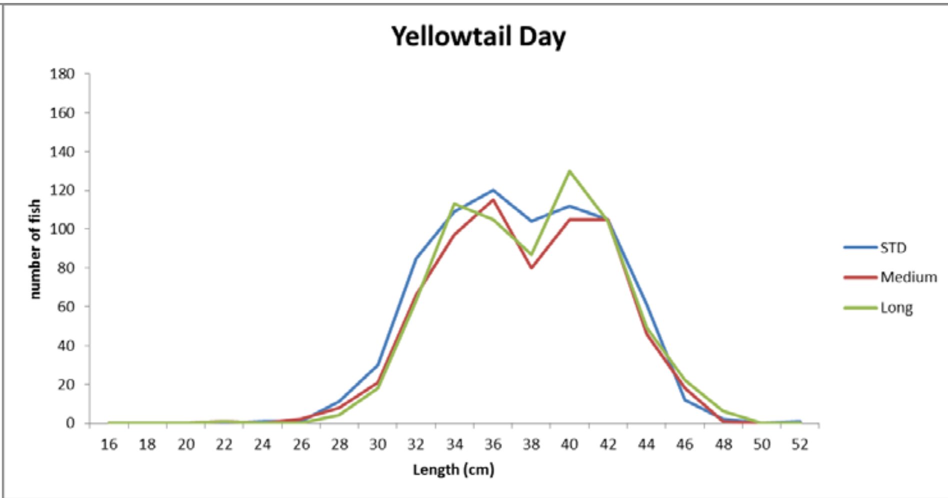
Results – Flatfish Catch Per Block

SPECIES	Total Blocks	Number Day Blocks	Num Night Blocks	Num TotalFish	Mean Catch Per Block	Pct Caught Day	Pct Caught Night	Mean Catch Per Block Day	Mean Catch Per Block Night
Yellowtail Flounder	51	22	29	4062	79.6	0.52	0.48	96.4	66.9
WinterFlounder	46	28	18	2834	61.6	0.43	0.57	43.5	89.7
SummerFlounder	36	18	18	2933	81.5	0.29	0.71	46.8	116.2
FourspotFlounder	63	31	32	3892	61.8	0.24	0.76	30.1	92.4
WindowpaneFlounder	28	13	15	2148	76.7	0.13	0.87	21.5	124.5
Gulfstream Flounder	20	5	15	14130	706.5	0.01	0.99	39.8	928.7

- Mean catch per block higher during the day for yellowtail flounder

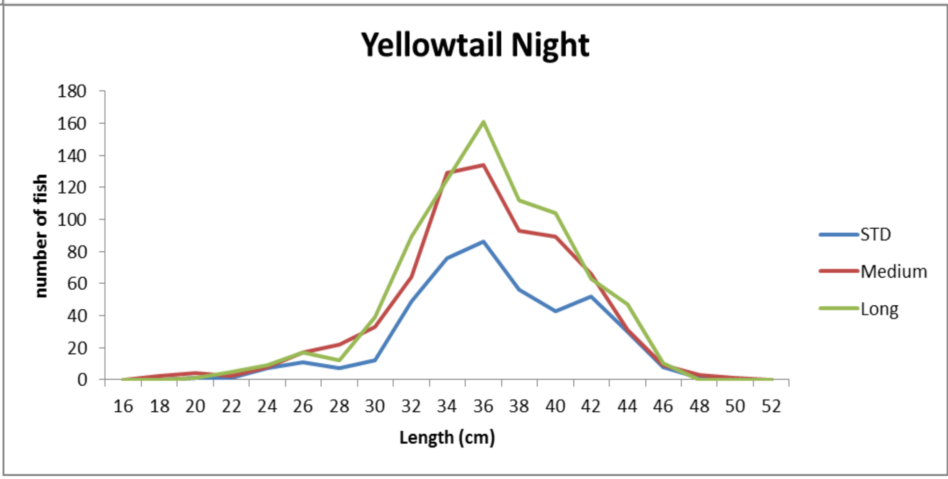
Results – Catch Proportions Combined, Day and Night: Yellowtail Flounder





- 51 Blocks – 22 Day\29 Night

	Total	Std	Med	Long	PropSTD	PropMED	PropLNG
All	4062	1194	1372	1496	0.29	0.34	0.37
Day	2121	754	665	702	0.36	0.31	0.33
Night	1941	440	707	794	0.23	0.36	0.41



ANOVA Treatment=Bridle Length

Day/Night	p-value
All	0.25
Day	0.8
Night	0.03*

Results

- Proportion of yellowtail fl increased with increasing bridle length both combined and during night blocks

- Increase of yellowtail fl catch was not observed during day block when extending from the standard length to the medium length bridle

- Significant difference in number of yellowtail fl captured between bridle length configurations at night only

- Similar day and night length frequencies for yellowtail fl
  - More smaller fish captured during night blocks

Results – Parameter Estimates – Yellowtail Flounder

SPECIES	Model 1 Fit by NLS Nij = ki*Anij + ki*Eb*Abij				Model 2 Fit by NLL Nij/Ni= Anij + Eb*Abij/∑(Anij+Eb*Abij)			
	Eb	Variance	CI Low	CI Up	Eb	Variance	CI Low	CI Up
Yellowtail Fl All	0.15	1.26	0.02	0.62	0.25	0.15	0.2	0.31
Yellowtail Fl Day	NA	NA	NA	NA	0	1382.71	0	1
Yellowtail Fl Night	NA	NA	NA	NA	1	1055.16	0	1

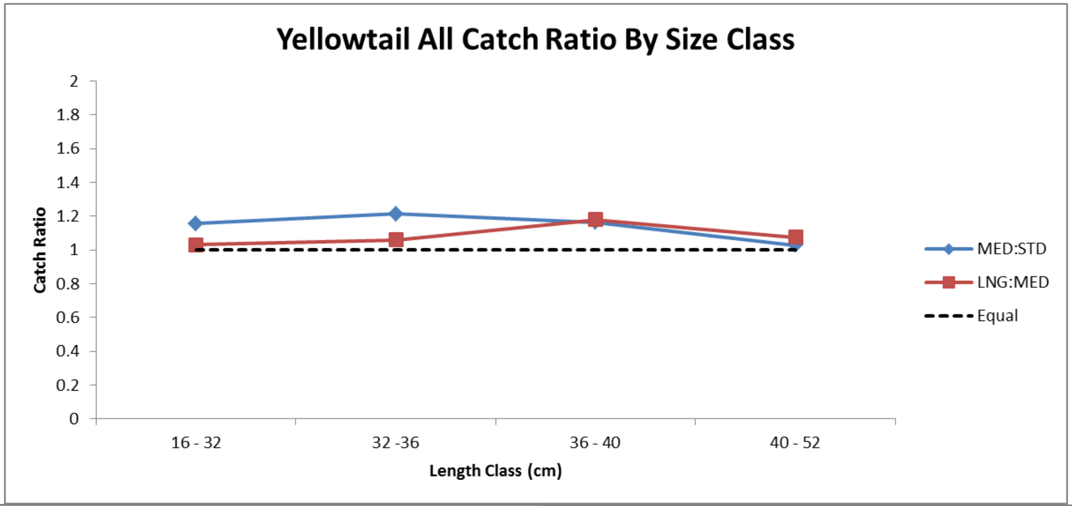
- Parameter estimates were poor for all species
- Estimates of Eb for yellowtail fl converged only when all data were combined

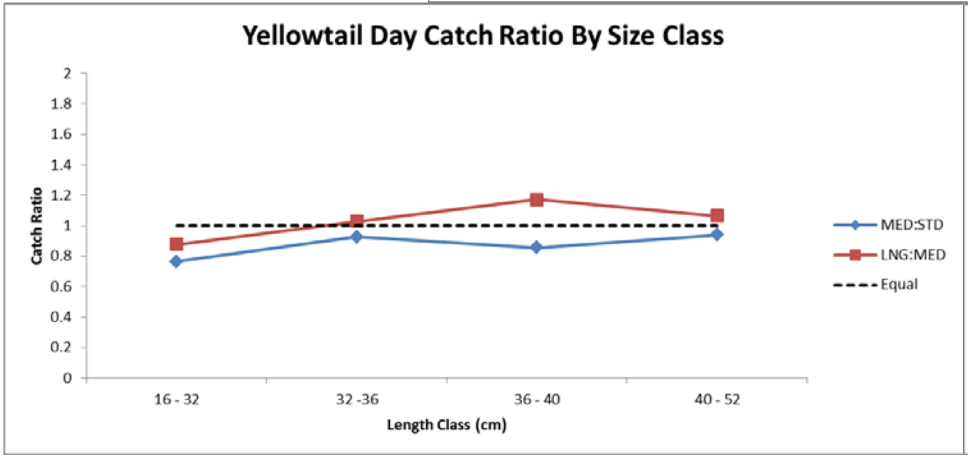
Results – Length Specific Parameter Estimates – Yellowtail Flounder

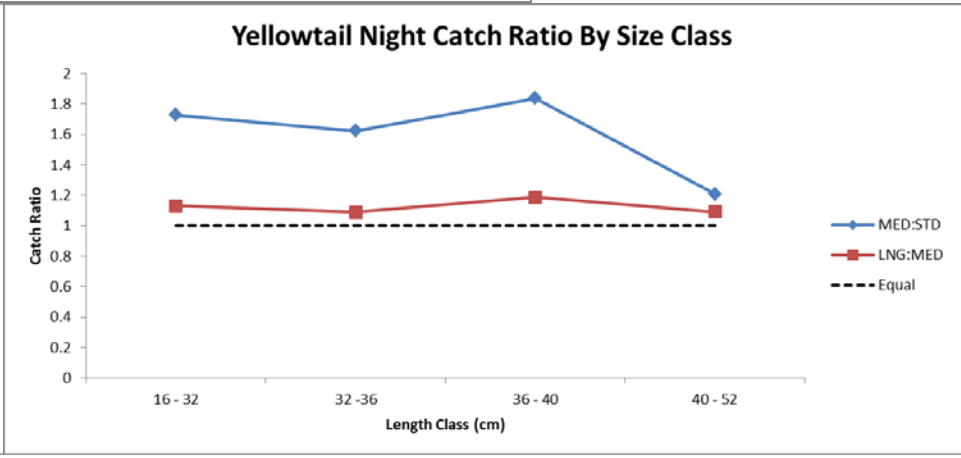
	Model 1 Fit by NLS Nijl = kil*Anij l+ kil*Ebl*Abijl				Model 2 Fit by NLL Nijl/Nil = Anij l+ Ebl*Abijl/∑(Anijl+Ebl*Abijl)			
Size Class (cm)	Eb	Variance	CI Low	CI Up	Eb	Variance	CI Low	CI Up
Yellowtail Fl All								
16-32	NA	NA	NA	NA	0.2	0.86	0.04	0.57
32-36	0.35	0.94	0.07	0.78	0.31	0.49	0.15	0.54
36-40	0.1	1.29	0.01	0.51	0.46	0.86	0.14	0.82
40-52	0.04	3.66	0	0.64	0.07	1.79	0	0.71
Yellowtail Fl Day								
16-32	NA	NA	NA	NA	NA	NA	0	1
32-36	NA	NA	NA	NA	NA	NA	0	1
36-40	NA	NA	NA	NA	NA	NA	0	1
40-52	NA	NA	NA	NA	NA	NA	0	1
Yellowtail Fl Night								
16-32	NA	NA	NA	NA	NA	NA	0	1
32-36	NA	NA	NA	NA	NA	NA	0	1
36-40	NA	NA	NA	NA	NA	NA	0	1
40-52	0.12	1.5	0.01	0.61	0.34	2.08	0.01	0.97

- Length specific parameter estimates were poor as well

Results – Length Specific Catch Ratios – Yellowtail Flounder







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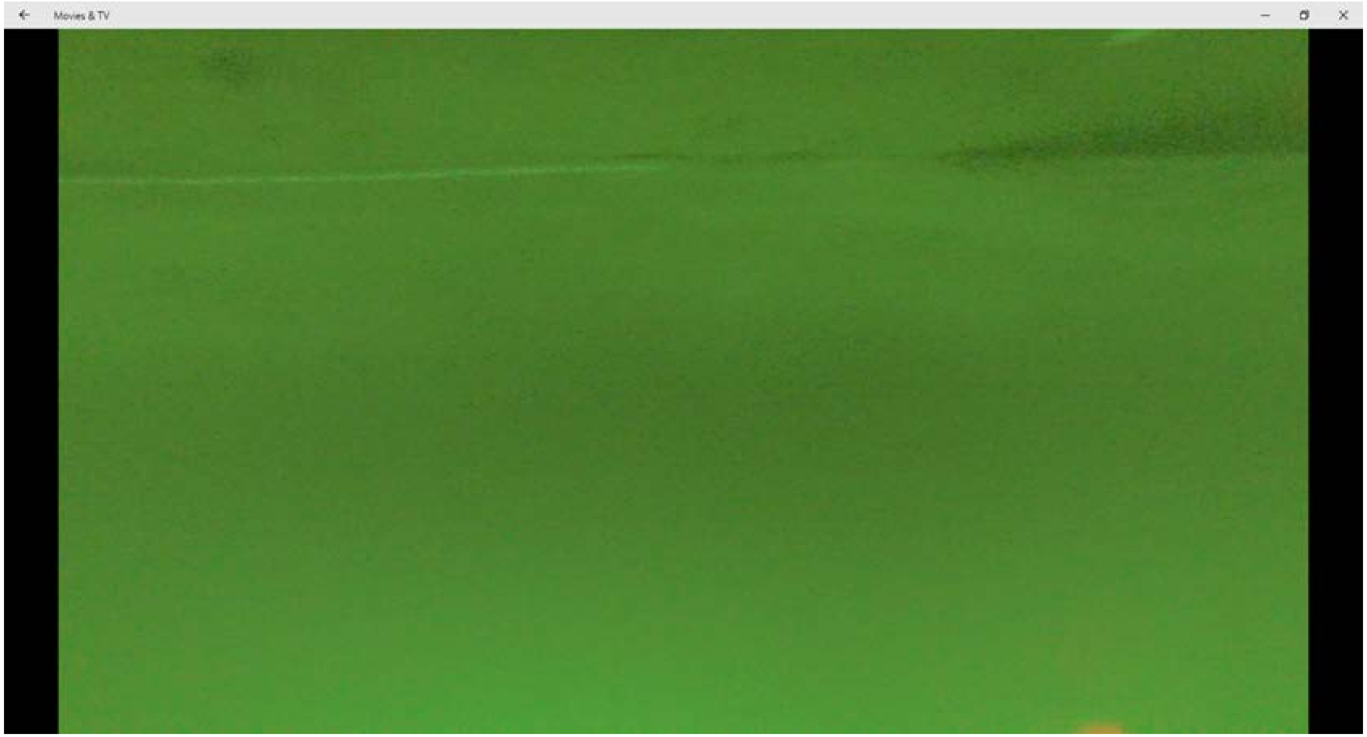
Results – Underwater Video Observations

- 20 tows with underwater cameras
  - South of Martha's Vineyard and Vineyard Sound
- Water clarity and limited ambient light affected video quality
  - Species identification is problematic
  - Several videos are unusable
- Few fish observed in the majority of video
- Camera was unstable mounted on bridles
  - Video orientation is difficult to determine
- Video evidence of bridles light on the bottom
  - Some observations of skates and possibly summer flounder reacting to the bridle

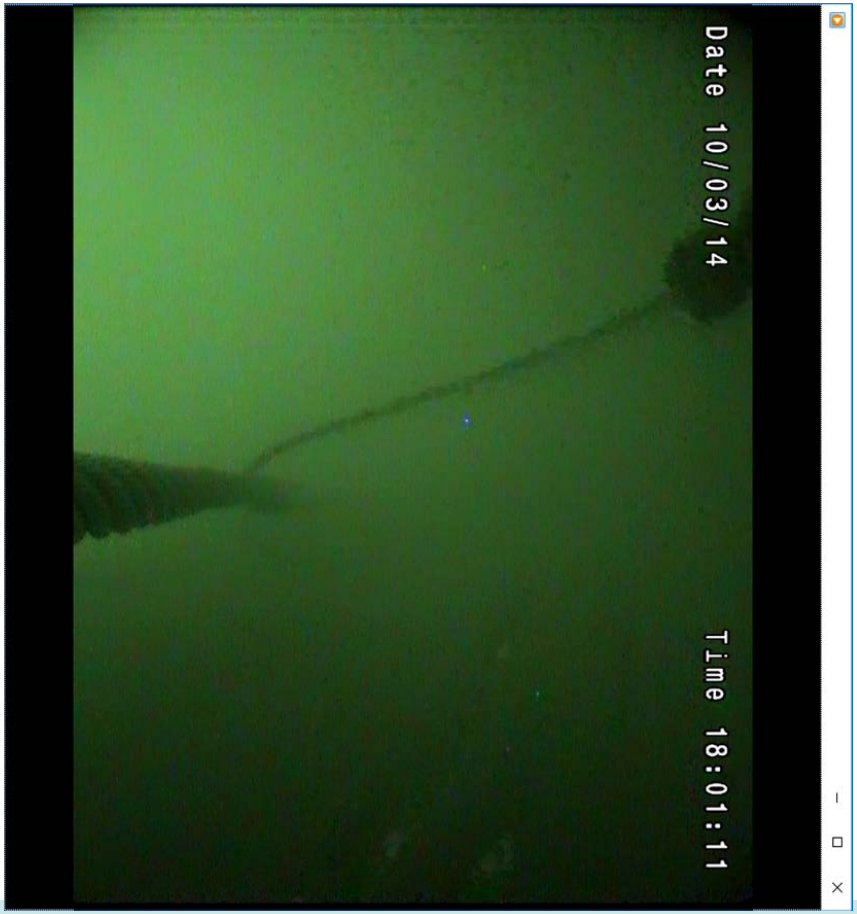
Results – Underwater Video Observations

- Camera mounted on middle bridle, pointed downward towards the lower bridle
  - Lower bridle bottom contact is intermittent



Results – Underwater Video Observations

- Camera mounted on lower bridle approximately 2m forward of the bunt bobbin, pointed aft towards the wing-end
  - This portion of lower bridle is off-bottom



Results – Underwater Video Observations

- Camera mounted on middle bridle, pointed downward towards the lower bridle
  - Fish observed reacting and moving away from the lower bridle

Bridle Bottom Contact

- Inconsistent shine along wire
- Minimal shine on longest bridle

Discussion

- Diel Catch Differences
  - Higher catch per block of yellowtail flounder during day blocks
    - Different than the other flatfish species
  - Possibly affected by high sampling intensity of a small area on eastern Georges Bank

- Yellowtail length frequencies were similar for each bridle length
  - Increased catch of smaller sizes for at night
    - Likely due to rockhopper sweep efficiency

- Yellowtail flounder catch increased with increasing bridle length only during night blocks
  - Differs from other research (Walsh, 1988; Glass & Wardle, 1989; Wardle, 1993)
  - Suggest another influential factor on these results

Discussion

- Shine pattern suggests longest bridle had minimal bottom contact
  - Unknown bottom contact for standard and medium bridle lengths
  - May help to explain observed catch ratio differences between medium and long bridle lengths
  - Video supports bridle bottom contact is intermittent

- Attempted corrections for effective bridle herding lengths did not alter results
  - Convergence issues remain

- Estimated of bridle herding efficiency from this study are poor
  - May have been affected by limited numbers and distribution of fish
  - Several blocks and tows within a block on eastern Georges Bank sampled over the same bottom
    - May have affected fish behavior and density in that area

Discussion

- In order to fully understand the bridle herding efficiency of the NEFSC survey bottom trawl it is critical to determine the actual length and region of the bridle in contact with the bottom
- Lack of consistent bottom contact of the lower bridle is likely a significant factor limiting the daytime herding of flatfish for the NEFSC standard survey trawl gear
- The portion of lower bridle extending from the wing-ends are a potential area of significant flatfish escapement minimizing the effective herding efficiency of the standard survey bridles
    - Further work should be done to observe and quantify fish escapement in this region of the survey trawl gear