Testing of Modified Groundgear to Reduce Capture of Yellowtail Flounder (*Limanda ferruginea*) and Sublegal Atlantic Cod (*Gadus morhua*) in the Georges Bank Multispecies Otter Trawl Fishery

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Abstract

Fishing on Georges Bank faces great challenges due to low stock abundances for many species including Atlantic cod (*Gadus morhua*) and yellowtail flounder (*Limanda ferruginea*) that often inhabit the same area and caught together. Quotas for both species have been drastically reduced in recent years. With the recently implemented sector management, any fish caught during fishing operations counts towards a fishermen's annual allocation regardless of whether the fish is retained for sale or discarded due to size or regulatory restrictions. The discards represent a direct economic loss to the fishermen and waste of valuable resource since mortality can be high for these individuals. One method of reducing discards is to modify fishing gears so that they are more selective. This project evaluated the modification to the groundgear of a multispecies trawl and its effect on the retention of cod and yellowtail flounder. A modified groundgear with 8 inch by 8 inch "escape windows" in the center and 8 inch by 6 inch in the wings was tested with the aim to reduce the catch of yellowtail flounder and juvenile cod. Comparative fishing trials were conducted with F/V "Hera" on Georges Bank in June 2013. The modified groundgear showed a 67% reduction in yellowtail flounder catch and a 37% reduction in sub-legal cod catch compared to a traditional rockhopper groundgear. The modified gear reduced overall bycatch by 61% when compared to the control net. However, the reduction in legal-sized cod (39%) makes the modification commercially unviable at the current fishing regime. As fishing condition changes with the time and management measures, understanding of the effect of gear design on catch of different species and sizes is valuable for future implementation and further research.

Introduction

Fishery targeting Atlantic cod (cod, *Gadus morhua*) is one of the oldest fisheries in New England, dating back almost 400 years. While relatively recent, yellowtail flounder (*Limanda ferruginea*) began to grow in popularity in the 1930's, but is now a highly sought after food fish. The quotas for the Georges Bank stocks of these species have been drastically cut when compared to previous years. For yellowtail flounder the quota was reduced by 68%, from 368 metric tons (MT) in 2012 to 116 MT in 2013. Similarly, the cod quota was reduced by 59% from 4,605 MT in 2012 to 1,899 MT in 2013 (NOAA, 2013).

Over time the laws and regulations that govern fishermen have changed. A new management system in New England has put new emphasis on bycatch and methods to reduce it. Under the new sector quota

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system, everything caught and brought on board is deducted from the overall quota regardless whether it is sold or not. Because of this, there has been a growing need to reduce the bycatch and discards associated with fishing. The term bycatch refers to the non-intentional capture of a non-target species (Kumar and Deepthi, 2006). It also refers to the part of the catch that is returned to the ocean because of economic, legal or personal considerations (Hall et al., 2000). The term discard represents the part of the catch that is dumped back into the sea (Kumar and Deepthi, 2006). These terms are sometimes used interchangeably.

The United States and Canadian fisheries share quota for Georges Bank yellowtail flounder. In the United States, yellowtail flounder is further allocated mainly between the groundfish fishery and the scallop fishery. The Georges Bank scallop fishery is the "most-valued" fishery in the country, producing hundreds of million dollars in landed value and supporting substantial number of direct employment. Yellowtail flounder is the "choke" species in the scallop fishery and poses the risk of closing the fishery if the bycatch quota is reached.

The reduction of bycatch and juvenile fish is important in maintaining the health of the ocean. There are at least two ways to reduce bycatch: reducing fishing effort and developing gears that separates the fish by size or differences in their behavior (Kumar and Deepthi, 2006). Conservation engineering methods to reduce the capture of unwanted fish will benefit the fishing community, as well as the ecosystem. Fish separated at depths are more likely to survive than those brought on board a vessel and then thrown back. The pressure and temperature change associated with hauling up a net has the potential to damage fish's internal organs, such as the swim bladder and blood vessels.

This project was to modify the groundgear incorporating "escape windows" to increase the opportunity for flounders to escape. The size of window takes into the account the distance from the seafloor a flatfish will rise. Generally, flatfish cease movement when a predator approaches and are reluctant to flee (Ryer, 2008). The majority of flatfish enter a trawl net at no more than 50-60 cm off the seafloor (Bubliz, 1996). In the natural environment, winter flounder (*Pseudopleuronectes americanus*) were observed to never raise higher than 30 cm from the seafloor as observed by an underwater camera (He, 2003).

Objectives

The objectives of this study were:

1. To design a groundgear that reduces the catch of yellowtail flounder and sub-legal Atlantic cod while maintaining commercial catches of Atlantic cod and other commercial species.

2. To promote the modified groundgear as an alternative to traditional groundgear through outreach to members of the industry, the management council, and to NOAA fisheries.

Methods

Gear Design

The modified net was designed and built by Reidar's Manufacturing, Inc. (Fairhaven, Massachusetts). The modified groundgear had 8"x 8" (203 x 203 mm) escape windows located in the center of the gear and tapered to 8"x 6" (203 x 152 mm) in the wing (Figure 1). The windows are constructed of 3" (76 mm) rubber cookies and rubber risers with 10" (305 mm) rockhopper discs to help the net transverse rocky terrains.

The control net's groundgear included 18" (457 mm) rock-hoppers separated by one 6" (152 mm) cookie in the center and tapered at the wings to 16" (406 mm) rock-hoppers (Figure 1). Except differences in the groundgear, other components of the trawl system, including the trawl net, were identical between the control and the modified gear. An identical 6.5" (165 mm) mesh size square mesh codend was used on both nets.

Sea Trials

Comparative fishing trials were carried out to evaluate the performance of the modified groundgear against a commercial rockhopper gear (control gear). To mimic commercial fishing operations and catch, the locations of tows were picked by the captain based on his experience. Pairwise towing was performed with a pattern of ABBA, where the control net is A and the modified net is B as recommended by Wileman et al. (1996). Tow duration was set for one hour.

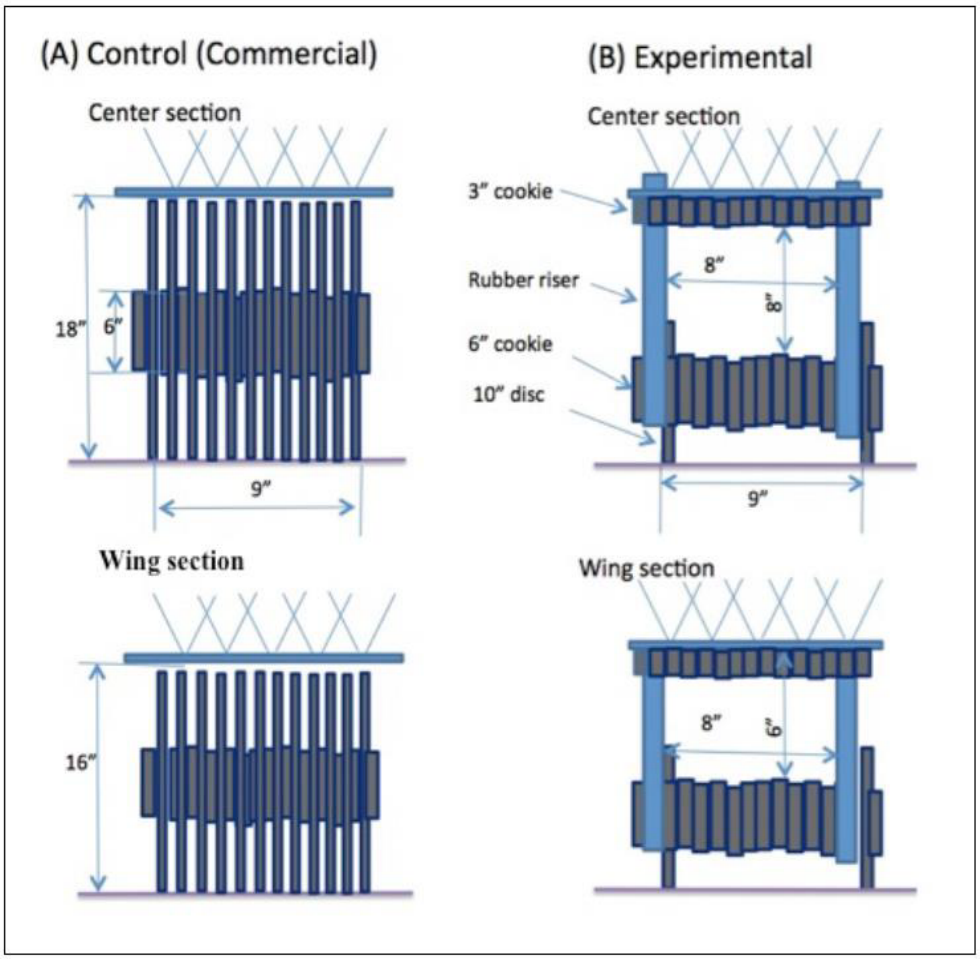

Figure 1. *Schematic drawing of the groundgear and escape window configurations. A is the commercial control groundgear and B is the modified experimental groundgear.*

Operational parameters and procedures (placement of net, time, direction, warp-out) were impacted by environmental conditions (i.e., water depth, current, weather) but were similar for paired tows. Nets were towed in one direction and then towed back over a similar area, but not over the exact same path as recommended in Wileman et al. (1996). Sampling occurred during the daylight hours as Gadoids exhibit diel changes in availability and are usually closer to the bottom during the daytime. Most flatfish are believed to remain consistently available on the seabed regardless of time of day.

Sea trials were conducted in June 2013. The fishing effort was dispersed along the western edge of Closed Area II at depths ranging from 24 to 36 fathoms. There was no significant difference in tow duration between the pairs for both trips (randomization test; p=0.311). A total of 36 pairs of tows were completed.

Environmental and operational conditions were recorded for each tow. These included location and time at the start and end of the tow, wind speed, wave height, depth, and towing speed. Net geometry was recorded using a TrawlMaster system (Notus Inc, St John's, Newfoundland) using a hull-mounted hydrophone. The system monitored headline height, wingspread, and door spread. These measurements were used to evaluate how the net was fishing in the water.

Video observations were made on the groundgear to ensure the gear was fishing perpendicular to the sea floor. Both a GoPro camera (GoPro Inc., St. Mateo, CA) and a low-light camera (Multi-SeaCam 1060, DeepSea Power & Light, San Diego, CA) were used for underwater observations.

Sampling and Analysis

The catch was separated into species and weighed to the nearest 0.1 kg. The weight of cod and haddock (*Melanogrammus aeglefinus*) was broken down into kept and discarded weights. The weights of target species were standardized into catch rates (kg/h). Data was tested for normality by using the Shapiro-Wilks test. Due to the lack of normality that is typically seen

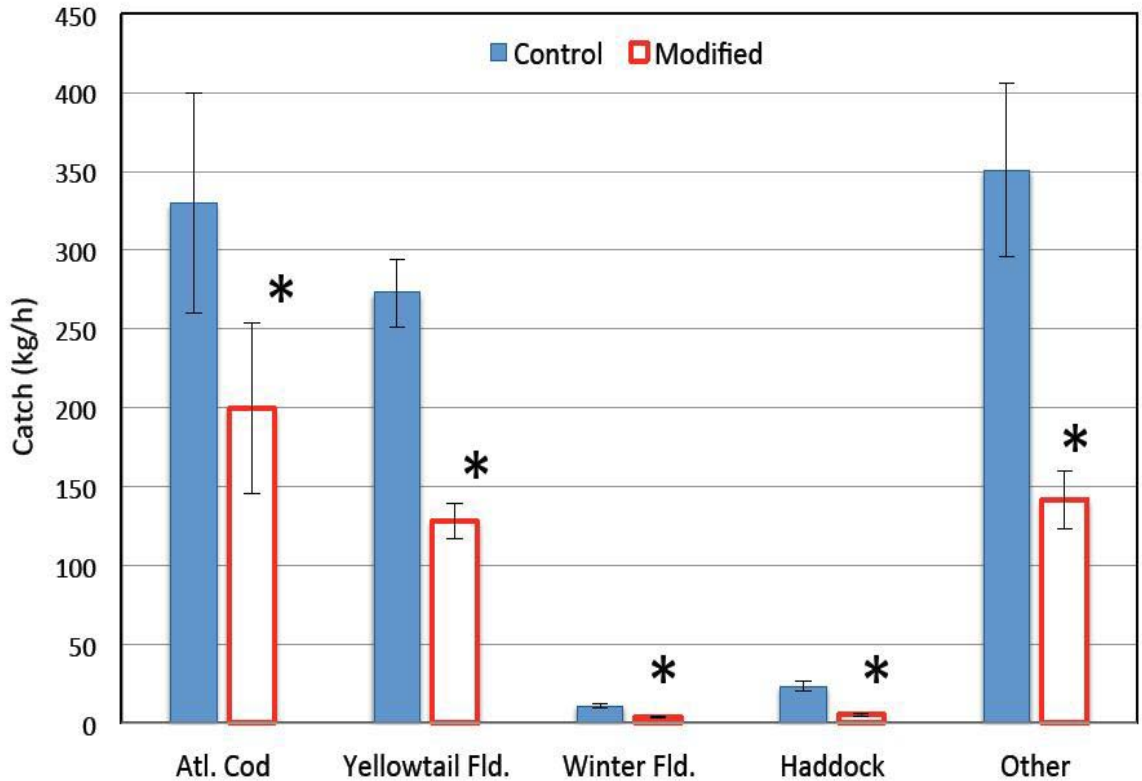

Figure 2. *The average catch rates of target and non-target species. (mean ± SEM). The 'Other' category include skates, spiny dogfish, lobster, halibut, butterfish, cunner, American plaice, sand dab, witch, and summer flounder, longhorn sculpin, monkfish, ocean pout, sea raven, and Pollock. *denotes significant difference.*

in catch data, a nonparametric Wilcoxon signed-rank test was used to compare the control and modified nets (King et al., 2004).

Total lengths were measured for all fish except haddock for which the fork length was measured. Lengths of cod, yellowtail flounder, winter flounder, and haddock were measured to the nearest cm. Sub-samples were taken when necessary. Length frequencies were analyzed using a Generalized Linear Mixed Model (GLMM) to test for a size-based selectivity between gears (Bolker et al., 2008; Holst and Revill, 2009).

Results

The data from the catch indicated a substantial decrease in total catch for the modified nets (22,711.0 kg) compared with the control net (46,146.2 kg). The control net caught 15 species while the modified net caught 17 species.

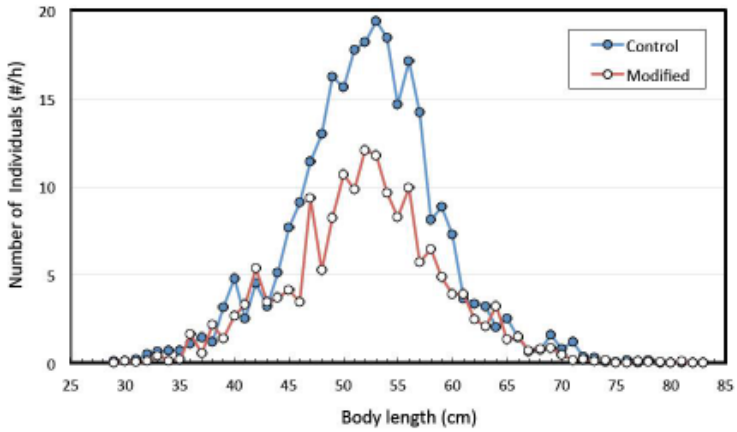

Figure 3. *The length frequency of Atlantic cod with standard error bars from both gear configurations with the black dots representing the proportion of the modified catch at length over total catch at length.*

Species	Control		Modified		P-value
	Mean	SE	Mean	SE	
Atlantic cod (total)	329.54	69.90	199.38	53.93	0.002 *
Atlantic cod (kept)	152.65	25.39	87.56	13.62	<0.001 *
Atlantic cod discarded)	181.45	55.64	114.08	46.54	0.01 *
Yellowtail flounder	272.86	21.49	127.93	10.75	<0.001 *
Winter flounder	10.96	1.63	3.51	0.61	<0.001 *
Haddock (total)	23.25	3.35	5.33	1.29	<0.001 *
Haddock (discarded)	18.93	2.45	3.93	0.98	<0.001 *
All Flatfish	299.36	23.06	132.88	10.51	<0.001 *

Table 1. *Mean catch rate (kg/h), standard error (SE) and p-value (significance indicated by an *) from a Wilcoxon Signed Rank Test for both control and modified nets. "All flatfish" category includes yellowtail flounder, winter flounder, American plaice (*Hippoglossoides platessoides*), witch flounder (*Glyptocephalus cynoglossus*), Atlantic halibut (*Hippoglossus hippoglossus*), summer flounder (*Paralichthys dentatus*), and windowpane (*Scophthalmus aquosus*).*

The modified net caught significantly less sublegal sized cod (by 38%, p <0.001), yellowtail flounder (by 67%, p<0.001), winter flounder (by 54%, p<0.001), and haddock (by 77%, p<0.001). The reduction in discarded haddock was 79% (p<0.001) (Figure 2, Table 1). However, there was also a significant reduction in the catch of legal-sized cod (by 39%, p<0.001) compared to the control net.

The modified net caught significantly less flatfish than the control net (54% reduction, p<0.001). Additionally, there was a significant reduction (by 58%, p<0.001) in catch of other non-target species.

The GLMM showed there was no size-based selectivity in cod (Figure 3) and winter flounder (Figure 4). For yellowtail flounder, the modified net caught fewer fish in smaller size class (Figure 5). Similarly, the modified net caught fewer haddock in smaller size classes, but no difference in the number of haddock >54 cm (Figure 6).

Disscussion

The modified groundgear used in this project reduced the catch of sub-legal cod and yellowtail flounder, as well as other flatfish species, including winter flounder. The escape windows were effective in allowing the flatfish to escape capture. The reduction of flatfish species retention is promising for the modified gear, while the reduction in yellowtail flounder capture alone is very encouraging.

Yellowtail flounder are an important species to many fishermen in different fisheries. By not capturing yellowtail, the fishermen's yellowtail quota would no longer be a limiting factor of a fishing trip. Reducing yellowtail flounder capture allows a vessel to continue fishing for other species. Additionally, there is an economic benefit to the fishermen when quota is primarily used for landed fish and not those discarded.

While there was a great reduction in the catch of sub-legal Atlantic cod, there was also a significant reduction in the catch of legal-sized cod. The modified net could not compete commercially with the standard bottom otter trawl in catching legal-sized cod.

Designing gear to reduce capture of certain fish based on their behavior can be difficult when the species have similar behavioral patterns. The behaviors between flatfish and roundfish are very different. The escape windows located on the groundgear are more suited to flatfish than to roundfish. Flatfish react to an approaching net at shorter distance than roundfish, usually less than 1 m (Ryer, 2008). While cod also tend

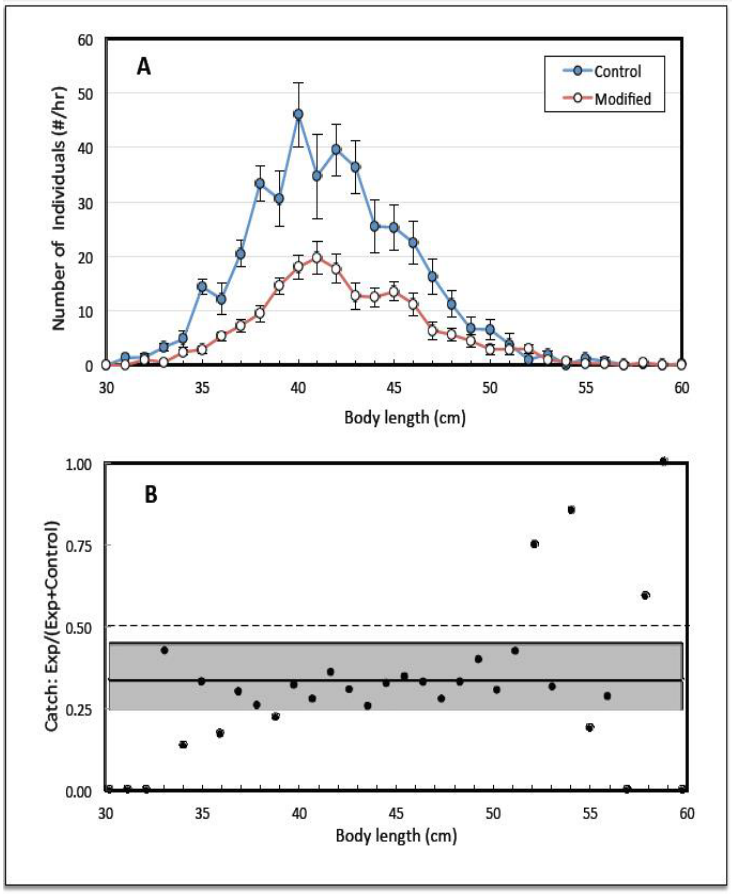

Figure 4. *The length frequency of winter flounder from both gear configurations (A). A logit linear GLMM model showed the best fit for the catch length data (B) with intercept p = 0.003. There is no significant difference in length between the two nets.*

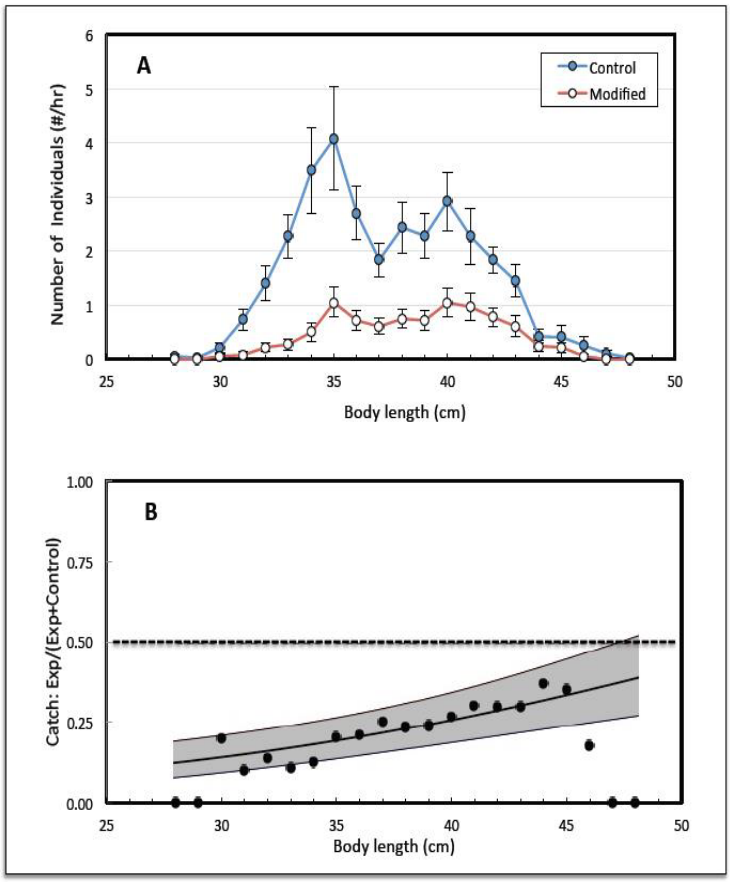

Figure 5. *The length frequency and the catch proportion of yellowtail flounder from both gear configurations (A). A logit linear GLMM model showed the best fit for the catch length data (B) with intercept p < 0.0001. This model indicated significantly more yellowtail flounder under 47cm (red vertical line) are caught in the control net compared to the modified while there are no statistical difference for those flounders > 47cm.*

stay low when entering a trawl (Main and Sangster, 1981), there may be differences in the reaction between large and small cod, resulting in different levels of reduction between size categories.

The modified net also reduced the retention of other bycatch species, including skates and spiny dogfish. Skates and spiny dogfish are known to damage other fish while in the codend. The dogfish has dorsal spines that could damage fish. Skates have rough skin that causes abrasions to the other fish. Reducing skates and dogfish catch can improve the quality of fish retained and the price paid to the fishermen.

There was no difference between nets in the catch of non-targeted commercial species such as monkfish and pollock. However, the catch of haddock was found to be different between the nets. The majority of haddock caught during the experiment were discarded because they were below the minimum size limit.

There was no size-based selectivity between the nets for cod and winter flounder. The size effect of yellowtail flounder and haddock indicates that the modified net caught proportionally fewer small fish.

Designing fishing gear that reduces bycatch is of great importance. Developing selective fishing gears allows the fishermen to only catch what can be landed and sold. Fishing gears designs that allow juvenile fish to escape, grow and reproduce benefit the long-term sustainability of the fishery.

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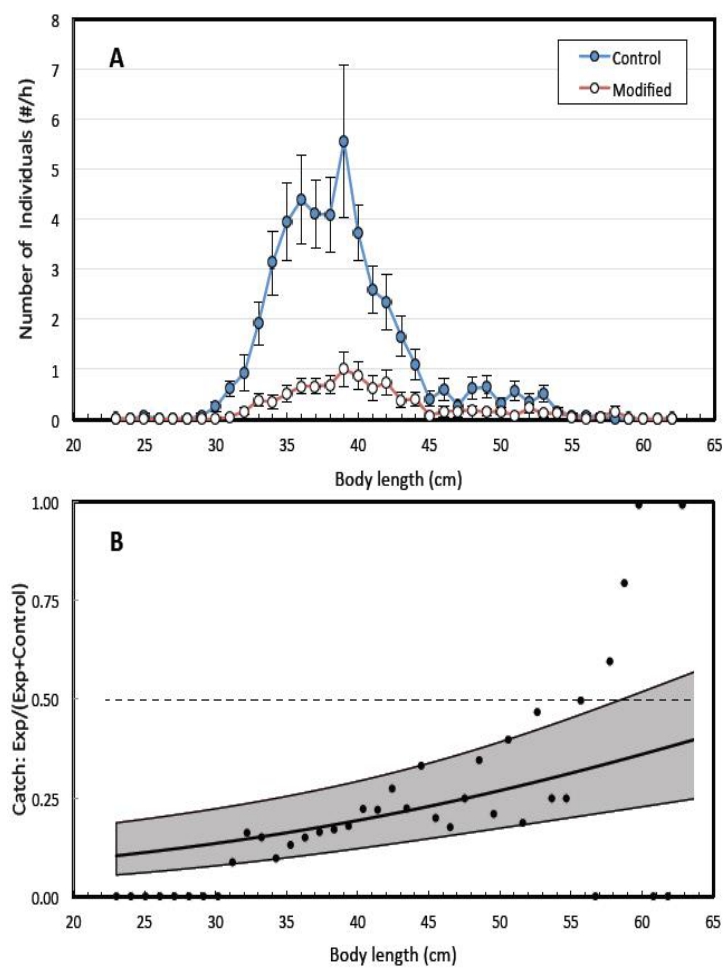

Figure 6. *The length frequency of haddock from both gear configurations (A). A logit linear GLMM model showed the best fit for the catch length data (B) with intercept $p < 0.0001$ and length $p = 0.001$. Based on the data, significantly more haddock under 54cm (red vertical line) are caught in the control net compared with the modified while there are no statistical difference for those haddock 54cm larger.*

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