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Analysis of the Performance of the Campelen 1800 Shrimp Trawl during the Annual Canadian Bottom Trawl Surveys of Subarea 2J + Divisions 3KLMNO, 3Ps and 3LNO, 1995-98.

by

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Introduction

The catchability of a survey trawl will be dependent on its design, its application, the behavior of the individual fish in the population and the interaction of these factors within the fish capture process (Pope et al, 1975). Changes in the fishing power of the trawl as a result of changes to vessel power, vessel emitted noise, crew, trawl design and construction can result in a systematic error in the abundance estimate (Byrne et al. 1981: Walsh et al. 1993). Trawl geometry and performance can vary from set to set and the use of SCANMAR acoustic instrumentation allows geometry to be monitored and its variability estimated.

In 1995, the Northwest Atlantic Fisheries Centre adopted the Campelen 1800 shrimp trawl as it's standard bottom trawl gear to replace the Engel 145 High-Lift otter trawl used onboard the research vessel's Wilfred Templeman and Teleost. Trawl performance data are recorded for all sets during each survey using SCANMAR instrumentation. This paper presents an analysis of the performance of the Campelen 1800 during the 1995 to 1998 annual fall surveys of NAFO Sub-area 2J+ Divisions 3KLMNO and the 1996 to 1998 spring surveys of Divisions 3PS and 3LNO.

Materials and Methods

The Campelen 1800 shrimp trawl is a four panel design with cut-away lower wings and is rigged with 40 m upper and lower bridles, a 20.0 m middle bridle with a 4.0 m extension and 6.1 m sweep wires. The 1400 kg, 4.3 m^2 Morgere Polyvalent trawl doors are connected to the sweep wires with 3.05 m door legs. Trawl opening is provided by 88 x 200 mm diameter plastic trawl floats that are attached to a 29.5 m long headline. The 35.6 m long rockhopper footrope is constructed of 355 mm diameter rubber disks spaced evenly apart with rubber and iron spacers, 178 mm and 200 mm long respectively. The body of the trawl is constructed of 4.0, 3.0 and 2.0 mm diameter polyethylene twine with mesh sizes (knot centre measurement) varying from 80 mm in the wings and 60 mm in the square and first bellies to 44 mm in the second and third bellies, extension and codend (see Fig. 1 and 2). A 7.0 m long knotless nylon liner of 12.7 mm mesh size was attached to the inside of the extension and codend. The extension, codend and liner are covered with a 140 mm cover bag constructed of 2.0 mm polyethylene twine (see McCallum & Walsh, 1996).

Trawl Standardization

Prior to the beginning of each survey and after any major damage, the survey trawls are measured using the NWAFC Survey Trawl Checklist (McCallum & Walsh, 1995). Trawls not conforming to specification are repaired prior to the next fishing set.

Door spread, wing spread, headline height and trawl depth were measured using SCANMAR hydroacoustic instrumentation mounted on each trawl door, on the headline at the wing ends[1] and on the square 1.0 m behind the center of the headline. SCANMAR signals, Doppler Log vessel and current speed and DGPS (Differential Global Positioning System) navigational data were logged at 5-second intervals with a custom designed data acquisition software package (SEATRAWL). DGPS vessel speed was also logged by hand at 3 minute intervals by bridge staff. Acoustic noise was edited from the data in post mission processing with the application of range checks of: 0-1200 m for depth, 0-100 m for door spread, 0-30 m for wing spread, 0-35 m for opening and 0-50 m for clearance. Filters are also applied to remove noise spikes and smoothing duplicates generated by SCANMAR receiver software. Survey tows are generally 15 minutes long starting from the moment the trawl touches bottom. Touch down and lift-off are determined using SCANMAR instrumentation. Gear performance data is collected from the time the trawl doors enter the water until the moment they are retrieved, flags are placed in the data to indicate the start and end of the 15 minute tow. The trawl is towed at a vessel speed of 3.0 kts as indicated by the DGPS and the heading is in the direction of the next fishing station. The correct warp ratio (warp length/water depth) for a given fishing depth was determined using the NWAFC Warp Ratio Protocol.

Bridle angles (θ) were calculated using the following equation:

$$\sin q = \frac{1/2(ds - ws)}{bl}$$

Where ds is the door spread, ws is the wing spread and bl is the bridle length (sum of the lengths of the sweep wire + lower bridle + door leg extensions).

Results and Discussion

Trawl Geometry

Tables 1 and 2 show the summary gear performance statistics for the Wilfred Templeman and Teleost during the annual 2J+3KLMNO survey for the years 1995 to 1998 inclusive. Table 3 presents Teleost data that has been partitioned into fishing depths that make it more comparable with the Templeman over the same years. Tables 4 and 5 show similar statistics for the 3PS and 3LNO surveys respectively conducted by the Wilfred Templeman from 1996 to 1998. We present a summary of all data in Table 6.

Table 7 shows the results of a MANN-WHITNEY rank sum test on the differences in Campelen trawl geometry between the Wilfred Templeman and the Teleost for the survey years 1997 and 1998.

Wilfred Templeman – Table 1 shows a reduction in mean door spread of 4.6 m or 9.4% from 1995 to 1998 and a reduction in the mean wing spread of 1.6 m or 9.3% over the same period during the fall groundfish surveys. Headline opening has increased from 4.4 m to 5.2 m or 18% which is consistent with the decrease in mean door spread and wing spread. There is a statistically significant difference when comparing door spread, wing spread and opening between 1997 and 1998 (Table 7). There was no difference in these parameters between the survey years 1995 and 1996 (McCallum and Walsh, 1997). Differences between 1997 and 1998 may be due to the differences in the depth range fished during the individual surveys. Surveys in 1997 were carried-out to a maximum depth of 784 m and in 1998 the maximum depth was 1092 m and this may be reflected in the increase in variability around mean door spread.

Teleost- Table 2 shows summary statistics for the Teleost survey data at all fishing depths. Mean door spread shows an overall increase of 3.4% from 1995 to 1998 and while there is no statistical difference in this parameter between 1995 and 1996 (McCallum and Walsh, 1997) there is a difference between 1997 and 1998 (Table 7). Whereas survey years 1996 and 1997 produced identical mean door spreads the greatest increase occurred between 1997 and 1998. There is no statistical difference in wing spread between 1997 and 1998 and both these years demonstrate low variability in wing spread when comparing 1995 to 1996 (7.9%, 7% and 12%, 8.4%). Trawl opening was not

[1] The wing end sensors are mounted in stainless steel canisters to provide protection from trawling damage. The weight of the canisters in water is offset by adding five 8” floats (15.6 kg buoyancy) to each wingend.

statistically different between 1995 and 1996 but showed a surprising decrease of 13.3% from 1997 to 1998. This decrease in opening was associated with an increase in door spread between 1997 and 1998.

Wilfred Templeman and Teleost – Table 3 shows summary statistics for gear geometry for the Teleost at depths comparable to those fished by the Templeman . A significant difference in all three-gear parameters was found when comparing between vessels in 1997 and 1998 (Table 7). This is in contrast to 1995 and 1996 where there was a significant difference in door spread and in opening between the two vessels and no difference in wing spread (Walsh and McCallum, 1996). Trawl door and wingspread performance appears more variable in the Templeman than the Teleost. This variability in door performance may be a result of differences in vessel displacement and sea motion and how these translate to the gear particularly in shallow water.

Figures 3 to 6 shows the relationship between wingspread and door spread for each survey. For most cases a significant predictive relationship exists ie. wing spread increases with door spread.

Wilfred Templeman (3PS) – Table 4 shows the summary statistics for the Wilfred Templeman during the annual spring survey of 3PS. Wing spread was not collected during this survey in 1997 due to operational difficulties with damage to the SCANMAR instrumentation. While door spread increased marginally in 1997 over 1996 (2.7%) this increase was not seen in 1998, variability in this parameter showed a similar trend. Mean wing spread decreased from 16.1 m in 1996 to 15.4 m in 1998, this was reflected in trawl opening which increased from 4.7 m to 5.0 m over the same period. The variability in wing spread and door spread from 1996 to 1998 decreased by 5.3% and 10.7% respectively.

Wilfred Templeman (3LNO) – Table 5 shows the summary statistics for the Wilfred Templeman during the annual spring survey of 3LNO. Mean door spread decreased by 3.3% from 1996 to 1997 but was found to be statistically significant (43.4 m verses 43.8 m respectively) between 1997 and 1998. Variability around the mean estimate of door spread was highest in 1997 ie. 13.1% in 1997 as opposed to 10.4% and 10.9% in 1996 and 1998. While mean wing spread in 1996 and 1998 were almost identical this same parameter was 6.3% lower in 1997. Variability in wing spread increased marginally between 1996 and 1997 and then doubled in 1998 despite the comparability of the depth zones fished. As expected trawl opening generally mirrored changes in door spread and wing spread. There was no significant difference in trawl opening between the survey years 1997 and 1998. Trawl opening tends to be less sensitive than wing spread to changes in door spread.

Gear Performance

Figures 7 to 20 show the effect of fishing depth on gear performance. Unsuccessful sets, while not included in the statistical analysis have been included in the plots to show their relationship with successful data. In general door spread, wing spread and bridle angle increases with depth and opening decreases with depth. These relationships are more defined in the Teleost data probably due to a greater difference in fishing power (Walsh and McCallum, 1997). Most of the unsuccessful sets have doors spreads occurring well below the mean, a slightly lesser tendency is seen in the wing spread. Low door spread and wing spread and high opening can result in slack lower belly twine making the trawl more susceptible to bottom damage.

Figure 21 shows a comparison of tow duration between the Wilfred Templeman and Teleost for survey years 1997 and 1998. Tow duration is determined from the trawl mounted CTD profile of depth to determine the time elapsed between trawl touch down and lift-off. Distance towed is calculated based on tow duration and vessel speed. In practice the fishing officer will use a SCANMAR depth sensor in conjunction with the height sensor to determine when the trawl has touched bottom and when it has left bottom after haul-back has commenced. A 15 minute tow at 3.0 kts will generally cover 0.75 nm under normal conditions. The Wilfred Templeman and Teleost compare closely with the slightly longer tow duration occurring on the Teleost in both 1997 and 1998 (15.6 min. vs. 15.1 min.). However, tow duration was the highest during the 1998 3PS survey indicating longer fishing times.

Conclusions

There are many statistical differences in survey gear geometry between research vessels and between surveys conducted with the same research vessel in different years. Differences in fishing power between research vessels can be explained by comparing the physical characteristics of the two research vessels ie. displacement, horsepower and deck layout. For example the higher door spreads encountered on the Teleost when compared to the Templeman in similar depths are most likely the result of the greater distance found between the gallows blocks on the Teleost. These higher door spreads on the Teleost, result in greater herding angles which could effect the catchability of gadoids (Engas and Godo 1989; Engas, 1994). Other sources of variability are differences in bottom type, depth, bottom currents and the human factor, i.e. fishing crew all contribute to variation in trawl geometry and performance (Walsh et al. 1993)

There is a linear relationship between door spread and wing spread, which will now permit the prediction of these parameters to fill in missing values. Tow duration is highly comparable between survey years and survey vessels suggesting that the newly adopted touchdown and lift-off protocols have succeeded in standardizing on bottom tow time. Noteworthy is the fact that average wing spread calculated for individual surveys range between 14.8 to 17.4 m, well below the 18.23 m value used to calculate survey indices based on swept area. Techniques, which restrict trawl door spread (restrictor rope), can minimize differences in trawl geometry and hence swept area. This should help standardize between vessels and the variability in trawl geometry between survey years (Engas and Ona 1991;Walsh and McCallum 1996, 1997)

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Table 1. Comparison of summary statistics of trawl parameters for the Campelen 1800 shrimp trawl used by the Wilfred Templeman during the 1995 to 1998 fall groundfish surveys.

Survey	Variable	No. Obs.	$\overline{X}$	CV (%)	Min.	Max.
1995	Depth	169	285.4			
	Doors	169	48.8	13.0	16.1	56.4
	Wings	167	17.1	9.0	12.5	22.8
	Opening	161	4.4	13.0	3.5	7.6
	Bridle Angle	161	19.2	15.0	7.4	22.6
1996	Depth	312	239.0			
	Doors	319	48.3	10.1	15.6	60.7
	Wings	327	16.9	10.9	6.0	23.6
	Opening	312	4.7	14.6	2.5	11.7
	Bridle Angle	249	18.6	2.2	0.5	23.7
1997	Depth	268	169.0			
	Doors	278	45.6	10.7	26.5	58.3
	Wings	244	16.2	13.3	6.6	28.1
	Opening	274	4.8	10.9	2.5	7.8
	Bridle Angle	239	17.2	15.9	7.5	29.0
1998	Depth	365	213.3			
	Doors	389	44.2	13.1	26.5	63.8
	Wings	356	15.5	9.5	11.6	20.3
	Opening	366	5.2	12.8	2.3	10.3
	Bridle Angle	351	17.0	16.3	8.7	26.3

Table 2. Comparison of summary statistics of trawl geometry for the Campelen 1800 shrimp trawl used by the Teleost during the 1995 to 1998 fall groundfish surveys.

Survey	Variable	No. Obs.		CV (%)	Min.	Max.
1995	Depth	139	418.6			
	Doors	140	53.0	13.0	21.7	72.6
	Wings	137	17.0	12.0	10.4	24.0
	Opening	142	4.1	15.0	2.2	6.4
	Bridle Angle	126	21.5	15.0	6.6	31.8
1996	Depth	396	426.2			
	Doors	338	52.3	10.3	21.6	65.2
	Wings	292	16.6	8.4	11.6	24.9
	Opening	332	4.2	13.3	1.9	6.7
	Bridle Angle	291	21.2	13.4	4.4	27.9
1997	Depth	371	465.4			
	Doors	394	52.3	12.4	21.6	65.8
	Wings	377	17.4	7.9	11.5	20.7
	Opening	401	4.5	15.8	3.3	10.5
	Bridle Angle	360	20.8	15.4	2.7	27.4
1998	Depth	387	473.9			
	Doors	418	54.8	11.3	36.1	70.2
	Wings	402	17.4	7.0	12.4	21.4
	Opening	412	3.9	14.8	2.4	6.3
	Bridle Angle	383	22.3	15.1	13.3	39.9

Table 3. Comparison of summary statistics of depth adjusted data of trawl geometry parameters for the Campelen 1800 shrimp trawl used by the Teleost during the 1995 to 1998 fall groundfish surveys.

Survey	Variable	No. Obs.		CV (%)	Min.	Max.
1995	Depth	111	298.8			
<615m	Doors	103	51.4	11.0	21.7	63.1
	Wings	104	16.7	12.0	10.4	24.0
	Opening	104	4.1	14.0	3.3	6.4
	Bridle Angle	94	20.5	12.0	6.0	26.1
1996	Depth	300	336.6			
<855m	Doors	295	51.3	9.5	21.6	64.0
	Wings	259	16.5	8.3	11.6	24.9
	Opening	288	4.6	13.3	1.9	6.7
	Bridle Angle	257	20.7	12.5	4.4	27.9
1997	Depth	316	3444			
<788m	Doors	303	49.8	10.3	12.1	64.4
	Wings	293	16.9	7.5	5.7	20.7
	Opening	310	4.6	15.1	3.4	10.5
	Bridle Angle	281	19.6	12.8	2.7	27.1

Table 4. Comparison of summary statistics of trawl geometry parameters for the Campelen 1800 shrimp trawl used by the Wilfred Tempelman during the 1996 to 1998 spring surveys of 3PS.

Survey	Variable	No. Obs.		CV (%)	Min.	Max.
1996	Depth	143	215.2			
	Doors	153	46.6	11.2	24.5	53.8
	Wings	149	16.1	7.5	13.1	21.6
	Opening	153	4.7	8.5	4.0	5.9
	Bridle Angle	144	18.0	15.4	5.4	22.0
1997	Depth	158	209.6			
	Doors	162	47.9	12.2	28.5	58.9
	Wings	-	-	-	-	-
	Opening	164	4.6	10.2	2.7	6.9
	Bridle Angle	-	-	-	-	-
1998	Depth	118	238.8			
	Doors	126	46.2	10.0	33.0	55.1
	Wings	110	15.4	7.1	11.3	17.3
	Opening	124	5.0	8.3	3.5	6.4
	Bridle Angle	104	18.4	12.7	12.2	23.7

Table 5. Comparison of summary statistics of trawl geometry parameters for the Campelen 1800 shrimp trawl used by the Wilfred Templemen during the 1996 to 1998 spring survey of 3LNO.

Survey	Variable	No. Obs.		CV (%)	Min.	Max.
1996	Depth	337	185.0	81.0	42.0	685.0
	Doors	337	44.9	10.4	13.9	65.6
	Wings	305	15.8	8.6	11.9	24.3
	Opening	334	4.9	8.9	3.1	6.2
	Bridle Angle	300	17.3	11.3	11.3	30.2
1997	Depth	153	175.4	99.7	35.0	689.0
	Doors	152	43.4	13.1	25.5	56.7
	Wings	147	14.8	8.8	10.3	18.1
	Opening	149	5.0	11.0	4.1	9.2
	Bridle Angle	146	16.8	8.9	8.6	23.4
1998	Depth	243	158.5	99.2	38.0	721.0
	Doors	192	43.8	10.9	30.4	68.4
	Wings	88	15.9	16.1	6.2	25.0
	Opening	222	4.9	10.4	3.4	10.2
	Bridle Angle	76	17.0	16.2	9.4	32.7

Table 6. Comparison of summary statistics of trawl geometry parameters for the Campelen 1800 shrimp trawl used by Wilfred Templeman and Teleost during the 1995 to 1998 fall surveys of 2J+3KLMNO and spring surveys of 3Ps and 3LNO.

Depth. (adj.)	Var.	1995				1996				1997				1998			
		WT Fall x	Tel Fall x	WT 3Ps x	WT 3LNO x	WT Fall x	Tel Fall x	WT 3Ps x	WT 3LNO x	WT Fall x	Tel Fall x	WT 3Ps x	WT 3LNO x	WT Fall x	Tel Fall x	WT 3Ps x	WT 3LNO x
	Depth	285.4	418.6			239.0	426.2	215.2	185.0	169.0	465.4	209.6	175.4	213.3	473.9	238.8	158.5
	Doors	48.8	53.0			48.3	52.3	46.6	44.9	45.6	52.3	47.9	43.4	44.2	54.8	46.2	43.8
	Wing	17.1	17.0			16.9	16.6	16.1	15.8	16.2	17.4	-	14.8	15.5	17.4	15.4	15.9
	Open	4.4	4.1			4.7	4.2	4.7	4.9	4.8	4.5	4.6	5.0	5.2	3.9	5.0	4.9
	BA	19.2	21.5			18.6	21.2	18.0	17.3	17.2	20.8	-	16.8	17.0	22.3	18.4	17.0
Tel.	Depth		298.8														
<615	Doors		51.4														
	Wing		16.7														
	Open		4.1														
	BA		20.5														
Tel.	Depth						336.6										
<855	Doors						51.3										
	Wing						16.5										
	Open						4.6										
	BA						20.7										
Tel.	Depth										344.0						
<788	Doors										49.8						
	Wing										16.9						
	Open										4.6						
	BA										19.6						

Table 7. Results of the MANN-WHITNEY rank sum test on the Campelen 1800 geometry parameters.

Parameter	Comparison	T	P<0.05
Door Spread	Teleost(Fall 97)/Teleost(Fall 98)	140296	P<0.001
	Templeman(Fall 97)/Templeman(Fall 98)	95181	P<0.001
	Teleost(Fall 97)/Templeman(Fall 97)	43362	P<0.001
	Teleost(Fall 98)/Templeman(Fall 98)	77789	P<0.001
	Templeman(3PS-97)/Templeman(3PS-98)	16043	P<0.001
	Templeman(3LNO-97)/Templeman(3LNO-98)	26221	P=1.000
Wing Spread	Teleost(Fall 97)/Teleost(Fall 98)	144106	P=0.352
	Templeman(Fall 97)/Templeman(Fall 98)	82960	P<0.001
	Teleost(Fall 97)/Templeman(Fall 97)	53553	P<0.001
	Teleost(Fall 98)/Templeman(Fall 98)	84378	P<0.001
	Templeman(3LNO-97)/Templeman(3LNO-98)	12685	P<0.001
Opening	Teleost(Fall 97)/Teleost(Fall 98)	205739	P<0.001
	Templeman(Fall 97)/Templeman(Fall 98)	67032	P<0.001
	Teleost(Fall 97)/Templeman(Fall 97)	94200	P<0.001
	Teleost(Fall 98)/Templeman(Fall 98)	209247	P<0.001
	Templeman(3PS-97)/Templeman(3PS-98)	23189	P<0.001
	Templeman(3LNO-97)/Templeman(3LNO-98)	28045	P=0.801

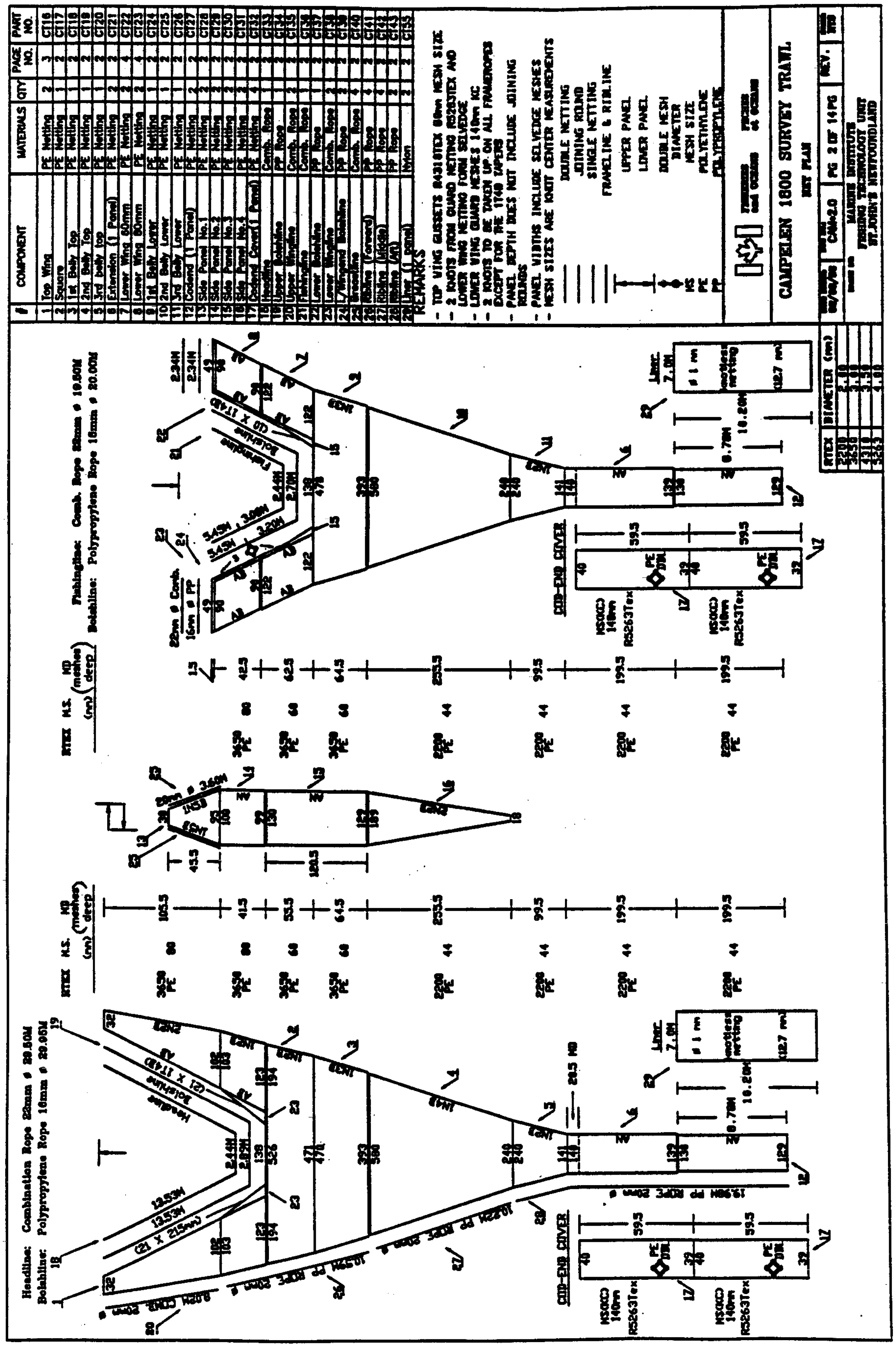
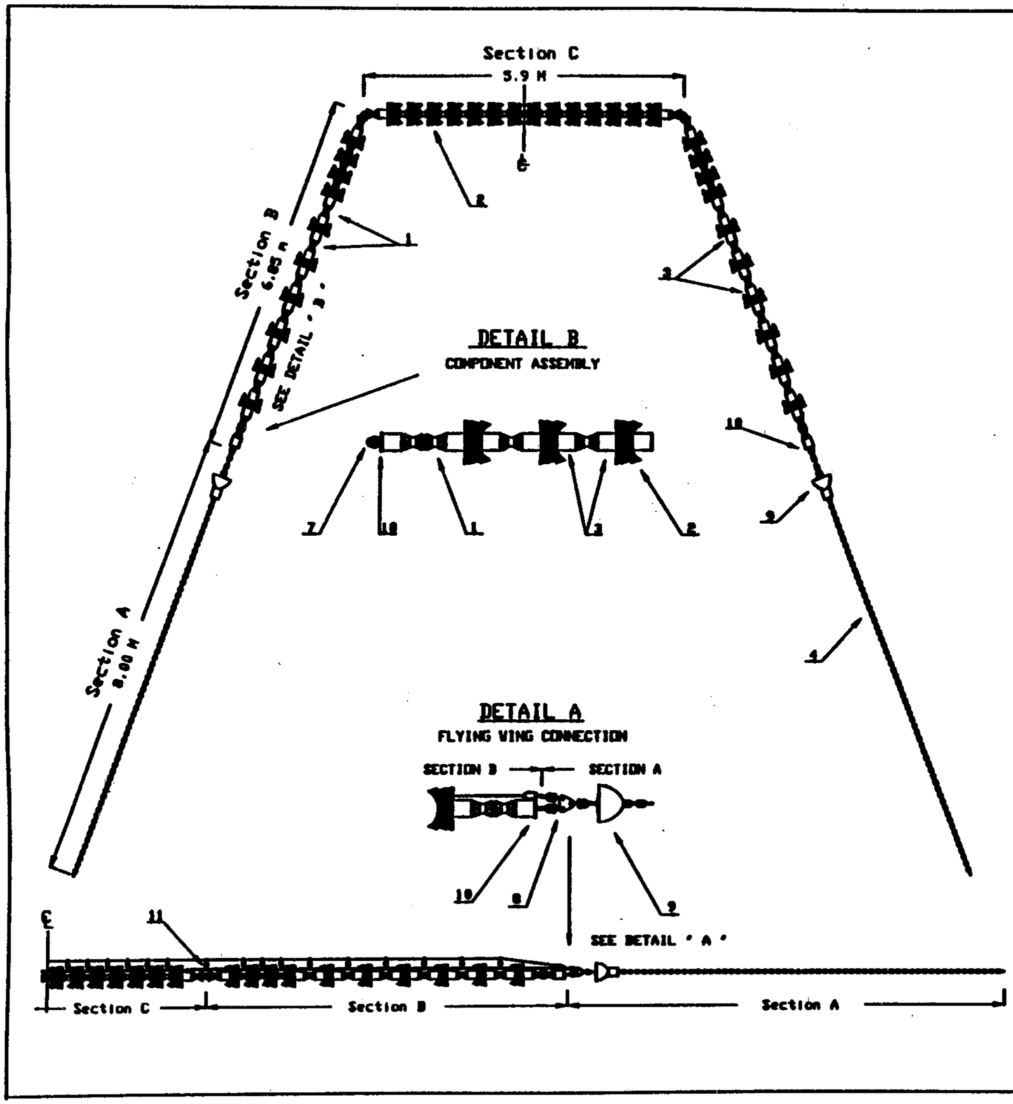


Fig. 1. Trawl plan of the Campelen 1800 survey trawl.



DRAWING NOTES:
- GROUND GEAR IS SYMMETRICAL ABOUT CENTERLINE.
- LENGTHS FOR SECTION B & C ARE MEASURED FROM CENTRE HAMMERLOCK TO CENTRE HAMMERLOCK.
- LENGTH OF SECTION A IS MEASURED FROM CENTRE HAMMERLOCK TO END OF CHAIN (SEE DETAIL A).

#	COMPONENT	WEIGHT (KGS) (IN SEAWATER)		NUMBERS				Page NO.	PART NO.
		UNIT	TOTAL	TOTAL	SECT. A	SECT. B	SECT. C		
1	8" (200mm) Iron Spacer	5.29	206.31	39	0	2x12	1x15	8	CT44
2	14" Rockhopper Sets of 3 Disk	0.55	56.1	34X3	0	2x10	1x14	9	CT45
3	7" (178MM) Rubber Spacer	0.43	14.62	34	2X1	2x15	1x2	10	CT46
4	5/8" (16mm) Mid Link Chain	4.96/M	74.30	14.98	2x7.49m				CT12
5	5/8" (16mm) Mid Link Chain	4.96/M	66.96	13.5m		2x6.75m			CT13
6	5/8" (16mm) Mid Link Chain	4.96/M	28.76	5.80m			1X5.80m		CT14
7	5/8" (16mm) Hammerlock	1.0	12	10	2x4	2x2	0		CT48
8	Delta Plate (362mm)	4.76	9.52	2	2	0	0	11	CT49
9	14"(356mm) Rubber Bunt Bobbin	4.98	9.96	2	2	0	0	12	CT50
10	6" (152mm) Washer	0.42	3.36	8	2x1	2x2	1x2	13	CT51
11	15.5" (393mm) Bobbin Chain	0.58	19.14	33	0	2x10	1x13	14	CT52
	TOTAL WEIGHT		501.03						

Fisheries and Oceans / Pêches et Océans

CAMPELEN 1800 SURVEY TRAWL
GROUND GEAR

DATE DRAWN	DWG NO.		REV.	SCALE
02/08/93	CAN3.0	PG 7 OF 14 PG		NTS

DRAWN BY: MARINE INSTITUTE FISHING TECHNOLOGY UNIT ST.JOHN'S NEWFOUNDLAND

Fig. 2. Footgear details of the Campelen 1800 survey trawl.

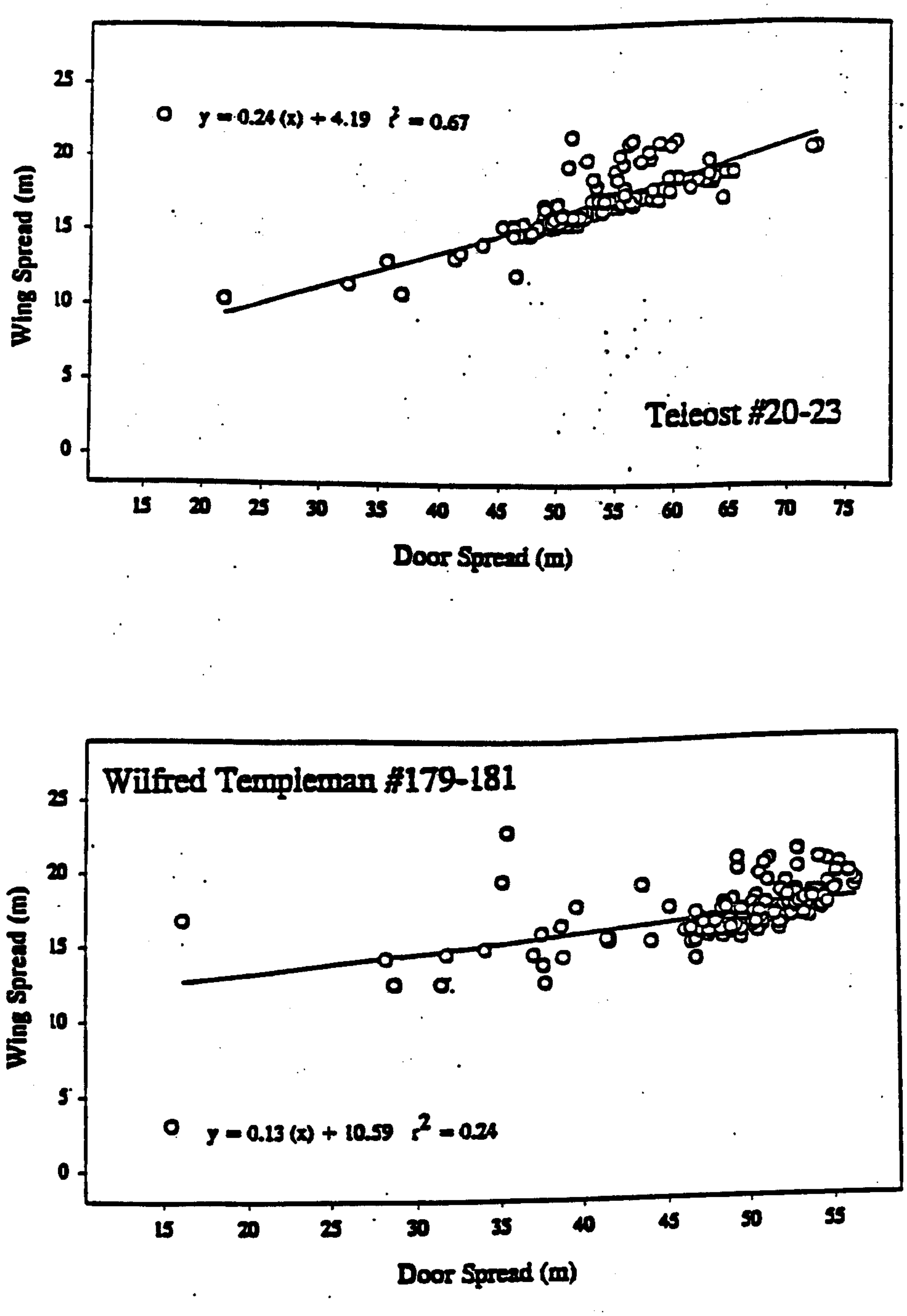


Fig. 3. Relationship between wing spread and door spread for the Teleost and Wilfred Templeman survey trawls during the fall 1995 survey.

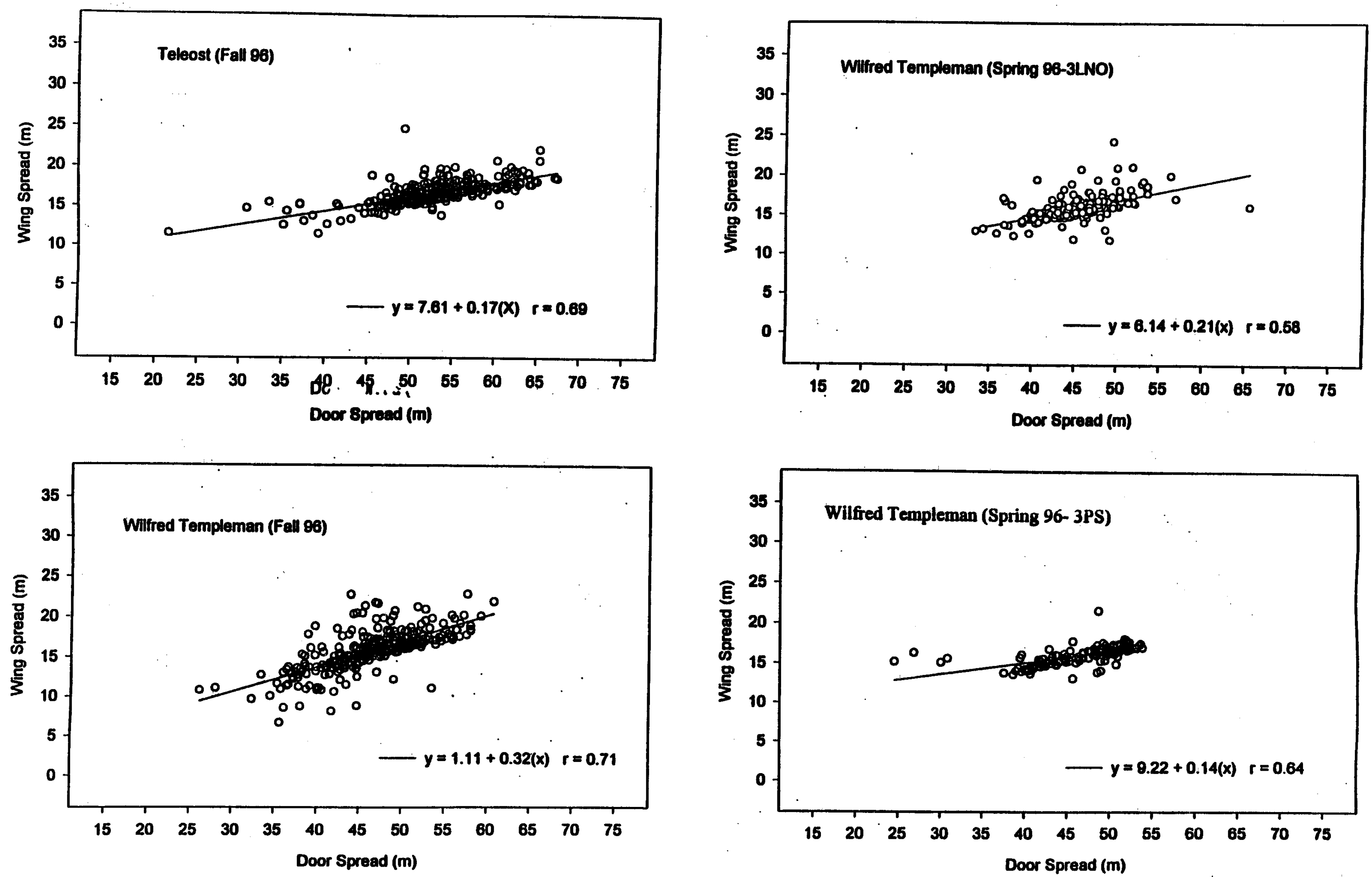


Fig. 4. Relationship between wing spread and door spread for the Teleost and Wilfred Templeman survey trawls during the 1996 fall surveys and spring surveys of 3Ps and 3LNO

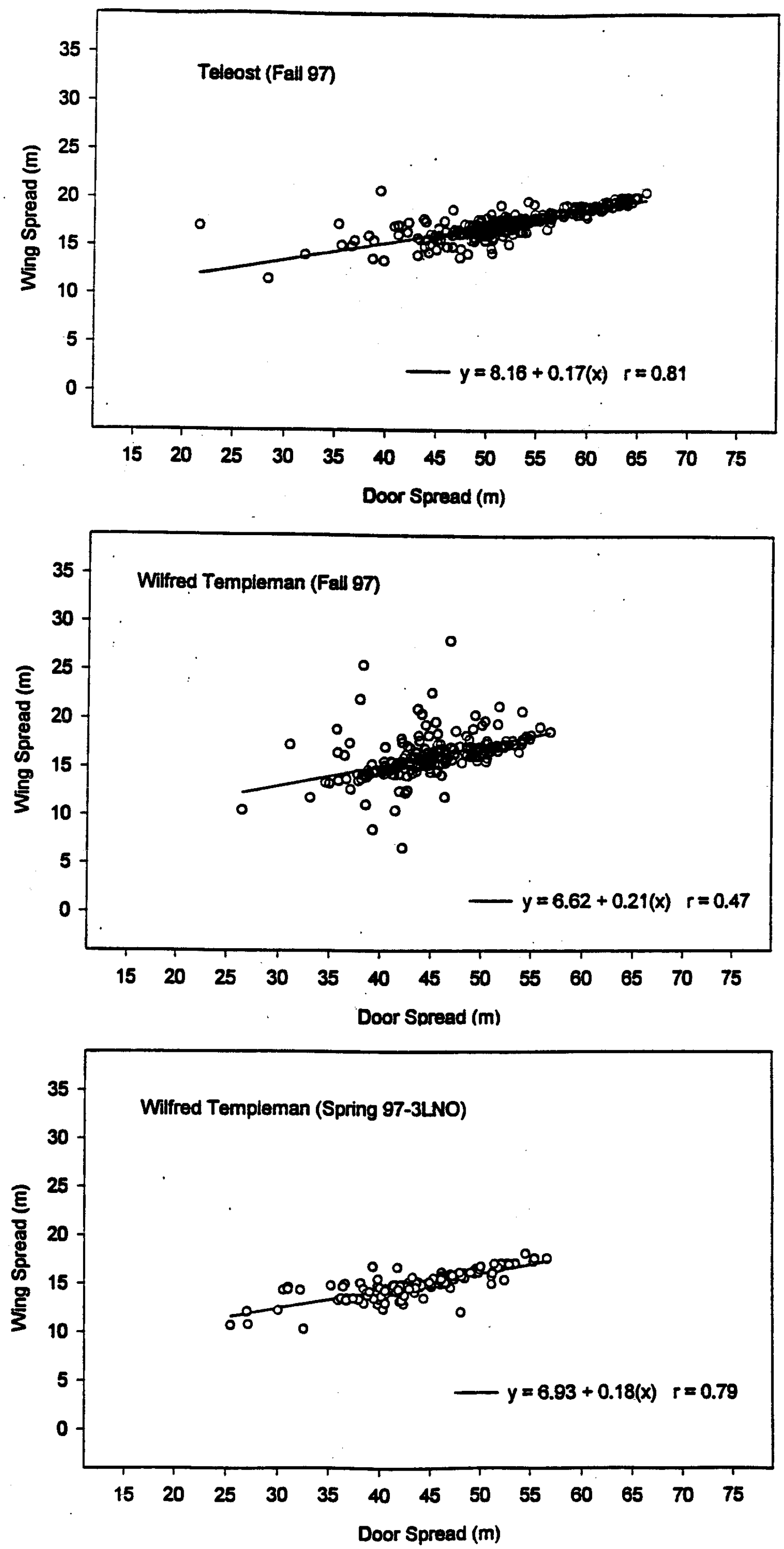


Fig. 5. Relationship between wing spread and door spread for the Teleost and Wilfred Templeman survey trawls during the 1997 fall surveys and spring survey of 3LNO.

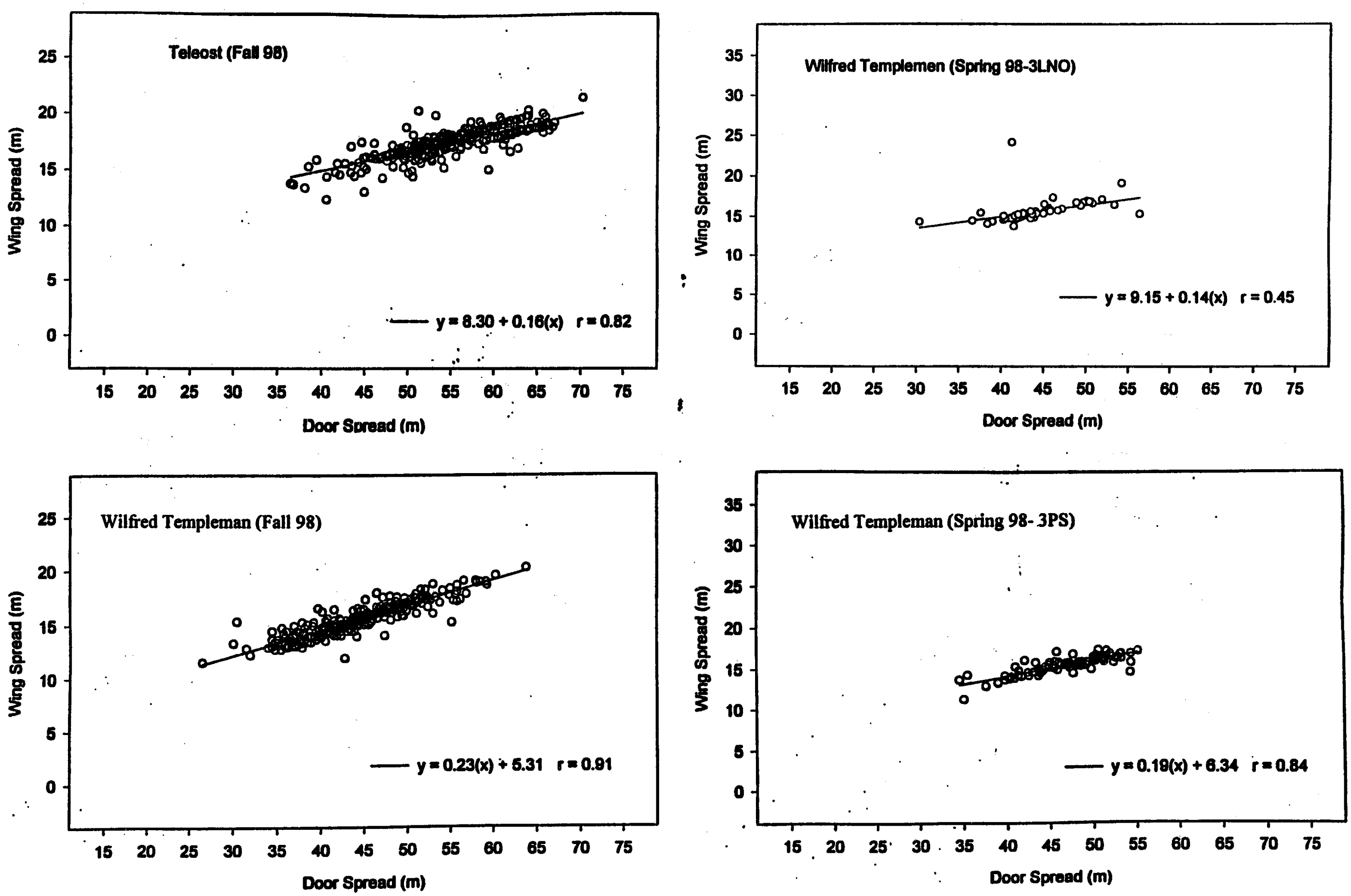


Fig. 6. Relationship between wing spread and door spread for the Teleost and Wilfred Templeman survey trawls during the 1998 fall surveys and spring surveys of 3Ps and 3LNO.

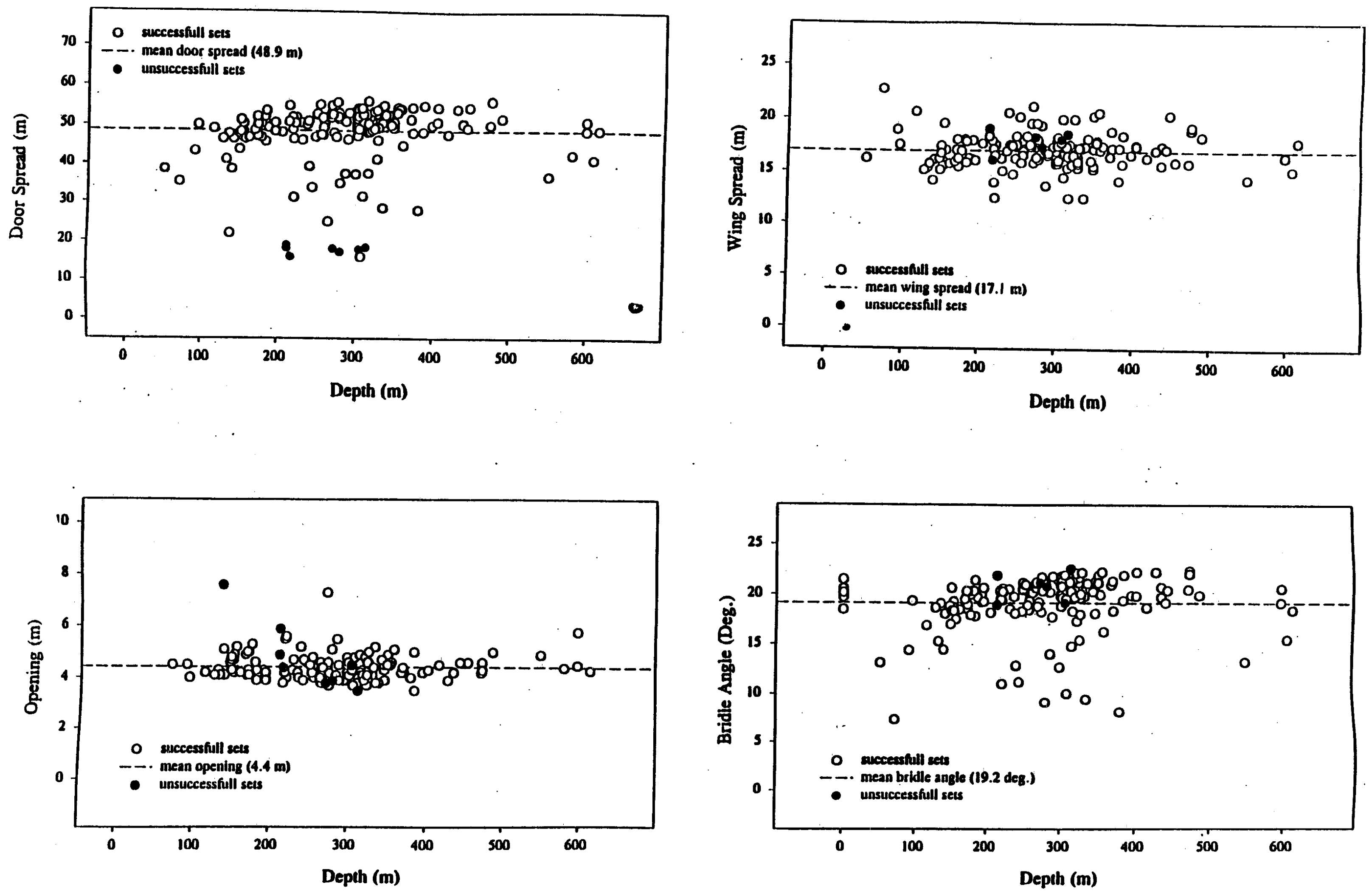


Fig. 7. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1995 fall survey.

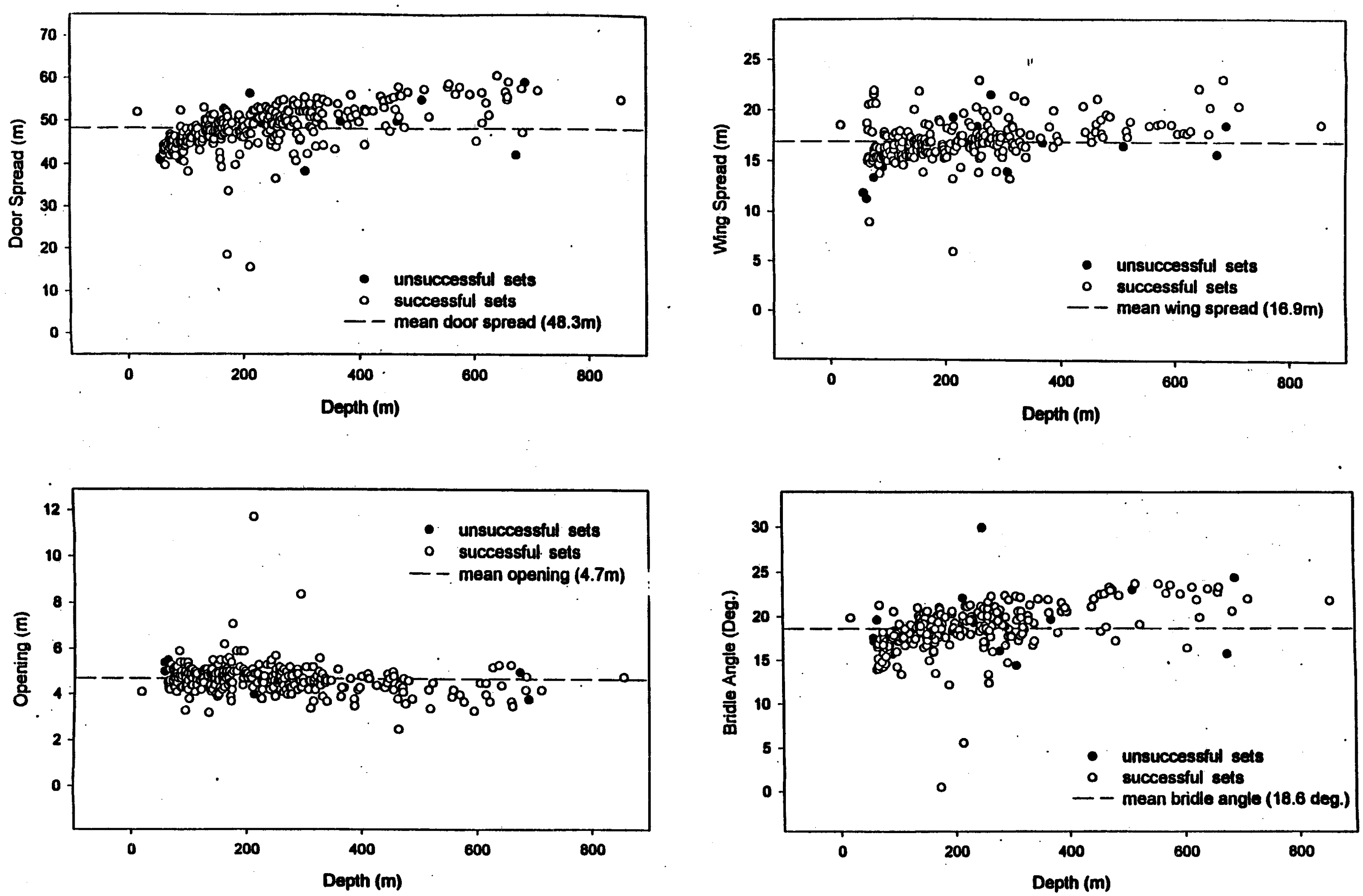


Fig. 8. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1996 fall survey.

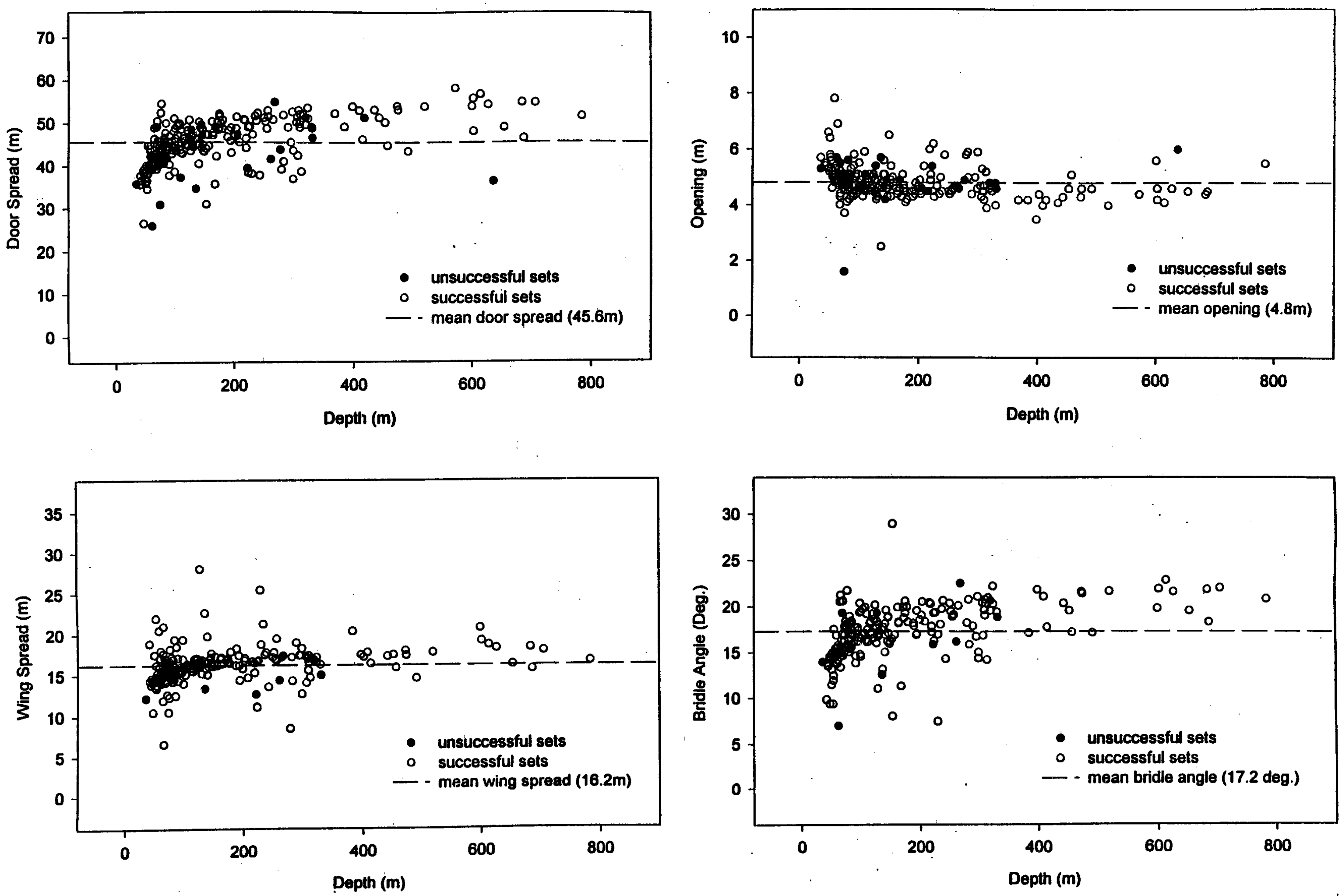


Fig. 9. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1997 fall survey.

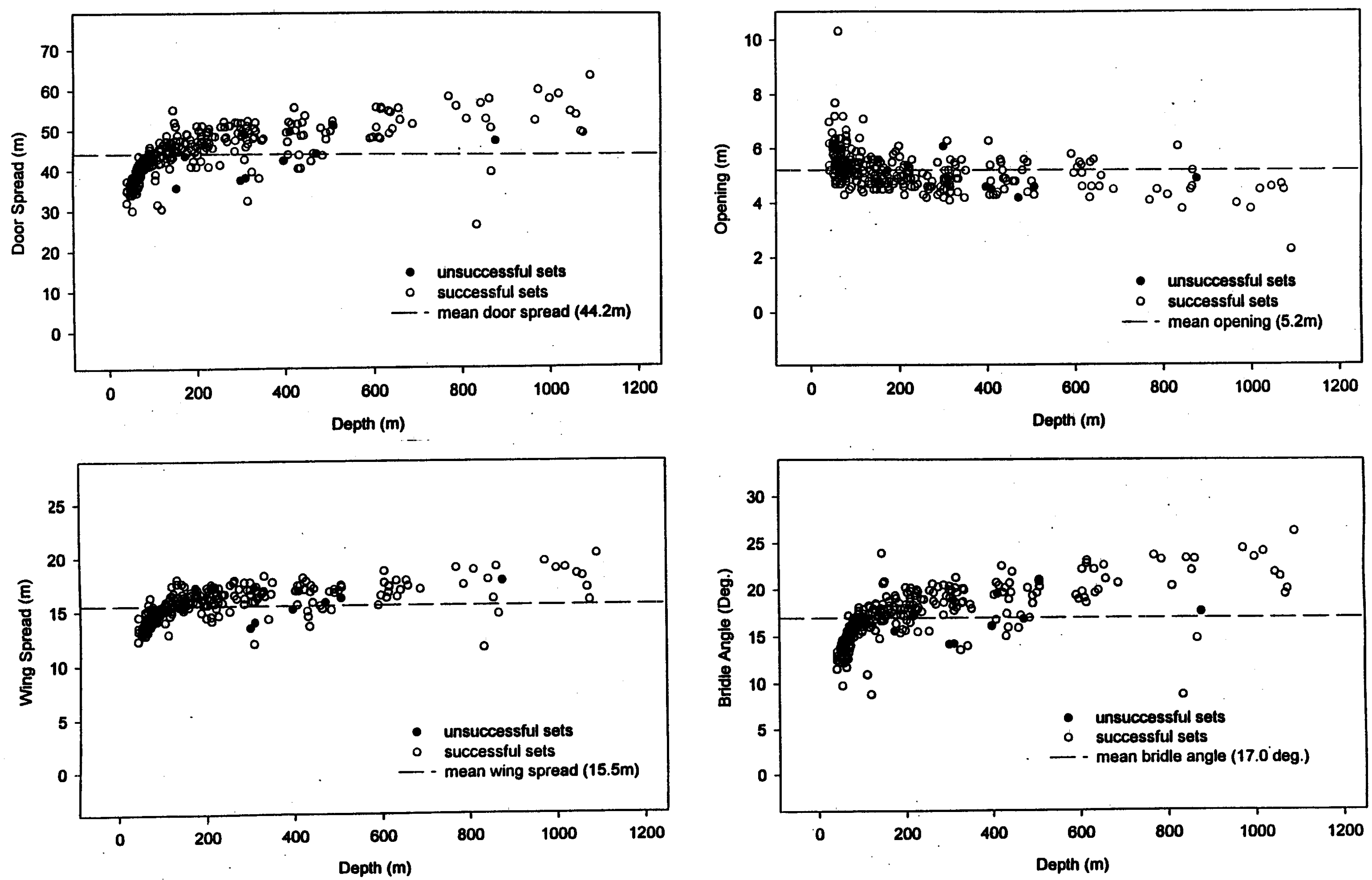


Fig. 10. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1998 fall survey.

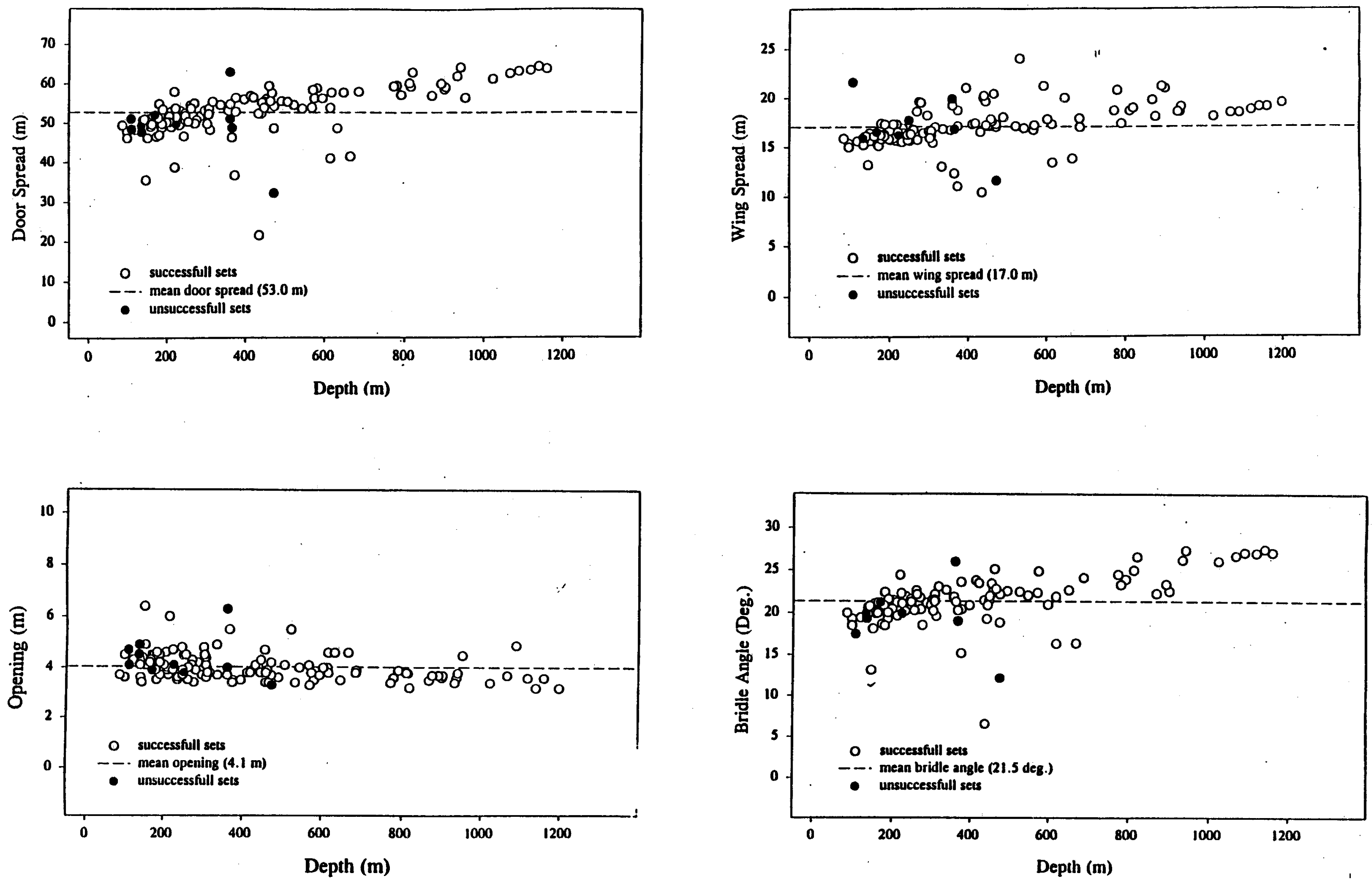


Fig. 11. Relationship of Teleost door spread, wing spread, opening and bridle angle with depth during the 1995 fall survey.

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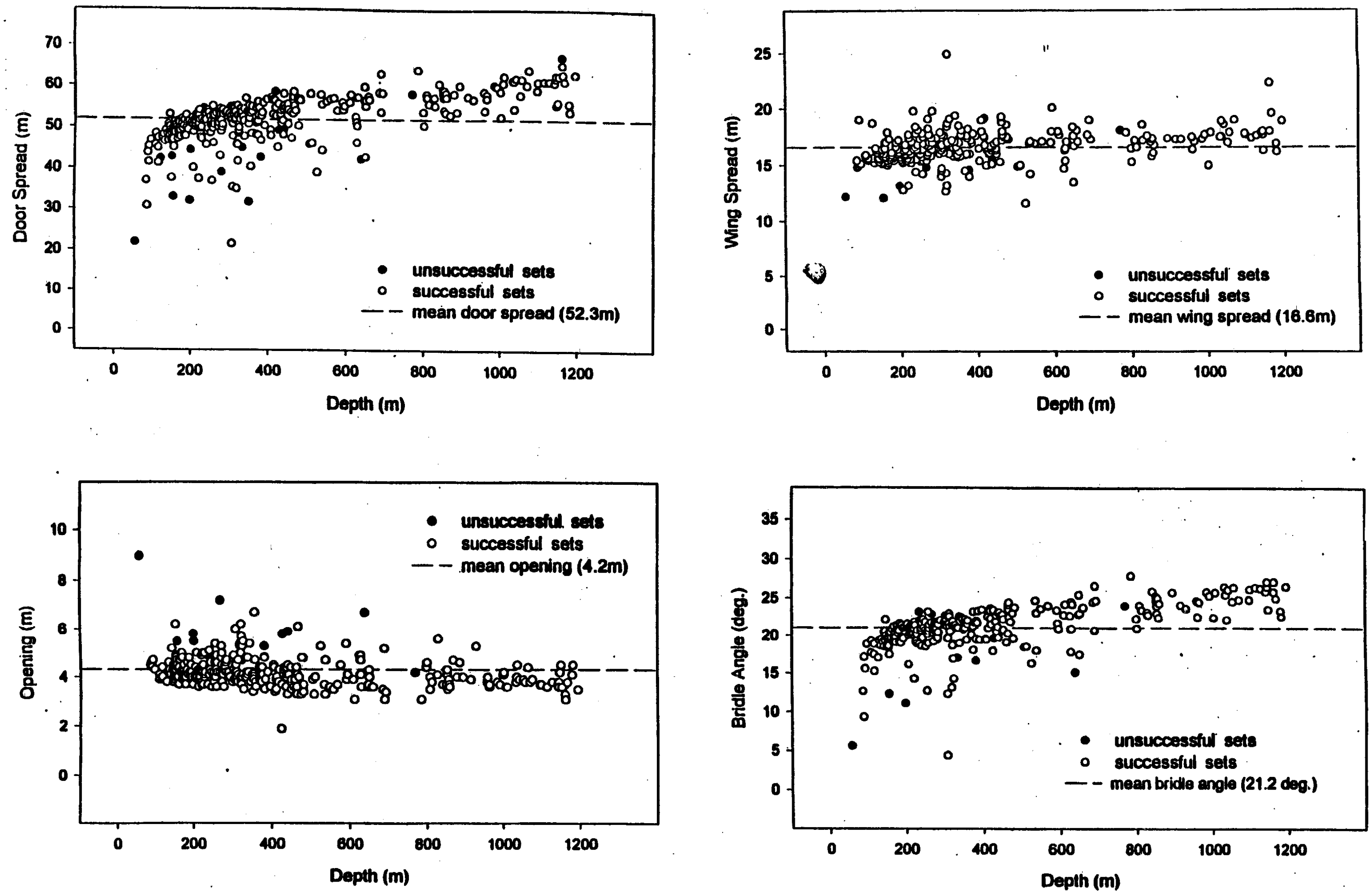

Fig. 12. Relationship of Teleost door spread, wing spread, opening and bridle angle with depth during the 1996 fall survey.

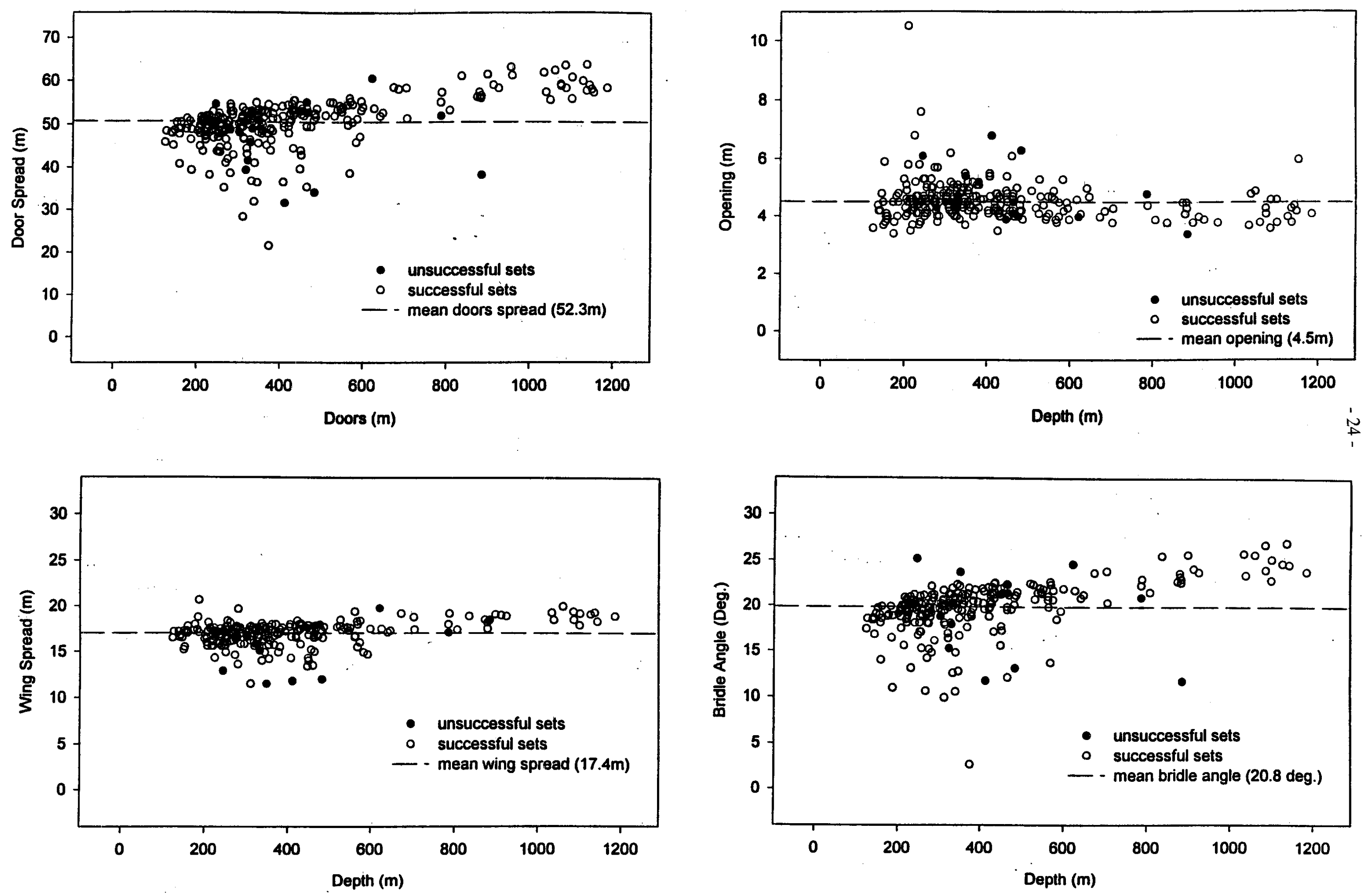

Fig. 13. Relationship of Teleost door spread, wing spread, opening and bridle angle with depth during the 1997 fall survey.

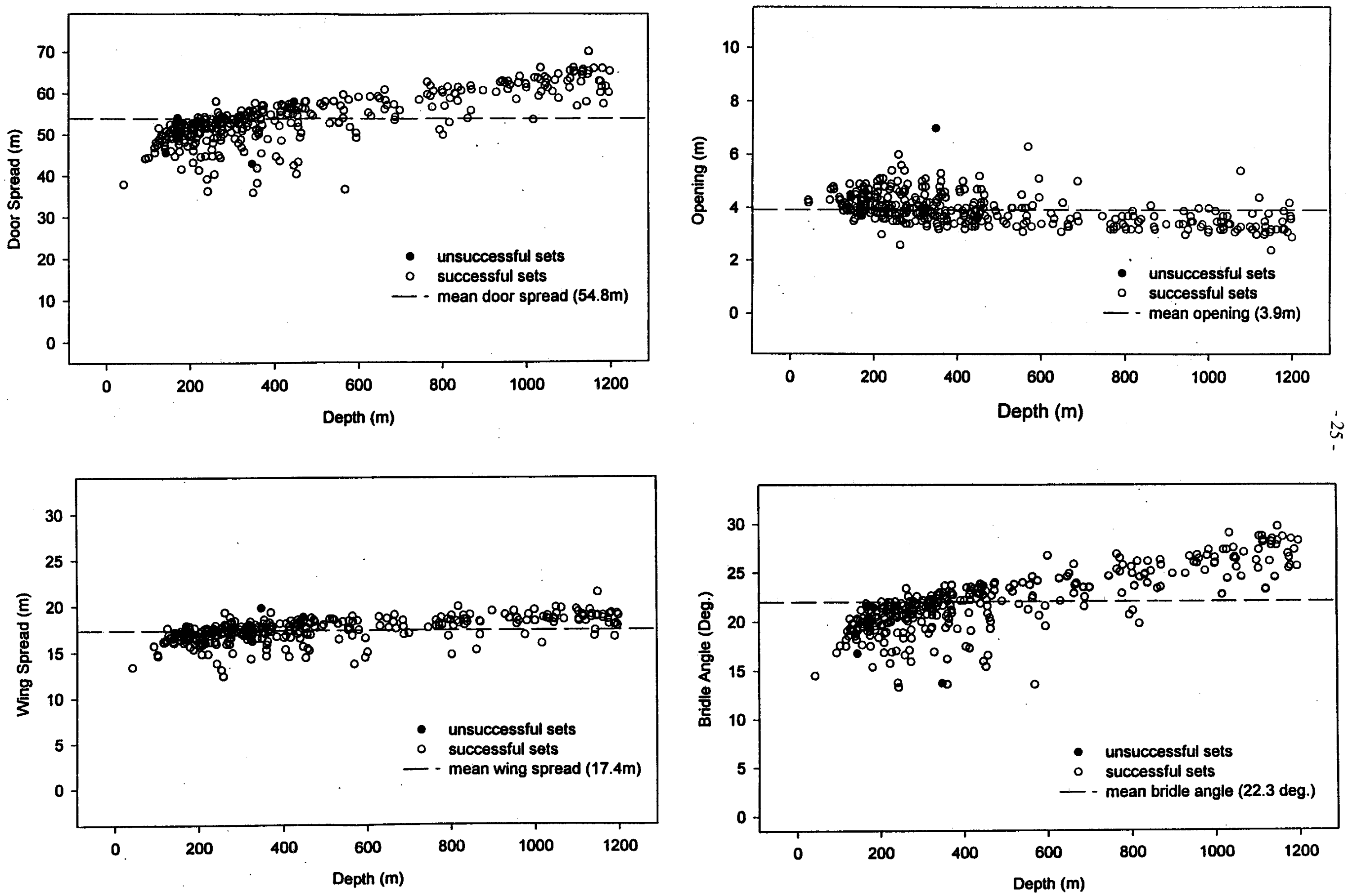

Fig. 14. Relationship of Teleost door spread, wing spread, opening and bridle angle with depth during the 1998 fall survey.

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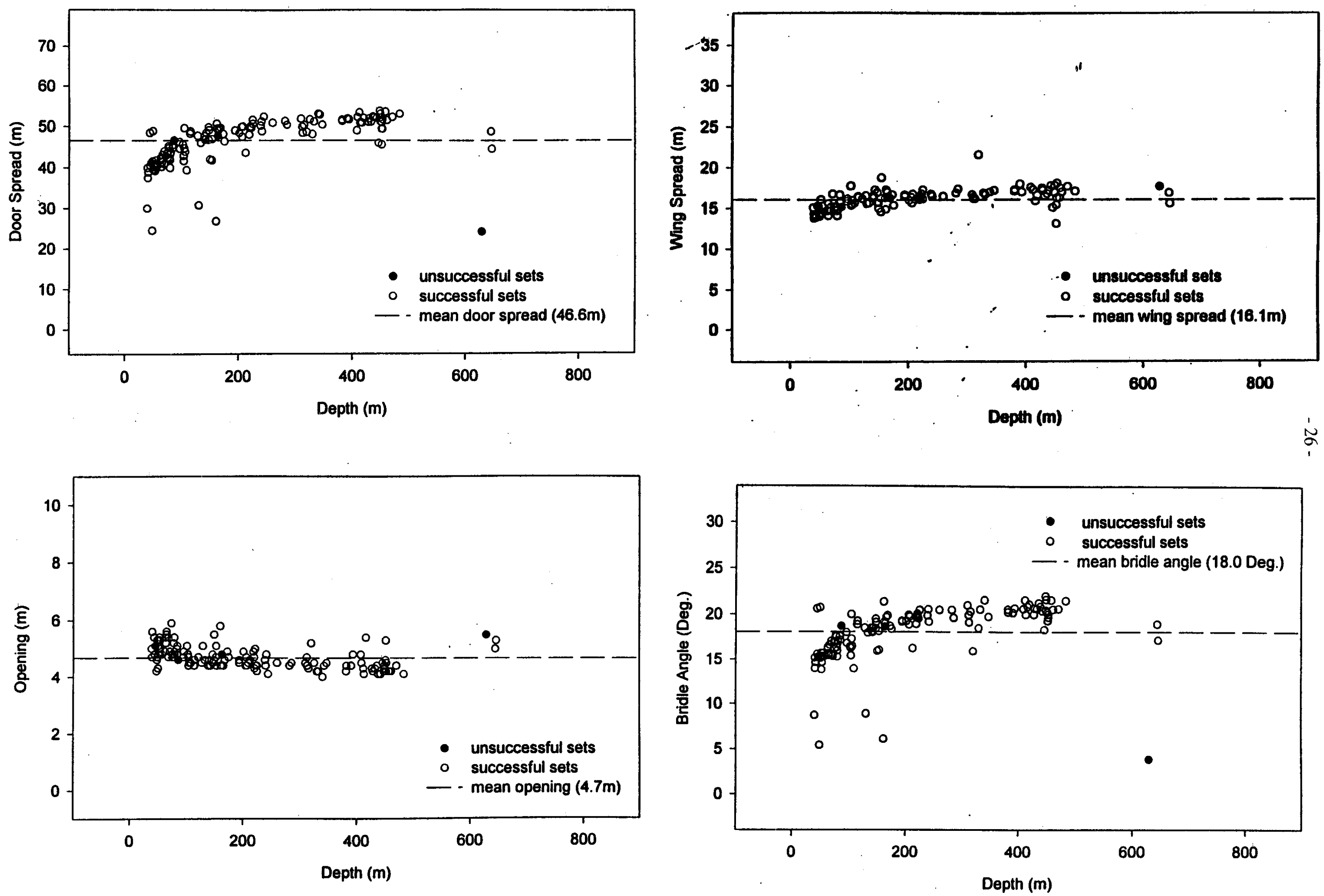
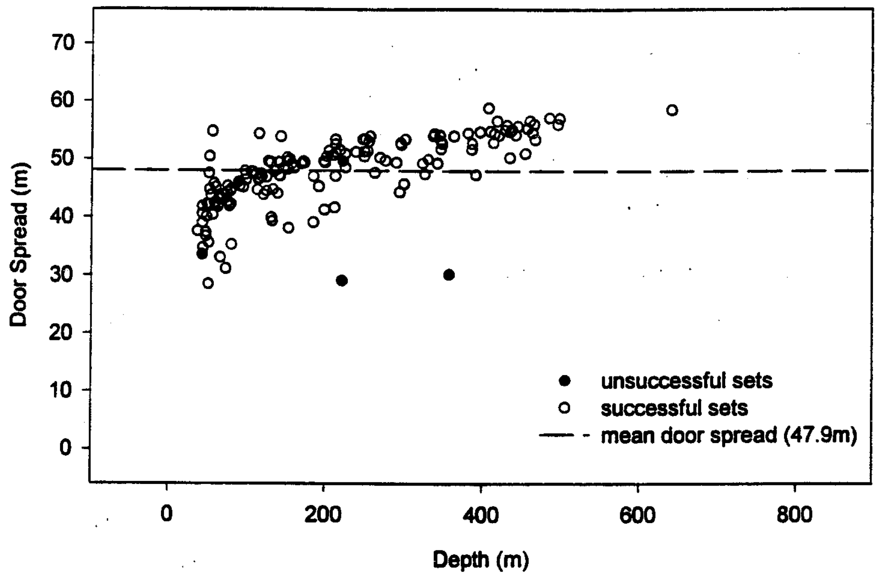


Fig. 15. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1996 spring survey of 3Ps.



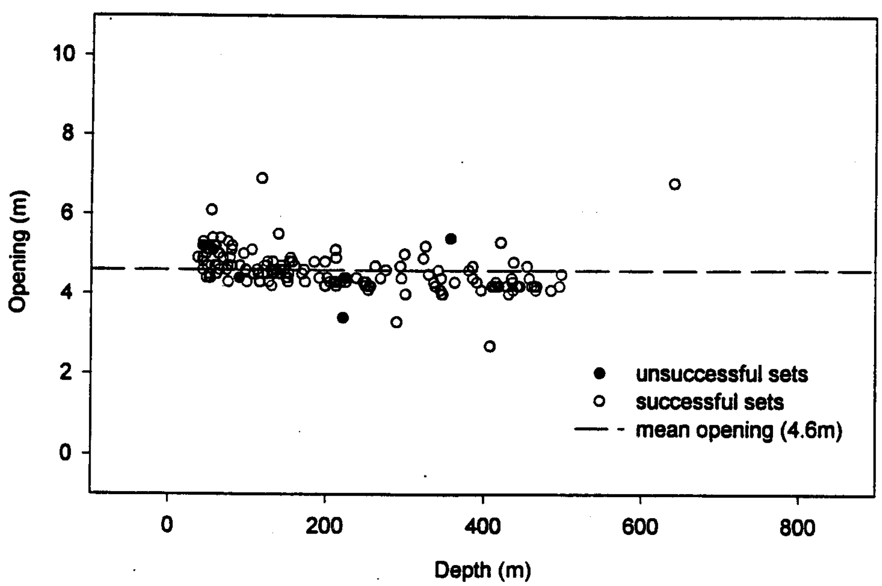


Fig. 16. Relationship of Wilfred Templeman door spread and opening with depth during the 1997 spring survey of 3Ps.

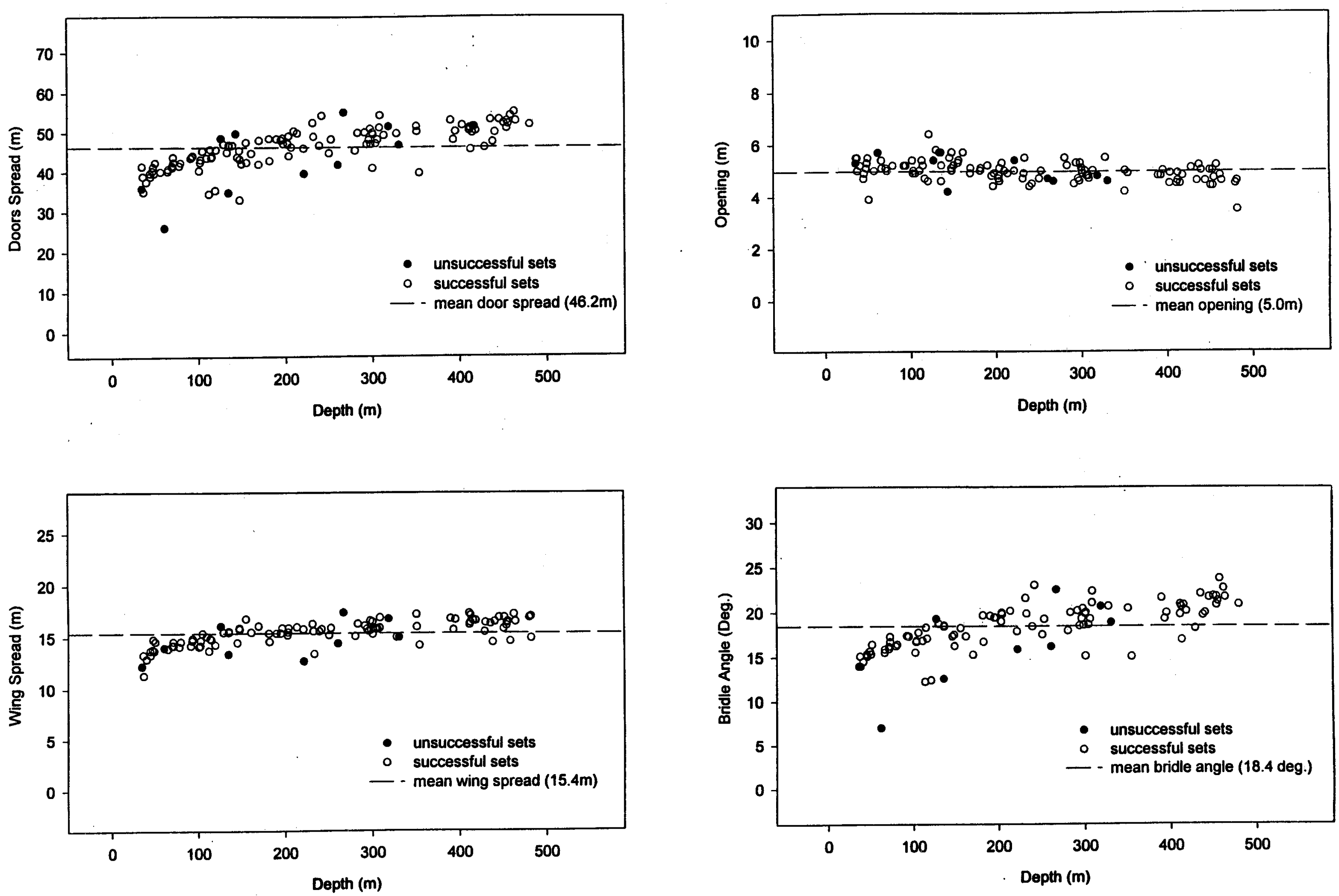


Fig. 17. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1998 spring survey of 3Ps.

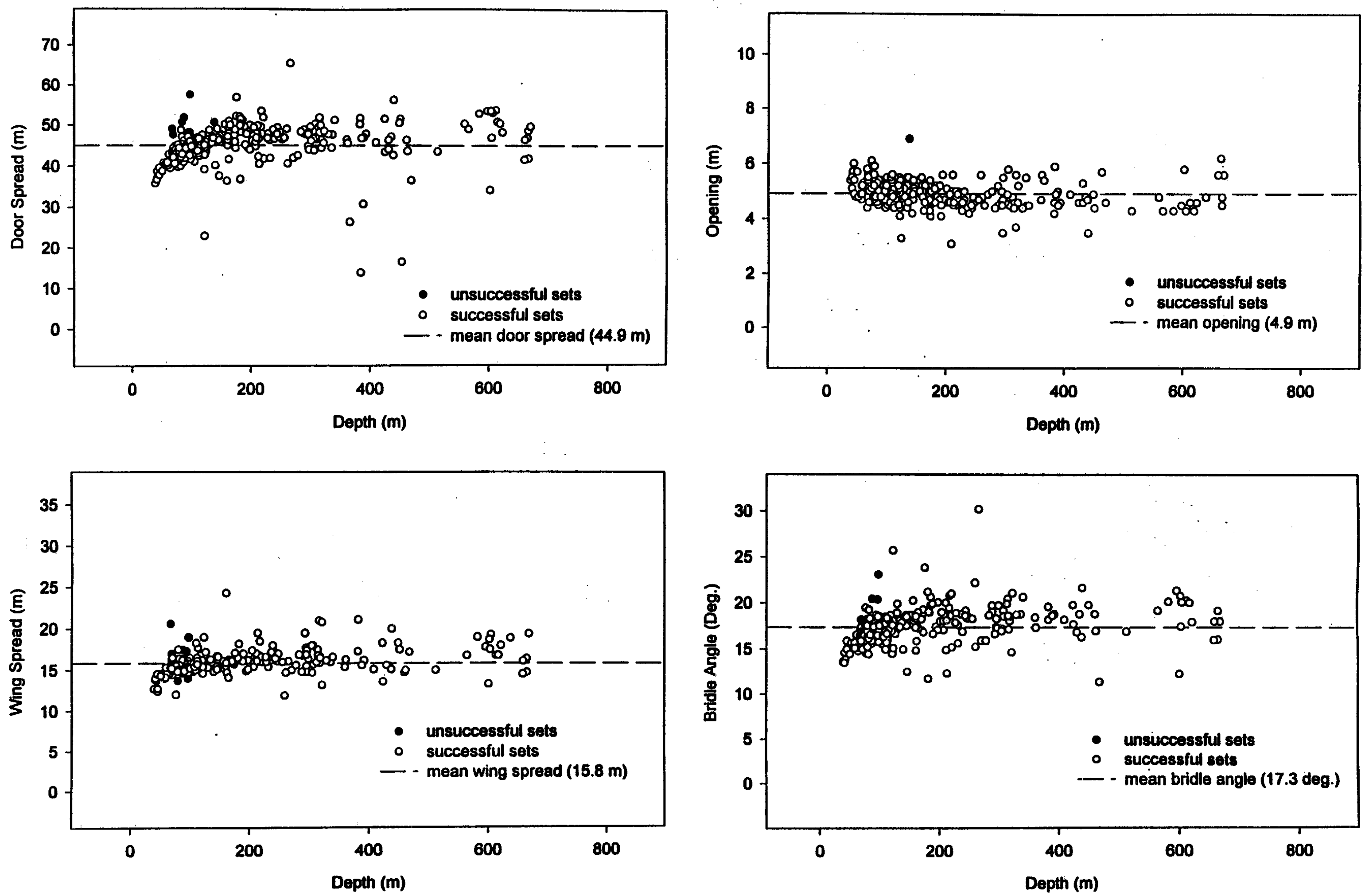


Fig. 18. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1996 spring survey of 3LNO.

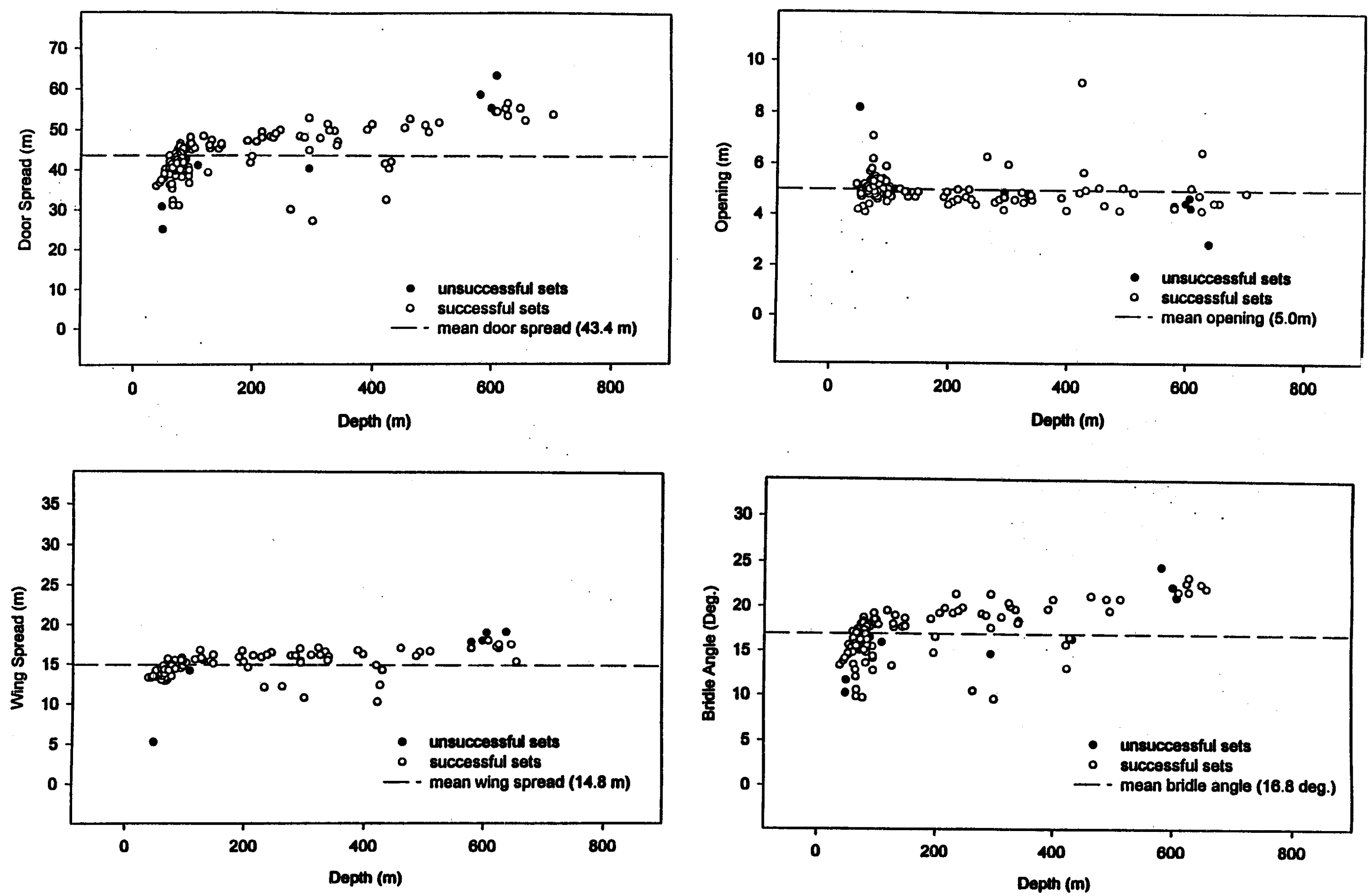


Fig. 19. Relationship of Wilfred Templeman door spread, wing spread, opening and bridle angle with depth during the 1997 spring survey of 3LNO

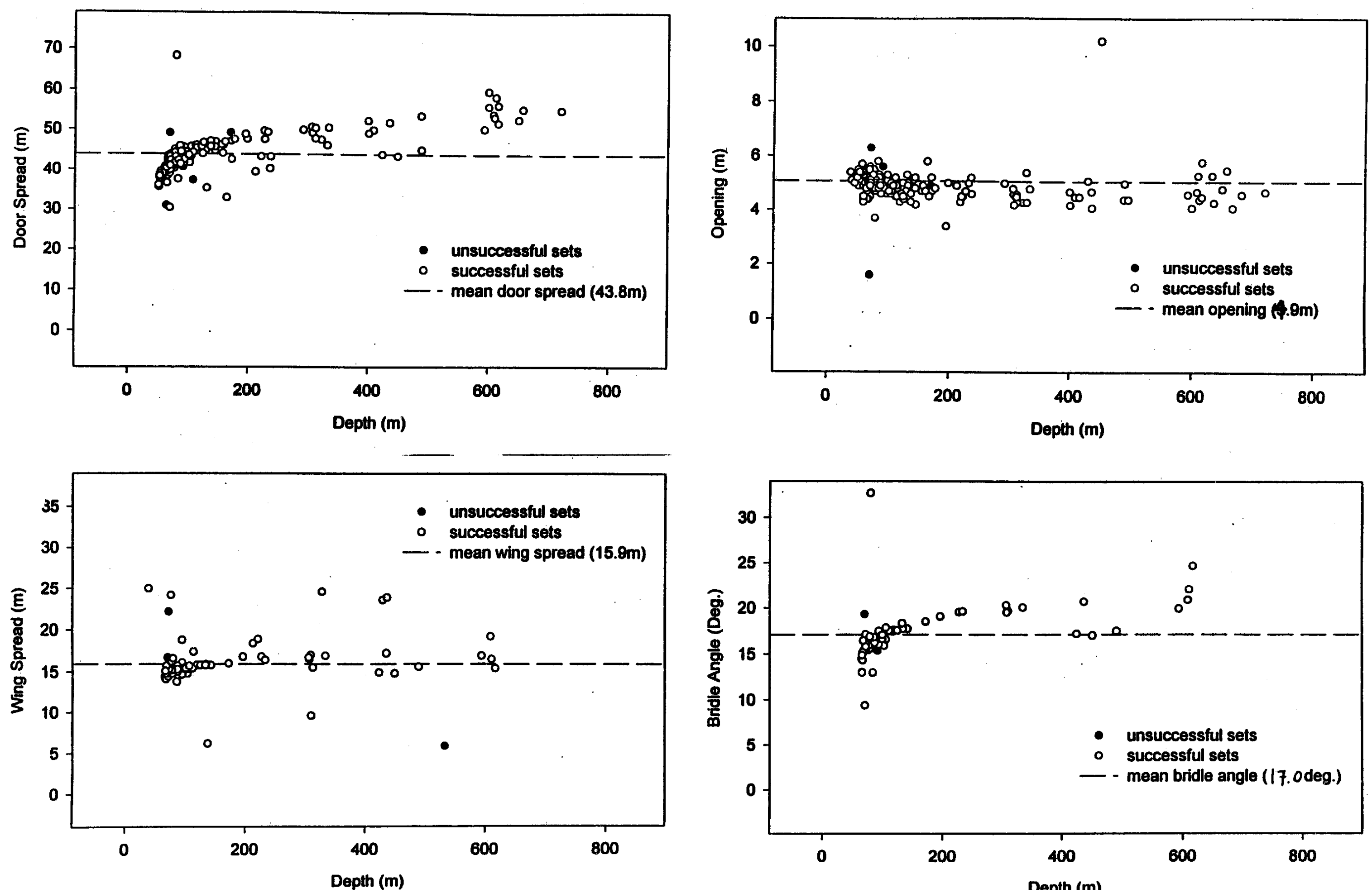
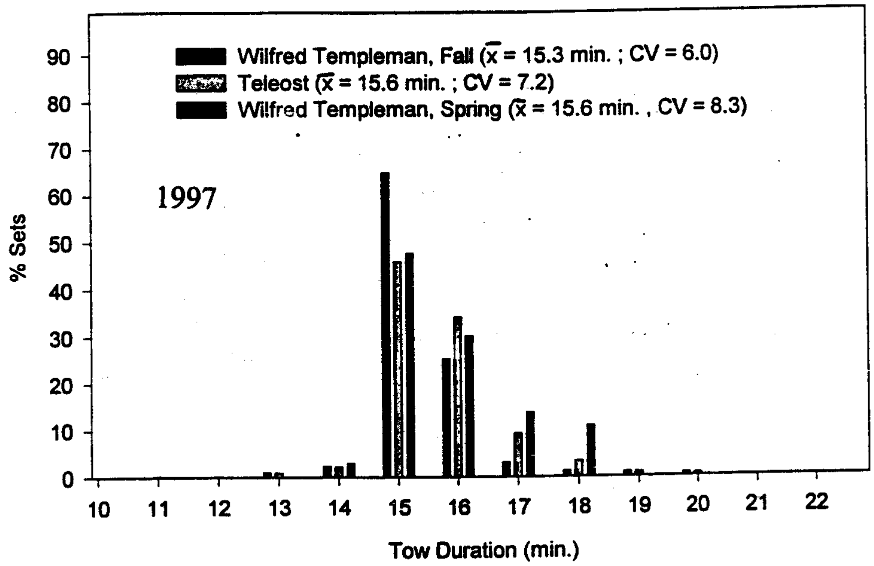


Fig. 20. Relationship of Wilfred Temopleman door spread, wing spread, opening and bridle angle with depth during the 1998 spring survey of 3LNO.



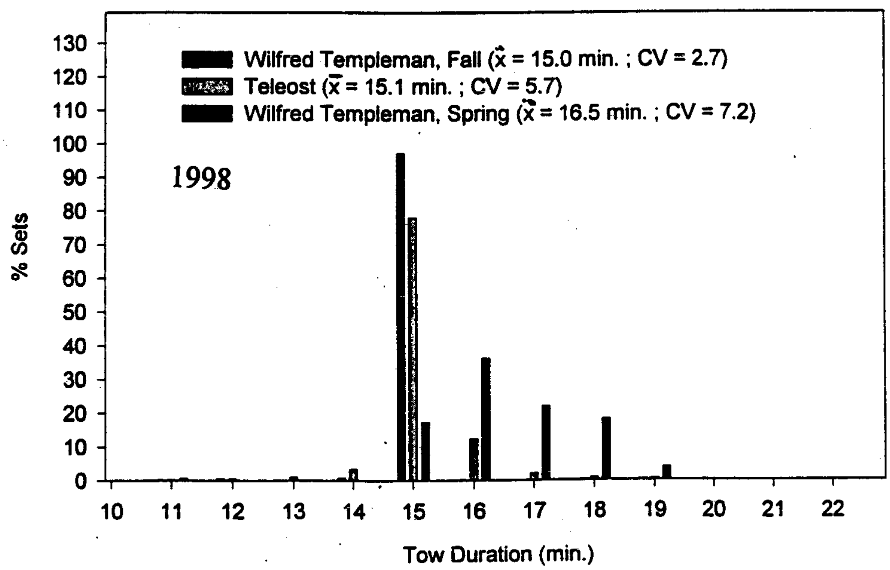


Fig. 21. Tow duration for the Wilfred Templeman and Teleost during the 1997 and 1998 fall surveys and spring survey of 3Ps.