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Performance of Trawls Used in Joint US-USSR Groundfish Studies

by

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Introduction

The USA and USSR conducted a cooperative cruise in the autumn 1970 aboard the USSR scouting vessel KVANT for the purpose of measuring the performance characteristics of trawls used in the joint US-USSR surveys and testing several additional trawls as possible candidates for a new standard trawl. The cruise was divided into two parts. Part I of the cruise took place during the daylight hours from September 25 through October 1 in an area 25-30 miles south of Martha's Vineyard in water about 50-100 meters deep. The objective of this part was to measure the vertical and horizontal spread of six trawls (three USSR, two Canadian, and one US) under varying towing conditions. Part II of the cruise was conducted from October 2-10 in the same general area as Part I and the purpose of this part was to compare the fishing power of two USSR trawls.

Part I Trawl Measurements

Methods

The sonic trawl net measuration and telemetering system developed by French (1968) was used in measuring trawl wingspread and height. Measurements were obtained by means of echo-sounding transducers on the wings and headrope (Fig. 1). The transducers were connected electrically to shipboard by a 4-conductor cable which was attached to a special constant-tension winch on the deck. Continuous graphic representation of the measurements was made on an ELAC recorder. Tensionmeters were used to record the strain on each of the trawl warps.

Of the six trawls tested, three have been used for the joint US-USSR groundfish surveys. These were the USSR 27.1 and 24.6 trawls and the Yankee #36. The other three trawls tested were the USSR 23.5 and the Atlantic Western II(A) and Atlantic Western IV from Canada. The nets are described in Table 1 and Figures 2-7.

The principal factors which were controlled in the tests were rigging, scope, and vessel speed. The various riggings for each net are listed by individual tows in Table 2. Vessel speeds varied from 3.1-4.6 knots. The KVANT was not equipped with a speed log, therefore speed was measured by finding the amount of time required for the vessel to pass a wood chip in the water by using a stop watch. The ratios of wire to depth used were 3:1, 3.5:1, and 5:1.

A total of 30 tows were made with the six trawls, representing a total of 88 "observations". Usually several different speeds and scopes were tried with each rigging, and thus a single "observation" corresponds with a specific combination of speed and scope within a tow. When changing variables within a tow, the net was allowed to stabilize after the change before measurements were taken. Each net was tested until, through changes in scope and rigging, it fished properly at several speeds. Then the next net was tested. However the tests with the Atlantic Western trawls were abbreviated because it was the feeling of the gear experts aboard that no amount of testing could get these nets to fish properly with the relatively large trawl doors available.

The cod end was kept tied on all tows, but the testing area was selected so as to avoid large catches. Frequently, two or three consecutive tows were made without removing catches, i.e. if the changes in operational procedures to be made between tows did not require bringing the net completely on board, the net was left in the water to save time and the catch was left in the net.

In addition to the controlled factors measured above, concomitant variables which were recorded were direction and speed of wind, direction and speed of current, and vessel direction for each tow. Tidal currents were about 2 knots or less throughout the testing, winds ranged from 0-17 knots, and the sea state was ideal for gear testing. Although these variables were recorded, there was insufficient time for adequately testing their effects on gear performance.

The principal criterion for evaluating trawl performance in the tests was the ratio of wingspread to headrope length, and in particular that ratio which would maximize the trawl opening and allow proper opening of the meshes. According to both Kurlyandsky and Twohig these desired openings are achieved when the ratio of wingspread to headrope length is 50-60 percent. Significant departures from this range of values were used as evidence of improper balance in the stresses on a net, and the nature of these departures served as a guide for making adjustments to the rigging as well as for interpreting the cause of the observed performance.

Results

The following discussion describes the gear tests in the order in which they were conducted. Results of the mensuration experiments are summarized in Table 3 and the complete set of observations is presented in Appendix 1.

The 27.1 trawl seemed to fish very well throughout the test with wingspread to headrope ratios ranging from 52 to 60 percent. The average headrope height was 11.3 feet (3.4m) and the average wingspread was 49.2 feet (15.0m). Scope was 5:1 throughout the test and rigging was not changed. The lowest headrope height and largest wingspread occurred during the first tow when the vessel operated with the wind and against the current. However, these extremes were not duplicated in tow 3 when the vessel operated under the same conditions. A slight inverse relationship was noted between vessel speed and wingspread.

The test of the 24.6 trawl was short because the net performed well without changes in scope, which was 5:1, or rigging. However, during the first tow with this net, tow 5, the electronic cable wrapped around the headrope so that results from this tow were not included in the analysis. The wingspread to headrope length ratio ranged from .57 to .60, and the average headrope height and wingspread were 10.5 feet (3.2m) and 50.5 feet (15.4m) respectively. The overall dimensions of the 24.1 are somewhat larger than the 27.1 and a higher headrope height was expected. However, it was not achieved for unknown reasons. As in the 27.1 net, a slight inverse relationship was noted in the 24.6 net between wingspread and vessel speed. Also the largest opening of the 24.6 net resulted when it was towed in the same direction as the current in tow number 6. The catch accumulated throughout the testing of the 24.6 trawl and totaled about 3000 kg. This was noted against a general decline in trawl opening in tows 6 and 7.

During the first few tows of the Soviet 23.5 net, wingspread to headrope length ratios were excessive, averaging about 70 percent. The point of attachment of the legs was adjusted, but then the trawl doors did not operate properly as indicated by uneven warp tension readings. Then the trawl door brackets were adjusted and the headrope height increased to 11 feet (3.4m) but the wingspread remained an excessive 53 feet (16.1m). The headrope transducer was moved back over the top square of the net directly over the footrope to check bottom contact in tow 12. Thus the lower "headrope readings" for this tow do not reflect the actual headrope height. Following this, a 1-meter strap was added to the top leg and an increased headrope height of 13.8 (4.2m) and decreased wingspread of 50 feet (15.2m) was recorded. The wingspread to headrope length ratio decreased to 65 percent. During tows 9 and 10 with the 23.5 net, 7500 kg. of fish was caught. This was the largest catch recorded during gear testing, but it apparently had no effect on the wingspread and headrope height.

Tests on both Western trawls gave excessive wingspread to headrope length ratios, ranging from .72 to .88, indicating the doors were too large. Wingspread and headrope height for the Western II(A) averaged 44.2 feet (13.5m) and 12.3 feet (3.7m), and for the Western IV, 48 feet (14.6m) and 12 feet (3.6m) respectively. Presumably, the headrope height of these nets would be higher still with proper sized doors which would give reduced wingspread. However, the relationship between headrope height and fishing power remains a question to be answered with future gear testing.

The Yankee 36 trawl was tested extensively, partly with a view toward measuring the effects of operational parameters at different depths and partly to get a more precise measure of the effects of scope since U.S. surveys with the Yankee 36 have been mostly at a 3:1 scope. The first tows showed erratic warp tension readings and undulating headrope movement with whipping trawl wires. These problems were resolved in later tows by the addition of 10-fathom ground cables which isolated trawl door bounce from the net. The wingspread to headrope length ratio also improved from about .72 to .61 when ground cables were used in conjunction with a 3:1 scope. Under all conditions, this ratio was more satisfactory with a 3:1 scope than a 5:1 scope. However, the U.S. and Soviet gear experts feel the net would be more stable and thus more efficient using a 5:1 scope. Average wingspread and headrope height of the Yankee 36 using the ground cables and a 3:1 scope were 37.5 feet (11.4m) and 10.2 feet (3.1m) respectively. No relationship between net opening and speed could be found. During the final tests of the Yankee 36 in deeper water, the tension from the third wire lifted the net off the bottom. Tension was reduced and additional wire was paid out, and then the net settled back to the bottom where it fished with a wingspread to headrope length ratio of 72 percent. Finally, a 1-meter strap was added to the top leg and the headrope height increased from a deep water average of 9.6 feet (2.6m) to 10.7 feet (3.3m), the wingspread decreased from 43.0 feet (13.1m) to 36.0 feet (11.0m) and the wingspread to headrope length ratio decreased to 60 percent.

Summary and Conclusion

The most important factors affecting trawl performance in these tests were rigging and scope. Changes in lengths of legs by addition of a strap and changes in door angle resulted in major changes in headrope and wingspread in the case of the 23.5 net. Addition of a strap to the Yankee 36 also affected its measurements. The addition of ground cables resulted in increased stability of the Yankee 36 trawl and changes in scope affected its wingspread and headrope height. During the experiment, it was necessary to change the rigging frequently in order to attain satisfactory performance from the nets. Therefore it is impossible to make generalizations from these data concerning the effect of such things as vessel speed, wind, current, and sea state on trawl performance since the effect of these latter variables is probably small compared to the changes brought on by alterations in rigging.

These tests demonstrated the sensitivity of trawl performance and stability to seemingly minor adjustments in rigging. Thus serious bias might result in survey data unless some form of monitoring gear performance is employed.

There was little difference in the wingspread and headrope height of the Soviet trawls. The 27.1 net had a slightly smaller wingspread than the other two trawls, and headrope height was about the same in all three. The Yankee 36 trawl had a headrope height 2-3 feet less than the Soviet nets and a wingspread 8-12 feet less. A relative index of net opening obtained by calculating average wingspread x headrope height indicates the Soviet nets filtered roughly 1.5 times the water filtered by the Yankee 36. The Atlantic Western II trawl probably would exhibit about twice the headrope height and somewhat greater wingspread than the Yankee 36. The Western IV would be slightly smaller than the Western II but larger than the 36 in both headrope height and wingspread.

However, there are other factors, such as durability, to consider when using the Western trawls. These, hopefully, will be evaluated by further U.S. testing planned for 1971.

In general, catches were small and no general effect of catch could be seen on net performance.

The so-called "3rd wire" monitoring system used in this experiment functioned reasonably well. However, it has limitations in that it is cumbersome and may directly affect the performance of the trawl in deeper water.

Part II Fishing Comparisons with USSR 27.1 versus 23.5 Trawls

Methods

Sampling was done at randomly selected stations within two blocks, each 10 miles on a side. The original sample design called for six tows (three with each of the two nets) in each period of daylight and darkness for at least 4 days in each block. The first net to be used within each diurnal period was to be alternated on successive days. Each of the three tows with each net in each period was to be made in succession. Therefore, an even number of days was required in each block through time. However, frequent tear-ups dictated that operations should move to the second block after 2 1/2 days and 18 tows. During operations in the first block, the weather was windy and the seas rough. The weather moderated considerably for the whole of the second block.

Tows were 30 minutes long at 3.5 knots using a 5:1 scope. Standard rigging for the two nets was as given in Table 1. A total of 36 daylight and 34 night tows were made. Catches were processed using standard survey procedures (Grosslein, 1969).

Results

Preliminary comparisons of average catch/haul of the two nets on a linear scale indicates fairly comparable fishing power. Although the catches showed considerable variability, catch ratios for most of the major species were not greatly different from one for both day and night and in both sampling blocks (Table 4). Catch rates of all species combined were also quite similar after transformation to a natural log scale (Fig. 8). As indicated in Part I, the 23.5 trawl presumably had a slightly larger mouth opening than the 27.1 trawl. However, for the tows considered here, the total catch of the 27.1 slightly exceeded that of the 23.5. Of 40 species caught, spiny dogfish accounted for over 50 percent of the total catch (Fig. 9), therefore any significant effects of net, block, or time of day in the catch rate of spiny dogfish would have a prominent influence on total catch.

There is a suggestion of possible block x net x time of day interaction particularly for skates, yellowtail, and silver hake (Figs. 10-12). Further analysis on a natural log scale will be required to test the significance of these interactions before a detailed analysis of between net differences can be made for combined blocks.

There were some within net within block diurnal differences which deserve mention. T-tests showed a significant difference ($p \leq .05$) between day and night mean catch/haul of skates, yellowtail, and red hake with catches being greater at night for these species. Round herring were consistently more available during daylight, but this difference was not statistically significant.

Conclusions

With the variability involved in trawl catches, it should be stressed that precise fishing power comparisons cannot be expected with the small sample size used in this test. However, preliminary calculations indicate that the Soviet 27.1 and 23.5 trawls have approximately the same fishing power as might be expected from the similarity in their design and mouth openings. There were significant diurnal differences in catch rates of skates, yellowtail, and silver hake. A more detailed analysis of this data will be completed later in 1971.

Literature Cited

French, L. E. Jr. 1968. Sonic system for determining distance between selected points of an otter trawl. Fish. Ind. Res., 4(3): 113-125.

Grosslein, M. D. 1968. Results of the joint USA-USSR groundfish studies. Part II. Groundfish survey from Cape Hatteras to Cape Cod. ICNAF Res. Doc. 68/87, 28 pp.

'able 1.--Description of trawls used in mensuration studies

	TYPES OF TRAWLS					
'rawl Parts	Yankee #36 Trawl	27.1 meter Soviet	24.6 meter Soviet	23.5 meter Soviet	Atlantic Western IIA	Atlantic Western IV
)verall length (wings to codend)	31.6 m	42.0 m	59.8 m	44.4 m	39.2 m	17.6 m
leadrope (total length)	19.7m	27.5 m	24.6 m	23.5 m	18.6 m	16.6 m
Bosom	4.8 m	1.6 m	3.2 m	1.7 m	10.7 m	8.9 m
Wings	7.9 m	12.75 m	10.7 m	10.9 m	4.6 m	3.8 m
;roundrope (total length)	24.6 m	27.8 m	20.4 m	22.8 m	28.7 m	23.8 m
Bosom	3.0 m	1.6 m	2.4 m	1.6 m	8.3 m	3.6 m
Wings	10.7 m	12.9 m	9.0 m	10.6 m	3.9 m	6.4 m
'rawl Opening						
Headrope height	3.0 m	3.4 m	3.2 m	4.2 m	3.8 m	3.6 m
Wingspread	12.2 m	15.0 m	15.4 m	15.2 m	13.5 m	14.6 m
Approximate mouth area	30.0 m^2	48.0 m^2	45.5 m^2	43.0 m^2	36.2 m^2	40.2 m^2
laterial	#54 tan nylon (except codend = 102 white nylon and liner - knotless white nylon)	Capron (nylon) 8 mm diameter	Capron	Capron	Braided Drylene or courlene 175 yds/lbs Twisted courlene or equal	Braided Drylene or courlene 175 yds/lbs Twisted courlene or equal
lesh Size (stretch measurement)						
Wings	129.0 mm	160.0 mm	160.0 mm	200.0 mm	127.0 mm	127.0 mm
Square	132.0 mm	160.0 mm	160.0 mm	200.0 mm	127.0 mm	127.0 mm
Bellies	114.0-130.0 mm	80.0-160.0 mm	60.0-120.0 mm	90.0-160.0 mm	114.3 mm	114.3 mm
Codend	95.0 mm	32.0-40.0 mm	36.0-40.0 mm	24.0-40.0 mm	114.3 mm	114.3 mm
	13.0 mm	--	--	--	114.3 mm	76.2 mm
.ollers	Hard rubber disks Total of 19 on center 35' section of footrope (each disc 12.7 cm wide by 40.6 cm in diameter)	6-75 mm Katuschka (wing) 4-75 mm Katuschka (bosom)	9-75 mm Katuschka (wing & bosom) 2-200 mm Katuschka (wing end)	8-75 mm Katuschka (evenly spaced)	Same type as used on Yankee #36 Net	

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Table 1. (cont.)

Trawl Parts	TYPES OF TRAWLS: Yankee #36 Trawl	27.1 meter Soviet	24.6 meter Soviet	23.5 meter Soviet	Atlantic Western IIA	Atlantic Western IV
Trawl Doors						
Type	oval	oval (Matrosova)	oval	oval	oval	oval
Area	3.0 m^2	3.0 m^2	3.0 m^2	3.0 m^2	3.0 m^2	3.0 m^2
Weight	670 kg	670 kg	670 kg	670 kg	670 kg	670 kg
Ground Cables	18.3 m	20.0 m	40.0 m	20.0 m & 15.0 m	18.3 m	18.3 m
Bridal Wires (Legs)						
Top	10.4 m	50.0 m	50.0 m	50.0 m	27.7 m	27.6 m
Center	--	57.8 m	50.0 m	50.0 m	--	1.0 m
Bottom	10.4 m	51.7 m	50.0 m	50.0 m	27.4 m	27.4 m
Floats						
Type	Aluminum deep sea (20.3 cm diam.)	Steel 20-25.0 cm diam.				
No. on Headrope bosom section	20	12			12	10
No. on each wing	7	15			19	16
Total No. on Headrope	34	42	67	40	50	42
Chafing gear	Mat of polythene strands covering aft half (and underside only) of codend	103 mm (stretch netting around entire codend	Same as 27.1 m Soviet trawl	Same as 27.1 m Soviet trawl	Same as Yankee #36 trawl	Same as Yankee #36 trawl
Codend Float	--	Rubberized canvas float	Rubberized canvas	Rubberized canvas	--	--

Table 2.--All tows were made with Soviet 3-meter^2 doors weighing 670 kg in air
Specifications of trawls as used in trawl mensuration studies.

Tow No.	Net	No. of Floats	Roller Gear	Length of Legs	Length of Ground Cables
, 2, , 4	27.1 Soviet	42	Wing 6 Katuschka 75 mm evenly spaced Bosom 4 Katuschka 75 mm evenly spaced	3 legs - 50 m ea.	40 meters
, 6,	24.6 Soviet	34	Bosom & wing along net - 9 Katuschka (75 mm 5.4 kg (air)) evenly spaced Wing end - 2 Katuschka 200 mm - 9.4 kg (air)	3 legs	40 meters
, 9, 0	23.5 Soviet	40	Same as 24.6 Soviet	3 legs - 50 m ea.	40 meters
1, 11B, 1C, 12	23.5 Soviet	40	8 Katuschka 75 mm - 5.4 kg (air) evenly spaced along footrope	Top leg - 65 m 15 strap Middle - 50 m Bottom - 50 m	20 meters
3	23.5 Soviet	40	Same as 23.5 Soviet above	1 m strap added to top leg	20 meters
4, 15	Atlantic Western II(A)	50	Flying Wing 13'4" - 6" rubber discs Bunt & Wing 27'1.5" - 12" wing bobbins Bosom 13'6" - 18"x5" rubber rollers 5 - 6 - 5	Top leg - 91' Bottom leg - 90'	10 fathoms
6, 17	Atlantic Western IV	42	Flying Wing 12'3" - 6" rubber discs Bunt & Wing 21' - 12" bullet rollers Bosom 11.7" - 18" rubber rollers	Top leg - 90' 8" Bottom leg - 90'	10 fathoms

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Table 2.--(Cont.)

Tow No.	Net	No. of Floats	Roller Gear	Length of legs	Length of Ground Cables
18, 19, 20A, 20B, 21A, 21B	Yankee #36	34	35' 10 - 15 - 10	5 fm top bottom	No ground cable
22A, 22B	Yankee #36	34	35' 10 - 15 - 10	5 fm	10 fm ground cable
23, 24	Yankee #36	34	35' 10 - 15 - 10	5 fm	No ground cable
25	Yankee #36	34	35' 10 - 15 - 10	1 meter strap added to top leg	No ground cable

Table 3.--Summary of results of trawl mensuration studies. Warp tension is given in pounds (kilograms) and trawl dimensions in feet (meters)

Tow	Net	Scope	Vessel Speed (knots)		Warp Tension		Trawl Dimensions				Remarks
							Mean		Range		
			$\bar{x}$	Range	$\bar{x}$	Range	WS	HR	WS	HR	
1	27.1	5:1	3.9	3.6-4.1	8040 (3650)	7000-9000 (3170-4080)	52.6 (16.0)	10.5 (3.2)	52-54 (15.8-16.5)	10.2-11.0 (3.1-3.4)	Tow with 2k wind
2	27.1	5:1	3.8	3.3-4.1	7500 (3400)	6500-8500 (2950-3850)	46.0 (14.0)	11.9 (3.6)	46 (14.0)	11.8-12.0 (3.6-3.7)	Tow against 2k wind
3	27.1	5:1	3.9	3.7-4.2	7150 (3240)	6500-8000 (2950-3630)	48.3 (14.7)	11.7 (3.6)	48-49 (14.6-14.9)	11.5-12.0 (3.5-3.7)	Tow with 2k wind
4	27.1	5:1	3.8	3.6-4.0	7650 (3470)	6000-9000 (2720-4080)	47.6 (14.5)	11.7 (3.6)	47-48 (14.3-14.6)	11.5-12.0 (3.5-3.7)	Tow against 2k wind
5	24.6	5:1	3.8	3.6-4.0	7580 (3440)	6500-8500 (2950-3850)	51.6 (15.7)	8.7 (2.7)	51-52 (15.5-15.8)	8.5-9.0 (2.6-2.7)	Headrope malfunction
6	24.6	5:1	3.8	3.6-4.0	7750 (3520)	6500-8500 (2950-3850)	51.3 (15.6)	10.8 (3.3)	51-52 (15.5-15.8)	10.5-11.0 (3.2-3.4)	Net all right
7	24.6	5:1	4.0	3.8-4.4	7150 (3240)	6000-8500 (2720-3850)	50.4 (15.4)	10.3 (3.1)	49-50 (14.9-15.2)	9.5-10.8 (2.9-3.3)	
8	23.5	5:1	3.7	3.3-4.1	7350 (3330)	6000-8500 (2720-3850)	55.4 (16.9)	7.3 (2.2)	54-56 (16.5-17.1)	7.0-7.5 (2.1-2.3)	Doors too big
9	23.5	5:1	4.5	4.4-4.6	6000 (2720)	5500-7000 (2490-3170)	54.0 (16.5)	7.7 (2.3)	54 (16.5)	7.0-8.5 (2.1-2.6)	Doors too big
10	23.5	5:1	3.5	3.2-4.0	7000 (3180)	6500-7500 (2950-3400)	53.0 (16.2)	7.7 (2.3)	52-54 (15.8-16.5)	7.5-8.0 (2.3-2.4)	
11-11B	23.5	5:1	-	-	5700 (2590)	2800-8500 (1270-3850)	- -	18.0 (5.5)	- -	18.0 (5.5)	Net off bottom
11C	23.5	5:1	4.1	3.8-4.4	8300 (3760)	7500-9000 (3400-4080)	52.7 (16.1)	11.0 (3.4)	52-53 (15.8-16.2)	10.5-11.5 (3.2-3.5)	Adjust door bracket
12	23.5	5:1	3.7	3.6-3.7	7250 (3290)	6500-8000 (2950-3630)	53.6 (16.3)	7.7 (2.3)	53-54 (16.2-16.5)	7.5-7.8 (2.3-2.4)	Transducer moved to top square

Table 3.--(continued)

Tow	Net	Scope	Vessel Speed (knots) $\bar{x}$	Vessel Speed (knots) Range	Warp Tension $\bar{x}$	Warp Tension Range	Trawl Dimensions Mean WS	Trawl Dimensions Mean HR	Trawl Dimensions Range WS	Trawl Dimensions Range HR	Remarks
13	23.5	5:1	3.4	3.1-3.7	8000	7000-8500	est 50.0	13.7	est. 50	13.5-14.0	Add 1-meter strap
					(3630)	(3170-3850)	est(15.2)	(4.2)	est(15.2)	(4.1-4.3)	
14	West.II	5:1	4.1	3.9-4.3	7100	7000-7500	44.7	12.0	41-45	11.5-12.5	Doors too big
					(3220)	(3170-3400)	(13.6)	(3.7)	(12.5-13.7)	(3.5-3.8)	
15	West.II	5:1	3.7	3.4-4.1	7250	6000-8500	43.8	12.7	43-44	12.0-13.0	Doors too big
					(3290)	(2720-3850)	(13.4)	(3.9)	(13.1-13.4)	(3.7-4.0)	
16	West.IV	5:1	3.9	3.6-4.3	6500	5500-7000	48.0	11.5	48	11.0-12.2	Doors too big
					(2950)	(2490-3170)	(14.6)	(3.5)	(14.6)	(3.4-3.7)	
17	West.IV	5:1	4.1	4.0-4.2	6800	6500-7000	48.0	12.7	48	12.0-13.0	Doors too big
					(3080)	(2950-3170)	(14.6)	(3.9)	(14.6)	(3.7-4.0)	
18	Yankee 36	3.5:1	4.0	3.9-4.1	7650	7000-8000	42.3	9.8	42-43	9.0-10.0	
					(3470)	(3170-3630)	(12.9)	(3.0)	(12.8-13.1)	(2.9-3.0)	
19	Yankee 36	5:1	4.0	3.8-4.2	6625	6000-7500	44.0	8.5	44	8.4-8.5	Net bouncing
					(3000)	(2720-3400)	(13.4)	(2.6)	(13.4)	(2.5-2.6)	
20A	Yankee 36	3:1	4.1	3.9-4.4	8000	7000-9000	41.7	10.0	41-42	10.0	
					(3630)	(3170-4080)	(12.7)	(3.0)	(12.5-12.8)	(3.0)	
20B	Yankee 36	5:1	3.9	3.6-4.2	7150	6000-8500	45.0	8.7	44-46	8.5-8.8	
					(3240)	(2720-3850)	(13.7)	(2.7)	(13.4-14.0)	(2.6-2.7)	
21A&B	Yankee 36	3:1	3.9	3.6-4.6	7125	6000-8000	40.6	8.7	39-42	8.2-9.0	Transducer moved to top square
					(3230)	(2720-3630)	(12.4)	(2.7)	(11.9-12.8)	(2.5-2.7)	
22A&B	Yankee 36	3:1	4.0	3.3-4.5	6500	5000-7500	37.5	10.2	37-40	10.0-10.5	10 fm ground cable
					(2950)	(2270-3400)	(11.4)	(3.1)	(11.3-12.2)	(3.0-3.2)	
22B	Yankee 36	5:1	4.0	4.0	7000	7000	44.0	8.5	44	8.5	10 fm ground cable
					(3170)	(3170)	(13.4)	(2.6)	(13.4)	(2.6)	
23	Yankee 36	3:1	4.1	4.0-4.2	6400	5500-7500	37.7	15.0	37-38	12.2-19.7	Deeper water net off bottom
					(2900)	(2490-3400)	(11.5)	(4.6)	(11.3-11.6)	(3.7-6.0)	
24	Yankee 36	3:1	3.7	3.3-4.2	7250	6500-8000	43.0	8.6	43	8.5-8.6	Loosen 3rd wire
					(3290)	(2950-3630)	(13.1)	(2.6)	(13.1)	(2.5-2.6)	
25	Yankee 36	3:1	4.2	4.2	7875	7000-9000	36.0	10.7	36	10.5-11.0	Add 1-meter strap
					(3570)	(3170-4080)	(11.0)	(3.3)	(11.0)	(3.2-3.4)	

Table 4.--Mean catch per tow in pounds (kilograms in paraentheses) for the 70 tows in the fishing comparison experiment with the Soviet 27.1 and 23.5 trawls

	B L O C K I				B L O C K II			
	Day	Night	Mean	27.1/23.5	Day	Night	Mean	27.1/23.5
Number of tows								
27.1	7	3			12	14		
23.5	5	3			12	14		
All Species								
27.1	409	655	532	1.08	938	903	920	1.07
	(186)	(297)	(241)		(425)	(410)		
23.5	523	458	491		1055	668	861	
	(237)	(208)	(222)		(479)	(303)		
Spiny Dogfish								
27.1	165	87	126	1.11	755	502	628	1.13
	(75)	(39)	(57)		(342)	(228)	(284)	
23.5	190	35	113		670	437	554	
	(86)	(16)	(51)		(304)	(198)	(251)	
Combined Skates								
27.1	11	54	33	1.32	43	106	74	2.18
	(5)	(24)			(20)	(48)	(33)	
23.5	9	41	25		17	50	34	
	(4)	(19)			(8)	(23)	(15)	
Round Herring								
27.1	17	0	17	0.20	18	0	9	0.70
	(8)	(0)	(8)		(8)	(0)	(4)	
23.5	83	0	83		26	0	13	
	(38)	(0)	(38)		(12)	(0)	(6)	
Yellowtail								
27.1	35	266	151	1.49	1	16	8	1.14
	(16)	(121)	(68)		(.5)	(7)	(4)	
23.5	39	163	101		7	7	7	
	(18)	(74)	(46)		(3)	(3)	(3)	
Blackback								
27.1	18	8	13	1.44	10	19	15	0.79
	(8)	(4)	(6)		(5)	(9)	(7)	
23.5	15	3	9		31	8	19	
	(7)	(1)	(4)		(14)	(4)	(9)	
Silver Hake								
27.1	48	78	63	0.85	16	79	47	1.07
	(22)	(35)	(29)		(7)	(36)	(21)	
23.5	112	36	74		30	58	44	
	(51)	(16)	(34)		(14)	(26)	(20)	
Red Hake								
27.1	56	147	101	1.01	2	31	16	1.14
	(25)	(67)	(46)		(1)	(14)	(7)	
23.5	48	153	100		1	26	14	
	(22)	(69)	(45)		(.5)	(12)	(6)	

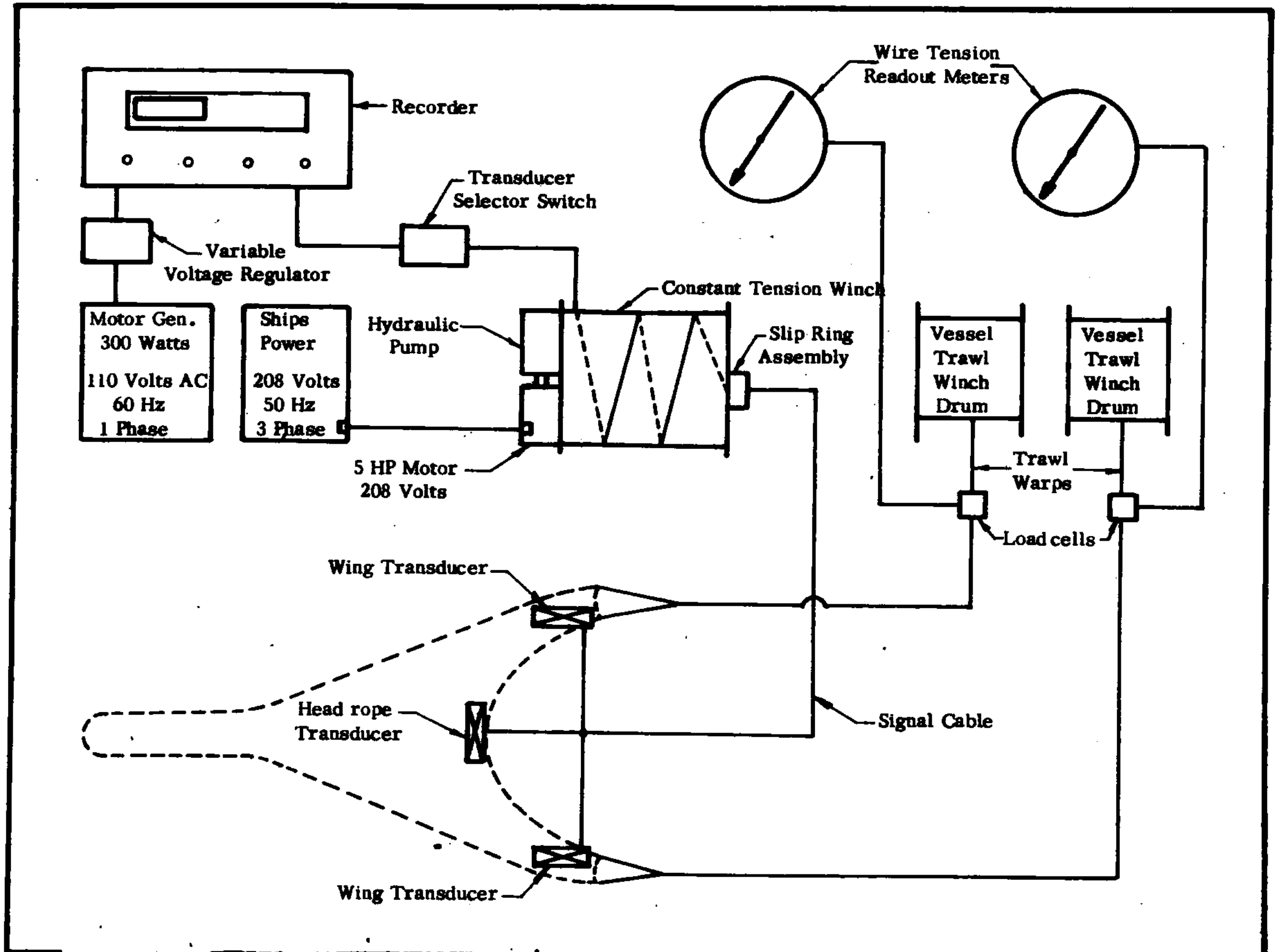


Figure 1.--The trawl net mensuration and telemetering system used to measure trawl wingspread and headrope height.

Figure 2

Soviet 27.1 m Trawl

NYLON TWINE

HEADROPE

Wing	42'
Wing	42'
Bosom	5'3"
Total	89'3"

FOOTROPE

Wing	42'4"
Wing	42'4"
Bosom	5'3"
Total	89'11"

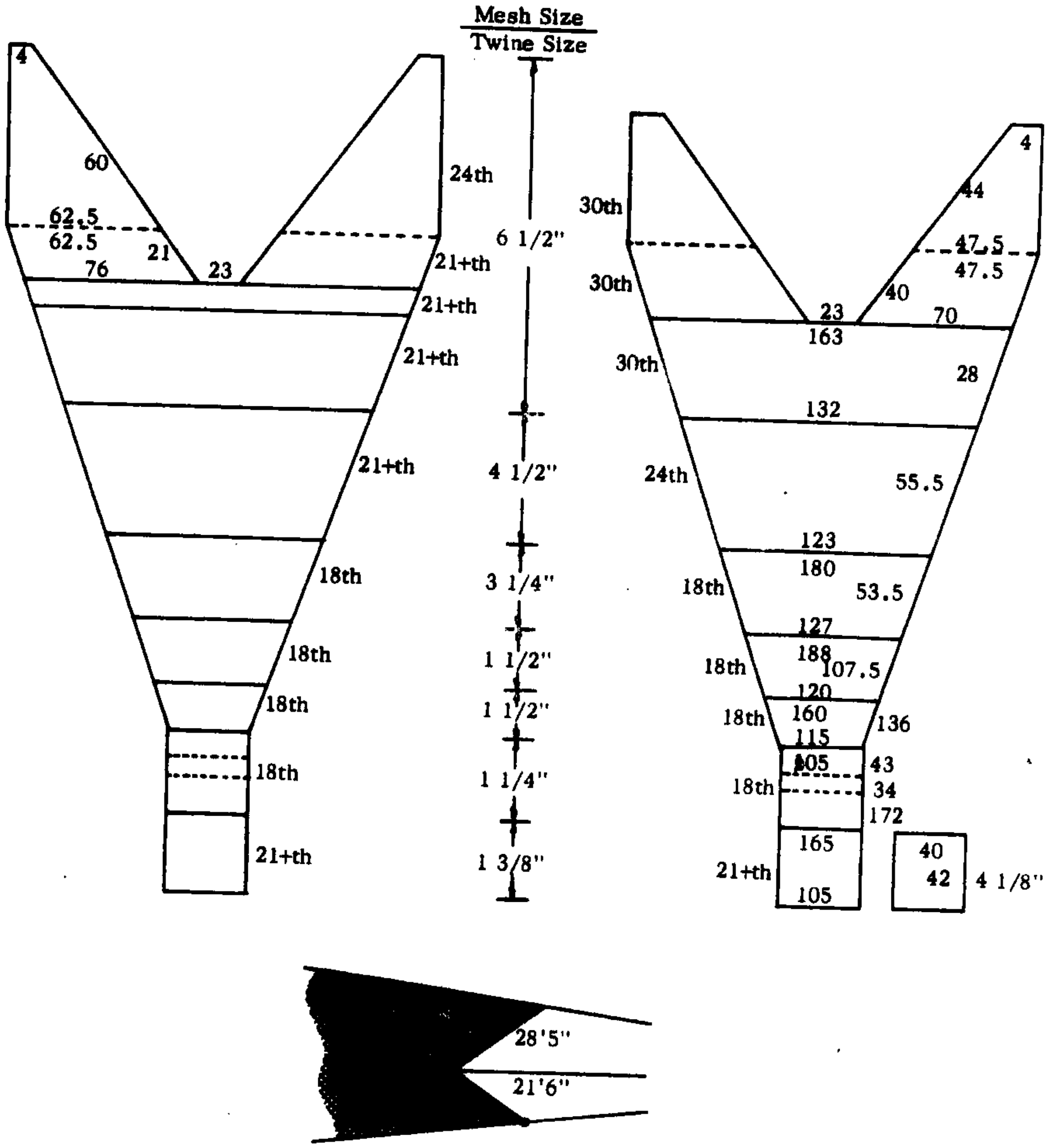
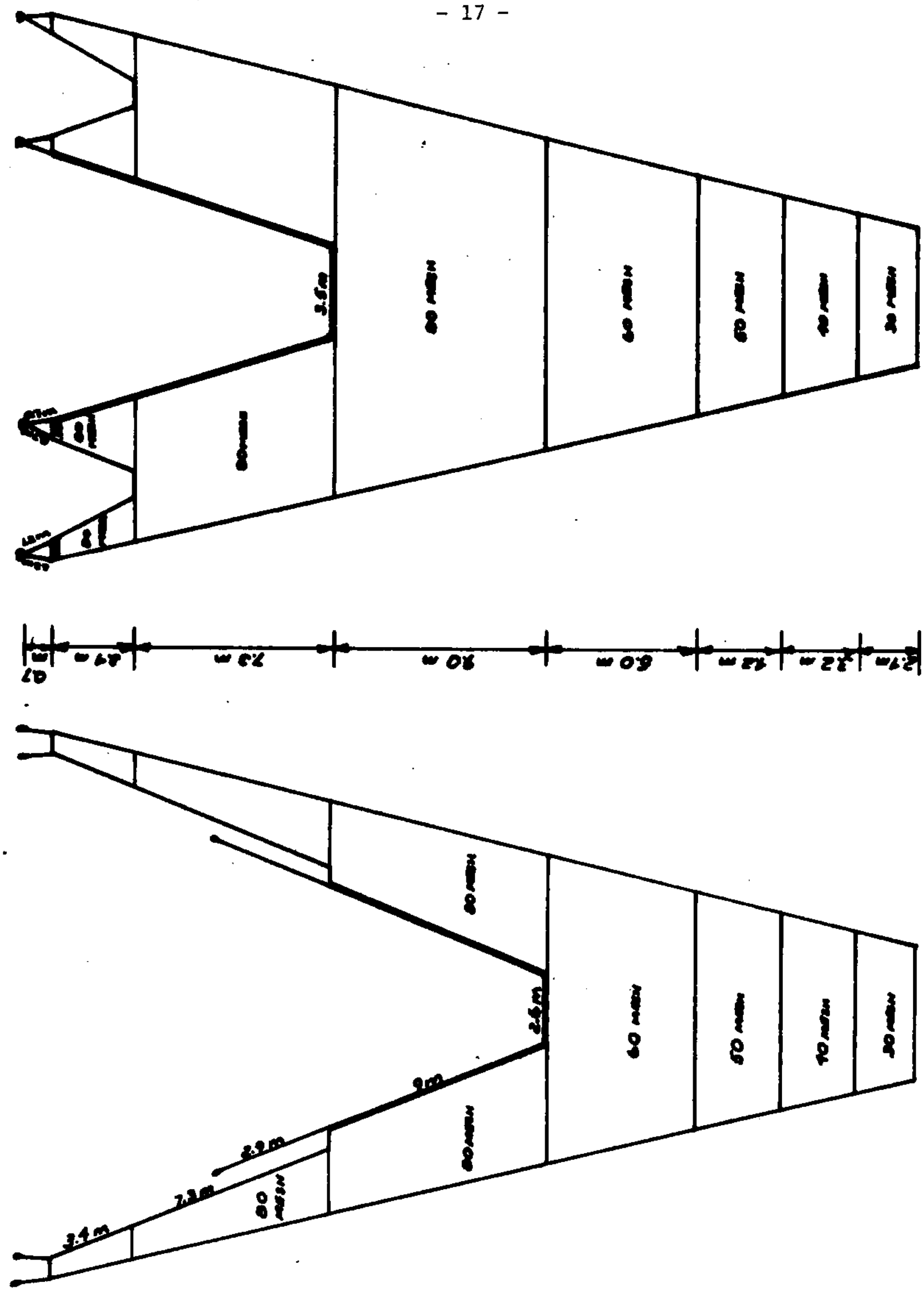
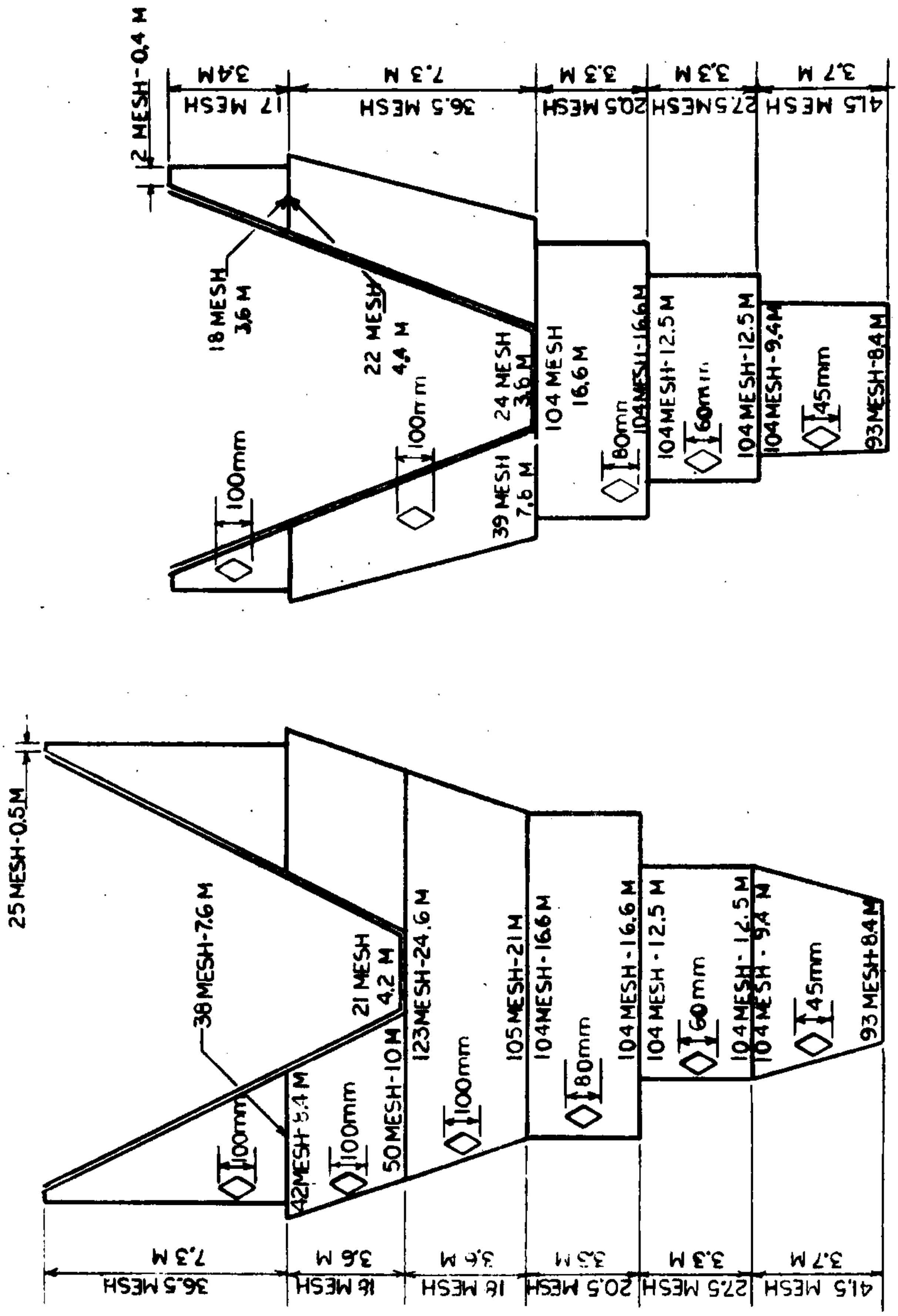


Figure 3



SOVIET 24.6 M TRAWL

Figure 4



SOVIET 23.5 M TRAWL

Figure 5

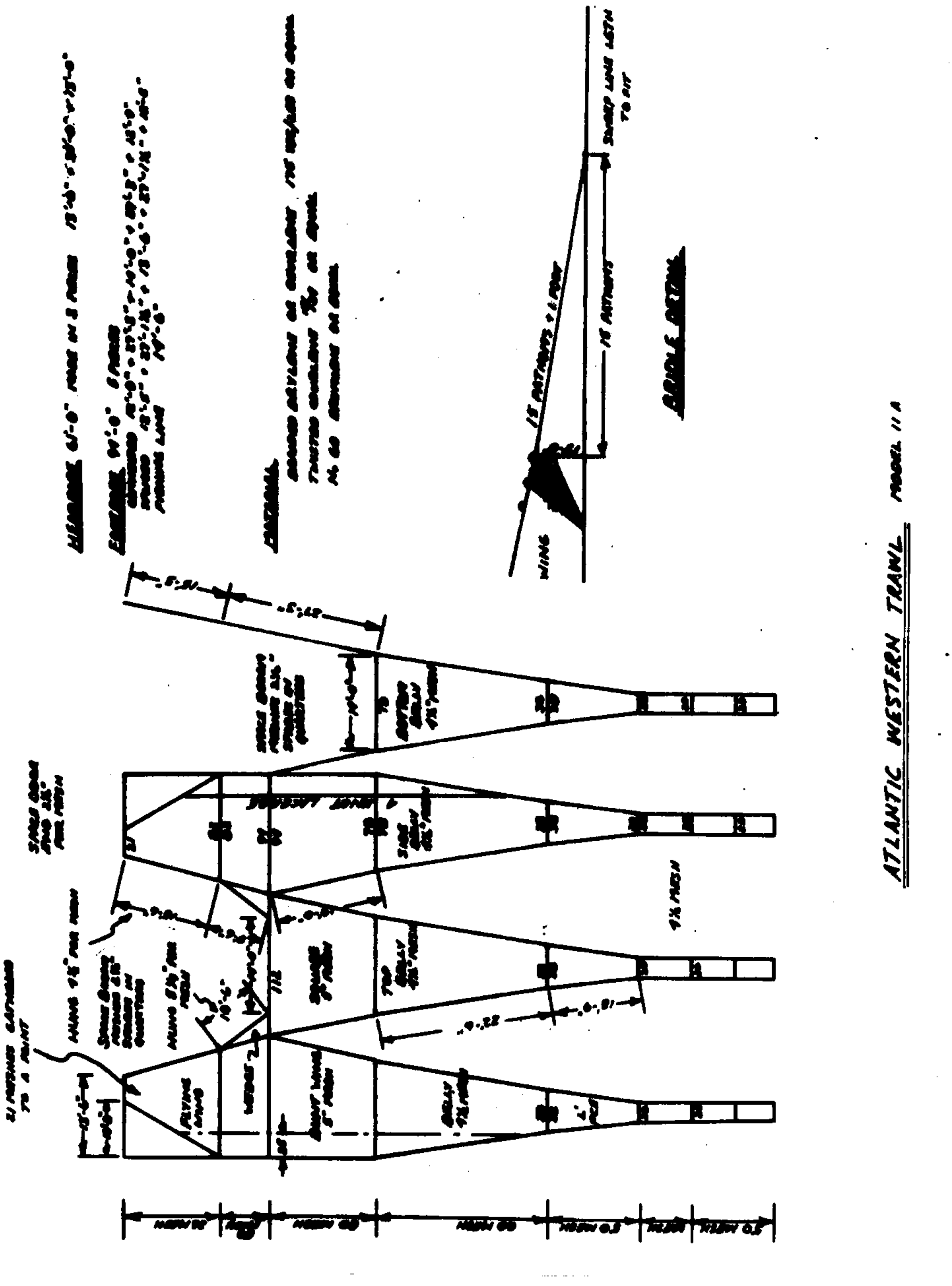


Figure 6

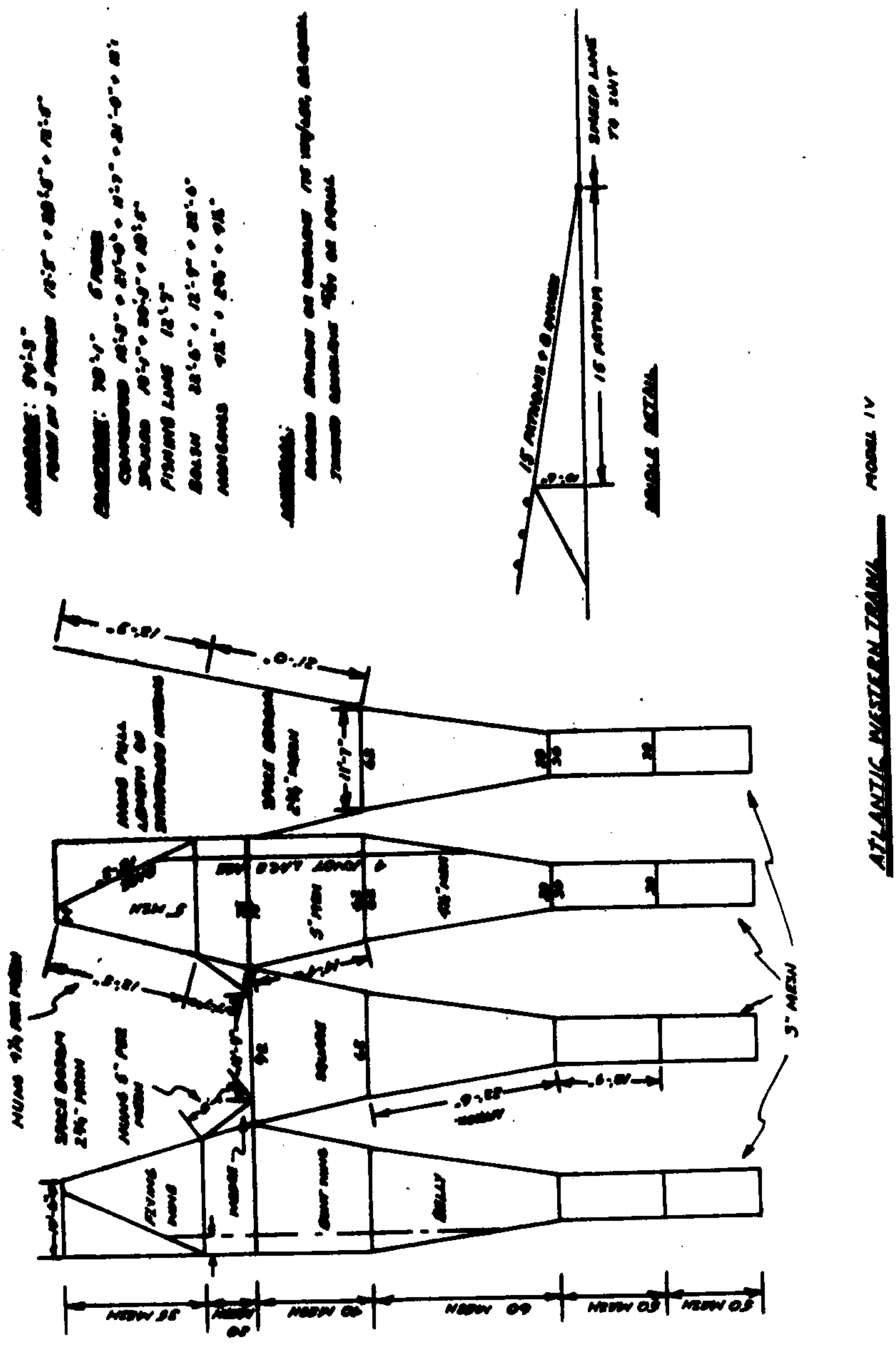
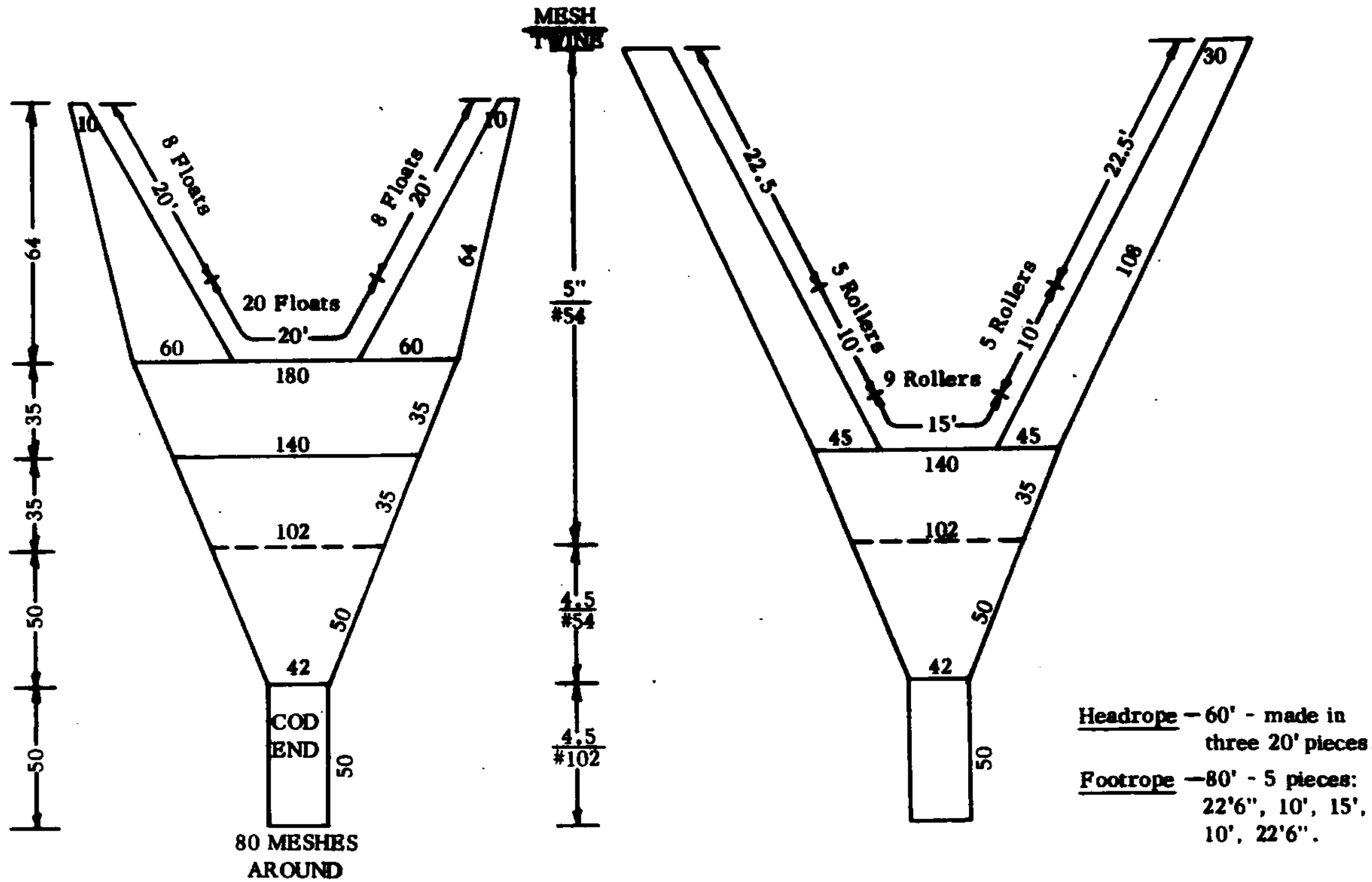


Figure 7

#36 YANKEE TRAWL



SCHEMATIC FIGURE

Trawl dimensions in meshes -- Mesh sizes in inches -- Footrope and headrope sections in feet.

Figure 8.--Mean catch per haul of all species combined for the Soviet 27.1 and 23.5 trawls in 1970 for comparative fishing power experiments expression as a logarithmic transformation.

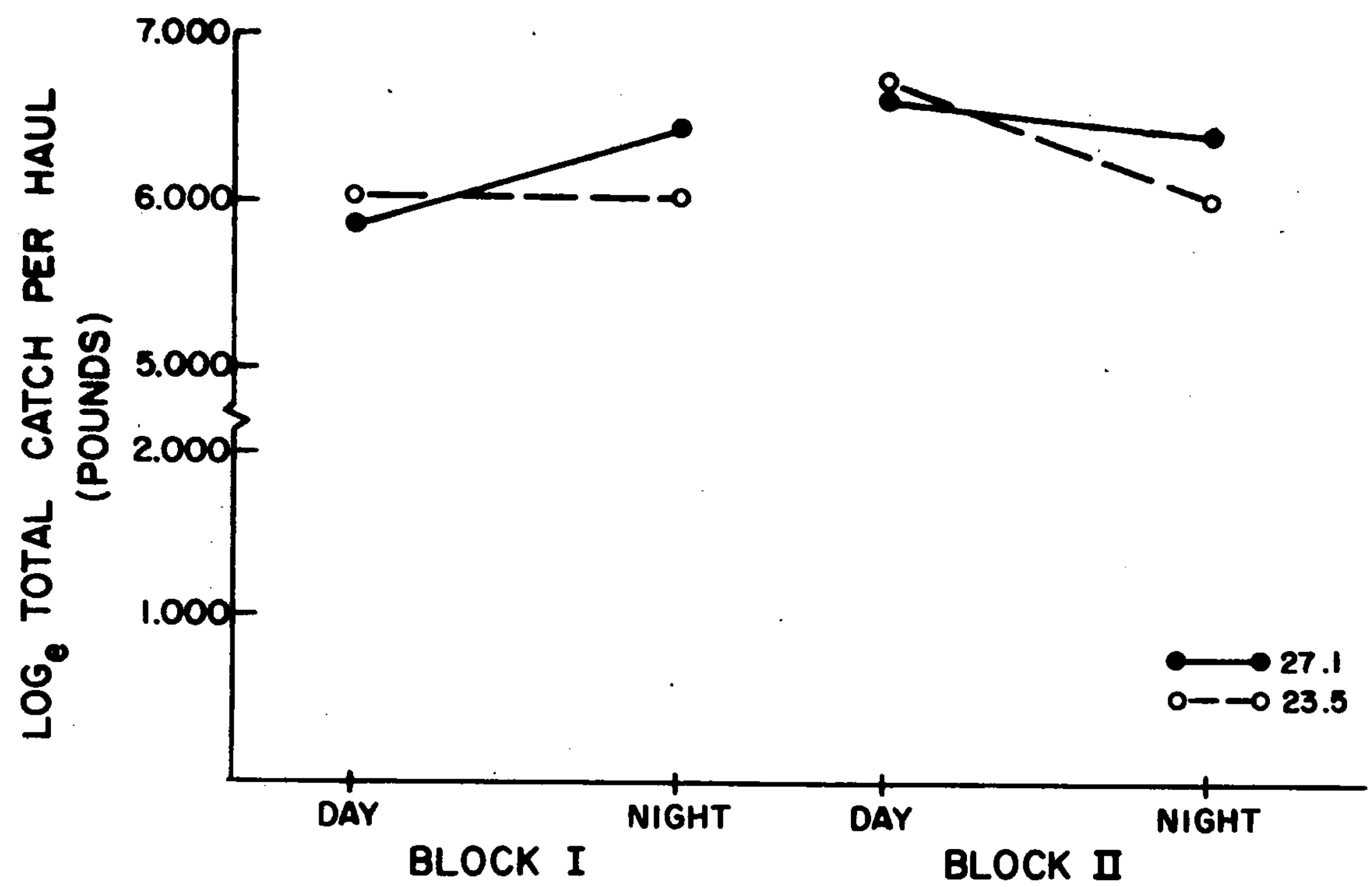


Figure 9.--Mean catch per haul of all species combined and spiny dogfish for the Soviet 27.1 and 23.5 trawls in 1970 comparative fishing power experiments.

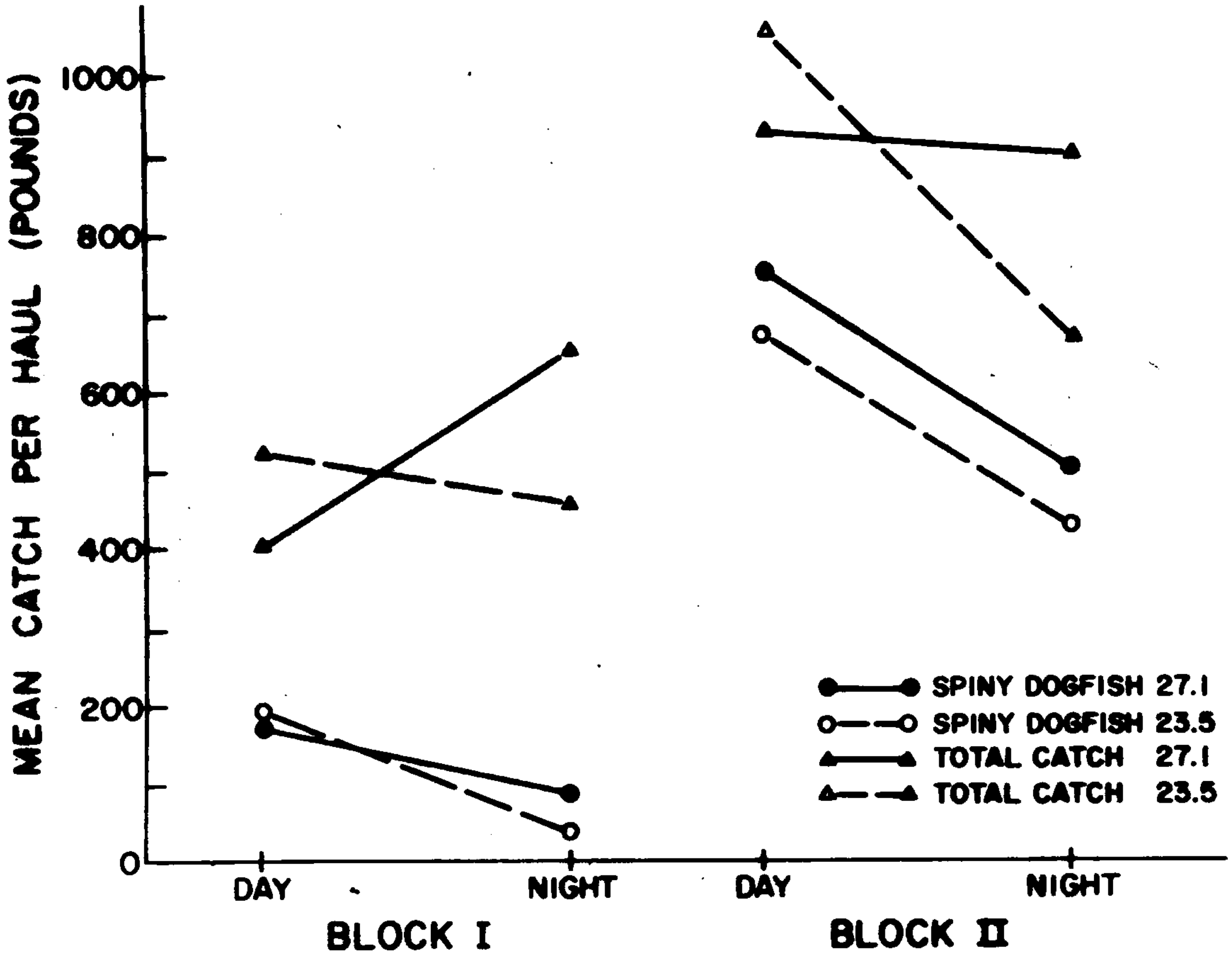


Figure 10.--Mean catch per haul of skates and round herring for the Soviet 27.1 and 23.5 trawls in 1970 comparative fishing power experiments.

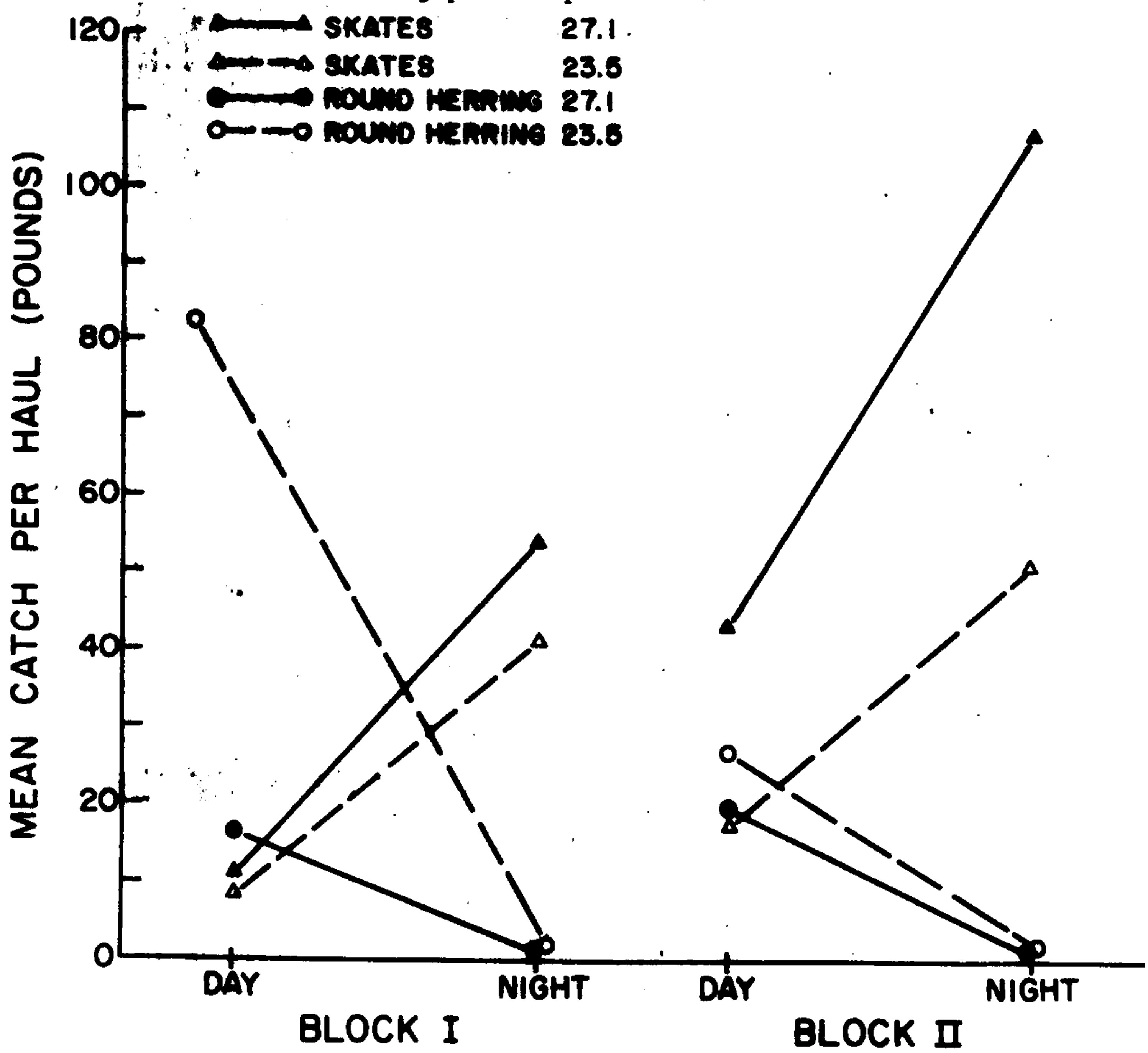


Figure 11.--Mean catch per haul of yellowtail and blackback for the Soviet 27.1 and 23.5 trawls in 1970 comparative fishing power experiments.

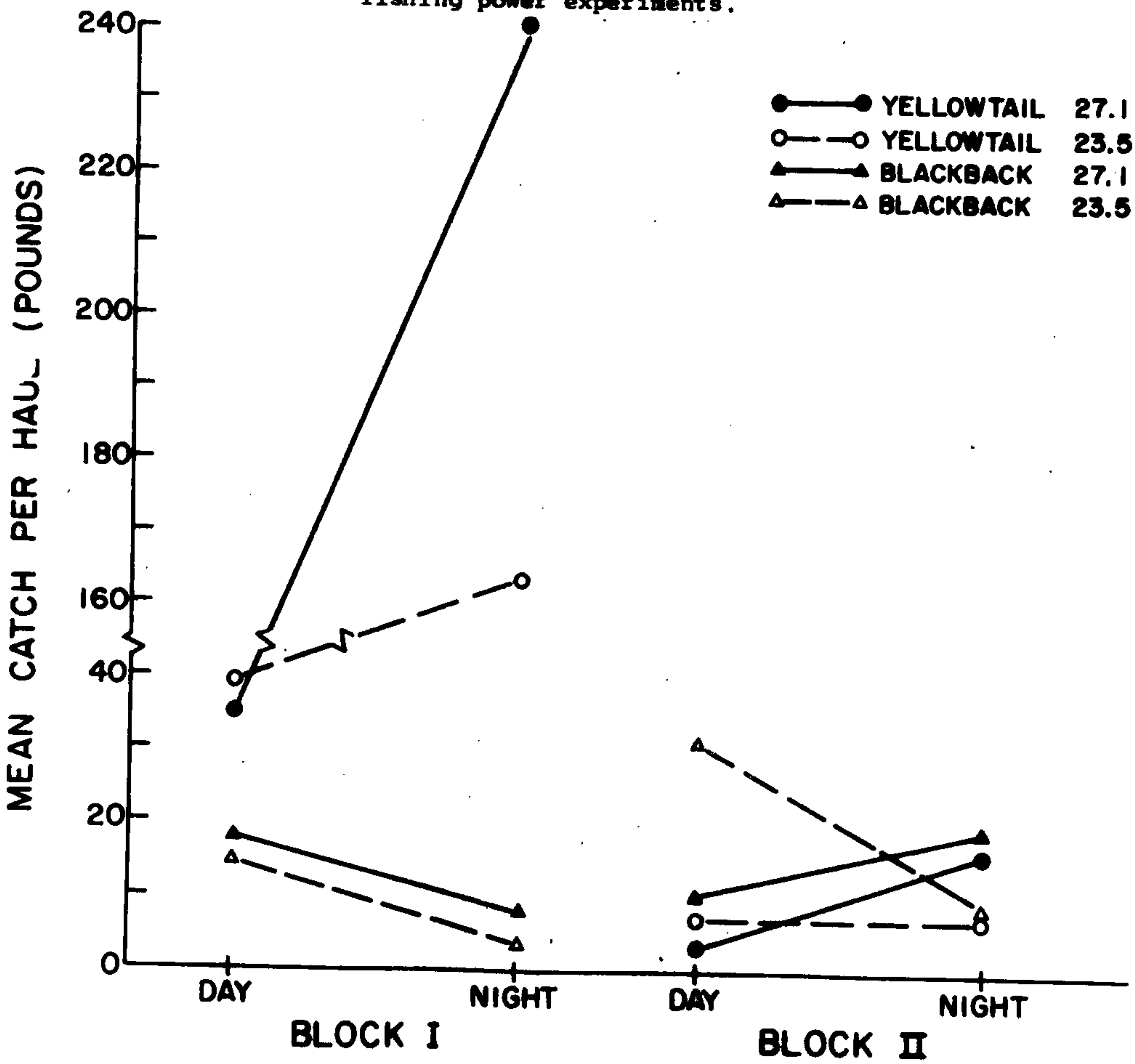


Figure 12.--Mean catch per haul of silver and red hake for the Soviet 27.1 and 23.5 trawls in 1970 comparative fishing power experiments.