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Procedure for estimating mackerel catch from overflights and ICNAF inspection boardings in Subarea 5 and Statistical Area 6, January-April 1975[1]

by

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In 1975 ICNAF inspectors boarding USSR fishing vessels in SA 5 and 6 during January-April 1975 gathered information concerning total catch of these vessels since arrival in SA 5 and 6. Captains aboard all of the vessels boarded in the BMRT, PRT, RRT, and Super-Atlantic classes professed to be in a mackerel fishery. The total mackerel catch and length of time on the grounds are given in Table 1 by vessel. In addition, most of the Captains interviewed concerning the final date of the mackerel fishery indicated that mid-April was the final date of the fishery (Table 2). In order to establish a relationship between catch and days on ground, the data of Table 1 were fit to the following model to estimate the unknown parameters:

$$y_i = \hat{a}\, x_i^{\hat{b}}\, \varepsilon_i \qquad (1)$$

where x_i = days on ground of vessel i,

y_i = catch of mackerel during X_i,

ε_i = error of observation y_i, assumed to be log Normal$(0,\sigma^2)$,

and $\hat{a}$ and $\hat{b}$ are constants to be estimated.

The model was fit using a least squares procedure on the logged model (1) and applying data of the following vessel groups: 1) Super-Atlantic class; 2) BMRT, PRT, RRT and RTM combined. The results were as follows:

1) Super-Atlantic class:

$$\hat{y}_i = 59.74\, x_i^{.78} \qquad (2)$$

r = .86, F = 11.54, d.f. = 25

Standard deviation from regression = $s(y' \cdot x')$ = .45

Standard deviation of ln a = .76

Standard deviation of b = .25

$\overline{x'} = \overline{\ln x}$ = 3.20, Sum of squares of x'(= ln x) = 3.39

$\overline{y'} = \overline{\ln y}$ = 6.59, Sum of squares of y'(= ln y) = 3.19

[1] Revision of Working Paper 76/IV/52 presented to the Assessments and Biological Surveys Subcommittee Meetings, April 1976.

Table 1. USSR fishing vessels boarded during January 1 - April, 1975 and interviewed concerning mackerel catch to date and days on ground since January 1, 1975. * indicates boarding report showed vessel entered mackerel fishery during January, 1975.

Vessel Number and Name	Mackerel Catch	Time Period	No. Days	
0126 Karpogary	345	1/7-3/5	57	BMRT, PRT, RRT or RTM class
0227 August Alle	1000	1/3-4/11	98	
0233 Gubertas Barisa	55	1/6-1/12	6	
0277 Timofey Khryukin	800	2/5-3/15	38	
0326 Van Gogh	500	1/15-3/18*	62	
0330 Izumrud	405	1/1-2/20	50	
0331 Zarechensk	125	3/18-3/28	10	
0337 Kantapy	180	1/3-1/18	15	
0356 Kronstadt	200	2/7-3/10	31	
0369 Bykovo	390	1/1-1/28	27	
0386 Brilliant	80	3/24-3/30	6	
0433 Putvil	500	1/15-2/18	34	
0490 Yan Berzin	572	1/31-4/15	74	
0549Volzhanin	250	3/6-3/24	18	
0573 Lunokhod I	1800	1/15-3/16*	60	
0589 Valka	788	1/28-3/5	36	
0710 Ekholt	300	1/20-3/10	49	
0802 Ska. Anderson	350	2/20-3/10	20	
0808 Priluki	1150	1/2-3/24	81	
0820 Kovdor	2000	1/15-4/11*	86	
7039 Deneb	131	3/12-3/30	18	
7055 Dobrovolsk	80	3/7-3/19	12	
7057 Gurjevsk	40	1/8-1/15	7	
7104 Anderma	40	1/2-1/6	4	
7112 Alsu	1042	2/1-4/8	66	
7156 Darial	435	1/20-3/20	59	
7506 Valentin Shewchuk	2750	1/15-3/16*	60	SUPER-ATLANTIK class
7507 Sandaky	914	1/1-2/28	58	
7508 Batilman	360	1/1-1/18	17	
7509 Aukshataitija	328	1/11-1/18	7	
7510 Mustarv	500	2/2-2/15	13	
7516 Retavas	1000	1/1-2/10	40	

Table 2. Information given US boarding officials by Captains of USSR vessels fishing in SA 5 or 6 during January-April 1975, pertaining to date of cessation of USSR mackerel fishery.

Vessel no.	Date of boarding	Notes
8041	4/8/75	Captain had been told to cease mackerel fishery 4/10/75.
0227	4/10/75	Captain told inspector mackerel fish ery would cease 4/15/75.
0820	4/11/75	Captain had no instructions to cease mackerel fishery.
0234	4/11/75	Captain had been told to cease mackerel fishery 5/15/75.
0536	4/11/75	Captain told inspector mackerel fishery ended 4/10/75.
7508	1/18/75	Captain told inspector he was in a mackerel fish ery.
0272	4/18/75	Captain told inspector mack erel fishery had ceased 4/10/75.
0340	4/21/75	Captain told inspector mackerel fish ery had ceased.
(Ostrav Atlasova)	4/21/75	Captain told inspector mackerel fishery had ceased 4/15/75.

Note: Only 35 (1 Super-Atlantik class, 34 of the other classes) of the vessels used in the analyses were sighted after 4/10/75. Thus using 4/10 as the termination date rather than 4/15 would not markedly alter the estimated catches (about 3500 MT).

2) BMRT, PRT, RRT, RTM classes:

$$\hat{y}_i = 8.00\, x_i^{1.10} \qquad (3)$$

$r = .92$, $F = 12.9$, d.f. $= 25$
Standard deviation from regression $= s(y'.x') = .45$
Standard deviation of $\ln a = .35$
Standard deviation of $b = .33$
$\overline{x'} = \overline{\ln x} = 3.13$, Sum of squares of x' $(= \ln x) = 21.45$
$\overline{y'} = \overline{\ln y} = 5.74$, Sum of squares of y' $(= \ln y) = 34.22$

Since in fitting (1) by least squares the assumption is made that at each x', y' has a normal distribution, an estimate of the variance of a predicted y for a given x is:

$$\mathrm{Var}(\hat{y}\ \mathrm{at}\ x) = \left[\exp\left(2.0\,\overline{y'} + s^2\right)\right]\left[\exp(s^2) - 1.00\right] \qquad (4)$$

where

$$s^2 = s^2(y'.x')\left[\frac{n+1}{n} + \frac{(x' - \overline{x'})^2}{\sum_{i=1}^{n}(x_i' - \overline{x'})^2}\right] \qquad (5)$$

and

$$s^2(y'.x') = \left(\frac{1}{n-2}\right)\left[\sum_{i=1}^{n}(y_i' - \overline{y_i'})^2 - b^2\left(\sum_{i=1}^{n}(x_i' - \overline{x'})^2\right)^{\frac{1}{2}}\right] \qquad (6)$$

These results were applied to sea patrol data and slightings data gathered by US Surveillance flights January 1-April 15, 1975. USSR vessels of the above-mentioned classes observed during this time period, were included in the analysis. However, only vessels observed at least twice were included. This policy seems reasonable since of those vessels seen at least twice, most vessels were observed 7-8 times during that period (Figure 1). Also, vessels without distinct numbers (8 vessels) were excluded (64 observations). The resultant data set thus consisted of 134 vessels of the BMRT, RRT, PRT or RTM classes, and 12 vessels of the Super-Atlantic class.

If the covariable (days on ground) used to estimate mackerel catch for these vessels were taken as the length of time between first and last sighting during January 1 and April 15, the resultant time periods would be under-estimates of the actual length of time the vessel was in the mackerel fishery. This contention is supported by information taken from boardings, which indicated a lag in time between arrival in SA 5 and 6 and date of first sighting (Figure 2). The average lag was calculated to be about 14 days. Applying these results to the calculated time between date of first and last sighting (but truncating at January 1, if necessary), the following estimates of total catch were derived:

Table 3. Estimates of USSR mackerel catch, January 1-April 15, 1975, by vessel group.

Class	Total Catch(MT)	Variance	Stand. Dev.
Super Atlantic	20,138	1.83×10^7	4275
BMRT, PRT, RRT RTM	109,214	3.28×10^7	5728
Total	129,352	5.11×10^7	7148

The total catch of Table 3 is based on the assumption that all catches were recorded as whole fish. Boarding reports indicate that this was not the case, and the following statistics on the percentage of fillet in the catch composition on board of vessels interviewed were made:

Table 4. Estimates of fillet composition in total mackerel catch.

Average percent of fillets in total catch = $\bar{p}$	.10
Standard deviation of p	.16
Standard error of p	.04
Sample size	20

Applying this estimate of fillets in the total catch to the results of Table 3, and using a 50% fillet to whole fish ratio, the following estimate of total USSR mackerel catch January 1-April 15, 1975, was made:

Table 5. Estimates of USSR mackerel catch, January 1-April 15, 1975, using additional factor due to fillet composition of total catch of Table 3.

Total Catch (mt)	Variance	Stand. Dev.
142,287	5.32×10^8	23,085

The following statistics were used in estimating the catch and variance:

$$\text{Total catch} = [(1-\bar{p})+\bar{p}+\bar{p}]\,T = (1+\bar{p})T \qquad (7)$$

$$\text{Variance} = V(T) + [\bar{p}^2 V(T) + T^2 V(\bar{p}) + V(\bar{p})V(T)] \qquad (8)$$

where T (total catch) and V(T) (variance of total catch) are from Table 3, calculated using (2)-(4), and $\bar{p}$ (average percent of fillets) and $V(\bar{p})$(variance of average percent) are from Table 4.

In setting confidence intervals for the estimated total catch of Table 5, it is important to consider acceptable ranges of the component variables T and $(1+\bar{p})$ This is necessary in order to guarantee that a value of total catch' = $(1+\bar{p})'T'$ was derived from values of $(1+\bar{p})'$ and T' which had a specified chance of being the true values , given the observed data.

Since T is the sum of predicted catches of 146 vessels, standard Normal theory can be used to set its confidence bounds for given values of α; since $\bar{p}$ is a sample mean, its distribution can be assumed Normal. Let the terms "Upper bound$_{\alpha 1,\alpha 2}$" and "Lower bound$_{\alpha 1,\alpha 2}$" be defined as follows:

$$\text{Upper bound}_{\alpha 1,\alpha 2} = \text{Max}(1+\bar{p})_{\alpha 1} \times \text{Max}(T_{\alpha 2}) = ((1+\bar{p}) + t_{\alpha 1}\sigma_{1+\bar{p}}) \times (T + t_{\alpha 2}\sigma_T) \quad (9)$$

$$\text{Lower bound}_{\alpha 1,\alpha 2} = \text{Min}(1+\bar{p})_{\alpha 1} \times \text{Min}(T_{\alpha 2}) = ((1+\bar{p}) - t_{\alpha 1}\sigma_{1+\bar{p}}) \times (T - t_{\alpha 2}\sigma_T) \quad (10)$$

where $\text{Max}(1+\bar{p})_{\alpha 1}$ is the largest of the two confidence limits of $(1+\bar{p})$ at the level $\alpha 1$, and $\text{Min}(1+\bar{p})_{\alpha 1}$ is the smallest of the two confidence limits of $1+\bar{p}$ at the level $\alpha 1$, etc.; where T, $1+\bar{p}$, $\sigma_{1+\bar{p}}$ = standard error of p, (or standard deviation of $\bar{p}$, or of $(1+\bar{p})$) and σ_T = standard deviation of T, are from Tables 3 and 4; and where $t_{\alpha 1}$ and $t_{\alpha 2}$ are Standard Normal values corresponding to probability levels of $\alpha 1$ and $\alpha 2$ respectively. For specified levels of $\alpha 1$ and $\alpha 2$ then, (9) and (10) provide bounds above which and below which estimated values of total catch must be the product of values of T' and $(1+\bar{p})'$ both or one of which lies outside the $\alpha 2$ and $\alpha 1$ confidence belt of T and $(1+\bar{p})$ respectively. Table 6 lists values of (9) and (10) for specified values of $\alpha 1$ and $\alpha 2$, as well as the associated percentage range of the resultant confidence belt relative to the values of $(1+\bar{p})$ = 1.10

and T = 129,352. The percentage range for a specified value of $\alpha 1$, for example, is

$$\% = t_{\alpha 1}\, \sigma_{\overline{(1+\bar{p})}} \,/\, (1+\bar{p}) \tag{11}$$

Similarly for T,

$$\% = t_{\alpha 2}\, \sigma_{\overline{T}} \,/\, T \tag{12}$$

Table 6. Confidence levels ($\alpha 1$ and $\alpha 2$) and associated % range in confidence band of $(1+\bar{p})$ and T which give upper and lower bounds (re: (9) and (10)) of estimated total catch of 142,287 MT.

$(1+\bar{p})$		T		total catch 142,287	
$\alpha 1$	%	$\alpha 2$	%	lower bound re: (10)	upper bound re: (9)
.01	9%	.01	15%	110,910	177,353
.05	7%	.01	15%	113,128	174,397
.05	7%	.05	11%	117,649	169,167
.40	3%	.05	11%	123,416	161,999

The estimate of USSR mackerel catch of Table 5 must be considered an underestimate of the catch taken during the period January 1-April 15, 1975. Several small vessels (numbers 8000+) which may have been catching mackerel were excluded from the analyses, due to the lack of sufficient boardings information on these catches of mackerel. More important, however, is the exclusion of a fish meal factor in the total catch, although several boardings indicated that mackerel catches had been converted to meal.

With respect to the total USSR mackerel catch during January-December 1975, 20% of the vessels included in the analysis were sighted between April 15-April 30, 1975. If this time period is included, an additional 2000 metric tons should be added to the catch of Table 5. In addition, a certain amount must be added to include the mackerel by-catch in the USSR silver hake fishery, which was between 20-30% during 1972-1974.

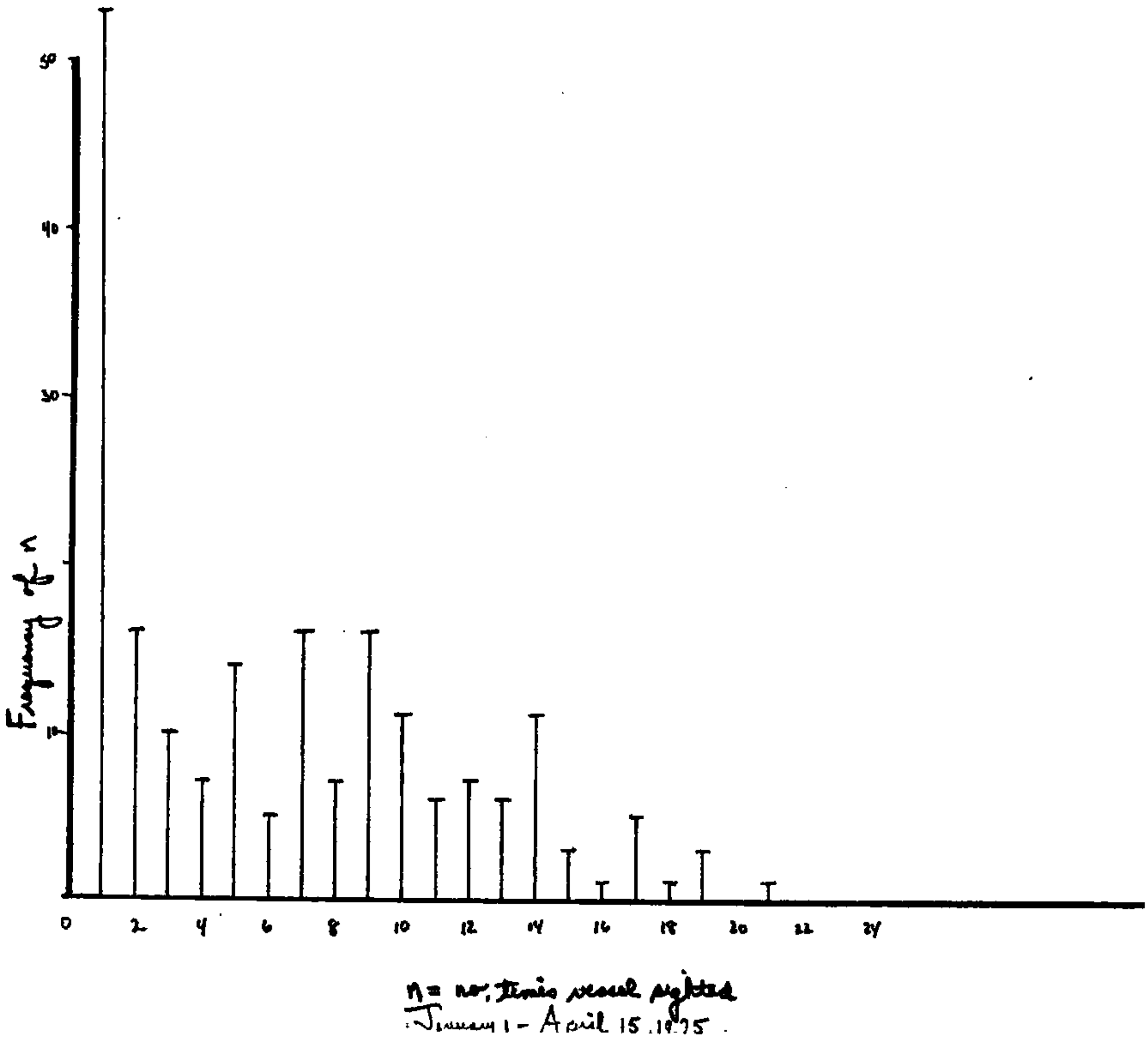

Fig. 1. Frequency distribution of sightings of USSR fishing vessels used in analysis during 1 January-15 April 1975, in SA 5 and/or 6.

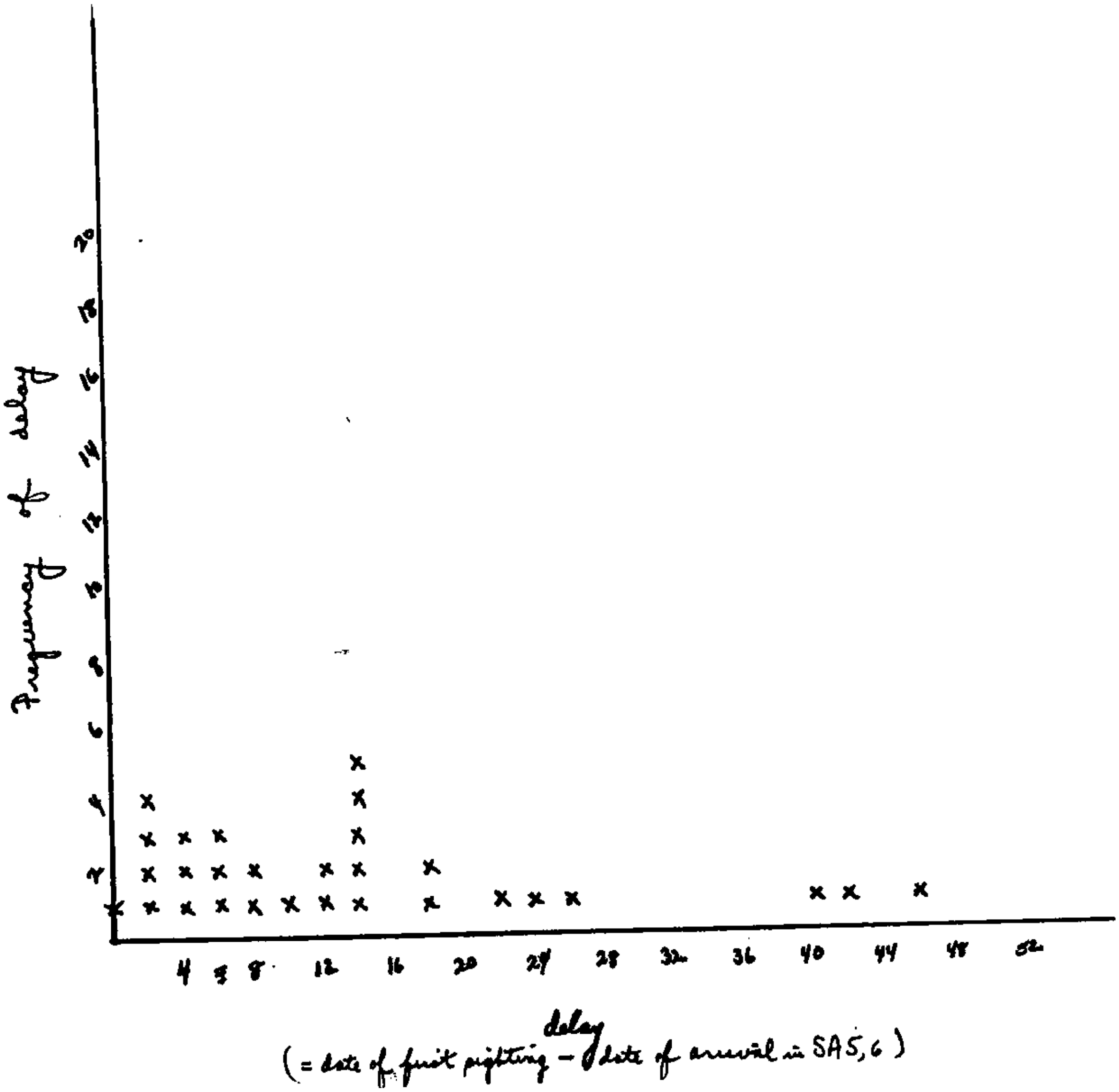

Fig. 2. Frequency distribution of delay in first sighting of a sample of USSR fishing vessels in SA 5 and 6, 1 January-15 April 1975. Information taken from boardings of USSR vessels.