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First Attempts to Quantify Variations in Behaviour of Groundfish Otter Trawls Used by the Federal Republic of Germany in North Atlantic surveys

by

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1. Introduction

Estimates of stock biomass based on the virtual population analysis are entirely dependant on the accuracy and reliability of commercial catch and effort statistics and on accurate estimations of fishing mortality in most recent years. These data are not always available with sufficient reliability due to several reasons, particularly in more recent years. Therefore, direct biomass estimates from research vessel surveys are of growing importance for assessments of exploited fish populations.

The swept area method based on a stratified random sampling design was used in bottom trawl surveys of the Federal Republic of Germany's research vessels. This method requires estrapolation of data from the area swept by the survey trawl to the much larger area of the corresponding stratum. Important parameters for the definition of the area swept and the proportion of the fish within the trawls path which is actually caught are the operational characteristics of the survey trawl.

Due to the lack of quantitative data on trawl behaviour most biologists tend to consider bottom trawls to be in a quasi-steady-state during the tow. In fact, however a number of variables, e.g. trawling speed through the water, warp length and tension in relation to depth, ocean currents, weather conditions, various types of sea beds (for extensive discussion, see CARROTHERS, 1981), submits the trawl to continually changing conditions which may bias the abundance estimates from research

vessel surveys to a considerable but unknown extent. Additionally, different behaviour of the target fish species forms another important source of bias which has to be taken into account (see CARROTHERS, 1981).

In 1981 the Institute for Fishing Gear Technology and the Institute for Sea Fisheries of the Federal Research Centre for Fisheries started a series of investigations to quantify these variables. A first set of experiments determining the influence of different ship speeds and fishing depths (≙ warp lengths) on trawl headline height and wing spread was carried out with FRV "Walther Herwig" in the Rockall area in August 1981. Since the area provided rather even trawling grounds down to 700 m depth and the season was selected when weather conditions could be expected to be comparatively stable, external conditions for the experiments could be considered as quasi-steady within a set of measurements.

2. Measuring Techniques and Data Analysis

The net under investigation was a 140 feet groundfish otter trawl (see fig. 1-3) which is one of the two standard trawls used by the Institute for Sea Fisheries for bottom trawl surveys in the North Atlantic. Ship speed ranged from 3.0 - 5.0 kn and was changed in 0.5 kn intervals. The depth fished ranged from about 150 to 700 m (≙ 700 to 2000 m warp length) but varied only within 10m in each set of measurements.

Headline height and wing spread were measured by means of a multi-netsonde monitoring several recorders on headline and tips of the wings. Measurements were taken by turns each minute. When monitoring one recorder (~ 60 sec), ship speed was registered parallely each five sec by means of an Ott Current Meter and a pitotmeter. Wind speed and direction were recorded each 60 sec. Wave height was estimated by an experienced meteorologist each 4 hours. All signals were compiled for each measuring period under constant conditions. They were later discriminated into 1 sec invervals and their means and variances evaluated. Each mean represents one "y" value in tabs. 1 and 2 (right column), the number of measurements for each mean are given in the column "DATA".

3. Results

The amount of data so far collected has not been fully analysed at present. However some preliminary conclusions seem to be obvious.

In fig. 4 all measurements of headline height (a) and wing spreas (b) (regardless of the different fishing depth, course

etc.) are plotted against ship speed. It is clearly demonstrated that the variations of both parameters decrease considerably with increasing ship speed and remain more or less constant from about 4.2 kn onwards.
To find out which variables are major contributors to these variations data were further grouped on the basis of particular warp lengths. The trawl parameters are relatively stable at all speed levels for 700 and 850 m warp length (fig. 5 and 6). However, as indicated in fig. 7 to 9; variation of headline height and wing spread is higher at lower speed ranges with warp lengths above 1450 m. It may therefore be assumed that warp length may contribute to the variance at least in a critical speed range and at greater fishing depths.

The first conclusion from this experiment is that trawling speed of FRV "Walther Herwig" should be about 4.5 $\pm$ 0.5 kn in order to keep trawl height and wing spread relatively stable.

4. Literature

CARROTHERS, P.J.G. 1981 : Catch variability due to variations in groundfish otter trawl behaviour and possibilities to reduce it through instrumented fishing gear studies and improved fishing procedures.
in : Bottom Trawl Surveys, Doubleday, W.G. & Rivard, D. (ed.) : 247-257, Dept. Fish. and Oceans Ottawa.

Acknowledgement : We are very much indebted to Mr. Winston Phillips, Sea Fish Industry Authority, Hull (UK) for his valuable help.

Tab. 1: Headline Height of 140' BT (y-Value)

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
157	700	7	290	82	1.0	23	5.0	4.3
156	700	7	290	81	1.0	21	4.5	5.2
155	700	7	290	81	1.0	19	4.1	5.4
155	700	7	290	83	1.0	21	3.7	5.6
156	700	4	0	250	.5	14	5.1	3.7
156	700	4	0	250	.5	17	4.3	5.1
155	700	4	0	250	.5	19	4.0	5.3
155	700	4	0	250	.5	16	3.5	5.6

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
215	850	25	270	245	2.5	25	4.9	3.3
212	850	25	270	245	2.5	16	4.6	3.1
210	850	25	270	245	2.5	17	4.2	5.1
207	850	25	270	240	2.5	16	3.4	5.5
206	850	25	270	240	2.5	23	2.9	5.6
205	850	25	270	240	2.5	23	5.0	3.4
204	850	25	270	240	2.5	15	4.5	3.3
201	850	25	270	239	2.5	13	4.0	4.3
201	850	25	270	240	2.5	21	3.5	5.3
203	850	25	270	238	2.5	27	3.0	5.3
207	850	25	270	40	2.5	21	5.0	4.1
208	850	25	270	41	2.5	22	4.5	4.1
208	850	25	270	41	2.5	13	4.0	5.7
209	850	25	270	40	2.5	21	3.5	6.0
208	850	25	270	40	2.5	20	3.0	8.1

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
438	1450	18	250	58	1.0	23	5.0	3.2
452	1450	18	250	28	1.0	14	4.4	3.0
445	1450	18	250	28	1.0	14	3.8	2.8
446	1450	18	250	40	1.0	18	3.2	2.8
453	1450	18	250	41	1.0	13	2.8	2.9
447	1450	18	250	227	1.0	12	5.0	3.3
449	1450	18	250	224	1.0	16	4.4	3.2
448	1450	18	250	231	1.0	12	4.1	3.8
442	1450	18	250	231	1.0	29	3.8	4.1
442	1450	18	250	231	1.0	29	3.8	4.1
455	1450	18	250	38	1.0	18	5.1	3.4
457	1450	18	250	37	1.0	21	4.5	3.5
459	1450	18	250	37	1.0	22	4.0	3.3
464	1450	18	250	30	1.0	23	3.7	3.4
462	1450	18	250	30	1.0	17	3.0	3.5
453	1450	18	250	225	1.0	17	5.0	3.7
456	1450	18	250	230	1.0	12	4.5	3.3
452	1450	18	250	230	1.0	24	4.1	3.4
450	1450	18	250	221	1.0	16	3.7	4.1
454	1450	18	250	223	1.0	16	3.3	4.8
449	1450	19	250	35	1.0	28	5.0	2.6
459	1450	19	250	33	1.0	25	4.4	2.7
453	1450	19	250	34	1.0	13	4.1	3.2
451	1450	19	250	30	1.0	23	3.7	6.4
450	1450	19	250	35	1.0	29	3.2	8.7
448	1450	17	260	35	1.0	9	4.8	3.5
444	1450	17	260	35	1.0	15	4.5	3.4
443	1450	17	260	34	1.0	21	4.2	4.4
442	1450	17	260	55	1.0	25	3.5	5.7
447	1450	17	260	52	1.0	16	3.2	7.1
450	1450	17	260	240	1.0	24	5.1	2.9
427	1450	17	260	225	1.0	9	4.5	3.2
440	1450	17	260	220	1.0	19	4.1	4.4
445	1450	17	260	225	1.0	14	3.5	9.2
447	1450	17	260	230	1.0	20	3.2	9.6

Tab. 1: (cont.)

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
595	1800	9	330	28	1.0	20	5.1	3.3
593	1800	9	330	32	1.0	23	4.4	3.3
594	1800	9	330	42	1.0	19	3.9	4.2
602	1800	9	330	43	1.0	19	3.4	5.5
601	1800	9	330	41	1.0	26	3.0	7.6
599	1800	8	160	208	.5	24	5.1	3.4
597	1800	8	160	208	.5	17	4.4	3.4
597	1800	8	160	208	.5	19	4.1	3.4
596	1800	8	160	210	.5	14	3.8	5.3
610	1800	8	160	30	.5	21	5.1	2.2
612	1800	8	160	40	.5	64	4.5	2.4
612	1800	8	160	42	.5	16	4.0	2.4
602	1800	8	160	44	.5	36	3.5	3.8
607	1800	8	160	38	.5	40	3.0	7.9
604	1800	8	160	211	.5	24	5.0	2.9
598	1800	8	160	210	.5	23	4.7	2.4
607	1800	8	160	200	.5	22	4.1	3.1
606	1800	8	160	208	.5	35	3.5	2.6
599	1800	8	160	203	.5	36	3.0	2.7
598	1800	13	180	38	.5	22	4.9	2.5
595	1800	13	180	39	.5	20	4.5	2.4
599	1800	13	180	45	.5	22	4.1	2.4
600	1800	13	180	45	.5	21	3.6	2.1
605	1800	13	180	44	.5	20	3.0	3.1

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
703	2000	19	250	228	1.0	26	5.1	3.4
696	2000	19	250	190	1.0	33	4.4	3.0
701	2000	19	250	194	1.0	22	4.0	4.0
695	2000	19	250	225	1.0	58	3.5	6.5
704	2000	19	250	223	1.0	17	3.0	9.4
688	2000	19	250	218	1.0	20	5.0	3.7
689	2000	19	250	215	1.0	26	4.7	3.4
702	2000	19	250	35	1.0	20	5.0	3.3
704	2000	19	250	42	1.0	37	4.2	3.0
707	2000	19	250	16	1.0	46	3.6	3.5
702	2000	19	250	20	1.0	16	3.2	3.9
701	2000	13	180	39	.5	18	4.9	3.4
698	2000	13	180	38	.5	23	4.5	3.2
690	2000	13	180	40	.5	34	4.0	3.1
713	2000	13	180	30	.5	56	3.6	3.8

Tab. 2: Wing Spread of 140' BT (y-Value)

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
157	700	7	290	82	1.0	17	5.0	22.8
156	700	7	290	81	1.0	19	4.5	23.6
155	700	7	290	81	1.0	22	4.1	23.1
155	700	7	290	83	1.0	23	3.7	20.1
156	700	4	0	250	.5	17	5.1	23.3
156	700	4	0	250	.5	17	4.3	23.5
155	700	4	0	250	.5	20	4.0	23.9
155	700	4	0	250	.5	23	3.5	22.9

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
215	850	25	270	245	2.5	23	4.9	22.9
212	850	25	270	245	2.5	21	4.6	23.2
210	850	25	270	245	2.5	16	4.2	23.3
207	850	25	270	240	2.5	11	3.4	23.4
206	850	25	270	240	2.5	12	2.9	23.2
205	850	25	270	240	2.5	12	5.0	23.4
204	850	25	270	240	2.5	17	4.5	23.5
201	850	25	270	239	2.5	13	4.0	23.4
201	850	25	270	240	2.5	14	3.5	23.6
203	850	25	270	238	2.5	14	3.0	23.4
207	850	25	270	40	2.5	33	5.0	22.7
208	850	25	270	41	2.5	23	4.5	22.9
208	850	25	270	41	2.5	17	4.0	23.0
209	850	25	270	40	2.5	18	3.5	21.8
208	850	25	270	40	2.5	17	3.0	12.9

Tab.2: (cont.)

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
438	1450	18	250	58	1.0	23	5.0	23.4
452	1450	18	250	28	1.0	19	4.4	23.2
445	1450	18	250	28	1.0	17	3.8	23.6
446	1450	18	250	40	1.0	14	3.2	23.2
453	1450	18	250	41	1.0	23	2.8	21.3
447	1450	18	250	227	1.0	16	5.0	22.4
449	1450	18	250	224	1.0	27	4.4	22.5
448	1450	18	250	231	1.0	23	4.1	20.3
442	1450	18	250	231	1.0	52	3.8	13.9
455	1450	18	250	38	1.0	17	5.1	21.9
457	1450	18	250	37	1.0	16	4.5	22.4
459	1450	18	250	37	1.0	21	4.0	23.1
464	1450	18	250	30	1.0	17	3.7	22.7
462	1450	18	250	30	1.0	37	3.0	19.6
453	1450	18	250	225	1.0	17	5.0	22.0
456	1450	18	250	230	1.0	15	4.5	22.7
452	1450	18	250	230	1.0	15	4.1	22.3
450	1450	18	250	221	1.0	24	3.7	14.3
454	1450	18	250	223	1.0	28	3.3	11.3
449	1450	19	250	35	1.0	24	5.0	21.5
459	1450	19	250	33	1.0	17	4.4	21.8
453	1450	19	250	34	1.0	23	4.1	22.4
451	1450	19	250	30	1.0	22	3.7	21.0
450	1450	19	250	35	1.0	10	3.2	13.7
448	1450	17	260	35	1.0	7	4.8	21.4
444	1450	17	260	35	1.0	13	4.5	22.3
443	1450	17	260	34	1.0	11	4.2	22.1
442	1450	17	260	55	1.0	13	3.5	21.2
447	1450	17	260	52	1.0	20	3.2	19.3
450	1450	17	260	240	1.0	23	5.1	21.1
427	1450	17	260	225	1.0	11	4.5	21.3
440	1450	17	260	220	1.0	14	4.1	19.2
445	1450	17	260	225	1.0	19	3.5	10.4
447	1450	17	260	230	1.0	21	3.2	12.1

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
595	1800	9	330	28	1.0	25	5.1	22.0
593	1800	9	330	32	1.0	27	4.4	23.0
594	1800	9	330	42	1.0	21	3.9	21.5
602	1800	9	330	43	1.0	14	3.4	19.8
601	1800	9	330	41	1.0	20	3.0	18.9
599	1800	8	160	208	.5	26	5.1	22.5
597	1800	8	160	208	.5	48	4.4	23.1
597	1800	8	160	208	.5	17	4.1	22.1
596	1800	8	160	210	.5	17	3.8	19.0
610	1800	8	160	30	.5	25	5.1	23.0
612	1800	8	160	40	.5	42	4.5	23.7
612	1800	8	160	42	.5	51	4.0	23.9
602	1800	8	160	44	.5	24	3.5	21.8
607	1800	8	160	38	.5	40	3.0	19.2
604	1800	8	160	211	.5	25	5.0	22.5
598	1800	8	160	210	.5	13	4.7	24.0
607	1800	8	160	200	.5	22	4.1	20.8
606	1800	8	160	208	.5	35	3.5	17.8
599	1800	8	160	203	.5	28	3.0	19.6
598	1800	13	180	38	.5	17	4.9	21.8
595	1800	13	180	39	.5	21	4.5	22.8
599	1800	13	180	45	.5	15	4.1	23.7
600	1800	13	180	45	.5	17	3.6	23.7
605	1800	13	180	44	.5	24	3.0	22.7

DEPTH (M)	WARP (M)	WIND- (KN)	WIND- (DEG)	COURSE (DEG)	WAVE (M)	#DATA	SPEED (KN)	Y-VALUE (M)
703	2000	19	250	228	1.0	22	5.1	21.5
696	2000	19	250	190	1.0	24	4.4	22.6
701	2000	19	250	194	1.0	40	4.0	20.1
695	2000	19	250	225	1.0	45	3.5	16.2
704	2000	19	250	223	1.0	31	3.0	15.5
688	2000	19	250	218	1.0	31	5.0	21.4
689	2000	19	250	215	1.0	13	4.7	22.5
702	2000	19	250	35	1.0	17	5.0	22.1
700	2000	19	250	42	1.0	15	4.7	22.1
704	2000	19	250	42	1.0	16	4.2	23.7
707	2000	19	250	16	1.0	27	3.6	23.2
702	2000	19	250	20	1.0	19	3.2	21.5
701	2000	13	180	39	.5	12	4.9	21.1
698	2000	13	180	38	.5	21	4.5	21.8
690	2000	13	180	40	.5	14	4.0	22.4
713	2000	13	180	30	.5	18	3.6	22.9

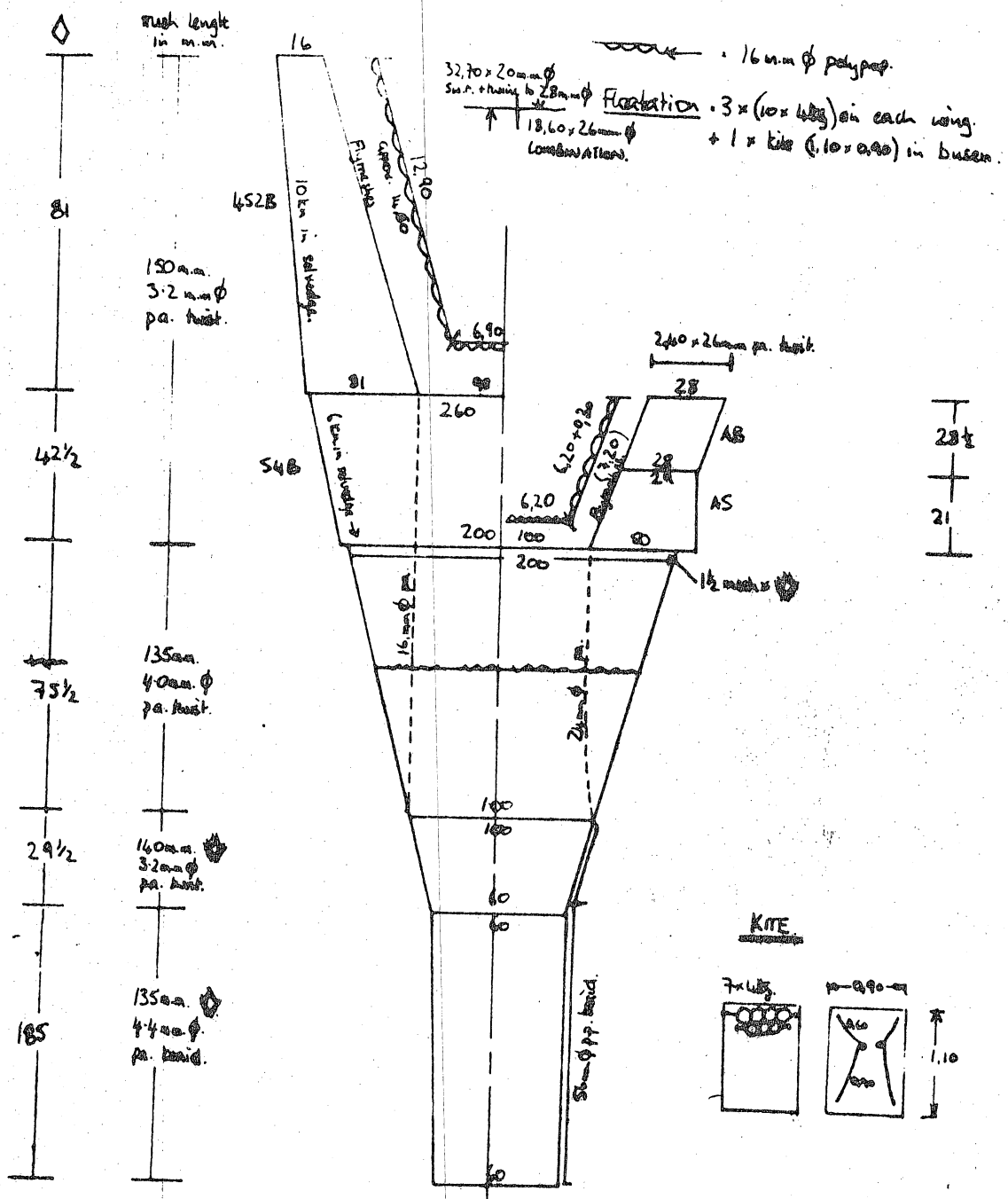
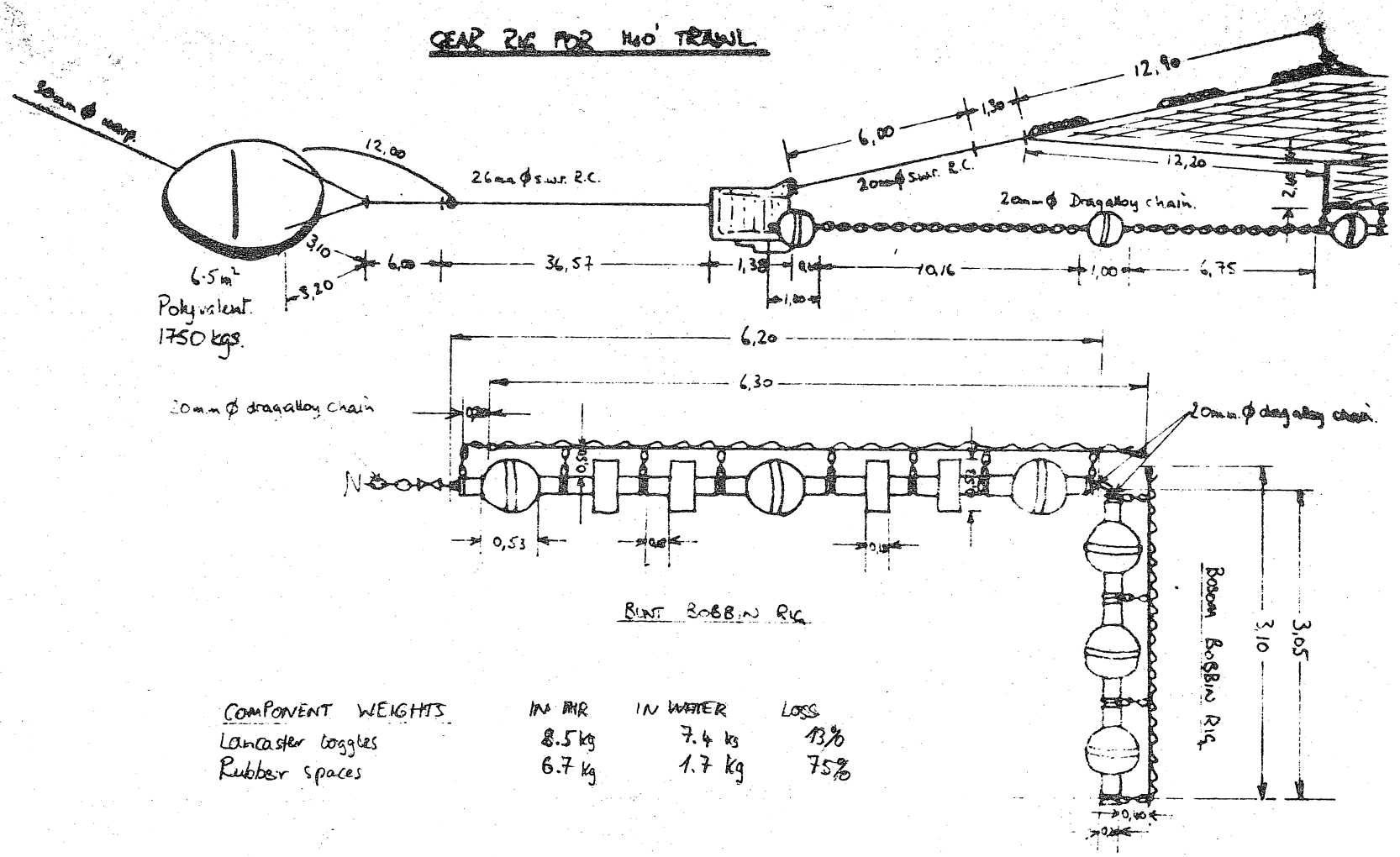


Fig. 1: 140'BT Netting and Frame Lines



COMPONENT WEIGHTS	IN AIR	IN WATER	LOSS
Lancaster toggles	8.5 kg	7.4 kg	13%
Rubber spaces	6.7 kg	1.7 kg	75%

Fig. 2: 140'BT Attachments

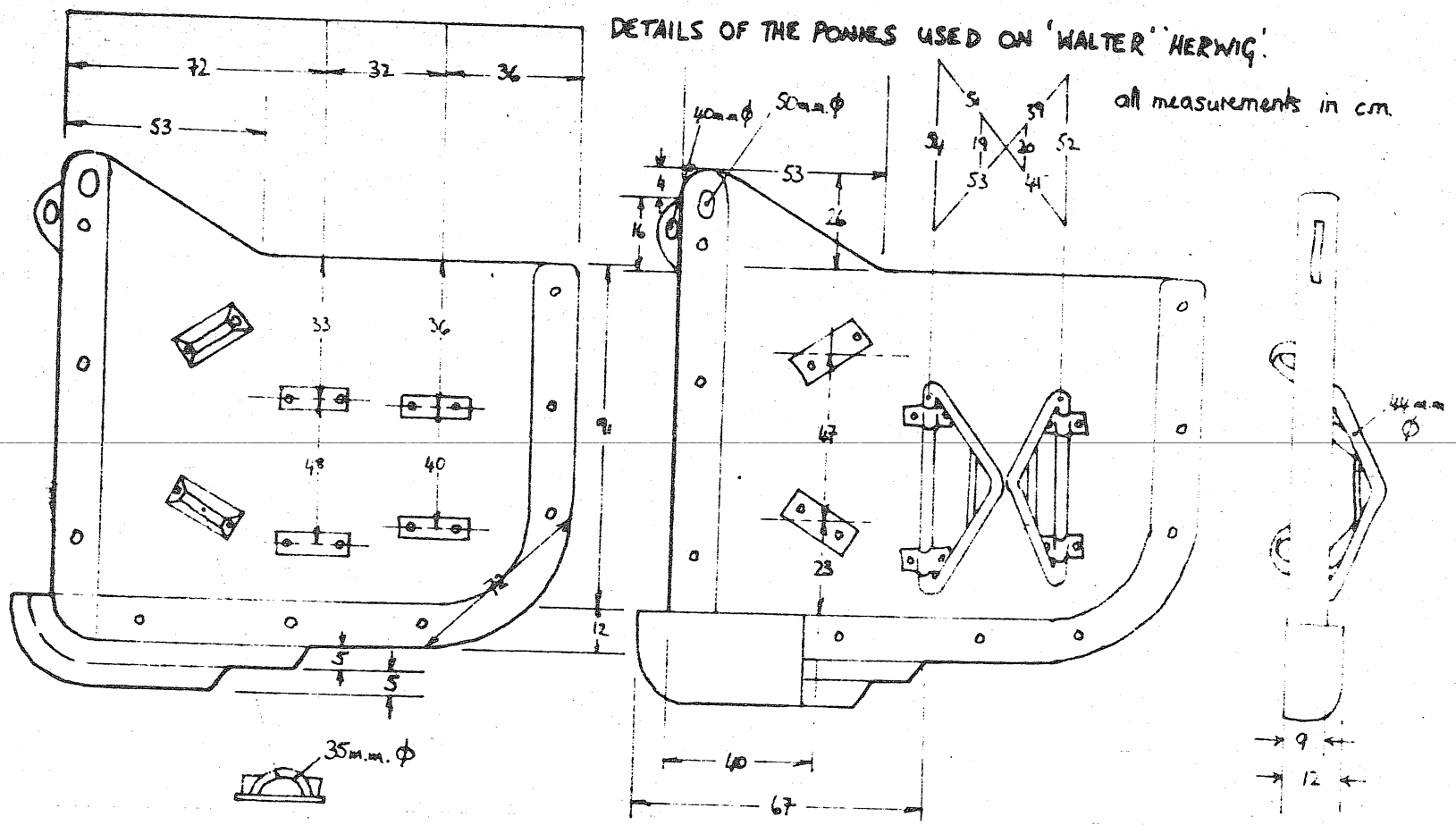
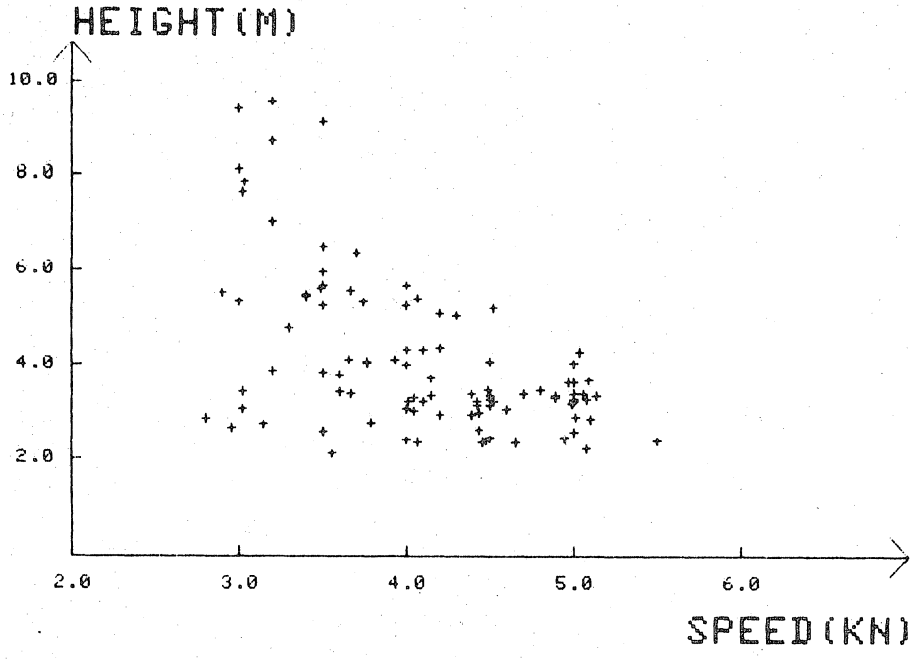


Fig. 3: Details of Ponies used on "Walther Herwig"



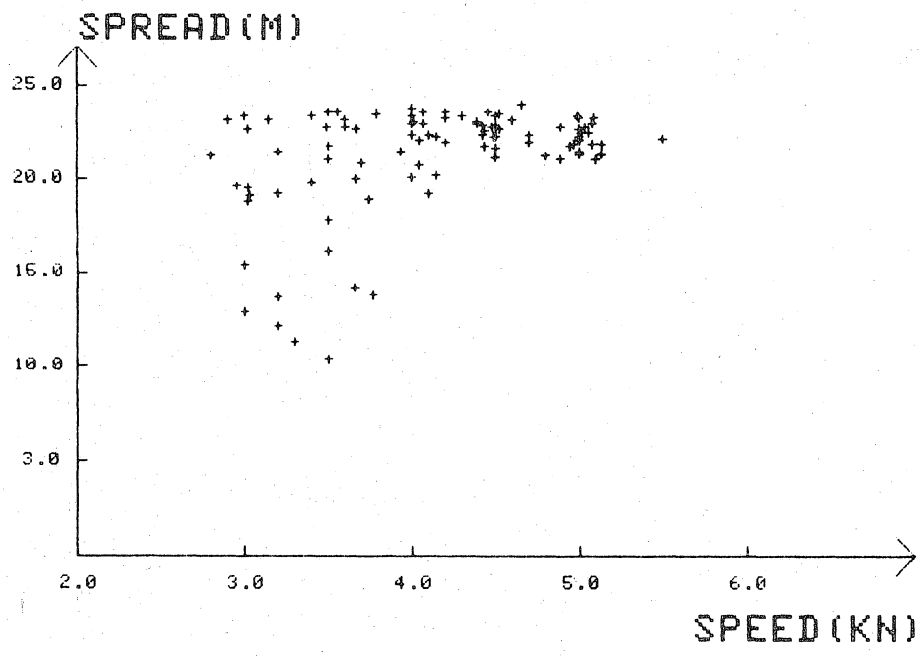


Fig. 4a,4b: 140'BT, headline height and wing spread (warp 700-2000 m)

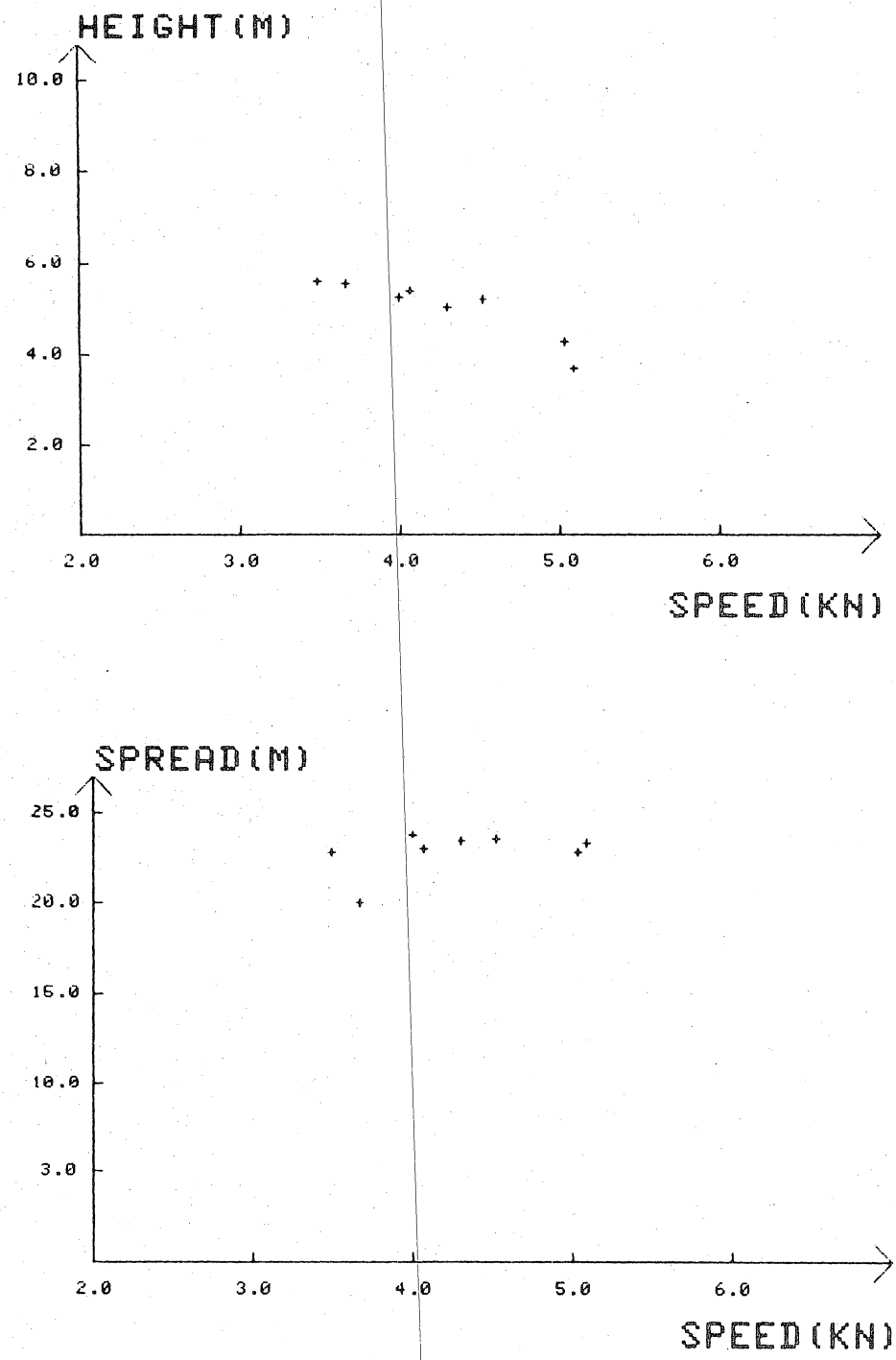
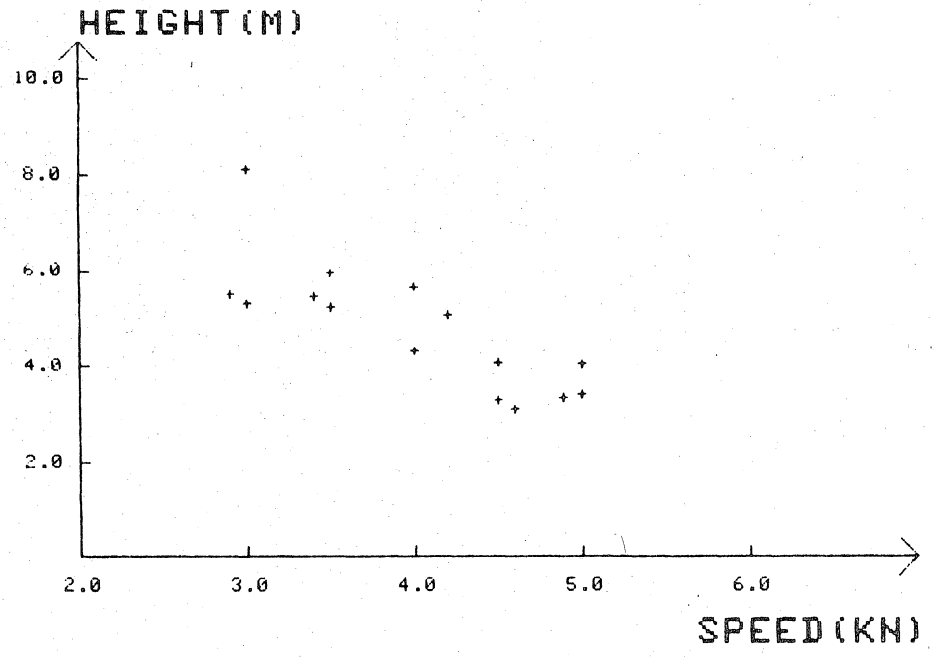


Fig. 5a,5b: 140'BT, headline height and wing spread (warp 700 m)



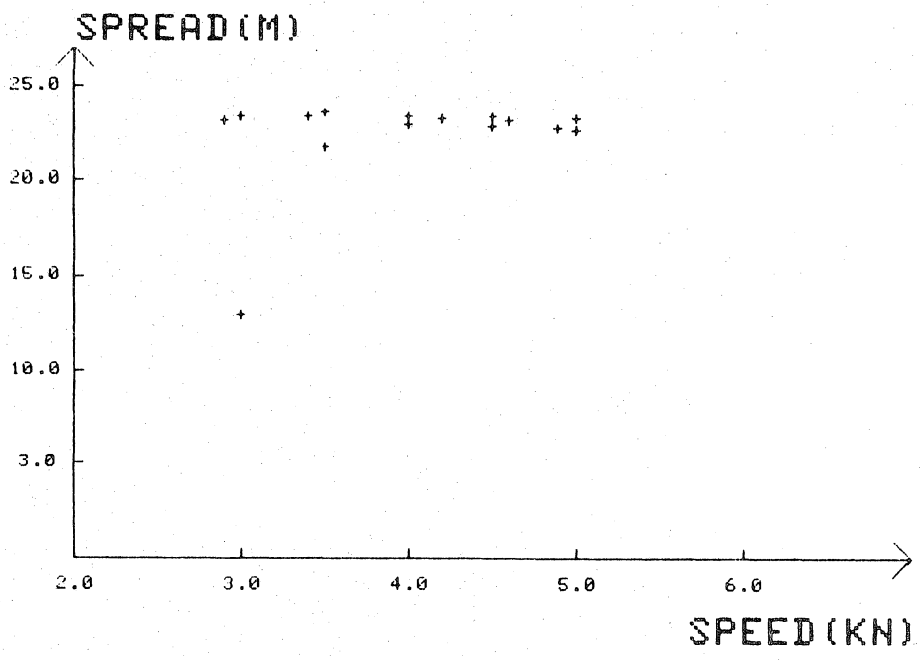
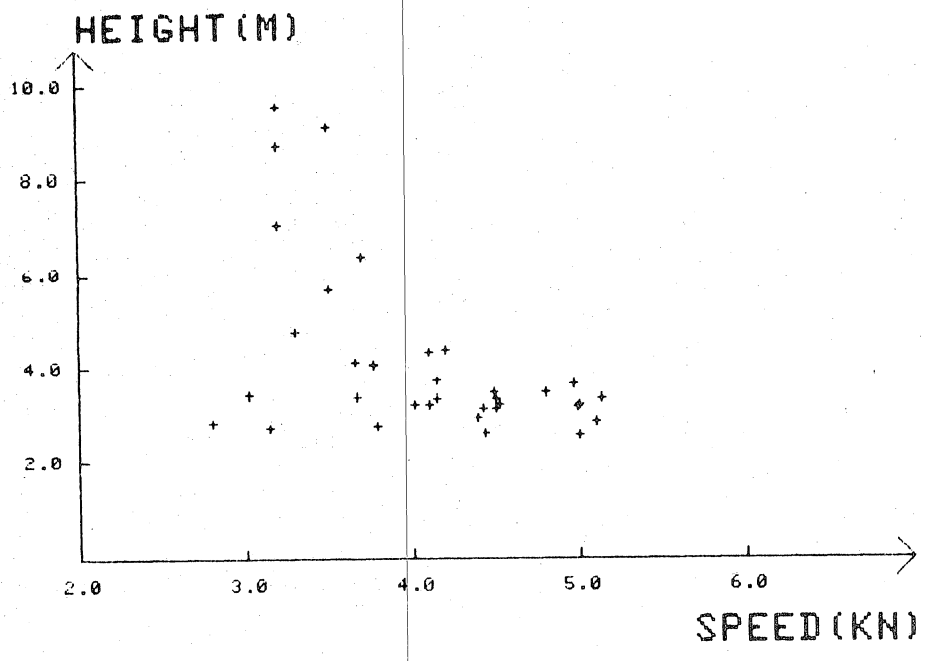


Fig. 6a,6b: 140'BT, headline height and wing spread (warp 850 m)



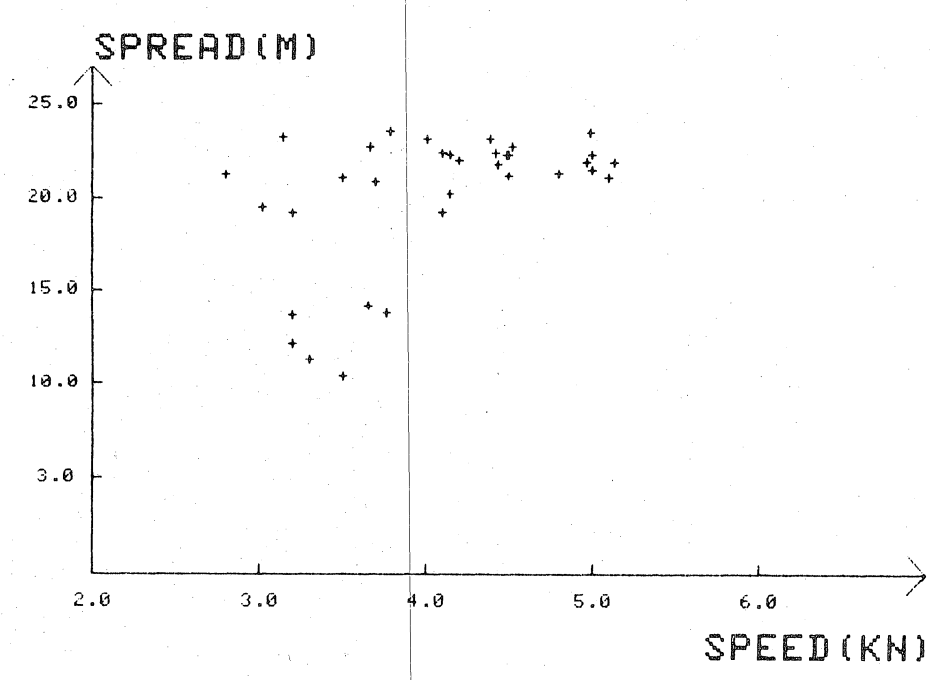
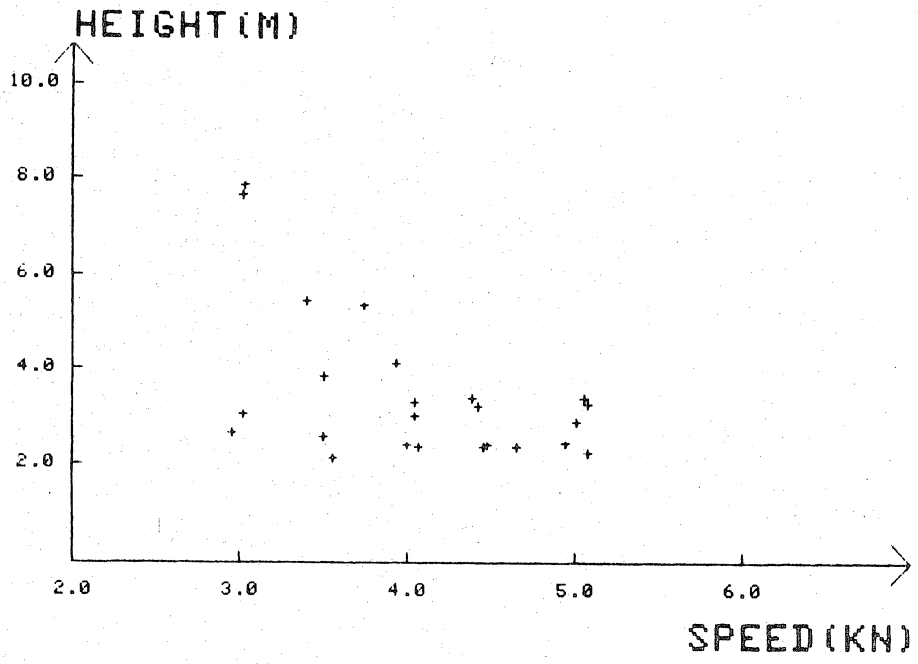


Fig. 7a,7b: 140'BT, headline height and wing spread (warp 1450 m)



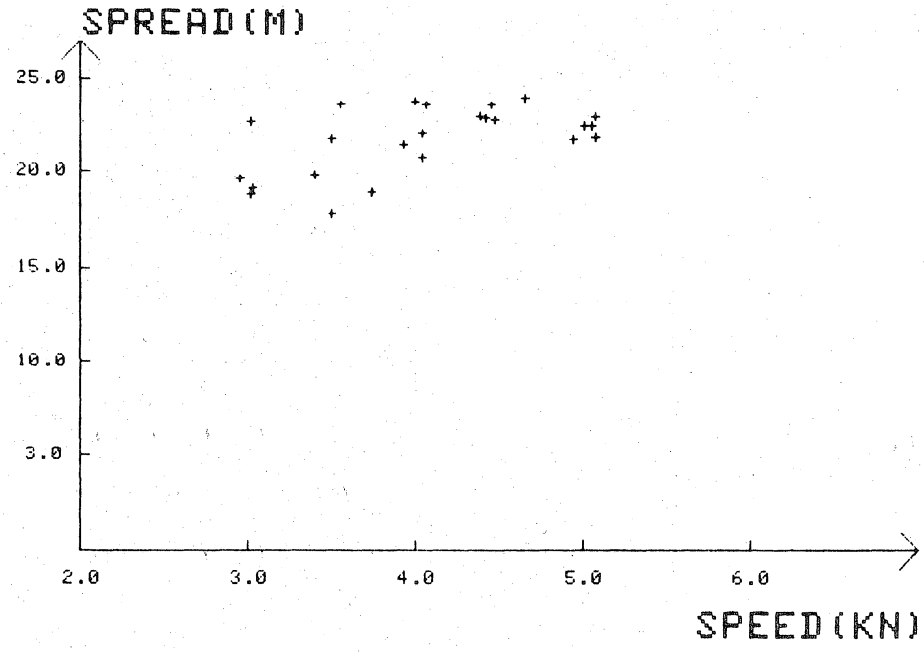
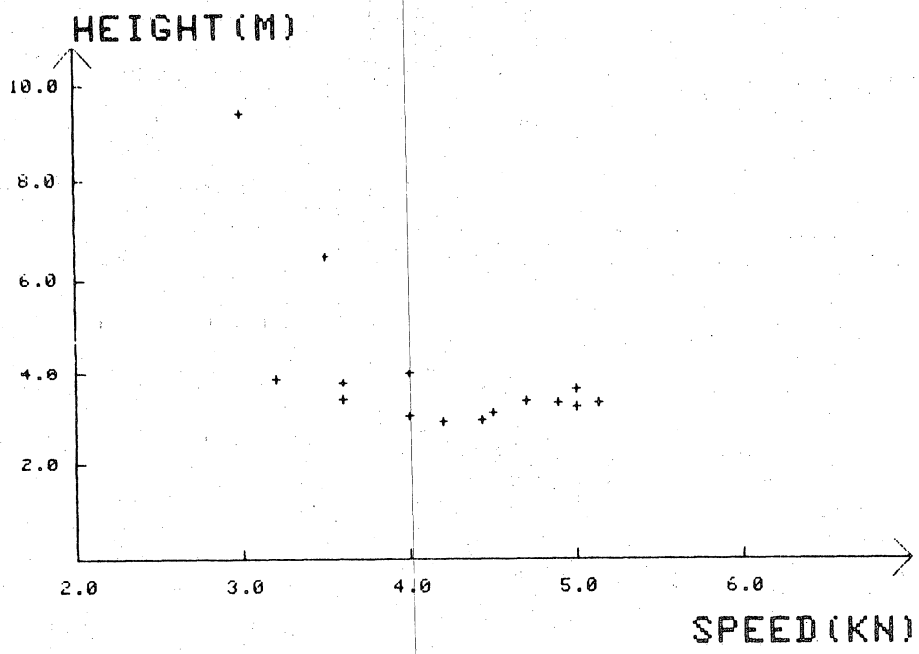


Fig. 8a,8b: 140'BT, headline height and wing spread (warp 1800 m)



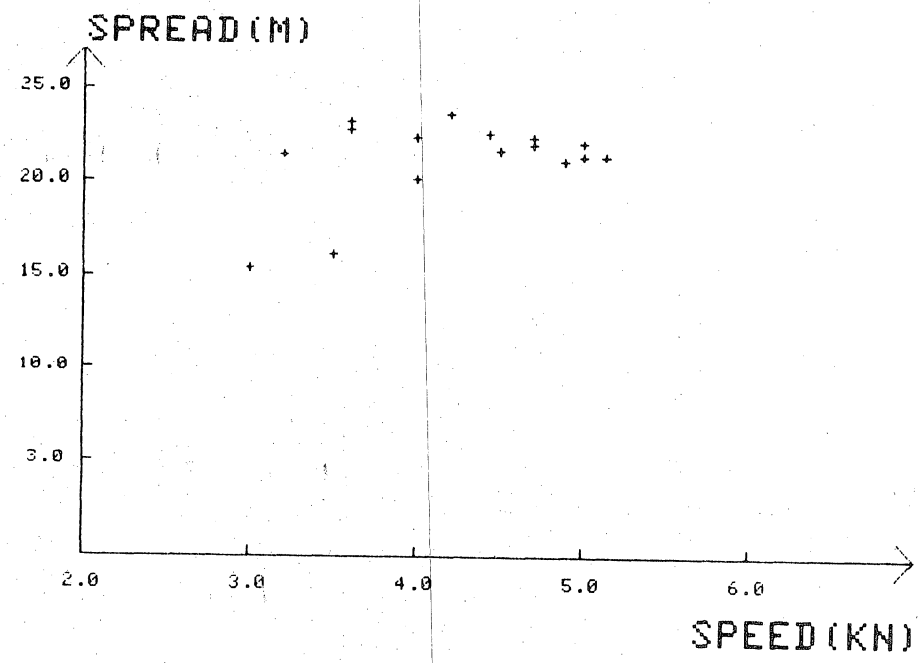


Fig. 9a,9b: 140'BT, headline height and wing spread (warp 2000 m)