TRAWL DESIGNS AND TECHNIQUES USED BY NORWEGIAN RESEARCH VESSELS TO SAMPLE FISH IN THE PELAGIC ZONE

by

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ABSTRACT

In resource surveys, representative identification of species and sizes of fish is of vital importance. Various designs and sizes of pelagic trawls and techniques are used in the pelagic zone by Norwegian research vessels for this purpose. This paper describes trawl designs used for 0-group surveys and a larger trawl used for adult fish. The largest trawl, which has a vertical opening of 30 m when towed at 3.5 - 4 knots, can be rigged for close-to-surface trawling as well as for mid- and deep-water trawling with minor adjustment of the rigging. The performance of the various trawls is described, based on geometric measurements using Scanmar instruments and observations with a TV-camera in a towed underwater vehicle. The trawl mouth area of the 0-group trawl is approximately 10 x 10 m, and it can be rigged to catch efficiently in all depths from surface downwards. The large pelagic trawl is rigged with large surface buoys and lenghtened upper bridles when used in the surface layer to sample herring and mackerel.

INTRODUCTION

In the Barents Sea a combination of fishery-dependent and fishery-independent methods is used for assessment of important fish stocks, like cod, haddock, herring, and capelin. Fishery-independent methods are mainly based on echo integration and trawl sampling. Echo intregration depends on representative identification of targets with respect to fish species and sizes, and trawling is at present the only applicable method for this purpose. Trawl sampling may also give information on fish density directly if the sampling area and selection properties of the trawl are known (Dickson 1975).

Small and large fish targets behave differently in the trawling process. Small fish have low swimming capability and can be captured with a small pelagic trawl, whereas a larger trawl opening is needed to capture larger fish effectively. Based on these assumptions, two trawls of different size have been developed in Norway in recent years, one small trawl for sampling of small fish (< 10 cm) and one bigger trawl for larger fish.

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Studies of early recruitment of fish in the Barents Sea (0-group surveys) have been carried out since 1965 in August-September in joint Norwegian-Russian cruises. Relative abundance indices of different 0-group fish is found using a standard pelagic trawl (16x16 fathoms capelin trawl) towed for 30 minutes in three depth intervals, 0-20, 20-40, and 40-60 m, 10 minutes in each depth (Hylen *et al.* 1995). Based on performance studies of the trawl (Godø *et al.* 1993) and special studies of near-surface vertical distribution of 0-group fish (Godø and Valdemarsen 1993), it was recognised that the trawl and technique used were not optimal. This paper describes an alternative trawl design, its rigging and performance data.

When fish are distributed in the pelagic zone, echo integration is widely used for stock assessment. The targets must be identified to species and sizes for converting echo integration values to abundance estimates (Dalen and Nakken 1983). The trawl used for this purpose should ideally have the same efficiency for all species and sizes of fish, or at least its relative efficiency for different species and sizes should be known. A pelagic trawl for research purposes should be relatively easy to handle onboard when shooting and hauling, and it should function well at any depth from the surface downwards. Another factor to have in mind when designing a pelagic trawl for a research vessel which will also operate bottom trawls with combination trawl doors, is that the trawl size must match the doors and therefore also the size of the bottom trawl. The resulting pelagic sampling trawl design therefore must be a compromise among various conflicting considerations. Until 1992 Norwegian research vessels used the 16x16 fathoms capelin trawl for sampling in the pelagic zone in the Barents Sea. On herring cruises in the North Sea and along the Norwegian coast, a pelagic trawl of swedish design (Fotø) have been used with reasonable success, especially when rigged with buoys at the wing tips for sampling near surface (Misund and Aglen 1992). The pelagic trawl now used by all Norwegian research vessels ("Johan Hjort", "G. O. Sars", "Jan Mayen", and "Michael Sars") was designed in 1991 and first introduced on "Johan Hjort" in 1992. This paper describes the trawl design, rigging alternatives, and results from performance tests with this trawl.

0-GROUP TRAWL

Trawl design and rigging

The design of the 0-group trawl is shown in Figure 1. The trawl consists of four identical panels in green coloured nylon material. Mesh size ranges from 200 mm in the front to 10 mm in the codend. These small mesh sizes are intended to reduce the escape losses for smaller fish.

Rigging of the trawl is illustrated in Figure 2. All rigging components were made very light to make it possible to tow the trawl near the surface. The trawl doors were constructed in aluminium, and their design is shown in Figure 3.

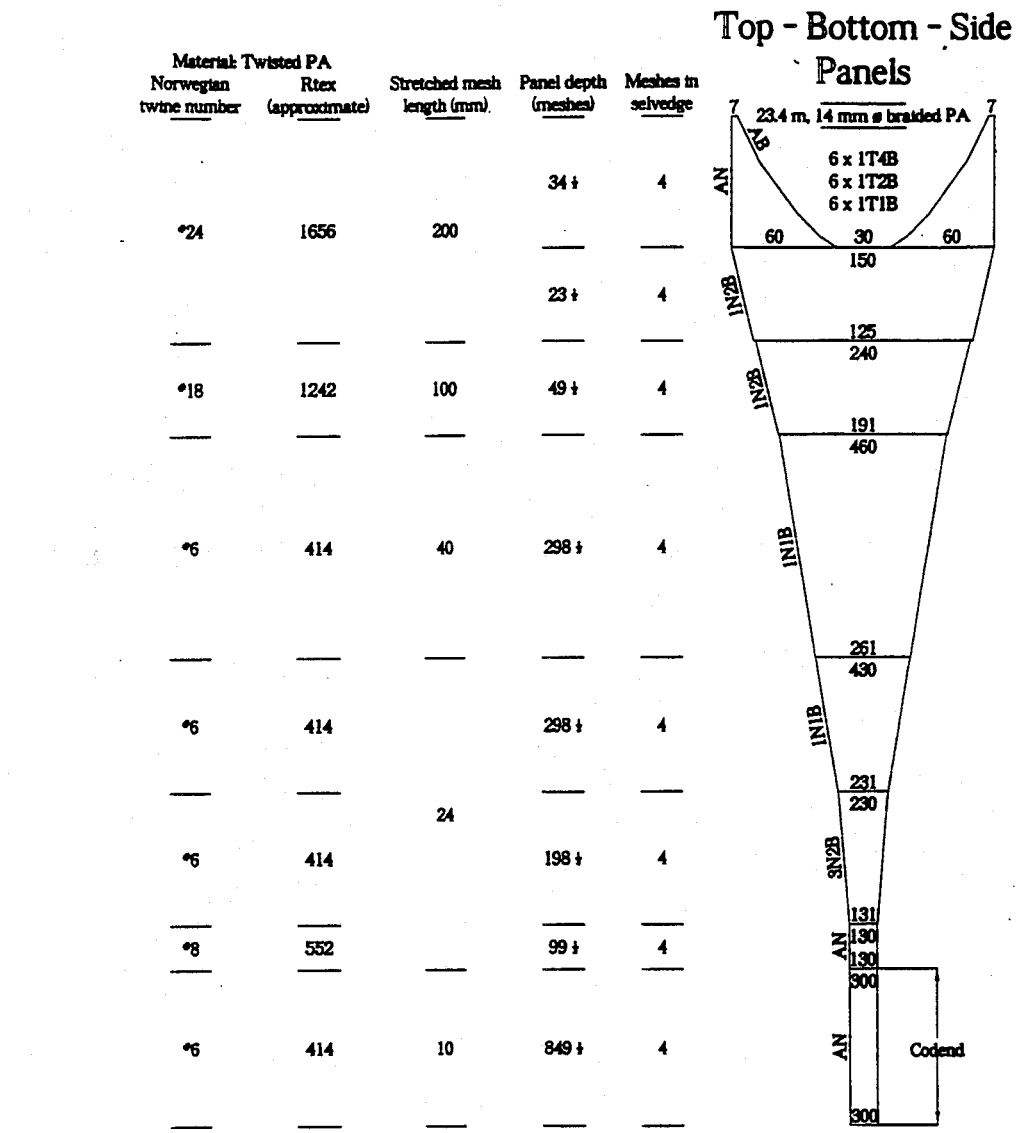

Figure 1. 0-group sampling trawl (113 m net circumference).

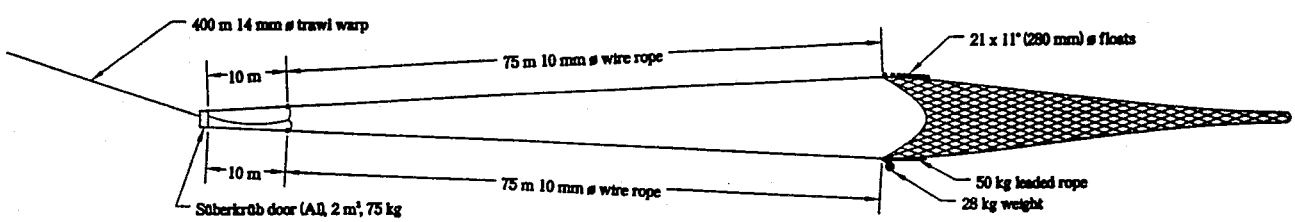

Figure 2. Rigging of the 0-group sampling trawl.

Trawl performance

The geometry of the trawl with different length of warp was measured with Scanmar instruments in a trial with F/F "Michael Sars" in April 1993. Data from this test are given in Table 1.

Table 1. Trawl geometry and vertical position of the 0-group sampling trawl with different warp lengths when towed at 2.3 knots.

Warp length (m)	Trawl depth (m)	Door depth (m)	Trawl height (m)	Door spread (m)	Wing spread (m)
100	0	10	10.5	30	9
150	17	24	10	36	10
200	29	35	10	38	10
250	41	47	10	39	11
300	54	60	10	39	11
350	67	73	10	40	11

A recommended procedure when catching 0-group fish in the upper 60-70 m is to start with 100 m warp for towing in the surface position for 5 minutes, then shoot successively 50 m warp for towing 5 minutes in each depth until the maximum depth for the fish recordings is reached.

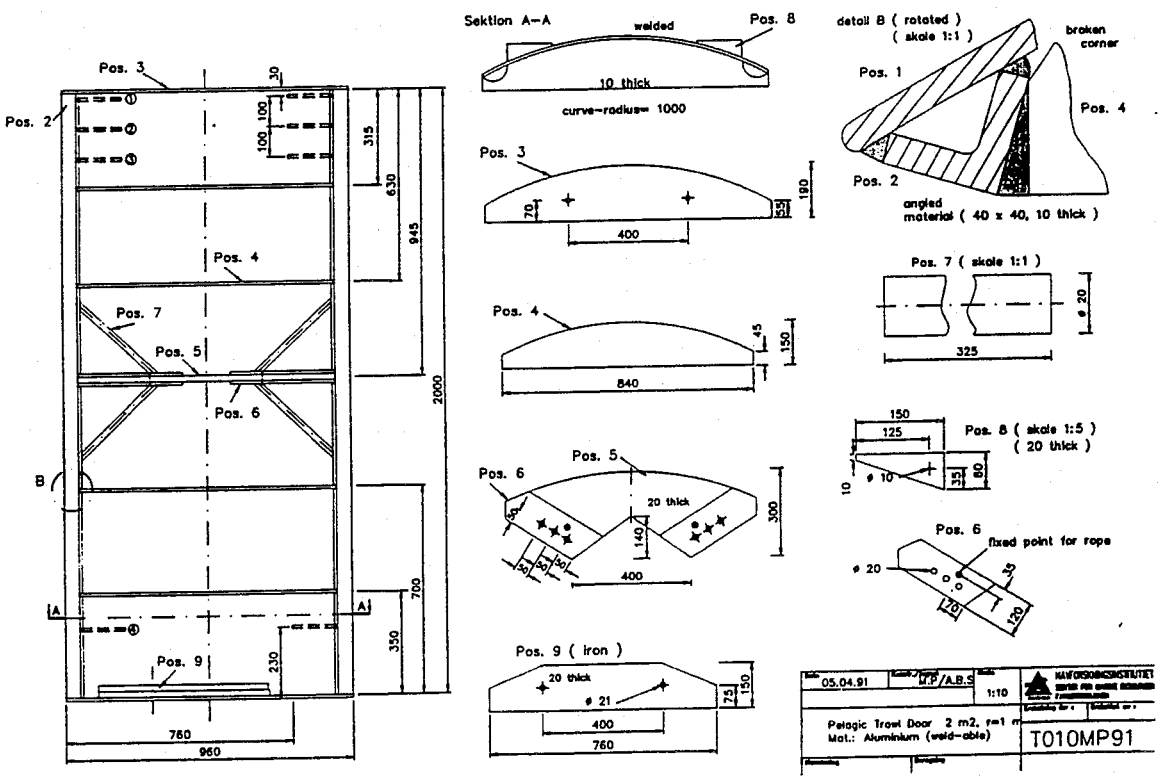

Figure 3. Süberkrüb trawldoor 2m^2 in aluminium used with the 0-group sampling trawl.

PELAGIC SAMPLING TRAWL (ÅKRA TRAWL)

Trawl design and rigging

The design of the Åkra trawl is illustrated in Figure 4. The trawl is made from four identical panels of black coloured nylon netting. The mesh size ranges from 3200 mm in the front to 20 mm in the codend.

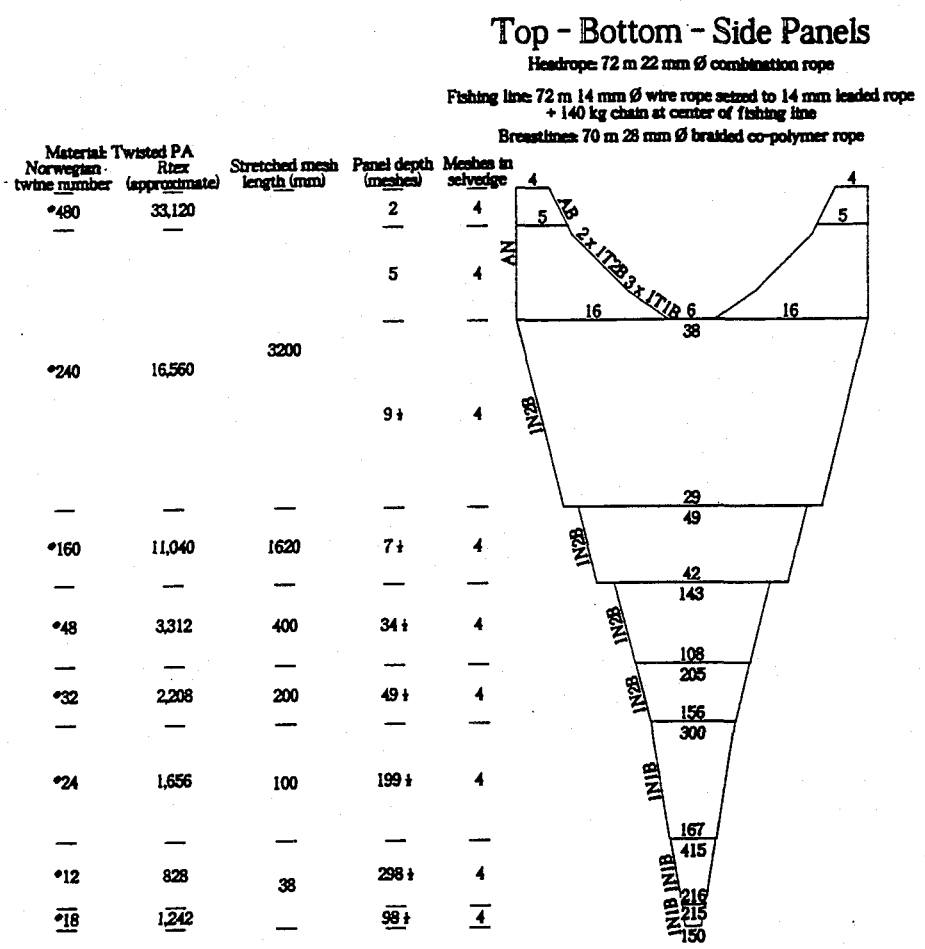

Figure 4. The pelagic sampling trawl (Åkra trawl), 384 m net circumference.

For fishing at greater depth than 50 m, the trawl is rigged as shown in Figure 5 B (standard rigging). Two sizes of trawl doors (Waco type 6 m^2 and 7 m^2) have been tested with this rigging. It should be noted that the lower bridles had an extension of 6 m with this rigging, and 500 kg weights were used on each lower wing tip.

For surface trawling the trawl was rigged as shown in Figure 5a. The difference from the standard rigging is the extra extension of the upper bridles, omission of the weights at the wing tips, and the two large surface buoys (675 kg buoyancy each) attached to each upper wing.

Trawl performance studies

Two series of experiments were conducted to measure trawl performance. The first test was conducted onboard "Johan Hjort" in April 1993, using various Scanmar gear monitoring instruments, Scantrol load cells, Simrad trawl sonar, and a towed vehicle (Ocean Rover). The second set of experiments was carried out onbord "G.O. Sars" during ordinary sampling cruises in January and July 1993.

Test trials

The trawl, rigged as shown in Figure 5 B, was tested with 6 and 7 m^2 Waco doors at towing speeds between 3 and 4 knots and with warp lengths ranging from 150 to 450 m. Doorspread, vertical trawl opening, and trawl depth were recorded when the trawl had stabilized at the

fishing depth. Tension was measured with two load cells attached in front of and behind one trawl door. For calculations of drag, it was assumed that the tension was identical on both sides.

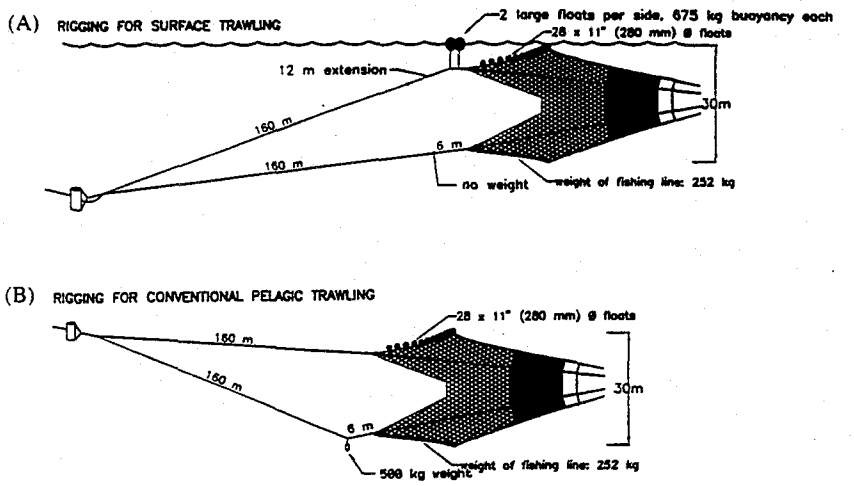

Figure 5. Rigging of the Åkra trawl for surface (A) and midwater (B) trawling.

The door spread for the two door sizes with different warp lengths when towed at 3,4 knots is illustrated in Figure 6. The difference in door spread was approximately 10 m between the two door sizes. The spread reached its maximum with 400 m towing warp.

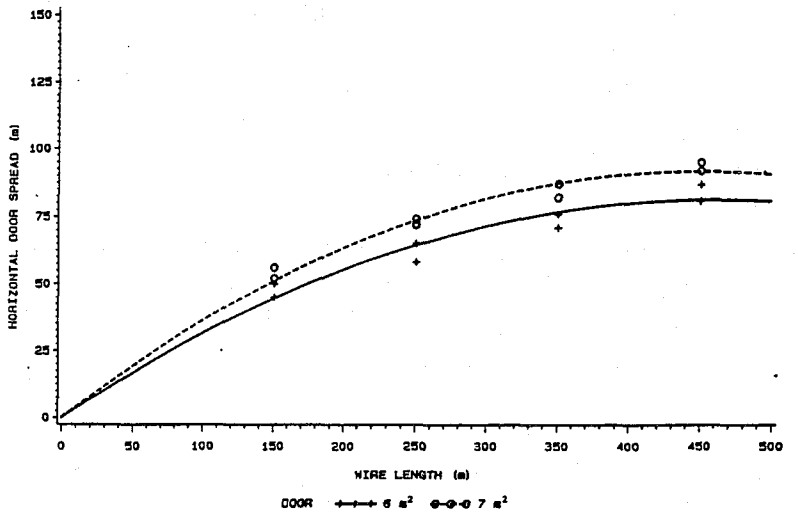

Figure 6. Door spread versus warp length for the two Waco doors (6 and 7 m^2) during test trails with the Åkra trawl onboard F/F "Johan Hjort" in April 1993.

The vertical trawl opening decreased with increased towing speed as shown in Figure 7 for two different warp lengths.

The total drag (trawl doors + trawl net) and drag of the trawl net only as calculated from tension measurements in front of and behind one door are illustrated in Figure 8. The total drag increases from 10 tons at 3 knots to 13 tons at 4 knots. The difference between total drag and trawl net drag is the resistance of the two doors (7 m^2).

Sampling trials

In the January 1993 trial, the trawl was used with conventional rigging to sampling of midwater recordings. The rigging was as shown in Figure 5 B with 6 m^2 Waco doors and 280

kg weight on the wing tips. In the July 1993 trial, the trawl was rigged for midwater sampling as well as for near surface sampling (Figure 5A, B). Larger Waco doors (7 m^2) were used in the July cruise.

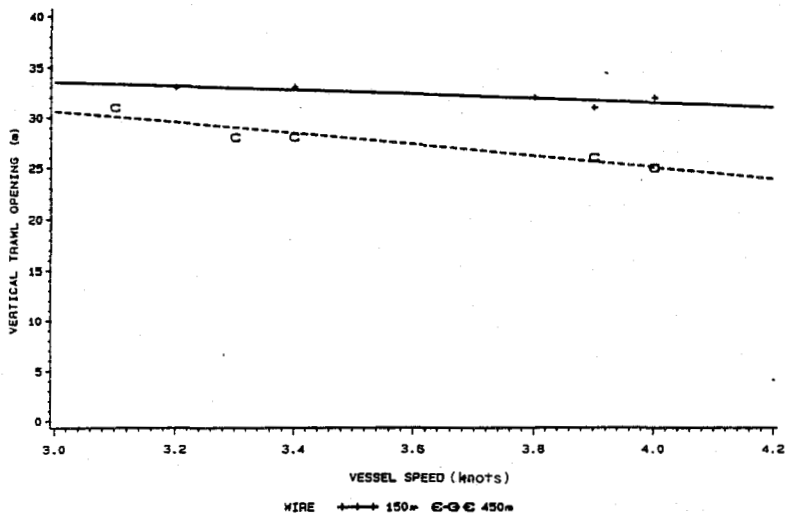

Figure 7. Åkra trawl vertical opening versus towing speed for two different warp lengths (150 and 450 m) during test trails onboard F/F "Johan Hjort" in April 1993.

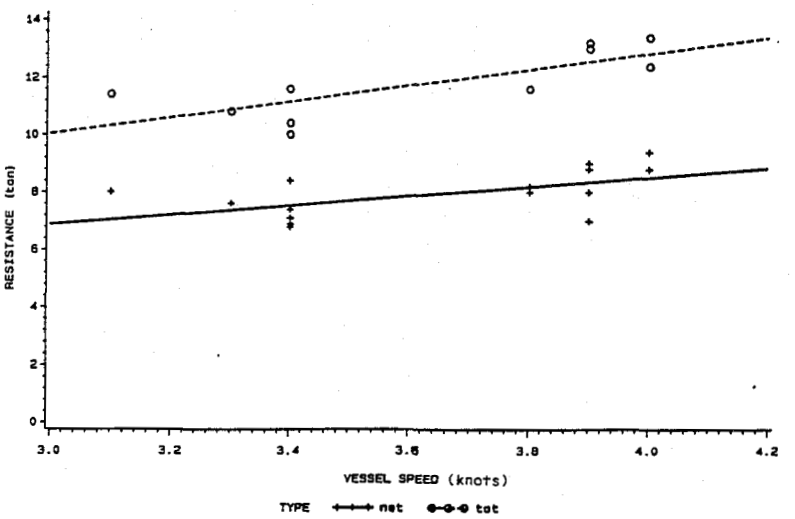

Figure 8. Total and trawl drag versus towing speed calculated from tension measurements in front of and behind one trawl door (7 m^2) during test trials with the Åkra trawl onboard F/F "Johan Hjort" in April 1994.

The depth of the trawl headline versus warp length with 3.5 knots towing speed is illustrated in Figure 9. The trawl depth increased linearly with warp length.

The door spread obtained with the two sizes of Waco doors (6 and 7 m^2) is shown in Figure 10. A difference of 5-10 m in spread was found between the two sizes. The data for the 7 m^2 doors also include hauls when the trawl was towed in surface position.

The vertical opening was 28-32 m with standard rigging and with 300-1200 m of towing warp (Figure 11). Rigged for surface trawling, the vertical opening increased from 24 to 35 m when the warp length increased from 150 to 350 m (Figure 12). The increase in vertical

opening is explained by the increase in downward pull of the lower wings as the doors go deeper with increased warp length. Approximately 350 m warp could be shot before the big surface buoys went under. With a towing warp length of 350 m, the trawl's position was 500 m behind the vessel, which was well outside the propeller wake.

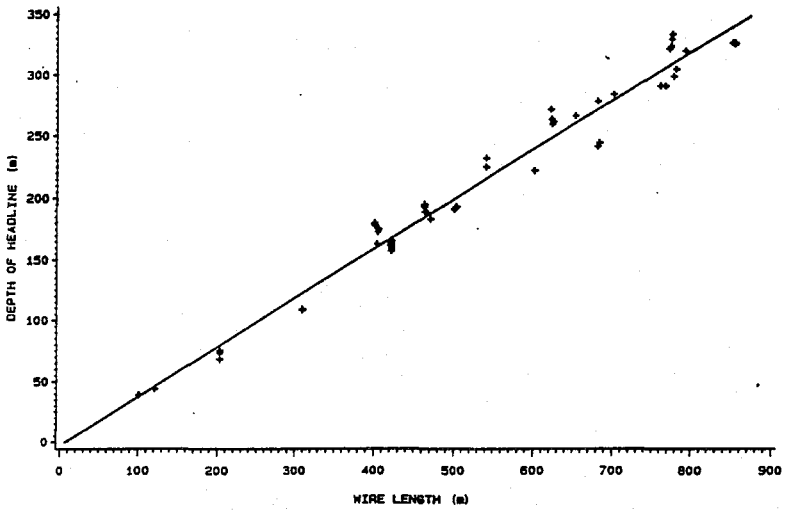

Figure 9. Depth of tawl headline versus warp length when towed at 3,5 knots during sampling trials with the Åkra trawl onboard F/F "G. O. Sars" in January 1993.

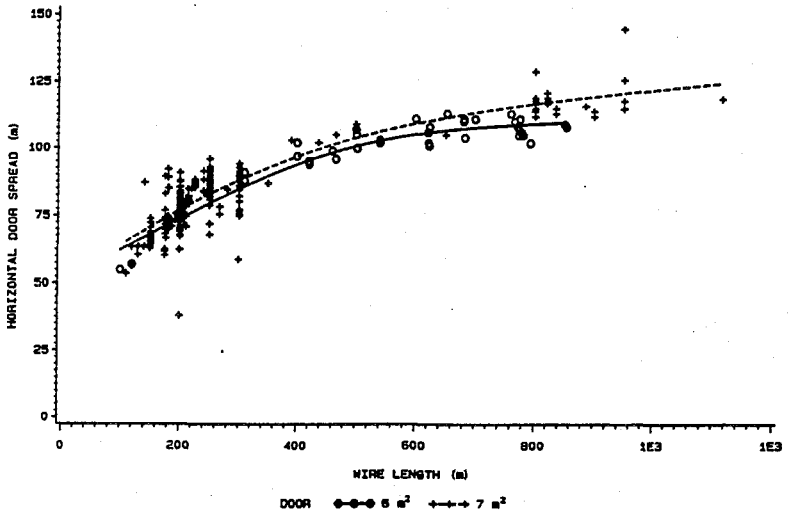

Figure 10. Door spread for 6 and 7 m^2 Waco doors versus warp length during sampling trials with the Åkra trawl in January 1993 (6 m^2) and in July 1993 (7 m^2).

The practical experience with handling of the trawl onboard the research vessels have been satisfactory. Rerigging from standard to surface tows by installing the 12 m extensions in the upper bridles and attaching the buoys at the wing tips were done quite easily.

The catching efficiencies for various species and sizes have not been evaluated. However, the trawl seemed to catch reasonable samples of the important pelagic species. The surface rigging was successfully used to catch scattered concentrations of mackerel and herring in the upper 30 m. Aimed trawling for schools near the surface recorded with sonar has also been successful. The best efficiency for such schools was obtained by towing along a cruved track, so that the trawl passed inside the propeller wake. Nevertheless, occasionally schools avoided

the gear. Often these schools seemed to be influenced by the trawl warp and avoided it to pass outside the trawl.

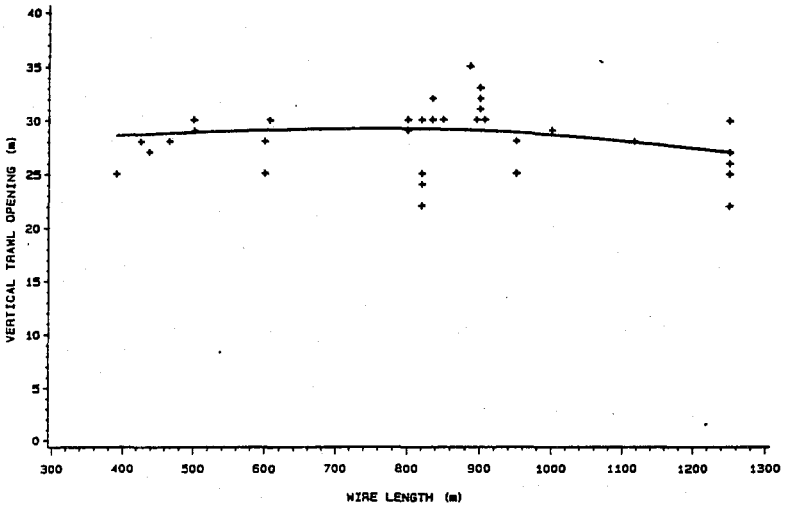

Figure 11. Vertical trawl opening versus warp length with 3,5 knots towing speed during sampling trials with the Åkra trawl onboard F/F "G. O. Sars" in July 1993.

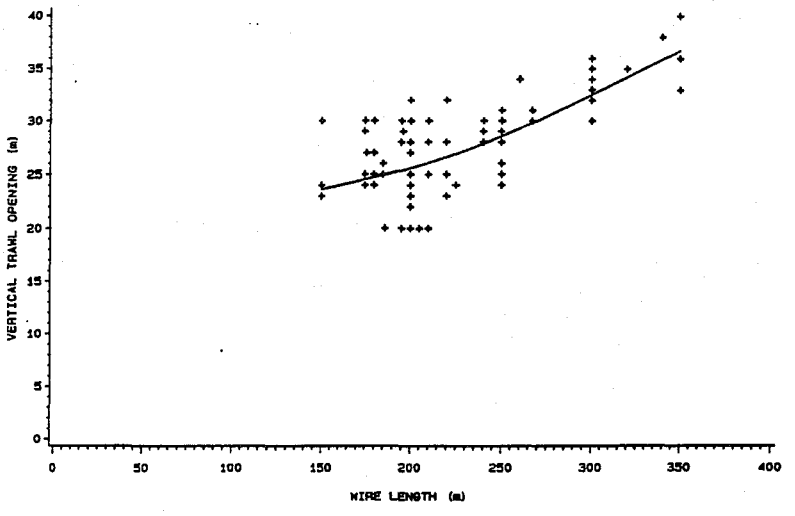

Figure 12. Vertical trawl opening versus warp length when the trawl was rigged for surface towing during sampling trials with the Åkra trawl onboard F/F "G. O. Sars" in July 1993.

DISCUSSION

The advantages of the newly designed 0-group trawl are that it can be towed in any depth from the surface downwards with the same rigging, and that the trawl has nearly the same geometry in all depth intervals. This means that quantitative data can be recorded in any depth independent of the vertical distribution.

Based on a 10 m vertical opening and a 1 m diameter at the entrance of the codend, the belly slope is on average 8°. Such a slope might be too steep to efficiently herd the smallest individuals. A 3 cm fish encountered near the front panel must for example swim at a minimum speed of 5 bodylengths/second for 30 seconds to end up in the codend. Further, the

fish must swim away from the netting at right angles, which is unlikely to happen. In the herding process, fish most often avoid an approching object by swimming forward, and therefore the speed and distance the fish must swim to arrive in the codend will exceed the capability of the smallest fish. Some proportions of smaller 0-group fish may be lost, while increasing proportions of larger fish are captured. To evaluate the efficiency for various sizes of fish, small bags covering some areas of the netting outside the trawl could be used to collect the escaping fish. Another method is to observe any escapement through the meshes with a TV- camera either in a towed vehicle or attached to the trawl.

The trawl was tested in three surveys in 1993, for 0-group saithe in the North sea, for herring larvae along the Norwegian coast and in the Norwegian Sea, and for 0-group fish in the Barents Sea. In the first surveys the trawl was considered an improvement compared to the earlier used capelin trawl. The catching performance was, however, not studied in these cruises. In 0-group surveys in the Barents Sea the efficiency of the trawl have been compared with the standard 0-group trawl (Hylen *et al.* 1995).

For sampling schools of larger individuals, which are likely to completely avoid the relatively small fishing area of the 0-group trawl, the Åkra trawl functions well.

The Åkra trawl has been used on several cruises since it was introduced on F/F "Johan Hjort" in 1992. The efficiency of the trawl has not been evaluated in a systematic way. A general experience is, however, that the trawl catches most types of fish recorded with echo sounder and sonar. Compared to catches taken with the former capelin trawl, samples taken with the new trawl consist of larger fish individuals of species like cod and haddock as well as fast swimming pelagic species like herring, mackerel, and horse mackerel.

The rerigging from standard to surface tows is quite simple, and the trawl can therefore be used routinely to sample fish recordings at any depth from the surface downwards. The 6 m^2 Waco doors are, however, not optimal for this trawl, since their spreading force is too low when using short lengths of towing warp. This problem is greatest when fishing on recordings in depths from 30 to 70 m, which is too deep to use the surface rigging. Shallower recordings can be caught with the surface rigging, wheras fish deeper than 70 m are efficiently taken with the standard rigging.

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