

CORRELATION BETWEEN THE CATCH AND THE TRACES ON THE NET SOUNDER ECHOGRAMS IN THE FUNCTION OF TRAWLING SPEED

KORELACIJA IZMEĐU REZULTAT ULOVA I ZNAKOVA NA EHOGRAMIMA
MREŽNIH SONDA TE BRZINE KOČARENJA

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This paper gives an analysis of the dependence between the shoal traces registered on the net sounder echograms and the results of the catch at various trawling speeds. The analysis involves the results of pilchard, horse mackerel, mackerel, and cutlass fish catches. These researches have shown that the trawling speed is a very important factor in catching the pelagic fish that live in shoals.

1. INTRODUCTION

The information obtained from the net sounder echograms can be a great help in determining the size of the fish shoal concentrations, number of fish shoals that find themselves in the direction of trawling, reaction of fish to the operation of the fishing gear, and also in evaluating the degree the trawl is filled with fish. This is very important for fishing, regarding both the quantity of the fish caught and their quality and usability in processing industry.

2. MATERIAL AND TEST METHODS

The material used in tests was collected by the Polish refrigerated cargo trawlers type B-29, B-18, B-23 and B-413, which fished with pelagic trawls. These trawlers, were equipped, among other things, with hydro-location instruments of the firm ELAC and KRUPP ATLAS ELEKTRONIK.

The dependence between the traces on the net sounders and the results of the catch was examined by applying the model of linear regression with two variables (dependent and independent variables). The »traces on the

net sounder» mean the length and breadth of the fish shoals registered on the echogram of the net sounder (by multiplying both parameters the surface of the traces is obtained) and also the degree of the shoal traces blackening.

The correlation between the surface of the shoal traces registered on the echograms of the net sounders and the results of the catch was calculated, and the same was done between the surface of the shoal traces multiplied by the degree of blackening of the shoal traces and the result of the catch.

The surface of the »regular« traces was calculated as the product of their length and breadth, and the surface of the »irregular« traces was determined by means of the millimeter paper with the exactness of 0.25 mm² or by planimeter. The degree of blackening of the shoal traces was evaluated by means of a graduated scale in the following way: for the pilchard traces from the north-west African fishing grounds and for mackerel from the fishing grounds of Ireland the scale with three degrees was used, for the cutlass fish traces from the south African fishing grounds the scale with four degrees was used, and for horse mackerel traces from the south-west African fishing grounds the scale with five degrees was used. The scales were compounded so that a more intensive trace corresponds to a higher degree. The same and similar method was applied in the researches in the Adriatic (Kačić 1972, Grubišić, Kačić, Cetinić 1974).

3. RESULTS OF THE RESEARCHES

3.1. Pilchard catches (*Sardina pilchardus* Risso)

The dependence between the traces on the echograms of the net sounders and the results of the pilchard catches was calculated on the basis of the material collected by the refrigerated cargo trawlers B-29, which were fishing with pelagic trawls using the otter-boards Suberkruba in the north-west African fishing grounds.

The trawler »Kanaryjka« was trawling from March 29, to January 6, 1973 on these positions:

$$\begin{array}{ll} \varphi = \begin{array}{l} 24^{\circ}20' \text{ N} \\ 25^{\circ}20' \text{ N} \end{array} & \lambda = \begin{array}{l} 015^{\circ}48' \text{ W} \\ 015^{\circ}07' \text{ W} \end{array} \\ \varphi = \begin{array}{l} 24^{\circ}20' \text{ N} \\ 24^{\circ}58' \text{ N} \end{array} & \lambda = \begin{array}{l} 015^{\circ}55' \text{ W} \\ 015^{\circ}05' \text{ W} \end{array} \end{array}$$

The trawler »Kniazik« was trawling from March 29 to April 10 1975 on these positions:

$$\varphi = \begin{array}{l} 24^{\circ}44' \text{ N} \\ 24^{\circ}05' \text{ N} \end{array} \quad \lambda = \begin{array}{l} 016^{\circ}26' \text{ W} \\ 015^{\circ}53' \text{ W} \end{array}$$

The trawler »Korwin« was trawling from April 23 to June 16, 1975 on these positions:

$$\varphi = \begin{matrix} 23^{\circ}25' \text{ N} \\ 22^{\circ}40' \text{ N} \end{matrix}$$

$$\lambda = \begin{matrix} 016^{\circ}27' \text{ W} \\ 016^{\circ}53' \text{ W} \end{matrix}$$

For analysis only those echograms of the net sounders were taken on which the traces of pilchard were registered and readable (corroborated by the results of the catch), and also those that were registered during the undisturbed work of the trawling system. In the first phase the correlation between the surface of the traces registered on the echograms of the net sounders and the results of the catch was calculated taking into consideration the parameter of the trawling speed. In the second phase the correlation between the surface of the traces multiplied by the degree of blackening and the results of the catch was calculated by, also, treating the trawling speed as the parameter of the investigated function. At the examination the following intervals of the trawling speed were considered:

- below 4.0 knots,
- from 4.0 to 4.5 knots,
- beyond 4.5 knots.

Table 1 shows the calculated coefficients of the correlation between the examined characteristics. Figures 1 and 2 show the echograms of the net sounders obtained at different times by day and night at different trawling speeds.

Table 1. Survey of correlation coefficients between the surface of traces and the results of the catch, the surface of traces multiplied by thickness and the results of the catch, and mean quantities mm² relevant to the mean ton of the catch for separated trawling speed intervals

| Name of the vessel | Trawling speed intervals | Mean quantity mm ² relevant to 1 ton of the catch | Correlation coefficient between the surface of traces and the result of the catch r_{Σ_1} | Correlation coefficient between the surface of traces multiplied by the density and the results of the catch r_{Σ_2} |
|--------------------|--------------------------|--|--|---|
| m/t »Kanaryjka« | < 4.0 knots | 61 | 0.60 | 0.63 |
| | 4.0 to 4.5 knots | 29 | 0.77 | 0.89 |
| | > 4.5 knots | 13 | 0.91 | 0.94 |
| | 3.8 to 4.8 knots* | 25 | 0.36 | 0.49 |
| m/t »Kniazik« | < 4.0 knots | 71 | 0.52 | 0.57 |
| | 4.0 to 4.5 knots | 27.3 | 0.64 | 0.82 |
| | > 4.5 knots | 11.3 | 0.89 | 0.89 |
| | 3.8 to 4.8 knots* | 33 | 0.34 | 0.39 |
| m/t »Korwin« | < 4.0 knots | 95.4 | 0.57 | 0.64 |
| | 4.0 to 4.5 knots | 30 | 0.81 | 0.90 |
| | > 4.5 knots | 18 | 0.88 | 0.90 |
| | 3.8 to 4.8 knots* | 37 | 0.37 | 0.39 |

*) This involves all the values of the trawling speed, while the calculated correlation dependences refer to the examined dependences not affected by the trawling speed

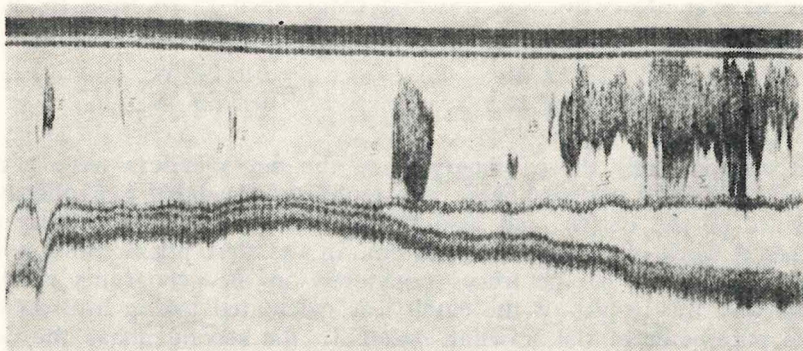


Photo 1. Net sounder echogram. Fishing position $25^{\circ} 04' N$ $015^{\circ} 13' W$. Hour of trawling 16.40 (4.40 p. m.) to 17.10 (5.10 p. m.). Catch 10 ton pilchard. Trawling speed 3.8 knots. Surface of registered traces $1,294 \text{ mm}^2$.

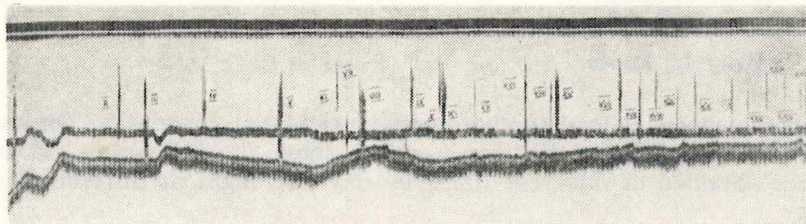


Photo 2. Net sounder echogram. Fishing position $25^{\circ} 07' N$ $015^{\circ} 25' W$. Hour of trawling 08.00 (8 a. m.) to 08.45 (8.45 a. m.) Catch 40 ton pilchard. Trawling speed 4.8 knots. Surface of registered traces 506 mm^2 .

3.2. Horse mackerel catches (*Trachurus trachurus* L.)

The dependence between the traces on the echograms of the net sounders and the results of the horse mackerel catches was calculated on the basis of the material collected by the trawler B-29 »Kantar« which, in the May-August 1974 period, was fishing in the south-west African fishing grounds. By basing it on the measurement of the surface of the traces and the evaluation of the degree of blackening of the traces on the echograms of the net sounders the coefficients of correlation between the surface of the traces and the evaluation of the degree of blackening of the traces on the echograms of the net sounders the coefficients of correlation between the surface of the traces and the results of the catch were calculated as well as the surface of the traces multiplied by the density and the results of the catch. Their value is as follows:

- the correlation coefficient between the surface of the traces and the results of the catches $r_{\Sigma_1} = 0.62$,
- the correlation coefficient between the surface of the traces multiplied by thickness and the results of the catch $r_{\Sigma_2} = 0.81$.

3.3. Mackerel catches (*Scomber scombrus* L.)

The quantity of the mackerel catches depending on the traces on the echograms of the net sounders was analysed on the basis of the material gathered by the trawlers B-29 »Kunatka« and »Kulbak« from April to July 1974 in the fishing grounds in Ireland. Only those echograms on which 90% of traces referred to mackerel were taken. Table 2 illustrates the calculated correlations between the analysed characteristics of the mackerel shoals. As seen from Table 2 when not the trawling speed but the sum of the surface of the traces on the echograms has been considered the correlation coefficient between that surface ($r\Sigma_1$) and the result of the catch is 0.65. Considering also the degree of the trace blackening, the correlation coefficient ($r\Sigma_2$) increases to 0.73.

Table 2. Correlation between the results of mackerel catches and the surface of traces, and the degree of their blackening for separated trawling speeds

| Correlation between | r | Simple regression equation |
|--|--------|--------------------------------|
| trace surface and catch | 0.6512 | $W_1 = 0.00094 \Sigma_1 + 8.4$ |
| trace surface and catch at the trawling speed interval < 4.0 knots | 0.5166 | $W_1 = 0.00099 \Sigma_1 + 6.8$ |
| trace surface and catch at the trawling speed interval 4.0 to 4.5 knots | 0.8192 | $W_1 = 0.003 \Sigma_1 + 6.0$ |
| trace surface multiplied by the degree of blackening and the results of the catch | 0.7300 | $W_2 = 0.00073 \Sigma_2 + 8.6$ |
| trace surface multiplied by the degree of blackening and the result of the catch at the trawling speed interval < 4.0 knots | 0.6680 | $W_2 = 0.00079 \Sigma_2 + 6.4$ |
| trace surface multiplied by the degree of blackening and the result of the catch at the trawling speed interval 4.0 to 4.5 knots | 0.8314 | $W_2 = 0.003 \Sigma_2 + 5.8$ |

3.4. Cutlass fish catches (*Trichiurus lepturus* L.)

Similar dependences as in the preceding researches were obtained in cutlass fish catches in the African fishing grounds by the trawler B-18 »Langusta« from January 23 to February 7, 1973. The regions of researches were:

$$\varphi = \begin{matrix} 28^{\circ}11' \text{ N} \\ 28^{\circ}51' \text{ N} \end{matrix}$$

$$\lambda = \begin{matrix} 012^{\circ}05' \text{ W} \\ 013^{\circ}27' \text{ W} \end{matrix}$$

The calculated correlation coefficient between the surface of the traces and the result of the catch $r\Sigma_1$ was 0.07, while the correlation coefficient between the surface of the registered traces multiplied by thickness at the applied scale of 4 degrees for evaluating the blackening and the result of the catch $r\Sigma_2$ was 0.16.

4. ANALYSIS OF THE RESULTS

4.1. Pilchard catches

The calculated correlation coefficients between the trace surface and the results of the catches were low ($r = 0.36$; 0.34 , and 0.37) for all the intervals of the trawling speeds. This shows that a rather loose connection exists among the examined characteristics, caused especially at low trawling speeds, disproportionately in relation to actual parameters, the fish shoals entering the net and the long duration of the registration of these shoals on the echograms of the net sounders, and the repeated registration of the fish shoals getting in and out of the net. The examinations conducted on the research ship »Profesor Sidlecki« with vehicles for underwater observations, and also the underwater observations by Korotkov and Kuzmin (1972) and the analyses of the net sounders echograms show that at the analysed trawling speeds, especially under 4 knots, the greatest part of fish escape from the trawl. The subsequent analyses of the net sounder echograms, vertical echosounders and sonars used at catching pilchard in shallow waters (north-western Africa) suggest an unambiguous conclusion that the daily and compact pilchard shoals react strongly to the interferences caused by the work of the fishing complex. Such a situation requires that under these conditions the corresponding fishing tactics be applied. The same correlation coefficients calculated for each individual interval of the trawling speed show considerably higher values (Table 1). This suggests the conclusion that at catching pilchard in shallow waters, when great reaction of the fish to the interferences caused by the work of the fishing complex exists (mainly noises of the propeller), trawling should be done at great speed. Similar conclusions can be deduced by analysing the values of the correlation coefficients between the surface of the registered traces multiplied by thickness and the results of the catch. Relatively small differences between the values of the correlation coefficients r_{Σ_1} and r_{Σ_2} for individual intervals of the trawling speed show that for the needs of the fishing practice the results of the catch can be concluded from the surface of the »readable«*) registered traces on the net sounder echograms without entering into detailed analyses of thickness (degree of blackening). At this evaluation it is of help to know the mean value of the surface of the registered traces by mm^2 relative to the mean ton of the catch. It follows from the data in Table 1 that the mean values of the surface of the registered traces by mm^2 , relative to the mean ton of the catch, decreases with the increase of the trawling speed.

The dependence between the surface of the registered traces of shoals on the net sounder echogram (Krupp Atlas Polynetzsonde 800) and the results is illustrated by Fig. 1. The dependence between the number of the registered shoals on the net sounder echogram and on the vertical echo sounder (Krupp Atlas) and the results of the catch is shown in Fig. 2. Fig. 3 shows the geometrical parameters of the pilchard shoals of compact concentrations at various times of day and night.

*) »Readable« traces represent compact traces with more or less constant degree of blackening (thickness) relating to the pilchard shoals entering the net

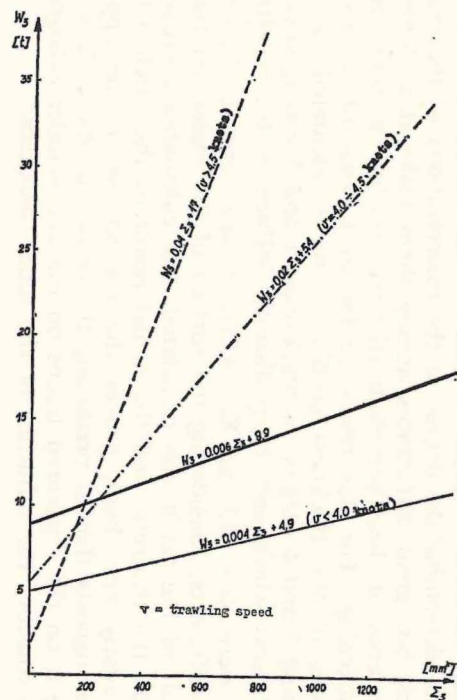


Fig. 1. Dependence between the surface of the registered traces of shoals on the net sounder echogram and the result of the pilchard catch at various trawling speeds.

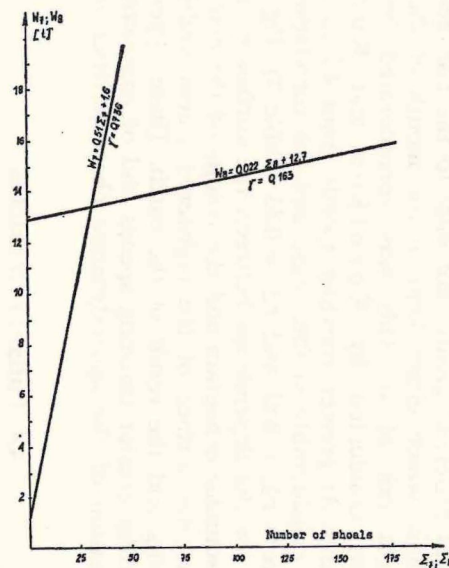


Fig. 2. Dependence between the number of registered shoals on the net sounder echogram and the vertical echosounder and the result of the catch.

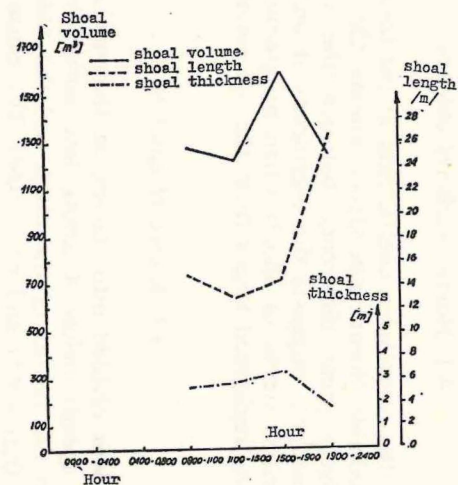


Fig. 3. Parameters of the pilchard shoals of compact concentrations at various times of day and night.

4.2. Horse mackerel catches

The value of the correlation coefficients at catching the horse mackerel prove an unmistakable linear dependence among the examined characteristics. The relatively great difference between the values of correlation coefficients $r\Sigma_1$ and $r\Sigma_2$ suggests the usefulness of analysing the degree of blackened (thickness) traces of shoals when programing the results of the catch based on the registered traces from the net sounder echograms.

4.3. Mackerel catches

When speed was divided into classes, at the mackerel catches analysis, at the trawling speeds below 4 knots low correlation coefficients were obtained between the results of the catch and the summary surface of the registered traces ($r\Sigma_1 = 0.51$ and $r\Sigma_2 = 0.66$). The cause of such low correlation coefficients is, above, all, the inadequate trawling speed, due to which the registered traces referred greatly not only to the fish getting into the net but also to those which either kept in the mouth of the trawl for a longer time or got out of it. This was corroborated by the underwater observations conducted by Korotkov and Kuzmin (1972) at catching mackerel. At greater trawling speeds from 4.0 to 4.5 knots the situation changed considerably in this sense and the correlation coefficients at these speeds were $r\Sigma_1 = 0.81$ and $r\Sigma_2 = 0.83$ (Table 2). Fig. 4 shows the simple regression for the dependence between the surface of the registered traces on the net sounder echogram and the results of the mackerel catches, while Fig. 5 shows the surface of the registered traces multiplied by the degree of blackening and the result of the catch. These dependences show the necessity of using greater trawling speeds and of conducting researches into the optimalization of the hydrodynamic characteristics of the trawls.

4.4. Cutlass fish catches

Low correlation coefficient values at catching the cutlass fish do not make it possible to determine the degree of the interrelations of the examined characteristics, but great differences among them make it possible to determine the tendency of their behaviour (the interrelation at considering the degree of blackening). For this reason in the next phase of researches the theoretic values of the thickness coefficient were calculated for the degree of blackening 3 and 4 (degree of blackening 1 and 2 was ignored as a very small thickness which only insignificantly influences the results of the catch) which were $\bar{X}_3 = 1.83$ and $\bar{X}_4 = 67.87$. On the basis of the calculated thickness coefficients, considering the surface of the registered traces, the theoretic result of the catch was calculated. The calculated correlation coefficient between the theoretic and the actual result of the catch, which was 0.91, consequently very high, proves the correctness of the applied method. This also suggests that at predicting the results of the cutlass fish catches by basing it on the registered traces on the net sounder echograms it is necessary to consider the influence of the shoal thickness.

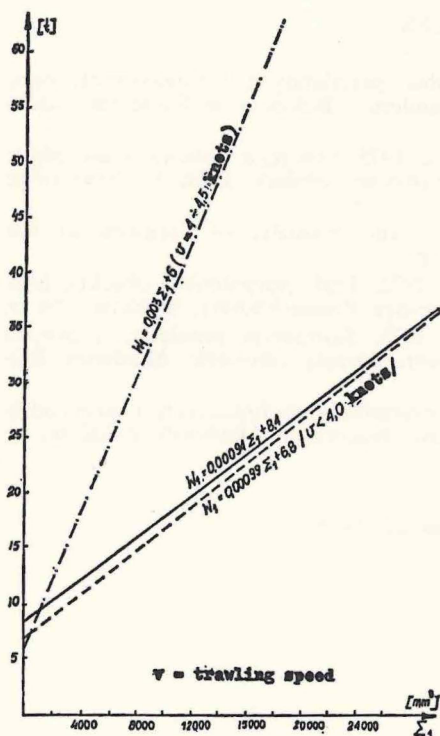


Fig. 4. Dependence between the surface of the registered traces of shoals on the net sounder echogram and the result of the mackerel catches.

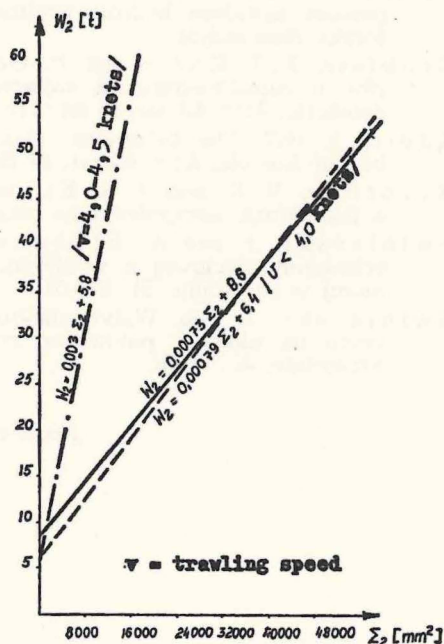


Fig. 5. Dependence between the surface of the registered traces of shoals on the net sounder echogram multiplied by the degree of blackening and the results of the mackerel catches.

5. CONCLUSION

5.1. The correlation coefficient between the surface of the registered traces on the net sounder echograms and the result of the catch is different for different species of fish and it depends on the trawling speed. The small value of the correlation coefficient at the trawling speed below 4 knots shows that a great number of fish escape from the trawl. At trawl fishing of the pelagic fish that live in shoals the trawling speed should be over 4.4 knots.

5.2. The correct interpretation of the echogram can be used at evaluating the degree to which the trawl is filled with fish.

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KRATAK SADRŽAJ

Autori su izvršili analizu zavisnosti između površine znakova jata registriranih na ehogramima mrežnih sonda i rezultata ulova kao i između površine znakova jata puta stupanj zacrnjenosti znakova jata i rezultata ulova pri različitim brzinama kočarenja. Kod ispitivanja su uzimane u obzir brzine kočarenja ispod 4,0 uzla, od 4,0 do 4,5 uzla i iznad 4,5 uzla. Materijal za ispitivanje je sakupljen na kočarima hladnjačama koji su obavljali ribolov lebdećim kočama na lovištima sjevero-zapadne, jugo-zapadne i južne Afrike te Irske. Analizom su obuhvaćeni rezultati ulova srdele, šaruna, skuše i zmijičnjak sabljaša.

Izračunate koeficijente korelacije između ispitivanih osobina kod ulova srdele pokazuje tabela 1, a kod ulova skuše tabela 2. Crtež ilustrira ovisnost između površine registriranih znakova jata na ehogramu mrežne sonde i rezultata ulova srdele pri različitim brzinama kočarenja, a crtež 2 ovisnost između broja registriranih jata na ehogramu mrežne sonde i okomitog ehosondera te rezultata ulova srdele. Na crtežu 3 su pokazani geometrijski parametri jata srdele zbijenih koncentracija u različitom vremenu dana i noći.

Prostu regresiju za ovisnost između površine registriranog znaka na ehogramu mrežne sonde i rezultata ulova skuše pokazuje crtež 4, dok za površinu registriranog znaka puta stupanj zacrnjenosti i rezultata ulova skuše crtež 5.

Analizom je utvrđeno da je koeficijent korelacije između površine registriranog znaka na ehogramima mrežnih sonda i rezultata ulova različit za različite vrste riba i ovisi o brzini kočarenja. Mala vrijednost koeficijenta korelacije pri brzini kočarenja ispod 4 uzla pokazuje da znatan dio ribe bježi iz kočice. Kod kočarskog ribolova pelagičnih riba koja žive u jatima treba kočariti brzinom preko 4,4 uzla. Pravilna interpretacija ehograma može biti iskorištena pri ocjeni stupnja napunjenosti kočice ribom.

