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Observations on the Varying Fishing Powers of Canadian Survey Vessels and Trawls

by

Stephen J. Walsh and Barry R. McCallum
Northwest Atlantic Fisheries Center, Department of Fisheries and Oceans
P.O. Box 5667, St. John's, Newfoundland, Canada, A1C-5X1

Abstract

Fishing power is defined here as the vessel size-dependent changes in trawl geometry, performance and swept area. Data on trawl geometry and performance were collected by an acoustic trawl instrumentation package. This permitted a comparision of fishing power differences between 4 research vessels using various survey bottom trawls. It was shown that when two vessels of difference size and horsepower used the same survey trawl there was generally a strong vessel induced change in trawl geometry, gear performance, swept area and hence fishing power. Variation in swept area of each individual trawl could bias estimates of abundance due to changes in catchability and the simple addition of abundance indices from two trawls with different fishing powers could produce unreliable indices of stock size. The use of a restrictor rope to physically restrain door spread and standardize trawl geometry and performance would minimize these differences.

Introduction

Trawl efficiency and performance can be affected by various aspects of gear design and construction and the size of the vessel which cause selectivity to be size and/or species dependent (Walsh et al. 1993). This vessel/gear combination effects are more commonly refered to as fishing power. Fishing power has been defined as the mortality generated by a particular vessel/gear combination (see Gulland 1956 and Beverton and Holt 1957 for detailed discussion). Here we define fishing power as the vessel size-dependent changes in trawl geometry, performance and swept area when the same trawl is used in multi-vessel surveys. Changes in the fishing power of the trawl can result from changes in the vessel power, vessel noise, crew, trawl design/construction, and trawl repairs or the addition of one or more vessels to the survey (Byrne et al. 1981; Walsh et al. 1993). These changes in trawl geometry and performance could affect catchability and create a bias in the form of a systematic error in the abundance estimate. Minimizing these errors to an acceptable level must be the prime focus in any survey operation (see Walsh 1996 for a discussion). However, in many multi-vessel surveys , little attention is paid to differences in fishing power.

Bottom trawls are used by many NAFO research institutes to measure abundance, distribution and diversity of organisms which inhabit near-bottom waters. In the current assessment of many NAFO groundfish stocks trawl surveys provide the only source of stock size estimates available to assessment biologists and fishery managers. Consequently, errors and unexplained variability in survey indices of population size and age composition could seriously impact stock assessment advice. Annual groundfish surveys have carried out by the Northwest Atlantic Fisheries Center (NAFC), St. John's, Newfoundland, since 1971. Beacuse of an expansion in survey area after 1977, these surveys have been carried out using more than one research vessel with the same standard survey trawl. No attempt has been made to estimate differences in fishing power arising from the vessel/gear combination used in the surveys.

In 1995, NAFC replaced one of its two deepsea research vessels and two of its survey gears (McCallum and Walsh 1996). The new research vessel *FRV Teleost* replaced the *FRV Gadus Atlantica* which, along with the *FRV Wilfred Templeman* and to a lesser extent her sister ship *FRV Alfred Needler* conducted stratified random surveys in the

Canadian and NAFO zones. This change in research vessel was accompanied by replacing the standard bottom trawls used in the spring and fall surveys (Engel 145 high lift otter trawl) and the juvenile groundfish surveys (Yankee 41 shrimp trawl) with the Campelen 1800 shrimp trawl (McCallum and Walsh 1996).

Comparative fishing experiments were carried out in 1995 to derive factors by which survey catches prior to 1995, carried out by the *Gadus Atlantica* with the Engel trawl could be converted to values equivalent to what would be obtained by the *Teleost* with the Campelen (see Warren 1996). In 1996, comparative fishing experiments were carried out to derive factors by which survey catches prior to 1996, carried out by the *Wilfred Templeman* with the Engel trawl could be converted to values equivalent to what would be obtained with the Campelen trawl. This latter comparative experiments involved the use of the *FRV Alfred Needler*, the sister ship of the *Wilfred Templeman* (see Warren et al. 1997). In the latter case it is assumed that there should be no difference in fishing power between the *Needler* and *Templeman*.

This paper examines fishing power as measured by differences in trawl geometry of survey trawls onboard different research vessels at NAFC. It will encoporate data from engineering sea trials, regular surveys and comparative fishing experiments.

Materials and Methods

Survey Trawls

The Campelen 1800 shrimp trawl is a four panel design with cut-away lower wings and is rigged with two 40 m bridles and a 24 m middle bridle. The trawl is spread with 1400 kg, 4.3 m^2 Morgere Polyvalent trawl doors. The 35.6 m long rockhopper footrope is constructed of 355 mm diameter rubber disks spaced evenly apart with rubber and/or iron spacers, 178 mm and 200 mm long respectively. The trawl body is made of 4.0, 3.0 and 2.0 mm diameter polyethylene twine with mesh sizes (knot centre) 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 is attached to the inside of the extension and codend (see McCallum & Walsh, 1996).

The Engel 145 is a two panel trawl constructed of 180 mm mesh (kc) in the wings and square, 150 mm in the 1st and 2nd bellies and 130 mm in the last belly, extension and codend . All panels are made of 4.0 mm polyethelyene twine with the exception of the codend and extension which is made of 6.0 mm nylon. A 30 mm liner is attached to the inside of the codend. The upper and lower bridles are 50 m long and the middle bridle is 43.75 m long. Unlike the Campelen's rockhopper footrope the Engel uses a 44.2 m footrope composed of 25 steel bobbins varying in size from 53 mm, 46 mm and 36 mm and 4 rubber rollers. Trawl doors are the Morgere Polyvalent type weighting 1250 kg with a surface area of 3.8 m^2.

Engineering Seatrials

Gear performance data was collected during dedicated engineering seatrials on the *Gadus Atlantica* and *Wilfred Templeman* over the period 1990-92. Each vessel's own version of the Engel 145 hi-lift otter trawl was equipped with SCANMAR instrumentation to measure doorspread, wingspread, opening and trawl depth. Vessel speed was measured using a Doppler speed log. Experimental stations were choosen to approximate those fished during a regular groundfish survey. At each station tows were made using the standard survey towing speed of 3.5 kts: one to the north and a reciprocal tow to the south. Warp ratios were selected using the standard survey warp ratio protocol for each vessel. Once full bottom contact was determining using SCANMAR a 5-10 minute stabalization period was allowed for followed by a 10 minute tow. All data was recorded on SEATRAWL at 15 second intervals. The codend was left open for all tows.

Groundfish Surveys (prior to 1994)

Prior to 1994 Groundfish surveys were undertaked by the *Gadus Atlantica* and *Wilfred Templeman* using their own versions of the Engel 145 Hi-Lift trawl. Each survey trawl was fitted with SCANMAR instrumentation to determine doorspread, wingspread, opening and trawl depth. Gear performance data was logged at 15 second intervals using SEATRAWL a customized software package. Unlike latter surveys with the Campelen SCANMAR was used in a strictly passive manner with fishing staff forbidden to alter survey protocol based on this information. The *Templeman* used undocumented warp ratios of 3:1 in all depths less than 500 m decreasing somewhat proportionately to 2:1 at 1000 m. The survey tow was 30 minutes long timed from the moment shooting stopped ie. winchs blocked. The standard towing speed of 3.5 kts was determined using a Doppler speed log. Tow heading was generally in the direction of the next fishing station.

Comparative Fishing

During 1996 the NAFC undertook a comparative fishing experiment to determine the differences in catchability between the Engel 145 *(Templeman* version) and the Campelen 1800. The *Wilfred Templeman* fished the Campelen while the *Alfred Needler* fished the Engel 145 side by side at each station. The standard groundfish survey protocol was used with the Engel 145 while a new protocol was adopted for the Campelen trawl as follows: tow speed using GPS was standardized to 3.0 kts and tow duration was set at 15 minutes Tow duration began the moment the trawl touched bottom to lift-off, both being determined using a combination of the SCANMAR depth and height sensors. GPS vessel speed was also logged by hand at 3 minute intervals by bridge staff. Acoustic noise is edited from the data in post mission processing by the application of range checks of: 0-1200 m for depth, 0-85 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 software.

Trawl Standardization

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

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

Bridle angles (Θ) for each Campelen trawl used onboard all three research vessels were calculated using the following equation:where ds is the door spread, ws is the wing spread and bl is the bridle length (sum of the sweep wire + lower bridle + door leg extensions).

Results

Survey Trawls

Table 1 shows a comparison of the trawl parameters derived for the old standard trawl , Engel 145 Hi-Lift otter trawl, as used onboard the research vessels, *Gadus Atlantica* and *Wilfred Templeman-Alfred Needler* and the new standard trawl, the Campelen 1800 shrimp trawl now used by the *Wilfred Templeman* and *Teleost* and occasionally the *Alfred Needler*. Although the Engel trawl is a physically larger trawl when compared to the Campelen trawl many of the geometry parameters are also influenced by differences in trawl door size and the length of sweeps/bridles.

Table 2 shows a comparison of trawl geometry measured during groundfish surveys with the Campelen trawl in 1995 and 1996. In both 1995 and 1996, there is a difference in trawl geometry at comparable depths when this trawl is used onboard the Teleost (vessel length of 63 m) and *W. Templeman* (vessel length of 50m) due to differences in vessel size and propulsion. Table 3 shows that this difference is significant ($p<0.5$) for door spread and opening but not wingspread. Both table 2 and 3 show that between years there is very little difference in geometry of the Campelen trawl within each vessel category.

Table 4 shows that this vessel created difference is also evident in the comparison of the old standard trawl, Engel 145 hi-lift otter trawl, used onboard the larger vessel, *Gadus Atlantica* (vessel length of 74m) , and the smaller *W. Templeman* over comparable depths. Although it is suspected that some of these differences were also related to the unregulated diferences in rigging the standard trawl.

In 1996 the *Alfred Needler*, sister ship to the *W. Templeman*, conducted a portion of the fall groundfish survey using the Campelen 1800 shrimp trawl. Table 2 shows that at comparable depths and towing speeds (GPS), there is a difference in trawl geometry of the trawl used by the sister ships. From Table 3 we see that there was a significant difference in door spread, wing spread and trawl opening ($p<0.5$) of the Campelen trawl as measured in the *Needler* and *Templeman* data at comparable depths. Table 5 shows the summary statistics for the Engel 145 hi-lift otter trawl used on board the *Needler* and *Templeman* at comparable depths. Here there was little differences in trawl geometry.

Since bridle angles are a function of door spread and wing spread differences between trawl/vessel combinations will have an effect on bridle angle and hence the fish herding behaviour by the trawl.

Discussion

Differences in vessel size and hence fishing power had an obvious effect on the geometry of the NAFC bottom trawls and these differences will increase with depth as seen in the *Templeman* and *Teleost* comparisons. The differences in geometry of the Campelen trawl onboard the sister ships, *Needler and Templeman*, measured in 1996 is difficult to explain and was totally unexpected. Since these vessels were built in the early 1980's, differences in vessel characteristics have occurred: 1) *Needler* had its main propulsion system changed in 1993 and its output is 400 Hp higher than the *Templeman*; 2) the *Needler* uses 28.6 mm diameter (and hence heavier) main trawl warps and the *Templeman* uses lighter 25.4 mm diameter trawl warps and 3)only the*Templeman* has been outfitted with ice davits. However, these vessel differences existed in the comparison of the Engel survey trawl with no obvious effect The differences in the Campelen trawl geometry between the two sister ships are without any clear explanation. It is obvious that the Needler's trawl was underspread . Normally underspread trawls are result from rigging problems, slow vessel speeds or heavy bottom currents, however, at the time of the survey such differences were not apparent. It is strongly recommended that prior to using the A. Needler with the Campelen in future NAFC surveys that engineering sea trials dedicated to measuring trawl geometry and performance must take place to determine if the measurements reported here are real or not. Direct addition of Campelen catches from the Needler with the Templeman could seriously bias stock estimates.

These analysis serves to illustrate that fishing power, i.e vessel-trawl differences, can exist when more than one vessel is employed in groundfish surveys. Differences in trawl geometry will affect catchability due to differences in bridle angles, the herding behaviour of the trawl doors, sweeps and sand clouds (Carrothers 1981; Byrne et al. 1981). The fact that there was no year to year difference in geometry parameters calculated for the Templeman and Teleost, separately, illustrates that the strict standardization procedures enforced at NAFC and the use of SCANMAR acoustic trawl monitoring sytem (McCallum and Walsh 1995). However, it does imply that catchability may be different for both trawls and that abundance indices derived from both vessels may not directly be added together without reducing the reliability of the

In calculating swept area estimates, it is common to fixed wing spread and tow duration to some derived values. Present day instrumentation allow researchers to measure wing spread and tow duration for each fishing haul and incoporate these values in their models. One of the main sources of variability in trawl swept area is depth dependent variation in wing spread/door spread and trawl opening (Godø and Engås 1989). This variability in trawl geometry and performance with depth can change from vessel to vessel. Because many surveys are either multi-vessel, multi-trawl surveys or both the analysis of fishing power and the development of conversion factors, where needed, is necessary in order to produce a standarized survey trawl CPUE. In the NAFC surveys the fishing power of the vessel/gear combination has yet to be measured.

One of the promising methods to minimize trawl width variation and hence standardized swept area estimates involves physically restricting door spread with a (restrictor) rope placed ahead of the trawl doors (Engås and Ona 1993; Walsh and McCallum 1996). One major advantage of the restrictor rope is that it may be used to standardize fishing power when two or more vessels use the same survey trawl in annual surveys and the second major advantage that itis simple, cheap and easy to use. Table 6 shows a comparison of geometry parameters from preliminary trials with this method using the Campelen trawl in alternate tow design and it is evident that the restrictor rope technique was successful in minmizing trawl width variation. As well it has been shown from the same data that there was little difference in length composition of trawl catches in a restricted trawl and unrestricted trawl, eg. in catches of yellowtail flounder, cod, plaice, skate, Greenland halibut and redfish (Walsh and McCallum 1996). By minimizing these differences in vessel power and depth-dependent variation in swept area, there should be no need for using conversion factors. Consequently, the variance around average catch per tow (or biomass indices) should reflect primarily changes in abundance. Another advantage of the restrictor rope is that failure to reach the target reference door spread value during actual fishing operations in the survey would alert the fishing master that something was wrong with the gear. Further testing of the restrictor rope technique with the NAFC Campelen survey trawl is necessary to further refine the technique in very shallow water and along the shelf edge. It offers a promising alternative to derivation of fishing power coefficients.

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Table 1. Comparision of trawl parameters of the Engel 145 hi-lift otter trawl (old standard survey trawl) and the Campelen 1800 shrimp trawl (new standard trawl) used in the annual spring and fall the Northwest Atlantic Fisheries Center (adapted from McCallum and Walsh 1996).

Parameter	**Engel 145 Hi-Lift Otter trawl**		**Campelen 1800 Shrimp trawl**
	Gadus Atlantica	**Wilfred Templeman & Alfred Needler**	**Wilfred Templeman & Teleost**
Doors	5.6m²/1400kg	3.8m²/1250kg	4.3m²/1400kg
Sweeps (m)	17	15.2	6.1
Bridles (m)	50	50	40
Bouyancy (kg)	300	283.5	226.5
Headline (m)	29.2	29.2	29.5
Fishing Line (m)	31.2	31.2	19.5
Footgear			
Length (m)	44.2	44.2	35.6
Material	27 Steel Bobbins	25 Steel Bobbins & 4 Rubber Rollers	102 Rubber Disks (Rockhopper)
Weight Air (kg)	3168.6	2349.7	501.3
Size (dia./cm)	61/53/46/36	53/46/36	35
Mesh Size (mm)			
Wings/Square	180	180	80/60
Bellies	160	150/130	60/44
Codend	160	130	44
Liner	30	30	12.7
Material	Nylon	Polyethelyene Nylon Codend	Polyethylene
Doorspread (m)	70-90	60-75	45-55
Wing Spread (m)	18-25	17-22	15-17
Opening (m)	3-6	4-6	4-5
Tow Speed (kts)	3.5	3.5	3.0

Table 2 . Summary statistics of trawl geometry parameters for the Campelen 1800 shrimp trawl used by the R.V. Wilfred Templeman and R.V. Teleost during the 1995 and 1996 fall groundfish surveys. (Adopted from McCallum and Walsh 1997)

Trawl Rig	Survey	Variable	No. Obs.	x̄	CV (%)	Min.	Max.
Templeman	1995	Depth	169	285.4			
		Doors	169	48.8	13	16.1	56.4
		Wings	167	17.1	9	12.5	22.8
		Opening	161	4.4	13	3.5	7.6
		Bridle Angle	161	19.2	15	7.4	22.6
Templeman	1996	Depth	312	239			
		Doors	319	48.3	10.1	15.6	60.7
		Wings	327	16.9	10.9	6.	23.6
		Opening	312	4.7	14.6	2.5	11.7
		Bridle Angle	249	18.6	2.2	0.52	23.7
Needler	1996	Depth	84	113.6			
		Doors	90	40.1	10.8	26.1	53.5
		Wings	82	13	13.4	6.8	15.9
		Opening	85	5.5	10.5	4.6	9.7
		Bridle Angle	77	16.2	14.3	8.9	25.4
Teleost (<615 m)	1995	Depth	111	298.8			
		Doors	103	51.4	11	21.7	63.1
		Wings	104	16.7	12	10.4	24.0
		Opening	104	4.1	14	3.3	6.4
		Bridle Angle	94	20.5	12	6.0	26.1
Teleost (<855 m)	1996	Depth	300	336.6			
		Doors	295	51.3	9.5	21.6	64
		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	4.43	27.9
Teleost (86 -1200 m)	1995	Depth	139	418.6			
		Doors	140	53.0	13	21.7	72.6
		Wings	137	17.0	12	10.4	24.0
		Opening	142	4.1	15	2.2	6.4
		Bridle Angle	126	21.5	15	6.6	31.8
Teleost (86-1194 m)	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

Table 3 Results of the Kruskal-Wallis One Way Analysis of Variance of the Campelen geometry parameters measured during the 1995-96 fall surveys by the FRV's Wilfred templeman. Teleost and Alfred Needler. Pairwise comparisons are based on the Dunn method (McCallum and Walsh 1977).

Parameter	Comparison	Diff. Ranks	Q	P<0.05
Door spread	Templeman(1995)/Templeman(1996)	52.1	1.4	No
	Teleost (1995)/Teleost (1996)	12.9	0.3	No
	Templeman(1996)/Teleost (1996)	129.0	3.2	Yes
	Needler (1996)/Templeman(1996)	165.2	4.2	Yes
Wing spread	Templeman(1995)/Templeman(1996)	12.2	0.3	No
	Teleost (1995)/Teleost (1996)	26.2	0.6	No
	Templeman(1996)/Teleost(1996)	38.2	0.8	No
	Needler (1996)/Templeman(1996)	158.3	3.8	Yes
Opening	Templeman(1995)/Templeman(1996)	80.4	2.1	No
	Teleost (1995)/Teleost (1996)	50.8	1.3	No
	Templeman(1996)/Teleost (1996)	135.6	3.3	Yes
	Needler (1996)/Templeman(1996)	167.7	4.2	Yes

Table 4. Summary statistics of trawl geometry parameters for the Engel 145 trawl used by the R.V. Wilfred Templeman in the fall of 1993 and R.V. Alfred Needler during the 1996 Engel 145/Campelen 1800 comparativefishing.

Trawl Rig	Survey	Variable	No. Obs.	X	CV	Min.	Max.
Templeman	1993	Depth	263	204.9			
(Engel 145)		Doors	291	62.7	11.0	37.6	79.2
		Wings	234	18.4	14.5	8.6	27.8
		Opening	276	5.9	13.7	3.3	11.8
		Bridle Angle	275	19.3	13.5	10.9	25.1
Needler	1996	Depth	148	182.9			
(Engel 145)		Doors	140	63.7	14.1	48.8	80.1
		Wings	125	17.7	12.4	11.5	25.6
		Opening	138	6.4	13.7	2.1	9.7
		Bridle Angle	122	17.1	14.4	14.3	26.3

Table 5. A comparison of trawl mensuration statistics derived from engineering seatrials of the Engel 145 High Lift otter trawl used aboard the R.V. Wilfred Templeman and R.V. Gadus Atlantica. (Adopted from Walsh and McCallum 1995)

Trawl Rig	Survey	Variable	No. Obs.	$\bar{x}$	CV (%)
Templeman	Trials	Doors	9	66.3	9.0
(Engel 145)		Wings	8	19.8	13.0
		Opening	7	5.3	10.0
Gadus Atlantica	Trials	Doors	31	83.5	9.0
(Engel 145)		Wings	26	22.9	11.0
		Opening	37	4.5	21.0

Table 6. Comparison of the geometry of the Canadian Campelen 1800 survey trawl with the door spreads restricted and unrestricted from alternate tows in a depth range of 43 to 1244 m. CV= coefficient of variation expressed as a percentage (Adopted from Walsh and McCallum 1996)

	Unrestricted			Restricted		
	Hauls	x	CV	Hauls	x	CV
Doorspread (m)	41	51.9	13	41	45.1	7
Wingspread (m)	40	15.5	7	41	14.3	9