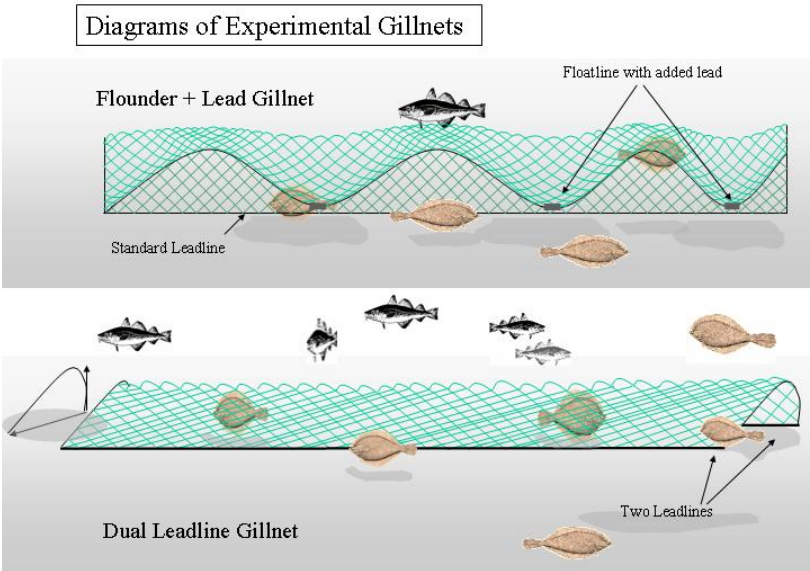
Testing of Low-Profile, Low Cod-Bycatch Gillnets: Phases I and II

Award ZZ-487: 7/1/2000-12/31/2001

Award ZZ-569: 7/1/01-6/30/2003 (Extended to 5/31/2004)



Submitted: 22 June 2006

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Abstract

Reduction of gillnet height through the addition of spaced weights on a foamcore floatline and replacement of the floatline with another leadline was effective in maintaining flatfish catch amounts and sizes while reducing bycatch of Atlantic cod by 49% and 58%, compared to standard commercial flatfish gillnets in the Gulf of Maine. Thirty-five sets of experimental gillnets, developed collaboratively between a commercial fisherman and Division of Marine Fisheries biologists, and standard gillnets demonstrated reductions in catch rates of retained and discarded Atlantic cod Gadus morhua between designs. No differences were found in catch rates of legal-sized winter flounder Pleuronectes americanus and yellowtail flounder Limanda ferruginea among flatfish gillnet designs. Undersized winter flounder catch rates were reduced by experimental designs by 88%. Underwater examination of nets verified that the experimental modifications lower floatline heights and increased slack in webbing. These results indicate that bycatch of cod in flatfish gillnets can be reduced by limiting floatation in the floatline.

Introduction

Gillnets can be an excellent way to target a particular-sized fish if the appropriate mesh size is used (Lagler 1978, Blady et al. 2002). Theoretically, mesh size is closely linked to fish girth (or its proxy, fish length) by the mechanism of wedging or gilling (Hamley 1975; Reis and Pawson 1999). In practice, gillnets catch fish several ways that are not directly linked to mesh size, such as entanglement by jaws or lips (Mentjes and Panten 2000). Also, stiffness of fish bodies can make the size-to-mesh relationship less clear (Lucena et al. 2000). Despite these sources of variability, gillnets usually select a certain size fish better than other gears, including longlines (Santos et al. 2002, Erzini et al. 2003) and trawls (Nedreaas et al. 1996; Halliday 2002; Olin and Malinen 2003).

Narrow selectivity for fish size, when correctly matched to minimum landing size, can avoid discards of sublegal fish and contribute to a sustainable fishery. However, gillnets can catch a wide range of species (Järv et al. 2000). Recent reported unwanted catches of concern in gillnets include pipe clay (Williamson 1998), seabirds (Melvin et al. 1999; Simeone et al. 1999; Österblom et al. 2002), turtles (Santora 2003), seals (Baraff and Loughlin 2000), whales and dolphins (Trippel et al. 1999; Culik et al. 2001; Amir et al. 2002; Borodino et al. 2002), rare marine species (Stein et al. 2004), marine species in a weak condition (Godøy et al. 2000) and under strict management controls (Spingle 2002a).

Reduction of unwanted bycatch by altering where a gillnet fishes in the water column was tested by Samaranayaka et al. (1997). In that study, gillnets were hung below the surface at 1, 6, and 8 m the species composition of the catches was compared. Godøy et al. (2003) floated gillnets 0.5 m above the sea floor using norsels. This small relative height difference resulted in a 58% reduction in unwanted catches of red king crab Paralithodes camtschaticus. Brothers (2002) tested a similar design to avoid snow crab Chionoecetes opilio that resulted in excessive losses of the target.

The latter two projects exploit small-scale differences in habitat use by different species. In both, lifting the webbing of the gillnet 0.5 m off-bottom decreased crab bycatch substantially, taking advantage of the demersal orientation of crabs. Our project similarly attempted to use small differences in habitat use by decreasing the vertical height of bottom-set gillnets.

The concept of altering vertical height of gillnets to separately target flatfish is not new. Within multispecies fisheries, flatfish are traditionally targeted by altering the vertical profile of gillnets. Floatlines constructed of foamcore (which contains its own flotation), polyethylene with no added flotation (Carr and Blott 1991, Ulrik Jes Hansen, SINTEF, personal communication), or tie-downs (tying the floatline of a full-size net to the leadline) (Spingle 2002a), have been used, in contrast to cod gillnets (or “stand-up gear”) that maximize floatline height with deepwater floats.

Industry gear modifications, especially if unquantified, are often less-preferred in designing management measures. Effort controls such as time and area closures, limits on the amount of gear, and vessel size limits are more popular (for example, see Kelly and Griffin 2004). In New England, the species selectivity of gillnets designed to target flatfish is not well quantified, including the bycatch of Atlantic cod. Extensive management measures triggered to control cod bycatch in flatfish fisheries do not distinguish flatfish gillnets from cod gillnets. As a result of these measures, exploitable flatfish populations at times cannot be fished due to fears of bycatch of cod. Therefore, the potential benefit of gillnets that can be demonstrated to catch flatfish and not catch cod is large both by economic and ecological measures.

We lowered the vertical profile of gillnets in two ways: replacement of the floatline with another leadline (“dual leadline”); and by adding lead weight at intervals along a foamcore floatline (“lead-added”). Similar work on dual leadline gillnets to avoid cod bycatch in an American plaice Hippoglossoides platessoides fishery was also developed by local fishermen in Cape Breton, Canada (Spingle 2002b). Also, based partly on this research, gillnets with lower floatlines resulting from a reduction in the mesh depth were tested in the Gulf of Maine by He (2006).

This project fulfilled the goals of its primary funder, the Northeast Consortium, by developing partnerships between commercial fishermen and scientists, enabling commercial fishermen and commercial fishing vessels to participate in cooperative research and the development of selective gear technologies, bringing fishermen's information, experience, and expertise into the scientific framework needed for fisheries management, and by using commercial fishing vessels as research and monitoring platforms.

Project Objectives and Scientific Hypotheses

The goal of this project was to test gillnet modifications that reduced the bycatch of Atlantic cod in flatfish gillnets, cooperatively with gillnet fishermen. We constructed the following hypotheses:

1) Cod catch:

H_A: The experimental designs (dual leadline; lead-added) each catch cod at lower rates than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch cod at the same rates as a standard flatfish design.

2) Cod length:

H_A: The experimental designs (dual leadline; lead-added) catch cod of different lengths than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch cod of similar lengths compared to a standard flatfish design.

3) Flatfish catch:

H_A: The experimental designs (dual leadline; lead-added) each catch individual species of flatfish at lower rates than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch individual species of flatfish at the same rates as a standard flatfish design.

4) Flatfish size:

H_A: The experimental designs (dual leadline; lead-added) catch flatfish of different lengths than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch flatfish of similar lengths compared to a standard flatfish design.

Our intent was to catch less cod than standard flatfish gillnets while catching flatfish of similar size at similar rates. The ultimate use of the experimental nets, if proven, was to either allow fishing for flatfish in areas closed for cod, or to reduce the bycatch of cod in open areas.

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Methods

Four types of gillnets were constructed for this study (Table 1). Each gillnet was 91 m (300 ft) long. Two complete sets of nets (48 nets) were constructed. All reported gillnet characteristics are nominal.

The standard flatfish, lead-added, and dual leadline nets were identically designed except for the construction of the floatline. Each type was constructed of light green (mesh size: 178 mm (7 in)), monofilament mesh webbing with a diameter of 0.47 mm, twenty-five meshes deep. The leadline was 91 m (50 fm) of 23 kg/183 m (50 lb/100 fm) leadline.

The floatline of the standard flatfish net consisted of 91 m (50 fm) of 13 mm (0.5 in) diameter foamcore float line with built-in floatation (1.7 oz./yd (52.5 g/m)). The lead-added design was made with a floatline the same as the standard flatfish net, but with flat pieces of lead weight wrapped around the floatline every 9 m (5 fm). The dual leadline net was made with the floatline and leadline consisting of 91 m (50 fm) of 23 kg/ 183 m (50 lb/100 fm) leadline. This net had no floatline as it is normally defined.

The standard cod net was used to determine if cod were present in the study area. It was designed following industry practice, and differed from the other three nets in color, twine diameter, leadline weight, and hanging ratio. It was constructed of light green monofilament mesh webbing (mesh size: 178 mm (7 in)) with a diameter of 0.57 mm, twenty-five meshes deep. The floatline was 91 m (50 fm) of 9.5 mm (0.375 in) twisted polyethylene (PE) floatline with one deepwater gillnet float every fathom, or fifty floats per net. Each float provided approx. 3 oz. (85 g) of flotation. The leadline was 91 m (50 fm) of 29 kg/ 183 m (65 lb/100 fm) leadline.

Eight nets of the same design were tied into a string; one string of each design was set in the same general location. The geographical arrangement of the strings was changed each time the nets were hauled, based on a modified Latin square design to reduce bias. In general, strings were set and hauled following normal commercial fishing practice. However, soak times were limited to overnight (~24 h), shorter than standard when targeting flatfish. This shorter soak time was selected to allow more rapid testing and to increase survival of discarded fish. A “set” was defined as each instance of a net being hauled and its catch quantified.

Strings were fished on consecutive days whenever possible. Testing was halted for safety reasons and scientific validity when weather conditions were poor. Bottom temperatures were collected by probes attached to nets during the May 2001 and February 2002 testing periods.

Soak durations were defined as the difference between the time when the setting of the nets began until the end of the hauling of the nets. On trips where the gear was set and not hauled, set times were recorded by the vessel captain. When only the time that setting ended was recorded, an estimate of the begin time was made by using other set durations for that vessel. When no set time was recorded, soak times were estimated using water temperatures collected by sensors attached to three of the four nets, if available. Durations were used to normalize catches to lb/hr.

Modified box-and-whisker plots were constructed for catch rates (lb/hr) of cod and yellowtail flounder separately above and below minimum landing size (MLS) and for winter flounder above MLS. Box-and-whisker plots give a visual representation of the distribution of the catch rates for each net by set. The box ends are defined as the first and third quartile of all observed catch rates for that net. The median is a solid line through the box. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots.

Box-and-whisker plots typically cannot be used for hypothesis testing. To determine the appropriate statistical test, Bartlett’s test for homogeneity of variance (Sokal and Rohlf 1995) was first employed; catch rates (lb/hr) were found to be heteroscedastic, making use of ANOVA or t-tests for catch comparisons inadvisable unless transformed. As an alternative to transforming data, the non-parametric randomization test (Sokal and Rohlf 1995, Rago 2004) was chosen to compare the catch of several species and size groups in each experimental net (lead-added and dual leadline) against the control, the standard flatfish net.

Using this method, mean differences in catch rates were compared set-by-set for cod, yellowtail and winter flounders above and below MLS. Sets that had zero catches in all four designs were excluded from analysis. The observed mean difference between the catch rate in each experimental string and the standard flatfish string for each set was compared to a distribution of 1000 or more differences determined from random assortments of the pool of catch data. The p-value was defined as the percentage of the mean differences more extreme than the observed difference.

Length-frequencies of target species were pooled and compared between the standard net and each of the control nets using the Kolmogorov-Smirnov test (Sprent 1989). Sample sizes were adjusted for cluster effects following the methods of Pennington et al. (2001).

One day of filming was conducted with an underwater remotely-operated vehicle (ROV) to examine the underwater profile of individual nets.

Data

Operational and environmental data were recorded by Manomet Center for Conservation Sciences (Manomet) or DMF observers for each set following NMFS Northeast Fisheries Science Center (NEFSC) protocols and forms. Species composition and weights of catch was recorded. Lengths of cod and flatfish species were recorded to the nearest centimeter. Set locations and durations, along with weather and additional data, were also recorded. Where the level of identification of catch was inconsistent, catches were combined during analysis to the broadest common taxa. For example, some skates were identified as “All Skates”.

All data were submitted to the Northeast Consortium Fisheries & Ocean database on 5 January 2005.

Results and Conclusions

Thirty-five overnight sets of all four nets were completed between 12 December 2000 and 23 February 2002 in three phases: December 2000 – January 2001; May 2001; February 2002 (Table 2). Nets were set off the coast of Massachusetts, USA in the vicinity of Cape Ann and Provincetown (Figure 1). Some of the testing occurred in areas closed to general fishing, under an experimental fishing permit issued by the National Marine Fisheries Service (NMFS). Timing and location of sets were determined by fishermen’s experience, catches and regulatory limits. Nets were set overnight, with durations of soak time ranging from 16.9 to 76.4 hours. The longest set was due to engine difficulties which required the vessel to return to port for repair without hauling all gear.

Approximately 17,081 kg (37,578 lb) of vertebrate and invertebrate marine organisms were caught during the thirty-five overnight sets completed for this study. 68% of this catch was categorized as “kept”, and were landed for sale or consumption, representing 18 taxa (Table 3). The remaining 32% of the catch was discarded for a variety of reasons, including size limits, lack of quota, poor condition, or lack of market. Organisms representing thirty-five taxa were caught and discarded (Table 4). Table 6 includes the common and scientific names for species mentioned in this study.

Cod made up the majority of kept species, contributing 39% of the kept catch (4528 kg, 9961 lb). Yellowtail flounder (28%, 3187 kg, 7011 lb) and skates Rajidae

(16%) were the other major landed species. All other kept species contributed less than 9% each to the total kept catch.

Skates (42% of all discards), crabs Infraorder Brachyura (11%), and spiny dogfish Squalus acanthias (10%) were the primary discard taxa. Discarded cod represented 12% (685 kg, 1507 lb) of overall discard; all other taxa contributed less than 7% each of the total discard.

Overall, catch rates during the experiment were typical of commercial operations with short soak durations (R. MacKinnon, pers. communication). Catch rates of cod above MLS (19 in (48.3 cm) at the time of the experiment) per string were highest in the cod gillnet (6.1 lb/hr (2.77 kg/hr), Table 5, Figure 2). The two experimental flatfish gillnets caught less cod per hour than the standard flatfish design (3.27 lb/hr (1.48 kg/hr), Table 5, Figure 2). The gillnet with lead added to the floatline caught an average of 1.91 lb/hr (0.86 kg/hr; 58%) less than the standard design (p=0.00); the dual leadline flatfish gillnet caught 1.59 lb/hr (0.72 kg/hr; 49%) less (p=0.01).

Catch rates of cod below MLS were lowest in the cod gillnet (0.05 lb/hr (0.02 kg/hr), Table 5, Figure 2). The three flatfish nets averaged 0.77 lb/hr (0.35 kg/hr) (standard flatfish), 0.38 lb/hr (0.17 kg/hr) (lead-added), and 0.48 lb/hr (0.22 kg/hr) (dual leadline). The differences among the flatfish nets were not significant when all data were included. However, catch data for undersized cod were widely dispersed, with one set having a large influence (Figure 2). Reanalysis with this set removed as an outlier showed much lower cod catches with approximately 41% less small cod in the experimental nets (standard: 0.37 lb/hr (0.17 kg/hr); lead-added: 0.22 lb/hr (0.10 kg/hr); dual leadline: 0.23 lb/hr (0.10 kg/hr)). These differences approached the 0.05 level of significance between both experimental flatfish nets and the standard control flatfish net (Table 5).

Average catch rates of yellowtail flounder above MLS (13 in (33.0 cm)) per string were highest in both experimental nets (lead added: 3.56 lb/hr (1.62 kg/hr); dual leadline: 3.57 lb/hr (1.62 kg/hr) but were not significantly different from the standard flatfish gillnet (2.50 lb/hr (1.14 kg/hr)) (Table 5, Figure 3). The cod gillnet caught only an average of 0.15 lb/hr (0.07 kg/hr) of yellowtail flounder. Catch rates of undersized yellowtail flounder were also not significantly different among the flatfish nets (range of means: 0.36-0.45 lb/hr (0.16-0.20 kg/hr). The cod gillnet averaged 0.02 lb/hr (0.009 kg/hr).

Catch rates of winter flounder above MLS (12 in (30.5 cm)) were low among all flatfish nets (0.75-0.84 lb/hr (0.34-0.38 kg/hr) and not significantly different (Table 5, Figure 4). The cod gillnet averaged 0.22 lb/hr (0.10 kg/hr). Catches below MLS in all nets were significantly lower in the experimental nets (0.01 lb/hr (0.007 kg/hr) for both, a reduction of 88% from the standard flatfish net (0.16 lb/hr (0.07 kg/hr)). The cod net caught undersized winter flounder at the lowest rate (<0.01 lb/hr (0.003 kg/hr); Table 5, Figure 4).

Catch weights are an important measure of comparative net performance. Additionally, comparison of pooled length-frequency distributions were necessary to determine whether gillnets caught similar sizes of fish. No significant differences (p = 1.00) were found among any of the three flatfish net designs for the three species examined: cod, yellowtail, and winter flounders (Figures 5, 6, 7). A curious non-significant anomaly was observed in the pooled flatfish flounder catches: the standard flatfish gillnet caught more winter flounder at the most common size, as illustrated by the differences in the peaks in Figure 7, while the relationship was inverted in catches of yellowtail flounder (Figure 6).

The cod gillnet caught a different size range of fish than the three flatfish gillnets for all three species. In general, the cod gillnet caught fewer flatfish over the same size range as the flatfish nets. Its catch was more selective for larger cod, >63 cm (25 in), than all three flatfish nets. The flatfish nets appeared to catch far more cod below MLS.

Pooling of length frequencies for all sets ignores variation between sets, often masking important information. For example, a very large majority of the small cod (32-59 cm (13-23 in)) were caught by the flatfish nets in one set. Otherwise, catches of cod were evenly distributed across a size range similar to the cod gillnets, which caught similar sizes of cod during the entire experiment.

Bottom temperatures were retrieved for one string in May 2001 and varied little between sets, with mean temperatures ranging from 4.1-4.2 °C (39–40 °F). Temperatures were retrieved from three strings during the February 2002 testing. Temperatures between sets and among strings ranged from 4.9-5.4 °C (41-42 °F).

A remotely operated vehicle (ROV) was used to view the nets underwater. Deployment of an ROV near the gillnets led to frequent tangling. Low water clarity and rough seas contributed to the difficulty of seeing the nets and measuring heights. These conditions also required the ROV to approach the nets closely. Sufficient video was collected to characterize but not quantify the vertical profile of the nets. The cod gillnet with floats attached stood up to the maximum height of its endlines (14.6 ft (4.5 m)) with no slack in the webbing and was even across its length. The foamcore-only floatline maintained an even low height with visible slack in the webbing. Carr and Blott (1991) found that gillnets with no floatation had heights only 15% of maximum height. Using this relationship translates to a minimum estimated height of the standard design of 2.1 m (6.9 ft). The effect of the lead added to the foamcore floatline created a series of quaternary arcs in the floatline. The maximum height of the arcs appeared to be equal to the height of the unmodified foamcore floatline. Wherever lead was added, that part of the floatline was in contact with the bottom, with a steep-sided arc leading to the next piece of added lead. The dual leadlines of the dual leadline net were seen to rest very close together on the sea floor, at times touching. This configuration resulted in a cloud of nearly invisible webbing that drifted back and forth with local current.

Several important conclusions can be drawn from these results. First, we confirm that the traditional industry-developed cod and flatfish gillnets are each effective at targeting cod and flatfish; the cod gillnet was especially selective for legal-sized cod, with a small bycatch of spiny dogfish. The relatively small bycatch of spiny dogfish differs from He’s (2006) similar study, although this difference may be due to densities of dogfish rather than gear design. Secondly, the experimental designs reduced cod catches in the flatfish gillnet by 49% and 58%, demonstrating that the floatline modifications were effective in avoiding cod. Catches of cod below MLS, following removal of one anomalous set, were reduced at levels approaching the 0.05 significance level. Catches of legal-sized yellowtail and winter flounder in experimental nets were not different from catches in the standard flatfish gillnet. Further, catches of undersized winter flounder were also significantly lower in the experimental designs. These results indicate that adoption, mandated or voluntary, of the modified gillnet designs would lead to reductions in cod bycatch compared to standard flatfish gillnets.

The lengths of flatfish caught in the experimental gillnets, as reflected in length-frequency distributions, were not different from the standard flatfish gillnet. This result indicates that adoption of these designs would not lead to any reduction in the landed value of flatfish catches due to size differences. In short, evidence was found to reject the first null hypothesis and, with the caveats of one anomalous set and p-values close to 0.05 in the case of sublegal cod, that the experimental designs do catch cod (above and below MLS) at a lower rate than the standard flatfish net (Hypothesis 1). No evidence was found to refute the null hypothesis for cod length that all flatfish designs would catch cod of similar lengths (Hypothesis 2). No evidence was found to refute Hypothesis 3 (All flatfish designs, experimental and standard, would catch flatfish at similar rates) for yellowtail above and below MLS, and winter flounder above MLS. It was rejected for winter flounder below MLS. Lastly, no evidence was found to reject Hypothesis 4. All flatfish nets caught similar lengths of flatfish. The experimental nets therefore performed as hoped, improving the standard flatfish design by reducing cod bycatch, while also reducing winter flounder below MLS, too.

The ROV work provided evidence to determine why the experimental nets worked as hoped. The underwater footage indicated that modifications to the floatline resulted in a reduction in overall vertical profiles and an increase in the vertical slack of the net webbing. The footage showed that the floatation on the cod gillnet caused that net to assume a maximum vertical profile that created a certain amount of stiffness in the webbing panel, in contrast to the standard flatfish net, whose vertical profile was much lower and resulted in loose webbing. The degree of stiffness in the webbing resulting from the buoyancy of the floatline has an impact on the mechanics of meshing or wedging of fish into the net opening (Wan et al. 2004). Loose slack webbing probably contributed to the catch of undersized cod in all flatfish designs. Also, extra netting on the seabed was found by He (2006) to be a factor in increased flatfish catches.

ROV observations of decreased net height in gillnets and the catch differences found in this study support the conclusion that cod and flatfish have differences in their use of the ocean space just above the bottom, apparently with flatfish lower and cod higher. While it would be simplistic to assert that a clear line of separation between species exists, other studies support the existence of near-bottom species separation. He (2003), using video, found that winter flounder were limited in activity to no more than 0.6 m off bottom, a result in line with fishermen’s experience. The raised-footrope trawl, fishing approximately 0.5 m (1.5 ft) off-bottom, reduces catch of flatfish by over 80% (DMF, unpubl. data). Using gillnets, He (2006) found decreases in cod bycatch by use of 8 mesh deep gillnets with low floatation and a maximum height of 1.2 m (3.9 ft). The actual fishing height was certainly lower. The occupation of near-bottom space may be species- or size-specific. In contrast to winter flounder, yellowtail flounder have distinct off-bottom behavior, with periodic movements averaging 15 m (49 ft) to a maximum off-bottom height of 56 m (184 ft) (Cadrin and Westwood 2004). In this study, catch rates of sublegal winter flounder were much lower in the lower gillnets while legal-sized winter flounder were caught at similar rates. Detailed examination of bottom-orientation and species-specific behavior appear to provide a potential pathway toward improved species selectivity of gillnets, and requires further investigation.

Measurement of gillnet height is necessary to determine if separation zones between species exist. However, use of ROVs or divers to obtain these heights is complicated, expensive, and unreliable, and usually results in single data points. The use of small sensors attached to the floatline and leadline and capable of measuring depth at less than 0.5 m resolution over long time periods has recently been pioneered by DMF (Ed Lyman, DMF, unpubl. data) using data storage tags. This tool should be examined for monitoring of gillnet height during fluctuations of tide and current as an aid to understanding gillnet and species behavior.

We presented results with one outlier representing a single day's high catch of cod below MLS in the experimental and standard flatfish nets removed. One can reasonably argue from a scientific viewpoint that this removal is legitimate: the catches of small cod occurred on one single set (8 Dec 2000) in a location known by our industry partners to be suboptimal for flatfish. Typically, flatfish gillnets are not deployed by industry where small cod are present, or are removed if small cod are present (R. MacKinnon, personal communication). Although the experimental nets caught less cod than the standard flatfish nets, these guidelines should be considered when deploying these experimental nets as well. Further, while ignoring a rare event may be scientifically defendable, risks of rare events may need to be considered by managers when contemplating implementation.

The development and mandated use of species-specific gear has become useful as a way to maintain fishing opportunity where some stocks are in a weakened condition. However, this form of management runs counter to a historical multispecies approach to commercial fishing. While gillnetters have developed separate flatfish and cod gillnets, lack of species-specificity may be in fact be desirable to allow some valuable bycatch; for example, cod in flatfish gillnets. It is more of a management imperative to refine gillnets to catch exclusively one species. It should be recognized that, especially where bycatch quotas exist, decreasing bycatch of non-target species may lead to loss of expected and economically vital landings. This loss is one reason that highly species-selective fishing gear may not be embraced by industry.

It was theorized that the experimental nets would be less vulnerable to harbor porpoise Phocoena phocoena due to lower vertical profiles. The use of acoustic warning devices was mandated during part of the study. No harbor porpoises were caught. The avoidance of porpoises is highly desirable, but many obstacles impede testing of this avoidance, not least of which is the rarity of capture.

A further by-product of this study is the documentation of catch rates for standard cod and flatfish gillnet designs. Information on these catch rates is scarce, and the results may provide valuable information for management and assessment. The combined impact of all of these results allows managers or fishermen to reduce bycatch of cod when targeting flatfish with gillnets by lowering or restricting gillnet height by using either the addition of spaced weight to the floatline or replacement of the floatline with leadline. If cod catch rates are low enough based on stock assessments, consideration should be given to allowing access by fishermen to healthy flatfish populations where cod bycatch is a concern.

Time and resources often limit gear testing to certain areas and seasons. Generalization from this study to the broader Gulf of Maine and at all times of year, however, is supported by the results of He (2006) who also found reduced bycatch of cod by using gillnets of shorter height. Further research, jointly led by He and Pol on shorter gillnets, has been funded by the Northeast Consortium and is currently underway.

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Table 1. Net characteristics of the four types of gillnets built and tested.

NET CHARACTERISTICS	**Standard Cod**	**Standard Flatfish**	**Lead-Added**	**Dual Leadline**
Mesh size (mm)	178 (7 in)	178 (7 in)	178 (7 in)	178 (7 in)
Material	Mono	Mono	Mono	Mono
Twine diameter (mm)	0.57	0.47	0.47	0.47
Color	Light blue	Light green	Light green	Light green
Mesh depth	25	25	25	25
Floatline	9.5 mm (3/8 in) poly with one gillnet float per 1.8 m (1 fm)	13 mm (1/2 in) foamcore, no floats	13 mm (1/2 in) foamcore floatline with lead wrapped every 9 m (30 ft).	23 kg/ 183 m (50 lb/600 fm) leadline
Leadline	29 kg/ 183 m (65 lb/600 fm)	50 lb/600 fm	50 lb/600 fm	50 lb/600 fm
Hanging Ratio	1/2	1/3	1/3	1/3
Net Length (m)	91 (300 ft)	91 (300 ft)	91 (300 ft)	91 (300 ft)

Table 2: Fishing log of experimental sets included in analysis. Trip ID is a unique identifier for each fishing trip.

Date	Trip ID	Vessel	Latitude (N)	Longitude (W)
12/03/00	GN002	Lady Irene	42.1315	-70.5307
12/04/00	GN003	Lady Irene	42.3596	-70.2432
12/08/00	GN004	Lady Irene	42.2278	-70.6916
12/09/00	GN005	Lady Irene	42.2557	-70.6230
12/10/00	GN006	M. Brandon	42.2543	-70.6228
12/11/00	GN007	Lady Irene	42.2523	-70.6286
01/12/01	GN015	Sasquatch	42.5722	-70.5091
01/13/01	GN008	Lady Irene	42.5375	-70.3869
01/13/01	GN016	Sasquatch	42.5394	-70.3756
01/14/01	GN009	Lady Irene	42.5471	-70.4011
01/14/01	GN010	Sasquatch	42.5307	-70.3784
01/17/01	GN011	Lady Irene	41.9384	-70.5144
01/18/01	GN012	Lady Irene	41.9436	-70.5156
01/23/01	GN013	Sasquatch	42.5834	-70.4245
01/26/01	GN014	Sasquatch	42.5281	-70.6348
05/08/01	GN00	Sasquatch	42.4797	-70.6696
05/09/01	GN01	Sasquatch	42.4893	-70.6772
05/10/01	GN02	Sasquatch	42.4886	-70.6793
05/11/01	GN03	Sasquatch	42.4937	-70.6912
05/12/01	GN04	Sasquatch	42.4872	-70.6834
05/18/01	GN04B	Sasquatch	42.4933	-70.6831
05/19/01	GN05	Sasquatch	42.4930	-70.6933
05/20/01	GN06	Sasquatch	42.4967	-70.6911
05/21/01	GN07	Sasquatch	42.4930	-70.6933
05/30/01	GN08	Sasquatch	42.4940	-70.6811
02/07/02	GN01	Lady Irene	42.3889	-70.3046
02/14/02	GN02	Lady Irene	42.3760	-70.3074
02/16/02	GN03	Lady Irene	42.3832	-70.3134
02/17/02	GN04	Lady Irene	42.3808	-70.3114
02/19/02	GN05	Lady Irene	42.3933	-70.2811
02/20/02	GN06	Lady Irene	42.3925	-70.3320
02/21/02	GN07	Lady Irene	42.3932	-70.3489
02/22/02	GN08	Lady Irene	42.3808	-70.3114
02/23/02	GN09	Lady Irene	42.3856	-70.3154
02/23/02	GN10	Lady Irene	42.3872	-70.3005

Table 3: Summary of species caught and total kilograms kept. Some taxa were grouped at levels higher than species. K = retained by vessel; D = discarded at sea.

	Disp.	Total	Standard Cod	Standard Flatfish	Lead-Added	Dual Leadline
Atl. Cod	K	4527.7	2275.5	1193.2	481.4	577.7
Yellowtail Fl.	K	3187.0	50.9	909.1	1133.4	1093.6
All Skates	D	2331.3	45.0	803.9	811.0	671.4
All Skates	K	1841.4	47.7	580.9	883.6	329.1
Winter Fl.	K	906.0	78.9	322.0	261.5	243.6
Atl. Cod	D	685.1	18.2	330.0	146.9	190.0
All Crabs	D	590.1	29.7	154.8	222.3	183.4
Spiny Dogfish	D	533.6	325.0	119.1	49.1	40.5
Yellowtail Fl.	D	343.1	5.8	98.6	118.9	119.8
Haddock	K	303.2	231.8	42.3	13.6	15.5
Monkfish	K	296.8	65.9	155.0	58.6	17.3
Sea Raven	D	291.6	45.5	90.5	94.8	60.9
Lobster	D	205.0	1.4	74.5	78.2	50.9
Am. Plaice	K	170.8	15.8	55.2	58.0	41.8
Lobster	K	151.0	10.0	50.4	54.8	35.9
Am. Plaice	D	115.8	3.3	37.3	41.4	33.9
Atl. Sturgeon	D	85.0	37.3	22.7	25.0	
Atl. Mackeral	K	75.0	68.2	3.6	0.9	2.3
All Others		441.6	100.5	166.3	92.0	82.8
	Total	17081.3	3456.2	5209.5	4625.3	3790.3

Table 4: Species present at 1% or less of total catch in different net types. K = retained by vessel; D = discarded at sea.

			Net Type			
Species	**Disp.**	**Total**	**Standard Cod**	**Standard Flatfish**	**Lead-Added**	**Dual Leadline**
Am. Shad	D	X	X	X		
Atl. Mackeral	D	X	X	X		X
Atl. Wolffish	K	X	X	X	X	
Cunner	D	X		X	X	X
Cusk	K	X		X		
Cusk	D	X		X	X	X
Fourspot Fl.	D	X	X	X	X	X
Gray Sole	K	X	X	X	X	X
Gray Sole	D	X			X	
Guillemot	D	X	X			
Haddock	D	X	X	X		X
Harbor Seal	D	X	X			
Lumpfish	D	X		X		X
Monkfish	D	X	X	X	X	X
Ocean Pout	D	X	X			
Pollock	K	X	X	X		
Pollock	D	X	X		X	X
Red Hake	D	X		X	X	X
Redfish	K	X	X	X	X	X
Redfish	D	X	X	X	X	
Sculpin	D	X	X	X	X	X
Sea Robin	D	X			X	X
Sea Scallop	K	X		X		X
Sea Stars	D	X	X	X	X	X
Sea Urchin	D	X		X	X	X
Seaweed	D	X	X			
Striped Bass	K	X				X
Striped Bass	D	X	X	X		
Summer Fl.	D	X		X		
Tautog	K	X		X		
Whelks	D	X		X	X	
Whiting	K	X	X	X		X
Whiting	D	X	X	X		X
Windowpane Fl.	D	X	X	X		X
Winter Fl.	D	X	X	X	X	X

Table 5: Mean catch for four different gillnet designs. MLS = minimum landing size. N = number of sets. Asterisk indicates one outlier set was deleted. P-values are bolded where significant or marginally significant.

			Mean Catch (lb/hr)				Mean Difference			
		N	Standard Cod	Standard Flatfish	Lead-Added	Dual Leadline	Lead-Added v. Std Flat	p-value	Dual Lead v. Std Flat	p-value
Atl. Cod	>MLS	33	6.10	3.27	1.36	1.68	-1.91	**0.00**	-1.59	**0.01**
	<MLS	35	0.05	0.77	0.38	0.48	-0.39	0.28	-0.29	0.29
	<MLS*	34	0.04	0.37	0.22	0.23	-0.15	**0.07**	-0.14	**0.09**
Yellowtail Fl.	>MLS	30	0.15	2.50	3.56	3.57	1.06	0.17	1.07	0.11
	<MLS	26	0.02	0.36	0.45	0.45	0.08	0.25	0.09	0.24
Winter Fl.	>MLS	32	0.22	0.84	0.75	0.78	-0.09	0.65	-0.07	0.63
	<MLS	33	0.01	0.16	0.01	0.01	-0.14	**0.00**	-0.14	**0.00**

Table 6. 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

Figure 1: Locations of testing of gillnets for this study and continued testing. The area shown is off the coast of Massachusetts, USA.

Figure 2: Modified box-and-whisker plots of Atlantic cod catches above (bottom) and below (top) MLS. The box ends represent the first and third quartile. The solid line through the box is the median. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots. Numbers in parentheses are values beyond the scale of the plot.

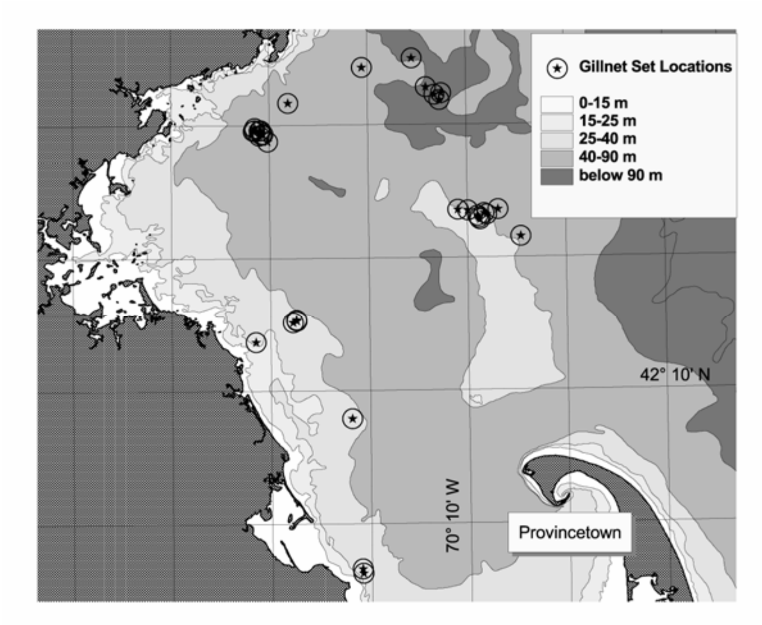
Figure 3: Modified box-and-whisker plots of yellowtail flounder catches above (bottom) and below (top) MLS. The box ends represent the first and third quartile. The solid line through the box is the median. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots. Numbers in parentheses are values beyond the scale of the plot.

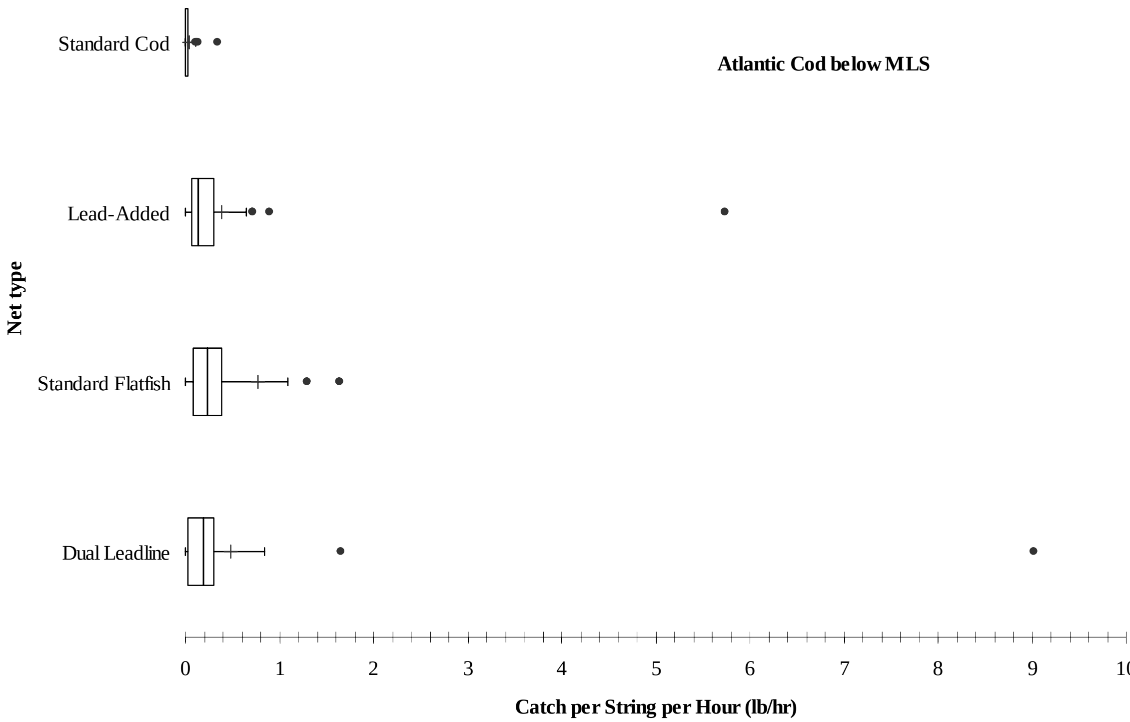
Figure 4: Modified box-and-whisker plots of winter flounder catches above MLS. The box ends represent the first and third quartile. The solid line through the box is the median. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots. Numbers in parentheses are values beyond the scale of the plot.

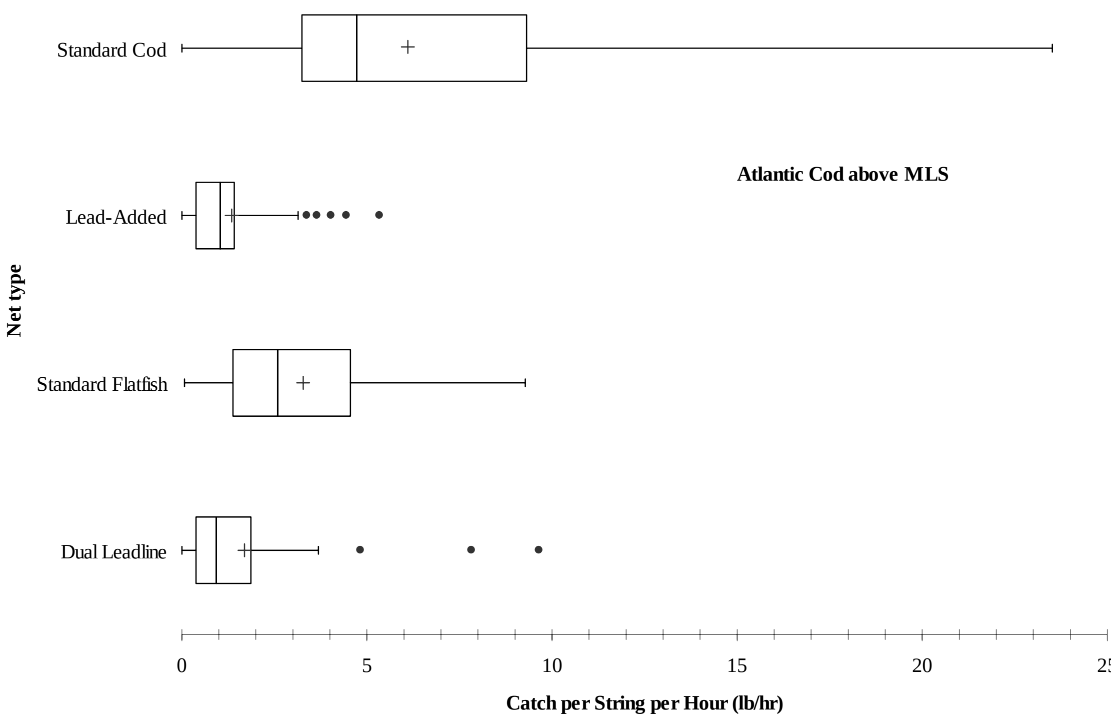
Figure 5: Pooled lengths of Atlantic cod by net type. Solid vertical line indicates minimum landing size. N = unadjusted sample size.

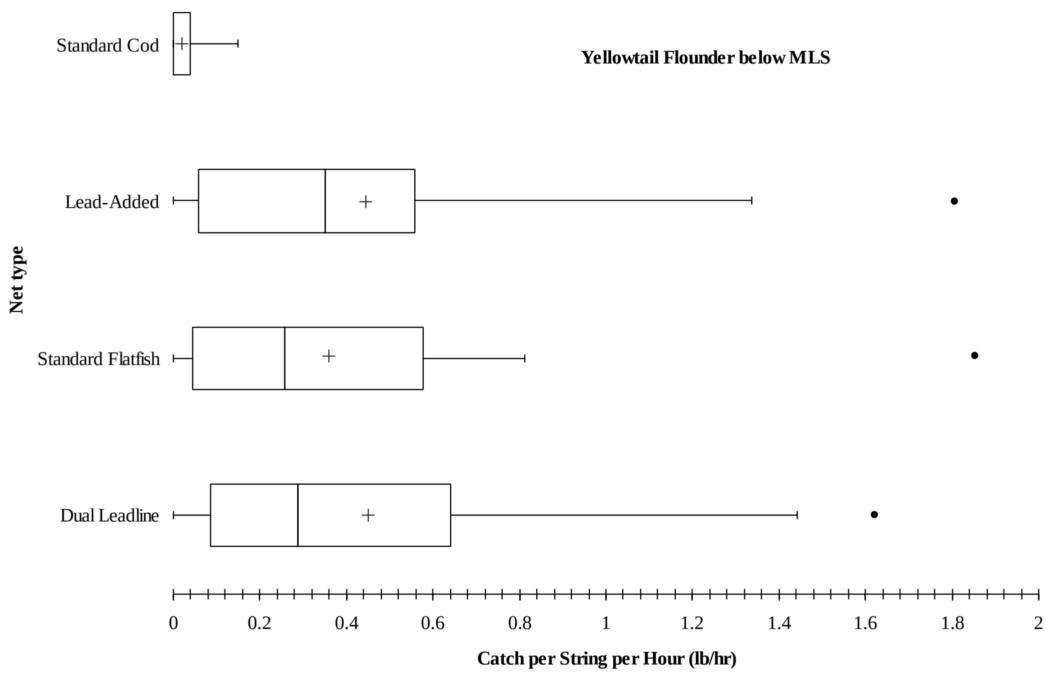
Figure 6: Pooled lengths of yellowtail flounder by net type. Solid vertical line indicates minimum landing size. N = unadjusted sample size.

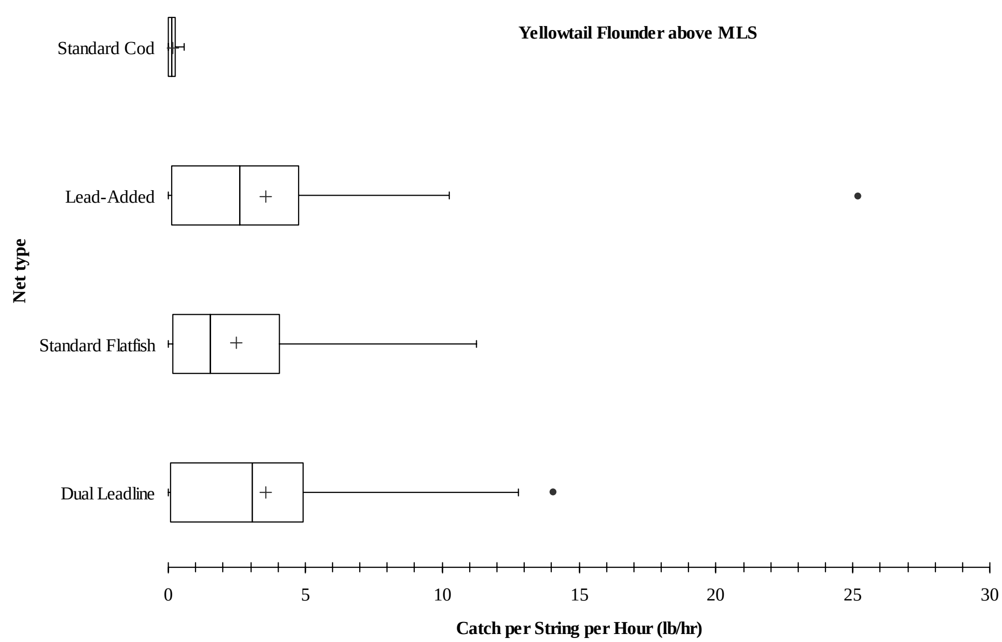
Figure 7: Pooled lengths of winter flounder by net type. Solid vertical line indicates minimum landing size. N = unadjusted sample size.

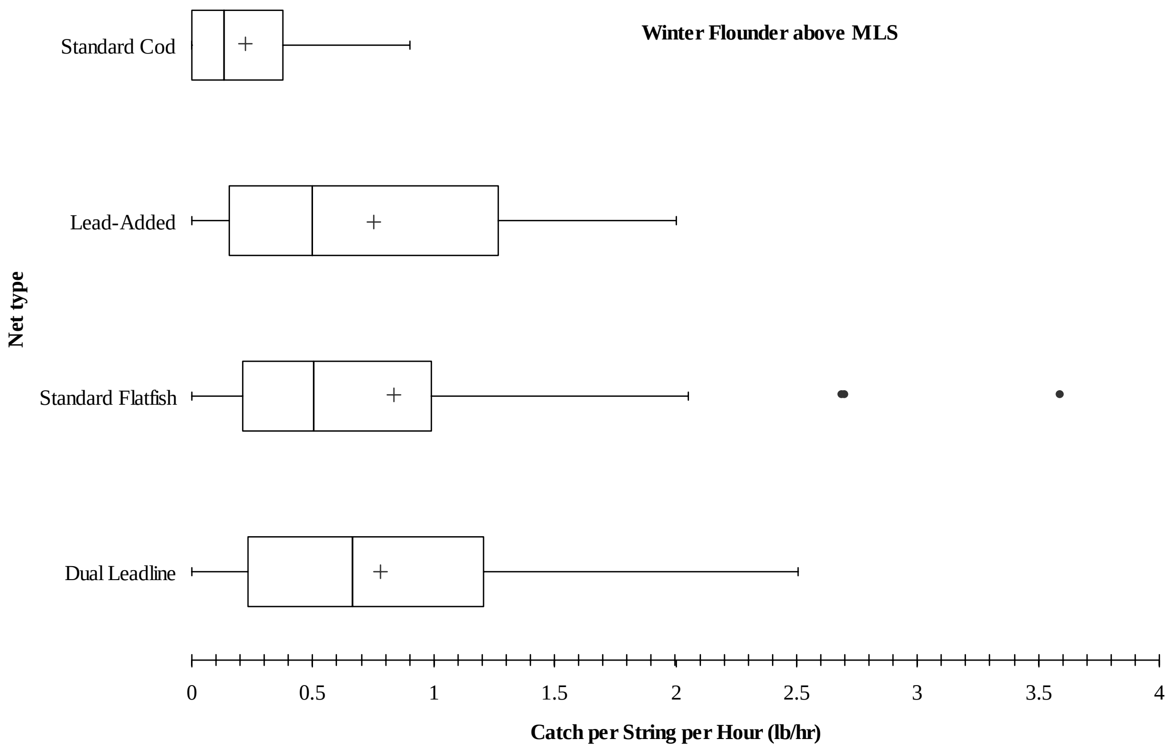

Gillnet Set Locations
0-15 m
15-25 m
25-40 m
40-90 m
below 90 m
42° 10' N
70° 10' W
Provincetown

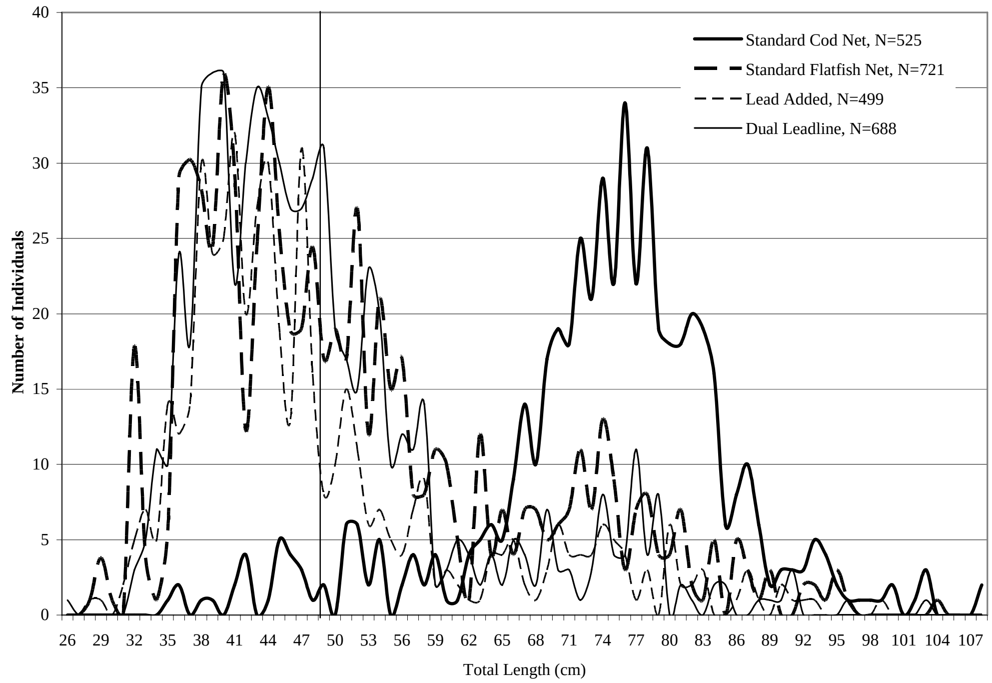

Atlantic Cod below MLS
Net type
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
0
1
2
3
4
5
6
7
8
9
10
Catch per String per Hour (lb/hr)

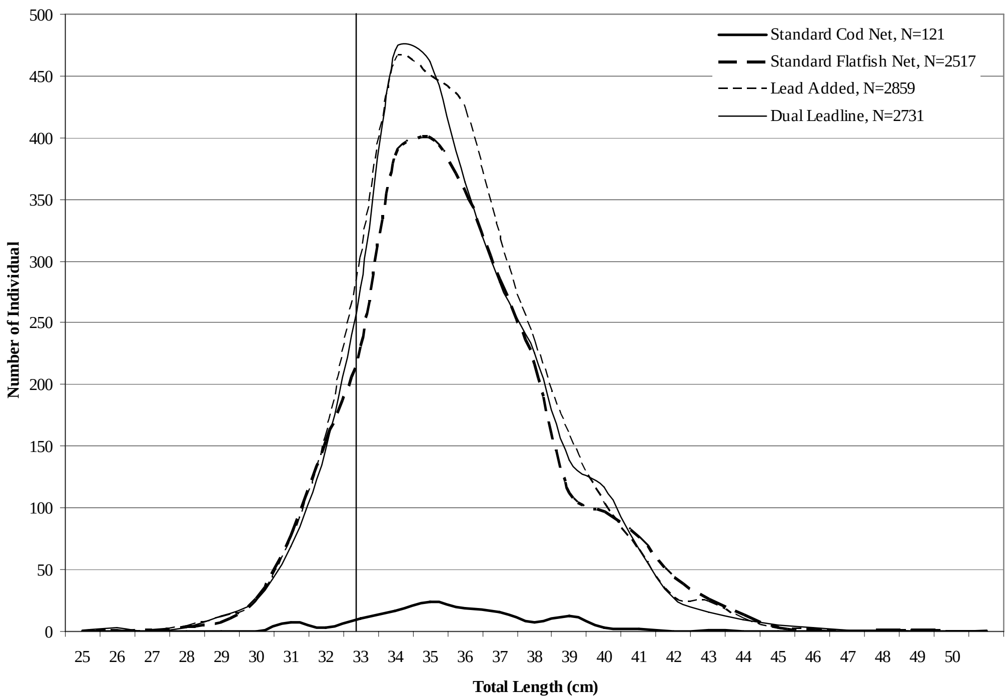

Atlantic Cod above MLS
Net type
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
0
5
10
15
20
25
Catch per String per Hour (lb/hr)


Yellowtail Flounder below MLS
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
Net type
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Catch per String per Hour (lb/hr)

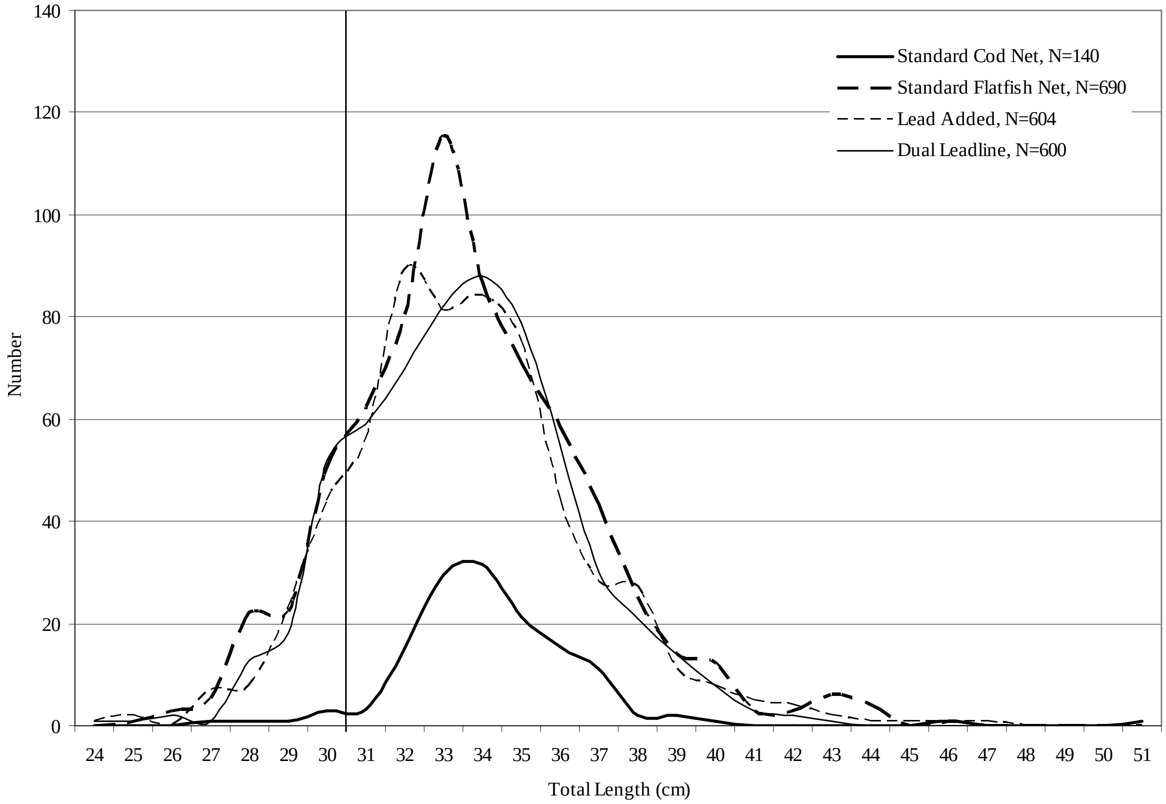

Yellowtail Flounder above MLS
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
Net type
0
5
10
15
20
25
30
Catch per String per Hour (lb/hr)


Winter Flounder above MLS
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
Net type
0
0.5
1
1.5
2
2.5
3
3.5
4
Catch per String per Hour (lb/hr)


40
35
30
25
20
15
10
5
0
Number of Individuals
26 29 32 35 38 41 44 47 50 53 56 59 62 65 68 71 74 77 80 83 86 89 92 95 98 101 104 107
Total Length (cm)
Standard Cod Net, N=525
Standard Flatfish Net, N=721
Lead Added, N=499
Dual Leadline, N=688



Standard Cod Net, N=121
Standard Flatfish Net, N=2517
Lead Added, N=2859
Dual Leadline, N=2731
Number of Individual
Total Length (cm)
0
50
100
150
200
250
300
350
400
450
500
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50



Standard Cod Net, N=140
Standard Flatfish Net, N=690
Lead Added, N=604
Dual Leadline, N=600
Number
0
20
40
60
80
100
120
140
24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51
Total Length (cm)

Partnerships

It has always been the goal of the Conservation Engineering Program to collaborate as fully as possible with fishermen. Fishermen identify the problems we seek to solve with gear modifications. We see fishermen as primary experts on the design, construction, and use of fishing gear. In addition, we rely on them to identify testing locations and times for testing purposes, and for many other reasons.

This project from its inception represented a full partnership between Bob MacKinnon and Arne Carr and Mike Pol. The idea for the gear alteration came from Bob, as did many other factors related to the project, including possible end uses for the gear design. The other participants, in the form of testing platforms, included fishing vessels, captains, and crews. They provided valuable guidance in terms of testing locations and times, rigging needs, regulatory problems and maintained safe conditions for scientists working onboard their vessels.

Manomet Center for Conservation Sciences, Inc. under the guidance of Dr. Chris Glass, acted as the funding recipient for this project prior to DMF developing the ability to receive funding from the Northeast Consortium. We are grateful for that support, and its success is testament to the already strong relationship between DMF and Manomet.

The project allowed the participants to understand each other's capabilities and motivations to a greater extent, and contributed to development of personal relationships across professions.

Related Projects

This report describes two separate projects funded by the Northeast Consortium. Phase II simply carried on the work begun in the first phase. Also, Bob MacKinnon and David Martins of the School for Marine Science and Technology (SMAST), University of Massachusetts-Dartmouth tagged cod caught during this study as part of the Cod Tagging Project developed through the Massachusetts Fisheries Recovery Commission (MFRC) and funded through the NOAA Fisheries Northeast Region Cooperative Research Partners Initiative (CRPI).

Impacts and Applications

Groundfish gillnets in New England are managed through a fishery management plan (FMP). The Groundfish FMP includes provisions for limiting gillnet effort with time and area restrictions, and gear limitations. These restrictions are primarily aimed a limiting cod bycatch, and are based on available information on cod bycatch in flatfish gillnets. This project was successful in quantifying bycatch and demonstrating the ability of experimental designs to limit cod bycatch while maintaining flatfish catches, and demonstrates that reducing gillnet height appears to reduce cod catch.

Two pathways are available for further development or implementation of these gear modifications. One avenue is to encourage voluntary industry adoption of these designs, which are legal for use anywhere flatfish gillnets may be used. Participating fishermen in this study kept the gillnets built for this project, and one of them continued to fish them. However, no other efforts have been made to encourage industry to use them.

A second pathway for further implementation would be to allow additional opportunities for gillnetting for flatfish where the presence of cod limits it. The best judges of these opportunities sit on the Plan Development Team (PDT) of the Groundfish Oversight Committee (GOC); they can judge the validity of the research from the Council perspective. Following a technical review by the Northeast Consortium and management review by the Research Steering Committee, the PDT in turn can recommend management options to the GOC, which then presents recommendations to the NEFMC at large. Council approval is then reviewed by NMFS.

David Pierce, Deputy Director of DMF, Council designee, and chair of the GOC, has been briefed on the results of this research, primarily with the intent of understanding the bycatch of cod in flatfish nets and trying to understand how tie-downs might affect management options.

The potential implementation could take several forms. A Special Access Program (SAP) where flatfish levels are high offers the maximum reward to fishermen, but a broader requirement to use only these designs anywhere flatfish are targeted would, based on these results, result in less cod bycatch. It should be remembered, however, that some fisheries are only practical where a certain level of cod bycatch is allowed. In other words, reducing cod bycatch might benefit cod rebuilding, but may result in significant economic loss to fishermen due to the loss of cod landings.

Presentations

M. Pol. Testing of Low Cod-Bycatch Gillnets Phases I and II - An Update. Northeast Consortium Annual Meeting, 24 October, 2002, Portsmouth, NH.

M. Pol. Cooperative Design and Testing of Gillnets and Trawl Nets to Target Flatfish and avoid Atlantic Cod *Gadus morhua*. ICES Working Group on Fishing Technology and Fish Behaviour, 5-8 June 2002, Sete, France.

M. Pol. Testing of Low Cod-Bycatch Gillnets. NMFS National Standing Working Group on Fishing Technology, March 6-7, 2002, Woods Hole, MA.

M. Pol. Testing of Low Cod-Bycatch Gillnets. Northeast Consortium Annual Meeting, 3 October 2001, Portsmouth, NH.

H. A. Carr. Improving Selectivity of Various Gears in New England Waters (gillnets, longlines, and trawls). Second North Atlantic Responsible Fishing Conference, 7-9 November 2000, St John’s, Newfoundland.

Student Participation

None

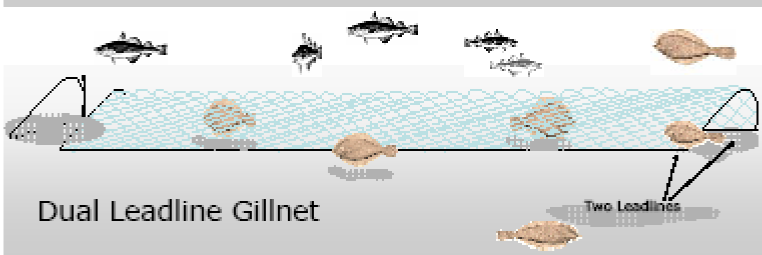
Published Reports and Papers

Poster presented at the 2006 Maine Fishermen's Forum

Low-Profile Flatfish Gillnets Catch Fewer Cod

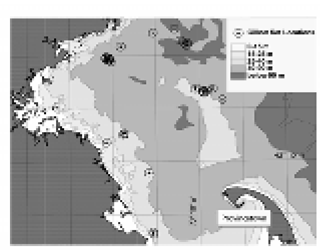
Lowering the height of the floatline in flatfish gillnets reduced cod bycatch by 50%. Flatfish catches and sizes stayed the same.

We added lead to a Foamcore floatline in one net…



…and replaced the floatline with another leadline in another net.

Study Area



- Nets were compared to a standard flatfish gillnet.
- All were light blue, 8-gauge, 7-inch monofilament, hung on the half.
- Catch rates of cod: standard flatfish net - 60 lb/set; low-profile – 30 lb/set
- Catch rates of yellowtail: 70 lb/set (all nets)
- Catch rates of blackback: 17 lb/set (all nets)

Industry Partners
F/Vs *Lady Irene* & *Michael Brandon*, Scituate MA
F/V *Sasquatch III*, Gloucester MA

Net Designer and Industry Lead:
Robert MacKinnon
F/V *Antigonish*
Scituate MA

Scientific Lead:
Michael Pol
Conservation Engineering
Massachusetts Division of
Marine Fisheries

Field and budget help from:
MANOMET
Center for Conservation Sciences

This project funded by:
Northeast Consortium

Conservation Engineering Program awarded $300,000 for gear research

Over $200,000 earmarked for cooperating fishermen

Arne Carr and Michael Pol of DMF's Conservation Engineering Program are continuing their cutting-edge fishing gear research. They've received three new grants from the Northeast Consortium to work with local fishermen to test innovations, and they are indirectly involved in a fourth.

The Northeast Consortium (www.northeastconsortium .org) is a coalition of the Maine, New Hampshire, MIT and Woods Hole Sea Grant Programs. It was given $2 million in federal funds to distribute for cooperative research between scientists and commercial fishermen. The goals of the funding included the development of selective fishing gear and programs to utilize commercial fishing vessels in oceanographic research. Following a competitive process where anyone could submit research ideas, ten research projects were funded. All of these research projects were developed in cooperation with commercial fishermen and use commercial vessels as research platforms. Approximately 70% of the funding will be paid to fishermen for sea-time, net building, and other activities. The following projects were also originally part of the Massachusetts Fisheries Recovery Commission's Fisheries Research Strategic Plan.

• Testing of Low-Profile Low Cod-Bycatch Gillnets

Robert MacKinnon, a commercial fisherman from Scituate, has developed two gillnets that are designed to target flatfish while avoiding cod. He, Michael Pol, and Arne Carr have been awarded $90,000 by the Northeast Consortium to test the cod-avoiding ability of these nets . On one net, the floatline is completely replaced by another leadline so that both the top and bottom of the net rest on the ocean bottom, with standard webbing floating in between. The dual leadline is the only difference between this net and standard gillnets. The second net to be tested has lead attached to the floatline every 30 feet to sink it to the bottom at set intervals. The catch from these two nets will be compared to a standard gillnet.

Both designs reduce the height of the nets underwater. Reducing the height of the nets may allow fishermen to catch flatfish, which stay very close to the bottom, and avoid cod, which tend to stay at least a short distance above the bottom. Also, lowering the height of the nets may reduce incidental takes of harbor porpoises.

Underwater cameras will be used to examine behavior of cod and flatfish near gillnets, in addition to gillnet sets that directly compare the catch of the two nets to the standard nets. Testing is planned for this winter aboard the *Lady Irene* off Scituate, and the *Sasquatch III* off Gloucester.

• Groundfish Trawlnets Designed to Reduce the Bycatch of Cod

Two trawl nets designed to catch flatfish and avoid cod will be tested. Luis Ribas, a leader among Provincetown commercial fisherman, has designed a trawl net with very large mesh openings all along the middle of the upper half of the net. The second net has been adapted by Arne Carr from a European net design that removes some of the webbing in the upper half of the net, moving the headrope as far back as practical. Both designs are based on the behavior of cod as they swim along in front of a trawl net. Underwater video shows that cod slowly rise as the net overtakes them. Placing large mesh on the top of the net, or removing some of the webbing on top of the net, should allow cod to rise and escape. This project, awarded to Capt. Ribas, Arne Carr and Michael Pol, is budgeted at about $100,000.

Sixteen days of gear testing are planned aboard the *Blue Skies* for this winter. Each net will be tested compared to a standard net, alternating nets every other tow.

The goal of this study and the gillnet study is to develop gear that allows fishermen to continue to trawl for flatfish without high discards of cod. Cod in the Gulf of Maine remains the most depleted of the commercially valuable groundfish species, and cod conservation is the driving force behind the restrictive closures.

• Improving the Selectivity and Utility of Demersal Hook Fishing

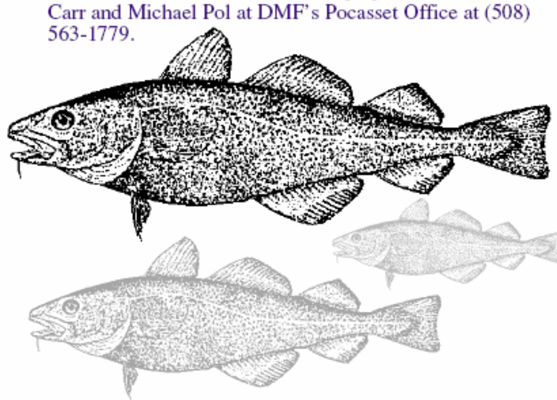
The Cape Cod Commercial Hook Fishermen's Association (www.ccchfa.org), working with Dr. Susan Goldhor of the Center for Applied Regional Studies (CARS), is participating with DMF to look at several aspects of bottom longlining. This project, funded for $111,000, has four goals: examining feeding and hooking responses of cod, haddock, and yellowtail flounder; find gear and artificial bait combinations that minimize bycatch; determine if certain flatfish species can be caught with longline gear in commercial quantities; and educate local fishermen about the results of the study.

The first step in this project, slated for this fall, is capture and holding of live cod, haddock, and yellowtail. These fish will be exposed to artificial baits. Field-testing of effective baits is scheduled for the beginning of 2001.

• A Collaborative Program to Reduce Bycatch and Discard in Gulf of Maine Otter Trawl Fisheries: Effect of Composite Mesh Codends on Trawl Selectivity

Proctor Wells, a fisherman from Maine, and two prominent Massachusetts fishermen, Frank Mirarchi and Russell Sherman, have teamed with Dr. Chris Glass of the Manomet Center for Conservation Sciences to continue testing codends composed of diamond and square mesh openings. Previous work has indicated that composite codends can be used to limit sizes of flatfish and roundfish by separately adjusting the mesh sizes. DMF has collaborated with Manomet on a similar project in the past, and will continue to do so with this funding.

For more information on these projects, contact Arne Carr and Michael Pol at DMF's Pocasset Office at (508) 563-1779.



http://www.mass.gov/dfwele/dmf/publications/dmfnq300.pdf

Work continues to improve commercial fishing gear

DMF's Conservation Engineering Program was awarded \$300,000 in federal funding through the Northeast Consortium last year (see DMF NEWS, 4th Quarter 2000, page 5). Since last fall DMF personnel, Manomet Center for Conservation Sciences (MCCS) observers, participating fishermen, and scientists have spent many days at sea and on land conducting experiments and analyses. The following summaries describe progress for each project.

Improving Selectivity and Utility of Hook Fishing

This study has four objectives, and progress has been made on two of them. From February through April, live cod captured by Chatham hook fishermen were transported to Woods Hole Oceanographic Institution raceways. Fish response to artificial baits developed by Dr. Susan Goldhor of the Center for Applied Regional Studies was filmed and evaluated by DMF personnel using underwater video cameras. The best recipes will be tested at sea. These artificial baits may allow fishermen to be more selective when targeting cod. This study also will determine if flatfish can be caught in commercial quantities using hook gear. The Cape Cod Commercial Hook Fishermen's Association has three boats testing some gear. Data on flatfish catch are being collected for analyses. Work continues on this project.

Trawl Nets Designed to Reduce Cod By-catch

Thirteen days of field testing (48 hauls) of two modified trawl nets were completed during May and June off Provincetown on the fishing vessel ***Blue Skies***. Capt. Luis Ribas' design, replacing most of the twine on top of a groundfish net with large square mesh, and DMF's Arne Carr's design, removing the top wings and belly to shift the headrope back to the start of the extension, appear to be able to remove up to 90% of cod when compared to a standard net. DMF underwater video cameras revealed how fish behavior is key to project's success. In Luis Ribas's net, cod passed upwards through the large square mesh and escaped; in Arne Carr's design, cod rose ahead of the headrope and escaped.

Testing of Low-Profile Gillnets to Reduce Cod By-catch

Fifteen overnight sets of two experimental gillnets designed by Bob MacKinnon of Scituate were made in December 2000 and January 2001. F/V *Lady Irene* (Capt. Scott MacKinnon), F/V *Michael Brandon* (Capt. Tom Bell) of Scituate and F/V ***Sasquatch III*** (Capt. Paul Cohan) of Gloucester participated in the study, carrying DMF personnel and Manomet observers.

Bob MacKinnon's designs alter the floatline. In one net the floatline is replaced by a second leadline; in the other, lead is added to the floatline every 30 feet. The point of the modifications is to lower the profile of the net so cod swim over it while flatfish are caught.

An ROV (remotely operated vehicle with a TV camera) was used to profile the nets underwater. We were surprised to see that the two leadlines from the dual leadline net ended up laying close together with a cloud of webbing drifting between them. Both this net and the added-lead net in fact stood lower than standard gillnets.

Catch data so far are encouraging. Modified nets catch fewer cod. However, data from some days were unusable due to small catches. Bad weather and area closures forced us to set nets in places where fish were scarce. We recently have been awarded further funding by the Northeast Consortium to continue this project.

Effect of Composite Mesh Cod-ends on Trawl Selectivity

DMF is a collaborator with Dr. Chris Glass of MCCS, who leads this project. Composite mesh codends (a "cod-end" is the bag at the tail-end of a trawl net where fish are collected) were comprised of square mesh and diamond mesh panels. Diamond mesh is more efficient at letting small flounders escape and square mesh does a better job of letting small roundfish (e.g. cod, haddock) avoid capture. Manomet has collected data using Massachusetts and Maine fishing vessels and currently is analyzing results.

For more information contact Arne Carr or Mike Pol at DMF's Pocasset office @508-563-1779

Capt. Mark Leach of the longliner Sea Holly (pictured) and Capt.Thomas Luce of the Longliner Sea Win assisted DMF in the longline bait sea trials.

2001 Sportfish Program Guide

DMF's Sport Fisheries Program has produced the 2001 "Massachusetts Saltwater Fishing Guide." As in previous years, the guide contains current information on boat-launch sites, tackle shops, charter and party boats, fish profiles, and fishing tournaments to assist you in enjoying our spectacular array of fishing opportunities from shore or by boat.

A copy of the guide can be obtained at most bait and tackle shops, or at one of the field offices.

http://www.mass.gov/dfwele/dmf/publications/dmfnq201.pdf

Experiments continue without inventor

Pol, Michael (Massachusetts DMF) and Robert MacKinnon (Mass. Bay Inshore Commercial Gear Fishermen's Assoc.

Project Title: ***Phase II: Testing of Low-Profile Low Cod-Bycatch Gillnets*** ($71,710)

Although he designed them, Robert MacKinnon is no longer taking part in a collaborative research project that will continue fieldtesting two of his experimental gillnets.

The first phase of the project was funded by the Northeast Consortium in 2000, and the project received $71,710 in funding thisyear.

MacKinnon, however, says he is now out of the business.

"I came up with all of the ideas and now I'm out of the box," MacKinnon said, citing increasing regulations as one of the reasons he gave up commercial fishing as part of the Massachusetts Bay Inshore Commercial Gear Fishermen's Association.

Paul Cohan of Gloucester, Mass., has agreed to help with the project in MacKinnon's absence, but he was unavailable for comment at publication time.

According to Michael Pol of the Massachusetts Division of Marine Fisheries, one of the experimental designs adds lead weight to an otherwise ordinary floatline; the second experimental design replaces the floatline of the gillnet with another leadline.

Both designs, Pol said, attempt to reduce the vertical profile of the nets and take advantage of a behavioral difference between cod and flatfish. Fishing experience and video observation suggest that cod do not often hang out on the very bottom of the ocean, and flatfish do not often rise more than one foot above the bottom. The potential use of the experimental nets, if proven, is to either allow fishing for flatfish in areas closed for cod, or to reduce the bycatch of cod in open areas, Pol wrote in his summary report.

Pol said he was able to get an experimental permit to go into Block 124 (Stellwagen), but was denied access to closed areas during the first phase of the project

"For consistency and simplicity, we're limiting all of the sets to 24 hours," he said.

Pol said uncooperative weather has slowed the project, but 10 sets were completed in May 2001 and another 10 sets should be completed soon.

Field testing was designed to allow comparisons of catch rates of cod and commercially valuable flatfish between experimental nets and standard nets. Results so far indicate that the designs are working; the net with added lead catches less cod than the standard cod and flatfish nets; the mean catch rate of the dual leadline net is lower than the standard nets, but not significantly so. Not enough flatfish were captured in the nets to allow comparisons of flatfish catch rates, Pol said.

http://www.namanet.org/collaborations/collab_mar_02.pdf

Images

Videotape footage was collected as part of the project by M. Pol. The footage is provided on the accompanying DVD, and archived by the Conservation Engineering Program of DMF using the following information. DMF logs of the footage are including in Appendix A.

ID Number	Title	Date	Medium
01MADMF567	NEC GILLNET STUDY TAPE 2	5/17/2001	MINIDV
00MADMF566	NEC GILLNET TAPE 1	12/2/2000	MINIDV

Photographs were collected on conventional 35 mm film; prints were scanned and are also included on an accompanying CD.

Captions for Gillnet Photographs

The first group of photos were all taken by M. Pol on 6 February 2002 on the Lady Irene.

Filename	Caption
Scan0001.jpg	Capt. Welch and crew prepare to remove gillnet from the bag.
Scan0002.jpg	A gillnet, visible on the spreading bar, is set as the boat move forward. The crewman watches to make sure the net does not tangle. Highflyers used to mark the ends of a string of nets are visible in the foreground.
Scan0003.jpg	Rough seas, difficult to convey through a photograph, complicate setting.
Scan0004.jpg	A crewman reaches for a coil of line being passed up from a hold.
Scan0005.jpg	Same as above.
Scan0006.jpg	Capt. Welch cuts open a net bag.
Scan 0007.jpg	Capt. John Welch is seen standing in the hold.
Scan0008.jpg	Crewman prepares endline for gillnet.
Scan0009.jpg	A gillnet, visible on the spreading bar, is set as the boat move forward. The crewman watches to make sure the net does not tangle.
Scan0012.jpg	Capt. Welch and crew prepare to remove gillnet from the bag.
Scan0013.jpg	A gillnet, visible on the spreading bar, is set as the boat move forward. The crewman watches to make sure the net does not tangle.
Scan0014.jpg	Gillnets are delivered in large plastic bags. This photo shows the name of the net maker.

The last two photographs were taken by Bill Campbell, ROV owner/operator, on 17 May 2001 on the Lady Irene.

Scan0010.jpg. Mike Pol looks at an ROV.
Scan0011.jpg Mike Pol (on right) watches Capt. Scott MacKinnon make an adjustment on the ROV.

Future Research

Additional research has already grown out of this project, primarily led by Dr. Pingguo He of the University of New Hampshire. The success of this project prompted him to conduct a project on half-height gillnets, building on the proposition that cod and flatfish can be caught separately with a small difference in height. His work had some success, leading to a joint project with Mike Pol of DMF to further investigate lower rigging of gillnets.

Further research is not planned on dual leadline or lead-added gillnets. This study effectively establishes their efficiency, and lack of expressed interest also has limited further efforts.

Appendix A: Logs for video footage

·OOBMADMF 566

12/8/2000, 1/17/01, 5/17/01

MDMF CAMERA LOG

DATE: ______ SUBJECT: NEC GILLNET ______ SPECIES: ______

BOAT: LADY IRENE WEATHER: OVERCAST SEAS: calm moderate rough

DEPTH: 17 M Fa CAMERA POSITION: ______ TAPE#: 1

SYSTEM: ROV TOW#: ___ START TIME OF TOW: __:__ UNIQUEID#: ______ 620

BEGIN: LAT: ______ LONG: ______ END: LAT: ______ LONG: ______

off Scituate

LOCATION: CAPE COD BAY COMMENTS: LOTS of SURGE

CLARITY OF FOOTAGE: good fair poor TAPE PROTECTED? Yes no

Tape Time	Event of Interest	Tape Time	Event of Interest
00:00:00	5.17.01 · TIME WRONG	~:48:00	END
: :	1800 LADY IRENE AT DOCK	: :	
:00:32	~~12.17.01~~ 12.00.00 ~2:30	: :	
: :	~~5.17.01~~ BOB MACKINNON	: :	
00:00:00	1.17.01 LADY IRENE	: :	
:51:04	DECK SHOTS	: :	
: :	HAULING - SCOTT MACKINNON ·	: :	
:2:24	DAVE MARROCCO OBSERVER	: :	
: :	DAVE MARTINS TAGGER -	: :	
: :	FROM MANOMET SMAST	: :	
:3:57	VIEW of ~~DUAL LEADLINE~~ FOAM CORE	: :	
: :	ON HAULING TABLE	: :	
:4:31	MIKE DL PICKING	: :	
:6:41	VIEW of SETTING NET	: :	
:7:41	HAULING FOAMCORE + LEAD	: :	
:10:58	DUAL LEADLINE	: :	
:11:30	FLOATS - COD GEAR	: :	
:~~24~~:00	5/17 R.O.V.	: :	
:00:21		: :	
: :44	BILL CAMPBELL, 2 CREW	: :	
:1:10	OVER THE SIDE	: :	
:1:20	U/W VIEW	: :	
: :	FOLLOWING BUOY LINE	: :	
: :	LOOKING FOR NET	: :	
:24:13	FIND NET - FOLLOW to	: :	
: :	ANCHOR	: :	
:25:40	SEE NET. DUAL LEADLINE	: :	
:27:00	UNSPIN ROV. ROV TIME	: :	
:37:00	WEBBING 10:47	: :	
:38:15	VIEW of 2 LEADLINES	: :	
:41:50	+ WEBBING	: :	
: :	SPREAD LEAD LINES	: :	

RESET COUNTER

01MADMF567

MDMF CAMERA LOG

DATE: 5.17.01 SUBJECT: N.E.C GILLNET. SPECIES:

BOAT: LADY IRENE WEATHER: OVERCAST SEAS: calm moderate rough

DEPTH: 17 M Fa CAMERA POSITION: ROV / SURFACE TAPE#: 1

SYSTEM: ROV/DV TOW#: START TIME OF TOW: : UNIQUEID#:

BEGIN: LAT: LONG: END: LAT: LONG:

LOCATION: CAPE COD BAY COMMENTS: Off SCITUATE; LOTS of SURGE

CLARITY OF FOOTAGE: good fair poor TAPE PROTECTED? Yes no

	Tape Time	Event of Interest	Tape Time	Event of Interest
	:00:00	ROV HAULING		JUST TO SEE VIZ
		CAUGHT IN GILLNET		AT DEEPER DEPTH
	:39	~~E~~ SCOTT MACKINNON		- TO CHECK if WE
		BILL CAMPBELL (BLUE SHIRT)		SHOULD VIEW DEEPER
	:2:04	U/W CUNNER		SET of 14 NETS
		LEADLINE IN VIEW	:45:57	HAULING, BACK
		CUNNER SWIM THROUGH		
		NET?		
*	:4:49	FLOATLINE CAUGHT ON ROV		
F	:6:20	CUNNER (LEAD		
*	:7:07	ADDED)		
	:7:36	~~EACH~~ LOTS of SLACK IN		
		WEBBING		
	:9:17	FLOATLINE		
	:10:58	NICE FISH - SP?		
		SURGE		
	:12:10	FLINE AT 4.7 FT		
*	:13:20	LEAD AT BOTTOM		
	:14:15	LEAD IN VIEW		
GOOD VIEWS	:15:40	FLOATLINE DRIFTING		
*	:18:32	LEAD ON BOTTOM		
	:22:26	SETTING GEAR		
		COD NET - FLOATS		
#57ft	:21:30	COD TRAPS		
	:28:14	Before POWER LOSS		
	:28:30	VIEW of FLOATLINE?		
	:30:00	LOBSTER POT WARP		
	:33:00	~~WARP OVER~~ NET OVER WARP		
*	:35:27	NICE WEBBING VIEW		
*	:36:11	VIEW of FLOATLINE		
	:38:12	FLOATLINE VIEW		
	:42:50	DEEP WATER		
		@ 98 FT		