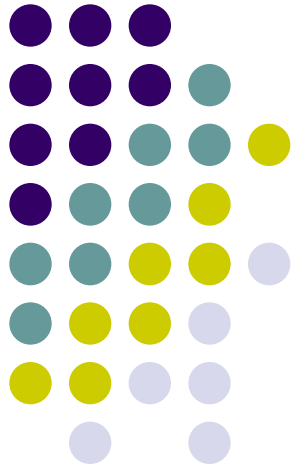
10th International Workshop in University of Split
DEMaT'2011

FEATURES OF DISTRIBUTION OF LOADING IN COD-END OF TRAWL OF A VARIOUS DESIGN



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Introduction

- *Total Allowable Catch (TAC)* - fishery regulation measures;
- *The selectivity* - minimal legal landing size and a minimal inner mesh size in fishing gear used;
- *The mesh size* - in turn, determines the selectivity of fisheries on the whole;
- *The number of net panels around the perimeter of the netting surface* - is the main distinguishing feature in modern trawl designs;
- *The mesh size alone, without taking into account the features of a fishing gear design* - cannot be regarded as a technical regulatory measure that fully accomplishes this objective.

! The purpose of this report is to detect differences in the distribution of load in trawl netting surfaces of cod-ends, which have a different number of panels around the perimeter, their shapes and selective properties.

Substantiation

Distribution of load in the netting surface of trawls which have a different number of panels

The trawl netting surface handles the larger resistance of trawl gear and, hence, the load (about 70%) and trawl doors and rigging handle the remaining 30%.

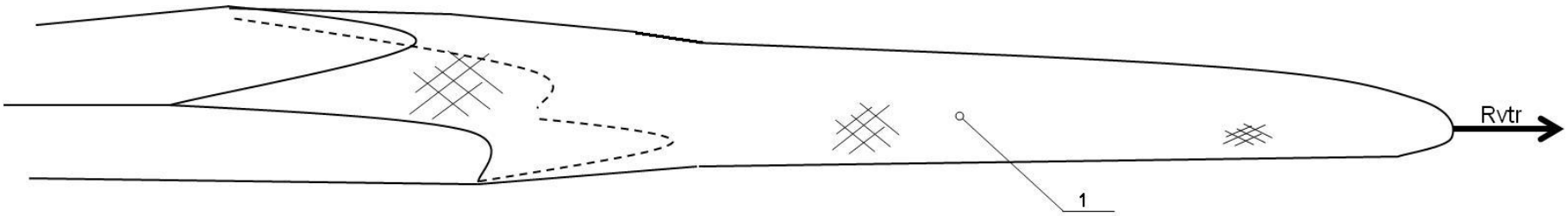
→ Opposite forces acting upon the trawl netting surface contribute to the shape of the trawl.

↓ The correlation of forces acting in the trawl netting surface is, in turn, responsible for the pattern of load in the mesh and a size of mesh opening.

↘ At the same time, a trawl design specifies a pattern of distribution of forces over the trawl netting surface and correlation of forces.

A one-panel trawl net

The netting surface in such trawls is made from a single piece of net, lateral edges in which are connected by mesh to mesh and there are no seams.



R_{vtr} - total force of drag force of the whole trawl.

Figure 1
Trawl made with a one- net panel
1 - trawl netting surface

A one-panel trawl net

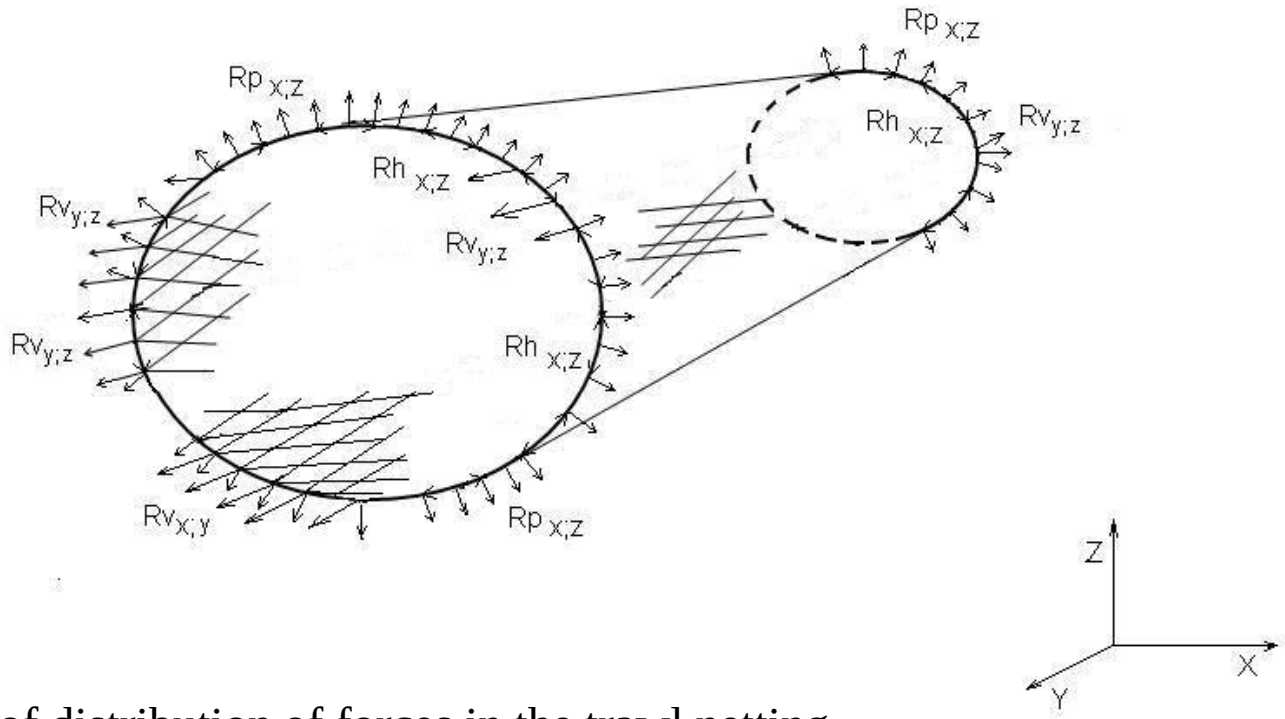


Figure 2
Diagram of distribution of forces in the trawl netting surface in a one-panel trawl net section

- R_{vtr} - total force of drag force of the whole trawl;
- R_v - total force, working on axis Y (a projection of forces R_{vtr});
- R_h - total force, working in a plane XZ (a projection of forces R_{vtr});
- R_p - total force, working on axis X (a projection of forces R_{vtr}).

A one-panel trawl net

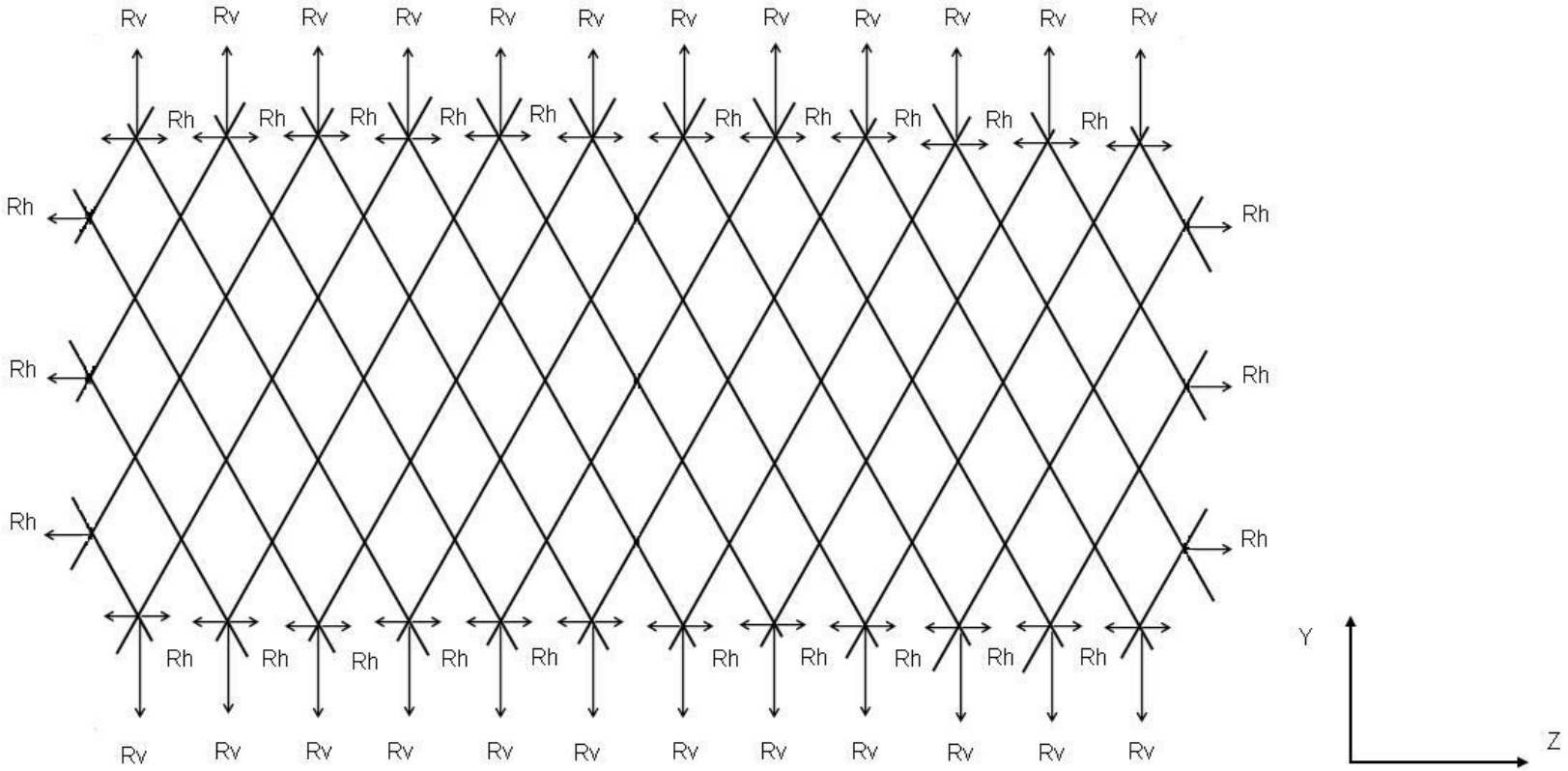


Figure 3
Horizontal scanning of the trawl netting surface in a one-panel trawl net section

A two-panel trawl net

The netting surface in such trawls is made of two panels of netting, lateral edges in which are attached to each other by lacings, so making up a two-seam netting surface.

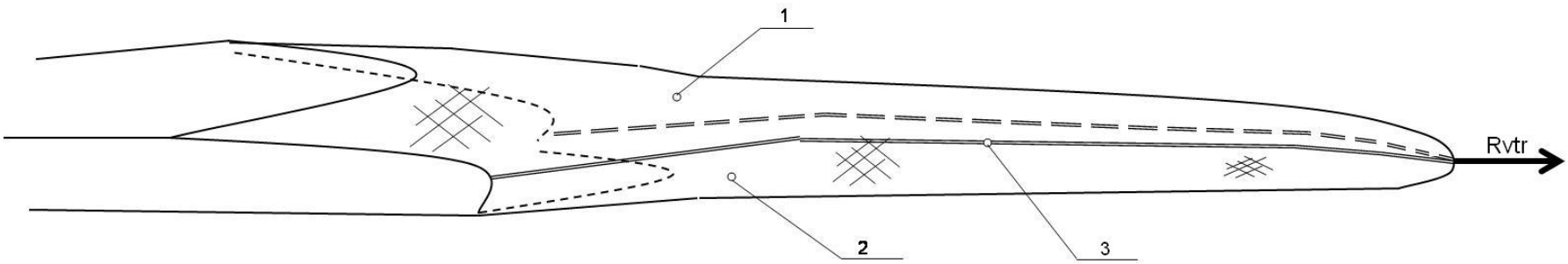


Figure 4
Trawl made with two- net panels.
1 - top panel; 2 - lower panel; 3 - seam

A two-panel trawl net

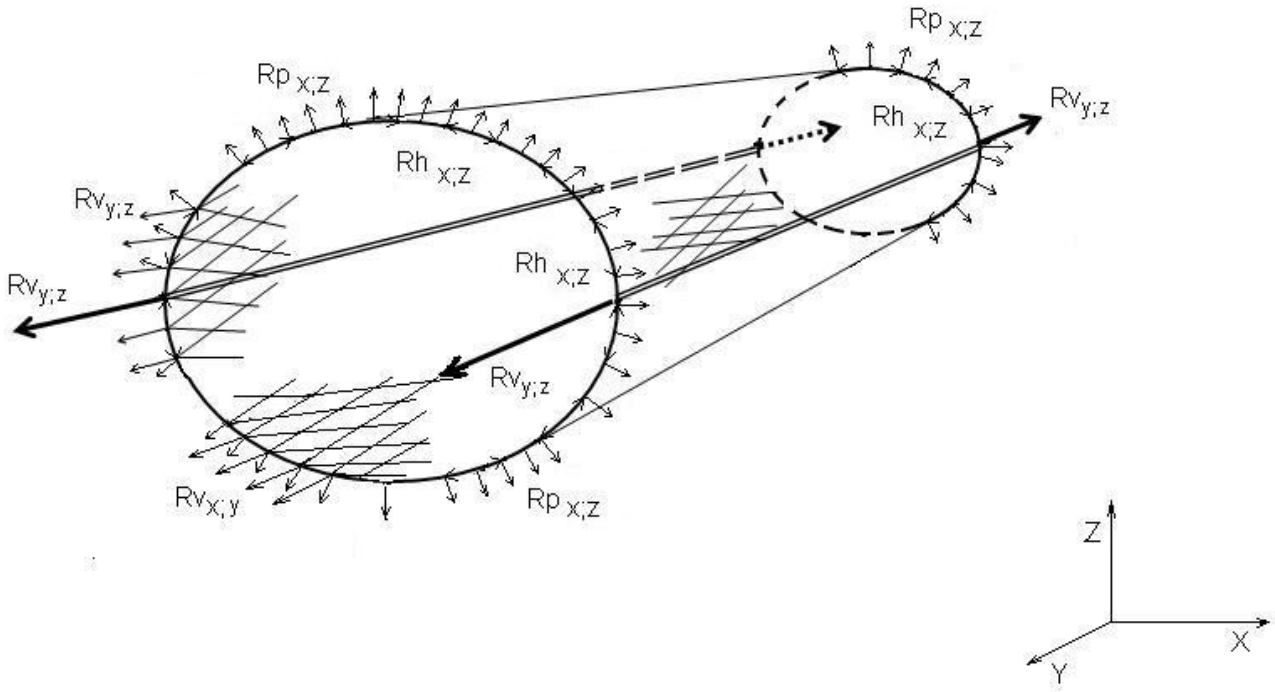


Figure 5
Diagram of distribution of forces in the trawl netting surface in a two-panel trawl net section

A two-panel trawl net

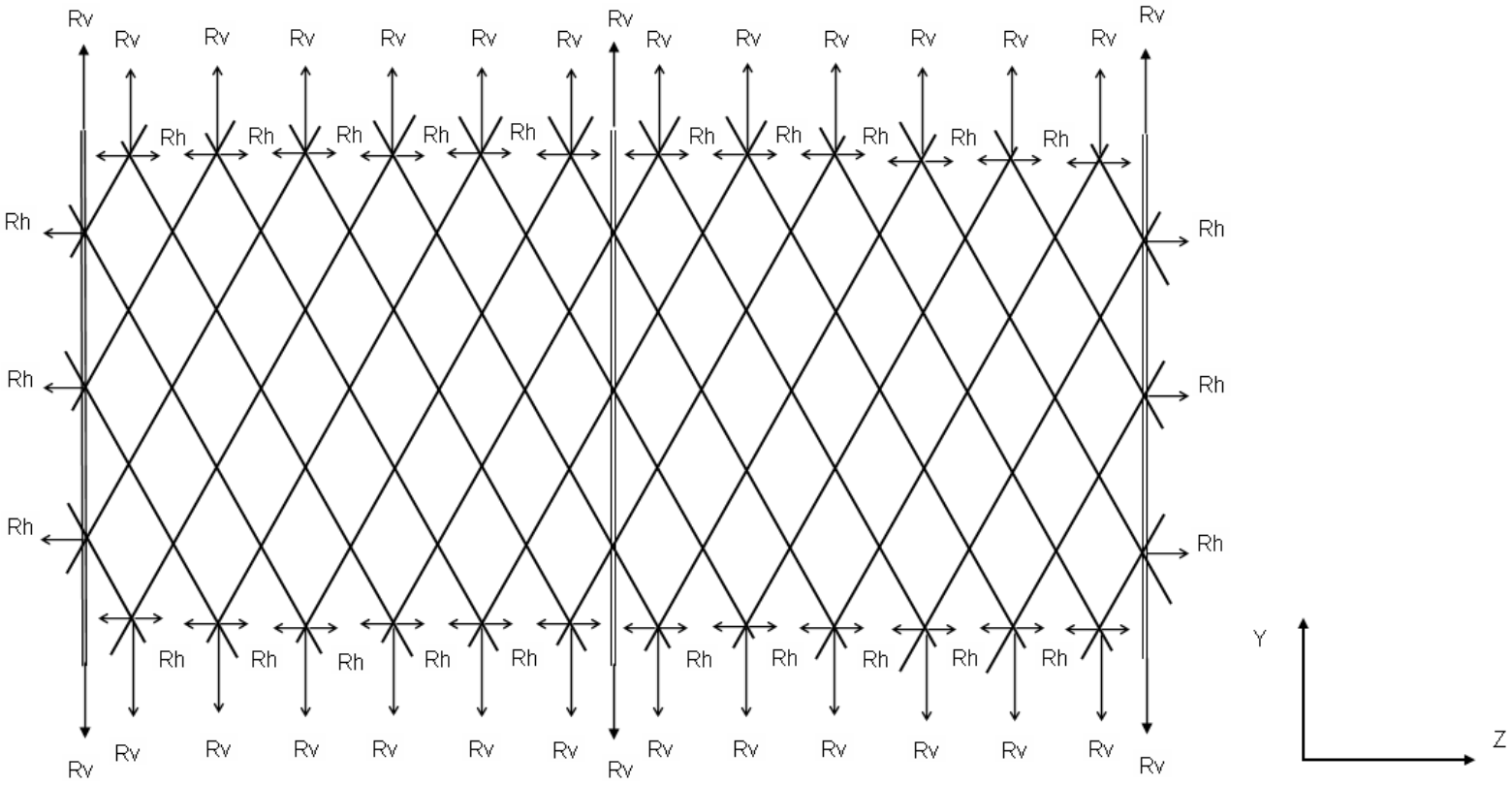


Figure 6
Horizontal scanning of the trawl netting surface in a two-panel trawl net section

A four-panel trawl net

A four-panel trawl consists of four net panels, lateral edges in which are attached to each other by a seam that is formed by connecting two or more mesh rows of net panel selvages, so making up a four-seam trawl net.

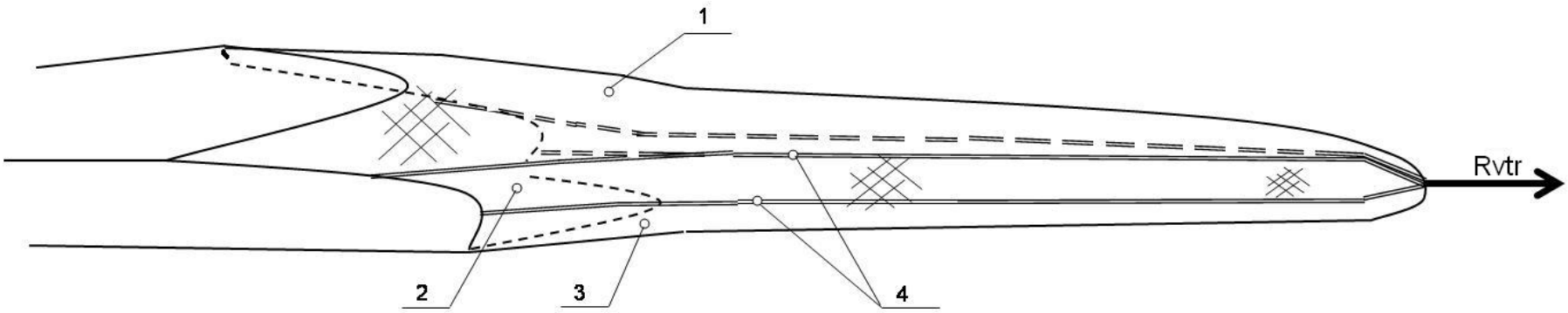


Figure 7
Trawl made with four-net panels.
1 - top panel; 2 - side panel; 3 - lower panel; 4 - seams

A four-panel trawl net

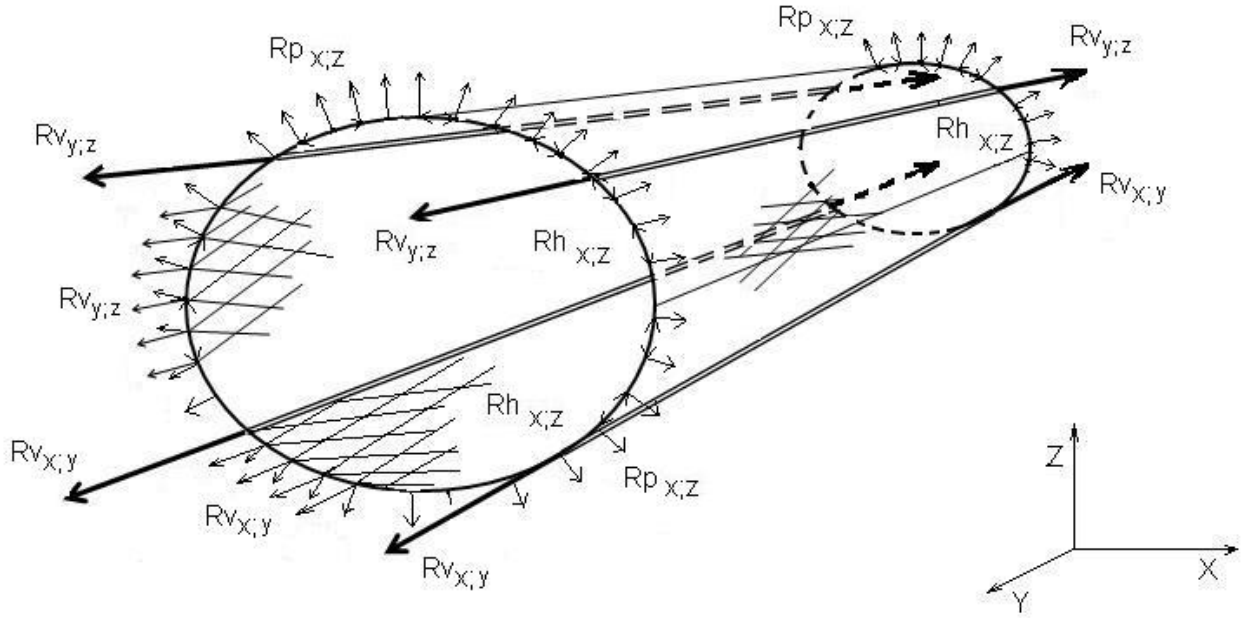


Figure 8
Diagram of distribution of forces in the trawl netting surface in a four-panel trawl section

A four-panel trawl net

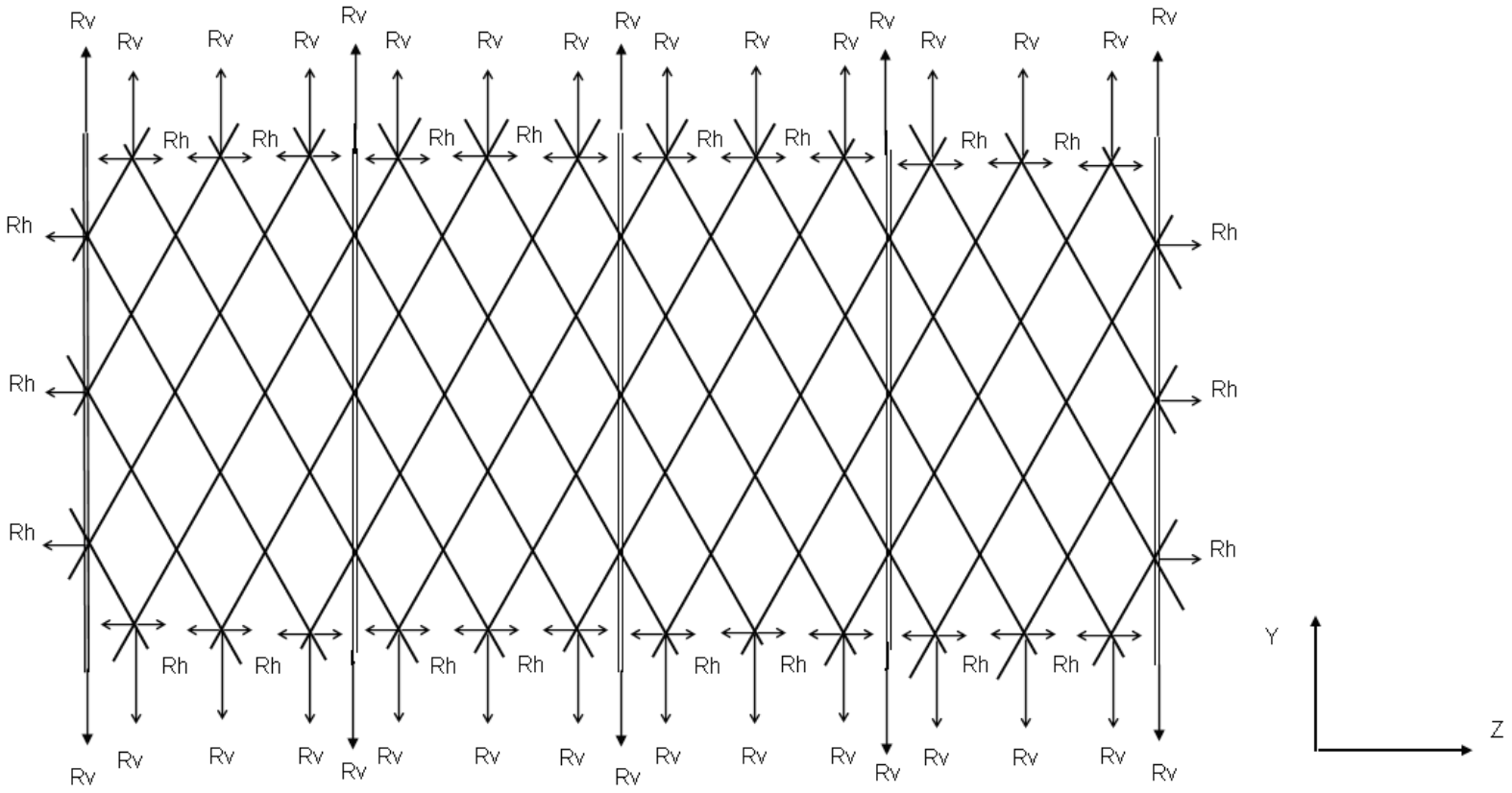
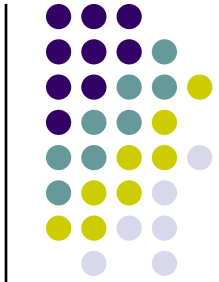


Figure 9
Horizontal scanning of the trawl netting surface in a four-panel trawl section

It is a little conclusions

! From the diagrams above, one can tell that external forces, which extend the trawl netting surface, are distributed over the netting in proportion to the number of meshes and seams. Thus, it appears that trawl seams, while carrying a part of the load from the resistance force, will affect the relation of axial and lateral forces that extend a mesh. Taking the force of inner water pressure R_p in one-panel and multi-panel trawls identical, we can express the forces which extend one mesh proportionally to the total number of meshes and seams.

Mathematical interpretation



A one-panel trawl net

$$Rv = \frac{Rvtr}{k} \qquad (1)$$

$$Rh = \frac{Rhtr}{k} \qquad (2)$$

where k - the number of meshes.

A two-panel, four-panel and so on trawl net with seams

$$Rv = \frac{Rvtr}{k+n} \qquad (3)$$

$$\frac{Rvtr}{k} > \frac{Rvtr}{k+n} \qquad (4)$$

where n - the number of seams.

It is a little conclusions

! From the formulas above, it is clear that the force R_v in trawls, which have the equivalent mesh size and number of meshes, decreases proportionally to the number of panels and, correspondingly, to the number of seams in their designs. Therefore, when comparing a size of mesh opening in two-panel and four-panel trawl designs, it is safe to assume that four-panel trawls will have a larger mesh opening compared to two-panel ones. A difference in the mesh type, in turn, determines various selective properties of trawls relative to a single target species.

Experiments with full-scale trawls

Underwater video observations

A special trial was conducted to visually assess differences in the mesh opening and proper shape of cod-ends in two-panel and four-panel bottom trawls. To this end, an underwater video camera, which recorded the cod-end operation directly in the process of trawling, was mounted in the cod-ends of different design. Standard, identical in size cod-ends having a mean inner mesh size of 133 mm were used in the trial in two-panel and four-panel bottom trawls.

The cod-ends were made with double polyethylene twine of 4 mm in the diameter. All the hauls were conducted at a same towing speed of 3,5 knots that corresponded to the speed of fishing for the majority of Barents Sea bottom fishes.

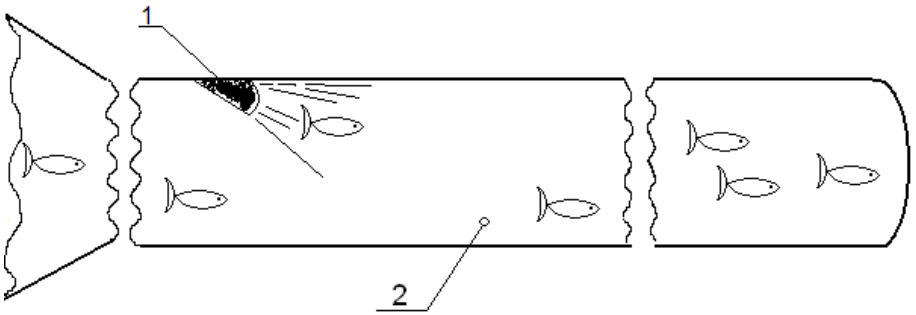
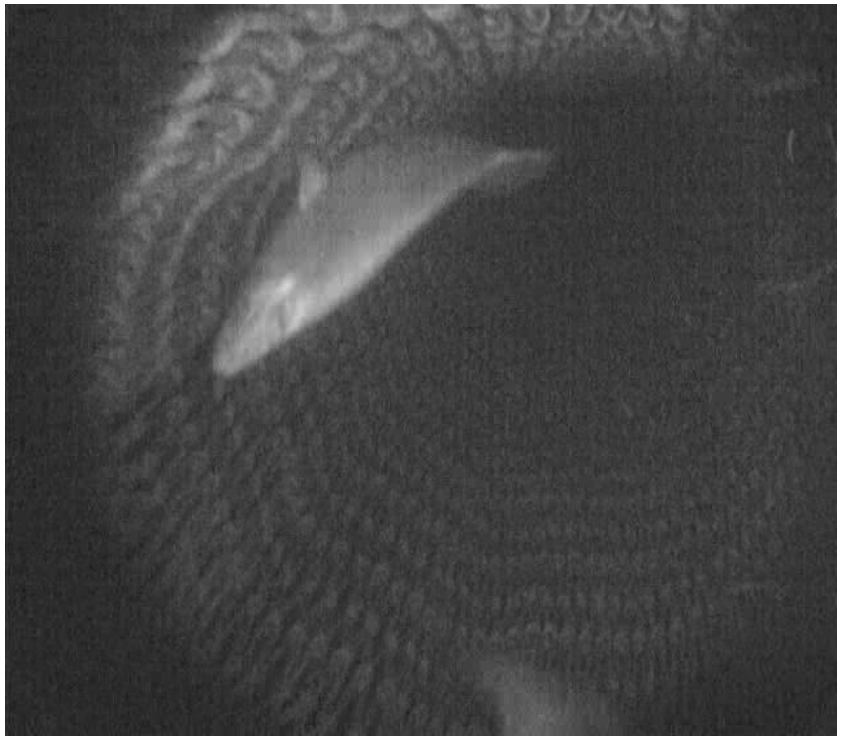


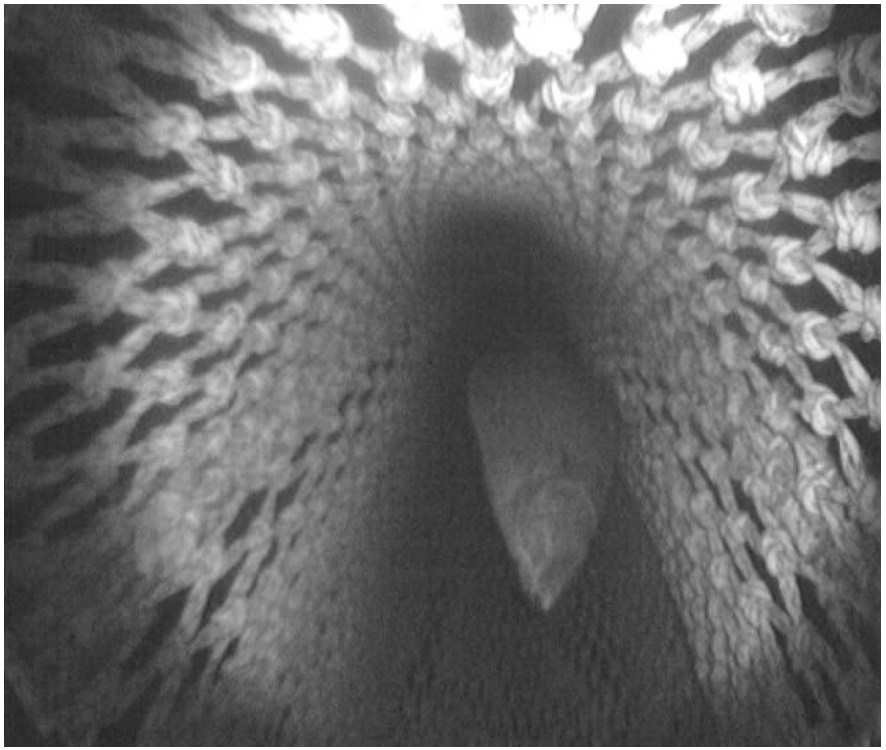
Figure 10
The placement of the underwater video camera in the cod-end.
1 - placement of the underwater video camera; 2 - cod-end

A stand-alone video recording device AVU developed by the Polar Research Institute of Marine Fisheries and Oceanography (PINRO) and an autonomous deep sea video recording system “SeaCorder” manufactured by Tritech International Limited were used for underwater video recording.

Photos from video recording



a)



b)

Figure 11
Video recordings of the shape and the mesh opening in a two-panel trawl (a) and in a four-panel trawl (b) during trawling process

Determination of the selectivity in two-panel and four-panel cod-end designs

Special experiment with full-scale trawls

A field experiment was carried out to estimate differences in selective parameters in cod-ends made of the same material, which had an equivalent mesh size, but differed from each other in their designs. The selectivity of two-panel and four-panel cod-end designs was estimated. To exclude the effect of a small-meshed fish trap on the selectivity of the cod-end, the field experiment was conducted using a double cod-end trawl (a “trouser” trawl) method. A special double-cod-end bottom trawl 2650-01, 44,1/52,2 m was used for this purpose.

The cod-ends were made with double polyethylene twine of 4 mm in the diameter. Mesh measurements were performed following the method accepted by PINRO (VNIRO, 2004). Not less than 20 meshes that were at least 5 meshes from the lacings were measured along the long axis. The inner mesh size in the two-panel cod-end was 133,3 mm (±1,2) and in the four-panel cod-end was 134.6 mm (±1,6). With 95% confidence interval, the average mesh size was taken to be 133 mm.

Experimental studies were conducted on the Kopytov Bank area in the Barents Sea at depths of 650-730 m. Hauling operations were performed at a speed ranging from 2,8 to 3,1 knots. The vertical opening of the trawl was 5-7 m. The horizontal opening was 20-22 m. The selectivity of two-panel and four-panel cod-ends was estimated relative to Greenland halibut (*Reinhardtius hippoglossoides*).

Curves of the selectivity of two-panel and four-panel cod-ends in bottom trawls relative to Greenland halibut (*Reinhardtius hippoglossoides*)

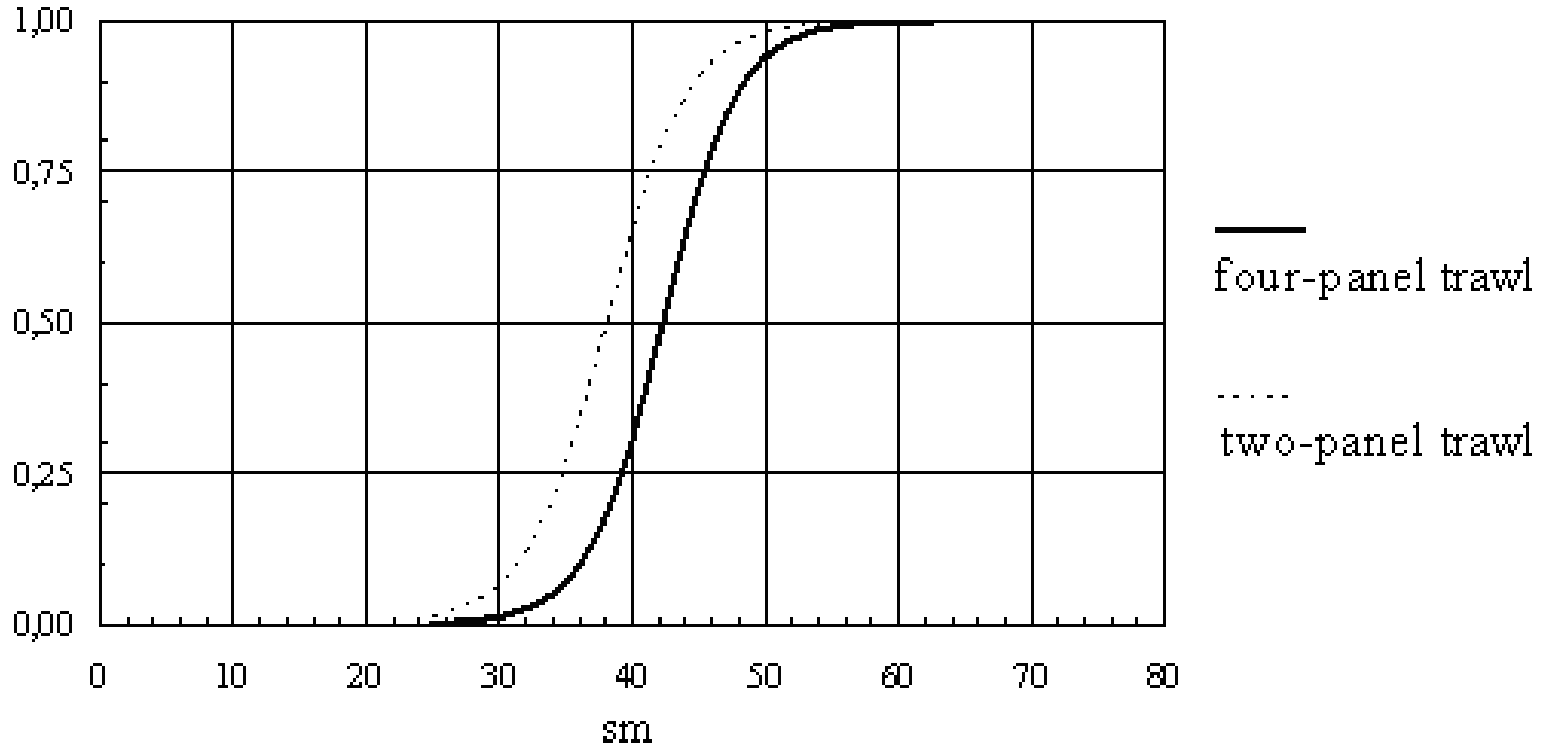


Figure 12
Curves of the selectivity of two-panel and four-panel cod-ends in bottom trawls relative to Greenland halibut (*Reinhardtius hippoglossoides*)

Selectivity parameters in the experimental cod-ends relative to Greenland halibut calculated from the logistic function

The experiment was performed following the accepted method, when one of the cod-ends was alternately rigged with a small-meshed liner, whereas the other cod-ends were without any covers, with the mesh size under study. Two series of experimental hauls were carried out. A total of 18 record hauls were performed, where 10 hauls were conducted to study selectivity in the two-panel cod-end and 8 hauls - in the four-panel cod-end. The selectivity data were processed using the SELECT model following the method approved by ICES (Anon, 1996). The main findings from calculations to determine the selectivity of the experimental cod-ends relative to Greenland halibut are given in Table.

Table

Selectivity parameters in the experimental cod-ends relative to Greenland halibut calculated from the logistic function

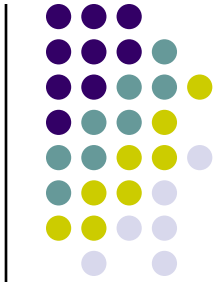
Indicators	Calculation	Standard error
Experimental two-panel cod-end		
$L_{50\%}$	38,0	1,6
S.R.	6,7	3,7
Experimental four-panel cod-end		
$L_{50\%}$	42,3	0,3
S.R.	6,2	0,5

! The analysis of the selectivity parameters in the experimental cod-ends relative to Greenland halibut showed an increase in the 50% retention length of fish from 38 to 42,3 cm that is indicative of the increase in selective properties of the cod-ends in question, from two-panel to four-panel cod-ends.

Acknowledgements

The findings from the experiment support the assumption that, apart from the mesh size, features of a trawl design affect selective properties of trawls, e.g., the cod-ends made with the same material, which have an equivalent mesh size but differ from each other in the design, possess different selective properties. The obtained data showed that the 50% retention length of Greenland halibut *(Reinhardtius hippoglossoides*) in a four-panel cod-end design is 10% higher than in a two-panel cod-end design, given the practically identical selectivity range. However, it should be noted that such an effect will be different relative to different fish species, which are different in body shapes. This property is explained by different relation between the body shape and the mesh type.

Thus, given all other factors being equal, the selectivity in four-panel trawls differs from the selectivity in two-panel trawls due to a difference in size of mesh opening in cod-ends. A difference in the mesh opening, in turn, depends on different distribution of forces in the trawl netting surfaces of different designs.



Thank you for attention!