Development of an Extended Link Apron: A Broad Range Tool for Bycatch Reduction

Prepared by

Farrell Davis, Liese Siemann, and Ricky Alexander

Coonamessett Farm Foundation, Inc

In collaboration with

Ronald Smolowitz – Coonamessett Farm Inc.

David Rudders

277 Hatchville Road
East Falmouth, Massachusetts, USA 02536
508-356-3601 FAX 508-356-3603
contact@cfarm.org
www.coonamessettfarmfoundation.org

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1.0 EXECUTIVE SUMMARY

Project Title: Development of an Extended Link Apron: A Broad Range Tool for Bycatch Reduction

Year Awarded: 2017

RSA Priorities Addressed By This Research: Bycatch research

Industry Partners: F/V Celtic (Charlie Quinn), F/V Concordia (Brian Kvilhaug), F/V Diligence (Scott Larsen), and F/V Beiningen (Dan Eilertsen)

In 2016, Coonamessett Farm Foundation, Inc. (CFF) developed and tested an extended link apron with increased inter-ring spacing in both the horizontal and vertical directions. By increasing the inter-ring spacing of the dredge apron, mechanical sorting of the catch should improve, thereby reducing the bycatch of finfish and pre-recruit sea scallops. Results from this study indicated that extended link aprons warranted further research; however, changes to the apron were necessary to improve scallop catch efficiency. We hypothesized that increasing the inter-ring spacing in just the vertical direction would have equivalent catches of commercial-sized scallops while maintaining the bycatch reductions previously observed and improving sea scallop size selection.

During this project, the vertically extended link apron was tested during four research cruises aboard commercial sea scallop vessels. With the exception of the first research cruise, when CFF provided both dredges, the participating vessel supplied their dredges for the gear comparison study, and the experimental gear for these cruises was the vessel's dredge modified to incorporate the extended link apron. Two dredges were towed simultaneously using commercially representative parameters. Upon completion of each tow, both dredges were emptied on deck and catch was sorted by scientists with assistance from the vessel's crew. Scallop and finfish catch was counted, weighed, and measured for each valid tow. Following the completion of all four cruises, the tow data were analyzed using appropriate statistical analyses.

Our results demonstrate that the vertically extended link apron is capable of significantly reducing windowpane flounder bycatch while having an equivalent or greater catch efficiency for larger scallops compared to a standard apron. There was a trend of reduced bycatch of other flatfish species like yellowtail flounder despite relatively low catches of these species. The overall performance of this modification satisfied our research objective of improving the extended link apron scallop catch efficiency while reducing the bycatch of non-target species.

The findings from this study provide fisheries managers with a gear-based solution for the reduction of incidental mortality to small scallops and the bycatch of flatfish in the sea scallop fishery. Our results in combination with findings from other studies investigating the seasonal and spatial distribution of scallop dredge bycatch can be used by fisheries managers to sustainably exploit exceptional recruitment events while minimizing fishery impacts to incoming year classes of scallops and non-target species.

2.0 PRELIMINARY RESULTS AND DISCUSSION

The project objectives included:

(1) Improve the relative sea scallop catch efficiency of an extended link apron while still reducing dredge impacts to incoming year scallop classes.

(2) Evaluate the efficacy of an extended link apron to reduce scallop dredge impacts to critical bycatch species like windowpane (*Scopthalmus aquosus*) and yellowtail (*Limanda ferruginea*) flounder.

(3) Explore the mechanisms behind changes to dredge efficiency when using an extended link apron.

Accomplishments by objective are described below.

(1) Improve the relative sea scallop catch efficiency of an extended link apron while still reducing dredge impacts to incoming year scallop classes.

A vertically extended link apron has improved scallop catch efficiency relative to the two-way extended link apron tested in previous research. There was a minimal reduction in overall scallop catch (<10%) and the extent of the reduction varied from cruise to cruise when using the vertical extended link apron, while scallop catch was reduced by >20% when using the two-way extended link apron. There was also an increase of 2.31 mm in the mean scallop shell height for the vertical extended link apron and modelling indicates that fewer smaller scallops were being retained (**Table 1 and Figures 1, 2, and 3**). This contrasts to the decrease in means scallop shell height that was observed during testing of the two-way extended link apron. Given these results, we can conclude that the vertically extended link apron is an improvement over both the previously tested two-way extended link apron and the control dredge used in the current study.

Table 1: *The observed and model estimated total changes in catch using tow-by-tow data.*

Species	Extended Link Dredge	Control Dredge	Percent Difference	Model Estimate	Significance
Uncl. Skates	19,253	21,761	-11.53%	-11.46%	**YES**
Barndoor Skate	197	159	23.90%	34.16%	NO
Summer Flounder	107	122	-12.30%	-12.29%	NO
Fourspot Flounder	141	151	-6.62%	-10.32%	NO
Yellowtail Flounder	46	66	-30.30%	-30.30%	NO
Windowpane Flounder	2,003	2,861	-29.99%	-34.47%	**YES**
Monkfish	933	996	-6.33%	-7.82%	NO
Sea Scallops	279,774	291,103	-3.89%	-9.58%	**YES**

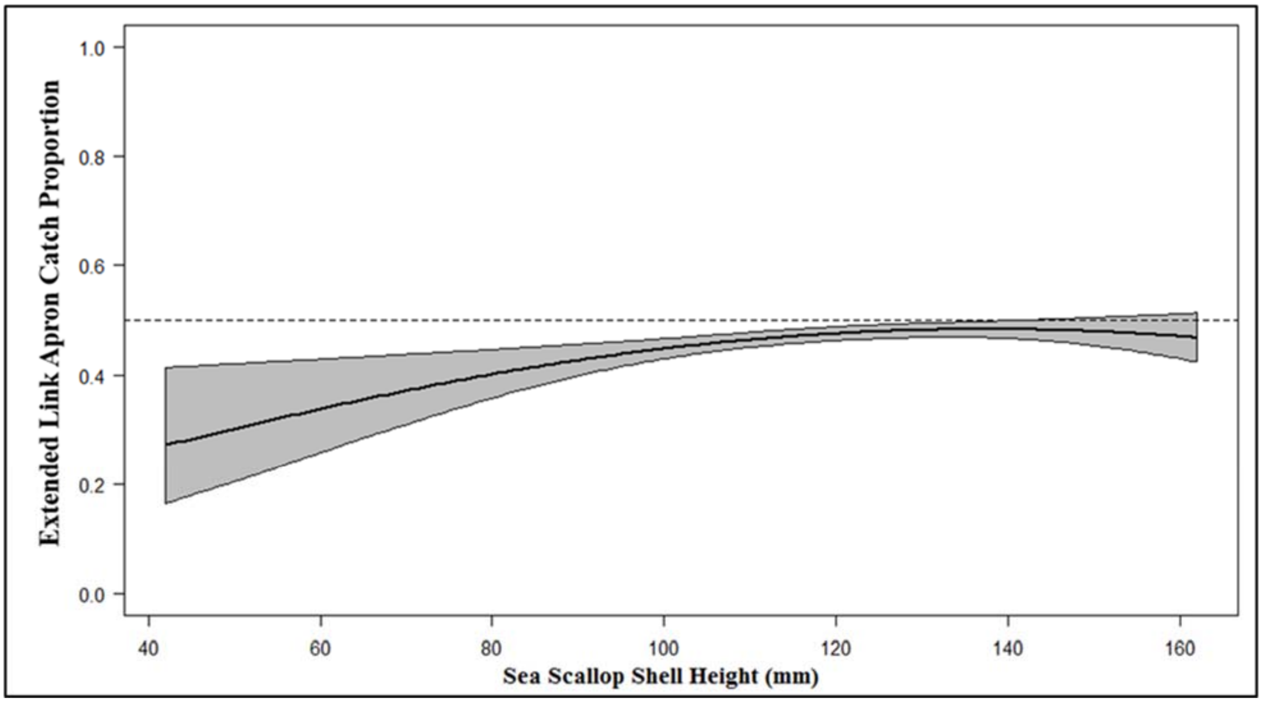

Figure 1: *Pooled relative sea scallop catch by the two dredge configurations as supported by the second order polynomial model (catch in the extended link apron/total catch). The grey area represents the 95% confidence band.*

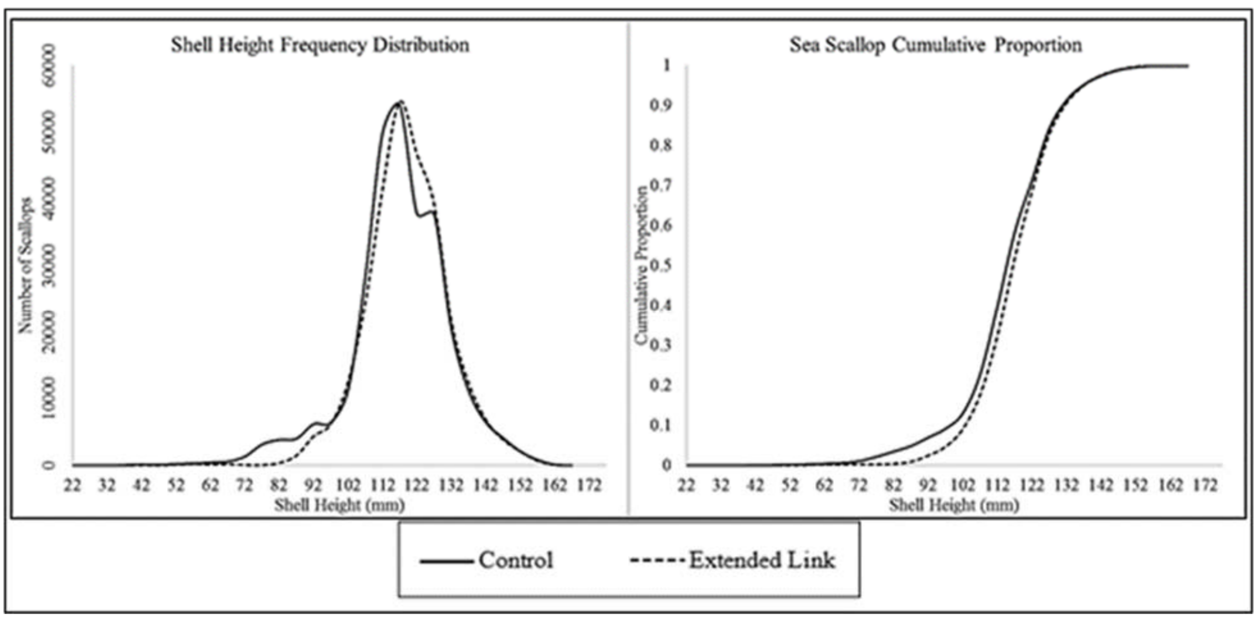

Figure 2: *The pooled scallop shell height frequency distribution and cumulative proportion curves for the control dredge (solid line) and the extended link apron (dashed line).*

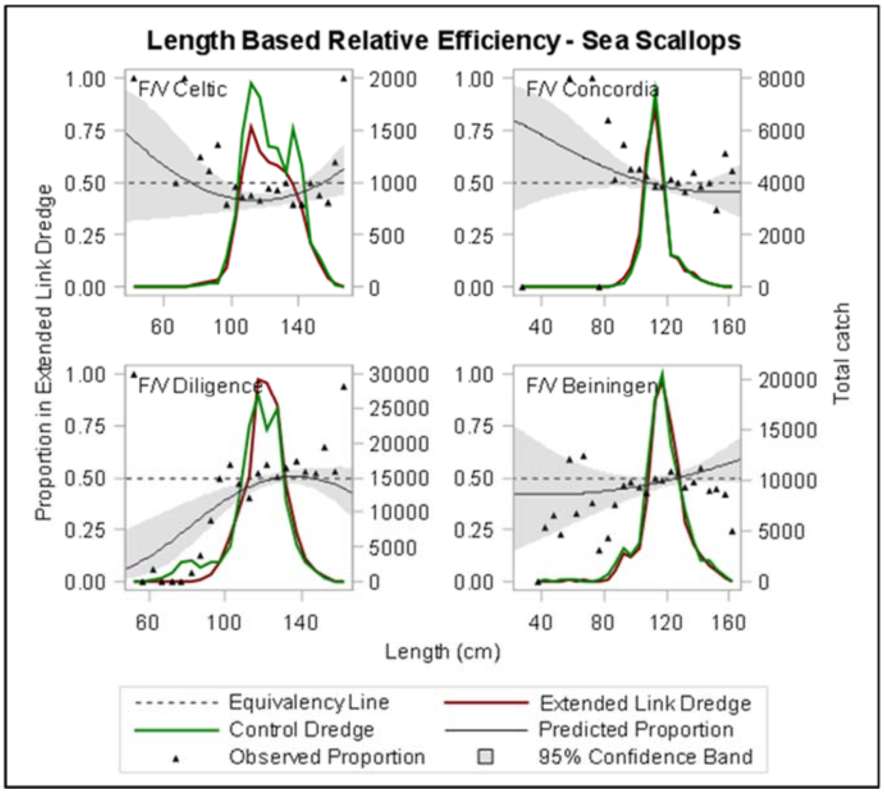

Figure 3: *Relative sea scallop catch by the two dredge configurations by cruise as supported by the selected length-based model. The grey area represents the 95% confidence band.*

(2) Evaluate the efficacy of an extended link apron to reduce scallop dredge impacts to critical bycatch species like windowpane (*Scopthalmus aquosus*) and yellowtail (*Limanda ferruginea*) flounder.

There was an observed reduction in windowpane flounder bycatch during all four research cruises and the reduction was statistically significant for three of the four cruises. Modelling of the pooled catch data for windowpane flounder found the reduction in bycatch to be significant for all cruises (**Figure 4**). Unfortunately, catches of yellowtail flounder were low and highly variable, making it difficult to determine the significance of the observed reduction in this bycatch species.

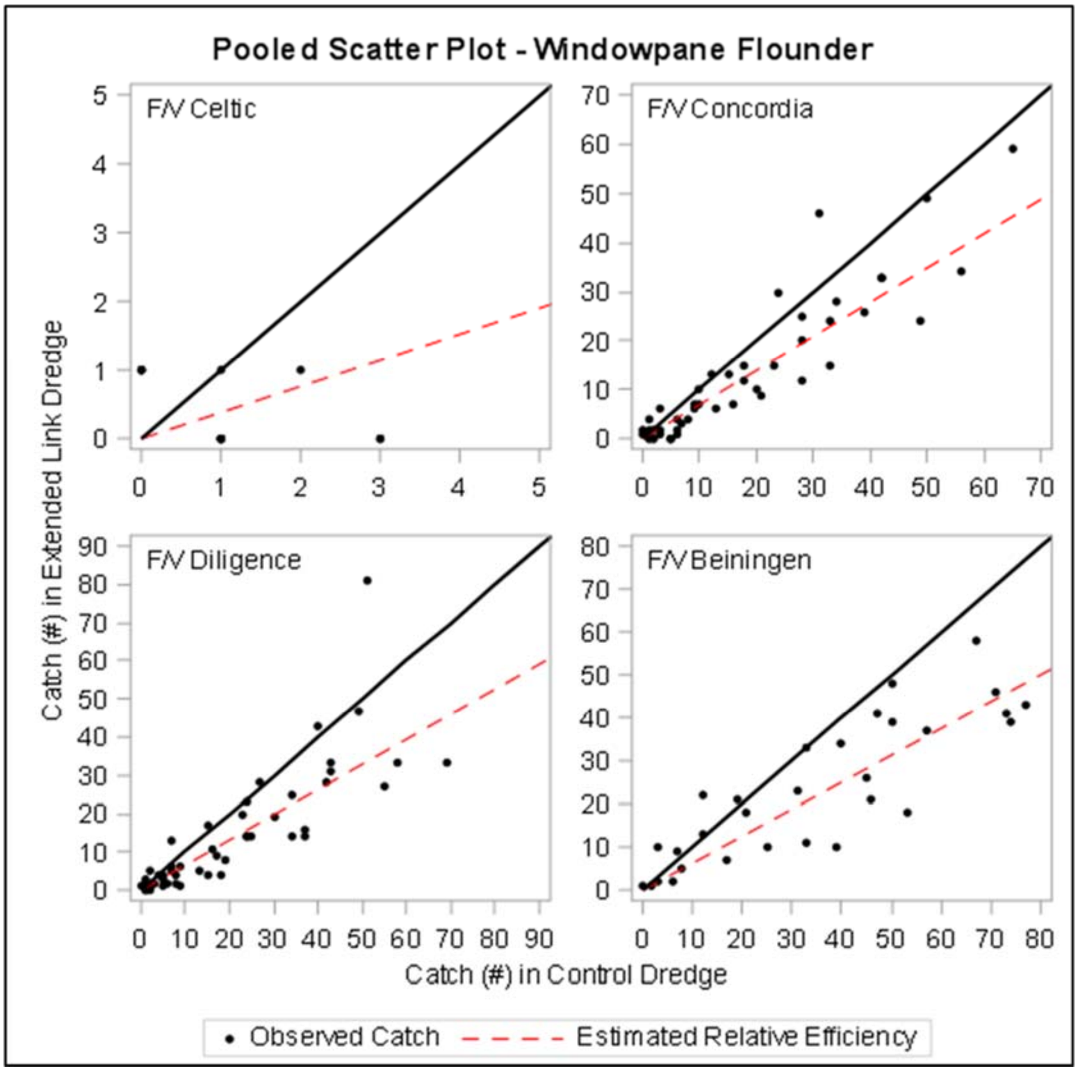

Figure 4: *Total pooled catches for windowpane flounder for the extended link dredge vs. the control dredge. The visualization of these data is represented by the selected model from the pooled over length data. For this species, cruise was a significant predictor of the relative efficiency. The estimated relative efficiency (model prediction) is show as the red dashed line. The black (equivalency) line has a slope of one.*

(3) Explore the mechanisms behind changes to dredge efficiency when using an extended link apron.

Table 2: *Parameter estimates for the best fit models examining the catch data for species with length as a significant effect.*

Species	Effect	Vessel	Estimate	SE	DF	t value	p value	LCL	UCL
Barndoor Skate	Intercept		-0.422	0.361	308	-1.168	0.2436	-1.133	0.289
	Length		-0.002	0.167	308	-0.01	0.9919	-0.331	0.328
	Length^2		0.026	0.041	308	0.633	0.527	-0.054	0.106
	Cruise	Beiningen	0.87	0.401	308	2.171	0.0307	0.081	1.659
		Celtic	0.049	0.417	308	0.118	0.9059	-0.771	0.869
		Concordia	1.365	0.445	308	3.07	0.0023	0.49	2.24
		Diligence	0	.	.	.	.	.	.
Summer Flounder	Intercept	-0.044	0.135	201	-0.3	0.7447	-0.311	0.223	
	Length	-0.313	0.172	201	-1.8	0.0712	-0.652	0.027	
Monkfish	Intercept	-0.119	0.055	1442	-2.1	0.0322	-0.227	-0.01	
	Length	0.166	0.067	1442	2.48	0.0132	0.035	0.297	
	Length^2	0.123	0.067	1442	1.83	0.0681	-0.009	0.254	
Sea Scallop	Intercept		-0.049	0.055	186	-0.891	0.3743	-0.157	0.059
	Length		0.295	0.113	186	2.615	0.0097	0.072	0.518
	Length*Cruise	Beiningen	-0.084	0.158	1827	-0.534	0.5936	-0.394	0.225
		Celtic	-0.201	0.165	1827	-1.219	0.2231	-0.525	0.123
		Concordia	-0.462	0.15	1827	-3.072	0.0022	-0.756	-0.17
		Diligence	0	.	.	.	.	.	.
	Length^2		-0.312	0.114	1827	-2.748	0.0061	-0.535	-0.09
	Length^2*Cruise	Beiningen	0.351	0.129	1827	2.728	0.0064	0.099	0.604
		Celtic	0.516	0.151	1827	3.413	0.0007	0.219	0.812
		Concordia	0.395	0.144	1827	2.736	0.0063	0.112	0.679
		Diligence	0	.	.	.	.	.	.
	Cruise	Beiningen	0.005	0.079	1827	0.065	0.9479	-0.149	0.16
		Celtic	-0.297	0.084	1827	-3.529	0.0004	-0.462	-0.13
		Concordia	-0.056	0.075	1827	-0.744	0.4572	-0.202	0.091
		Diligence	0	.	.	.	.	.	.

Since the experiment was conducted over four cruises, we examined the relationship between the length-based relative efficiency and cruise. The covariates tested in this analysis were length, the second-order polynomial of length (to capture potential non-linearity in the length term), cruise, Beaufort number (a semi-quantitative measure of sea and wind conditions), and the interaction between cruise and length. For some species, there was simply not enough data to provide meaningful results for the more complex models. In most of these cases this failure resulted from a small number of tow pairs where there were non-zero observations and the model failed to converge or produce parameter estimates that were unrealistic. While it was hypothesized that weather sea state and wind conditions (Beaufort number) had a negative impact on catch due to increased mechanical sorting, the Beaufort number was not a significant predictor for dredge efficiency. Parameter estimates associated with the selected model specification for each species where length was an included factor in the selected model are shown in in **Table 2**.

For the length-based model, sea scallops, barndoor skate, summer flounder, and monkfish were the only species where length represented a significant or marginally significant predictor of relative efficiency. In addition, sea scallops also exhibited differences in the slope of the length-based relationship as a function of cruise. Looking across the landscape of species that showed significant length-based estimates, there was no consistent directionality across species and cruises. For example, cruise-specific curves generated for sea scallops were highly variable (**Figure 3**). During some of the cruises, the extended link dredge captured fewer smaller scallops and efficiency increased as scallop size increased, while during other cruises, this pattern was reversed (**Figure 3**).

3.0 SPECIAL COMMENTS

Examination of the length-based relative efficiencies by cruise (**Figure 3**) suggested that scallop density might impact the performance of the extended link apron, with catch of small scallops reduced in areas with higher scallop densities. Additional analysis of the data set, with tows aggregated based on relative scallop density, confirm this observation (**Table 3 and Figure 5**). Density category cutoffs were based on the catch in the control dredge during a 30-minute tow, with low density tows in the lower 25th percentile, mid density tows between the 25th and 75th percentile, high density tows between the 75th and 90th percentile, and very high density tows in the upper 90th percentile (cutoff values shown in **Table 3**). Use of an extended link apron may be particularly beneficial in areas of high abundance of pre-harvest size scallops where there are also large scallops.

Table 3: *Catch per scallop size class, with catch weight estimated from measured shell heights using the shell height/meat weight equation for Georges Bank from the 65th SAW.*

	All catch (kg/size group)		Low density <5 bushels/30-min tow (kg/size group)		Mid density 5-27 bushels/30-min tow (kg/size group)		High density 27-83 bushels/30-min tow (kg/size group)		Very high density >83 bushels/30-min tow (kg/size group)	
Shell height	**Control**	**Extended link**	**Control**	**Extended link**	**Control**	**Extended link**	**Control**	**Extended link**	**Control**	**Extended link**
<75mm	18.09	3.53	0.02	0.13	3.90	3.04	0.50	0.37	13.67	0.00
75-100mm	320.12	192.46	9.48	7.20	116.01	95.38	16.30	16.90	178.33	72.99
100-125mm	4840.78	4855.46	379.51	336.82	1240.88	1114.92	1318.42	1434.30	1901.96	1969.41
>125mm	3339.86	3483.68	366.08	345.95	963.57	862.65	1063.42	1078.23	946.80	1196.85

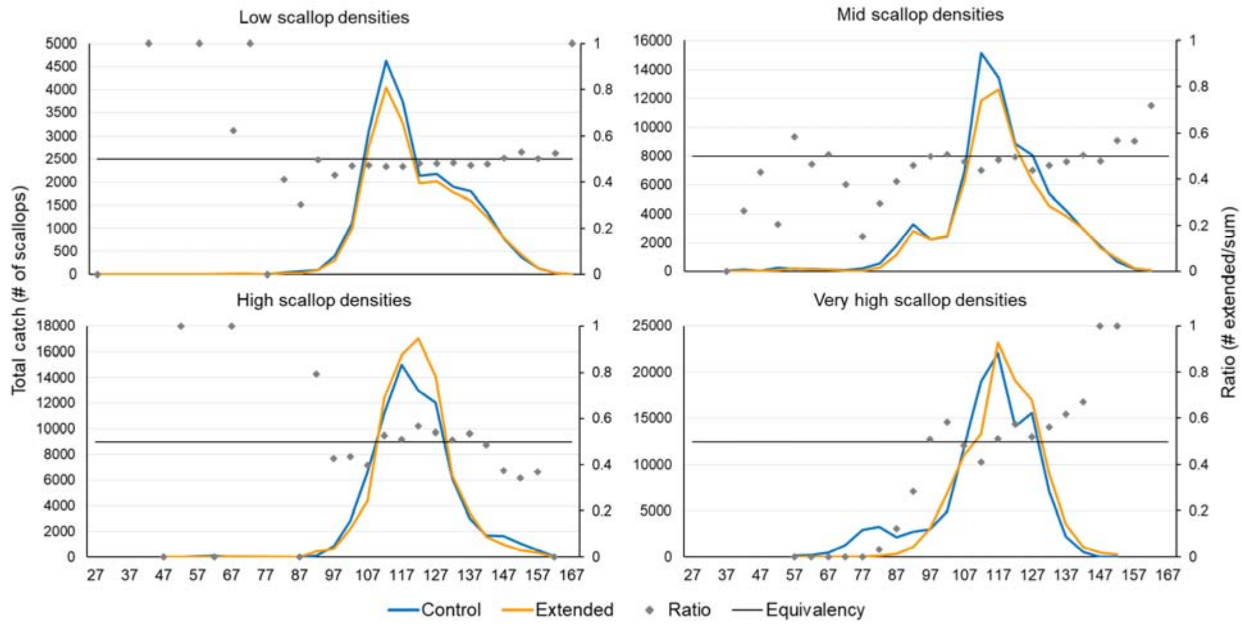

Figure 4: *Relative sea scallop catch by the two dredge configurations with tows categorized by sea scallop density. Scallop density was based on catch per tow in the control dredge.*