Conducting scientific research projects that support sustainable fisheries, aquaculture, and agriculture

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Research Cruise Summary Report
2024

Project Name:	Tension in the Air: Using a tensiometer to assess dredge fullness and loss during haul back comparing the 5-row and extended-link apron dredge configurations
Vessel Name:	F/V Diligence
Departure Date:	9/3/2024
Land Date:	8/12/2024
Port:	Fairhaven, MA
Chief Scientist:	Farrell Davis
Scientific Crew:	Ryan Munnelly, Victoria Brendler, Tanner Fernandes
Report Completed by:	Victoria Brendler, Tanner Fernandes, Farrell Davis

STUDY AREA

Research trips for this gear efficiency project occur in Western Georges Bank and the Great South Channel fishing areas (**Figure 1**) as fishers are concerned about the performance of the experimental gear modifications in these high current areas.

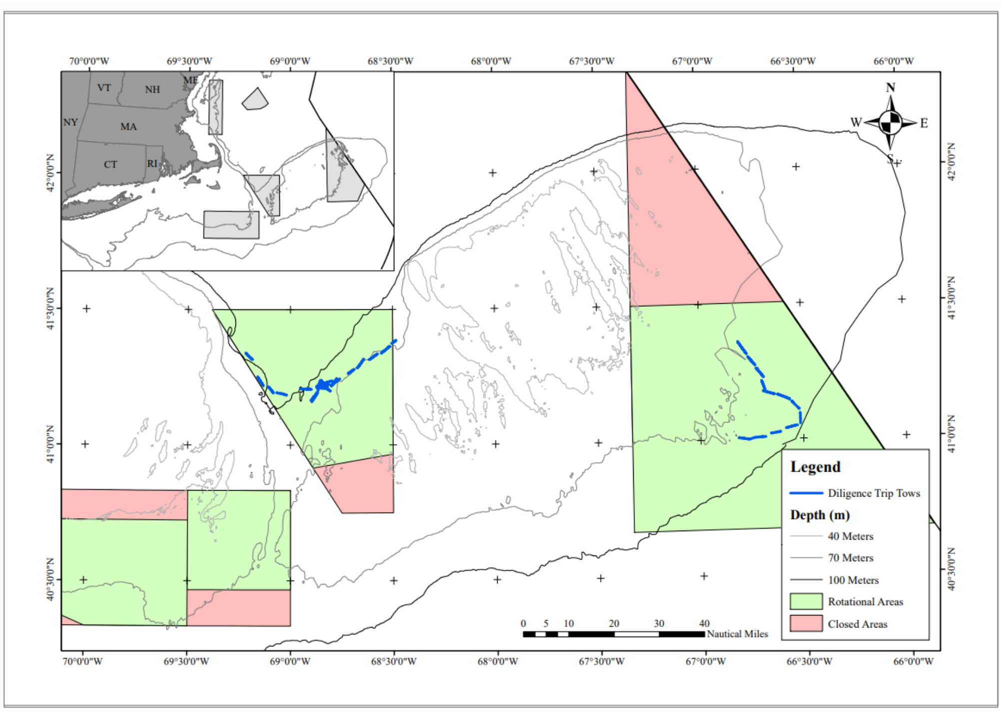

Figure 1: Chart of study area, including rotational management areas, and locations of tows conducted during the trip.

CRUISE OBJECTIVES

Objective 1: Investigate the performance of a five-row apron with a 1.5:1 twine top relative to an extended-link apron with a 2:1 twine top.
Objective 2: Evaluate warp tension (pounds-force) relative to bag configuration, catch weight/composition, and relevant tow and environmental variables e.g. speed and Beaufort number.
Objective 3: Investigate the impact of apron configuration on the winnowing of catch during dredge retrieval.

A total of four research trips will occur during the project period. This first research trip (**Figure 1**) was dedicated to completing the first objective of comparing a five-row apron with a 1.5:1 twine top to an extended-link apron **(Figure 2)** with a 2:1 twine top. Aside from these differences, all other aspects of the dredge bags and head bales were standardized.

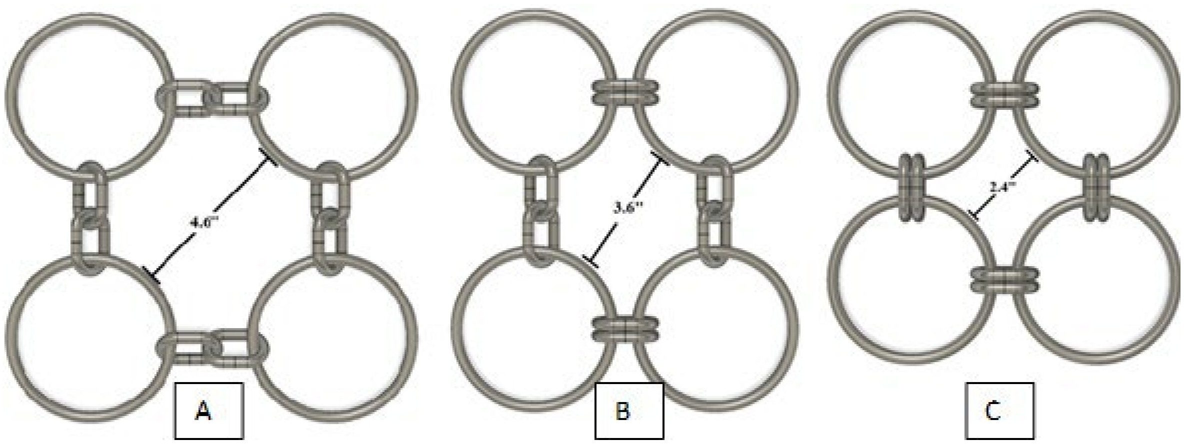

Figure 2: A comparison of the inter-ring spacing of tested extended link configurations. A) Bi-directional extended-link: 4.6", B) Vertical extended-link apron: 3.6", and C) a standard apron: 2.4".

Two dredges were towed simultaneously for 30 minutes with a tensiometer **(Figure 3)** secured to the warps during each tow to collect tension information in pounds-force (1 lb. f=4.44822 N), and inclinometers secured to the center bale bar to measure pitch and roll for the orientation of the dredge during the tow. These sensors are used to indicate the performance of the dredge. A temperature-depth (TD) logger was affixed to the dredge frame to collect environmental data during the trip.
Sea scallop and bycatch information were collected from each side, each tow. For the first research trip, only bushel counts,

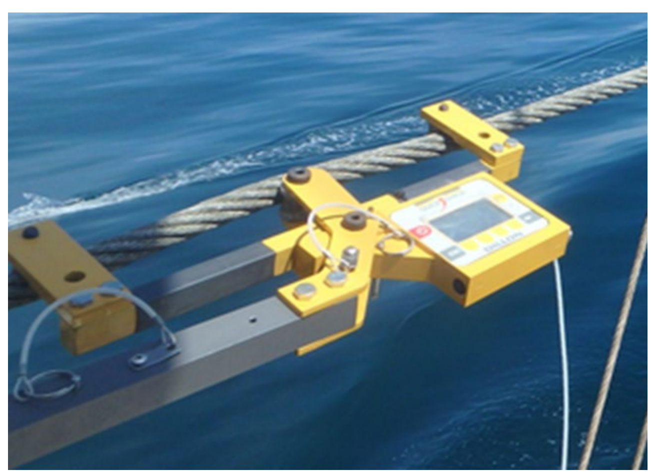

Figure 3: Tensiometer secured to the warp cable of the scallop dredge.

weights, and shell heights were collected for sea scallops as the shell height/meat weight relationship was not necessary for this part of the analysis. Bycatch was sampled per species category, i.e. "trash" encompassing shell hash, sponges, sand dollars, etc. were accounted for by bushel counts and weights, while commercially significant groundfish or invertebrate species were enumerated, weighed, and measured for assessing length frequencies, and all other finfish and invertebrates were counted and weighed. Species weight over the course of 36 total tows are represented in (**Table 1**).

Tow_i	Side	Treatment (minutes)
1	Port	5
2	Stbd.	15
3	Stbd.	30
4…	Port	5
…60	Port	30

Table 2: Project design for evaluating loss while retrieving the dredge.

Winnowing, or the amount of catch lost while hauling back, was measured by hanging one dredge over the side of the vessel for treatments of 5, 15, and 30-minute intervals prior to releasing the catch onboard. The catch from the other dredge would be immediately released and sampled after haulback to serve as the control. Both port and starboard dredges switched as the control and treatment dredge each tow (**Table 2**).

Observations and Key Points

The tensiometer was able to show when a set was fouled (rider) i.e. when one dredge lands on the other. With the information from the tensiometer, the captain was able to adjust the wire during the tow to disentangle the dredges and ensure they fished properly for the remainder of the tow. Without this information a vessel would continue to tow, wasting both fuel and time as well as causing unnecessary impacts to habitat and sea scallop resources. This demonstrates the value this sensor could have at improving a scallop vessel operator's decision-making relative to tow duration.

A Generalized Linear Model (GLM) was used to determine the significance of catch weight in kilograms for predicting tow tension in Newtons. Catch weight was significant and positively correlated with tension i.e. higher catch weights had higher tension values at the end of the tow. Though additional field work is needed, this preliminary analysis further suggests that warp tension during a tow could be used to reliably predict catch weight before hauling back.

RESULTS

- 36 tows completed (3 were riders and excluding from the analysis)
- Total of 2 trips conducted with a total of 7 sea days and 3 fishing days

The species and weights that comprised the catch on this research trip are listed in **Table 1** by the total and mean catch in kg.

Species	Total Catch (kg)	Mean Catch (kg)	Std Dev	Std Error
AMERICAN LOBSTER	150.21	5.180	5.802	0.967
BARNDOOR SKATE	326.61	5.832	7.376	1.229
FOURSPOT FLOUNDER	35.48	1.044	2.661	0.443
GULFSTREAM FLOUNDER	0.82	0.164	0.094	0.016
HADDOCK	1.09	1.090		
ILLEX SQUID	0.14	0.140		
JONAH CRAB	80.85	1.720	1.608	0.268
LONGHORN SCULPIN	1.52	0.217	0.143	0.024
MONKFISH	1311.43	21.499	25.767	4.295
RED HAKE	18.90	0.525	0.693	0.115
ROCK CRAB	6.25	0.391	0.273	0.046
SEA RAVEN	8.59	1.718	1.133	0.189
SEA SCALLOP (RETAINED)	16811.48	233.493	541.187	90.198
SILVER HAKE	7.13	0.198	0.133	0.022
SMOOTH SKATE	4.64	0.516	0.350	0.058
TRASH	12454.84	194.607	519.033	86.506
UNCLASSIFIED SKATES	4513.70	67.369	66.247	11.041
WHITE HAKE	1.09	0.363	0.504	0.084
WINDOWPANE FLOUNDER	3.03	0.337	0.093	0.015
WINTER FLOUNDER	24.00	1.846	0.720	0.120
WITCH FLOUNDER	0.44	0.440		
YELLOWTAIL FLOUNDER	0.86	0.860		

Table 1: Collected weights from caught species in kg from the 36 tows completed.

The tension data from 33 of the 36 tows were analyzed to evaluate tension in Newtons relative to total catch weight in kilograms. Do to the relatively high sampling rate, ~1 Hz, there is inherent autocorrelation or the relationship between a signal and a copy of itself as a function of delay. To reduce the noise, it is necessary to smooth the data but,

	Tension (lbs. force)		Speed (m/s)		
	Mean	***Std Dev***	***Mean***	***Std Dev***	***N***
Port	6074.93	1012.176	2.60	0.718	53,856
Starboard	6050.80	980.912			

Table 3: Summary statistics of tension by side and vessel speed during a tow.

the smoothing interval needs to be an appropriate length to avoid unnecessarily smoothing important variations. To determine what the appropriate smoothing interval should be for these data, an autocorrelation analysis was performed. The analysis showed significant autocorrelation up to a lag of 40 seconds which was then used as to calculate a rolling mean of the tension data during each tow. Pairing the last smoothed tension value with the total catch weight in (kg) for a given tow allowed for a linear regression to determine if catch is a predictor of tow tension. Results from the model indicate that catch weight is significant predictor of tension (**Figure 4**).

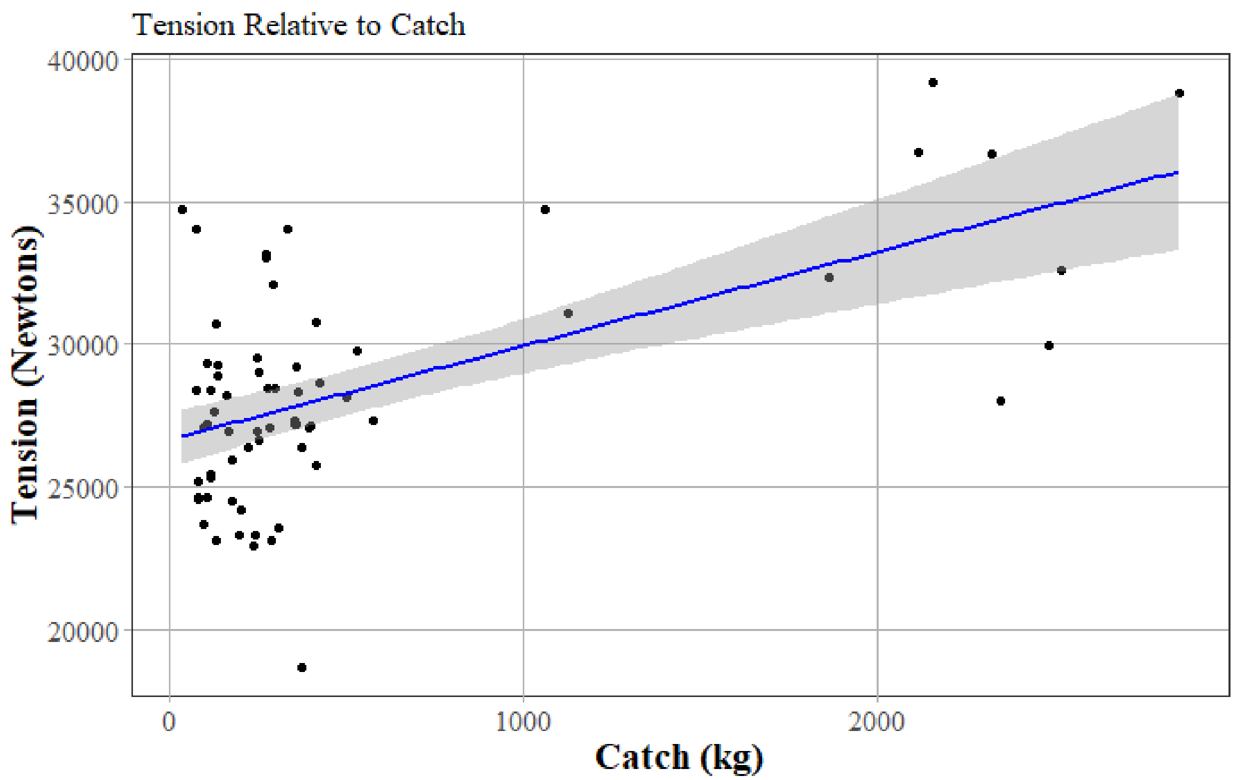

Figure 4: Linear model of tension (Newtons) relative to catch (kg). Black dots represent observed tension

ADDITIONAL COMMENTS

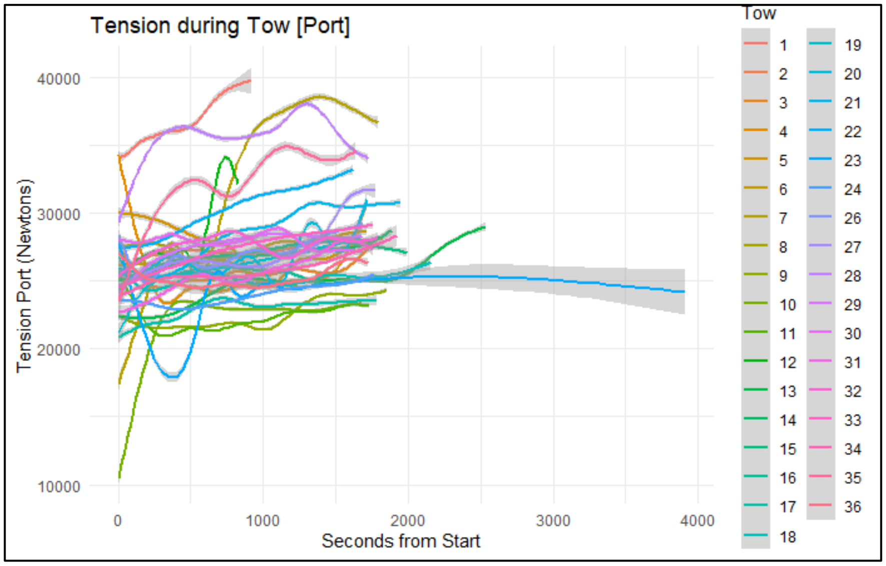

Figure 5: Port tension relative to seconds from the start of a tow.

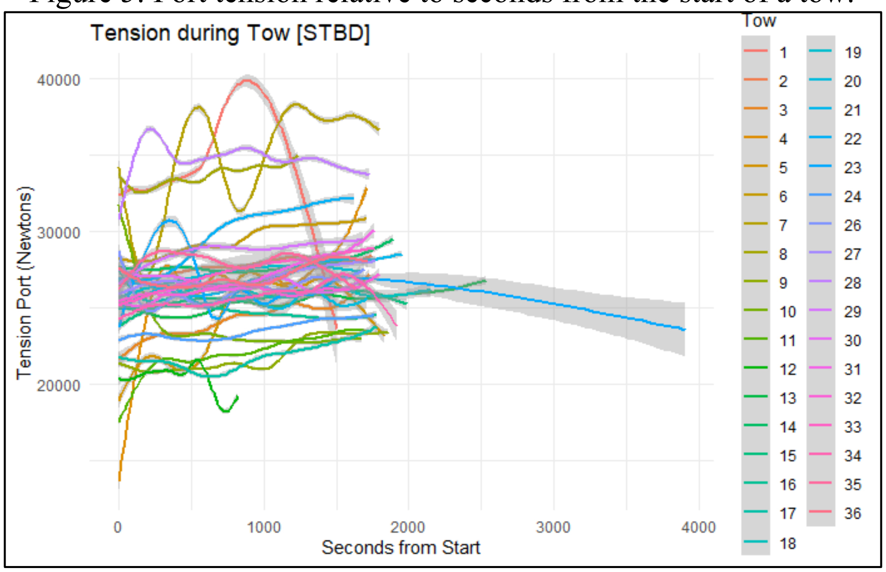

Figure 6: Port tension relative to seconds from the start of a tow.