SEA FISH INDUSTRY AUTHORITY

Industrial Development Unit

TOWING REQUIREMENTS FOR A DEMERSAL PAIR TRAWL

(2 x 340 H.P. VESSELS)

Technical Report No. 256

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C. Brady

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SUMMARY

This report contains the performance data of a F.M.A. Buckie Pair Trawl - BT154 rigged with two bridles and Rockhopper gear.

The net was towed between two vessels - the Aquila and the Poseidon - each having nominally 365 H.P. installed. The vessels were instrumented to record the performance parameters and will be the subject of further investigations to be covered in a later report.

The trials were carried out in March 1984 jointly by the SFIA and DAFS who instrumented the trawl. It is from DAFS recorded measurements of the net that this report has been compiled.

The report expresses the power requirements in terms of warp tensions and settings of net speed, warp length and vessel distance. While it would have been of greater convenience to fishermen to use horsepower or fuel flow rather than warp tension as an indicator of vessel performance, an assumed pull/power characteristic would not be valid for other vessels. The two vessels used in the trials had dissimilar characteristics; the reasonS for this are being investigated and will be discussed in a later report. The requirement for any net setting are defined and the data is presented in a manner which can readily be used by skippers provided that their vessels are equipped with warp tension meters.

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1 INTRODUCTION

The trials described herein form part of the fuel conservation investigations commissioned by the Ministry of Agriculture, Fisheries and Food. (Commission A.1.3 JAB16).

The overall aim of the trials was to obtain information which may enable comparisons to be made of net efficiencies in terms of volume of water fished per unit work done and also to obtain data on vessel performance for correlation with prediction.

The trawl net is a F.M.A. Buckie Pair Trawl - BT154 rigged with two bridles and Rockhopper gear and was towed between two vessels - the Aquila and the Poseidon - each having nominally 365 installed horsepower. The trials were carried out during March 1984 in Broad Bay - Isle of Lewis - jointly by the SFIA and DAFS.

A measure of work done to tow the net may be expressed in terms of warp tension and in this manner is applicable regardless of the vessels towing it. The power requirements of the two vessels used in these trials and the relationships to the net and warp tensions will be the subject of a further report. This report therefore expresses the power requirements in terms of warp tensions and is addressed to defining the settings of speed, warp length and vessel distance, to give the best efficiency with respect to warp tension for any defined net opening. The data is presented in a manner which can readily be used by commercial vessels provided they are fitted with warp load meters. Data on actual powers recorded on the vessels has been analysed but is not presented here since the trials vessels had widely dissimilar power/pull characteristics and power or fuel consumption values would not necessarily be valid for other vessels.

The trials were carried out in conjunction with DAFS who instrumented the trawl. It is from their measurements that the data given in this report has been compiled. The engineering performance, geometery and drag of the various gear components will be reported by DAFS.

It is known that the angular arrangement of the warps has an effect on the efficiency of the gear because of their herding effect on the fish. This cannot be quantified by these trials and skippers must use their own experience to guide them. However the report does give an indication of the change in power demands and net opening when the settings of the warps are changed. Skippers may use this to assess whether the change in power and thus fuel is justified.

2 TRAWL DESCRIPTION

The trawl net chosen for the trials was F.M.A. Buckie Pair Trawl - BT154. This is a commercial two panel balloon trawl designed by the Buckie F.M.A. and a drawing is given in Appendix I.

As the design is confidential to FMA Buckie only the basic parameters are given.

The net was primarily rigged with Rockhopper gear on a two bridle rig though measurements were also recorded with the net having a 3 bridle rig and also when rigged with conventional bobbins. These latter two rigs are diagrammatically detailed in Appendix II.

The technical details are as follows:

Net		
Headline	37.5 metres (1.55m+14.6m+5.2m+14.6m+1.55m)	..(123 ft)
Footrope	45.8 metres (0.6m+7.0m+30.5m+7.0m+0.6m)	..(150 ft)
Hoppers	30.5 metres	..(100 ft)
Chain Leg	7.0 metres	..(23 ft)
Adjust Chain	0.9 metres	..(3 ft)
Floats	36 x 280 mm	..(11 in)
Bridles		
Upper	55.0 metres	..(180 ft)
Middle	27.5 metres	..(90 ft)
Lower	55.0 metres	..(180 ft)
Sweeps	91.5 metres	..(300 ft)
Bobbins	6.1 metres	..(20 ft)

3 VESSEL DESCRIPTIONS

The two vessels towing the net were the AQUILA - BCK 214, and the POSEIDON - BF 191. Both vessels are typical Scottish trawler seiners constructed in wood and fitted with three quarter length aluminium shelters. Outline technical specifications are as follows.

3.1 Aquila

Dimensions

Length Overall	16.76 m
Length Registered	15.24 m
Breadth	5.49 m
Depth	2.74 m

Configuration

Conventional round bilge hull form with transom stern. Closed aluminium shelter extending from stem to aft side of wheelhouse. The main hull is subdivided into five compartments viz:

fore peak
fishroom
engine room
crews cabin
steering gear compartment

Machinery

Main Engine - Caterpillar D343 nominally rated at 365 HP @ 1800 RPM

Gearbox - Caterpillar twin disc with 4.5:1 ratio

Propeller - Brunton 'Superston 70' 4 bladed 52in dia 40in pitch right hand.

3.2 Poseidon

Dimensions

Length Overall	... 19.20 m
Length Registered	... 17.98 m
Breadth	... 6.50 m
Depth	... 3.76 m

Configuration

Conventional round bilge hull form with transom stern. Closed aluminium shelter extending from stem to aft side of wheelhouse. The main hull is subdivided into five compartments viz:

fore peak
fishroom
engine room
crews cabin
steering gear compartment

Machinery

Main Engine - Caterpillar D343 nominally rated at 365 HP @ 1800 RPM

Gearbox - Caterpillar twin disc with 4.5:1 ratio

Propeller - Brunton manufacture 4 bladed 56in dia 37in pitch right hand.

4 TRIALS LOG

27th February 1984

Final instrumentation of vessels and net completed in Stornoway.

28th February

Preliminary tows carried out to test instrumentation. Tows terminated at 1500 hours due to worsening weather conditions.

29th February

Five tows carried out with part instrumentation prior to carrying out ten fully instrumented tows with 175 fathoms of warp out in a water depth of 12-26 fathoms.

1st March 1984

Five tows carried out with part instrumentation prior to carrying out ten full instrumented tows with 250 fathoms of warp out in a water depth of 45-56 fathoms.

5th March

Seven fully instrumented tows carried out with 350 fathom of warp out in a water depth of 47-58 fathoms. The gear became fast after the seventh tow and the trial was terminated for this warp length.

6th March

Ten fully instrumented tows carried out with 300 fathom of warp out in a water depth of 42-58 fathoms.

7th March

Six fully instrumented tows carried out with 300 fathom of warp out in a water depth of 46-55 fathoms and the net rigged with three bridles.

8th March

Nine fully instrumented tows carried out with 300 fathoms of warp out and five with 350 fathoms of warp out all using conventional bobbin gear. These tows were carried out in a water depth of 48-58 fathoms.

9th March

The trial now being complete the instrumentation was removed from the vessels.

5 PROCEDURE

All tows, with the exception of those with 175 fathom of warp out, were made on the same tow between Tiumpen Head and Tolsta Head across Broad Bay. Each tow consisted of up to 10 blocks (periods of 15 minutes whilst towing at constant RPM). Half the blocks were taken in one direction while the remainder were taken on the reciprocal course to allow tide corrections to be made.

Towing speeds and net speeds were measured using Braystoke logs. The warp tension at each of the vessels (position ref T1) was measured using strain gauge tension meters. Tensions were also recorded using self recording load cells, fitted at the following positions - (refer to Appendix I for diagram).

T2 warp - sweep connection
T3 mid sweeps
T4 sweep - bridle connection
T5 upper briddle-net
T6 lower bridle-net

Self recording acoustic meters were fitted to measure wing end spread, mid bridle spread, fore sweep spread and headline height. A manometer was also used to measure headline height.

The average results of the various recorded parameters supplied by DAFS are given in Appendix III.

6 DATA ANALYSIS

The recorded parameter values read in this analysis are summarised in Appendix IV. The values have been analysed in such a manner that tidal effects have been accounted for and the data examined collectively to enhance the analysis.

6.1 Derived Formula

In the analysis methods using multiple linear regression have been used to determine formula which give the best fit to the recorded values and enable graphical presentations to be derived for predicting the mouth opening of the net and the warp tension.

6.1.1 Single Warp Tension ~ W.T.

$$WT = \exp(-0.30524+0.3003*Vn+0.00027*W -0.0036*d+1.10046*D)$$

For 31 data points this formula predicts the warp tension with a standard deviation in proportional error of 0.049 and on average overestimates by 2.6%.

6.1.2 Horizontal Opening ~ Ho (Wing End Spread)

$$Ho = \exp(4.43014-0.02302*Vn-0.0039*W +1.66405*D-0.00142*d)$$

For 20 data points this formula predicts the Horizontal Opening with a standard deviation in proportional error of 0.018 and on average overestimates by 0.1%.

6.1.3 Vertical Opening ~ Vo (Headline Height)

$$Vo = \exp(3.46534 - 0.20779*Vn + 0.00254*W - 1.35148*D - 0.006926*d)$$

For 23 data points this formula predicts the Vertical Opening with a standard deviation in proportional error of 0.049 and on average underestimates by 0.1%

where	Vn	=	net speed	(knots)
	W	=	warp out	(fathoms)
	D	=	vessel distance	(naut. miles)
	d	=	water depth	(fathoms)

6.2 Comparison of Predicted and Recorded Values

Plots of the recorded values and the resulting curves derived from the analysis are shown in Figs. 1 to 11 inclusive.

Tabulated analysed values for nominated net speed values for the tows comprising the trial are given in Tables 1-3 for the average depths of water recorded on that tow. Tabulated predicted results for nominated values of warp, vessel distance, water depth and net speed are given in Tables 4-12.

7 RESULTS

The results of the analysis show that whilst holding the remainder of the variables constant (i.e. to consider net speed; warp, distance and depth remain constant), the effect of:

(i) increasing net speed gives - over an operating range of 2.4 to 3.8 knots

a) increased warp tension at a rate of 35% per knot
b) decreased horizontal opening at a rate of 2% per knot
c) decreased vertical opening at a rate of 19% per knot

(ii) increasing the length of warp out gives

a) increased warp tension at a rate of 1.4% per 50 fathoms
b) decreased horizontal opening at a rate of 2% per 50 fathoms
c) increased vertical opening at a rate of 13.5% per 50 fathoms

(iii) increasing the vessel distance apart

a) increased warp tension at a rate of 11% per 1/10th nautical mile
b) increased horizontal opening at a rate of 16.6% per 1/10th nautical mile
c) decreased vertical opening at a rate of 13.5% per 1/10th nautical mile

(iv) increasing water depth gives -

a) decreased warp tension at a rate of 3.6% per 10 fathoms

b) decreased horizontal opening at a rate of 1.4% per 10 fathoms

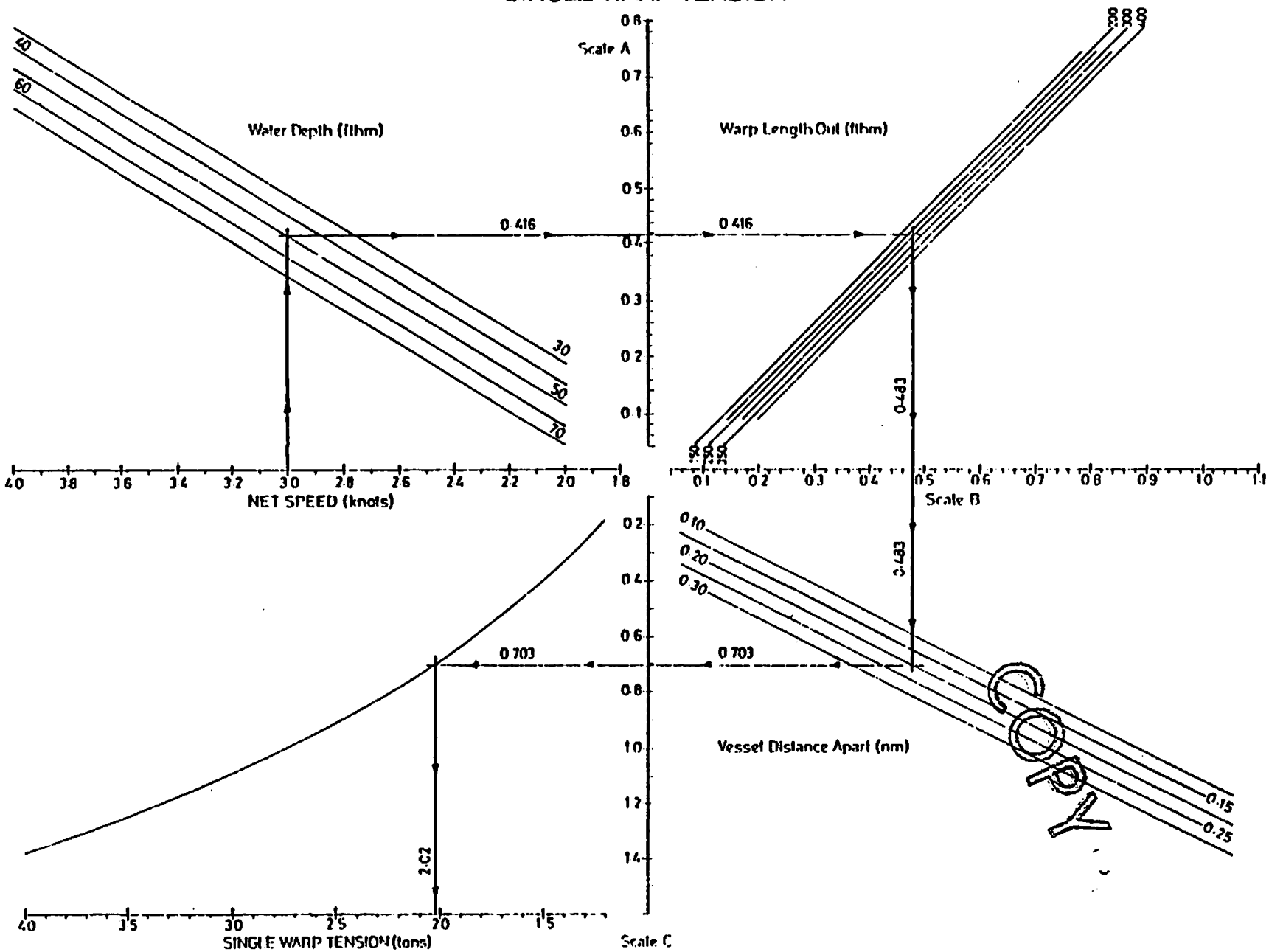
c) decreased vertical opening at a rate of 10.9% per 10 fathoms.

A tabulated summary of these results is given in Table 13.

In order that these results may be readily used a graphical method is presented from which the values of warp tension, horizontal opening, and vertical opening can be determined - ref. Figs. 15 to 26.

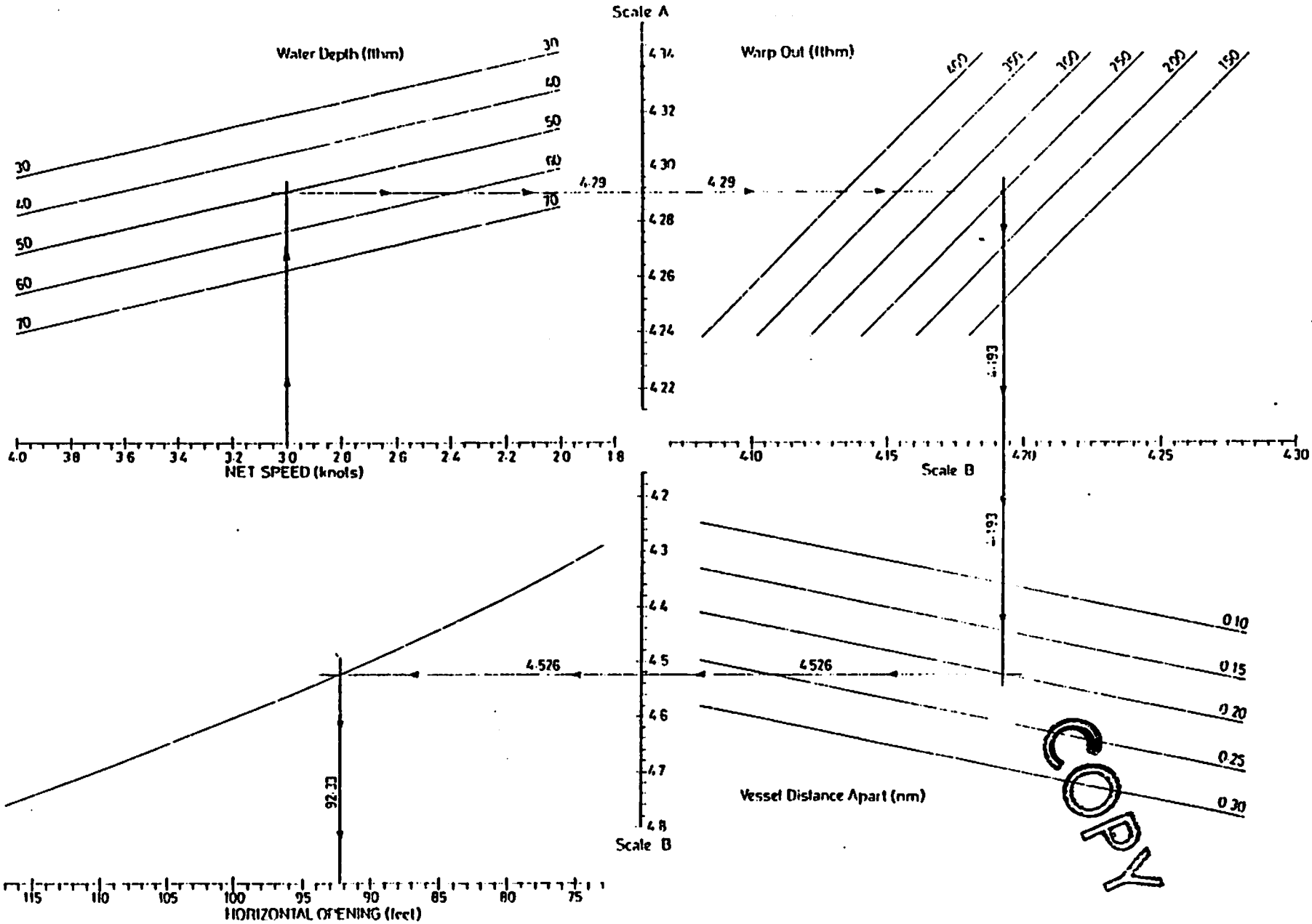
This presentation is based on the premise that the user is familiar with the grounds he wishes to fish and the type of fish to be caught. Using his knowledge and experience he will know therefore the speed required to catch the fish, the depth of water, and the net setting most suitable for the shoaling characteristics of that type of fish. A summary presentation - comprising three graphs - of Figs. 15 to 26 is given overleaf, and also in Appendix V. A combined cross plot of this data for a typical net speed of 3 knots is also given in Appendix V.

SINGLE WARP TENSION

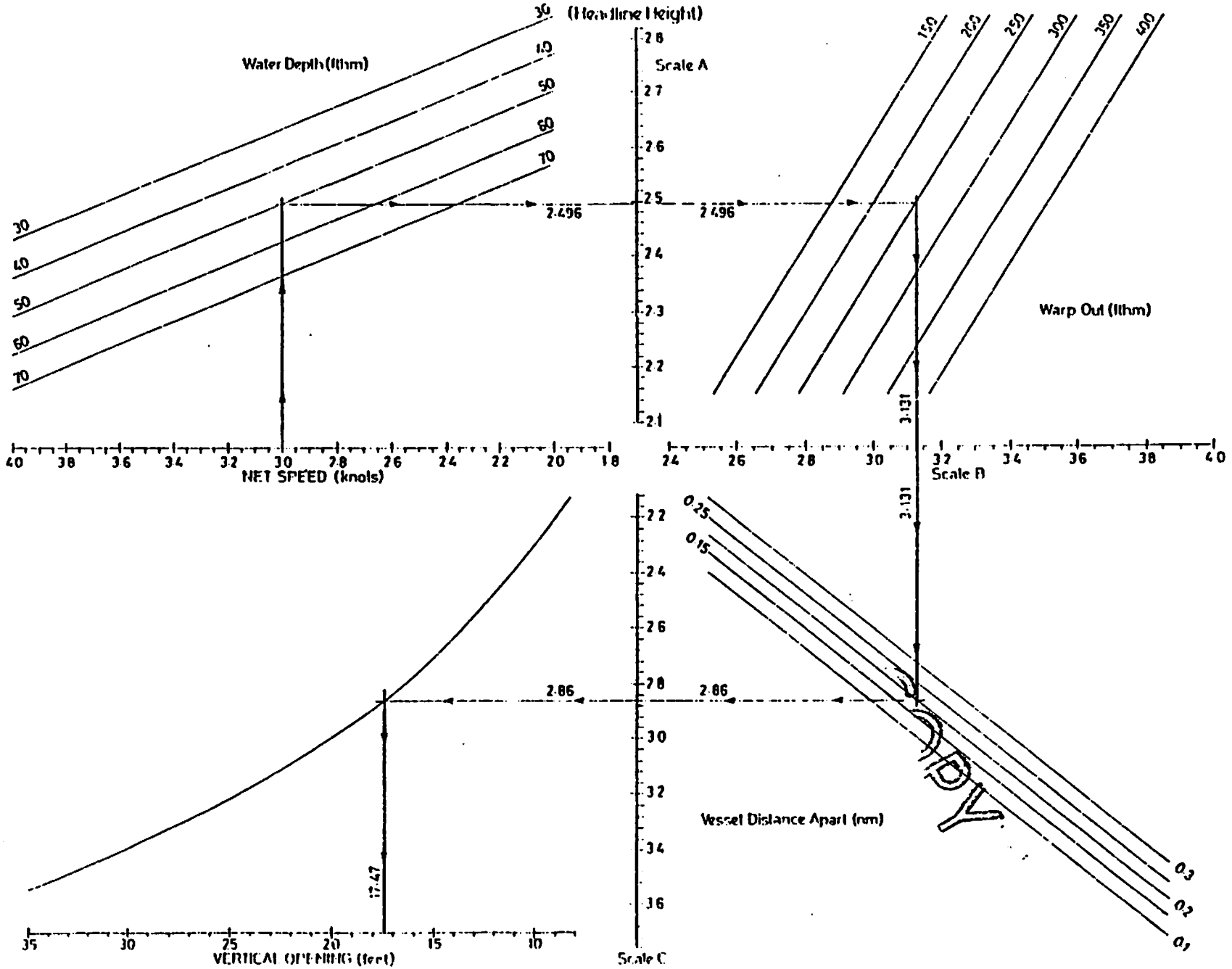


HORIZONTAL OPENING

(Wing End Spread)



VERTICAL OPENING



8 DISCUSSIONS

8.1 General

When a change in either vertical or horizontal opening is required it can be achieved by changing either vessel speed, warp out, vessel distance apart or a combination of these. The effects of changes in these variables is summarised in Table 13.

If an increase in warp tension is incurred then an increase in fuel consuption is also incurred. The potential increase in catch rate effected by a change in one or more of the above variables must justify the increase in fuel consumption. In order to assist skippers in making decisions which are relative to fuel costs a guide is necessary which relates fuel costs to warp tension. To this end it may be said that:

(i) whilst maintaining a constant net speed a change in warp tension of 10% will incur a change in fuel rate of approximately 20% (i.e. varying warp and vessel distance to change warp tension)

(ii) whilst maintaining constant warp and vessel distance a change in warp tension of 10% will incur a change in fuel rate of approximately 23% (i.e. varying vessel speed)

A tabulated summary of the changes incurred equivalent to a 10% increase in warp tension is given below.

For 10% increase in Warp Tension

Change incurred by	Amount of Change	Approximate % Change		
		Horizontal Opening	Vertical Opening	Fuel Rate
Speed	+ 0.3 knot	- 0.6	- 5.4	+23
Warp	+ 357 fathom	-14.3	+96.4	+20
Vessel Distance	+ 0.09 nm	+15.1	-12.3	+20
Depth	-27.8 fathom	-3.9	+30.3	+20

The vertical and horizontal openings decrease as net speed increases. The natural explanation for this is that as speed increased more of the sweepwire is pulled off the seabed by virtue of increasing the net resistance and this reduces the spreading force contributed by the friction between the sweeps and the seabed. This is in contrast to single boat trawling using trawl doors where higher net speeds usually give greater spreads.

8.2 **Horizontal Opening**

The horizontal opening decreases as speed, warp and water depth increases and increases as vessel distance increases. Referring to Table 13 it can be seen that in order to increase the horizontal opening an increase in vessel distance is the most efficient option.

e.g. to increase the horizontal opening by 15.1% the vessel distance should be increased by 0.09nm which incurs an increase in fuel rate of 20% and a decrease in vertical opening of 12.3%.

8.3 **Vertical Opening**

The vertical opening increases as warp increases and decreases as speed, vessel distance or water depth increases. Referring to the table above it can be seen that if a change in the vertical opening is required it is best achieved by either increasing the amount of warp out or by decreasing the vessel distance. To increase the vertical opening by 12.3% (a 10% increase in WT incurred) by either:-

increasing warp by 45 fathoms which would increase the fuel rate by 2.6% and decrease the horizontal opening by 1.8%

or

decreasing the vessel distance by 0.09nm which would decrease the fuel rate by 20% and also decrease the horizontal opening by 15.1%.

Thus it may be said that for a similar increase in vertical opening a fuel rate decrease of 20% and decrease in horizontal opening of 15.1% must be compared with a fuel increase of 2.6% and decrease in horizontal opeing together with the unquantifiable effect extra warp would have on herding the fish.

9 CONCLUSIONS

9.1 Horizontal Opening

The most effective and efficient method of changing the horizontal opening is by varying the distance apart of the vessels. Adjustments to the warp out or the speed of the vessel must be quantified in other terms to substantiate their use to change the horizontal opening. The effect of a change in depth is minimal -1.4% per 10 fathoms - and therefore a substantial change in depth is necessary to warrant an adjustment being made.

9.2 Vertical Opening

To effect a change in vertical opening the most effective method is a choice between changing the amount of warp out or changing the vessel distance. The former incurs little change in fuel consumption and horizontal opening but has an unquantifiable effect of warp on fish herding. The latter has a substantial effect on both fuel consumption and horizontal opening. The effect of a change in depth is also quite substantial - 30% per 10 fathoms and therefore adjustments to the vessel distance or warp out may be necessary when fishing on a shoaling tow.

9.3 Vessel Speed

A change in vessel speed to improve fishing effort must be used with caution since an increase in speed whilst only marginally effecting the set of the nets, does so negatively and incurs a substantial increase in fuel rate.

9.4 Warp

A change in the amount of warp out will incur a substantial change in vertical opening whilst giving only small changes in horizontal opening and fuel costs.

9.5 Vessel Distance

Changing the vessel distance is the most effective way of changing the set of the net. It does however give a greater percentage change in fuel rate then it does on either vertical or horizontal opening.

9.6 Water Depth

A variation in water depth substantially effects both the vertical opening and fuel rate. However, as depth changes the effects on vertical opening and fuel rate, in terms of efficiency, oppose each other.

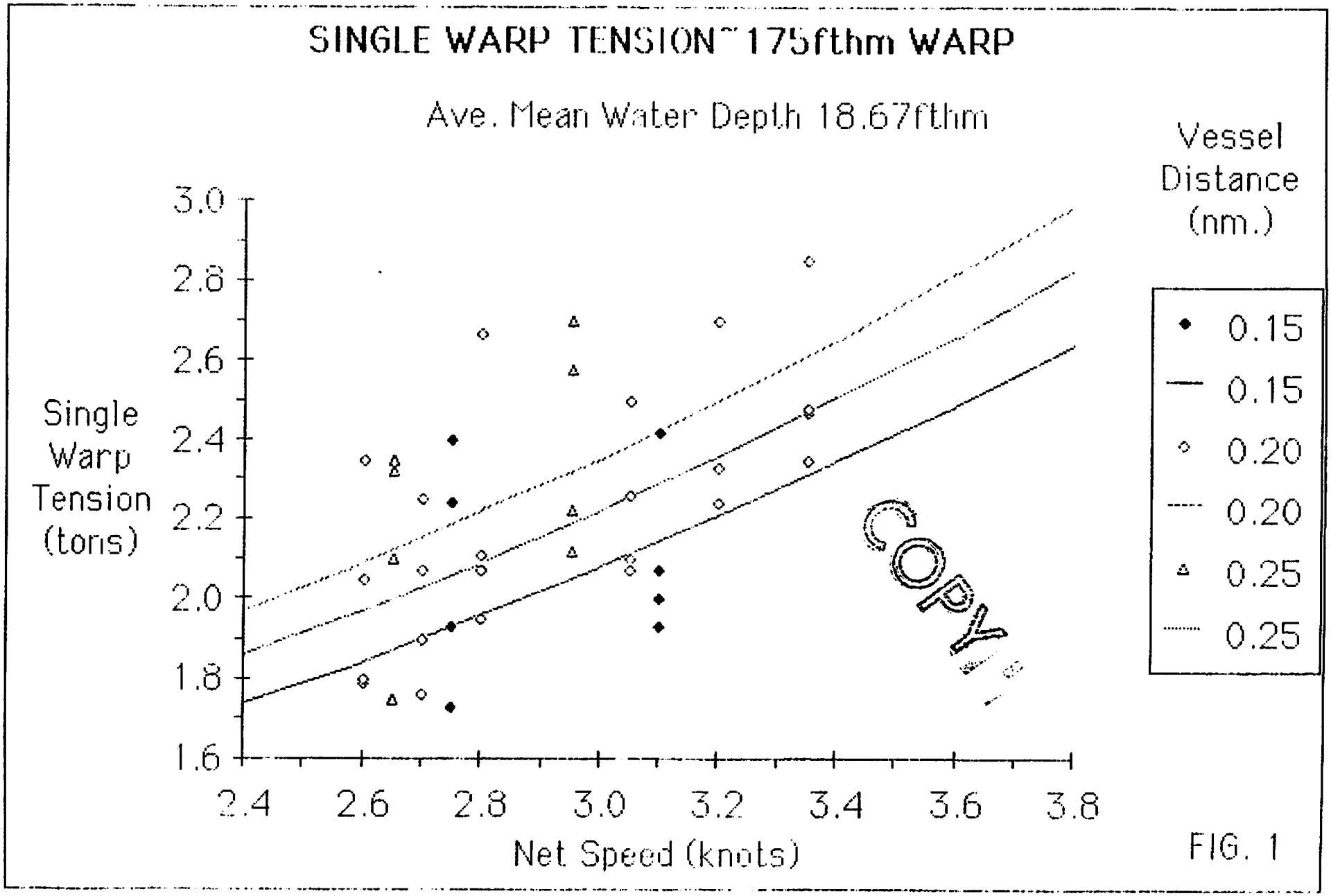

SINGLE WARP TENSION 175fthm WARP
Ave. Mean Water Depth 18.67fthm
Vessel Distance (nm.)
0.15
0.15
0.20
0.20
0.25
0.25
Single Warp Tension (tons)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)
COPY

FIG. 1

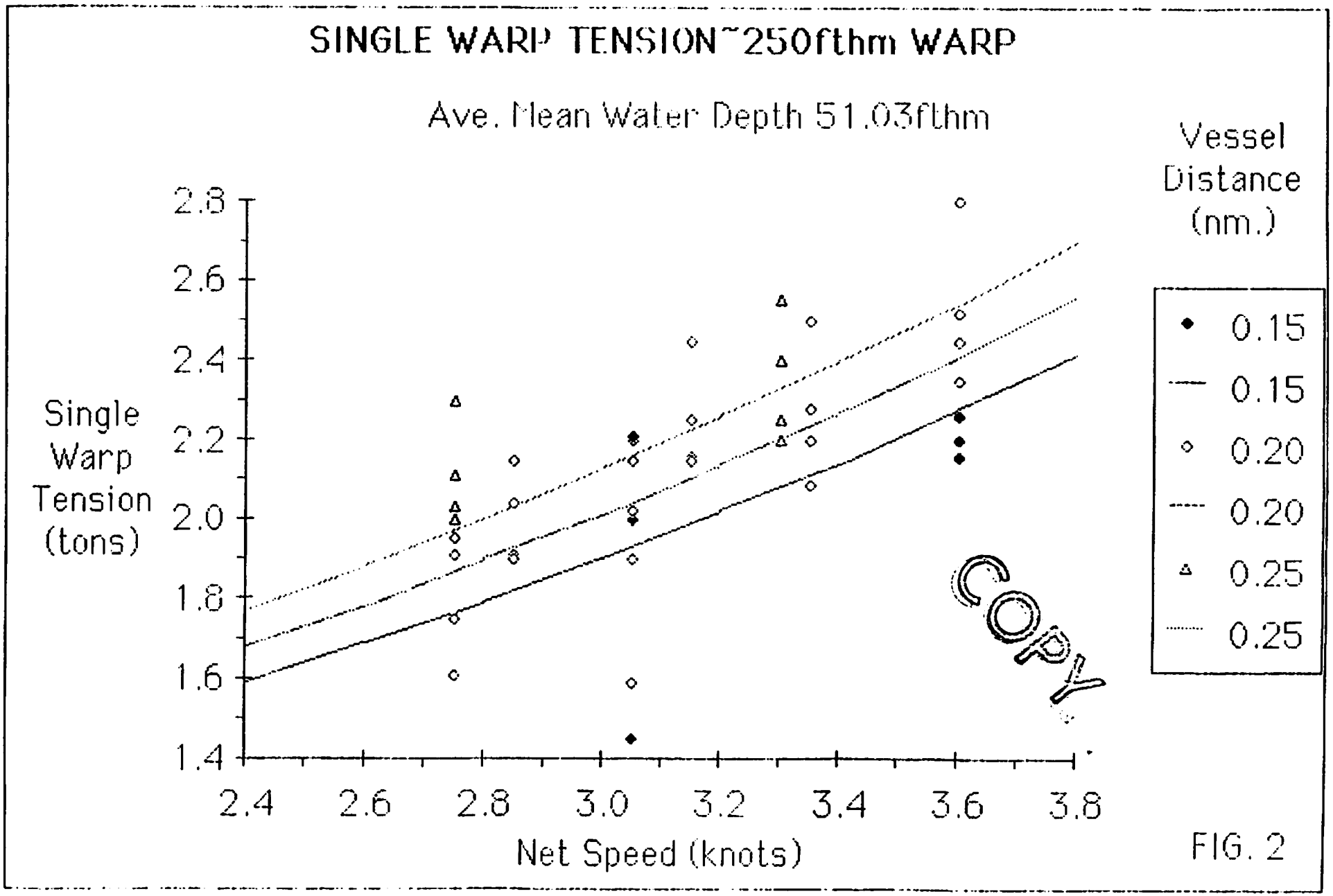

SINGLE WARP TENSION~250fthm WARP
Ave. Mean Water Depth 51.03fthm
Single Warp Tension (tons)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)
Vessel Distance (nm.)
0.15
0.15
0.20
0.20
0.25
0.25
COPY

FIG. 2

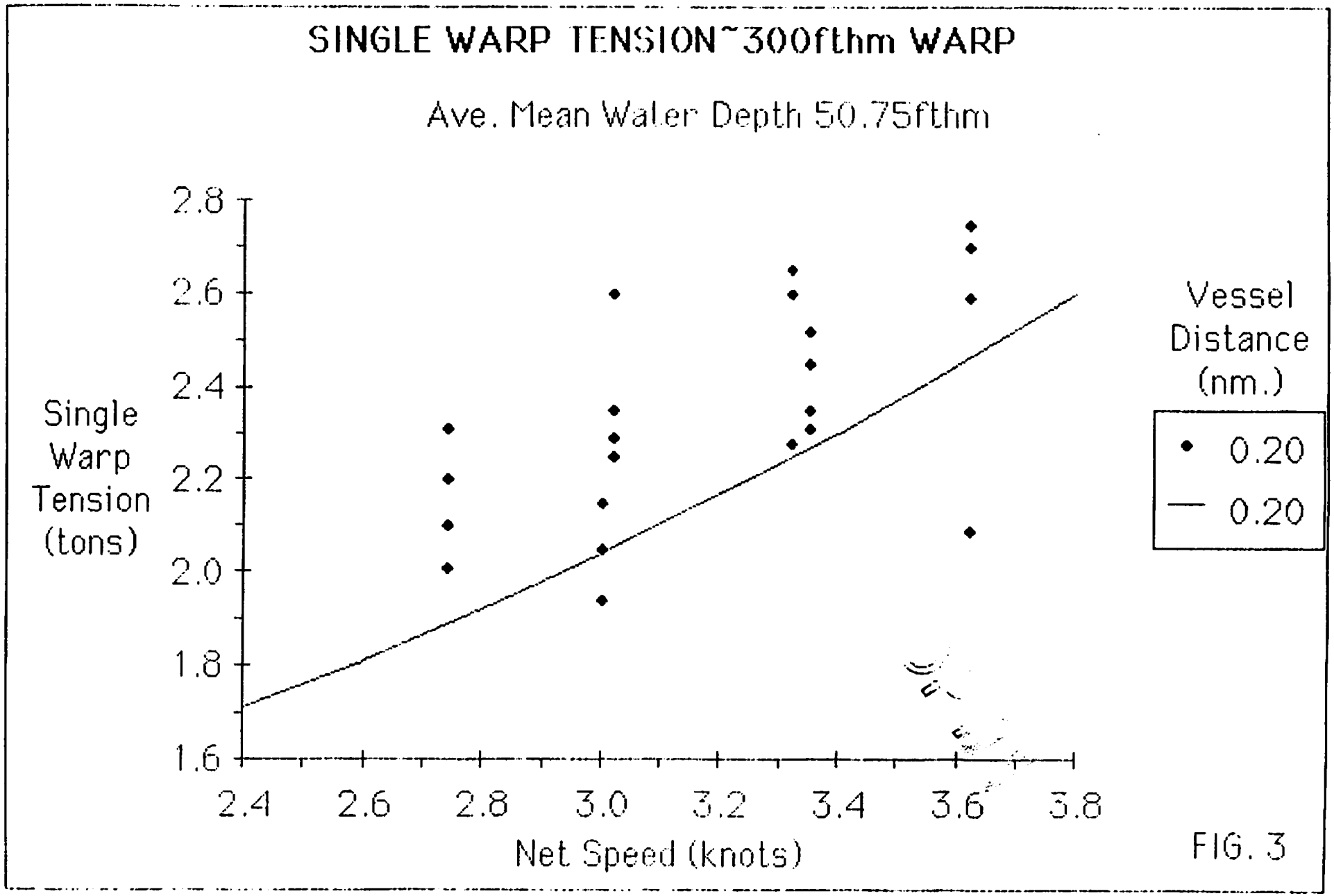

SINGLE WARP TENSION~300fthm WARP
Ave. Mean Water Depth 50.75fthm
Single Warp Tension (tons)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)
Vessel Distance (nm.)
0.20
0.20

FIG. 3

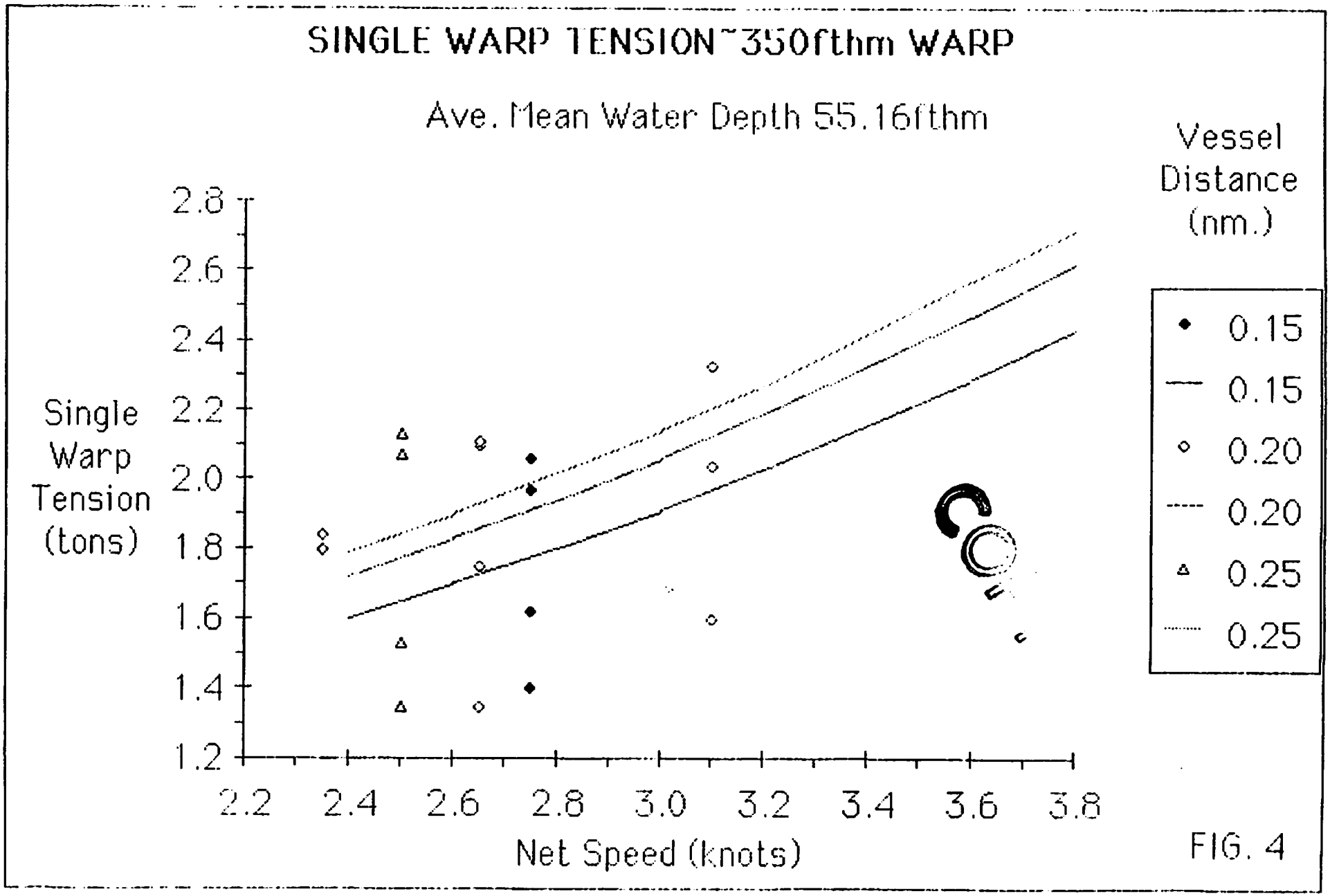

SINGLE WARP TENSION~350fthm WARP
Ave. Mean Water Depth 55.16fthm
Single Warp Tension (tons)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)
Vessel Distance (nm.)
0.15
0.15
0.20
0.20
0.25
0.25

FIG. 4

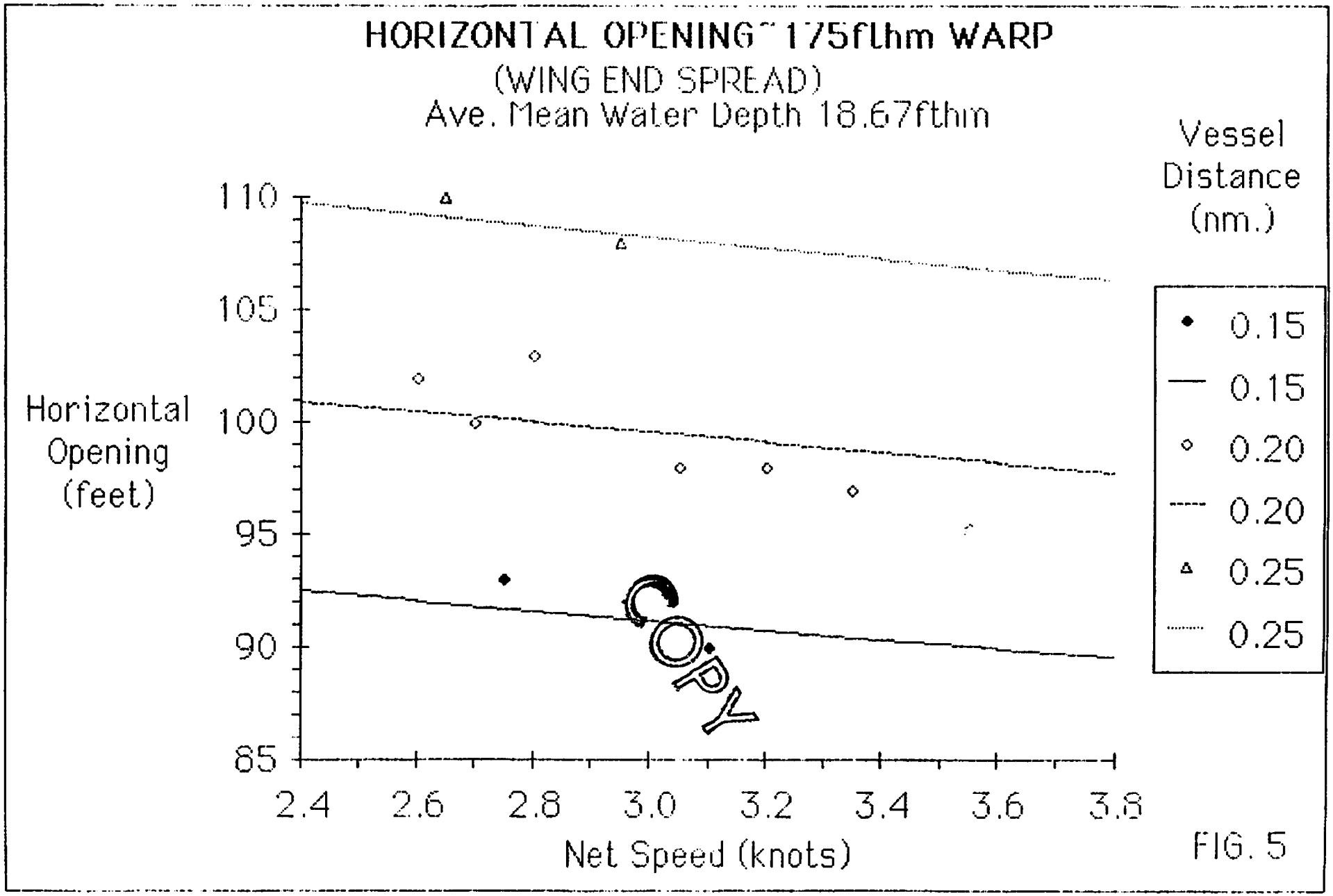

HORIZONTAL OPENING 175fthm WARP
(WING END SPREAD)
Ave. Mean Water Depth 18.67fthm
Vessel Distance (nm.)
0.15
0.15
0.20
0.20
0.25
0.25
Horizontal Opening (feet)
110
105
100
95
90
85
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)
COPY

FIG. 5

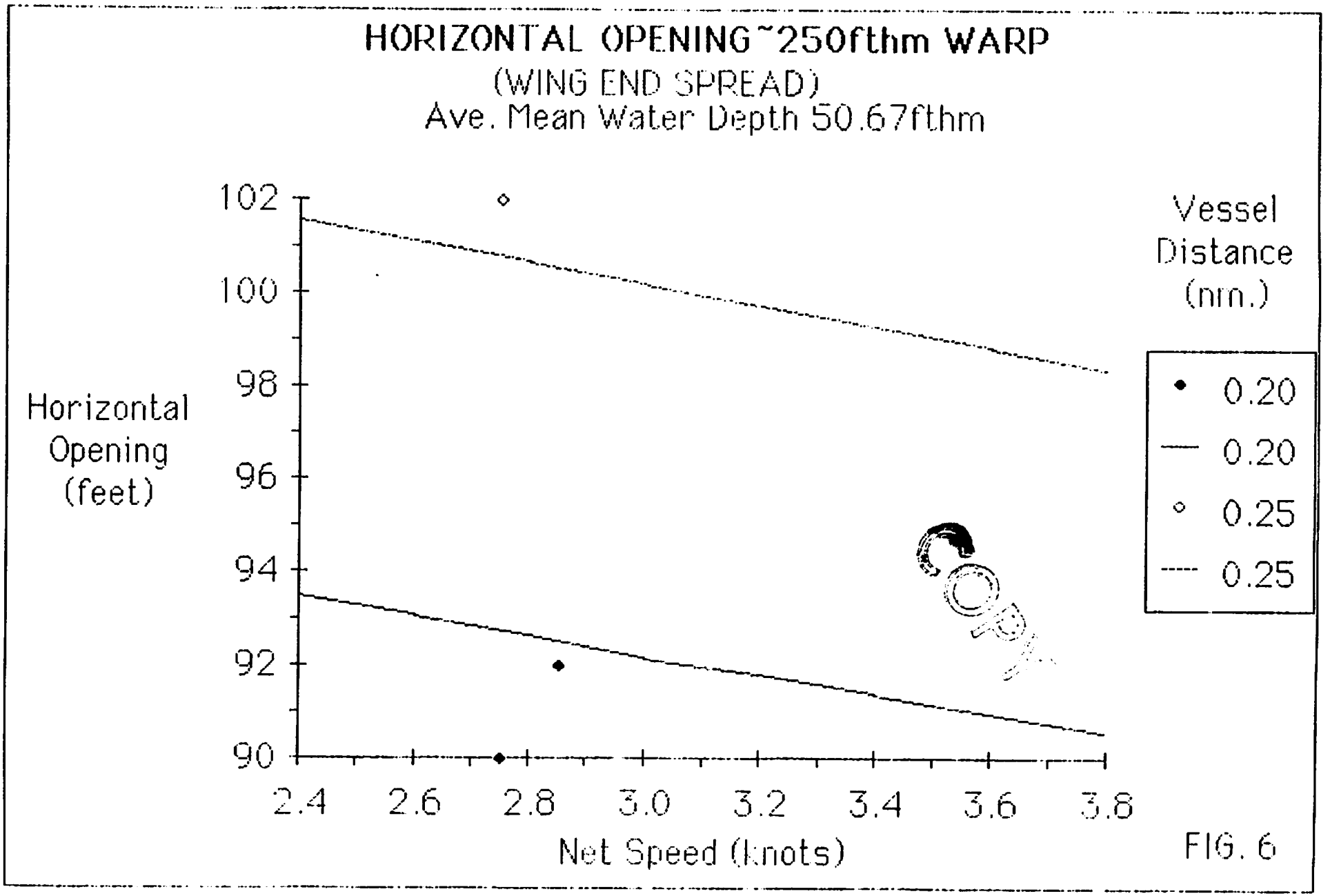

HORIZONTAL OPENING~250fthm WARP
(WING END SPREAD)
Ave. Mean Water Depth 50.67fthm
Horizontal Opening (feet)
102
100
98
96
94
92
90
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)
Vessel Distance (nm.)
0.20
0.20
0.25
0.25

FIG. 6

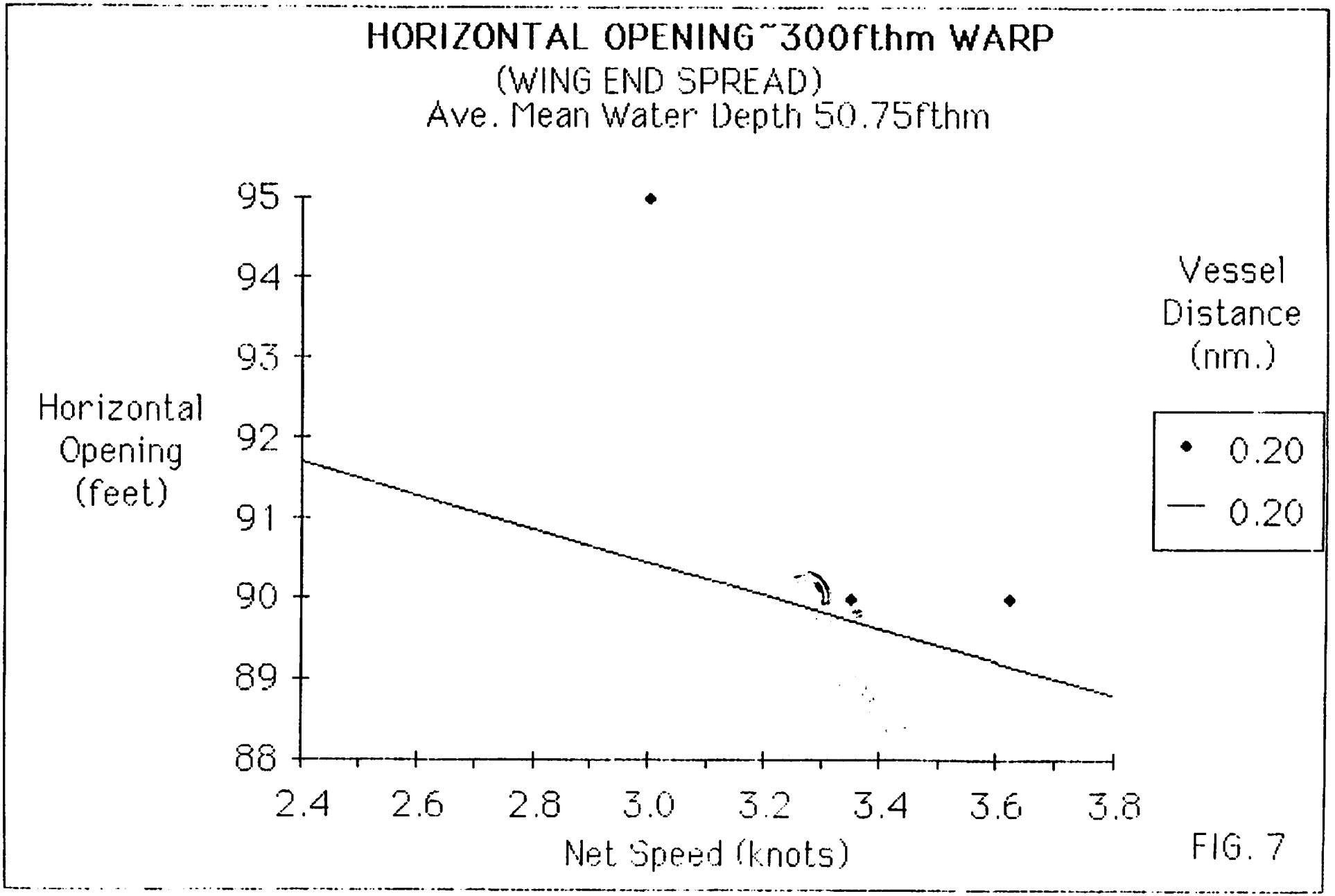

HORIZONTAL OPENING~300fthm WARP
(WING END SPREAD)
Ave. Mean Water Depth 50.75fthm
Horizontal Opening (feet)
95
94
93
92
91
90
89
88
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)
Vessel Distance (nm.)
0.20
0.20

FIG. 7

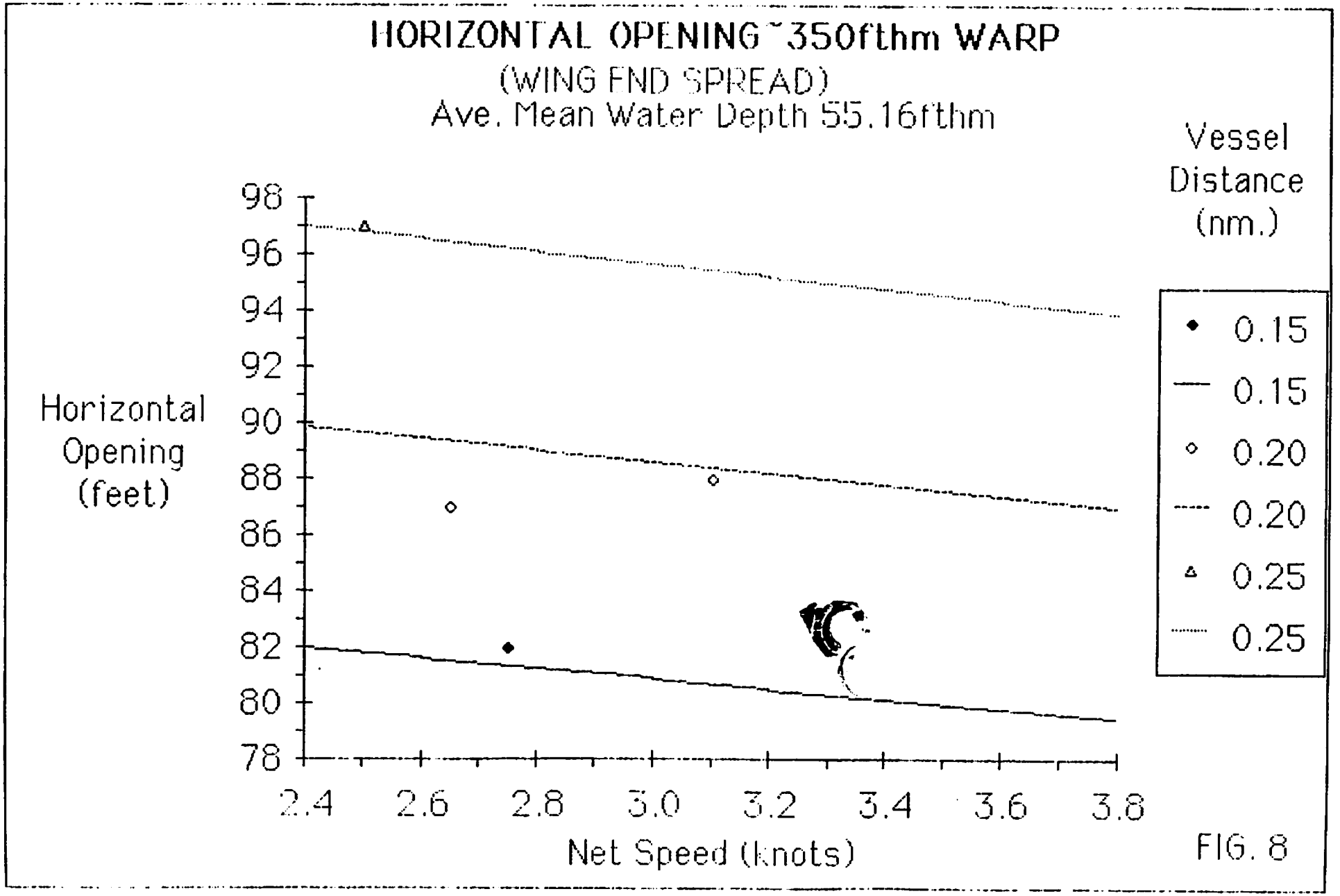

HORIZONTAL OPENING ~350fthm WARP
(WING END SPREAD)
Ave. Mean Water Depth 55.16fthm
Vessel Distance (nm.)
0.15
0.15
0.20
0.20
0.25
0.25
Horizontal Opening (feet)
98
96
94
92
90
88
86
84
82
80
78
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)

FIG. 8

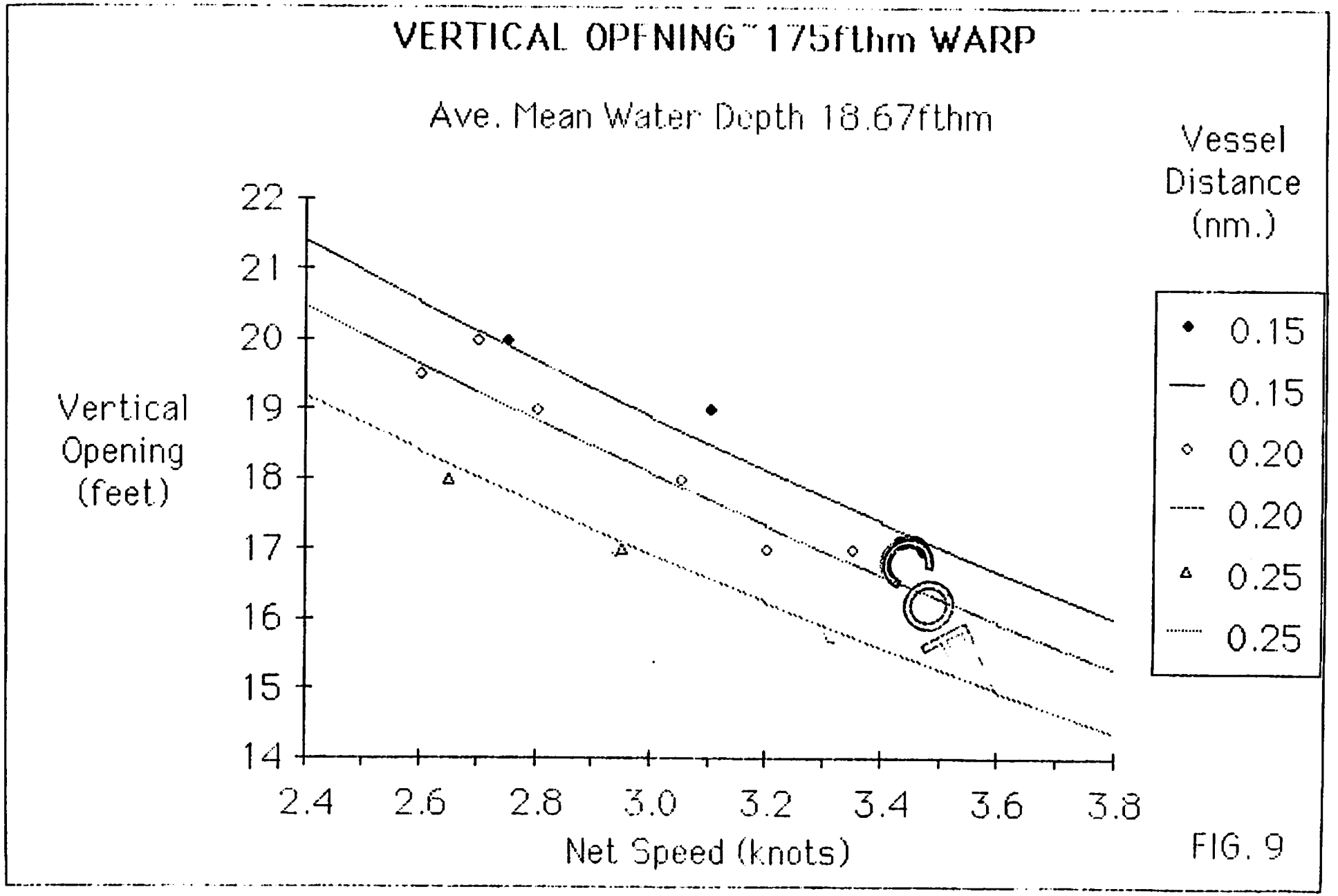

VERTICAL OPENING 175fthm WARP
Ave. Mean Water Depth 18.67fthm
Vessel Distance (nm.)
0.15
0.15
0.20
0.20
0.25
0.25
Vertical Opening (feet)
22
21
20
19
18
17
16
15
14
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)

FIG. 9

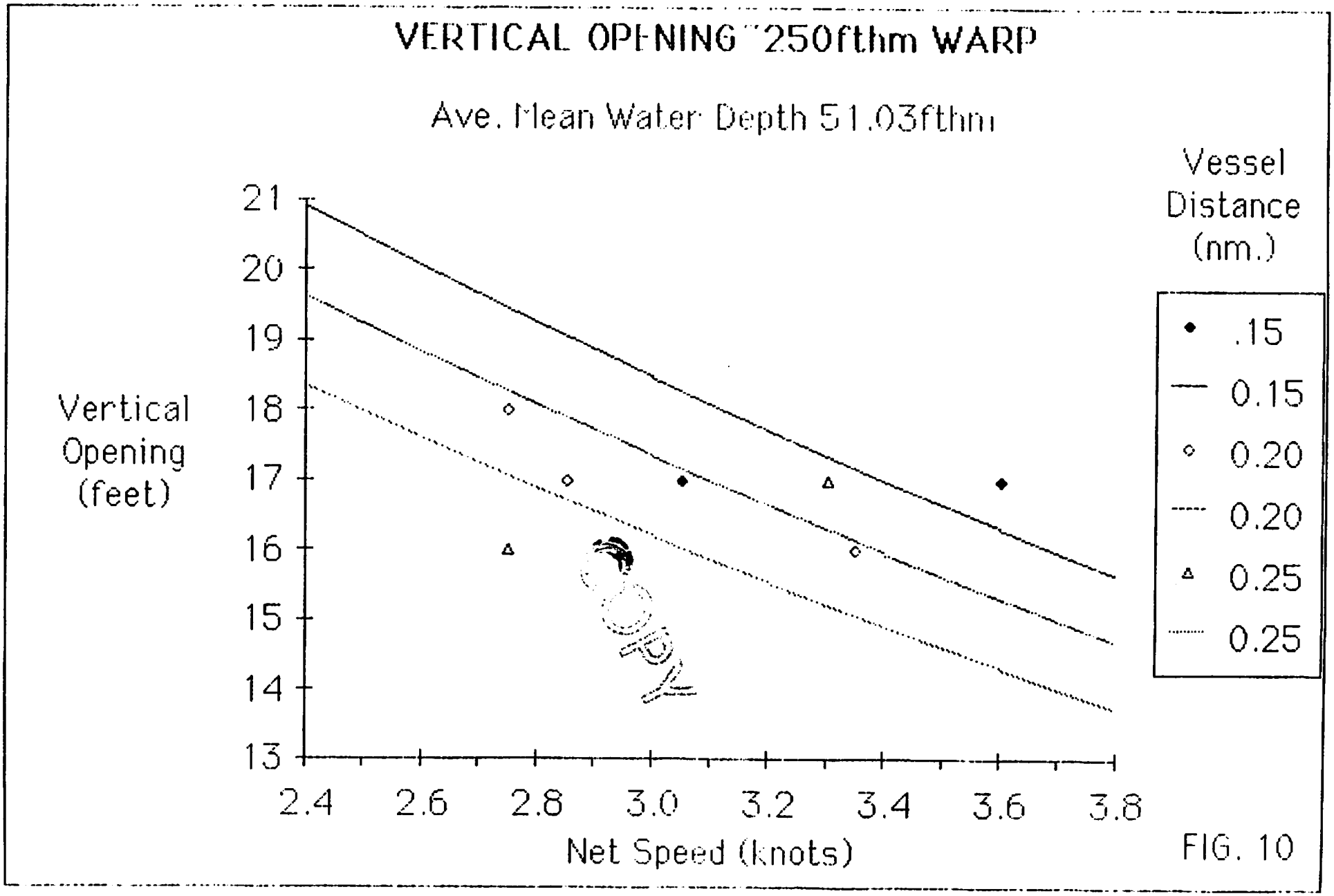

VERTICAL OPENING "250fthm WARP
Ave. Mean Water Depth 51.03fthm
Vessel Distance (nm.)
.15
0.15
0.20
0.20
0.25
0.25
Vertical Opening (feet)
21
20
19
18
17
16
15
14
13
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)

FIG. 10

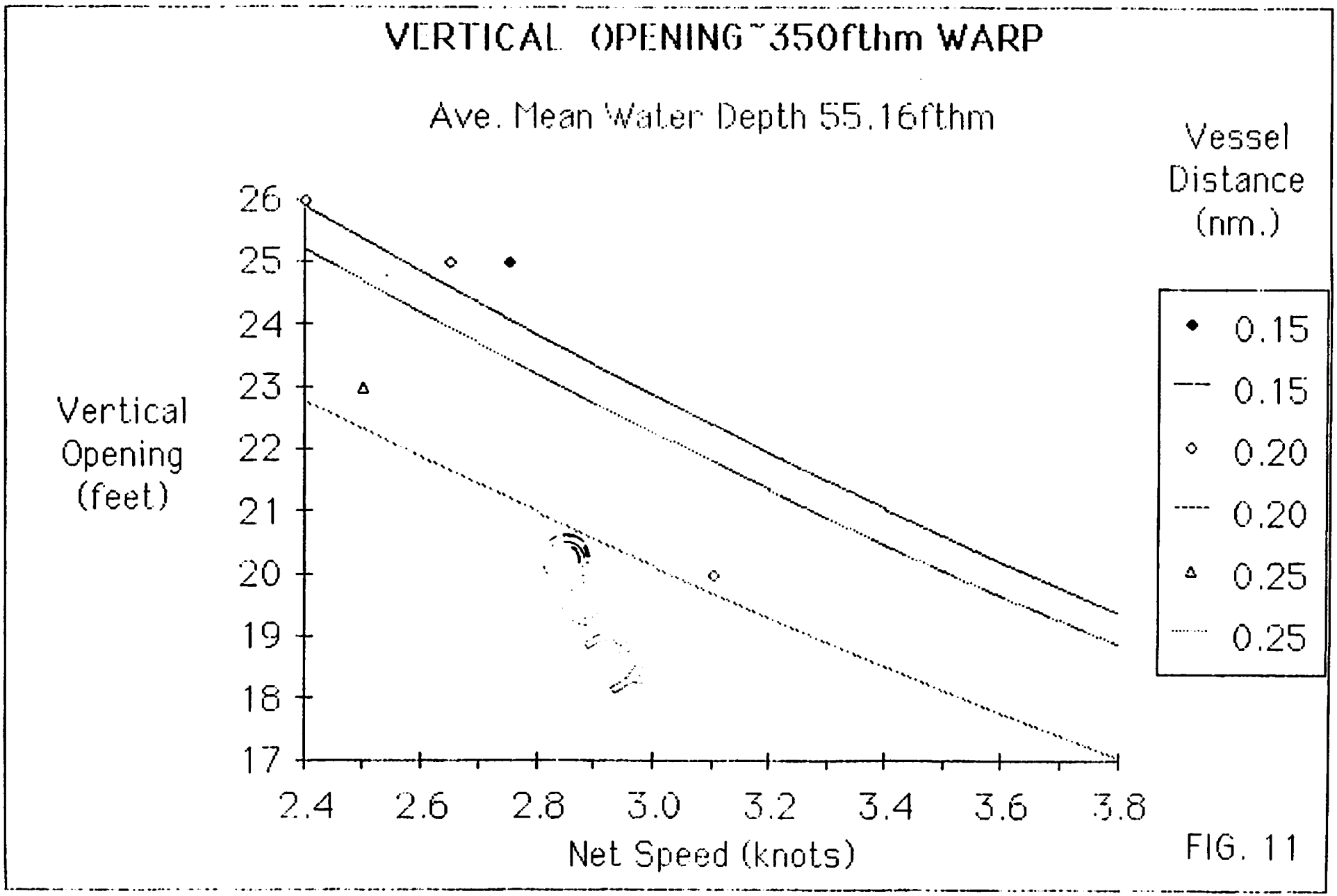

VERTICAL OPENING~350fthm WARP
Ave. Mean Water Depth 55.16fthm
Vessel Distance (nm.)
0.15
0.15
0.20
0.20
0.25
0.25
Vertical Opening (feet)
26
25
24
23
22
21
20
19
18
17
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
Net Speed (knots)

FIG. 11

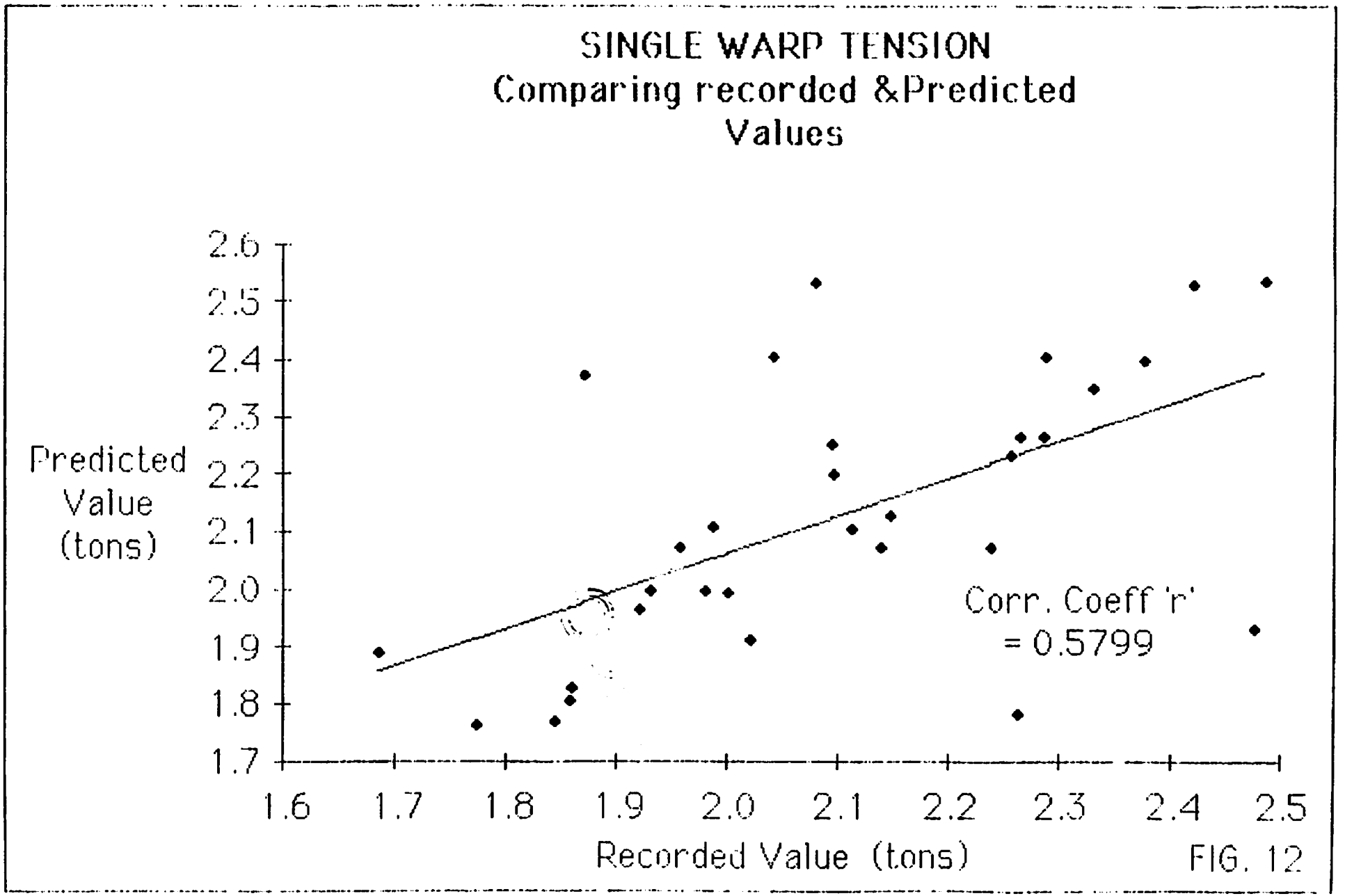

SINGLE WARP TENSION
Comparing recorded &Predicted Values
Predicted Value (tons)
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
Recorded Value (tons)
Corr. Coeff 'r' = 0.5799

FIG. 12

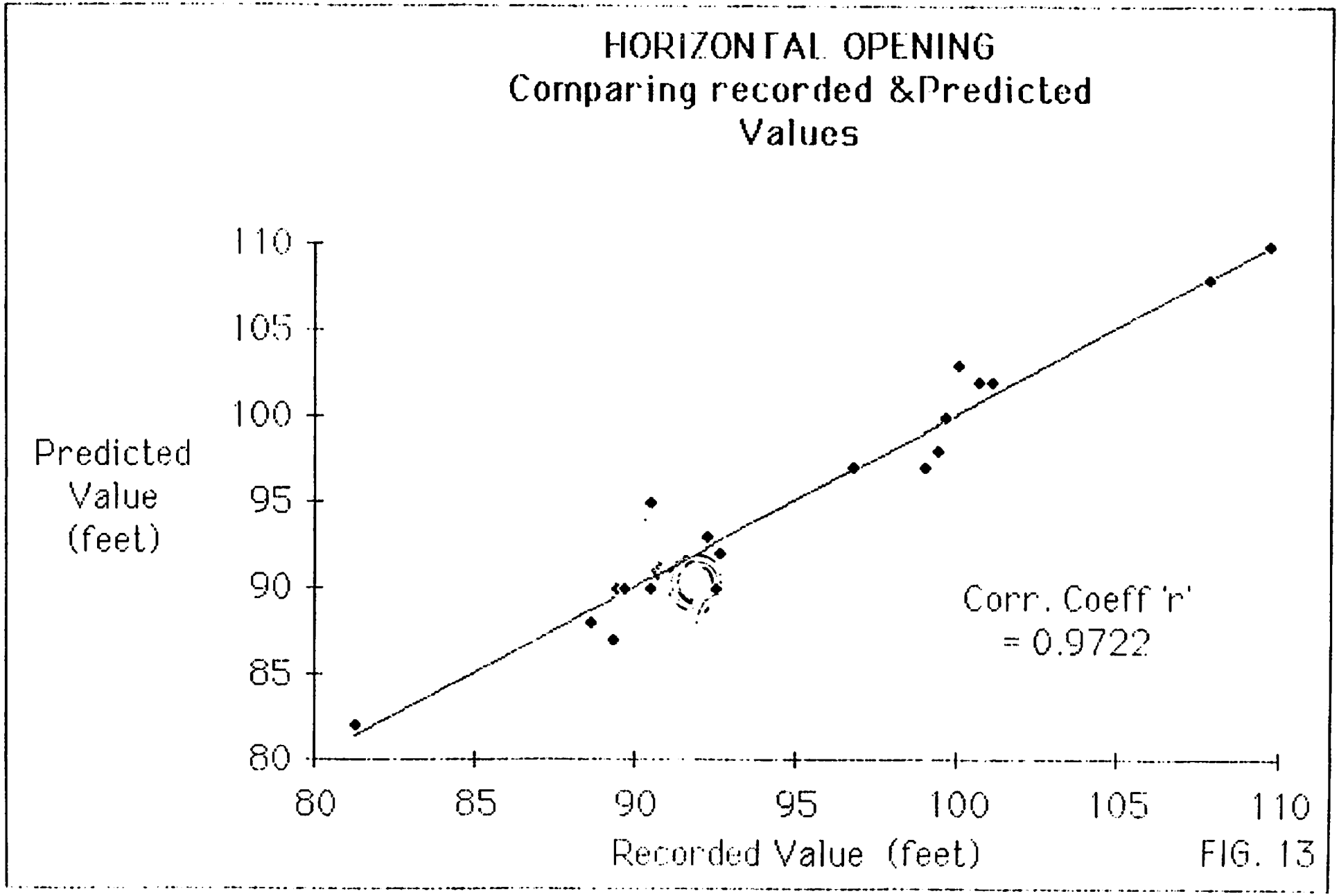

HORIZONTAL OPENING
Comparing recorded &Predicted Values
Predicted Value (feet)
110
105
100
95
90
85
80
80
85
90
95
100
105
110
Recorded Value (feet)
Corr. Coeff 'r' = 0.9722

FIG. 13

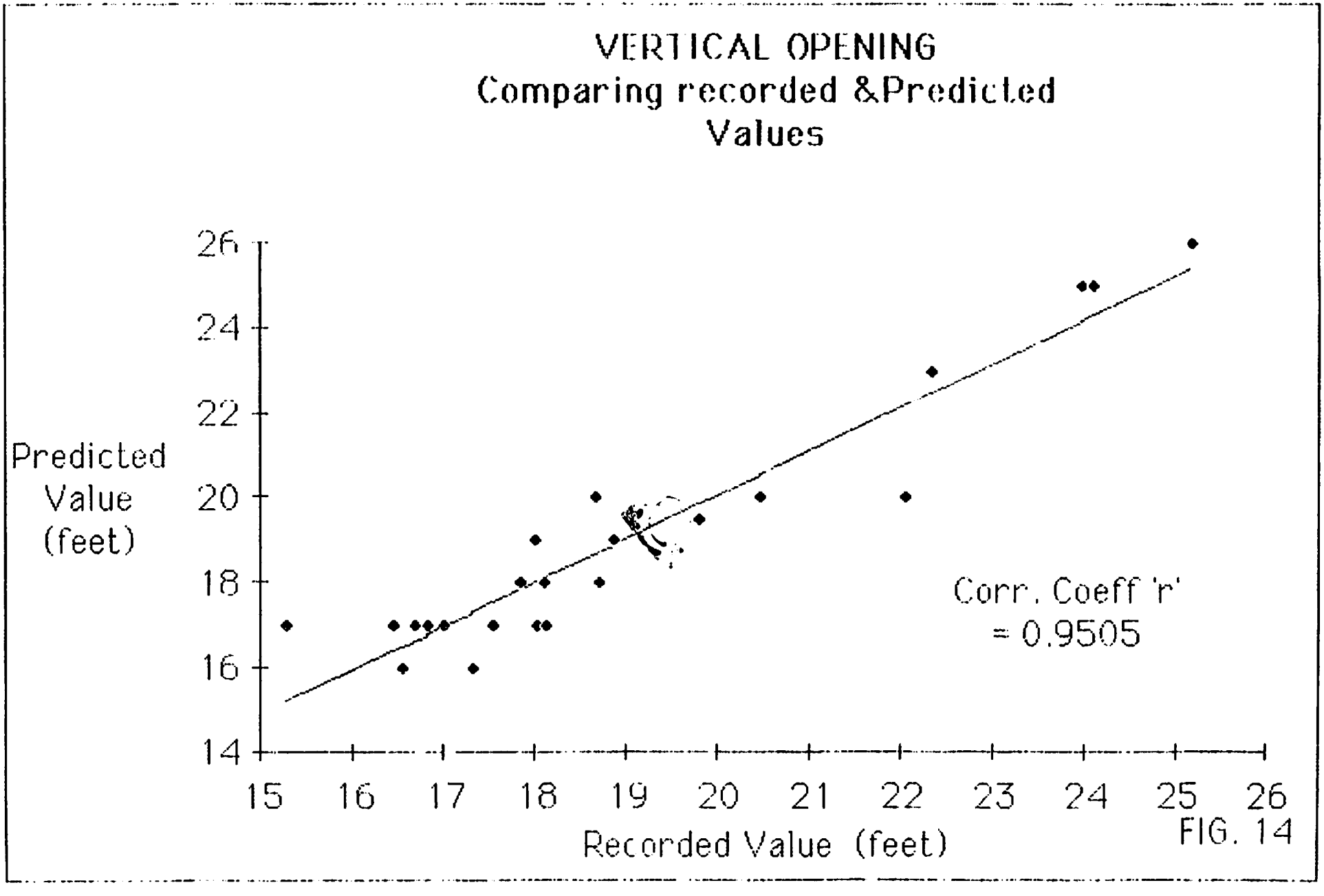

VERTICAL OPENING
Comparing recorded &Predicted Values
Predicted Value (feet)
26
24
22
20
18
16
14
15
16
17
18
19
20
21
22
23
24
25
26
Recorded Value (feet)
Corr. Coeff 'r' = 0.9505

FIG. 14

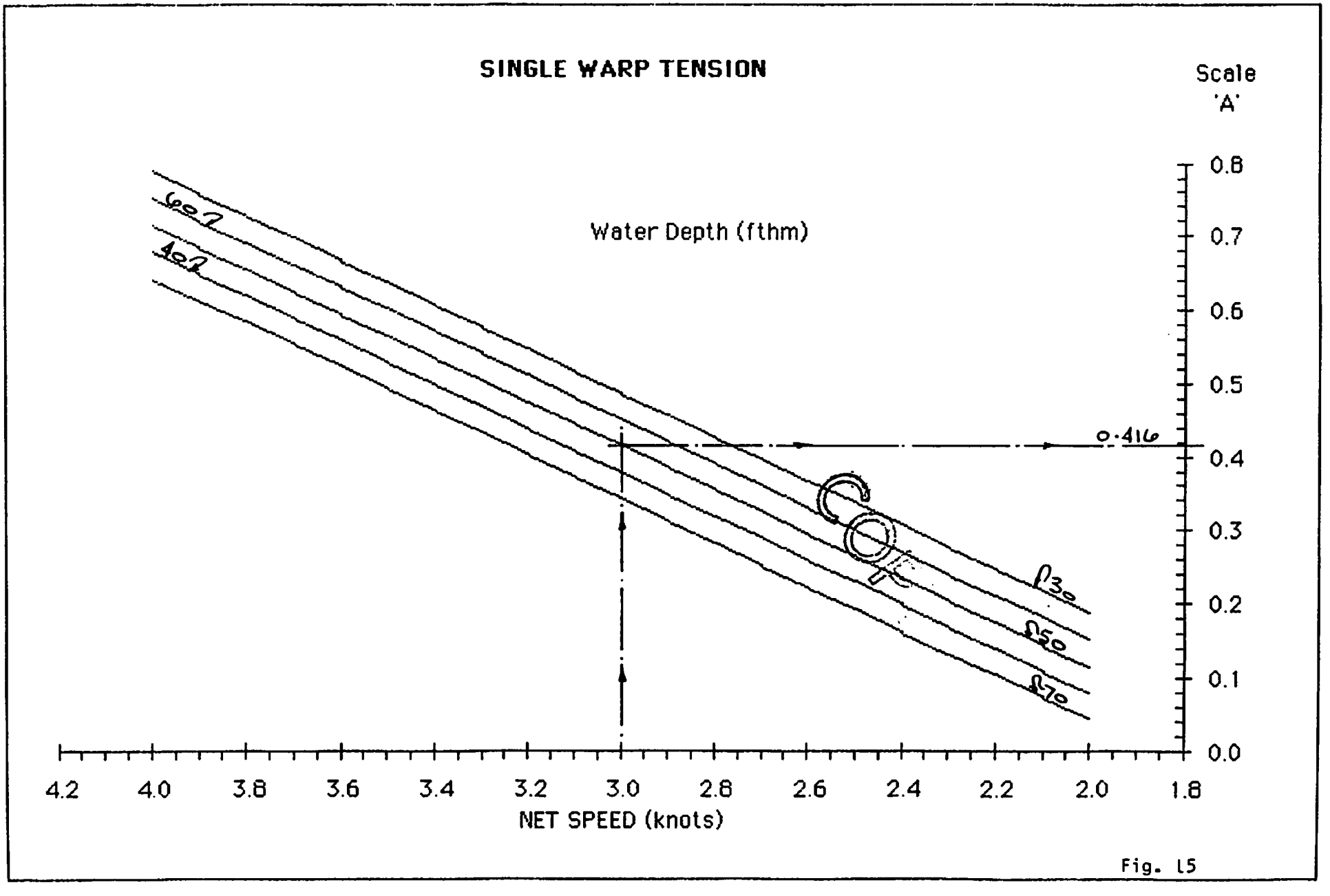

SINGLE WARP TENSION
Scale 'A'
Water Depth (fthm)
90 f
40 f
0·416
30
50
70
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
NET SPEED (knots)

Fig. 15

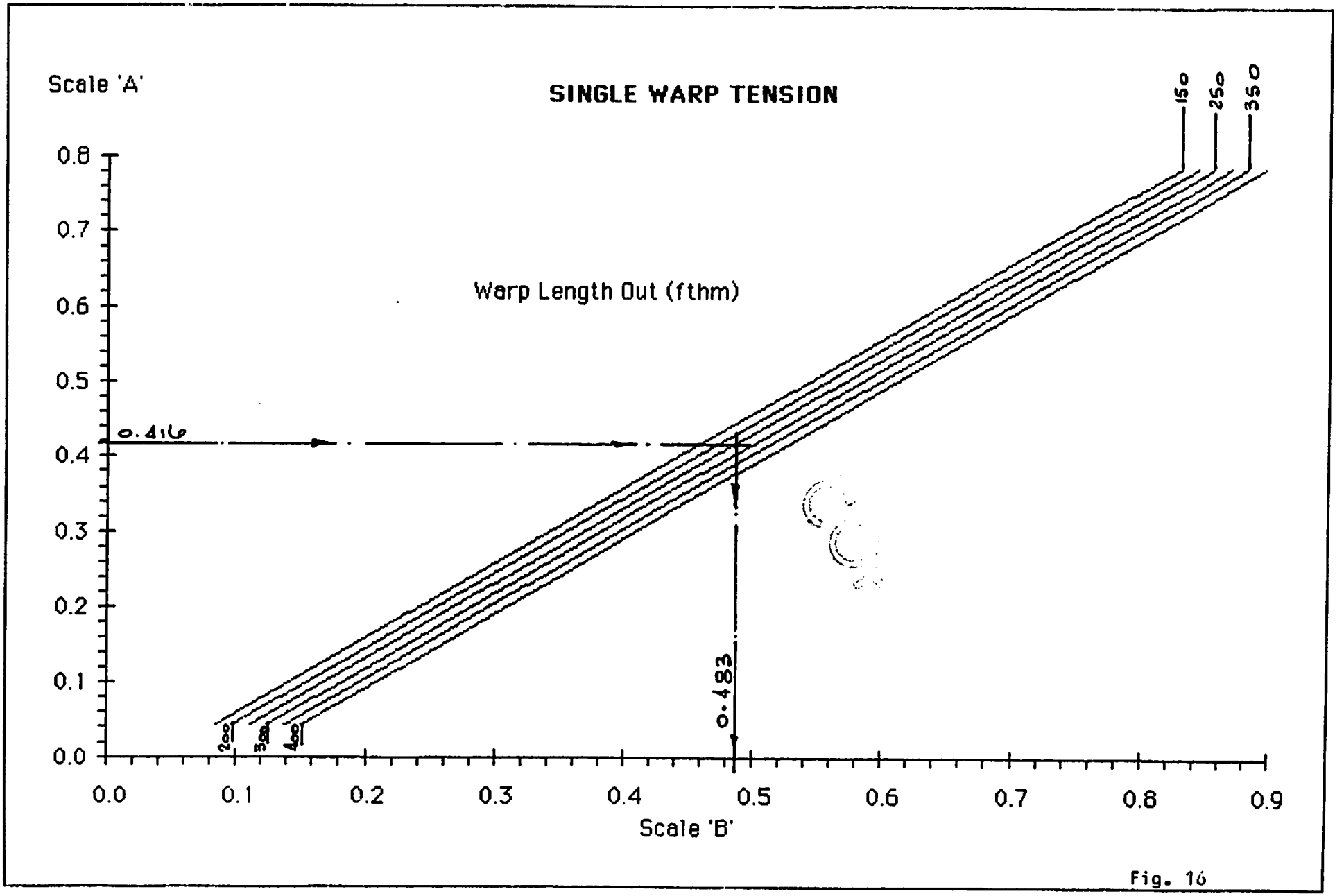

SINGLE WARP TENSION
Scale 'A'
Warp Length Out (fthm)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.416
0.483
150
250
350
200
300
400
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Scale 'B'

Fig. 16

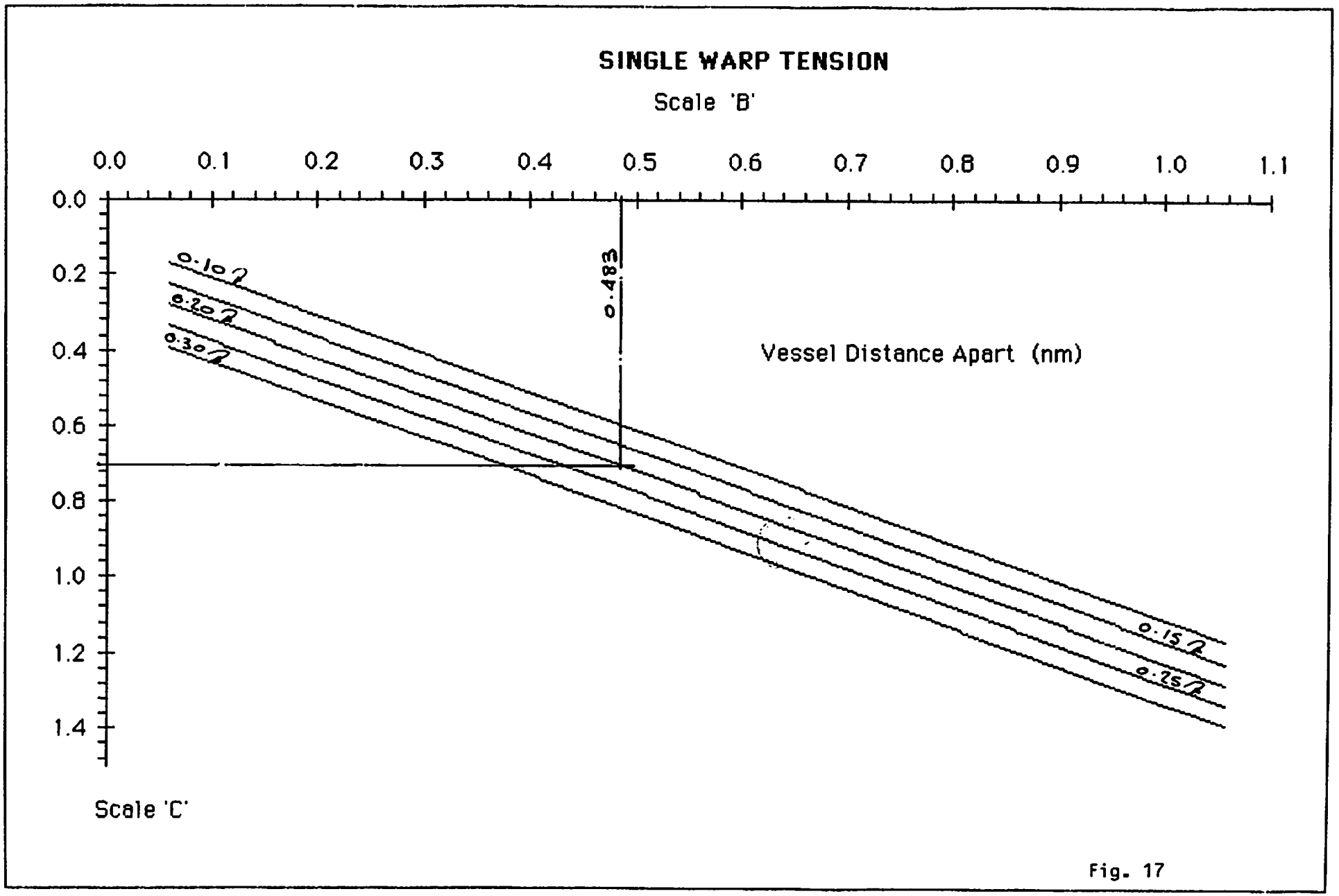

SINGLE WARP TENSION
Scale 'B'
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.483
0.10 T
0.20 T
0.30 T
0.15 T
0.25 T
Vessel Distance Apart (nm)
Scale 'C'

Fig. 17

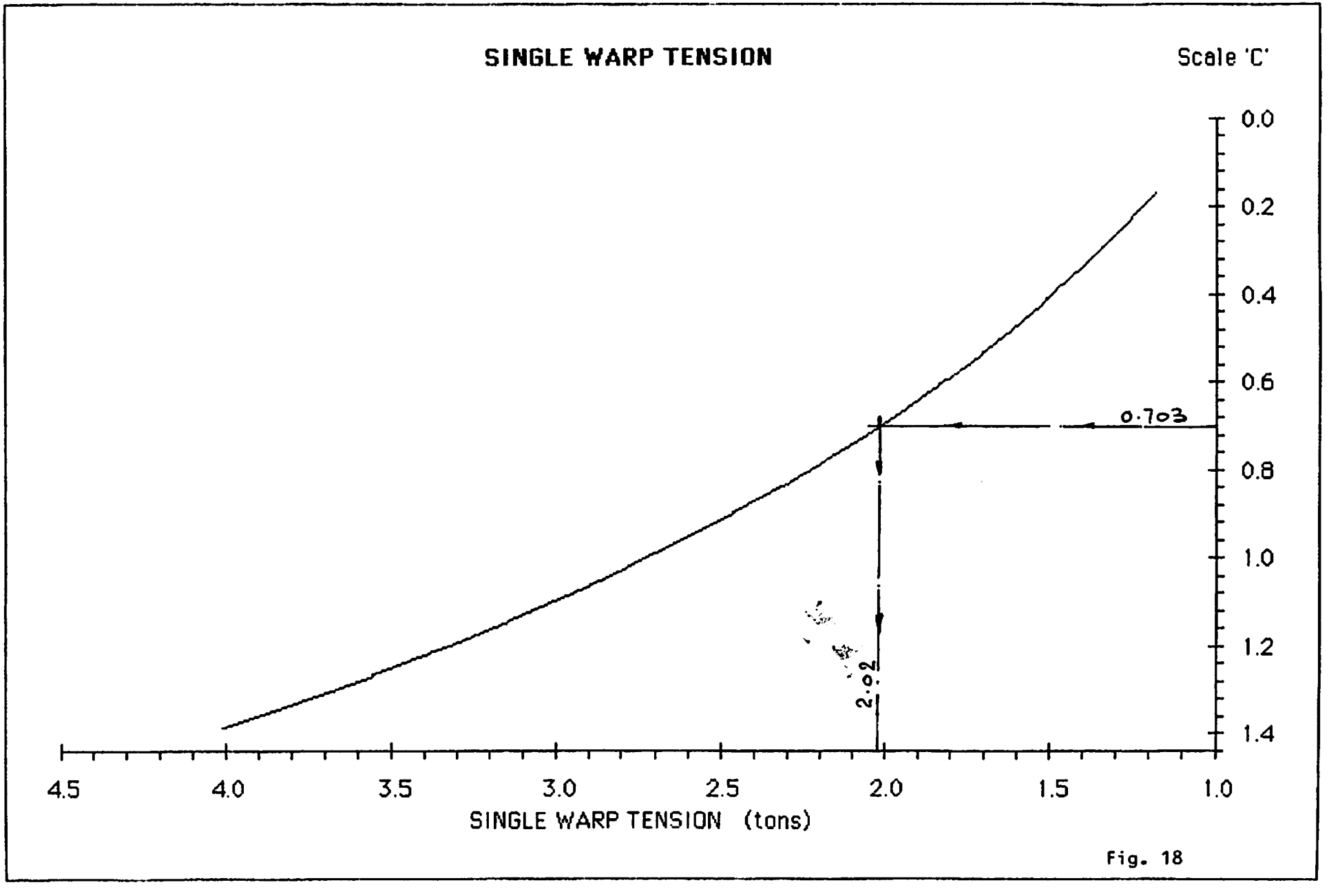

SINGLE WARP TENSION
Scale 'C'
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.703
2.02
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
SINGLE WARP TENSION (tons)

Fig. 18

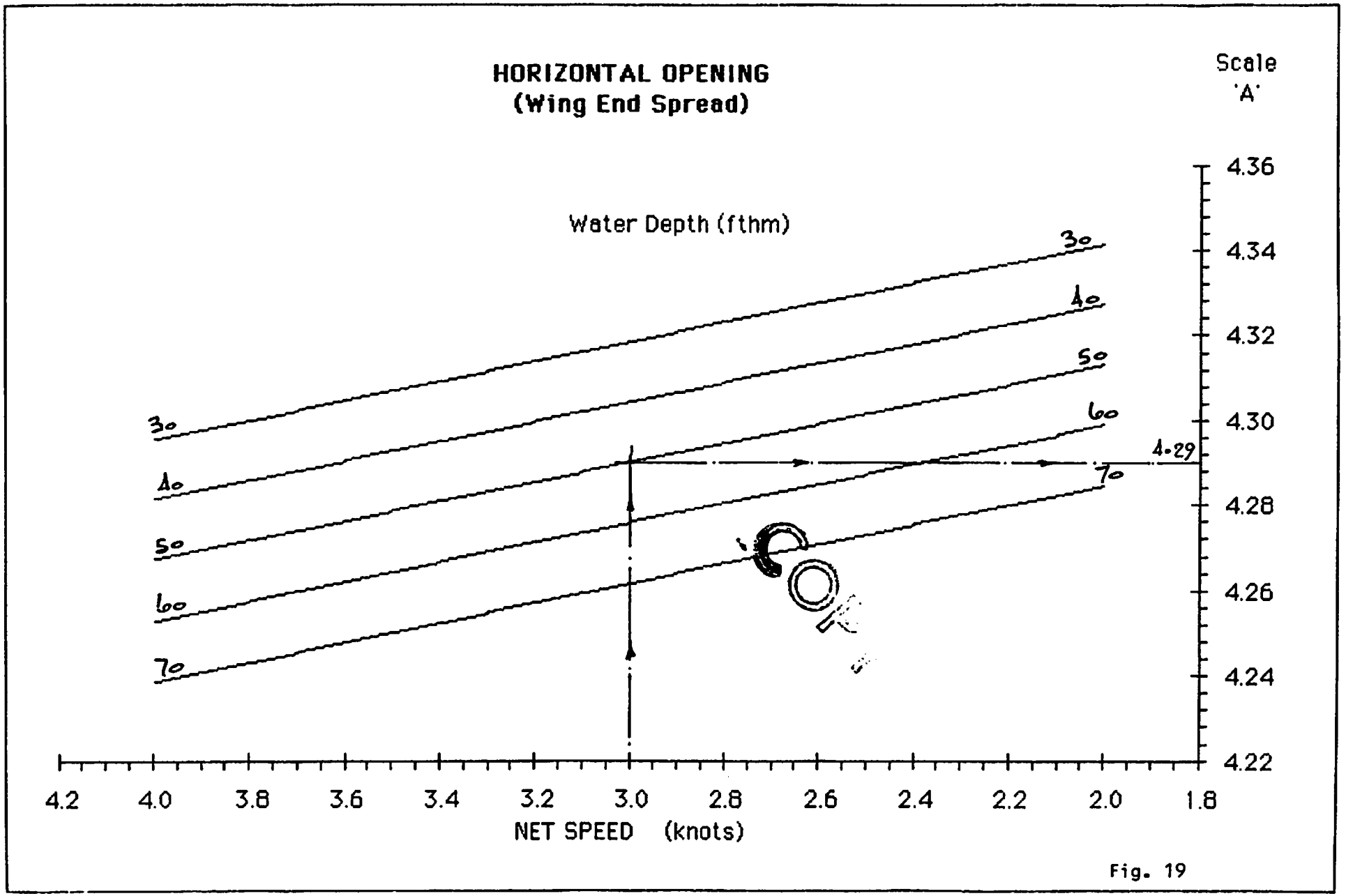

HORIZONTAL OPENING
(Wing End Spread)
Scale 'A'
Water Depth (fthm)
30
40
50
60
70
4.29
4.36
4.34
4.32
4.30
4.28
4.26
4.24
4.22
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
NET SPEED (knots)

Fig. 19

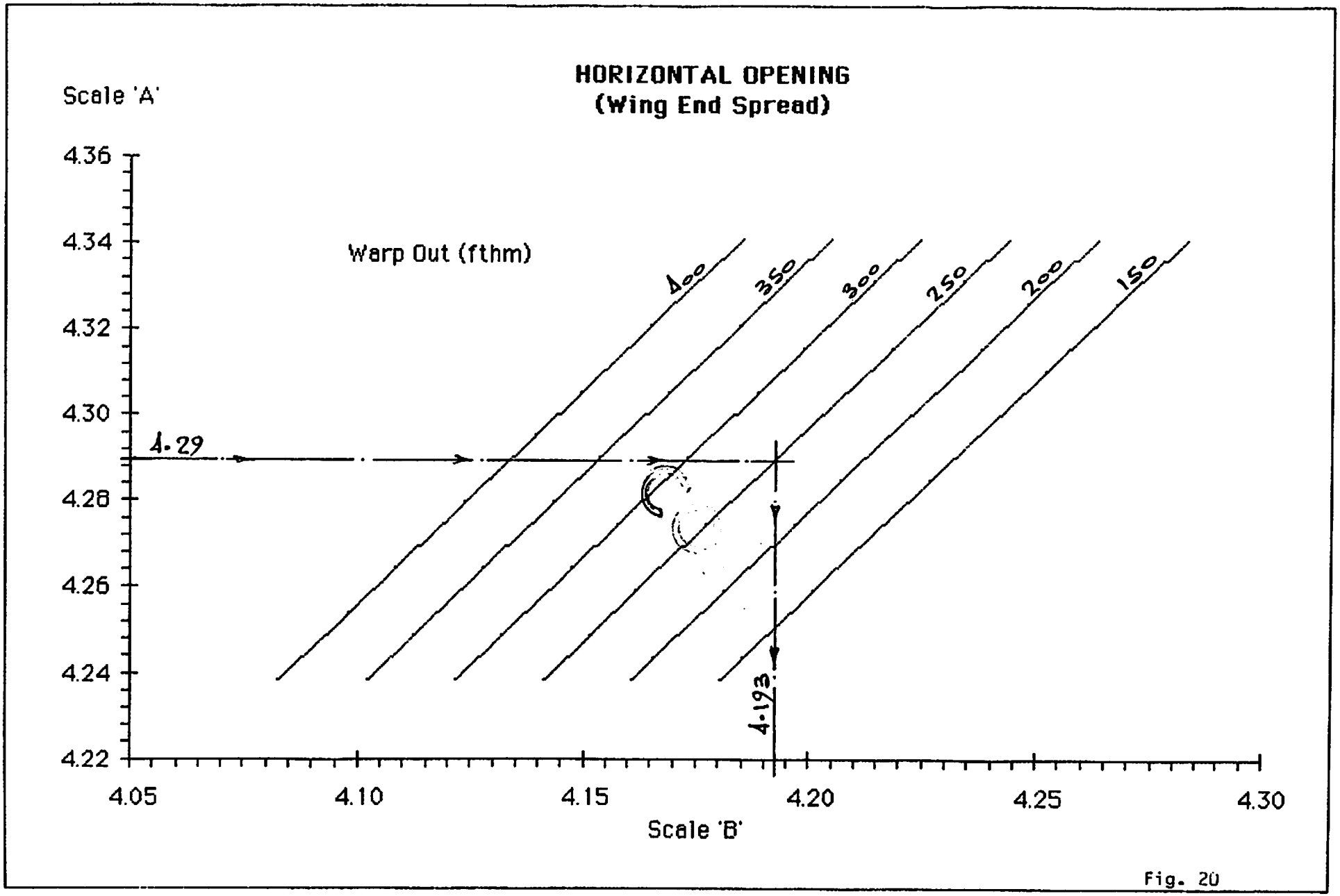

HORIZONTAL OPENING
(Wing End Spread)
Scale 'A'
Warp Out (fthm)
400
350
300
250
200
150
4.29
4.193
4.36
4.34
4.32
4.30
4.28
4.26
4.24
4.22
4.05
4.10
4.15
4.20
4.25
4.30
Scale 'B'

Fig. 20

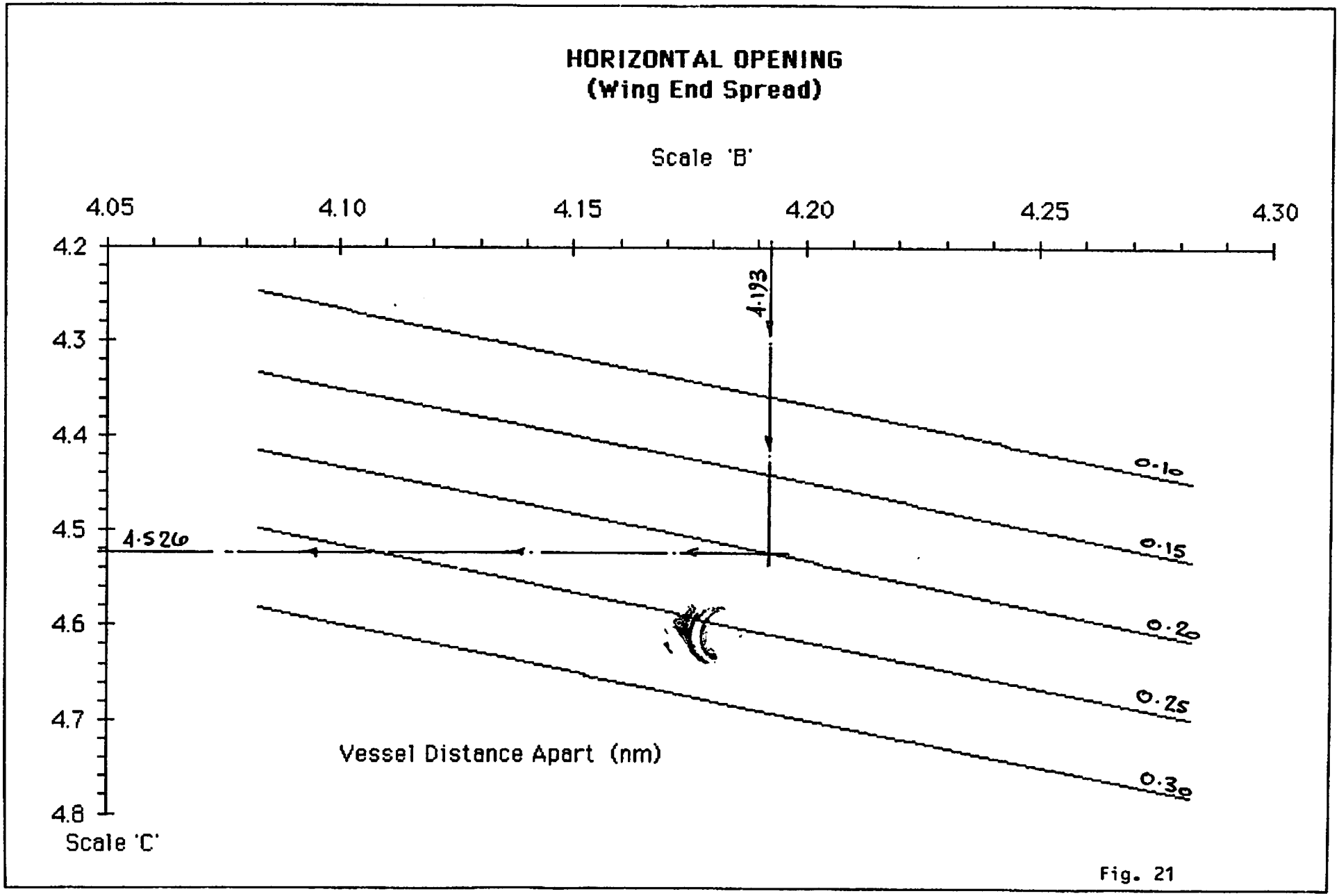

HORIZONTAL OPENING
(Wing End Spread)
Scale 'B'
4.05
4.10
4.15
4.20
4.25
4.30
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4·193
4·526
0·10
0·15
0·20
0·25
0·30
Vessel Distance Apart (nm)
Scale 'C'

Fig. 21

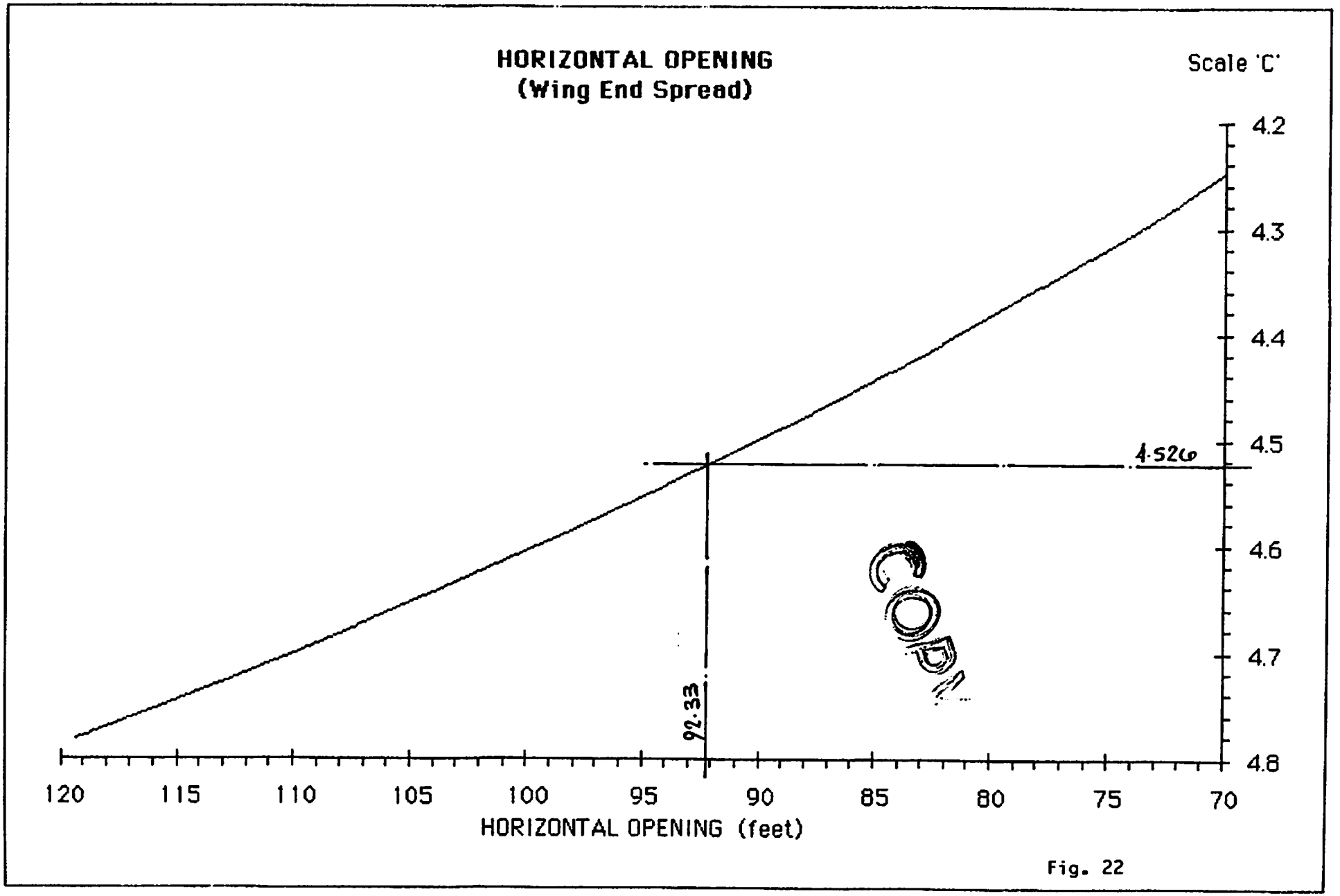

HORIZONTAL OPENING
(Wing End Spread)
Scale 'C'
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.526
92.33
120
115
110
105
100
95
90
85
80
75
70
HORIZONTAL OPENING (feet)

Fig. 22

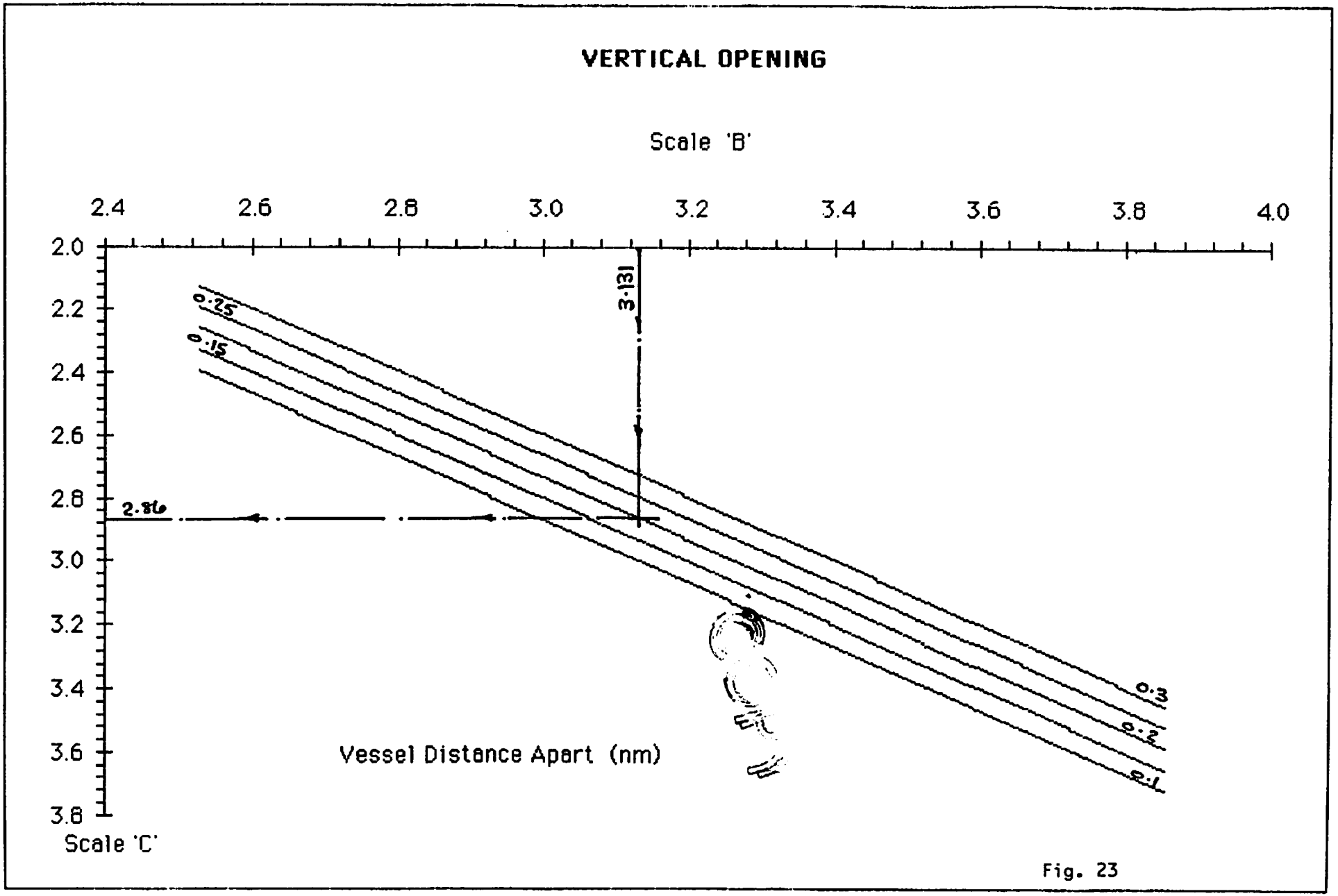

VERTICAL OPENING
Scale 'B'
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
3·131
0·25
0·15
2·86
0·3
0·2
0·1
Vessel Distance Apart (nm)
Scale 'C'

Fig. 23

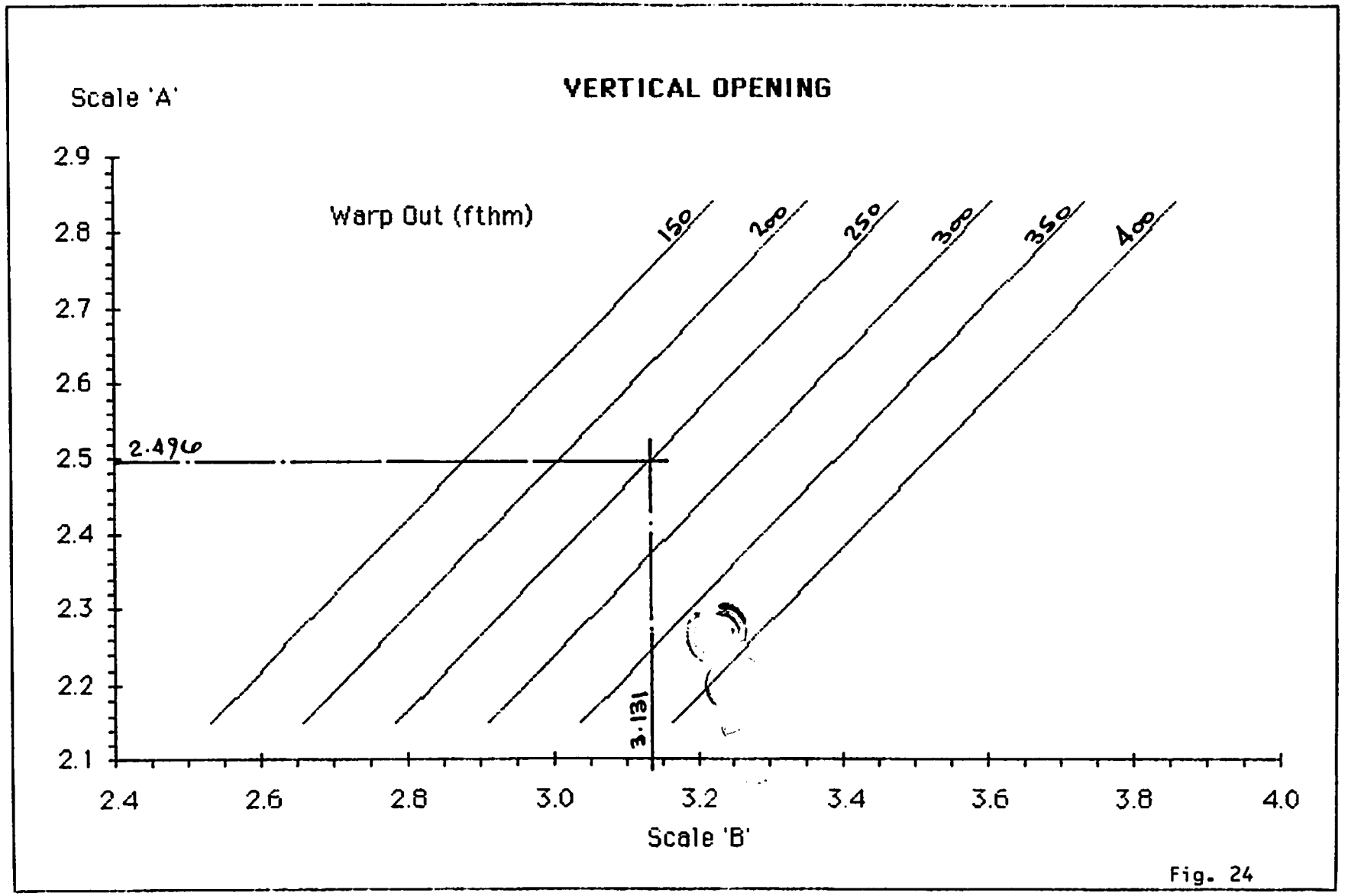

VERTICAL OPENING
Scale 'A'
Warp Out (fthm)
150
200
250
300
350
400
2.4960
3.131
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
Scale 'B'

Fig. 24

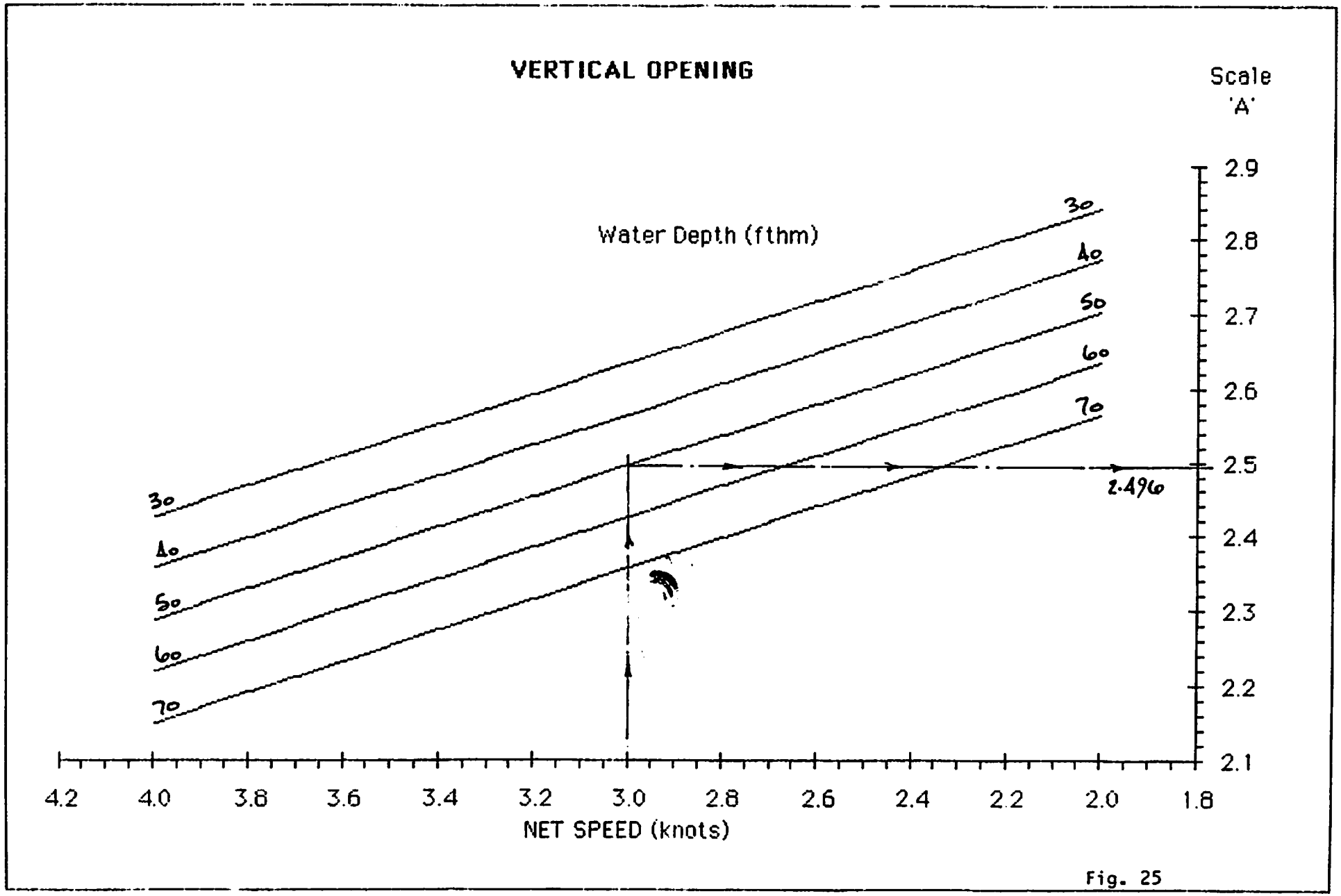

VERTICAL OPENING
Scale 'A'
Water Depth (fthm)
30
40
50
60
70
2.496
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
NET SPEED (knots)

Fig. 25

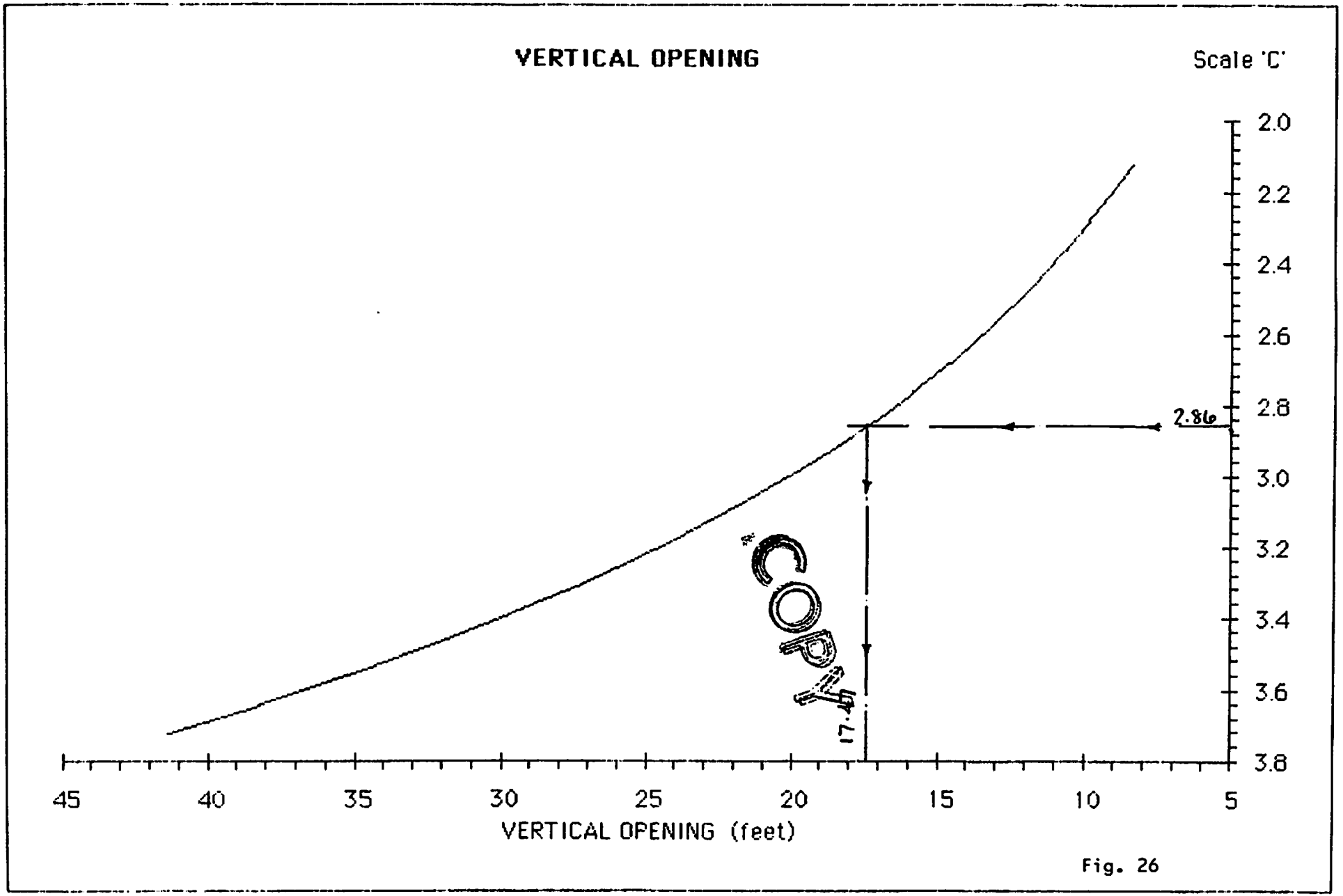

VERTICAL OPENING
Scale 'C'
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
2.86
45
40
35
30
25
20
15
10
5
VERTICAL OPENING (feet)
COPY
17.47

Fig. 26

ANALYSED VALUES FOR AVERAGE TOW PARAMETERS ON TRIAL

TABLE 1

Values of WT ; Ho , Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.15 n.m.

Warp Length= 175 fthm

Ave mean d= 21 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.74	92.43	21.39
2.6	1.84	92.00	20.52
2.8	1.96	91.58	19.69
3.0	2.08	91.16	18.88
3.2	2.21	90.74	18.12
3.4	2.35	90.32	17.38
3.6	2.49	89.91	16.67
3.8	2.64	89.50	15.99

Warp Length= 250 fthm

Ave mean d= 51.75 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.59	85.93	20.92
2.6	1.69	85.53	20.06
2.8	1.79	85.14	19.25
3.0	1.90	84.75	18.46
3.2	2.02	84.36	17.71
3.4	2.14	83.97	16.99
3.6	2.28	83.59	16.30
3.8	2.42	85.20	15.64

Warp Length= 300 fthm

Ave mean d= 50.5 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.62	84.42	23.95
2.6	1.72	84.03	22.98
2.8	1.82	83.64	22.04
3.0	1.93	83.26	21.15
3.2	2.05	82.88	20.29
3.4	2.18	82.50	19.46
3.6	2.32	82.12	18.67
3.8	2.46	81.74	17.91

Warp Length= 350 fthm

Ave mean d= 57.5 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.60	81.97	25.91
2.6	1.70	81.59	24.86
2.8	1.80	81.22	23.84
3.0	1.91	80.85	22.87
3.2	2.03	80.47	21.94
3.4	2.16	80.10	21.05
3.6	2.29	79.74	20.19
3.8	2.43	79.37	19.37

ANALYSED VALUES FOR AVERAGE TOW PARAMETERS ON TRIAL

TABLE 2

Values of WT ; Ho; Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.20 n.m.

Warp Length= 175 fthm

Ave mean d= 17.67 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.86	100.92	20.46
2.6	1.97	100.46	19.63
2.8	2.09	100.00	18.83
3.0	2.22	99.54	18.06
3.2	2.36	99.08	17.33
3.4	2.51	98.63	16.62
3.6	2.66	98.17	15.94
3.8	2.83	97.72	15.30

Warp Length= 250 fthm

Ave mean d= 51.08 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.68	93.47	19.64
2.6	1.78	93.04	18.84
2.8	1.90	92.62	18.07
3.0	2.01	92.19	17.34
3.2	2.14	91.77	16.63
3.4	2.27	91.35	15.96
3.6	2.41	90.93	15.31
3.8	2.56	90.51	14.69

Warp Length= 300 fthm

Ave mean d= 50.75 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.71	91.71	22.35
2.6	1.81	91.29	21.44
2.8	1.92	90.87	20.57
3.0	2.04	90.45	19.73
3.2	2.17	90.04	18.93
3.4	2.30	89.62	18.16
3.6	2.45	89.21	17.42
3.8	2.60	88.80	16.71

Warp Length= 350 fthm

Ave mean d= 51.67 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.72	89.82	25.22
2.6	1.83	89.41	24.19
2.8	1.94	89.00	23.20
3.0	2.06	88.59	22.26
3.2	2.19	88.18	21.35
3.4	2.33	87.78	20.48
3.6	2.47	87.37	19.65
3.8	2.62	86.97	18.85

ANALYSED VALUES FOR AVERAGE TOW PARAMETERS ON TRIAL

TABLE 3

Values of WT; Ho; Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.25 n.m

Warp Length= 175 fthm

Ave mean d= 17.25 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.97	109.75	19.18
2.6	2.09	109.24	18.40
2.8	2.22	108.74	17.65
3.0	2.35	108.24	16.93
3.2	2.50	107.74	16.24
3.4	2.65	107.25	15.58
3.6	2.82	106.75	14.95
3.8	2.99	106.26	14.34

Warp Length= 250 fthm

Ave mean d= 51.25 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.77	101.56	18.34
2.6	1.88	101.09	17.59
2.8	2.00	100.63	16.87
3.0	2.13	100.16	16.19
3.2	2.26	99.70	15.53
3.4	2.40	99.25	14.91
3.6	2.54	98.79	14.29
3.8	2.70	98.34	13.71

Warp Length= 300 fthm

Ave mean d= 50.5 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.80	99.70	20.93
2.6	1.92	99.24	20.07
2.8	2.03	98.79	19.26
3.0	2.16	98.34	18.47
3.2	2.29	97.88	17.72
3.4	2.44	97.43	17.00
3.6	2.59	96.99	16.31
3.8	2.75	96.54	15.64

Warp Length= 350 fthm

Ave mean d= 56.5 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng Ho (ft)	Vert. Opng Vo (Ft
2.4	1.79	96.95	22.79
2.6	1.90	96.50	21.87
2.8	2.02	96.06	20.98
3.0	2.14	95.62	20.12
3.2	2.27	95.18	19.30
3.4	2.42	94.74	18.52
3.6	2.57	94.31	17.76
3.8	2.72	93.87	17.04

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 4

Values of WT, Ho, Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.15 n.m.

Warp Length= 175 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.68	91.25	20.10
2.6	1.79	90.84	19.28
2.8	1.90	90.42	18.50
3.0	2.01	90.00	17.74
3.2	2.14	89.59	17.02
3.4	2.27	89.18	16.33
3.6	2.41	88.77	15.66
3.8	2.56	88.36	15.03

Warp Length= 250 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.72	88.62	24.32
2.6	1.82	88.22	23.33
2.8	1.94	87.81	22.38
3.0	2.05	87.41	21.47
3.2	2.18	87.01	20.59
3.4	2.32	86.61	19.75
3.6	2.46	86.21	18.95
3.8	2.61	85.81	18.18

Warp Length= 300 fthm

Ave mean d= 30 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.74	86.91	27.61
2.6	1.85	86.51	26.49
2.8	1.96	86.12	25.41
3.0	2.08	85.72	24.37
3.2	2.21	85.33	23.38
3.4	2.35	84.93	22.43
3.6	2.49	84.54	21.52
3.8	2.65	84.16	20.64

Warp Length= 350 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.76	85.23	31.35
2.6	1.87	84.84	30.07
2.8	1.99	84.45	28.85
3.0	2.11	84.06	27.67
3.2	2.24	83.68	26.55
3.4	2.38	83.29	25.47
3.6	2.53	82.91	24.43
3.8	2.68	82.53	23.44

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 5

Values of WT; Ho, Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.15 n.m.

Warp Length= 175 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.56	88.70	17.50
2.6	1.66	88.29	16.79
2.8	1.76	87.89	16.10
3.0	1.87	87.48	15.45
3.2	1.99	87.08	14.82
3.4	2.11	86.68	14.22
3.6	2.24	86.28	13.64
3.8	2.38	85.89	13.06

Warp Length= 250 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.60	86.14	21.17
2.6	1.70	85.75	20.31
2.8	1.80	85.35	19.48
3.0	1.91	84.96	18.69
3.2	2.03	84.57	17.93
3.4	2.16	84.18	17.20
3.6	2.29	83.80	16.50
3.8	2.43	83.41	15.83

Warp Length= 300 fthm

Ave mean d= 50 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.62	84.48	24.04
2.6	1.72	84.09	23.06
2.8	1.83	83.70	22.12
3.0	1.94	83.32	21.22
3.2	2.06	82.94	20.36
3.4	2.19	82.56	19.53
3.6	2.32	82.18	18.73
3.8	2.46	81.80	17.97

Warp Length= 350 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng Ho (ft)	Vert. Opng Vo (Ft)
2.4	1.64	82.85	27.33
2.6	1.74	82.47	26.16
2.8	1.85	82.09	25.12
3.0	1.96	81.71	24.09
3.2	2.09	81.34	23.11
3.4	2.22	80.96	22.17
3.6	2.35	80.59	21.27
3.8	2.50	80.22	20.40

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 6

Values of WT ; Ho ; Vo @ Net Speeds(Vn) for each Warp Length(W) & Vessel Distance(D)

Distance= 0.15 n.m.

Warp Length= 175 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.46	86.22	15.24
2.6	1.55	85.82	14.61
2.8	1.64	85.43	14.02
3.0	1.74	85.03	13.45
3.2	1.85	84.64	12.90
3.4	1.97	84.25	12.38
3.6	2.09	83.87	11.87
3.8	2.22	83.48	11.39

Warp Length= 250 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.49	83.73	18.43
2.6	1.58	83.35	17.68
2.8	1.68	82.96	16.96
3.0	1.78	82.58	16.27
3.2	1.89	82.20	15.61
3.4	2.01	81.82	14.97
3.6	2.13	81.45	14.36
3.8	2.26	81.07	13.78

Warp Length= 300 fthm

Ave mean d= 70 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.51	82.11	20.93
2.6	1.60	81.74	20.08
2.8	1.70	81.36	19.26
3.0	1.80	80.99	18.48
3.2	1.92	80.61	17.72
3.4	2.03	80.24	17.00
3.6	2.16	79.88	16.31
3.8	2.29	79.51	15.65

Warp Length= 350 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.53	80.53	23.76
2.6	1.62	80.16	22.80
2.8	1.72	79.79	21.87
3.0	1.83	79.42	20.96
3.2	1.94	79.06	20.12
3.4	2.06	78.69	19.30
3.6	2.19	78.33	18.52
3.8	2.32	77.97	17.76

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 7

Values of WT ; Ho ; Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.2 n.m

Warp Length= 175 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.78	99.17	18.79
2.6	1.89	98.72	18.02
2.8	2.00	98.26	17.29
3.0	2.13	97.81	16.58
3.2	2.26	97.36	15.91
3.4	2.40	96.91	15.26
3.6	2.55	96.47	14.64
3.8	2.71	96.03	14.04

Warp Length= 250 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	[illegible]	96.31	22.73
2.6	[illegible]	95.87	21.90
2.8	2.04	95.43	20.91
3.0	2.17	94.99	20.06
3.2	2.31	94.56	19.25
3.4	2.45	94.12	18.46
3.6	2.60	93.69	17.71
3.8	2.76	93.26	16.99

Warp Length= 300 fthm

Ave mean d= 30 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.84	94.45	25.80
2.6	1.95	94.02	24.75
2.8	2.07	93.59	23.75
3.0	2.20	93.16	22.78
3.2	2.34	92.73	21.85
3.4	2.48	92.30	20.96
3.6	2.64	91.88	20.11
3.8	2.80	91.46	19.29

Warp Length= 350 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.86	92.63	29.30
2.6	1.98	92.20	28.11
2.8	2.10	91.78	26.96
3.0	2.23	91.36	25.87
3.2	2.37	90.94	24.81
3.4	2.52	90.52	23.80
3.6	2.67	90.11	22.83
3.8	2.84	89.69	21.90

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 8

Values of WT ; Ho ; Vo @ Net Speeds(Vn) for each Warp Length(W) & Vessel Distance(D)

Distance= 0.2 n.m.

Warp Length= 175 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.65	96.39	16.36
2.6	1.76	95.95	15.69
2.8	1.86	95.51	15.05
3.0	1.98	95.07	14.44
3.2	2.10	94.64	13.85
3.4	2.23	94.20	13.29
3.6	2.37	93.77	12.75
3.8	2.52	93.34	12.23

Warp Length= 250 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng Vo (Ft)
2.4	1.69	93.62	19.79
2.6	1.79	93.19	18.98
2.8	1.90	92.76	18.21
3.0	2.02	92.33	17.47
3.2	2.15	91.91	16.76
3.4	2.28	91.49	16.07
3.6	2.42	91.07	15.42
3.8	2.57	90.65	14.79

Warp Length= 300 fthm

Ave mean d= 50 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.71	91.81	22.47
2.6	1.82	91.39	21.55
2.8	1.93	90.97	20.68
3.0	2.05	90.55	19.83
3.2	2.17	90.13	19.03
3.4	2.31	89.72	18.25
3.6	2.45	89.31	17.51
3.8	2.60	88.90	16.80

Warp Length= 350 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng Ho (ft)	Vert. Opng Vo (Ft)
2.4	1.73	90.04	25.51
2.6	1.84	89.62	24.47
2.8	1.95	89.21	23.47
3.0	2.08	88.80	22.51
3.2	2.20	88.39	21.60
3.4	2.34	87.99	20.72
3.6	2.49	87.58	19.88
3.8	2.64	87.18	19.07

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 9

Values of WT ; Ho ; Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.2 n.m.

Warp Length= 175 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng Vo (Ft)
2.4	1.54	93.70	14.24
2.6	1.63	93.27	13.66
2.8	1.73	92.84	13.10
3.0	1.84	92.41	12.57
3.2	1.96	91.99	12.06
3.4	2.08	91.56	11.57
3.6	2.21	91.14	11.10
3.8	2.34	90.72	10.65

Warp Length= 250 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.57	90.99	17.23
2.6	1.67	90.58	16.53
2.8	1.77	90.16	15.85
3.0	1.88	89.75	15.21
3.2	2.00	89.33	14.59
3.4	2.12	88.92	14.00
3.6	2.25	88.52	13.43
3.8	2.39	88.11	12.88

Warp Length= 300 fthm

Ave mean d= 70 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.59	89.24	19.56
2.6	1.69	88.83	18.76
2.8	1.79	88.42	18.00
3.0	1.91	88.01	17.27
3.2	2.02	87.61	16.57
3.4	2.15	87.21	15.89
3.6	2.28	86.81	15.24
3.8	2.42	86.41	14.62

Warp Length= 350 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng Vo (Ft)
2.4	1.61	87.51	22.21
2.6	1.71	87.11	21.31
2.8	1.82	86.71	20.44
3.0	1.93	86.31	19.61
3.2	2.05	85.92	18.81
3.4	2.18	85.52	18.04
3.6	2.31	85.13	17.31
3.8	2.46	84.74	16.60

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 10

Values of WT ; Ho ; Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.25 n.m.

Warp Length= 175 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.88	107.78	17.56
2.6	1.99	107.28	16.84
2.8	2.12	106.79	16.16
3.0	2.25	106.30	15.50
3.2	2.39	105.81	14.87
3.4	2.53	105.32	14.26
3.6	2.69	104.84	13.68
3.8	2.86	104.36	13.13

Warp Length= 250 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.92	104.67	21.24
2.6	2.03	104.19	20.38
2.8	2.16	103.71	19.55
3.0	2.29	103.23	18.75
3.2	2.44	102.76	17.99
3.4	2.59	102.29	17.26
3.6	2.75	101.82	16.55
3.8	2.92	101.35	15.87

Warp Length= 300 fthm

Ave mean d= 30 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.94	102.65	24.12
2.6	2.06	102.18	23.14
2.8	2.19	101.71	22.20
3.0	2.33	101.24	21.29
3.2	2.47	100.77	20.43
3.4	2.62	100.31	19.59
3.6	2.78	99.85	18.80
3.8	2.96	99.39	18.03

Warp Length= 350 fthm

Ave mean d= 30 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.97	100.67	27.38
2.6	2.09	100.20	26.27
2.8	2.22	99.74	25.20
3.0	2.36	99.28	24.18
3.2	2.50	98.83	23.19
3.4	2.66	98.37	22.25
3.6	2.82	97.92	21.34
3.8	3.00	97.47	20.47

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 11

Values of WT; Ho; Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.25 n.m.

Warp Length= 175 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.75	104.76	15.29
2.6	1.86	104.28	14.66
2.8	1.97	103.80	14.07
3.0	2.09	103.32	13.49
3.2	2.22	102.85	12.95
3.4	2.36	102.37	12.42
3.6	2.50	101.90	11.91
3.8	2.66	101.44	11.43

Warp Length= 250 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng Vo (Ft)
2.4	1.78	101.74	18.49
2.6	1.89	101.27	17.74
2.8	2.01	100.81	17.02
3.0	2.13	100.34	16.33
3.2	2.27	99.88	15.66
3.4	2.41	99.42	15.02
3.6	2.56	98.97	14.41
3.8	2.71	98.51	13.83

Warp Length= 300 fthm

Ave mean d= 50 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.81	99.77	21.00
2.6	1.92	99.32	20.14
2.8	2.04	98.86	19.32
3.0	2.16	98.41	18.54
3.2	2.30	97.95	17.78
3.4	2.44	97.50	17.06
3.6	2.59	97.06	16.36
3.8	2.75	96.61	15.70

Warp Length= 350 fthm

Ave mean d= 50 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng Vo (Ft)
2.4	1.83	97.85	23.84
2.6	1.94	97.40	22.87
2.8	2.07	96.95	21.94
3.0	2.19	96.50	21.05
3.2	2.33	96.06	20.19
3.4	2.47	95.62	19.37
3.6	2.63	95.18	18.58
3.8	2.79	94.74	17.82

PREDICTING VALUES FOR A CONSTANT WATER DEPTH

TABLE 12

Values of WT, Ho, Vo @ Net Speeds(Vn) for each Warp Length(W) &Vessel Distance(D)

Distance= 0.25 n.m.

Warp Length= 175 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.63	101.82	13.31
2.6	1.73	101.36	12.77
2.8	1.83	100.89	12.25
3.0	1.95	100.43	11.75
3.2	2.07	99.97	11.27
3.4	2.19	99.51	10.81
3.6	2.33	99.05	10.37
3.8	2.48	98.60	9.95

Warp Length= 250 fthm

Ave mean d= 70 fthm

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.66	98.89	16.10
2.6	1.76	98.44	15.45
2.8	1.87	97.98	14.82
3.0	1.99	97.53	14.21
3.2	2.11	97.09	13.64
3.4	2.24	96.64	13.09
3.6	2.38	96.20	12.55
3.8	2.53	95.75	12.04

Warp Length= 300 fthm

Ave mean d= 70 fthm(assumed)

Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.68	96.98	18.28
2.6	1.79	96.53	17.54
2.8	1.90	96.09	16.82
3.0	2.01	95.65	16.14
3.2	2.14	95.21	15.48
3.4	2.27	94.77	14.85
3.6	2.41	94.34	14.25
3.8	2.56	93.90.	13.67

Warp Length= 350 fthm

Ave mean d= 70 fthm

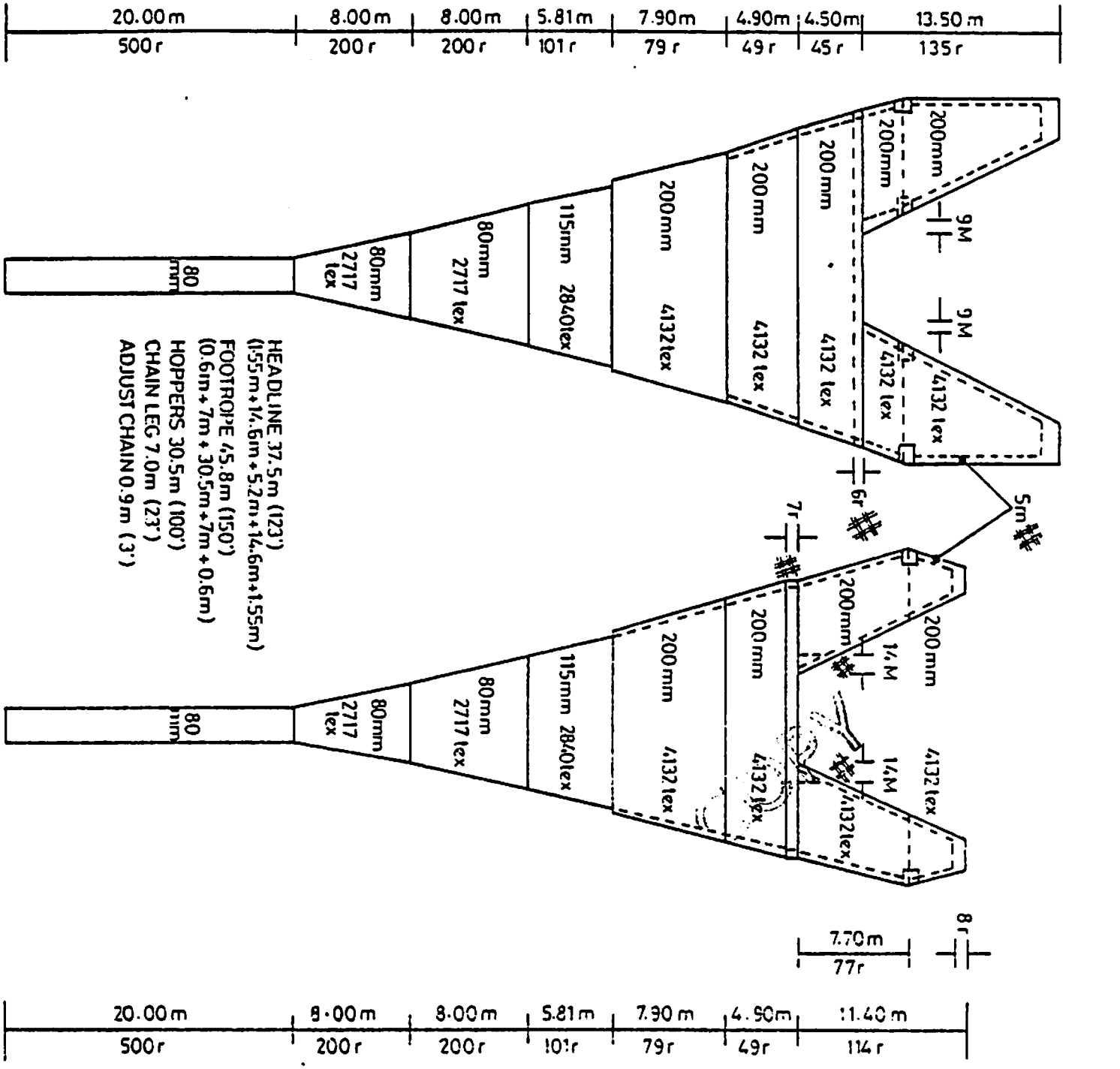
Net Speed Vs (knots)	Warp Tension WT (tons)	Hor. Opng. Ho (ft)	Vert. Opng. Vo (Ft)
2.4	1.70	95.11	20.76
2.6	1.81	94.67	19.91
2.8	1.92	94.24	19.10
3.0	2.04	93.80	18.33
3.2	2.17	93.37	17.59
3.4	2.30	92.94	16.86
3.6	2.44	92.52	16.18
3.8	2.59	92.09	15.52

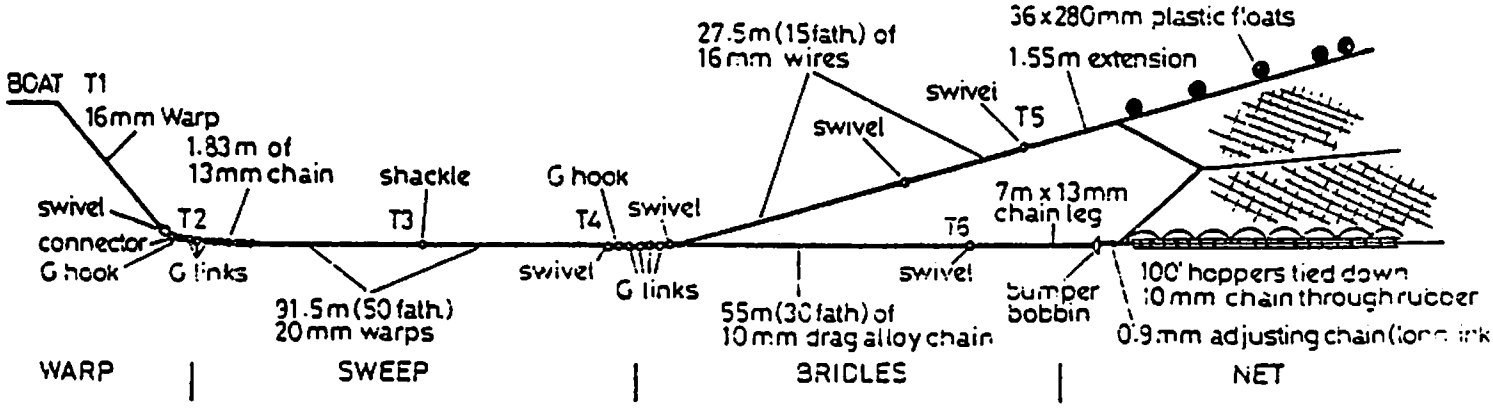
TABLE 13

EFFECT OF CHANGING ONE VARIABLE WHILST MAINTAINING THE VALUES OF THE REMAINING VARIABLES

The effects are expressed as percentages of the original values

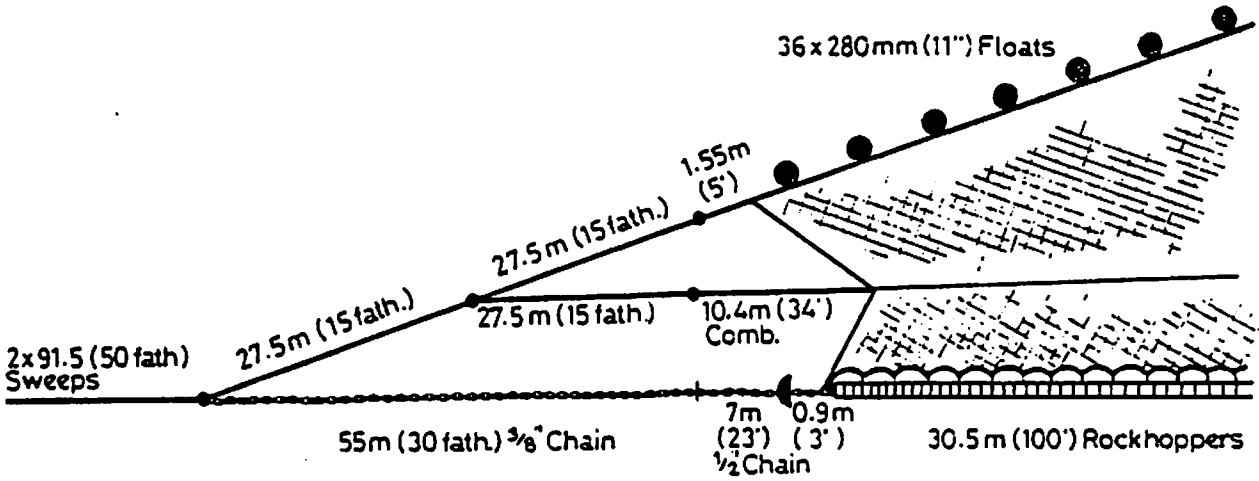
VARIABLE INCREASED		APPROX % CHANGE		
		WARP TENSION	HORIZONTAL OPENING	VERTICAL OPENING
SPEED	per knot	+35	- 2	-19
WARP	per 50 fathoms	+ 1.4	- 2	+13.5
DISTANCE	per 1/10 naut mile	+11	+16.6	-13.5
WATER DEPTH	per 10 fathoms	- 3.6	- 1.4	-10.9



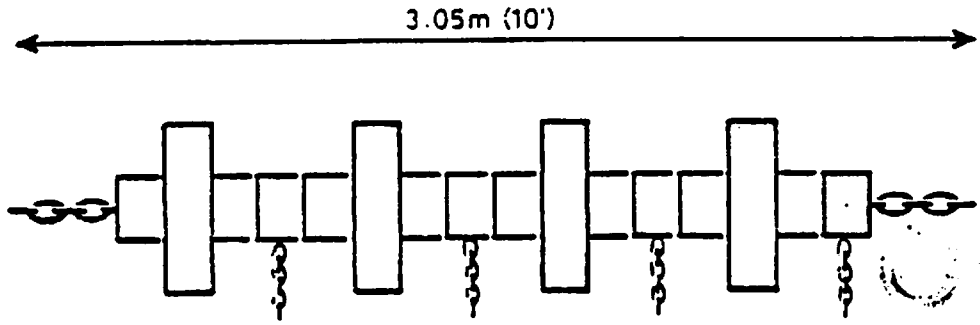


F.M.A. Buckie Pair Trawl BT 154
(Rigged with two bridles and rockhopper gear)

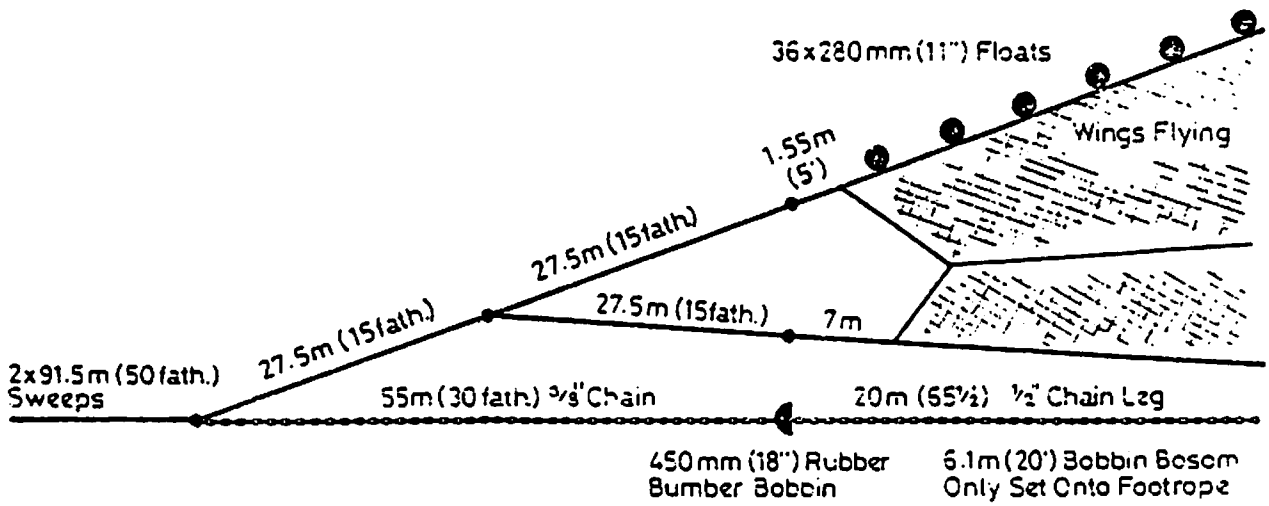
Appendix I



3 Bridle and Rockhopper Rig



Bobbins. 2 off x 10 ft. Strings Giving 20 ft. Bobbin Bosom



AVERAGE RESULTS OF RECORDED PARAMETERS DERIVED BY DAPS

TOW REF. DAPS AP04/4 DATE 29TH FEBRUARY 1984

SPIA 1/-

WARP OUT 175 FATHOMS TRAWL RIG 2 BRIDLE WITH ROCKHOPPER GEAR

BLOCK NO.		1	2	3	4	5	6	7	8	9	10
Vessel Distance Apart	(nm)	0.20	0.20	0.20	0.25	0.15	0.20	0.20	0.20	0.25	0.15
Engine RPM		1400	1500	1450	1450	1450	1400	1500	1450	1450	1450
AQUILA											
Warp Tension T1 starb	(tons)	2.50	2.85	2.70	2.70	2.42	2.25	2.67	2.35	2.35	2.40
Ship Speed	(knots)	2.90	3.15	3.00	3.20	3.30	2.55	2.65	3.10	3.10	2.95
Warp Declination	(deg)	9	8	8.5	9.5	10	9.5	8	8	8.5	9
Water Depth	(fthm)	19	18	18	24	26	20	15	15	12	16
POSEIDON											
Warp Tension T1 port	(tons)	2.07	2.35	2.24	2.12	1.93	1.90	1.95	1.80	2.10	1.93
Ship Speed	(knots)	3.07	3.15	3.10	2.88	3.05	3.00	3.00	3.50	2.50	3.00
Warp Declination	(deg)	-	-	-	-	-	-	-	-	-	-
Water Depth	(fthm)	17	14	14	18	24	24	20	18	15	18
SPREADS (FEET)											
Wing End		98	97	98	100	90	100	103	102	110	93
Mid Bridle		-	-	-	-	-	-	-	-	-	-
Fore Sweep		-	-	-	-	-	-	-	-	-	-
TENSIONS (TONS)											
T2 starb		-	-	-	-	-	-	-	-	-	-
T2 port		2.00	2.28	2.17	2.08	1.84	1.80	1.85	1.76	2.05	1.82
T3 starb		-	-	-	-	-	-	-	-	-	-
T3 port		-	-	-	-	-	-	-	-	-	-
T4 starb		-	-	-	-	-	-	-	-	-	-
T4 port		-	-	-	-	-	-	-	-	-	-
T5 starb		-	-	-	-	-	-	-	-	-	-
T5 port		0.98	1.05	1.02	1.03	0.90	0.87	0.94	0.84	1.02	0.77
T6 starb		0.81	0.95	0.95	0.90	0.83	0.80	0.95	0.80	0.80	0.84
T6 port		-	-	-	-	-	-	-	-	-	-
VERTICAL OPENING (FEET)											
Acoustic Meter		-	-	-	-	-	-	-	-	-	-
Manometer		18	17	17	17	19	20	19	19.5	18	20
NET SPEED (KNOTS)		3.05	3.35	3.20	2.95	3.10	2.70	2.80	2.60	2.65	2.75

APPENDIX III

AVERAGE RESULTS OF RECORDED PARAMETERS DERIVED BY DAFS

TOW REF. DAFS AP84/6 DATE 1ST MARCH 1984

SF1A 3/-

WARP OUT 250 FATHOMS TRAWL RIG 2 BRIDLE WITH ROCKHOPPER GEAR

BLOCK NO.	1	2	3	4	5	6	7	8	9	10
Vessel Distance Apart (nm)	0.15	0.25	0.20	0.20	0.20	0.15	0.25	0.20	0.20	0.20
Engine RPM	1450	1450	1450	1550	1350	1450	1450	1450	1550	1350
AQUILA										
Warp Tension T1 starb (tons)	2.45	2.55	2.50	2.80	2.15	2.20	2.30	2.15	2.45	1.95
Ship Speed (knots)	3.15	3.10	3.00	3.50	3.10	3.15	2.90	3.80	3.90	3.30
Warp Declination (deg)	13	13	13	12.5	14	13.5	13	13	12.5	14
Water Depth (fthm)	55	54	50	51	56	52	48	47	49	47
POSEIDON										
Warp Tension T1 port (tons)	2.20	2.25	2.20	2.45	1.90	2.00	2.00	1.90	2.15	1.75
Ship Speed (knots)	2.95	2.95	3.30	3.45	3.05	3.30	3.50	3.70	4.00	3.30
Warp Declination (deg)	13.5	13.5	13	12.5	14.5	14.5	13.5	14.5	12.5	15.5
Water Depth (fthm)	46	47	45	49	52	54	50	53	56	58
SPREADS (FEET)										
Wing End	-	-	-	-	-	-	102	92	-	90
Mid Bridle	135	158	147	148	149	140	160	145	147	148
Fore Sweep	-	-	-	-	-	-	-	-	-	-
TENSIONS (TONS)										
T2 starb	2.44	2.54	2.46	2.72	2.08	2.12	2.28	2.04	2.34	1.84
T2 port	-	-	-	-	-	-	-	-	-	-
T3 starb	-	-	-	-	-	-	-	-	-	-
T3 port	-	-	-	-	-	-	-	-	-	-
T4 starb	2.70	2.54	2.40	2.73	2.02	2.10	2.26	2.00	2.36	1.77
T4 port	2.04	2.08	2.00	2.24	1.73	1.82	1.84	1.69	1.92	1.52
T5 starb	1.09	1.09	1.09	-	1.04	1.04	1.06	0.99	1.07	0.93
T5 port	1.06	1.08	1.04	1.10	0.90	0.90	0.94	0.85	0.98	0.82
T6 starb	0.84	0.90	0.86	0.99	0.73	0.78	0.84	0.74	0.87	0.66
T6 port	0.84	0.83	0.82	0.94	0.71	0.80	0.76	0.72	0.82	0.63
VERTICAL OPENING (FEET)										
Acoustic Meter	17	17	16	-	17	17	16	17	-	18
Manometer	-	-	-	-	-	-	-	-	-	-
NET SPEED (KNOTS)	3.60	3.30	3.35	3.60	3.05	3.05	2.75	2.85	3.15	2.75

AVERAGE RESULTS OF RECORDED PARAMETERS DERIVED BY DAFS

TOW REF. DAFS AP84/7 . DATE 5TH MARCH 1984

SF1A 7/-

WARP OUT 350 FATHOMS TRAWL RIG 2 BRIDLE WITH ROCKHOPPER GEAR

BLOCK NO.		1	2	3	4	5	6	7
Vessel Distance Apart	(nm)	0.15	0.25	0.20	0.20	0.20	0.15	0.25
Engine RPM		1450	1450	1450	1550	1350	1450	1450
AQUILA								
Warp Tension T1 starb	(tons)	1.97	2.07	2.10	2.33	1.84	2.43	2.54
Ship Speed	(knots)	3.90	3.73	3.64	4.30	3.40	3.20	2.84
Warp Declination	(deg)	15	14.5	14	13	15.5	13.5	13
Water Depth	(fthm)	57	56	51	49	52	56	51
POSEIDON								
Warp Tension T1 port	(tons)	1.40	1.35	1.35	1.60	0.83	-	
Ship Speed	(knots)	3.75	3.34	3.63	4.00	3.20	2.84	-
Warp Declination	(deg)	16	15.5	15	13.5	15.5	-	-
Water Depth	(fthm)	58	57	52	51	55	54	47
SPREADS (FEET)								
Wing End		82	97	87	88	-	-	-
Mid Bridle		-	-	-	175	172	150	-
Fore Sweep		540	720	635	600	610	480	-
TENSIONS (TONS)								
T2 starb		1.89	1.95	1.98	2.22	1.72	2.43	-
T2 port		1.57	1.80	1.73	2.05	1.54	2.10	-
T3 starb		-	-	-	-	-	-	-
T3 port		-	-	-	-	-	-	-
T4 starb		-	-	-	-	-	-	-
T4 port		-	-	-	-	-	-	-
T5 starb		-	-	-	-	-	-	-
T5 port		0.63	0.73	0.69	0.91	0.62	0.35	-
T6 starb		0.70	0.74	0.72	0.82	0.64	0.84	-
T6 port		0.53	0.59	0.56	0.69	0.49	0.73	-
VERTICAL OPENING (FEET)								
Acoustic Meter		25	23	25	20	26	20	-
Manometer		-	-	-	-	-	-	-
NET SPEED (KNOTS)		2.75	2.50	2.65	3.10	2.35	-	-

AVERAGE RESULTS OF RECORDED PARAMETERS DERIVED BY DAFS

TOW REF. DAFS AP84/8 DATE 6TH MARCH 1984

SFIA 7/-

WARP OUT 300 FATHOMS TRAWL RIG 3 BRIDLE WITH ROCKHOPPER GEAR

BLOCK NO.		1	2	3	4	5	6	7	8	9	10
Vessel Distance Apart	(nm)	0.15	0.25	0.20	0.20	0.20	0.15	0.25	0.20	0.20	0.20
Engine RPM		1450	1450	1450	1550	1350	1450	1450	1450	1550	1350
AQUILA											
Warp Tension T1 starb	(tons)	2.55	2.50	2.55	-	2.20	2.23	2.27	2.25	2.25	-
Ship Speed	(knots)	2.87	2.76	2.75	-	2.40	3.65	3.50	3.70	-	-
Warp Declination	(deg)	14.5	14.7	14.5	15.0	15.0	16.0	15.7	15.5	14.5	-
Water Depth	(fthm)	52	51	55	52	48	56	57	52	49	48
POSEIDON											
Warp Tension T1 port	(tons)	2.08	-	2.20	2.55	2.13	1.78	1.98	1.67	2.30	1.92
Ship Speed	(knots)	2.75	-	2.85	3.00	2.40	3.88	3.43	3.45	4.00	3.43
Warp Declination	(deg)	17.0	-	-	12.5	13.5	17.5	12.0	10.5	12.0	14.5
Water Depth	(fthm)	47	48	48	48	42	58	58	53	50	55
SPREADS (FEET)											
Wing End		75	100	90	85	90	80	105	90	85	90
Mid Bridle		140	160	150	150	155	130	160	155	150	150
Fore Sweep		470	720	590	575	620	480	740	600	550	570
TENSIONS (TONS)											
T2 starb		2.33	2.38	2.34	2.66	2.03	2.02	2.11	2.07	2.37	1.82
T2 port		2.17	2.22	2.13	2.46	1.99	1.83	1.98	1.93	2.19	1.78
Centre starb		0.57	0.33	0.45	0.56	0.295	0.45	0.225	0.36	0.49	0.265
Centre port		0.49	0.30	0.395	0.485	0.31	0.435	0.25	0.39	0.47	0.305
T4 starb		-	-	-	-	-	-	-	-	-	-
T4 port		2.06	2.06	2.04	2.34	1.82	1.78	1.76	1.86	2.11	1.71
T5 starb		0.80	0.93	0.85	0.95	0.72	0.71	0.85	0.77	0.84	0.62
T5 port		0.72	0.93	0.78	0.93	0.75	0.66	0.91	0.75	0.90	0.72
T6 starb		0.615	0.75	0.695	0.79	0.605	0.545	0.66	0.61	0.695	0.53
T6 port		-	-	-	-	-	-	-	-	-	-
VERTICAL OPENING (FEET)											
Acoustic Meter		32	24	28	27	28	33	26	30	27	29
Manometer		-	-	-	-	-	-	-	-	-	-
NET SPEED (KNOTS)		3.22	2.98	3.02	3.37	2.62	2.92	2.82	2.96	3.25	2.62

AVERAGE RESULTS OF RECORDED PARAMETERS DERIVED BY DAFS

TOW REF. DAFS AP84/9 DATE 6TH MARCH 1984

SP1A 8/-

WARP OUT 300 FATHOMS TRAWL RIG 2 BRIDLE WITH ROCKHOPPER GEAR

BLOCK NO.		1	2	3	4	5	6
Vessel Distance Apart	(nm)	0.20	0.20	0.20	0.20	0.20	0.20
Engine RPM		1450	1550	1350	1450	1550	1350
AQUILA							
Warp Tension T1 starb	(tons)	2.45	2.75	2.15	2.35	2.65	2.10
Ship Speed	(knots)	3.00	3.45	2.90	3.45	3.05	3.10
Warp Declination	(deg)	15.5	14	16	14	14	16.5
Water Depth	(fthm)	55	51	52	46	50	50
POSEIDON							
Warp Tension T1 port	(tons)	2.52	2.70	2.15	2.60	2.65	2.20
Ship Speed	(knots)	2.90	3.35	3.0	3.80	3.95	3.40
Warp Declination	(deg)	15	13	15	12.5	13	15.5
Water Depth	(fthm)	48	47	50	49	54	57
SPREADS (FEET)							
Wing End		90	90	95	-	-	-
Mid Bridle		145	145	150	150	150	145
Fore Sweep		580	590	590	600	620	590
TENSIONS (TONS)							
T2 starb		2.26	2.52	1.96	2.14	2.44	1.88
T2 port		2.06	2.26	1.72	1.91	2.22	1.72
T3 starb		-	-	-	-	-	-
T1 port		-	-	-	-	-	-
T4 starb		-	-	-	-	-	-
T4 port		-	-	-	-	-	-
T5 starb		1.06	1.09	0.96	0.96	1.06	0.84
T5 port		1.07	1.16	0.89	0.96	1.08	0.82
T6 starb		0.80	0.39	0.68	0.36	0.97	0.74
T6 port		-	-	-	-	-	-
VERTICAL OPENING (FEET)							
Acoustic Meter		-	-	-	-	-	-
Manometer		-	-	-	-	-	-
NET SPEED (KNOTS)		3.35	3.62	3.00	3.02	3.32	2.74

AVERAGE RESULTS OF RECORDED PARAMETERS DERIVED BY DAFS

TOW REF. DAFS AP84/10 DATE 7TH MARCH 1984

SFIA 9/-

WARP OUT 300 FATHOMS TRAWL RIG BOBBIN GEAR

BLOCK NO.	1	2	3	4	5	6	7	8	9
Vessel Distance Apart (nm)	0.15	0.25	0.20	0.20	0.15	0.25	0.20	0.20	0.20
Engine RPM	1450	1450	1450	1550	1450	1450	1450	1550	1350
AQUILA									
Warp Tension T1 starb (tons)	2.40	2.35	2.40	2.80	2.20	2.35	-	2.55	1.95
Ship Speed (knots)	3.15	3.25	3.10	3.20	3.70	3.40	3.75	4.25	3.75
Warp Declination (deg)	13	13	13	12	14	13	12.5	12	14.5
Water Depth (fthm)	50	48.5	49.5	51	59	58	53.5	53	56.5
POSEIDON									
Warp Tension T1 port (tons)	2.84	2.95	3.05	3.40	2.88	2.94	2.63	-	2.62
Ship Speed (knots)	3.03	2.90	3.05	3.27	3.70	3.35	3.70	4.20	3.45
Warp Declination (deg)	14.5	14.5	15	13.5	15.5	15.5	14.5	14.5	16.5
Water Depth (fthm)	54	51	55	55	57	56	50	48	50
SPREADS (FEET)									
Wing End	70	95	-	85	-	-	-	-	-
Mid Bridle	130	174	156	153	137	181	158	158	158
Fore Sweep	320	545	470	475	600	680	640	645	650
TENSIONS (TONS)									
T2 starb	2.03	2.00	2.03	2.17	1.91	1.96	1.93	2.01	1.79
T2 port	-	-	-	-	-	-	-	-	-
Centre starb	0.46	0.47	0.49	0.56	0.43	0.44	0.42	0.52	0.39
Centre port	0.53	0.55	0.54	0.65	0.50	0.52	0.48	0.60	0.42
T4 starb	2.03	2.00	2.04	2.17	1.91	1.96	1.92	2.02	1.75
T4 port	2.12	2.10	2.10	2.30	1.98	2.06	2.02	2.16	1.88
T5 starb	1.12	1.10	1.11	1.27	1.01	1.03	0.99	1.08	0.77
T5 port	1.22	1.23	1.22	1.24	1.18	1.13	1.17	1.23	1.04
T6 starb	0.26	0.24	0.28	0.30	0.21	0.22	0.26	0.24	0.17
T6 port	-	-	-	-	-	-	-	-	-
VERTICAL OPENING (FEET)									
Acoustic Meter	23	20	21	21	28.5	22	22	23	24
Manometer	-	-	-	-	-	-	-	-	-
NET SPEED (KNOTS)	3.38	3.07	3.20	3.58	3.19	2.98	3.07	3.31	2.67

AVERAGE RESULTS OF RECORDED PARAMETERS DERIVED BY DAFS

TOW REF. DAFS AP84/10 DATE 7TH MARCH 1984

SFIA 10/-

WARP OUT 300 FATHOMS TRAWL RIG BOBBIN GEAR

BLOCK NO.		10	11	12	13	14
Vessel Distance Apart	(nm)	0.15	0.25	0.20	0.20	0.20
Engine RPM		1450	1450	1450	1550	1350
AQUILA						
Warp Tension T1 port	(tons)	2.50	2.50	2.50	2.75	2.20
Ship Speed	(knots)	3.15	2.95	3.15	3.50	3.10
Warp Declination	(deg)	14.5	14	14	13	14.5
Water Depth	(fthm)	58	56	-	54	55.5
POSEIDON						
Warp Tension T1 stbd	(tons)	3.17	3.16	3.16	3.43	3.07
Ship Speed	(knots)	3.00	3.10	3.40	3.45	2.65
Warp Declination	(deg)	15	15	16	13.5	15.5
Water Depth	(fthm)	58	56	55	55	56
SPREADS (FEET)						
Wing End		-	-	-	-	-
Mid Bridle		135	164	150	142	153
Fore Sweep		480	690	600	570	580
TENSIONS (TONS)						
T2 starb		1.92	2.01	1.98	2.09	1.95
T2 port		-	-	-	-	-
Centre stbd		0.42	0.45	0.44	0.50	0.41
Centre port		0.55	0.58	0.58	0.66	0.44
T4 starb		1.90	1.99	1.96	2.09	1.93
T4 port		2.18	2.16	2.13	2.23	1.88
T5 starb		1.13	1.14	1.12	1.23	1.05
T5 port		1.22	1.22	1.22	1.24	1.03
T6 starb		0.23	0.25	0.25	0.26	0.18
T6 port		-	-	-	-	-
VERTICAL OPENING (FEET)						
Acoustic Meter		24	20.5	19	21	23
Manometer		-	-	-	-	-
NET SPEED (KNOTS)		3.31	3.18	3.21	3.60	3.00

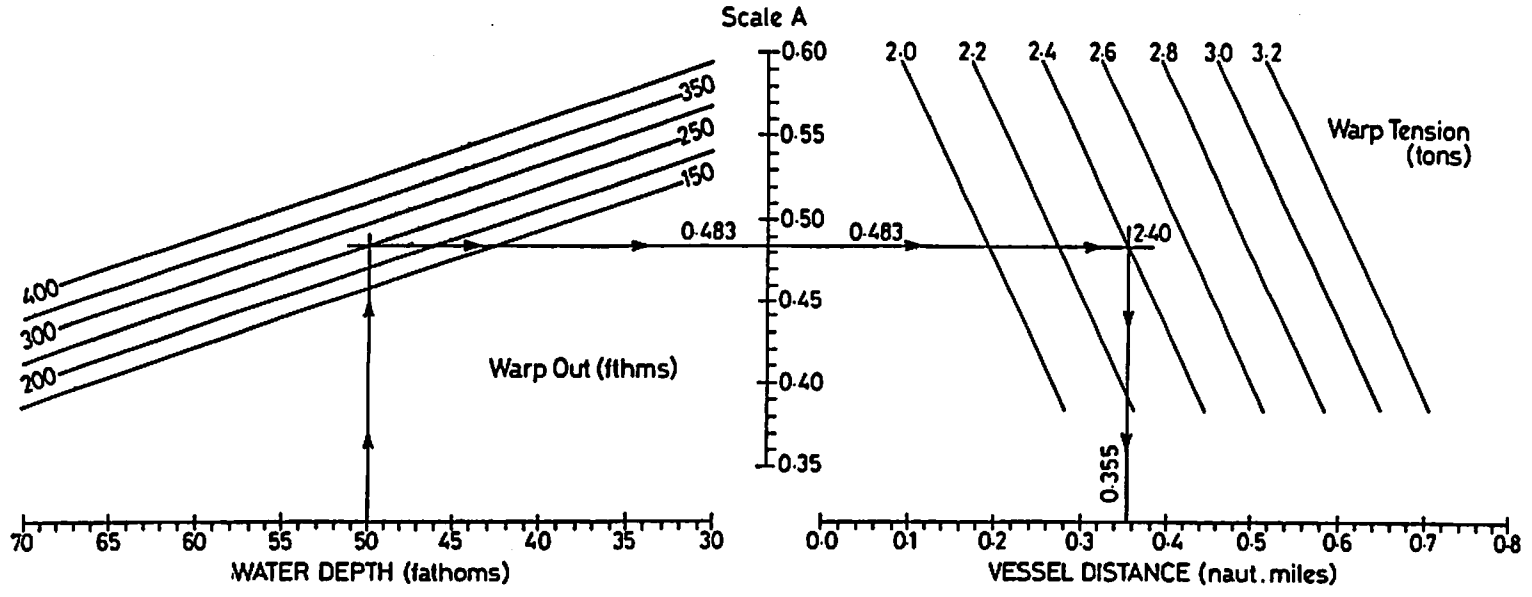
SUMMARY OF RECORDED DATA

WTd	Denotes	Warp Tension (tons) recorded by DAFS
WTa	Denotes	Warp Tension (knots) recorded by SFIA
Vn	Denotes	Net speed (knots)
d	Denotes	Water Depth (fathoms) mean between vessels
Ho	Denotes	Horizontal Net Opening (feet)
Vo	Denotes	Vertical Net Opening (feet)
W	Denotes	Warp Out (fathoms)
D	Denotes	Vessel Distance Apart (naut. miles)

Tow Ref	AQUILA WTd	WTa	POSEIDON WTd	WTa	MEAN WT	Vs	D	Ho	Vo	W	d
1/1	2.50	2.10	2.07	2.26	2.23	3.05	0.20	98.00	18.00	175	1[illegible]
2	2.65	2.47	2.35	2.48	2.23	3.35	0.20	97.00	17.00	175	1[illegible]
3	2.70	2.33	2.24	2.33	2.23	3.20	0.20	98.00	17.00	175	16.1
4	2.70	2.22	2.12	2.58	2.23	2.95	0.25	108.00	17.00	175	21.1
5	2.42	2.00	1.93	2.07	2.23	3.10	0.15	90.00	19.00	175	25.0
6	2.25	1.76	1.90	2.07	2.23	2.70	0.20	100.00	20.00	175	22.0
7	2.67	2.11	1.95	2.07	2.23	2.80	0.20	103.00	19.00	175	17.5
8	2.35	1.79	1.80	2.05	2.23	2.60	0.20	102.00	19.50	175	16.5
9	2.35	1.75	2.10	2.32	2.23	2.65	0.25	110.00	18.00	175	13.5
10	2.40	1.73	1.93	2.24	2.23	2.75	0.15	93.00	20.00	175	17.0
3/1	2.45	2.16	2.20	2.26	2.23	3.60	0.15		17	250	30.5
2	2.55	2.20	2.25	2.40	2.23	3.30	0.25		17	250	50.5
3	2.50	2.09	2.20	2.28	2.23	3.35	0.20		16	250	47.5
4	2.80	2.35	2.45	2.52	2.23	3.60	0.20			250	50.0
5	2.15	1.59	1.90	2.02	2.23	3.05	0.20		17	250	34.0
6	2.20	1.45	2.00	2.21	2.23	3.05	0.15		17	250	33.5
7	2.30	2.11	2.00	2.03	2.23	2.75	0.25	102.00	16	250	49.5
8	2.15	1.91	1.90	2.04	2.23	2.85	0.20	92.00	17	250	50.0
9	2.45	2.16	2.15	2.25	2.23	3.15	0.20			250	32.5
10	1.95	1.61	1.75	1.91	2.23	2.75	0.20	90.00	18	250	32.5
6/1	1.97	2.06	1.40	1.62	2.23	2.75	0.15	82.00	25	350	57.5
2	2.07	2.13	1.35	1.53	2.23	2.50	0.25	87.00	23	350	56.5
3	2.10	2.11	1.35	1.75	2.23	2.65	0.20	87.00	25	350	51.5
4	2.33	2.33	1.60	2.04	2.23	3.10	0.20	88.00	20	350	50.0
5	1.84	1.80	0.83	3.09	2.23	2.35	0.20		26	350	55.5
6	2.43	2.51		2.19	2.23		0.15		20	350	55.0
7	2.54	2.67		2.52	2.23		0.25			350	49.0
7/1	2.45	2.35	2.52	2.31	2.23	3.35	0.20	90.00		300	51.5
2	2.75	2.59	2.70	2.09	2.23	3.62	0.20	90.00		300	49.0
3	2.15	2.05	2.15	1.94	2.23	3.00	0.20	85.00		300	51.0
4	2.35	2.29	2.60	2.25	2.23	3.02	0.20			300	47.5
5	2.65	2.60	2.65	2.28	2.23	3.32	0.20			300	51.0
6	2.10	2.01	2.20	2.31	2.23	2.74	0.20			300	58.5

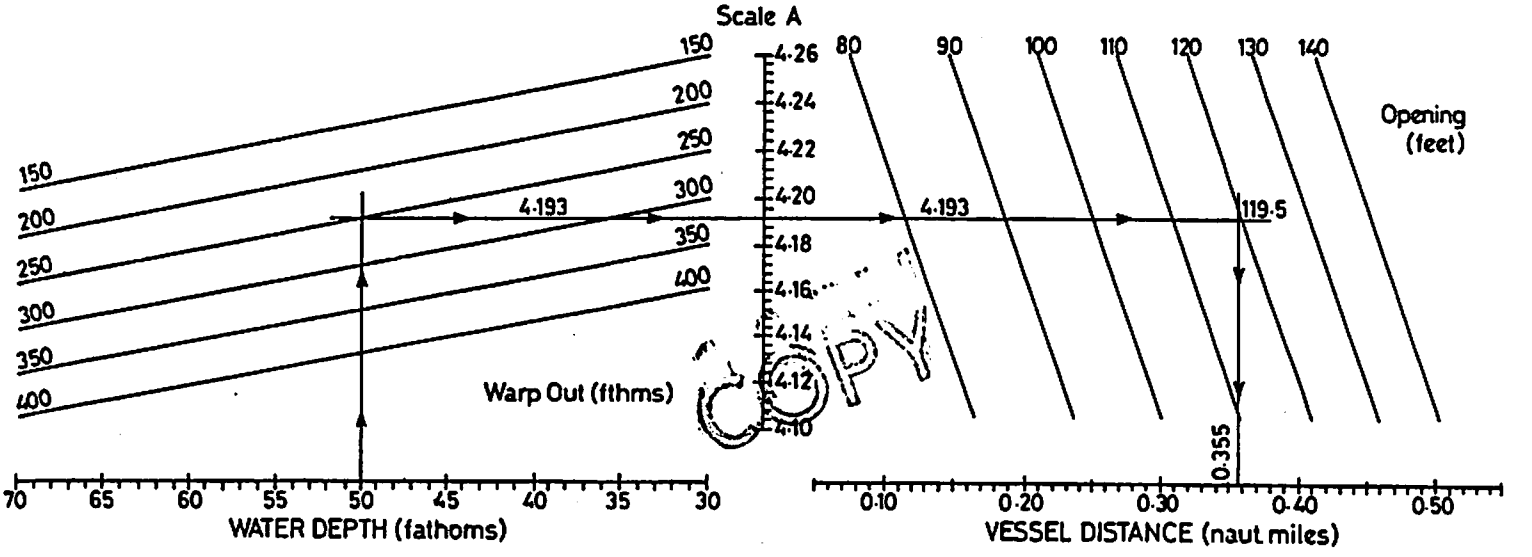
SINGLE WARP TENSION

NET SPEED 3 knots



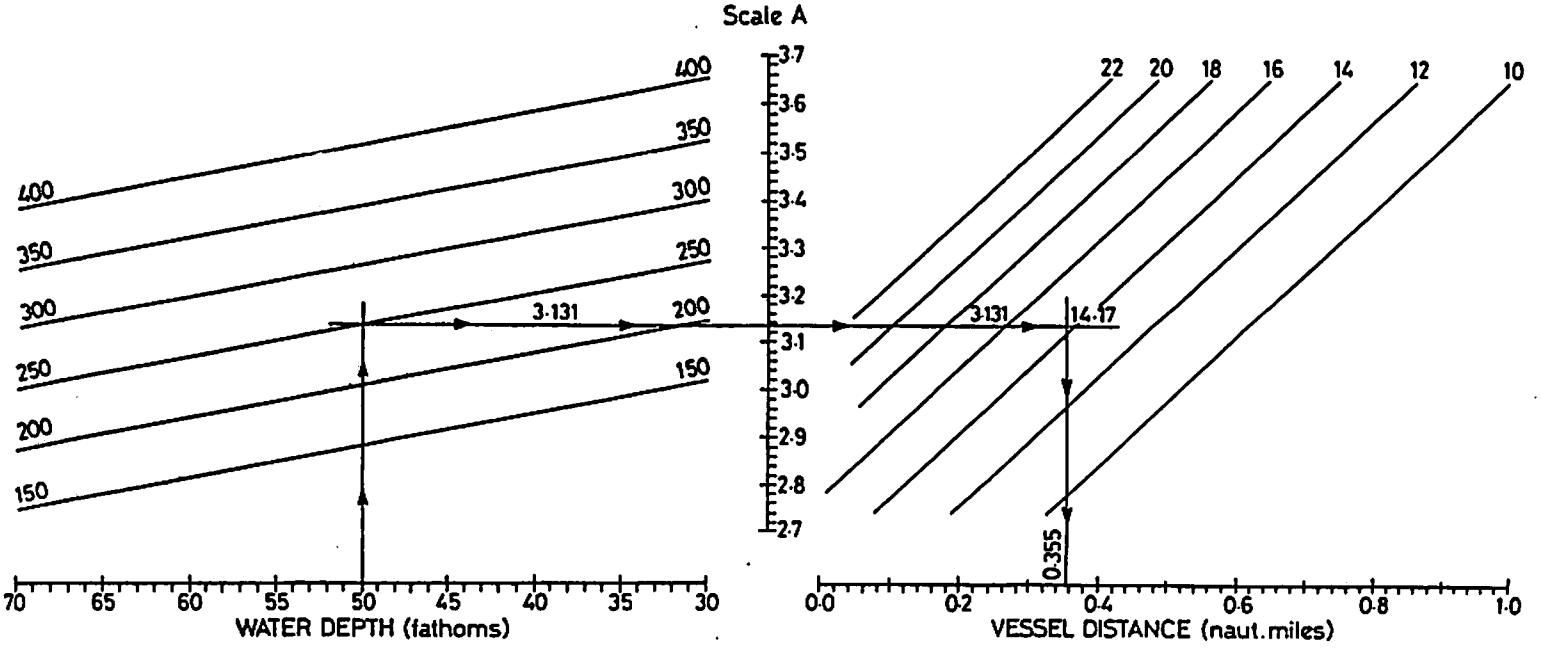
HORIZONTAL OPENING

NET SPEED 3 knots



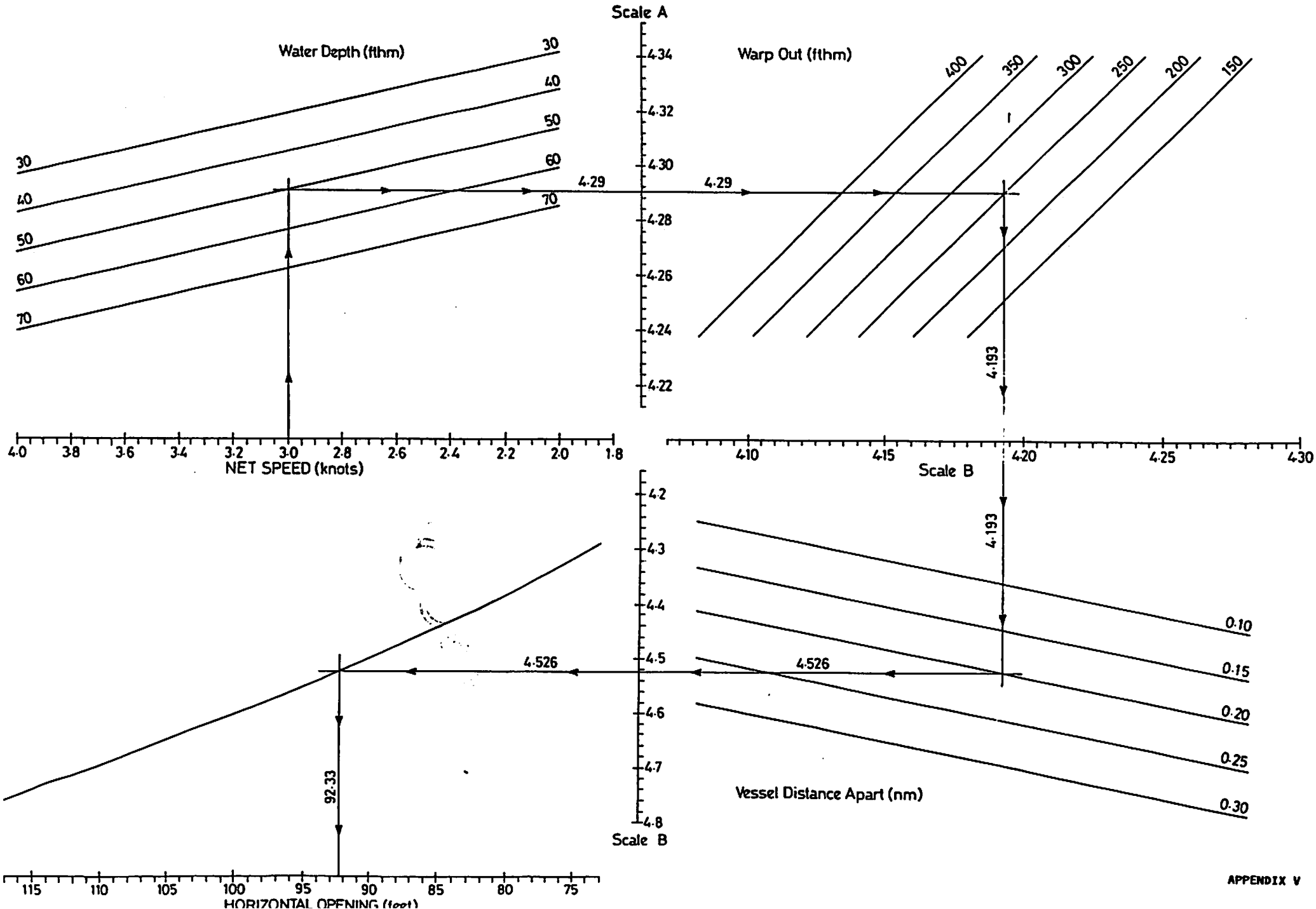
VERTICAL OPENING

NET SPEED 3 knots



HORIZONTAL OPENING

(Wing End Spread)



APPENDIX V