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# FURTHER EXPERIMENTS WITH RADIAL ESCAPE SECTION (RES) AS FISH-SHRIMP SEPARATOR IN TRAWL.

by

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ABSTRACT

A new approach to the bycatch problem when trawling for shrimp was initiated in Norway in 1984 utilizing the difference in swimming behaviour of fish and shrimp. A radial escape section (RES) in the aft belly of the trawl allowed fish to activly escape as shrimp was guided by funnels of netting towards the codend.

The performance of the new selective device (RES) as well as behaviour of fish in trawls has been observed by a remote controlled television vehicle (RCTV).

Comparative fishing experiments to evaluate its selective properties was conducted with a siamese twin trawl as well as with two trawlers fishing in the same area.

The design of the radial escape section (RES) was gradually improved based on RCTV observations. Fishing experiments indicate that fish actively escape through the RES arrangement and that its efficiency is dependant on the size of fish. Larger fish escape easier than smaller fish. The RES also increased escapement of small shrimp resulting in better size selection.

## INTRODUCTION

Research aimed to minimize bycatch of juvenile fish in shrimp trawling has been carried out by several countries during the last 10 - 20 years (Anon 1973, Isaksen 1984, Karlsen 1976, Watson 1983, Way & Hicky 1978).

In the Norwegian shrimp trawl fishery juveniles of cod (**Gadus morhua**) and haddock (**Melanogrammus aeglefinus**) are the major bycatch species. A selective principle primarily utilizing different sizes of shrimp and fish together with different behaviour (Karlsen 1976) has been used with some success in the coastal shrimp fishery.

The major disadvantage of this principle is the loss of shrimp especially the larger ones, when the panel is blocked by debris, flatfish or meshed fish.

A different approach to overcome these problems was therefore initiated in 1984 based on the development of the radial escape section, the so-called RES, (West et al. 1984). Encouraged by the initial results with this system, further research has been carried out to improve the design of the RES and to evaluate its potential as fish/shrimp separator in commercial fishing operations. The results, which are summarized in this report, relate to three different cruises in 1985, all carried out in coastal areas off the Finnmark coast, Northern Norway. The performance of different RES designs and the behaviour of fish when passing through the RES was directly observed by using a remote controlled television vehicle (RCTV). These experiments were followed by comparative fishing experiments to evaluate the effect of RES on fish and shrimp on commercial fishing grounds.

## MATERIALS AND METHODS

The first trial was conducted in May - June 1985 with the multipurpose research vessel "Kystfangst" (60' OAL, 540 HP). The vessel was equipped for shrimp trawling and for RCTV observations. The RCTV was used to observe behaviour of gear and fish during the first period of the cruise in 50-70 meter depth on smooth bottom west of Vardø in Finnmark.

Different designs of RES (Fig. 1) were observed both in the aft belly of a "Sputnik 1400" trawl, (Fig. 2), and in the starboard part of the experimental siamese twin trawl, (Fig. 3), (Valdemarsen et al. 1984). Based on the direct observations made, the RES was redesigned. The behaviour of fish when passing through the RES was an important factor to consider when designing a RES which seemed effective for fish escapement.

Towing speed during RCTV-observation was as when ordinarily trawling, 1.5 - 2.0 kn. The observations lasted from short periods (10-15 minutes) with imperfect RES-designs, till 2 hours when the fish behaviour was of major interest of the experiment. Because of large quantities of small sized cod and haddock in the experimental area the codends were left open, except for one haul with the siamese twin trawl where the catch composition in the trawl parts with and without RES was compared.

A RES design that seemed to perform well was later tested in the siamese twin trawl on commercial shrimp grounds. The catch of each codend was counted by species and measured (to nearest cm below). The weight of shrimp was estimated and samples of 0.5-0.6 kgs were measured (tail-eye length).

Duration of tows were from 1 h 30 min to 4 h 25 min. Data from 5 successful hauls during the May/June cruise are used in this report.

Because the bycatch of fish was relatively low during the above experiment further experiments were conducted in October and again in Novem-

ber the same year. Both these trials were carried out with the commercial shrimp trawler "Polarhav" (60' OAL, 320 HP). These trials took place in the Varangerfjord in Finnmark.

In the October experiments the same gear (Siamese twin trawl) and RES as used on "Kystfangst" were tested in 3 hauls of 3 - 4 hours duration. Composition of the catch from both codends were analyzed with regard to number, weight (shrimp) and length (fish).

To verify the selection results obtained with the RES in the experimental twin trawl, the RES was installed and tested in a Sputnik 1600 shrimp trawl (Fig. 4) onboard M/S "Polarhav" in November. To evaluate the selective properties of the RES in that particular trawl, comparative hauls were conducted with a similar sized vessel using a comparable trawl gear. The other vessel (M/S "Stentor") also had a HH fish-shrimp separator in the aft belly of the trawl with an extra fish bag to collect escaping fish. Thus the selective properties of the RES-design could also be compared with another selective device developed for the Norwegian shrimp fishery.

## RESULTS

### Direct observations

The observations with the RCTV were carried out in an area with large consentrations of cod and haddock. From trawl catches the size ranges were estimated to 25 - 65 cm and 25 - 50 cm for cod and haddock, respectively. Observation conditions were fairly good with visual range of at least 20 metres. The observations of gear performance clearly demonstrated a bulb form of the funnels of the RES when tapered as in Fig. 1. A better shape was obtained with a modified tapering of the second funnel, as also shown in in Fig. 1. It was observed that the meshes of both funnels of the RES had maximum opening giving them a squared shape.

Fish passing backwards inside the trawl were always stimulated to swim forward in front of the first funnel. After a while, depending on the fish size, the fish dropped back through the first funnel normally with the tail first. The second funnel than acted as a new stimulus forcing the fish to swim harder in front of it and eventually escape between the ropes outside the funnels.

Escape routes were either upwards or sidewise. Fish that passed the second funnel normally swam towards the codend.

To illustrate the separation effect of the RES in the siamese twin trawls during RCTV-observation, the numbers and average lengths of cod and haddock from the codend, with and without RES, are presented in Table 1. In that particular experiment escapement rates of haddock and cod of 93% and 54%, respectively, were obtained.

Fishing experiments

Data from the three different experiments are presented in Tables 1-3 and Figures 5-7.

The bycatch of juvenile cod and haddock was low during the experiments with "Kystfangst" in May. The separation efficiency for fish is therefore difficult to evaluate. The size composition of shrimp from the two trawl parts, with and without RES, clearly shows that the major shrimp losses were of small sized shrimp, with no significant loss of shrimp larger than 8-9 cms.

During the second experiments with the twin trawl onboard "Polarhav" two valid hauls (7 and 8) indicated no loss of shrimp larger than 7 cm, while more than 50% of the smaller shrimp had escaped from the trawl part with RES arrangement. The escapement of cod was rather good, approximately 70%, and was dependant on size. The data also indicate that very small fish like capelin will escape from the trawl with the RES system, most likely the same way as small shrimp, through the open meshes of the funnels.

The last experiment with the RES installed in a Sputnik 1600 trawl indicated similar results as obtained with RES in the twin trawl.

Variations in efficiency of the RES was, however, experienced between fishing grounds. The HH-net gave a slightly better escapement rate of cod and haddock than the RES. The length distribution of shrimp from the two trawlers show that larger shrimp are caught with trawls having RES in the aft belly (Figure 7). This difference might originate both from loss of small shrimp with the RES arrangement and from loss of larger shrimp with the HH separator.

## DISCUSSION

The RCTV-observations proved to be an efficient method to identify design failures of the RES and to verify improvements resulting from the construction changes made. The disadvantage of such trials is that the observations were conducted in better light conditions than what is the case at 300-400 meters depth, where shrimp trawling actually takes place. The behaviour of fish might thus be different in the dark than observed at good light conditions. Neither was it possible to observe the reaction of shrimp passing through the RES because the shrimp in the experimental area are found deeper than 150 metre, which exceed the maximum operational depth for the RCTV-equipment used.

The experiments also proved that the siamese twin trawl design is an efficient gear to evaluate the effect of various selective devises in the belly-codend region of a trawl. The direct observations showed that the two trawl parts preformed equally, and that differences in catches in the two codends did not create serious distortion of either trawl parts. The efficiency of both trawl parts can thus be considered similar when fishing on flat bottom with the same warp tension on both sides.

Regarding the selective performance of the RES it is obvious that fish will more actively escape from an approaching stimulus created by the

netfunnels than shrimp. The separating efficiency of the RES is depending on the size and species of fish.

The most encouraging result from the experiments was the escapement of small sized shrimp. That particular result might be of special interest in those shrimp trawl fisheries where the target shrimp species is bigger than the deepwater shrimp, **Pandalus borealis**.

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Table 1. Composition of fish catch in the two parts of the siamese twin trawl when RCTV-observed (1. haul)

| | RES | | Standard | | Escapement |
|---|---|---|---|---|---|
| Species | no | length(cm) | no | lenght(cm) | % |
| Haddock | 175 | 31.98 | 2415 | 35.71 | 92.8 |
| Cod | 57 | 32.88 | 125 | 38.31 | 54.4 |
| Plaice | 51 | | 71 | | 28.2 |

Table 2. Composition of catches from 5 hauls with RES in starboard part of the siamese twin trawl, R/V "Kystfangst", May - June 1985.
Fish in numbers, shrimp in weight (kg).

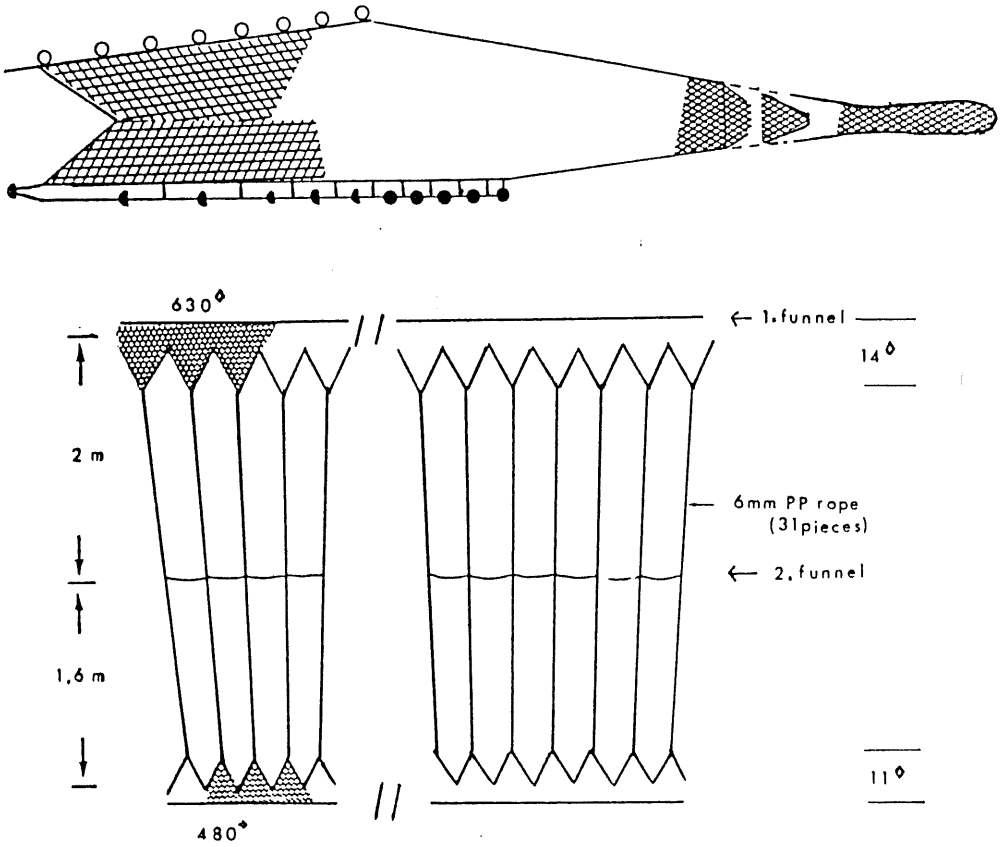
| Towing time | 36 4 hs | | 37 3hs 25 min | | 38 1 hs 40 min | | 39 3hs 05 min | | 40 2 hs | | SUM | | % avoidance with RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RES | Normal | RES | Normal | RES | Normal | RES | Normal | RES | Normal | RES | Normal | |
| Haddock ≥ 20 cm | 3 | 8 | 14 | 14 | 7 | 2 | 1 | 1 | 0 | 0 | 25 | 25 | 0 |
| Haddock < 20 cm | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 100 |
| Cod ≤ 20 cm | 7 | 4 | 8 | 4 | 0 | 0 | 2 | 1 | 0 | 0 | 17 | 9 | 0 |
| Cod > 10 cm | 1 | 3 | 0 | 2 | 1 | 3 | 2 | 27 | 3 | 2 | 7 | 37 | 81 |
| Redfish (1-2 gr) | 14 | 44 | 21 | 40 | 49 | 49 | 112 | 200 | 13 | 25 | 209 | 358 | 41.6 |
| Redfish > 2 gr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 50 | 30 | 50 | 40 |
| Blue whiting | 4 | 6 | 73 | 94 | 307 | 370 | 105 | 139 | 160 | 250 | 649 | 859 | 24.4 |
| Capelin | 4 | 7 | 41 | 120 | 5 | 6 | 3 | 9 | 1 | 2 | 54 | 144 | 62.5 |
| Long rough dab | 17 | 29 | 9 | 14 | 9 | 10 | 130 | 251 | 9 | 10 | 174 | 314 | 44.5 |
| Other | 1 | 4 | 0 | 2 | 0 | 2 | 4 | 2 | 2 | 1 | 7 | 11 | |
| Shrimp (kgs) | 120 | 140 | 75 | 90 | 75 | 85 | 105 | 225 | 40 | 40 | 415 | 580 | |

Table 3. Composition of catches from 3 hauls with RES in the starboard part of the siamese twin trawl, M/S "Polarhav", October 1985. Fish in numbers, shrimps in weight (kg).

| Station no. | 7 | | 8 | | 9 | | SUM | | % avoidance with RES |
|---|---|---|---|---|---|---|---|---|---|
| Towing time | 3 hs 30 min | | 2 hs 55 min | | 3 hs 40 min | | | | |
| | RES | Normal | RES | Normal | RES | Normal | RES | Normal | |
| Haddock | 2 | 3 | 0 | 0 | 0 | 4 | 2 | 7 | 71 |
| Cod | 29 | 66 | 40 | 89 | 25 | 169 | 94 | 324 | 71 |
| Redfish (1-2gr) | 328 | 489 | 318 | 438 | 370 | 682 | 1016 | 1608 | 36.8 |
| Plaice | 7 | 31 | 6 | 15 | 7 | 20 | 20 | 64 | 69.7 |
| Long rough dab | 14 | 14 | 8 | 13 | 10 | 14 | 32 | 41 | 21.9 |
| Capelin | 4 | 9 | 0 | 2 | 1 | 31 | 5 | 42 | 88.1 |
| Blue whiting | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 4 | 75 |
| Others | 5 | 5 | 6 | 10 | 8 | 9 | 19 | 24 | |
| Shrimp | 77 | 132 | 44 | 50 | 115 | 172 | 236 | 354 | |

Table 4. Bycatch of cod and haddock in shrimp trawl with HH-net ("Stentor") and RES arrangement ("Polarhav") compared with summarized catch from fish and collecting bag with "Stentor" from 3 areas.

| Fishing ground | Species | | STENTOR | | | POLARHAV | | |
|---|---|---|---|---|---|---|---|---|
| | | Codend catch | Total incl. fish bag | o/o escapem. with HH-net | o/o escapem. with HH-net | Total catch | o/o escapem. with RES | o/o escapem. with RES |
| Vadsø Ground 2 hauls | Cod 0-20 cm | 13 | 22 | 40 | | 19 | 14 | |
| | Cod 20-40 cm | 25 | 156 | 84 | 83 | 119 | 24 | 33 |
| | Cod > 40 cm | 0 | 37 | 100 | | 6 | 84 | |
| | Haddock 0-20 cm | 148 | 258 | 43 | | 124 | 52 | |
| | Haddock 20-38 cm | 67 | 391 | 83 | 74 | 83 | 79 | 74 |
| | Haddock > 38 cm | 0 | 169 | 100 | | 3 | 98 | |
| Bugøy Ground 1 haul | Cod 0-20 cm | 8 | 16 | 50 | | 13 | 19 | |
| | Cod 20-40 cm | 11 | 78 | 86 | 82 | 20 | 74 | 66 |
| | Cod > 40 cm | 0 | 13 | 100 | | 3 | 77 | |
| Bøkfjord 1 haul | Cod 0-20 cm | 1 | 1 | 0 | | 3 | 0 | |
| | Cod 20-40 cm | 35 | 764 | 95 | 96 | 18 | 91 | 90 |
| | > 40 cm | 0 | 47 | 100 | | 4 | 91 | |



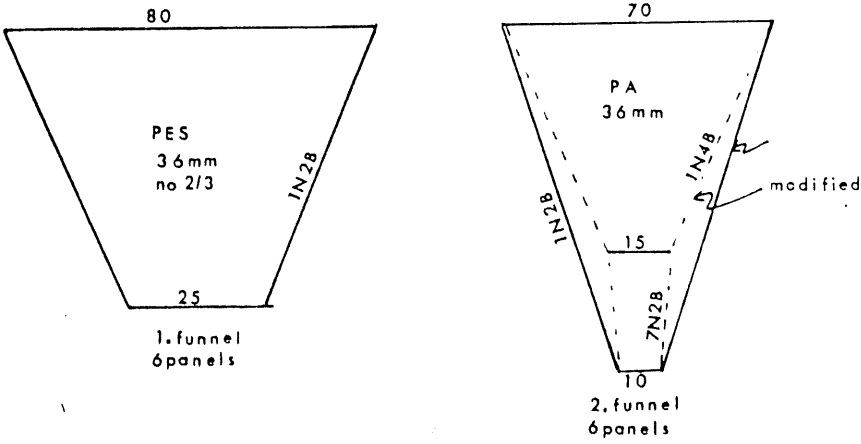




Figure 1. Design of the RES arrangement and its position in the aft belly of the shrimp trawl.

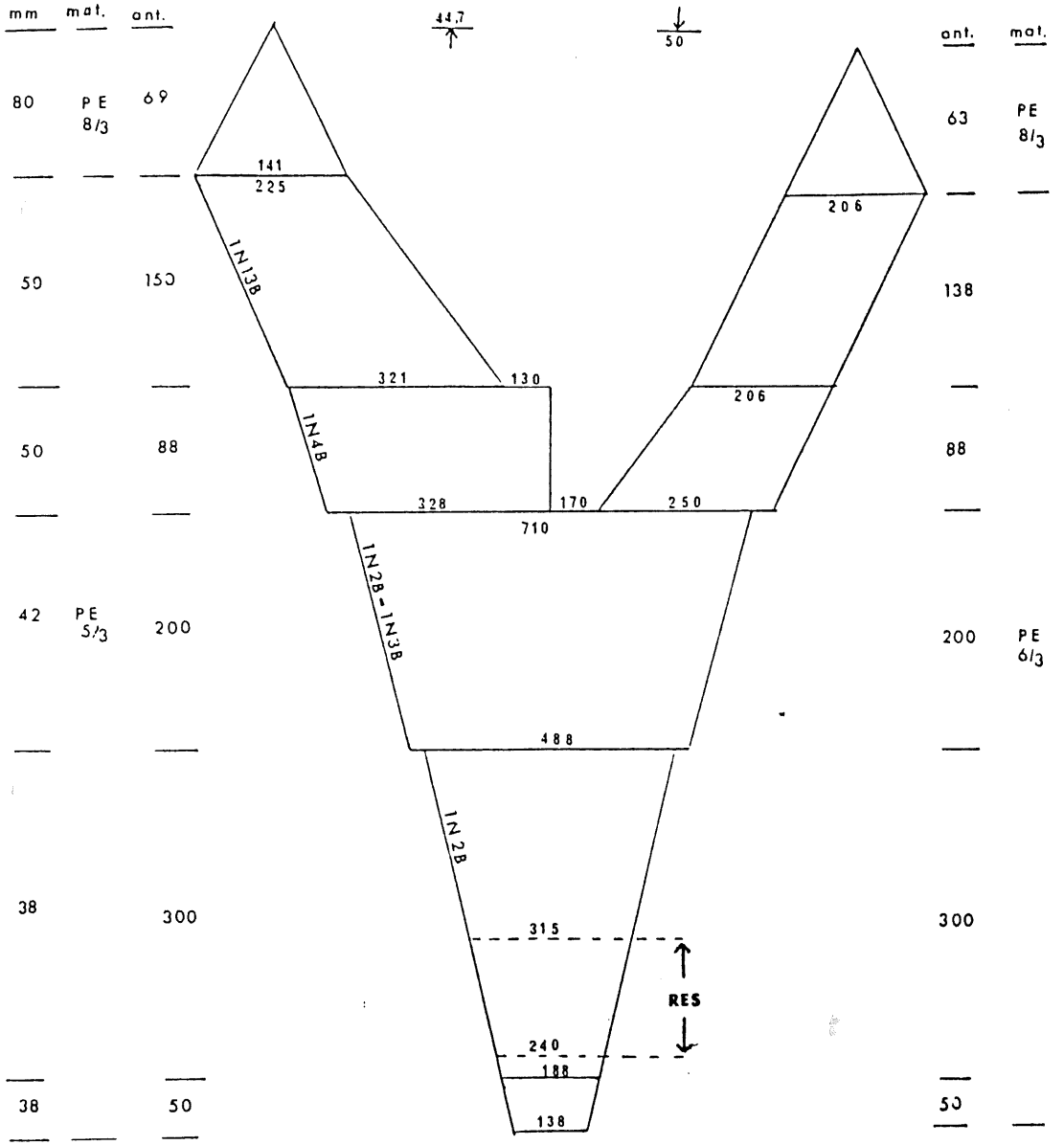



Figure 2. Design of the 1400 SPUTNIK shrimp trawl with position of RES.

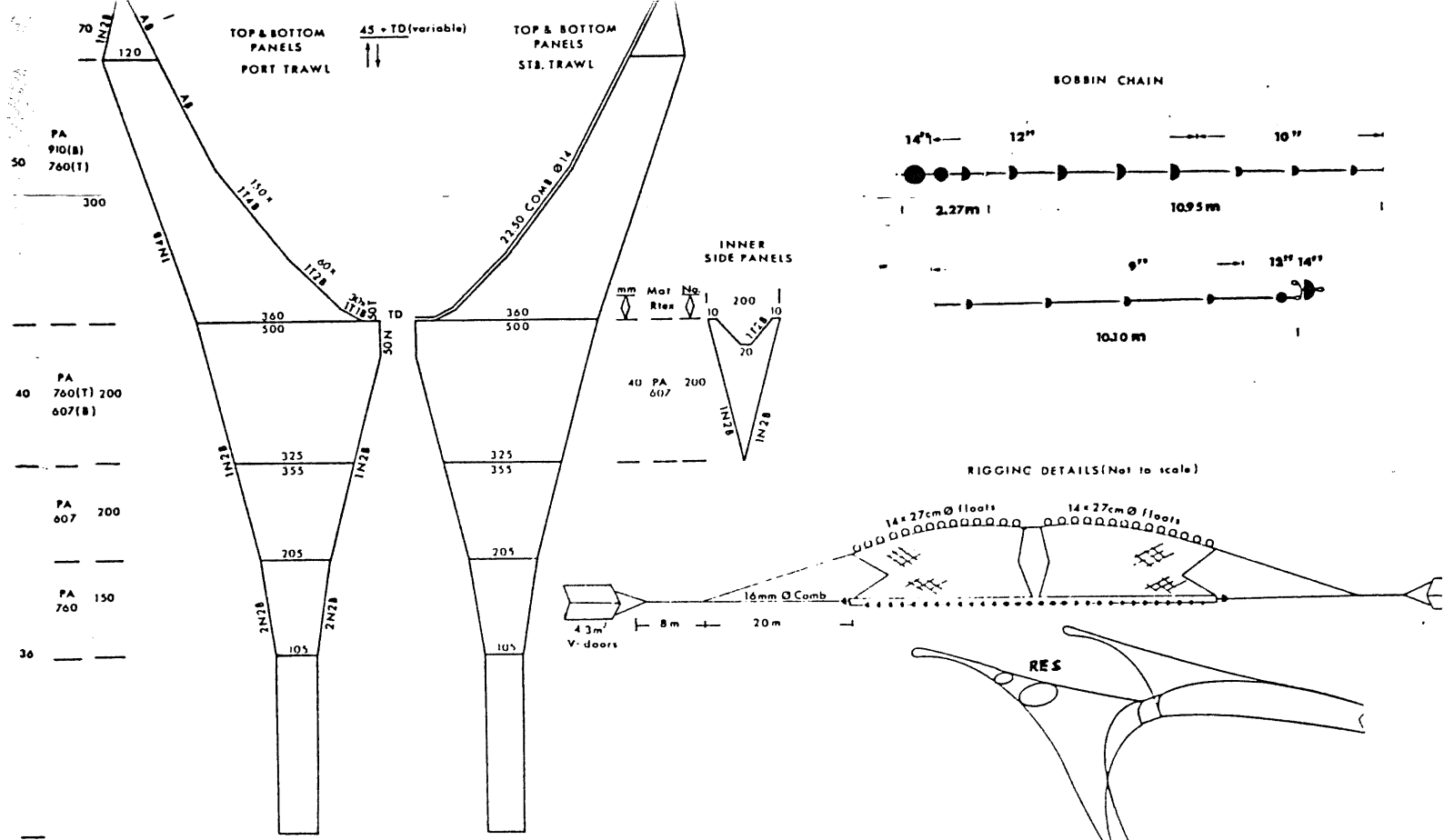



Figure 3. Design of the 2 x 1200 meshes siamese twin trawl with rigging plan and indicated position of the RES in the starboard trawl part.

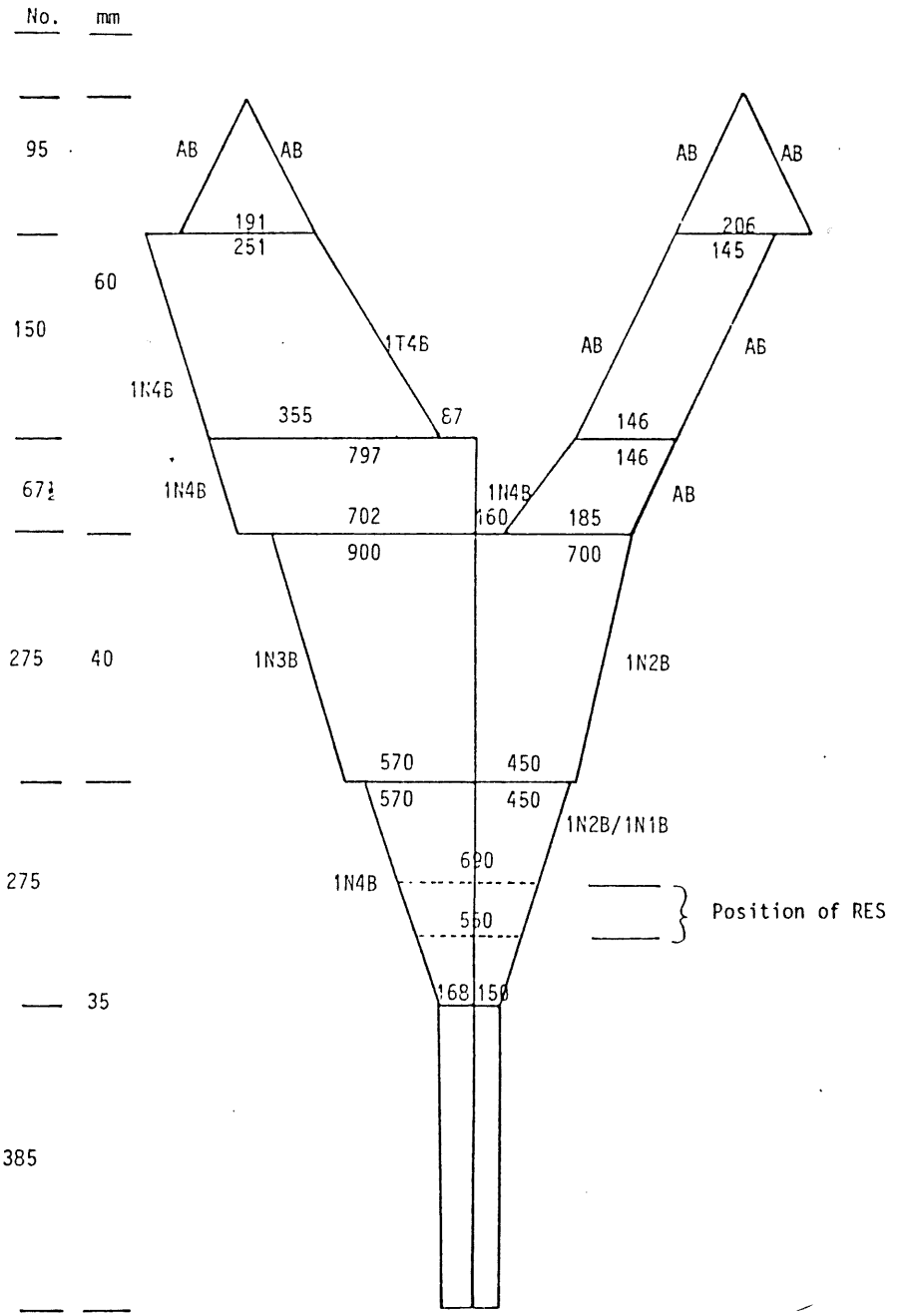



Figure 4. Design of the SPUTNIK 1600 shrimp trawl with position of RES.

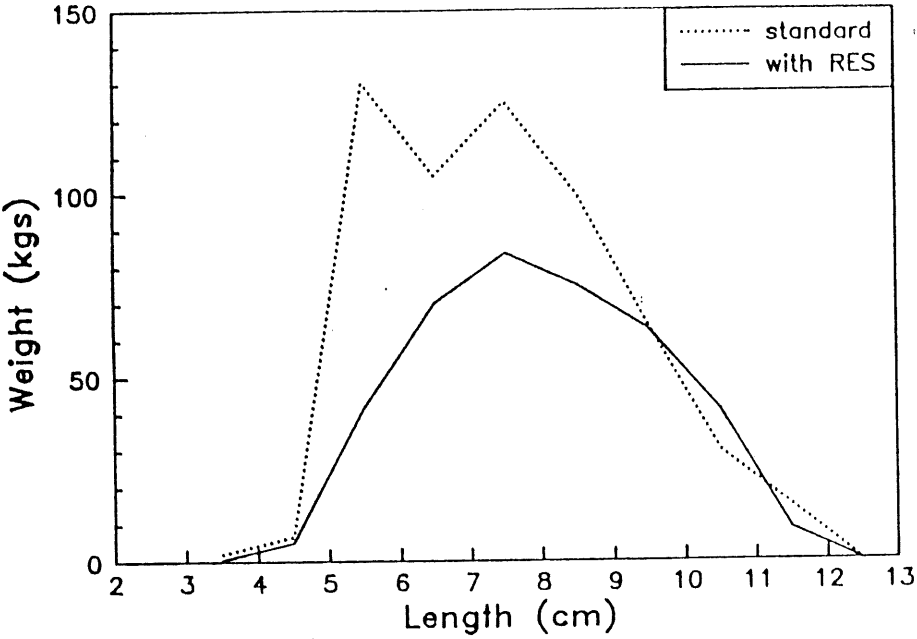



Figure 5. Length composition of shrimp catch in the siamese twin trawl with RES in the starboard trawl part. Summarized from 5 hauls (no. 35, 37, 38, 39 and 40) R/V "Kystfangst" May/june 1985.

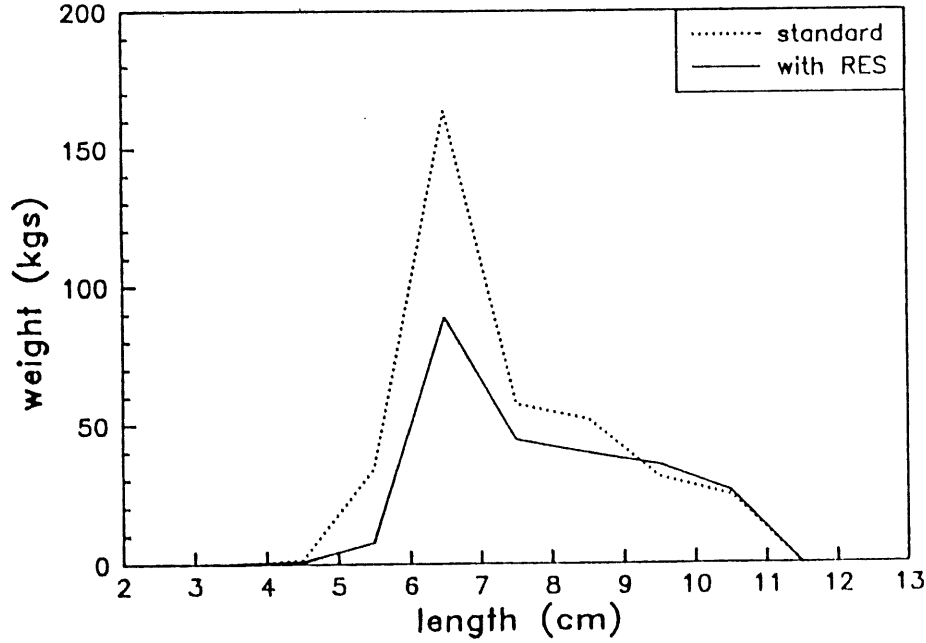



Figure 6. Length composition of shrimp catch in the siamese twin trawl with RES in the starboard part, summarized from 3 hauls (no. 7, 8 and 9). M/S "Polarhav", October 1985.

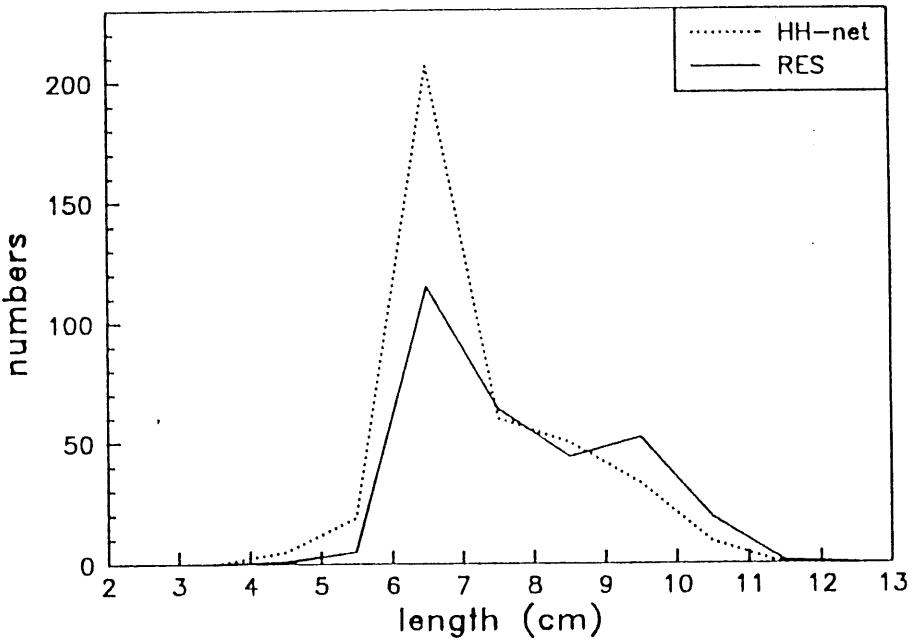



Figure 7. Length composition of shrimp catch from parallel hauls with RES (Polarhav) and HH-net (Stentor).