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TRAWLING ACROSS PIPELINES

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ABSTRACT

The effect on trawl gear crossing pipelines for oil and gas transport was studied in the North Sea in August 1988, using a towed Remote Controlled TV-vehicle (RCTV). The trials were conducted with R/V "G.M. Dannevig", 27.8 m, 540 HP, in the crossing area between Statpipe and Oseberg in 120-140 m depth.

40 crossings were TV-observed, with observations at the doors and at various positions of two trawl types, shrimp and industrial trawl, when crossing at different angles of attack. The direct observations, together with acoustic geometry measurements of the trawl gear, proved to give valid information about the interaction between trawling and pipelines.

The pipelines with dimension and configuration as Statpipe and Oseberg could be crossed without any serious risk of gear damage when crossing angle was above 45°. At lower crossing angles the trawl door, hitting the pipeline first, normally slided along the pipe for a while, resulting in reduced distance between the doors, and consequently a deformated trawl. When the door passed the pipe in this situation, it normally came to the bottom with its backside downwards. Normally, the door remained in this position as towing continued. A special arrangement to rise the door was successfully tested.

When the trawl is deformated as when the door distance is greatly reduced, some risk of gear damage occur. Trawl techniques to catch fish consentrated along the pipeline proved efficient.

1. INTRODUCTION

At present approximately 1300 km of pipelines for oil and gas transport are constructed in the Norwegian sector of the North Sea. Within the next 10 years, this length will increase significantly, mainly as a result of the planned Zeepipe. Existing and planned pipes are crossing important trawl grounds. Most of the pipelines are laying uncovered on the seabed and will consequently reach a height above the seabed comparable to their diameter. Fishermen have in recent years claimed that the pipes and activities associated with their construction represents a hindrance for trawling.

Statoil carried out experimental trawling across Statpipe with a shrimp trawler in 1984 (Anon 1984). The most important conclusion from those experiments was that Statpipe could be crossed with a shrimp trawl in the experimental areas W of Utsira, with minor risk of damage. The fishing organizations doubted this conclusion, and it was claimed that most trawlers did not take the risk of trawling across the pipes.

The Directorate of Fisheries, representing the interest of the fishermen, suggested a new "Trawling across pipelines"-project, using a towed, remote controlled TV-vehicle (RCTV) to document what happens to the trawl gear when passing pipelines. The project was also approved by the Directorate of Petroleum. Statoil and Norsk Hydro A/S, as operators of Statpipe and Oseberg pipe, respectively, financed the project. A Steering committee with members from the oil companies, Directorate of Fisheries, Directorate of Petroleum and Fishermen´s Associations was responsible for the project. Institute of Fishery Technology Research (FTFI) was responsible for planning, running and analysing the experimental results.

The main aim of the project was to investigate whether pipelines caused damage to trawling gear, and whether they are a hindrance to trawling. The observation technique with the RCTV ("Ocean Rover") was tested in a pilot form during the winter of 1987/88 (Valdemarsen 1987). The trials were carried out aboard R/V "G.M. Dannevig" during the period 8 - 27 August 1988.

This report summarizes the results from these trials and gives conclusions about interaction between trawling and pipelines.

2. INSTRUMENTATION

Instruments for underwater TV observations, trawl geometry measurements and exact navigation were used during the trials. The specifications of these are given below.

2.1 TV-Vehicle

Type:	Ocean Rover Mk III.
Cable:	800 metre Kevlar armoured, 28 mm dia., 16 core.
Camera:	Osprey OE 1323 S.I.T.
Pan & Tilt:	Osprey OE 1140 A
Depth meter:	Maywood Instruments P 102.
Log:	Valeport BFM 050.
Sonar:	Simrad FS 3300.
Light:	Mercury Vapor MV-3000, 4X250 watt.

2.2 Trawl gear monitoring

Otterboard spread:	Scanmar spread meter S40 A3L og MT144.
Headline height:	Scanmar height meter S40.
Data logger:	Scanmar data plotter SDP 01.
Warp tension meter:	Telmec

2.3 Navigation

Type:	Seyledis.
Computer equipment:	HP 9826 m/ discdriver.
	HP printer
	Scope interface
	Colour display

3. SHIP AND FISHING GEAR

3.1 Ship

F/V "G.M.Dannevig"

Length: 27,85 m

Tonnage: 171 g.r.t.

Motor: 2 x 270 hp Volvo Penta

3.2 Trawl gear

Two industrial trawls, type Expo 1200, produced by Åkrehamn Trålbøteri, were used for the conduct of the trials. One was made of nylon and rigged with a rope-rounded groundrope for bottom protection. The specification of this trawl is given in Figure 1. The other Expo trawl had an almost identical construction, but with the forward part made in somewhat larger mesh polyethylene twine. This trawl was moreover rigged with bobbin gear (Fig. 2).

The shrimp trawl was a 2000 mesh Combi trawl produced by Nordsjønot A/S, Egersund. The trawl was rigged with bobbin gear, the bobbins being 20 cm diam. perforated plastic balls. The construction is shown in Figure 3.

3.3 Otterboards

Åkra V-doors 2.65x1.85m, 650 kg, were used throughout the trials. The construction of these is shown in Figure 3.

4. PLANNING AND CONDUCT OF THE TRIALS

The trawl trials were planned to be conducted East of the crossover between Statpipe and the Oseberg pipe. The depth (120-140 m) and the bottom conditions in that area were favourable for observations with the TV camera. Statpipe is a 30" tube and Oseberg 28". Outside the pipes is a covering concrete, 12-13 cm thick.

Norsk Hydro had immediately beforehand video-inspected the Oseberg pipeline, and at the same time inspected an area 1000 m wide on each side of the pipeline with scanning sonar. There were no irregularities on the pipeline or bottom fasteners in the immediate neighbourhood of it. Inspection of Statpipe had been carried out by video in 1987 and with scanning sonar in 1988. Additionally the pipelines in the test area were video-inspected with the Ocean Rover during the trials period. Ocean Rover was towed at 2-3 kn. at a range of 1-4 m above the pipeline.

4.1 Trawl trials

The Expo trawls were rigged for the trials as shown in Figure 5, with 120 m sweeps and bridles (60 m sweeps, 60 m triple bridles). The shrimp trawl was rigged as shown in Figure 6, with 75 m triple bridles.

The trawl which was going to be observed, was set out 2-3 n.m. from the pipe which would be crossed first. This was done to give adequate time to set out the TV-vehicle and to get it positioned close to the otterboard or the trawl before crossing the pipeline. The approximate angle of encounter was decided beforehand, so that the trawl path toward the pipeline would be almost straight. However, the trawl path, and therewith the angle of encounter, often had to be adjusted early in the two because wind and current conditions made it difficult to bring the TV-vehicle into the desired position with respect to the trawl.

The towing speeds with the industrial trawl and the shrimp trawl were 2.6 - 3.0 kn and 1.5 - 2.0 kn, respectively. The warp length was 3-4 times the bottom depth.

Oseberg and Statpipe pipelines were crossed 20 and 30 times, respectively. 40 crossings were observed by TV. Most crossings were carried out with the Expo 1200 trawl, made in nylon, and rigged with the rope-rounded groundrope. The V-doors from Åkra were used in all trials. The shrimp trawl was observed in 9 crossings. The Expo trawl with polyethylene forepart and bobbin groundrope was observed 5 times.

The pipes were passed over 1 to 5 times in one trawl haul. Table 1 shows how many crossings were made with the different trawls, and grouped by angle of encounter.

Table 1. Number of crossings of the piplelines with 3 trawl types, and grouped by angle of encounter, 0-30, 30-45, 45-60 and 60-90 degrees, respectively.

Angle of encounter Trawl type	0-30	30-45	45-60	60-90
Expo 1200 with rope-rounded groundrope	10	11	6	9
Expo 1200 with bobbins	0	3	0	2
Shrimp trawl	1	2	1	5

In addition to crossing over the pipelines, two trials were made towing along them. The technique which was practised, was to trawl at a very small angle toward the pipeline. When the otterboard encounters the pipeline, the distance between the otterboards is reduced. This spread reduction is registered on the Scanmar spread meter. The otterboard, which met and was dragged along th pipeline, was observed by TV. With the help of a track plotter and spread meter, it was thus possible to trawl along the pipeline where the one door only was in contact with the pipeline.

4.2 TV observations

Critical to the planning and conduct of the trials was to document what happened to the trawl itself when crossing the pipelines. For this, good observation conditions are a precondition, i.e. good light conditions and low turbidity in the sea. Ocean Rover is equipped with a light sensitive camera (SIT), which can be used at light levels down to 10^{-3} lux. It is also equipped with spot lighting of variable power up to 500 Watt.

In the trials area, where the depth varied from 110 to 140 m, there was sufficient light in daytime for objects to be seen in fair detail at 6-8 m range. However, light conditions varied from day to day. The observations were in the main carried out without artificial lighting. The reason for this is primarily that there are often objects between the camera and the main object being observed. When such intermediate objects are illuminated, the camera automatically adjusts focus to their illumination level, with the results that the main object which lies farther away is poorly seen.

The TV-vehicle can be manouvered about 60 m vertically and horizontally with 300-400 m of towing cable, when the towing speed is about 3 kn. Lower speed reduces its stearing possibilities. It was thus difficult to manouvre the vehicle to study the shrimp trawl towed at 1.5 to 2.0 kn. Normally, the vehicle is kept positively buoyant so that it must be steared down towards the objective. Positive bouyancy is used to avoid the vehicle sinking down into the trawl with consequent loss of its motor function. The observation of the otterboards was concentrated on the one which would encounter the pipeline first. This was because among other things the pilot trials showed that it was this one which could give problems. Observations of the otterboard crossing was normally made with the vehicle 5-10 m from the otterboard, preferably a little aft and to the inside of it.

Observations of the trawl itself crossing the pipeline were carried out with the Ocean Rover situated in different positions with respect to trawl, such as inside or outside the trawl wings, between the trawl wings, in front of the groundrope bosom, and above the trawl. Two observations were also made of the codend when it passed over the pipeline.

4.3 Measuring operational geometry of the fishing gear

The pilot trial in 1987 showed that crossing the pipelines at small angles of encounter often resulted in reduced otterboard spread. The reason was that the one otterboard was dragged along pipe and crossed over the pipe only when its trawl warp assumed the same direction as the line of tow or even inwards with respect to it.

In all trawl hauls, the Scanmar height and spread meters were used. Placed aft of the otterboard, these gave information on how the distance between the otterboards was affected during their passage over the pipeline. For the trials, the range sensor and the mini-transponder were attached to the upper backstrops, about 1.5 m aft of the otterboards. Such a fastening arrangement gave the possibility of receiving signals, even with the otterboard fallen over.

The height meter on the headline gives information on any variations in trawl height which occur. The height and spread sensors together give information on state of the trawl during the quite dissimilar trial tests. This is important when evaluating the particular test which is being carried out.

Data from the sensors were recorded manually from the display for the first 8 trawl hauls. When the otterboard and trawl crossed the pipeline, such data were recorded and notated every 10 seconds. In the subsequent trawl hauls (9-24), the height and otterboard spread were continuously recorded on the data plotter SPD 01.

5. ANALYSIS OF THE TRIALS INFORMATION

The video documentation is clearly the most important material from the trials. The description of how the various fishing gear components pass over the pipelines is based upon it. In addition to the written report, a video film was made, showing all the crossing.

The otterboard spread, together with the TV observations, gave very useful information. The spread meter almost always gave information on how long the otterboard followed along the pipe, when it crossed it, whether it fell over after crossing, and whether it eventually righted itself. These items of information rendered superfluous the need for many direct observations of otterboard crossing, so that more observations could be concentrated on the trawl itself. The angle of encounter showed itself to be a specially important parameter during the trials. Three independant methods were used to judge this.

1. The ship´ movement direction relative to the pipeline. The angle of encounter was measured from the Seyledis plotter.
2. The gear´s angle relative to the pipeline estimated from the video picture.
3. The angle of encounter reckoned on the basis of the plot of otterboard spread.

The accuracy of the different methods varies. As a general rule, method 1 is used in the analysis of the material. When the shots from the TV camera were in conflict with the track plotter data, the video data were used to correct the angle of encounter.

6. RESULTS

The video inspection of the pipelines showed that the Oseberg pipeline (1 year old) lay gently on top of the sediment, had an even surface without special overgrowth, even pipe joints without loose shuttering bands, and with a few minor things lying close to the pipe.

Statpipe, which is about 3 years older, had a more uneven surface, which was overgrown, and where the shutterings was loosened to a great extent and partly hung fast to the underside of the pipe. There was also observed to be more small junk along the pipe. None of it was so high that it reached above the pipe.

Data on damage to the trawl and to what extent the trawl door fell down after crossing the pipe, are reproduced, together with other operational data, in Table 2. The Expo trawl with the rope-rounded groundrope had minor tearing damage in the underwing after two crossings of the pipeline. The split is for each case illustrated in Figures 7 and 8. The shrimp trawl had a 2-3 m split in the underwing after crossing the pipeline (Figure 9). None of the damage was observed while it happened. In two of the hauls when tearing took place, the otterboards were being observed on TV.

Table 2. Operational data on the different crossings of the pipelines.

T.St.	Crossing	Date	Pipe	Trawl type	Encounter angle	TV obs. pos.	Otter board pass.	Otter board after	Trawl state
With restraining chain:									
AT01	01	1008	O	I1	60	3	1	1	1
"	02	"	S	"	35	3	1	1	1
AT02	03	"	O	"	45	2	1	1	1
AT03	04	"	O	"	70	1	1	1	1
"	05	"	S	"	15	0	1	1	1
"	06	"	S	"	13	0	2	2	1
AT04	07	"	S	"	23	3	2	2	1
AT05	08	1108	S	"	10	1	2	2	1
"	09	"	S	"	25	2	2	2	1
"	10	"	O	"	55	0	1	1	1
AT06	11	"	O	"	37	3	1	1	1
"	12	"	S	"	11	3	2	2	2a
AT07	13	"	S	"	40	1	2	2	1
"	14	"	S	"	60	1	1	1	1
"	15	"	S	"	45	1	2	2	1
"	16	"	O	"	85	3	1	1	1
AT08	17	1208	S	"	40	0	1	1	1
"	18	"	O	"	37	1	2	2	2b
AT09	19	"	O	"	66	3	1	1	1
"	20	"	S	"	44	2/3	1	1	1
AT10	21	1308	S	"	75	2	1	1	1
"	22	"	O	"	80	2	1	1	1
AT11	23	"	O	"	72	2	1	1	1
"	24	"	S	"	42	3	1	1	1
AT12	25	"	O	"	90	2	1	1	1
"	26	"	S	"	55	3	1	1	1
AT13	27	1408	O	R1	80	1	1	1	1
Without restrining chain:									
AT14	28	1708	O	"	75	2	1	1	1
AT15	29	"	O	"	80	0	1	1	1
AT16	30	"	O	"	70	3	1	1	1
"	31	"	S	"	57	3	1	1	1
AT17	32	1808	O	"	75	2/3	1	1	1
"	33	"	S	"	35	1	2	1	2b
AT18	34	"	O	"	39	3	2	1	1
"	35	"	S	"	24	1	2	1	1
AT19	36	1908	S	I1	90	4	1	1	1
"	37	"	S	"	55	4	1	1	1
AT20	38	2008	O	"	38	3	2	1	1
"	39	"	S	"	40	3	2	1	1
"	40	"	S	"	26	2/3	2	1	1
"	41	"	S	"	28	0	2	1	1
AT21	42	"	S	"	15	0	2	1	1
"	43	"	S	"	02	0	2	1	1
AT22	44	2308	O	"	53	0	2	1	1
"	45	"	S	"	31	0	2	1	1
AT24	46	2408	O	I2	75	3	1	1	1
"	47	"	S	"	40	2	1	1	1
"	48	"	S	"	31	3	2	1	1
"	49	"	S	"	90	3	1	1	1
"	50	"	S	"	40	3	2	1	1

Code key:
O=Oseberg I1= Expo 1200 roperouned groundrope TV 1= Otterboard observed
S=Statpipe I2= Expo 1200 bobbin groundrope TV 2= Trawl wing observed
R1= Shrimptrawl TV 3= Gear centre observed
TV 4= Codend observed
Otterboard crossing: 1= upright, 2= falls over
Otterboard after crossing pipe: 1= upright, 2= fallen over
Trawl state: 1= no damage, 2a-c= tearing damage

The following section describes in more detail how the otterboards passed over the pipelines at varying angles of encounter, and what effect the passage over the trawl doors had had on the trawl itself. The passage over of the pipe by the various trawl types is also clarified in more detail.

6.1 Passage of otterboards over pipeline

Based on direct observations with the TV camera together with otterboard spread measurements, there emerges a relatively uniform pattern of how the otterboards encounter the pipeline at different approach angles. The passage over at 90 and about 30 degrees angle of encounter are illustrated in Figure 10.

When the angle of encounter is over 45 degrees, both otterboard manage to pass over the pipe satisfactorly. At lesser angles of encounter, the otterboard which first encounters the pipeline follows along the pipeline for a shorter or longer time, depending on the encounter angle. This leads to the spread between the otterboards being reduced. After the otterboard has crossed over the pipeline it most often falls down. Without any form of remedial correction, the otterboard remains fallen with its outside face next to the ground during continued towing. This situation can be registered on the spread meter and on the warp tension meter, which showed less tension when the otterboard remained fallen over. The otterboard which encounters the pipeline last is pulled quickly across it without the spread being affected.

Table 3 shows how the otterboards passed over the pipelines when the angle of encounter was 0-30, 30-45, 45-60 and 60-90 degrees, respectively. It was presumed that the otterboard has not fallen over when after passing over the pipeline the otterboard spread is reduced by less than 10 m. It appears from the table that when the angle of encounter is greater than 45 degrees, the otterboard crosses the pipeline without serious risk that it will remain fallen down after crossing. With decreasing angle of encounter the risk increases, and with less than 30 degrees the otterboard will almost always fall over on its back with its outside face next to the ground.

Table 3. Otterboard state just after passing over the pipeline for different angles of encounter.

Angle of encounter/ otterboard state after	0-30	30-45	45-60	60-90
Upright	1	8	3	17
Fallen over	10	10	1	0

Attempts were made to bring the otterboards upright again, by altering course, increasing speed, heaving up warp and remedial correction of the otterboard.

With a swing inwards from the otterboard which had fallen over, it came upright again in some of the attempts. Increasing speed had no effect. Heaving in warp to lift the fallen otterboard off the bottom will always work. Introducing a corrective restraining chain as shown in Figure 11, was used from trawl haul AT 14 onwards. The result was that the otterboard righted itself shortly after passing over the pipe. That appeared to occur when the otterboard lay in a direct line between the ship and the trawl wing.

The next session looks more closely at what happens to the trawl itself when the otterboard spread is reduced while the board is dragged along the pipeline and when it continued to be fallen down after passing over the pipe.

6.2 Passage of trawl over pipeline

In its passage over the pipelines, the trawl was either normally operative or distorted as consequence of the otterboard having fallen down after its passage over the pipeline. The description of its passage over the pipeline covers the industrial trawl with rope-rounded groundrope and with bobbins, and the shrimp trawl with bobbins.

6.2.1 Industrial fish trawl with rope-rounded groundrope

The forward part of the trawl was observed during 18 crossings, of which 5 were of the wing part, and the remainder of the bosom part of the bobbin groundrope. Additionally, the codend was observed twice with 35-40 hl of catch. In none of the passages was any tearing observed, or any form of hooking onto fasteners which could result in tearing. In spite of that a tear in the trawl wings was found twice when the trawl was inspected after hauling it in. The damage is shown in Figures 7 and 8.

The passage where the trawl had normal shape were well documented. The sweeps and bridles in front of the trawl wing were drawn across the pipeline. The nearer the trawl wing, the greater was the friction between the bridles and the pipe. This resulted in greater wear and tear on the lower bridle nearest to the trawl than on the opposite end, nearest the otterboard. The trawl wings were lifted up by the sweeps in front of them when these lay across the pipeline. The fishing line was pressed down against the pipe as it passed over it.

The netting in the trawl wings did not have contact with the pipe. The rope-rounded groundrope under the fishing line was pushed up by the side of the fishing line, so that it did not have any protective effect when the trawl was drawn across the pipeline.

The result was that the seizing on the fishing line became somewhat chafed because of this friction. The trawl which was used for these tests, was equipped with 7 mm diam. rope served round the fishing line. The purpose of this is protection from friction wear and tear against the bottom. Without this the chafing against the pipelines would undoubtably have resulted in the netting being torn loose from the fishing lines.

When the otterboards fell down, this resulted in lopsideness, which deformed the trawl itself. With 400 m of warp out and normal otterboard spread of 80 m, the spread between otterboards were measured as 50 m when the one otterboard lay on its back. The result of this is that the trawl wing on that side lay about 5 m behind the other trawl wing. The wing spread is also reduced while the height increases. The lopsideness is also to be observed in the upper belly behind the headline, where the tension becomes borne along netting bars, which again reduces the strenght of the net.

Although the tearings were not observed, there is strong likelihood that these occured in just such situations where the trawl was deformed as described above. In the first instance, where there were 3 minor holes in the starboard lower wing, the starboard otterboard fell down after crossing Statpipe at 11 degrees angle of encounter. In the other instance, where there was a bigger tear in the same lower wing, the situation was analogous, crossing Oseberg at about 35 degrees angle of encounter.

6.2.2 Industrial fish trawl with bobbins

The passage of the trawl over the pipeline was in the main as described for the trawl with the rope-rounded groundrope. It is worth remarking that the bobbin groundrope does not appear to have any protective effect on the trawl when passing over the pipeline. Similarly with the rope-rounded groundrope, the fishing line is dragged down against the pipe so that it becomes exposed to chafing.

6.2.3 Shrimp trawl

As shown in Figure 3, the shrimp trawl was made in very thin nylon material, and protected with a light groundrope, consisting of perforated 8" plastic balls. Nine crossings were made with this trawl, of which 5 were observed. The smallest angle of encounter was 24 degrees. On account of the big height, 15 m, the observations had to be carried out with the TV vehicle positioned in the trawl mouth. In this position the passage can be watched from wingtips to mid groundrope.

With angles of encounter over 60 degrees, the state of the trawl was normal in passage over the pipelines, 50 m otterboard spread and 15-16 m height. The trawl passed easily over the pipeline. The fishing line was pressed down against the pipe, and therewith exposed to chafing just like the industrial trawl. The bobbin groundrope eased itself up beside the fishing line, and had in consequence no protective function in passage over the pipeline.

The underbelly of the shrimptrawl comes obliguely up over the back of the bobbins, so that the netting was in short term contact with the pipe after the groundrope centre had come over the pipe.

A minor tear (2-3 m) was found after one crossing where the otterboard spread was reduced and the otterboard fell down for a short time after the crossing. It is probable that the damage occurred when the trawl was deformed during the crossing. When that happened, the otterboard passage was being observed on TV.

6.2.4 Codend with catch

How the trawl behaves in passage over the pipelines when it contains a catch, was one of the problems posed, upon which it was necessary to throw light within the whole complexity of problems raised by trawling over pipelines.

In the trials area, there was not fish enought to achieve this. A longer tow was therefore made on the industrial trawl grounds farther down the slope in about 200 m depth. After 4 or 5 hours towing at that depth, the trawl was towed up the slope before crossing Statpipe at a suitable depth of 120-130 m. The trawl was inspected with the TV vehicle before crossing and found to be in order. The codend held 30-40 hl mixed fish before the crossing.

The first passage was made with about 90 degrees angle of encounter. The codend oscillated a bit up and down and touched bottom before passage over the pipeline. During the actual passage, the oscillatory movement was directed downwards so that the codend also touched the pipeline.

The second passage was at about 75 degrees angle of encounter. The codend oscillated less than in the first crossing. It was also clear of the pipe when crossing it.

7. EVALUATION OF THE TRIALS

The trials showed that the TV vehicle is a well-suited tool for obtaining a qualitative insight into what happens when otterboard, sweeps and trawl are hauled across a pipeline.

The ship that was used for the trials was especially suited for this type of trial, where the use of trawl and observations by TV vehicle were necessary. Other trawlers which were evaluated for the task would not have been able to manage the vehicle so simply.

The area chosen was well-suited with regard to depth and bottom conditions. The bottom around the pipelines was without fasteners so that it was possible to cross over both the pipelines in the same trawl haul. By altering direction, it was possible to cross several times over the same pipeline in the same tow. The visibility was somewhat variable, depending on light conditions at the surface. Some planktonic organisms also rendered visibility less than always the optimum. A weakness with the trials area is that it is not a typical industrial fish trawl ground. Such fishing occurs rather deeper, from 180 m and on down the slope. Smooth bottom as in the trials area is, however, also common in these depths.

Little catch in the codend during the crossings is another condition which in some measure can have influenced the results. The observations which were made on the dissimilar passages across the pipes, does not, however, imply that a large catch will influence the manner in which the trawl crosses the pipeline. A large catch at the same time as the trawl is deformed after one otterboard has fallen down, can, however, increase the risk of tearing in such situations.

The trials showed unambiguously that otterboard passage over the pipelines is a problem when the crossing angle is small enough. The explanation is that the pipelines represent a hindrance to the spreading force of the otterboards. Firstly the otterboard will pass over the pipe when the warp between otterboard and ship assumes an angle which will pull it over.

Then, after crossing, the result is a rule that the otterboard falls down with the outer face to the ground. This is a situation that could be more of a problem than was experienced during the trials. An otterboard, which is pulled forward when lying with its outside face down, can easily become stuck, if the bottom is soft. The otterboard digging, for example into clay, can end with loss of the whole gear. However, when the composition of the ground is as in the trials area, there is little risk of the otterboard coming fast. Besides, the tests with the restraining chain showed that simple modifications can be used to bring the otterboard upright again. Even though the tests were carried out with industrial and shrimp trawls with relatively small otterboards, similar problems will also be likely to arise with larger otter-boards and in other trawl fisheries, like trawling for consumption fish.

The trials with the industrial trawl were concentrated on the trawl with a rope-rounded groundrope. It is undoubtedly this type of trawl which is least protected against bottom snags. It is normally used only in areas where the fishermen know that the bottom is composed of pure sand or mud. Traditionally, Norwegian fishing has been conducted on the "Edge" grounds or on the shrimp grounds in the "Trench", with a rope-rounded groundrope as the only protection. Development in the last few years has, however, gone towards increased use of one or another form of bobbin gear, also in these areas. The results coming from the trials thus presumably represent worst situation concerning protection against bottom snags.

The Expo 1200 trawl with the rope-rounded groundrope was pulled across the pipeline 34 times. The wear and tear on the underbelly was not worse than is common after corresponding use in other areas. The trawl was new when the trials started. This obviously makes the netting stronger than in a trawl that has been long used. This is a consideration which has to be taken into account when evaluating the trials results.

The Expo trawl was, however, made in relatively thin nylon material, and therefore weaker than is normal in bigger industrial trawlers. The trawl which was used in the trials is moreover the smallest type used by Norwegian industrial trawlers. No demonstrable damage to the bottom panel during the trials, together with the observations of the crossings, implies that the lower netting panel is not in direct contact with the pipeline, suggesting that the netting strenght has not decisive importance for the results.

Another important consideration is that the bottom panel is often torn out of the trawl for other reasons. The results is that the bottom panel has to be renewed more often than the rest of the trawl.

On the grounds that the industrial trawl was given priority, the trials with the shrimp trawl were few, and all the crossings were carried out at relatively big angles of encounter. The trials showed fairly convincingly that crossing the pipeline is satisfactorily achieved only if the angle of encounter is big enough, e.g. over 45 degrees.

Moreover, the shrimp trawling grounds are commonly down in the Norwegian "Trench". The towing direction is not there of the same importance as it is when industrial trawling on "Edge". Crossing a possible pipeline which crosses a shrimp ground can therefore be tackled at a big crossing angle.

As already mentioned, the types of groundgear which were used in the trials, were little effective for protection of the trawl in passing over the pipelines. This is because of the manner in which the groundrope was mounted onto the fishing line. The groundrope is pushed up by the pipe without the trawl wing being rising in a comparable way. The result is that the fishing line also touches the pipe in passing over it, such that both it and the netting immediately adjoining it are subject to the friction wear against the pipe. The groundgear that was used on the trawl in the pilot experiments in December 1987 had a long way better protective effect.

The technique which was used for trawling along the pipelines has interesting possibilities. The pipelines undoubtedly gather different types of fish. Fishermen have established this fact, and attempt to use it for catching purposes. Crossing and trawling along pipelines is already practiced with varying success.

The problems of crossing at small approach angles, highlighted during these trials, shows that this technique can best be practiced with the help of a spread meter at the otterboards. A spread meter, together with a navigational track plotter, makes it possible to precision trawl with one otterboard touching the pipe, and thereby frightening the fish situated on one side of the pipe into the catching path of the trawl. Trawling with a trawl wing on each side of the pipe would hardly give the same result when the pipe raises up the trawl and gives fish the possibility to escape underneath it.

8. CONCLUSIONS

The trials were carried out in depths between 120 and 140 m on a hard bottom of fine sand. The results and appraisal of these trials form the basis for the following conclusions.

Pipelines with dimensions and character like Statpipe and the Oseberg pipeline can be trawled over without risk of tearing becoming greater than normal so long as the encounter angle is 45° or more.

With decreasing angle of encounter the pipelines can become a hindrance for trawl fishing. The reason is that the otterboard which encounters the pipeline first and when the angle is small, will often follow along the pipe for a greater or lesser distance. After passing over the pipeline the otterboard can be laid with its outside face down. This leads to the trawl itself becoming deformed, resulting in uneven tension loading in the trawl netting.

When the otterboard falls over onto its back and the trawl is deformed, there is increased risk of the otterboard becoming stuck in soft bottom and of the trawl tearing on bottom snags.

The trials showed that the tendency for the otterboard to be lying on its back after crossing increased with decreasing angle of encounter below 45°.

Further trials showed, however, that an otterboard rigged with a controlling chain will come upright again soon after crossing the pipeline.

Pipelines increase the friction wear on sweeps and fishing line but without this leading to any important damage to the trawl equipment. Rope rounded groundrope and traditional groundrope gear construction give little extra protection to the trawl when crossing pipelines.

During the trawling trials no difference was registered in the degree of disadvantage between crossing over Statpipe and the Oseberg pipeline.

9. REFERANCES

Anon, 1984. Prøvetråling over Statpipe-rørledningen. Sluttrapport, 1. august - 28. august 1984.

Valdemarsen, J.W. 1988. Observasjoner ved tråling over rørledninger. FTFI-arbeidsnotat 11.12.87.

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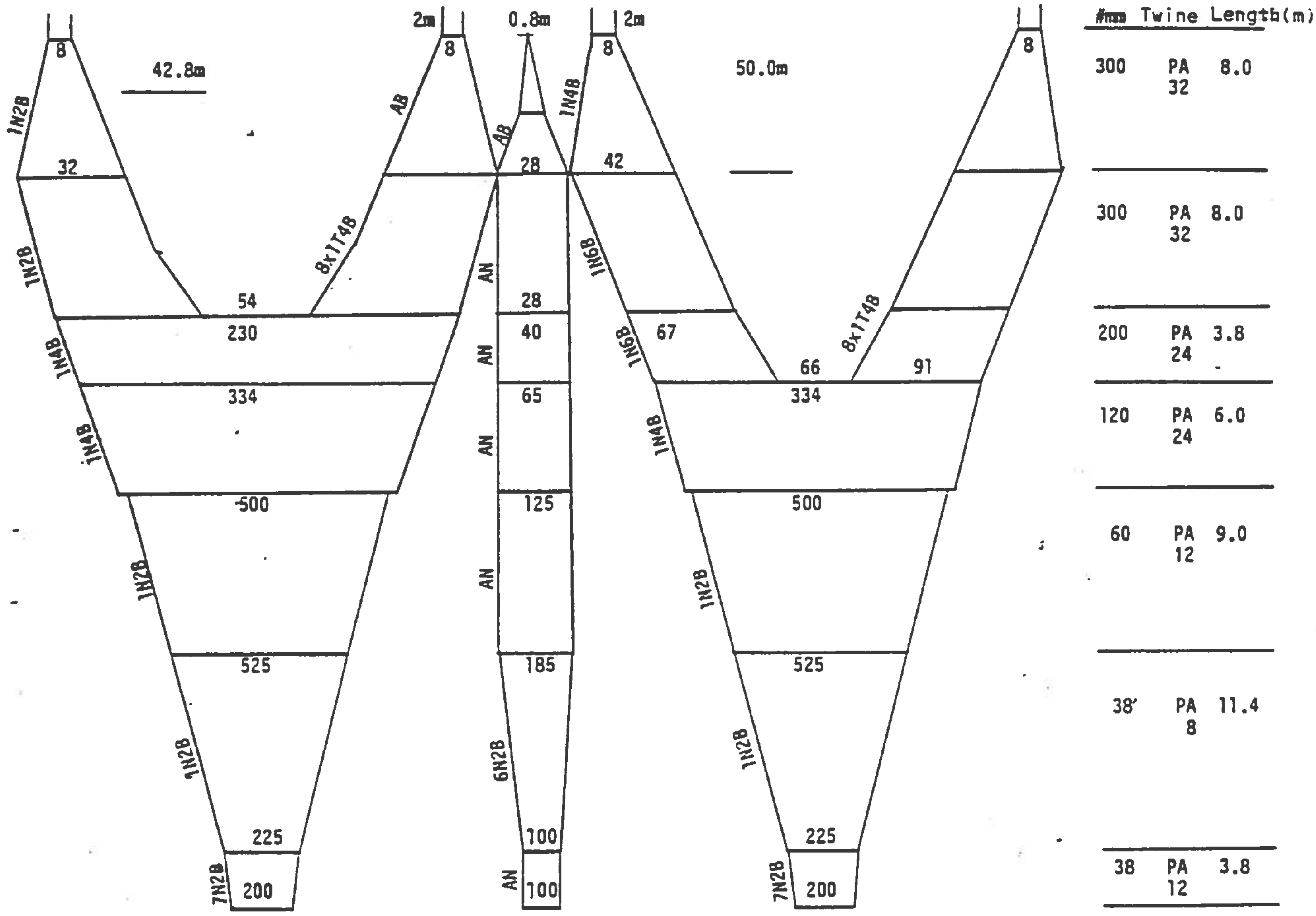

Rope-rounded groundrope rigging:
Core: 12 mm diam. wire
Cover: 14 mm diam rope with lead core in each strand
Weight/metre: ca. 2 g.

Figure 1. Expo 1200 Industrial fish trawl.
Nylon forward part, rigged with rope-rounded groundrope.

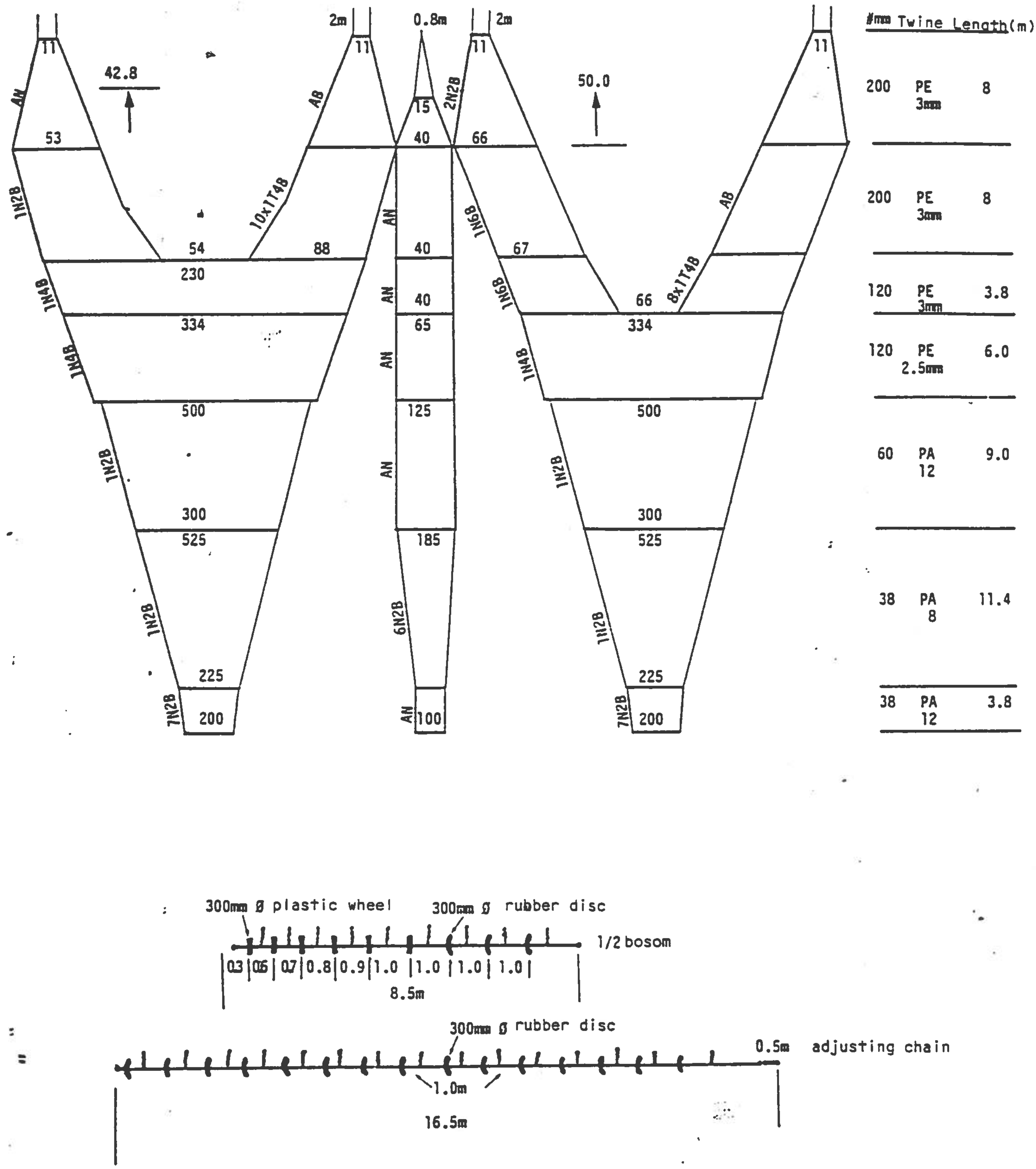

Figure 2. Expo 1200 Industrial fish trawl.
Polyethylene forward part.

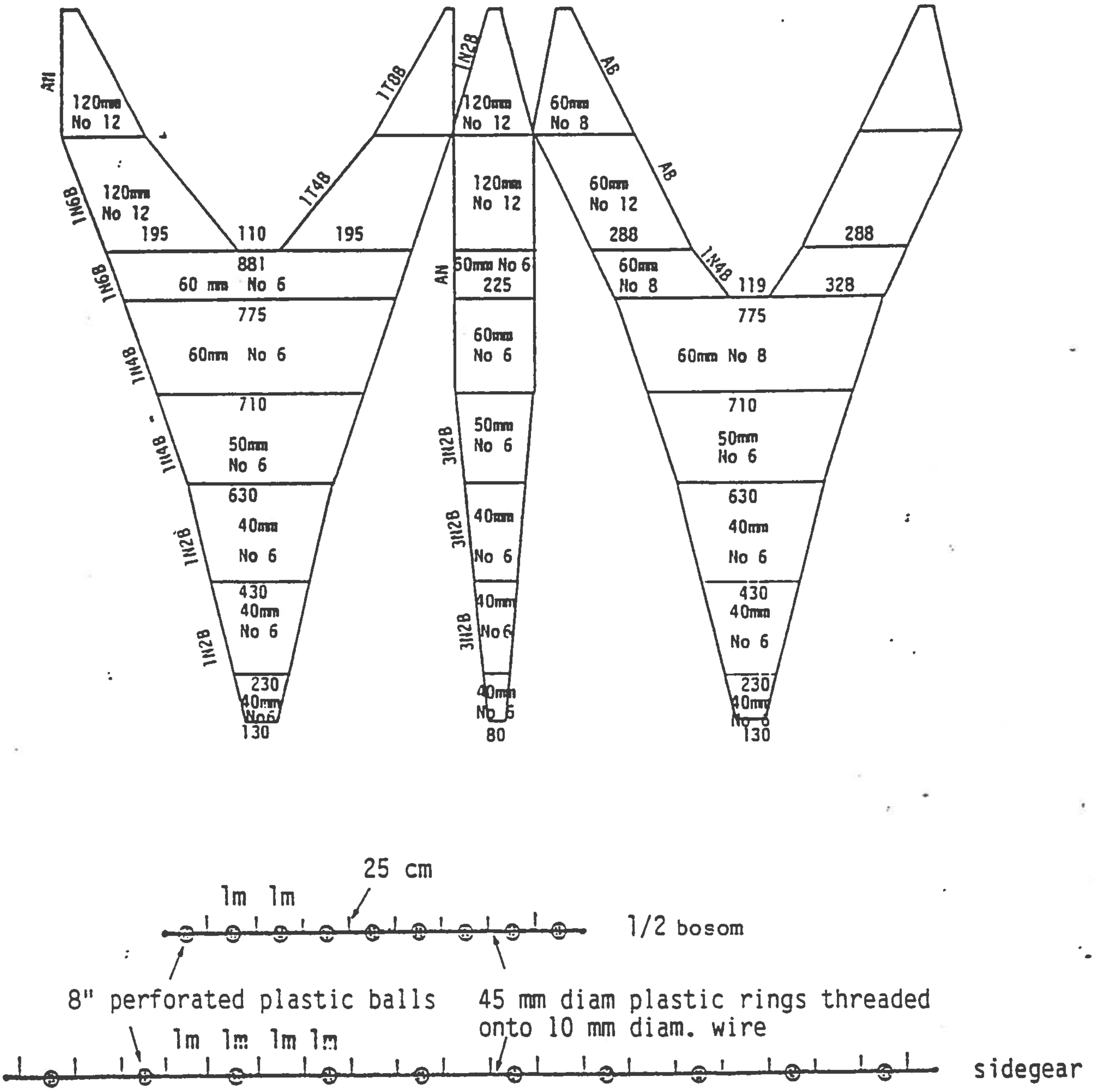

Figure 3. Combi 2000/60 shrimp trawl with groundrope of perforated plastic balls.

AAKRA V DOORS

265 x 185 cm
weight 650 kg each

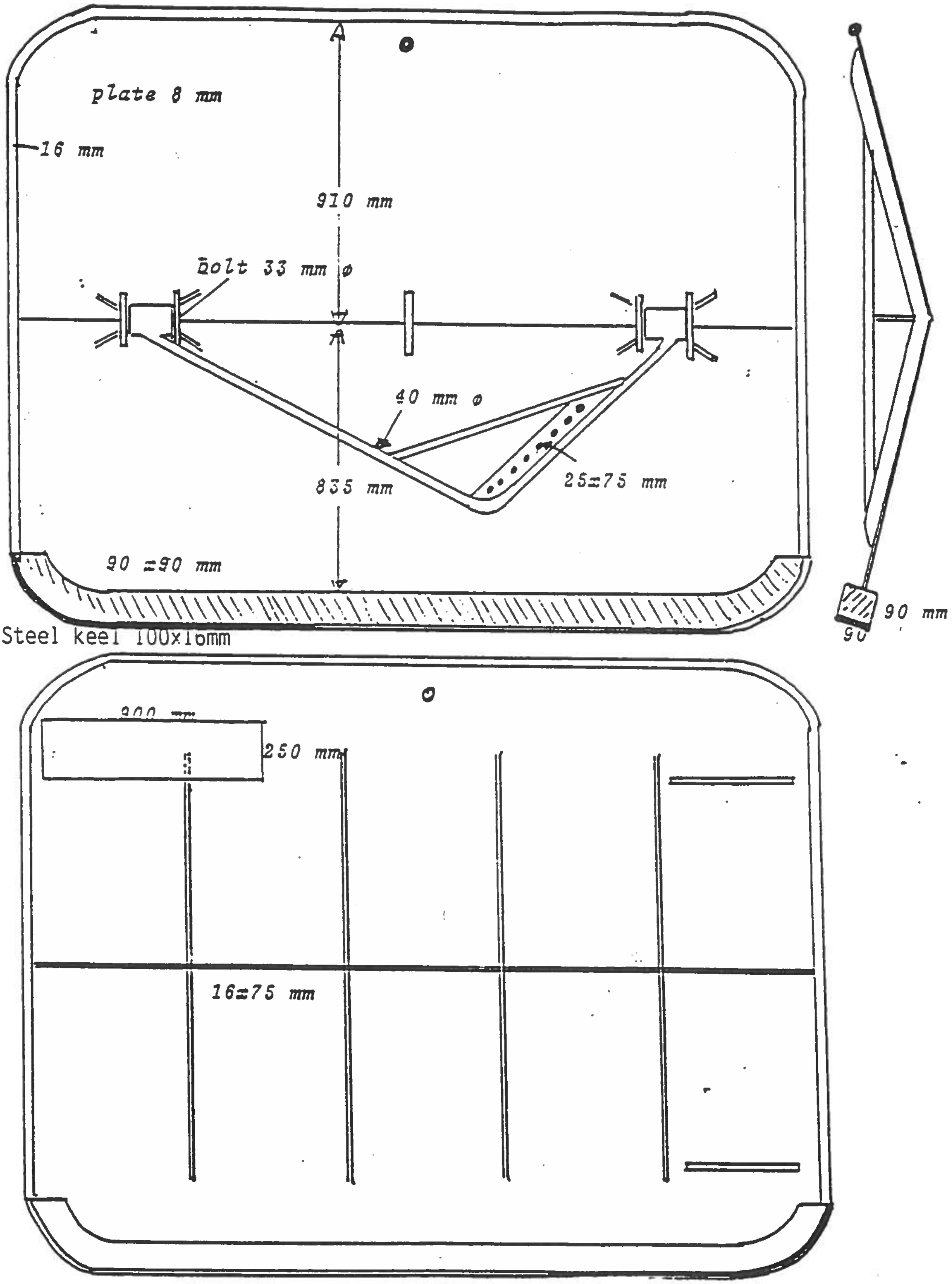

Figure 4. Otteboard used in trials.

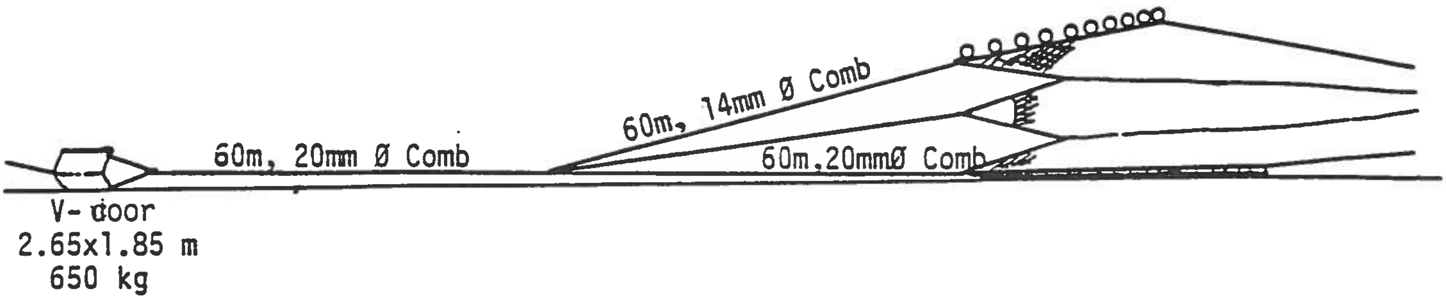

Figure 5. Rigging of Expo 1200 Industrial trawl.

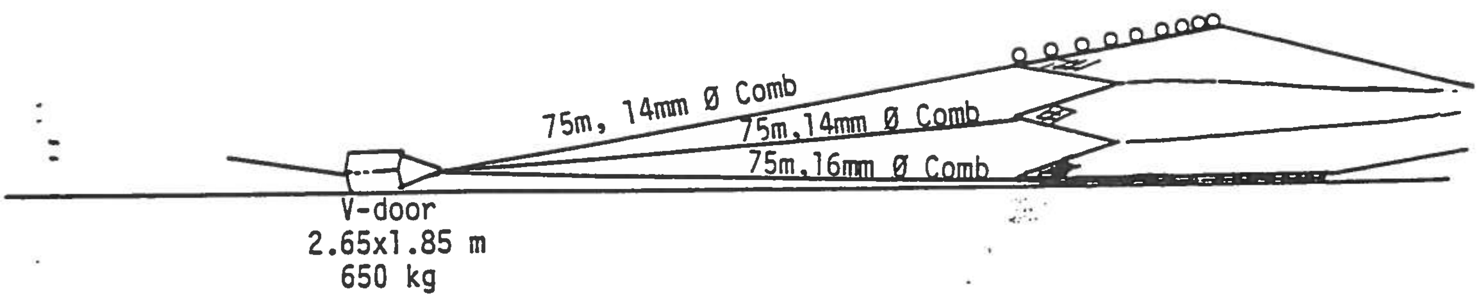

Figure 6. Rigging of Combi 3 bridle 2000/60 mesh shrimp trawl.

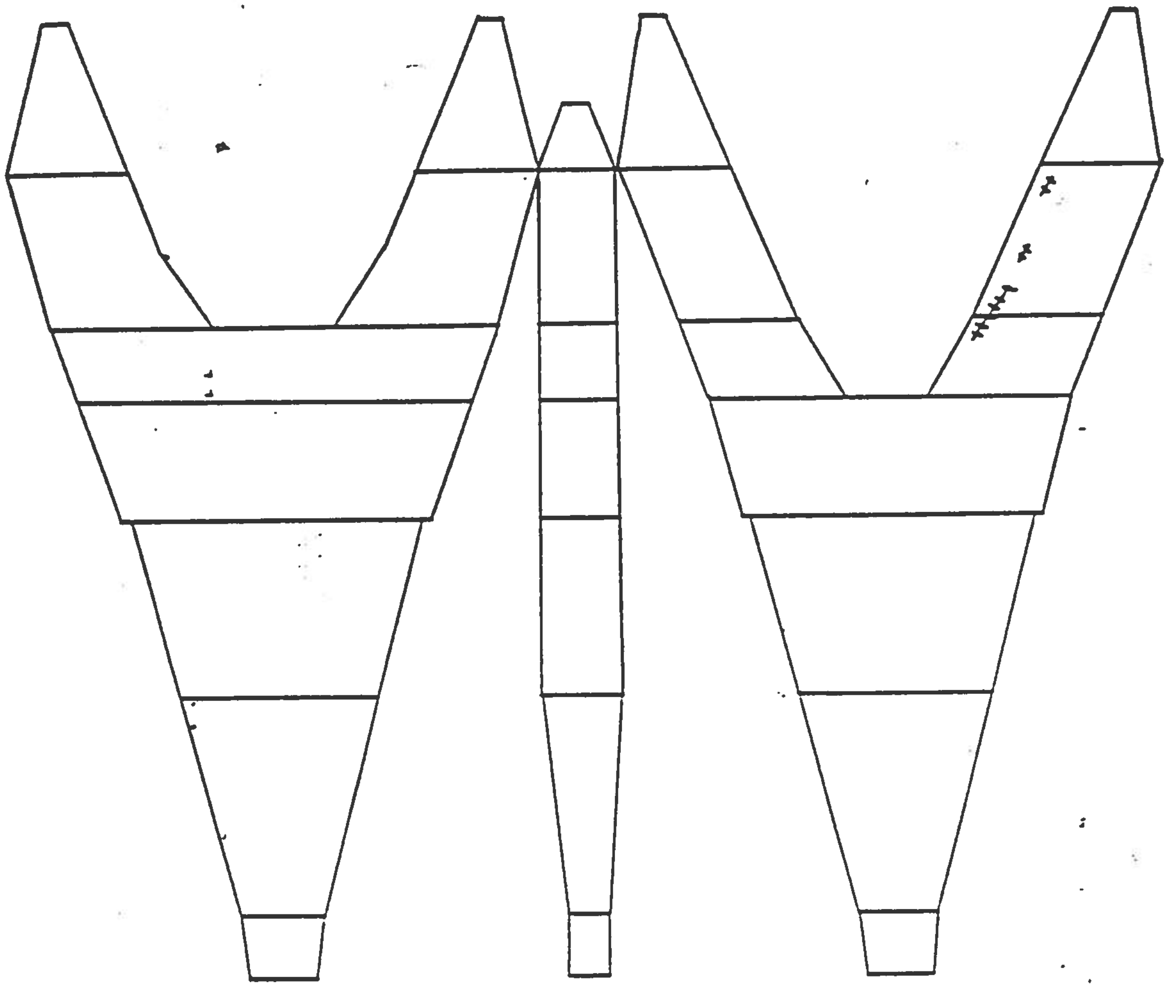

Figure 7. Tearing damage (3 lesser holes) in starboard lower wing (AT6).

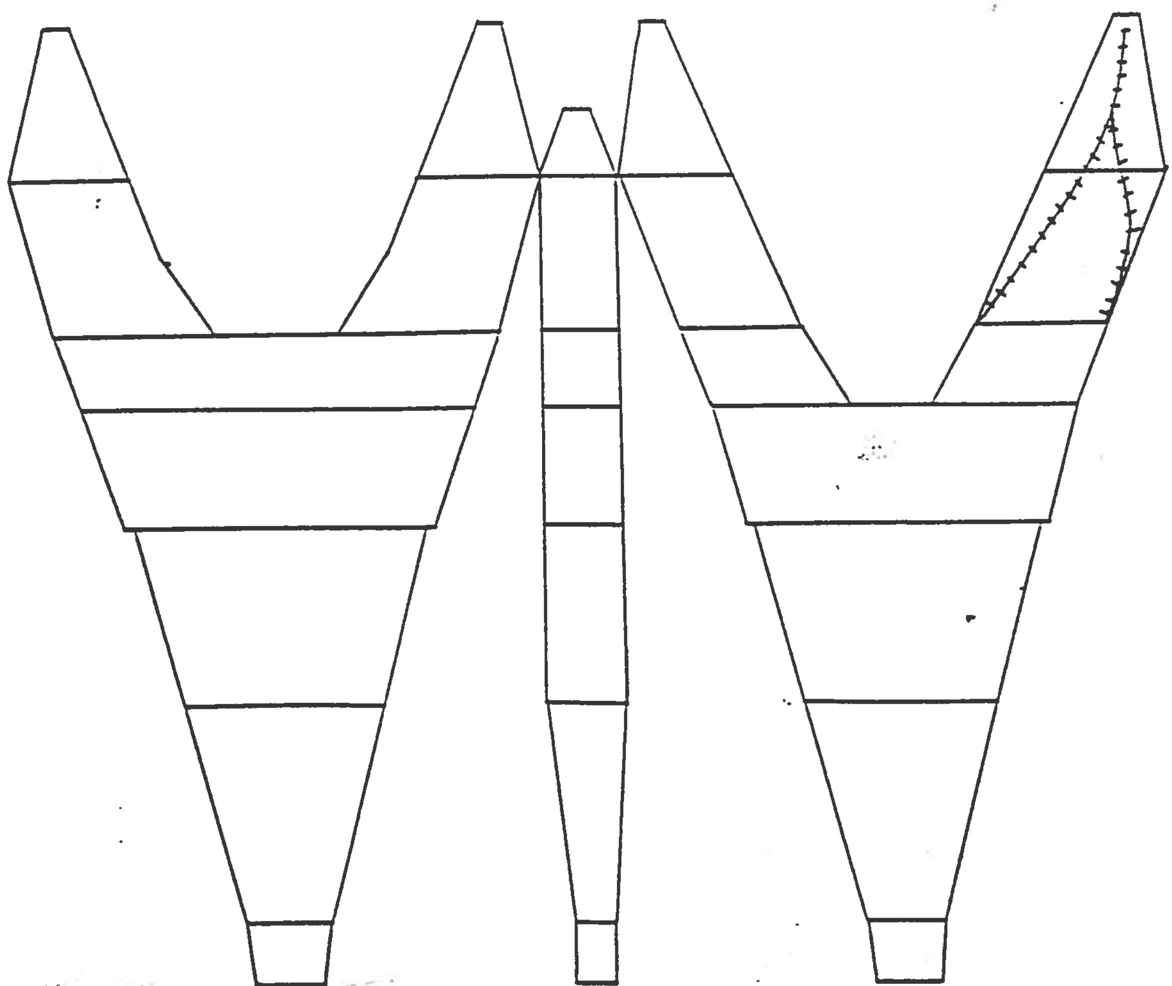

Figure 8. Tearing damage, major splits in starboard lower wing (AT8).

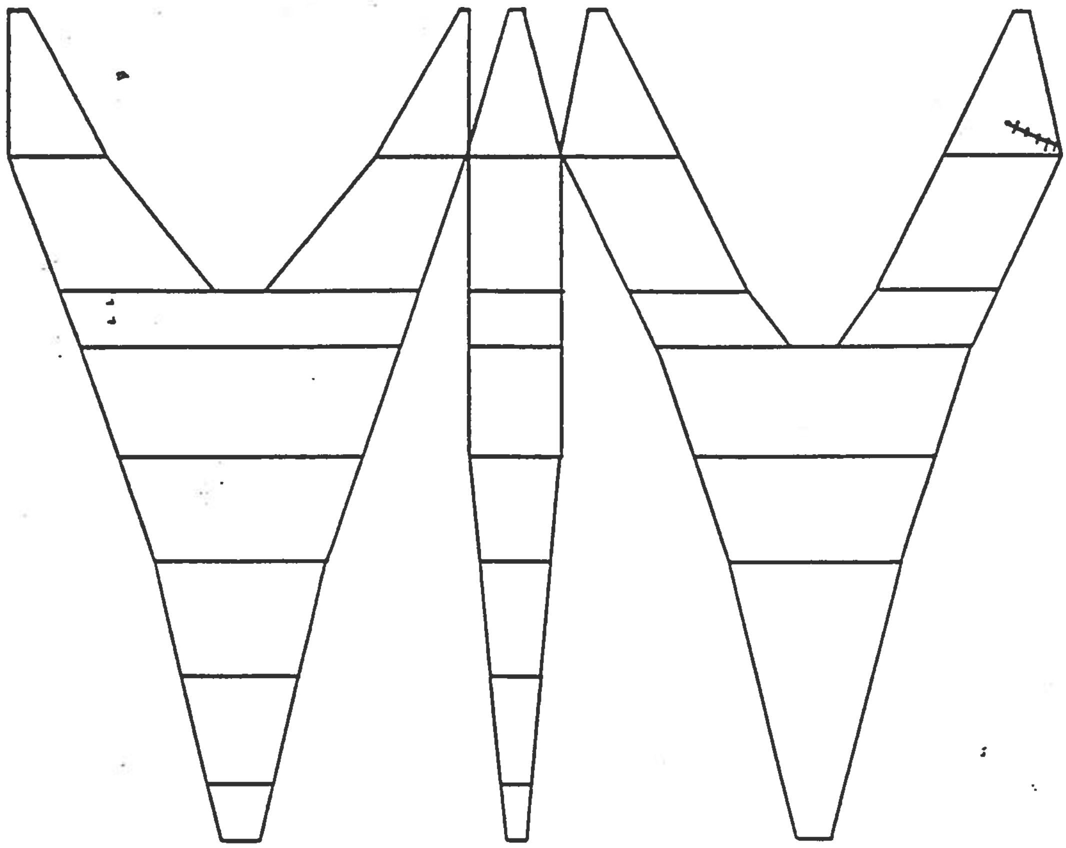

Figure 9. Tearing damage (3 m) in starboard lower wing (AT17).

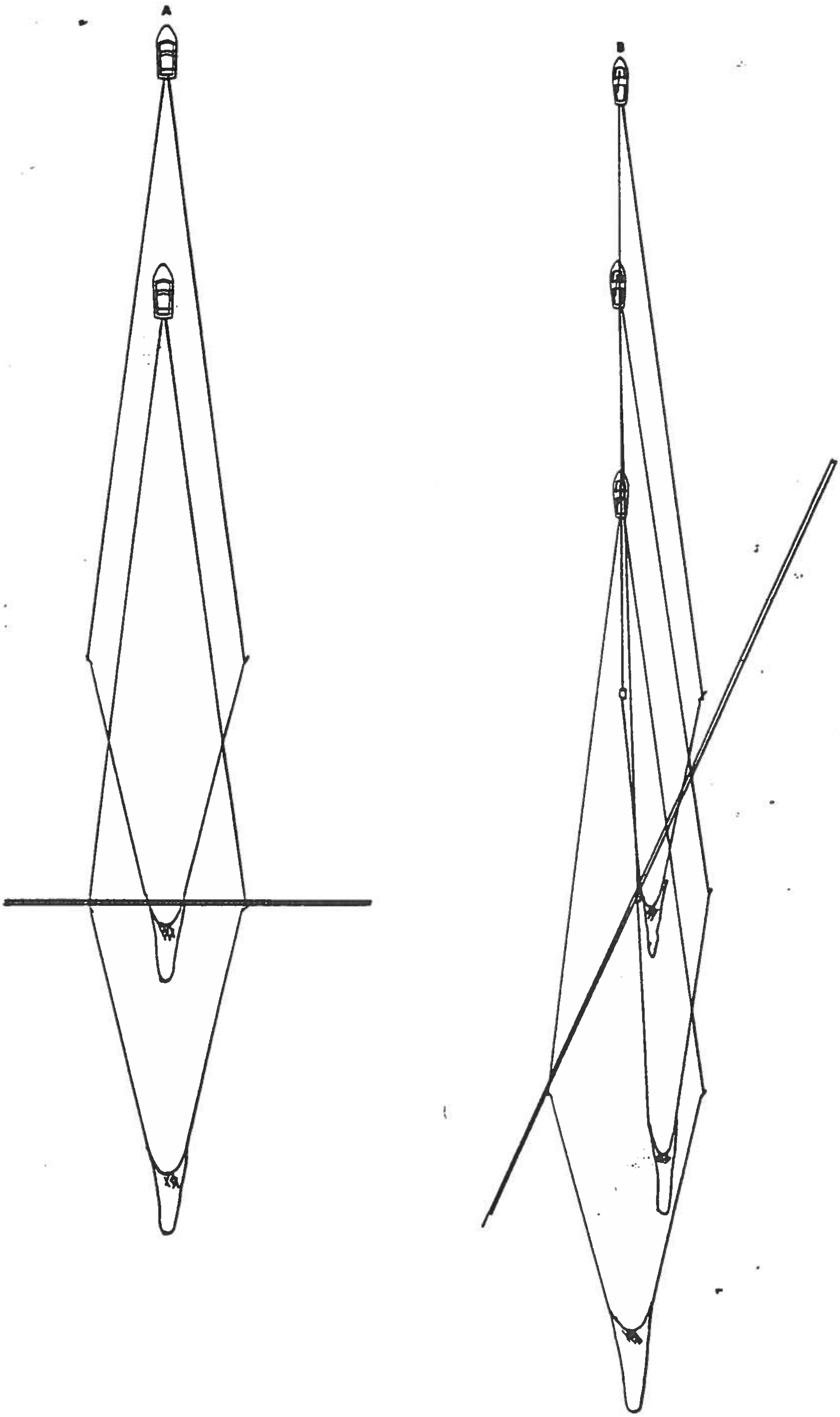

Figure 10. General performance pattern of otterboards and trawl crossing a pipeline at 90° (A) and 30° (B) angle of encounter, respectively.

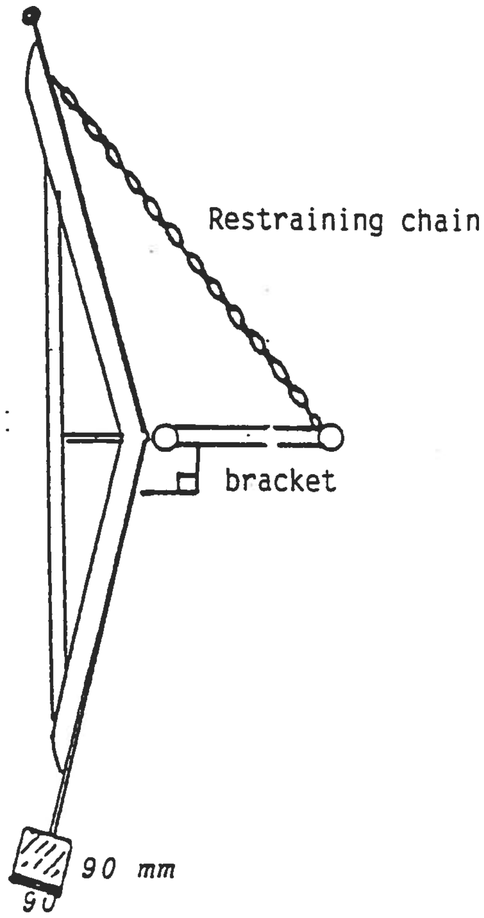

Figure 11. Illustration of V door with restrained towing bracket.