International Council for the
Exploration of the sea

ICES CM 2002/J:04

Estimates of towing time in surveys

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Abstract

To decide the start and stop time for a survey haul the current method used in Norwegian sampling are the data from the door sensors and height sensors of the trawl. When the trawl has achieved its right geometry, the start time for the haul is recorded. A multisampling device was used for separating catches in a survey for three different time periods: the time before the trawl had the right geometry, when sampling, and after the haul was defined to be at the end, when the haulback started. Significant differences were found in mean length of saithe between the periods of sampling, but for cod, capelin, haddock and Norwegian pout no significant change in mean length was found. A bottom contact sensor showed that the trawl had bottom contact several minutes both before and after the sampling period was defined. A change in sampling strategy and use of bottom contact sensors and MultiSampler may reduce variance in survey towing time.

Keywords: sampling, strategy, precision

Introduction

Survey-based assessments often appear to provide a more accurate prognosis of the status of a fish stock than catch-based assessments (Walters and Maguire, 1996; Nakken, 1998; Pennington and Strømme, 1998; Korsbrekke *et al*., 2001). This has raised the question of weather more weight should be given to the survey indices in the assessment procedures. Either the surveys in the future are used to generate an assessment independent of catch statistics, or they are used as today, to tune the VPA, a better understanding of the survey errors is necessary in order to decrease the uncertainty in the abundance estimates and improve the reliability of all studies aimed at determining population regulating mechanisms.

Surveys are expensive and time consuming, and making estimates more precise for less effort has always been a challenge. Therefore it has been argued that shortening of sampling time (Godø *et al.*, 1990, Pennington and Vølstad, 1991; Gunderson, 1993; Carlsson *et al.*, 2000; Pennington *et al*., 2002) and increasing the numbers of stations (Pennington and Vølstad, 1994) will provide more efficient surveys and more precise estimates. As the bottom trawl will fish as long as the ground gear are on the bottom, and maybe also when the trawl is on its way down to /up from the bottom, shorter tows makes it even more important to know the exact size of the area sampled by the trawl. In this paper we try to shed light on some of the problems related to defining the effective fishing area of the trawl by examining the amount and length of fish caught from the time the trawl is launched into the sea, until it is back on deck, by using a multisampler device with 3 codends.

Materials and Methods

This experiment was conducted the 12-13 March 2000, during the Institute of Marine Research (Norway) annual methodical test-survey. To determine if fish was entering the trawl codend before start and after stop of the sampling of a station, a MultiSampler device with 3 different codends (Engås *et al.*, 1997) was used (Figure 1). The MultiSampler device sampled in the first codend from the shooting of the gear and until the skipper decided the starting time of the station. Then the first bag was closed, and the second bag opened. The operation of closing and opening bags takes at most 30 seconds. During what normally would be called the sampling period, the second bag was sampling. The second bag was closed and the third opened at the time when the skipper started the haulback procedure.

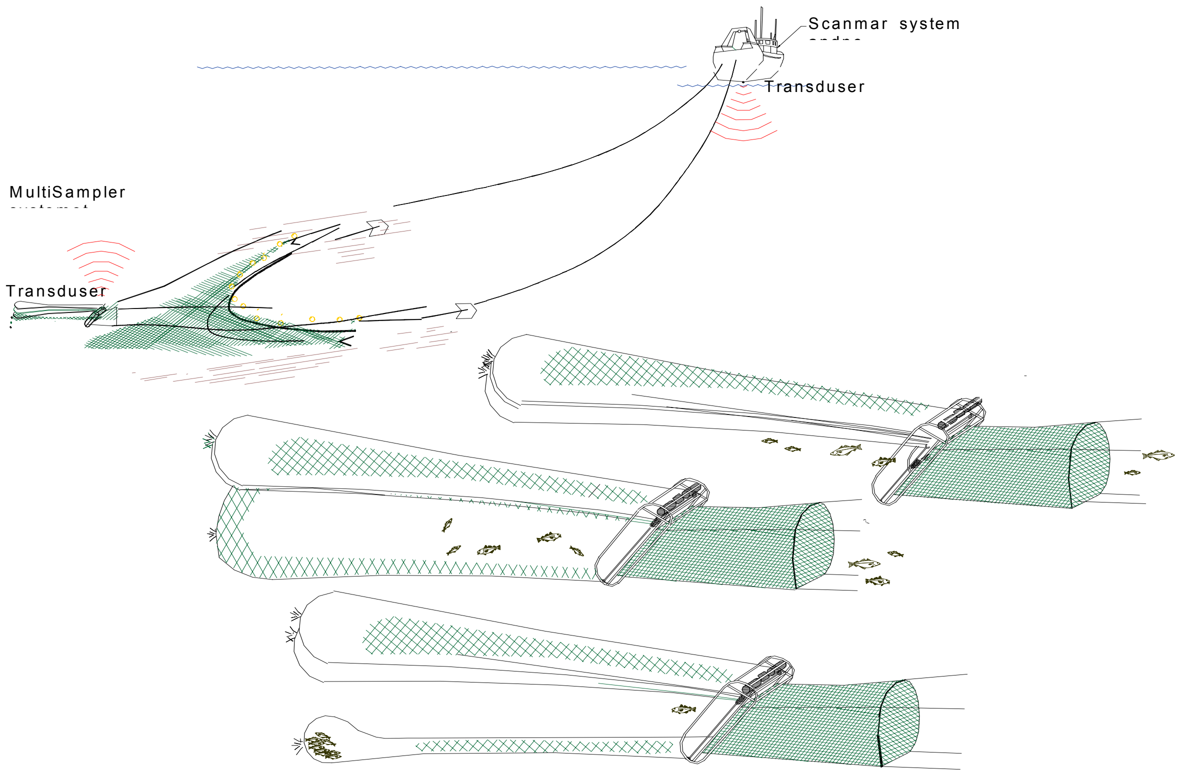

Figure 1. Principal sketch of the multisampler system used.

A total of 8 hauls were done with the MultiSampler. The standard sampling trawl Campelen 1800 with rockhopper gear was used (described in: Engås and Godø, 1989) the depth was 270 to 320 m and trawl speed was 1.5 m/s. The RV "G.O. Sars" was used, and the skipper and crew conducted the shooting and haulback as standard bottom trawl survey hauls. The tows varied in length from 5 to 35 minutes, and shooting time was defined as 15 minutes before start of the tow, while heaving was set as 20 minutes after stop.

As an illustration of the sensor data input, the same haulback procedure was used when the trawl was equipped with a bottom contact sensor (Engås *et al.*, 2001). To illustrate the problem in estimating the right sampling time, the sensor input for two typical tows are shown. The parameters given by the sensors are:
Bottom contact: 0 when the sensor touches the bottom, 10 else.
Door spread: door spread in meters.
Water flow: water flow in knots (multiplied by 10 to make it visible in the plots) in the length direction of the trawl.
Shooting/towing/heaving: set to 100 under towing, 110 for shooting and heaving.
Height: the height of the headline over bottom, in meters.

All values are measured averaged over 5 seconds. These tows shown are not the same as those used in the mean length comparisons, and will only be illustrating the discussion.

Data analysis

The length of the different fish species in each bag cannot be considered to be normally distributed, however, the mean length in each bag is (Central Limit Teorem). Thus, for presenting mean length for each bag, the mean is calculated for each bag per haul and then averaged over all hauls. Variation in fish mean length due to the towing time, part of tow and day/night was examined using GLM. GLM was preferred over ANOVA because the data is unbalanced. The GLM model used for estimating the mean length was:

$$y_{ijkl}=\mu+\alpha_i+\beta_j+\delta_k+\varepsilon_{ijkl} \qquad \text{Model 1}$$

where y is the mean length of each species, μ is the overall mean, α is the duration effect, β is the effect of which part of the tow we have: shooting, towing or haulback, and δ is the effect of night/day. ε is the random error, supposed to have a mean of zero and to be distributed normally and independent. The model was weighted by the number of fish in each bag.

Analysis is conducted for each species that was represented in at least two bags in a haul, and mean size of the fish was weighted by the catch in each bag, as the sampling unit is one bag, not individual fish, since it tend to aggregate and not be independent and randomly distributed (Godø *et al.*, 1990).

Results

Five species were caught in at least two bags in each haul, and in all three bags total, this was cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), capelin (*Mallotus villosus*), saithe (*Pollacius virens*), and Norway pout (*Trisopterus esmarki*). Mean length of cod, saithe and Norwegian pout in different bags of the MultiSampler is lowest for Multi 1 (shooting), middle for Multi 2 (towing) and largest for Multi 3 (heaving), but for haddock and capelin the mean length is largest for Multi 2 (towing) and lower during shooting and heaving (Table 1).

Table 1. Catch in numbers, mean length and sampling time for the species analysed. Total time reflects the accumulated sampling time for each of the 3 bags.

Species	Parameter	Multi 1	Multi 2	Multi 3
	N	16	2599	410
Cod	Mean length	39.3	46.9	48.5
	Total time	1:15	2:31	2:20
	N	24	2907	225
Haddock	Mean length	16.4	27.9	24.4
	Total time	1:15	2:31	2:20
	N	24	49	28
Capelin	Mean length	15.6	17.3	16.2
	Total time	1:15	1:24	2:00
	N	4	1139	382
Saithe	Mean length	51.3	52.0	54.1
	Total time	0:45	2:31	2:00
	N	27	792	93
Norwegian Pout	Mean length	13.9	14.5	15.7
	Total time	1:15	2:31	2:00

When testing the effects in Model 1 for the dependent variable mean length, the model was significant only for saithe (Table 2), and the significant effect was the bag effect. Tow duration was an important (not significant) effect for haddock, but the total model was not significant.

Table 2. Results from Model (1) using mean length per bag as independent variable.

Haddock	DF	Mean square	F	Significance level
Total model	3	1943,451	2,24	0,1235
Multi	1	324,622	0,37	0,5499
Day/Night	1	91,298	0.10	0,7502
Tow duration	1	3552,050	4.08	0,0604
Error	16	870,286		

Capelin	DF	Mean square	F	Significance level
Total model	3	4.348	0,69	0.5897
Multi	1	1,273	0,20	0.6637
Day/Night	1	4,698	0,75	0.4103
Tow duration	1	12,117	1,92	0.1989
Error	12	6,302		

Saithe	DF	Mean square	F	Significance level
Total model	3	852,203	5,70	0,0102
Multi	1	2500,605	16,72	0,0013
Day/Night	1	512,429	3,43	0,0870
Tow duration	1	577,424	3,86	0,0711
Error	13	149,526		

Cod	DF	Mean square	F	Significance level
Total model	3	2761,153	0.87	0,4757
Multi	1	3941,401	1,25	0,2808
Day/Night	1	18,681	0,01	0,9397
Tow duration	1	1799,544	0,57	0,4617
Error	16	3162,721		

Norway pout	DF	Mean square	F	Significance level
Total model	3	13,301	0,77	0,5285
Multi	1	20,478	1,19	0,2934
Day/Night	1	24,333	1,41	0,2537
Tow duration	1	14,149	0,82	0,3797
Error	15	17,271		

Trawl geometry sensors may indicate different values, and the addition of a bottom contact sensor might in some cases help detect abnormalities in a trawl haul. In Figure 2 a trawlhaul is shown where shooting, towing and heaving is monitored by four different sensors. The cyan line indicates the skippers definition of the tow duration (towing = 100), and it can be seen here that the bottom contact sensor is at the bottom more than two minutes before and six minutes after this defined time period.

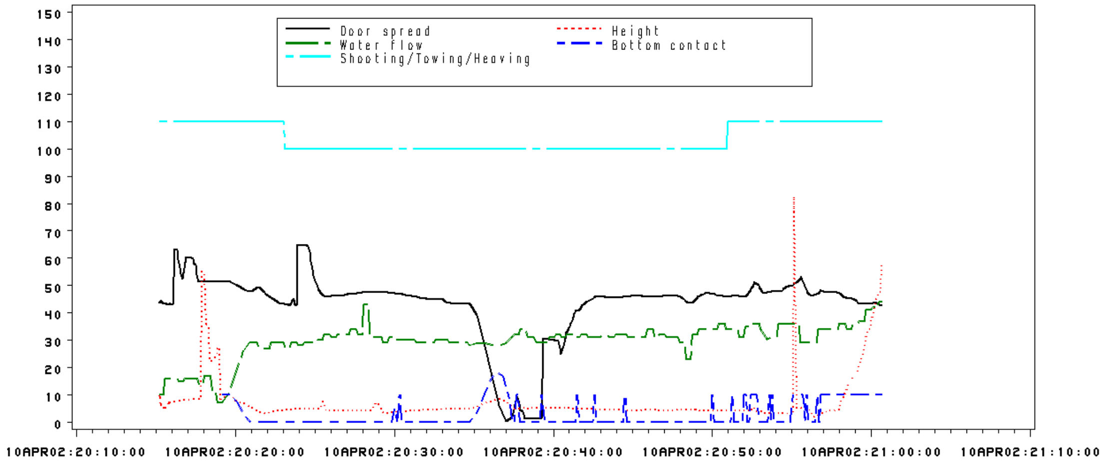

Figure 2. Sensor data from the shooting, towing and heaving phase of a trawlhaul conducted as a standard sampling haul.

The haul illustrated in Figure 3 has no registration of the heaving of the trawl. However, it can be seen from the bottom contact sensor in Figure 3 that the trawl has less bottom contact than in the haul shown in Figure 2.

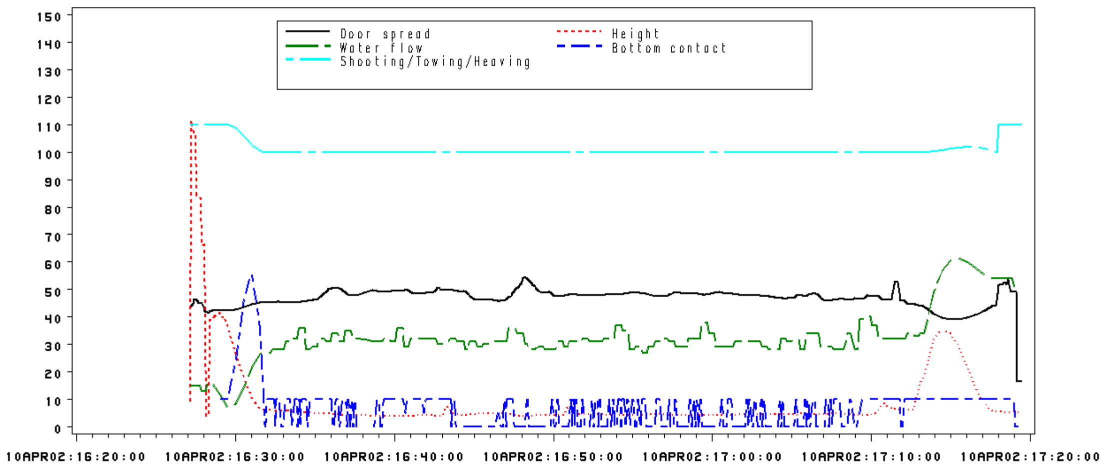

Figure 3. Sensor data from the shooting and towing of a trawlhaul conducted as a standard sampling haul.

Discussion

This study is based on a small sample (8 hauls times 3 bags) and merely suggests that results found here needs further study. We have examined the mean length of samples from the shooting, towing and heaving phases of a trawl haul, and have found, even in this small material, a significant effect on mean length from the different phases of sampling. We have found that mean length in the heaving phase of the haul is largest in 3 out of 5 species analysed, but only in one of these (saithe) are the effect of sampling phase (Multi) significant. The towing time is used as an effect in the variance model, but was not significant in any sub-sample. The effect of towing time may be masked in the data, as the towing time of Multi 1 and 3 (shooting and heaving) is set to constant 15 and 20 minutes respective.

The shooting procedure may result in differences in the way the trawl hits bottom. If the trawl is shot without breaks, most likely, the doors will touch the bottom first, before the gear. If breaks are used during shooting the gear may touch bottom and the trawl fish before the doors and sweeps are sweeping fish in front of the trawl. This, together with the fact that the fish may be caught before and after the period of bottom contact would bias the estimates of tow duration and the bias would be relatively larger for shorter tows.

When haulback starts, the strategy of the skipper determine whenever the speed of the trawl is sufficient to make fish that is standing in the opening of the trawl will be caught or released. A footrope can stay in contact with the bottom and continue to fish several minutes after haulback has started, or, if the trawl stops, the fish inside the belly of the trawl may escape. If current is strong, this may lead to additional variation in trawl speed during heaving.

Our data (Figure 2 and 3) suggests large differences in bottom contact in two hauls conducted in the same area. There is a potential loss of fish under a ”flying” ground gear (Engås, 1994; Godø, 1994). This was observed also in this survey, but the videos are not analysed and compared to bottom contact data. Whenever the binary data of bottom contact are adequate for quality judgements of a trawl haul should be discussed. As a combined input with the height sensor the bottom contact sensor may give valuable information.

Previous studies of the effect of tow duration have found that the catch per unit of effort (CPUE) increased as tow duration decreased while the mean length were nearly constant (i.e. Godø *et al.*, 1990; Walsh, 1991; Somerton *et al*., 2002). The explanation for the increase in CPUE is not clear even though the authors suggest several different theories. One possibility is an error in the measurement of the effective towed distance. Godø *et al.* (1990) argued that this could not be the sole explanation because the estimated inaccuracy in the measured tow length was too small to account for the observed difference in CPUE. They did probably not consider that large of the catch can be caught when the trawl is on its way up and down from/to the bottom.

Significant improvements have been made on gear standardisation, with trawl monitoring equipment to ensure stable trawl performance, towing distance and bottom contact (Engås, 1994). When headline height, wing spread and door spread are monitored, the main sources of uncertainty in a swept area estimate is variability in towing speed and effective tow duration or towed distance. Tow duration used to be recorded manually, where start of a tow was judged from definitions of when the correct trawl geometry on the bottom was established, as measured by the trawl instrumentation. However, operational instability (variation between the crew) demanded new and improved instrumentation for an exact and objective definition of effective duration. A bottom contact sensor mounted at the ground gear monitoring the bottom contact during the tow could therefore now be introduced in our annual bottom trawl surveys (Engås *et al.,* 2001) but still, the skippers strategy will influence the additional time of bottom contact the trawl will have before and after the stop time is set. Most probably, the skipper's strategy will contribute to the total catch of each station in a stronger degree if the towing time is reduced. If a MultiSampler device is used, sampling only in the time period defined as towing time can reduce the variation in effective towing time. The MultiSampler should also be used in an extended study of variation in sampling time before survey strategy is altered.

References

Carlsson, D., Kanneworff, P., Folmer, O., Kingsley, M. and Pennington, M. 2000. Improving the West Greenland trawl surveys for shrimp (Pandalus borealis). Journal of Northwest Atlantic Fisheries Science, 27: 151-160.

Engås, A. 1994. The effects of trawl performance and fish behaviour on the catching efficiency of demersal sampling trawls. In: Fernø and Olsen (Eds): Marine fish behaviour in capture and abundance estimation. Fishing News Books, Blackwell Science Ltd, Oxford, UK, p 45-65.

Engås, A. and Godø, O.R. 1989. Escape of fish under the fishing line of a Norwegian sampling trawl and its influence on survey results. Journal du Conseil International pour l'Exploration de la Mer, 45: 269-276.

Engås, A., Ona, E. and Ramberg, K. 2001. In situ determination of bottom trawl ground gear contact. ICES CM 2001/Q:07, 9 p.

Engås, A., Skeide, R., and West, C.W. 1997. The "MultiSampler": a system for remotely opening and closing multiple codends on a sampling trawl. Fisheries Research, 29: 295-298.

Godø, O.R. 1994. Factors affecting the reliability of groundfish abundance estimates from bottom trawl surveys. In: Fernø and Olsen (Eds): Marine fish behaviour in capture and abundance estimation. Fishing News Books, Blackwell Science Ltd, Oxford, UK, p 166-195.

Godø, O.R., Pennington, M. and Vølstad, J.H., 1990. Effect of tow duration on length composition of trawl catches. Fisheries Research, 9: 165-179.

Gunderson, D.R. 1993. Surveys of fisheries resources. John Wiley and Sons, New York, NY, 248 p.

Korsbrekke, K., Mehl, S., Nakken, O. and Pennington, M. 2001. A survey-based assessment of the Northeast Arctic cod stock. ICES Journal of Marine Science, 58: 763-769.

Nakken, O. 1998. Past, present, and future exploitation and management of marine resources in the Barents Sea and adjacent areas. Fisheries Research, 37: 23-35.

Pennington, M., Burmeister, L-M. and Hjellvik, V. 2002. Assessing the precision of frequency distributions estimated from trawl-survey samples. Fishery Bulletin. 100, no 1: 74-80.

Pennington, M. and Godø,O.R. 1995. Measuring the effect of changes in catchability on the variance of marine survey abundance indices. Fisheries Research, 37: 97-106.

Pennington, M. and Strømme, T. 1998. Surveys as a research tool for managing dynamic stocks. Fisheries Research, 37: 97-106.

Pennington, M. and Vølstad, J.H. 1991. Optimum size of sampling unit for estimating the density of marine populations. Biometrics, 47: 717-723.

Pennington, M. and Vølstad, J.H. 1994. Assessing the effect of intra-haul correlation and variable density on estimates of population characteristics from marine surveys Biometrics, 50: 725-732.

Somerton, D.A., Otto, R.S. and Syrjala, S.E. 2002. Can changes in tow duration on bottom trawl surveys lead to changes in CPUE and mean size? Fisheries Research, 55: 63-70.

Walsh, S. J. 1991. Effects of tow duration on gear selectivity. Northwest Atlantic Fisheries Organisation SCR Doc. 84, 9 pp.

Walters, C. and Maguire, J.J. 1996. Lessons for stock assessment from the northern cod collapse. Reviews in Fish Biology and Fisheries, 6: 125-137.