The Journal of the Shimonoseki University of Fisheries 24(3)321—336(1976)

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

The Role of the Information from the Fellow Seiners in Determining the Position of Shooting the Gear

By

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The second report[2] revealed that the Danish seiners of the fleet type Alaska pollack fishing in the Eastern Bering Sea inclined to shift over a long distance after a poor catch but to stick to the similar position after a good catch. The fourth report[4] revealed that the seiner inclined to shift over a long distance when the catch was poorer than the average of catch within two hours before the next shooting or when she fished distant from the center of catch estimated from the informations from the fellow seiners supplied within two hours before the shooting, but she inclined to shift only a short distance when the catch was better or when she fished near the center of catch. These facts suggested a possibility of the informations from the fellow seiners used as the bases for determining the position of the next shooting. To confirm this possibility, however, it is necessary to sweep out a doubt as to the fact that the seiner would shift towards the center of catch. Examining through the multiple linear regression equations of the difference of the distance between the position of the shooting under consideration and the center of catch from that between the position of the preceding shooting and the latter on the three independent variables of the preceding report[4], it was found out that the seiner inclined to approach to the center of catch when she fished distant from the center, suggesting the role of the informations in determining the position of the next shooting. The details of the examinations were shown in the present report.

Material and Method

The same materials as those of the preceding reports[1)-4)] were used in the present

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*Contribution from the Shimonoseki University of Fisheries, No. 752.

Received Jan. 16, 1976.

report. They were the complete set of the telegrams during the entire season of 1964 from the 22 Danish seiners consisting of a fleet fished the Alaska pollack along the outer edge of the continental shelf of the Eastern Bering Sea. The telegrams on the 15 days were chosen randomly from those in each of the 15 10-calendar-day intervals. The same set of the independent variables used in the preceding report were estimated from these telegrams. They were the difference of catch (x_1) from the average of catch within two hours before the i-th shooting, the distance of the position of the (i-1)-th shooting (x_2) from the center of catch, and the standard deviation of catch by a shooting (x_3). The distance of shift was used in the preceding report as the dependent variable; but y', i.e. $(d_2 - d_1)$, was used in the present report, where d_1 was the distance of the position of the (i-1)-th shooting from the center just before the start of the i-th shooting and d_2 was that of the i-th shooting from the center, for the purpose of finding out whether the seiner would incline to approach to the center of catch or not. And the multiple linear regressions of y' on x_1, x_2, and x_3 were estimated either stratifying the records according to the date and the seiner, according to the month and the seiner, or according to the date.

Results

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

A set of the variables on June 17 by the seiner No. 12 for estimating a multiple linear regression equation was shown in Table 1 for the easy explanation of the variables. As shown in Table 2, the coefficient of the difference of catch from the average, a_1, was significantly positive in the four strata (the groups of the records on a day by a seiner) out of the 189 ones, insignificantly positive in the 97 ones, but insignificantly negative in the 84 ones, and significantly negative in the four ones. The rate of the strata taking the positive a_1 did not show any significant difference according to the date ($\chi_0^2 = 4.82$, with 13 degrees of freedom; $0.98 > \Pr\{\chi_0^2 > \chi^2\} > 0.95$) or according to the seiner ($\chi_0^2 = 17.38$, with 21 degrees of freedom; $0.70 > \Pr\{\chi_0^2 > \chi^2\} > 0.50$). The coefficient of the distance from the center of catch, a_2, was significantly positive in one of the strata, insignificantly positive in the 27 ones, but insignificantly negative in the 146 ones, and significantly negative in the 15 ones. These facts meant that the seiner fished distant from the center of catch inclined to approach to the center. Here attention should be paid to the following point: this fact does never mean that the seiner shifted to the fixed point, because the center of catch was estimated from the records within two hours before respective shootings and the estimated center shifted according to passing of hour. The rate of the strata taking the positive a_2 did not show any significant difference according to the date ($\chi_0^2 = 18.86$, with 13 degrees of freedom; $0.20 > \Pr\{\chi_0^2 > \chi^2\} > 0.10$) or according to the seiner ($\chi_0^2 = 17.14$, with 21 degrees of freedom; $0.80 > \Pr\{\chi_0^2 > \chi^2\} > 0.70$). The coefficient of deviation of catch, a_3, was

Table 1. An example of a set of the variables for estimating the 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	$\bar{x}$	$x_1(=x-\bar{x})$	$x_2(=d_1)$	$x_3(=\sigma)$	d_2	$y(=d_2-d_1)$
2	4 : 57	2 :57— 4 :56	15	1	1.67	−0.67	4.98	0.70	3.77	−1.21
3	6 : 52	4 :52— 6 :51	19	2	1.84	0.16	4.71	0.74	5.67	0.96
4	8 : 36	6 :36— 8 :35	20	2	1.90	0.10	5.28	0.70	6.60	1.32
5	10 : 30	8 :30—10:29	22	1	2.05	−1.05	7.68	0.71	7.58	−0.10
6	12 : 22	10:22—12:21	21	1	1.95	−0.95	7.99	0.79	6.02	−1.97
7	14 : 13	12:13—14:12	17	4	2.24	1.76	7.08	0.73	6.43	−0.65
8	16 : 04	14:04—16:03	21	4	2.29	1.71	5.16	0.70	4.96	−0.20

Note:

Number of shootings in the time range:... To count the number of shootings in the time renge, 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

d_2 ·········The distance of the position of the i-th shooting from the center of catch

d_2 for the (i-1)-th shooting is not always the same as d_1 of the i-th shooting, for the center of catch was estimated from the records within two hours before the shooting and shifted with the passing of hour.

significantly positive in the two strata, insignificantly positive in the 93 ones, but insignificantly negative in the 89 ones,and significantly negative in the five ones. The rate of the strata taking the positive a_3 differed according to the date ($\chi_0^2 = 26.47$, with 13 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 in the i-th order regression equation of the rate—after the arc sine transformation—on the number of the 10-calendar-day intervals counted from late in April were as follows: $F_3 = 1.99$, $F_2 = 1.01$, and $F_1 = 2.76$, with 1 and n-i-1 degrees of freedom; $n = 14$]. The rate did not show any significant seiner-by-seiner difference, ($\chi_0^2 = 16.96$, with 21 degrees of freedom; $0.80 > \Pr\{\chi_0^2 > \chi^2\} > 0.70$).

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

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

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
Late in April	4	−18.77	0.43	− 2.55	10.09	6.35	17.17	7.76	5
	8	− 4.25	0.03	− 0.10	1.34	0.18	0.15	3.13	5
	21	2.69	− 0.26	− 0.66	− 0.09	1.55	0.68	0.02	5
Middle of May	1	4.50	−1.41	−0.56	−2.21	0.65	0.84	0.27	6
	2	1.19	0.52	−0.43	−0.46	1.02	0.93	0.60	6
	3	1.58	−0.06	−0.97	−0.004	0.01	1.16	0.000004	6
	4	3.79	−0.37	0.02	−2.21	0.55	0.001	0.53	5
	5	4.98	−0.12	−0.27	−2.47	0.04	0.19	1.59	6
	7	5.67	−0.23	−0.39	−2.36	0.11	0.23	0.17	6
	9	13.22	3.60	−1.43	−1.36	73.70	112.06	2.69	5
	10	2.91	−0.54	−0.60	−1.22	0.17	1.32	0.22	6
	11	3.34	−0.81	−0.42	−2.63	0.92	1.08	1.26	6
	12	8.19	1.69	−0.52	−3.33	0.17	0.23	1.59	5
	13	11.56	0.90	−0.45	−6.70	0.82	0.83	2.65	5
	15	4.73	0.70	−0.25	−3.05	0.44	0.25	1.08	6
	16	1.42	0.20	−0.66	−0.11	97.34	1522.17*	2.72	5
	17	4.44	1.31	−1.36	0.34	2.61	3.56	0.01	6
	18	7.99	0.21	−1.04	−3.28	0.06	3.28	1.18	5
	19	3.74	0.37	−0.40	−1.83	0.13	0.15	0.08	5
	20	−14.24	1.39	−0.45	9.02	3.53	0.37	2.35	6
Late in May	2	10.52	−0.03	−1.43	− 3.38	0.0002	3.94	0.26	7
	3	−0.40	1.90	0.25	−1.33	1.53	0.87	0.11	6
	4	−1.26	−1.94	− 1.42	6.67	0.81	0.57	1.53	5
	5	3.36	−1.66	−0.11	−4.73	8.10	0.46	5.39	5
	7	−0.23	1.62	−0.05	2.34	0.50	0.002	0.16	6
	8	5.18	−1.92	−0.85	−2.96	2.87	7.91	1.72	6
	10	0.93	0.03	−0.39	0.68	0.02	7.32	0.32	6
	12	−4.24	3.34	−1.44	12.72	0.30	0.98	1.59	5
	13	56.71	−7.69	−13.91	−53.80	12.41	12.10	9.81	5
	20	6.40	−0.25	−0.54	−5.68	0.11	2.06	5.94	5
Early in June	1	1.74	−0.17	−1.18	0.71	0.14	3.75	0.12	7
	2	6.66	0.28	−0.86	−5.14	4.15	55.20	139.80	5
	3	−5.28	1.10	−1.05	7.15	3.23	8.42	7.41	6
	4	2.52	−0.11	−0.76	−1.02	0.07	1.78	0.46	7
	6	−1.51	0.38	−0.11	2.50	0.03	0.02	0.24	5
	7	1.41	−0.42	−1.22	0.24	64.26	201.82*	3.02	5
	8	1.10	0.34	−0.14	−0.86	3.35	0.87	1.18	7
	10	1.15	0.50	−1.10	1.18	3.17	3.06	2.65	7
	11	0.23	0.90	−0.60	1.16	0.35	0.24	0.07	6
	12	7.25	0.75	−1.26	−2.94	0.73	3.27	0.56	6
	13	7.09	0.32	−1.23	−3.34	0.16	10.83	2.75	6
	15	2.73	−0.28	−0.55	−1.04	0.10	0.45	0.10	7
	16	12.46	0.92	−0.98	−8.44	157.39	525.11*	1151.26*	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	0.38	−0.74	−0.10	−0.24	1.61	0.11	0.02	6
	18	−3.66	0.35	−0.97	4.56	0.97	0.44	2.92	7
	20	5.25	0.27	−0.67	−3.40	0.16	3.44	4.57	7
	21	10.08	−3.50	−2.45	−4.97	17.04 *	34.73 **	9.15	7
	22	−2.37	−0.25	0.45	2.00	1.26	0.59	2.61	7
Middle of June	1	−3.24	0.08	−0.43	6.31	0.05	0.58	1.17	8
	3	5.34	0.003	−0.76	−4.21	0.00003	1.97	0.66	8
	4	3.29	−0.91	−0.12	−4.44	5.77	0.24	3.06	8
	5	19.92	0.31	−2.41	−14.07	0.13	9.29	0.47	5
	6	2.71	−0.58	0.39	−5.47	0.51	0.68	0.40	8
	7	−0.21	−0.86	−0.42	4.28	0.33	0.35	0.14	7
	8	−3.19	0.10	−0.71	9.98	0.04	9.06	1.03	7
	9	1.81	−0.58	−0.49	0.97	0.88	6.24	0.08	7
	10	0.19	−1.34	−0.35	1.88	1.43	2.20	0.17	7
	11	3.59	−0.34	−1.55	3.68	0.72	4.39	2.76	7
	12	8.56	0.04	−0.32	−9.50	0.01	0.47	0.23	7
	13	−1.64	0.02	−0.04	2.41	0.01	0.05	0.84	8
	15	1.83	0.04	−0.39	0.46	0.60	30.84 *	1.44	7
	16	−5.66	−1.77	−0.002	10.41	1.83	0.00001	1.11	7
	17	4.05	1.18	−0.44	−3.17	2.84	2.37	0.97	7
	20	1.91	−0.18	−0.27	−1.70	3.97	7.92	4.41	6
	21	2.85	2.15	−0.48	−3.71	11.04	3.39	2.41	6
	22	8.07	−1.66	−0.84	−6.04	1.91	3.97	0.30	7
Late in June	2	2.65	−0.61	0.13	−1.37	3.22	1.21	5.33	6
	12	18.73	3.40	0.42	−15.00	0.93	0.25	1.34	5
	13	1.17	0.01	−0.29	0.52	0.0001	0.10	0.04	6
	22	3.45	−0.36	−0.08	−1.56	0.33	0.34	2.23	7
Early in July	2	−0.13	0.35	1.01	−0.31	0.40	0.23	0.03	6
	7	5.56	−0.24	−0.94	−1.11	0.63	2.32	1.29	7
	8	6.71	0.94	−0.21	−2.29	0.38	0.07	0.31	7
	10	2.56	0.05	−1.21	−0.29	0.01	13.40	0.02	6
	11	4.99	−0.30	−0.31	−1.57	0.22	1.03	0.28	6
	12	−1.30	−0.22	0.69	0.59	0.06	0.03	0.06	6
	14	3.48	0.18	−0.64	−0.59	0.05	0.80	0.12	7
	15	7.62	0.51	−1.94	−0.22	4.44	554.79 *	0.02	5
	16	9.41	0.63	−2.80	−0.79	0.14	2.22	0.19	5
	17	−2.82	0.15	1.26	0.94	2.29	1.84	2.59	7
	18	−0.33	−0.76	−0.18	1.21	1.01	0.05	0.47	6
	20	−3.72	0.001	0.27	2.23	0.00001	0.62	13.33	6
	22	1.32	−0.07	−0.43	0.53	0.13	2.96	0.36	6
Middle of July	1	1.72	−0.15	−0.85	0.26	0.05	2.29	0.04	6
	2	4.48	−2.23	−0.46	−0.25	0.93	0.11	0.003	5
	3	−6.08	−0.17	−0.91	5.35	0.02	3.07	0.19	5
	4	8.15	0.96	1.66	−6.75	0.18	0.17	0.91	5
	6	2.08	1.44	−0.99	1.66	7.97	13.00	1.06	5
	8	5.00	0.62	−0.59	−1.17	0.08	0.57	0.22	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	−4.02	0.14	−0.72	3.95	0.03	2.74	7.87	5
	10	−3.54	−0.54	−0.92	4.22	0.26	4.56	0.50	5
	11	2.49	1.10	−0.69	1.24	1.10	0.30	0.31	6
	12	36.27	−7.59	−11.06	−5.06	4.09	6.79	4.79	6
	14	4.52	−0.53	−1.95	0.04	0.56	2.24	0.0001	6
	15	10.02	−0.13	−1.34	−2.40	0.04	7.57	1.53	5
	17	−2.18	0.73	−1.02	3.11	0.61	2.57	0.58	5
	18	6.29	−0.74	0.34	−1.63	0.10	0.01	0.08	5
	20	−11.82	−5.35	8.86	−1.51	11.56	17.40	0.55	5
	21	0.06	−1.37	−1.37	2.88	28.55 *	87.04 *	17.55	6
	22	0.54	0.39	1.03	−1.89	0.50	0.49	0.33	6
Late in July	1	8.07	−0.55	−1.52	−0.55	0.55	1.45	0.01	6
	2	−2.14	−0.39	0.44	1.48	1.15	0.08	0.67	5
	3	−8.85	0.22	−0.03	2.96	1.01	0.01	1.22	6
	4	−1.88	1.27	−0.05	0.47	41.96	0.13	0.30	5
	6	0.50	−0.38	−1.46	0.90	0.48	9.29	0.70	5
	7	6.57	−0.01	−0.49	−2.18	0.0002	0.61	0.28	5
	8	0.39	0.34	−0.92	0.31	114.16	42.71	1.64	5
	9	5.55	0.17	−0.71	−1.23	1.82	12.72	3.24	6
	10	−129.10	−0.48	2.99	55.23	0.34	0.35	0.77	5
	13	8.06	0.32	−0.85	−1.91	3.56	76.31 *	5.08	6
	14	−14.24	1.69	−1.59	7.05	11.88	15.20	5.45	5
	15	−2.95	0.44	−0.07	1.00	0.51	0.01	0.06	5
	16	−4.04	0.42	−1.64	3.93	0.27	7.33	0.60	5
	21	−40.54	−0.21	1.21	15.19	2.28	9.05	25.28	5
	22	−7.04	0.67	−0.15	2.76	1.60	0.09	33.41	5
Early in Aug.	1	1.26	−0.51	−0.35	0.47	1.76	1.29	0.63	6
	3	4.41	−0.97	−0.83	−1.17	10.93 *	3.66	0.63	7
	6	4.10	0.29	−0.29	−0.80	0.50	2.68	1.17	7
	7	−4.78	−1.98	6.76	−4.42	80.12	209.94 *	54.73	5
	10	−0.67	0.03	0.19	0.62	0.02	0.18	0.28	6
	11	3.52	0.001	−0.34	−0.81	0.000002	0.04	0.07	5
	12	10.44	−1.12	−0.37	−4.64	0.54	0.30	0.74	5
	14	−0.42	1.50	0.70	0.62	27.32	6.41	1.96	5
	16	−2.19	−0.58	−0.79	1.60	9.94	1.88	2.08	5
	17	11.54	−4.31	−1.85	−2.82	3.24	3.58	2.32	5
	19	1.61	−0.36	−0.80	0.19	0.63	1.85	0.003	6
	20	9.94	1.20	−0.54	−3.17	44.77 *	18.23	14.47	6
Middle of Aug.	1	1.13	0.46	−0.60	1.58	0.77	1.22	0.11	8
	2	−1.61	−1.62	−0.14	4.21	12.05 *	0.81	2.35	7
	3	9.08	−0.27	−1.62	−4.52	0.94	15.13 *	3.74	7
	4	10.79	−0.14	−0.84	−8.40	0.13	2.18	1.75	7
	6	14.37	−0.03	−1.26	−11.28	0.02	28.57 *	26.01*	7
	7	12.08	−0.53	−0.86	−8.52	0.31	2.20	0.57	7
	9	−5.88	2.49	0.17	8.00	1.04	0.11	0.46	7
	10	8.81	0.03	−1.21	−5.22	0.13	277.66 **	90.21 **	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	10.52	−0.10	−1.00	−7.88	0.06	6.78	6.39	7
	12	2.21	0.41	−1.18	1.43	0.10	5.03	0.13	7
	13	6.08	0.33	−0.80	−2.56	0.05	0.35	0.14	6
	14	−0.62	−0.46	0.09	1.25	1.22	0.09	0.09	7
	15	15.82	0.42	−0.24	−15.98	0.61	0.49	4.30	6
	16	−0.27	−0.15	0.03	0.76	0.02	0.02	0.02	7
	17	13.40	0.97	−1.02	−11.19	0.52	0.95	2.83	6
	20	−0.54	0.80	−1.70	6.14	0.21	10.52	0.63	6
	21	7.21	0.36	−0.43	−6.60	15.84	19.31 *	47.18*	6
	22	1.87	−0.35	−0.69	1.56	0.05	0.54	0.03	6
Late in Aug.	1	−2.07	0.25	−0.01	1.85	0.45	0.001	0.31	7
	2	24.50	−1.04	−0.52	−15.40	0.18	1.01	0.19	6
	4	−0.19	0.78	−0.69	2.99	67.93 **	83.16 **	12.56*	7
	6	−6.90	0.83	−0.77	8.97	8.98	44.60	31.75	5
	7	14.59	0.27	−0.50	−10.44	0.09	1.29	2.40	6
	8	−8.98	1.14	−0.53	11.53	7.11	5.77	18.14	6
	9	−0.87	0.40	−0.25	2.92	0.05	0.20	0.40	6
	10	29.43	−0.18	−0.36	−17.35	0.49	78.09	104.00	5
	11	9.80	3.45	−1.63	8.07	3.20	3.99	1.60	6
	12	−24.47	−0.87	−0.27	23.21	1.07	0.41	4.79	5
	13	4.69	0.12	−0.31	−3.38	0.01	0.38	0.32	5
	14	3.36	−1.07	−1.64	3.41	5.10	2.85	0.96	5
	15	−1.36	−0.25	−0.60	2.00	7.39	836.25 *	78.59	5
	16	4.40	−0.19	−1.40	0.19	0.01	4.08	0.002	6
	17	−7.72	0.41	0.23	4.87	0.26	0.29	0.35	5
	19	0.85	−1.06	−0.57	1.96	0.02	0.36	0.02	6
	20	30.87	−4.29	−1.26	−22.03	4.99	5.54	3.95	6
	22	9.45	−0.53	−1.74	−2.95	2.30	59.51	3.54	5
Early in Sept.	1	−2.55	0.54	0.12	2.09	1.71	0.10	1.72	7
	2	0.73	−0.56	−0.71	2.08	2.97	2.41	1.86	6
	3	−1.12	−0.40	−0.70	5.32	2.29	3.06	9.15	6
	4	−1.47	0.17	−0.31	2.90	0.90	15.47	8.61	6
	6	3.57	0.80	−0.67	−1.04	2.26	2.43	0.06	7
	7	15.89	0.51	−3.57	−4.71	0.40	23.85	1.36	6
	8	2.91	−0.88	−1.71	6.52	0.28	8.63	0.63	6
	9	−0.06	0.25	−0.34	1.90	0.82	3.15	9.53	5
	10	−1.40	−0.48	−0.20	2.10	0.44	0.02	0.20	7
	11	−2.78	0.43	−0.40	4.39	2.13	0.59	3.04	7
	12	−0.15	−0.50	−0.16	1.42	2.15	1.92	2.90	7
	13	4.57	−0.37	−1.30	1.59	0.20	3.02	0.26	6
	14	−11.93	−7.47	−3.57	15.20	4.14	13.10	8.72	6
	15	−5.00	2.01	−2.53	16.40	0.61	1.06	0.98	6
	16	6.45	0.33	−1.54	0.89	815.63*	27724.91**	415.79*	5
	20	−2.76	1.72	−0.07	3.99	5.24	0.01	1.96	7
	21	4.12	1.85	−3.37	2.52	5.58	12.89	1.97	6
	22	8.01	1.37	−0.52	−5.83	1.59	0.94	2.46	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	1.73	−2.39	−0.01	1.15	3.90	0.0002	0.24	5
	6	2.98	−1.00	−1.13	−0.13	0.77	1.41	0.04	5
	7	−0.40	0.15	−0.24	0.51	0.21	1.07	0.73	6
	9	−0.50	0.42	−0.18	0.85	0.90	0.21	2.84	6
	10	1.21	0.13	0.20	−0.90	0.05	0.36	0.43	5
	12	0.66	−0.42	0.01	−0.25	0.66	0.0002	0.06	5
	14	1.30	1.15	0.06	−1.39	792.68*	3.26	371.75*	5
	19	0.57	0.26	−0.81	1.23	0.82	5.50	2.39	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

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

The examination in the preceding section clarified that the coefficient of the distance of shooting position from the center of catch, a_2, took the negative value in 85% of the strata, but it was hard to say that the trend of long shift after the shooting distant from the center was clear, because the coefficient was significant only in less than 10% of the strata. In regard to the other coefficients, the examination in the preceding section could not lead to any clear suggestion. These results may be due to the insignificance of the estimated coefficient in most of the strata, 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 three days in the same month), and the same relations were examined again. But the results were similar to those of the preceding section. The coefficient of the difference of catch, a_1, was significantly positive in the three strata out of the 102 ones, insignificantly positive in the 60 strata but insignificantly negative in the 57 ones, and significantly negative in the two ones. The rate of the strata taking the positive a_1 did not show any significant difference according either to the month ($\chi_0^2 = 2.29$, with 5 degrees of freedom; $0.90 > \Pr\{\chi_0^2 > \chi^2\} > 0.80$) or to the seiner ($\chi_0^2 = 32.09$, with 21 degrees of freedom; $0.10 > \Pr\{\chi_0^2 > \chi^2\} > 0.05$). The trend of the coefficient of the distance from the center of catch, a_2, taking the negative value became clearer. The coefficient a_2 was significantly positive only in one of the strata, insignificantly positive in the eight ones, but insignificantly negative in the 62 ones, and significantly negative in the 31 ones. These facts meant that the seiner fished distant from the center of catch inclined to approach to the center. The rate of the strata taking the positive a_2 did not show any significant difference according either to the month ($\chi_0^2 = 9.81$, with 5 degrees of freedom; $0.10 > \Pr\{\chi_0^2 > \chi^2\} > 0.05$) or to the seiner ($\chi_0^2 = 14.16$, with 21 degrees of freedom; $0.90 > \Pr\{\chi_0^2 > \chi^2\} > 0.80$). The coefficient of the deviation of catch, a_3, was significantly positive in the four strata, insignificantly positive in the 34 ones, but insignificantly negative in the 61 ones

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	1.80	−0.06	−0.54	−0.05	0.03	2.19	0.01	12
	2	3.93	−0.43	−0.84	−0.69	0.60	14.36**	1.07	16
	3	0.11	0.48	−0.07	−0.26	1.41	0.09	0.60	14
	4	1.89	−0.47	−0.33	0.05	0.64	0.36	0.001	10
	5	2.49	−0.18	−0.23	−1.17	0.28	0.63	2.29	11
	6	4.25	−0.29	−1.23	−0.72	0.34	14.92*	0.93	7
	7	1.86	−0.13	−0.29	−0.34	0.27	0.82	0.75	15
	8	0.58	3.39	0.07	1.03	2.38	0.01	1.40	9
	9	13.22	3.60	−1.43	−1.36	73.70	112.06	2.69	5
	10	2.03	0.32	−0.38	−0.35	1.04	3.03	1.03	16
	11	2.95	0.16	−0.28	−1.15	0.44	2.81	5.60*	12
	12	1.66	−0.30	−0.36	0.10	1.49	3.51	0.04	14
	13	3.85	0.07	−0.80	−0.75	0.04	14.54**	4.77	13
	15	0.15	0.57	−0.16	−0.21	2.61	0.74	0.40	14
	16	1.21	0.38	−0.43	−0.04	4.68	4.52	0.02	12
	17	5.76	1.28	−1.41	−0.30	4.77	7.23	0.03	8
	18	2.83	−0.03	−0.61	−0.47	0.001	3.25	0.25	7
	19	1.46	0.40	−0.52	−0.38	1.31	2.02	0.30	9
	20	2.56	0.30	−0.46	−0.43	0.35	1.76	0.23	13
	21	1.61	0.35	−0.28	−0.20	0.96	0.50	0.24	10
	22	0.20	1.45	0.51	0.11	5.17	1.09	0.06	12
June	1	2.31	0.32	−0.71	−0.36	1.43	5.03*	0.30	19
	2	0.99	−0.41	0.09	−0.70	1.04	0.83	0.61	14
	3	2.13	0.17	−0.61	−0.42	0.35	4.40	0.39	18
	4	−0.68	−0.94	0.63	0.002	2.63	1.26	0.000002	19
	5	0.55	−0.87	−0.44	0.71	1.48	0.97	0.40	11
	6	−1.79	−0.17	0.05	2.64	0.12	0.05	2.64	16
	7	5.40	0.48	−0.67	−3.36	1.25	3.54	3.84	16
	8	4.54	1.26	−0.22	−4.06	3.67	0.42	3.69	18
	9	3.58	−0.39	−0.45	−2.05	0.50	6.04*	3.20	11
	10	0.83	0.07	−0.18	0.05	0.11	1.97	0.02	18
	11	2.01	0.16	−0.45	−0.12	0.32	2.91	0.01	17
	12	1.61	0.27	−0.28	0.18	0.74	7.22*	0.02	18
	13	0.25	−0.10	−0.19	0.48	0.09	0.64	0.28	20
	15	2.74	−0.20	−0.42	−0.84	0.17	3.11	0.97	18
	16	5.02	0.26	−1.00	−1.59	0.25	11.25**	3.43	15
	17	−2.24	1.46	0.83	1.67	4.03	5.70*	0.72	17
	18	11.43	−0.61	0.42	−9.93	0.39	0.23	2.86	11
	20	2.20	−0.30	−0.45	−1.07	1.37	6.86*	3.05	16
	21	4.70	0.65	−0.81	−2.15	2.03	9.84**	1.25	16
	22	1.05	−0.33	−0.05	−0.45	0.95	0.31	0.48	21

Table 3 . — (Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
July	1	0.36	−0.24	−0.84	1.37	0.87	6.50*	3.33	15
	2	4.89	−0.12	−0.37	−1.16	0.31	0.65	2.35	16
	3	2.44	0.20	−0.80	−0.28	1.90	20.71**	0.10	15
	4	2.14	0.62	−0.32	−0.64	3.62	1.52	0.48	13
	5	−0.42	0.84	−1.93	3.64	1.62	3.48	0.79	6
	6	5.44	0.24	−0.84	−1.27	0.48	17.16**	3.97	13
	7	5.59	−0.14	−0.54	−1.64	0.31	5.23*	4.00	15
	8	4.47	0.13	−0.60	−1.22	0.52	8.19*	3.34	18
	9	0.95	0.32	−0.71	0.73	2.71	9.40*	1.44	15
	10	2.62	0.21	−1.10	0.16	1.09	21.76**	0.02	16
	11	4.51	0.54	−0.53	−0.83	3.02	5.56*	0.62	16
	12	5.21	0.10	−1.07	−0.92	0.07	8.64*	0.58	16
	13	5.08	−0.07	−1.00	−0.91	0.25	55.10**	1.48	13
	14	3.02	0.24	−0.65	−0.47	0.89	5.34*	0.19	18
	15	9.16	−0.23	−1.33	−2.68	0.61	17.52**	6.86*	15
	16	4.65	−0.26	−1.05	−0.62	2.79	41.34**	1.85	14
	17	1.87	0.39	−0.91	0.24	2.58	18.24**	0.08	16
	18	5.55	−0.18	−0.68	−1.20	0.11	0.61	0.50	12
	20	6.26	0.34	−0.37	−2.09	0.17	0.09	1.34	15
	21	0.68	0.03	−0.92	0.68	0.01	8.43*	0.33	14
	22	1.53	0.15	−0.31	−0.18	0.81	1.59	0.10	17
Aug.	1	1.65	0.06	−0.45	0.39	0.08	5.34*	0.54	21
	2	2.11	−0.59	−0.12	0.29	0.33	0.75	0.02	16
	3	1.44	−0.52	−0.25	−0.23	4.49	3.13	0.13	18
	4	2.56	−0.04	−0.70	0.45	0.05	16.83**	0.44	18
	6	1.21	−0.05	−0.27	0.35	0.04	3.94	0.27	19
	7	4.04	−0.11	−0.41	−1.40	0.09	2.83	1.10	18
	8	1.25	−0.09	−0.19	−0.31	0.02	0.52	0.02	12
	9	6.39	1.11	−0.67	−1.13	3.70	8.93*	1.03	17
	10	3.14	0.48	0.001	−1.24	1.31	0.0003	0.63	18
	11	1.91	0.02	−0.15	−0.66	0.01	1.41	0.35	18
	12	0.60	−0.25	−0.54	1.42	0.16	3.25	0.94	17
	13	6.16	0.20	−0.66	−3.02	0.17	1.54	3.89	14
	14	1.30	0.02	−0.12	−0.73	0.01	0.38	0.97	17
	15	0.41	−0.33	−0.30	0.54	1.01	1.27	0.12	14
	16	1.87	−0.06	−0.05	−1.16	0.01	0.10	0.90	18
	17	3.00	0.40	−0.04	−2.35	1.03	0.15	5.84*	16
	19	2.59	−0.26	−0.54	−0.52	0.38	2.95	0.06	12
	20	2.24	0.25	−0.25	−0.41	0.30	1.43	0.11	18
	21	1.44	0.95	−0.24	0.01	3.57	1.01	0.003	13
	22	5.56	0.08	−0.83	−2.19	0.04	7.54*	4.60	14

Table 3 . — (Cont'd)

	Boat No.	a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
Sept.	1	−0.72	1.90	0.55	−1.57	3.17	0.42	0.06	9
	2	2.95	−0.39	−0.001	−3.02	0.34	0.0002	4.27	8
	3	1.43	−1.69	−0.23	1.70	9.48*	0.68	2.52	11
	4	0.60	−0.18	−0.15	0.19	1.81	2.79	0.13	8
	6	1.13	0.72	−0.45	0.76	5.52*	4.65	1.95	12
	7	1.32	0.69	−0.57	0.30	0.85	1.70	0.10	12
	8	3.90	0.86	−1.41	2.50	0.78	6.64	0.39	8
	9	−0.32	0.57	−0.01	0.63	7.02*	0.01	7.57*	11
	10	−0.28	−0.58	−0.21	0.95	2.79	0.55	1.49	12
	11	−2.37	0.08	−0.06	2.25	0.11	0.09	9.62*	11
	12	0.94	−0.55	−0.03	−0.30	5.45*	0.09	0.85	12
	13	4.49	0.04	−0.89	0.14	0.04	4.79	0.03	10
	14	4.12	0.46	−0.83	−1.35	0.64	5.30	1.62	11
	15	1.29	0.06	−0.51	1.24	0.04	4.47	2.79	10
	16	5.62	0.85	−1.12	−0.17	8.75*	29.67**	0.04	9
	17	0.72	0.05	−0.74	1.68	0.08	19.78*	10.55*	7
	19	0.57	0.26	−0.81	1.23	0.82	5.50	2.39	6
	20	−5.07	−0.01	−2.09	15.85	0.0001	8.97*	7.68*	11
	21	1.55	−0.12	−0.75	0.48	0.06	1.15	0.04	9
	22	1.89	0.20	−0.26	−0.92	0.11	0.40	0.24	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

and significantly negative in the three ones. These facts meant that the trend of the seiner approaching to the center of catch was stronger when the catch showed a larger deviation. The rate of the strata taking the positive a_3 differed according to the month ($\chi_0^2 = 13.87$, with 5 degrees of freedom; $0.02 > \Pr\{\chi_0^2 > \chi^2\} > 0.01$), but it was hard to find its change relating to the passing of season ($F_3 = 0.14$, $F_2 = 0.58$, and $F_1 = 0.11$, with 1 and n-i-1 degrees of freedom; $n = 6$). The rate did not show any significant seiner-by-seiner difference ($\chi_0^2 = 21.00$, with 21 degrees of freedom; $0.50 > \Pr\{\chi_0^2 > \chi^2\} > 0.30$).

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

The results of the second section were clearer than those of the first one, but still somewhat obscure. The regression equations were estimated in the first section and the second one after the twofold stratification according to the date (or the month) and the seiner, because of the following reasons: the behavior of the objective fish and the workable hour of the seiner differ according to the season, in consequence, the results may differ according to the season. The problem treated here is likely to depend

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

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

		a_0	a_1	a_2	a_3	F_1	F_2	F_3	n
April	late	2.86	0.03	−0.48	−0.16	0.27	19.40**	0.22	68
May	early	3.44	0.15	−0.50	−0.50	3.33	16.73**	7.16*	50
	middle	3.51	0.08	−0.45	−1.43	0.66	42.42**	9.80**	105
	late	2.49	−0.11	−0.50	−0.48	0.34	38.55**	0.48	86
June	early	1.96	0.14	−0.54	−0.71	2.33	36.90**	2.71	116
	middle	−3.00	−0.15	−0.11	5.10	1.65	7.48**	19.77**	130
	late	3.20	0.13	−0.18	−1.15	0.52	0.86	6.77*	90
July	early	2.05	0.09	−0.59	−0.07	1.59	42.28**	0.05	109
	middle	4.83	0.04	−0.96	−0.62	0.13	71.80**	1.72	105
	late	3.17	0.10	−0.72	−0.50	2.79	101.55**	1.15	98
Aug.	early	2.02	0.11	−0.27	−0.39	1.16	11.23**	0.79	98
	middle	3.27	0.06	−0.30	−1.82	0.30	26.01**	3.75	125
	late	2.38	0.28	−0.04	−1.67	2.03	0.54	1.50	109
Sept.	early	0.45	0.25	−0.59	2.08	3.43	40.71**	8.58**	117
	middle	1.32	0.10	−0.13	−0.11	0.44	3.31	0.05	86

Note:

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

*significant at 0.05 levnl **significant at 0.01 level

on the temperament and preference of the skipper, and the possibility of the results differing according to the seiner could not be neglected. But the results in the preceding two sections did not show any fact supporting this possibility. Accordingly, the records were stratified according to the date pooling those of the different seiners, and the same relations were examined. Then the trend found out in the preceding two sections became clearer, probably because of the increase in the sample size for estimating respective equations. The coefficient of the difference of catch, a_1, was insignificantly positive in the 13 strata (the groups of the records on the same day) out of the 15 ones, and insignificantly negative in the two strata. It was hard to find its change with passing of season ($F_3 = 0.67$, $F_2 = 1.08$, and $F_1 = 3.16$, with 1 and n-i-1 degrees of freedom; $n = 15$). The coefficient of the distance from the center of catch, a_2, was insignificantly negative in the three strata and significantly negative in the 12 ones. This coefficient did not show any significant seasonal change ($F_3 = 0.55$, $F_2 = 0.59$, and $F_1 = 0.70$, with 1 and n-i-1 degrees of freedom; $n = 15$). The coefficient of the deviation of catch, a_3, was significantly positive in the two strata, but insignificantly negative in the ten ones, and significantly negative in the three ones. This coefficient also did not show any significant seasonal change ($F_3 = 0.97$, $F_2 = 0.02$, and $F_1 = 0.00$, with 1 and n-i-1 degrees of freedom; $n = 15$). All the results of these three sections may be summarized into as follows: among the three factors examined, the influence of the distance from the center of catch was clearest: the seiner fished at the distant position from the center of catch inclined to approach to the center when the shifts after the shootings of the catch difference of the same grade under the same deviation of catch were compared with one another. The deviation of the catch was the factor next to the distance from the center of catch in respect of the influence on the approaching trend of the seiner to the center. The seiner decided the position of shooting basing on the information of the larger deviaiton of catch inclined to show the stronger trend of approaching to the center of catch, when the shootings yielded the catch difference of the same grade from the average at the position the same distance apart from the center were compared with one another. The difference of the catch had the roughest relation to the trend of the seiner approaching to the center of catch. And it may be said that the seiner inclined to approach to the center after the poorer catch than the average just before but inclined to shift away from the center after a better catch.

Discussion

The clearest finding in the preceding three reports[1)-3)] was the trend of the seiner shifted over a long distance after a poor catch but sticked to the similar position to the preceding shooting after a good catch. And the similar trend was found out in the fourth report[4)]. The seiner inclined to shift over a long distance after a poor catch but only a short distance after a good catch when the relation between the distance of shift and the difference of the catch from the average of catch just before the shooting was discussed. These findings were relating to the distance of shift. The results were different when the direction of shift was taken into account. Only a rough trend of the seiner approaching to the center after a poor catch but shifting away after a good catch was found in the present report when the records of the different seiners were pooled. The second[2)] and the fourth[4)] reports dealt with the relation between the distance of shift and the catch. The catch in the second report was that of the same seiner by the shooting just before the shift, but that in the fourth report was the difference of the catch by the shooting just before the shift from the average of catch by the fellow seiners. And the meanings were different but the results were similar. The present report was the same to the fourth one in respect of the independent variables but different in the dependent one. And it may be concluded as follows: the amount of catch not only by the same seiner but also by the fellow ones should be the most important motives of the shift, but the scouting direction was not exclusively towards the center of catch but also probably towards the most profitable depth zone, because the objective fish shows a well-defined bathymetric difference in the density and the fleet fished along the edge of the continental shelf. The shift of the latter direction made the result of the present report obscure, in spite of somewhat clear results in the preceding reports.

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. But this factor had the clearest influence on the trend that the seiner approaches to the center of catch. These findings meant that the influence of the distance from the center of catch had only a rough relation to the distance of shift; but if the seiner distant from the center shifts, she shifts mainly towards the center. This may be due to the following reason: the seiners, were distributed roughly along an isobath and the influence of the difference of catch may be the shift mainly towards the probably profitable depth zone but that of the distance from the center may be mainly along the isobath towards the center of catch. But there remained a doubt as to whether the shift along the isobath towards the center—i.e. roughly towards the center of the distribution of the fellow seiners—was mainly for increasing the catch or for convenience of the fleet operation.

The influence of the deviation of catch could be divided into the two types: one is through the different influence of catch and that of the distance from the center, and the other is direct one. The approaching trend was clearer when the catch difference was the larger or when the seiner fished at the further point from the center. It is probable that the catch difference of the same grade may be more serious and the distance from the center of catch may be less serious when the deviation of catch was small. But it was hard to isolate the indirect influences, although they were eliminated from the results of the influence of the above-mentioned two factors, for the standard deviation of catch was adopted as one of the independent variables. The results showed that the seiner decided the position of the next shooting basing on the catch of large variation inclined to show the stronger trend of approaching to the center of catch when the shootings at the same grade of catch difference from the average at the same distance apart from the center were compared with one another.

All these facts may suggest that the informations from the fellow seiners should be used as the important bases of determining the location of the next shooting.

Conclusion

All the results of the examinations and discussion were summarized, and the following trends supporting the role of the informations in determining the position of the next shooting were obtained: the seiner inclined to approach to the center of catch after a poor catch when the catch was compared with the average of catch estimated from the informations of the fellow seiners just before determining the position of shooting. The seiners fished the more distant from the center of catch showed the stronger trend of approaching to the center of catch. And the approaching trend of the seiner to the center of catch was clearer when the seiner decided the position of shooting basing on the dishomogeneous catch, when the trends after the shooting of the same grade of catch difference at the same distance apart from the center were compared with one another.

Summary

For the purpose of examining the possibility of the informations from the fellow seiners used as the bases of determining the position of the next shooting (whether the seiner would approach to the center of catch or not), the records of respective shootings on the 15 days were chosen randomly from all the catch records during the entire season of 1964 by 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. And the average, standard deviation (x_3), and the center of catch just before respective shootings were estimated from the records within two hours before respective shootings. Then, the difference of the catch by respective shootings from the floating average (x_1) of catch and the distance (x_2) of the position of shooting from the center of catch were estimated. And the multiple linear regression equation of $x_{2i}-x_{2(i-1)}$ on x_1, $x_{2(i-1)}$, and x_3 were examined in the present report, and the following trends supporting the role of the informations in determining the position of the next shooting were found out:

1. When the records were stratified according to the date and the seiner, the coefficient of the difference of catch from the average, a_1, took the positive value in a half of the strata but the negative one in the other half, and was significant only in less than 5% of the strata.
2. The coefficient of the distance from the center of catch, a_2, was negative in the 85% of the strata although significantly negative in only a little more than 5% of the strara.
3. The coefficient of the deviation of catch (standard deviation), a_3, was positive in a half of the strata but negative in the other half.
4. When the records in the same month were pooled (stratifying the records according to the month and the seiner), the similar results were obtained in regard to a_1 and a_3, but the trend of a_2 taking the negative value became clearer (in 90%).
5. Because the above-mentioned steps did not show any significant seiner-by-seiner difference, the records of the different seiners were pooled, and the following trends were found out: the coefficient a_1 became insignificantly positive, a_2 significantly negative, and a_3 insignificantly negative in most of the strata.
6. These facts meant that the influence of distance from the center of catch was clearest (the seiner fished distant from the center inclined to approach to the center), the deviation of catch succeeded to this in respect of the influence on the approaching trend (under the larger deviation of catch, the approaching trend became the clearer), but the influence of catch difference was most rough—the seiner inclined to approach to the center after a poor catch when the relation between the distance of shift and the difference of catch from the average just before shooting the gear was discussed.

References

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