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Demersal Pair Trawling and its Operational Parameters

by

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Abstract

Demersal pair trawl gear was studied with regard to resistance and geometry during two cruises in the North Sea area in 1980 and 1981. On smooth grounds where fairly long and heavy sweeps (400-500 metres) can be used, the potential fishing area is about 4 times greater than for a comparable sized single boat trawl. The total gear drag, however, is of about the same order.

A noticable curvature was observed for the warps-sweep system, increasing with dimension of sweeps, softness of the bottom and with decreasing towing speed.

Distribution of tension between the towing vessels and the trawl, including effect of bottom friction is discussed in the paper as well as factors effecting the net drag of two sizes of similar designed trawls.

Introduction.

Demersal pair trawling has in recent years become of increased importance for exploiting white fish in the North Sea. Compared to otter trawling, pair trawling has advantages in lower fuel consumption and greater area swept by the ground gear. A joint project was arranged between the Institute of Fishery Technology, Bergen and the Marine Laboratory, Aberdeen and was conducted during 1980 and 81. The main objective was to study the performance of different parts of the pair trawl gear with regard to geometry and resistance, this being essential for assessing fishing performance, energy consumption and gear development.

Vessels and gear.

The vessels used were about 30 m loa with 950 and 750 hp engines respectively. The experiments were carried out on Tolsta ground east of the Hebridies, SW of Ling Bank in 63 to 70 m depth and on the western slope of the Norwegian Trench in 130-200 m depth. Soft muddy as well as hard sandy bottom were encountered in all areas. All nets were of the same fundamental design, two panel balloon trawls with widened top panels. Two nets had 600 meshes in 200 mm mesh size round the fishing circle and one of the 600 B net was used in 1980 also. The other two were 723$^{\diamond}$ x 200 mm nets. Such nets have so far been the most popular with Norwegian pairs. The wire rigging was as in commercial fishing with 82 m bridles and 400 m wire sweeps with a nominal diameter of 28 mm. The 1980 rig was with 55 m bridles and 400 mm sweeps, 24 mm diameter.

A series of measurements was then also done with shortened sweeps. All measurements were made in almost ideal weather conditions except with the long sweeps in 1980. A general arrangement of the rigging and instrument positions is given in Fig. 1.

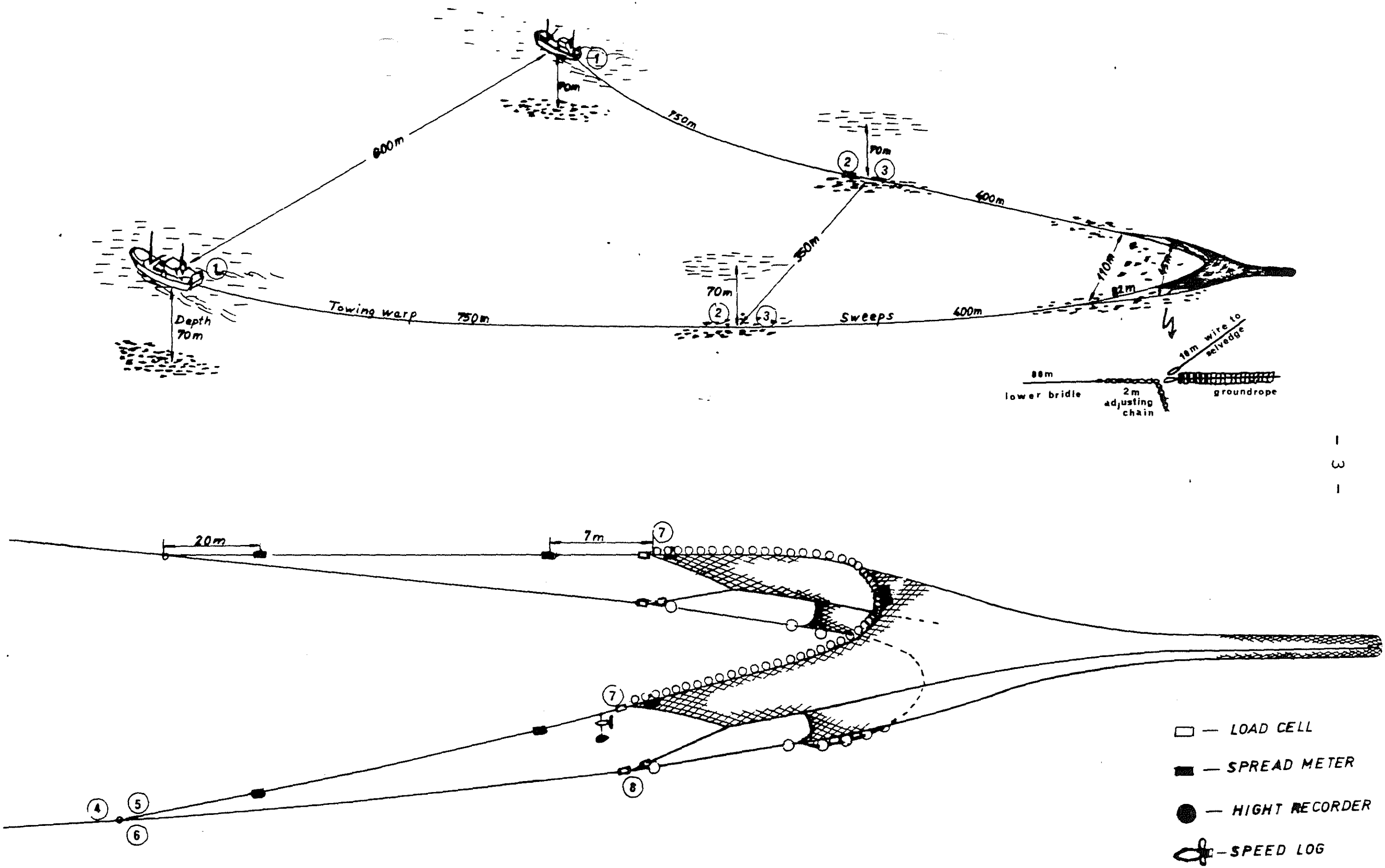

Figure 1. Pair trawl rigging and underwater instrument position used during experiments.

Instrumentation/measurements.

The underwater instruments were loadcells, speed log, headline height meters and spreadmeters. The shipboard instruments were deck tension meters, speed logs, warp declination meters plus echosounder, radar for ship distance and Decca for groundspeed. A self recording current meter giving water speed and direction was also used mostly for recording bottom currents which were never more than 0.5 knots, always less than the surface current and generally slewed about 45° clockwise of it.

All instruments were not used on each haul and instrument failures also occurred, but generally combining the results of the two years experiments the main components to an understanding of pair trawl engineering performance now exist and some examples of the results follow.

Gear and net drag.

Gear and net drag for different towing speeds and for the four trawls are shown in Figs. 2 and 3. The resistance of the two 600 mesh trawls appears to be different and as the netting area is the same for both, the difference was surprising. The 600A net also had markedly lower headline height, about 2.5 m less which made it scarcely acceptable and the net suspect.

The 720 nets had only little more drag than the 600 nets. With only 120 x 8" floats the 720 nets did not have more headline height than the 600 B net with 115 floats and full use was not being made of the potential mouth opening of the 720. Since the difference in netting area between the two trawls is about 30%, it follows that trawl geometry must be considered in calculation of drag. Spread geometry is also much more easily changed than with an otter trawl and it is generally apparent that larger spreads do cause larger drags. In two cases for the 720 net the drag calculated from the measured and geometry netting area has

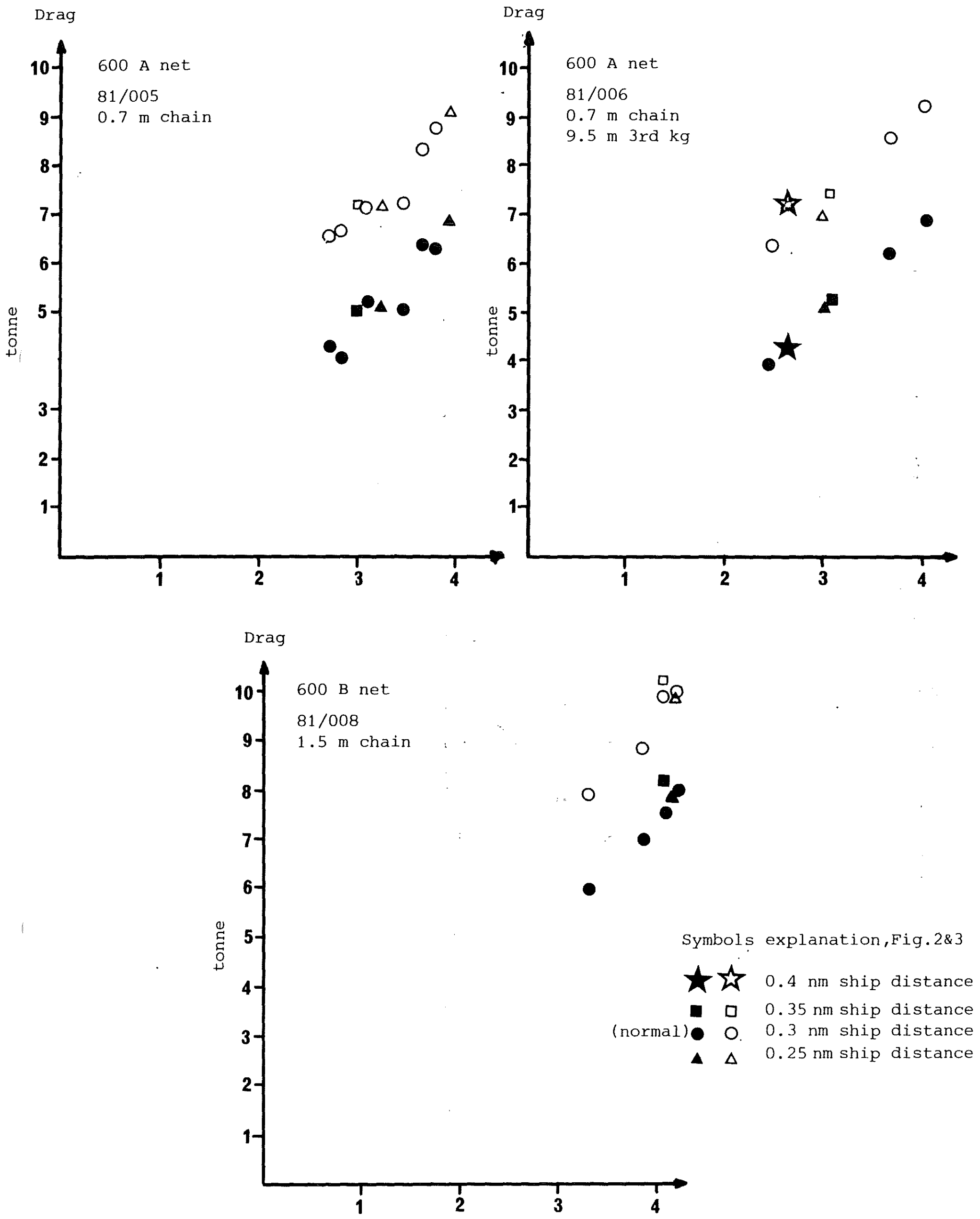

Figure 2. Gear drag (empty symbols) and net drag (filled symbols) versus net speed for the two 600 mesh trawls with different riggings and ship distances.

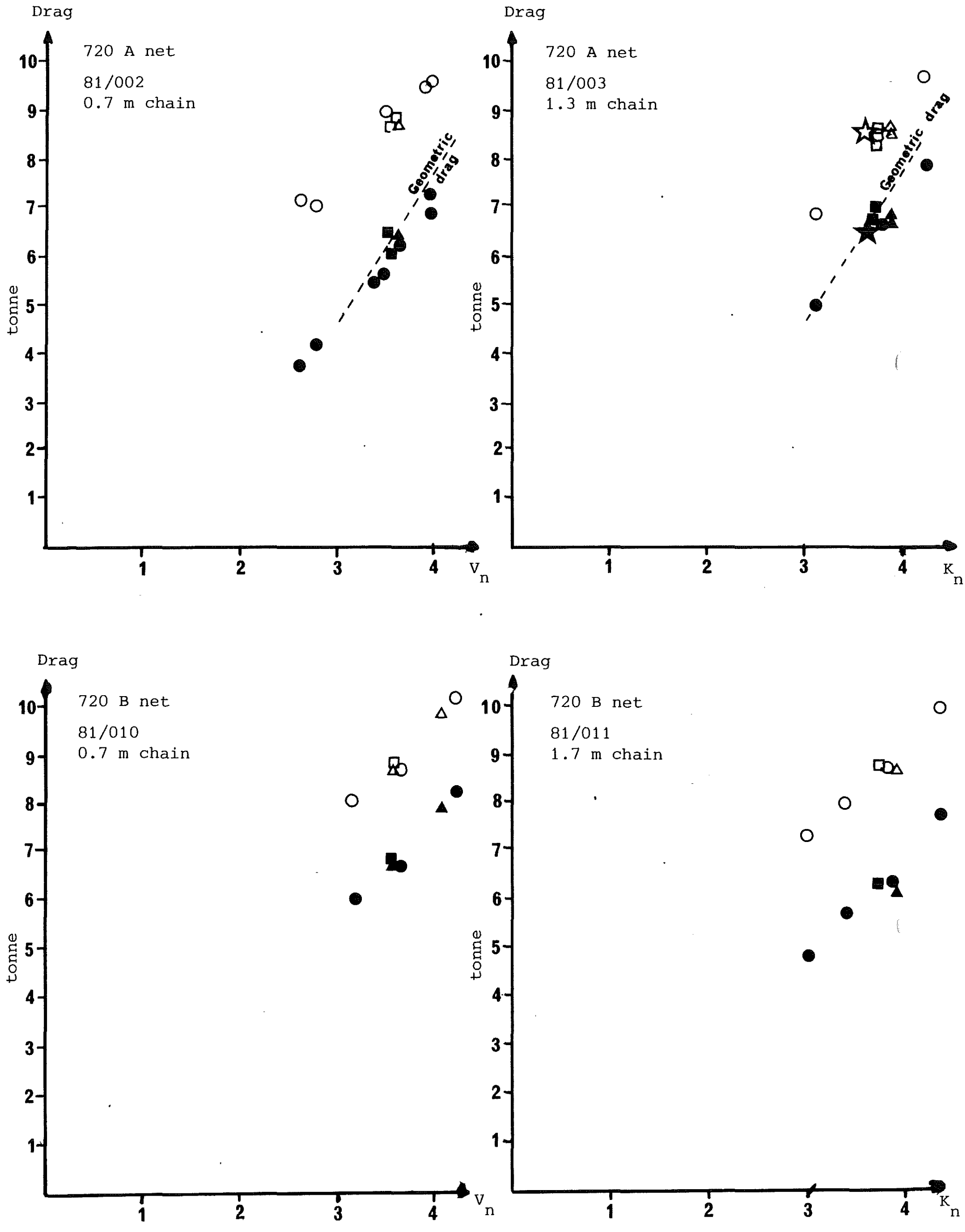

Figure 3. Gear drag (empty symbols) and net drag (filled symbols) versus net speed for the two 723 mesh trawls with different riggings and ship distances.

been sketched in to Fig. 3.

That the slopes of the gear drag and netting drag do not appear to converge much, indicates the strong influence of ground friction on the system.

Headline height and spread changes with speed.

As can be seen from Fig. 4 reduction of headline height is governed by several factors, increase of speed, increase of spread distance between the ships and lengthening of the lower bridle. The top bridle is 82 m and the lower between 80 and 82 depending on the length of the adjusting chain (usually 0.5 to 1.5 m long). Similar data was obtained for the 600A and B nets. Since a 1 m difference in bridle adjustment is quite critical it would seem to follow that a similar stretch in netting or its misadjustment on the selvedge ropes could be as important and this is why the 600A net with its low headline height and larger spread is suspect.

A feature of pair trawling with these heavy sweeps is the marked incresase of net spread with lowered speed.

Tension estimates at lower end of warp.

As well as measuring deck tensions T1 and tensions at the net T7 and T8, on two occasions tension T2 at the join of warp and sweep and in front of the weight was measured on one side only. This was done once in shallow water with no weight present and once in deeper water with 200 kg weight present. The measured and computed values of T2/T1 and T1-T2 are compared. The computed values are obtained from input information giving warp length, warp diameter, weight of warp in water, mean horizontal and vertical wire angles to the direction of motion and water speed.

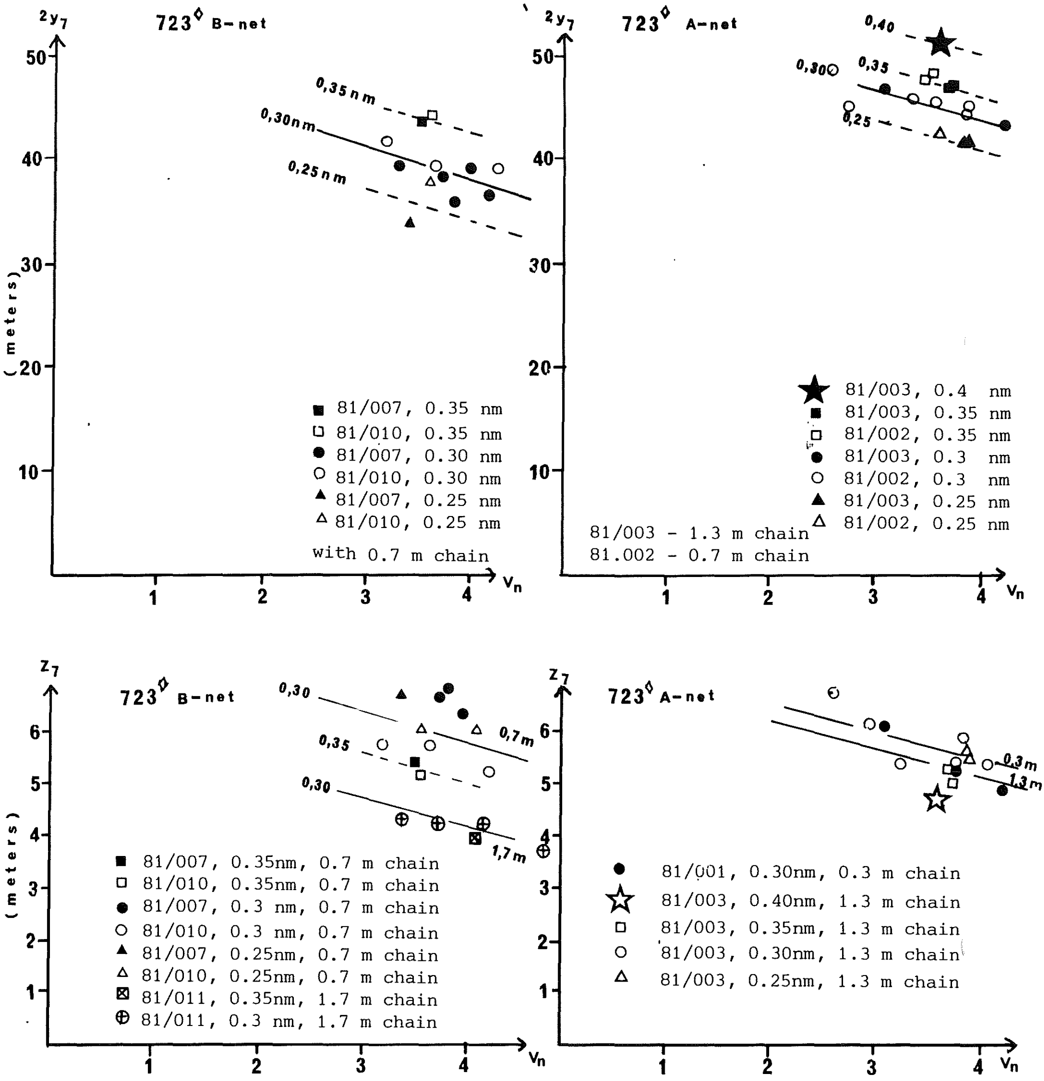

Figure 4. Headline spread ($2y_7$) versus net speed (top) and headline height (z_7) versus speed (bottom) for different riggings and ship distances for the two 723 mesh nets.

Being calculated from experimental data the computed values also have a scatter. Results are given in Table 1.

Table 1. Comparison of measured and computed values of warp tension at bottom end.

	T2/T1 measured	T2/T1 computed	T1-T2 measured	T1-T2 computed
mean	0.941	0.944	251 kp	251 kp
std.devn.	0.043	0.004	177 kp	41 kp
	shallow water	9 observations		
mean	0.867	0.906	593 kp	420 kp
std.devn.	0.051	0.004	202 kp	27 kp
	deeper water	7 observations		

Since (T1-T2)<<0.5(T1+T2) the measured values of T1-T2 are bound to be erratic. The agreement between computed and measured values is fairly reasonable. Since the deck tension T1 is more accurately measured than T2 the calculated values of T2 are generally more useful than the measured values once their general agreement with measured values has been established.

Distribution of tensions drags and curvatures.

These are given in Table 2 for 4 cases, two from 1980 and two from 1981. Tension T2 is computed from measured T1, tensions T3,4,5 and 6 are computed from measured T7 and T8. In the absence of a weight at the join of warp and sweep tensions and angles at (2) and (3) should agree; so should angles at (4) and (5).

Agreement is never complete but is good enough to show the very considerable curvature in the wire system of pair trawling gear

Table 2. Distribution of tensions, drags and curvatures.

I net $600^{\diamond}$ x 200 mm, warp 650 m 20 mmØ, weight 200 kg, sweep 400 m 24 mmØ, bridles 55 m

ship spread	556 m (0.3 nm)	total drag	7370 kp
weight spread	287 m	net drag	6410 kp
bridle spread	74 m	wire + weight drag	960 kp
net spread	40 m	mean speed	3.3 knot
		depth	68 m

	1	2	3	4	5	6	7	8
Tension (kp)	3840	3660	3600	3400		3400	3370	
Angle ($^{\circ}$)	11	12.9	13.9	17		17.4	18.6	

Total curvature 8°

II net $600^{\diamond}$ x 200 mm, warp 750 m 20 mmØ, weight 0 kg, sweep 400 m 28 mmØ, bridles 82

ship spread	556 m	total drag	7870 kp
weight spread	306 m	net drag	5670 kp
bridle spread	98 m	wire drag	2200 kp
net spread	43 m	mean speed	3.3 knot
		depth	68 m

	1	2	3	4	5	6	7	8
Tension (kp)	4070	3830	3850	3070		3070	3030	
Angle ($^{\circ}$)	8.9	10.3	12.5	18.4		18.7	20.8	

Total curvature 12°

III net $727^{\diamond}$ x 200 mm, warp 750 m 20 mmØ, weight 0 kg, sweep 400 m 28 mmØ, bridles 82 m

ship spread	556 m	total drag	8260 kp
weight spread	296 m	net drag	5950 kp
bridle spread	96 m	wire drag	2310 kp
net spread	44 m	mean speed	3.3 knot
		depth	68 m

	1	2	3	4	5	6	7	8
Tension (kp)	4260	4020	3980	3190		3190	3150	
Angle ($^{\circ}$)	9.3	10.7	12.0	17.4		17.6	19.3	

Total curvature 10°

IV net $600^{\diamond}$ x 200mm, warp 300m 20 mmØ+300 m 24mmØ, weight 400kg, sweep 100m 24mmØ, bridles 55m

ship spread	387 m (0.21 nm)	total drag	6950 kp
weight spread	119 m	net drag	6050 kp
bridle spread	67 m	wire + weight drag	900 kp
net spread	36 m	mean speed	3.3 knot
		depth	74.5 m

	1	2	3	4	5	6	7	8
Tension (kp)	3640	3390	3240	3190		3190	3150	
Angle ($^{\circ}$)	11.7	14.1	14.7	15.5		15.6	16.8	

Total curvature 5°

and how this is increased with longer and with heavier sweep wires. The drag of the wires particularly those on bottom is a considerable proportion of the total gear drag. There is little doubt that the wire drag in the first section of the table was considerably underestimated because of the poor weather conditions prevailing that time. These comparative data are for rather low mean towing speed (3.3 knots) and it was found that with very long 400 m sweeps made of heavy 28 mmØ wire snagging frequently occured at speeds below 3 knots. Faster towing speeds reduce the curvature of the wire system and in doing so decrease the spread of the net also.

Relationship between mean bridle angle and headline spread.

This relationship is to be seen in Fig. 5. The headline spread is here normalized to a proportion of headline length for convenience when two slightly different nets are being considered. It will be seen that in 1980 the same net was slightly more V-shaped than a catenary and in 1981 slightly more U-shaped. The reason for this is not certain but probably relates to the fact that the 600 B net even when rigged with bridle length arrangements exactly as they had been the previous year showed a higher T7/T8 ratio, probably due to net stretching. Lower loading in those mesh bars which are not running parallel to the wing end section of the headline could cause the net to be more V-shaped.

Headline shape is reasonably well defined by headline length, headline spread and lead in angle. Furthermore if the headline is imagined as subdivided into a reasonable number of sections and each section is given a loading pattern, by repetition then an overall loading pattern can be computed to fit the spread and lead in angle obtained experimentally. A diagram such as Fig. 5 makes a useful starting point to such procedures.

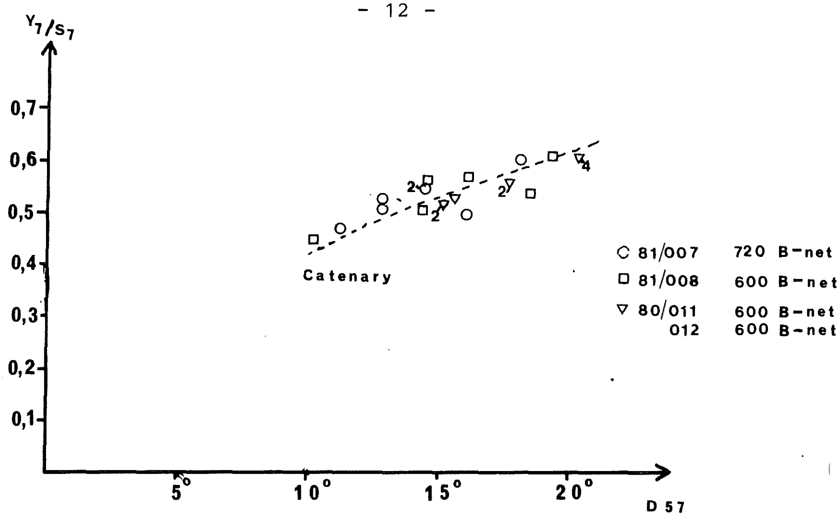

Figure 5. Headline spread/headline height versus bridle angle

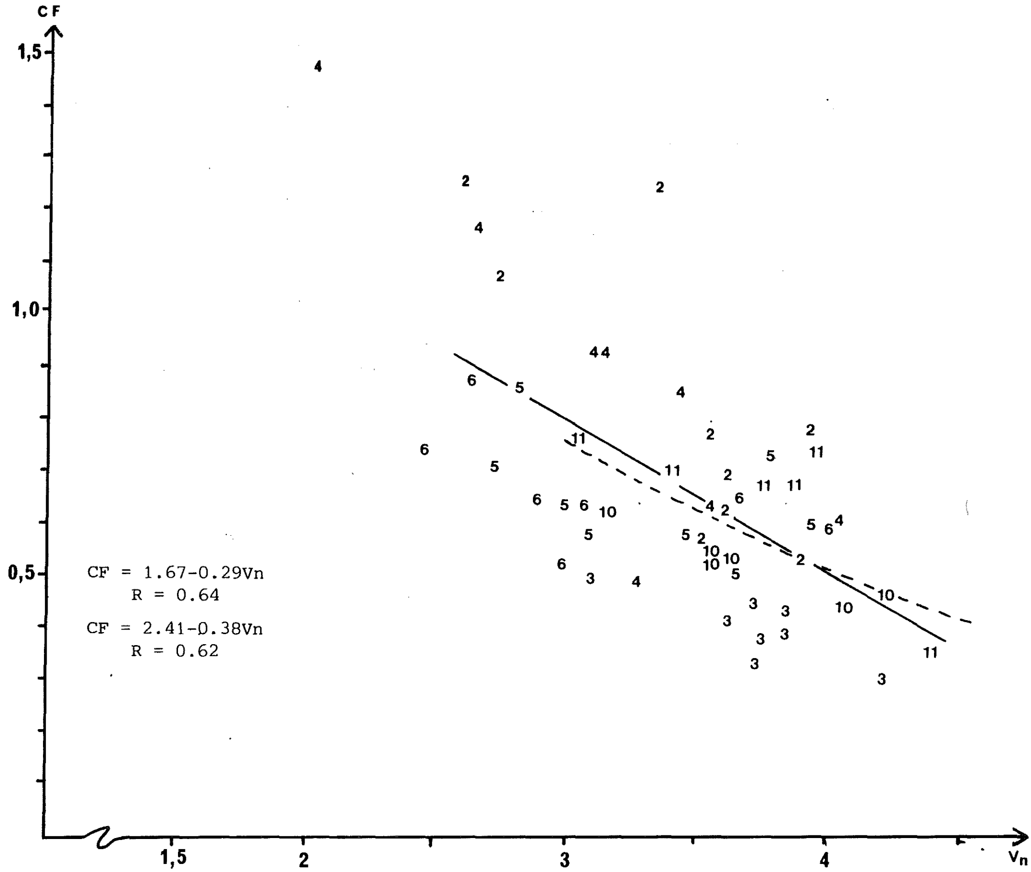

Figure 6. Ground friction versus net speed (numbers indicates haul number).

Ground friction and speed.

As already seen from the drag/speed curves, the effect of ground friction becomes increasingly important as speed is reduced. It is not possible to measure the hydrodynamic and ground friction forces on the wire system separately except in so far as the warp does not have a ground friction component. A hydrodynamic drag coefficient of 1.5 and a hydrodynamic skin friction coefficient of 0.07 both based on wire diameter fitted fairly well with the warp configuration so these values are used for sweeps and bridles also and the residual required to fit both the total sweep and bridle drags and curvatures is taken to be the ground friction coefficient, the heavy 28 mm diameter sweeps having a nominal weight in water of 2,45 kg/m. As seen in Fig. 6 this cofficient appears to rise substantially at lower speeds and puts an effective limit to slow towing. This ground friction adds much to the gear drag but contributes less than the hydrodynamic forces to wire curvatures. Two curves have been fitted to this data, one on the asumption that is falls linearly with speed and the other that it falls exponentially which is more likely. In anycase since the value CF does not appear to be even approximately constant ground friction coefficient is probably a misnomer and its nature requires further examination.

Comparison with single boat trawling.

The comparison with single boat trawling, Table 3, shows that a pair trawl even rigged with long and heavy sweeps has less total drag than a single boat trawl with otterboards. The ground area swept is 4 times greater when fishing on smooth bottom and unlikely to be less than 2 times greater even on rough bottom.

Table 3. Comparison with single boat trawl at 3 knots

	net drag tonne	door drag tonne	wire and weight drag tonne	total drag tonne	bridle angle	net spread m	ground spread m	headline height m
Pair trawl 750 m warp 400 m sweep 82 m bridles	5.4	-	2.0	7.4	19^{o}	42	300	7.5
Single boat trawl 400 m warp 1400 kg otter-boards 86 m sweep and bridles	5.6	1.6	0.3	7.5	15^{o}	27	70	9
Pair trawl 600 m warp 400 kg weight 100 m sweep 55 m bridles	5.4	-	0.9	6.3	16^{o}	36	120	8.5

Conclusions.

1. The energy expended in drag/unit swept area is much less than with single boat trawling.

2. Because of the case with which gear spread can be changed and because of the very long and heavy sweeps it becomes possible to investigate effects of changing net geometry, wire curvature and ground friction not hitherto easily examined.

3. A generalized picture of pair trawling emerges which enables it to be inferred what is likely to happen when other nets, wire rigs boats etc. have to be used.