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EXPERIENCES USING THE CONSTRAINT TECHNIQUE ON BOTTOM TRAWL DOORS

By

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ABSTRACT

The constraint technique, i.e. using a rope between the warps, has the intention of minimizing the variability in trawl geometry with depth. Experiments with the constraint technique on two different bottom trawls used in the Norwegian surveys are reported and discussed. In addition, modifications of trawling technique, which enable the trawl doors to maintain constant ground contact under different conditions, are presented.

INTRODUCTION

Observations of bottom trawl performance using acoustic gear monitoring equipment have shown that the geometry of the trawl is quite variable. This is considered to be a major problem, since the data from surveys are interpreted, assuming a constant catch efficiency for each age group over areas and years (Carrothers, 1981; Hysten et al., 1986).

In the Norwegian bottom trawl survey for cod and haddock in the Svalbard - Barents Sea area the depth of trawling varies from 50 m to about 600 m. Similar, the International Bottom Trawl Survey (IBTS) in the North Sea is carried out in areas from 30 m to 250 m depth, and difficulties with keeping a constant swept area over the entire depth range have long been recognized (Hagstrøm, 1987; Godø & Engås, 1989). The equipment and procedures used give reduced door and wing spread in shallow water and overextended door spread in deeper waters. Trials to correct the survey estimates for a depth dependent swept area have been made, based on measurements of door and wing spread (Godø & Engås, 1989; Koeller, 1990; Yatsu & Jørgensen, 1988).

The problem, however, is that when changing the door spread, the effectiveness of the entire trawl gear change. In particular, a change in door spread will change the position of the herding sand cloud relative to the wing ends of the trawl, a critical area for escapement of fish (Main & Sangster, 1981a; Kortokov, 1984).

A change in door spread may also influence the bottom contact of the trawl itself, as the bottom contact of the ground gear is reduced when overspreading the trawl. As shown by Main & Sangster (1981b); Korotkov (1984); Engås & Godø (1989) and Walsh (1992), bottom contact of the trawl is critical for catching downward escaping species.

Equally important is the ground contact of the door, i.e. the part of the weight of the door actually resting on the bottom, which affect the sand cloud formation, the acoustic noise produced by the door and the bottom contact of the trawl itself. We therefore question the validity of corrections only based on geometrical adjustment of the swept area, and recommend methods aiming to stabilize trawl performance.

In order to maintain constant trawl performance at all fishing depths, several methods have been applied. Increased sweep length with depth have been recommended (Wilemann 1984; Palsson et al. 1989) and also a specified warp-to-depth ratio for different depths are commonly used (Anon. 1992). However, instrumented studies of trawl performance have shown that use of different sweep lengths is an unsatisfactory solution; increasing sweep with increasing depth results in higher door spread (Hagstrøm 1987). Furthermore, different sweep lengths have been shown to have a profound effect on the catch efficiency for different length groups of fish (Engås and Godø 1989).

Realizing that the catch efficiency of the trawl is determined not only by the geometry of the trawl, but rather its entire performance, a method to reduce systematic variability by using a constraint rope between the warps was presented by the authors (Engås & Ona 1991). In this paper, experiences of using the method in order to obtain constant door spread and bottom contact with two different bottom trawls used in Norwegian surveys are presented and discussed.

MATERIAL AND METHODS

The trawls used during the experiments were the 36/47 m GOV-trawl and the Campelen 1800. The GOV-trawl is used during the IBTS in the North Sea, while Campelen 1800 is used during the Norwegian bottom trawl survey for cod and haddock in the Barents Sea and Svalbard area.

The experiments with the GOV trawl were conducted throughout the fourth quarter of the International Bottom Trawl Survey (IBTS) 1992 on R/V "G.O. Sars". The GOV trawl was rigged with the recommended kite, floats, groundgear, 60 m sweeps (including backstops of the doors) and 4.5 m² Polyvalent doors (1100 kg) as described in the IBTS Manual (Anon, 1992). The recommended warp-to-depth ratio for the trawl was used on all hauls.

At six of the fixed stations of the survey, the trawl haul was repeated over the same area using the constraint technique. A rope (9.0 m, 12 mm polyamide) was mounted between the warps 150 m (the shortest warp length permitted according to the IBTS Manual (Anon 1992)) in front of the doors (exact description of mounting is found in Engås and Ona, 1991). A calibrated depth sensor was mounted in the middle of the constraining rope, or on the warp 150 m in front of the door.

Investigations using the Campelen 1800 bottom trawl were carried out during surveys on R/V "Johan Hjort" and R/V "G.O.Sars in September 1992, and in February 1993 at depths between 50 and 370 m. The trawl was rigged with 40 m sweeps and 6.0 m² Waco doors (1500 kg in air) according to the IMR trawl manual (Engås, 1988). During trawling, the speed was maintained constant, 3.0 knots, as measured by the GPS. Constraining of the trawl warps was done as for the GOV trawl, and the normal warp-depth ratio used during the survey was not modified.

A series of 25 comparative hauls covering a depth range from 50 to 370 m, south west of Bear Island were made in September at the end of the O-group survey from "Johan Hjort", alternating between free and constrained door spread over the same depth.

During the standard bottom trawl survey for cod and haddock in the Barents Sea, in February 1993, the constrain technique was used on 57 bottom trawl stations on both of the research vessels.

In situ warp load were measured with a tensiometer (Scantrol, Bergen, Norway, Prototype with accuracy ± 120 kg) on some hauls with both trawls. When measuring warp tension, the tensiometer was shackled into the wire between the warp and the door bracket. The speed of the gear through the water was measured during this experiments with a Scanmar speed sensor mounted on the central headline.

The trawl geometry (vertical opening, door spread, and depth of constraining rope) was either logged continuously or each 30 sec. throughout the hauls, using Scanmar sensors. The depth sensor was calibrated with an accurate pressure sensor on the STD system.

RESULTS AND DISCUSSION

GOV-trawl

Measurements of the door spread show that the requirements or assumptions of a depth independent swept area are not met during the survey. The door spread increased from 80 m to 110 m when the fishing depth increased from 70 m to 300 m (Table 1). The increase in door spread with depth also influenced the geometry of the trawl, and the vertical opening of the trawl was reduced by approx. 1 m when going from 70 m to 300 m fishing depth. By using the constraint technique, the door spread and thus the vertical opening were almost constant under varying conditions, approx. 66 m and 6 m, respectively.

A spesific warp-to-depth ratio is recommended by the IBTS Manual for the GOV trawl during the survey in order to obtain constant ground contact of the doors under varying conditions. Recordings from the depth sensor showed that the elevation angle increased with depth when using the recommended warp-to-depth ratio. When fishing at approx. 70-80 m depth, the elevation angle of the warps is 8.5 degrees, but increasing to approximately 13 degrees when fishing at depths greater than 150 m. The speed of the trawl through water was kept as close to 4.0 knots as possible. The warp tension was measured in two hauls only (Table 2), both taken in shallow water. If we assume that the warp tension is nearly the same in all hauls taken at 4.0 knot, the ground contact of the doors would be reduced by 330 kg when fishing in deeper waters.

In the report by Engås and Ona (1991), it was suggested that the length of the warps should be adjusted so that 2/3 of the trawl door weight in water is counteracted by the upward pull of the warp end nearest the door. After further discussion and criticism from leading gear technologists, we have decided to increase the previously suggested ratio to 3/4, i.e. that 1/4 of the weight of the door should be resting on the bottom during trawling. With a weight of the door of 942 kg (in water), this correspond to a warp elevation angle of 9.5° when trawling at 4.0 knots (height of constraint rope 25 m above bottom). As shown, with the observed elevation angle when using the recommended warp to depth ratio of the GOV trawl, the doors are firmly on the bottom only when fishing in shallow water, <150m.

CAMPELEN-1800

Similar to the GOV trawl, the door spread of Campelen increased with depth when using the trawl in standard mode, Fig. 1, Table 3. By using the constrain technique, the door spread was fairly constant, approx. 46 m, when fishing deeper than 100 m. When fishing shallower than 100 m, the door spread is gradually reduced to 42 m when constrained by the rope. The main reason for this is obviously that the spreading forces contributed by the ground friction as the doors shear along the bottom is low, due to poor bottom contact in shallow water with the used warp to depth ratio.

It has been common practice in the Norwegian bottom trawl surveys in the Barents Sea to use a warp-to-depth ratio close to 3:1 at all depths. As shown in Fig. 2, this has a severe effect on the elevation angle of the warps and thus on the bottom contact of the trawl doors. The elevation angle increase from 11.5 degrees at 350 m depth to 17.5 degrees at 100 m depth. With a warp tension of 3800 kg (Table 4), the bottom contact of each door is reduced by as much as 380 kg when trawling in shallow water. In order to achieve 1/4 of the door weight on bottom, the elevation angle should be 14.7 degrees. This means that, in contrast to what was observed for the GOV trawl, that the trawl doors here are firmly on bottom only in deep waters.

The measurements on 57 stations taken during the survey, and 13 during the comparative experiment using the constraining method, summarized in Fig. 3, clearly show that the systematic variability in door spread with depth is reduced. The remaining apparent variability is caused by variable bottom substrate and current conditions at the different locations. During all measurements the warp to depth ratio determined by the operating officer was used. Clearly, a more constant door spread, even with a constraining rope, could be achieved if the warp length was regulated to maintain a constant bottom contact by the door. If an elevation angle of 14.7° is decided to be appropriate, a warp length placing the depth sensor of the constraining rope 38 m above the bottom would be correct. In Fig. 2 it can then be seen that the used warp to depth ratio is correct only between 140 - 200 m depth. If trawling in more shallow water, a significantly higher warp to depth ratio should be used, and opposite in deeper waters.

CRITIQUE OF THE METHOD

During the experiments, no technical problem occurred, but problems during trials of the method have been reported from two of the vessels using the Campelen 1800 during the survey trials.

(1) Using the auto trawl system during very strong side current, the constraint rope was snapped during shooting on several occasions on "G.O.Sars". A more careful shooting of the trawl doors, allowing a maximum warp length difference of < 5 meters is necessary when using this method.

(2) Under very strong side current, the door spread measured was lower than normal, due to the warp length difference, controlled by the autotrawl system. Changing trawling direction, or omitting the constraint rope for "normal" operation on these particular stations is probably the only solution. Very strong side current is a problem in the Barents Sea - Svalbard area only close to the coast and close to Bear Island, and for less than 5% of the regular stations.

(3) Under extreme weather conditions, heavy sea and wind speeds above 30 knots, attaching the rope to the warp, behind the towing blocks could be dangerous for the crew, at least on board "Johan Hjort". Omitting the rope for "normal" trawling was natural for these stations, or setting an earlier stop condition for weather.

(4) In some hauls, the immediate spreading response of the door after hitting the bottom was delayed by up to 5 minutes in a 30 min. towing. The door spread increased slowly from about 35 m to 47 metres during this period, rather than normal: obtaining a constant, full spread within the first 30 seconds.

The attack angle and size of the door may be increased without large effects on door spread when using the constrain method. In the experiments reported, no changes were made in order to improve the performance of the door using this method, and further investigations are needed to find a optimal balance between the door and constraint rope.

CONCLUSION

The constrain method have shown to reduce the systematic variability of two standard bottom trawls, The GOV trawl and the Campelen 1800. The handling and practical problems of using the constraint rope are minimal in fair weather conditions.

The constrain technique is now applied as a standard routine during the Norwegian bottom trawl survey for shrimp in the Barents Sea and Svalbard area, and will probably also be adopted during the surveys for cod and haddock in the near future.

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Table 1. Summary of measurements made during comparative experiments using the constrain technique on the GOV trawl.

	Water depth (m)	Warp length (m)	Trawl speed (knots)	Vertical opening (m)	Door spread (m)	Warp depth (150 m)
Without rope	82	400	3.9-4.1	4.9-5.1	85-91	60
With rope	82	400	3.9-4.1	5.8-6.1	65-67	61
Without rope	110	460	3.9-4.1	4.8-5.1	91-95	86
With rope	110	460	3.9-4.1	5.9-6.1	66-67	85
Without rope	150	590	3.9-4.1	4.4-4.6	98-99	120
With rope	150	590	3.9-4.1	5.6-5.9	66-68	120
Without rope	68	350	3.9-4.1	4.9-5.2	81-84	49
With rope	68	350	3.9-4.1	5.8-6.1	64-66	48
Without rope	163	600	3.9-4.1	4.3-4.6	96-98	131
With rope	163	600	3.9-4.1	5.8-6.1	65-66	131
Without rope	306	900	3.9-4.1	4.1-4.2	106-110	272
With rope	306	900	3.9-4.1	5.9-6.1	65-67	272

Table 2. Measurements of warp tension close to the door on the GOV trawl.

Depth (m)	Warp length (m)	Speed (knots)	Warp tension (kg)
68	350	4.0	4120-4400
82	400	4.0	4200-4400

Table 3. Summary of measurements of trawl geometry during comparative measurements using the constraint technique on the Campelen 1800. R - rope, NR - No rope.

Station no.	Depth (m)	Warp (m)	Doorspread (m), SD	Constrain height (m), SD	Trawl height (m), SD	Speed (GPS) (knots)
483, R	50	150	43.1(0.56)	nm	4.5(0.11)	3.0
483b NR	58	190	47.2(1.77)	-	4.7(0.44)	3.0
485, R	68	210	43.0(1.77)	50(1.9)	4.5(0.12)	3.0
484, NR	65	210	49.3(0.44)	-	4.0(0.11)	3.0
487,R	90	315	43.8(0.74)	45(1.0)	4.3(0.39)	3.0
486, NR	90	318	49.4(0.32)	-	5.9(0.15)	3.0
489,R	125	430	46.4(0.61)	44(2.5)	4.0(0.23)	3.0
488, NR	120	430	57.5(1.19)	-	4.2(0.37)	3.0
491, R	128	450	46.5(0.18)	41(1.2)	4.0(0.08)	3.0
490, NR	125	450	57.2(0.62)	-	3.6(0.09)	3.0
493,R	136	480	46.6(0.79)	37(0.8)	4.1(0.12)	3.1
492, NR	145	480	53.2(0.68)	-	4.1(0.25)	3.1
495, R	178	610	46.5(1.0)	41(1.1)	4.0(0.11)	3.0
494, NR	182	594	58.1(1.11)	-	3.6(0.31)	3.0
497, R	186	610	47.0(1.0)	36(4.0)	4.0(0.72)	3.0
496, NR	183	610	59.6(0.96)	-	3.5(0.13)	3.0
499,R	235	820	47.1(0.49)	36(1.9)	3.9(1.15)	3.0
498, NR	225	820	61.2(0.66)	-	3.8(0.38)	3.0
500, R	277	900	48.0(1.07)	30(1.1)	4.2(0.25)	3.0
501, NR	279	900	62.0(1.56)	-	3.5(0.44)	3.0
504,R	337	1070	47.3(2.69)	30(2.1)	4.4(0.21)	3.0
503, NR	335	1070	61.9(1.12)	-	3.4(0.23)	3.0
505, R	362	1100	46.3(3.39)	30(1.0)	4.2(0.67)	2.9
506, NR	350	1050	64.0(1.37)	-	3.7(0.25)	3.0
507, R	360	1050	48.3(0.52)	31(1.5)	3.8(1.9)	3.0

Table 4. Measurements of warp tension close to the door on the Campelen 1800.

Depth (m)	Warp length (m)	Speed (knots)	Warp tension (kg)
88	360	2.9-3.1	3700-3900
88	410	2.9-3.1	3800-3900

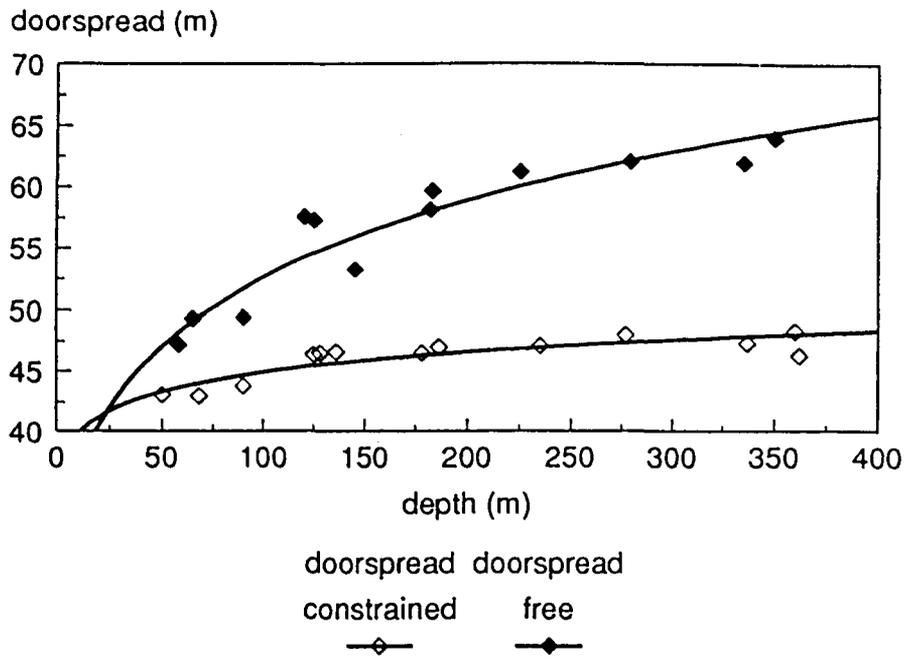


Figure 1. Door spread on the Campelen 1800 during comparative trawling with (open symbols) and without (closed symbols) constraint rope as a function of depth.

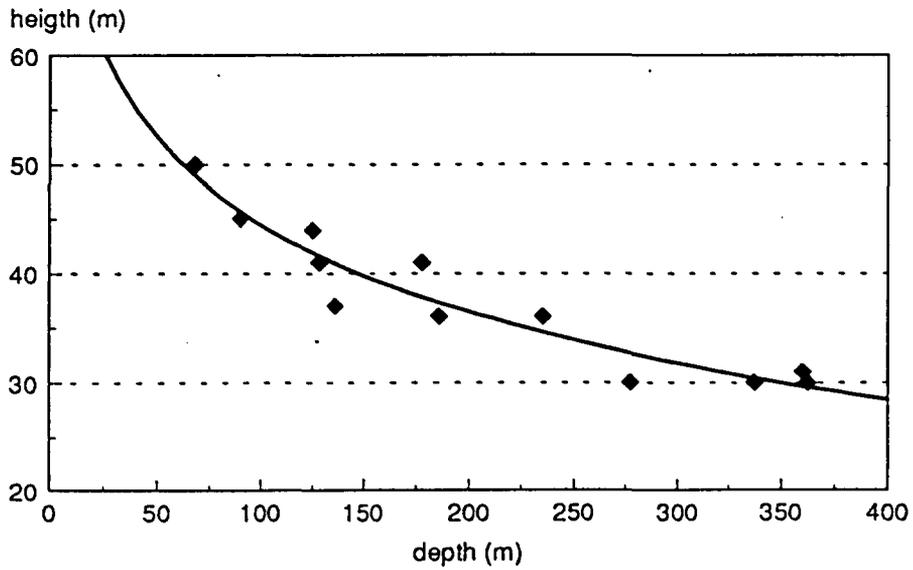


Figure 2. Height of constraint rope above bottom as a function of depth.

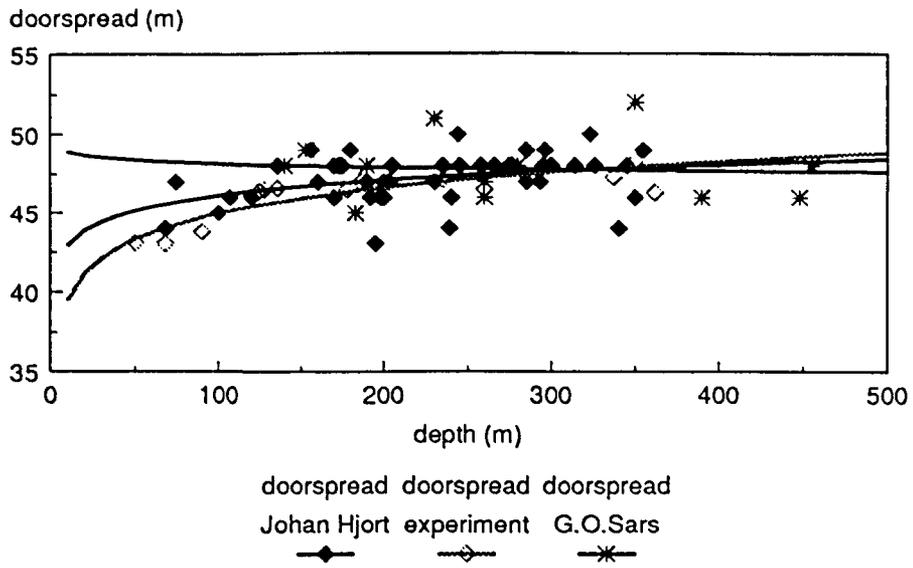


Figure 3. Door spread on 57 stations using the constrain technique during the vinter survey 1993, included data from the comparative experiment.