Expanding the Use of the Sweepless Raised Footrope Trawl in Small-Mesh Whiting Fisheries

NOAA/NMFS Cooperative Research Partners Initiative
Unallied Science Grant NA16FL2261
Final Report

Final Report Prepared By:
John Sheppard
Massachusetts Division of Marine Fisheries
30 Emerson Ave
Gloucester MA 01930

Principal Investigators:
Michael Pol
Massachusetts Division of Marine Fisheries
50A Portside Dr
Pocasset MA 02559

Daniel McKiernan
Massachusetts Division of Marine Fisheries
251 Causeway St – Suite 400
Boston MA 02114

Period Covered: 1 April 2002 - 30 September 2003
Start/End Dates: 1 April 2002 - 30 September 2003
Date Prepared: 24 June, 2004

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Abstract
The purpose of this study was to monitor the exempted small-mesh raised-footrope trawl (RFT) fishery using data collected by sea samplers, and to improve adoption of the sweepless RFT (SRFT) through net modification at sea and production of a video. Eighteen trips were conducted from September 13 – December 19, 2002; 7 trips in which the standard whiting RFT or a raised footrope Scottish seine were used and eight trips in which the SRFT design was used. Three trips were conducted in which nets were modified at-sea from a standard RFT to the SRFT (changeovers). Biological data (catch composition, catch and discard rates, and length frequencies of whiting and regulated groundfish species) were collected during sea-sampling as part of short and long-term monitoring. Monitoring of the fishery resulted in redirection of effort away from cod concentrations, and more uniform bycatch regulations.

Efforts to improve adoption through outreach were successful. Changeover trips helped convince two of three fishermen to use the sweepless RFT. An edited video distributed to all fishery participants received positive feedback. Also, net mensuration data showed that the sweepless net appeared stable during fishing, although more measurements under varying towing conditions would be helpful to achieve optimum performance of this design.

Separate analysis of catch data verified low bycatch with all three gears observed, although data were limited and non-random and should be interpreted with caution. Additionally, catches of vessels that underwent net modifications (changeovers) appeared to perform comparably to vessels that fished the standard RFT and sweepless RFT, although adjustments in the form of headrope extensions were required.

Overall, results from this study support the SRFT as a viable option to the RFT. These preliminary results suggest that both designs can benefit the rebuilding of groundfish stocks while sustaining small-mesh trawl fisheries. It is recommended that further research and monitoring of these two gear types be conducted to further improve these designs and continue to verify low overall bycatch levels.

Introduction
Federal regulations implemented in 1994 prohibited small-mesh trawls in the southern Gulf of Maine and in Cape Cod Bay to protect juvenile groundfish species. Although these regulations allowed some small-mesh fisheries to be exempted from mesh requirements if bycatch levels were low (NEFMC 2000), trawling for whiting *Merluccius bilinearis* in Cape Cod Bay was not allowed, based on evidence of high by-catch rates during 1992-1994 (McKiernan et al. 1996).

These prohibitions had a severe impact on fishing fleets from Gloucester, Chatham, and Provincetown, Massachusetts that relied on small-mesh trawls to target whiting, red hake *Urophycis chuss*, and other species. Although Cape Cod Bay is managed under Commonwealth jurisdiction, nearly all trawlers hold Federal permits and are subject to Federal regulations. Therefore, Massachusetts fishermen could not fish with small-mesh trawls in Cape Cod Bay (McKiernan et al. 1998, 1999).

The Division of Marine Fisheries (DMF) began in 1989 to investigate this fishery and to develop gear-based solutions to high bycatch levels (Pierce and McKiernan 1990; Pol 2003). Specifically, the goal of that research was to decrease bycatch of regulated species (Atlantic cod *Gadus morhua*, witch flounder *Glyptocephalus cynoglossus*, American plaice *Hippoglossoides platessoides*, yellowtail flounder *Limanda ferruginea*, haddock

Melanogrammus aeglefinus, pollock *Pollachius virens*, winter flounder *Pseudopleuronectes americanus*, windowpane flounder *Scophthalmus aquosus*, redfish *Sebastes fasciatus*, and white hake *Urophycis tenuis*). Trials involving a trouser-trawl fitted with a removable horizontal separator panel determined that optimum catches of whiting could be obtained with a 90% reduction of regulated flatfish species at a height of 1-2 feet (0.5 m) off the bottom (Carr and Caruso 1993). This result inspired Robert Bruce, a former draggerman working for DMF, to develop the raised footrope trawl (RFT), a net that fishes 1-2 feet off the bottom. Reportedly, this design was adapted from a shrimp trawl used on the US Northwest coast (Richard Taylor, pers. comm.).

Additionally, a separator grate, based on the Nordmøre shrimp grate, was tested during a limited experimental fishery from 1995 – 1997 by the Maine Department of Marine Resources. This device was eventually adopted for small-mesh whiting fisheries in the northern Gulf of Maine. Although results indicated a substantial reduction in regulated species, the grate was never popular with Massachusetts fishermen in part because large (or "king" (> 12 in (30.5 cm))) whiting were excluded by the grate along with regulated species (Amaru 1996).

Results using the RFT were promising. Initial testing of the RFT in 1995 on one vessel resulted in catches of regulated groundfish species that comprised less than 5% of the total (McKiernan and King 1996; McKiernan et al. 1996). In spring 1997, extensive paired tows comparing the RFT to a standard small-mesh whiting net demonstrated that the RFT could reduce catch of regulated species by 70% and of regulated flatfish by 83% with no significant reduction in whiting catch (DMF, unpubl. data).

RFT design and modifications (including a sweepless version of the RFT) were also tested in a flume tank in Newfoundland, Canada by DMF in March 1998. Flume tank testing was used to refine the RFT (and sweepless RFT), and to define the exact rigging necessary for the design to fish cleanly. The key to the effectiveness of the RFT is the height of the footrope off the bottom. By raising the footrope 1-2 feet above the bottom, the net exploits differences in habitat preferences and swimming behaviors between target and non-target species. At this height, the RFT retains whiting and red hake that swim above the substrate, while passing over non-target species such as flatfish that stay close to the bottom. To raise the footrope, a chain sweep longer than the footrope is attached to the footrope using "drop chains" that are 42 inches (1 m) long (Figure 1a). The weight of the chain keeps the trawl mouth open while the drop chains allow the footrope (fishing line) to fish 1 – 2 feet off the bottom. The sweep is longer than the footrope to prevent it acting as a "tickler chain" and thereby encouraging demersal species to enter the net. A fuller description of the RFT is provided by NEFMC (2000).

One notable and useful characteristic of the RFT was that it could easily be applied to almost any net design (that otherwise fit the regulations). Because only the ground gear, headrope and footrope are affected, the RFT is a modification that can be applied to two and four seam nets, and even three bridle nets and Scottish seines. No changes to webbing or codends are necessary. Consequently, while the regulations are specific about the rigging of the sweep and other aspects of the forward part of the net, they are not specific about the net design. This flexibility has resulted in a wide diversity from vessel-to-vessel in the design of their individual "whiting nets."

Modifications of the RFT continued to be tested. A sweepless design (Figure 1b), which is identical to the RFT (except that the chain sweep is removed and the dropper chains are made heavier) was flume tank tested (Figure 2) and field tested in the 1998 fishery (McKiernan et al. 1999) on a limited basis. In 1999, field testing of the sweepless trawl continued and demonstrated that the sweepless trawl was a viable alternative to the RFT. However, comparisons of catch rates of whiting and red hake were inconclusive (Pol 2000). Power analysis showed that the number of tows necessary to detect true differences was unreasonably high (Pol 2000).

DMF's RFT research efforts culminated in Framework Adjustment 35 to the Northeast Multispecies Fishery Management Plan (Multispecies Plan) (NEFMC 2000). Framework 35 created an exempted whiting fishery in Upper Cape Cod Bay and southern Stellwagen Bank (UCC). The New England Fishery Management Council (NEFMC) and the National Marine Fisheries Service (NMFS) approved this exemption based on observed bycatch levels below 5% for 111 of 130 observed trips. Under Framework 35, the use of the raised footrope trawl (RFT) or the sweepless RFT was mandated in the Provincetown-area exempted whiting fishery.

The seasonal RFT whiting fishery in upper Cape Cod Bay thus joined two other small-mesh whiting exempted fisheries off New England. The Cultivator Shoal fishery was established in the early 1990's under an earlier exemption program, and was continued after the passage of Amendment 5 to the Multispecies Plan (NEFMC 2000). The Ipswich Bay (Area I) and Jeffries Ledge (Area II) fisheries were established in 1994. The new RFT fishery was the first exempted fishery established based on an experimental fishery conducted by a conservation engineering program. The different origins of these fisheries contributed to differences in bycatch retention limits. For example, monkfish *Lophius americanus* and lobster *Homarus americanus* could be retained, within limits, when fishing in Areas I, II and on Cultivator Shoals. No retention of these species was permitted in the new RFT fishery. The differences in the bycatch allowance for different regions in effect at the beginning of this study are summarized in Table 1.

The successful creation of an exempted RFT whiting fishery was the result of more than nine years of testing (Pol 2003). Over that time, the RFT gained acceptance throughout the fleet, partly because its use was mandatory and partly because reductions in bycatch were dramatic. Additionally, DMF conducted substantial outreach by working with individual vessels. While the RFT is a popular and successful net design, several problems arose that led DMF to prefer the sweepless version.

The RFT, although relatively simple in design, can be difficult to rig and to enforce because the regulations implementing it are numerous and detailed (see Table 2 for specifications). This specificity was determined during flume tank testing to be necessary to ensure the net fished cleanly. However, this complexity also makes the net difficult to enforce. For example, measuring the length of the sweep chain requires having the net run down onto the deck and the help of another person; this level of effort hinders enforcement. The SRFT represents an improvement because it eliminates the sweep chain, which can be easily adjusted to act as a tickler chain and increase bycatch. Also, the shine produced by bottom contact on the drop chains of the SRFT can be used to indicate the approximate height of the footrope off bottom as an initial simple enforcement step.

In addition, the RFT can get hung up on ghost fishing gear or other debris, causing the net to fish closer to the bottom and incur higher bycatch. In fact, many of the tows and trips with bycatch levels above 5% during field testing were the result of interaction with other gear. Eliminating the sweep chain appears to reduce or eliminate hang-ups, based on reports from fishermen. Finally, the SRFT has less bottom contact than the RFT, and presumably less bottom impact. For these reasons, DMF sought to encourage voluntary industry adoption of the sweepless RFT.

DMF conducted several forms of outreach to encourage use of the sweepless net prior to this study. Conservation Engineering personnel offered gear inspections, presented results from fishermen who used the sweepless net, and displayed raw footage of net testing. While both versions of the RFT were written into the exempted fishery, interest in and adoption of the sweepless version remained rare. DMF's experience with video presentations has shown that a video extolling the virtues of the sweepless net might be effective and persuasive.

Objectives

At the time of the grant application, an experimental fishery along the eastern coast of Cape Cod was in existence and was intended to expand the boundaries of the Upper Cape Cod Bay fishery established by Framework 35. To augment DMF monitoring resources, and to encourage the use of the sweepless net, DMF developed a dual-purpose project that was funded by NMFS Cooperative Research Partners Initiative (CRPI). The initial objectives of this project were to monitor in "real-time" the small-mesh experimental raised-footrope trawl fishery in waters east of Cape Cod, and to improve adoption of the sweepless RFT in both the experimental fishery and the exempted Seasonal Whiting RFT Fishery. The experimental fishery was not implemented, and a formal request was submitted to NEFMC to open the area east of Cape Cod as an exempted fishery. Consequently, the experimental fishery was not opened during September and October of 2002. As DMF and fishermen awaited the approval of the exempted fishery, DMF requested a revision to the goals and objectives of the project, which was subsequently approved by NMFS. The revised goals were to monitor the exempted small-mesh RFT fishery, and to improve adoption of the sweepless RFT through net modifications at sea (changeovers) and the production and distribution of a video describing the benefits of the sweepless RFT.

Methods

The exempted fishery was monitored "real-time" (during the fishery) by deployment of DMF sea samplers on participating vessels. Additional information was obtained from routine sea-sampling by NMFS observers (although these trips were not supported by the funding from this grant.) Analysis of RFT and SRFT whiting catches was conducted because data comparing these two gear types are limited. This analysis was not an objective of this project; therefore these results are presented separately in Appendix A.

Sea sampling was conducted during the exempted whiting fishery (September 1 – November 20, 2002) in upper Cape Cod Bay and southern Stellwagen Bank (UCC), and in Ipswich Bay (Area I). Monitoring also occurred during the exempted whiting fishery (November 21 – December 31, 2002) in waters east of Cape Cod. Sampling was performed on vessels hailing from Chatham, Gloucester, Provincetown and Scituate, Massachusetts.

Sea sampling was carried out predominately following protocols established by the NMFS-NEFSC observer program (NEFSC Fisheries Sampling Branch 2004). Sea samplers selected vessels opportunistically in the whiting fleet, collected catch information on landings and discards, length frequencies of whiting and certain bycatch species, tow location, duration, depth, net characteristics and other conditions.

The second goal of this study was to encourage fishermen to adopt the sweepless RFT. Adoption of the sweepless RFT was encouraged in two ways: "changeover" trips, and the production of a videotape. The purpose of "changeover" trips was to encourage adoption of the sweepless design through direct demonstration by re-rigging and tuning a vessel's net during fishing operations. A contracted fisherman (who has demonstrated proficiency using the sweepless RFT) performed the gear modifications while at sea on the participating vessel, accompanied by DMF personnel. The RFT that belonged to the vessel was re-rigged by the contracted fisherman into an SRFT. Re-rigging consisted of severing the sweep chain from the drop chains by cutting chain links or removing shackles and then hanging an additional 42-in chain at each attachment point.[1] Additional weight was found in the flume tank to be necessary to keep the footrope at the right height. One other primary modification was made: if high bycatch levels were observed, extensions ((1, 1.5, 2.0 ft) (0.3, 0.5, or 0.6 m)) were added to the end of each top wing to increase headrope length (Figure 3). Extensions would therefore increase headrope length twice the length of the extension and raise the footrope further off the bottom. Other adjustments were made based on the contracted fisherman's experience. Catches were monitored and recorded (using the same sampling protocol) by tow on these trips also.

Letters (Appendix B) were sent to 33 previous fishery participants (Appendix C) explaining the project and soliciting interest. Vessels were offered a small amount of compensation for lost income due to reduced fishing time during the trip. Trips were arranged with vessels from Gloucester, Provincetown and Scituate.

An edited video documenting at-sea modifications of the RFT was produced. Filming was performed on vessels hailing from Gloucester and Provincetown. Trawl nets were deployed using an underwater video camera attached to the headrope with live feed to a monitor inside the vessel's wheelhouse. Footage of whiting and other species interactions to the trawl were observed and recorded. Additionally, remote sensors were attached to trawl doors, headrope and wings to record data on net geometry. Information on door spread, wing end spread, and headrope- and footrope height were recorded by sensors and transmitted to a wheelhouse computer.

Net mensuration data collected from Netmind software were recorded into Excel spreadsheets and audited to exclude outlier measurements (periods where accurate net geometry measurements were not obtained). In addition to net mensuration parameters collected, distances between headrope and footrope were calculated for each tow. To measure the distance between footrope and the seafloor, data measuring headrope height from the seafloor and distance between headrope and footrope were audited and cross-referenced based on the time in which the data point was collected for both parameters. Differences were generated for each pair of data points and basic statistical variables (mean, variance, standard deviation, standard error and 95% confidence limits) were calculated for each parameter measured.

Results

Eighteen trips (50 tows, 88 hours towing) were observed by DMF (N = 15) and NMFS (N = 3) personnel on vessels targeting whiting (all gear and trip types combined) from September 13 – December 19, 2002 (Table 3). Fifteen trips were observed in Upper Cape Cod Bay and two trips were observed in Area I (Ipswich Bay) (Table 4). One trip (3 tows) was observed in the

[1] The maximum size drop chain stock when used with a sweep is 5/16-inch. Drop chains may be a maximum of 3/8-inch stock when no sweep is used. Hanging two 5/16-in chains is also common when using the SRFT.

small-mesh exempted area east of Cape Cod which was opened from November 21 – December 31, 2002. As observed in previous years, additional trips were limited by adverse weather conditions in the months of November and December as well as the size of vessels in the fleet (larger vessels being able to tolerate more severe weather): seven additional trips were attempted but prevented by weather. Catch composition is summarized in Table 4. Whiting (44,978 lb (20,402 kg)) dominated the total catch, whereas total catch of regulated species (2,846 lb (1,291 kg)) accounted for 3% of the total catch (92,724 lb (42,059 kg)).

Selection of vessels was opportunistic and was not representative of the fleet as a whole (Table 3) and net size and type and codend mesh size varied from vessel to vessel. The fifteen trips conducted under this study by DMF consisted of 6 sea sampling trips onboard vessels using the standard RFT, 5 onboard vessels using the sweepless RFT, 3 trips onboard vessels undergoing modifications (changeovers), and 1 trip onboard a Scottish seine vessel. The three trips conducted by NMFS observers were performed onboard vessels using standard RFT. Total catch weights for all observed trips are presented in Table 4. CPUE is presented in the separate analysis (Appendix A).

One trip was conducted onboard a Scottish seine fishing vessel in the small-mesh exempted area east of Cape Cod on December 19, 2002. Scottish seiners use a net similar in shape and design to an otter trawl; however, in Scottish seining the net is set in the water and slowly hauled to the boat, without the use of trawl doors (Sainsbury 1971). Three tows were conducted for 4.5 hours of fishing time. Whiting (840 lbs (381 kg)) dominated the catch with regulated species (30 lbs (14 kg)) comprising 3.1% by weight of the total catch.

Three vessels (one each from Gloucester, Provincetown and Scituate) participated in changeover trips. Two trips were conducted in upper Cape Cod Bay; one trip was prosecuted in Area 1. Total landings and discards for changeover trips are separately summarized in Table 5. Whiting (5,438 lb caught; 5,238 lb landed) dominated the total catch. Total catch of regulated species (362 lb) constituted 3.7% of the total catch (9,912 lb). Catch results by tow for changeover trips are analyzed and described in Appendix A.

Filming was limited by weather conditions and water clarity. Two filming trips, during which 5 tows were performed, were conducted on October 9 and 10, 2002. One tow was filmed and measured with the sweepless RFT without added extensions, two tows were filmed after insertion of 1 ft extensions on either end of the headrope, one tow using 1.5 ft extensions, and one tow using 2 ft extensions. Net mensuration data were collected during these two filming trips. Measurements of headrope height, footrope height, wing spread and door spread for each modification are summarized in Table 6, and shown in Figure 5. Mean height (± SE) from seafloor was lowest during the two tows when the 1-ft extension was added (9 October) (0.26 ± 0.2 ft (0.08 ± 0.06 m) (N_{obs} = 20) and 1.44 ± 0.52 ft (0.44 ± 0.16 m) (N_{obs} = 26)). For the rigging without extensions (10 October), the footrope was further off the bottom (6.8 ± 0.36 ft (2.07 ± 0.11 m), N_{obs} = 101). The addition of the 1.5 and 2-ft extensions (10 October) raised the footrope further, to 8.4 ± 0.36 ft (2.56 ± 0.11 m) (N_{obs} = 112) and 8.63 ± 0.36 ft (2.63 ± 0.11 m) (N_{obs} = 114).

A 12 minute video tape (Szymanski 2003) was produced and distributed to 67 participants in the 2002 whiting fishery and other interested parties, including the New England Fishery Management Council (Appendix D, E). Footage collected from both sea-sampling trips, and scale-model testing at the flume tank from the Marine Institute at Memorial University in Newfoundland, show how this net design became management’s new tool and helped re-establish the whiting fishery. The video starts with a historical account of the importance of the whiting fishery for Massachusetts small fishing vessels, the reasons why the fishery was closed, and the re-opening of this fishery in the advent of the standard RFT. The video then discusses advantages of a sweepless RFT over a standard RFT. The source for the regulations surrounding small mesh fishery exemptions was also presented. The end of the video shows the potential of the improved design in other fisheries. This video is catalogued in the DMF Conservation Engineering Program's video library as 03MADMF845.

Discussion

Monitoring of the fishery had both short- and long-term effects. For example, sea sampling was used during the project (11/4/02) to redirect effort from the top of Stellwagen Bank to avoid high cod bycatch, meeting one of our objectives (Table 4). This redirection helped keep the overall percentage of regulated species bycatch for all observed trips during the 2002 season low (< 5%) (Appendix A).

A long-term effect resulting from monitoring of the fishery was a change in the bycatch regulations for Areas I and II. The trip in the Area I fishery on 13-14 September highlighted differences in lobster and monkfish possession limits between exempted small-mesh fisheries (Table 1). In DMF's view, these differences in possession limits provided an incentive for fishermen to rig the RFT improperly to increase bottom contact, and increase the catch of these bottom-tending organisms. This trip provided evidence that improper rigging was taking place in this area to capitalize on the bycatch allowance. DMF contacted NEFMC staff to rectify the inconsistencies between bycatch limits in different small-mesh whiting areas. Consequently, uniform bycatch allowances were proposed through Framework 38 (NEFMC 2003).

The substantial number of observer trips that were conducted also allowed monitoring of the exempted fishery in a longer term, by comparing the level of bycatch of regulated species (Appendix A). Tremendous effort is often put into establishing the effectiveness of a gear modification; however, measurements of its effectiveness once widely implemented are rare. This overall "fleet selectivity" expresses the fleet's geographical and seasonal utilization of the gear (Danish Institute for Fisheries Research 2003) and the resulting variability. This study offered an opportunity to quantify the effectiveness of the RFT and sweepless RFT on a variety of vessels under true fishing conditions, and not in the context of an experiment.

This project was not designed as a gear comparison, so caution must be used when interpreting results of the limited catch analysis presented in Appendix A. Overall, the measured fleet selectivity was low, closely matching experimental results. Bycatch levels of regulated species from this fishery, compared to sea sampling data from previous years (McKiernan et. al. 1998, 1999, NEFMC 2000), continue to remain low (3% (this study) v. 3% (1999)). These results are consistent with or better than those measured in the years of the experimental fishery and indicate the exempted fishery is in good condition in terms of avoiding bycatch. A further investigation of the whiting fleet selectivity (the bycatch levels in the exempted fishery) is currently underway using a combination of sea sampling data and vessel logs by DMF as a separate project.

The presence of cod was responsible, in one trip (11/4/02), for bycatch levels above 5% in individual tows using the sweepless RFT. The occurrence of high cod bycatch on individual tows has been observed in previous years as well, and further demonstrates that although the sweepless and standard RFT are effective in reducing bycatch levels of regulated flatfish species, they do not minimize the bycatch of cod. In fact, results from paired testing of the

RFT and a standard net showed no effect on the catch of cod (DMF, unpublished data). This lack of effect was taken into consideration in establishment of the exempted fishery by closing the fishery before the seasonal arrival of cod on Stellwagen Bank.

Large-mesh nets are being developed that avoid cod in flatfish fisheries. We have observed a rising behavior of cod as they are overtaken by the trawl, where they ascend above the footrope and are caught. Possible net modifications to reduce cod catches include avoiding areas where cod are present or further net modifications such as large square-mesh panels in the tops of nets or removing the top panels in nets (thereby moving the headrope further back in the trawl).

As conservation measures result in increasing numbers of cod in the Gulf of Maine, cod bycatch may become more prevalent in small-mesh fisheries. However, our observations that the RFT and SRFT continue to have low overall bycatch bodes well for this fishery. Proposed fishery regulations have recently required periodic renewal of exempted fisheries. If bycatch levels observed here continue, the exempted RFT fishery should be sustained.

Net mensuration data verified that insertion of extensions increased footrope height. However, results also showed an unexplained difference in net performance. The same net on the same vessel was measured on consecutive days, carrying both mensuration sensors and film equipment. Unexpectedly, headrope and footrope height were significantly lower on the first day than on the second, despite the use of 0.3 m extensions on the first day. Insertion of longer extensions on the second day did increase the footrope height although the measured heights (over six feet from headrope to seafloor) were much greater than expected for every configuration: no extensions; 1.5 ft and 2.0 ft extensions. Camera footage and logs supported the mensuration data; on film, the net can be seen to be higher than 1-2 ft off bottom. Despite this height, various species of fish can still be seen entering the net.

The rigging of the net was identical from the first day to the next. Although the reason for the change in height cannot be identified, the headrope and footrope heights observed on the second day should be considered anomalies, and not indicative of a failure of the sweepless design. Flume tank testing, the shine on the drop chains, and its popularity with some fishermen all demonstrate that the sweepless design is effective. Tidal currents may have influenced net height; they can increase or decrease a net’s speed over ground and therefore its headrope and footrope height. Measurements of tide were not recorded on this day. It may be possible that the electrical cable connecting the camera to its winch was tighter on the second day, providing additional lift to the net. Further, the performance of the sensors over different bottom types may create erroneous readings. It appears imperative that further examination of variation in net performance, and verification of net mensuration equipment, be conducted to understand the factors affecting headrope and footrope height.

Use of the extensions on the headrope did have a noticeable effect on catch on a couple of tows (Appendix A). In one case, use of an extension resulted in elevated bycatch. On a changeover trip conducted on November 1, 2002, extensions were added to the headrope of the net with the purpose of raising the footrope off the bottom. However, increased levels of flatfish and lobsters were observed in the tow, the opposite of the result expected. On another trip (10/24/02), extensions were added to the lower legs of the sweepless RFT, the opposite of the usual practice, to demonstrate both the effect of the insertion as well as the results of fishing the footrope closer to the seafloor. The presence of mud and a lobster trap and increased volumes of skates, flatfish, monkfish and lobster were observed in the catch presumably as a result of this modification. The combination of mensuration data and some catch results indicates both that the use of extensions can have an impact on the net, and that other small adjustments may be needed to optimize net performance. The catch and mensuration results emphasize the need for tuning and for further underwater at sea measurement of nets, as the number of observations under this study was very small and the results unexpected.

The small confidence intervals observed in the measurement data indicate that while headrope height may vary from day to day, the net shape during individual tows remained stable at towing speed ranging from 2.5 – 3.1 knots. Questions have been raised about the impact of towing speed on bycatch. Flume tank testing indicated a trend of increasing footrope height and decreasing headrope height with increasing speed (DMF, unpubl. data). The flume tank data suggested that towing below 2.5 knots may result in lower footrope heights and therefore higher bycatch. At least two factors might inhibit slower towing during the fishery: risk of damage to the footrope from bottom contact; and stalling of the trawl doors resulting in a collapsed net. To accurately determine the effect of slower speeds on footrope height, further net mensuration of this design should be conducted under varying speeds. Overall, however, we did not observe any results to discount the assumption that the sweepless RFT performs acceptably compared to the standard RFT, and that the sweepless net continues to have the advantages of simplicity of rigging, enforcement, and lower susceptibility to entanglement.

The primary purpose of the changeover trips and the production of the video were focused on encouraging voluntary adoption of the sweepless RFT. Two of the vessels which participated in the changeover trips plan to use the sweepless RFT during the 2003 fishing season, an encouraging sign. One vessel's crew simply rejected the sweepless design, and the captain acceded to their choice. Further participation was limited both by lack of response, and because of weather and the delay in opening of the Chatham area fishery. As the distribution of the video occurred between whiting seasons, we cannot measure its impact yet. However, early responses from fishermen have been favorable.

The sweepless net design has been popular with gear scientists. A portion of the video was displayed at a recent international meeting of gear scientists during a presentation on the reduced bottom impact of this gear (Pol et al. 2004). This viewing has resulted in over 15 requests for a copy of the video. Also, the activities of this study, and other results, prompted Maine DMR to propose an exempted fishery for whiting along the Maine coast, using the SRFT in conjunction with a Nordmøre grate. This response and those of scientists at the recent gear meeting illustrates that this design and the outreach associated with this project have been successful in encouraging its use among the scientific and regulatory community.

DMF's strategy for the SRFT will continue to be to work cooperatively with fishermen in a manner that encourages them to adopt gear modifications voluntarily before, or instead of, incorporating them into regulations. If DMF seeks eventually to mandate the use of the sweepless net, the cooperative work funded by this project will encourage compliance because fishermen will have been introduced to the sweepless net before it was required.

Future Research

Future work with the sweepless RFT must include at-sea demonstration and tuning, as well as continued measurement of net geometry and calibration of net sensors. We believe that demonstration of the practical use of this lower-impact gear will continue to be essential to further industry acceptance of the sweepless RFT.

One modification we propose testing is the addition of cookies to the ground cables (Pol et al. 2003). The regulations for the RFT are very specific, limiting ground cables to "all bare wire not larger than ¾-inch diameter" (NEFMC 2000). However, fishermen allege that this restriction makes fishing in areas with mud bottom difficult because the bare wire digs into the mud, thereby causing the net to fill with mud and fish closer to the bottom. The addition of cookies (1.5 – 2 inch diameter rubber discs) makes the ground cable much less likely to dig into mud, allowing whiting to be caught cleanly in areas of mud bottom.

Further improvement of the RFT is important because the northern stock of whiting is fully rebuilt (NEFMC 2003) and offers opportunity for redirection of groundfishing effort. The proposed research seeks to keep the fishermen safer and their catch even cleaner than earlier versions of the RFT.

Also, DMF plans to make the sweepless design an essential feature of a haddock-specific trawl currently in the process of development (Moth-Poulsen et al. 2003). The reduced bottom contact of the sweepless net makes its potential use in sensitive habitat areas more likely.

Acknowledgements
Many thanks to Brian Kelly and William Hoffman of DMF, former DMF employees Rebecca Jones and Vincent Manfredi for securing fisheries-dependent data during both standard sea sampling trips and changeover trips. Special thanks to Mark Szymanski of DMF for his assistance in setting up and calibrating the Netmind system on vessels for collecting net mensuration data as well as setting up underwater cameras onto trawl nets and his time and effort collecting and editing video footage to create the project documentary. Thanks to the NMFS Northeast Regional Office (especially Ted Hawes and Don Paskowski) for help determining fishery participants, and to the NMFS Northeast Fishery Science Center for help with the OBDBS database.

References
Amaru, W.H. 1996. A size-selective, near-zero mortality trawl for silver hake. Saltonstall-Kennedy Report NA66FD0011. National Marine Fisheries Service.

Carr, H.A., and P. Caruso. 1993. Application of a horizontal separating panel to reduce bycatch in the small mesh whiting fishery. Proceedings of the Marine Technology Society Global Ocean Partnership Conference. Oct. 19 – 21. Washington D.C. p. 401 – 407.

Danish Institute for Fisheries Research. 2003 (accessed). DIFRES Strategy 2005. http://www.dfu.min.dk/uk/Publications/Strategy%202005.pdf. 22 pp.

McKiernan, D.J., and J. King. 1996. Analysis of Sea Sampling Results from Trawlers Fishing in Small-Mesh Area I (Ipswich Bay) During July – November 1995. A Report to the National Marine Fisheries Service. March 19, 1996. 17 pp.

McKiernan, D.J., J. King, H.A. Carr, and J. Harris. 1996. Final report on the fall 1995 small-mesh experimental silver hake fishery in Cape Cod Bay employing a DMF raised footrope bottom trawl. A Report to the National Marine Fisheries Service. April 2, 1996. 8pp.

McKiernan, D., R. Johnston, B. Hoffman, A. Carr, H. Milliken, D. McCarron. 1998. Southern Gulf of Maine Raised Footrope Trawl 1997 Experimental Whiting Fishery. Division of Marine Fisheries, Boston, MA.

McKiernan, D., R. Johnston, B. Hoffman, A. Carr, D. McCarron. 1999. Southern Gulf of Maine Raised Footrope Trawl Experimental Whiting Fishery. Division of Marine Fisheries, Boston, MA.

Moth-Poulsen, T., M. Pol, and B. Lane. 2003. Development of an industry- and environmentally-friendly species-selective haddock trawl without horizontal separator panels. Northeast Consortium Proposal. Submitted 14 July 2003

New England Fishery Management Council. 2000. Framework Adjustment 35 to the Northeast Multispecies Fishery Management Plan. Newburyport, MA.

New England Fishery Management Council. 2003. Framework Adjustment 38 to the Northeast Multispecies Fishery Management Plan. Newburyport, MA.

Northeast Fisheries Science Center Fisheries Sampling Branch. 2004 (accessed). Fisheries Observer Program Manual. http://www.nefsc.noaa.gov/femad/fsb/. 310 pp.

Pierce, D.E. and D. McKiernan. 1990. Report on DMF November 1989 Sea Sampling On Board Draggers Fishing in Cape Cod Bay and Lower Massachusetts Bay. Mass. Div. Mar Fish., 23 pp.

Pol, M. 2003. Turning Gear Research into Effective Management: A Case History (poster). Managing Our Nation's Fisheries. November 13-15, 2003. Washington, DC.

Pol, M. 2000. Effect of Removal of the Chain Sweep from a Whiting Raised Footrope Trawl. Div Mar Fish Cons Eng Project Report. 7 pp.

Pol , M., J. Sheppard, and D. McKiernan 2004. Expanding the Use of the Sweepless Raised Footrope Trawl in Small-Mesh Whiting Fisheries. ICES Working Group on Fishing Technology and Fish Behavior. Gdynia, Poland, 20-23 April 2004.

Pol, M.V., T. Moth-Poulsen, and L. Ribas. 2003. The Third Generation Raised Footrope Trawl Improving Safety and Reducing Impact. Proposal to the Northeast Consortium. July 14, 2003. 17p.

Sainsbury, J. C. 1971. Commercial Fishing Methods. Fishing News (Books) Ltd, Surrey, U.K.

Szymanski, M. (producer). 2003. Expanding the Use of the Sweepless Raised Footrope Trawl in Small-Mesh Whiting Fisheries. [video] Available from Division of Marine Fisheries, Pocasset MA. 12 min.

Table 1: Summary of incidental catch allowances in exempted fisheries for small-mesh multispecies at the start of the grant (source: NEFMC 2002).

Exempted Fishery	Season	Gear Requirements	Allowable Incidental Catch
Small Mesh Area I	6/15 – 11/15	RFT	Herring, Sculpin, Squid, Butterfish, Mackerel, Dogfish, Ocean pout, Scup, Red hake, *Monkfish, **Lobster
Small Mesh Area II	1/1 – 6/30	RFT	Herring, Sculpin, Squid, Butterfish, Mackerel, Dogfish, Ocean pout, Scup, Red hake, *Monkfish, **Lobster
Raised Footrope Trawl Cape Cod Bay	9/1 – 11/20 Cape Cod Bay; 11/21 – 12/31 eastern area only	Minimum 2.5-inch mesh RFT	Red Hake, Squid, Butterfish, Mackerel, Dogfish, Herring, Scup
Cultivator Shoal Whiting Fishery	6/15 – 9/30	Minimum 3-inch mesh	Herring, Sculpin, Squid, Butterfish, Mackerel, Dogfish (up to 10% by weight), Ocean pout, Scup, Red hake, *Monkfish, **Lobster

Incidental catch amounts limited only by the regulations for that species (i.e. dogfish is limited to 600 lb May 1 – Oct. 31 and 300 lb 11/1 – 4/30, or zero lb if quota closes.
* Monkfish can be retained up to 10% by weight OR 50 lb tail/166 lb whole, whichever is less.
** Lobster can be retained up to 10% by weight OR 200 lobsters, whichever is less.

Table 2: Raised footrope trawl gear specifications for use in small mesh whiting fishery.

Net Characteristic	Specifications
*Codend mesh size	Minimum 2.5-inches square or diamond counting from terminus of the net, the first 50 meshes or first 100 bars with square mesh (vessels up to 60 feet in length). Minimum 2.5-inches square or diamond counting from the terminus of the net, the first 100 meshes or first 200 bars with square mesh (vessels greater than 60 feet in length).
*Outside net strengtheners	Prohibited along with liners and codend covers.
Headrope	Floats minimum diameter 8-inch attached along entire headrope length; 4 feet maximum spacing between floats.
Ground gear	All bare wire not larger than ½-inch diameter (top leg), 5/8-inch diameter (bottom leg), ¾-inch diameter (ground cables). Top and bottom legs must be equal in length with no extensions. Total length of ground cables and legs must not be greater than 40 fathoms (73 m) from the doors to wing ends.
Footrope	Must be longer than headrope, not more than 20 feet longer than headrope; must be rigged so that it does not contact the bottom.
Drop chains	42 inches in length or greater, 5/16-inch maximum stock (with sweep); 3/8-inch maximum stock (sweepless). Additional weights and cookies prohibited. Must be hung from center and each corner of footrope; must be hung at 8-foot intervals along footrope from corners to wing ends.
Sweep	Must be bare chain the same length as footrope. Maximum size is 5/16-inch stock chain and must be attached to ends of drop chains. Center of sweep must be attached to the drop chain from the center of footrope. Ends of sweep must be attached to drop chains at the end of footrope.

* Gear specifications apply only to vessels fishing in all small-mesh whiting areas except Areas I and II.

Table 3: Summary report of the number and type of sampling trips prosecuted for the whiting sweepless raised footrope trawl project.

Date	Trip type	Sampler	Vessel	Port	Results
9/13/2002	Regular	BH	Lady Jane	Gloucester	Success
9/14/2002	Change/Film	VM/MS/RJ	Lady Jane	Gloucester	Success
9/23/2002	Regular	BK	Blue Ocean	Provincetown	Success
9/25/2002	Regular	BK	Antonio Jorge	Provincetown	Success
9/26/2002	Regular	BK	Blue Ocean	Provincetown	Success
9/26/2002	Regular	BH	Rose Marie	Gloucester	Success - Shortened due to gear damage
9/30/2002	Regular	NMFS	Pat Sea	Provincetown	Success
10/2/2002	Regular	NMFS	Jersey Princess II	Provincetown	Success
10/2/2002	Regular	JS	Richard & Arnold	Provincetown	Failure - Weather
10/3/2002	Regular	NMFS	Santa Luzia	Provincetown	Success
10/8/2002	Change/Film	JS/MS	Blue Skies	Provincetown	Failure - Weather
10/9/2002	Change/Film	JS/MS	Blue Skies	Provincetown	Success
10/10/2002	Change/Film	JS/MP	Blue Skies	Provincetown	Success
10/22/2002	Regular	BK	Ancora Praia	Provincetown	Success
10/23/2002	Regular	BK	Sao Jacinto	Provincetown	Success
10/24/2002	Regular	BK		Provincetown	Failure - Weather
10/24/2002	Changeover	JS	Christopher Andrew	Scituate	Success
10/28/2002	Regular	BK		Provincetown	Failure - Weather
10/29/2002	Changeover	JS	Ancora Praia	Provincetown	Failure - Weather
10/31/2002	Regular	BH	Lady Jane	Gloucester	Success
11/1/2002	Regular	BH	Lady Jane	Gloucester	Success
11/1/2002	Changeover	JS	Ancora Praia	Provincetown	Success
11/4/2002	Regular	JS	Blue Skies	Provincetown	Success
11/8/2002	Changeover	JS	Midnight Sun	Gloucester	Failure - Weather & boat repairs
11/14/2002	Film	JS/MS	Blue Skies	Provincetown	Failure - Weather
11/19/2002	Film	MS	Blue Skies	Provincetown	Success
12/19/2002	Regular	BK	Coming Home	Chatham	Success

Trip Types:
1. Regular - Regular sea sampling conducted in accordance with NMFS sampling protocol.
2. Changeover - Modifications made to trawl nets and catch data recorded for each haul.
3. Film - Underwater camera and sensors fitted to trawl net to record gear performance.

Table 4: 2002 Exempted whiting fishery sea sampling results trip summary - total catch from all observed trips (weights in pounds).

TRIP DATE	AREA(S) FISHED	TRIP TYPE	NO. TOWS	TOW TIME (HRS.)	WHITING	SPINY DOGFISH	RED HAKE	ALEWIFE	ATLANTIC HERRING	ATLANTIC COD	WINTER FLOUNDER	AMERICAN PLAICE	YELLOWTAIL FLOUNDER	WINDOWPANE	WITCH FLOUNDER	POLLOCK	HADDOCK	WHITE HAKE	REDFISH	LOLIGO SQUID	AMERICAN LOBSTER	ILLEX SQUID	LONGHORN SCULPIN	MONKFISH	OTHER	REG. FLATFISH	REG. ROUNDFISH	TOTAL REG. SPECIES	PERCENT REG. SPECIES	TOTAL CATCH
9/13	1	SRFT	1	4	232	0	16	75	42	0	16	17	1	0	0	0	6	1	0	0	103	0	3	16	51	34	7	41	7.1%	579
9/14	1	*SRFT	2	4.25	1,938	40	628	0	765	0	14	49	4	0	5	1	0	7	0	0	61	1	1	164	14	72	8	80	2.2%	3,692
9/23	UCC	SRFT	1	0.5	203	1,200	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0.0%	1,411
9/25	UCC	RFT	4	6.8	5,088	4	689	145	15	1	36	19	2	0	1	1	0	0	0	24	6	25	12	6	30	58	2	60	1.0%	6,104
9/26	UCC	RFT	2	1	180	6,480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	0.0%	6,666
9/26	UCC	SRFT	4	7.3	2,800	10	456	80	3	0	151	161	18	0	5	0	0	2	0	18	43	88	19	15	127	335	2	337	8.4%	3,996
9/30	UCC	RFT	4	5.8	3,350	715	2,380	0	100	85	205	25	21	0	0	0	0	0	0	10	0	65	20	15	588	251	85	336	4.4%	7,579
10/2	UCC	RFT	4	8.9	3,800	41	1,120	0	35	21	49	8	0	120	0	1	0	0	0	12	0	25	3	12	30	177	22	199	3.8%	5,277
10/3	UCC	RFT	3	6.2	1,435	62	250	0	0	0	18	0	0	0	1	0	0	0	0	68	9	14	5	7	66	19	0	19	1.0%	1,935
10/9	UCC	SRFT	2	3.5	142	15,132	21	0	20	15	14	6	2	0	1	0	0	0	0	5	11	5	0	14	2	23	15	38	0.2%	15,390
10/22	UCC	RFT	3	4.5	1,012	1,041	174	23	0	3	43	28	3	3	1	0	0	0	0	0	54	19	5	2	95	78	3	81	3.2%	2,506
10/23	UCC	RFT	4	7.5	2,001	665	279	128	10	34	20	94	4	0	2	0	0	0	0	42	37	2	5	15	82	120	34	154	4.5%	3,420
10/24	UCC	*SRFT	2	3	1,150	194	191	0	60	15	36	1	5	5	0	0	0	0	0	19	19	17	22	0	463	47	15	62	2.8%	2,197
10/31	UCC	RFT	2	3	5,657	110	1,267	600	23	104	21	42	11	2	2	1	1	0	0	162	30	50	69	13	137	78	106	184	2.2%	8,302
11/1	UCC	*SRFT	3	5.25	2,350	65	165	0	360	101	130	10	1	7	0	0	0	0	0	40	215	0	50	1	360	148	101	249	6.5%	3,855
11/1	UCC	RFT	2	5	8,700	45	1,151	1,280	11	65	44	50	6	8	0	8	0	0	0	278	15	50	64	2	229	108	73	181	1.5%	12,006
11/4	UCC	SRFT	4	6.5	4,100	560	190	0	850	554	143	28	61	7	0	2	0	0	0	85	36	0	46	5	173	239	556	795	11.6%	6,840
12/19	3	**SCS	3	4.5	840	57	28	0	0	26	0	0	0	0	0	0	4	0	0	4	0	0	5	0	5	0	30	30	3.1%	969
Totals			50	87.52	44,978	26,421	9,007	2,331	2,297	1,024	940	538	139	152	18	14	11	10	0	767	639	366	329	289	2,454	1,787	1,059	2,846		92,724
Mean			3	4.862	2,499	1,468	500	130	128	57	52	30	8	8	1	1	1	0.556	0	43	36	20	18	16	136	99	59	158		5,151
Median			3	4.75	1,970	88	221	0	18	15	29	18	3	0	0	0	0	0	0	15	17	10	5	7	74	75	15	81		3,926

*SRFT - trips in which vessels participated in net modifications (changeovers).

**SCS - Scottish seine

* EXT – "tuning tows" in which extensions were applied to the net to increase footrope height from the seafloor.

Table 5: Combined sea sampling results (all areas and treatments combined) of vessels undergoing headrope modifications using the sweepless raised footrope trawl during changeover trips. All landings and discards in pounds.

Area(s) Fished: Upper Cape Cod Bay (UCC) / Ipswich Bay (IPSB)

N trips	3 (2 UCC / 1 IPSB)
N tows	7 (5 UCC / 2 IPSB)
Hours fished	13 (8 UCC / 5 IPSB)

Species	Landings	Discards	Total
Whiting	5,238	200	5,438
American lobster	32	263	295
Atlantic herring	987	360	1,347
American shad	0	0	0
Alewife	0	0	0
Red hake	874	165	1,039
Sea scallop	0	6	6
Butterfish	78	33	111
Hake, NK	0	0	0
Monkfish	72	111	183
Loligo squid	61	0	61
Atlantic mackerel	2	13	15
Illex squid	18	0	18
Spiny dogfish	0	299	299
Black sea bass	81	34	115
Bluefish	24	1	24
Scup	2	0	2
Sea raven	0	4	4
Longhorn sculpin	0	73	73
Jonah crab	0	1	1
Rock crab	0	20	20
Little skate	0	361	361
Winter skate	0	46	46
Fourspot flounder	0	29	29
Ocean pout	0	8	8
Wrymouth	0	3	3
Summer flounder	0	24	24
Striped bass	0	15	15
Smooth dogfish	0	11	11
Striped sea robin	0	1	1
Other	0	4	4
Atlantic cod	0	116	116
Haddock	0	0	0
Pollock	0	1	1
White hake	0	7	7
Redfish	0	0	0
Winter flounder	0	150	150
American plaice	0	59	59
Yellowtail flounder	0	12	12
Windowpane	0	12	12
Witch flounder	0	5	5
Totals	7,468	2,444	9,912
Total Regulated Species			362
Percent Regulated Species			3.7%

Table 6: Summary of statistical variables calculated (by modification) for each parameter measured using Netmind software. CI = 95% confidence interval, based on the t-test. Measurements in meters.

Treatment	EXT 0.3*							
Net Measurement	Date	Tow No.	Tow Time (Hrs)	No. Observations	Mean	Max	Min	CI
Doorspread	10/9/02	1	1.67	310	60.9	62.1	62.1	0.02
Wingspread				357	14.3	14.3	14.3	0.02
Headrope - Seafloor				233	2.6	2.6	2.6	0.02
Headrope - Footrope				30	2.3	2.3	2.3	0.01
Footrope - Seafloor				20	0.08	0.2	0.0	0.11

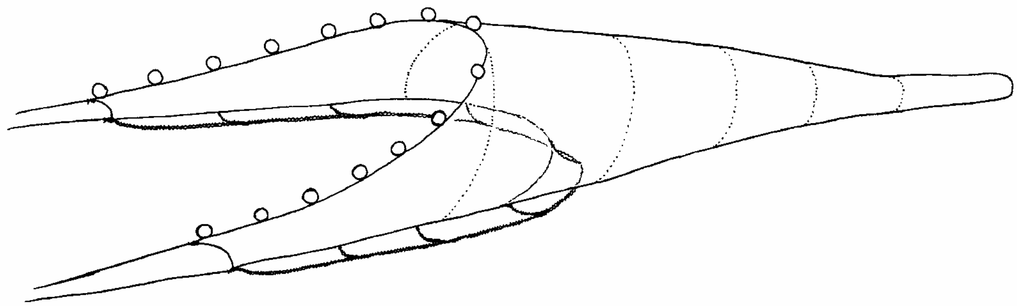
Treatment	EXT 0.3*							
Net Measurement	Date	Tow No.	Tow Time (Hrs)	No. Observations	Mean	Max	Min	CI
Doorspread	10/9/02	2	2.08	304	38.4	38.5	38.4	0.05
Wingspread				443	10.8	10.9	10.8	0.01
Headrope - Seafloor				233	2.8	2.8	2.8	0.02
Headrope - Footrope				37	2.3	2.3	2.3	0.01
Footrope - Seafloor				26	0.44	3.3	0.0	0.32

Treatment	SWRFT							
Net Measurement	Date	Tow No.	Tow Time (Hrs)	No. Observations	Mean	Max	Min	CI
Doorspread	10/10/02	3	1.0	188	41.7	41.9	41.5	0.20
Wingspread				224	11.2	11.3	11.2	0.02
Headrope - Seafloor				155	4.3	4.3	4.3	0.02
Headrope - Footrope				109	2.5	2.5	2.5	0.01
Footrope - Seafloor				101	2.07	6.5	0.2	0.22

Treatment	EXT 0.5							
Net Measurement	Date	Tow No.	Tow Time (Hrs)	No. Observations	Mean	Max	Min	CI
Doorspread	10/10/02	4	0.83	131	43.9	44.2	43.7	0.20
Wingspread				206	9.7	11	10.9	0.02
Headrope - Seafloor				146	5.2	5.2	5.1	0.02
Headrope - Footrope				121	2.5	3.0	2.9	0.01
Footrope - Seafloor				112	2.58	6.3	0.2	0.21

Treatment	EXT 0.6							
Net Measurement	Date	Tow No.	Tow Time (Hrs)	No. Observations	Mean	Max	Min	CI
Doorspread	10/10/02	5	0.67	137	40.5	40.7	40.3	0.20
Wingspread				212	9.8	9.8	9.7	0.03
Headrope - Seafloor				138	5.6	5.7	5.6	0.03
Headrope - Footrope				123	3.1	3.2	3.1	0.01
Footrope - Seafloor				114	2.63	5.1	0.0	0.21

A. Standard Raised Footrope Trawl (RFT)



B. Sweepless Raised Footrope Trawl (SRFT)

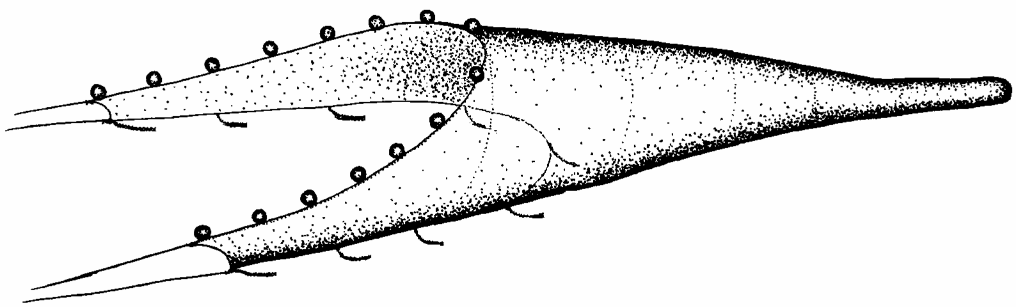


Figure 1: Drawings of the standard raised footrope trawl (A), and sweepless raised footrope trawl (B).

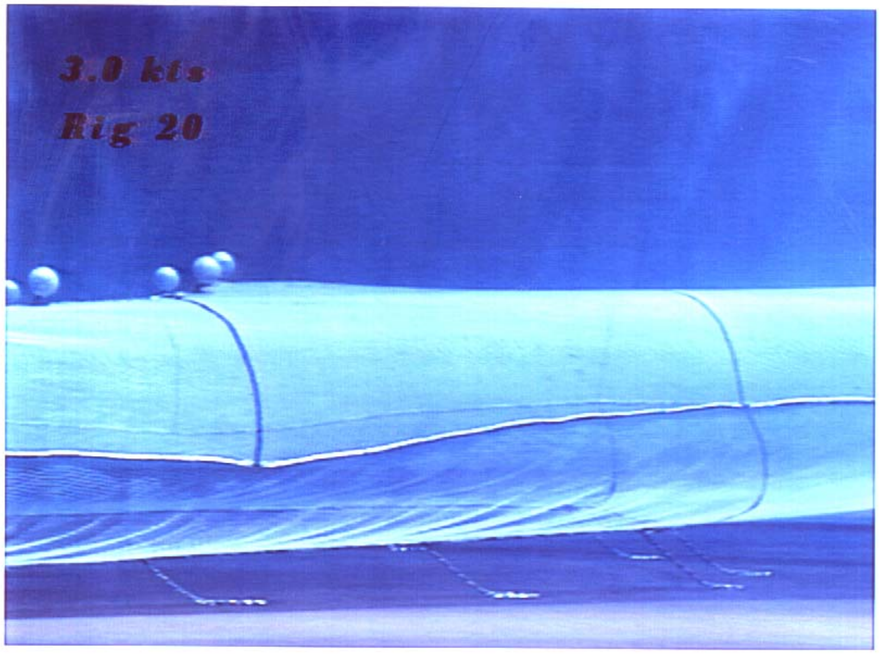


Figure 2: Flume tank model of the sweepless RFT undergoing a towing simulation (3 knots).

Figure 3: Extension piece added during at sea modification of the sweepless RFT to raise the footrope off the seafloor.

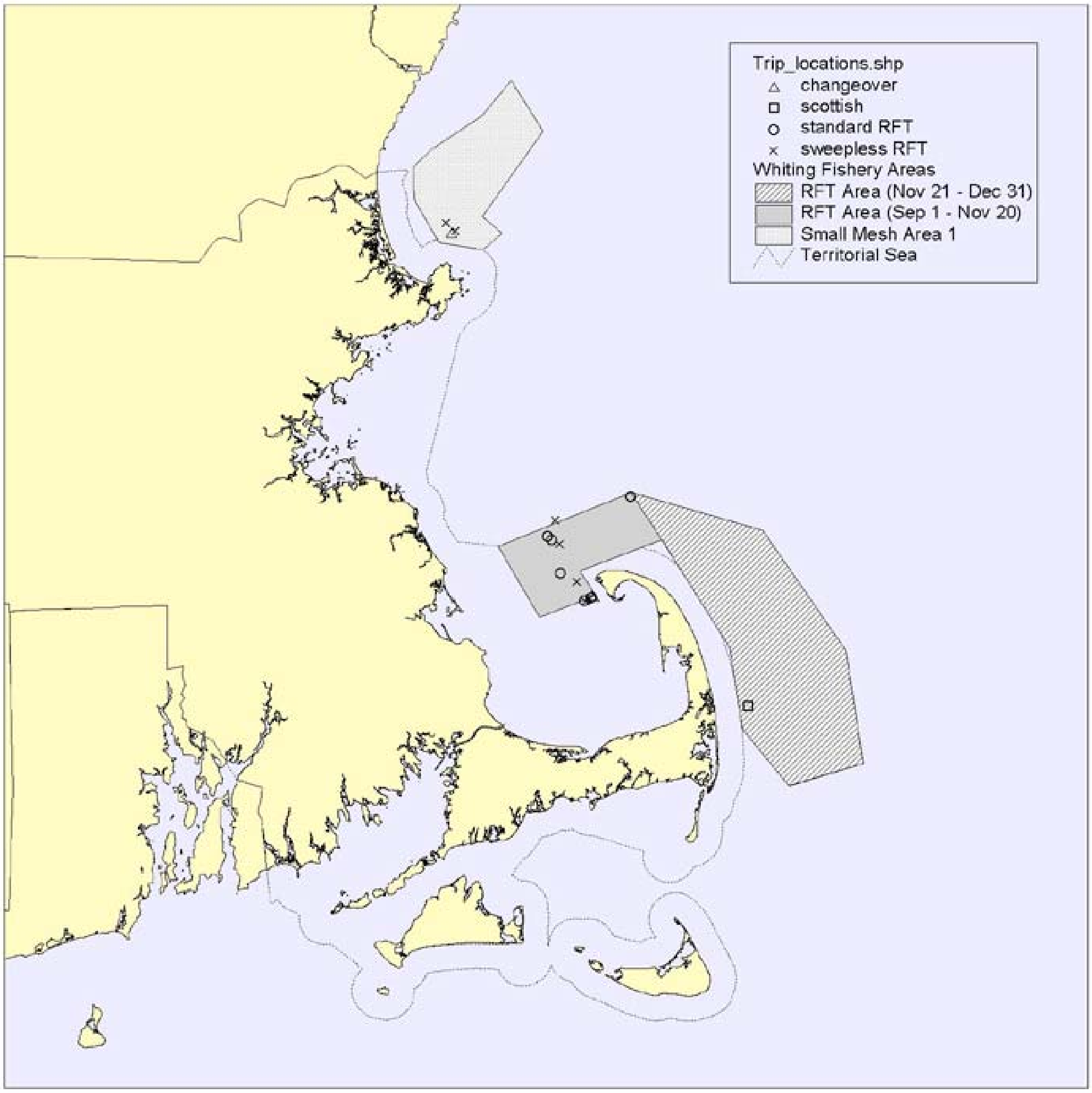


Figure 4: Locations of sea-sampling trips by small-mesh area (SMA).

.

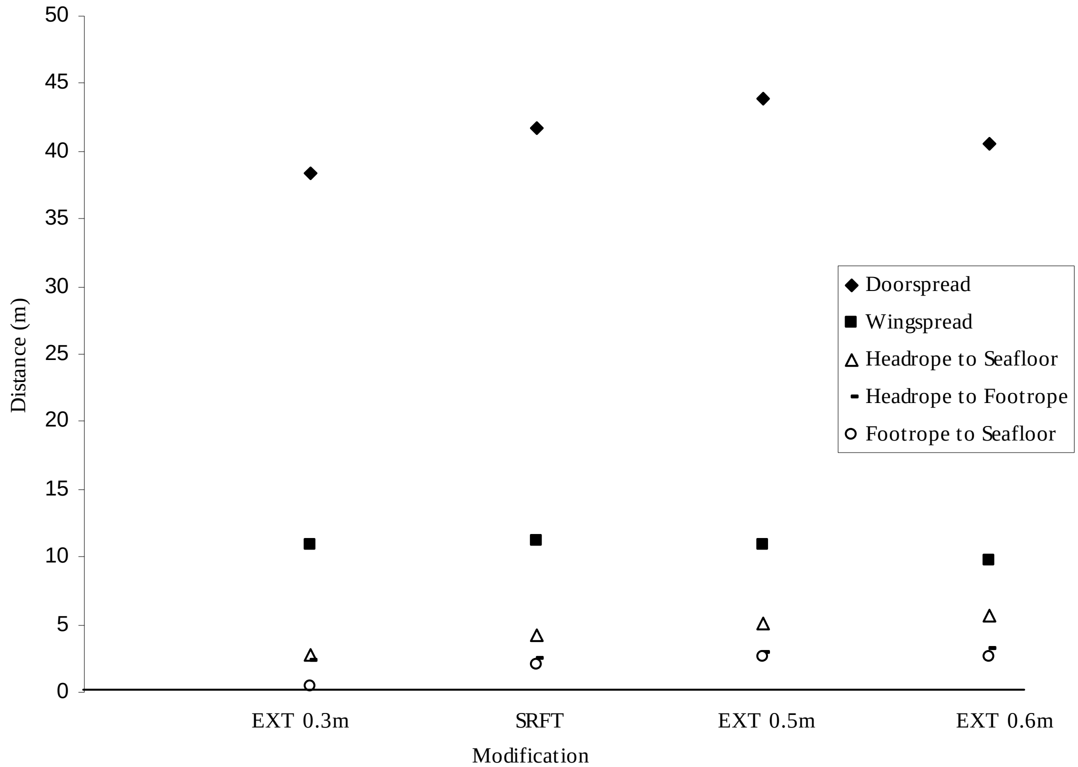


Figure 5: Net mensuration data (mean and standard error) generated from the Netmind system during filming trips (10/9/02 – 10/10/02) on the F/V Blue Skies. Net dimensions recorded in meters.

Appendix A: Comparing the Performance of the Sweepless Raised Footrope Trawl to the Raised Footrope Trawl and the 5% Bycatch Standard

John Sheppard
Massachusetts Division of Marine Fisheries
30 Emerson Ave
Gloucester MA 01930

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract
Quantitative analysis of sea sampling results verified low overall bycatch results (less than the 5% Federal bycatch standard) for both gear types (2.3% RFT; 4.3% SRFT). Results indicated that the SRFT performed similar to the RFT in terms of target catch rates, bycatch percentage and retention size of whiting catches. While these data were not part of a rigorous gear comparison, and are non-random, they suggest that the SRFT, when fished properly, can maintain efficient whiting catch rates and low bycatch rates, while decreasing interaction with other gear and the sea floor, and simplifying rigging and enforcement. Further, although some sample sizes were small, the low bycatch levels of both net types in this fishery indicate whiting fishing can continue with these net designs without major impact on most recovering species.

Introduction
High variability in whiting catches makes direct catch comparisons of the raised footrope trawl (RFT) and the sweepless RFT (SRFT) difficult. The comparison of target catch levels is critical to fishermen; the comparison of the bycatch level, especially in relation to the 5% bycatch standard, is critical to managers. Indirect measures, including comparisons of fishermen's logs from vessels using the RFT to those using the SRFT, have been used previously and indicate a rough similarity in whiting catch and bycatch between designs (Pol 2000).

Monitoring activities supported by the present study produced sea sampling data from different vessels using the RFT and SRFT that included catch composition and effort. Catch data were separated only by whether an RFT or a sweepless RFT were used. This method of analysis ignores multiple significant known sources of variability: codend mesh size; net type and design; vessel; fishing depth. Additionally, tow-to-tow catches of whiting are highly variable even when other sources of variation are controlled. While the results of this type of analysis must be interpreted cautiously, it was felt that the opportunity to look at this aspect of the nets' performance should be addressed.

Methods
A total of seventeen sampling trips (excluding the Scottish seine trip) (Table 3) were conducted by DMF (N = 14) and NMFS (N = 3) personnel from September 13 – November 4, 2002 for all gear types and areas fished. Vessels were selected opportunistically by sea samplers. Nets varied in design from vessel to vessel, except that all nets used an RFT or SRFT. All catch and gear information were recorded using NMFS sea sampling logs and subsequently entered into the NMFS Observer Database (OBDBS).

Catch and gear information on trips sampled by NMFS observers were accessed from the OBDBS by DMF staff. Landings and discard data for all species were summarized for gear types (RFT and SRFT), for changeover trips, and for all areas combined (see main text). Effort between vessels was standardized using catch-per-unit-effort (CPUE) scores for all species landed and discarded (by tow and by trip). CPUE was generated by dividing the total catch by total towing hours to allow comparisons among tows of different lengths. Bycatch percentages (by trip) for all regulated species were calculated as the sum of all regulated species caught divided by the summed weight of all species combined. Mean percentage of regulated species caught per trip were generated for both gear types. Length frequencies were expanded to the total catch of each trip.

Catch information was collected during the changeover trips to monitor catch levels of target species and non-target species. Catches were examined for each configuration to observe changes in species composition and catch levels in the presence and absence of the sweep (when the trawl was converted from a standard RFT to a sweepless RFT). Catch data was also recorded by headrope adjustment (when extensions were added) to observe the effects of headrope and footrope height on trawl performance and the resulting catch.

Results and Discussion

Whiting CPUE using the RFT and the SRFT did not appear to be significantly different between gear types, although mean catch rates appeared twice as great with the RFT and variability was high (Figure A.1). Red hake CPUE, the second major landed species for the fishery, was also not significantly different between gear types, although again the mean rate with the RFT appeared twice as great. Results for both species seem to suggest that the highest catch rates only occurred using the RFT, indicating performance differences between nets (see also Table A.2 and Table A.3, respectively). However, as noted earlier, the sampling of vessels was non-random, and therefore other sources of variation may explain any similarities or dissimilarities in catches. For example, nets were categorized only by footrope type, and not by any other net characteristic. It may be that the vessels sampled using RFTs were using larger nets or smaller codends. The high variability observed in catches may also reflect vessel and net effects: the sweepless RFT is used on only a limited number of vessels. This limitation may have resulted in less variation in the sweepless RFT catch data compared to the RFT data which were collected on larger range of vessels.

Mean bycatch percentages were below the federal standard (5% regulated species bycatch per trip) for both gear types (Figure A.2), although it appeared the SRFT had a significantly higher bycatch level. Overall, a level of 5% was exceeded in three of the five trips; however, noticeable causes were observed in two of these trips (Table A.4). Gear was out of compliance for one trip (9/13/02), and this problem was determined after the trip was completed. Improper dimensions of the lower leg cables created direct contact between the footrope and the seafloor as evidenced by underwater video taken during these trips. The vessel captain was notified of this situation.

In another trip (9/26/02), the second tow reported elevated catches of flatfish and skates (Table A.3). This high level may be due to towing against a strong tide, which resulted in a lower reported towing speed (2.4 knots); lower towing speeds result in higher headrope heights and lower footrope heights. Subsequent tows during this trip were done at a higher towing speed (2.9 knots), and had lower catches of flatfish. It is suspected that there was increased contact between the footrope and the seafloor during the second tow. This result suggests that towing speed is an important factor influencing the performance of the SRFT (with respect to footrope height), under varying current speed and direction. As discussed in the main text, additional net mensuration under different speeds would illuminate speed’s impact on net geometry.

Another sweepless RFT trip (11/4/02) was prosecuted along the southwest edge of Stellwagen Bank and cod were present (Table A.3). The proximity of this area to the Bank (a prime seasonal habitat for cod) has been problematic for trawlers in the past, and action has been taken to direct fishing outside of this area when cod are present in the area in previous years. Cod present a special concern with the exempted fishery. Cod stocks were low during historic testing, and have increased in average size over recent years, but fishing mortality for cod must still be kept at low levels.

Certain individual performance differences in terms of bycatch rates may be attributable to rare events, but they are nevertheless part of the actual selectivity level and both the events and the resulting bycatch should be considered in the management of the fishery. Because, however, both nets performed below the 5% bycatch level established by fisheries managers, the small difference between nets may not be a cause for concern.

Tow-by-tow catch results for changeover trips, separated by each configuration, are shown in Table A.5. As discussed in the main text, these modifications had unpredicted effects on net geometry and catch in some tows. Clearly, one result from this study is that removing the sweep chain is not enough to produce an effective SRFT. Some adjustments, such as increased floatation, may be necessary. Tows where the vessel was using the SRFT for the first time on changeover trips should be interpreted recognizing that some small adjustments to nets may be necessary to decrease bycatch.

Length frequencies constructed from whiting catches also show some differences between net designs, although the differences were small (Figure A.3). Mean size (cm TL) of whiting caught using the standard RFT (26 ± 0.03 (10.2 ± 0.01 in), N = 91,916) was lower than catches using the SRFT (28 ± 0.07 (11.0 ± 0.03 in), N = 20,216). Length frequencies of regulated species were constructed for plaice (Figure A.4), winter flounder (Figure A.5) and yellowtail flounder (Figure A.6); all other species were collected in numbers too small for any comparative analyses between gear types. Visual analysis of length frequency histograms suggest that mean size for plaice in the sweepless RFT (29 ± 0.6 cm (11.4 ± 0.24 in), N = 412) were larger than catches using the standard RFT (27 ± 0.5 cm (10.6 ± 0.02 in), N = 727). Mean size for yellowtail flounder (32 ± 1.0 cm (12.6 ± 0.4 in)) were similar for both the RFT (N = 58) and SRFT (N = 139). In addition, mean size of winter flounder (30 ± 1.0 cm (11.8 ± 0.4 in)) were similar for both standard (N = 212) and sweepless (N = 370) trawl designs.

The differences in sizes as shown by the length frequencies show no simple pattern. The sweepless RFT caught whiting that were slightly larger, in general, although the mean size difference was only 2 cm (about 0.75 in). This size difference that may not matter to fishermen, since there are no regulatory or market size restrictions. The difference in plaice size, and in whiting size, may be a result of footrope height. Some have suggested that schools of whiting can be structured by fish size, and that different flatfish have slight differences in behavior in front of nets. The relationship between footrope height and size or species selectivity needs further examination and clarification.

Conclusion

By comparing the amount of target species landed, bycatch percentage, and fish sizes, the results of the net comparisons provided a small amount of evidence that the sweepless and standard RFT gear types perform similarly. Differences observed between nets may be more attributable to boat-to-boat differences such as mesh size and fishing technique or tow-to-tow variation caused by patchy fish distributions.

It must be emphasized that these results are only preliminary observations in which no definitive conclusions concerning which gear design is better can be made at this time. It is recommended that a future study with a robust sampling design (incorporating differences in net characteristics and vessel capabilities) be conducted to test the performance of these gear designs and therefore provide a more comprehensive measure of fleet selectivity in this fishery.