Northwest Atlantic Fisheries Organization

Serial No. N4399 **NAFO SCR Doc. 01/26**

SCIENTIFIC COUNCIL MEETING – JUNE 2001

Evaluating the Success of the Survey Trawl Standardization Program at the Northwest Atlantic Fisheries Centre

by

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Abstract

In 1995, the Northwest Atlantic Fisheries Centre adopted the Campelen 1800 shrimp trawl as the standard bottom trawl to replace the Engel 145 High-Lift otter trawl used onboard its research vessels, the CCGS Wilfred Templeman and CCGS Teleost. Standardization protocols were adopted to minimize the uncertainty in estimates of abundance that could be associated with variations in trawl construction and fishing practices. Trawl performance data are recorded for all fishing sets during the bottom trawl surveys using SCANMAR acoustic trawl instrumentation. This paper presents an assessment of the effectiveness of the NAFC standardization protocols during the 2000 annual fall surveys off Canada's east coast. There is a difference in trawl geometry between research vessels and between survey years. Analysis of tow duration for each research vessel has shown that the Wilfred Templeman has a higher proportion of tows longer than the standard 15 minutes when compared to the Teleost. This may be related to the vessel's inability to maintain speed during haul-back, resulting in longer on bottom times. Differences in survey gear performance between the two research vessels may be due to differences in horsepower, displacement, trawl winches and depth fished.

Introduction

The catchability of a survey trawl will be dependent on its design, application, the behaviour of the individual fish in the population and the interactions 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 abundance estimates (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.

This study was conducted to evaluate the success of the NAFC survey trawl standardization program six years after its introduction. We analysis the performance of the Campelen 1800 during the 1995 to 2000 annual fall surveys of NAFO divisions 2J+3KLMNO and the 1996 to 2000 spring surveys of 3PS and 3LNO. The year 2000 survey will be examined in detail.

Materials and Methods

The Campelen 1800 is a four-panel shrimp trawl with cut-away lower wings and is rigged with 40 m bridles, 6.1 m sweep wires and 4.0 m middles bridle extensions. The 1400 kg, 4.3 m^2 Morgere Polyvalent trawl doors are connected to the sweep wires with 3.05 m door legs. The trawl is held open vertically by 88 plastic trawl floats (200mm diameter) 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. 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 leg and after major damage the survey trawls are measured using the NAFC Survey Trawl Checklist (McCallum & Walsh, 1985). Trawls not conforming to specification are repaired prior to the next fishing set.

Door spread, wingspread, 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 as well as Doppler Log and DGPS navigational information were logged at 5 second intervals on a custom 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 during 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 wingspread, 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 15 minutes long, starting from the moment the trawl touches bottom and ending when the trawl leaves the bottom. Touchdown and lift-off are determined using SCANMAR instrumentation. Gear performance data is collected from the time the trawl doors enter the water until they are retrieved, flags are placed in the data to indicate the start and end of the 15 minute tow. Tow duration is corrected post mission using a more precise measure of on bottom time provided by the CTD (conductivity/temperature/depth) sensor. 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 NAFC 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 wingspread 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 2000 inclusive. Table 3 presents Teleost data that has been partitioned into fishing depths that are 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 during the spring from 1996 to 2000. A summary of all data is presented in Table 6.

Table 7 shows the results of a MANN-WHITNEY rank sum test on the differences in geometry between the Wilfred Templeman and the Teleost for the survey years 1998 to 2000. Table 8 shows the differences in horizontal gear geometry between vessels by depth for the survey year 2000.

[1] Wing end sensors are mounted in stainless steel canisters to provide protection from trawling damage. Their weight in water is offset by adding 6 x 200 mm diameter floats (15.6 kg buoyancy) to the port wing end and 4 x 200 mm diameter floats (10.4 kg buoyancy) to the starboard wing.

Wilfred Templeman – Table 1 shows the summary statistics of trawl gear performance on the Wilfred Templeman during the fall groundfish surveys from 1995 to 2000. Doorspreads ranged from a low of 42.5 m (2000) to a high of 48.8 m (1995) with a mean of 45.9 m. Wingspreads ranged from 15.5 m (1998) to 17.1 m (1995) with a mean of 16.3 m. The mean depth fished from 1995 to 2000 was 237 m. There was no statistical difference in door spread, wingspread and opening parameters between the survey years 1995 and 1996 (McCallum and Walsh, 1997). However there was a difference between 1997 and 1998 (McCallum and Walsh, 1999) and there is a statistically significant difference when comparing door spread and wingspread between 1998 and 2000 (Table 7). Differences between 1997 and 2000 may be explained by the differences in the depth range fished during the individual surveys. Surveys in 1997 to 2000 were carried-out to a maximum depth of 784 m, 1118 m, 1407 m and 654 m respectively.

Teleost- Table 2 shows summary statistics for the Teleost survey data from 1995 to 2000 for all fishing depths. Door spreads ranged from a low of 52.3 m (1996/1997) to a high of 54.8 m (1998/2000) with a mean of 53.5 m. Wingspreads ranged from 16.6 m (1996) to 17.8 m (1999) with a mean of 17.3 m. The mean depth fished from 1995 to 2000 was 463 m. There was no difference between wingspread, door spread or trawl opening between 1995 and 1996 and there is no statistical difference in door spread between 1998 and 2000. Wingspreads are comparable between 1997 and 2000 and trawl opening was comparable between 1999 and 2000 only.

Wilfred Templeman and Teleost – Table 3 shows the Teleost summary statistics for gear geometry at depths comparable to those fished by the Wilfred Templeman. A significant difference in all three-gear parameters was found when comparing between vessels in the same survey year and between survey years for 1997, 1998, 1999 and 2000. This is in contrast to 1996 where there was a significant difference in door spread and in opening between the two vessels but no difference in wingspread (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.

Wilfred Templeman (3PS) – Table 4 shows the summary statistics for the Wilfred Templeman during the annual spring survey of 3PS. Wingspread was not collected during the survey in 1997 due to operational difficulties with SCANMAR instrumentation. Door spreads range from a low of 44.8 m (1999) to a high of 47.9 m (1997), mean door spread over the survey years 1996 to 2000 was 46.1 m. Wingspreads over this period ranged from 15.4 m to 16.4 m, with a mean of 15.9 m. There was no statistical difference in door spread between 1998 and 2000. The variability of door spread and wingspread between all survey years is relatively consistent, which may be a result of the low variation in depths fished.

Wilfred Templeman (3LNO) – Table 5 shows the summary statistics for the Wilfred Templeman during the annual spring survey of 3LNO. Mean door spread over the period 1996 to 2000 was 43.3m, ranging from a low of 41.9 m (2000) to a high of 44.9 m (1996). Wingspread ranged from a low of 14.8 m (1997) to a high of 15.9 m (1998) with a mean of 15.5 m. With the exception of door spread between 1999 and 2000, there was no statistical difference in either door spread or wingspread between the survey years 1998, 1999 and 2000. As expected opening generally mirrored changes in door spread and wingspread. Trawl opening tends to be less sensitive than wingspread to changes in door spread.

Gear Performance

Figure 1 demonstrates differences in mean door spread and wingspread between survey years. Figure 2 shows a comparison of distances towed during the survey set between the Wilfred Templeman and Teleost for survey year 2000. GPS tow distance is calculated from the start and end position of the tow as determined by the fishing officer and measured by the GPS unit. In practice the fishing officer will use SCANMAR depth and height sensors 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 trawl mounted CTD is used to determine a more precise measure of the time elapsed between trawl touch down and lift-off, however this is done post mission. Distance towed is calculated using tow duration and vessel speed. A comparison of GPS and CTD measured tow distances shows that fishing officers perceive the trawl to be on the bottom for periods shorter than it actually is. The Wilfred Templeman and Teleost CTD calculated mean tow distances compare closely, however slightly longer tow durations are occurring on the Wilfred Templeman (0.79 nm vs. 0.76 nm).

Figure 2 shows a comparison of tow duration calculated from CTD time on bottom between the Wilfred Templeman and Teleost for the survey year 2000. Average tow durations are longer on the Wilfred Templeman than the Teleost and this difference is consistent across all surveys done in 2000. Figure 3 shows a comparison of CTD calculated time on bottom for each shift and watch on the Wilfred Templeman and Teleost during the survey year 2000. While there appears to be little difference between shifts and watches on either vessel, tow durations on the Wilfred Templeman are consistently. Figure 4 and 5 demonstrate the relationship between tow duration and depth. There appears to be no relationship between tow duration and depth to explain the higher percentage of longer duration tows i.e >15 min. occurring in less than 200m of water. Figure 7 shows trawl depth over time for a selected set completed by the Wilfred Templeman and the Teleost. On the Wilfred Templeman vessel speed decreases shortly after haul-back commences however the CTD indicates that the trawl has not left the bottom, this does not appear to happen for the Teleost. The plot of vessel speed suggests that the Wilfred Templeman may have stopped and therefore the trawl is sitting on the bottom for up to 3 minutes.

Conclusions

There is a statistical difference in survey gear performance between research vessels and between surveys conducted with the same research vessel in different years. However, some of this difference may be explained by differences in mean depth fished. Other differences in fishing power between research vessels can be explained by comparing the physical characteristics of the two research vessels i.e. displacements, 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. The effect of differences in fishing power between Teleost and Wilfred Templeman on the catchability of gadoids can be measured in side-by-side comparative fishing tows similar to the comparative fishing exercise with Spain in the regulatory area.

The Wilfred Templeman has a higher proportion of tows >15 minutes long. This difference does not appear to be related to differences in crews on either vessel or fishing depth. This may be due to the differences in horsepower, displacement and winches between the two vessels. In practice, CTD measures of tow duration are converted to distance towed assuming a constant vessel speed of 3.0 kts. If the vessel stops during the tow or during haul-back, a period during which the CTD is indicating the trawl is on the bottom distance towed and consequently swept area will be over estimated. This situation could be avoided by strict adherence to the NAFC touchdown and lift-off protocols (Walsh & McCallum, 1999), including the requirement for power lift-offs. However, it is suspected that the Wilfred Templeman has insufficient power to do this effectively. Therefore, it is suggested that vessel speed be incorporated into the analysis of CTD tow duration, allowing for verification that the net is moving and therefore fishing over the entire tow period. This would require a small modification to existing analytical software.

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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 2000 fall groundfish surveys.

Survey	Variable	No. Obs.	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
1999	Depth	312	342.6			
	Doors	290	46.2	16.6	14.9	69.5
	Wings	294	16.6	11.4	7.5	21.9
	Opening	273	4.9	16.4	2.2	10.9
	Bridle Angle	274	17.3	21.3	7.1	31.3
2000	Depth	168	172.6			
	Doors	156	42.5	10.3	30.5	54.3
	Wings	155	15.6	6.8	12.5	18.4
	Opening	155	4.6	12.7	2.9	8.0
	Bridle Angle	143	16.0	13.8	9.5	21.9

Table 2. Comparison of summary statistics of trawl geometry for the Campelen 1800 shrimp trawl used by the Teleost during the 1995 to 2000 fall groundfish surveys.

Survey	Variable	No. Obs.	X	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
1999	Depth	275	430.3			
	Doors	274	54.0	10.2	28.1	69.7
	Wings	260	17.8	6.6	12.5	22.0
	Opening	268	4.0	14.0	3.2	9.6
	Bridle Angle	259	22.0	12.9	9.1	29.5
2000	Depth	414	563.3			
	Doors	409	54.8	10.3	25.8	67.0
	Wings	327	17.8	7.4	11.0	22.1
	Opening	386	4.0	17.7	3.1	9.4
	Bridle Angle	324	22.3	13.5	8.6	28.8

Table 3. Comparison of summary statistics of depth adjusted data of trawl geometry for the Campelen 1800 shrimp trawl used by the Teleost during the 1995 to 2000 fall groundfish surveys. Depths are those fished by the Wilfred Templeman.

Survey	Variable	No. Obs.	X	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	291	20.7	12.5	4.4	27.9
1997	Depth	316	344.0			
<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
1998	Depth	272	432.2			
<1100	Doors	262	54.0	9.7	36.7	66.3
	Wings	254	17.3	8.2	3.4	19.8
	Opening	258	3.9	13.9	2.6	6.3
	Bridle Angle	246	21.8	12.7	13.5	31.8
1999	Depth	263	387.6			
<1300m	Doors	262	54.1	9.5	28.1	68.2
	Wings	249	17.7	6.2	12.5	22.0
	Opening	256	4.0	14.0	3.2	9.6
	Bridle Angle	248	21.7	12.0	9.1	28.1
2000	Depth	273	298.9			
<654m	Doors	272	52.2	7.5	25.8	59.4
	Wings	207	17.4	6.6	11.0	22.1
	Opening	255	4.1	17.5	3.3	9.4
	Bridle Angle	207	20.8	9.8	8.6	24.4

Table 4. Comparison of summary statistics of trawl geometry for the Campelen 1800 shrimp trawl used by the Wilfred Templeman during the 1996 to 2000 spring surveys of 3PS.

Survey	Variable	No. Obs.	×	CV (%)	Min.	Max.
1996	Depth	143	215.2	70.2	39.5	646
	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	67.0	37.0	641.6
	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	58.7	35.4	482.3
	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
1999	Depth	190	220.5			
	Doors	173	44.8	11.5	14.1	56.3
	Wings	184	15.8	7.2	12.6	18.6
	Opening	180	4.6	10.3	3.8	6.4
	Bridle Angle	166	17.3	12.7	11.9	22.5
2000	Depth	177	213.3			
	Doors	175	45.4	12.1	30.8	62.8
	Wings	168	16.4	8.1	10.9	21.1
	Opening	158	4.4	14.4	2.5	8.1
	Bridle Angle	166	17.2	16.3	10.0	26.1

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 2000 spring survey of 3LNO.

Survey	Variable	No. Obs.	x	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
1999	Depth	368	179.0			
	Doors	358	42.8	9.6	30.0	53.7
	Wings	341	15.4	6.5	12.3	18.2
	Opening	339	4.6	13.1	1.8	10.9
	Bridle Angle	340	16.3	13.0	10.4	29.7
2000	Depth	282	181.3			
	Doors	278	41.9	10.6	25.7	54.8
	Wings	266	15.4	6.6	12.1	19.4
	Opening	265	4.5	12.4	2.3	9.6
	Bridle Angle	262	15.7	13.9	7.9	22.1

Table 6. Comparison of summary statistics of trawl geometry parameters for the Campelen 1800 shrimp trawl used by the Wilfred Templeman and Teleost during the fall surveys of 2J+3KLMNO and spring surveys off 3PS and 3LNO, 1995 to 2000.

		1995				1996				1997				1998				1999				2000			
Depth (m) Adjusted	**Variable**	**WT fall mean**	**Tel Fall mean**	**WT 3Ps mean**	**WT 3LNO mean**	**WT fall mean**	**Tel Fall mean**	**WT 3Ps mean**	**WT 3LNO mean**	**WT fall mean**	**Tel Fall mean**	**WT 3Ps mean**	**WT 3LNO mean**	**WT fall mean**	**Tel Fall mean**	**WT 3Ps mean**	**WT 3LNO mean**	**WT fall mean**	**Tel Fall mean**	**WT 3Ps mean**	**WT 3LNO mean**	**WT fall mean**	**Tel Fall mean**	**WT 3Ps mean**	**WT 3LNO mean**
	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	342.6	430.3	220.5	179.0	172.6	298.9	213.3	181.3
	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	46.2	54.0	44.8	42.8	42.5	52.2	45.4	41.9
	Wings	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	16.6	17.8	15.8	15.4	15.6	17.4	16.4	15.4
	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	4.9	4.0	4.6	4.6	4.6	4.1	4.4	4.5
	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	17.3	22.0	17.3	16.3	16.0	20.8	17.2	15.7
Tel.	Depth		298.8																						
<615m	Doors		51.4																						
	Wings		16.7																						
	Open		4.1																						
	BA		20.5																						
Tel.	Depth						336.6																		
<855m	Doors						51.3																		
	Wings						16.5																		
	Open						4.6																		
	BA						20.7																		
Tel.	Depth										344.0														
<788m	Doors										49.8														
	Wings										16.9														
	Open										4.6														
	BA										19.6														
Tel.	Depth														432.2										
<1100m	Doors														54.0										
	Wings														17.3										
	Open														3.9										
	BA														21.8										
Tel.	Depth																		387.6						
<1300m	Doors																		54.1						
	Wings																		17.7						
	Open																		4.0						
	BA																		21.7						
Tel.	Depth																						298.9		
<654m	Doors																						52.2		
	Wings																						17.4		
	Open																						4.1		
	BA																						20.8		

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 98)/Teleost(Fall 99)	77557	P=0.162
	Teleost(Fall 99)/Teleost(Fall 20)	93318	P=0.878
	Templeman(Fall 98)Templeman(Fall 99)	92106	P<0.001
	Templeman(Fall 99)Templeman(Fall 20)	30265	P<0.001
	Teleost(Fall 98)/Templeman(Fall 98)	50755	P<0.001
	Teleost(Fall 99)/Templeman(Fall 99)	107110	P<0.001
	Teleost(Fall 20)/Templeman(Fall 20)	15012	P<0.001
	Templeman(3PS-98)/Templeman(3PS-99)		P=0.728
	Templeman(3PS-99)/Templeman(3PS-20)	29205	P=0.295
	Templeman(3LNO-98)/Templeman(3LNO-99)	55660	P=0.134
	Templeman(3LNO-99)/Templeman(3LNO-20)	81305	P<0.001
Wingspread	Teleost(Fall 98)/Teleost(Fall 99)	76739	P=0.027
	Teleost(Fall 99)/Teleost(Fall 20)	75910	P=0.795
	Templeman(Fall 98)Templeman(Fall 99)	66213	P<0.001
	Templeman(Fall 99)Templeman(Fall 20)	30792	P<0.002
	Teleost(Fall 98)/Templeman(Fall 98)	46947	P<0.001
	Teleost(Fall 99)/Templeman(Fall 99)	97317	P<0.001
	Teleost(Fall 20)/Templeman(Fall 20)	16895	P<0.001
	Templeman(3PS-98)/Templeman(3PS-99)	33656	P<0.001
	Templeman(3PS-99)/Templeman(3PS-20)	27154	P<0.001
	Templeman(3LNO-98)/Templeman(3LNO-99)	20176	P=0.226
	Templeman(3LNO-99)/Templeman(3LNO-20)	80057	P=0.707
Opening	Teleost(Fall 98)/Teleost(Fall 99)	86090	P<0.001
	Teleost(Fall 99)/Teleost(Fall 20)	90678	P=0.221
	Templeman(Fall 98)Templeman(Fall 99)	66406	P<0.001
	Templeman(Fall 99)Templeman(Fall 20)	25213	P<0.001
	Teleost(Fall 98)/Templeman(Fall 98)	118371	P<0.001
	Teleost(Fall 99)/Templeman(Fall 99)	45139	P<0.001
	Teleost(Fall 20)/Templeman(Fall 20)	60816	P<0.001
	Templeman(3PS-98)/Templeman(3PS-99)	24346	P<0.001
	Templeman(3PS-99)/Templeman(3PS-20)	23240	P<0.001
	Templeman(3LNO-98)/Templeman(3LNO-99)	76765	P<0.001
	Templeman(3LNO-99)/Templeman(3LNO-20)	70243	P<0.001

Table 8. Horizontal gear geometry increases with depth with little difference in variability between survey vessels in the year 2000 survey.

	Door Spread				Wingspread			
	Teleost		W.T.		Teleost		W.T.	
Depth	x	cv	x	cv	x	cv	x	cv
0-100	-	-	39.2	7.1	-		14.9	6.0
101-200	50.5	5.3	44.2	6.6	17.3	5.9	16.1	4.9
201-300	51.7	6.2	45.1	6.6	17.2	7.0	16.1	5.6
301-400	53.3	8.6	47.1	7.2	17.5	7.4	16.3	6.7
401-500	53.7	8.6	49.7	7.6	17.4	6.9	16.9	5.3
501-600	56.0	4.5	51.3	8.9	18.2	4.9	17.5	5.7
601-700	53.6	10.3	50.4	5.4	17.2	6.4	17.1	4.7

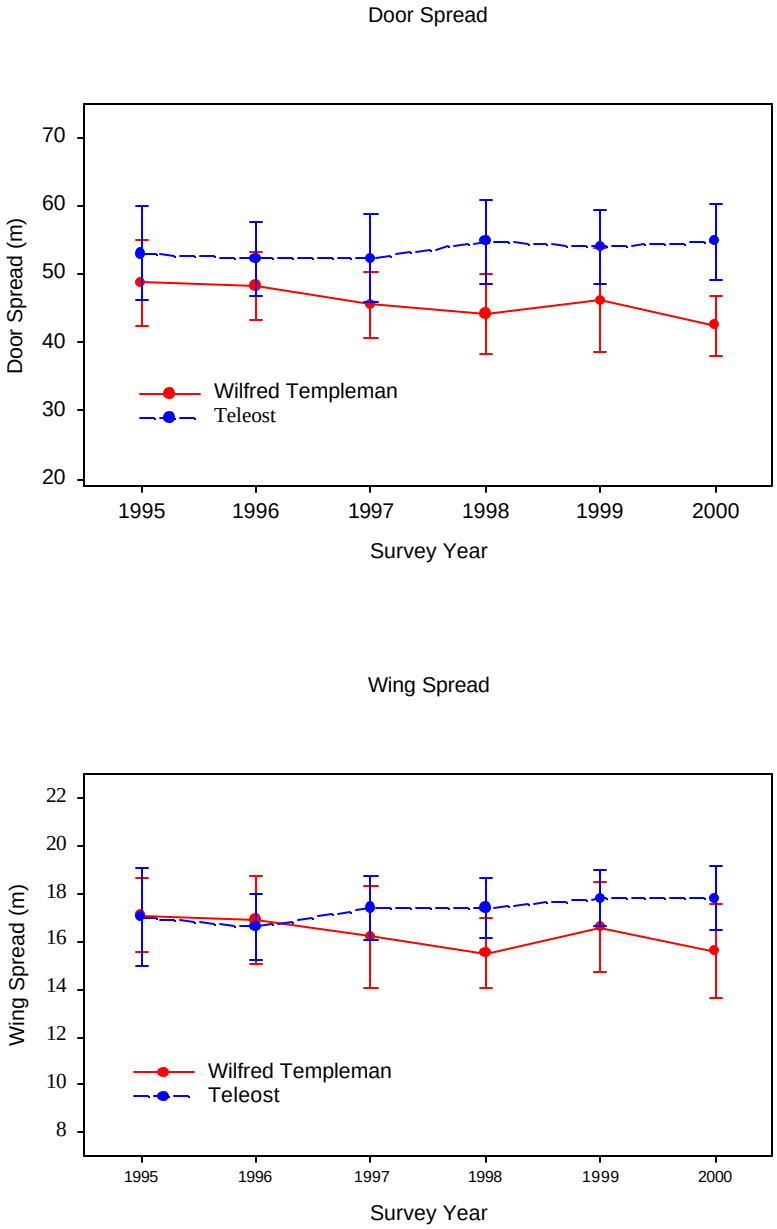


Fig. 1 Differences in mean door spread and wing spread between survey years are the result of differences in the mean depth fished between years.

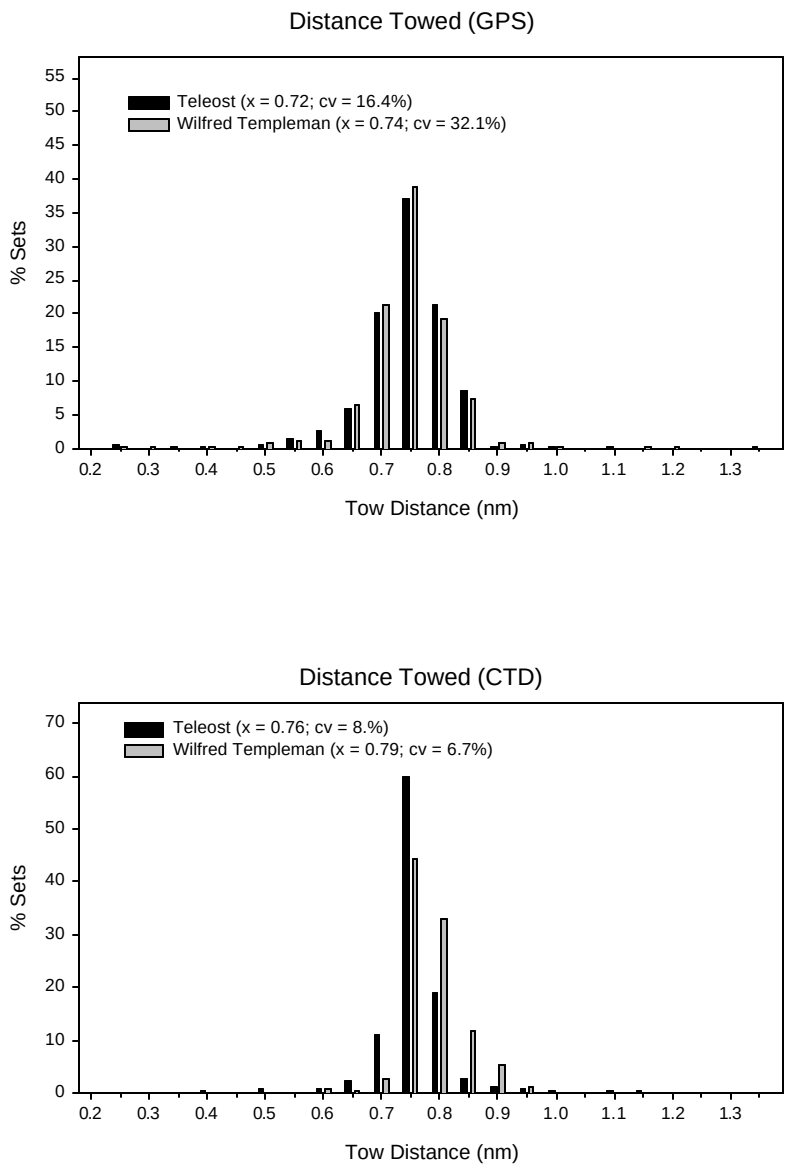


Fig. 2 Tow distance calulated from GPS vessel position and CTD time on bottom for the Wilfred Templeman and Teleost during the 2000 survey year.

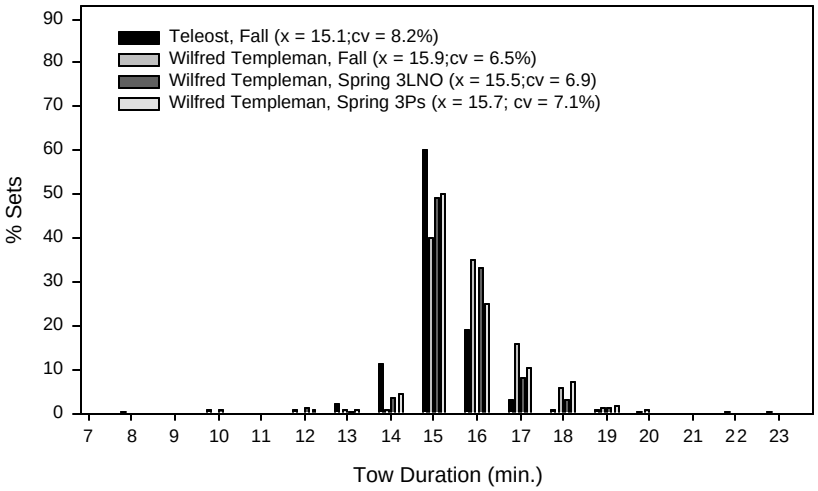


Fig. 3 Tow duration from CTD time on bottom for the Wilfred Templeman and Teleost during the 2000 survey year.

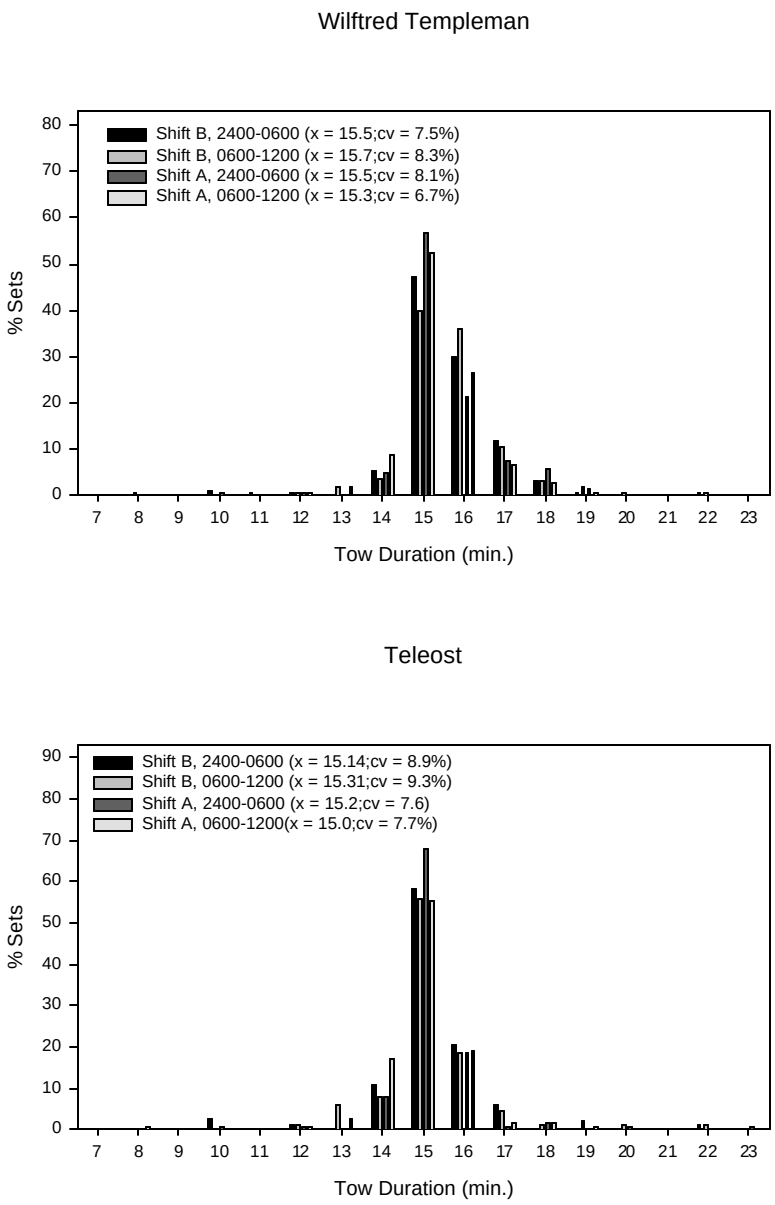


Fig. 4 Tow duration from CTD time on bottom for various vessel crews on Wilfred Templeman and Teleost during the 2000 survey year.

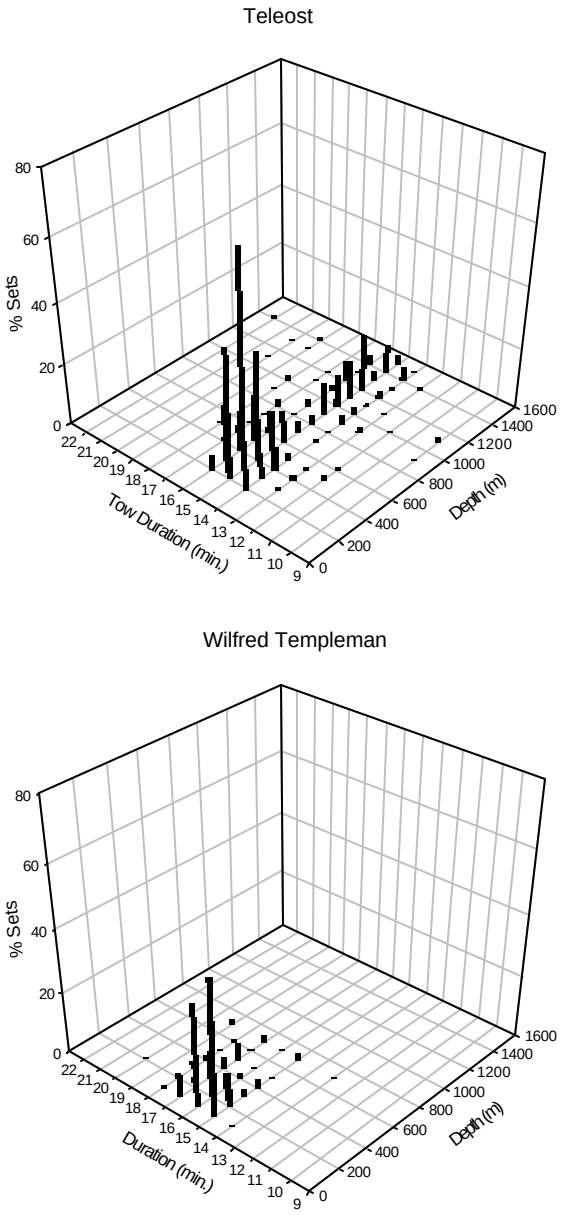


Fig. 5 Tow duration from CTD time on bottom plotted against depth for the Wilfred Templeman and Teleost fall survey in 2000.

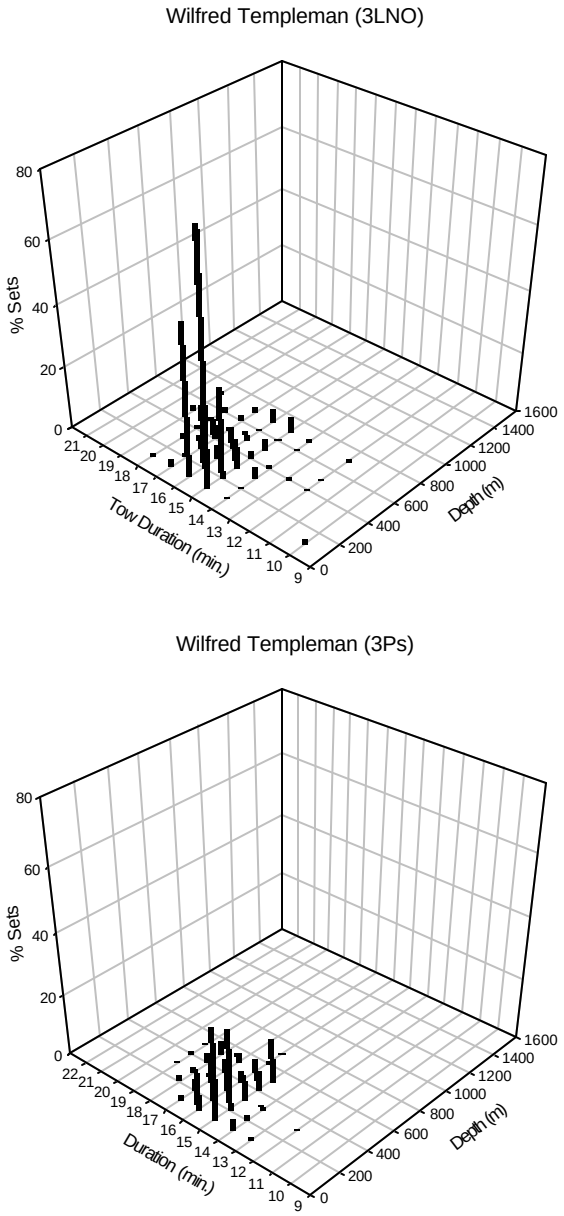
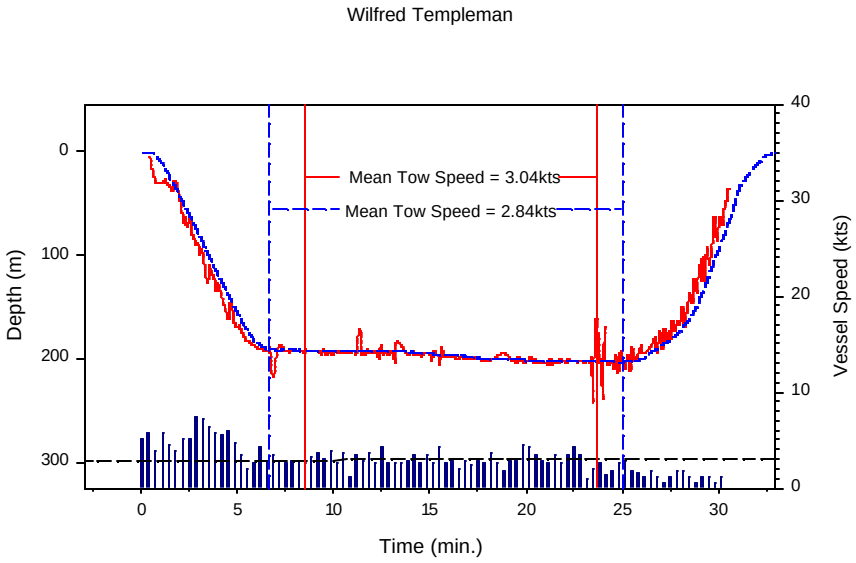


Fig. 6 Tow duration from CTD time on bottom plotted against depth for the Wilfred Templeman spring survey of 3LNO and 3Ps during 2000.



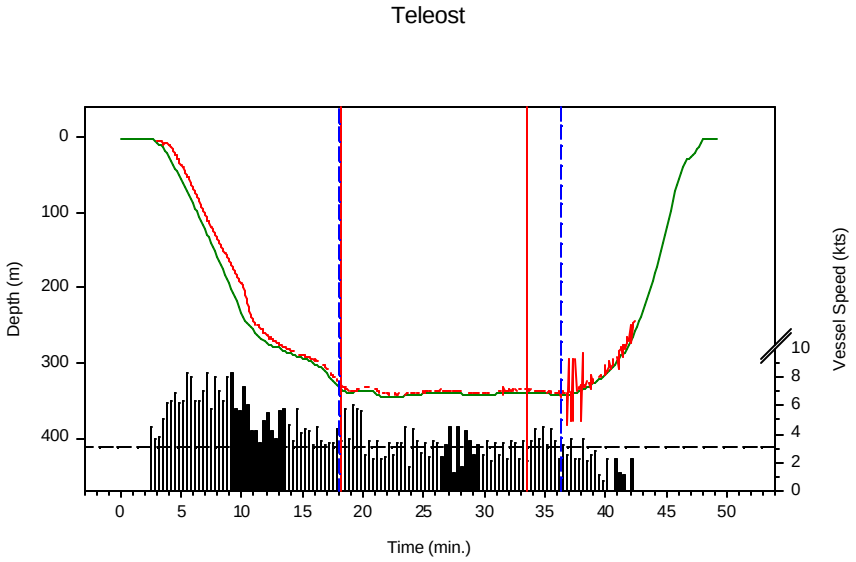


Fig. 7 Trawl depth over time with vessel speed for selected survey sets by the Wilfred Templeman and Teleost. Vertical lines represent the start and end of the tow as determined by vessel crew (solid) and by the CTD profile (dashed).