INTERNATIONAL COUNCIL FOR
THE EXPLORATION OF THE SEA

C.M. 1991/B:21
Fish Capture Committee

MODEL RESEARCH ON A SINGLE-DOOR TRAWL AT LAKE INSKO IN 1990

by

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Abstract

Experiments on a 1 to 7 scale trawl model of a net of type "FANNY II", rigged with one door at the port side and a Dan-leno at the starboard side are described in this paper. The aim of this rigging is to catch fish in close proximity of the sea surface outside the wake of the trawler thus making use of avoidance reactions of fish to emitted sound in the path of the vessel. The trials were conducted at station Insko, Poland in cooperation with the University of Agriculture, Szczecin and the University and "Institut für Hochseefischerei und Fischverarbeitung - (IfH)" of Rostock, Germany in June 1990. The geometry and resistance of the trawl model were measured and recorded with variable components of the rigging and the results are explained. A variant with two doors spreading in the same direction has also been tried with success. It is recommended to prove the concept of this rigging prior to further technical optimization. The rigging may become appropriate for a sampling gear for pelagic fish close to the surface.

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1. INTRODUCTION.

Research on a single-door rigging for pelagic trawls has been described in [6] with a review of activities until September 1989. The current research programme has been extended in June 1990 with model tests at the station Insko of the "Instytut Akwakultury i Techniki Rybacki" (IATR), a faculty of the University of Agriculture, Szczecin in Poland under the initiative of the "Universität Rostock, Sektion Schiffstechnik" in co-operation with the "Institut für Hochseefischerei und Fischverarbeitung, Rostock" (IfH). The following persons were involved in the experiments:

Dr. -Ing. Mathias Paschen,	University of Rostock (research leader)
Dipl. Ing. Bodo Schäfer,	IfH, Rostock
Dr. -Ing. Henryk Sendlak,	University of Agriculture, Szczecin
Ir. Bob van Marlen,	RIVO, IJmuiden
Harry de Jong	RIVO, IJmuiden

The objective of these experiments was to find the rigging with a maximum horizontal netopening at the largest sideways displacement of the gear.

Some background information is relevant for this study. Recent literature revealed results of observations of the reaction of schools of herring to an approaching research vessel. The findings given in [1, 2, 5] indicate potential for increasing catchability when avoiding the wake of the vessel. The presentation of this alternative rigging invoked interest within the International Council for the Exploration of the Sea (ICES) to apply this method to sampling gear for identification of fish close to the surface. Meanwhile the idea generated interest in the Dutch fishing industry, which resulted in contract research carried out by RIVO and the Dutch company IJmuiden Stores B.V. Model tests were done in the flume tank of Hirtshals in April 1990 on models scale 1 to 25 and 1 to 35 of commonly used Dutch trawls. These trials are not described in this paper. They indicated that without difficulties a single-door rigging could also be used for these nets. This finding was confirmed later on during the year on FRV "Tridens II", during full scale tests in May 1990. The research activities are summarised in Table 1 below.

2. FISHING GEAR PRINCIPLE.

The principle of this rig is depicted in Figure 1. The door is rigged at the port side and the Dan-leno at the starboard side. The warp running to the door crosses the path of the mouth opening of the trawl, which may be overcome by using an extension piece at the door and additional weight to press the warp end down. This variant has been tried but not succesfully until now. Very large floats attached to the wing ends avoid them to sink.

3. RIGGING OBJECTIVE.

The main objective is to catch fish close to the surface that is believed to escape through avoidance of the wake of the vessel.

The escape mechanism due to emitted sound in the wake of a trawler has been described by Ona and Misund, who studied the behaviour of schools of herring to an approaching vessel [1, 2]. The fish seem to stay clear of the wake behind the vessel and migrate sideways. Side-scan sonar observations showed that a surface layer of herring diverted sideways and cleared the path of an approaching trawl. This phenomenon explains the differences found during echo-surveys between the received echos and samples of fish caught with a trawl. Dutch trawler skippers report using a zig-zagging course when steering towards a school of herring, resulting in better catch rates.

Table 1: Review of research activities until 1990.

No	Year	Location	Method	Subject
1	1987 August	Lake Insko	Model study	Mechanical feasibility study
2	1988 August	Baltic Sea	Full-scale	Technical feasibility study on FRV "Ernst Haeckel"
3	1989 March	West of Ireland	Full-scale	Gear handling study on FRV "Ernst Haeckel"
4	1989 September	Atlantic Ocean	Full-scale	Measurements of drag and geometry on FRV "Ernst Haeckel"
5	1990 April	Flume tank Hirtshals	Model study	Net geometry and drag at scale 1 : 25 and 1 : 35, feasibility study of Dutch midwater trawls
6	1990 May	North Sea	Full-scale	Fishing trials with a 5600 meshes trawl on FRV "Tridens II"
7	1990 June	Lake Insko	Model study	Measurements of drag and geometry at scale 1 : 7 with several different riggings.

4. DESCRIPTION OF MODEL EXPERIMENTS.

4.1 General.

Research Station Lake Insko is a post of the "Instytut Akwakultury i Techniki Rybacki" (IATR) of the University of Agriculture, Szczecin used for model experiments on trawls and educational purposes. The lake is approximately 3.5 km long and has a depth of some 15 m. The circumstances can be ideal for trawl model experiements. There is little current and the wind conditions are mostly mild. Tows can de done on straight line tracks, but not over the total length of the lake without changing course. A specially designed catamaran is used for the trials. Nets can be observed mounted to two vertical poles at the bow of the vessel or rigged with warps, doors and bridles and towed behind the boat. Kwidzinski describes these facilities in great detail in [3]. For reference sake the principle dimensions of the catamaran are given in Table 2.

Table 2: Principle dimensions of Insko catamaran

Item	Value	Unit
length over all	11.70	m
beam	8.80	m
distance between the hulls	7.15	m
draught	0.70	m
displacement volume	8.50	m3
maximum speed	4.50	m/s
engine power	2*77	kW
thrust at v=3m/s	6000	N
number of propellers	2	-
number of rudders	2	-
number of winches	3	-

Instruction about the handling of trawls is regularly given to students of the University of Szczecin. The procedures in commercial trawling can be simulated accurately.

4.2 Data-acquisition.

The vertical, horizontal netopening and doorspread were measured with small echo-sounders tied on these parts of the trawl. The door attitude angles were measured with equipment developed at the University of Rostock. The angle of attack could be measured up to 40° and the angle of heel between -30° and +30°. The angle meters and a netsonde were linked to a "Spectrum ZX" personal computer to record the data. This computer was placed in the right cabin of the catamaran, used to store and process data. The left cabin is used to control the engines and winches. Table 3 gives an overview of recorded data:

Table 3: Data measured

Variable	Channel	Unit
Port warp load	1	N
Starboard warp load	2	N
Port divergence angle	3	millirad
Starboard divergence angle	4	millirad
Vertical netopening	5	cm
Horizontal netopening	6	cm
Port declination angle	7	millirad
Starboard declination angle	8	millirad
Towing speed	9	m/s
Door angle of attack	10	degrees
Door trim angle	11	degrees
Door heel angle	12	degrees
Water temperature	13	deg. C

Data was copied to an IBM-compatible PC at the end of each day and printed. The towing speed was recorded with an Ott-impeller log hanged between the bows of the catamaran in front of the net. This log is claimed to have an accuracy of ± 0.02 m/s. The exact weight attached to the wingends was measured before each haul and when necessary corrected for differences in water temperature and density.

4.3 Gear and rigging.

A model at scale ratio **1 to 7** of net **P-87/90-169 ("FANNY II")** has been used for all trials. Floats were attached to the wingends to keep the trawl at the surface. In the model they had a buoyancy of 235.5N. In addition floats were attached to the headline in bundles of three, with a buoyancy of 3.3N each. The warp length was kept constant at 50m and an extension of 1.5m was applied to the port warp to ensure the wingends to be at the same distance from the vessel. In order to appraise the influence of this extension in some experiments 2.5m was used. Three different types of doors have been tried. A bi-plane door, a profile door (Type Süberkrüb) and a Polish designed high lift door with end-plates, a leading edge flap and higher aspect ratio. This door is described in [4]. The various doors are sketched in Figure 2 and their dimensions, weights and codes of designation are given in Table 4.

Table 4: Dimensions and weights of doors. (* = measured under water with angle meters attached)

Dimension	Unit:	Area (m2)	Height (cm)	Width (cm)	Weight (kg)	Area FS (m2)
Type	Code					
Bi-plane	BP	2x0.1163	46.5	25	6.4*	2x5.64
Polish High Lift	PHL	0.1700	68	25	18	8.33
Polish High Lift	PHL	0.0630	52.5	12		3.09
Süberkrüb	S	0.1152	48	24		5.69

4.4 Design of experiments.

The following parameters of the rigging were varied throughout the experiments:

- Type of door
- Attachment of backstrops and warp to the door
- Extra weight attached to the Dan-leno
- Dan-leno weight
- Second door spreading to port, replacing Dan-leno
- Bridle weights attached to the lower wingends
- Extension of port warp

The towing speed was varied between 1.0m/s and 1.8m/s with steps of approximately 0.1m/s. Froude's Law was used to determine the towing speed for the model.

For most cases only one door has been used on the port side of the gear. In hauls 22 to 25 two doors were rigged to the net, both spreading in the same direction and of different size. The one on the port side being the largest. The net was towed with the headline centre and the wing-ends at the surface. Buoyancy and weight forces for the model were calculated with the cube of the length scale ratio (1 : 7).

4.5 Data analysis.

32 instrumentated hauls were done with an average duration of 25 minutes. A part of these trials were unsuitable for further comparison and analysis. The reason is unreliable recording of data due to malfunctioning of instruments or data transmission through cables, which unfortunately occured to some extent. The analysis was hempered also by the lack of information about the true course and drift angle of the catamaran, that obviously altered course during measurements to align with the centre of the lake. 22 hauls were grouped into four comparative sets of trials, for which the variables of the rigging were equal. Set 5 did not get a counterpart due to lack of comparable data. For this case the Dan-Leno had been replaced with a small trawl door rigged at starboard to generate spreading force in the same direction as the large door at the portside of the trawl. The measurements of the horizontal netopening were not further analysed due to cable transmission problems. The various comparative sets and groups are given in Table 5 and Table 7 with respective haul numbers.

Table 5: Review of comparitive experiments

Comparative set	Group a	Group b	Door type	Door area m2 (FS)
1	2, 6, 7	4, 5, 8, 9	Bi-plane	2 x 5.7
2	10, 13	11, 12	Bi-plane	2 x 5.7
3	14, 17, 21	18, 19	Polish high lift	8.33 (3.1)
4	28	29, 30	Süberkrüb	5.6
5	23, 24, 25	*	Bi-plane	2 x 5.2

In many cases more than one data-point was found at a certain towing speed leading to a large amount of scatter in the data. A possible explanation for some of this scatter is the fact that the vessel altered course during measurements. In other cases equal values were found at different speeds, which could indicate that new readings were not transmitted to the datalogger and old ones repeated.

Figures 3 to 35 depict the results of the measurements for the various comparative sets of hauls. The following parameters have been plotted against towing speed:

- Distance between centre line of vessel and Dan-leno
- Warp loads
- Divergence angles
- Declination angles
- Vertical netopening
- Distance between Dan-leno and door
- Door attack, trim and heel angles

Where appropriate, the upper regression formula given in the graphs represent the port side parameter and the lower one the starboard one.
Concerning the plots of door attitude angles it should be noted that positive heel means heeling inward, positive trim means falling backwards and of course positive attack means that the flow is directed to the inner surface of the door.

5 DISCUSSION OF RESULTS.

5.1 Distance between Dan-leno and centre-line of vessel.

The scatter in the results is large, presumably due to changes in course of the boat during measurements. It is hard to draw conclusions about the best rigging for the largest sideways displacement of the gear. Set 5 produces the largest values indicating the Bi-plane door to be the best spreader. It is recommended to measure the drift angle of the catamaran in future experiments to avoid these problems.

5.2 Warp loads.

Contrary to earlier findings at full-scale on FRV "Ernst Haeckel" the starboard side shows higher warp loads in most cases. It was expected that the warp with the door would have the highest load, but this appears not to be the case. Calculating the various weight components attached to the gear shows large discrepancies between the full-scale and equivalent model values, that could be the explanation.

Table 6: Weights in model and full-scale equivalents

Experiment	FRV "Ernst Haeckel"		Lake Insko	
Gear component	Full-scale real value	Full-scale equivalent value	Model real value	Model equivalent value
Unit	(kg)	(kg)	(kg)	(kg)
Door	? ? ?	BP: 2195 PHL: 6174 S: 2709	BP: 6.4 PHL: 18 S: 7.9	- - -
Dan-leno	650 450	2126, 1098 5831, 5145 2435	6.2, 3.2 17, 15 7.1	1.89 1.23
Bridle weight	425	5042, 2161	14.7, 6.3	1.24

Comparative set 1:
Door attachment points of warps and bridles have been varied for the groups a and b of this set (see Table 7). The codes for these points are explained in Figure 2. The data points of haul 3 were substantially lower than for the other ones in the same group. No explanation could be found and therefore these data points were omitted from Figure 8. It is clear that the attachment of warps and bridles has a significant effect on the warp loads.

Comparative set 2:
For this set slightly longer bridles were used, 2.5m instead of 1.5m. Group a and group b also differ in respect of the bridle attachment points. In fact a true analysis of the effect

of the bridle elongation is therefore not possible as both effects are measured at the same time. The warp loads do not seem to be affected to a great extent (Figure 9).

Comparative set 3:
For this set the warp attachment to the PHL-door has been varied. Group a shows a higher load on the port warp than group b. (Figure 10)

Comparative set 4:
This set shows the effect of changing the warp attachment point on the S-door on the warp loads. In group b the warp is rigged at a higher angle of attack, but the spread and load are not higher, contrary to the expectation (Figure 11).

Comparative set 5:
Replacing the Dan-leno by a small door leads to more load on the S-warp. Both curves run almost parallel (Figure 12).

5.3 Divergence angles.

Comparative set 1:
The divergence angles do not vary much with towing speed for both the port and the starboard side. Group a shows an increasing angle especially at the door side, indicating the door still to be effective at higher speeds. For group b many data-points are found at 16.5 degrees. It looks as though the angle meter had reached its outer limit (Figure 13).

Comparative set 2:
Changing the backstrop attachment on the door from point 2 to point 1 improves the side-ways displacement of the gear by approximately 2^{o}. The distance between Dan-leno and door is not signeficantly changed however. Some S-divergence angles reach negative values, the Dan-leno does not pass the centreline of the vessel in those cases (Figure 14).

Comparative set 3:
The effect of attaching the warp in point 2 instead of point 1 to the PHL-door on the divergence angles is negligible (figure 15).

Comparative set 4:
Changing the warp point from 1 to 2 on the S-door results in slightly increased divergence angles, in other words the door pulls the gear more side-ways. As point 2 means a higher angle of attack this result is consistent (Figure 16).

Comparative set 5:
The use of two door spreading in the same direction has a great effect on the position of the gear (Figure 17). Both divergence angles are significantly increased and rise stronger with speed. This result confirms the result of Figure 7 showing a larger side-ways displacement of the gear.

5.4 Declination angles.
Comparative sets 1, 2, 4 and 5 do not show a large difference in declination angles. Set 3 shows larger angles, the gear sinks deeper as may be expected due to the larger weights of both door and Dan-leno. In most cases the port side sinks deeper which is consistent with negative door heel angles that often occured. (Figure 18-22).

5.5 Vertical netopening.
The normal tendency of headline height to decrease with increasing towing speed is clear in all cases. The differences between the various sets are rather large in some cases. Adding 1m warplength seems to cause the headline height to decrease (Set 2 vs Set 1),

especially for the hauls in groups b. The heavy PHL-door pulls the gear more open in vertical direction as can be seen from comparison of Set 2 and Set 3.

5.6 Distance between Dan-leno and door.

Sensible readings were only obtained for Sets 1, 2 and 3. In all cases the distance increases without reaching a maximum value, indicating that the door is not losing its spreading power (Figures 28 - 30).

5.7 Door angles.

Figures 31 - 35 depict the door attack, trim and heel angles plotted against the towing speed. The BP-door reaches attack angles of 30°-40°. The PHL-door comes to 25°-30°, whilst the S-door values are around 25°. Trim angles of the BP-door can be negative, indicating the door to tip the nose forward and the heel for this door is negative in many cases. The PHL-door shows a large negative trim and heel (Figure 33). The S-door has a positive trim, but a negative heel angle (Figure 34). This somewhat peculiar door attitude is caused by the fact that the gear top wing ends are on the surface and the door positioned deeper, contrary to normal midwater operations.

6. CONCLUSIONS AND RECOMMENDATIONS.

The results show that this rigging meets the objective of towing the gear outside the wake of the vessel. Comparative fishing trials are still necessary to prove whether this rigging also improves catchability. The best rigging for maximum sideways displacement of the gear seems to be a rig with two doors of unequal size spreading both in the same direction, although some additional loss in gear spread will result. The Bi-Plane door showed to be an effective spreader for this gear. The Polish High Lift door did not produce the best results, but the main reason may be the weight of this model door, that was too large to be representative. The geometry of the gear is also dependent on a proper extension of the warp to which the door is attached. The optimum value has not been found yet and will depend on the total length of warps applied. Further optimization of this rigging can be done once it has been proven that the principle works from a fish behaviour point of view.

The facilities at Lake Insko are very suitable for carrying out of training and research projects on large models in open water. The equipment needs to be improved however to avoid unnecessary loss in valuable research time. It is a common problem in East-European countries that electronic components and computer facilities are severely lacking. With financial input from aid-programmes in education and research a much higher quantitative and qualitative training and research output can be expected. A Joint European Project proposal between Poland, The Netherlands, Germany and the United Kingdom has been submitted in the EC-programme TEMPUS to achieve this objective.

7. ACKNOWLEDGEMENTS.

The authors are most indebted to prof dr. J. Swiniarski for his kind invitation to come to Insko to carry out these experiments. Furthermore we like to thank Dr. Henryk Sendlak for his data-acquisition and analysis work. A word of gratitude should also be addressed to the crew of the Insko catamaran and the various guests at the Station for their effort to run the vessel and handle the gears. We also like to thank Dr. Mathias Paschen from the University of Rostock for his organisation and management and Bodo Schäfer from IfH-Rostock for his professional input in the project. It was a stimulating and pleasant experience.

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ICES C.M. 1990/B:19

Table 7: Review of experiments with variables of the rigging.

Haul no.	Set	Grp	Warp length (m)	Bridle length (m)	Door type	Attachment point door: warp (nr)	Upper strop (nr)	Lower strop (nr)	Door weight P (kg)	Dan-leno weight S (kg)	Bridle weight P/S (kg)	variable identifier
1			50	1.5	BP	1	1	1	6.4	6.2	14.7	Hn/Bn
2	1	a	50	1.5	BP	1	1	1	6.4	6.2	6.3	Hn/Bn
3			50	1.5	BP	1	2	2	6.4	6.2	6.3	Hn/Bn
4	1	b	50	1.5	BP	1	2	2	6.4	6.2	6.3	Hn/Bn
5	1	b	50	1.5	BP	1	2	2	6.4	6.2	6.3	Bs
6	1	a	50	1.5	BP	1	1	1	6.4	6.2	6.3	Bs
7	1	a	50	1.5	BP	1	1	1	6.4	6.2	6.3	Hn/Bn
8	1	b	50	1.5	BP	1	2	2	6.4	6.2	6.3	Hn/Bn
9	1	b	50	1.5	BP	1	2	2	6.4	6.2	6.3	Hn/Bn
10	2	a	50	2.5	BP	1	2	2	6.4	6.2	6.3	Hn/Bn
11	2	b	50	2.5	BP	1	1	1	6.4	6.2	6.3	Hn/Bn
12	2	b	50	2.5	BP	1	1	1	6.4	6.2	6.3	Bs
13	2	a	50	2.5	BP	1	2	2	6.4	6.2	6.3	Bs
14	3	a	50	1.5	PHL	1	1	1	18	17	6.3	Hn/Bn
15			50	1.5 [.18]	PHL	1	1	1	18	17	6.3	Hn/Bn
16			50	1.5	PHL	1	1	1	18	8.4	6.3	Hn/Bn
17	3	a	50	1.5	PHL	1	1	1	18	17	6.3	Bs
18	3	b	50	1.5	PHL	2	1	1	18	17	6.3	Bs
19	3	b	50	1.5	PHL	2	1	1	18	17	6.3	Hn/Bn
20			50	1.5	PHL	1	1	1	18	17	6.3	Hn/Bn
21	3	a	50	1.5	PHL	1	1	1	18	17	6.3	Hn/Bn
22			50	1.5	PHL	1	1	1	18	15*	6.3	Hn/Bn
23	5	a	50	1.5	BP	1	3	3	6.4	6.2*	6.3	Hn/Bn
23a			60	1.5	BP	1	3	3	6.4	6.2*	6.3	Hn/Bn
24	5	a	50	1.5	BP	1	3	3	6.4	6.2*	6.3	Bs
24a			60	1.5	BP	1	3	3	6.4	6.2*	6.3	Bs
25	5	a	50	1.5	BP	1	3	3	6.4	6.2*	6.3	Bs
26			50	1.5	BP	1	1	1	6.4	3.2	6.3	Hn/Bn
27			50	1.5	BP	1	1	1	6.4	3.2	6.3	Bs
28	4	a	50	1.5	S	1	1	1	7.9	7.1	6.3	Hn/Bn
29	4	b	50	1.5	S	2	1	1	7.9	7.1	6.3	Hn/Bn
30	4	b	50	1.5	S	2	1	1	7.9	7.1	6.3	Bs

BP	- Bi-plane door
PHL	- Polish High Lift
S	- Süberkrüb

Bn	- horizontal netopening
Hn	- vertical netopening
Bs	- distance Dan-leno to door

* means second door on S-side used.

Figure 1 *Rigging principle.*

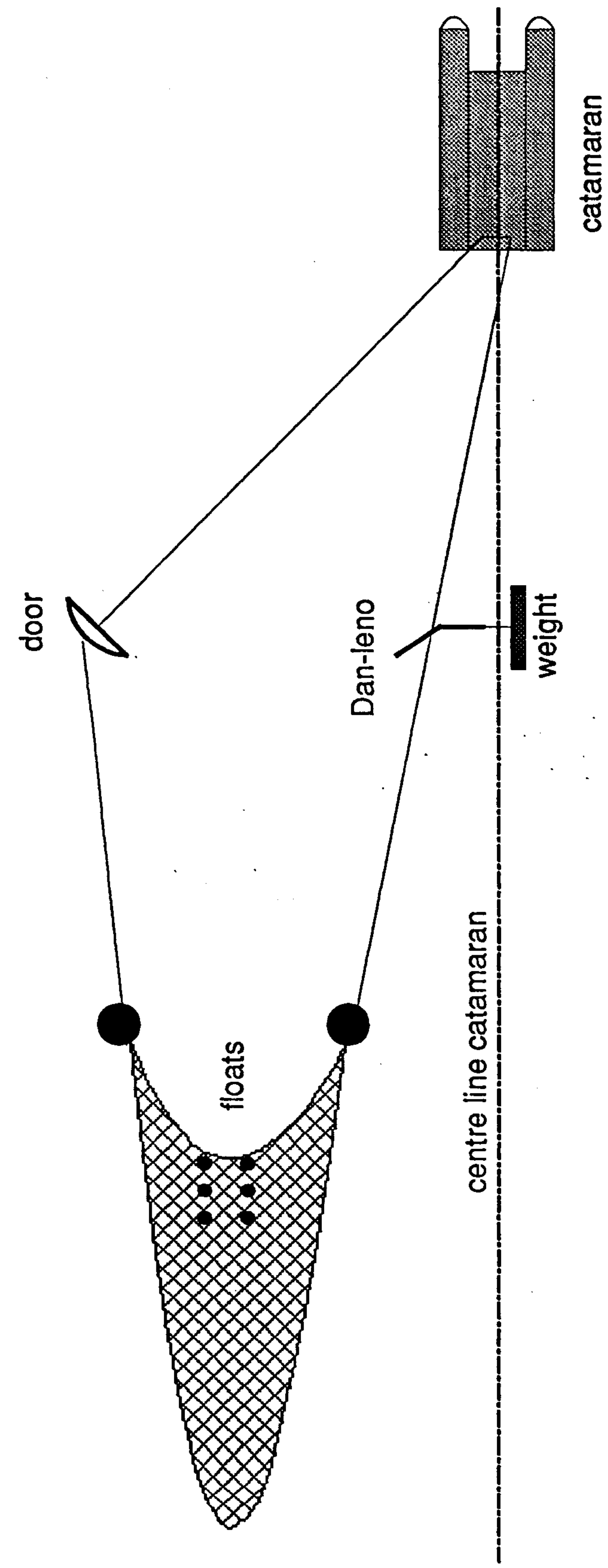


Figure 2 *Sketch of doors and Dan-leno with attachment points and codes.*

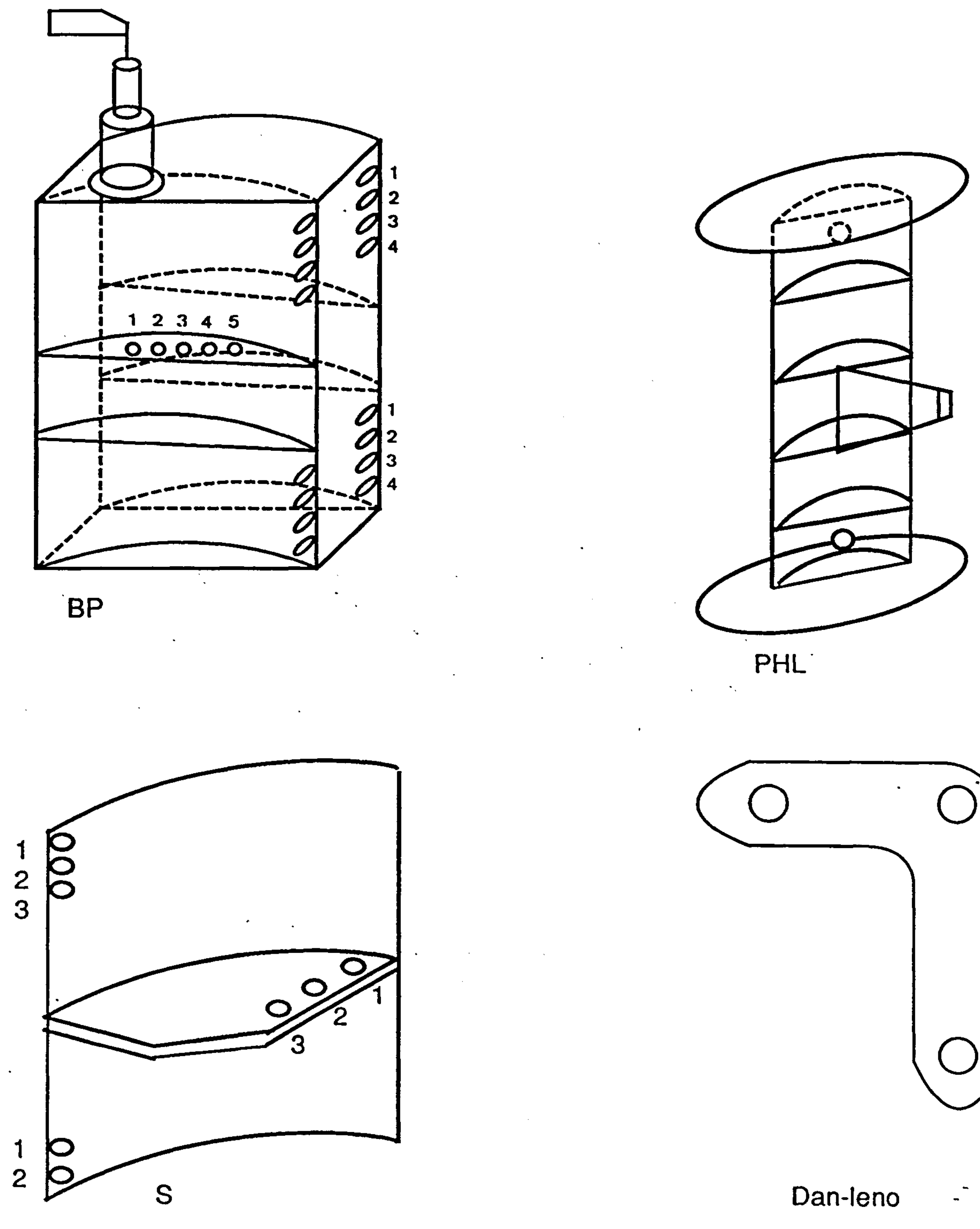


Figure 3 *Distance between Dan-leno and centreline of the vessel vs. towing speed.*

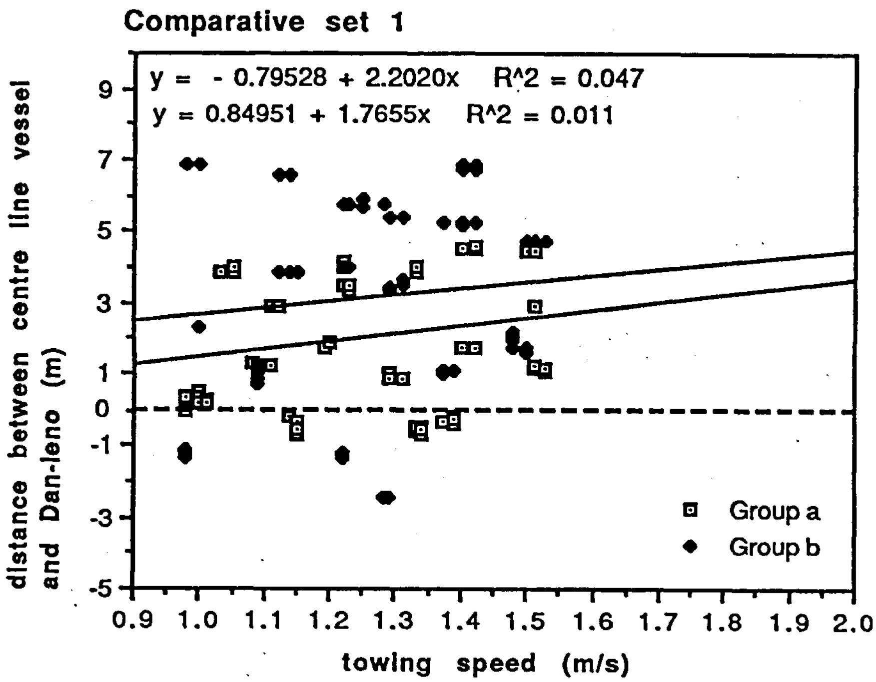


Figure 4 *Distance between Dan-leno and centreline of the vessel vs. towing speed.*

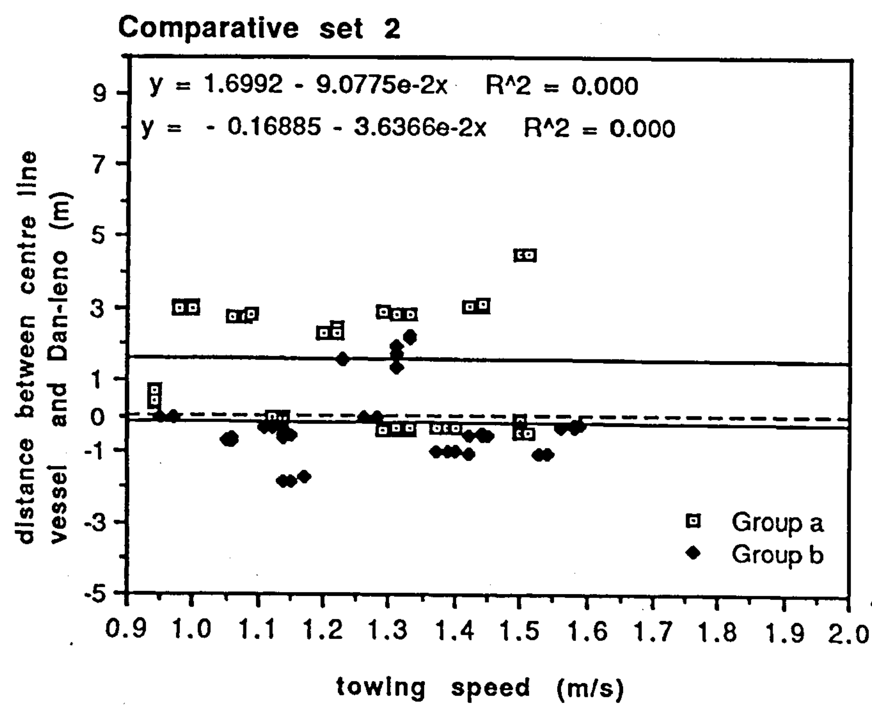


Figure 5 *Distance between Dan-leno and centreline of the vessel vs. towing speed.*

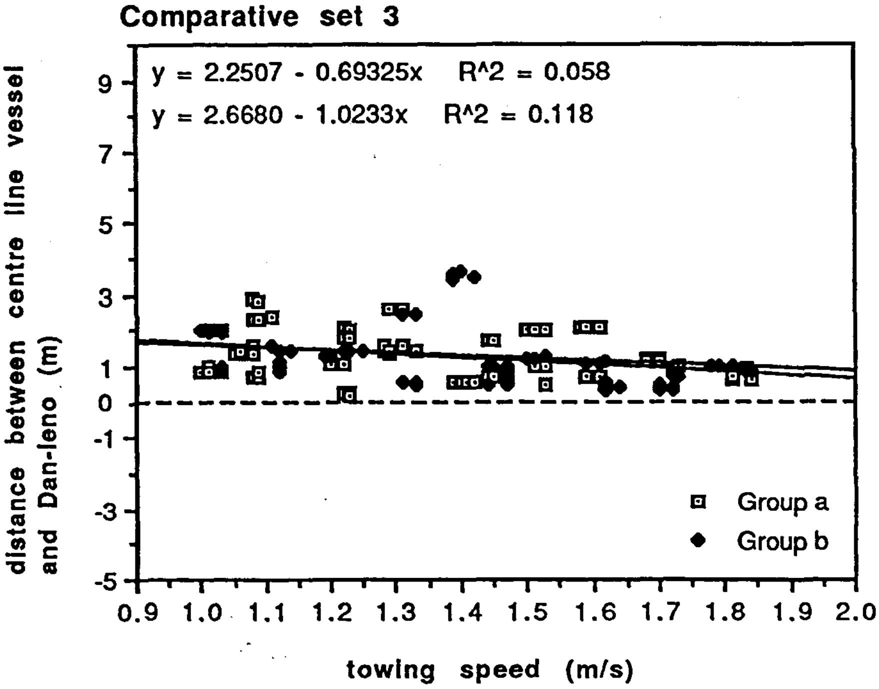


Figure 6 *Distance between Dan-leno and centreline of the vessel vs. towing speed.*

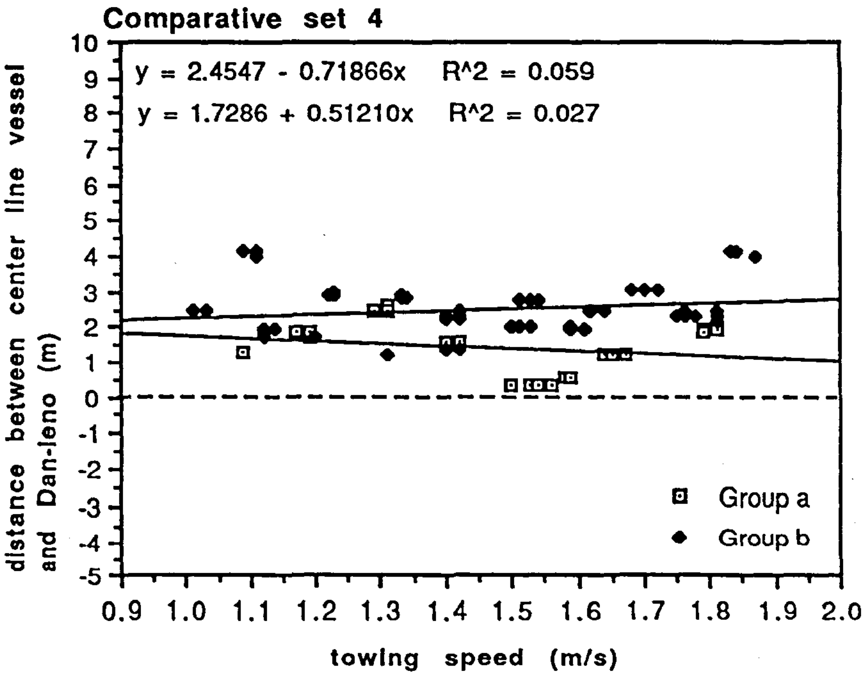


Figure 7 *Distance between Dan-leno and centreline of the vessel vs. towing speed.*

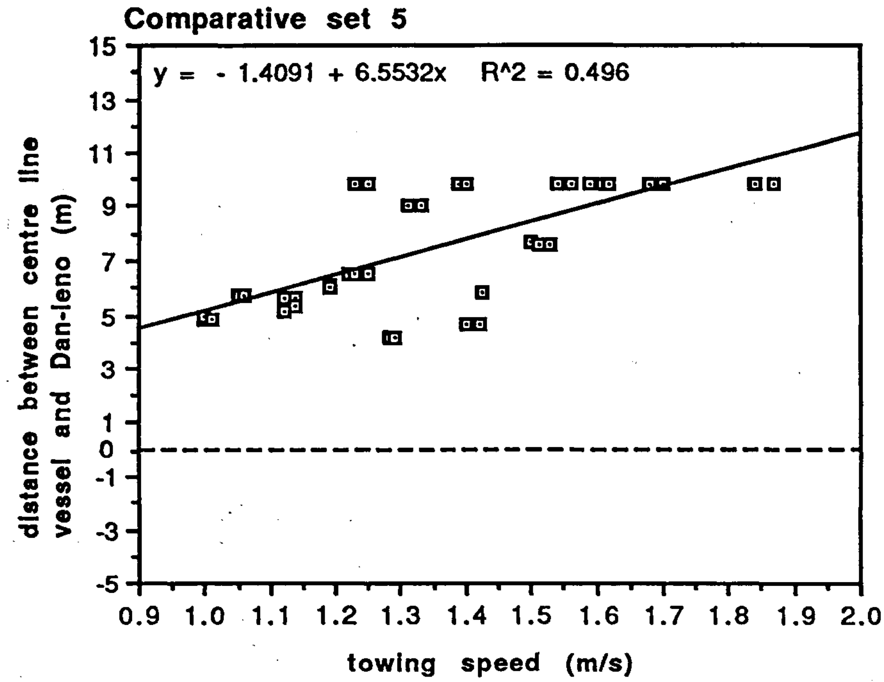
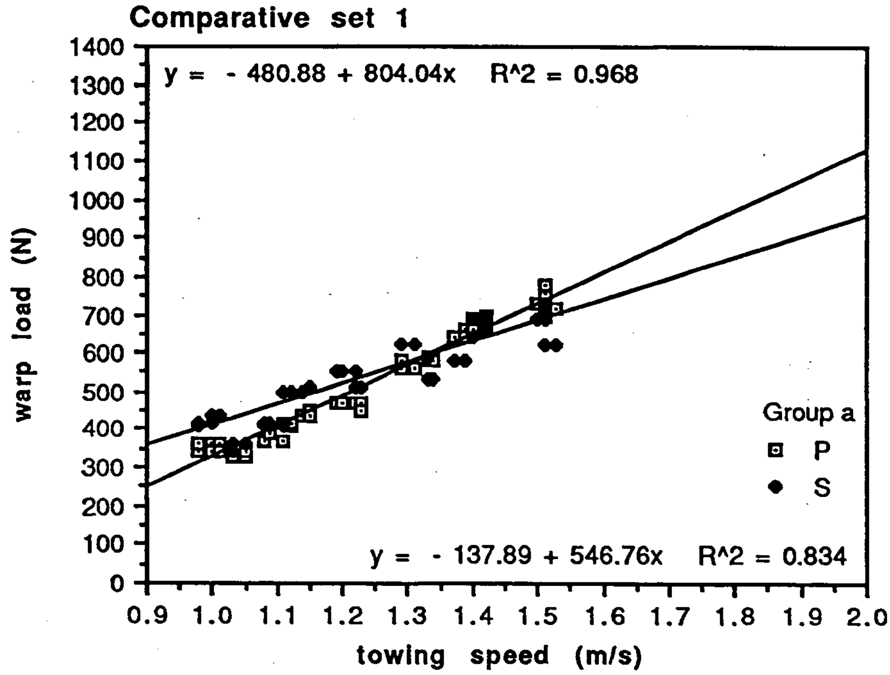


Figure 8 *Warp load vs. towing speed.*



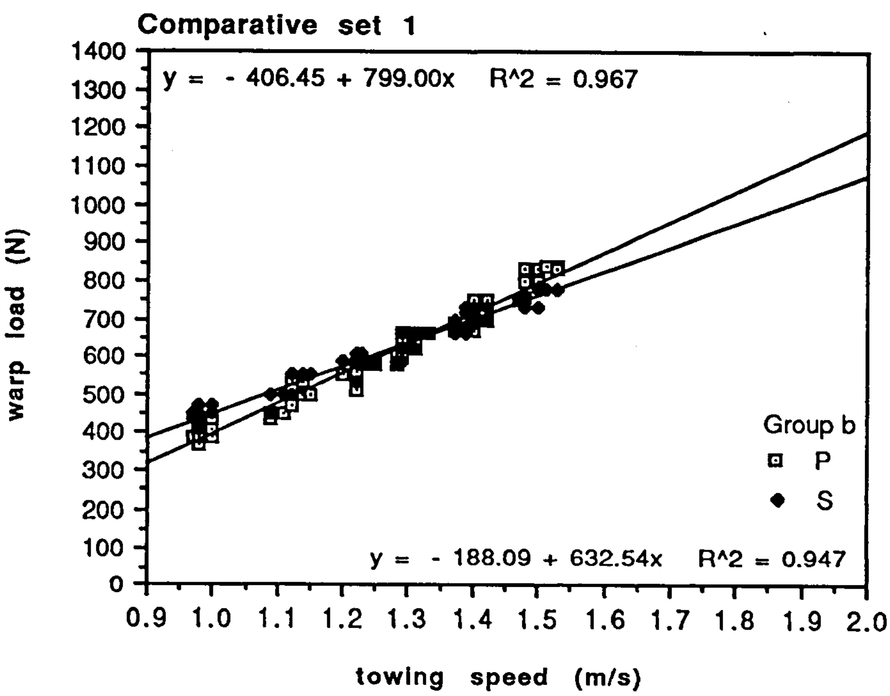
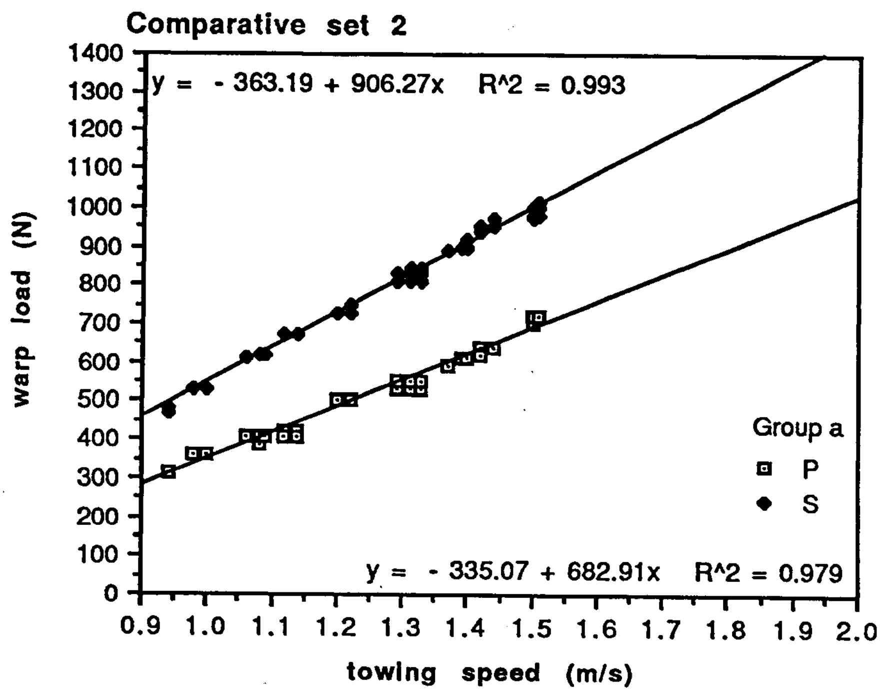


Figure 9 *Warp load vs. towing speed.*



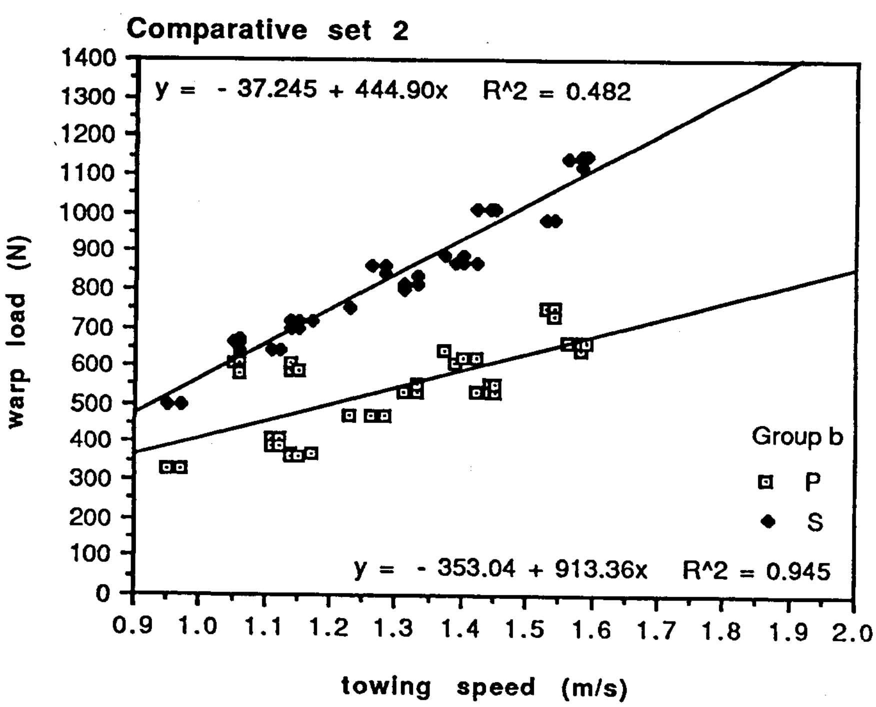
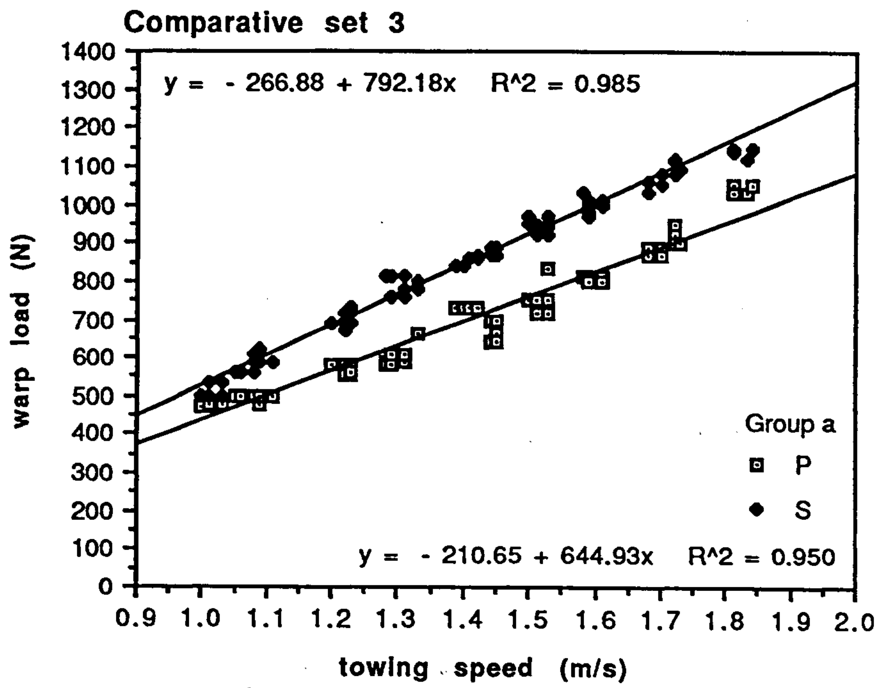


Figure 10 *Warp load vs. towing speed.*



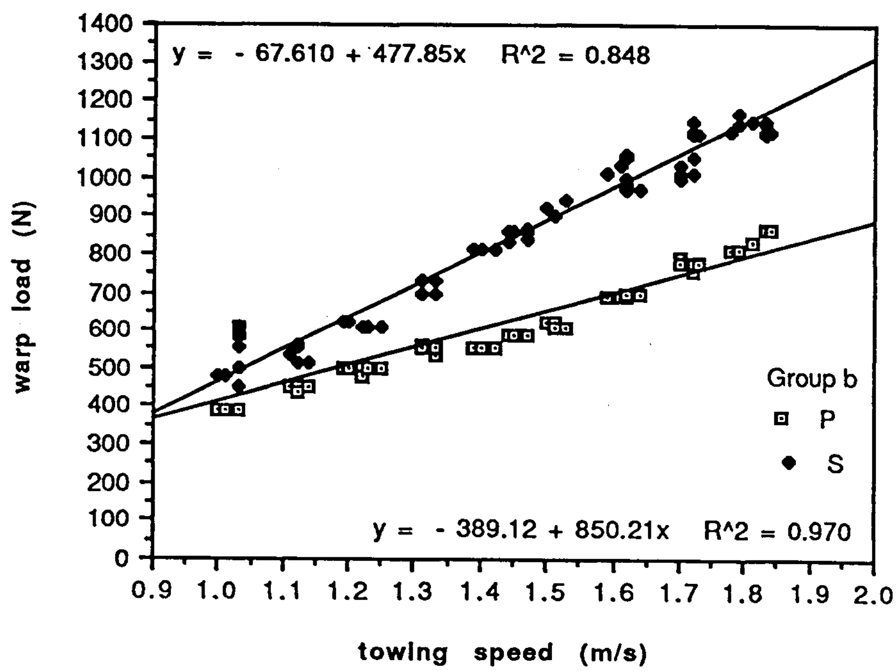
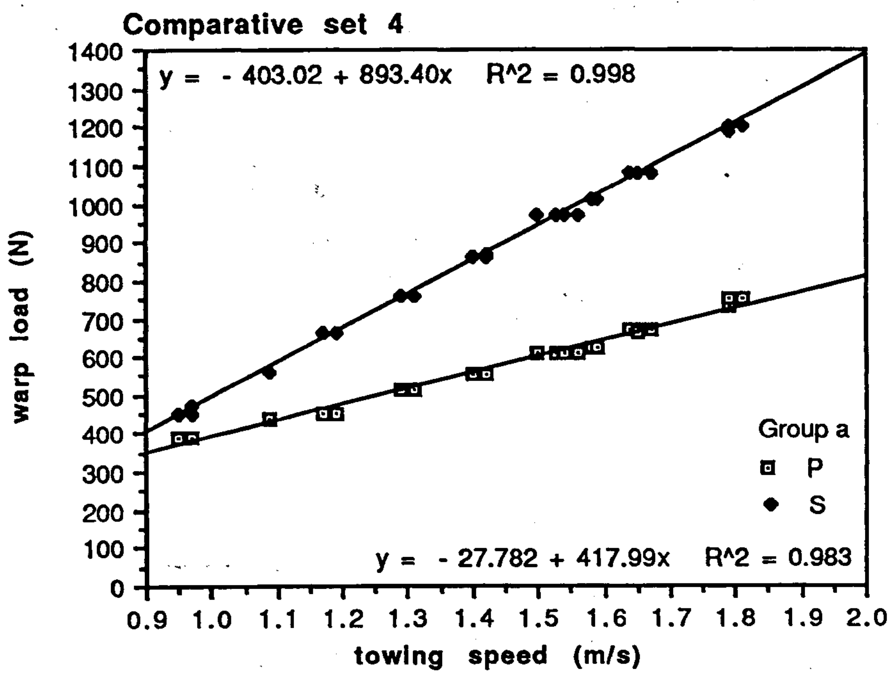


Figure 11 *Warp load vs. towing speed.*



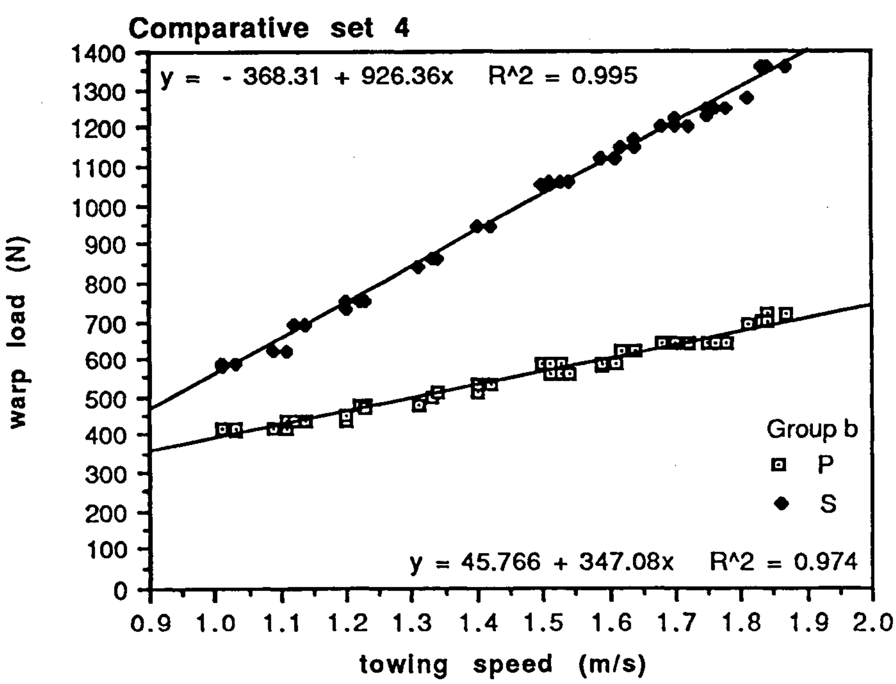


Figure 12 *Warp load vs. towing speed.*

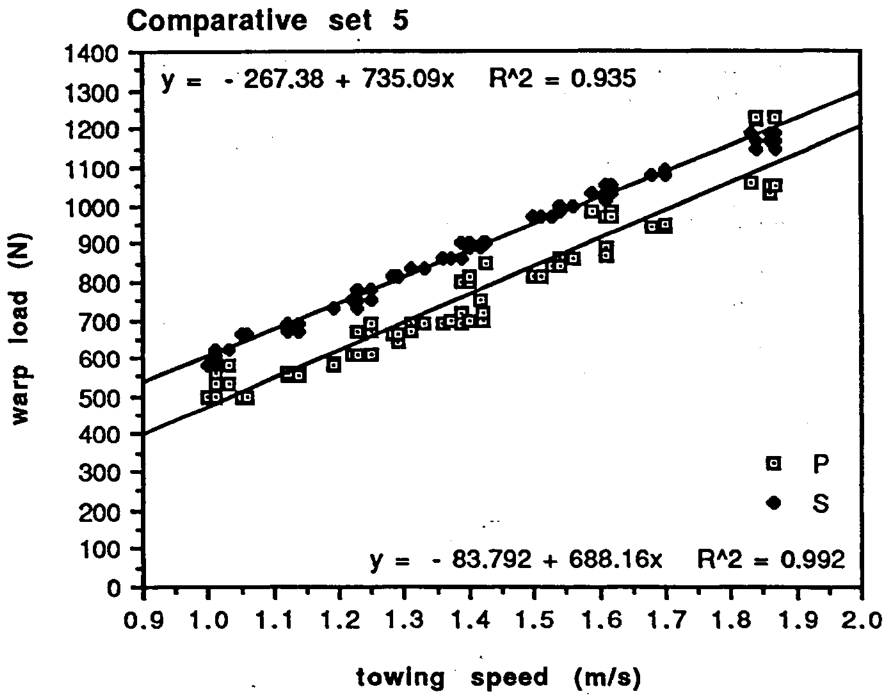
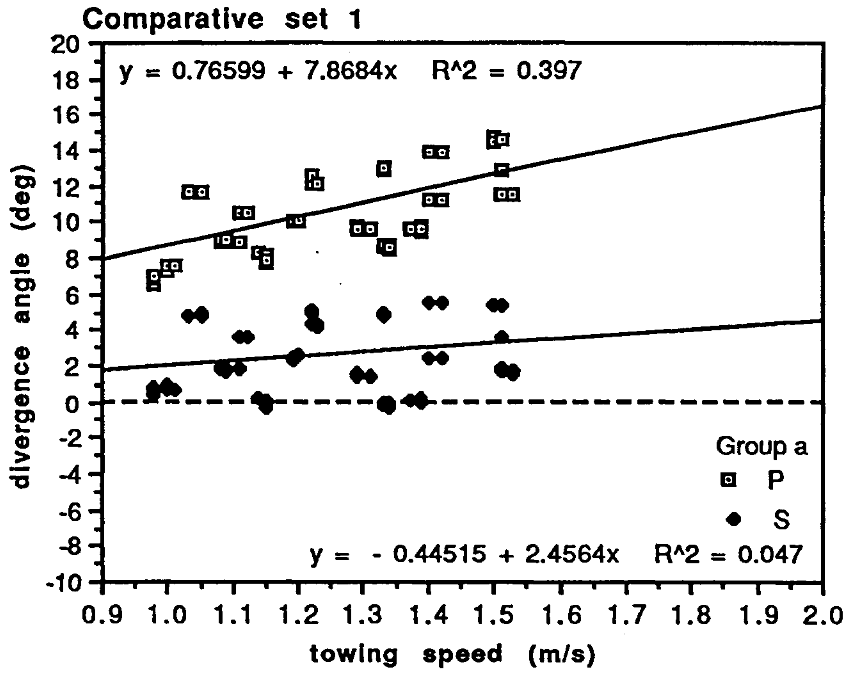


Figure 13 *Divergence angle vs. towing speed.*



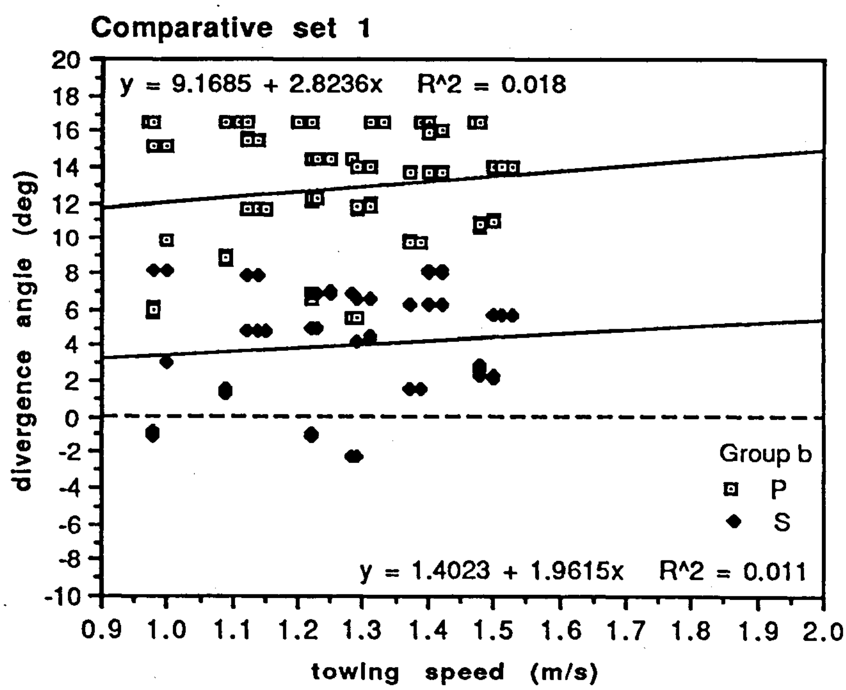
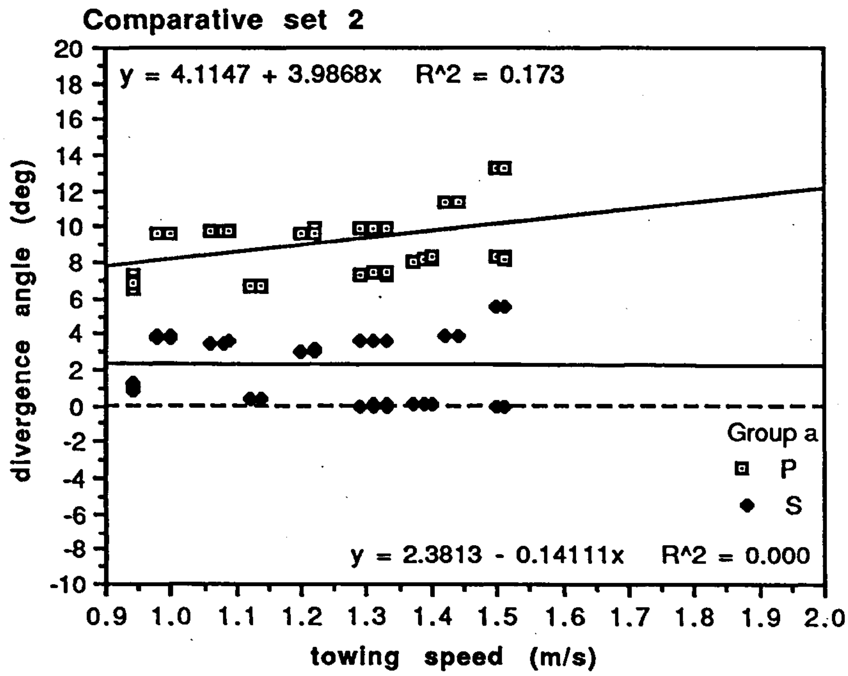


Figure 14 *Divergence angle vs. towing speed.*



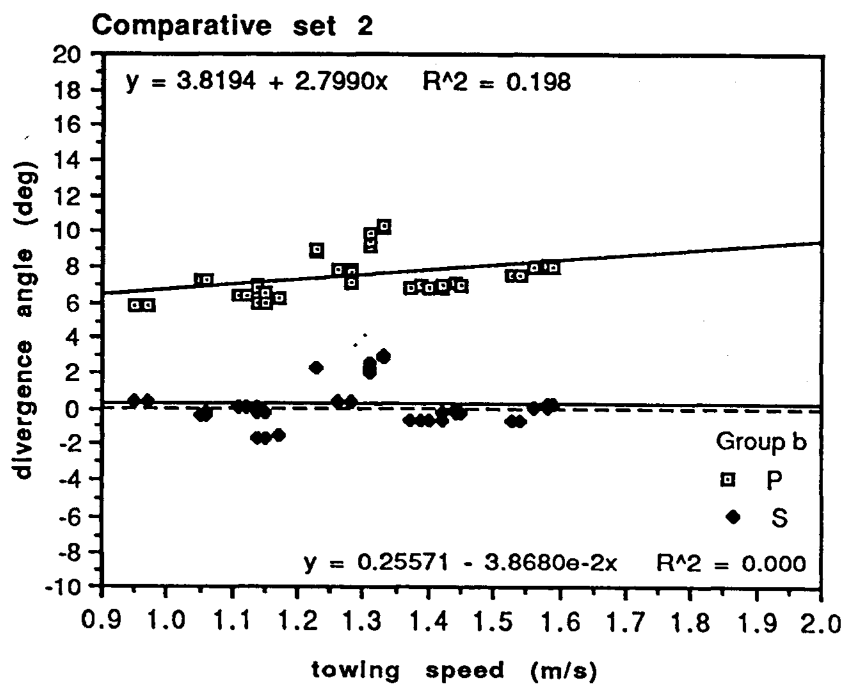


Figure 15 *Divergence angle vs. towing speed.*

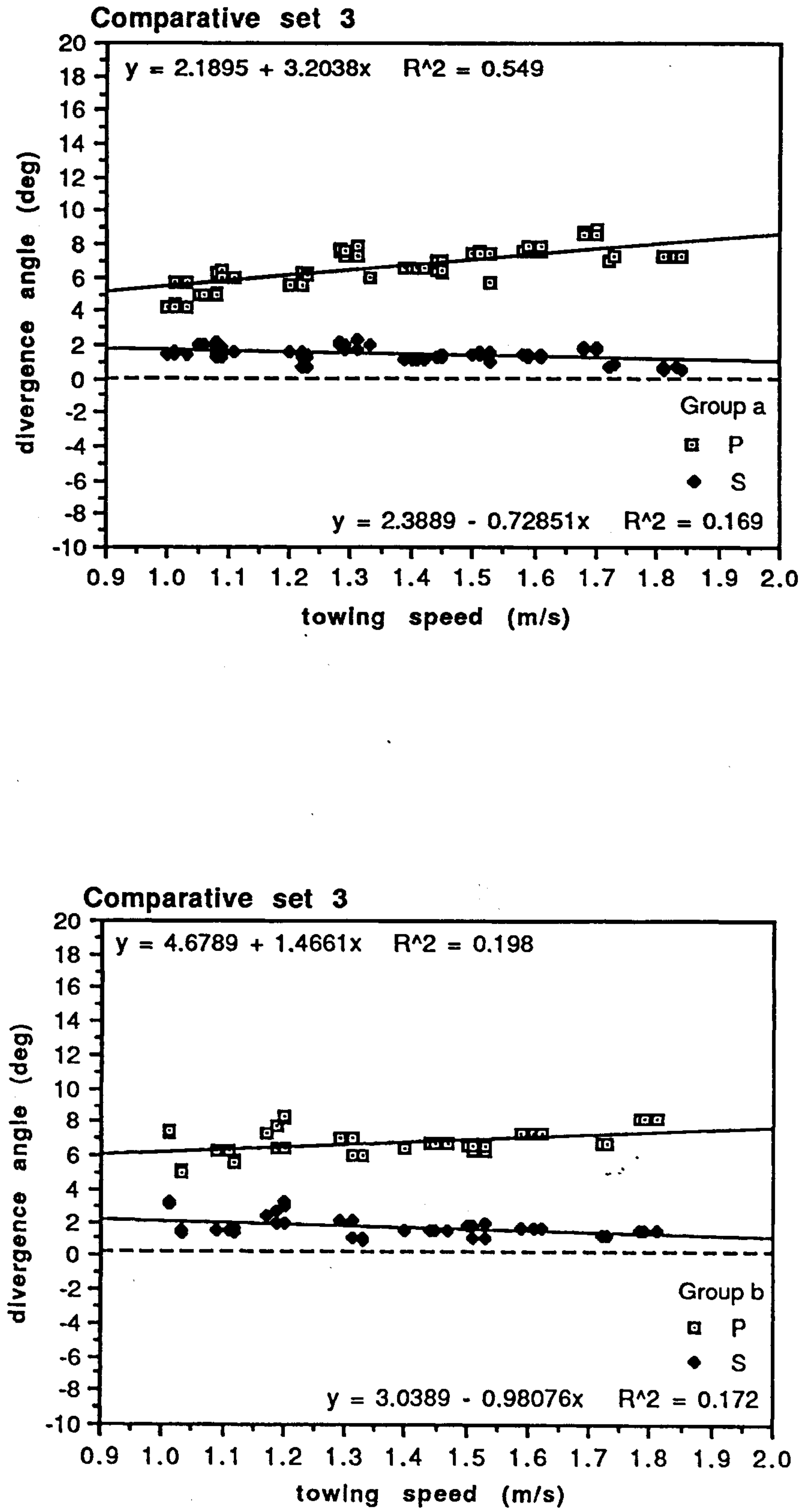
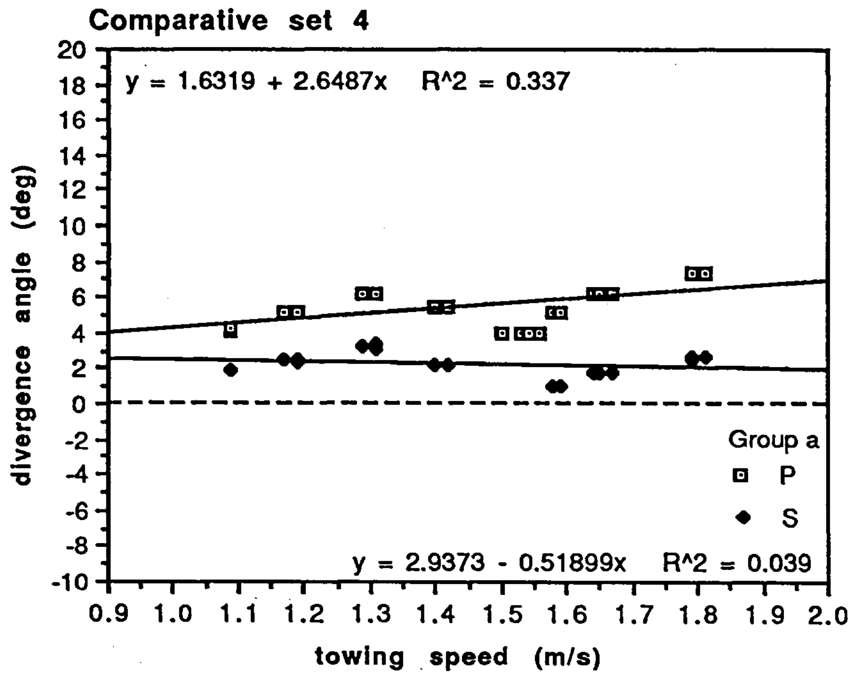


Figure 16 *Divergence angle vs. towing speed.*



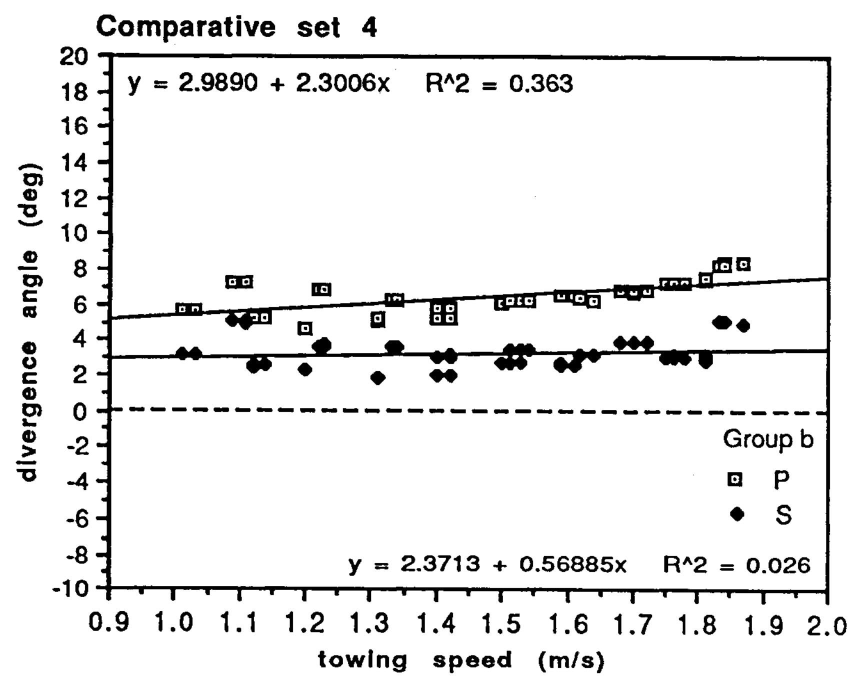


Figure 17 *Divergence angle vs. towing speed.*

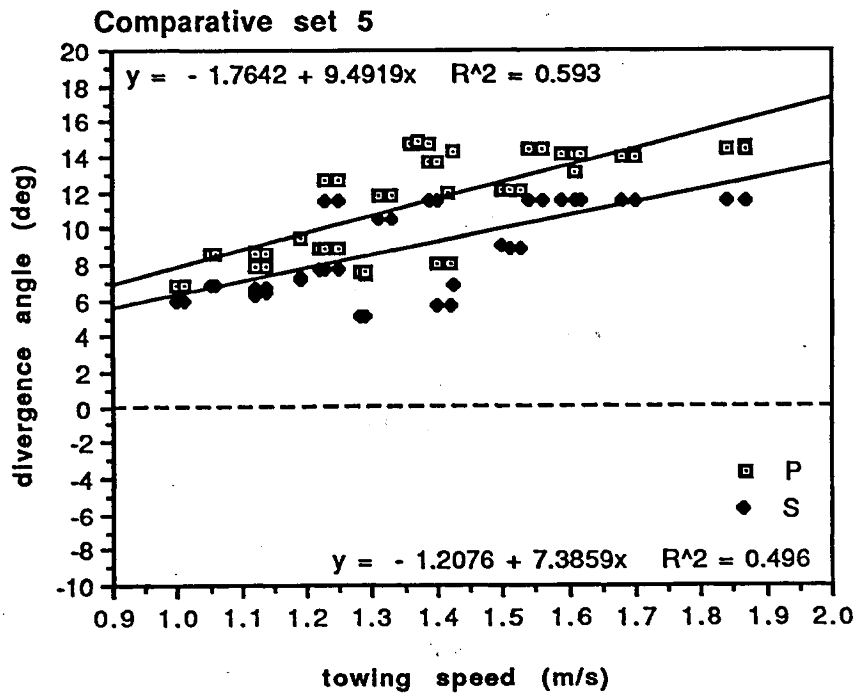
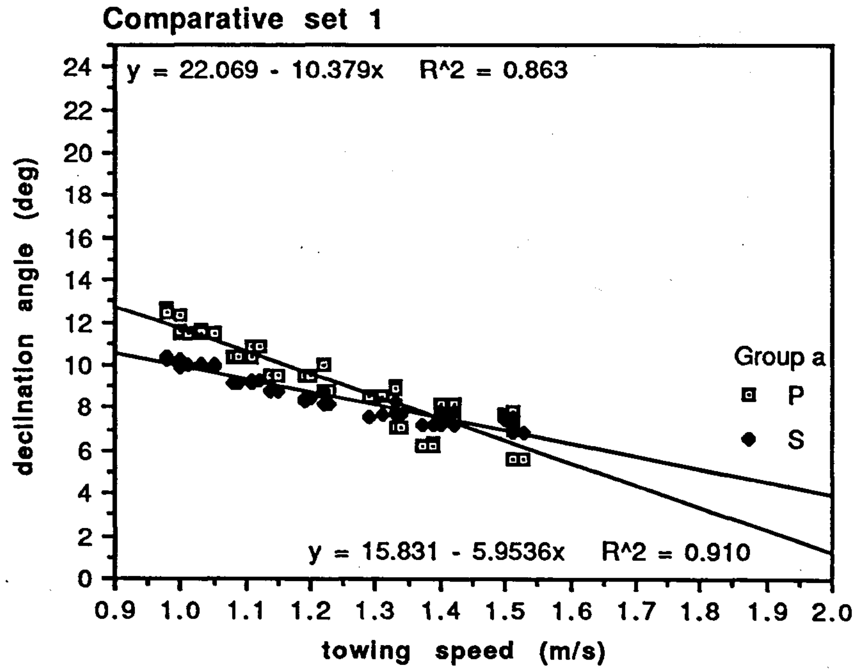


Figure 18 *Declination angle vs. towing speed.*



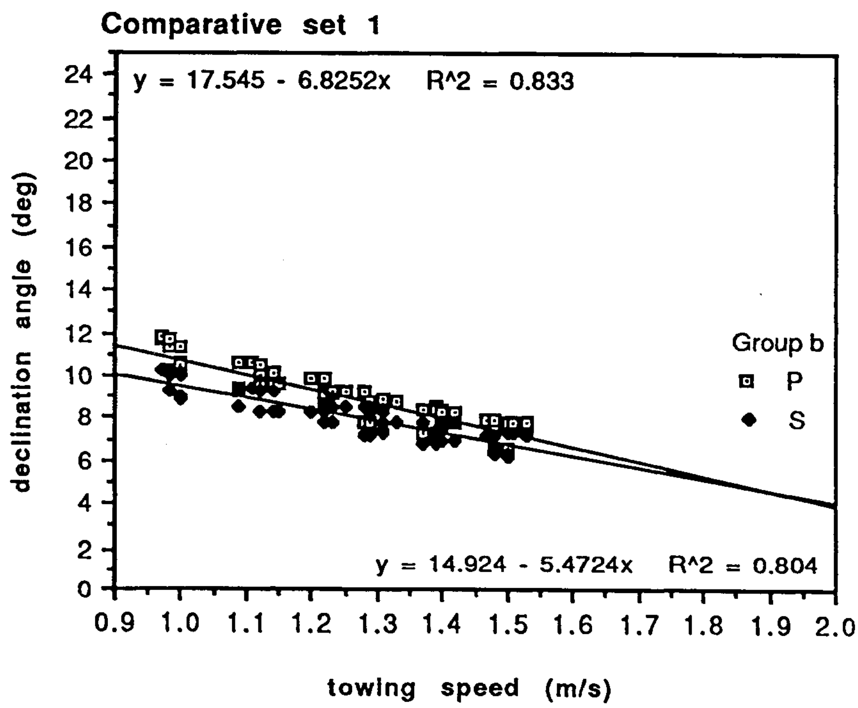
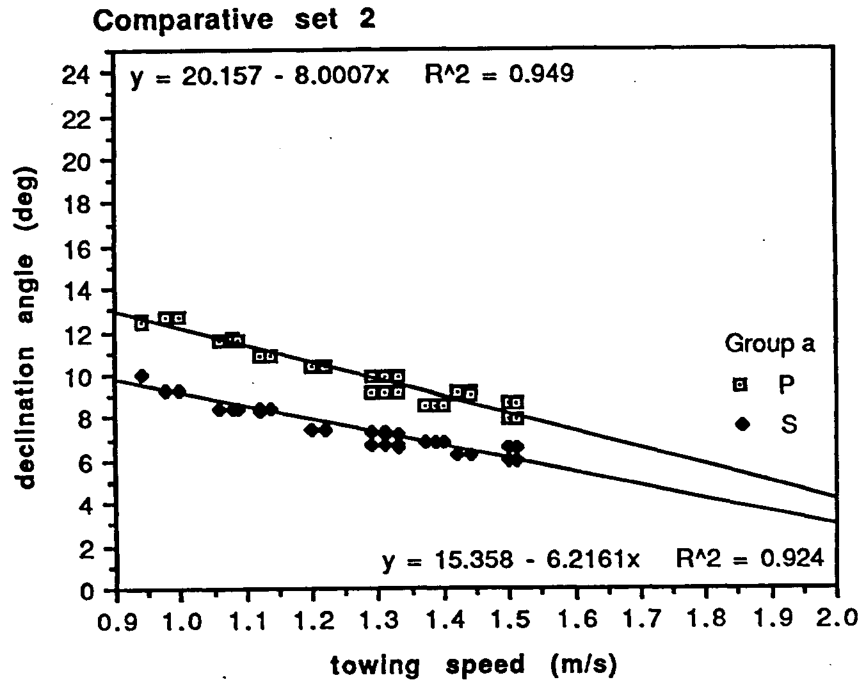


Figure 19 *Declination angle vs. towing speed.*



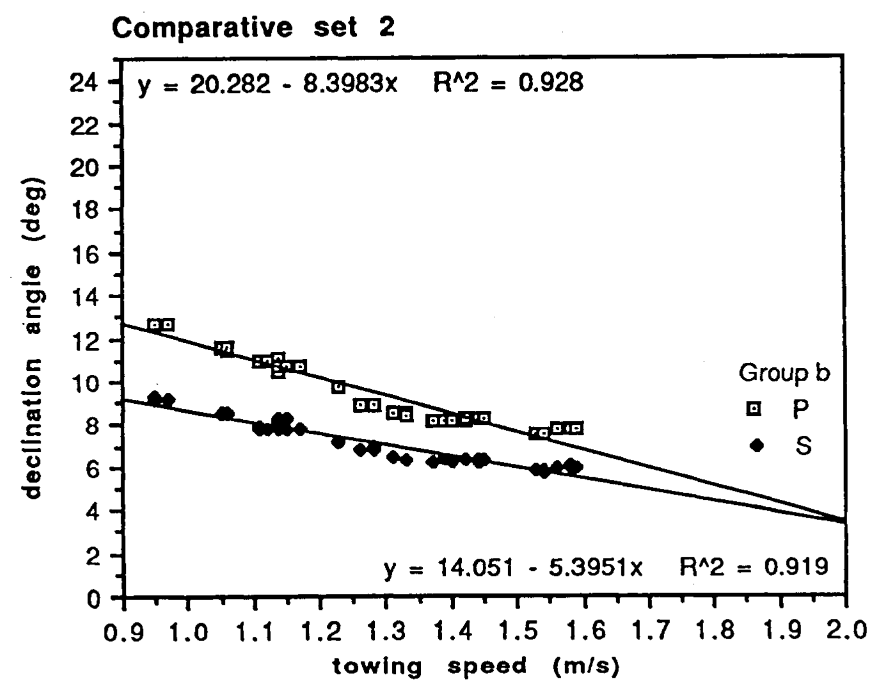
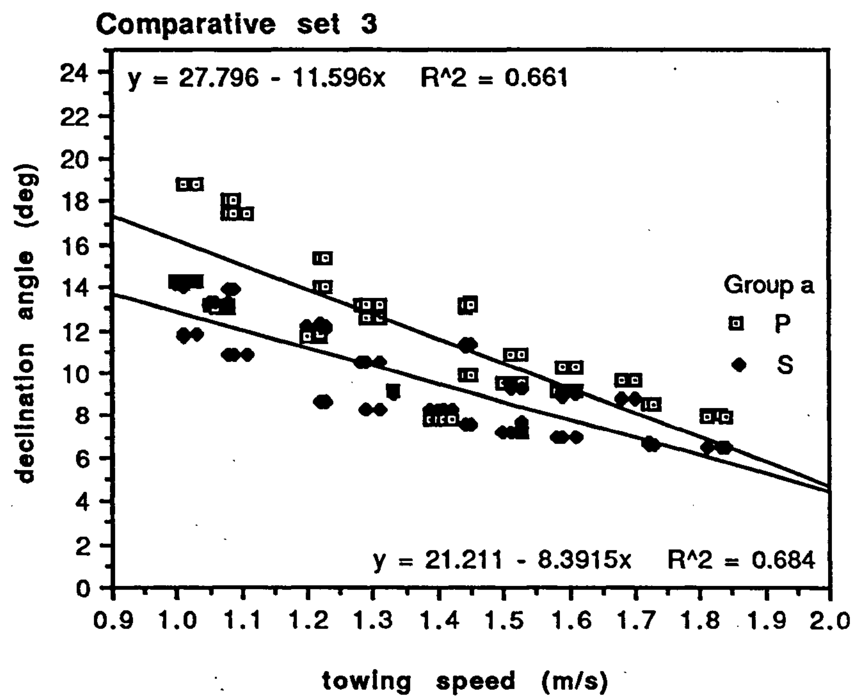


Figure 20 *Declination angle vs. towing speed.*



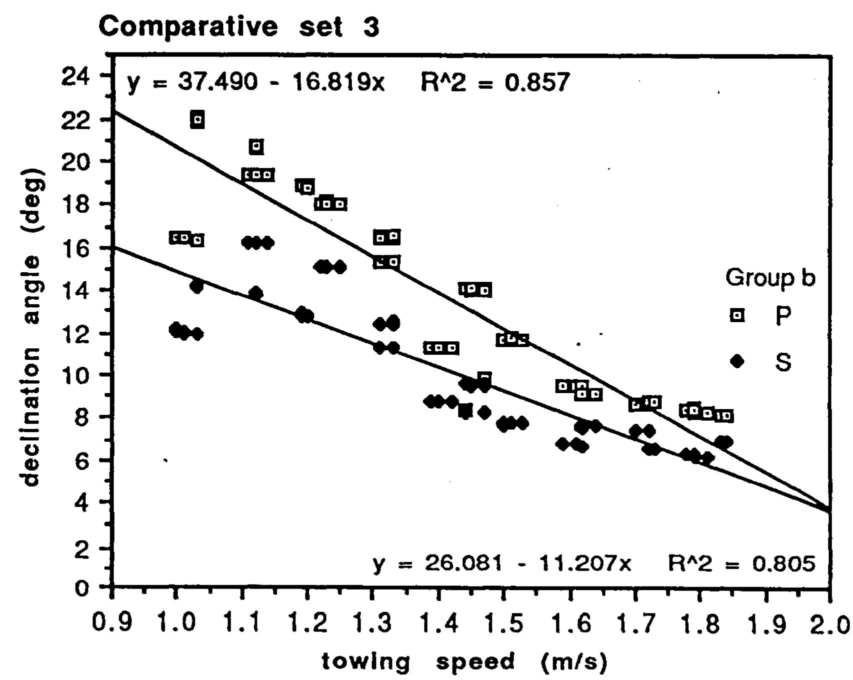
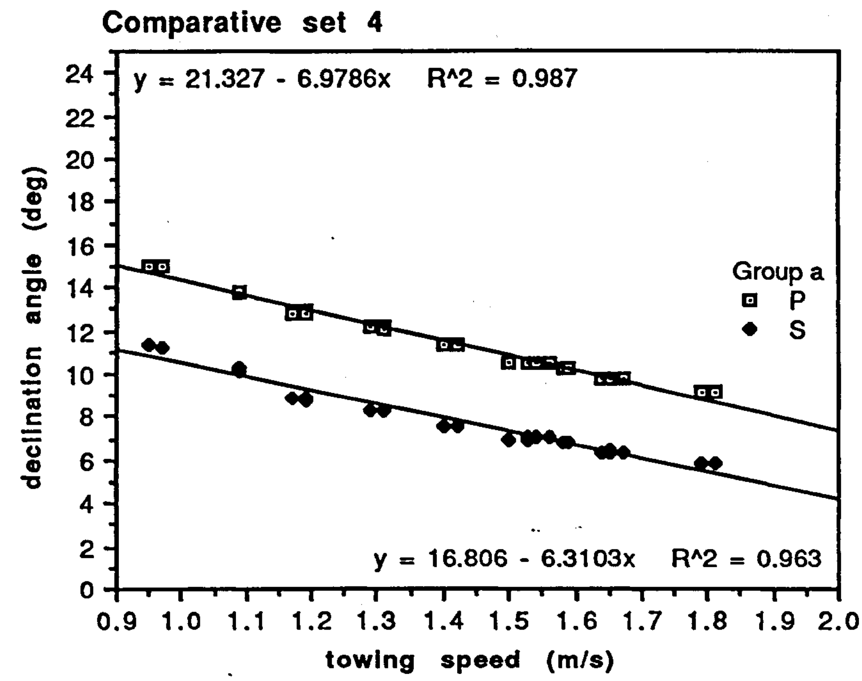


Figure 21 *Declination angle vs. towing speed.*



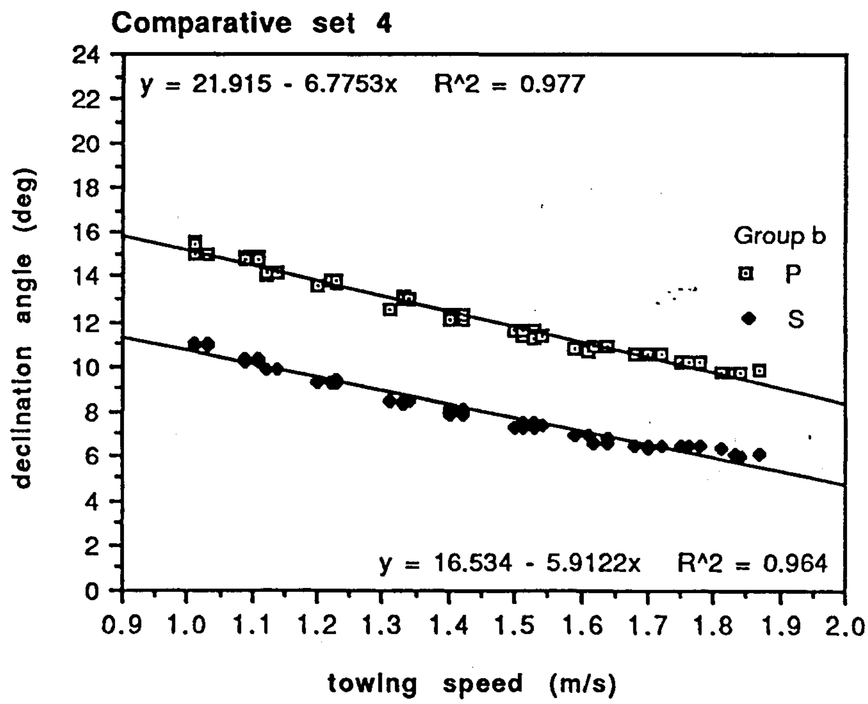


Figure 22 *Declination angle vs. towing speed.*

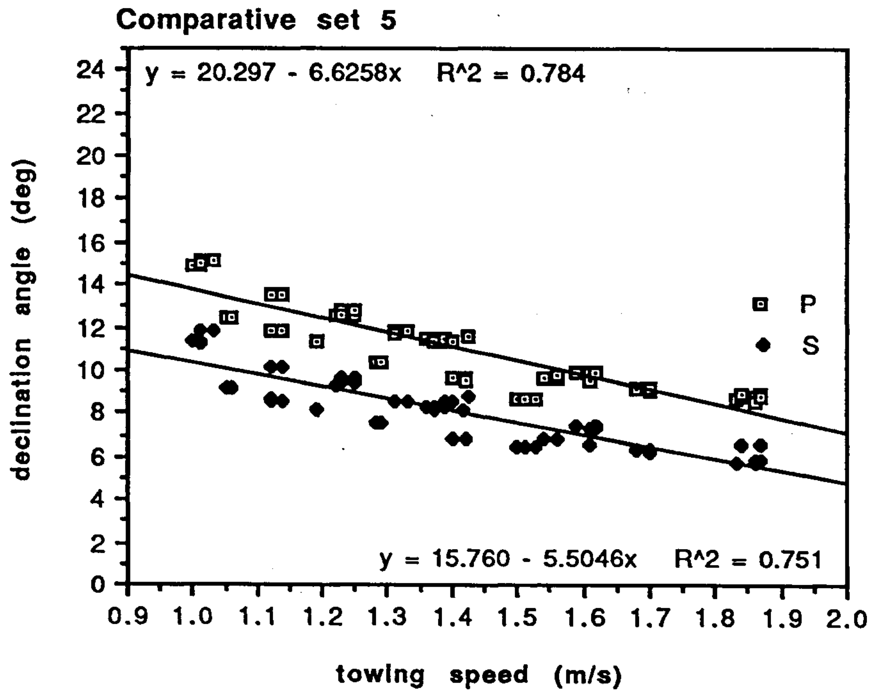
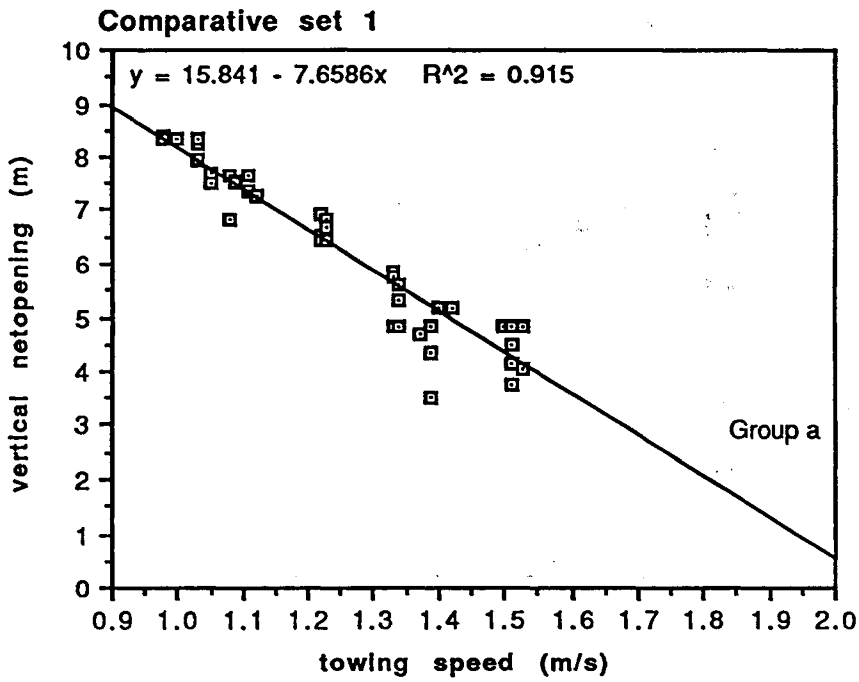


Figure 23 *Vertical netopening vs. towing speed.*



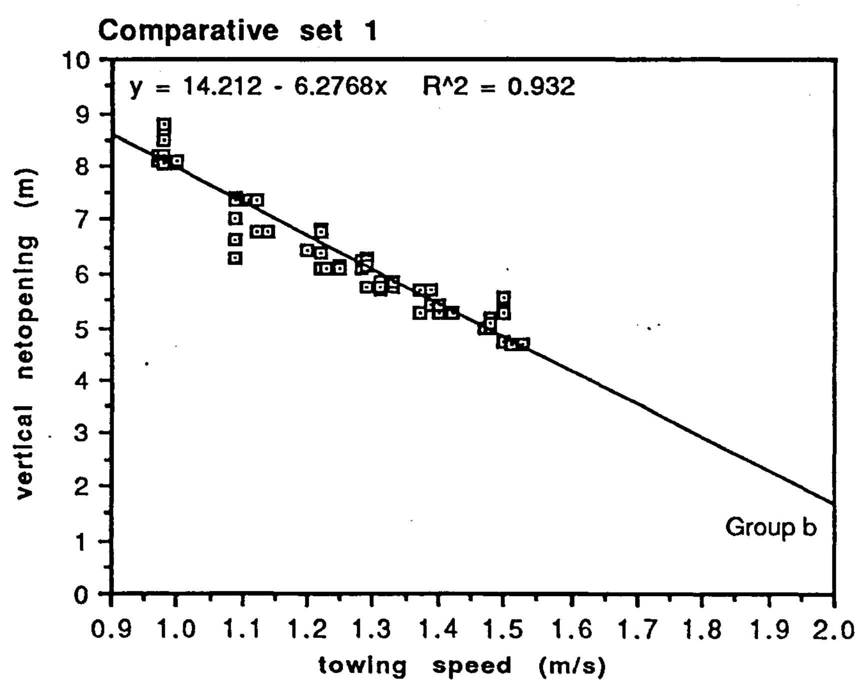
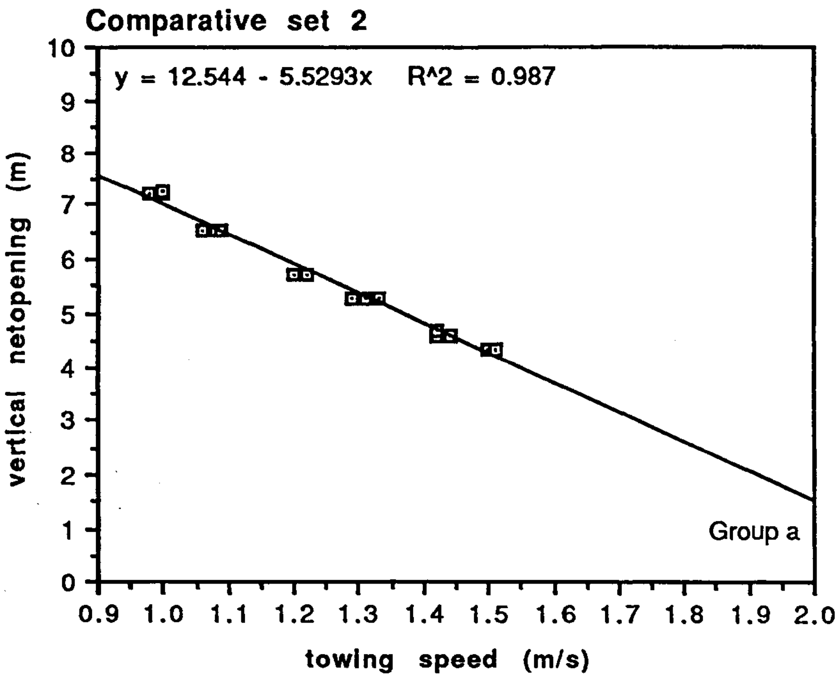


Figure 24 *Vertical netopening vs. towing speed.*



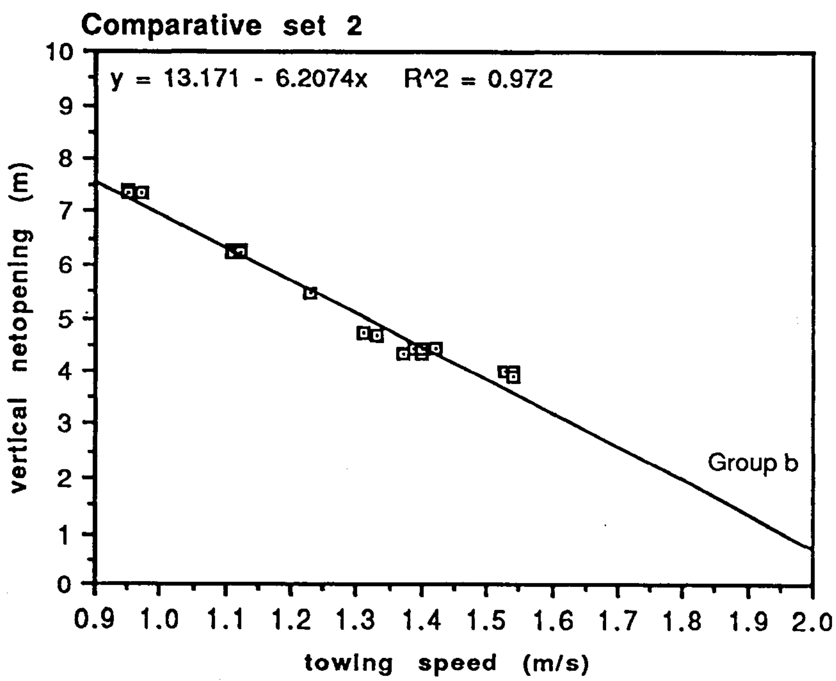
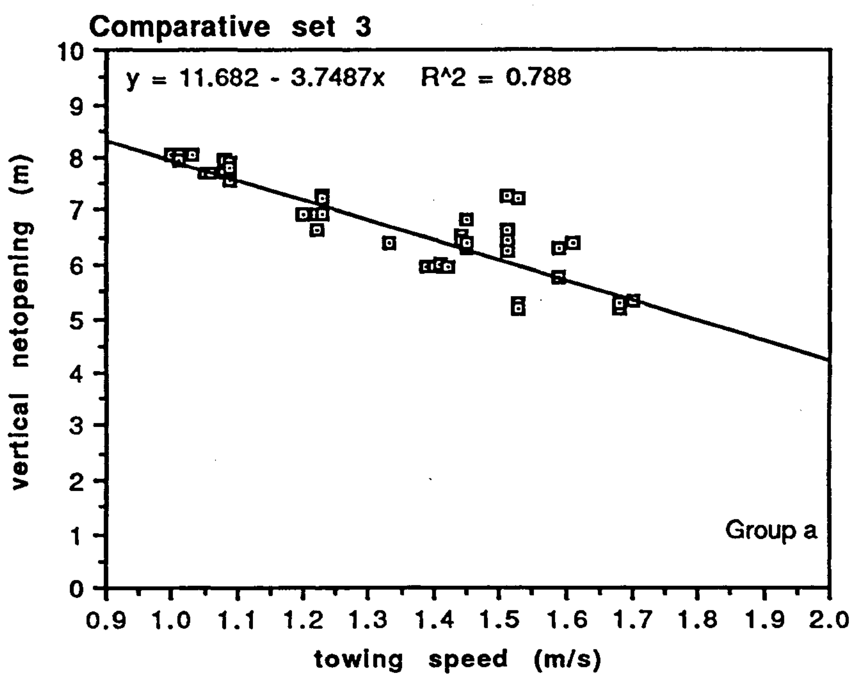


Figure 25 *Vertical netopening vs. towing speed.*



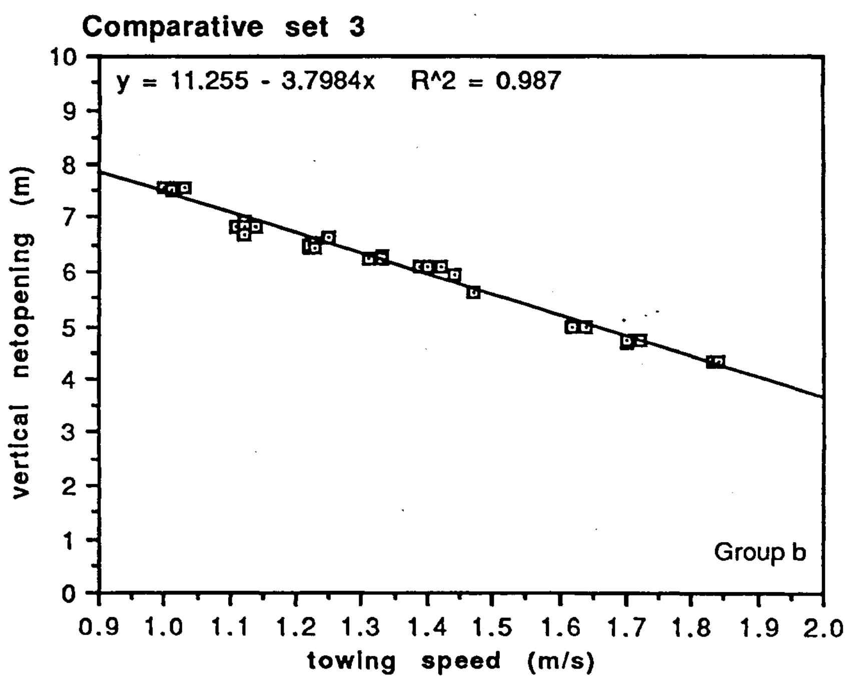
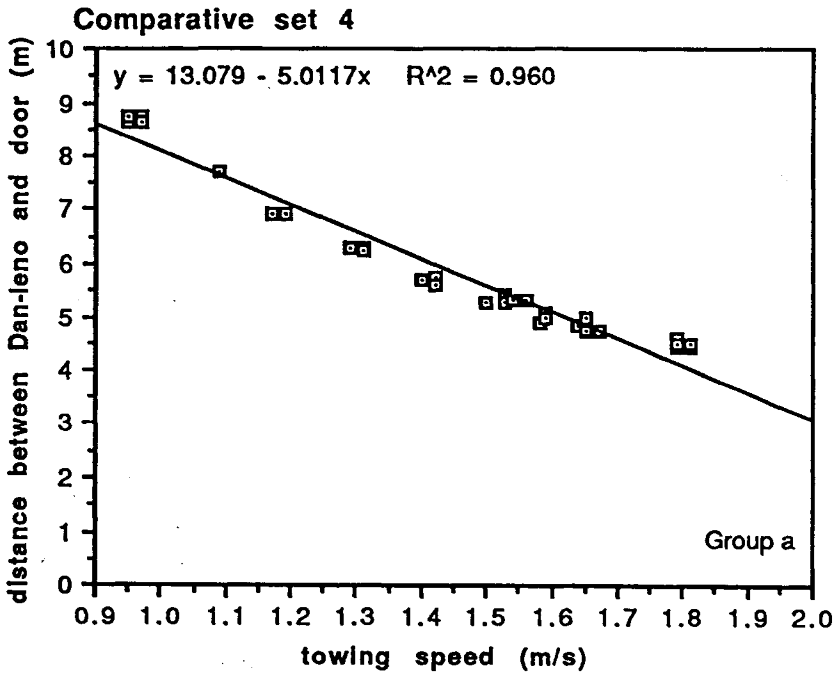


Figure 26 *Vertical netopening vs. towing speed.*



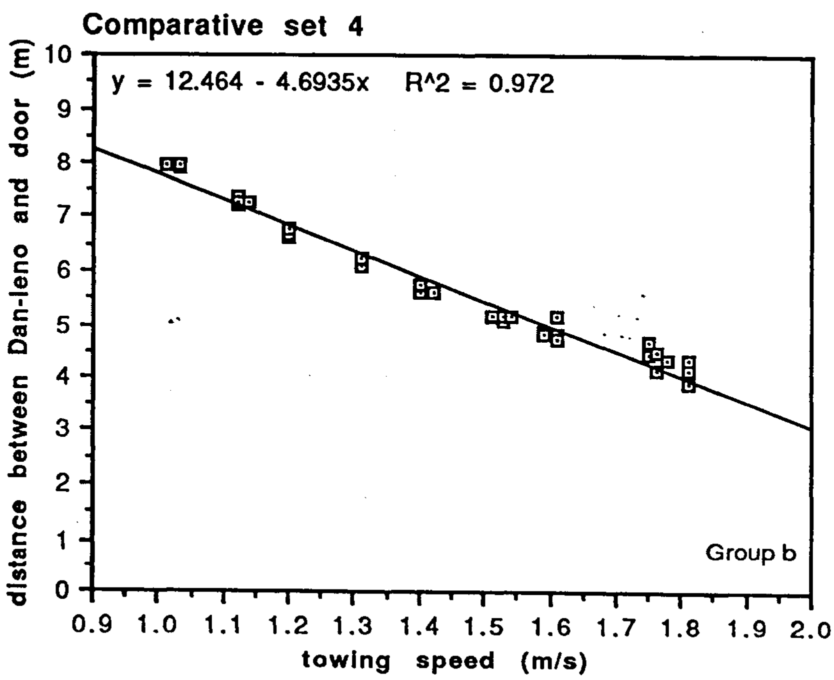


Figure 27 *Vertical netopening vs. towing speed.*

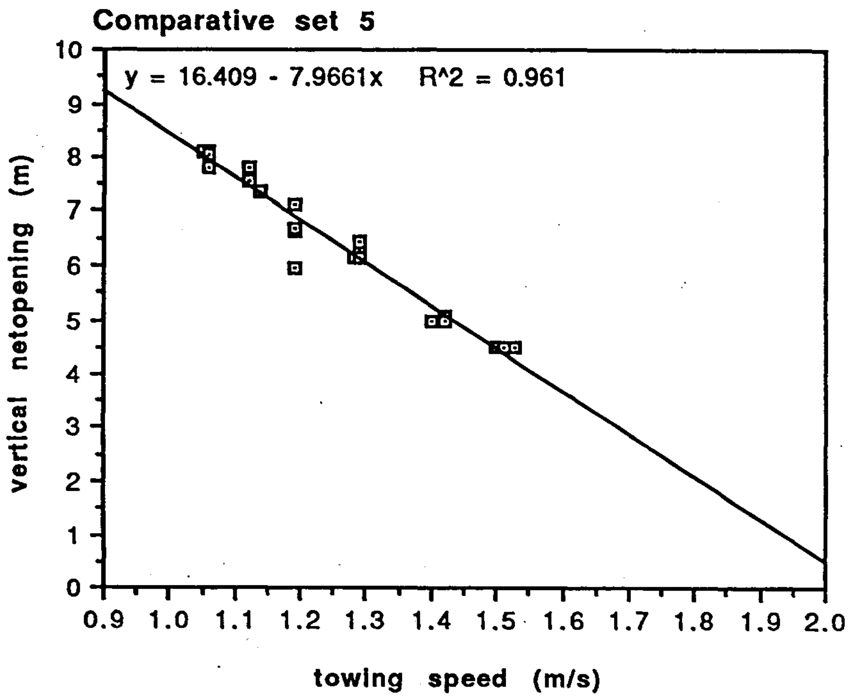
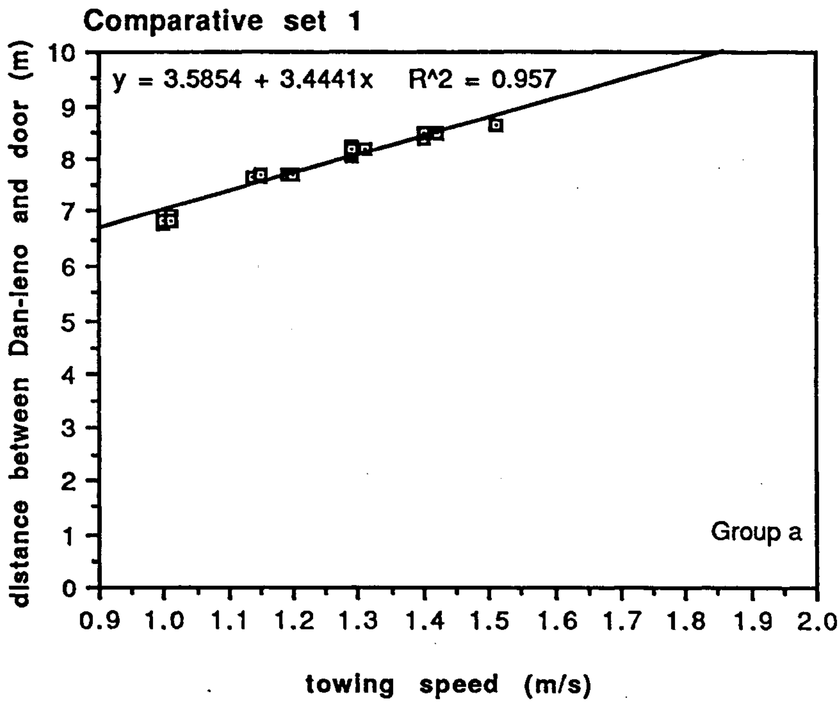


Figure 28 *Distance between Dan-leno and door vs. towing speed.*



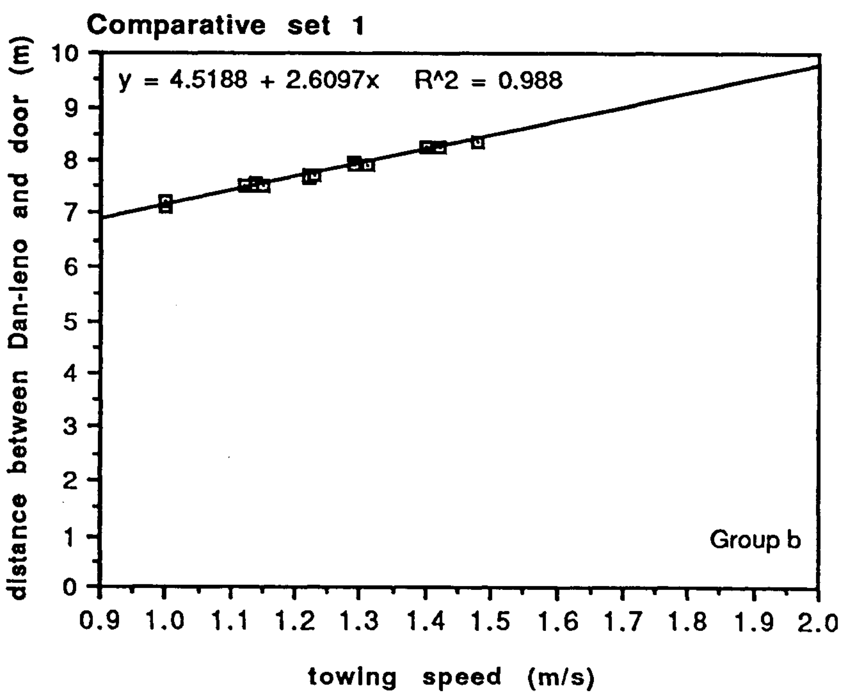
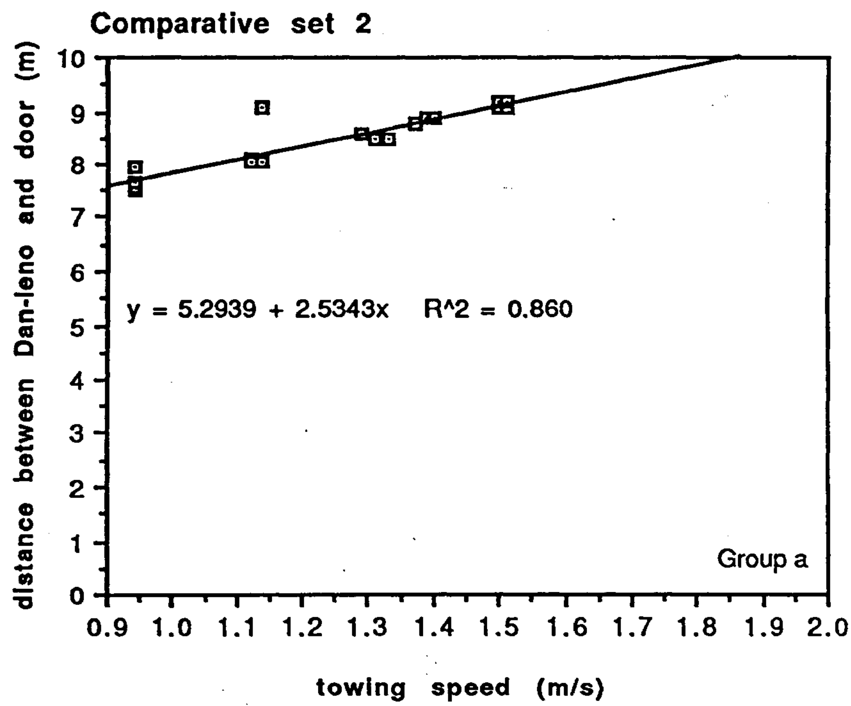


Figure 29 *Distance between Dan-leno and door vs. towing speed.*



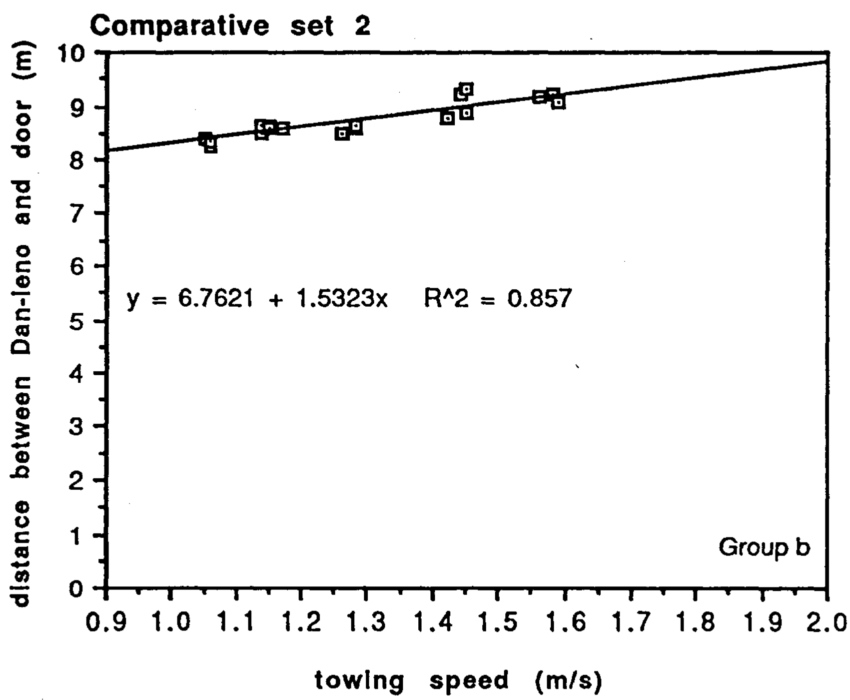
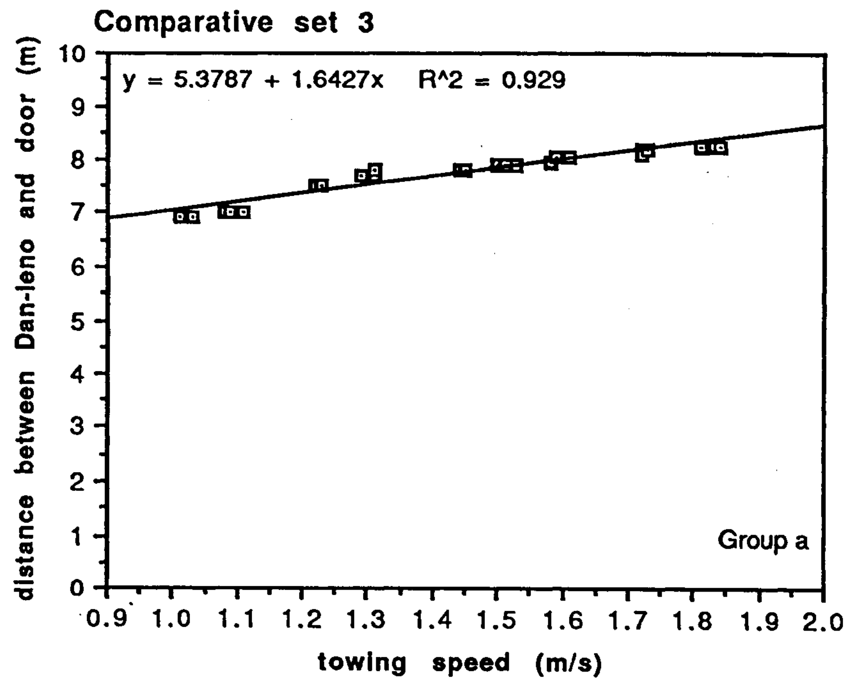


Figure 30 *Distance between Dan-leno and door vs. towing speed.*



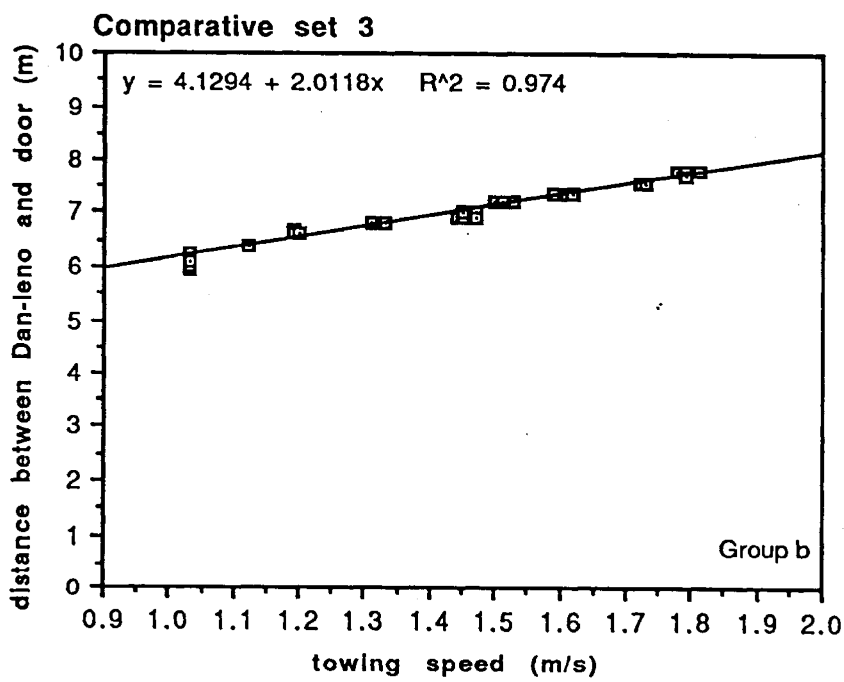
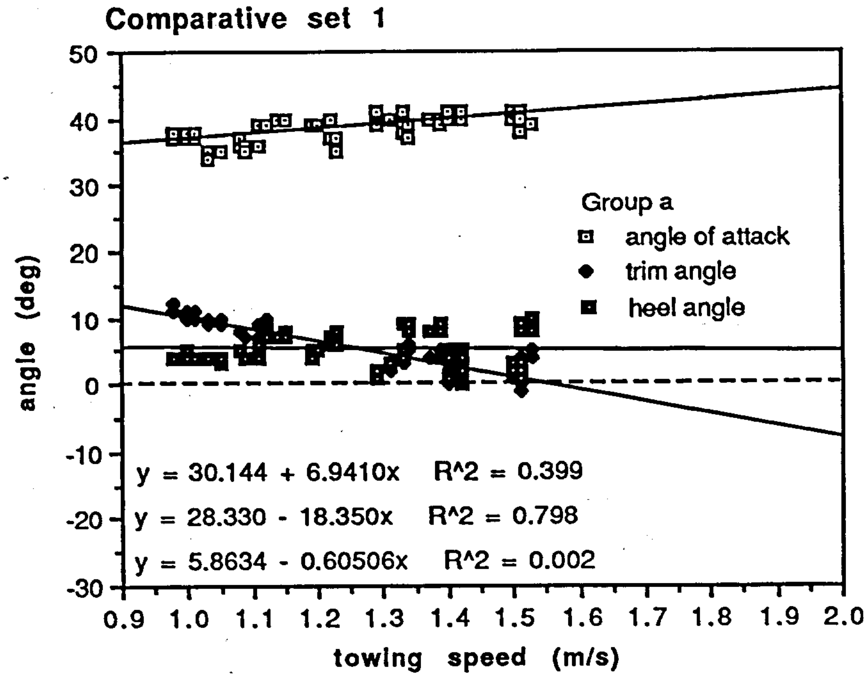


Figure 31 *Door angles vs. towing speed.*



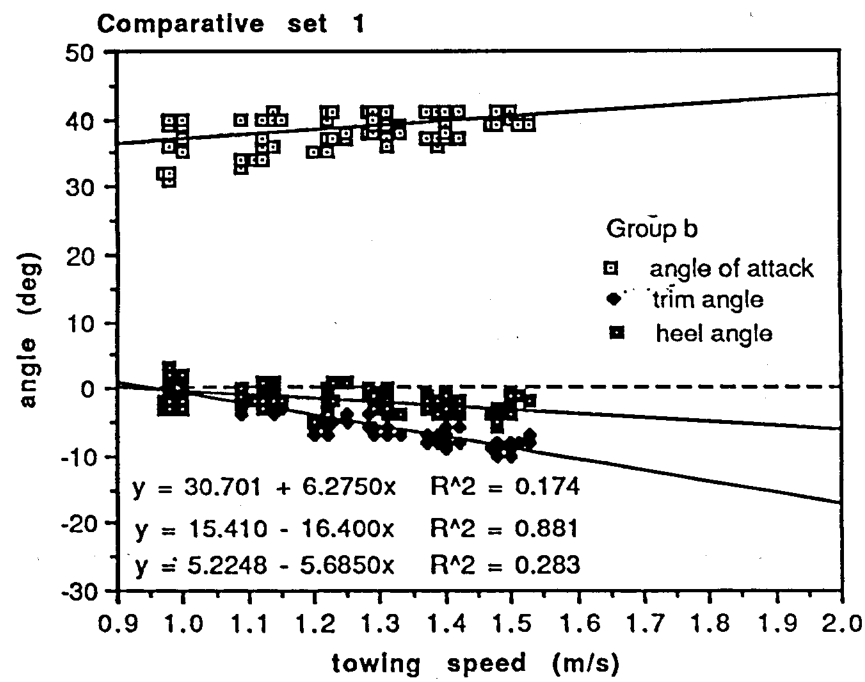
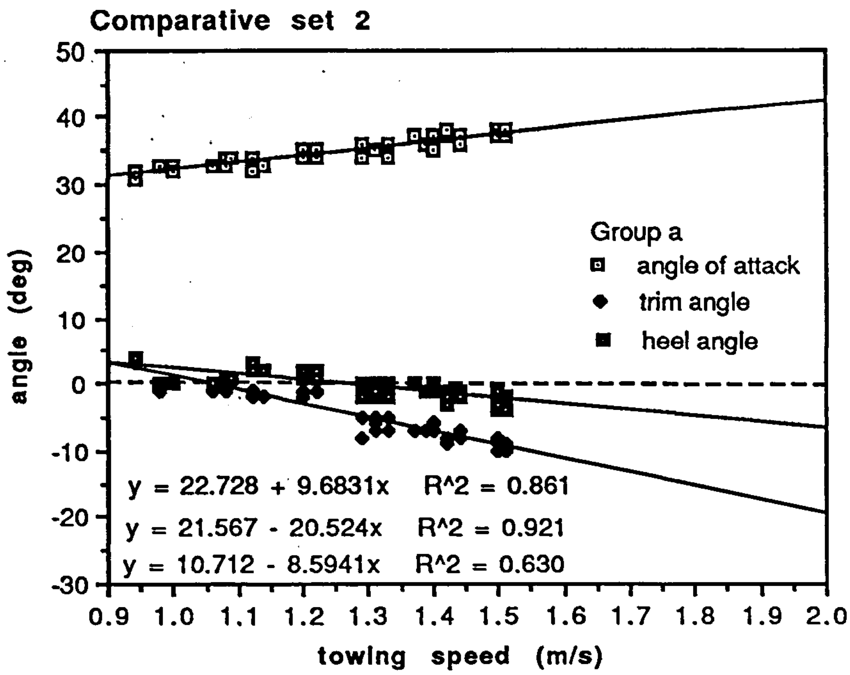


Figure 32 *Door angles vs. towing speed.*



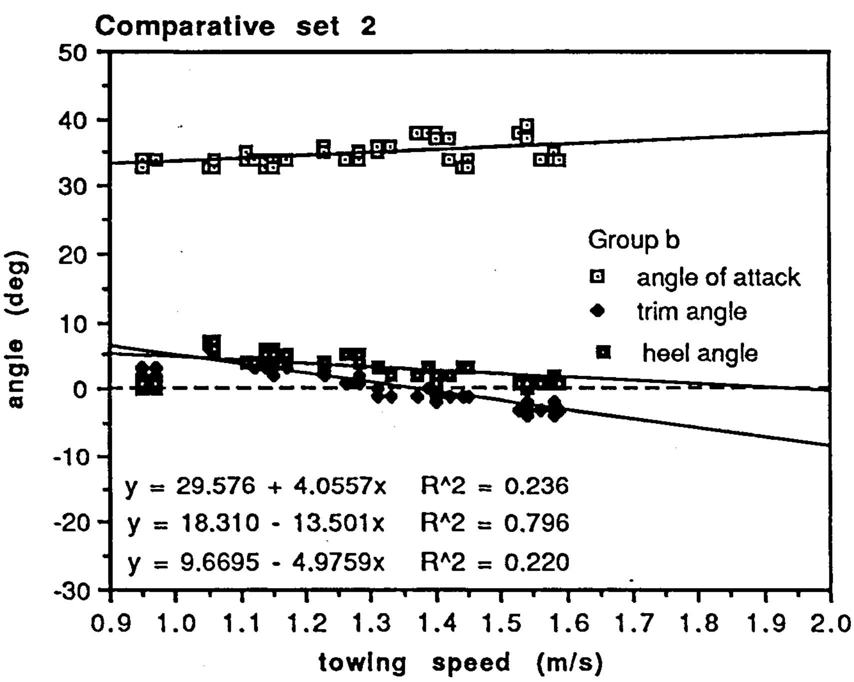
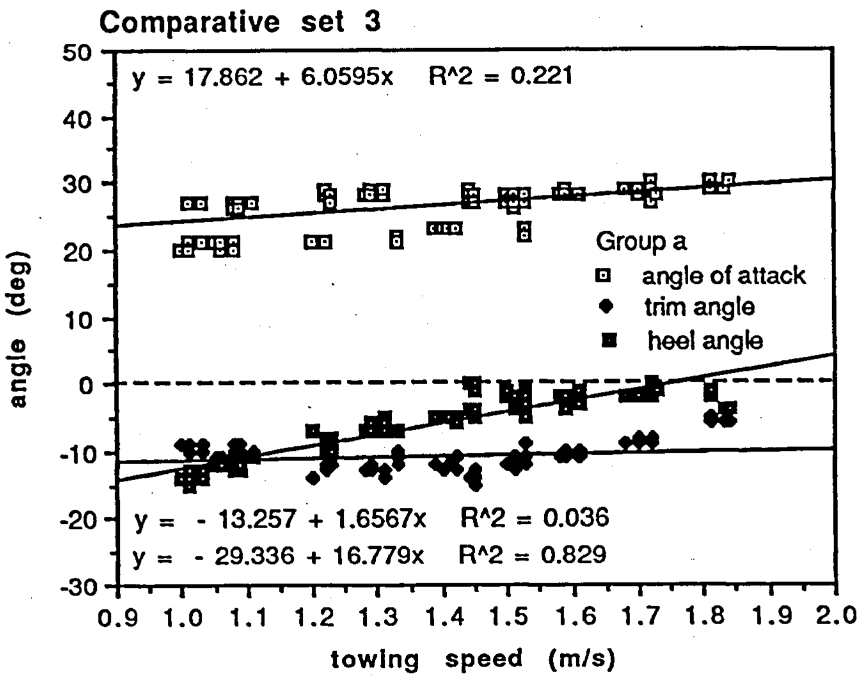


Figure 33 *Door angles vs. towing speed.*



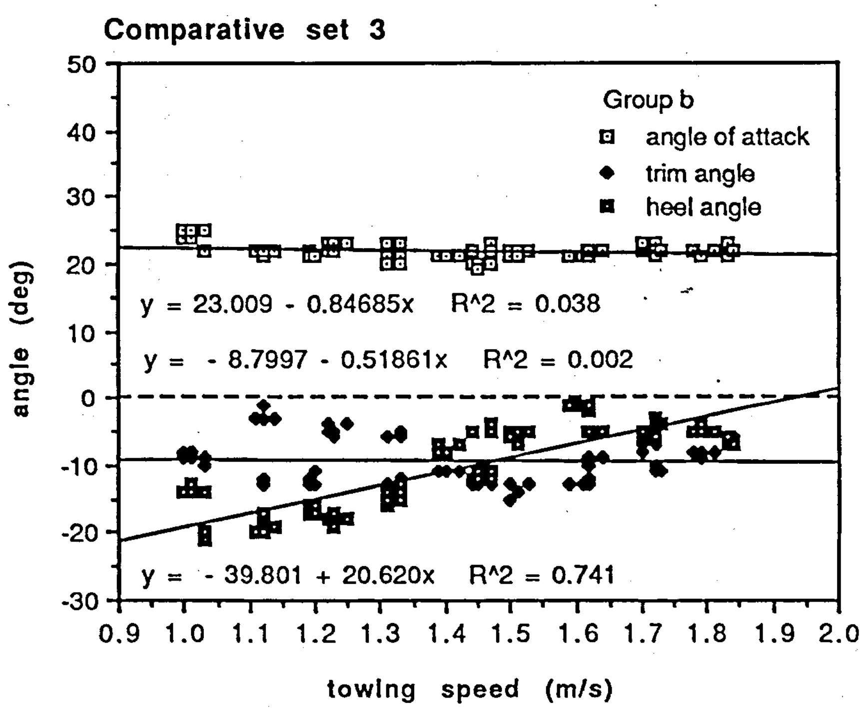
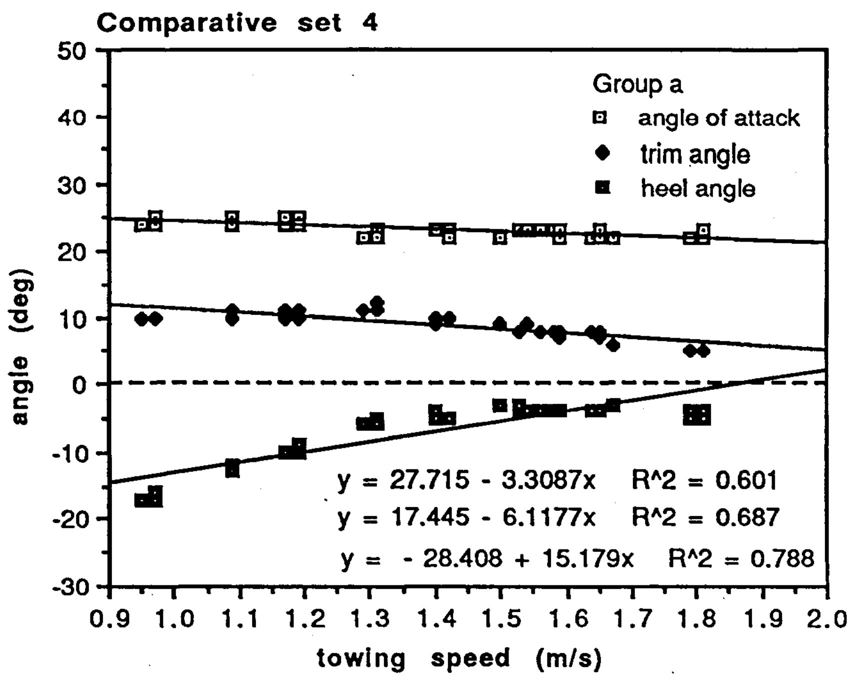


Figure 34 *Door angles vs. towing speed.*



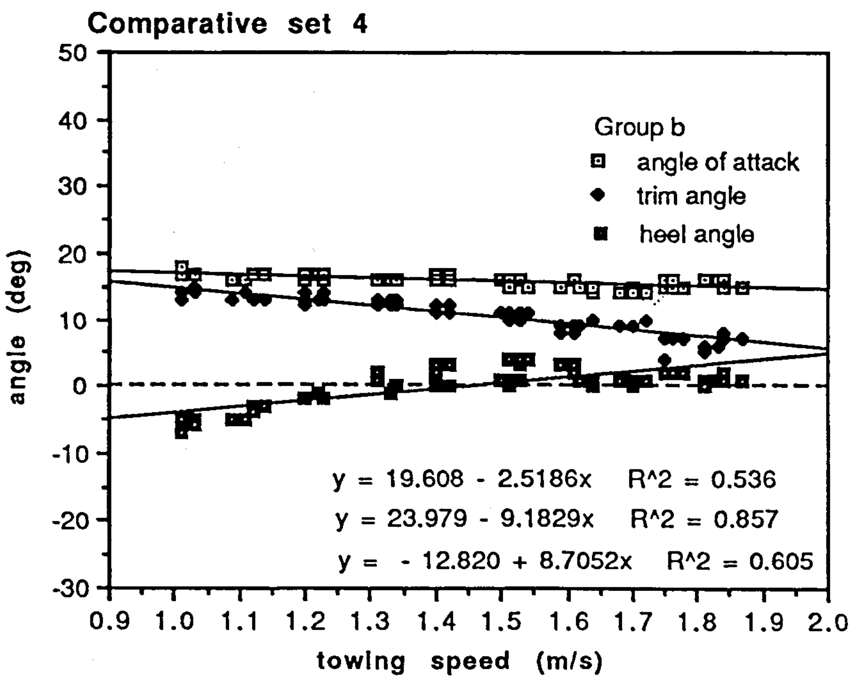


Figure 35 *Door angles vs. towing speed.*