APPENDIX 14. Chapter Excerpt from Book by V.P. Kondratev

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Modeling Commercial Fishing Gear by the Method of Analog Mechanisms

[Modelirovanie Orudii Promyshlennogo Rybolovstva Metodom Mekhanicheskikh Analogii]

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APPENDIX 14 (CONTINUED).

tear on the warps. The above condition is also important because modern commercial fishermen have started equating warps according to the tension at the points of suspension. Here the difference in the resistance of boards can lead to a situation where the warp from the side of the board with greater resistance will have more payout than the other.

Let similar type of quantitative evaluation of trawl parameters not be always irrefutable but at present it is more important that they allow qualitative consideration of a series of practical problems. They help, in particular, understand why the trawl occasionally moves away from the vessel. Test results allow us to judge how some deviation from normal rigging affects the operation of the trawl. Tests showed that the difference in the shear force of trawl boards has a strong influence but the difference in resistance hardly affects the horizontal opening of the mouth of the trawl or its displacement. Since displacement of the trawl increases proportionally with trawling speed and the shear force of the trawl boards is proportional to its square, then with any increase in speed the effect of a difference in shear force is more strongly felt. Therefore in rapid trawling it is necessary to pay special attention to accurate adjustment of the boards and regulation of the angles of attack.

Of course, here a somewhat simplified version of design layout will be considered. In reality everything is more complicated with the prototype trawl. In particular, with a change in the shear force or resistance of one of the boards its angle of attack may change and consequently the magnitude of the difference, too. However, apparently these are minor corrections to the layout in question.

Effect of Difference in Warp Length on the Working of the Trawl. When a trawl breaks down repairmen-technicians usually first verify the warps. A half-meter difference in the length of the warps (when their length is 500–700 m) is considered inadmissible. Can we justify such demands on warps and the associated loss of commercial fishing time to make partial measurements? To answer this question the effect of a difference in length of veered warps on the horizontal opening of a 31 m trawl was determined by the method of mechanical simulation.

Initial data. Length of headline and leadline along the net 28 m, length of free ends 1.5 m, length of bridles 50 m; hauling instruments: oval Matrosov trawl boards; area of trawl boards 4.5 m^2, trawling speed 4.5 knots, difference in warp length up to 5 m.

Since the effect of a difference in the warp length on the working of the trawl is greatest for a small length, the tests were conducted for a warp length of 300 m. The working of the trawl was simulated in the vertical plane and it was assumed that under the conditions of study of the difference in warp length the working of the trawl boards was not affected [35]. Let the left warp be shorter than the right warp by 5 m and let the left end of the headline exceed the right by 15% of its length along the net. From graphs for the determination of tension in flexible wire at points of suspension it is obvious that in this case the horizontal component of tension on the left end of the line practically does not change but the vertical component increases by approximately 15%.

Our tests also showed that the change in tension on the bridles practically does not alter the attitude of the trawl boards (see Fig. 21).

Basic data for the model. Taking into account the length of the lines and warps and the dimensions of the experimental setup, the linear scale of the model was taken $\lambda = 0.01$. Accordingly the model has a length of chain simulating lines of 0.28 m and lengths of wires simulating free ends of lines and warp of 0.015 and 2.85 m respectively.

Thin steel wire 0.2 mm in diameter weighing 0.27 N per 100 m was used to represent warps and bridles. The force scale τ was determined from the ratio of the load on the model to the resistance of the net part of trawl. The resistance of the trawl net was taken equal to 80 kN, the total weight of chain as 4.85 N. Thus the force scale was $\tau = 1 : 16500$, i.e. 1 N of the model corresponded to 16.5 kN on the full-scale version.

The value of the weights simulating shear force and resistance of trawl boards was 0.824 and 0.488 N respectively.

Experimental procedure and results. First the horizontal opening of a trawl with equal-length warps was measured. The distance between the trawl boards after conversion to full-scale values was found equal to 41.8 m, the distance between the free ends of lines 16.3 m, and the horizontal opening along the net 15.5 m. These data are close to the results of full-scale tests, which testifies to the suitability of the method of analog mechanisms for the solution of the problem.

We then determined the change in the horizontal opening of the trawl and the lag of one trawl board behind the other as a function of the difference in the length of the veered warps (Fig. 48), using a cathetometer.

The difference in warp length was determined from the ratio of its absolute value ΔL to the length of the headline S_0 along the net. The lag of trawl boards Δy and ends of lines Δy_0 was also determined on the basis of the ratio to the length of the headline. Results of simulation after conversion to full-scale values are shown in Fig. 49. Tests by mechanical simulation showed the change in the horizontal opening of the trawl to be significant only in the case where the difference in warp length exceeds 20% of the length of the headline.

When there is a difference in warp length the trawl lines take the form of catenary along the net with the point of suspension at different heights. With any further divergence in the length of the warps the inclination of the ends of the lines to the direction of trawl motion decreases on the shorter cable

APPENDIX 14 (CONTINUED).

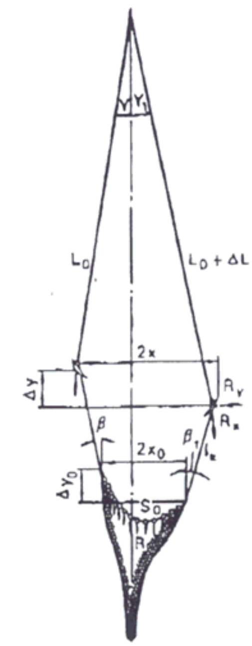

Fig. 48. Distortion of trawl for varying warp scope.

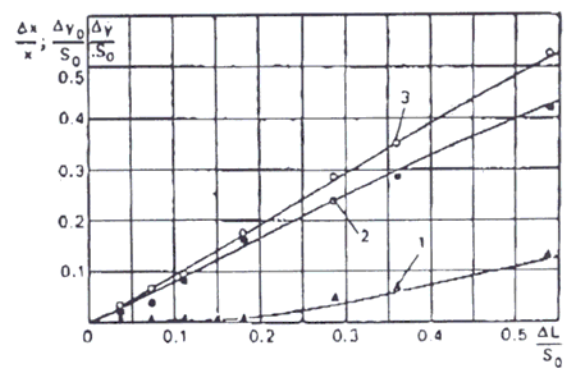

Fig. 49. Dependence of trawl distortion on difference in warp scope:

$1—\frac{\Delta x}{x}$; $2—\frac{\Delta y_0}{S_0}$; $3—\frac{\Delta y}{S_0}$.

side and increases on the longer cable side. The center of the lines is displaced toward the shorter warp (for example, by 3–4 m for a difference of 5 m). As a result the net may be deformed, the netting may be deflected and net 'bags' may form on the side of the longer warp. The net part of the trawl is deformed, the entrance to the dag and sack is constricted and the efficiency of fishing is reduced.

With any increase in the difference in the length of warps the distance between the trawl boards also increases somewhat. This is explained by the fact that the long warp is not as tight as the short one. As a result the trawl board on that side deviates more widely from the centerline plane of the vessel. When the difference in warp length is 10 m the trawl board on the side of the longer warp is at a distance of 26.8 m from the centerline plane. When the difference in length is 15 m, it is 30.2 m; from the shorter warp the trawl boards are at distances of 18.1 and 16.2 m, respectively. The ends of lines deviate from the centerline plane of the vessel by 9 and 10 m for the longer warp and by 7.5 and 6.4 m from the shorter warp.

When the warp lengths differ the trawl is asymmetric. The inclination of the warps to the direction of motion differs accordingly: the longer warp is inclined at a greater angle than the shorter. Since one trawl board lags behind the other their shear forces act in the horizontal plane but not along a straight line, and the trawl deviates from the centerline plane of the vessel toward the side of the longer warp (see Fig. 48). For example, when the difference in warp lengths is 5 m it is displaced by 2.4 m. If the trawl is moving in a mass of water an analogous picture is observed in the vertical plane too. Moving at different depths (deeper on the side of the longer warp than on the side of the shorter), the trawl boards create shear forces acting in different planes and the trawl is deformed in the vertical plane.

When the difference in warp lengths is appreciable there is a danger of the trawl gear getting tangled up.

A difference in warp lengths also results in nonuniform loading on them. The short warp is more loaded than the longer and is tighter. As a result residual strain may appear, altering the warp length. Computations show that this difference in elongation of the warps is considerably less than the initial difference in length and cannot compensate it.

Let the horizontal opening between the trawl boards be $2x$ and along the net $2x_0$. For $\frac{2x_0}{S_0}=0.5$, when the difference in the length of warps is 20% of the length of the headline the tension on the shorter warp increases by 20%. In the longer one it decreases by the same amount when compared to the tension on cables of identical length. Naturally, there is a redistribution of loads on the bridles and the trawl net too. These data tally with experimental results obtained at SEKB on the RT *Muksun* and in our experiments [34] on the *IRB-99* in the Bay of Kursk.

APPENDIX 14 (CONTINUED).

The dependence of the vertical component of tension in a flexible wire on the difference in height of points of suspension with $\frac{2x_0}{S_0} = 0.5$ is shown in Fig. 50 with a thick line. The mean experimental data are indicated by dots.

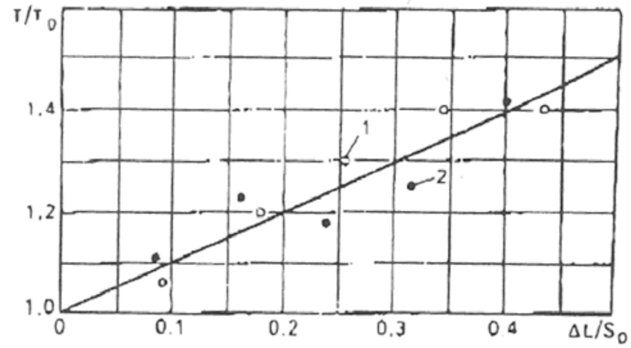

Fig. 50. Dependence of tension of warps on difference in length: *1*—RT *Muksun* SEKB (25 m trawl); *2*—*IRB99* KTI (11.6 m trawl).

In the tests on the *IRB-99* with a difference in warp length of up to 15% of the length of the headline the distance between the trawl boards and fishing efficiency did not change appreciably. With a larger difference in warp length (more than 30% of the length of the headline) fish were caught in the trawl wing on the side of the longer warp. An analogous situation is observed when there is a difference in the length of the bridles. In this case the change in the horizontal opening of the mouth of the trawl is somewhat more pronounced than when there is a difference in warp length. When the difference in warp length is larger one wing of the trawl moves ahead of the other, taking on a greater load. It is possible for the knots of the netting canvas to creep across and twist the trawl.

During underwater observation of a trawl from the bathyplane *Atlant* attached to the RT *Muksun* V.K. Korotkov noted that when there is a difference in warp length the sack twists. This is apparently to be explained by the fact that when there is a difference in warp length the flow becomes asymmetric and the tension on the fishing line appreciably weakens on the side of the longer warp. Under the impetus of an initial twist it continues to twist, engulfing the netting of the sack. Actually in tests from the trawler *Muksun* the sack always twisted around the fishing line on the side of the shorter warp.