

**Flume Tank Tests on  
Three Trawl Models**

**(Model-Full Scale Correlation)**

MAFF Commission

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# SEA FISH INDUSTRY AUTHORITY

## Seafish Technology

Seafish Report No. 407  
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Project Codes IAA16 (MAFF), GT1 (Seafish)

J N Ward  
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### FLUME TANK TESTS ON THREE TRAWL MODELS (MODEL-FULL SCALE CORRELATION)

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#### 1. INTRODUCTION

This report describes Flume Tank trials carried out on three trawl models. The work was undertaken by the Gear Technology group of Seafish Technology under the MAFF R&D Commission 1991/92, Project Reference IAA16 (MAFF), GT1 (Seafish).

These trials form part of an ongoing project to correlate the performance of trawl models to their full scale counterparts.

The trawl system which is modelled has several components each of which may behave differently when scaled from full scale to model, using the usual scaling rules.

- (i) net
- (ii) ground gear
- (iii) bridles
- (iv) doors
- (v) warps

Even if some components behaved in a similar way from full scale to model, other components may not, affecting the equilibrium and hence geometry and drag of the whole model.

For the first phase of the project, carried out jointly with Marine Laboratory, Aberdeen, it was decided to carry out trials on a pelagic trawl. The pelagic trawl was used in order to eliminate the effects of ground contact and hence establish the correlation of the net on its own. The trawl used was of 200h.p. rating, designated PT163, tested at sea by Marine Laboratory and modelled by Seafish at 1:10 scale. The net was held in position in the Flume Tank using a special rig, as the full length of bridles would not fit in the Flume Tank. From this model work it was established that the drag of this 1:10 scale model was between 20% and 60% higher than the equivalent drag of the full scale net. The results for tests on this pelagic trawl are given in Reference 1.

A further sea trial was conducted on a second pelagic trawl of 600h.p. rating, reported in Reference 2. This trawl was modelled at 1:25 scale so that the full sweeps and doors could be placed in the Flume Tank.

Although it was felt that work on pelagic trawls would assist in answering the basic problem of modelling net drag, most models used in the Flume Tank are demersal trawls.

Two demersal trawls of contrasting shape were therefore purchased and a full sea trials programme carried out on each.

The first trawl was a 300h.p. balloon trawl design with large headline height and the second was a 150h.p. dual purpose design with low headline height. These sea trials are described in References 3 and 4.

The two demersal trawls were measured in every detail and models constructed using the usual scaling techniques.

This report describes the correlation trials on the second pelagic trawl and two demersal trawls.

## 2. MODELLING TECHNIQUE AND CALCULATIONS

The basis for modelling trawls is that described by Dickson in Reference 5.

For a panel of netting to be a true scale model, both the mesh size and twine diameter would have to be scaled down by the scale factor S. The number of meshes along and across each panel would be the same in the model as in the full scale.

In Appendix I a full list is given of the model netting materials stocked by Seafish. Although a wide variety of mesh sizes is stocked these are held in only three twine diameters, 0.30mm, 0.37mm and 0.52mm.

As these twine diameters rarely correspond to the correct scale twine diameter, another method must be used to scale the net panels.

The important parameters to scale correctly are twine surface area and panel length and width due to their effect on model drag and geometry. A method must therefore be used to select an appropriate model mesh size and twine diameter and correct the number of meshes.

In order to model twine surface area correctly the ratio of twine diameter/mesh size must be the same in the model panel as found in the full scale panel.

$$D/2A \text{ (full scale)} = d/2a \text{ (model)}$$

After the model twine diameter has been chosen from the options available, the appropriate model mesh size can be calculated.

$$2a = (2A \times d)/D$$

As this full mesh size 2a may not be available in the model netting stock the nearest size 2a' would be chosen.

The number of meshes across and along each model panel can then be calculated to ensure that twine surface area and linear dimensions are modelled accurately.

$$n = (2A \times N)/(2a' \times S)$$

Where

n	=	number of meshes across or along the model panel
N	=	number of meshes across or along the full scale panel
2A	=	full mesh size in full scale net panel (knot centre to knot centre)
2a'	=	full mesh size in model net panel (knot centre to knot centre)
S	=	scale factor (e.g. S=10 for a scale of 1:10)

In practice the number of meshes across and along each model panel has to be rounded to the nearest whole or half mesh. Generally the decision to round up or down may be taken in conjunction with the decision on the number of meshes in an adjacent panel, or after consideration of the cutting rate of the panel.

Another problem which may be encountered is where two adjacent panels in the full scale net have been joined mesh for mesh due to similar full mesh sizes. However, the twine diameters may be different in each panel leading to the modelling calculation giving a different number of meshes across each panel. Baitings must therefore be used to join the two model panels even though these did not exist in the full scale net.

Before each panel is scaled, the selvedge meshes are deducted from each side of the panel. The panel is then scaled and an appropriate number of meshes added to each side to form a suitable selvedge in the model.

Although the model netting stock is polyamide and many full scale nets are constructed of polyethylene, this is not felt to cause a significant problem. Although polyamide is more dense than water and polyethylene less dense, the difference is very small compared to the drag forces on the net.

All wire components such as sweeps and ground gear wires are scaled down by the scale factor  $S$  and the nearest stock model wire chosen. Many components, however, such as headlines and sweeps may be constructed of combination wire/rope. More care must obviously be taken in scaling the weight of combination as no model equivalent is available.

### **3. 600 H.P. PELAGIC TRAWL**

This trawl was tested at sea in 1987 aboard the Dutch Fisheries Research Vessel *Tridens*. The trawl and doors were owned by the Dutch Fisheries Research Institute, R.I.V.O.

A full series of reciprocal tows were conducted with various bridle lengths and the results are given in Reference 2.

It was not possible to transport the net to Seafish for full measurement, so a 1:25 model was constructed from a plan supplied by R.I.V.O. as shown in Fig 1. The twine diameters were based on the twine rotations given on the plan.

The model, shown in Fig 2, was constructed at 1:25 scale so that the full bridles and doors could be fitted into the Flume Tank with a small length of warp. A set of model trawl doors were constructed based on the full scale doors shown in Fig 3. The arrangement and lengths of bridles and chain extensions are given in Fig 4.

The full scale net had a twine surface area of 128.3m<sup>2</sup>, equivalent to 0.205m<sup>2</sup> at 1:25 scale, compared to 0.215m<sup>2</sup> for the actual model as constructed.

This trawl was tested initially before trials had been completed on the 200h.p. trawl, PT163. The headline height of the model was so small that it was considered the toe end weights may have been incorrectly measured at sea.

The model was set aside until after the tests had been completed on the pelagic trawl PT163, by which time it was appreciated that the model drag was significantly higher than the equivalent for the full scale net.

Although full bridles and doors were fitted to this 1:25 scale model, it was decided that it should be retested using the same principal as for PT163. That is to say, the headline height and wingend spread would be artificially maintained so that a drag reading could be taken with the model equivalent to the full scale geometry.

The model was set up in the Flume Tank with the equivalent of the longest set of bridles used at sea. Due to excessive drag of the model trawl the model doors were unable to achieve the equivalent door spread of the full scale gear. The Flume Tank tow posts were therefore then progressively opened apart until the model equivalent of the full scale door spread. Door spread was used rather than wingend spread due to an instrument loss at sea and hence lack of wingend spread measurements.

From the full scale trials (Block 3 data, Reference 2) at 4.38 knots doorspread was 91.0 metres, headline height 23.5 metres and trawl drag 8.63 tonnes.

The Flume Tank results given in Appendix II, Run 1, show the effect of setting up the doorspread to the equivalent of the full scale value of 91.0 metres and allowing the headline height to take up its natural level. The headline height was only 14.1 metres compared to 23.5 metres found at sea. Drag was 13.1 tonnes compared to 8.63 tonnes found at sea.

After Run 1 was completed a float was added to a each top wingend and an equivalent weight added to each bottom wingend to open up the headline height to the value found at sea. The trawl was removed from the tank, more floats and more weight added until the headline height was nominally correct. This was found to occur when 60 grammes of flotation was added to each top wingend and 60 grammes of weight to each bottom wingend.

A comparison of the performance of the model to the full scale trawl is given in Appendix II, Run 2 and summarised in Table 1.

**Table 1**  
**Comparison of Full Scale Results and Model Drag Prediction**  
**4.38 knots**

	Model	Full Scale
<b>Door Spread (metres)</b>	91.4*	91.0
<b>Headline Height (metres)</b>	23.2*	23.5
<b>Wingend Spread (metres)</b>	35.1	-
<b>Drag (tonnes)</b>	14.86	8.63

\* The door spread and headline height were artificially held at these values.

When the wingend spread was measured at the beginning of the sea trials it was found to be between 36 and 37 metres before the instrument was lost.

The above table shows that the drag predicted from the model is 70% higher than found in full scale sea trials.

#### 4. 300 H.P. BALLOON TRAWL

The net was tested at sea with 94.8 metres of sweep between the doors and net. In the sea trials results given in Reference 4, three blocks of data, Blocks 8, 9 and 10, were carried out without any alteration to the gear, over the same reciprocal tow. These three blocks of data were found to be very consistent and therefore averaged to be used for the Flume Tank simulation.

The door spread for Blocks 8, 9 and 10 was approximately 54 metres. As it was felt beneficial to make the model as large as possible, a model scale of 1:10 was chosen. As the Flume Tank is 5 metres wide, the door spread of 5.4 metres (model scale) would not fit.

It was decided that the split bridles would be scaled correctly and attached directly onto the backstops of the doors. The full scale equivalent of total bridle length modelled was 48.8 metres compared to 94.4 metres used at sea. The full scale net plan is shown in Fig 5 and its model equivalent in Fig 6. The bridle system and ground gear are shown in Fig 7. A set of 1:10 scale vee door models were constructed based on the ones used at sea, and are shown in Fig 8.

The flotation was modelled in two separate sections for the bosom and wing. The full scale bosom had a total of 42.7kgs buoyancy compared to 42.6kgs for the model (full scale equivalent). Each wing in the full scale net had 26.5kgs buoyancy compared to 27.1kgs for the model.

The full scale net had a twine surface area of 63.3m<sup>2</sup>, equivalent to 0.633m<sup>2</sup> at 1:10 scale, compared to 0.632m<sup>2</sup> for the actual model as constructed.

A number of runs 1-17 were conducted in the Flume Tank to set up a procedure for testing the two demersal models. Full scale data was read from the graphs at 2.5, 2.75 and 3.0 knots for Blocks 8, 9 and 10 of sea trials data. The gear drag, door spread, wingend spread and headline height were averaged for these three blocks of full scale data and are given in Table 2.

Table 2  
Full Scale Results for Blocks 8, 9 and 10

	Speed (knots)		
	2.50	2.75	3.00
Door Spread (metres)	53.3	54.0	55.0
Wingend Spread (metres)	13.9	14.0	14.0
Headline Height (metres)	4.63	4.25	3.87
Gear Drag (tonnes)	1.66	1.88	2.13

These results were used as the target figures to achieve when setting up the model in the Flume Tank.

As it was not possible to put the full length of bridles in the Flume Tank, a method was used for linearly extrapolating the bridles to calculate the equivalent full scale door spread with full length bridles. From this extrapolated door position the warps could also be extrapolated parallel to the line from the model doors to tow posts to calculate the full scale equivalent warp length. This method of calculating full scale equivalent door spread and warp length is shown diagrammatically in Fig 9.

When the model was set up in the Flume Tank, the wingend spread, door spread and tow post spread were measured so that the equivalent full scale warp length could be calculated.

From the initial runs it was found that when the calculated warp length was approximately correct, the door spread was substantially lower than that found at sea and wingend spread was slightly lower. When the doors were artificially spread further apart to the correct value by opening the tow posts, the wingend spread was then slightly higher than found at sea.

It was therefore decided that at each speed, 2.5, 2.75 and 3.0 knots, three runs should be carried out.

- (i) Warp length correct (calculated)
- (ii) Door spread correct (calculated)
- (iii) Wingend spread correct (measured)

The results and calculations for these 9 runs (runs 18-26) are given in Appendix III.

The Flume Tank speed was measured at three points across the net and in front of each door. The average speed was then calculated for the net alone (3 values) and also for the net and doors together (5 values).

As these average speeds in the Flume Tank trials did not correspond exactly to the required speeds of 2.5, 2.75 and 3.0 knots the sea trials data (Blocks 8, 9 and 10) were read again to give the results at 2.6, 2.8 and 3.1 knots (average speed from the model tests). The full scale results together with the model predictions are given in Table 3.

**Table 3**  
**Comparison of Model Predictions to Full Scale Results for Balloon Trawl**

**2.6 knots\***

	<b>Full Scale</b>	<b>Correct Warp Length</b>	<b>Correct Door Spread</b>	<b>Correct Wingend Spread</b>
<b>Warp Length (m)</b>	232.0	238.2	1715.5	550.9
<b>Door Spread (m)</b>	53.6	42.4	53.2	46.7
<b>Wingend Spread (m)</b>	13.9	12.8	15.2	13.9
<b>Headline Height (m)</b>	4.5	4.47	3.86	4.25
<b>Drag (t)</b>	1.72	1.75	1.70	1.77

**2.8 knots\***

	<b>Full Scale</b>	<b>Correct Warp Length</b>	<b>Correct Door Spread</b>	<b>Correct Wingend Spread</b>
<b>Warp Length (m)</b>	232.0	245.4	915.2	502.5
<b>Door Spread (m)</b>	54.2	44.6	54.5	48.1
<b>Wingend Spread (m)</b>	14.0	13.1	15.1	13.7
<b>Headline Height (m)</b>	4.2	4.03	3.60	3.85
<b>Drag (t)</b>	1.91	1.98	2.01	2.01

**3.1 knots\***

	<b>Full Scale</b>	<b>Correct Warp Length</b>	<b>Correct Door Spread</b>	<b>Correct Wingend Spread</b>
<b>Warp Length (m)</b>	232.0	240.7	789.4	484.4
<b>Door Spread (m)</b>	55.4	45.1	55.5	49.0
<b>Wingend Spread (m)</b>	14.0	13.1	15.2	13.4
<b>Headline Height (m)</b>	3.7	3.75	3.28	3.59
<b>Drag (t)</b>	2.27	2.26	2.29	2.21

\* Speeds given are the equivalent full scale speeds based on five measurements across the model net and doors.

## 5. 150 H.P. DUAL PURPOSE TRAWL

This net was tested at sea with a total bridle length of 84.1 metres and achieved door spreads of between 50 and 55 metres. The sea trials are described in Reference 4.

Blocks 7 and 8 of the sea trials data were carried out with no alterations to the gear and so average values were used as a basis for the model tests.

The full scale net plan is shown in Fig 10 and its 1:10 scale model equivalent in Fig 11. The bridle system and ground gear are shown in Fig 12. A set of 1:10 scale trawl door models was constructed based on the full scale plans shown in Fig 13.

The full scale net had a twine surface area of 38.5m<sup>2</sup>, equivalent to 0.385m<sup>2</sup> at 1:10 scale, compared to 0.365m<sup>2</sup> for the actual model as constructed.

Flotation was calculated for the bosom and wing sections separately. The full scale bosom had 10.86kgs buoyancy compared to 10.9kgs equivalent for the model, whilst the full scale wings had 30.4kgs of buoyancy each and the model wings had 32.0kgs equivalent.

The data from sea trials Blocks 7 and 8 was read from the graphs and averaged to give the target figures for the Flume Tank tests at 2.5, 2.75 and 3.0 knots. These figures are given in Table 4.

**Table 4**  
**Full Scale Results for Blocks 7 and 8**

	Speed (knots)		
	2.50	2.75	3.00
Door Spread (metres)	53.5	52.9	52.6
Wingend Spread (metres)	12.2	12.0	11.7
Headline Height (metres)	1.77	1.72	1.70
Gear Drag (tonnes)	1.22	1.38	1.56

When preliminary tests were carried out it was found that the model headline height was well below that found in trials at sea. On investigation of the cause it was found that the model headline was made from wire which was heavier than the full scale equivalent. A piece of this model headline material was weighed and a series of small floats added evenly along the headline to give the model headline the correct weight in water.

As for the 300h.p. balloon trawl, Flume Tank tests were again carried out to achieve the correct calculated warp length and also correct calculated door spread. However, the wingend spread appeared to be correct when the calculated door spread was correct and so this third test was not carried out. The results and calculations for the Flume Tank tests are given in Appendix IV. Again, Flume Tank speeds were measured at five points across the net and doors and averages found to be 2.6, 2.8 and 3.05 knots. Results for these full scale equivalent speeds were read off the sea trials graphs and compared to the model predictions in Table 5.

**Table 5**  
**Comparison of Model Predictions to Full Scale Results for Dual Purpose Trawl**

**2.6 knots\***

	<b>Full Scale</b>	<b>Correct Warp Length</b>	<b>Correct Door Spread</b>
<b>Warp Length (m)</b>	187.0	182.1	777.3
<b>Door Spread (m)</b>	53.3	38.3	53.2
<b>Wingend Spread (m)</b>	12.2	9.8	11.6
<b>Headline Height (m)</b>	1.75	2.05	1.70
<b>Drag (t)</b>	1.28	1.03	1.04

**2.8 knots\***

	<b>Full Scale</b>	<b>Correct Warp Length</b>	<b>Correct Door Spread</b>
<b>Warp Length (m)</b>	187.0	201.4	716.3
<b>Door Spread (m)</b>	52.9	38.6	53.6
<b>Wingend Spread (m)</b>	11.9	9.8	11.6
<b>Headline Height (m)</b>	1.72	1.87	1.57
<b>Drag (t)</b>	1.42	1.18	1.26

**3.05 knots\***

	<b>Full Scale</b>	<b>Correct Warp Length</b>	<b>Correct Door Spread</b>
<b>Warp Length (m)</b>	187.0	195.3	714.4
<b>Door Spread (m)</b>	52.6	39.0	53.5
<b>Wingend Spread (m)</b>	11.7	9.8	11.9
<b>Headline Height (m)</b>	1.70	1.83	1.50
<b>Drag (t)</b>	1.60	1.33	1.40

\* Speeds given are the equivalent full scale speeds based on five measurements across the model net and doors.

## 6. DISCUSSION

### 6.1 Pelagic Trawl Models

Based on the model trials of the 600h.p. pelagic trawl described in this report and also the previous trials on the model of the 200h.p. pelagic trawl PT163 (Reference 2), it can be concluded that pelagic trawl models predict a substantially higher drag than is actually found in trials at sea.

This proportionately larger drag of the model trawl means that Flume Tank trials predict not only too great a towing requirement for the full scale net in terms of vessel power, but also door spreads and headline heights well below those found at sea. This in turn leads to the incorrect prediction of door size, toe end weights and flotation requirements.

For the 600h.p. pelagic trawl, Reynolds Number for the full scale twines are 9184 for 6.0mm twine in the square and 5357 for 3.5mm twine in the third panel (speed 2.25 m/sec, Viscosity  $1.47 \times 10^{-6}$  m<sup>2</sup>/sec).

To compare the drag of full scale and model twines over a range of Reynolds numbers, a tentative assumption would be that the drag behaviour is similar to a long cylinder, for which some data exists.

As the 3.5mm twine is probably representative of the average throughout the net, the drag coefficient of a cylinder of this diameter is 1.0 at Reynolds Number 5357. The drag coefficient of the model twine diameter of 0.30mm at Reynolds Number 118 is approximately 1.38 (speed 0.452 m/sec, Viscosity  $1.15 \times 10^{-6}$  m<sup>2</sup>/sec).

As the equivalent drag of the model was 72% higher than found in trials at sea (61% for PT163), the use of the drag data for cylinders, which predicts a 38% increase in drag (35% for PT163), underestimates the drag of the model.

This result agrees with the model trials for pelagic trawl PT163 in as much as the model drag is substantially higher than the equivalent which is greater than predicted by the drag coefficients of cylinders at the appropriate Reynolds Number.

Although artificial means can be used to give the correct net mouth geometry, it is more beneficial if the model net, flotation, weights, bridles, doors and part of the warp are correctly modelled to give a true representation of how the full scale net will behave.

As the excessive drag of the model reduces the door spread, wingend spread and headline height, a method must be used to correct the net drag in the modelling technique, thereby allowing the model net to take up the correct opening.

This could be achieved by reducing the twine surface area for each panel in the model pelagic trawl by an amount based both on the drag of cylinders and also empirical results.

In the two cases quoted the actual increase in drag of the model compared to the equivalent full scale drag is greater than predicted by the drag of cylinders.

1. 600h.p. trawl scale 1:25  
Model drag/Full scale drag = 1.72  
Model cylinder drag/Full scale cylinder drag = 1.38  
Model prediction/Cylinder prediction =  $1.72/1.38 = 1.25$
2. PT163 trawl (200h.p.) scale 1:10  
Model drag/Full scale drag = 1.61  
Model cylinder drag/Full scale cylinder drag = 1.35  
Model prediction/Cylinder prediction =  $1.61/1.35 = 1.19$

When calculating the specification for a pelagic trawl model, the correction factors could be applied to the normal modelling rule, by first calculating a correction due to Reynolds Number effects on the drag of cylinders, then increasing this correction by 1.19 to 1.25.

e.g. for the 600h.p. pelagic trawl the model net panels would be normal model twine surface area/ $1.38 \times 1.25$ .

However, in the first instance it would be prudent to apply the Reynolds Number correction only (model cylinder drag/full scale cylinder drag), until experience has been gained in applying corrections to twine surface area calculations.

As more experience and empirical results are gained the second correction (model prediction/cylinder prediction) could be refined.

## 6.2 Demersal Trawl Models

When the correct calculated warp length was used with both demersal trawl models, the predicted door spread was well below that found in trials at sea.

This was not due to the excessive combined drag of the model net and bridles as the Balloon trawl model drag was 1.98 tonnes at 2.8 knots compared to 1.91 tonnes at sea, and the dual purpose trawl model drag was 1.18 tonnes at 2.8 knots compared to 1.42 tonnes at sea.

From the work on pelagic trawls the drag of the netting is substantially greater for the model than the equivalent for the full scale net.

This means that if the netting drag is greater for demersal trawl models, the drag of the ground gear, bridles and doors must be well below the equivalent of that found at sea in order that the total drag is less.

Comparing the two demersal nets, the balloon trawl has a twine surface area of 63.3m<sup>2</sup> and total bridle length of 94.8 metres, whereas the dual purpose trawl has a twine surface area of 38.5m<sup>2</sup> and total bridle length of 84.1 metres.

The proportion of total drag due to ground friction is likely to be higher for the dual purpose trawl due to its proportionately greater bridle length, perhaps explaining why the model drag is lower than the full scale equivalent.

For both trawls the drag increased only very slightly at 2.8 knots when the door spread was increased to the values found at sea, 1.98 tonnes to 2.01 tonnes for the balloon trawl and 1.18 tonnes to 1.26 tonnes for the dual purpose trawl.

Predicted headline heights for both trawls were found to be lower than found at sea. For the balloon trawl at 2.8 knots the model predicted 3.6 metres, with correct door spread, compared to 4.2 metres at sea. The model headline height increased to 3.85 metres when door spread was reduced to give correct wingend spread. The headline height of the dual purpose trawl was 1.57 metres predicted from the model with correct door spread (and correct wingend spread) compared to 1.72 metres at sea.

This slightly reduced headline height in both models may be due to the equivalent model netting drag being greater than the full scale, thus creating lower headline height with the correctly scaled flotation. It may also be due in part to an incorrect scaling of headline and netting weight.

Considering the results for both nets the area where greatest inaccuracy occurs is that of prediction of door spread when the calculated warp out is correct.

At 2.8 knots the balloon trawl door spread was predicted at 44.6 metres compared to 54.2 metres in sea trials, and the dual purpose trawl door spread was predicted at 38.6 metres compared to 52.9 metres in sea trials.

This difference could be due to the full scale doors giving extra spreading force because of ground sheer effect which is not possible in the Flume Tank, or some ground effect from the bridles which is not found in the Flume Tank.

For both nets tested the calculated warp length was much greater than the actual warp length used at sea, to achieve the correct door spreads. When the door spread was correct for the balloon trawl the calculated warp length varied from 1715 metres at 2.6 knots to 789 metres at 3.1 knots (Table 3, p9), compared to 777 metres at 2.6 knots to 714 metres at 3.05 knots for the dual purpose trawl (Table 5, p11). The much larger value for the balloon trawl at low speed may be due either to the sensitivity or accuracy of the calculation where model door spread and tow post spread are very similar, or to the behaviour of the model doors at low speed.

Without being able to separate the model and full scale behaviour of each component making up a demersal trawl system, it is not possible to apply correction factors to each so that the model trawl behaves exactly the same as the full scale trawl.

Thus, empirical experience must be used to correct the results of model trials to use for full scale trawl prediction.

## **7. CONCLUSIONS**

### **7.1 Pelagic Trawls**

1. Model pelagic trawls, constructed to the usual modelling technique, predict gear drags which are substantially greater than found in full scale trials at sea.
2. This excessive drag causes the predicted headline height, wingend spread and door spread to be less than found in full scale trials at sea. (In the trials on the 600h.p. pelagic trawl and also the previous trials on the 200h.p. pelagic trawl PT163, the door spread and headline height values were artificially held open to the correct values to obtain drag readings).
3. The excessive drag in the model could be corrected by reducing the twine surface area of each panel in the model net.

### **7.2 Demersal Trawls**

1. When the calculated warp length out is correct in model trials, the predicted door spread is less than found in the full scale trawl.
2. When the calculated door spread is set to the equivalent value of the full scale trawl, the headline height is slightly low.
3. When a trawl has relatively long bridles the drag predicted from the model is marginally less than found at sea.

## **8. RECOMMENDATIONS**

1. The twine surface area of pelagic trawl models should be reduced by making an allowance for the difference in Reynolds Number between the model and full scale nets.
2. If full scale data is available, the correlation factor should be calculated and applied to future model pelagic trawl construction.
3. Although the drag of demersal trawls is generally predicted well by model tests, the drag and shape of bridles affects the model predictions.

Some work into the ground contact forces of bridles would therefore be beneficial.

## **9. REFERENCES**

1. J.N. Ward and R.S.T. Ferro. A Comparison of 1/10th and Full Scale Measurements of the Drag and Geometry of a Pelagic Trawl.
2. J.N. Ward. Sea Trials on a 600h.p. Pelagic Trawl (Model-Full Scale Correlation), Seafish Internal Report No. 1328.
3. J.N. Ward. Sea Trials on a 300h.p. Balloon Trawl (Model-Full Scale Correlation), Seafish Report No. 393.
4. J.N. Ward. Sea Trials on a 150h.p. Dual Purpose Trawl (Model-Full Scale Correlation), Seafish Internal Report No. 1387.
5. W. Dickson. Trawl Performance - A Study Relating Models to Commercial Trawls. Department of Agriculture and Fisheries for Scotland, Marine Research 1961, No. 1.

Net Plan of 600 h.p. Pelagic Trawl

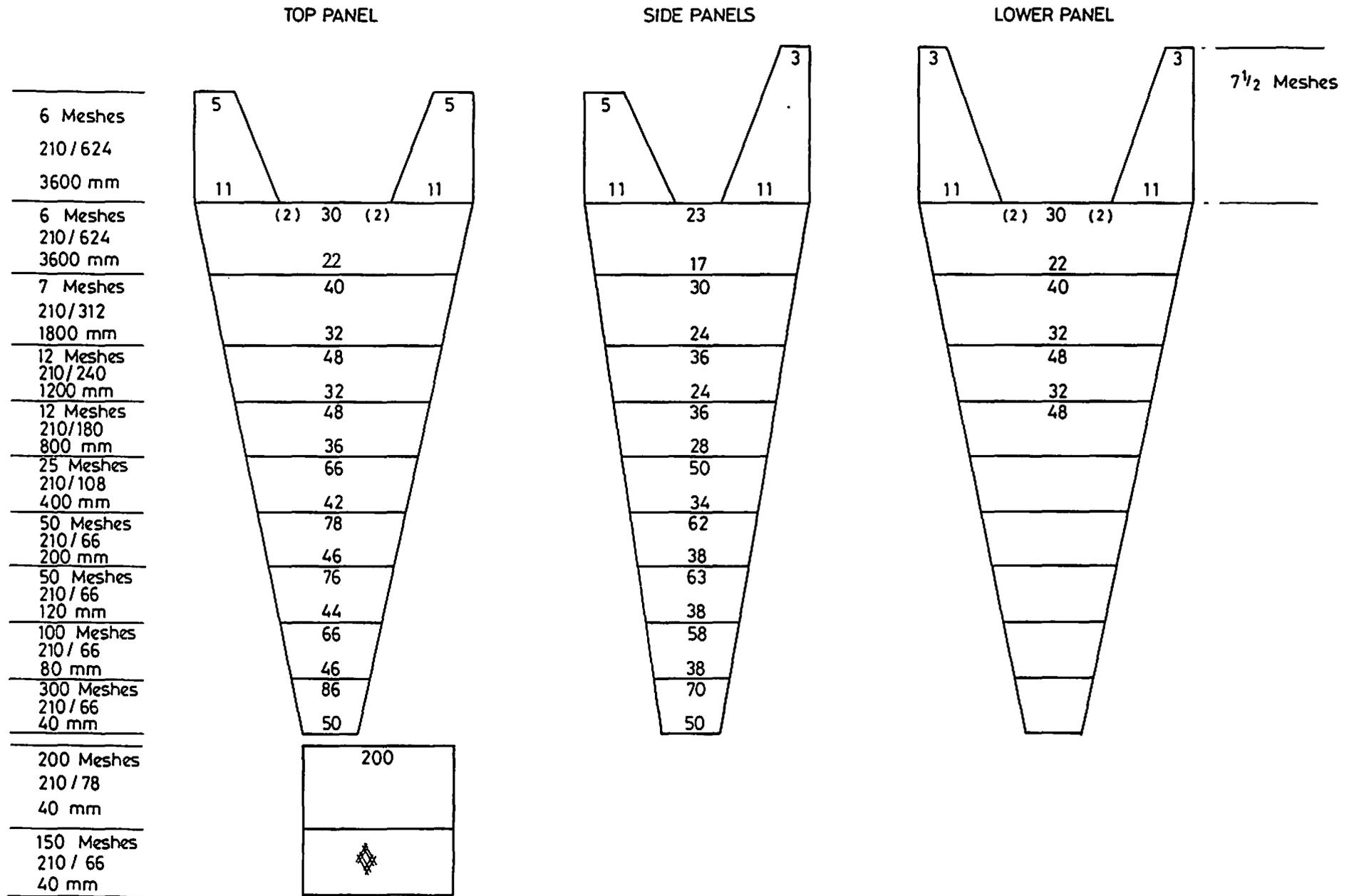
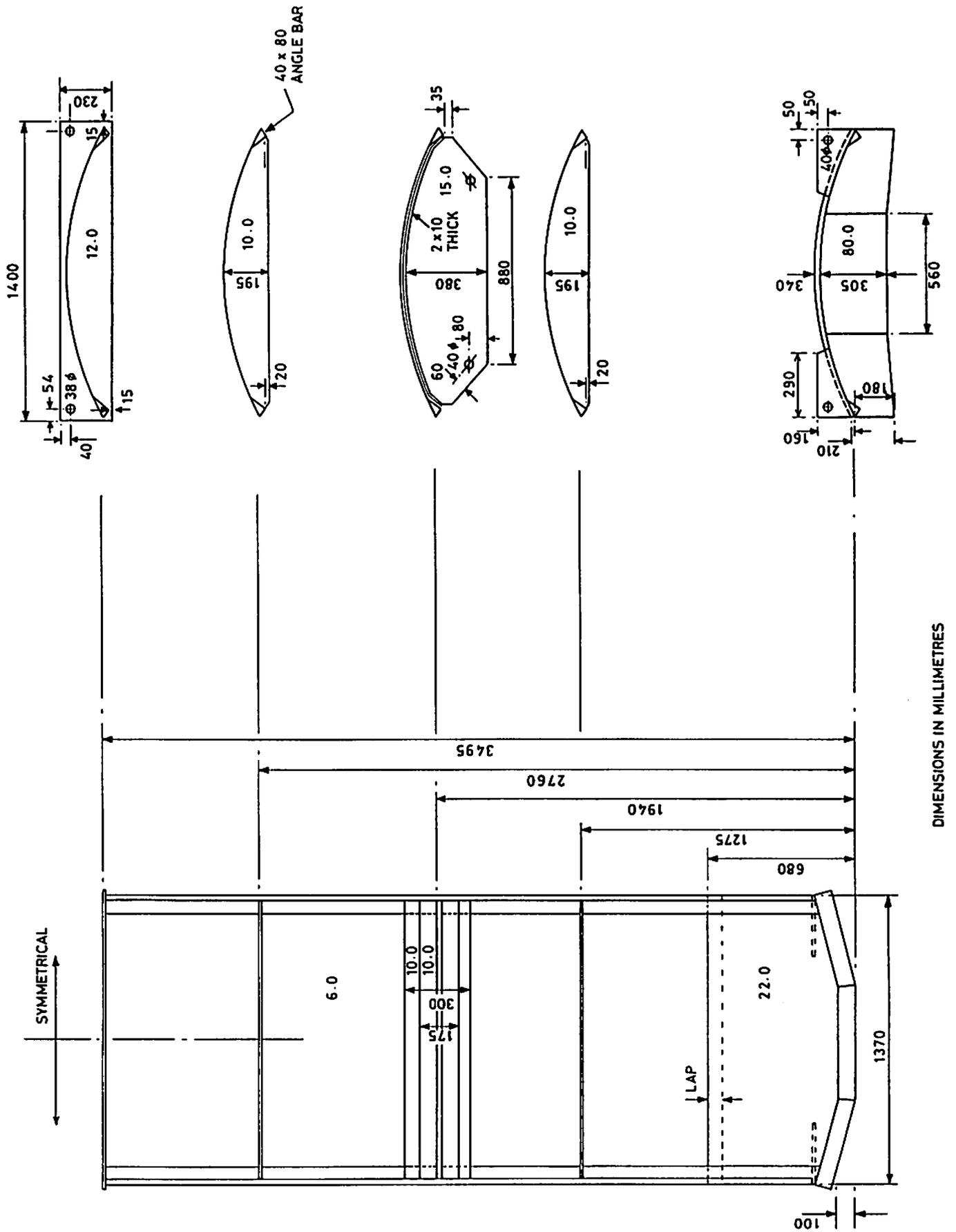
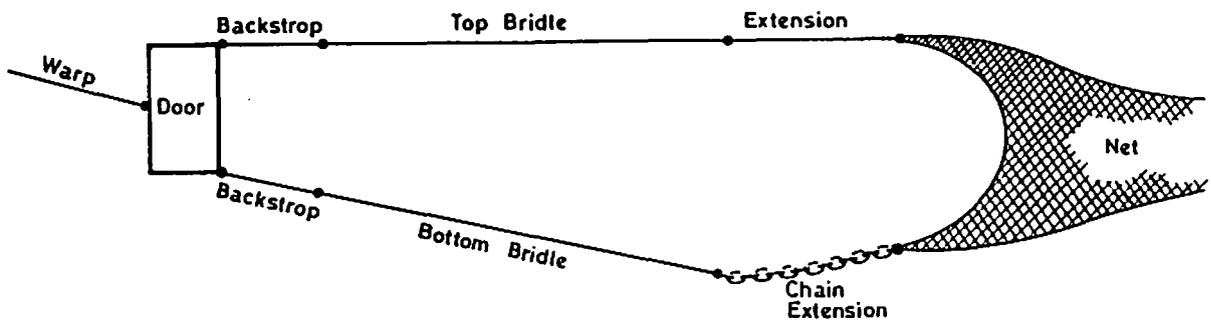


Fig 1



4.8m<sup>2</sup> Doors for 600 h.p. Pelagic Trawl

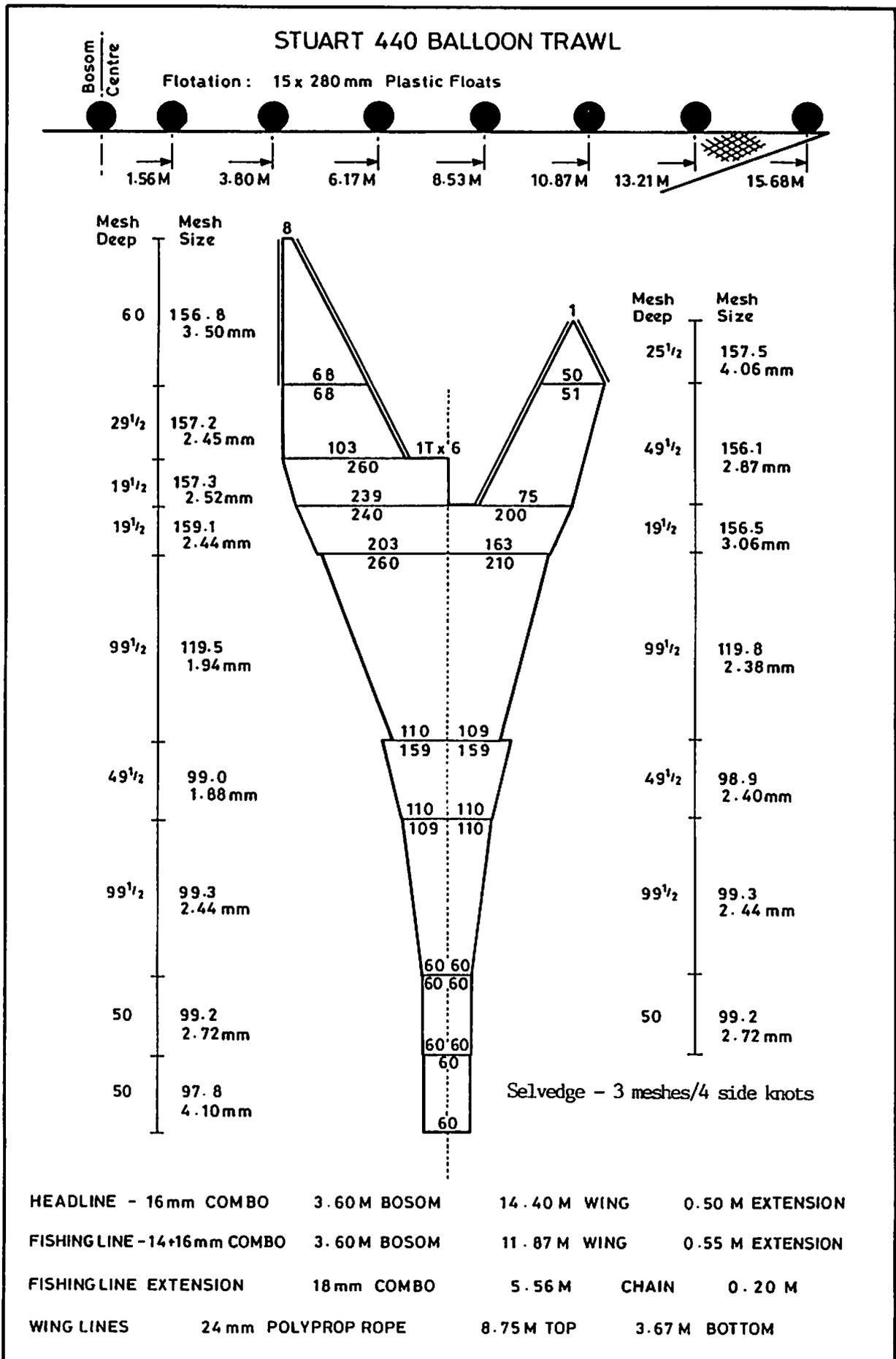
Fig 3



	Backstrop Metres	Bridle Metres	Extension Metres
Top	4.5	100.0	6.0
Bottom	4.5	100.0	7.0*

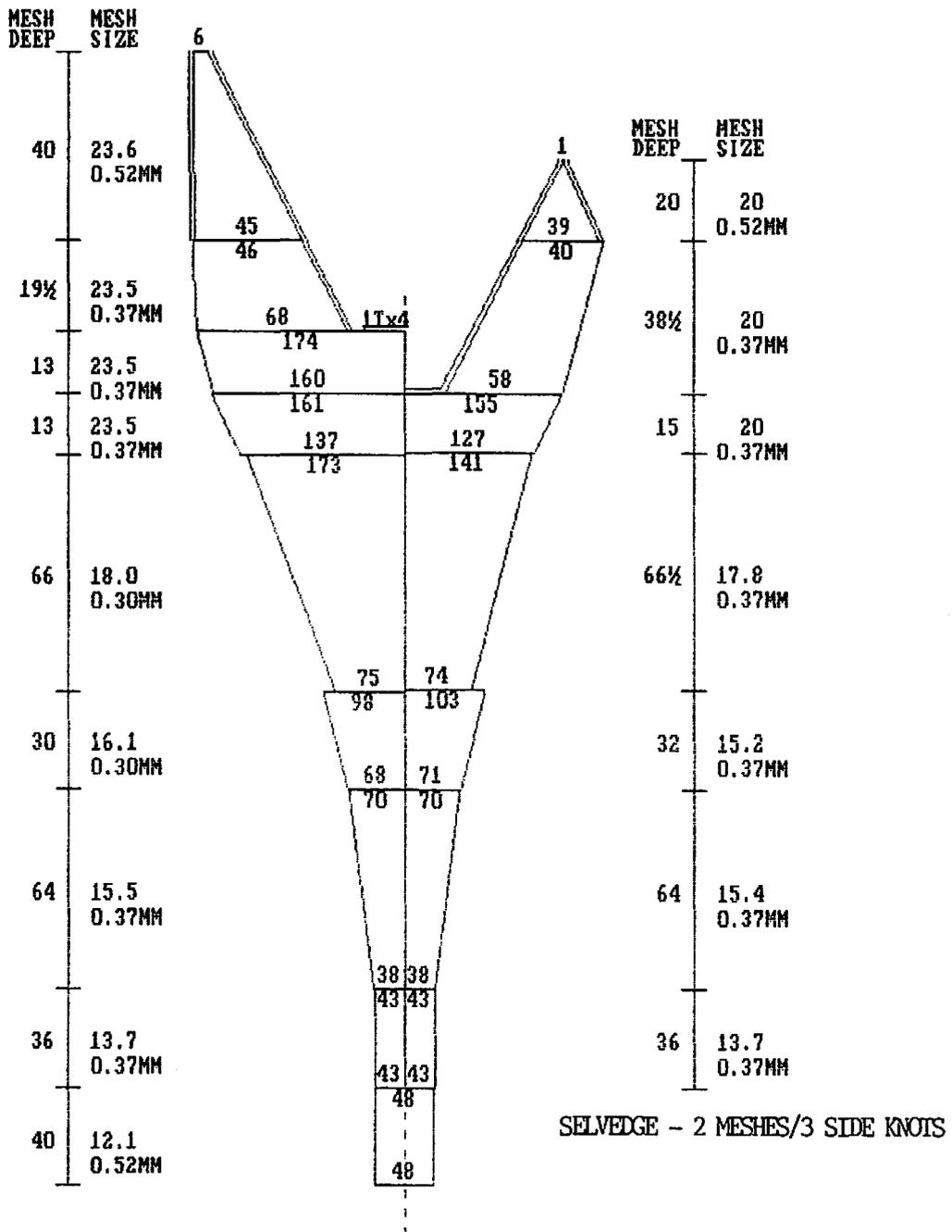
\* The bottom extension was made up of 600kgs of chain on each side.

Bridle Arrangement for 600 h.p. Pelagic Trawl



Net Plan of 300 h.p. Balloon Trawl

# STUART 440 BALLOON TRAWL MODEL



1:10 Scale Model Net Plan of 300 h.p. Balloon Trawl

Ground Gear and Bridle System of 300 h.p. Balloon Trawl

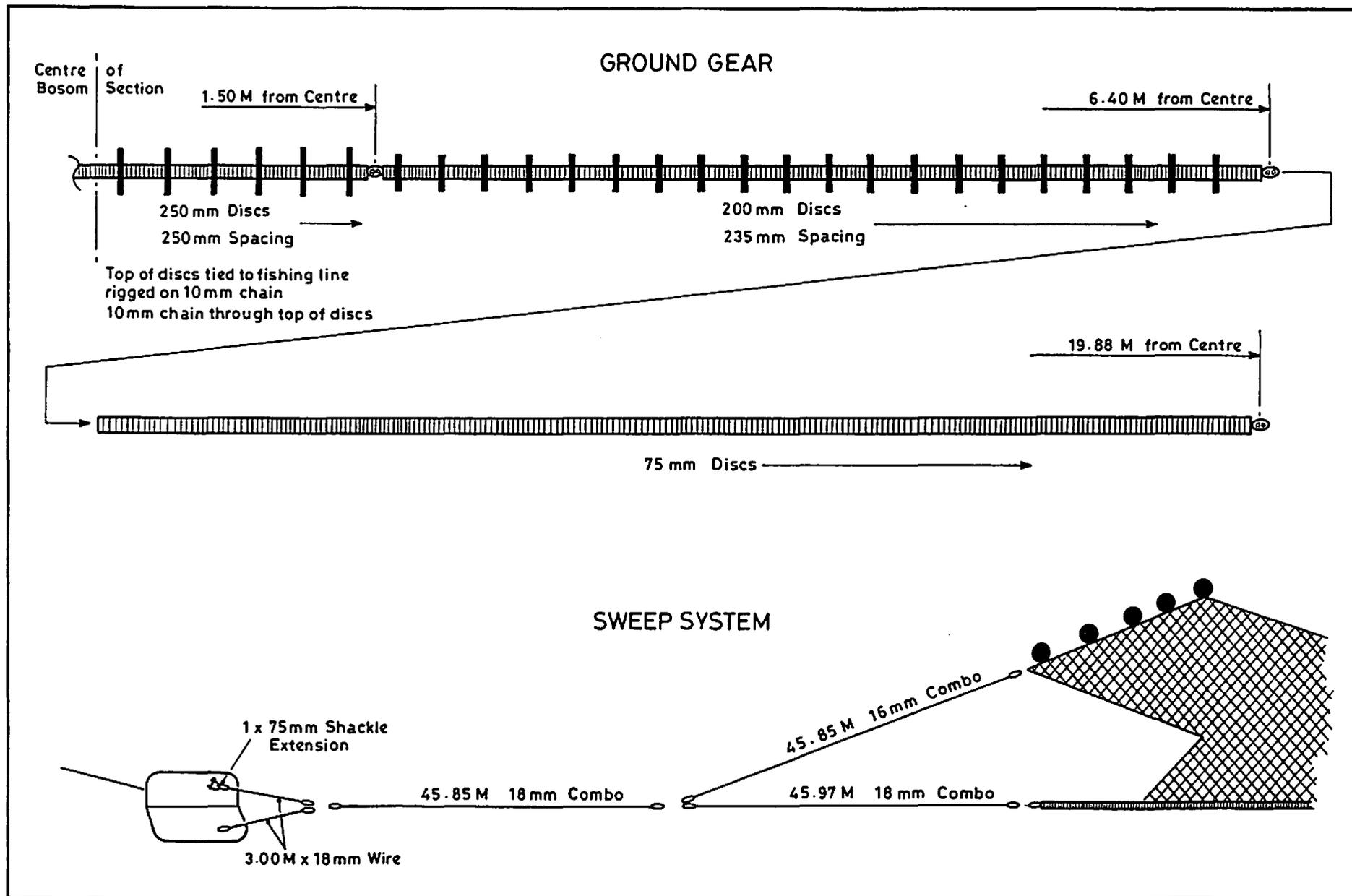


Fig 7

1.97m Vee Doors for 300 h.p. Balloon Trawl

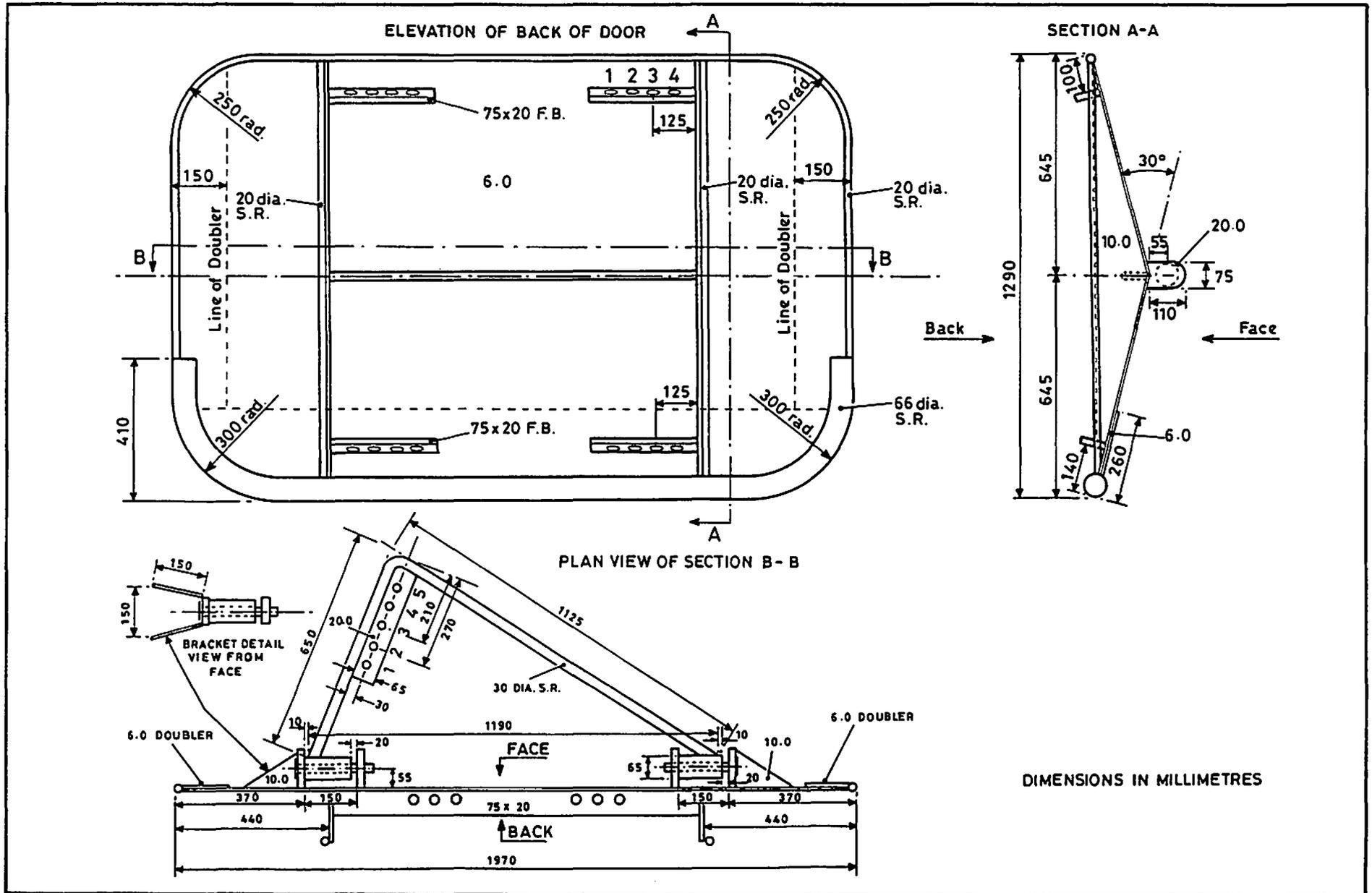


Fig 8

Method of Calculating Door Spread and Warp Length

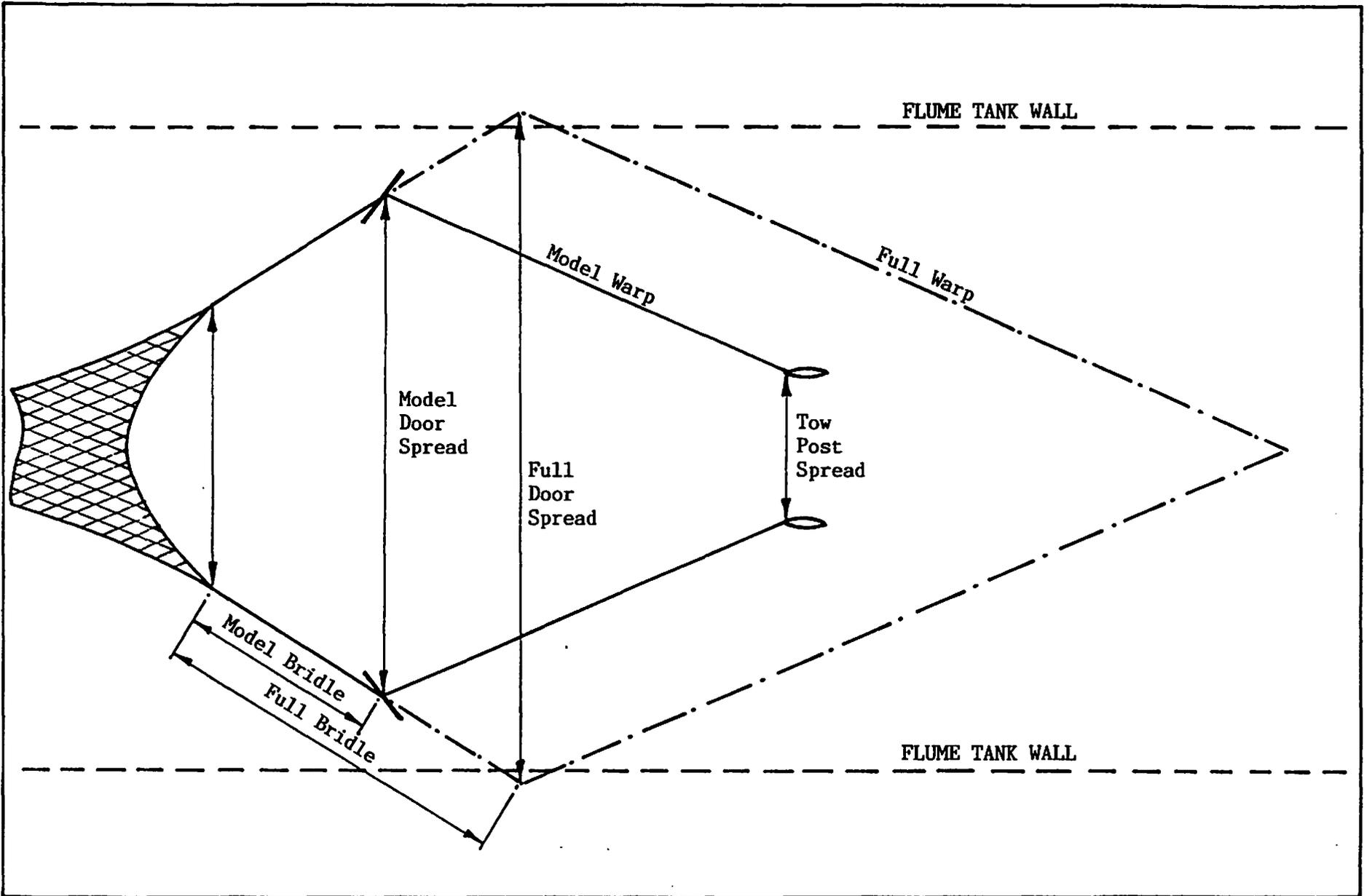
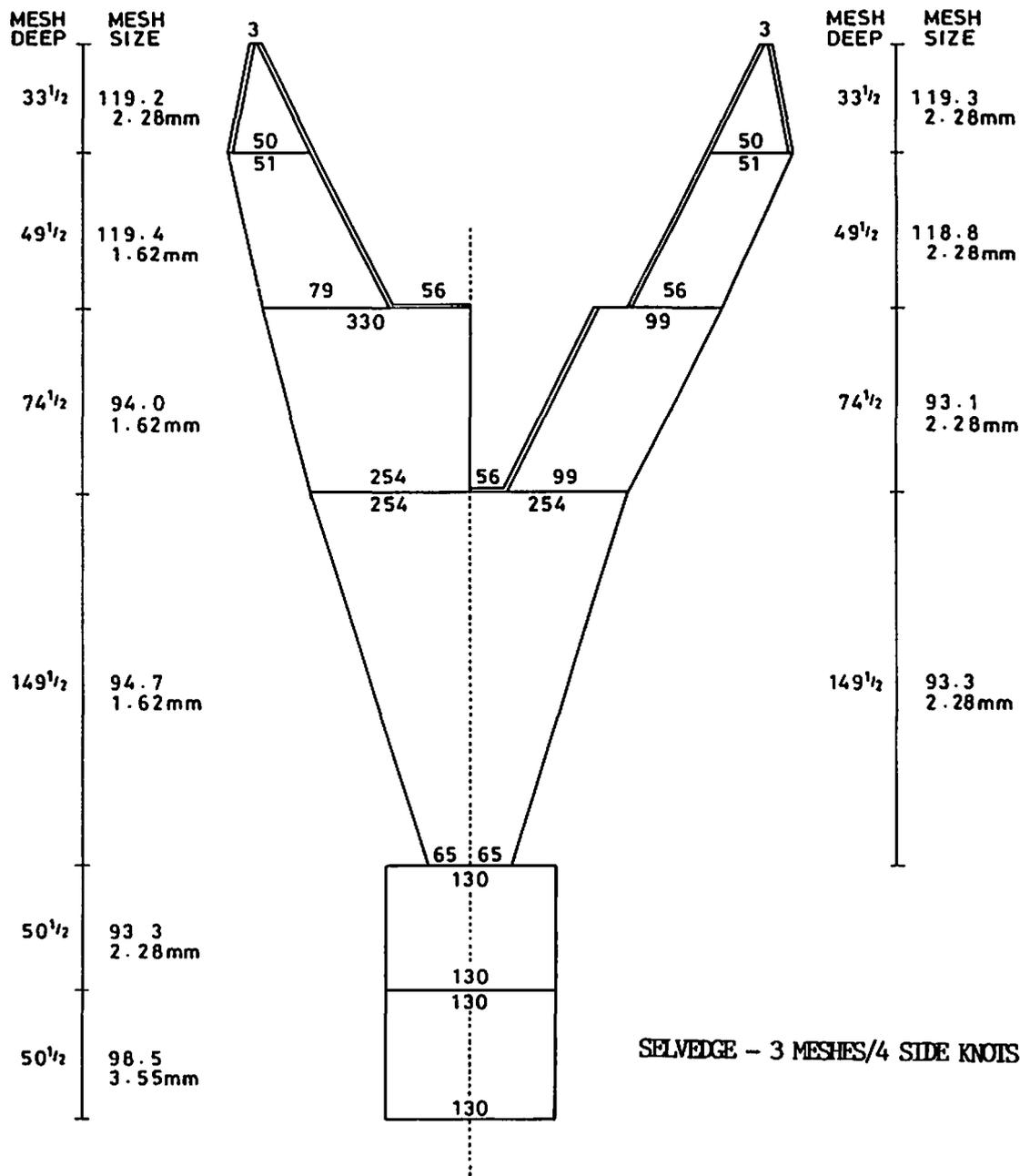
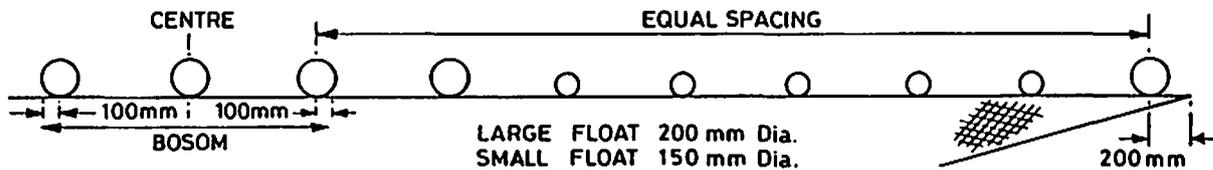


Fig 9

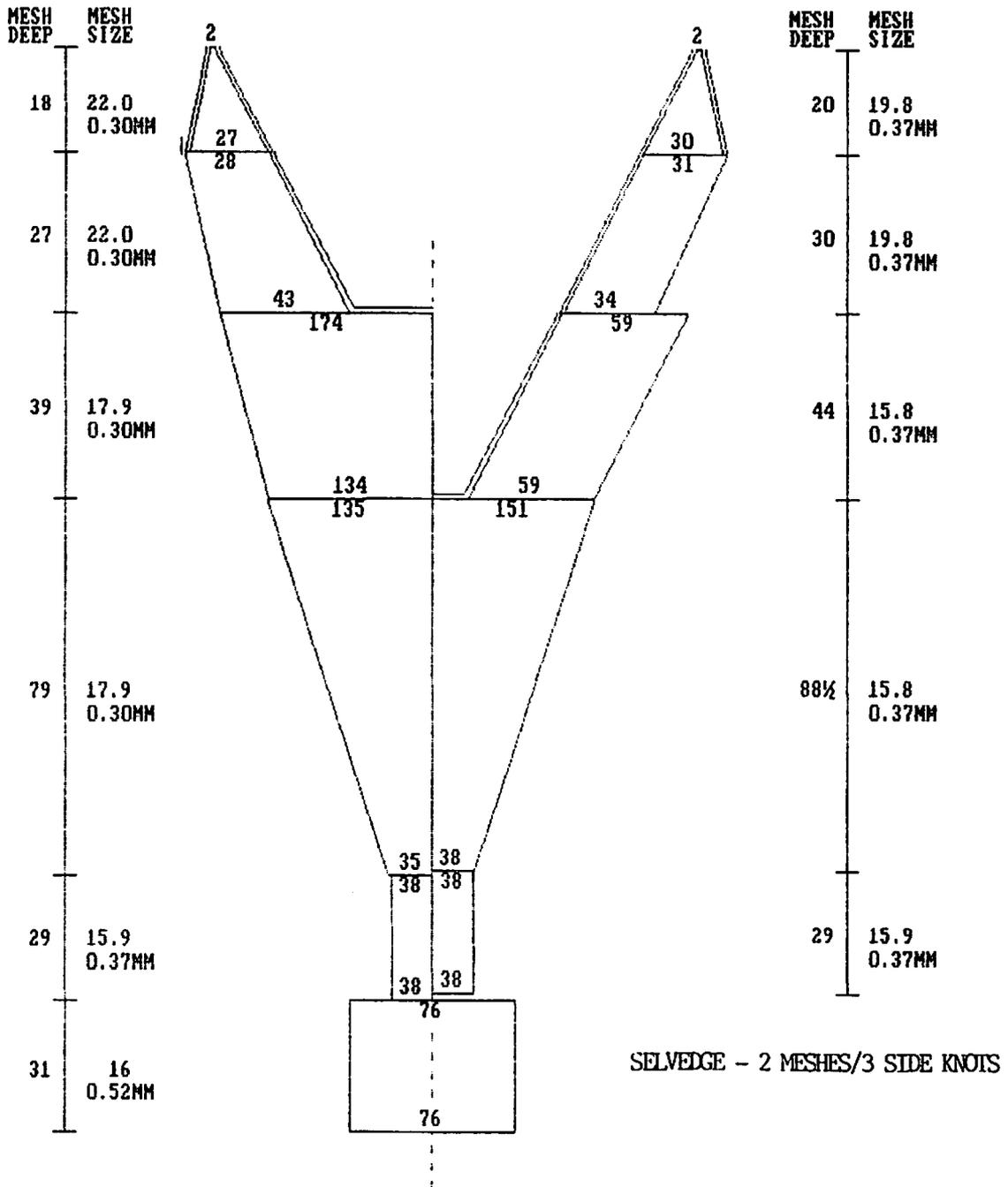
# STUART 20/500/90



HEADLINE - 16 mm COMBO	1.830m BOSOM	10.435 m WING	1.350m EXTENSION
FISHING LINE - 16 mm COMBO	1.830m BOSOM	17.480m WING	1.370m EXTENSION
WING LINE - 20 mm P.E. ROPE	3.550m TOP	3.550m BOTTOM	

Net Plan of 150 h.p. Dual Purpose Trawl

# STUART 20/500/90 TRAWL MODEL



1:10 Scale Model Net Plan of 150 h.p. Dual Purpose Trawl

Ground Gear and Bridle System of 150 h.p. Dual Purpose Trawl

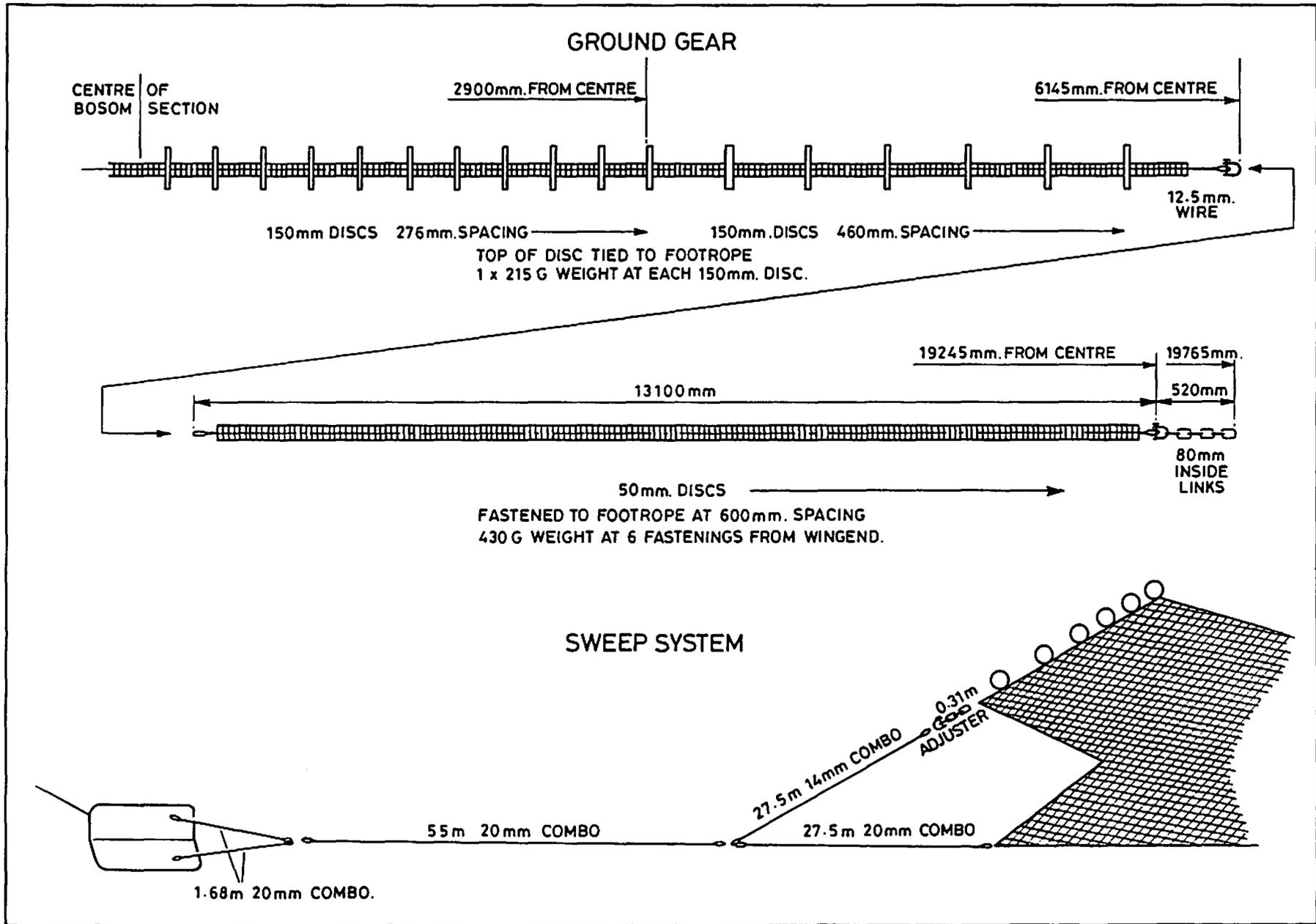


Fig 12

**APPENDIX I**

**STOCK OF MODEL NETTING HELD AT THE FLUME TANK**

<b>FULL MESH MM</b>	<b>0.30MM DIA.</b>	<b>0.37MM DIA.</b>	<b>0.52MM DIA.</b>
10	X	X	X
12	X	X	X
14	X	X	X
16	X	X	X
18	X	X	X
20	X	X	X
22	X	X	X
24	X	X	X
26	X	X	X
28	X	X	X
30	X	X	X
32	X	X	X
34	X	X	X
36	X	X	X
38	X	X	X
40	X	X	X
42	X	X	X
44	X	X	
46	X	X	
48	X	X	
50	X	X	
60	X	X	
70	X	X	
80	X	X	
90	X	X	
100	X	X	
120	X		
140	X		
160	X		
180	X		
200	X		

APPENDIX II

600 H.P. PELAGIC TRAWL

RUN	1	4.38 KNOTS SIMULATION	CORRECT DOOR SPREAD
SEA TRIALS			
BLOCK 3	SCALE	25	MODEL SPEED
	WARP LENGTH	5.64 M	PORT WING 0.489 M/S
	BRIDLE LENGTH	4.42 M	HEADLINE 0.440 M/S
	WINGEND SPREAD	1.40 M	CENTRE 0.467 M/S
	DOOR SPREAD	3.63 M	FOOTROPE 0.467 M/S
MODEL	TOW POINT HEIGHT	0.94 M	STBD WING 0.467 M/S
	TOW POINT SPREAD	3.60 M	
	HEADLINE HEIGHT	0.565 M	
	WARP TENSION-PORT	0.435 KGS	
	WARP TENSION-STBD	0.419 KGS	
	BRIDLE LENGTH	110.5 M	FULL SCALE SPEED
	WINGEND SPREAD	35.1 M	
	DOOR SPREAD	90.7 M	NET 4.53 KNOTS
	WARP LENGTH	18854.4 M	
FULL SCALE	DEPTH	3139.0 M	
	WARP/DEPTH	6.0	
	HEADLINE HEIGHT	14.13 M	
	WARP TENSION(P+S)	13.344 TONNES	
	GEAR DRAG	13.157 TONNES	
RUN	2	4.38 KNOTS SIMULATION	CORRECT DOOR SPREAD
SEA TRIALS			
BLOCK 3	SCALE	25	MODEL SPEED
	WARP LENGTH	5.64 M	PORT WING 0.467 M/S
	BRIDLE LENGTH	4.42 M	HEADLINE 0.424 M/S
	WINGEND SPREAD	1.40 M	CENTRE 0.445 M/S
	DOOR SPREAD	3.66 M	FOOTROPE 0.467 M/S
MODEL	TOW POINT HEIGHT	0.91 M	STBD WING 0.451 M/S
	TOW POINT SPREAD	3.70 M	
	HEADLINE HEIGHT	0.928 M	
	WARP TENSION-PORT	0.500 KGS	
	WARP TENSION-STBD	0.464 KGS	
	BRIDLE LENGTH	110.5 M	FULL SCALE SPEED
	WINGEND SPREAD	35.1 M	
	DOOR SPREAD	91.4 M	NET 4.38 KNOTS
	WARP LENGTH	- M	
FULL SCALE	DEPTH	- M	
	WARP/DEPTH	6.2	
	HEADLINE HEIGHT	23.20 M	
	WARP TENSION(P+S)	15.063 TONNES	
	GEAR DRAG	14.863 TONNES	

APPENDIX III

300 H.P. BALLOON TRAWL

RUN	18	3.00 KNOTS SIMULATION	CORRECT WARP LENGTH
SEA TRIALS			
BLOCK 8	SCALE	10	MODEL SPEED
	WARP LENGTH	5.64 M	PORT DOOR 0.509 M/S
	BRIDLE LENGTH	4.88 M	PORT WING 0.485 M/S
	WINGEND SPREAD	1.31 M	CENTRE 0.512 M/S
	DOOR SPREAD	2.96 M	STBD WING 0.501 M/S
MODEL	TOW POINT HEIGHT	1.22 M	STBD DOOR 0.515 M/S
	TOW POINT SPREAD	1.90 M	
	HEADLINE HEIGHT	0.375 M	
	WARP TENSION-PORT	1.180 KGS	
	WARP TENSION-STBD	1.150 KGS	
	BRIDLE LENGTH	94.8 M	FULL SCALE SPEED
	WINGEND SPREAD	13.1 M	
	DOOR SPREAD	45.1 M	NET 3.07 KNOTS
	WARP LENGTH	240.7 M	OVERALL 3.10 KNOTS
FULL SCALE	DEPTH	52.0 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	3.75 M	
	WARP TENSION(P+S)	2.330 TONNES	
	GEAR DRAG	2.264 TONNES	
RUN	19	3.00 KNOTS SIMULATION	CORRECT DOOR SPREAD
SEA TRIALS			
BLOCK 8	SCALE	10	MODEL SPEED
	WARP LENGTH	5.64 M	PORT DOOR 0.509 M/S
	BRIDLE LENGTH	4.88 M	PORT WING 0.515 M/S
	WINGEND SPREAD	1.52 M	CENTRE 0.504 M/S
	DOOR SPREAD	3.60 M	STBD WING 0.520 M/S
MODEL	TOW POINT HEIGHT	1.22 M	STBD DOOR 0.509 M/S
	TOW POINT SPREAD	3.20 M	
	HEADLINE HEIGHT	0.328 M	
	WARP TENSION-PORT	1.194 KGS	
	WARP TENSION-STBD	1.149 KGS	
	BRIDLE LENGTH	94.8 M	FULL SCALE SPEED
	WINGEND SPREAD	15.2 M	
	DOOR SPREAD	55.5 M	NET 3.15 KNOTS
	WARP LENGTH	789.4 M	OVERALL 3.14 KNOTS
FULL SCALE	DEPTH	170.7 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	3.28 M	
	WARP TENSION(P+S)	2.343 TONNES	
	GEAR DRAG	2.286 TONNES	

RUN	20	2.75 KNOTS SIMULATION	CORRECT WARP LENGTH
SEA TRIALS			
BLOCK 8	SCALE	10	MODEL SPEED
MODEL	WARP LENGTH	5.64 M	PORT DOOR 0.459 M/S
	BRIDLE LENGTH	4.88 M	PORT WING 0.459 M/S
	WINGEND SPREAD	1.30 M	CENTRE 0.456 M/S
	DOOR SPREAD	2.93 M	STBD WING 0.467 M/S
	TOW POINT HEIGHT	1.22 M	STBD DOOR 0.459 M/S
	TOW POINT SPREAD	1.90 M	
	HEADLINE HEIGHT	0.403 M	
	WARP TENSION-PORT	1.025 KGS	
	WARP TENSION-STBD	1.010 KGS	
		BRIDLE LENGTH	94.8 M
	WINGEND SPREAD	13.0 M	
	DOOR SPREAD	44.6 M	NET 2.83 KNOTS
	WARP LENGTH	245.4 M	OVERALL 2.83 KNOTS
FULL SCALE	DEPTH	53.1 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	4.03 M	
	WARP TENSION(P+S)	2.035 TONNES	
	GEAR DRAG	1.978 TONNES	
RUN	21	2.75 KNOTS SIMULATION	CORRECT DOOR SPREAD
SEA TRIALS			
BLOCK 8	SCALE	10	MODEL SPEED
MODEL	WARP LENGTH	5.64 M	PORT DOOR 0.461 M/S
	BRIDLE LENGTH	4.88 M	PORT WING 0.472 M/S
	WINGEND SPREAD	1.51 M	CENTRE 0.456 M/S
	DOOR SPREAD	3.54 M	STBD WING 0.475 M/S
	TOW POINT HEIGHT	1.22 M	STBD DOOR 0.456 M/S
	TOW POINT SPREAD	3.20 M	
	HEADLINE HEIGHT	0.360 M	
	WARP TENSION-PORT	1.041 KGS	
	WARP TENSION-STBD	1.016 KGS	
		BRIDLE LENGTH	94.8 M
	WINGEND SPREAD	15.1 M	
	DOOR SPREAD	54.5 M	NET 2.87 KNOTS
	WARP LENGTH	915.2 M	OVERALL 2.85 KNOTS
FULL SCALE	DEPTH	197.9 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	3.60 M	
	WARP TENSION(P+S)	2.057 TONNES	
	GEAR DRAG	2.007 TONNES	

RUN	22	2.50 KNOTS SIMULATION	CORRECT WARP LENGTH
SEA TRIALS			
BLOCK 8	SCALE	10	MODEL SPEED
	WARP LENGTH	5.64 M	PORT DOOR 0.427 M/S
	BRIDLE LENGTH	4.88 M	PORT WING 0.416 M/S
	WINGEND SPREAD	1.28 M	CENTRE 0.419 M/S
	DOOR SPREAD	2.80 M	STBD WING 0.427 M/S
MODEL	TOW POINT HEIGHT	1.22 M	STBD DOOR 0.429 M/S
	TOW POINT SPREAD	1.80 M	
	HEADLINE HEIGHT	0.447 M	
	WARP TENSION-PORT	0.923 KGS	
	WARP TENSION-STBD	0.872 KGS	
	BRIDLE LENGTH	94.8 M	FULL SCALE SPEED
	WINGEND SPREAD	12.8 M	
	DOOR SPREAD	42.4 M	NET 2.58 KNOTS
	WARP LENGTH	238.2 M	OVERALL 2.60 KNOTS
FULL SCALE	DEPTH	51.5 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	4.47 M	
	WARP TENSION(P+S)	1.795 TONNES	
	GEAR DRAG	1.745 TONNES	

RUN	23	2.50 KNOTS SIMULATION	CORRECT DOOR SPREAD
SEA TRIALS			
BLOCK 8	SCALE	10	MODEL SPEED
	WARP LENGTH	5.64 M	PORT DOOR 0.416 M/S
	BRIDLE LENGTH	4.88 M	PORT WING 0.424 M/S
	WINGEND SPREAD	1.52 M	CENTRE 0.411 M/S
	DOOR SPREAD	3.47 M	STBD WING 0.424 M/S
MODEL	TOW POINT HEIGHT	1.22 M	STBD DOOR 0.407 M/S
	TOW POINT SPREAD	3.30 M	
	HEADLINE HEIGHT	0.386 M	
	WARP TENSION-PORT	0.901 KGS	
	WARP TENSION-STBD	0.841 KGS	
	BRIDLE LENGTH	94.8 M	FULL SCALE SPEED
	WINGEND SPREAD	15.2 M	
	DOOR SPREAD	53.2 M	NET 2.58 KNOTS
	WARP LENGTH	1715.5 M	OVERALL 2.56 KNOTS
FULL SCALE	DEPTH	370.9 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	3.86 M	
	WARP TENSION(P+S)	1.742 TONNES	
	GEAR DRAG	1.701 TONNES	

RUN 24 2.50 KNOTS SIMULATION CORRECT WINGEND SPREAD

SEA TRIALS  
BLOCK 8

SCALE 10 MODEL SPEED

MODEL	WARP LENGTH	5.64 M	
	BRIDLE LENGTH	4.88 M	PORT WING 0.427 M/S
	WINGEND SPREAD	1.39 M	CENTRE 0.413 M/S
	DOOR SPREAD	3.08 M	STBD WING 0.432 M/S
	TOW POINT HEIGHT	1.22 M	
	TOW POINT SPREAD	2.60 M	
	HEADLINE HEIGHT	0.425 M	
	WARP TENSION-PORT	0.941 KGS	
	WARP TENSION-STBD	0.873 KGS	

FULL SCALE	BRIDLE LENGTH	94.8 M	FULL SCALE SPEED
	WINGEND SPREAD	13.9 M	
	DOOR SPREAD	46.7 M	NET 2.61 KNOTS
	WARP LENGTH	550.9 M	
	DEPTH	119.1 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	4.25 M	
	WARP TENSION(P+S)	1.814 TONNES	
GEAR DRAG	1.769 TONNES		

RUN 25 2.75 KNOTS SIMULATION CORRECT WINGEND SPREAD

SEA TRIALS  
BLOCK 8

SCALE 10 MODEL SPEED

MODEL	WARP LENGTH	5.64 M	
	BRIDLE LENGTH	4.88 M	PORT WING 0.469 M/S
	WINGEND SPREAD	1.37 M	CENTRE 0.448 M/S
	DOOR SPREAD	3.14 M	STBD WING 0.469 M/S
	TOW POINT HEIGHT	1.22 M	M/S
	TOW POINT SPREAD	2.60 M	
	HEADLINE HEIGHT	0.385 M	
	WARP TENSION-PORT	1.059 KGS	
	WARP TENSION-STBD	1.001 KGS	

FULL SCALE	BRIDLE LENGTH	94.8 M	FULL SCALE SPEED
	WINGEND SPREAD	13.7 M	
	DOOR SPREAD	48.1 M	NET 2.84 KNOTS
	WARP LENGTH	502.5 M	
	DEPTH	108.7 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	3.85 M	
	WARP TENSION(P+S)	2.060 TONNES	
GEAR DRAG	2.009 TONNES		

RUN 26 3.00 KNOTS SIMULATION CORRECT WINGEND SPREAD

SEA TRIALS  
BLOCK 8

SCALE 10 MODEL SPEED

MODEL	WARP LENGTH	5.64 M	
	BRIDLE LENGTH	4.88 M	PORT WING 0.504 M/S
	WINGEND SPREAD	1.34 M	CENTRE 0.489 M/S
	DOOR SPREAD	3.17 M	STBD WING 0.509 M/S
	TOW POINT HEIGHT	1.22 M	
	TOW POINT SPREAD	2.60 M	
	HEADLINE HEIGHT	0.359 M	
	WARP TENSION-PORT	1.160 KGS	
	WARP TENSION-STBD	1.110 KGS	

FULL SCALE	BRIDLE LENGTH	94.8 M	FULL SCALE SPEED
	WINGEND SPREAD	13.4 M	
	DOOR SPREAD	49.0 M	NET 3.08 KNOTS
	WARP LENGTH	484.4 M	
	DEPTH	104.7 M	
	WARP/DEPTH	4.6	
	HEADLINE HEIGHT	3.59 M	
	WARP TENSION(P+S)	2.270 TONNES	
	GEAR DRAG	2.213 TONNES	

## APPENDIX IV

### 150 H.P. DUAL PURPOSE TRAWL

RUN	1	2.50 KNOTS SIMULATION	CORRECT WARP LENGTH
SEA TRIALS			
BLOCK	7,8	SCALE	10
			MODEL SPEED
MODEL		WARP LENGTH	3.81 M
		BRIDLE LENGTH	6.57 M
		WINGEND SPREAD	0.98 M
		DOOR SPREAD	3.20 M
		TOW POINT HEIGHT	0.73 M
		TOW POINT SPREAD	2.40 M
		HEADLINE HEIGHT	0.205 M
		WARP TENSION-PORT	0.512 KGS
		WARP TENSION-STBD	0.543 KGS
			PORT WING 0.424 M/S
			CENTRE 0.419 M/S
			STBD WING 0.429 M/S
			STBD DOOR 0.416 M/S
FULL SCALE		BRIDLE LENGTH	84.1 M
		WINGEND SPREAD	9.8 M
		DOOR SPREAD	38.3 M
		WARP LENGTH	182.1 M
		DEPTH	35.0 M
		WARP/DEPTH	5.2
		HEADLINE HEIGHT	2.05 M
		WARP TENSION(P+S)	1.055 TONNES
		GEAR DRAG	1.029 TONNES
			NET 2.61 KNOTS
			OVERALL 2.57 KNOTS
RUN	2	2.75 KNOTS SIMULATION	CORRECT WARP LENGTH
SEA TRIALS			
BLOCK	7,8	SCALE	10
			MODEL SPEED
MODEL		WARP LENGTH	3.81 M
		BRIDLE LENGTH	6.57 M
		WINGEND SPREAD	0.98 M
		DOOR SPREAD	3.23 M
		TOW POINT HEIGHT	0.73 M
		TOW POINT SPREAD	2.50 M
		HEADLINE HEIGHT	0.187 M
		WARP TENSION-PORT	0.594 KGS
		WARP TENSION-STBD	0.613 KGS
			PORT WING 0.461 M/S
			CENTRE 0.456 M/S
			STBD WING 0.464 M/S
			STBD DOOR 0.443 M/S
FULL SCALE		BRIDLE LENGTH	84.1 M
		WINGEND SPREAD	9.8 M
		DOOR SPREAD	38.6 M
		WARP LENGTH	201.4 M
		DEPTH	38.7 M
		WARP/DEPTH	5.2
		HEADLINE HEIGHT	1.87 M
		WARP TENSION(P+S)	1.207 TONNES
		GEAR DRAG	1.179 TONNES
			NET 2.83 KNOTS
			OVERALL 2.78 KNOTS

RUN 3 3.00 KNOTS SIMULATION CORRECT WARP LENGTH

SEA TRIALS  
BLOCK 7,8

SCALE 10 MODEL SPEED

MODEL	WARP LENGTH	3.81 M	PORT DOOR	0.485 M/S
	BRIDLE LENGTH	6.57 M	PORT WING	0.496 M/S
	WINGEND SPREAD	0.98 M	CENTRE	0.493 M/S
	DOOR SPREAD	3.26 M	STBD WING	0.496 M/S
	TOW POINT HEIGHT	0.73 M	STBD DOOR	0.480 M/S
	TOW POINT SPREAD	2.50 M		
	HEADLINE HEIGHT	0.183 M		
	WARP TENSION-PORT	0.702 KGS		
	WARP TENSION-STBD	0.665 KGS		

FULL SCALE	BRIDLE LENGTH	84.1 M	FULL SCALE SPEED	
	WINGEND SPREAD	9.8 M		
	DOOR SPREAD	39.0 M	NET	3.04 KNOTS
	WARP LENGTH	195.3 M	OVERALL	3.01 KNOTS
	DEPTH	37.5 M		
	WARP/DEPTH	5.2		
	HEADLINE HEIGHT	1.83 M		
	WARP TENSION(P+S)	1.367 TONNES		
	GEAR DRAG	1.335 TONNES		

RUN 4 2.50 KNOTS SIMULATION CORRECT DOOR SPREAD

SEA TRIALS  
BLOCK 7,8

SCALE 10 MODEL SPEED

MODEL	WARP LENGTH	4.72 M	PORT DOOR	0.416 M/S
	BRIDLE LENGTH	5.79 M	PORT WING	0.416 M/S
	WINGEND SPREAD	1.16 M	CENTRE	0.408 M/S
	DOOR SPREAD	4.02 M	STBD WING	0.424 M/S
	TOW POINT HEIGHT	0.91 M	STBD DOOR	0.424 M/S
	TOW POINT SPREAD	3.70 M		
	HEADLINE HEIGHT	0.170 M		
	WARP TENSION-PORT	0.526 KGS		
	WARP TENSION-STBD	0.537 KGS		

FULL SCALE	BRIDLE LENGTH	84.1 M	FULL SCALE SPEED	
	WINGEND SPREAD	11.6 M		
	DOOR SPREAD	53.2 M	NET	2.56 KNOTS
	WARP LENGTH	777.3 M	OVERALL	2.57 KNOTS
	DEPTH	150.4 M		
	WARP/DEPTH	5.2		
	HEADLINE HEIGHT	1.70 M		
	WARP TENSION(P+S)	1.063 TONNES		
	GEAR DRAG	1.042 TONNES		

RUN 5 2.75 KNOTS SIMULATION CORRECT DOOR SPREAD

SEA TRIALS  
BLOCK 7,8

SCALE 10 MODEL SPEED

MODEL	WARP LENGTH	4.72 M	PORT DOOR	0.467 M/S
	BRIDLE LENGTH	5.79 M	PORT WING	0.467 M/S
	WINGEND SPREAD	1.16 M	CENTRE	0.461 M/S
	DOOR SPREAD	4.05 M	STBD WING	0.477 M/S
	TOW POINT HEIGHT	0.91 M	STBD DOOR	0.480 M/S
	TOW POINT SPREAD	3.70 M		
	HEADLINE HEIGHT	0.157 M		
	WARP TENSION-PORT	0.624 KGS		
	WARP TENSION-STBD	0.657 KGS		

FULL SCALE	BRIDLE LENGTH	84.1 M	FULL SCALE SPEED	
	WINGEND SPREAD	11.6 M		
	DOOR SPREAD	53.6 M	NET	2.88 KNOTS
	WARP LENGTH	716.3 M	OVERALL	2.89 KNOTS
	DEPTH	138.6 M		
	WARP/DEPTH	5.2		
	HEADLINE HEIGHT	1.57 M		
	WARP TENSION(P+S)	1.281 TONNES		
	GEAR DRAG	1.256 TONNES		

RUN 6 3.00 KNOTS SIMULATION CORRECT DOOR SPREAD

SEA TRIALS  
BLOCK 7,8

SCALE 10 MODEL SPEED

MODEL	WARP LENGTH	4.72 M	PORT DOOR	0.498 M/S
	BRIDLE LENGTH	5.79 M	PORT WING	0.498 M/S
	WINGEND SPREAD	1.19 M	CENTRE	0.489 M/S
	DOOR SPREAD	4.05 M	STBD WING	0.509 M/S
	TOW POINT HEIGHT	0.91 M	STBD DOOR	0.509 M/S
	TOW POINT SPREAD	3.70 M		
	HEADLINE HEIGHT	0.150 M		
	WARP TENSION-PORT	0.689 KGS		
	WARP TENSION-STBD	0.740 KGS		

FULL SCALE	BRIDLE LENGTH	84.1 M	FULL SCALE SPEED	
	WINGEND SPREAD	11.9 M		
	DOOR SPREAD	53.5 M	NET	3.06 KNOTS
	WARP LENGTH	714.4 M	OVERALL	3.08 KNOTS
	DEPTH	138.3 M		
	WARP/DEPTH	5.2		
	HEADLINE HEIGHT	1.50 M		
	WARP TENSION(P+S)	1.429 TONNES		
	GEAR DRAG	1.401 TONNES		