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TESTING OF TECHNICAL PARAMETERS OF BOTTOM TRAWLS DESIGNED FOR FISHING IN THE ADRIATIC SEA

ISPITIVANJE TEHNIČKIH PARAMETARA PRIDNENIH KOĆA ZA ULOV NA JADRANU

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INTRODUCTION

The bottom trawls known as tartana are still used in Croatian marine fisheries for demersal fish and other bottom organisms. This name, retained by now, referred once to a type of sailing boat towing the nets of the same name used for demersal fishing. Apart from the Adriatic this net is now used throughout the Mediterranean.

Tartana is a bottom trawl characterized by small vertical spread and square and bottom construction different from that of bottom trawls, used for chub mackerel fishing and fishing of some other bottom species in other seas. The square is not of a single conical webbing but a triangular webbing (wedge) is inserted. Headline bosom makes the base of this triangle. A similar wedge is inserted to the bottom, the base of which is groundrope bosom together making the bottom of tartana belly.

Since the recent years have seen an increased interest for bottom trawling, shown by a sudden increase in the number of fishing vessels used for this fishing (Cetinić, 1989) it has become necessary to promote the construction of these nets and to adapt them to the requirements of the Adriatic trawl fishing. The testing the body of model bottom trawls, designed for fishing in the Adriatic, having been successfully accomplished N o w a k o w s k i *et al.* (1992) two prototype bottom trawls for fishing with trawlers of 200-250 kW (270-340 HP) have been built. These two nets, along with already used tartana, are the subject of our study.

THE OBJECTIVE AND SUBJECT OF TESTING

The objective of this study is to promote the construction of bottom trawls adapted for demersal fishing in the Adriatic Sea, particularly hake, *Merluccius merluccius* (Linnaeus, 1758) and Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758), by the trawlers of our fleet.

The testing included:

- measurements of vertical and horizontal netmouth spread,
- resistance measurements,
- determination of the dependence of the otter board spread, vertical and horizontal spread, resistance, towing power and extent of dependence of penetrated substrate zone on the number of propeller revolutions (trawling speed),
- underwater observations and photographs.

The testing was performed at 20 m depth in the Brač Channel by the commercial trawler "Jadran I" of the Jadranribolov firm, Split, in 1988.

SUBJECT AND METHOD OF TESTING

The subject of testing were two prototype trawls, 30/25 and 22/20, as well as tartana already used in Croatian fishing. The schematic presentation of tartana and the way of its rigging are shown in Fig. 1, bottom trawl 30/25 in Fig. 2, its rigging in Fig. 3, the 22/20 net in Fig. 4 and its rigging in Fig. 5.

Underwater observations and photography

The underwater observations were carried out by the method applied in model net testing at the Model Research Station of the Agricultural Academy in Szczecin (N o w a k o w s k i *et al.*, 1992). This method is based on scuba-diver observations, who drags along the towline which at the same time is an underwater telephone cable. The net towing during underwater observations and measurement is shown in Fig. 6.

The underwater observations of completely rigged trawls were carried out on flat bottoms between 8 and 20 m depth. Upon the shooting of net, otter boards and 100 m of warps, a buoy of light colour were let down to the sea securely tied to a rope. It served diver to find more easily the net and the life boat with the diver-observer, the diver-rescuer and the boat skipper, who kept the telephone line by which the observations of the diver-observer were transmitted to the research vessel. When the life boat comes in the vicinity of the buoy completely equipped SCUBA diver with the knife, depth meter and aquaplane with the camera for underwater photography enters the sea Once about 50 m of warps having been let go, to which the diver is securely tied, and once the trawl towed by the research vessel having been found, that much warp is paid out with the life boat to let the diver-observer come to the point at the codend end. From that moment on the underwater observations start. The diver observes and takes photos of the characteristic trawl parts. Upon the completion of observations the trawl body was moved towards the otter boards by means of legs and bridles, during which the diver could asses the construction and operation of individual elements of towing trawl structure. The underwater observations ended at the otter boards, upon which the diver came back to the surface.

Methods of technical measurements

The apparatus used for technical measurements is schematically shown in Fig. 7. This apparatus comprised microcomputer, interface, cassette memory, monitor, printer and transmitter of signals from the speed meter and dynamometer indicators. The apparatus used on board the research vessel is shown in Fig. 8.

The apparatus recorded automatically the forces acting upon the warps and towing speed. The rest of parameters were obtained by individual instruments or by mathematical calculations. Each tested trawl was fitted net recorder and dynamometer. Net recorder transducer fitted to the headline bosom is shown in Fig. 9. Dynamometer on board the vessel connected to warps is shown in Fig. 10. Measurements of forces and cutters (section and top view) are given in Fig. 11.

Technical measurements were performed so that after the net recorder with transducer was fitted the trawl and the cable of net recorder were released together. A defined length of warps (depending on depth) and cable being released, the dynamometer was attached to the warps by bridles to which, by releasing additional length of warps, the trawl resistance was transferred. The speed meter was side released and towed at about 2.5 m depth by a steel rope. Thereupon the corresponding number of propeller revolutions was determined and the net spread kept stable, the resistance of warps could be measured as well as the difference of warp divergence in terms of the spread per meter and warp declination angles per meter length. Measurements of the divergence and declination angles are shown in Fig. 12. These values and vertical trawl spread were manually fed to the computer. Measurement cycle was altered after every change of trawling speed, that is the number of propeller revolutions.

TESTING RESULTS

Results of underwater observations

Tartana type trawl

This trawl, presented in Fig. 1, is of construction typical for bottom trawls used in the Adriatic and other Mediterranean parts, with characteristic triangle part below headline and groundrope bosom.

The underwater observations showed that:
- otter boards were very inclined sideward, due to which the horizontal spread was very small,
- with respect to its specific construction its vertical spread is relatively small, as assessed by the diver-observer, about 1.5 - 1.8 m,
- no other deformities of trawl body and towing system were observed.

Trawl 30/25 (two-seam)

This net, presented in Figs. 2 and 3, had the cylindrical codend of about 0.8 m diameter. At the point of joint of belly end to the codend it had the shape of a regular truncated cone whereas top and bottom bellies were compressed, ellipse-like in section. Netting meshes on the top below the bosom showed less tenacity and were more open than those of the adjacent net parts. According to the diver horizontal spread was 2.5 to 3.0 m. Wing was very rounded and the length of roundness chord at wing end was 1.8 to 2.0 m. The groundrope and the front part of the bottom belly scraped against the bottom. The codend and rear belly floated above the bottom. Otter boards were perpendicular to the ground.

Trawl 22/20

This trawl, shown in Figs. 4 and 5, was observed on the bottom overgrown by algae which filled the net closing the meshes of the codend and belly. Therefore, the codend was inflated and about 2.0 m in diameter. Vertical netmouth spread was about 2.5 to 3.0 m. Horizontal spread was relatively small, even smaller than in the trawl 30/25. The groundrope scraped against the bottom and the rear belly end and the codend floated above the bottom.

Otter boards were perpendicular to the bottom, but the spread between the boards was smaller than in the trawl 30/25.

Body shape of tested trawls 30/25 and 22/20 showed no differences from body shape of model nets, confirmed by the underwater observations and photography of full-size and model nets (N o w a k o w s k i , *et al.*, 1991).

Results of technical testing

Technical parameters of tested trawls are shown in Tables 1 through 4. Apart from the description of rigging of trawl system of tested trawls, these tables comprise also technical parameters in function of trawling speed. Calculated values of the equation of regression, correlation and F test (Snedecor) and the values for the respective speed interval, calculated on the basis of these equations, are also given in these tables.

For a better illustration, obtained results of measurements were recalculated to the function of the number of propeller revolutions of the cutter "Jadran I" and given as graphs for the trawl 30/25 and tartana in the Figs. 13 through 21.

As shown by the curve in Fig. 13, presenting the spread between otter boards in function of the number of propeller revolutions, the system of the 30/25 trawl appears to realize a considerably wider spread between otter boards (60-70 m) than tartana, in which it is maximum 55 m at 180 propeller revolutions per minute.

The horizontal spread between wing ends in the function of the number of propeller revolutions is quite different, as shown in Fig. 14. Both constructions appear to have approximately the same values of horizontal spread between wing ends at about 145 propeller revolutions per min. Below these values the trawl 30/25 has a greater horizontal spread between wing ends, whereas above these values the horizontal spread is greater in tartana reaching 18 m at 180 revolutions per min.

The shapes of the curves in Fig. 16 are similar. They depict horizontal spread at the level of headline bosom in function of the number of propeller revolutions. Fig. 15 shows the vertical spread at the level of headline bosom (AB) in function of the number of propeller revolutions. It appears that the trawl 30/25 shows a considerable vertical spread, from 3.8 to 4.8 m, whereas this spread is small in tartana, about 1.5-1.8 m.

Fig. 17 shows the resistance of both constructions, represented by a single curve since the resistance of both constructions at the range of 130-150 propeller revolutions per min is the same. However, beyond these values the curve refers to the resistance of the trawl 30/25.

The trawling speed as the function of the number of propeller revolutions per min is shown in Fig. 18. At the same number of revolutions the speed reached by the trawl 30/25 is slightly greater than that reached by tartana, although the differences are negligible. Fig 19. shows the towing force in function of the number of propeller revolutions per min. As shown by the curve in this figure both constructions require approximately the same towing force at the same number of revolutions.

However, when composing these two nets it should keep in mind that they differ not only in construction (different trawl types) but also in size (gabarites, mesh length, twine size, rigging) which significantly affects different parameters of their operation.

With respect to the fact that bottom trawls penetrate the sea bottom, penetration zone or bottom surface covered during trawling by towing system in unit time is one of relatively objective parameters of trawl gear construction (K r e p a *et al.*, 1987). This parameter is the product of horizontal spread and speed, horizontal spread being either that of the trawl, that at the wing end level or that between otter boards.

Fig. 20 depicts the penetration zone of the trawling system, which is the product of the spread between otter boards (m) and trawling speed (m/sec). These relationships point to the fact that to enclose the same bottom area, the 30/25 trawl should be operated at 150 propeller revolution per minute and tartana at 180.

If horizontal spread is multiplied by vertical spread and trawling speed penetration zone or water volume filtered by the trawl per unit time will be obtained. Such calculations for systems of bottom trawls could be met in Soviet investigations (J o n a s , 1967).

Values of bottom penetration zone (SQPS), trawl penetration zone (CPS) and energetic effort per square metre of passed bottom surface per sec and per cubic metre of bottom zone water per sec are shown in Table 5. As shown by the Table, the 30/25 trawl attains manifold greater vertical spread than tartana.

Energetic effort (k_1) in kw per square metre of passed bottom surface per sec is given in Fig. 21 for the 30/25 trawl and tartana in function of the number of propeller revolutions.

The value k_1 is obtained by dividing the towing force with the product of otter board spread and trawling speed. Fig. 21 points to the fact that energetic effort is by up to 100% greater for tartana than for 30/25 trawl, and therefore the expenses are lowest for tartana at trawling at 150 revolutions per minute.

CONCLUSIONS

Obtained results point to the following conclusions:

- underwater observations showed tested bottom trawls to be of regular construction with vertical and horizontal spreads in trawl prototypes 30/25 and 22/20 consider ably exceeding those in tartana;
- greater gabarites of 30/25 prototype trawl cause this net to penetrate larger bottom surface and to filtrate greater water volume;
- greater vertical spread of 30/25 trawl, greater mesh size and better water filtration point to the conclusion that it will be more selective and able to catch greater qua ntities of bottom fish.

REFERENCES

Cetinić, P. 1988. Analiza sadašnje stanja jugoslavenske koćarske i plivaričarske ribolovne flote. Morsko ribarstvo, 41: 69-76.

Jonas, V.A. 1967. Proizvoditielnost trala. Poščevaja promišlenost, Moskva.

Krepa, J., H. Stengel, A.L. Fridman. 1987. Narzedzia polowu rybolowstwa morskiego. Wydawnictwo morskie, Gdansk, 450 pp.

Nowakowski, P., P. Cetinić, J. Swiniarski, H. Sendlak and Z. Kwidzinski. 1992. Testing the body of bottom trawl model designed for operating in the Adriatic Sea. Studia marina, 22 (in press).

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KRATKI SADRŽAJ

Danas se još uvijek u našem morskom ribolovu za ulov demersalnih vrsta riba i drugih pridnenih morskih životinja uglavnom upotrebljava pridnena koća poznata pod nazivom tartana, koja je prikazana na slici 1.Kako posljednjih godina vlada kod nas sve veći interes za koćarski ribolov pridnenim povlačnim mrežama (koćama), sve se više javlja potreba za njihovim usavršavanjem, posebice zbog bolje zaštite oslića i škampa kao najvažnijih objekata ulova ovim alatima.

Nakon uspješno završenih ispitivanja modela tijela pridnenih povlačnih mreža (koća) za ulov na Jadranu, izradjena su dva prototipa tih mreža različitih konstrukcija za ribolov na koćarima od 200 - 250 kW (270 - 340 KS) koji su prikazani na slikama 2 (model 30/25) i 3 (model 22/20). Dva novoizradjena prototipa pridnenih povlačnih mreža i do sada primjenjivana koća za ulov demersalnih vrsta na Jadranu (tartana) bili su predmet istraživanja.

Ispitivanja su obuhvaćala:
- mjerenje okomitog i vodoravnog raspona usta koča,
- mjerenje otpora,
- odredjivanje ovisnosti izmedju broja okretaja propelera (brzina kočarenja) i udaljenosti (raspona) izmedju širilica, okomitog i vodoravnog raspona koče, otpora, snage povlačenja i veličine penetrirane zone dna,
- obavljanje podvodnih promatranja.

Rezultate ispitivanja tehničkih parametara koča prikazuju tablice 1 do 4. Radi bolje ilustracije dobiveni rezultati mjerenja su preračunati na funkciju broja okretaja propelera kočara "Jadran I", koji su prikazani u obliku grafikona za koču 30/25 i tartanu na slikama 13 do 21.

Na temelju dobivenih rezultata istraživanja može se zaključiti da su:
- podvodna promatranja pokazala da su istraživane pridnene povlačne mreže (koče) imale ispravnu konstrukciju pri čemu su okomiti i vodoravni rasponi prototipova koča 30/25 i 22/20 znatno veći nego kod pridnene koče tipa tartana;
- veći gabariti prototipa koče 30/25 čine da ta koča u jedinici vremena penetrira veću površinu dna i filtrira veći volumen vode;
- veći okomiti raspon koče 30/25 te veće veličine oka i bolja filtracija vode upućuju na zaključak da će ta koča biti selektivnija i izlovljavati veće količine pridnenih riba.

Table 1. Results of measurements of trawl parameters 30/25, Adriatic, Split channel, sept.1988. RIGGING: warps 250 m, otterboard type "V" 1.9 m^2, bridles 120 m, tow leg 24 m + 1 m of chain, headline leg 25 m, floats ϕ 200 mm 21 pieces, load of ground rope 92 kg of chain

Lp	V	α	β	R	RX	Y	CD*	CD	AB	Nt	RPM
1	0.92	125	389	8.4	7.5	62.5	13.0	8.5	4.8	7.1	100
2	0.92	125	389	8.4	7.5	62.5	13.0	8.5	4.8	7.1	100
3	0.95	125	389	8.4	7.5	62.5	13.0	8.5	4.8	7.4	100
4	0.92	125	389	8.4	7.5	62.5	13.0	8.5	4.8	7.1	100
5	0.94	125	389	8.4	7.5	62.5	13.0	8.5	4.8	7.3	100
6	1.05	125	368	9.8	9.5	62.5	13.0	8.5	4.6	9.6	110
7	1.03	125	368	9.8	9.5	62.5	13.0	8.5	4.6	9.4	110
8	1.06	125	368	9.8	9.5	62.5	13.0	8.5	4.6	9.7	110
9	1.07	125	368	9.8	9.5	62.5	13.0	8.5	4.6	9.8	110
10	1.08	125	368	9.8	9.5	62.5	13.0	8.5	4.6	9.9	110
11	1.19	130	368	11.0	10.5	65.0	13.5	8.9	4.4	12.2	120
12	1.19	130	368	11.2	10.5	65.0	13.5	8.9	4.4	12.4	120
13	1.17	130	368	11.2	10.5	65.0	13.5	8.9	4.4	12.2	120
14	1.19	130	368	11.0	10.5	65.0	13.5	8.9	4.4	12.2	120
15	1.17	130	368	11.0	10.5	65.0	13.5	8.9	4.4	12.0	120
16	1.28	140	346	12.2	11.5	70.0	14.6	9.5	4.2	14.7	130
17	1.28	140	346	12.2	11.5	70.0	14.6	9.5	4.2	14.7	130
18	1.29	140	346	12.2	11.5	70.0	14.6	9.5	4.2	14.8	130
19	1.29	140	346	12.2	11.5	70.0	14.6	9.5	4.2	14.8	130
20	1.26	140	346	12.2	11.5	70.0	14.6	9.5	4.2	14.5	130
21	1.34	140	304	12.8	12.5	70.0	14.6	9.5	4.0	16.4	140
22	1.33	140	304	12.8	12.5	70.0	14.6	9.5	4.0	16.2	140
23	1.33	140	304	12.8	12.5	70.0	14.6	9.5	4.0	16.2	140
24	1.36	140	304	12.8	12.5	70.0	14.6	9.5	4.0	16.6	140
25	1.36	140	304	12.8	12.5	70.0	14.6	9.5	4.0	16.6	140
26	1.45	135	304	14.6	13.5	67.5	14.1	9.2	3.8	20.2	150
27	1.47	135	304	14.6	13.5	67.5	14.1	9.2	3.8	20.5	150
28	1.48	135	304	14.6	13.5	67.5	14.1	9.2	3.8	20.6	150
29	1.47	135	304	14.6	13.5	67.5	14.1	9.2	3.8	20.5	150
30	1.45	135	304	14.6	13.5	67.5	14.1	9.2	3.8	20.2	150

COEFFICIENTS : REGRESSION (A) ; CORRELATION (r) ; TEST VALUE (F)					
	A0	A1	A2	r	F
RX	3.6046090	0.2786060	4.5941798	0.9966	1998.892500
Y	14.9996570	72.4513170	-24.3407700	0.8444	33.543716
CD*	3.4707933	14.3673850	-4.7157980	0.8459	33.962711
CD	1.9391409	10.0414140	-3.3905960	0.8643	39.879237
AB	5.5187885	-0.0469980	-0.7771600	0.9947	1278.410600
Nt	7.9103099	-16.4854800	17.0331200	0.9988	5826.355700

FUNCTION VALUE						
V	RX	Y	CD*	CD	AB	Nt
0.9	7.6	60.5	12.6	8.2	4.8	6.9
1.0	8.5	63.1	13.1	8.6	4.7	8.5
1.1	9.5	65.2	13.6	8.9	4.5	10.4
1.2	10.6	66.9	13.9	9.1	4.3	12.7
1.3	11.7	68.1	14.2	9.3	4.1	15.3
1.4	13.0	68.7	14.3	9.4	3.9	18.2
1.5	14.4	68.9	14.4	9.4	3.7	21.5

Table 2. Results of measurements of trawl parameters type tartana, Adriatic, Split channel, sept.1988. RIGGING : warps 400 m, rectangle otterboard type 1.5 m^2, bridles 140 m + 10 m of chain, without legs, floats ϕ 110 mm 50 pieces, load of ground rope 42 kg of plumb

Lp	V	α	β	R	RX	Y	CD*	CD	(AB)	Nt	RPM
1	1.22	40	315	11.8	11.2	32	10.3	6.3	1.5	13.7	130
2	1.22	40	315	11.8	11.2	32	10.3	6.3	1.5	13.7	130
3	1.20	40	315	11.8	11.2	32	10.3	6.3	1.5	13.5	130
4	1.23	40	315	11.6	11.0	32	10.3	6.3	1.5	13.6	130
5	1.22	40	315	11.6	11.0	32	10.3	6.3	1.5	13.5	130
6	1.28	55	315	12.8	12.2	44	14.2	8.7	1.5	15.6	140
7	1.31	55	315	12.4	11.8	44	14.2	8.7	1.5	15.4	140
8	1.26	55	315	12.8	12.2	44	14.2	8.7	1.5	15.3	140
9	1.29	55	315	12.4	11.8	44	14.2	8.7	1.5	15.2	140
10	1.29	55	315	12.4	11.8	44	14.2	8.7	1.5	15.2	140
11	1.42	60	263	14.4	13.9	48	15.5	9.5	1.5	19.7	150
12	1.40	60	263	14.4	13.9	48	15.5	9.5	1.5	19.5	150
13	1.42	60	263	14.4	13.9	48	15.5	9.5	1.5	19.7	150
14	1.40	60	263	14.6	14.1	48	15.5	9.5	1.5	19.7	150
15	1.42	60	263	14.6	14.1	48	15.5	9.5	1.5	20.0	150
16	1.54	65	263	15.6	15.1	52	16.7	10.3	1.5	23.2	160
17	1.54	65	263	15.6	15.1	52	16.7	10.3	1.5	23.2	160
18	1.51	65	263	15.6	15.1	52	16.7	10.3	1.5	22.7	160
19	1.50	65	263	15.6	15.1	52	16.7	10.3	1.5	22.6	160
20	1.53	65	263	15.6	15.1	52	16.7	10.3	1.5	23.0	160
21	1.70	65	253	18.0	17.4	52	16.7	10.3	1.5	29.6	170
22	1.65	65	253	18.4	17.8	52	16.7	10.3	1.5	29.4	170
23	1.65	65	253	18.4	17.8	52	16.7	10.3	1.5	29.4	170
24	1.67	65	253	18.0	17.4	52	16.7	10.3	1.5	29.1	170
25	1.68	65	253	18.4	17.8	52	16.7	10.3	1.5	29.9	170
26	1.79	70	201	20.2	19.8	56	18.0	11.1	1.5	35.4	180
27	1.81	70	201	20.2	19.8	56	18.0	11.1	1.5	35.8	180
28	1.81	70	201	20.2	19.8	56	18.0	11.1	1.5	35.8	180
29	1.78	70	201	20.2	19.8	56	18.0	11.1	1.5	35.2	180
30	1.81	70	201	20.2	19.8	56	18.0	11.1	1.5	35.8	180

COEFFICIENTS : REGRESSION (A) ; CORRELATION (r) ; TEST VALUE (F)					
	A0	A1	A2	r	F
RX	2.6240714	1.8053945	4.2830730	0.9938	1094.8188000
Y	-177.5371000	270.4418000	-78.6435400	0.9474	118.5067500
CD*	-57.1729700	87.0914270	-25.3258800	0.9474	118.5068200
CD	-35.1062100	53.4771920	-15.5509800	0.9474	118.5068500
AB	1.4999992	4.5150518	6.0349703	0.00004	2.2008863
Nt	14.3275880	-26.4175000	21.2222470	0.9978	3115.6398000

FUNCTION VALUE						
V	RX	Y	CD*	CD	(AB)	Nt
1.1	9.8	24.8	8.0	4.9	1.5	10.9
1.2	11.0	33.7	10.9	6.7	1.5	13.2
1.3	12.2	41.1	13.2	8.1	1.5	15.9
1.4	13.5	46.9	15.1	9.3	1.5	18.9
1.5	15.0	51.2	16.5	10.1	1.5	22.5
1.6	16.5	53.8	17.3	10.6	1.5	26.4
1.7	18.1	54.9	17.7	10.9	1.5	30.8
1.8	19.8	54.5	17.5	10.8	1.5	35.5
1.9	21.5	52.4	16.9	10.4	1.5	40.7

Table 3. Results of measurements of trawl parameters type tartana, Adriatic, Split channel, sept.1988. RIGGING : warps 400 m, rectangle otterboard type 1.5 m^2, bridles 140 m + 10 m of chain, without legs, floats ϕ 110 mm 50 pieces, load of ground rope 42 kg of plumb

Lp	RPM	α	β	R	RX	Y	CD*	CD	(AB)	Nt	V
1	130	40	315	11.8	11.2	32	10.3	6.3	1.5	13.7	1.22
2	130	40	315	11.8	11.2	32	10.3	6.3	1.5	13.7	1.22
3	130	40	315	11.8	11.2	32	10.3	6.3	1.5	13.5	1.20
4	130	40	315	11.6	11.0	32	10.3	6.3	1.5	13.6	1.23
5	130	40	315	11.6	11.0	32	10.3	6.3	1.5	13.5	1.22
6	140	55	315	12.8	12.2	44	14.2	8.7	1.5	15.6	1.28
7	140	55	315	12.4	11.8	44	14.2	8.7	1.5	15.4	1.31
8	140	55	315	12.8	12.2	44	14.2	8.7	1.5	15.3	1.26
9	140	55	315	12.4	11.8	44	14.2	8.7	1.5	15.2	1.29
10	140	55	315	12.4	11.8	44	14.2	8.7	1.5	15.2	1.29
11	150	60	263	14.4	13.9	48	15.5	9.5	1.5	19.7	1.42
12	150	60	263	14.4	13.9	48	15.5	9.5	1.5	19.5	1.40
13	150	60	263	14.4	13.9	48	15.5	9.5	1.5	19.7	1.42
14	150	60	263	14.6	14.1	48	15.5	9.5	1.5	19.7	1.40
15	150	60	263	14.6	14.1	48	15.5	9.5	1.5	20.0	1.42
16	160	65	263	15.6	15.1	52	16.7	10.3	1.5	23.2	1.54
17	160	65	263	15.6	15.1	52	16.7	10.3	1.5	23.2	1.54
18	160	65	263	15.6	15.1	52	16.7	10.3	1.5	22.7	1.51
19	160	65	263	15.6	15.1	52	16.7	10.3	1.5	22.6	1.50
20	160	65	263	15.6	15.1	52	16.7	10.3	1.5	23.0	1.53
21	170	65	253	18.0	17.4	52	16.7	10.3	1.5	29.6	1.70
22	170	65	253	18.4	17.8	52	16.7	10.3	1.5	29.4	1.65
23	170	65	253	18.4	17.8	52	16.7	10.3	1.5	29.4	1.65
24	170	65	253	18.0	17.4	52	16.7	10.3	1.5	29.1	1.67
25	170	65	253	18.4	17.8	52	16.7	10.3	1.5	29.9	1.68
26	180	70	201	20.2	19.8	56	18.0	11.1	1.5	35.4	1.79
27	180	70	201	20.2	19.8	56	18.0	11.1	1.5	35.8	1.81
28	180	70	201	20.2	19.8	56	18.0	11.1	1.5	35.8	1.81
29	180	70	201	20.2	19.8	56	18.0	11.1	1.5	35.2	1.78
30	180	70	201	20.2	19.8	56	18.0	11.1	1.5	35.8	1.81

COEFFICIENTS : REGRESSION (A) ; CORRELATION (r) ; TEST VALUE (F)					
	A0	A1	A2	r	F
RX	25.3721870	-0.3163830	0.00158728	0.9961	1733.6969000
Y	-255.5574000	3.5230439	-0.01000060	0.9791	313.5546500
CD*	-82.2981700	1.1345396	-0.00322050	0.9791	313.5546500
CD	-50.5339600	0.6966470	-0.00197750	0.9791	313.5541800
AB	1.4999829	9.7788870	-2.72848400	0.00004	2.9658055
Nt	82.3426500	-1.2342310	0.00541822	0.9981	3580.2656000
V	1.2894094	-0.0096641	0.00006964	0.9965	1957.5613000

FUNCTION VALUE							
RPM	RX	Y	CD*	CD	(AB)	Nt	V
130	11.1	33.4	10.8	6.6	1.5	13.5	1.21
140	12.2	41.7	13.4	8.2	1.5	15.7	1.30
150	13.6	47.9	15.4	9.5	1.5	19.1	1.41
160	15.4	52.1	16.8	10.3	1.5	23.6	1.53
170	17.5	54.3	17.5	10.7	1.5	29.1	1.66
180	19.9	54.6	17.6	10.8	1.5	35.7	1.81

Table 4. Results of measurements of trawl parameters 30/25, Adriatic, Split channel, sept.1988. RIGGING : warps 250 m, rectangle otterboard type "V" 1.9 m^2, bridles 120 m, tow leg 24 m + 1 m of chain, headline leg 25 m, floats ϕ 200 mm 21 pieces, load of ground rope 92 kg of chain.

Lp	RPM	α	β	R	RX	Y	CD*	CD	(AB)	Nt	V
1	100	125	390	8.4	7.8	62.5	13.0	8.5	4.8	7.1	0.92
2	100	125	390	8.4	7.8	62.5	13.0	8.5	4.8	7.1	0.92
3	100	125	390	8.4	7.8	62.5	13.0	8.5	4.8	7.4	0.95
4	100	125	390	8.4	7.8	62.5	13.0	8.5	4.8	7.1	0.92
5	100	125	390	8.4	7.8	62.5	13.0	8.5	4.8	7.3	0.94
6	110	125	368	9.8	9.1	62.5	13.0	8.5	4.6	9.6	1.05
7	110	125	368	9.8	9.1	62.5	13.0	8.5	4.6	9.4	1.03
8	110	125	368	9.8	9.1	62.5	13.0	8.5	4.6	9.7	1.06
9	110	125	368	9.8	9.1	62.5	13.0	8.5	4.6	9.8	1.07
10	110	125	368	9.8	9.1	62.5	13.0	8.5	4.6	9.9	1.08
11	120	130	368	11.0	10.3	65.0	13.5	8.9	4.4	12.2	1.19
12	120	130	368	11.2	10.4	65.0	13.5	8.9	4.4	12.4	1.19
13	120	130	368	11.2	10.4	65.0	13.5	8.9	4.4	12.2	1.17
14	120	130	368	11.0	10.3	65.0	13.5	8.9	4.4	12.2	1.19
15	120	130	368	11.0	10.3	65.0	13.5	8.9	4.4	12.0	1.17
16	130	140	347	12.2	11.5	70.0	14.6	9.5	4.2	14.7	1.28
17	130	140	347	12.2	11.5	70.0	14.6	9.5	4.2	14.7	1.28
18	130	140	347	12.2	11.5	70.0	14.6	9.5	4.2	14.8	1.29
19	130	140	347	12.2	11.5	70.0	14.6	9.5	4.2	14.8	1.29
20	130	140	347	12.2	11.5	70.0	14.6	9.5	4.2	14.5	1.26
21	140	140	305	12.8	12.2	70.0	14.6	9.5	4.0	16.4	1.34
22	140	140	305	12.8	12.2	70.0	14.6	9.5	4.0	16.2	1.33
23	140	140	305	12.8	12.2	70.0	14.6	9.5	4.0	16.2	1.33
24	140	140	305	12.8	12.2	70.0	14.6	9.5	4.0	16.6	1.36
25	140	140	305	12.8	12.2	70.0	14.6	9.5	4.0	16.6	1.36
26	150	135	305	14.6	13.9	67.5	14.1	9.2	3.8	20.2	1.45
27	150	135	305	14.6	13.9	67.5	14.1	9.2	3.8	20.5	1.47
28	150	135	305	14.6	13.9	67.5	14.1	9.2	3.8	20.6	1.48
29	150	135	305	14.6	13.9	67.5	14.1	9.2	3.8	20.5	1.47
30	150	135	305	14.6	13.9	67.5	14.1	9.2	3.8	20.2	1.45

COEFFICIENTS : REGRESSION (A) ; CORRELATION (r) ; TEST VALUE (F)					
	A0	A1	A2	r	F
RX	-4.1723900	0.12230640	-0.00001920	0.9956	1553.925100
Y	-14.1062500	1.15445290	-0.00401770	0.8744	43.872770
CD*	-2.9401490	0.24062130	-0.00083740	0.8744	43.872739
CD	-1.9213390	0.15724200	-0.00054720	0.8744	43.872722
AB	6.7999898	-0.01999960	-4.00177600	0.9999	491676.560000
Nt	-6.1819990	0.05735109	0.00078202	0.9956	1545.131200
V	-0.8519840	0.02285980	-0.00004990	0.9950	1343.824500

FUNCTION VALUE							
RPM	RX	Y	CD*	CD	(AB)	Nt	V
100	7.9	61.2	12.7	8.3	4.8	7.4	0.93
110	9.0	64.3	13.4	8.8	4.6	9.6	1.06
120	10.2	66.6	13.9	9.1	4.4	12.0	1.17
130	11.4	68.1	14.2	9.3	4.2	14.5	1.27
140	12.6	68.8	14.3	9.4	4.0	17.2	1.37
150	13.7	68.7	14.3	9.4	3.8	20.0	1.45

Table 5. INDICATORS OF PENETRATION OF THE NETS INTO THE BOTTOM AND OF ENERGETIC TENSION OF TARTANA AND TRAWL 30/25

RPM	SQPS		CPS		k_1		k_2	
	Y x V (m^2 / s)		Y x V x AB (m^3 / s)		Nt / (Y x V) (kW / m^2/s)		Nt / (Y x V x AB) (kW / m^3/s)	
n/min	30/25	TARTANA	30/25	TARTANA	30/25	TARTANA	30/25	TARTANA
100	56.916	-	273.197	-	0.130	-	0.0270	-
110	68.158	-	313.527	-	0.141	-	0.0306	-
120	77.922	-	342.857	-	0.154	-	0.0350	-
130	86.487	40.414	363.245	60.675	0.168	0.334	0.0399	0.2227
140	94.256	54.210	377.024	81.315	0.182	0.289	0.0456	0.1931
150	99.615	67.539	378.537	101.309	0.201	0.283	0.0528	0.1885
160	-	79.713	-	119.570	-	0.296	-	0.1974
170	-	90.138	-	135.207	-	0.323	-	0.2152
180	-	98.826	-	148.239	-	0.361	-	0.2408

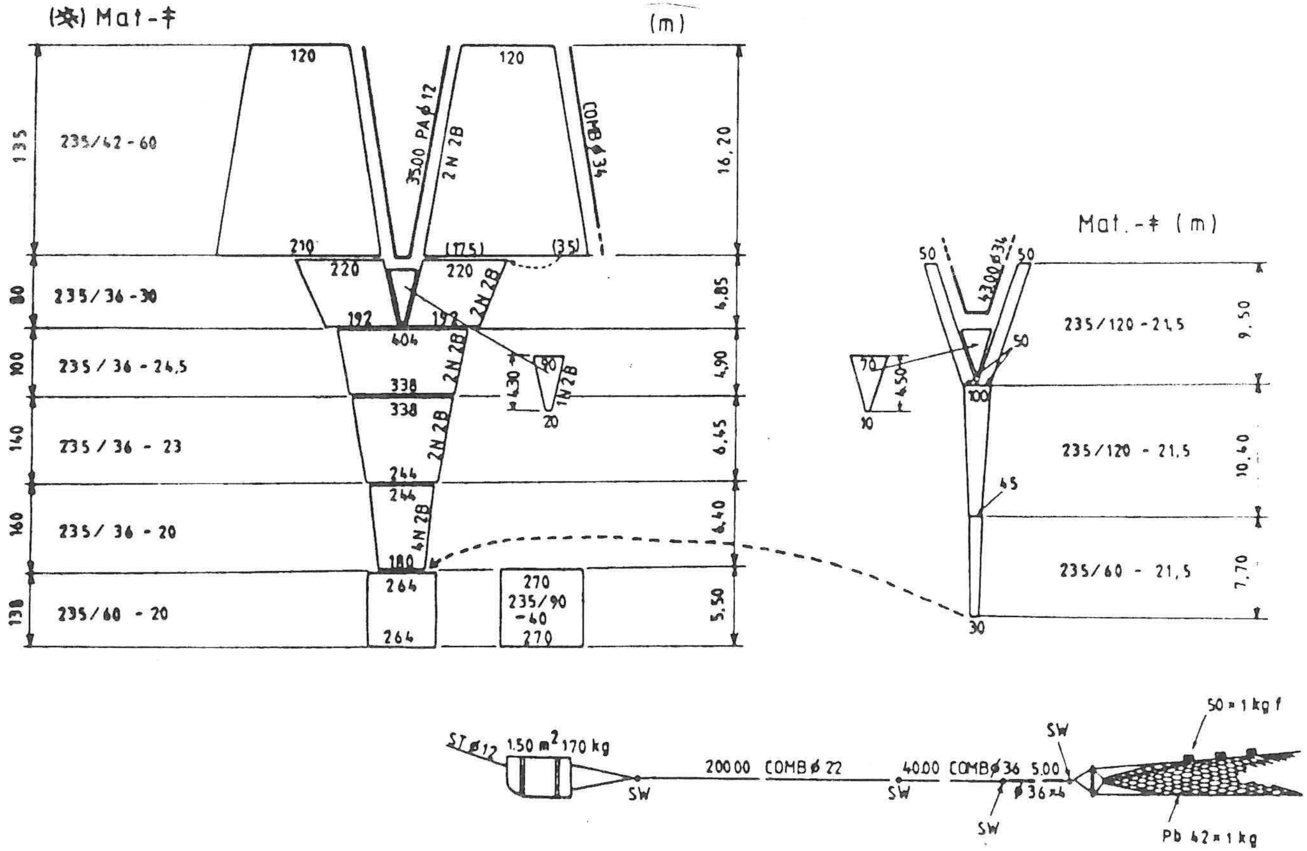

Fig. 1. Schematic representation of tartana construction

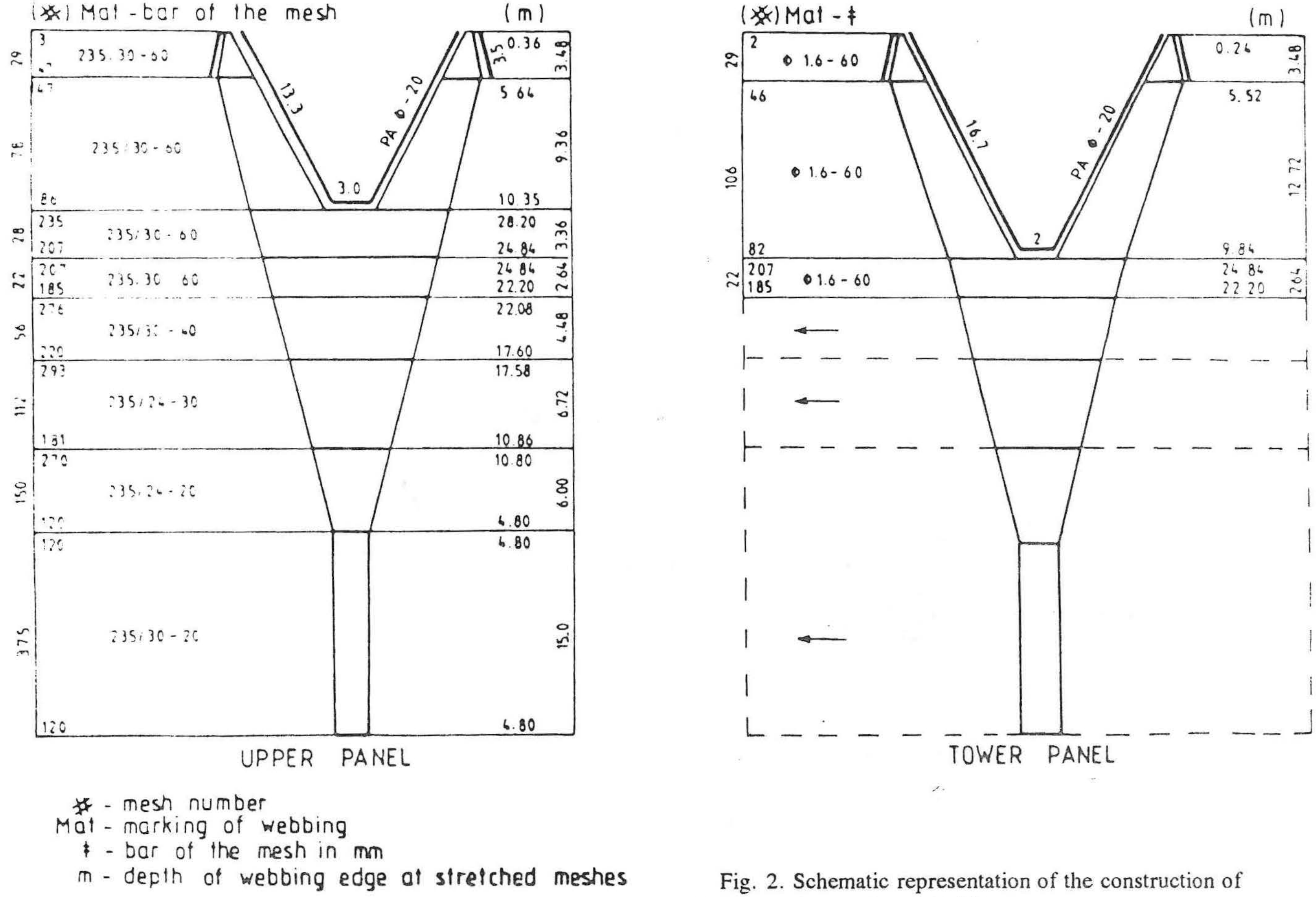

Fig. 2. Schematic representation of the construction of bottom trawl 30/25

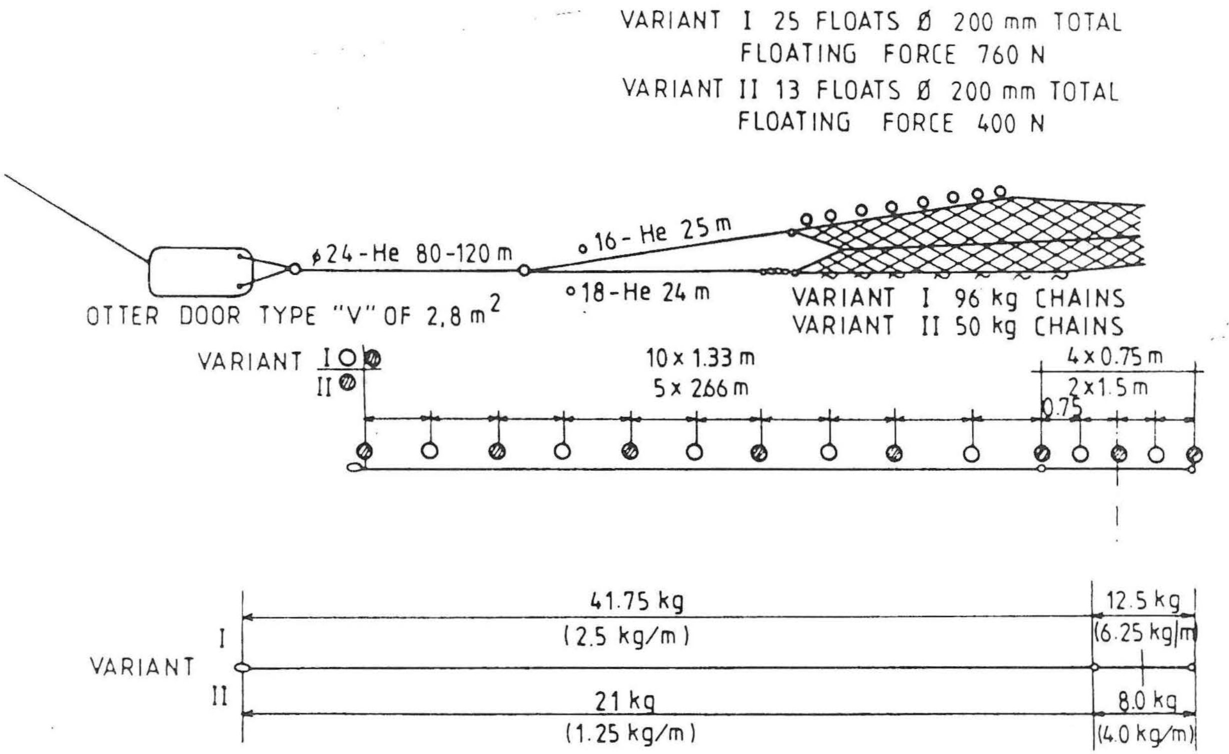

Fig. 3. Rigging of the bottom trawl 30/25

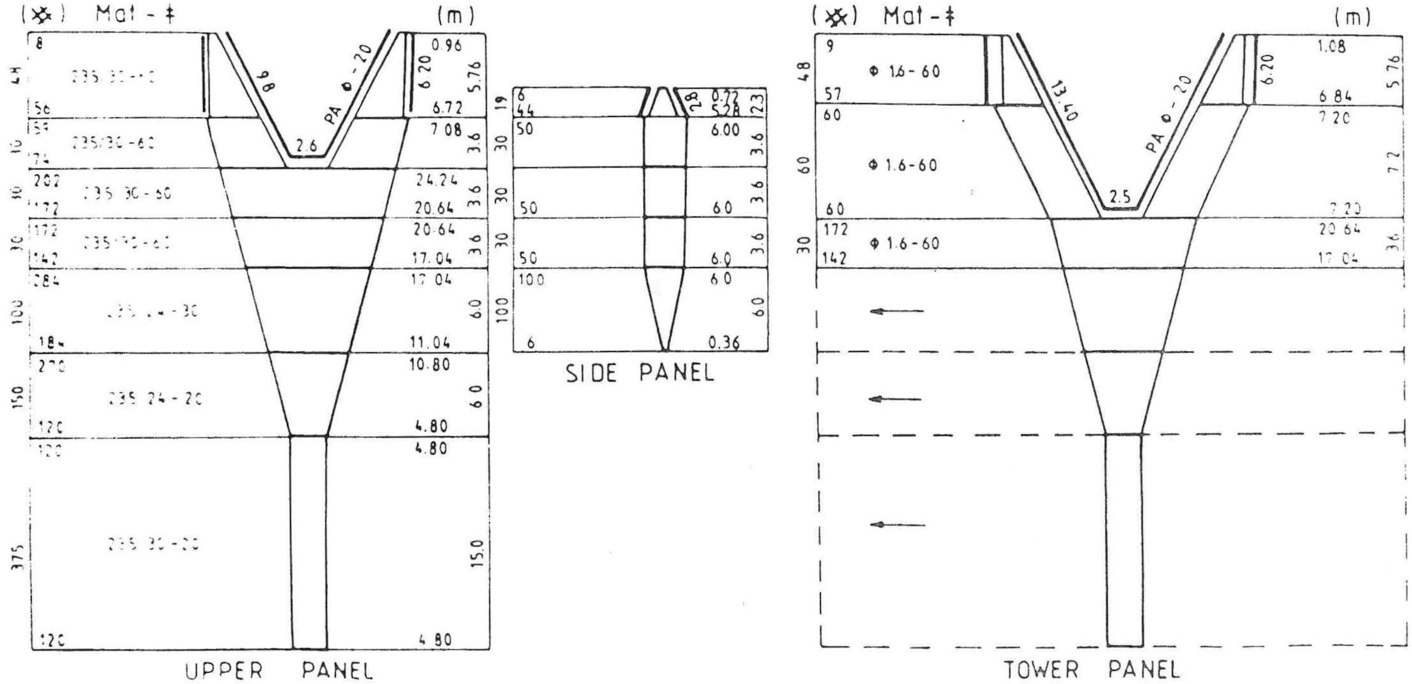

Fig. 4. Schematic representation of the construction of the bottom trawl 22/20

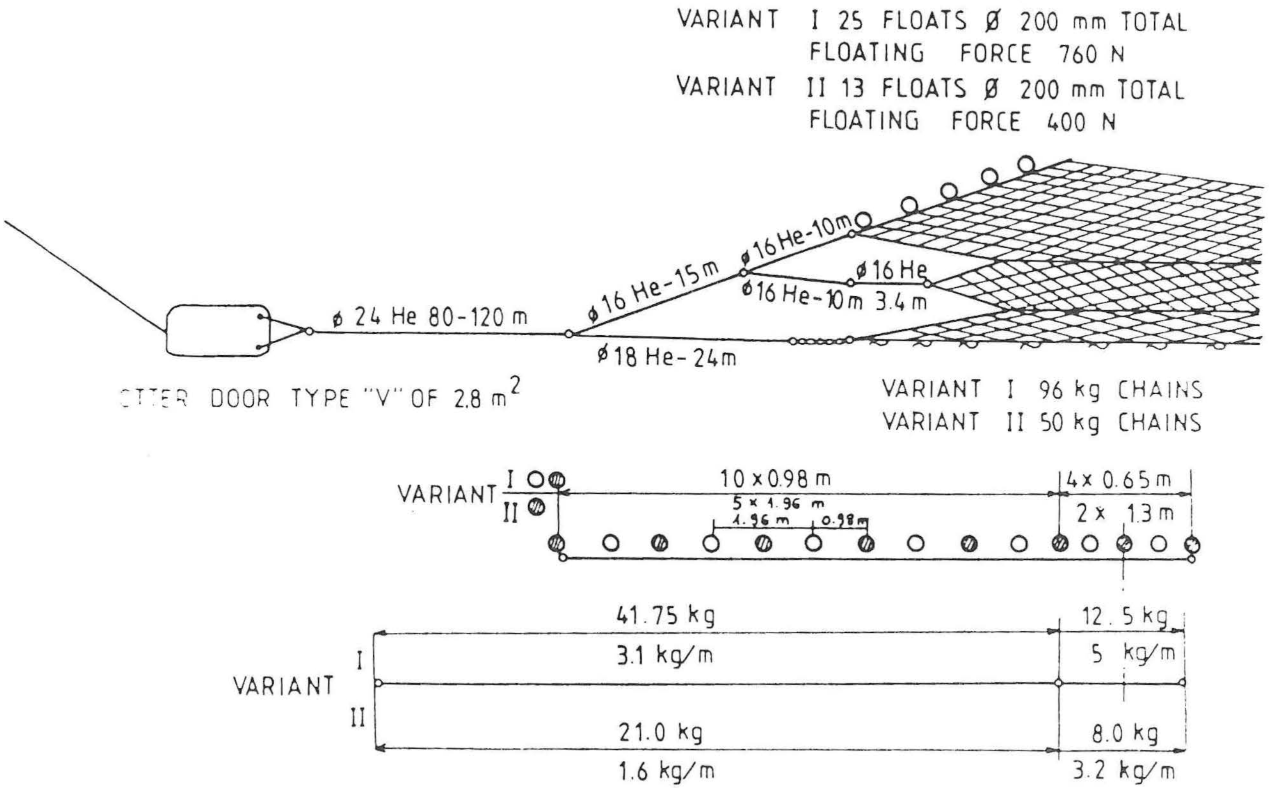

Fig. 5. Rigging of bottom trawl 22/20

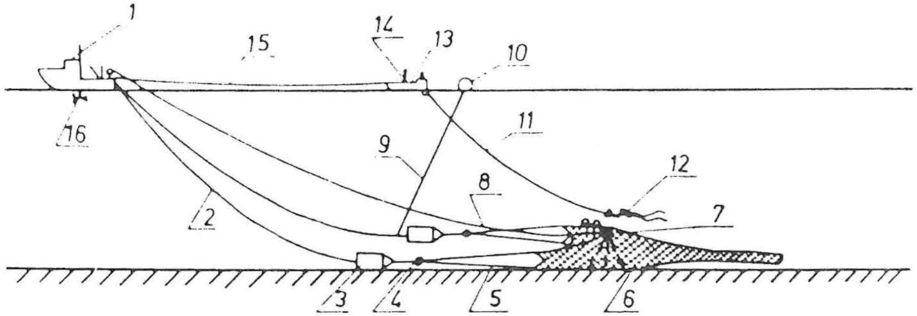

Fig. 6. Trawl towing during measurements and underwater observations

1. cutter
2. warps
3. otter board
4. bridles
5. legs
6. body of bottom trawl
7. netsonde transducer
8. netsonde cable
9. net floating mark rope
10. buoy marker
11. cable-tow line of frogman which is an underwater telephone cable
12. scuba diver-observer at aquaplane
13. accessory life boat
14. crew of the boat - security scuba diver and helmsman
15. rope for boat towing
16. speedometer

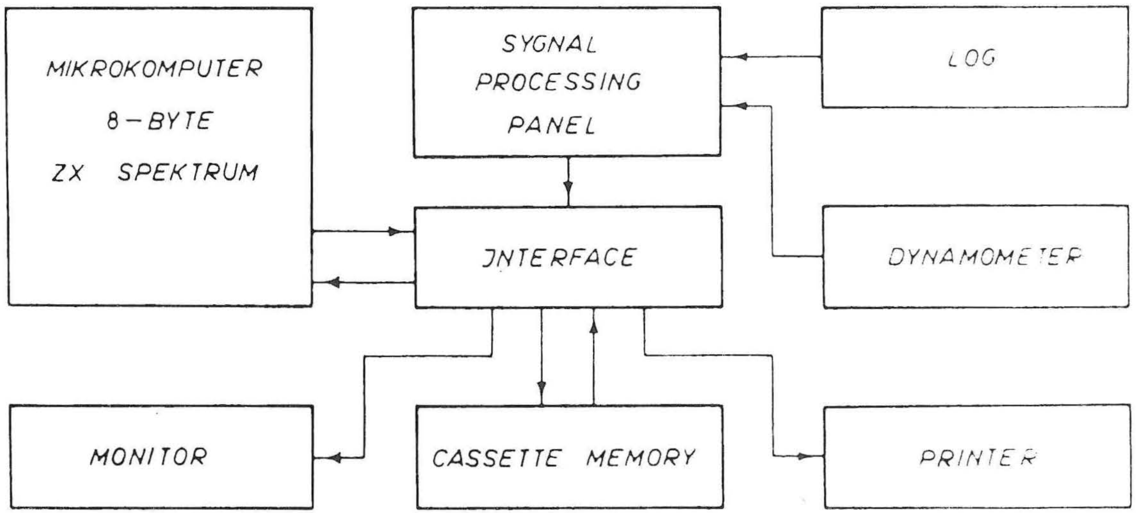

Fig. 7. Schematic representation of measurement apparatus

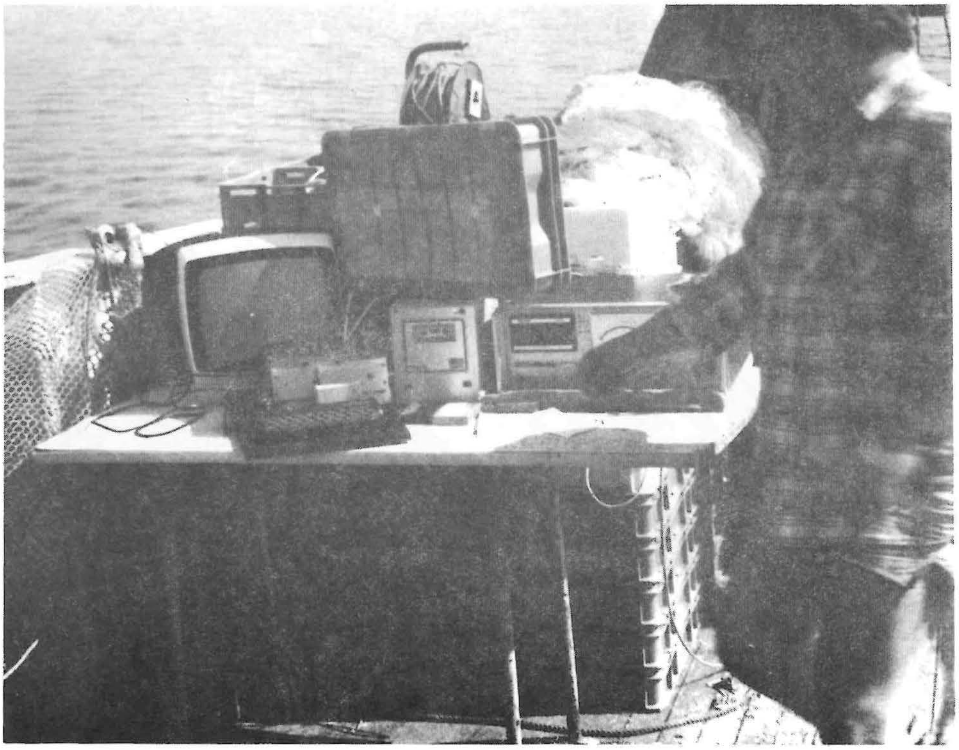

Fig. 8. Measurement apparatus used on board the research vessel

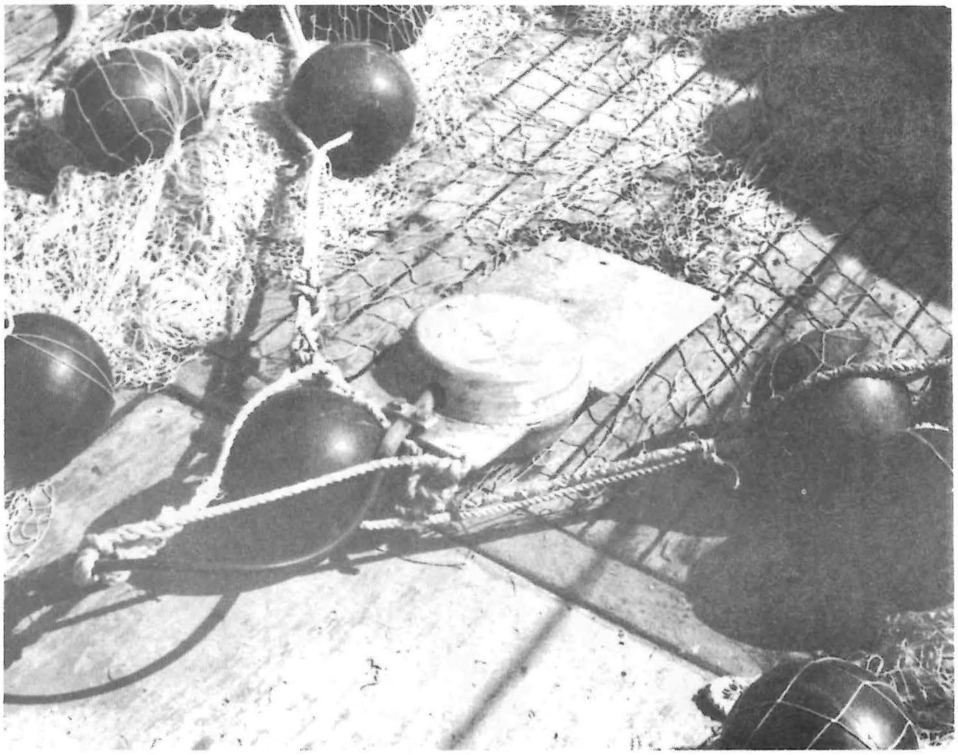

Fig. 9. Netsonde transducer fitted to the headline bosom

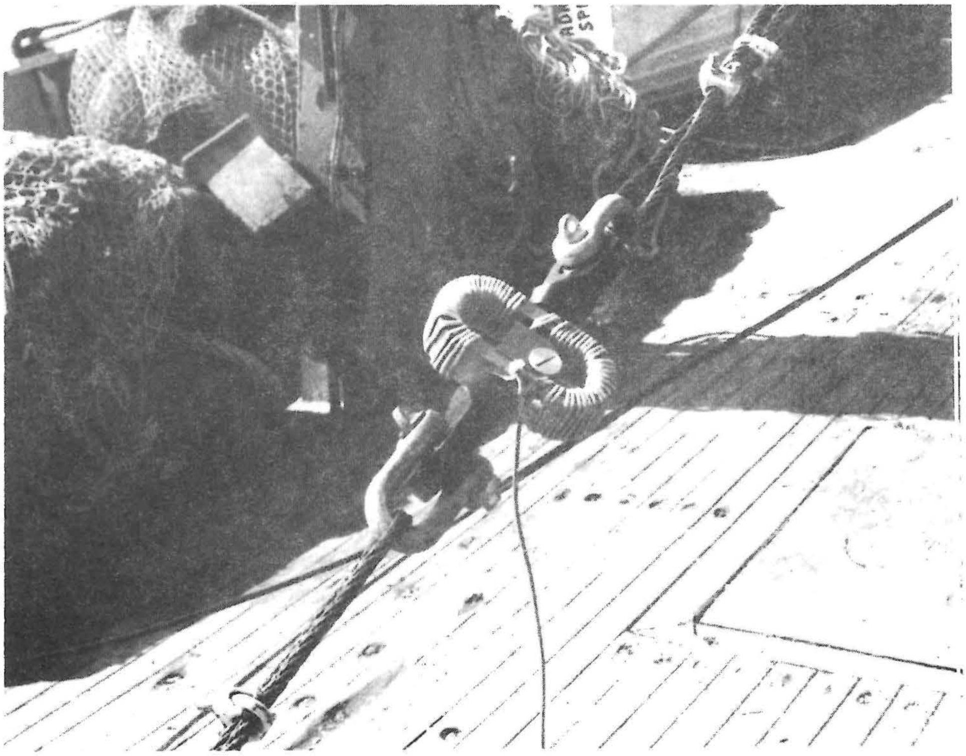

Fig. 10. Dynamometer on board the research vessel connected to warps

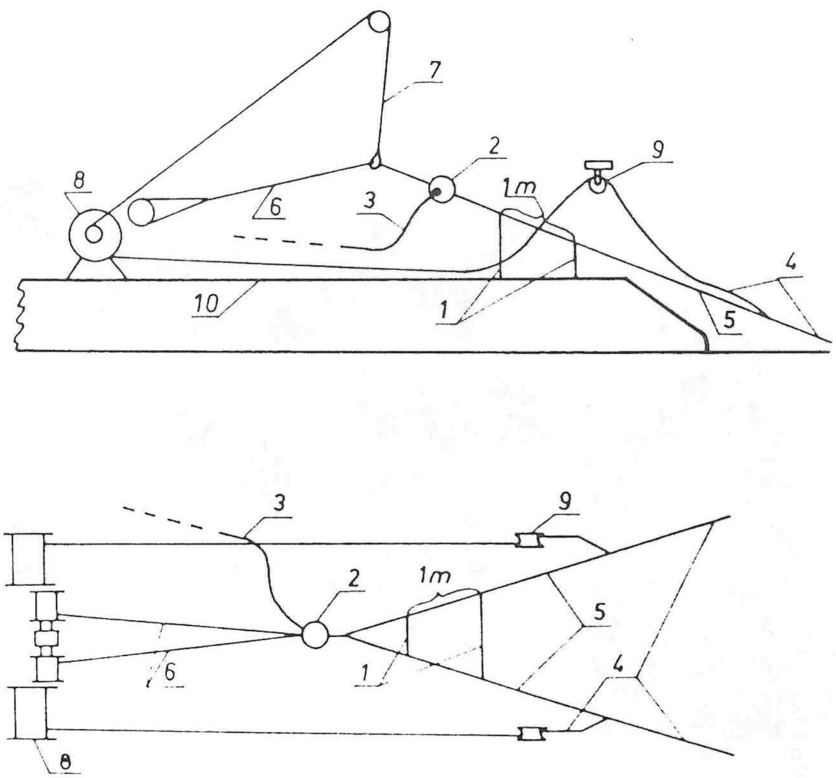

Fig. 11. Measurements of forces and angles
a) cross-section
b) top view

1. measurement of trawl sinking
2. dynamometer
3. cable connecting dynamometer and the apparatus
4. warps
5. bridles connecting dynamometer and warps
6. bridles fitting dynamometer to trawling winch
7. hanging of inboard runner system of measurement of forces on warps
8. trawling winch
9. pulley-blocks for warps

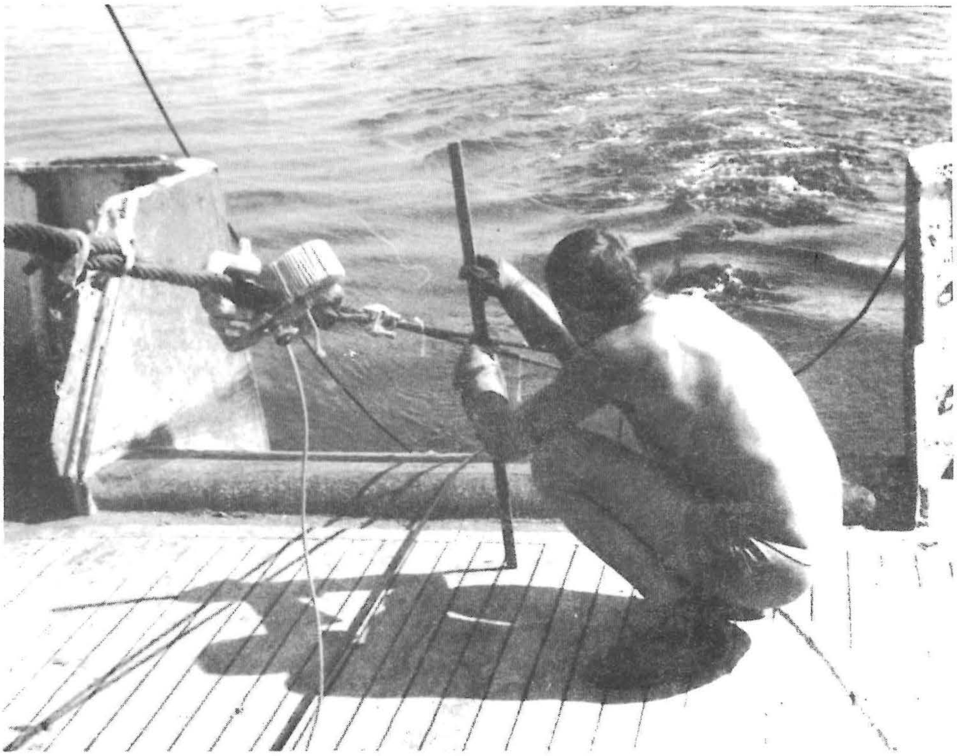

Fig. 12. Way of measurement of spread and inclination

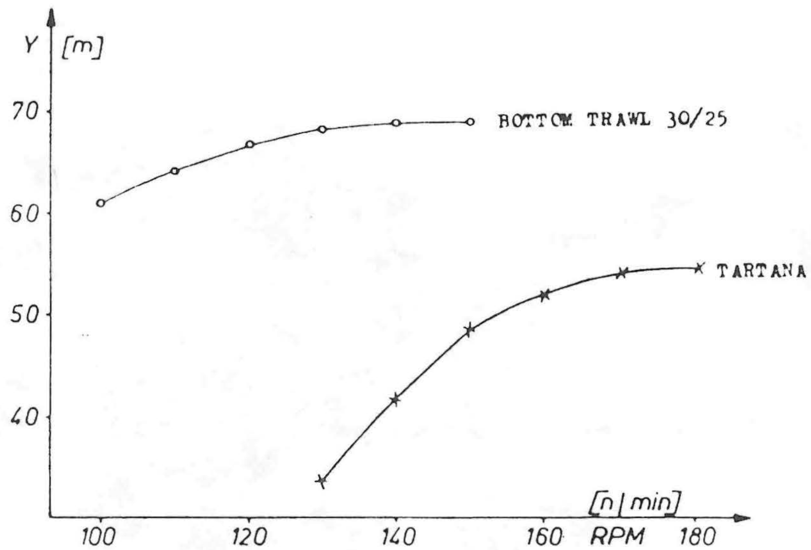

Fig. 13. Spread between otter boards in function of the number of propeller revolutions

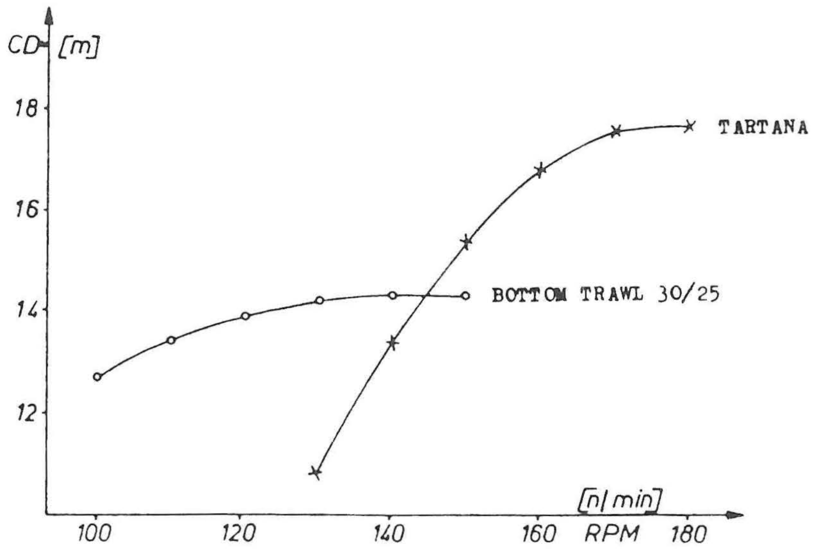

Fig. 14. Horizontal spread between wing ends in function the number of propeller revolutions

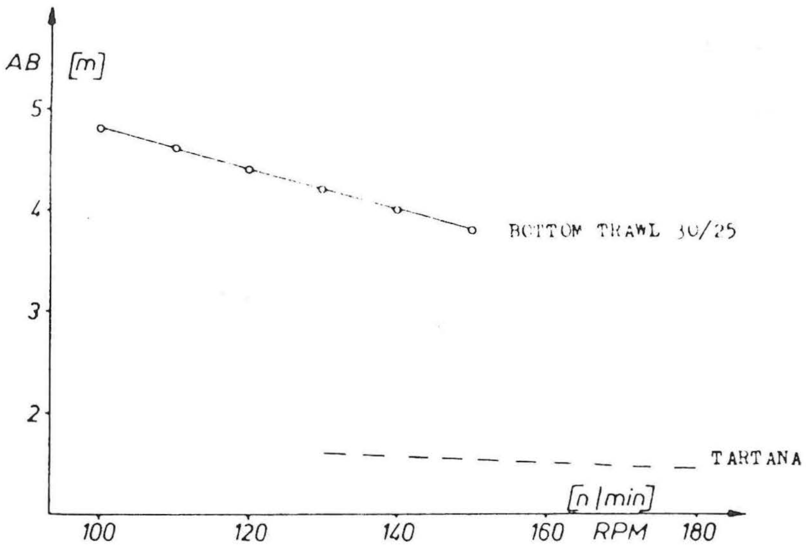

Fig 15. Vertical spread at the level of headline bosom in function of the number of propeller revolutions

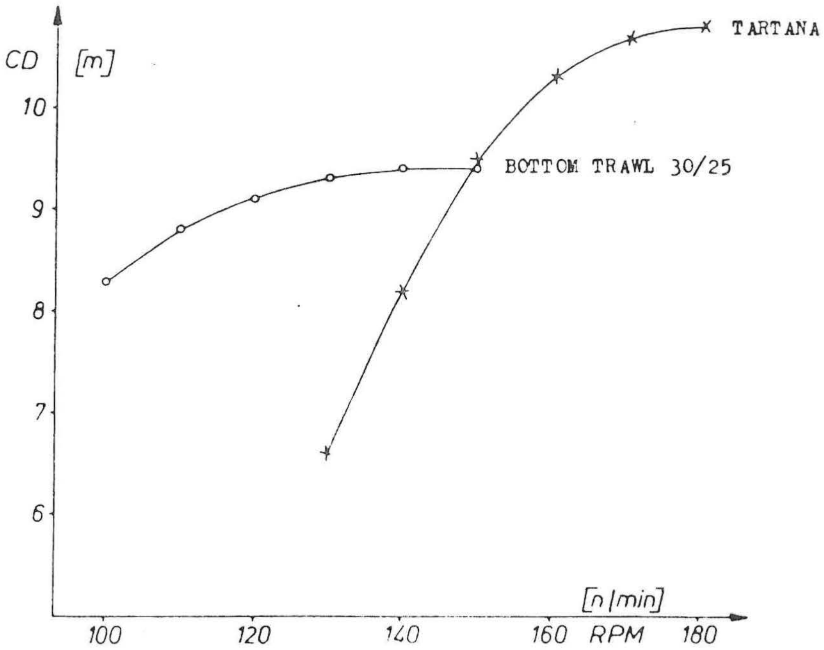

Fig. 16. Horizontal spread at the level of headline bosom in function of the number of propeller revolutions

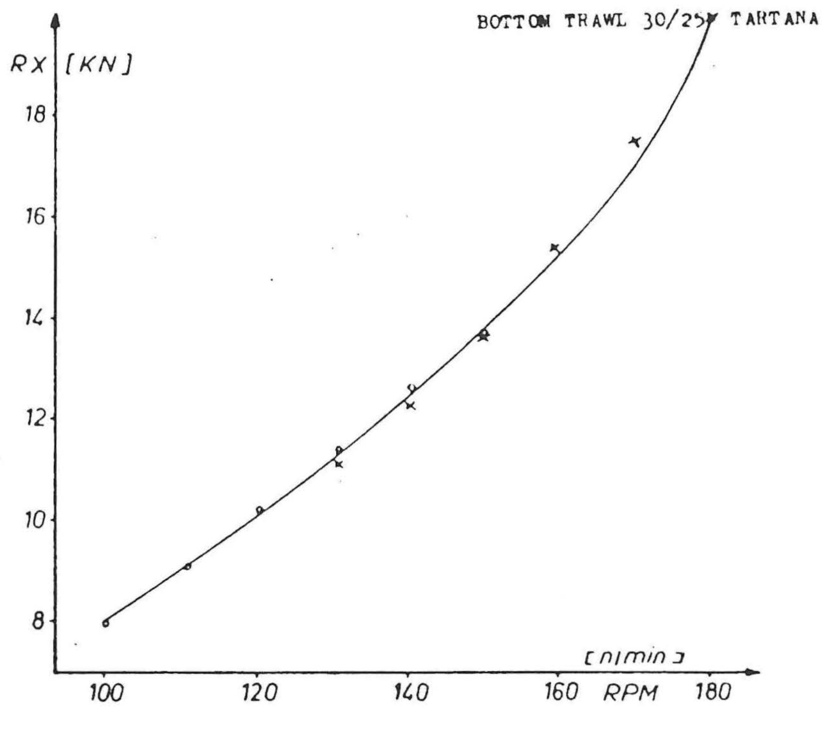

Fig. 17. Resistance in the function of the number of propeller revolutions

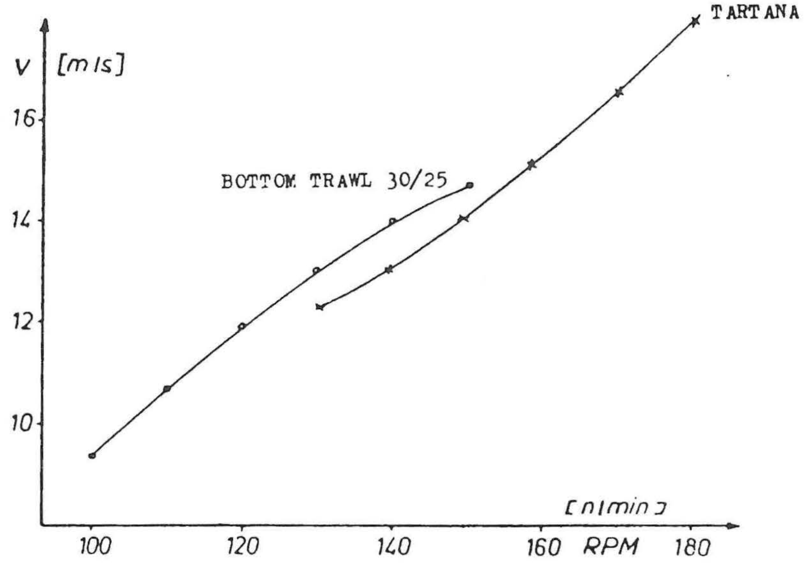

Fig. 18. Trawling speed in function of the number of propeller revolutions

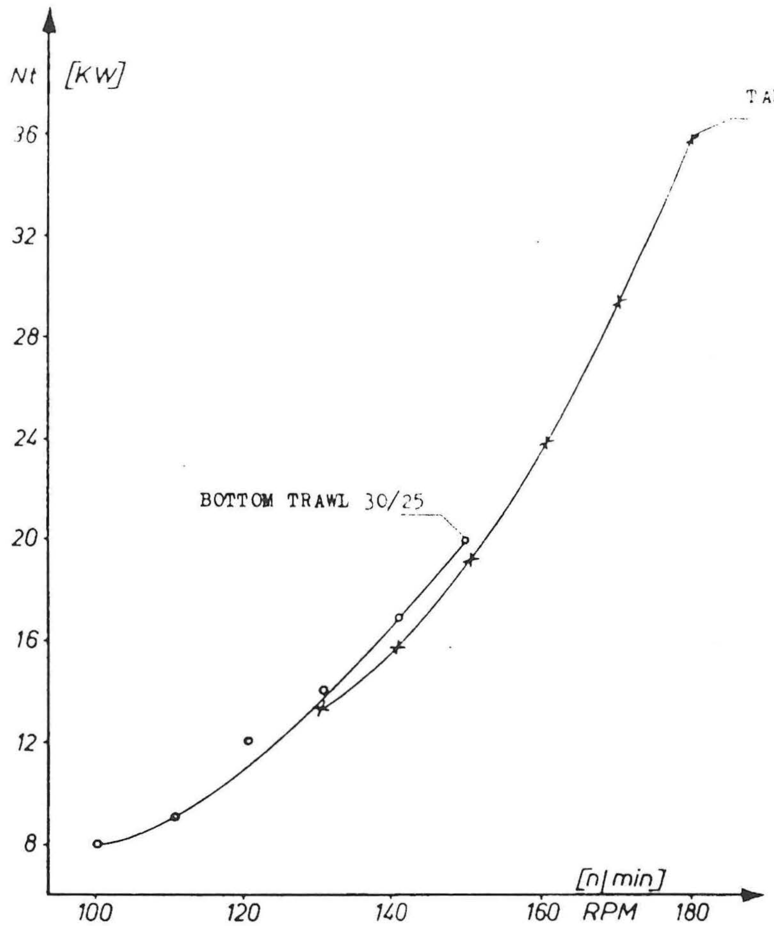

Fig. 19. Towing force in function of the number of propeller revolutions

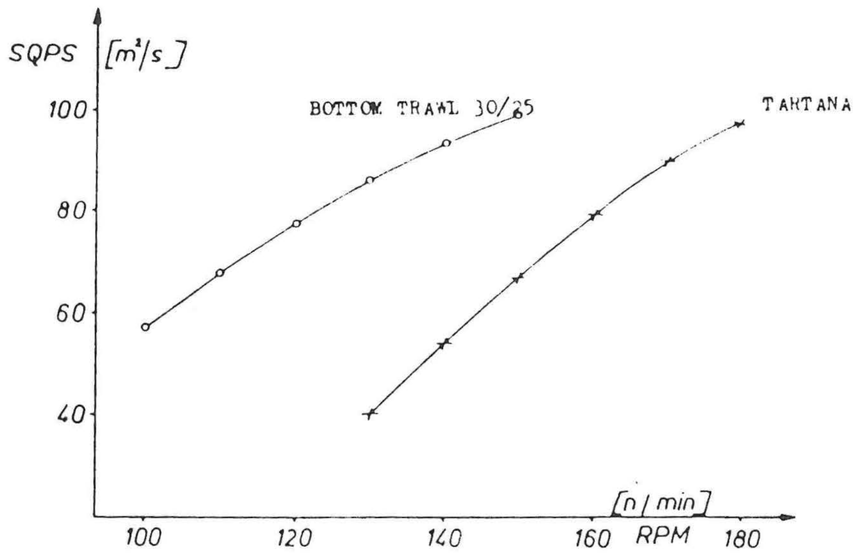

Fig. 20. Penetration area of trawling system

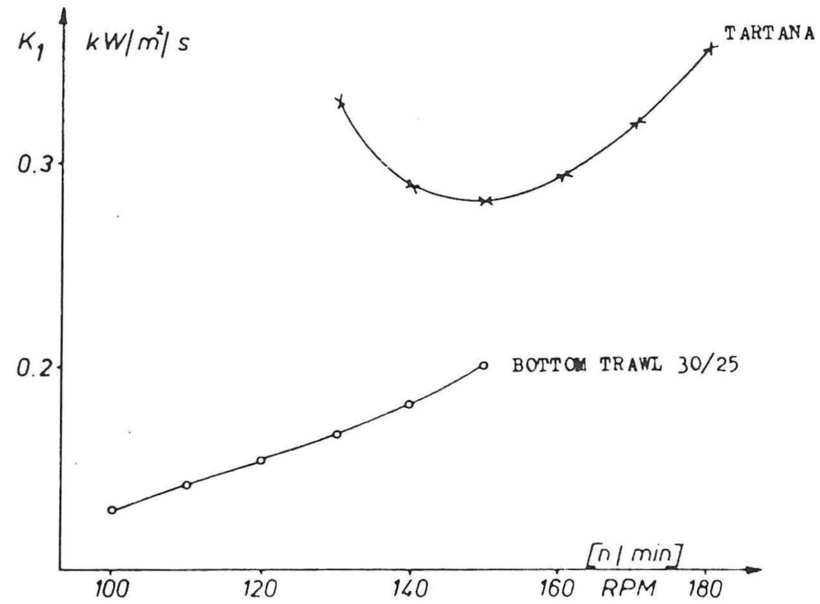

Fig. 21. Energetic effort in kW per square metre of crossed bottom surface per sec