# Suggested Design Modifications to the URI 340 Series Trawl Following Tank Testing

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Fisheries and Marine Technology
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University of Rhode Island
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## Acknowledgments

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## Abstract

The performance of six model bottom trawls was evaluated in the White Fish Authority Flume Tank in Hull, England. Five of the models incorporated modifications to the URI 340 trawl design, and the sixth was constructed to the standard design. The objective of the study was to assess the effectiveness of the various modifications in correcting the flattening and resulting chafing of lower wings reported with the standard design. The tests demonstrated that hanging the lower wings more tightly to the sweep resulted in a highly favorable net configuration. Instead of the standard 20 percent greater length of hanging line than sweep, a differential of roughly 6 percent resulted in uplifting of the lower wings, and elimination of distortion in the gore.

Contents



# 1. Introduction

## 1.1 URI 340 Trawl Design

The original design of the URI 340 Bottom Trawl was developed in 1972 under a contract from the National Marine Fisheries Service. The objective of the design was to modify the Yankee 41 net to provide greater headline height without using a three-bridle rig or other major deviation from the standard equipment.

The changes included deepening the square by 10 meshes and decreasing its forward end width by 20 meshes. The lower wings were widened to 60 meshes and cut along straight bars to provide the same width at both ends. The corresponding wings of the 41 were narrower, tapered, and slightly longer. The top wings of the 340 were 15 meshes shorter than those of the 41, and were considerably less tapered, reducing from 75 to 60 meshes along their length versus 75 to 10 meshes in the 41. Considerable portions of the hung length of the 340 wings consisted of straight bar jibs which formed V-shaped wing ends to enhance vertical separation of the legs.

The full-scale URI 340 net plan is presented in Figure 1. The plan assumes a standard mesh size of 5 inches, although other mesh sizes may be used while retaining the same design dimensions by varying the number of meshes accordingly. The various tapers specified in the plan should remain the same regardless of mesh size chosen.

The plan specified a 2:1 hanging ratio for the lower belly and the square. The wings are to be hung at a 1:1 ratio.

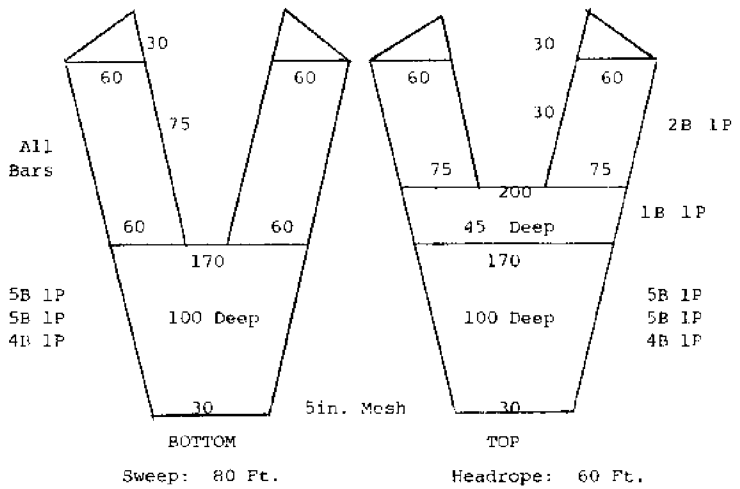



FIGURE 1. URI 340 BOTTOM TRAWL

The URI 340 net is designed to permit slacking the headline 5 feet on each end while maintaining sufficient overhang to catch "off bottom fish." However, when used as a combination net, a piece of chain should be fastened to the end of each wing.

The number of floats is unspecified, as requirements will vary according to the type of bottom, type of sweep, size and power of boat, species sought, etc.

The net was designed to be used with legs between the net and the doors. A minimum length of 10 fathom legs is recommended to allow the net to open on the wing ends giving a greater headline height.

Since the net was designed for hard bottom, the footrope length was specified to exceed the sweeprope length by 20 percent. The resulting slack twine in the bottom of the net mouth was intended to minimize net damage due to stresses



imposed by hangs on rough bottom.

1.2 Performance of the URI 340 Bottom Trawl

The URI 340 design was originally evaluated during fish-sampling trials carried out jointly by the United States and the USSR off the New England coast. Catch rates during these trials showed the 340 net to be considerably more effective than the corresponding Yankee nets, particularly in catching higher-swimming species. The 340 net also tended bottom well, maintaining effective catches of fish like flounder.

Despite these performance indications some users of the net reported excessive chafing of the lower wings and signs of overstressed twine in the square. Model experiments in the University of Florida's hydraulic flume confirmed these problems and demonstrated that the lower wings tended to the horizontal toward the lower belly end as a result of uneven stress distribution in the twine.

The objective of this study is to investigate design modifications directed towards the correction of the lower wing chafing problem.

The following section discusses net model testing and its application in this study.

## 2. Methodology: Modelling and Testing of Trawls

### 2.1 Trawl Modelling

The most desirable and conclusive method of trawl performance and behavior evaluation is observation of full-scale nets in an actual fishing environment. This method allows evaluation of the total trawl system in response to its interaction with the seabed. Observation of the otterboards in action together with their effect upon the towing cables and groundcables permits a thorough understanding of the resultant shape of the trawl mouth.

While this method has been used in various trawl performance studies, the major disadvantage of the technique is the considerable expense involved. In addition to the boat expenses there are the costs for divers, instruments, and full-scale trawls. These expenses are often prohibitive, particularly in studies of this nature where as many as six modifications of the basic trawl design are to be evaluated.

Simulation of the trawl system utilizing scale models under controlled conditions in a testing tank allows extended observation of gear behavior and general design characteristics under a variety of conditions for far less time and money. The value of this simulation technique depends to a great extent upon the authenticity of the scale model of the trawl system and the degree of accuracy to which its fishing environment may be duplicated. Building a truly representative simulation is an extremly difficult, if not impossible, task which requires minute attention to modelling laws.

The scale factor is defined as the quantity in the full-scale trawl, divided by the corresponding quantity in the model. Reductions to linear dimensions are made throughout the model by the amount of the basic scale factor. Components concerning drag, resistance, and lift, which are dependent



upon surface area, decrease by the square of the basic scale, while weight and buoyancy forces that rely on volume for their value are reduced by the cube of the basic scale.

When the flow of water through and around a trawl and its model is considered, the predominant forces are due to inertia, gravity, and the viscosity of the water (1). If the model is not too small, it may be assumed that the viscous forces have a relatively minor influence. This assumption applies only when a scale factor of less than about 12 is adopted. This requirement necessitates the use of relatively large models.

A basic model scale of 10 was employed in this study. Since the standard mesh size specified in the full-scale trawl is 5", a scale reduction of 10 in the model is achieved with the use of 1" mesh coupled with halving all mesh counts in the length and breadth of all sections in the standard full-scale design. The twine diameter must be carefully selected so that the overall hydrodynamic drag forces acting on any section of the full-scale trawl and the corresponding section of the model are related by the correct force scale. Calculations based upon the modelling laws indicated a twine diameter which is most closely approximated by #3 thread.

A more detailed treatment of modelling laws and their application to trawl design is presented in (2).

It should be emphasized that the major contribution of the tank testing of model trawls is primarily in the qualitative evaluation of general design and rigging. The value of the more rigorous quantitative analysis of tank testing results is limited by the difficulties in duplicating seabed interaction and in constructing truly representative model trawls.

## 2.2 Flume Tank Testing of Model Trawls

Since a scale factor of 10 was used in this study, the resulting large size of the models restricted testing to the few flume tank facilities in the world offering sufficient working dimensions. The tests were conducted in the British White Fish Authority Flume Tank in Hull, England, which is the largest facility expressly constructed for the testing of model nets.

The tank consists of a large reinforced concrete chamber, 31 m. long by 5 m. wide and 5 m. deep. It is divided horizontally into upper and lower sections which are joined at one end by four 93 KW pump units and at the other end by cascade and deflector devices. Net testing is conducted in the center portion of the upper tank which gives a working volume 11 m. long by 5 m. wide and 2.5 m. deep.

The tank provides water flow speeds of 0 to 1.0 m./sec. which simulates a velocity range of 0 to 6.14 knots at the model scale of 10 utilized for these tests.

Observations of the models in the tank are made through large windows in one side of the tank and from a motorized trolley which runs on rails above the tank (3). Accurate measurements of net dimensions in reaction to flow variation and other adjustments can be made against a matrix of calibrated lines on the bottom and back of the tank.

Measurements recorded in this study included the Warp Tension, Door Spread, Wing Spread, and Headline Height. The latter two measurements were recorded as distance ranges, since these features tended to oscillate in the flume tank flow. Of equal importance is observation of the general shape and configuration of the various modified trawl models. The large tank windows permitted photographing each model to gain a clear and detailed



visual record.

The net models were secured in the flume tank at each end of the headline and sweep rope by upper and lower legs of one fathom in length corresponding to the minimum 10 fathom legs specified for the full-scale trawl.

The legs in turn were secured to V-type doors which were scaled down from standard full-scale 7' 6" doors. The towing warps extended from rods which were positioned to maximize door spread within the 15-foot-tank width.

The models were hung and rigged as specified for the full-scale trawl. The one exception is found in Model #6 which exhibits less than the standard 20% greater length of footrope versus sweeprope.

Each model was fitted with a combination cookie/chain sweep. The number of floats was also held constant over all models with the exception of several tank tests of Model #6.

Simulated waterflow speeds of 3 and 3½ knots were selected for testing of each net, since these speeds represent realistic full-scale commercial conditions.

The following section presents a description of the various net models and the design modifications they incorporate. Also presented are the measured results of the tank tests together with the photographic observations of net configuration when subjected to tank flow conditions.

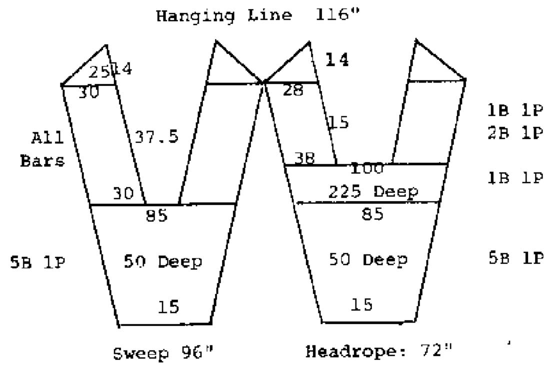
## 3. Trawl Modifications and Performance

### 3.1 Model Net 1

Description. The No. 1 trawl represents a scaled-down replica of the standard URI 340 design without modification. The number of meshes in the depth and breadth of each model net section has been reduced by half relative to the full-scale design in order to achieve a workable size while maintaining dynamic similarity in shape. One-inch mesh of #3 thread was used in the construction of all model nets.
This model represents the control or standard condition by which the performance of the modified nets may be evaluated.

Performance

| | |
|---|---|
| Wing Spread: | 30'/33' |
| Door Spread: | 112' |
| Headline Height: | 9.8'/7.6' |
| Warp Tension: | 3.25 |




Observations. As illustrated in Plate 1, slack, bagged twine is present in the lower wings, particularly at the wide ends. The wings tend to lie flat adjacent to the footrope along most of their length instead of lifting upwards in a smooth curve to the gore. Strain in the gore is uneven along its length as indicated by the slackness and distortion in the top belly and aft end of the square.
Uneven strain is also apparent in the upper wings and jibs, where the meshes along the headrope are stretched considerably more than in adjacent areas.



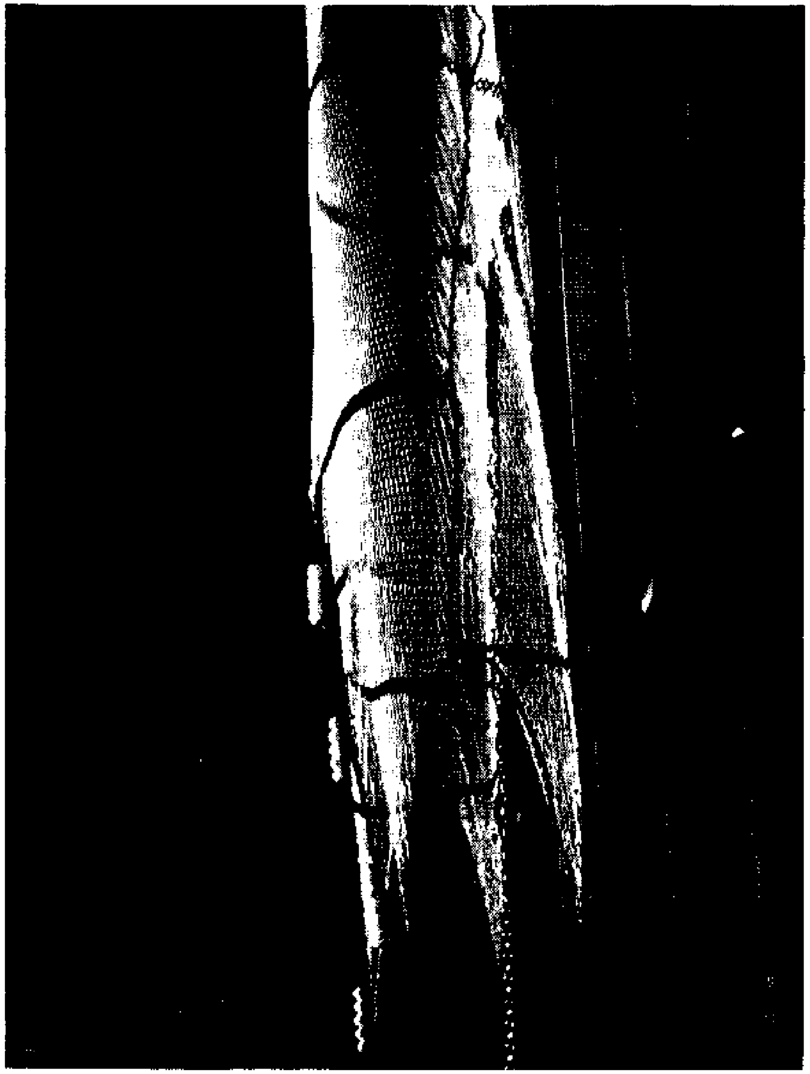


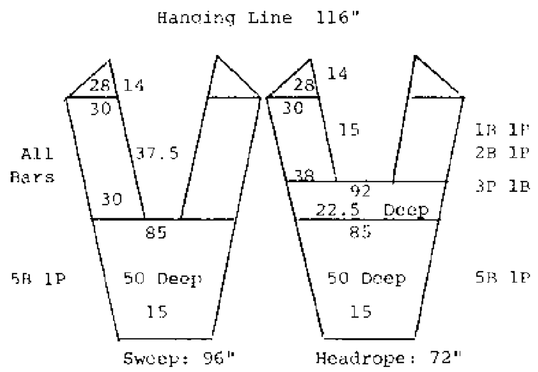
Plate 1. Model Net 1.

## 3.2 Model Net 2

Description. The No. 2 model net is identical to the No. 1 standard net in all respects except in the size and shape of the square. The modification involves narrowing the wide end of the square to 92 meshes from the 100 meshes of the original. This change results in a much more gradual taper in this section of the net, as the narrow end of the square is only 7 meshes less than the wide end. The hypothesis tested in this modification is that reduction in the net cross section at the wide end of the square should pull the lower wings up and in.

### Performance

| | |
|---|---|
| Wing Spread: | 31'/34' |
| Door Spread: | 107' |
| Headline Height: | 10.8'/8.5' |
| Warp Tension: | 3.20 |




Observations. Model No. 2 exhibited most of the same deficiencies evident in No. 1. Noticeable differences involve a tendency of the forward No. 2 lower wing to lift off the bottom. Slack twine is nevertheless present through the length of the wing, and the aft section lays flat adjacent to the footrope. Longitudinal strain is perhaps more uneven than in the original, as the gore line is more severely distorted. Most of the strain appears to be present in the top panels, while the bottom panels remain slack. Mesh tension in the top wings appears more evenly distributed than in the No. 1 net.



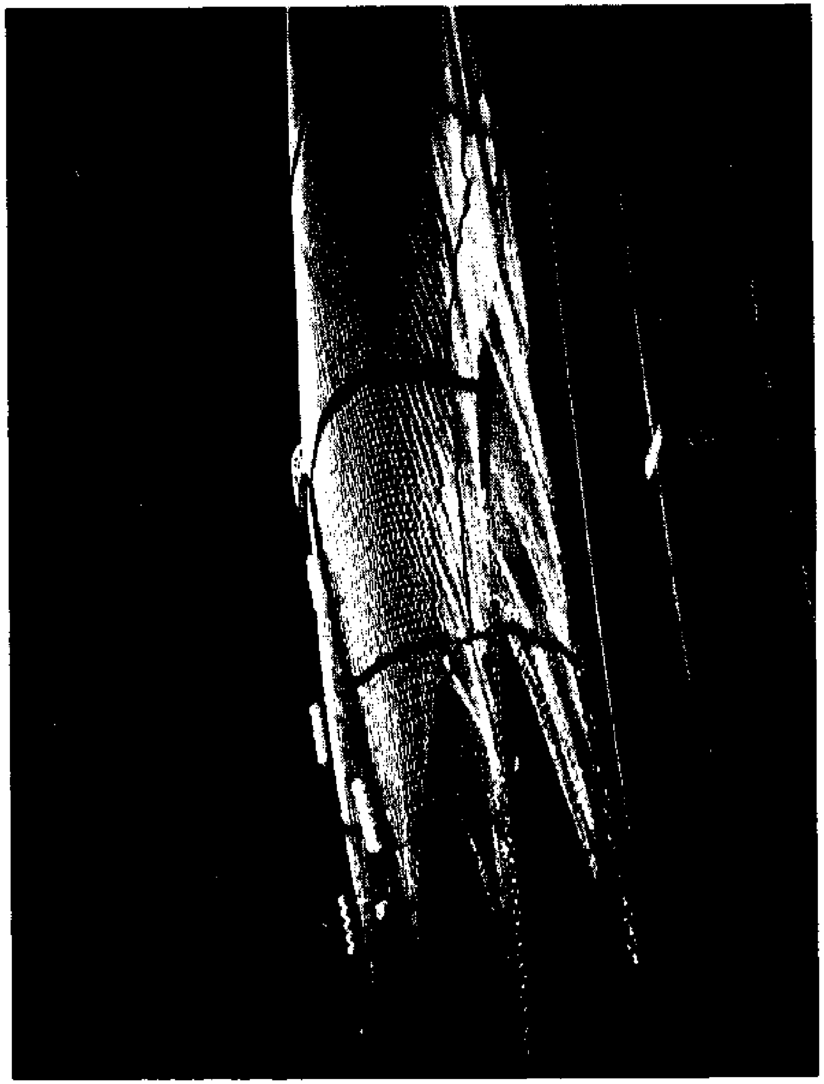


Plate 2. Model Net 2.

## 3.3 Model Net 3

Description. The No. 3 model net also differs from the standard No. 1 net only in the size and shape of the square. In this case, the square has no taper, since both the forward and aft ends of the section have 85 meshes. This change represents a narrowing of the forward end of the wing by 15 meshes from the 100 meshes of the No. 1 net. While following the same hypothesis as tested in the No. 2 net, the rectangular square of this model provides a further reduction in area at the cross section through the forward end of the square.

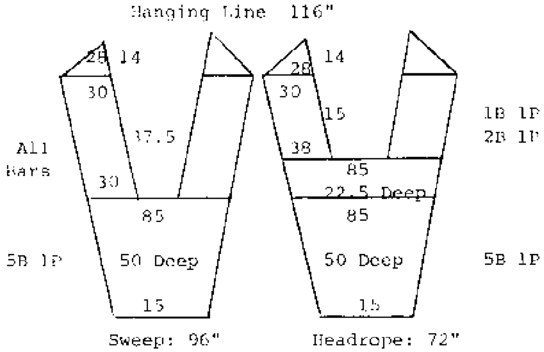
Performance

Wing Spread: 24'/34'

Door Spread: 113'

Headline Height: 9.2'/7.6'

Warp Tension: 3.20




Observations. Model No. 3 behaved quite similarly to No. 2 with some lifting at the forward end of the lower wings despite flattening in aft sections (Plate 3). Gore line distortion is present, although to a slightly lesser extent than in Model No. 2. Mesh tension in the top wings of No. 3 appears somewhat less even than that of No. 2, which may be attributable to differences in hanging alone.



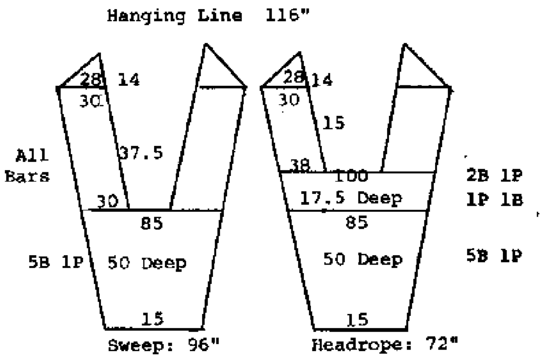
Plate 3. Model Net 3.

## 3.4 Model Net 4

Description. The No. 4 model net differs from the standard No. 1 net only in the depth of the square, which was reduced from 22.5 meshes to 17.5 meshes. This 5-mesh reduction at the model scale corresponds to a 10-mesh reduction at full scale, since all mesh counts are halved in the former.
Reducing the depth of the square in this modification requires a less gradual taper than in the No. 1 net, since the 15-mesh reduction from the wide to the narrow end occurs over a lesser depth. This modification moves the floats and their buoyant force aft, thus providing more uplift at the wide end of the lower wings.

Performance

| | |
|---|---|
| Wing Spread: | 31'/34' |
| Door Spread: | 112' |
| Headline Height: | 9.5'/7.9' |
| Warp Tension: | 3.20 |




Observations. Model No. 4 also failed to demonstrate uniform lifting along the entire length of the lower wings although the forward section did rise somewhat better than the previous models.
The significant difference or improvement evident in this design is the elimination of virtually all of the gore line distortion. Mesh tension in the top panels also appears fairly even except along the top jib adjacent to the up and down line which was apparently too long.



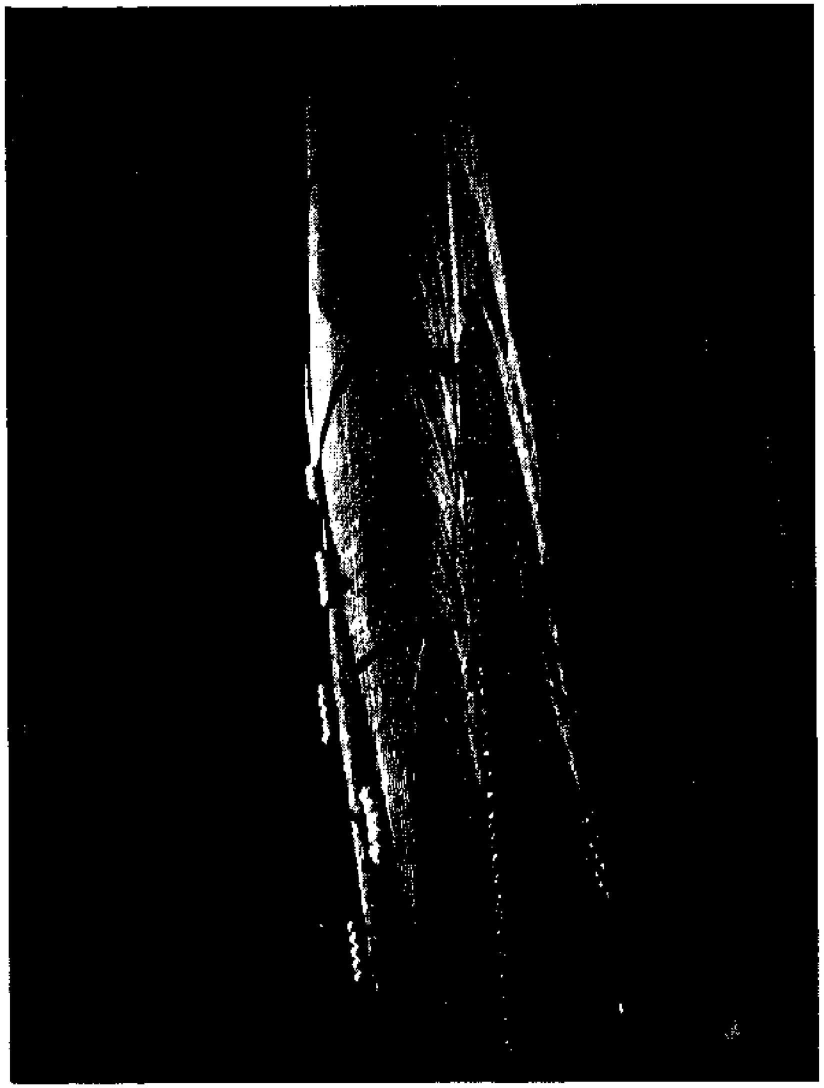


Plate 4. Model Net 4.

### 3.5 Model Net 5

Description. The No. 5 model net differs from the standard design in the lesser width of the lower wings. Both ends of the lower wings in this modification have been reduced to 20 meshes from the 30 meshes of the original. Although the wing lengths are unchanged, the proportion of dog ears in the wing versus the jib increases in this modification. The principle underlying this design change involves enhancing lower wing lift by reducing the amount of twine to be lifted.

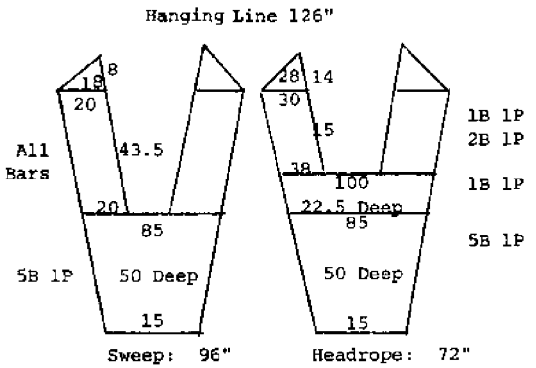
Performance

Wing Spread: 33'/35'

Door Spread: 112'

Headline Height: 10.2'/8.5'

Warp Tension: 3.35




Observations. Model No. 5 exhibited lifting in the forward section of the lower wings, yet bagging and flattening persisted in the aft sections. The most notable performance feature of this design was the tendency of sweep to lift off the bottom, particularly at the wing ends.
The narrowing of the lower wings necessarily placed the gore line at a lower level.
Distortion in the gore line, although present, was not pronounced forward of the bellies.



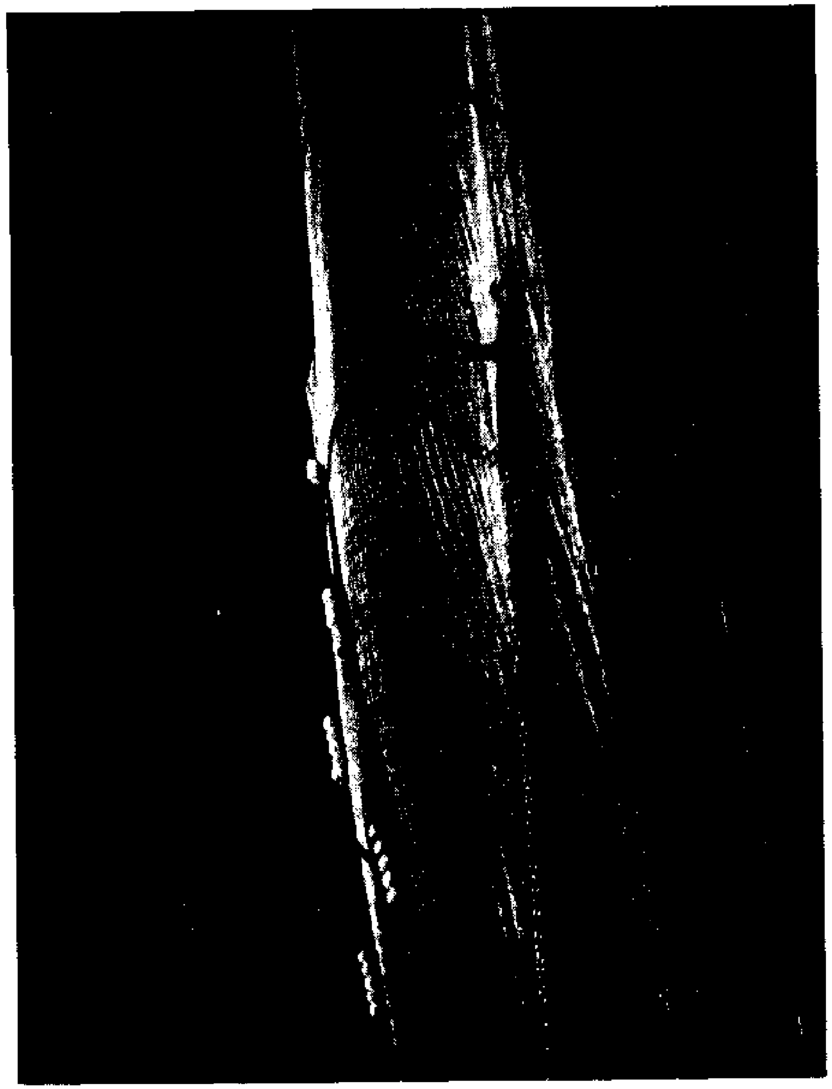


Plate 5. Model Net 5.

## 3.6 Model Net 6

Description. The No. 6 model net was constructed to the same specifications as the No. 4 net, which appeared to have the best general design features of the models tested. The net had a square depth of 17.5 meshes versus the 22.5 of the standard design. The particular modification in No. 6 involves rehanging the lower wings to a sweep 1 foot longer than that of the standard model, representing a 10-foot increment at full scale. This change results in a 6 percent greater length of hanging line versus sweep instead of this 20-percent slack in the original. Since the wing dimension is unchanged, the meshes are stretched longitudinally to conform to the greater hanging length. Ten additional floats were attached to the headrope of this model to compensate for lowered headline height found in the initial testing of this model.

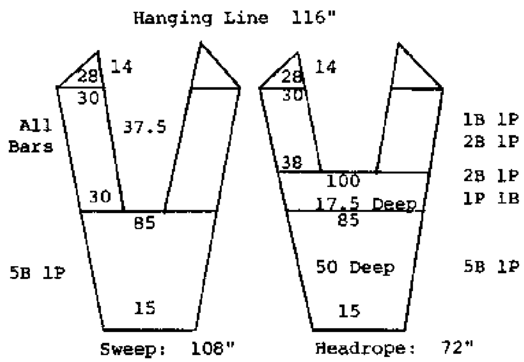
Performance

Wing Spread:

Door Spread:

Headline Height:

Warp Tension:




Observations. As illustrated in Plate 6, nearly all deficiencies of the other models are eliminated by the No. 6 modifications. Stress in the upper and lower panels is evenly distributed, resulting in a taut goreline that is well lifted and undistorted.

The lower wings responded to the improved stress distribution by lifting well clear of the bottom throughout their length. The wing ends retained some slack, which most probably could be eliminated by shortening the up and down lines to slightly less than the straight bar length on the jibs.



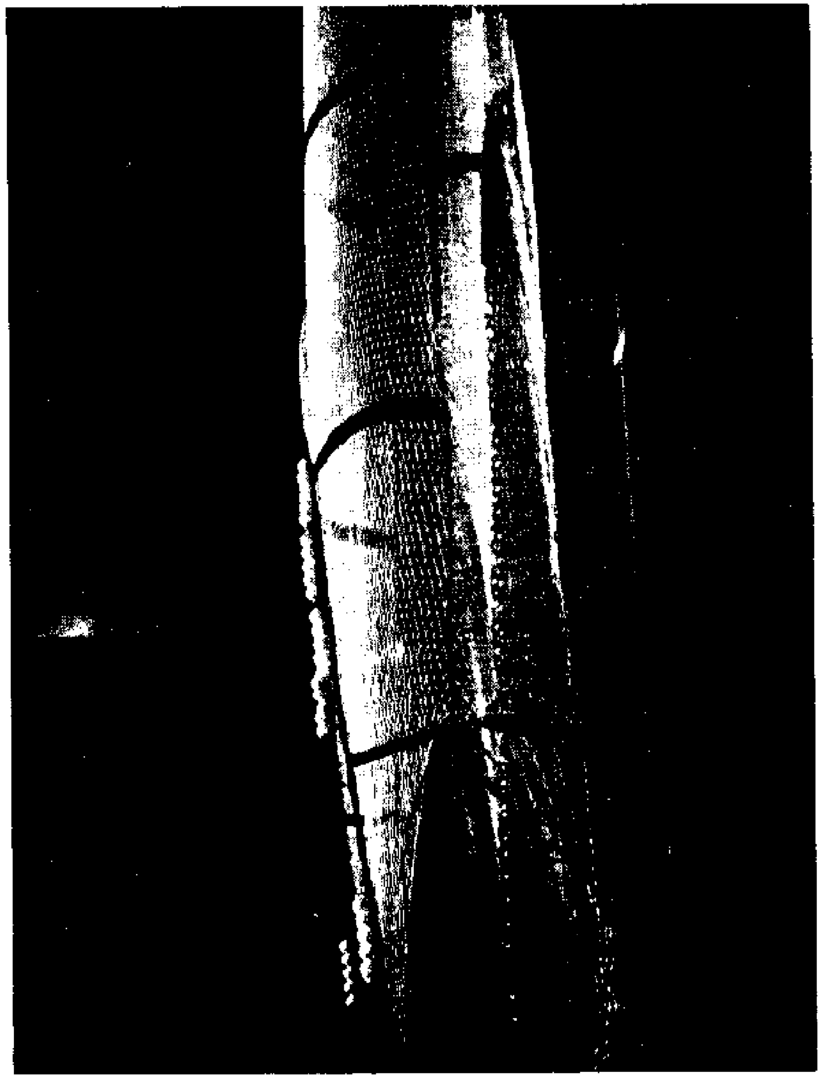


Plate 6. Model Net 6.

## 4. Conclusions and Recommendations

### 4.1 Summary of Model Test Results

As indicated in the previous section (3.6), rehanging the lower wings to an extended sweep demonstrated marked improvement in net configuration. While the standard design specifies a 20-percent greater length of hanging line than sweep, the No. 6 design utilized only a 7-percent differential. The apparent result was a significant reduction in slack twine in the lower wings, as the same number of meshes were hung in a greater length of sweep. The primary advantage of slack twine in the wings is greater strength to resist stresses imposed by hangs. Recommendations concerning modifications of full-scale trawls may therefore be based in part on the nature of the seabed typically fished by the user.

### 4.2 General Modifications to the URI 340 Trawl

Other modifications may be recommended for all URI 340 trawls regardless of bottom conditions. One such change is the elimination of the jibs on the lower wings. Fish behavior research (4) has indicated that groundfish may be effectively herded by the mud cloud above a sweep, ground cable, etc., without the need for long wings consisting of solid twine panels.

Research has also indicated that some fish exhibit an avoidance or escape response when confronted with vertical lines in net sections. Removal of the lower jib will result in an up-and-down line configuration less vertical than the standard design.

Jib removal will reduce the twine area subject to tears, hangs, chafe, etc., and will also reduce twine drag in the water.



The remaining lower wing section, in the absence of jibs, may be rehung in a greater length of sweep than originally specified.

The following sections discuss revised hanging ratios based upon the likely stress placed upon the trawl by seabed conditions.

### 4.3 Modifications to URI 340 Trawls Used Primarily on Hard Bottom

The model tests demonstrated a favorable net configuration with 7 percent greater length of hanging line than sweep. Since slack in the hanging line and the attached lower wings lends strength to the trawl, a slightly greater slack percentage than used in Model No. 6 may be advisable for stress areas of full-scale trawls used on hard bottom. A 10-percent slack may be provided for the aft half of the lower wings (quarters to mid-length) with no slack in the forward half of the wings. This modification represents a compromise in hanging to maintain an acceptable net configuration while allowing slack to strengthen the quarters.

These revised hanging specifications translate to a required hanging line length of 76 feet, which is to be hung in roughly 73 feet of the total sweep length of 80 feet. Thus, 3.5 feet of sweep extends beyond the wing ends on both sides. The hanging line should be extended beyond the wing ends and secured to the sweep ends.

### 4.4 Modifications to the URI 340 Trawls Used Primarily on Soft Bottom

Since soft bottom conditions offer less potential for hangs and resulting stress on the trawl, most of the slack can be removed from the hanging line and lower wings to obtain a better general net configuration. Instead of

the original 20 percent greater length of hanging line than sweep, a uniform slack of 5 percent is recommended for the lower wings.
The corresponding hanging line length is also 76 feet, hung in 73 feet of the 80-foot sweep, leaving 3.5 feet of sweep extending beyond both wing ends. The hanging line may be secured to the sweep in the same fashion as specified in the previous section.

## Footnote to the Second Printing

After some commercial evaluation, the trawl was further modified by removing 15 meshes from the depth of the square and 15 dogs ears from the lower wing.

This improvement has meant the adoption of the trawl in the New England ground fishery.

Further testing and modification to the design is continuing along with other fishing gear design research, and the results will be the subject of another publication.



## References


1. Motte, G. A., "Evaluation of Fishing Trawl Performance," Doctoral Thesis, Nov. 1977.

2. Motte, G. A., and A. J. Hillier, "Development of Trawl Design by Observation of Scale Models in a Flume Tank," URI Marine Technical Report 47.

3. White Fish Authority, "Fisheries Training Center and Flume Tank Manual," 1976.

4. Foster, J. J. Fisheries Forum, Galilee, R.I., March 1979.