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Shift and Catch of the Danish Seiner during the Alaska Pollack Trawling — IV.*

The Information from the Fellow Seiners and the Distance of Shift

By

Hiroshi MAÉDA and Shiro MINAMI

The relation between the distance of shift and the amount of catch by a shooting was examined in the preceding reports of this series[1)-3)]. And the clearest trend found out was that the Danish seiner in the fleet operation for the Alaska pollack inclined to shift over a long distance after a poor catch but to stick to the similar position after a good catch[2)]. But it was hard to find out any clear relation of the amount of catch by a shooting to the distance of shift just before it[3)], in spite of the fact that the workable hours were spent for shift especially for the long one. For the purpose of a clear understanding of the meaning of the shift and the role of the informations from the fellow seiners for determining the location of shooting the gear, the influence of the information of the distribution and the catch by the fellow seiners was examined through estimating the multiple linear regression equations. And the following trends coinciding with the results of the preceding reports and suggesting the role of the informations in determining the location of shooting were found out: 1) the seiner inclined to shift over a long distance after a poor catch but she stayed near the position of the preceding shooting after a good catch, and 2) the seiner inclined to shift over a long distance when she fished distant from the center of catch but she shifted only a short distance when she fished near the center. The details were shown in the present report.

Material and Method

The same materials as those used in the preceding reports[1)-3)] of this series were used in the present report. They were the complete set of the telegrams for respective

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shootings during the entire season of 1964 from the 22 Danish seiners consisting of a fleet for the Alaska pollack along the outer edge of the continental shelf of the Eastern Bering sea. All the telegrams were stratified into the 15 groups of the 10-calendar-day intervals, and those on a day each were sorted at random and used in the present report. The seiners exchange very frequently the informations and the opinions of the catch and behavior of the objective fish not only throughout the working hours but also before and after them. These informations may be a part of the most useful bases for determining the location of the next shooting. The telegrams to the head-quarter on the factory ship were their essentials. In accordance with the passing of working hour, the informations were accumulated, and the variables used in the present examination differ in accordance with the passing of hour and the time range for estimating them. But the informations passed over many hours faded into of no use, for the objective fish shows a well-defined daily rhythmic change in behavior and the seiners repeat frequent shootings within a limited area. It takes usually 1.5 to 2 hours to complete a shooting and a hauling. Accordingly, setting that the informations within two hours before the determination of shooting position were used as the bases of the determination, the average and standard deviation (x_3) of the catch by a shooting and the location of the center of catch of the records within this time range for respective shootings were estimated. And the distance of the location of the shooting just before the shift (x_2) from the center of catch and the difference of the catch (x_1) by the preceding shooting from the average were estimated. Then, the multiple linear regression equations of the distance of shift (y) on x_1, x_2, and x_3 were estimated either after the stratification of the records according to the date and the seiner, or according to the month and the seiner, or according to the date. Here, the distance (y and x_2 in miles) were used after the square root transformation, for their frequency distributions were agreeable to the square root normal series.

Results

1. The estimated multiple linear regression equations after the twofold stratification of the records according to the date and the seiner

When the informations from the fellow seiners just before the shooting are used as the bases of determining the location of shooting, it is natural that the seiner chooses the location near the center of catch, if there is no obstacle to do so especially in the distribution of the fellow seiners. And it is probable that the seiner does not approach to the center of catch when the catch is better than the average, but she approaches to it when the catch is poorer than the average, and the influence may be serious when the difference is large. Accordingly, the difference of the amount of catch (x_1) by the preceding shooting from the average of catch was chosen as one of the independent variables. When the seiner is near the center of catch she does not shift over a long distance however the catch might be poor. Accordingly, the distance of the location

of the preceding shooting (x_2) from the center of catch was adopted as another independent variable. The influence of the difference of catch and that of the distance from the center may be serious when the catch shows small deviation, but not serious when the catch shows a large deviation. Accordingly, the standard deviation ($\sigma = x_3$) of the amount of catch by a shooting was adopted as the other independent variable. A set of the variables on June 17 by the seiner No.12 was shown in Table 1 as an example,

Table 1. An example of a set of the variables for estimating a multiple linear regression equation (on June 17, by the seiner No. 12).

$$\sqrt{y} = a_0 + a_1 x_1 + a_2 \sqrt{x_2} + a_3 x_3$$

Order	Time to start shooting	Time range under consideration	Number of shootings in the time range	x	$\bar{x}$	$x_1(=x-\bar{x})$	$x_2(=d_1)$	$x_3(=\sigma)$	y
2	4 : 57	2 : 57— 4 : 56	15	1	1.67	−0.67	4.98	0.70	2.13
3	6 : 52	4 : 52— 6 : 51	19	2	1.84	0.16	4.71	0.74	1.00
4	8 : 36	6 : 36— 8 : 35	20	2	1.90	0.10	5.28	0.70	1.44
5	10 : 30	8 : 30—10 : 29	22	1	2.05	−1.05	7.68	0.71	3.55
6	12 : 22	10 : 22—12 : 21	21	1	1.95	−0.95	7.99	0.79	2.31
7	14 : 13	12 : 13—14 : 12	17	4	2.24	1.76	7.08	0.73	0.71
8	14 : 04	14 : 04—16 : 03	21	4	2.29	1.71	5.16	0.70	0.42

Note:

Number of shootings in the time range·····To count the number of shootings included in respective time range, the time of finish of hauling up was adopted.

x·····The amount of catch by the $(i-1)$-th shooting in tons

$\bar{x}$·····The average of catch by a shooting (in tons) estimated from the records of the shootings within two hours before the start of the i-th shooting.

$x_2 = d_1$·····The distance of the position of the $(i-1)$-th shooting from the center of catch estimated from the records within two hours before the start of the i-th shooting.

$x_3 = \sigma$·····The standard deviation of the catch by a shooting estimated from the above-mentioned records.

y·····Distance of shift between the $(i-1)$-th and the i-th shootings.

In the estimation, x_2 and y are used after the square root transformation.

and the distribution of the catch for estimating the variables for the sixth shooting in this example was shown in Fig. 1, for the purpose of assisting the explanation of the estimation of the variables and the equations.

The estimated multiple linear regression equations after the twofold stratification of the records according to the date and the seiner were shown in Table 2. The estimated regression coefficient of the difference of catch, a_1, was significantly positive in one of the strata (the groups of the records on a day by a seiner) out of the 189 ones, insignificantly positive in the 41 ones, but insignificantly negative in the 137 ones, and significantly negative in the 10 ones. These facts meant that the seiner inclined to shift only a short distance when the catch was better than the average but to shift

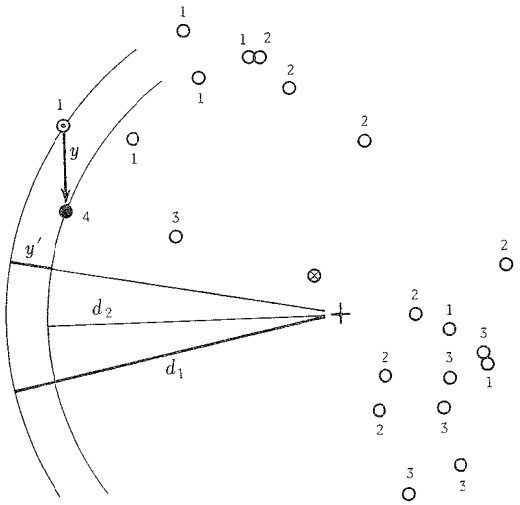

Fig. 1. The distribution of the fellow seiners and their catch used for the estimation of the variables for the sixth shooting of the example shown in Table 1. (on June 17, by the seiner No.12).
Note : The numeral attached to the circle shows the amount of catch (in tons) by a shooting. The circle with center dott shows the location of the fifth shooting. The solid circle shows that of the sixth shooting. The circle with cross shows the center of the distribution of the fellow seiners. The sign plus shows the center of catch. The present report does not deal with y' and d_2, but they are shown for they will be used in the succeeding report.

over a long distance when the catch was poorer than the average. The rate of the strata taking the positive a_1 did not show any difference according to the date (χ_0^2 =11.85, with 13 degrees of freedom; $0.70 > \Pr\{\chi_0^2 > \chi^2\} > 0.50$) or according to the seiner (χ_0^2 = 22.35, with 21 degrees of freedom; $0.50 > \Pr\{\chi_0^2 > \chi^2\} > 0.30$).

The coefficient of the distance of the preceding shooting from the center of catch, a_2, was significantly positive in the 11 strata, insignificantly positive in the 95 ones, but insignificantly negative in the 77 ones, and significantly negative in the six ones. These facts meant that the seiner showed a weak trend of shifting over a long distance when she fished distant from the center of catch but only a short distance when she fished near the center. The rate of the strata taking the positive a_2 did not show any difference according to the date (χ_0^2 = 22.29, with 13 degrees of freedom; $0.10 >$

Table 2. The estimated multiple linear regression equations after the twofold stratification of the records according to the date and the seiner.

$$\sqrt{y}=a_0+a_1x_1+a_2\sqrt{x_2}+a_3x_3$$

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
	4	−2.93	−0.07	−0.04	1.45	0.41	0.01	0.43	5
Late in April	8	−1.53	0.13	0.44	0.10	238.14*	171.38*	1.05	5
	21	0.67	−0.30	0.41	−0.11	8.98	1.14	0.09	5
	1	1.33	−0.57	0.32	−0.47	10.43	27.22*	1.17	6
	2	2.57	−0.02	−0.24	−0.66	0.004	1.04	4.32	6
	3	0.71	0.20	0.31	−0.01	2.64	5.25	0.001	6
	4	−1.00	−0.14	−0.04	1.71	18.47	1.61	76.40	5
	5	1.64	−0.08	0.13	−0.23	0.06	0.13	0.04	6
	7	5.71	−0.10	−0.04	−2.28	0.60	0.09	5.02	6
	9	0.72	−0.12	−0.24	1.50	0.04	1.81	1.84	5
	10	1.73	−0.65	−0.01	−0.83	7.88	0.01	3.41	6
Middle of May	11	0.36	0.44	0.34	0.57	0.43	1.12	0.10	6
	12	−0.84	−0.29	0.10	0.93	0.15	0.25	3.64	5
	13	−1.23	−0.20	0.16	1.18	1.46	3.98	3.08	5
	15	0.15	−0.32	0.09	0.43	1.00	0.33	0.24	6
	16	0.90	−0.20	0.17	−0.02	9.46	9.31	0.005	5
	17	0.96	−0.02	0.15	0.17	0.05	2.72	0.20	6
	18	3.08	−0.21	0.32	−1.10	1981.48*	10174.82**	4447.27**	5
	19	0.36	0.003	0.21	0.39	0.002	7.66	0.63	5
	20	6.63	−0.58	−0.17	−2.18	9.62	0.80	2.11	6
	2	2.25	0.36	0.06	−0.42	0.19	0.06	0.03	7
	3	−0.42	−1.84	0.10	3.04	44.37*	4.44	17.28	6
	4	0.06	−0.75	0.27	2.05	1.79	0.31	2.13	5
	5	1.19	−0.59	−0.03	−0.47	5.90	0.15	0.30	5
	7	0.47	0.64	0.34	0.71	0.37	0.38	0.07	6
Late in May	8	1.74	−0.48	0.08	−1.19	0.29	0.10	0.44	6
	10	−1.48	−0.29	0.40	2.01	0.86	2.97	1.10	6
	12	1.70	0.38	−0.04	0.55	0.02	0.003	0.02	5
	13	34.71	−4.69	−8.02	−34.07	29.77	25.99	25.40	5
	20	−0.73	−0.18	0.22	1.42	0.03	0.20	0.23	5
	1	0.50	−0.23	0.55	−0.50	1.26	3.88	0.28	7
	2	−0.74	0.09	0.42	0.84	0.04	1.26	0.36	5
	3	2.07	−0.30	0.16	−1.18	0.21	0.17	0.18	6
	4	2.61	−0.08	0.41	−1.87	0.29	3.84	11.69*	7
	6	0.87	0.06	0.02	0.20	0.01	0.01	0.01	5
	7	3.41	−0.40	−0.87	−0.86	0.44	0.77	0.29	5
Early in June	8	2.13	0.24	−0.13	−1.16	1.80	0.80	2.26	7
	10	1.29	0.22	−0.39	0.29	1.94	1.19	0.48	7
	11	1.73	−0.02	0.04	−0.68	0.0003	0.002	0.03	6
	12	−3.02	−0.11	0.41	2.80	0.51	11.68	17.02	6
	13	0.15	−0.16	0.28	0.10	3.46	50.12*	0.21	6
	15	1.73	−0.33	0.03	−0.57	0.75	0.01	0.17	7
	16	1.97	0.17	0.25	−0.73	5.07	33.04	8.58	5

Table 2 . — (Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
Early in June	17	0.28	−0.62	0.01	0.50	1.99	0.001	0.19	6
	18	0.68	−0.03	−0.38	1.02	0.17	1.28	2.74	7
	20	0.69	−0.73	−0.21	0.94	7.15	2.05	2.09	7
	21	2.25	−1.36	−0.36	−0.27	7.66	2.25	0.08	7
	22	0.93	−0.05	0.09	0.004	0.18	0.10	0.00005	7
Middle of June	1	6.69	0.004	−0.66	−5.24	0.001	10.13*	5.98	8
	3	−1.41	−0.38	0.14	2.97	0.75	0.13	0.65	8
	4	0.05	−0.19	0.02	1.24	0.56	0.02	0.51	8
	5	−5.04	−1.09	0.08	8.41	1.72	0.01	0.18	5
	6	2.57	−0.48	−0.04	−1.64	16.37*	0.36	1.73	8
	7	0.26	−1.19	0.15	1.17	2.26	0.16	0.04	7
	8	6.67	−0.60	−0.14	−6.82	23.05*	6.30	8.25	7
	9	0.12	−0.21	0.07	0.89	0.67	0.66	0.38	7
	10	0.49	−0.38	−0.02	0.89	4.95	0.24	1.59	7
	11	0.65	0.44	0.26	−1.17	3.40	0.38	0.83	7
	12	3.50	−0.32	0.13	−4.18	374.96**	64.15**	37.11**	7
	13	−1.37	−0.30	0.53	0.63	1.67	12.76*	0.11	8
	15	−0.16	−0.24	0.12	1.07	0.62	0.08	0.21	7
	16	−0.97	−0.51	0.04	3.16	1.27	0.05	0.85	7
	17	0.27	−0.47	−0.03	1.53	0.66	0.02	0.32	7
	20	0.0008	−0.07	0.04	1.00	1.26	0.26	2.94	6
	21	−1.30	−0.60	0.17	2.85	2.17	1.10	3.64	6
	22	−0.90	−0.43	−0.03	3.42	4.46	0.28	3.30	7
Late in June	2	1.54	−0.15	0.05	−0.32	72.60*	62.36*	101.25**	6
	12	3.99	0.23	0.10	−1.98	0.38	1.38	2.09	5
	13	1.80	−0.26	−0.13	−0.08	1.84	0.59	0.03	6
	22	1.37	−0.15	−0.002	−0.14	0.28	0.002	0.08	7
Early in July	2	0.62	0.04	0.56	−0.12	0.02	0.31	0.02	6
	7	2.81	−0.10	−0.29	−0.36	0.63	1.32	0.81	7
	8	1.26	−0.31	−0.13	−0.10	0.24	0.14	0.004	7
	10	1.09	−0.25	0.15	−0.003	15.89	11.58	0.0002	6
	11	3.44	−0.45	−0.08	−1.03	3.25	0.44	0.79	6
	12	1.11	−0.13	0.24	−0.13	0.18	0.03	0.02	6
	14	2.80	−0.18	−0.01	−0.87	1.36	0.003	6.47	7
	15	12.35	−1.21	0.14	−8.10	0.93	0.10	0.82	5
	16	3.30	0.18	−0.73	−0.08	0.01	0.19	0.002	5
	17	3.14	−0.04	−0.48	−0.48	0.19	0.26	0.64	7
	18	0.85	−0.25	−0.08	0.28	0.75	0.07	0.17	6
	20	1.39	0.20	−0.09	0.17	3.36	0.13	0.14	6
	22	0.15	−0.13	0.20	0.60	0.23	0.30	0.20	6
Middle of July	1	0.88	0.23	0.20	0.25	0.33	0.35	0.10	6
	2	1.60	−0.95	0.26	0.05	3.36	0.67	0.003	5
	3	−8.27	−0.62	0.37	5.32	415.10*	717.22*	260.27*	5
	4	2.68	0.07	0.94	−1.82	0.01	0.65	0.78	5
	6	−0.51	0.59	0.30	0.94	38.21	34.71	9.60	5
	8	0.46	0.44	0.19	0.91	0.10	0.16	0.35	6

Table 2. —(Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
Middle of July	9	1.04	0.31	0.07	0.34	0.21	0.04	0.08	5
	10	−1.59	−0.44	0.21	1.73	13303.71**	17991.70**	6596.08**	5
	11	9.73	−1.02	−1.60	−0.93	17.73	30.20*	3.26	6
	12	13.66	−3.31	−4.08	−1.54	6.64	7.94	3.83	6
	14	1.35	−0.27	−0.12	0.34	2.07	0.13	0.13	6
	15	0.25	0.03	0.34	0.38	0.003	1.09	0.09	5
	17	0.47	−0.27	0.31	0.12	5.93	17.01	0.06	5
	18	3.22	−0.40	0.22	−0.64	0.53	0.06	0.22	5
	20	−1.83	−1.27	1.66	0.15	4.11	3.88	0.04	5
	21	−0.17	−0.12	0.19	0.84	0.24	1.74	1.60	6
	22	1.29	−0.03	0.42	−0.80	0.62	15.54	11.41	6
Late in July	1	−0.78	−0.06	0.02	0.81	0.06	0.002	0.26	6
	2	1.87	−0.06	−0.32	−0.11	0.27	0.36	0.03	5
	3	0.84	−0.09	0.09	0.12	0.39	0.18	0.01	6
	4	0.79	−0.37	−0.06	0.38	0.71	0.04	0.04	5
	6	1.42	−0.30	0.20	−0.29	3.57	2.01	0.83	5
	7	1.16	−0.14	0.19	−0.02	0.36	1.28	0.0004	5
	8	−0.66	0.11	0.37	0.52	1.90	1.11	0.76	5
	9	2.38	−0.09	−0.02	−0.49	1.02	0.01	0.98	6
	10	19.65	0.13	−0.89	−7.32	0.69	0.94	0.41	5
	13	2.60	−0.09	0.20	−0.70	0.45	6.84	1.16	6
	14	5.46	−0.86	0.63	−2.31	450.59*	356.99*	86.00	5
	15	−2.32	−0.04	0.46	1.04	0.04	2.94	0.60	5
	16	4.34	−0.33	0.32	−1.60	36.35	58.21	21.42	5
	21	−3.86	−0.56	0.74	0.74	1207.57*	250.93*	4.42	5
	22	2.57	0.01	0.19	−0.62	0.00004	0.03	0.33	5
Early in Aug.	1	1.95	−0.35	−0.18	−0.16	4.17	1.70	0.36	6
	3	−0.10	0.15	0.03	0.76	1.67	0.02	1.65	7
	6	1.45	−0.17	−0.01	−0.18	0.28	0.002	0.09	7
	7	−2.13	−1.22	3.56	−2.01	22.41	43.00	8.34	5
	10	1.16	−0.02	−0.02	0.19	0.10	0.06	0.59	6
	11	7.75	−1.62	−1.70	3.55	87.37	42.17	47.91	5
	12	3.60	−0.52	0.07	−1.29	8.96	0.82	4.51	5
	14	1.55	−0.44	−0.15	−0.43	1.82	0.22	0.73	5
	16	1.57	0.26	0.98	−1.42	33.72	48.51	27.17	5
	17	1.95	−0.57	0.06	0.06	0.67	0.05	0.01	5
	19	−2.19	−0.05	0.16	1.66	0.93	5.45	20.26*	6
	20	0.47	−0.34	−0.28	1.31	8.70	11.88	5.98	6
Middle of Aug.	1	1.20	−0.03	−0.15	0.84	0.03	0.63	0.25	8
	2	−0.41	−0.50	0.05	2.02	5.08	0.40	2.37	7
	3	3.89	−0.20	−0.20	−2.30	2.05	0.93	3.83	7
	4	3.42	−0.36	−0.25	−1.63	5.92	1.46	0.49	7
	6	2.99	−0.25	−0.21	−1.00	0.78	0.59	0.15	7
	7	7.56	−0.41	−0.20	−5.84	2.65	1.78	3.85	7
	9	3.90	−0.74	−0.17	−2.67	1.83	2.17	1.02	7
	10	1.20	−0.29	−0.30	1.05	9.63	10.95*	2.42	7

Table 2 . — (Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
Middle of Aug.	11	3.77	−0.19	−0.35	−1.92	0.84	3.30	1.50	7
	12	2.12	−0.43	0.19	−1.61	1.87	2.06	2.54	7
	13	0.57	−0.41	−0.46	2.83	15.80	23.94*	35.68*	6
	14	2.32	−0.27	−0.06	−0.81	4.53	0.41	0.41	7
	15	2.27	−0.31	−0.01	−1.13	2.60	0.01	0.17	6
	16	2.19	−0.41	0.08	−0.97	5.74	5.41	1.24	7
	17	−1.85	−0.07	0.21	2.99	0.01	0.11	0.56	6
	20	3.01	−0.94	−0.35	−0.82	0.65	0.97	0.02	6
	21	0.76	−0.40	−0.56	1.84	3.10	4.92	0.56	6
	22	1.00	−0.16	−0.25	1.54	0.03	0.20	0.08	6
Late in Aug.	1	−0.94	−0.03	0.12	1.28	0.17	1.40	2.96	7
	2	−1.64	−0.23	−0.25	6.50	0.76	20.74*	2.89	6
	4	2.02	−0.23	0.13	−1.59	2.95	1.61	1.83	7
	6	−4.22	0.81	0.14	4.39	12.49	2.24	11.04	5
	7	4.61	0.16	−0.04	−2.64	4.12	1.10	21.35*	6
	8	0.78	−0.19	0.34	−1.72	0.49	6.01	1.01	6
	9	−0.11	0.71	−0.02	1.92	1.95	0.01	2.29	6
	10	7.65	−0.08	−0.11	−3.14	0.92	80.02	35.69	5
	11	−2.31	−1.09	0.37	−0.44	0.43	0.27	0.01	6
	12	6.43	0.23	0.31	−6.01	0.69	5.03	3.04	5
	13	0.83	−0.51	−0.25	1.21	2.69	4.41	0.74	5
	14	11.29	−0.37	−0.08	−9.05	20.60	0.25	232.51*	5
	15	2.39	−0.87	0.24	−1.36	1.88	2.81	0.74	5
	16	1.31	0.09	−0.54	1.53	0.32	74.13*	18.45	6
	17	1.09	−0.11	−0.05	0.47	0.25	0.19	0.04	5
	19	3.22	1.19	0.18	−3.22	0.27	0.39	0.59	6
	20	6.04	−1.10	−0.23	−2.93	1.84	1.01	0.39	6
	22	2.92	−0.14	−0.17	−0.79	0.02	0.06	0.03	5
Early in Sept.	1	0.65	−0.02	0.13	−0.10	0.04	1.64	0.05	7
	2	2.35	−0.63	−0.18	−0.15	6.34	0.26	0.02	6
	3	0.17	−0.18	0.05	1.05	0.99	0.03	0.73	6
	4	0.29	−0.08	−0.11	0.87	0.39	3.81	1.57	6
	6	0.41	−0.08	0.03	0.71	0.17	0.04	0.19	7
	7	−1.56	−0.29	0.06	3.57	4.34	0.24	26.11*	6
	8	−0.95	−0.88	0.08	3.03	1.29	0.08	0.63	6
	9	−1.74	0.15	0.36	2.08	0.04	0.49	1.55	5
	10	−0.69	−0.003	0.78	−0.49	0.0004	5.74	0.24	7
	11	1.85	−0.12	−0.06	−0.87	0.77	0.06	0.59	7
	12	0.67	−0.15	−0.12	0.78	0.21	1.28	0.97	7
	13	0.34	−0.21	0.26	0.04	0.16	0.32	0.0004	6
	14	−4.40	−2.49	−0.55	5.45	2.04	1.40	4.98	6
	15	−2.77	1.29	−0.96	8.57	2.11	1.25	2.23	6
	16	1.27	−0.56	0.01	0.37	0.28	0.0001	0.01	5
	20	3.64	−0.23	−0.40	−0.85	0.74	2.60	0.71	7
	21	2.17	1.06	−1.58	1.50	3.51	5.38	1.31	6
	22	2.00	0.25	−0.02	−0.44	0.64	0.02	0.17	7

Table 2. — (Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
Middle of Sept.	3	1.04	−0.26	−0.08	0.66	0.33	0.13	0.55	5
	6	1.09	0.19	0.35	−0.61	0.12	0.57	3.47	5
	7	0.16	0.02	−0.06	0.38	0.01	0.15	0.96	6
	9	0.49	−0.15	−0.20	0.53	1.93	4.52	18.46	6
	10	1.85	0.23	0.18	−0.89	1.90	3.56	5.31	5
	12	0.80	−0.23	0.01	0.21	4.02	0.01	0.85	5
	14	1.15	−0.55	−0.11	0.04	32.86	1.70	0.07	5
	19	1.40	−0.20	−0.01	−0.25	3.11	0.01	0.65	6

Note:
The variables are defined in Table 1.
F_i……Snedecor's F value for a_i with 1 and $(n-4)$ degrees of freedom
* significant at 0.05 level ** significant at 0.01 level

$\Pr\{\chi_0^2 > \chi^2\} > 0.05$) or according to the seiner ($\chi_0^2 = 22.42$, with 21 degrees of freedom; $0.50 > \Pr\{\chi_0^2 > \chi^2\} > 0.30$).

The coefficient of the deviation of catch, a_3, was significantly positive in the five strata, insignificantly positive in the 91 ones, but insignificantly negative in the 87 ones, and significantly negative in the six ones. These facts meant that the deviation of catch had no influence on the distance of shift. The rate of the strata taking the positive a_3 did not show any difference according to the date ($\chi_0^2 = 19.83$, with 13 degrees of freedom; $0.10 > \Pr\{\chi_0^2 > \chi^2\} > 0.05$) or according to the seiner ($\chi_0^2 = 17.86$, with 21 degrees of freedom; $0.75 > \Pr\{\chi_0^2 > \chi^2\} > 0.50$).

2. The estimated multiple linear regression equations after the twofold stratification of the records according to the month and the seiner

The examinations in the preceding section revealed that the seiner inclined to shift over a long distance after a poor catch or after the shooting at the position distant from the center of catch. But these trends were rough, probably because of the insufficient sample size used for estimation of respective equations. Accordingly, the records were stratified according to the month and the seiner (i.e. pooling those on the days in the same month), and the same relations were examined again. But the results were similar to those in the preceding section.

The coefficient of the difference of catch, a_1, was significantly positive in the three strata (the groups of the records by a seiner in a month) out of the 104 ones, insignificantly positive in the 16 ones, but insignificantly negative in the 71 ones, and significantly negative in the 14 ones. And the rate of the strata taking the positive a_1 did not show any difference according to the month ($\chi_0^2 = 2.95$, with 5 degrees of freedom; $0.80 > \Pr\{\chi_0^2 > \chi^2\} > 0.70$) or according to the seiner ($\chi_0^2 = 26.80$, with 21 degrees of freedom; $0.20 > \Pr\{\chi_0^2 > \chi^2\} > 0.10$).

The coefficient of the distance from the center of catch, a_2, was significantly positive in the 10 strata, insignificantly positive in the 61 ones, but insignificantly negative in the

Table 3. The estimated multiple linear regression equations after the twofold stratification of the records according to the month and the seiner.

$$\sqrt{y} = a_0 + a_1 x_1 + a_2 \sqrt{x_2} + a_3 x_3$$

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
May	1	0.63	−0.12	0.30	0.11	0.91	4.40	0.22	12
	2	0.97	0.06	0.16	0.04	0.09	4.62	0.04	16
	3	0.89	0.11	0.20	0.02	1.84	9.30*	0.06	14
	4	1.37	−0.20	−0.07	0.48	1.67	0.26	0.92	10
	5	0.95	−0.14	0.03	0.24	0.71	0.04	0.40	11
	6	0.92	0.18	0.42	−0.60	0.70	9.36	3.44	7
	7	1.26	−0.03	0.12	−0.004	0.09	0.76	0.0005	15
	8	0.24	1.13	0.32	0.37	2.65	2.36	1.82	9
	10	0.91	0.30	0.06	−0.04	9.73*	0.69	0.15	16
	11	0.75	−0.004	0.03	0.33	0.001	0.10	1.73	12
	12	1.41	−0.04	−0.03	0.11	0.28	0.23	0.63	14
	13	1.10	−0.26	0.13	−0.02	8.42*	6.32*	0.04	13
	15	0.73	−0.08	0.12	−0.03	0.39	3.11	0.05	14
	16	1.09	−0.13	0.26	−0.14	1.33	4.27	0.66	12
	17	0.70	−0.12	0.19	0.19	2.18	7.03	0.69	8
	18	1.62	−0.23	0.05	−0.02	0.61	0.22	0.004	7
	19	0.83	−0.12	0.21	0.02	2.75	8.58*	0.01	9
	20	1.29	−0.36	0.07	−0.17	5.89*	0.54	0.40	13
	21	1.47	−0.12	−0.05	0.09	2.17	0.34	0.86	10
	22	1.38	−0.16	0.09	−0.16	0.78	0.47	1.38	12
June	1	1.08	−0.15	0.09	−0.15	0.86	0.21	0.14	19
	2	1.42	−0.30	0.02	−0.25	6.40*	0.33	0.90	14
	3	1.29	−0.25	0.005	−0.19	2.19	0.001	0.23	18
	4	0.80	−0.15	0.31	−0.24	0.57	2.62	0.23	19
	5	0.88	−0.34	0.16	0.12	2.00	1.28	0.10	11
	6	0.86	−0.48	0.06	0.24	7.18*	0.59	0.20	16
	7	3.26	−0.13	−0.26	−1.38	0.36	2.24	2.67	16
	8	2.12	0.18	−0.01	−1.08	0.86	0.02	3.06	18
	9	0.25	−0.06	0.10	0.45	0.07	1.61	0.83	11
	10	1.03	−0.08	0.01	0.05	2.06	0.14	0.17	18
	11	0.90	−0.07	−0.07	0.44	0.50	0.57	1.58	17
	12	0.79	−0.10	0.05	0.37	1.23	2.78	0.90	18
	13	0.18	−0.43	0.25	0.01	12.10**	8.78**	0.001	20
	15	0.71	−0.08	0.11	0.22	0.15	1.14	0.38	18
	16	1.61	−0.23	−0.06	−0.11	2.34	0.47	0.20	15
	17	−0.31	0.08	0.38	1.00	0.10	9.99**	2.16	17
	18	4.28	−0.30	0.03	−2.47	1.44	0.02	2.69	11
	20	−0.17	−0.30	0.14	1.05	2.02	0.98	4.42	16
	21	0.48	−0.24	0.07	0.87	1.78	0.53	1.37	16
	22	1.47	−0.16	0.01	−0.25	2.36	0.10	1.57	21
July	1	1.37	−0.10	−0.03	0.05	1.23	0.07	0.04	15
	2	1.90	−0.13	0.22	−0.26	3.20	1.90	0.97	16
	3	2.25	−0.10	0.11	−0.42	5.21*	3.98	2.49	15

Table 3 . —(Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
July	4	1.64	−0.27	0.02	−0.05	5.35*	0.04	0.02	13
	5	2.59	−0.22	0.27	−0.94	4.62	2.89	2.17	6
	6	0.03	0.42	0.41	0.19	11.04**	32.46**	0.71	13
	7	1.69	−0.06	0.10	−0.18	0.51	1.37	0.41	15
	8	1.25	0.02	0.12	−0.09	0.04	1.07	0.05	18
	9	1.62	−0.02	−0.06	−0.04	0.08	0.42	0.04	15
	10	2.37	−0.04	0.06	−0.48	0.34	0.57	1.39	16
	11	3.11	−0.16	−0.19	−0.54	0.99	2.59	0.96	16
	12	1.13	−0.10	0.14	0.06	0.67	1.41	0.02	16
	13	2.23	−0.08	0.18	−0.49	2.62	14.83**	3.80	13
	14	1.61	−0.24	0.19	−0.36	8.89**	4.42	1.18	18
	15	0.44	−0.12	0.36	−0.01	1.06	8.38*	0.001	15
	16	0.63	−0.06	0.06	0.33	0.46	0.42	1.69	14
	17	1.72	−0.11	0.18	−0.35	2.24	8.14*	2.03	16
	18	2.92	0.01	−0.28	−0.49	0.004	0.82	0.66	12
	20	1.63	−0.003	0.004	−0.06	0.0004	0.0003	0.02	15
	21	0.81	−0.03	0.23	0.08	0.11	3.90	0.03	14
	22	0.90	−0.04	0.18	−0.004	0.24	2.16	0.0002	17
Aug.	1	2.10	−0.18	−0.17	−0.22	5.66*	5.37*	1.19	21
	2	1.70	0.28	0.01	−0.40	0.77	0.06	0.40	16
	3	1.54	−0.02	−0.10	−0.001	0.04	3.64	0.00001	18
	4	0.77	−0.21	0.05	0.25	2.56	0.15	0.26	18
	6	1.94	−0.07	−0.03	−0.31	0.34	0.17	1.07	19
	7	1.16	0.02	0.003	0.22	0.04	0.001	0.30	18
	8	−0.47	−0.06	0.17	0.66	0.09	4.18	0.93	12
	9	0.47	0.06	−0.01	0.90	0.09	0.02	5.76*	17
	10	1.81	−0.001	0.01	−0.13	0.0001	0.05	0.10	18
	11	0.46	−0.37	0.03	0.57	4.54	0.26	0.97	18
	12	1.36	−0.18	0.08	−0.21	1.10	0.93	0.29	17
	13	3.06	−0.19	−0.31	−0.47	1.45	3.07	0.88	14
	14	2.19	−0.29	−0.03	−0.76	10.04**	0.16	6.05*	17
	15	0.94	−0.31	0.03	0.30	9.58*	0.11	0.42	14
	16	1.49	−0.02	0.04	−0.26	0.01	0.53	0.37	18
	17	1.60	−0.30	−0.04	0.05	6.73*	1.45	0.03	16
	19	−0.52	−0.07	0.20	0.70	0.20	3.22	0.91	12
	20	1.63	−0.28	−0.07	0.08	3.13	1.10	0.03	18
	21	1.14	−0.12	−0.13	0.48	0.47	2.49	2.69	13
	22	2.20	−0.05	−0.06	−0.56	0.08	0.15	1.15	14
Sept.	1	0.90	−0.002	0.10	−0.24	0.0004	3.27	0.31	9
	2	1.53	−0.62	−0.07	0.32	11.14*	4.28	0.65	8
	3	1.09	−0.23	−0.08	0.65	2.33	1.13	4.83	11
	4	0.77	−0.11	−0.05	0.17	3.56	1.97	0.56	8
	6	1.77	−0.19	−0.04	−0.52	3.48	0.40	8.17*	12
	7	1.28	0.13	0.02	−0.15	0.26	0.03	0.25	12
	8	1.50	−0.23	0.16	−0.42	0.33	0.51	0.06	8
	9	0.02	0.16	0.27	0.23	0.37	2.14	0.69	11

Table 3. — (Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
Sept.	10	1.26	−0.09	0.06	−0.24	0.40	0.29	0.60	12
	11	0.96	−0.19	−0.06	0.02	3.90	0.72	0.004	11
	12	0.93	−0.24	−0.05	0.23	4.27	0.73	2.10	12
	13	1.53	−0.04	−0.08	0.22	0.47	0.49	0.95	10
	14	0.96	−0.49	0.003	0.04	6.40*	0.001	0.01	11
	15	0.53	0.002	0.12	0.35	0.0002	0.72	0.63	10
	16	0.97	−0.30	0.18	−0.09	1.58	1.12	0.02	9
	17	1.36	0.07	−0.17	0.23	0.14	1.14	0.22	7
	19	1.40	−0.20	−0.01	−0.25	3.11	0.01	0.65	6
	20	0.39	−0.04	−0.37	2.84	0.10	8.36*	7.25*	11
	21	1.63	0.001	−0.28	−0.11	0.00001	0.70	0.01	9
	22	1.32	−0.04	0.06	−0.19	0.07	0.37	0.16	10

Note:

F_i.....The estimated Snedecor's F for a_i with 1 and $(n-4)$ degrees of freedom

*significant at 0.05 level **significant at 0.01 level

31 ones, and significantly negative in the two ones. The rate of the strata taking the positive a_2 did not show any difference according to the seiner ($\chi_0^2 = 13.22$, with 21 degrees of freedom; $0.95 > \Pr\{\chi_0^2 > \chi^2\} > 0.90$). The rate differed according to the month ($\chi_0^2 = 13.50$, with 5 degrees of freedom; $0.02 > \Pr\{\chi_0^2 > \chi^2\} > 0.01$), but it was hard to find its change in accordance with the passing of season (The Snedecor's F values of the i-th order coefficient of the i-th order regression equation of the rate—after the arc sine transformation—on the number of the month counted from April were as follows: $F_3 = 1.71$, $F_2 = 7.01$, and $F_1 = 2.93$, with 1 and n-i-1 degrees of freedom n = 6).

The coefficient of the deviation of catch, a_3, was significantly positive in the two strata, insignificantly positive in the 48 ones, but insignificantly negative in the 52 ones, and significantly negative in the two ones. The rate of the strata taking the positive a_3 did not show any difference according to the month ($\chi_0^2 = 6.65$, with 5 degrees of freedom; $0.30 > \Pr\{\chi_0^2 > \chi^2\} > 0.20$) or according to the seiner ($\chi_0^2 = 24.21$, with 21 degrees of freedom; $0.30 > \Pr\{\chi_0^2 > \chi^2\} > 0.20$).

3. The estimated multiple linear regression equations after the stratification of the records according to the date

The difficulty in finding out significant regression may be due either to the independence of the distance of shift on x_1, x_2, and x_3 or to the insufficient sample size used for estimation of respective equations. As it was hard to find any significant seiner-by-seiner difference in the rate of the strata taking the positive coefficient (either a_1, a_2, or a_3) in the examinations of the preceding sections, the records on the same days were pooled neglecting of the difference of the seiner, and the same relations were examined. Then, the trend found out in the preceding two sections became

clearer. The coefficient of the difference of catch, a_1, was insignificantly negative in the five strata (the groups of the records on the same day) out of the 15 ones, and significantly negative in the 10 ones. The coefficient of the distance from the center of catch, a_2, was significantly positive in the four strata, insignificantly positive in the nine ones, but insignificantly negative in the two ones. The coefficient of the deviation of catch, a_3, was significantly positive in one of the strata, insignificantly positive in the five ones, but insignificantly negative in the nine ones.

Table 4. The estimated linear regression equations after stratificaition of the records according to the date.

$$\sqrt{y} = a_0 + a_1 x_1 + a_2 \sqrt{x_2} + a_3 x_3$$

		a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
April	late	1.38	−0.003	−0.04	0.10	0.02	0.87	0.59	68
May	early	1.09	−0.06	0.07	0.03	3.83	2.78	0.27	50
	middle	1.20	−0.14	0.08	−0.01	19.07**	13.91**	0.002	105
	late	1.63	−0.23	0.05	−0.39	10.95**	2.79	2.54	86
June	early	1.08	−0.13	0.10	−0.10	13.96**	7.47**	0.31	116
	middle	0.55	−0.35	0.02	0.76	42.21**	1.49	2.07	130
	late	1.86	−0.05	0.01	−0.23	1.09	0.36	3.47	90
July	early	1.41	−0.06	0.07	−0.09	4.19*	3.63	0.52	109
	middle	1.36	−0.08	0.12	0.02	3.95*	8.85**	0.02	105
	late	1.53	−0.09	0.11	−0.15	21.64**	22.04**	1.02	98
Aug.	early	1.47	−0.09	0.01	−0.06	5.92*	0.05	0.15	98
	middle	1.86	−0.21	−0.03	−0.47	25.63**	1.51	1.94	125
	late	1.66	−0.04	0.03	−0.36	0.32	2.43	0.66	109
Sept.	early	0.48	−0.09	0.06	0.66	2.95	2.90	5.76*	117
	middle	0.91	−0.10	0.02	0.12	8.70**	1.31	1.01	86

Note:

F_i……The estimated Snedecor's F for a_i with 1 and $(n-4)$ degrees of freedom

* significant at 0.05 level ** significant at 0.01 level

All the results of these three sections may be summarized into as follows: Among the three factors examined, the difference of the amount of catch from the average was the factor having the clearest influence on the distance of shift. And the seiner inclined to shift over a long distance after a poor catch but only a short distance after a good catch. The distance from the center of catch was the factor next to the catch difference in respect of the influence on the distance of shift. The seiners fished at a distant point from the center inclined to shift over a long distance but those fished near the center inclined to shift only a short distance. But it was hard to find any clear trend of the influence of the deviation of catch.

Discussion

The clearest finding in the preceding three reports was the trend of the seiner shifted over a long distance after a poor catch but sticked to the similar position after a good catch. The present report revealed the similar trend. But the exact meanings of the results were somewhat different. The basic difference was in the variables used in these reports. The trend found in the preceding reports was deduced from the regression of the distance of shift on the amount of catch by the shooting just before it. And the catch and the distance of shift used in these reports were naturally those of the same seiner, even when the records of the different seiners were pooled in the estimation. The trend found in the present report was deduced from the regression of the former on the difference of the amount of catch by the preceding shooting from the average of catch estimated from the records of all the members of the fleet supplied within two hours before the decision of shooting. And the importance of the catch by the preceding shooting of the seiner under consideration (the seiner whose shift was used as the dependent variable) was usually only the one twentieth. One of the principal aims of the present report was to examine the role of the informations from the fellow seiners in determining the position of shooting the gear, but the relation to the factors estimated from the informations directly not taken into consideration in the preceding reports. These differences in the bases of the examinations in the present report from those of the preceding ones were taken into consideration, and the results of the present report and those of the preceding ones may be concluded as follows: the seiner inclined to shift over a long distance after the shooting of poorer catch either than that of the fellow seiners just before determining the position of shooting or than that of the other shootings by the same seiner.

The preceding reports did not concern with the influence of the distance from the center of catch and that of the deviation of catch. The present report revealed that the seiner fished distant from the center of catch inclined to shift over a long distance. This finding and those of the present report relating to the difference of catch from the average suggested that it should be hard to neglect the role of the informations from the fellow seiners in determining the position of shooting the gear. In spite of this suggestion, the present report dealt with the distance of shift, but did not deal with the problem whether the seiner would incline to approach to the center of catch or not. If the informations play an important role in the determination of the position of shooting, the seiner has to shift towards the center of catch. To evaluate the importance of the informations, accordingly, it is necessary to examine whether the seiner should approach to the center of catch or not.

It is probable that the influence of the difference of catch from the average may be serious but that of the distance from the center of catch may be less serious when the deviation of catch was small. This probable difference in the influence of the other factors was eliminated from the results of the influence of the above-mentioned two

factors, for the standard deviation of the catch was adopted as one of the independent variables in the multiple linear regression equations. The regression of the distance of shift on the standard deviation of catch was examined in the present report, but it was hard to find any clear relation between them. This fact meant that the distance of shift did not show any difference according to the standard deviation, when the shift after the shootings at the positions same distance apart from the center of catch and yielded the catch of the same difference from the floating average were compared with one another. But attention should be paid to the fact that the above-mentioned difficulty in finding out any clear relation to the standard deviation does never deny the probable difference in the influence of the catch difference and of the distance from the center according to the deviation of catch.

Conclusion

All the results of the examinations and discussion were summarized, and it may be concluded as follows: The seiner inclined to shift over a long distance after poorer catch but only a short distance after better catch either than the average of catch by the shootings within two hours before the determination of the position of shooting or than that by the preceding shooting of the same seiner. And the seiner fished near the center of catch inclined to shift only a short distance but that fished distant from the center inclined to shift over a long distance. These facts suggested the possibility of the informations used as the important bases of determining the position of the succeeding shooting. And this possibility should be examined in the succeeding report.

Summary

The popularization of wireless telephone and telegraph on fishing boats makes it possible to determine the fishing position basing on abundant informations from the fellow boats. For the purpose of examining the possibility of the information used as the important bases of determining the fishing position, the records on respective shootings on 15 days were chosen randomly from all the catch records during the entire season of 1964 by the 22 Danish seiner consisting of a fleet for the Alaska pollack along the outer edge of the continental shelf of the Eastern Bering Sea. And the average, standard deviation (x_3), and the center of catch just before respective shootings were estimated from these records. Then the difference of catch by respective shootings from the floating average (x_1) and the distance of the position of shooting from the center of catch (x_2) were estimated. And the multiple linear regression equations of distance of shift (y) on x_1, x_2, and x_3 were estimated, and the following results were obtained:

1. When the records were stratified according to the date and the seiner, the coefficient of the difference of catch from the average of catch by the fellow seiners, a_1, was negative in the three fourths of the strata, although only the one twentieth was significant. The coefficient of the distance from the center of catch, a_2, was positive in a little more than a half of the strata, although only the one twentieth was significant. The coefficient of the standard deviation of catch, a_3, was negative in a half of the strata.

2. When the records on the three days in the same month were pooled, the above-mentioned trends became clearer. Namely, a_1 was negative in the four fifths of the strata, a_2 was positive in 70% of the strata, but a_3 was negative in a half of the strata.

3. When the records on the same days were pooled neglecting of the difference of the seiner, all the a_1 became negative including the significant one in the two thirds of the strata, a_2 was positive in the 13 ones including the significant one in the four strata out of the 15 ones, but a_3 was negative in only a little more than a half of the strata.

4. These facts meant that the seiner inclined to shift over a long distance after poorer catch but only a short distance after better catch either than that by the other shooting of the same seiner or than the average of catch by the fellow seiners within two hours before the shooting. And the seiner fished near the center of catch shifted only a short distance but that fished distant from it inclined to shift over a long distance.

5. These trends suggested the possibility of the informations from the fellow seiners used as the bases of determining the position of the next shootings.

References

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