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Catch rate of trawlers in relation to their technical parameters

SUMMARY

This paper presents results of the research on determination of the daily catch rate of vessel-trawl system. Mean, long-term catch rates and peak catch coefficients are expressed in function of trawl towing horsepower and vessel's ability to utilize the caught raw materials, viz. hold capacity - for wet fish trawlers, or processing and freezing capacity - for factory and freeezing trawlers.

Daily catch rate statistics and measurements of trawling system characteristics, carried out on some Polish fishing cutters (small trawlers), were used to determine the above mentioned relationships for the Polish cutter fleet in the Baltic Sea. (Results of measurements of trawl resistance and catch rates of Polish trawlers used in the North and Southern Atlantic and the North Pacific are presented elswhere [2].)

INTRODUCTION

Recognition of factors which influence the catch rate of trawlers is essential for standardization of fishing effort and assessment of exploitation intensity of fish stocks as well as for fishing vessel design and operation.

The oldest, still applied method of expressing catch rate is the relation of the catch, obtained by vessels of different type, size and power, to the catch available by a standard vessel [1]. However this approach is of little use in ship design.

A second quantitative method to express trawler's catch rate is applying functional relationship to the penetration zone of the fishing gear used by the trawler in question [2]. This method is more useful in trawling system's and ship's design because the zone depends upon technical characteristics of the vessel.

Apart from the above mentioned methods, catch rate can be expressed also as a random value.This paper presents results of application of this approach to determination of the mean daily catch rates and peak catch coefficients for the Polish cutter fleet in the Baltic Sea.

SOURCES AND METHODS

Trawler's catch rate obtained during one day operation is a random (stochastic) value. Daily catch statistics from a given operation area [3] may be used to prepare statistical distributions (histograms) of the catch rate.

Fig. 1 shows the histograms obtained for Polish cutters (small trawlers) operated in the Baltic Sea. These data enable to determine the catch rate mean values U_d, and the peak catch coefficients $\varphi_{(95)}$. The peak catch coefficients are assumed here as the ratio of the maximum catch amount $U_{d(95)}$, which appear with 95% cummulative probability (i.e. the largest out of 95% of all daily catch amounts which appear in operation), to the mean catch amount U_d:

$$\varphi_{(95)} = \frac{U_{d(95)}}{U_d}$$

The catch rates and peak catch coefficients depend on:

- several natural factors ρ
- effectiveness of directing the fishing gear onto shoals k_n
- trawl-net catchability k_z
- factors related to the crew's skill, fish reconnaissance quality, weather conditions etc $z_1,...,z_4,...$
- trawl towing horsepower N_h [kW] at v_t speed [m/s]
- trawl resistance R_z [kN]
- absolute and relative vessel's ability to utilize the caught raw material:
  - the hold capacity V [m^3] or V/N_h for wet fish trawlers and
  - the processing/freezing capacity Z_p[t/day] or Z_p/N_h for factory and freezing trawlers

The fishing process carried out by means of the vessel-trawl system can be described by a mathematical model (see also Fig. 2) as follows:

$$U_d = f\left[N_h, V\left(or Z_p\right), k_n, k_z, z_1, .., z_4, ..\right]$$

$$\varphi_{(95)} = g\left[N_h, V\left(or Z_p\right), k_n, k_z, z_1, .., z_4, ..\right]$$

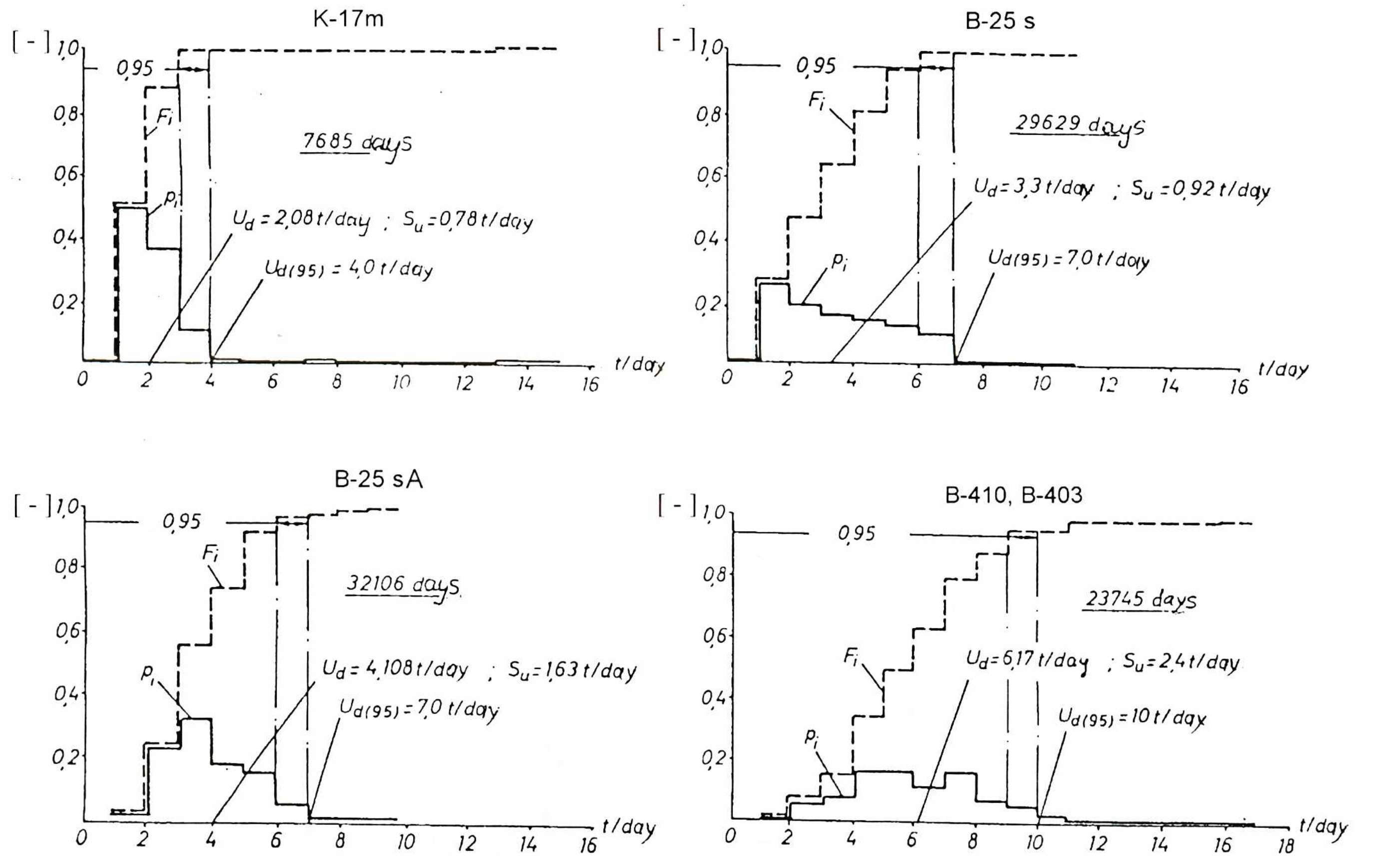

Fig. 1. Statistical histograms of the daily catch rates for cutters of K-17, B-25 s, B-25 sA, B-410 and B-403 types, fishing in the Baltic Sea
------ statical frequency distribution p_i ---- cummulative frequency distribution F_i
U_d - catch rate daily mean value S_u - standard deviation of U $U_{d(95)}$ - maximum catch amount p_i - relative fishing time

Tab. 1a. Particulars of some fishing vessels and measurement results of their trawl characteristics : R_z - trawl resistance, v_t - trawling speed, N_h - towing horsepower

Ship's length / Type	Main engine power	Hold capacity	Bottom trawl			Bottom pair trawl			Midwater trawl			Midwater pair trawl			Average		
	N [kW]	V [m³]	R_z [kN]	v_t [m/s]	N_h [kW]	R_z [kN]	v_t [m/s]	N_h [kW]	R_z [kN]	v_t [m/s]	N_h [kW]	R_z [kN]	v_t [m/s]	N_h [kW]	R_z [kN]	v_t [m/s]	N_h [kW]
17 m Storem 4, Storem 4A	88,2	35,0	11,8	1,15	13,57	8,7	1,12	9,74	-	-	-	10,2	1,3	13,26	-	-	11,18
24 m B-25s	165,4	80,0	17,7	1,44	25,5	15,5	1,44	22,32	-	-	-	19,85	1,7	33,75	-	-	29,65
24 m B-25sA	257,4	80,0	21,0	1,61	33,81	-	-	-	26,7	1,45	38,7	26,16	1,85	48,4	-	-	41,66
25 m B-410 I, II, III, B-403, B-410 IV	419,1	95,0	44,0	1,9	83,6	-	-	-	51,01	2,0	102,02	51,0	2,15	109,65	-	-	100,81

Tab. 1b. Catch results of the vessels in the Baltic Sea: U_d - daily catch rates , $\varphi_{(95)}$ - peak catch coefficients, p_i - relative fishing time

Ship's type	Bottom trawl			Bottom pair trawl			Midwater trawl			Midwater pair trawl			Average		
	U_d [t/day]	$\varphi_{(95)}$ -	p_i -	U_d [t/day]	$\varphi_{(95)}$ -	p_i -	U_d [t/day]	$\varphi_{(95)}$ -	p_i -	U_d [t/day]	$\varphi_{(95)}$ -	p_i -	U_d [t/day]	$\varphi_{(95)}$ -	p_i -
Storem 4, 4A	2,36	1,70	0,300	1,96	2,04	0,62	-	-	-	2,10	1,905	0,08	2,08	1,923	1,0
B-25 s	2,91	2,40	0,483	2,60	3,46	0,01	-	-	-	3,70	1,900	0,507	3,30	2,120	1,0
B-25 sA	3,80	1,76	0,445	-	-	-	3,50	2,00	0,025	4,40	1,590	0,530	4,11	1,700	1,0
B-410 I, II, III, B-403, B-410 IV	5,80	1,72	0,229	-	-	-	5,93	1,686	0,363	6,45	1,705	0,408	6,10	1,630	1,0

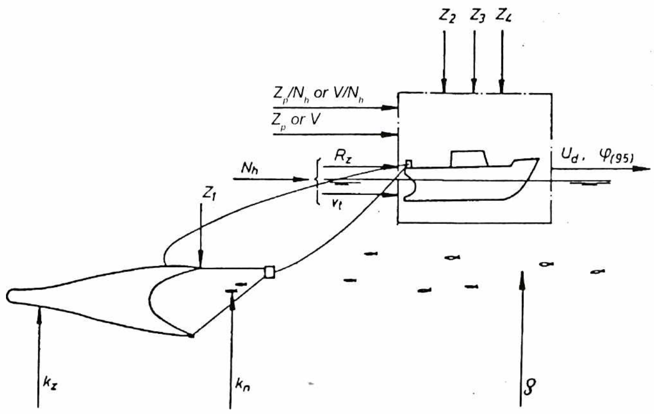

Fig. 2. Factors which influence the fishing process carried out by vessel-trawl system (notations are given in the text above)

In the model, momentary random changes in concentration of target species, skill in guiding the trawl onto fish concentrations and shoals, fishing gear catchability as well as other exploitation factors, which are difficult to express in the quantitative way, may be taken as disturbances, because usually several hundred to several thousand fishing days in a given area are taken into account to determine mean long-term catch rates.

Measurements of the trawl resistance and trawling speeds make it possible to determine towing horsepower. This information, together with the data on vessel's hold capacity or processing capability, enables to obtain input data needed to concretize the above described model for each fishing mode.

Summing up, the mean, long-term daily catch rate values in the trawl fishery and peak catch coefficients can be expressed in function solely of the trawl towing horsepower and the vessel's ability to utilize the catch.

For a given fishing area the following functions can be written:

$$U_d = f_1\left[N_h, V\left(orZ_p\right)\right] + e_u$$

$$\varphi_{(95)} = g_1\left[N_h, V\left(orZ_p\right)\right] + e_\varphi$$

where: e_u, e_φ - estimation errors.

Catch and trawl characteristics measured on some Polish fishing vessels are given in Tab. 1a and 1b. On this basis the above discussed relationships were determined with the use of the multi-parameter regression method.

FINAL RESULTS

The catch rate and peak catch coefficients for the Baltic Sea (mostly the Polish fishery zone), estimated in the presented way, can be finally described by the following formulas:

$$U_d = 1{,}236 + 0{,}0375 N_h + 0{,}01277 V \quad [\mathrm{t/day}]$$

$$\varphi_{(95)} = 0{,}0264 + 0{,}00429 N_h + 0{,}525 \frac{V_l}{N_h} + 0{,}00701 V \quad [-]$$

where:

N_h - trawl towing horsepower within the following limits:

$$110\ \mathrm{kW} \geq N_h \geq 10\ \mathrm{kW}$$

V/N_h - relative ability to stow raw materials, within the following limits:

$$3{,}6 \geq V/N_h \geq 0{,}9$$

The formulas are also presented graphically in Fig. 3.

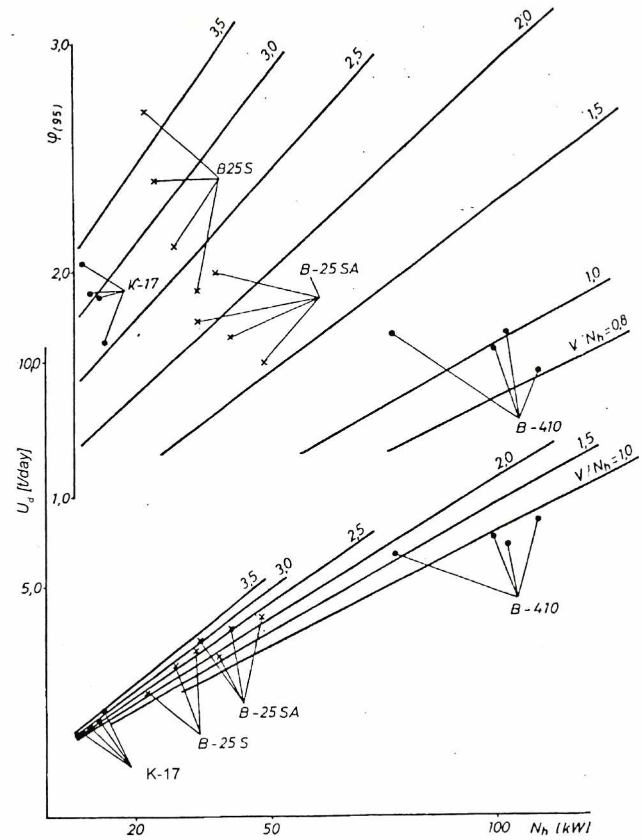

Fig. 3. Relations between the daily catch rate U_d, peak catch coefficient $\varphi_{(95)}$, towing horsepower N_h, and relative ability to stow raw materials V/N_h

The final analysis of the results showed that the chosen model made it possible to obtain a relationship of the investigated parameters with the correlation coefficient value $R \approx 0{,}9$ (according to Fisher-Suedecor's test) at the significance level $\alpha = 0{,}05$. This means also that the factors, assumed in the model as disturbances, can deviate the mean long-term daily catch rates by $1 - R^2 \approx 0{,}2$ (abt . 20 %).

The similar accuracy of estimation can be obtained for peak catch coefficients.

To determine catch rate of a trawler in the design phase, catch rate probability should be known of a similar trawler operated in a given region. Simultaneously, differences of parameters and design solutions assumed for each of these ships should be accounted for.

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