Groundfish trawl nets designed to reduce the catch of Atlantic cod Gadus morhua

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Abstract

Testing of two experimental trawl nets established that catch rates of Atlantic cod Gadus morhua could be reduced from standard practices while allowing the targeting of flatfish Pleuronectidae. The Ribas and topless nets both modify the top half of a trawl net; the Ribas net by using large square mesh; the topless net by removing much of the twine in the top of the net. Seventy pairs of alternate tows showed reductions of cod catch rates (kg/hr) that exceeded 76% for both nets. Catch rates of sublegal (<33 cm TL) yellowtail flounder Limanda ferruginea were more than 74% lower for both nets, compared to

standard flatfish trawl. Reductions of sublegal (<33 cm) catch rates for winter flounder Pseudopleuronectes americanus exceeded 61%. Significant reductions occurred in legal catch for yellowtail (>32%) and winter flounders (>44%) with some evidence that this reduction was lower for the topless trawl. Underwater video showed cod exiting the nets through the top mesh and through the gap made by the removal of twine.

Key words

trawl; Atlantic cod; flatfish; species separation; underwater video.

Introduction

A United States law, the Sustainable Fisheries Act, establishes standards for regulating the spawning stock biomass (SSB) of marine fish, including Atlantic cod Gadus morhua. Estimates of the SSB led the New England Fisheries Management Council to advise the National Marine Fisheries Service (NMFS) to restrict directed cod fisheries (including trawl fisheries) and to limit landings of cod through area closures and limits on landings of cod per day and per fishing trip (NEFMC 1999; NEFSC 2000).

Alternate fishing gear designs have been used in European Community fisheries, in particular the use of square mesh panels, to achieve stock rebuilding targets for several fisheries. For example, UK Nephrops and whitefish (groundfish) fishermen have been mandated since 1991 to fit square mesh panels in all trawls or seines with mesh size less than 100 mm (Zuur *et al*. 2001). In the Baltic cod fishery, EU council regulation No. 3362/94 Article 12 (December 20, 1994) allows the use of square mesh panels in codends of trawls and seines to give a 50% retention length (L_{50}) of 38 cm (Lowry *et al*. 1995).

The use of area closures designed to protect cod populations prevents targeting of flatfish, some populations of which are able to tolerate directed fisheries in New England. Landing limits and hard quotas on cod in open areas have led to substantial unmeasured capture, discard, and mortality of cod (pers. obs.) This cod mortality is demoralizing to fishermen and delays the rebuilding of the SSB, thus preventing easement of restrictions on fishing for cod. Closing of fishing grounds, limits on cod landings, and the delay in easing of restrictions all represent economic loss to the fishing industry.

In New England, trawl fishermen traditionally use the same gear to target cod and flatfish Pleuronectidae. However, little or no flatfish-specific gear is used or has been developed or tested locally. Results from species-selective trawl experiments conducted by the Danish Institute of Fisheries Research (reviewed by Wileman 1995) indicate that use of square mesh panels in the upper panel of a trawl at the start of the codend eases escapement of demersal roundfish while retaining flatfish. The basic idea behind use of square mesh panels, designed and fitted properly, is the need for stable openings in the codend through which effective escape can occur despite changes in towing speeds, catch sizes, etc. (Larsen and Isaksen 1993; Robertson 1993).

Separation of cod from flatfish has been regarded as problematic because both were thought to remain near the sea bottom even when approached by a trawl. Some experiments using square mesh separation panels (Main and Sangster 1982; Engas and West 1995; Wileman 1995) indicated a high degree of species separation with cod entering the lower part of trawls, although sorting efficiencies from haul-to-haul were inconsistent (Valdermarsen *et al*. 1985). In contrast, other studies were able to direct 98% of cod into an upper codend, using a horizontal separator trawl (Boudreau 1991). Prior to

this study, we observed cod rising as they become fatigued during pursuit by a trawl net (pers. obs.).

Net designs to exploit rising behavior of cod involved removing the front part of the upper panel and using large meshes in the upper panel of the baiting (upper square) (Main and Sangster 1981; Thomsen 1992; van Marlen 1993). Results suggested that cod were able to escape the trawl while reduction of flatfish was negligible. Suuronen et al. (1995) indicated that mortality of juvenile Baltic cod Gadus morhua callarias escaping through trawl codends with square mesh panels is negligible.

The two net designs tested in this project take advantage of the rising behavior of cod in two different ways. One net, dubbed the "topless" net, eliminates as much of the top of a trawl net as possible, following a design from the Faroe Islands (Thomsen 1993). The other design, named the "Ribas" net after its designer, Capt. Luis Ribas, replaces much of the top of the net with large square mesh. Square mesh was chosen over diamond mesh for its greater ability to release roundfish. The experimental designs mimicked the size of the standard net's footrope, but restricted the fishing circle to 100 meshes v. 140 meshes for the standard net.

Successful testing of these nets and demonstration of their practicality was sought to allow fishermen access to areas closed areas due to low cod stocks. Another possible application of a net that successfully separates cod from flatfish would be to reduce cod discard and mortality in open areas where groundfishing takes place.

Methods

The two experimental net designs were tested against a standard design using the paired tow method (Wileman et al. 1996; DeAlteris et al. 1999). Under this protocol, tows were repeated as similarly as possible in pairs, with one tow using an experimental net and the other a standard net. When possible, tow position, tow duration, and tides were duplicated, with one leg of the pair immediately following the other leg.

To allow simultaneous testing on two vessels, two standard nets were constructed of 15.2 cm 3 mm diamond polyethylene (PE) mesh throughout, with 50 mesh diameter 16.5-cm square knotless mesh in the codend, 20 meshes wide on the top and bottom. The headrope and footrope lengths were 12.2 and 18.3 meters (Figure 1). The fishing circle in the standard nets was 140 meshes. The Ribas (Figure 2) and topless (Figure 3) experimental nets were also constructed of 15.2-cm PE mesh with 75 mesh diameter 16.5-cm square mesh in the codend, 25 meshes wide on the top and bottom. The Ribas net replaced 15.2-cm diamond mesh on the top middle of the net with 25 meshes wide of 20.3-cm square mesh from the headrope to the codend. This design had a headrope and footrope length of 18.3 m. The two experimental nets had fishing circles with 100 meshes. All three codends had chaffing gear on the bottom half, consisting of unbraided strands of PE twine.

The topless net has no top wings, allowing the headrope to follow a taper of the net's gore into the top belly, reaching a length of 27.1 m. The bottom half of this net and the Ribas net are identical. Two sweeps were used during this study; a sweep with 15.2 cm cookies and a sweep with 10.2 cm cookies was used to increase flatfish catch rates.

Catch sampling was conducted by trained observers following protocols established by NMFS and modified by DMF for this study. For each tow, position, time, duration, weather conditions, catch composition and weights of all species, and length frequencies of target species were recorded. In cases of large volumes, subsampling of catch and extrapolation were performed using standard DMF protocols.

Catch rates were compared for cod (kept and discard combined), yellowtail flounder Limanda ferruginea (legal and sublegal separately), and winter flounder Pleuronectes americanus (legal and sublegal). Due to non-normal distributions of data, transformations of the logarithm of the rate plus 1 were performed. Transformed rates were then tested first with paired t-tests, and then with ANOVA modified for unequal sample size, with net and boat as factors (Sokal and Rohlf 1995). Tukey's b method was next used to find significant differences in means, if any.

Lengths of cod and commercially valuable flatfish were collected to the extent practicable; often all individuals caught were measured. These lengths were combined across all tows. When subsamples were measured or when kept and discarded fish were measured separately, the total estimated number of individuals (N) at each length was extrapolated from the proportion of the subsample to the total catch. These lengths were compared between experimental and controlled tests using the Kolmogorov-Smirnov tests, adjusted for sample sizes following DeAlteris et al. (1999) (Sprent 1989). Standard fishing practices were followed as much as possible. Fishing locations were selected to optimize catches of cod and flatfish.

Underwater video of cod and flatfish behavior was acquired with a third-wire pan-and-tilt system developed by DMF. The camera was mounted on the headrope of the

experimental nets. This system allows for viewing of the net while it is being towed. The pan-and-tilt unit has a 360-degree range of motion, allowing an ondeck operator to point the camera in a useful direction. Performance of the modified gear was viewed by the operator during filming and again later by DMF personnel at least once. Cod and flatfish reactions were logged and classified into two basic categories: fish that escaped and fish that are caught in the net. Flatfish species could not be distinguished due to inadequate video resolution and were grouped together.

Results

One hundred forty pairs of tows and two days of underwater filming were completed between December 2000 and May 2002 and included in analyses (Table 1). Fifty-nine tows were conducted and excluded due to inadequate pairing, gear damage, side experiments, or other factors. Tows were conducted near Provincetown, Massachusetts USA on Stellwagen Bank and other nearby grounds (Figure 4). Thirty-four pairs were conducted with the Ribas net; thirty-six with the topless net. Three commercial fishing vessels were used: Blue Skies (272 kW, 19 m LOA) and Blue Ocean (300 kW, 19 m) of Provincetown; Dolores Louise (248 kW, 14 m LOA) of Gloucester, Massachusetts.

The primary species caught and kept were: yellowtail flounder (30,328 kg); Atlantic cod (kept and discarded: 14,060 kg); and winter flounder (6,728 kg). Primary discards included: skates Rajidae (32,284 kg); yellowtail flounder (5,203 kg); ocean pout Macrozoarces americanus (3,873 kg); sculpins Myoxocephalidae (2,100 kg). A total of 109,066 kg of fish and shellfish from 31 taxa were caught during this study.

Catch rates of cod, yellowtail flounder, and winter flounder were highly variable and were log-transformed. Paired t-tests on the transformed data indicated significant reductions by both experimental nets in cod catches (Table 2). Results from the paired tows showed lower cod catch rates with both the Ribas net (71.5% less; $p = 0.0001$) and the topless net (86.9% less; $p = 0.0000$). The catch rates of legal yellowtail flounder were also lower in the Ribas net (37.7% less; $p = 0.0006$) and the topless net (32.0% less; $p = 0.0002$). Sublegal yellowtail flounder showed even higher differences in catch rates between the standard net and the experimental nets ((Ribas: 74.87% less; $p = 0.0000$)(topless: 81.2% less; $p = 0.0000$). Legal and sublegal winter flounder also had significantly lower catch rates in both experimental nets compared to the standard net (Ribas: Legal, 55.7% less; sublegal 82.2% less; $p = 0.0001$)(topless: legal, 44.7% less; sublegal 60.6% less; $p = 0.0000$).

Visual comparisons of the transformed catch rates reinforced the results of the paired t-tests. Catch rates of pairs of tows were used as XY coordinates and plotted. An equal catch line was added as a null hypothesis (catch rates are identical) comparison. Of the seventy pairs of tows testing the two experimental nets compared to the standard design, only four pairs of Ribas net tests and three pairs of topless net tests yielded lower cod catch rates for the standard designs (Figure 5A). Results for legal yellowtail were similar, although in general more pairs of tows were near the equal catch line (Figure 5B). Only four of seventy pairs (two Ribas, two topless) had higher catch rates of sublegal yellowtail flounder in the experimental nets (Figure 6A). Legal-sized winter flounder results were apparently similar between experimental nets (Figure 6B).

The effect of the different vessels used in the testing on these results was evaluated using a two-way ANOVA of catch rates using vessel and net as factors. For cod, a vessel effect ($F_{2, 140} = 12.35$; $p = 0.000$) and a net effect ($F_{2,140} = 12.57$; $p = .000$) were significant, but their interaction (net x vessel) was not ($F_{4, 140} = 0.852$; $p = 0.495$). Tukey's b test was used to compare net means. The results indicated that the mean catch rates for both experimental nets were significantly different ($p = 0.05$) from the standard design.

ANOVA results for legal yellowtail flounder also were significant for net effect ($F_{2, 140} = 0.495$; $p = 0.011$) but not for boat effect ($F_{2, 140} = 0.318$; $p = 0.728$). Vessel-net interaction was also not significant ($F_{4, 140} = 0.587$; $p = 0.672$). Tukey's b test indicated that the legal yellowtail flounder catch rates of the Ribas net were significantly lower ($p = 0.05$) than the standard; the standard net and the topless net performed similarly.

ANOVA of catch rates of sublegal yellowtail flounder found that the vessel effect ($F_{2, 140} = 6.767$; $p = 0.002$) and the effect of the nets ($F_{2, 140} = 21.469$; $p = 0.000$) were significant, but the interaction effect was not ($F_{4, 140} = 0.875$; $p = 0.481$). Tukey's b indicated that both experimental nets caught sublegal flounder at lower rates than the standard nets ($p = 0.05$).

Winter flounder results were similar: vessel ($F_{2, 140} = 3.668$; $p = 0.028$) and net type ($F_{2, 140} = 3.532$; $p = 0.32$) explained much of the variance in catch rates, but vessel-net interaction did not ($F_{4, 140} = 0.817$; $p = 0.517$). Tukey's b results provided evidence that the topless net caught winter flounder at rates similar to the standard design, and that the Ribas net caught fewer legal flounder ($p = 0.05$).

Sublegal winter flounder ANOVA results for vessel effect showed a significance level above 0.05 ($F_{2, 140} = 2.632$; $p = 0.076$). The effects of the different nets were significant ($F_{2, 140} = 7.992$; $p = 0.001$); net-vessel interaction was not ($F_{4, 140} = 0.823$; $p = 0.513$). Tukey's b showed that both experimental nets had catch rates lower than the standard net ($p = 0.05$).

Length-frequencies of fish were analyzed to determine whether the nets affected different sized fish differently. The size distributions of cod, yellowtail flounder, and winter flounder were all different in the standard and experimental codends. The Ribas design and the standard net caught different sizes of cod (KS = 0.27, p = 0.00, N = 1876, 435); comparison of the length distributions indicates the Ribas net caught larger cod overall (Figure 7A). The topless net cod distribution was also significantly different from the distribution in the standard net (KS = 0.29; p = 0.00, N = 1694, 220) (Table 5). The topless net also appeared to catch more larger cod (Figure 7B).

Length-frequency distributions of yellowtail flounder were significantly different between the standard net and the Ribas design (KS = 0.26; p = 0.00; N = 22761, 9313). The Ribas net caught few small (<30 cm) yellowtail flounder (Figure 8A). Length distributions of yellowtail flounder between the standard net and the topless net were also significant (KS = 0.29; p = 0.00; N = 28940, 15089). The topless net caught few fish below 33 cm, and more larger fish 41-50 cm (Figure 8B).

The length distributions of winter flounder caught in the Ribas net were significantly different from the lengths of winter flounder caught in the standard net (KS = 0.185; p = 0.00; N = 4600, 1382). The topless net lengths were also significantly different from those caught in the standard net tows (KS = 0.26; p = 0.00; N = 4158,

1912). The standard net caught greater amounts of smaller (< 32 cm or ~13 in) flounder. The modes of both experimental nets were higher than the standard nets (Figure 9A, 9B).

Video footage was collected on 4 December, 2000 and 5 January, 2001. For the Ribas net, most of the cod reacted similarly when first encountering the net, swimming low near the footrope. As they tired, fish rose up into the upper half of the trawl (above a visible sand cloud) and fell back into the net. Fish that went over the headrope either rose very quickly or were initially swimming higher in the mouth of the net. Two cod were observed escaping through the meshes in the upper half of the trawl (Table 3).

Flounder all seemed to exhibit similar behavior with regard to this net. They swam in short bursts in front of the footrope and then tired quickly and tumbled back into the net. They typically stayed close to the lower belly meshes as they fell into the net. Very few flounder tried to escape under the sweep when it bounced off the seafloor. In a few instances, flounder gave a strong burst of speed and swam up higher, but were caught in the net.

More cod went over the headrope of the topless net than fish that fell back into the net, which was expected. Fish that were in front of the footrope could not be seen, because the headrope (where the camera was mounted) was far back from the front of the net or because of sand clouds. Fish could only be seen when they were either above the sand clouds or directly in front of the camera. In a few instances, cod swam in one burst over the net or into the net.

It was difficult to determine if flounders escaped under the sweep because of the camera position. More flounder that got caught in the net were located in the sand cloud along the lower belly meshes than in other parts of the net. Some flounder near the wing-

ends were caught as they tired and were pushed down the net. A few flounder skipped over the headrope near the wing-ends (Table 3).

Discussion

Reductions in cod catches were substantial and dramatic with the experimental nets, providing strong evidence that the alterations in design allowed cod to escape through rising behavior. Underwater video provided additional evidence that cod were escaping either through large square meshes on the top or by rising through the space that would typically be occupied by meshes in the top of the net. These results contradict other findings that used the rising ability of haddock to separate cod and haddock Melanogrammus aeglefinus (Engas and West 1995). This contradiction might be explained by differential rising rates: that haddock rise quickly, and cod more slowly. It is also possible that behavior of Atlantic cod differs between stocks or geographical locations. Speed of movement of fish, and ability to penetrate cod end meshes is linked to temperature (Ozbilgin and Wardle 2002); temperature differences between studies might explain the differing results. In either case, it may be concluded that investigations of differing behaviors between stocks, and between species, would be enhanced by the determination of quantitative measures of behaviors, such as rising rates. In the Northwest Atlantic, exploitable haddock stocks that commingle with cod stocks provide a strong incentive for uncovering differences in their behaviors.

It is also possible that the difference in size of the fishing circles had the primary impact on the differences in catch between experimental and standard nets. However, the experimental nets were constructed so that the footropes swept the same area of the

bottom, allowing the connection of the differences in design of the tops of the nets to the differences in catch rates.

The loss of flatfish is a concern. Changes to the designs may be necessary to improve the economic viability of these nets. Decisions over tradeoffs will need to be made by regulators if the designs are written into legislation, or by individual fishermen if the nets remain optional.

The mechanism for the loss of flatfish is less clear. We have rarely seen flatfish escape nets through top meshes, yet the differences in catch rates are substantial between the standard and both experimental designs. We theorize several possible mechanisms (outside of unidentified sources of bias) to explain the differences. Some fish were observed spilling out of the topless net during haulback. This possible source of loss, likely due to the absence of much of the top of the net, needs investigation and possible mediation through changes in haulback procedures, or use of "net-lockers", a mesh panel that closes off the codend when towing stops, commonly used in Denmark.

A second potential loss of flatfish is through unmasked codend meshes. Field observations indicated that smaller fish tended to be associated with large catches. One possible reason for the capture of fish much smaller than the mesh size openings is that the openings are covered by cod, ocean pout, or other organisms that fill the codend, blocking escapement. It could be that design differences that reduce bycatch are allowing the codend to maintain its selectivity more so than if the codend was filled.

A third area of potential loss is along the wings of the trawls. This may be most prevalent with the topless trawl, which had no top wing. Testing of a model topless net in a flume tank indicated that the wings tended to lean outward. Some evidence that the

wings behaved similarly underwater was seen on underwater video. This leaning could lead flatfish and other fish to escape the net over the top of the wings. Further underwater observations of the fish capture process of these nets would aid in determining further modifications of the nets to reduce flatfish loss.

A fourth possible explanation is that the flatfish escaped upwards after perceiving the darkness of the cod end. This type of behavior has been observed for haddock and whiting and exploited through use of contrasting twine or a "black tunnel" (Glass and Wardle 1995). Studies indicate that cod are unaffected by codend color contrasts (Madsen et al. 1997, 1998). Flatfish may have charged upward just before the headrope (in the topless trawl) or through the large mesh (in the Ribas net). Further filming with the camera further back in the net may provide some evidence for this explanation.

The net factor was significant for cod, kept and discard yellowtail flounder, and kept and discarded winter flounder, indicating that the designs produced differences in catch. The vessel factor was only insignificant for kept yellowtail. Vessel was used in this analysis as a catch-all category, and encompasses seasonal effects, depth effects, and other factors that were conflated with vessel. This difference in significance among species suggests that, for yellowtail, one or more of the environmental variables played a role in the variability of yellowtail catches. The lack of a vessel-net interaction allows the prediction of the impact of the net designs based on the net and vessel (Sokal and Rohlf 1995).

One possible application for these net designs is access to areas closed to protect cod. Preliminary results from this study were presented to the Plan Development Team of the Groundfish Committee of the NEFMC, and were accepted as adequate, but limited in

demonstration to small boats during the day. Further work is planned to test these designs, at larger scale and during day and night.

This study presents another example of positive results that arise through partnerships and cooperation between managers, fishermen and fishery scientists. This study responded to a clear need: access to fishing while protecting selected species. The origin of the designs was disparate: the Ribas design developed through fishing experience; the topless design was a product of the scientific community. The conduct of the experiment was a partnership of biologists designing the study and collecting data and fishermen constructing nets, finding suitable fishing grounds and quantities of fish. In sum, this study follows a model that is, was, and continues to be effective in the development of sustainable fishing gear and methods.

Conclusions

Further testing should be conducted with larger net sizes, and during nighttime, to mimic typical fishing operations. Funding has been obtained to conduct this work. Careful consideration should be given toward the design of the standard and experimental nets as they are scaled up to larger sizes for testing. In addition, the ability of fishermen to use the nets must be considered along with the ability of inspectors to enforce regulations and the ability of clear regulations to be crafted when experimental net designs are considered.

Also, additional investigation of the mechanism of cod and flatfish loss should be conducted, as light conditions allow. Further examination of net models, appropriately sized and constructed, in a flume tank would permit more accurate estimation of the

possibility of escapement over wings. Finally, additional instrumentation to measure net geometry, water temperature, and light levels will be essential to understanding fish behavior in reaction to the experimental designs.

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Literature cited

Boudreau, M. 1991. The performance of a horizontal split level trawl in the Gulf of St. Lawrence segregating cod from flatfish. Fish. Aquat. Sci. Tech., Ancona, April 1991. ICES, Copenhagen, Denmark.

DeAlteris, J., Skrobe, L., Castro, K. 1999. Experimental designs and data analysis methodologies for the evaluation of trawl performance based on catch

comparisons. Presented at the Small Mesh Experimental Fisheries Workshop, URI. 13 August 1999.

Engas, A., West, C.W. 1995. Development of a species-selective trawl for demersal gadoid fisheries. ICES C.M. 1995/B+G+H+J+K,1.

Glass, C.W., Wardle, C. S. 1995. Studies on the use of visual stimuli to control fish escape from codends. II. The effect of a black tunnel on the reaction behaviour of fish in otter trawl codends. Fish. Res. 23:165-174.

Larsen, R.B., Isaksen, B. 1993. Size selectivity of rigid sorting grids in bottom trawls for Atlantic cod Gadus morhua and haddock Melanogrammus aeglefinus. ICES Mar. Sci. Symp. 196, 178 – 182.

Lowry, N., Knudsen, L.H., Wileman, D. 1995. Selectivity in Baltic cod trawls with square mesh cod-end windows. ICES C.M. 1995/B,5.

Madsen, N., Moth-Poulsen, T., Lowry, N. 1997. Experiments with contrast colours and estimates of the selectivity in window codends fished in the Baltic Sea cod (Gadus morhua) fishery. ICES CM 1997/FF:01.

Madsen, N., Moth-Poulsen, T., Lowry, N. 1998. Selectivity experiments with window codends fished in the Baltic Sea cod (Gadus morhua) fishery. Fish. Res. 36(1998):1-14.

Main, J., Sangster, G.I. 1981. A study of the fish capture process in a bottom trawl by direct observations from a towed underwater vehicle. Cited in: Thomsen, B. 1993. Selective flatfish trawling. ICES Mar. Sci. Symp. 196,161 – 164.

Main, J., Sangster, G.I. 1982. A study of multi-level bottom trawl for species separation using direct observation techniques. In: Engas, A., and C.W. West. 1995.

Development of a species-selective trawl for demersal gadoid fisheries. ICES C.M. 1995/B+G+H+J+K,1.

New England Fishery Management Council. 1999. Amendment 9 to the Northeast Multispecies Plan. Newburyport, MA.

Northeast Fishery Science Center, National Marine Fisheries Service. 2000. Status of the Fishery Resources off the Northeastern United States. NOAA Tech. Mem. NMFS-NE-115.

Ozbilgin, H., Wardle, C.S. 2002. Effect of seasonal temperature changes on the escape behaviour of haddock, Melanogrammus aeglefinus, from the codend. Fish. Res. 58,323-331.

Robertson, J.H.B. 1993. Design and fitting of square mesh windows in whitefish and Prawn trawls and seine nets. Scottish Office Agriculture and Fisheries Dept. Scottish fisheries info. pamphlet No. 20.

Sokal, R.R., Rohlf, F.J. 1995. Biometry. W.H. Freeman and Co., New York.

Sprent, P. 1989. Applied nonparametric statistical methods. Chapman and Hall, New York.

Suuronen, P., Lehtonen, E., Tschernij, V., Larsson, P.-O. 1995. Skin injury and mortality of Baltic cod escaping from trawl codends equipped with exit windows. ICES C.M. 1995/B,8.

Thomsen, B. 1993. Selective flatfish trawling. ICES Mar. Sci. Symp. 196,161 – 164.

Valdermarsen, J.W., Engas, A., Isaksen, B. 1985. Vertical entrance into a trawl of Barents Sea gadoids as studied with a two-level fish trawl. ICES C.M. 1985/B,46.

van Marlen, B. 1993. Research on improving the species selectivity of bottom trawls in the Netherlands. ICES Mar. Sci. Symp., 196, 165 – 169.

Wardle, C.S. 1987. Investigating the behaviour of fish during capture. In: Developments in fisheries research in Scotland. R.S. Bailey and B.B. Parrish (eds.) Fishing News Books, pp 139-155.

Wileman, D.A. 1995. Review of the progress made in Denmark in the development of species selective gears. ICES C.M. 1995/B+G+H+J+K,2.

Wileman, D.A., Ferro, R.S.T., Fonteyne, R., Millar, R.B.. 1996. Manual of methods of measuring the selectivity of towed fishing gears. ICES Coop. Res. Rep. No. 215, Copenhagen.

Table 1: Fishing log of experimental tows included in analysis. Trip ID is a unique identifier for each fishing trip. For each trip, tows were numbered sequentially starting with 1. The numbers under net type show which tows tested a particular net for a given trip.

		Net Type		
Date	**Trip ID**	**Standard**	**Ribas**	**Topless**
12/19/2000	MSC01	3, 6	4, 5	
5/1/2001	AF0101	2, 5	3, 4	
5/2/2001	AF0201	3, 4	2, 5	
5/17/2001	AF0301	1, 4		2, 3
5/21/2001	AF0501	2, 3		1, 4
5/25/2001	AF0601	2, 3		1, 4
5/26/2001	AF0701	2, 3		1, 4
6/4/2001	MS0201	1, 4		2, 3
6/5/2001	MIKE P.	1, 4		2, 3
6/7/2001	AF1101	2, 3	1, 4	
6/8/2001	AF1201	2, 3	1, 4	
4/4/2002	JS04	2, 3		1, 4
4/5/2002	JS05	2, 3	1, 4	
4/7/2002	JS06	1, 4	2, 3	
4/15/2002	BK1	1, 4		2, 3
4/15/2002	MS01	1, 5	2, 4	
4/16/2002	BK2	2, 3		1, 4
4/16/2002	MS02	2, 3	1, 4	
4/17/2002	BK3	3, 4	2, 5	
4/17/2002	MS03	2, 3, 6		1, 4, 5
4/18/2002	BK4	2, 3	1, 4	
4/18/2002	MS04	1, 4		2, 3
4/25/2002	VM1	1	2	
4/25/2002	MS06	1, 4		2, 3
5/20/2002	VM2	1, 4	2, 3	
5/20/2002	MS07	1, 4		2, 3
5/21/2002	VM3	2, 3	1, 4	
5/21/2002	MS08	2, 3		1, 4
5/22/2002	VM4	2, 3		1, 4
5/22/2002	MS09	2, 5	1, 6	
5/28/2002	BK5	1, 4, 5		2, 3, 6
5/28/2002	MS10	2, 5	3, 4	
5/29/2002	VM6	2, 3		1, 4
5/29/2002	MS11	1, 4, 5	2, 3, 6	

Table 2: Catch rates (kg/hr) of economically important species in this study. Significances were determined using paired-t tests on log-tranformed data. Reductions were calculated using the standard catch as a starting point.

	Average Catch Rates (kg/hr)			
34 Pairs	**Standard**	**Ribas**	**% Reduction**	**Sign. (2-tailed)**
Atl. Cod	141.4	40.3	71.5%	0.0001
Yellowtail Fl.				
Kept	155.8	97.1	37.7%	0.0006
Discard	36.5	9.2	74.8%	0.0000
Winter Fl.				
Kept	35.5	15.7	55.7%	0.0001
Discard	9.3	1.7	82.2%	0.0000
36 Pairs	**Standard**	**Topless**	**% Reduction**	**Sign. (2-tailed)**
Atl. Cod	120.9	15.9	86.9%	0.0000
Yellowtail Fl.				
Kept	144.9	98.6	32.0%	0.0002
Discard	28.7	5.4	81.2%	0.0000
Winter Fl.				
Kept	37.5	20.8	44.7%	0.0000
Discard	7.4	2.9	60.6%	0.0000

Table 3: Behavioral analysis of footage collected using underwater cameras

					# of Headrope Interactions		
Tape ID#	**Date**	**Net Type**	**Tape Length**	**Species**	**Over**	**Under**	**Through Mesh**
00MADMF674	12/4/00	Ribas Net	55 minutes	Cod	15	53	0
00MADMF675	12/4/00	Ribas Net	49 minutes	Cod	59	108	2
01MADMF676	1/5/01	Topless Net	60 minutes	Cod	74	57	1
01MADMF677	1/5/01	Topless Net	28 minutes	Cod	117	52	0
					# of Footrope Interactions		
Tape ID#	**Date**	**Net Type**	**Tape Length**	**Species**	**In Net**	**Under Net**	**Over Headrope**
00MADMF674	12/4/00	Ribas Net	55 minutes	Flounders	119	4	0
00MADMF675	12/4/00	Ribas Net	49 minutes	Flounders	44	1	0
01MADMF676	1/5/01	Topless Net	60 minutes	Flounders	65	0	8
01MADMF677	1/5/01	Topless Net	28 minutes	Flounders	10	0	0

Figure 1: Schematic of a flatfish trawl net used by the Massachusetts otter trawl fleet and used as the standard net in this study.

Figure 2: Schematic of the "Ribas" net designed by Captain Luis Ribas, based on the standard net design. The top of the net (left side) is constructed mostly of 20.3 cm (8 in) square mesh.

Figure 3: Schematic of the Topless trawl net modeled after the design from the Faroe Islands. The top half of the net (left side) is greatly reduced, lengthening the headrope.

Figure 4: Locations of the beginning of all experimental tows included in this study. The inset shows the NE coast of United States.

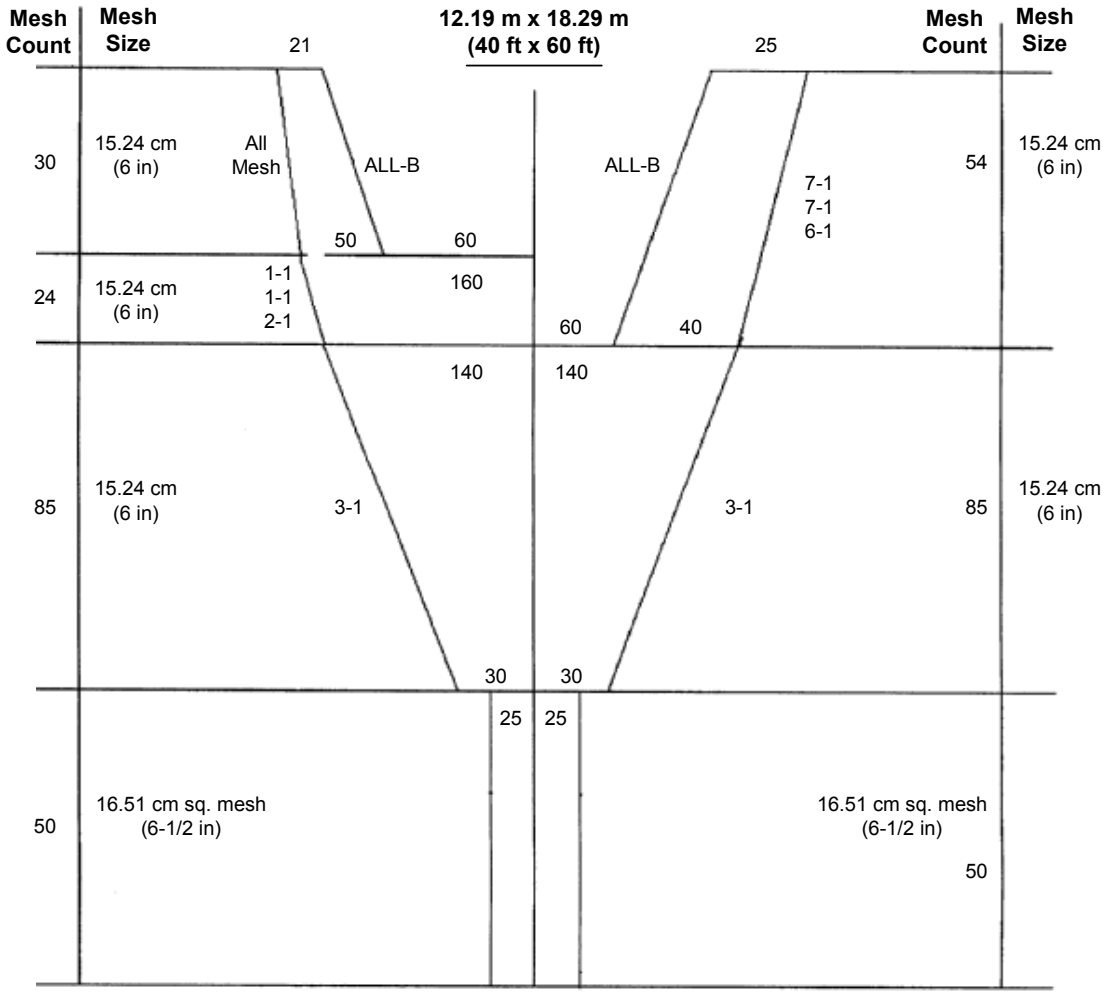
Figure 5: A (top) illustrates pairs of transformed catch rates for cod for comparisons of Ribas (solid diamonds) and topless (open squares) to the standard nets. A line illustrating equal catch is also included. B illustrates pairs of transformed catch rates for legal yellowtail flounder.

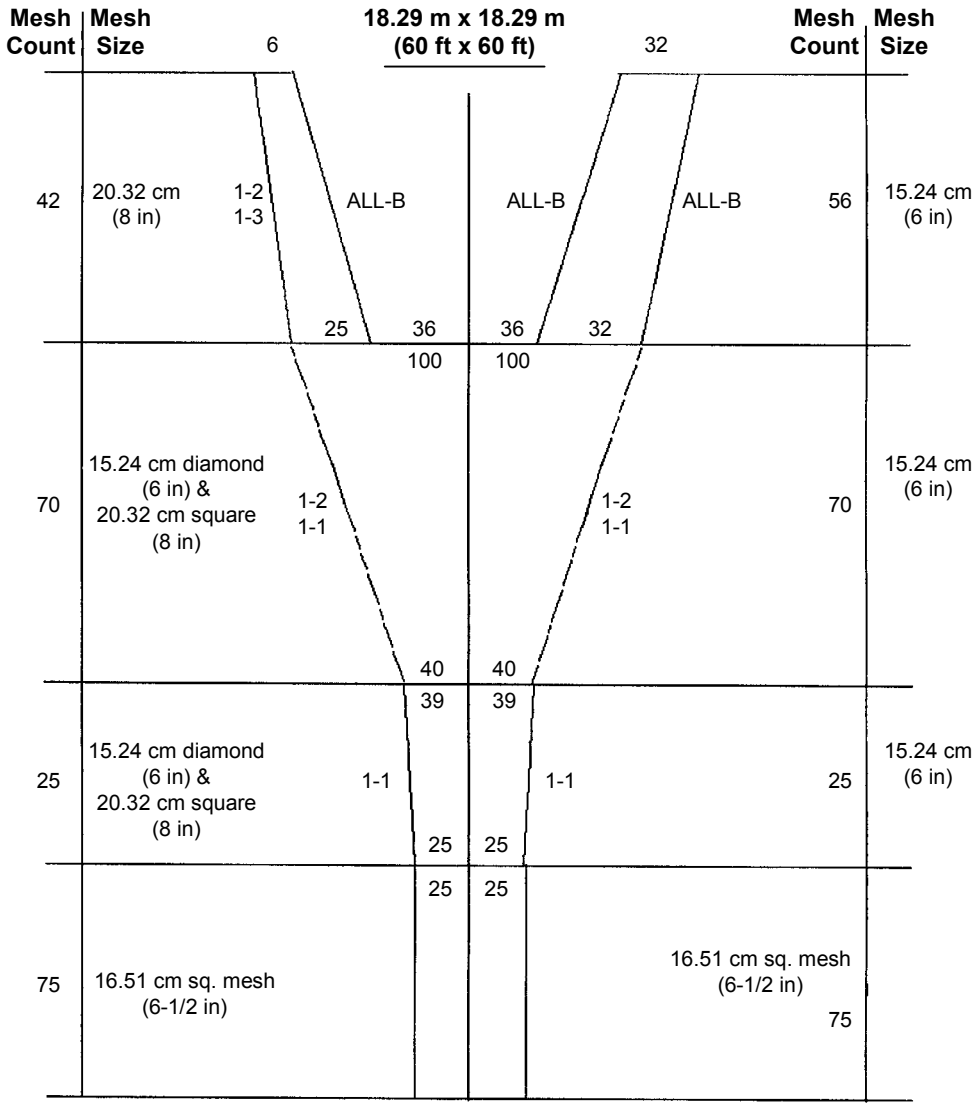
Figure 6: A (top) illustrates pairs of transformed catch rates for discarded yellowtail flounder for comparisons of Ribas (solid diamonds) and topless (open squares) to the standard nets. A line illustrating equal catch is also included. B illustrates pairs of transformed catch rates for legal winter flounder.

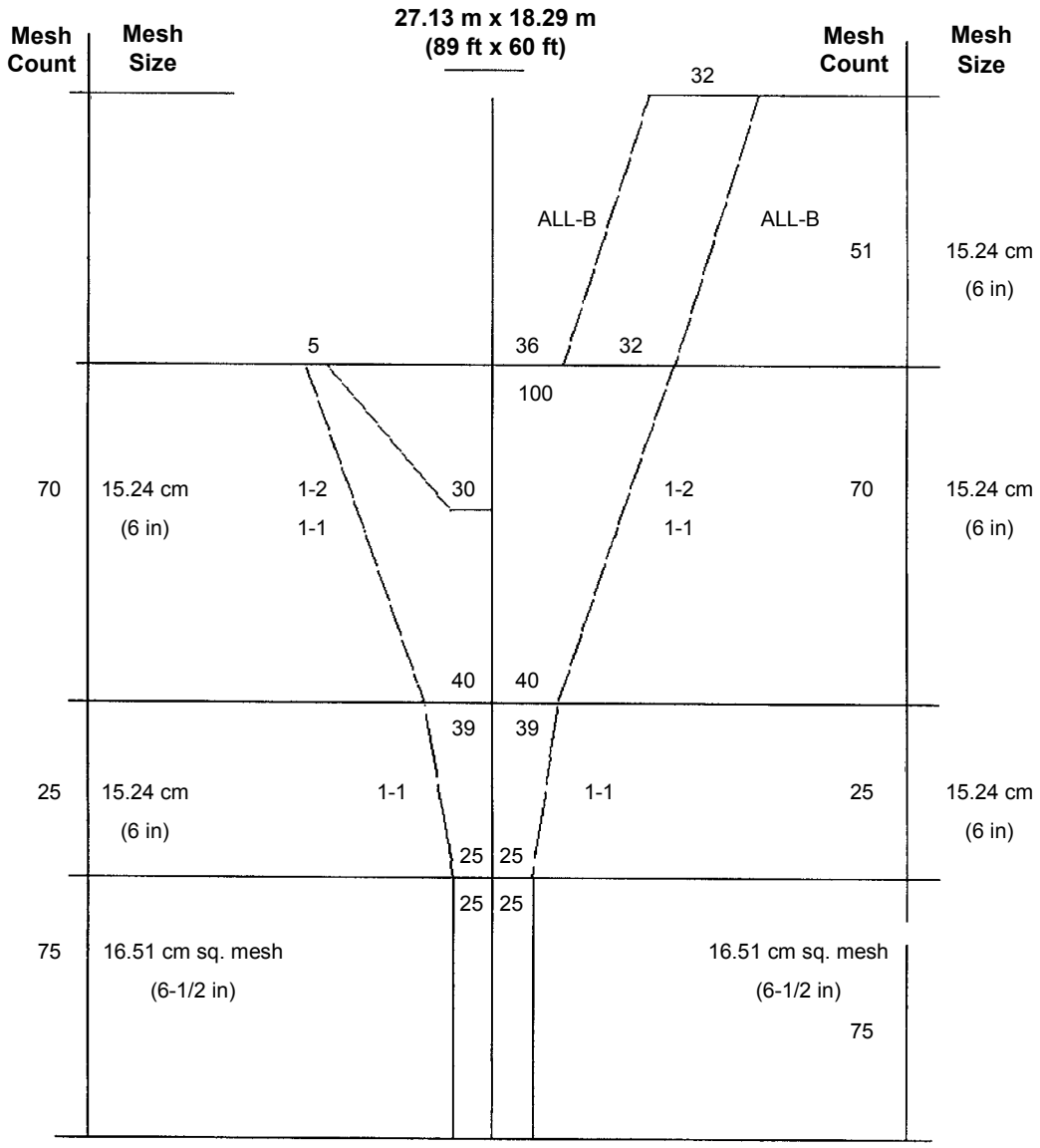
Figure 7: A (top) compares numbers caught during paired testing using the Ribas net and the standard net. B (bottom) compares numbers caught during paired testing of the Topless net and the standard net. Subsamples were extrapolated to the entire catch when necessary. N is the total extrapolated number of individuals. MLS = minimum landing size during testing.

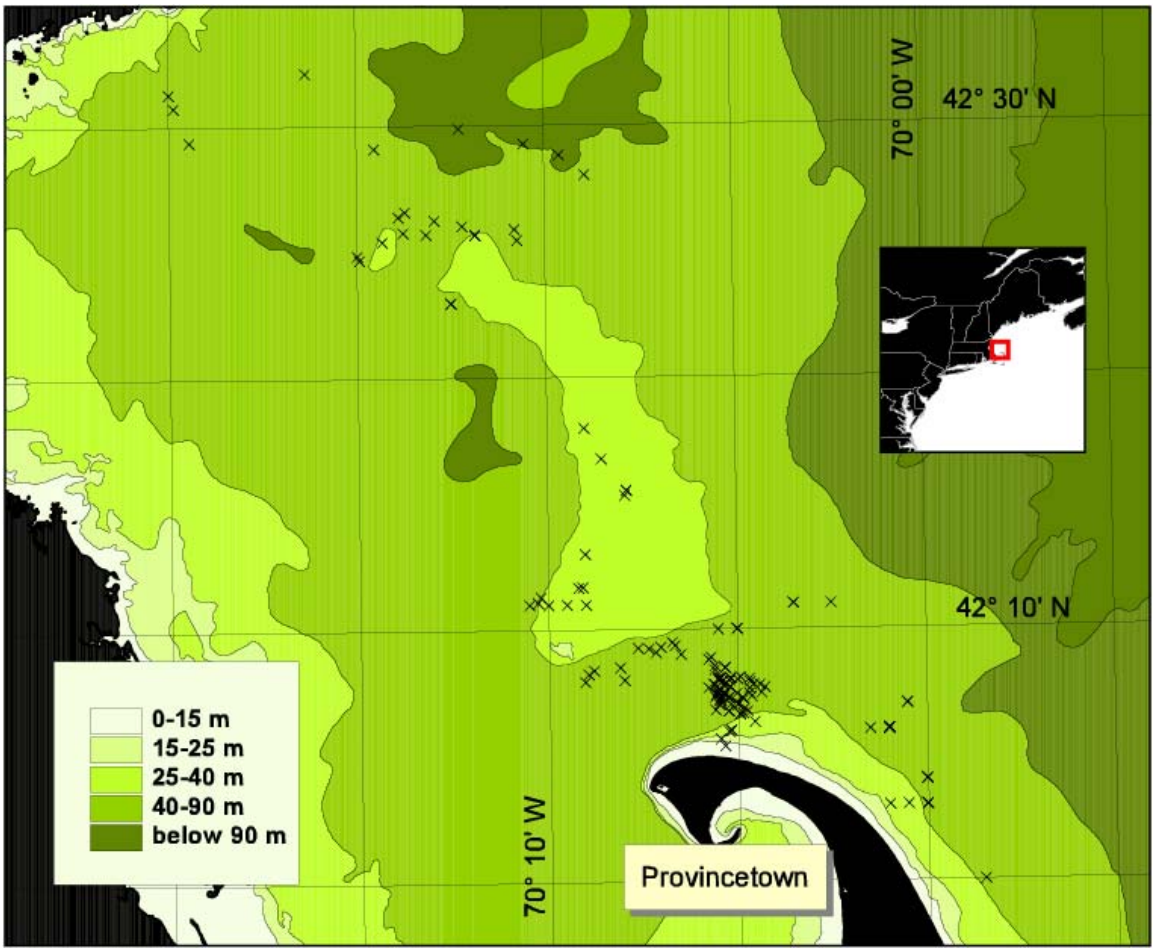
Figure 8: A (top) compares numbers caught during paired testing using the Ribas net and the standard net. B (bottom) compares numbers caught during paired testing of the Topless net and the standard net. Subsamples were extrapolated to the entire catch when necessary. N is the total extrapolated number of individuals. MLS = minimum landing size during testing.

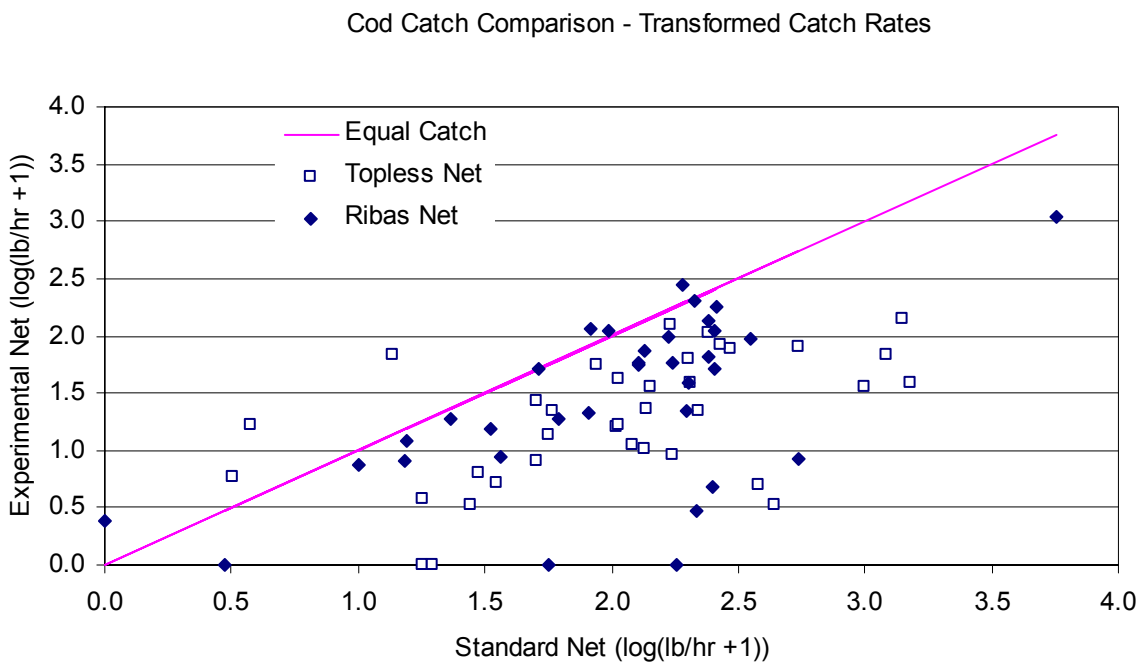
Figure 9: A (top) compares numbers caught during paired testing using the Ribas net and the standard net. B (bottom) compares numbers caught during paired testing of the Topless net and the standard net. Subsamples were extrapolated to the entire catch when necessary. N is the total extrapolated number of individuals. MLS = minimum landing size during testing.

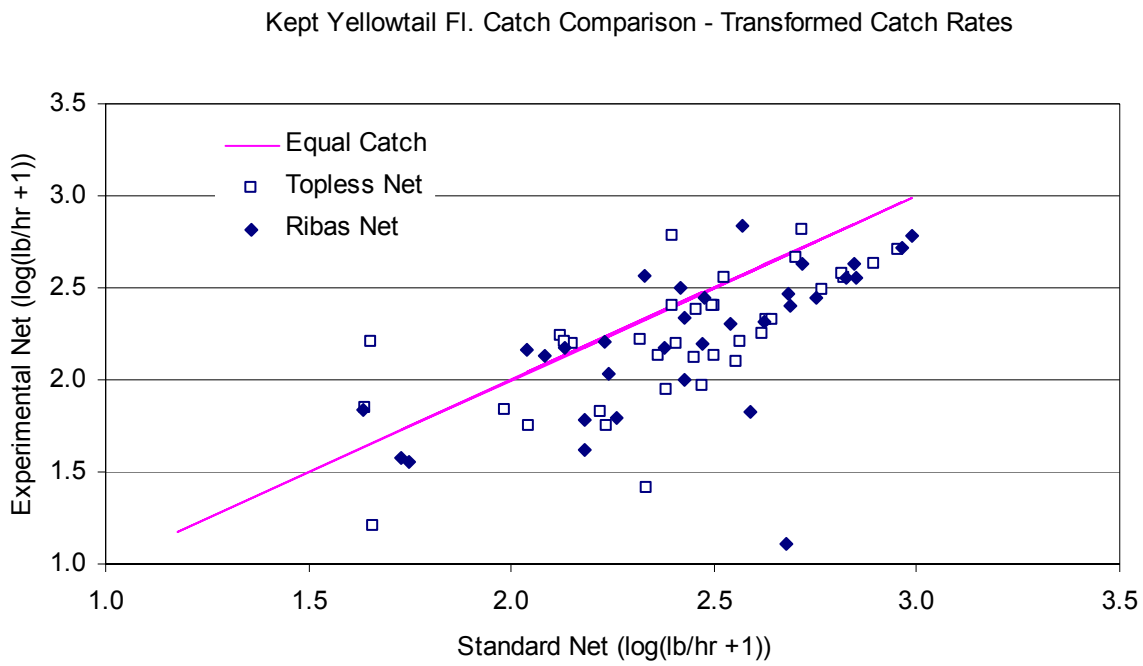

Mesh Count
Mesh Size
12.19 m x 18.29 m
(40 ft x 60 ft)
Mesh Count
Mesh Size
21
25
30
15.24 cm
(6 in)
All
Mesh
ALL-B
ALL-B
7-1
7-1
6-1
54
15.24 cm
(6 in)
50
60
24
15.24 cm
(6 in)
1-1
1-1
2-1
160
60
40
140
140
85
15.24 cm
(6 in)
3-1
3-1
85
15.24 cm
(6 in)
30
30
25
25
50
16.51 cm sq. mesh
(6-1/2 in)
16.51 cm sq. mesh
(6-1/2 in)
50

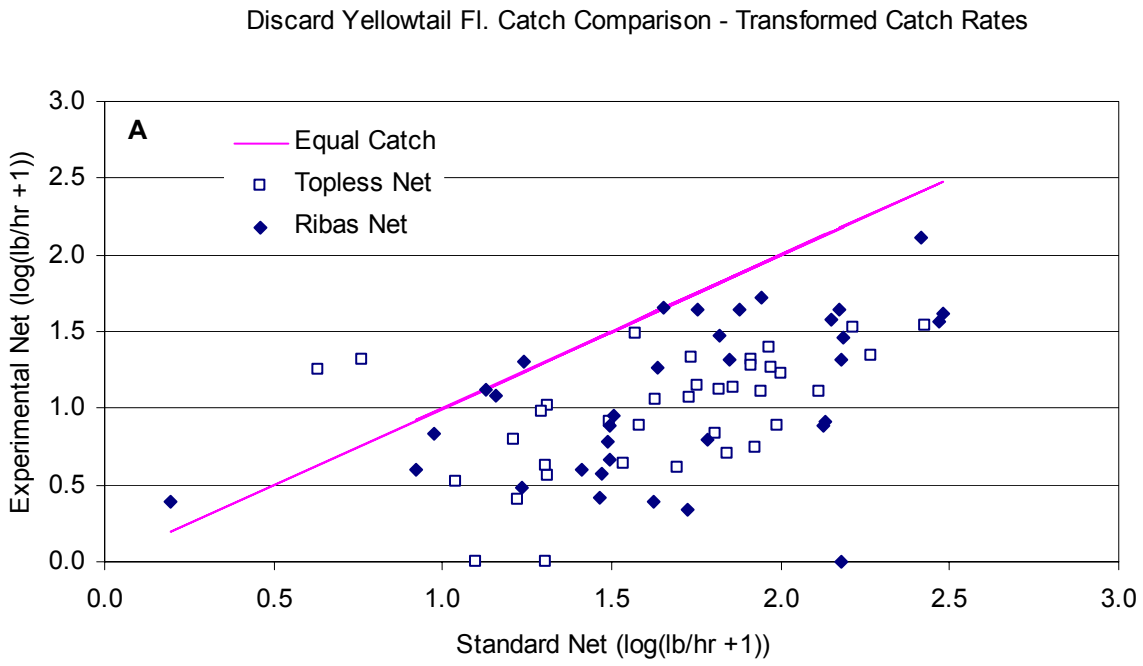

Mesh Count
Mesh Size
18.29 m x 18.29 m
(60 ft x 60 ft)
Mesh Count
Mesh Size
6
32
42
20.32 cm
(8 in)
1-2
1-3
ALL-B
ALL-B
ALL-B
56
15.24 cm
(6 in)
25
36
36
32
100
100
70
15.24 cm diamond
(6 in) &
20.32 cm square
(8 in)
1-2
1-1
1-2
1-1
70
15.24 cm
(6 in)
40
40
39
39
25
15.24 cm diamond
(6 in) &
20.32 cm square
(8 in)
1-1
1-1
25
15.24 cm
(6 in)
25
25
25
25
75
16.51 cm sq. mesh
(6-1/2 in)
16.51 cm sq. mesh
(6-1/2 in)
75

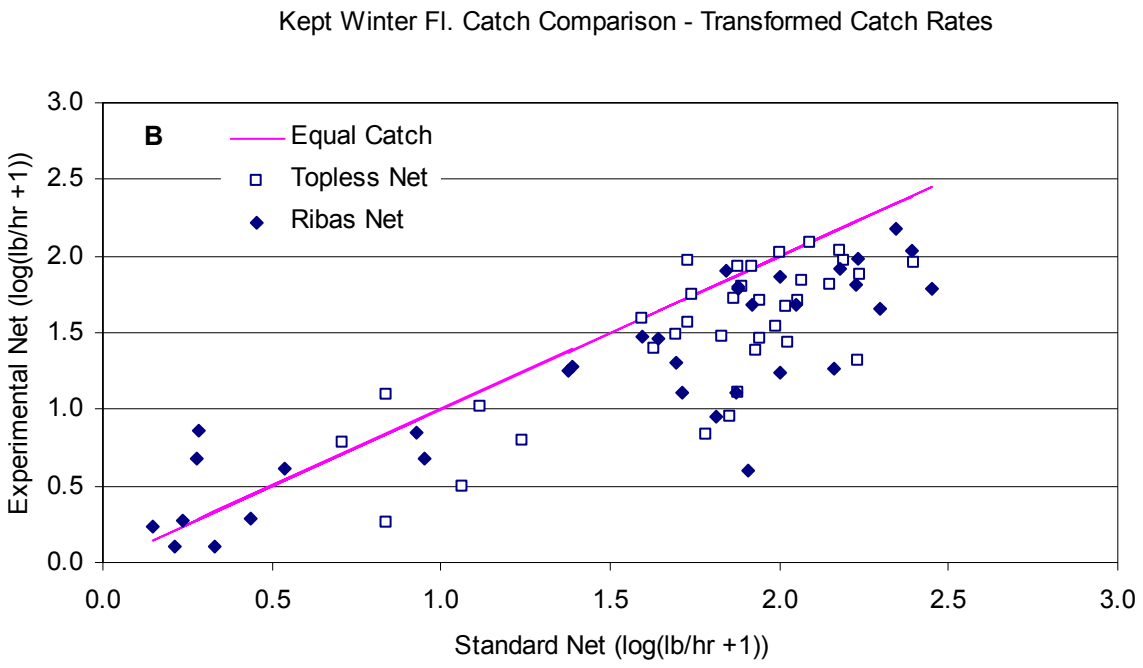

27.13 m x 18.29 m
(89 ft x 60 ft)
Mesh Count
Mesh Size
Mesh Count
Mesh Size
32
ALL-B
ALL-B
51
15.24 cm
(6 in)
5
36
32
100
70
15.24 cm
(6 in)
1-2
1-1
30
1-2
1-1
70
15.24 cm
(6 in)
40
40
39
39
25
15.24 cm
(6 in)
1-1
1-1
25
15.24 cm
(6 in)
25
25
25
25
75
16.51 cm sq. mesh
(6-1/2 in)
16.51 cm sq. mesh
(6-1/2 in)
75

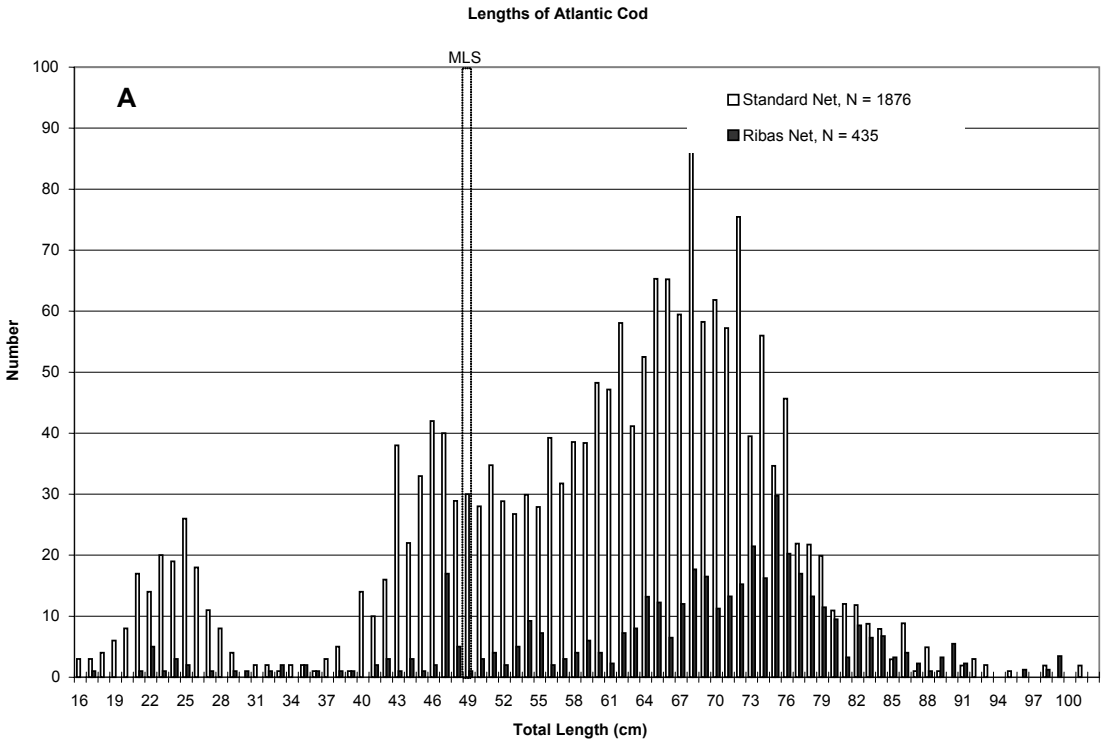

70° 00' W
42° 30' N
42° 10' N
70° 10' W
Provincetown
0-15 m
15-25 m
25-40 m
40-90 m
below 90 m

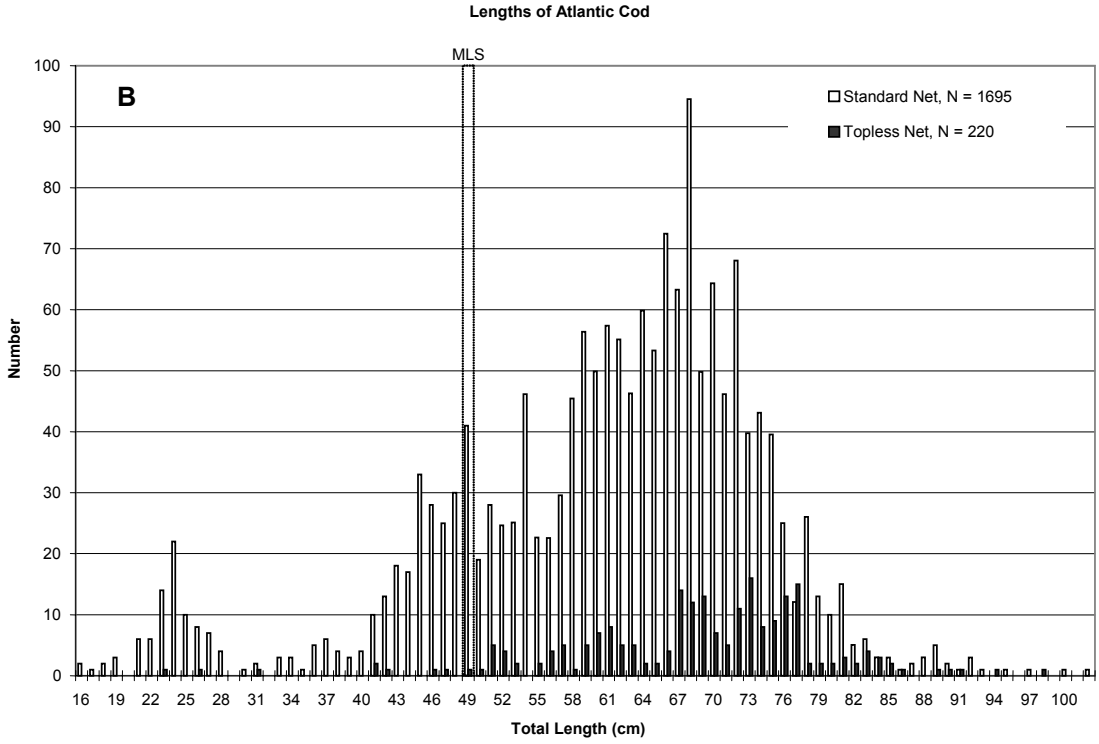

Cod Catch Comparison - Transformed Catch Rates
Equal Catch
Topless Net
Ribas Net
Experimental Net (log(lb/hr +1))
Standard Net (log(lb/hr +1))
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

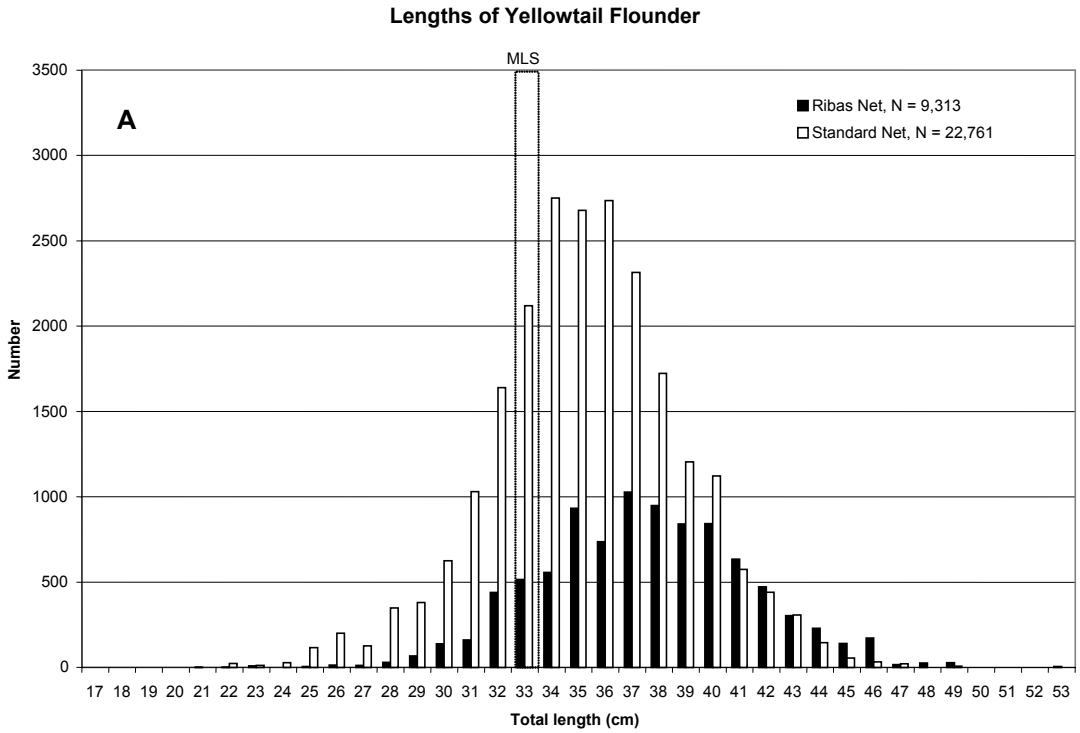

Kept Yellowtail Fl. Catch Comparison - Transformed Catch Rates
Equal Catch
Topless Net
Ribas Net
Experimental Net (log(lb/hr +1))
Standard Net (log(lb/hr +1))
1.0
1.5
2.0
2.5
3.0
3.5

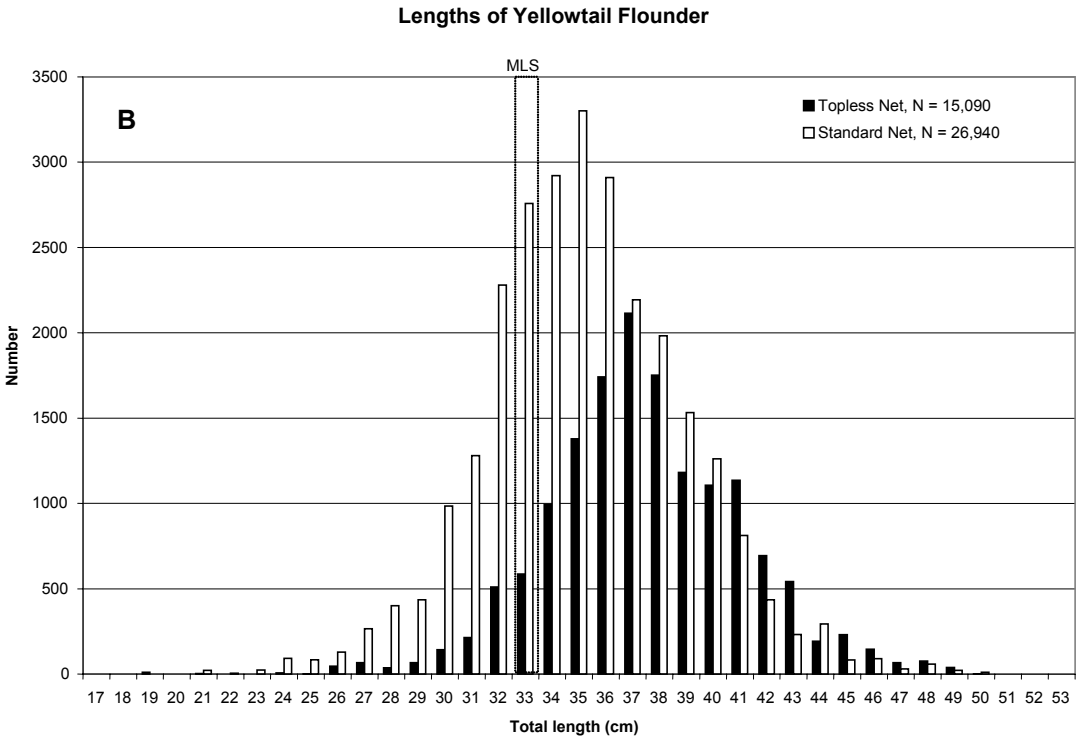

Discard Yellowtail Fl. Catch Comparison - Transformed Catch Rates
A
Equal Catch
Topless Net
Ribas Net
Experimental Net (log(lb/hr +1))
Standard Net (log(lb/hr +1))
0.0
0.5
1.0
1.5
2.0
2.5
3.0

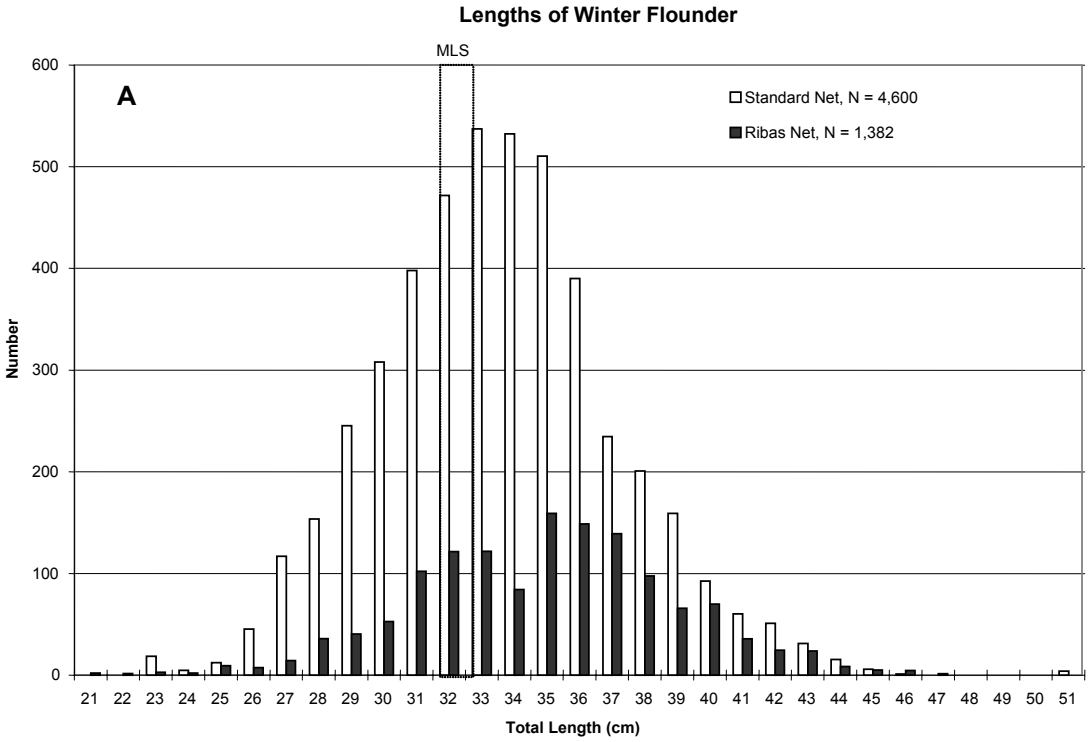

Kept Winter Fl. Catch Comparison - Transformed Catch Rates
B
Equal Catch
Topless Net
Ribas Net
Experimental Net (log(lb/hr +1))
Standard Net (log(lb/hr +1))
0.0
0.5
1.0
1.5
2.0
2.5
3.0

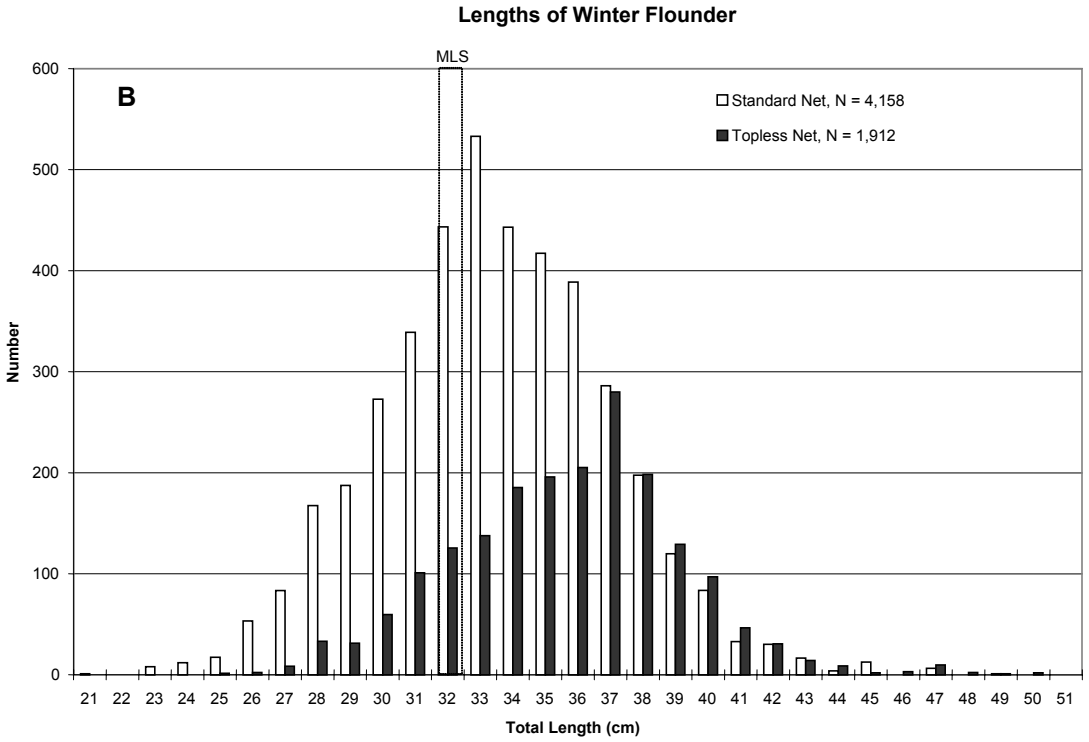

Lengths of Atlantic Cod
MLS
A
Standard Net, N = 1876
Ribas Net, N = 435
Number
Total Length (cm)


Lengths of Atlantic Cod
MLS
B
Standard Net, N = 1695
Topless Net, N = 220
Number
Total Length (cm)


Lengths of Yellowtail Flounder
MLS
A
Ribas Net, N = 9,313
Standard Net, N = 22,761
Number
Total length (cm)


Lengths of Yellowtail Flounder
MLS
B
Topless Net, N = 15,090
Standard Net, N = 26,940
Number
Total length (cm)


Lengths of Winter Flounder
MLS
A
Standard Net, N = 4,600
Ribas Net, N = 1,382
Number
Total Length (cm)


Lengths of Winter Flounder
MLS
B
Standard Net, N = 4,158
Topless Net, N = 1,912
Number
Total Length (cm)

APPENDIX A:

ADDITIONAL MATERIAL PROVIDED TO THE NORTHEAST CONSORTIUM, MANOMET CENTER FOR CONSERVATION SCIENCES and THE NATIONAL MARINE FISHERIES SERVICE

The study described in the manuscript was based on work initially funded by the Northeast Consortium (NEC) in 2000, based on a proposal of the same name. Manomet Center for Conservation Sciences (Manomet) agreed to administer funding due to limitations at that time on the ability of the Commonwealth of Massachusetts to receive this funding. Thirteen days at sea were used to film and test the Ribas and topless designs. The fieldwork conducted for the NEC was conducted between December 2000 and May 2001.

The National Marine Fisheries Service (NMFS) granted an Experimental Fishing Permit (EFP) on March 12, 2002 (and an extension to the end of May 2002) to continue the testing of these two nets, plus an additional design, dubbed the lowrider net, developed by Capt. Joseph Scola of Gloucester. Three vessels were issued permits: Miss Amanda; Blue Skies; Blue Ocean. Access to closed areas granted by the EFPs, and the landing of fish, was used to compensate vessels for participation in this study.

Additionally, data were collected by the Division of Marine Fisheries and used in this study outside of NEC funding or an NMFS EFP.

The purpose of this Appendix is to provide additional information to NEC, Manomet and NMFS in fulfillment of grant and permit requirements.

Summary of Lowrider Testing

This design was tested briefly both as part of DMF sea sampling and under the conditions of the EFP. The design, developed by Capt. Scola and tested in a flume tank, appeared promising as a cod-avoiding trawl design. Testing was conducted on the Dolores Louise.

The lowrider net was constructed of 15.1 cm diamond mesh PE with 16.5-cm knotless mesh in the codend. The headrope and footrope lengths were 12.2 and 18.3 m. The ground gear used for all four net designs was identical, 27.4 m of cable with 6.4 cm cookies. The headrope height was below 1 ft (30 cm); this low headrope height inspired the name of the net and our testing as a cod-avoiding design.

Paired tow comparisons of the lowrider to the standard net design indicated no change in the overall catch rates of cod (t-stat = 0.011, df = 5, p = 0.99). No further analysis was conducted on these results, and no further testing was conducted.

Data from these tows is included in the information in this Appendix.

Table A.1: Summary of all tows conducted during net testing.

		Tow Number						
		A	B	C	D			
Dates	Trip ID	Standard	Ribas	Topless	Lowrider	Excluded	Vessel	Support
12/19/2000	MSC01	3, 6	4, 5			1, 2	Blue Skies	NEC
5/1/2001	AF0101	2, 5	3, 4			1	Blue Skies	NEC
5/2/2001	AF0201	3, 4	2, 5			1, 6	Blue Skies	NEC
5/17/2001	AF0301	1, 4		2, 3			Blue Skies	NEC
5/19/2001	AF0401					1	Blue Skies	NEC
5/21/2001	AF0501	2, 3		1, 4			Blue Skies	NEC
5/25/2001	AF0601	2, 3		1, 4			Blue Skies	NEC
5/26/2001	AF0701	2, 3		1, 4			Blue Skies	NEC
6/4/2001	MS0201	1, 4		2, 3			Blue Skies	NEC
6/5/2001	MIKE P.	1, 4		2, 3			Blue Skies	NEC
6/7/2001	AF1101	2, 3	1, 4				Blue Skies	NEC
6/8/2001	AF1201	2, 3	1, 4				Blue Skies	NEC
6/9/2001	AF1301					1, 2, 3	Blue Skies	NEC
3/20/2002	JS01					1, 2, 3	Dolores Louise	DMF
3/28/2002	JS02					1, 2	Dolores Louise	DMF
4/2/2002	JS03					1-6	Dolores Louise	NMFS EFP
4/4/2002	JS04	2, 3		1, 4			Dolores Louise	NMFS EFP
4/5/2002	JS05	2, 3	1, 4				Dolores Louise	NMFS EFP
4/7/2002	JS06	1, 4	2, 3				Dolores Louise	NMFS EFP
4/11/2002	JS07	1, 4			2, 3		Dolores Louise	NMFS EFP
4/12/2002	JS08	2, 3			1, 4		Dolores Louise	NMFS EFP
4/15/2002	BK1	1, 4		2, 3		5	Blue Ocean	NMFS EFP
4/15/2002	MS01	1, 5	2, 4			3	Blue Skies	NMFS EFP
4/15/2002	JS09	1, 4			2, 3		Dolores Louise	NMFS EFP
4/16/2002	BK2	2, 3		1, 4			Blue Ocean	NMFS EFP
4/16/2002	MS02	2, 3	1, 4				Blue Skies	NMFS EFP
4/17/2002	BK3	3, 4	2, 5			1, 6	Blue Ocean	NMFS EFP
4/17/2002	MS03	2, 3, 6		1, 4, 5			Blue Skies	NMFS EFP
4/17/2002	JS10					1, 2, 3	Dolores Louise	NMFS EFP
4/18/2002	BK4	2, 3	1, 4				Blue Ocean	NMFS EFP
4/18/2002	MS04	1, 4		2, 3			Blue Skies	NMFS EFP
4/18/2002	JS11					1, 2, 3	Dolores Louise	NMFS EFP
4/24/2002	MS05					1	Blue Skies	NMFS EFP
4/25/2002	VM1	1	2			3	Blue Ocean	NMFS EFP
4/25/2002	MS06	1, 4		2, 3		5	Blue Skies	NMFS EFP
5/20/2002	VM2	1, 4	2, 3			5, 6	Blue Ocean	NMFS EFP
5/20/2002	MS07	1, 4		2, 3		5	Blue Skies	NMFS EFP
5/21/2002	VM3	2, 3	1, 4			5	Blue Ocean	NMFS EFP
5/21/2002	MS08	2, 3		1, 4		5	Blue Skies	NMFS EFP
5/22/2002	VM4	2, 3		1, 4		5	Blue Ocean	NMFS EFP
5/22/2002	MS09	2, 5	1, 6			3	Blue Skies	NMFS EFP
5/28/2002	BK5	1, 4, 5		2, 3, 6			Blue Ocean	NMFS EFP
5/28/2002	MS10	2, 5	3, 4			1, 6	Blue Skies	NMFS EFP
5/29/2002	VM6	2, 3		1, 4			Blue Ocean	NMFS EFP
5/29/2002	MS11	1, 4, 5	2, 3, 6				Blue Skies	NMFS EFP

Table A.3. Common and scientific names of organisms mentioned in this study.

Common name	Scientific name
All Clams	Order Bivalvia
All Crabs	Infraorder Brachyura
All Sculpins	Family Myoxocephalidae
All Skates	Family Rajidae
American Plaice	Hippoglossoides platessoides
Atlantic Cod	Gadus morhua
Atlantic Halibut	Hippoglossus hippoglossus
Atlantic Wolffish	Anarhichas lupus
Black Sea Bass	Centropristis striata
Fourspot Flounder	Paralichthys oblongus
Gray Sole	Glyptocephalus cynoglossus
Haddock	Melanogrammus aeglefinus
Lobster	Homarus americanus
Monkfish	Lophius americanus
Ocean Pout	Macrozoarces americanus
Sea Cucumber	Class Holothuroidea
Sea Raven	Hemitripterus americanus
Sea Scallop	Plactopecten magellanicus
Sea Star	Class Asteroidea
All Sea Urchins	Strongylocentrotus sp.
Spiny Dogfish	Squalus acanthias
Striped Sea Robin	Prionotus evolans
Striped Bass	Morone saxatilis
Summer Flounder	Paralichthys dentatus
Whiting	Merluccius bilinearis
Windowpane Flounder	Scophthalmus aquosus
Winter Flounder	Pleuronectes americanus
Yellowtail Flounder	Limanda ferrugineus
Pollock	Pollachius virens
Red Hake	Urophysis chuss
Redfish	Sebastes fasciatus
White Hake	Urophysis tenuis

Table A.2: Summary of species caught and total kilograms kept. Some taxa were grouped at levels higher than species. Disp refers to whether the weight represents species that were kept and landed, discarded, or kept and discarded combined together. Discards in this table are a result of no market or small size. Combined categories include cod because discarding was commonly a result of catch limits. Presence of members of the Other category, comprising one percent or less of the total catch, are indicated below the catch weights by an X.

Species	Disp	Grand Total	Blue Skies (NEC)	Total EFP	Blue Skies	Blue Ocean	Dolores Louise
All Skates	D	32,284.0	1,080.6	31,203.4	16,358.2	8,971.0	5,874.3
Yellowtail Fl.	K	30,328.3	4,669.9	25,658.4	11,853.1	8,630.9	5,174.3
Atl. Cod	K/D	14,059.7	3,209.3	10,850.4	4,660.4	4,043.9	2,146.2
Winter Fl.	K	6,728.0	902.9	5,825.1	2,519.1	2,637.3	668.7
Yellowtail Fl.	D	5,203.0	872.0	4,331.0	2,013.4	1,004.6	1,313.0
Ocean Pout	D	3,873.2	782.9	3,090.3	1,261.4	1,828.9	
Sea Raven	D	1,317.2	326.3	990.9	990.9		
All Sculpins	D	2,099.5	592.2	1,507.3	1,086.4		420.9
Sea Scallops	K	1,375.3	416.1	959.2	959.2		
Spiny Dogfish	D	991.9	97.8	894.1		894.1	
Am. Plaice	D	320.6		320.6			320.6
Am. Plaice	K	528.3		528.3			528.3
Gray Sole	K/D	763.5		763.5			763.5
All Crabs	D	1,598.3	407.4	1,190.9	1,190.9		
Windowpane Fl.	D	63.8	63.8				
Winter Fl	D	89.6	89.6				
Monkfish	D	242.6	242.6				
Monkfish	K	306.0	306.0				
All Skates	K	2,597.5	2,597.5				
All Others (<=1%)		6,981.3	538.3	6,443.0	2,964.3	1,922.4	1,556.3
	Total	109,065.8	17,195.4	91,870.5	45,857.3	28,010.6	18,002.6

Table A.2 (cont.): Species and Dispositions Present (below 1% of catch)

All Clams	D	X			
All Crabs	K/D			X	X
All Sculpins	D			X	
Am. Plaice	K/D	X	X	X	
Atl. Wolffish	D	X			
Atl. Wolffish	K	X	X	X	X
Atlantic Halibut	D	X	X		
Black Sea Bass	D		X	X	
Fourspot Fl.	D	X	X	X	X
Gray Sole	K/D	X	X	X	
Haddock	K/D	X	X	X	X
Lobster	K/D	X	X	X	X
Monkfish	K/D		X	X	X
Ocean Pout	D				X
Pollock	K/D	X	X	X	X
Red Hake	D		X		X
Redfish	K/D				X
Sea Cucumber	D	X			
Sea Raven	D			X	X
Sea Scallops	K/D	X		X	X
Sea Star	D	X			
Sea Urchin	D	X			
Spiny Dogfish	D		X		X
Str. Sea Robin	D	X			
Striped Bass	D	X	X	X	
Summer Fl.	D	X	X	X	X
White Hake	D		X		X
Whiting	D	X		X	
Whiting	K		X	X	X
Windowpane Fl.	D		X	X	X
Winter Fl.	D		X	X	X

Note: All reported skates, sculpins, crabs, clams, urchins, and sea stars were combined. Rocks/debris deleted.

Table A.4: Summary of underwater filming collected. Tape ID is a unique identifier used to catalogue tapes.

UNIQUEIDNUM	FILMTITLE	DATESTART	FILMMEDIUM
01MADMF567	NEC GILLNET STUDY TAPE 2	5/17/2001	MINIDV
00MADMF566	NEC GILLNET TAPE 1	12/2/2000	MINIDV

Table A.5: Equipment purchased as part of the NEC grant

Pan and tilt motor mount	ROS, Inc	For underwater filming
Bottom Contact sensors	Humphrey Instruments	Net mensuration

Figure A.1: An example of data collected for each haul. Position information removed.

Figure A.2: Underwater photo showing two Atlantic Cod swimming high in front of the "Ribas" Net.

Figure A.3: A Flounder falls back into the "Topless" Net after bouncing off the lower belly meshes.

Figure A.4: An Atlantic Cod falls back into the "Topless" Net above the sand cloud.

NMFS FISHERIES OBSERVER PROGRAM
TRAWL HAUL LOG

01/01/96
OBOTH, OBPRH, OBHAU, OBSPP

OBS/TRIP ID	VESSEL NAME	VESSEL NUMBER	DATE LANDED mm/dd/yy	HAUL #	GEAR CODE	PAGE #
AF-03-01	#1 BLUE SKIES #2	#1 273326 #2	05 / 17 / 01	1	050	4 OF 11

HAUL OBS?	CATCH?	INC TAKE?	WEATHER	WIND SPEED	WIND DIRECTION	WAVE HEIGHT	DEPTH RANGE, BOTTOM	GEAR COND	GEAR NUMBER(S)	TOW SPEED	WIRE OUT
NO 0 X YES 1	NO 0 YES 1 X	NO 0 X YES 1	01	3 kn	S-SE°	2-4 ft	25 -35 fm	01	2	2.2 kn	100 fm

HAUL INFO	DATE mm/dd/yy	TIME 24 hours	LORAN - LATITUDE / LONGITUDE Station 1	Bearing / Lat	Station 2	Bearing / Lon	TEMP fahrenheit (pair trawl only)	TARGET SPECIES
BEGIN	5 / 17 / 01	5 : 29		42		70		FLATFISH
END	5 / 17 / 01	7 : 35		42		70	51.7°	DEPTH RANGE, HEADROPE (pair trawl trips only) — fm

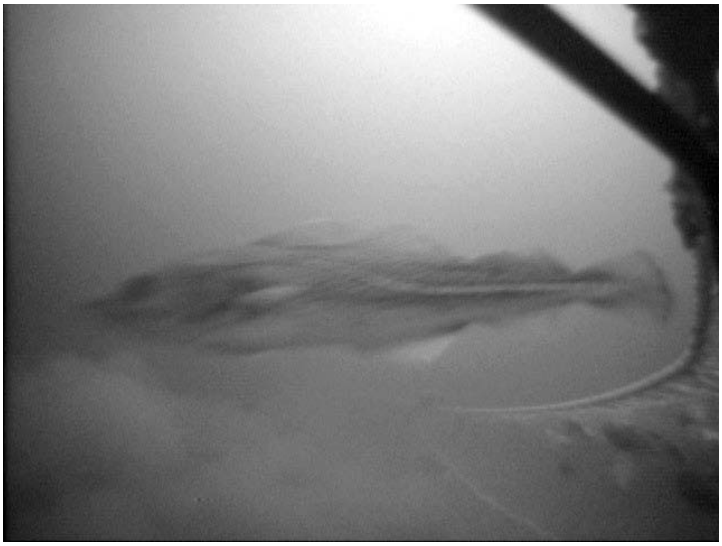
COMMENTS? NO 0 ___ YES 1 ___

(A)BBA (STANDARD NET) (against tide) VS. Arnie's European experimental net.

MM DETERRENT DEVICES USED?

TYPE	NO	YES	NUMBER
ACTIVE	0	1	
PASSIV	0	1	

DISTANCE RANGE BETWEEN BOATS (pair trawl trips only) — ft

GEAR MOUNTED ELECTRONICS USED? NO 0 X YES 1 ___

SPECIES NAME	CODE	POUNDS KEPT	POUNDS DISCARDED	DISC REAS	WEIGHT TYPE D/R	A/E	SPECIES NAME	CODE	POUNDS KEPT	POUNDS DISCARDED	DISC REAS	WEIGHT TYPE D/R	A/E
YELLOWTAIL		200%	40.7%			E/A	LOBSTER		1.5%				A
BLACKBACK		25.3%	3.3%			A	WINDOWPANE			2%			A
BIG SKATE		400%				E	PLACE		17.6%				A
LITTLE SKATE		100%				E	WOLFFISH		16%				A
COD		900%	23.1%			E/A	OCEAN POUT			30.8%			A
SEA RAVEN			4.4%			A	SCALLOPS			53.9%			A
LH SCULPIN			75%			A	Dogfish			6.5%			A
CRABS			3%			A	haddock		5%				A
							pollock		5%				A